Due to the topographic and geological conditions described above, three plans are compared for the penstock layout; the open plan, the tunnel plan and a combination of the open and tunnel plans.

The layout in each plan is shown in Fig. 9-11. The longitudinal section is shown in Fig. 9-12. An extension of each plan is described below. Comparing the construction costs for the three plans above, the tunnel plan of Route-2 provides the best economic factor.

| Route | Type of Penstock | Length (m) | | Total Length (m) | Adit (m) |
|---|---|---|---|---|---|
| | | Open | Tunnel | | |
| Route 1 | Open | 1,595 | 400 | 1,995 | 0 |
| Route 2 | Tunnel | 0 | 1,693 | 1,693 | 160 |
| Route 3 | Tun. Open | 450 | 1,225 | 1,675 | 100 |

(4) **Turbine Type**

Judging from the plan data (net head 359.4 m, maximum discharge 27 $m^3/s$), either a Francis or Pelton turbine may be considered. As this site was selected to deal with the peak load, a Francis turbine which provides high maximum efficiency and large maximum output is advantageous as shown in Table 9-15.

### 9.3.4 Optimum Development Plan

The previous study regarding a development plan on the Naranjo River confirmed as follows.

- General layout of Los Llanos hydroelectric project is as shown in Fig. 9-13.
- 62 m high gate type concrete gravity dam is constructed at the downstream axis with effective storage of 653 x $10^3$ $m^3$ allowing daily regulation as shown in Fig. 9-14.
- Peak running time is 5 hours.
- Maximum discharge is 27 $m^3/s$ as shown in Fig. 9-15.
- Power plant with 2 units of 42.5 MW is built on the left bank of the Paquita River.
- Compensation is estimated in the project cost in order to make up a poor African palm harvest owing to the decreased water caused by the project.

## (1) Basic Conditions for Study

(a) Annual Cost Method

In making examinations of the study for optimum development plan, the technique of taking a standard type of thermal power station that would have been constructed if the Project did not exist as an alternative facility and considering the cost of that thermal as the benefit was used.

The alternative facility selected was a combination of gas turbine and diesel engine power plants that could be considered as an alternative to Los Llanos Power Station.

In making the examination, market prices were used with the annual surplus benefit (B-C) and the benefit-cost ratio (B/C) as indices. Cost (C) is the equalized annual cost for the service life (50 years) of the hydro power facilities and Benefit (B) is the equalized cost of the alternative thermal.

The particulars of the alternative thermal power station are given in Table 9-16.

(b) Annual Cost

The equalized annual cost of a hydropower facility consists of depreciation, interest and operation and maintenance cost. The cost is obtained by multiplying the construction cost by the annual cost factor.

Annual Cost = Annual Cost Factor x Construction Cost
= Depreciation + Interest + Operation and Maintenance Cost

Depreciation + Interest = Construction Cost x Capital Recovery Factor

$$\text{Capital Recovery Factor} = \frac{i(1+i)^n}{(1+i)^n - 1}$$

where, n: service life,

| | | |
|---|---|---|
| | civil structure | 50 yr |
| | hydraulic equipment and facilities | 35 yr |
| | electrical equipment and facilities | 35 yr |

i: discount rate, 12 percent

Capital Recovery Factor:

| | |
|---|---|
| Civil structure | 12.0% |
| Hydraulic equipment and facilities | 12.2% |
| Electrical equipment and facilities | 12.2% |

Depreciation + Interest ≒ Construction Cost x 12%

Operation and Maintenance Cost ≒ Construction Cost x 1%

Therefore, Annual Cost ≒ Construction Cost x 13%

(c) Conception of Benefit

The benefit of the Project is to be the total of the overall depreciation, interest, maintenance and administration cost, and fuel cost of the alternative thermal power station. The output and energy production of the Project used for benefit calculations are obtained according to the conditions indicated below. These are respectively defined as effective output and effective electric energy. Transmission line losses are not considered in the study below.

i) The effective output is the dependable peak output less the station power ratio of 0.3 percent, accident ratio of 0.3 percent, and repair ratio of 2.0 percent. The dependable peak output is the average value of monthly minimum peak outputs during the energy calculation period (25 years).

Effective Output = (1 - 0.003) x (1 - 0.003) x (1 - 0.02) x Dependable Peak Output

ii) The effective electric energy is the annual energy production less the station service ratio of 0.3 percent.

Effective Electric Energy = (1 - 0.003) x Annual Effective Energy

Furthermore, firm electric energy is defined as the electric energy produced during the necessary equivalent peak duration. The secondary electric energy is defined as all other electric energy.

iii) Benefit = Effective Output x kW Value + Firm Energy x Firm kWh Value + Secondary Energy x Secondary kWh Value

(d) Result

Based on project cost, firm power, firm energy and secondary energy estimated for optimum development plan, benefit cost relation (B-C) have been estimated as shown in Table 9-17. The result reveals that Los Llanos Project is feasible.

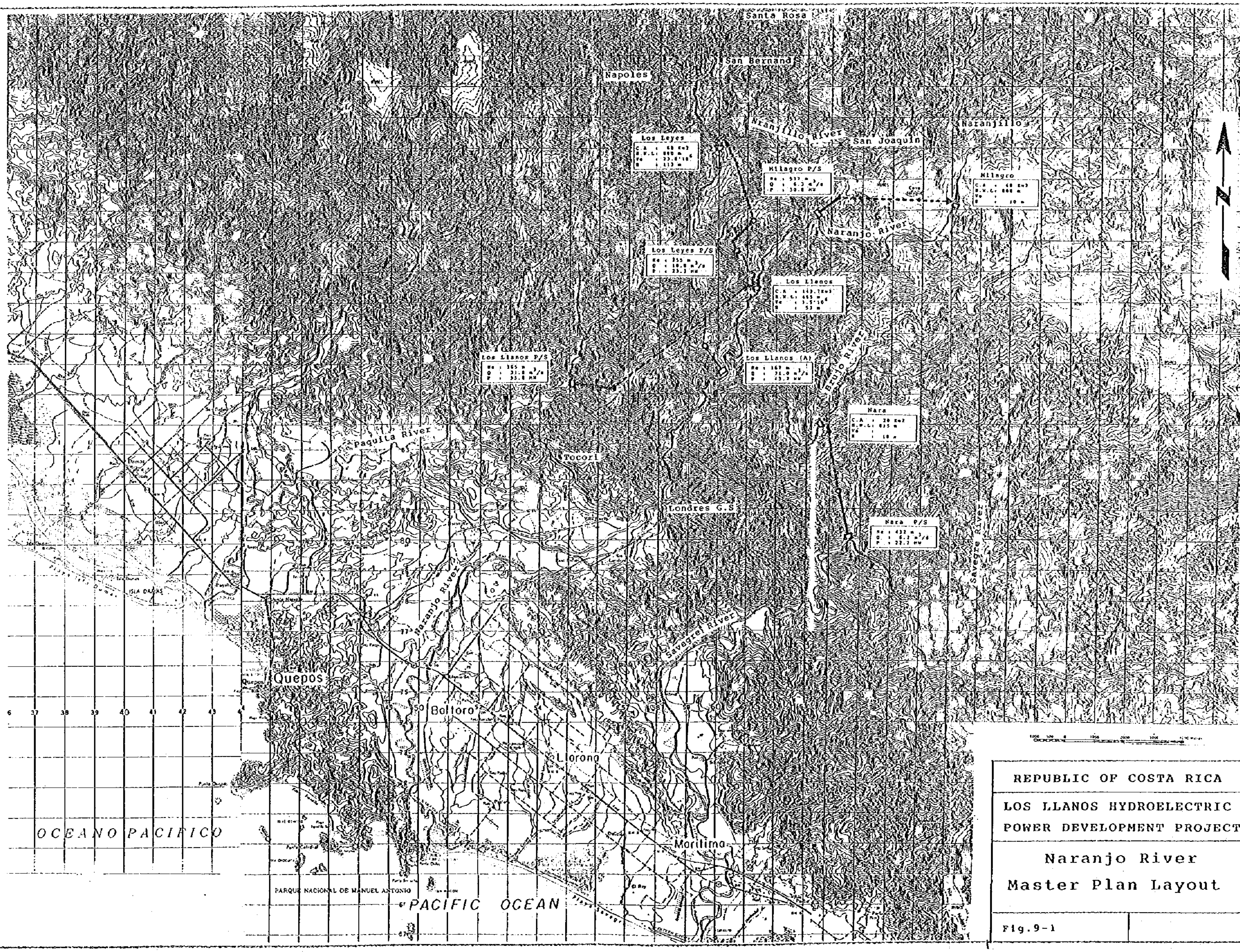
## (2) Optimum Development Plan

The projected outline for optimum development plan is as follows.

| | |
|---|---|
| High Water Level | EL. 477.4 m |
| Low Water Level | EL. 470.0 m |
| Effective Storage Capacity | 653 x $10^3$ $m^3$ |
| Tail Water Level | EL. 84.0 m |
| Gross Head | 389.7 m |
| Effective Head | 359.4 m |
| Maximum Discharge | 27 $m^3/s$ |
| Installed Capacity | 85 MW |
| Firm Power Output | 82.7 MW |
| Annual Available Energy | 389 GWh |
| Firm Energy | 107 GWh |
| Secondary Energy | 282 GWh |

Main Facilities

| | | |
|---|---|---|
| Dam | Concrete Gravity Type | 62.4 m x 114 m |
| Headrace | | 3.1 m x 5,540 m |
| Surge Tank | | 8.0 m x 58 m |
| Penstock | Tunnel Type | 3.10 m - 1.25 x 1,570 m |
| Powerhouse | Open Type | |
| | Francis Turbine | |

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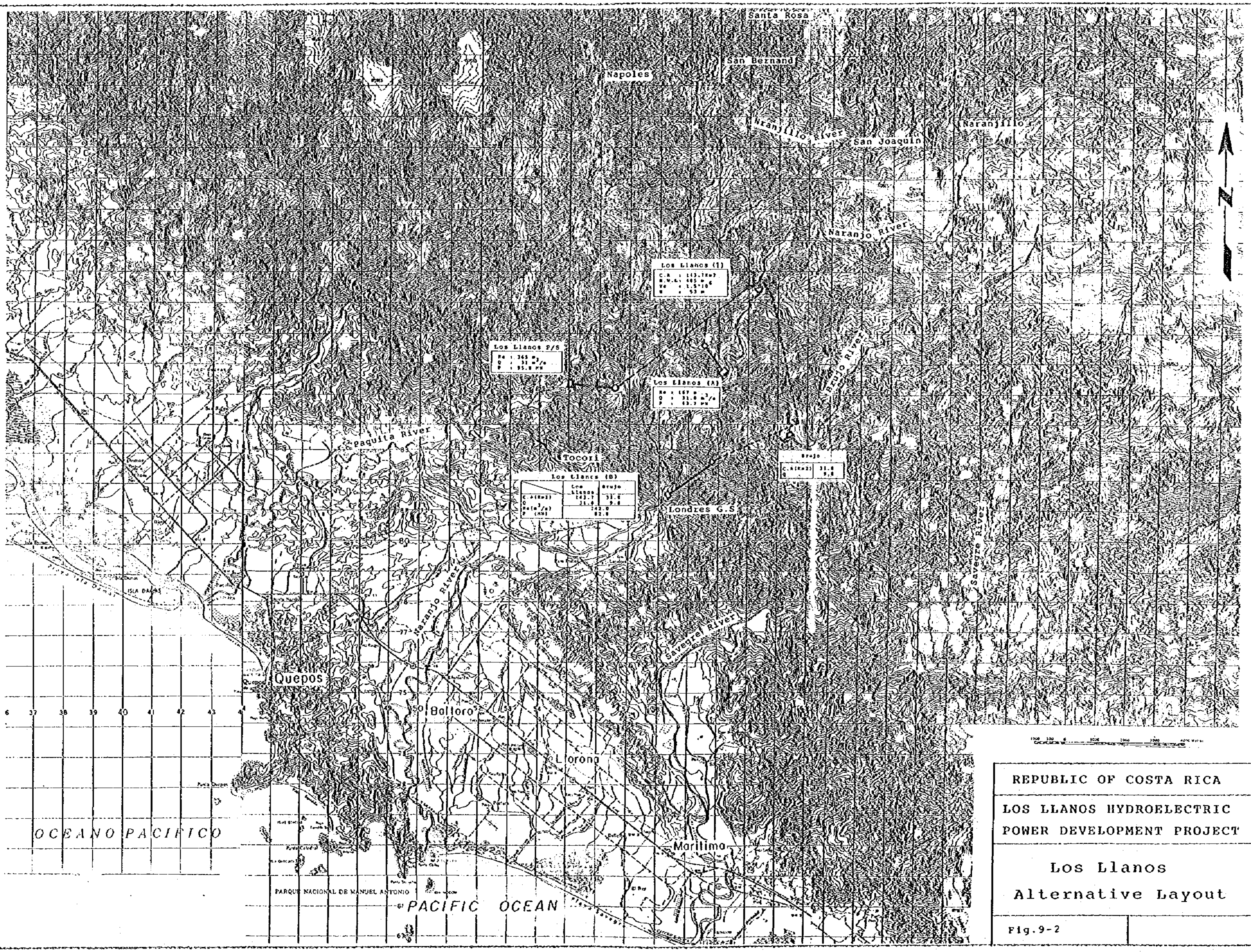
LOS LLANOS HYDROELECTRIC POWER DEVELOPMENT PROJECT

Naranjo River Master Plan Layout

Fig.9-1

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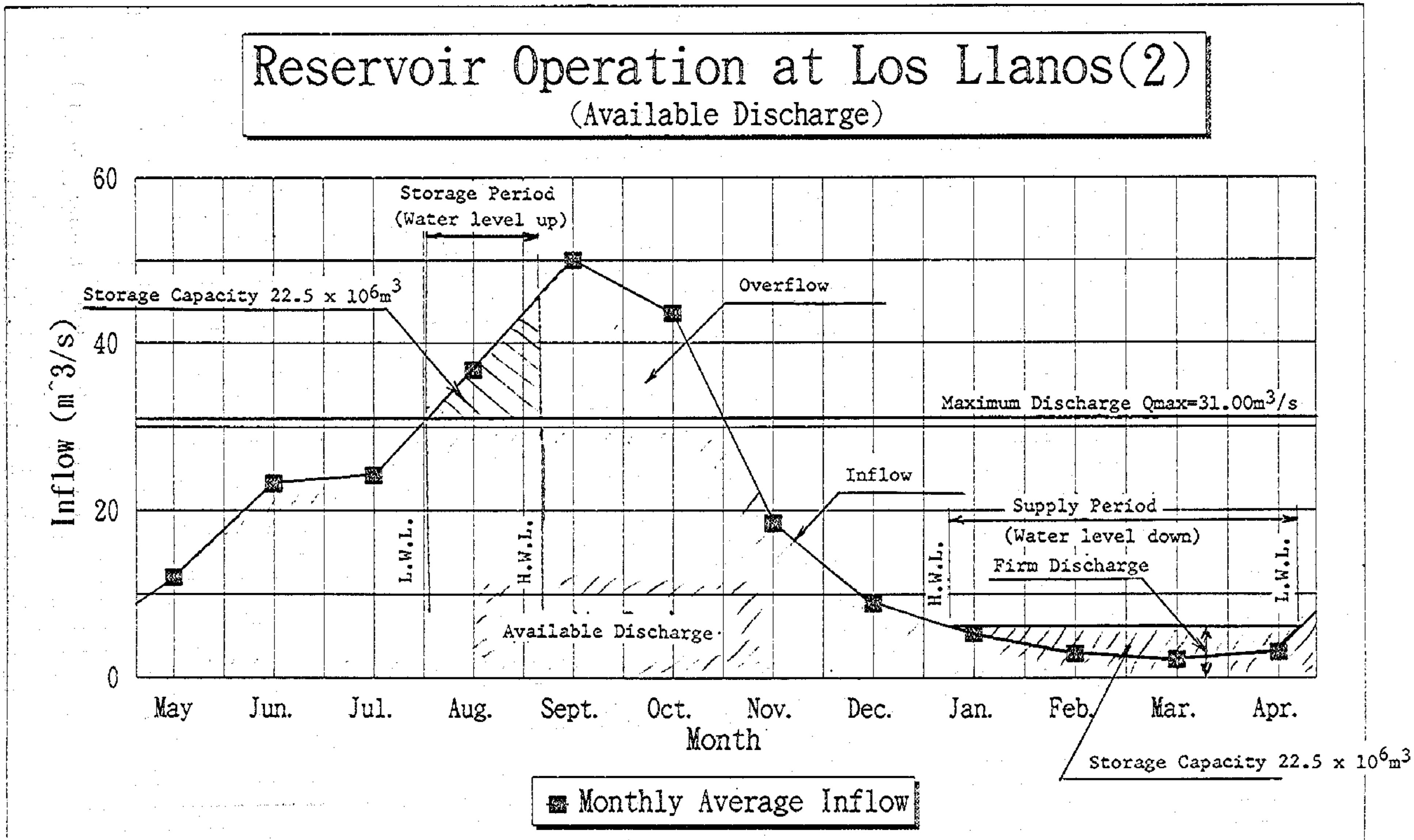
LOS LLANOS HYDROELECTRIC POWER DEVELOPMENT PROJECT

Los Llanos Alternative Layout

Fig.9-2

5-6




Period : May 1988 to Apr. 1989

Fig. 9-3 Reservoir Operation at Los Llanos (2)

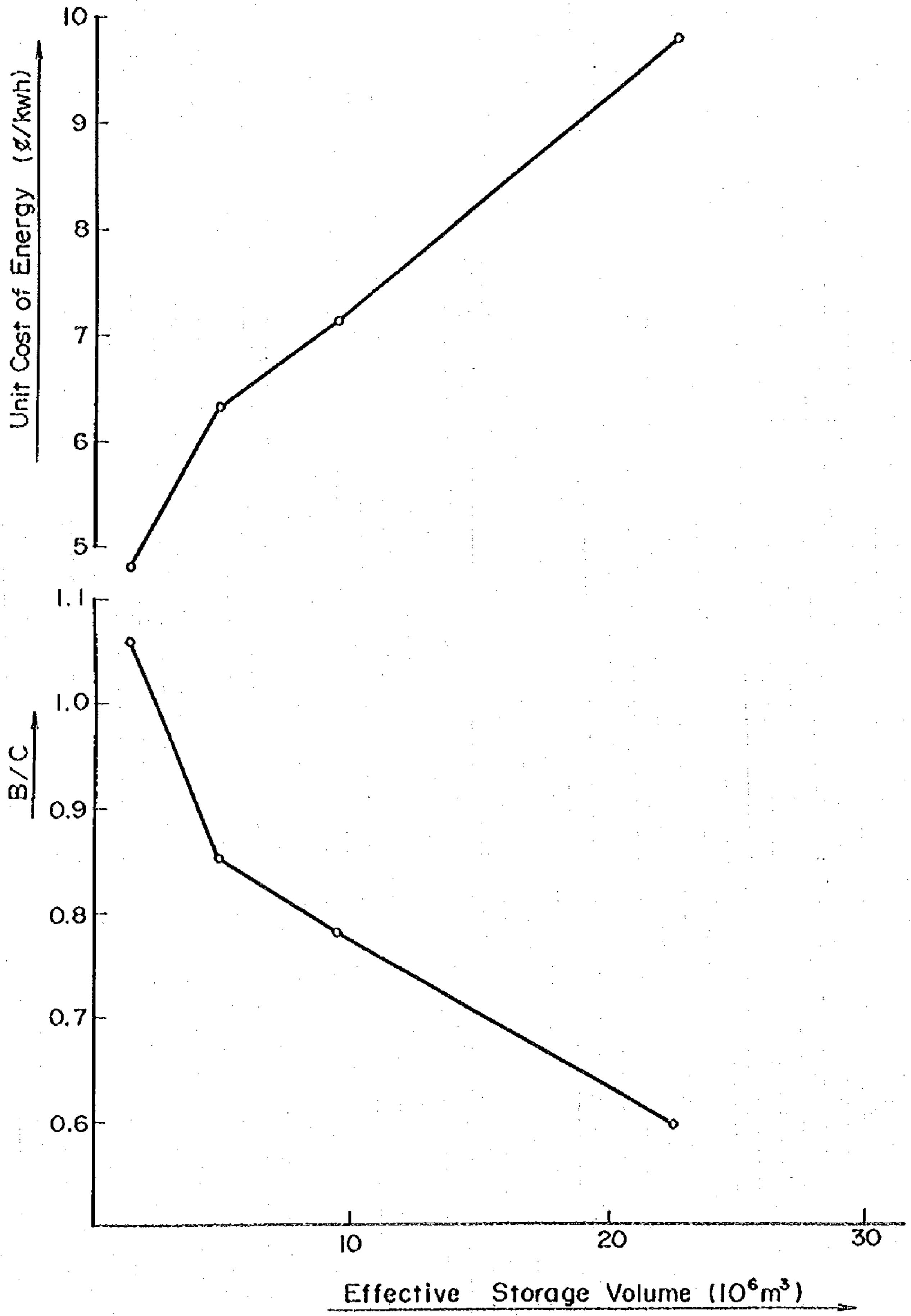
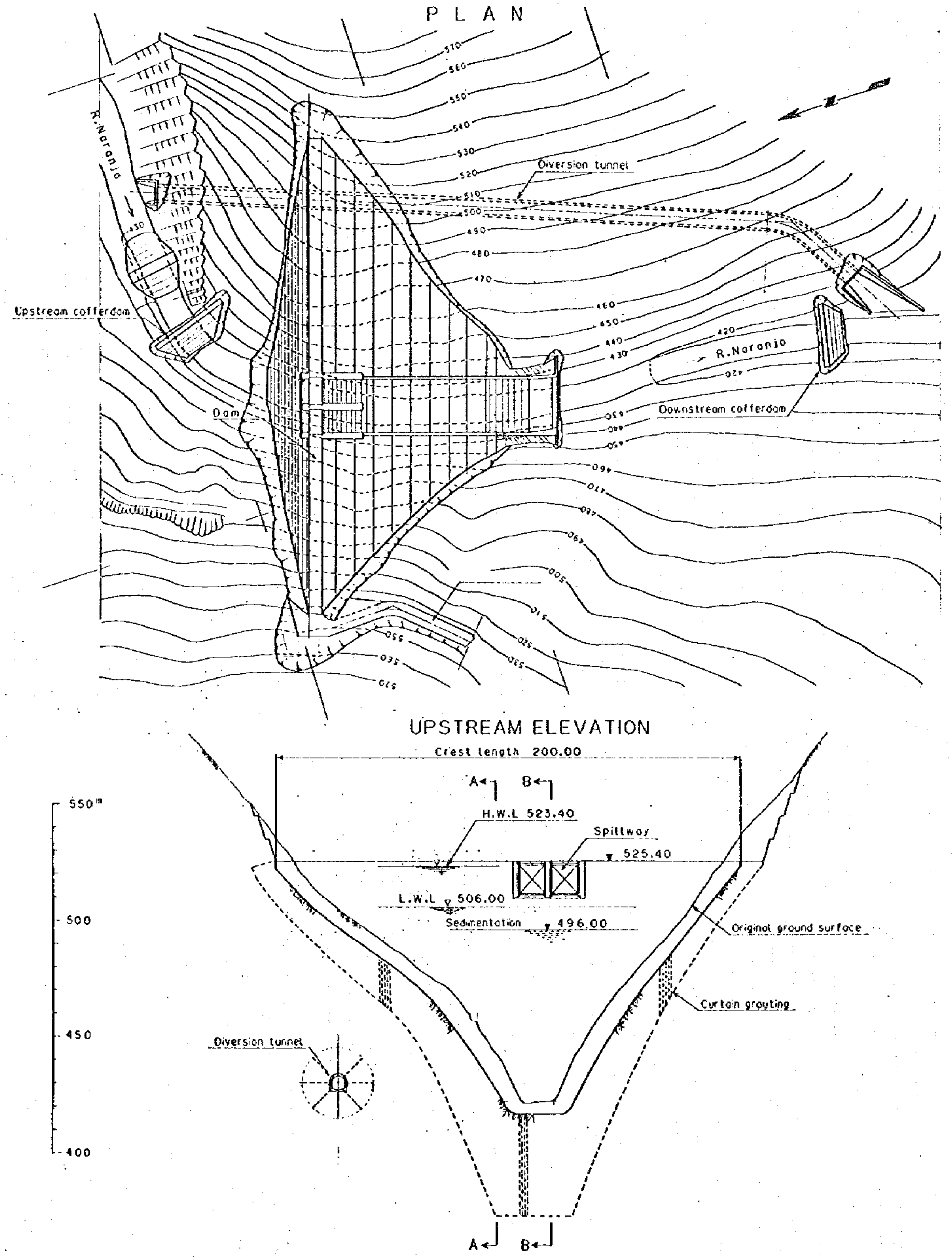
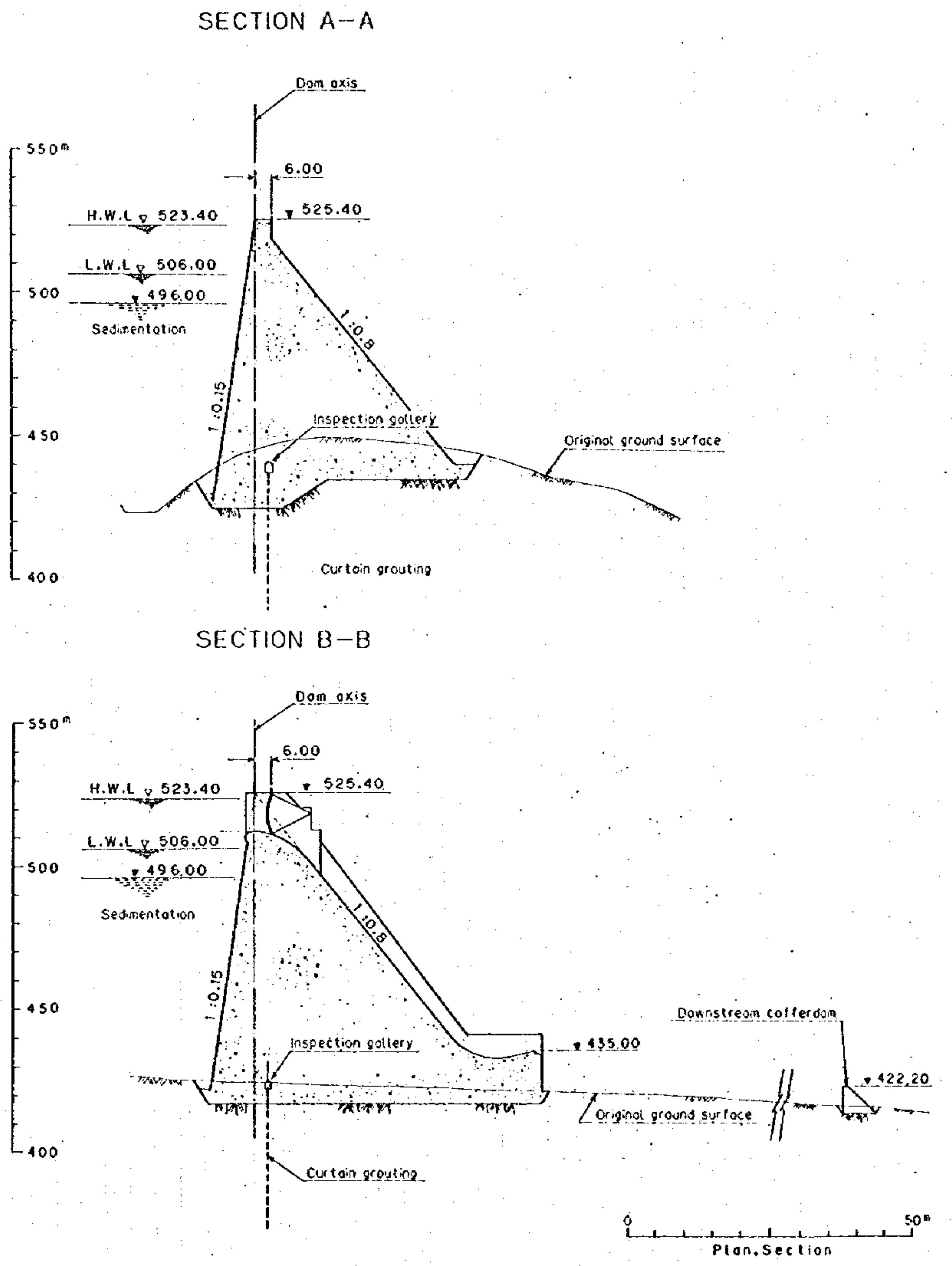



Fig. 9-4 Study on Reservoir Storage Volume at Los Llanos

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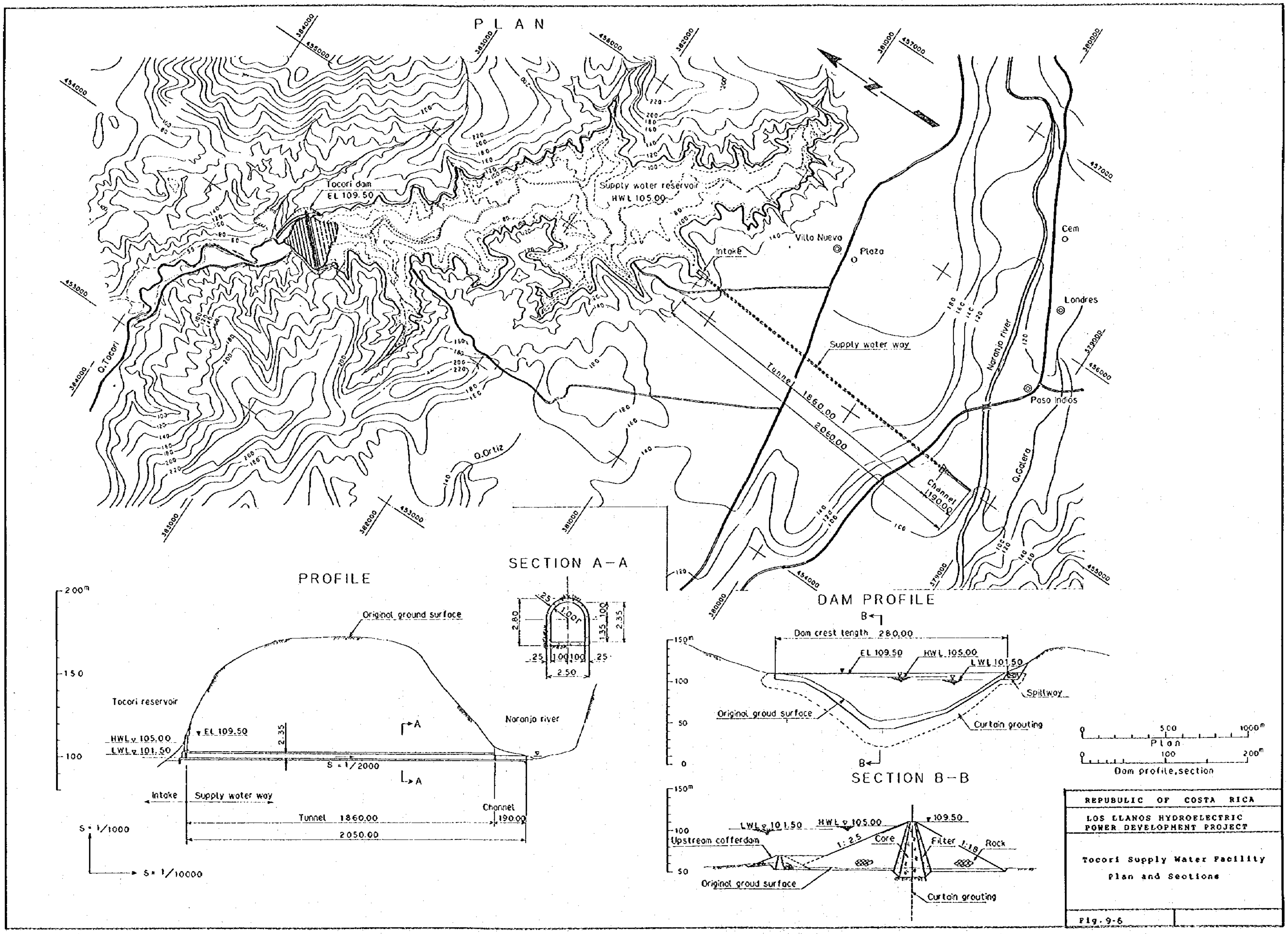
LOS LLANOS HYDROELECTRIC POWER DEVELOPMENT PROJECT

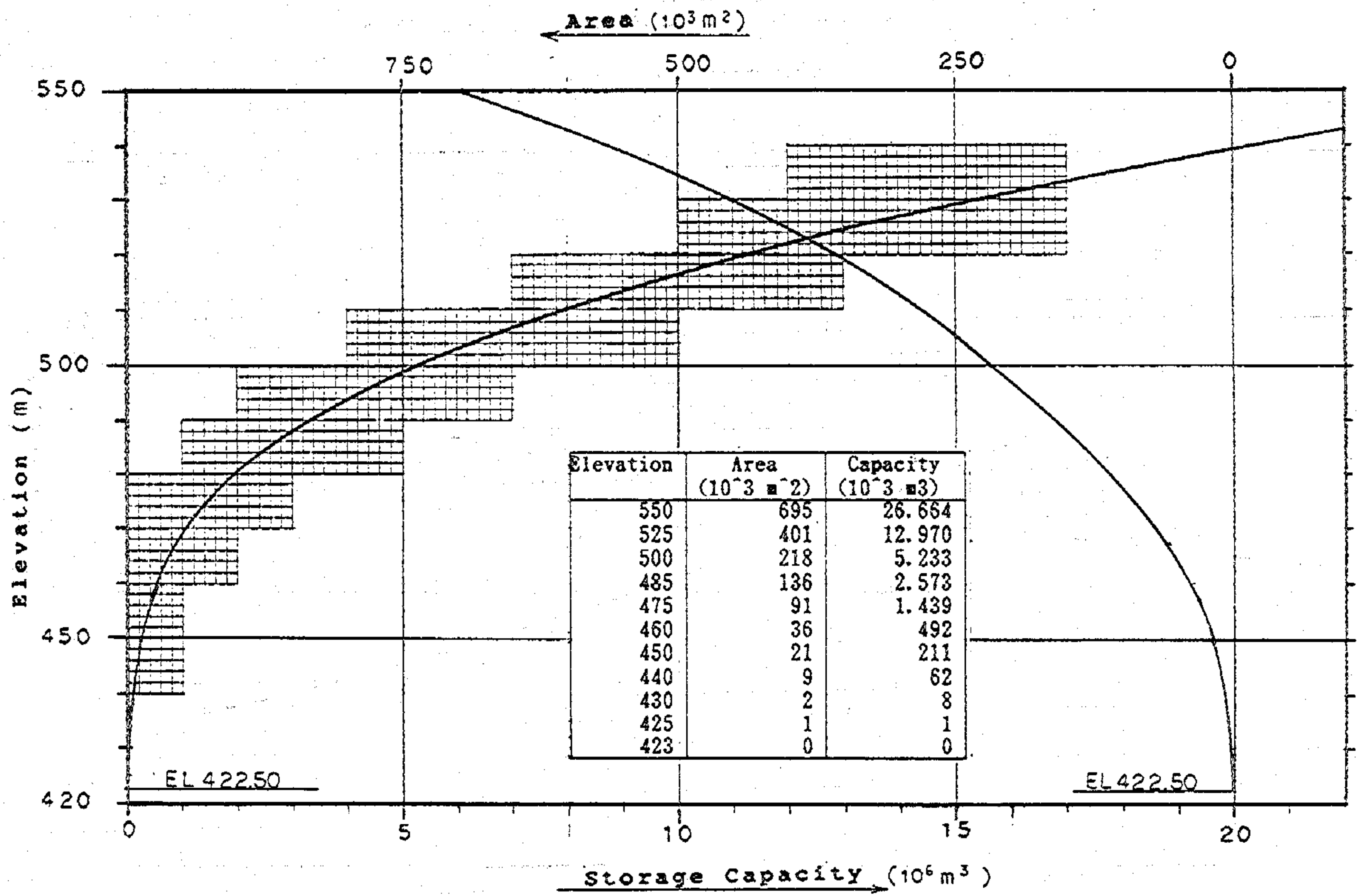
Los Llanos Dam (Case I -2)
Plan and Sections

Fig. 9-5


PLAN
Tocori dam
EL 109.50
Supply water reservoir
HWL 105.00
Intake
Villa Nueva
Plaza
Cem
Londres
Supply water way
Tunnel 1860.00
2050.00
Channel 190.00
Naranjo river
Paso Indios
Q.Galera
Q.Tocori
Q.Ortiz
PROFILE
Original ground surface
Tocori reservoir
Naranjo river
HWL 105.00
LWL 101.50
EL 109.50
S = 1/2000
Intake
Supply water way
Channel
Tunnel 1860.00 190.00
2050.00
S = 1/1000
S = 1/10000
SECTION A-A
DAM PROFILE
Dam crest length 280.00
EL 109.50
HWL 105.00
LWL 101.50
Spillway
Original groud surface
Curtain grouting
SECTION B-B
LWL 101.50
HWL 105.00
109.50
Upstream cofferdam
Core
Filter
Rock
1:2.5
1:1.8
Original groud surface
Curtain grouting
Plan
Dam profile, section
REPUBULIC OF COSTA RICA
LOS LLANOS HYDROELECTRIC POWER DEVELOPMENT PROJECT
Tocori Supply Water Facility
Plan and Sections
Fig. 9-6

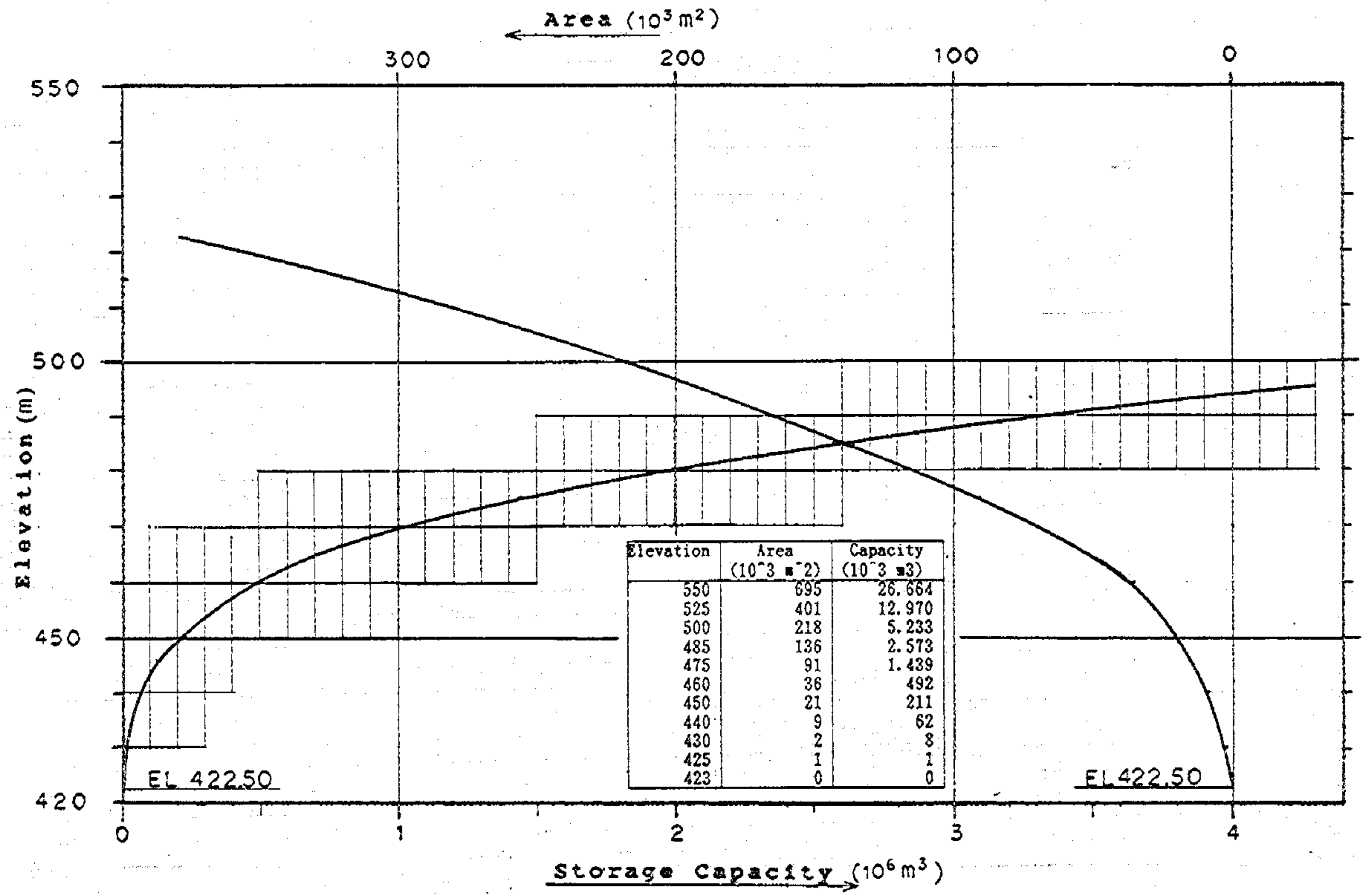
11-6.

1995·3·9



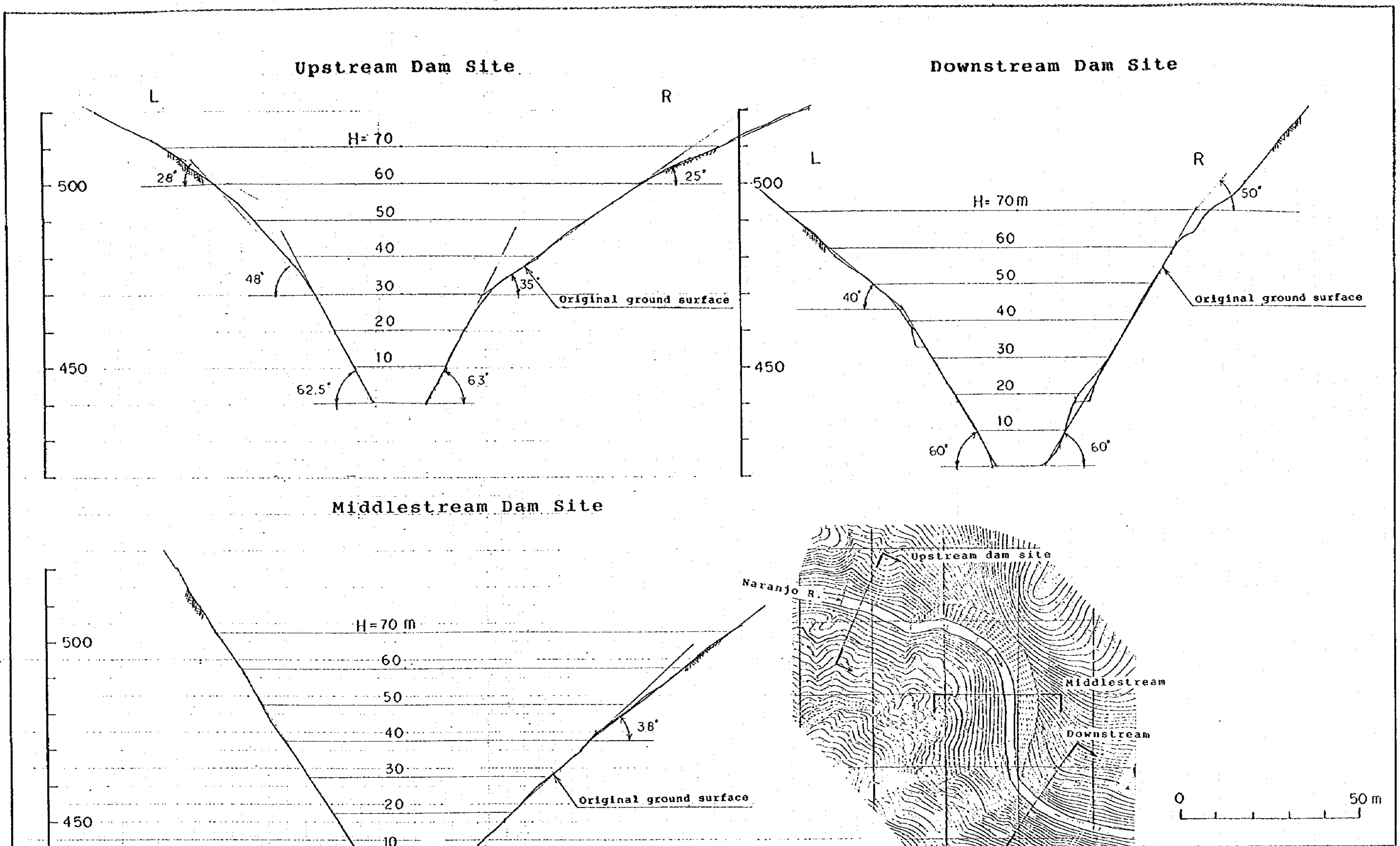

| Elevation | Area (10^3 m^2) | Capacity (10^3 m3) |
|---|---|---|
| 550 | 695 | 26.664 |
| 525 | 401 | 12.970 |
| 500 | 218 | 5.233 |
| 485 | 136 | 2.573 |
| 475 | 91 | 1.439 |
| 460 | 36 | 492 |
| 450 | 21 | 211 |
| 440 | 9 | 62 |
| 430 | 2 | 8 |
| 425 | 1 | 1 |
| 423 | 0 | 0 |

Fig.9-7(1) Area-Capacity Curve 1/2
(Downstream dam site)




| Elevation | Area (10^3 m^2) | Capacity (10^3 m3) |
|---|---|---|
| 550 | 695 | 26.664 |
| 525 | 401 | 12.970 |
| 500 | 218 | 5.233 |
| 485 | 136 | 2.573 |
| 475 | 91 | 1.439 |
| 460 | 36 | 492 |
| 450 | 21 | 211 |
| 440 | 9 | 62 |
| 430 | 2 | 8 |
| 425 | 1 | 1 |
| 423 | 0 | 0 |

Fig.9-7(2) Area-Capacity Curve 2/2
(Downstream dam site)




Los Llanos Dam
Cross Section of
Alternative Dam Site

Fig.9-8

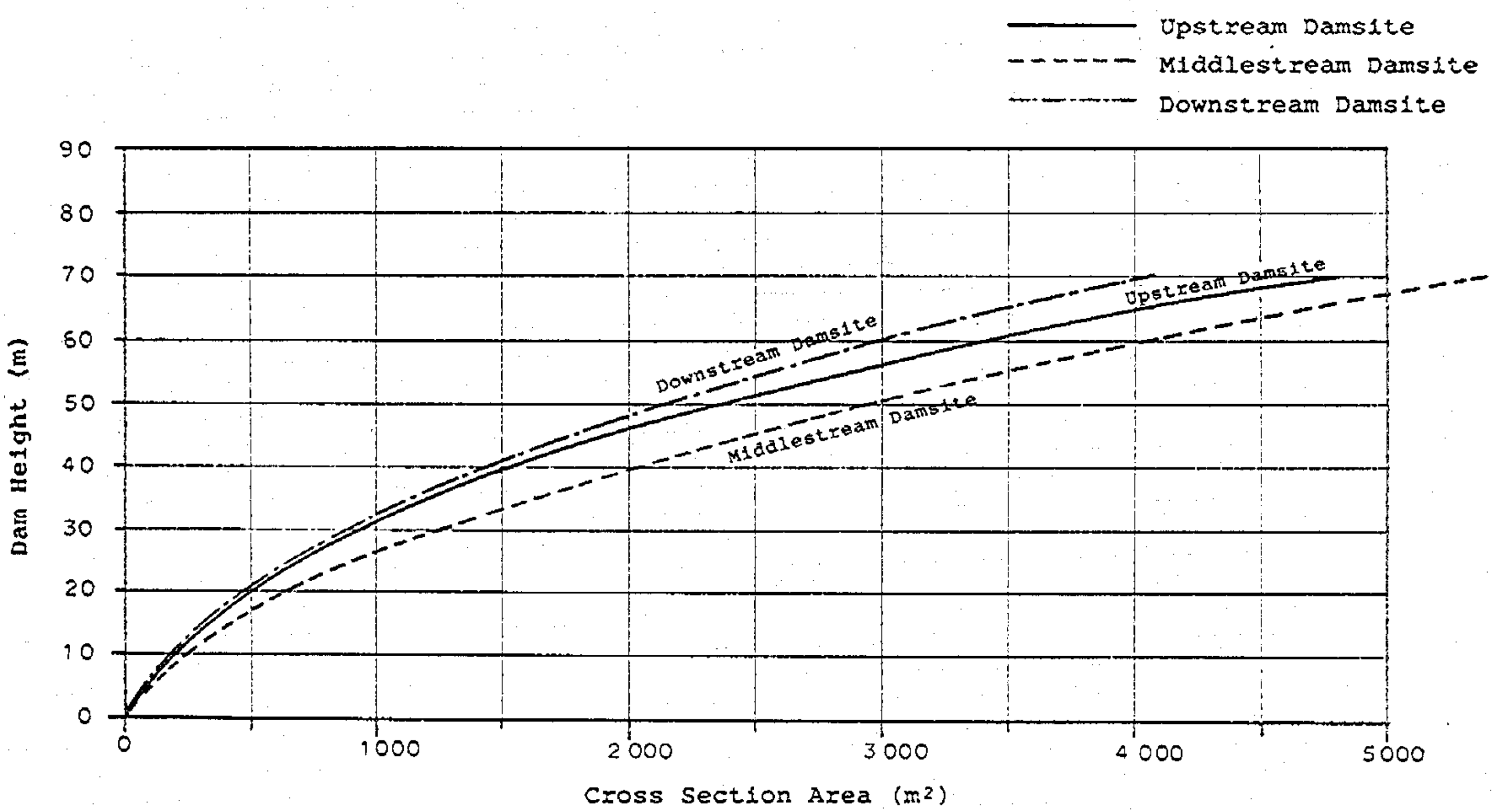



Fig.9-9 Cross Section Area~Dam Height Curve

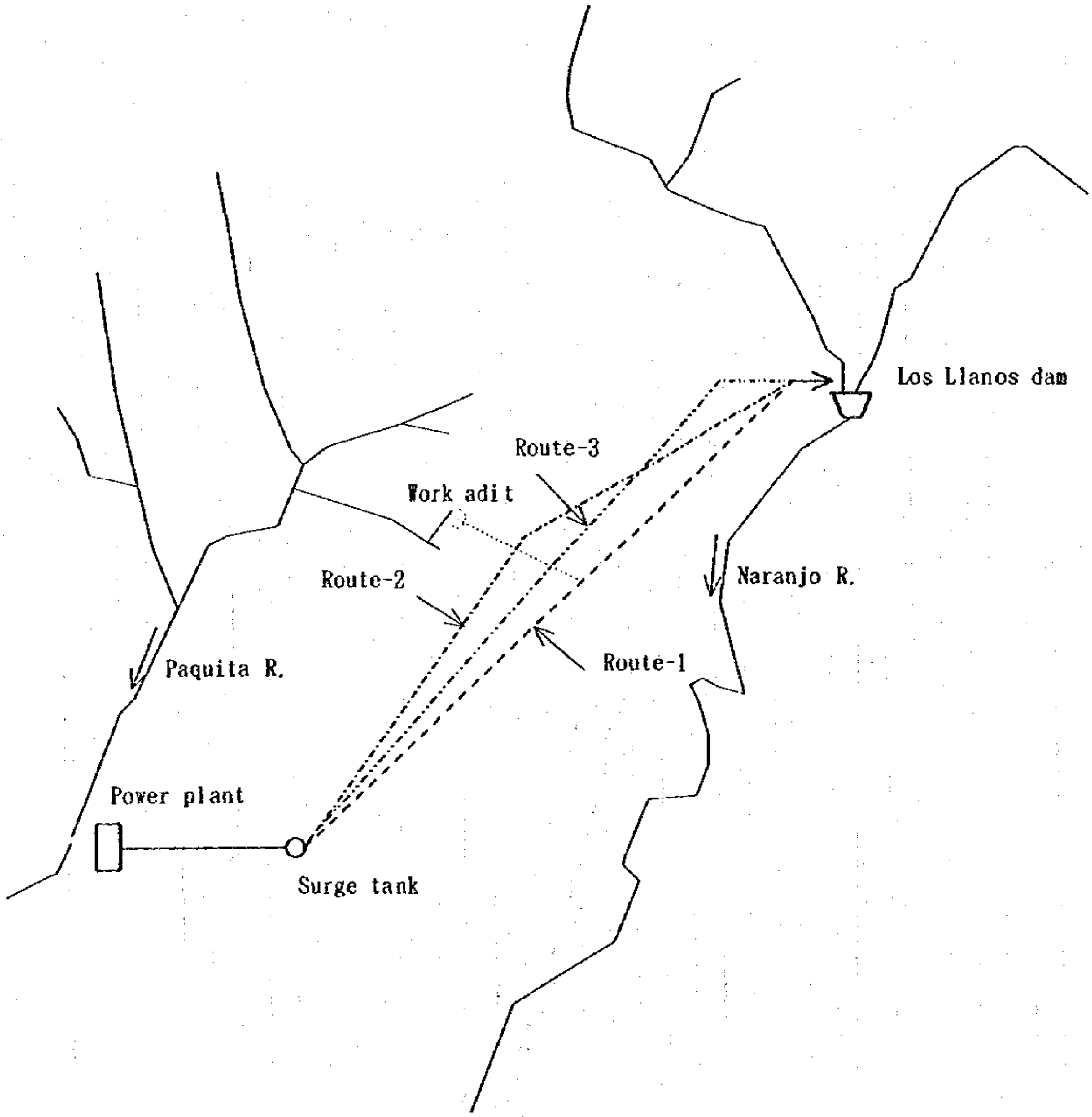
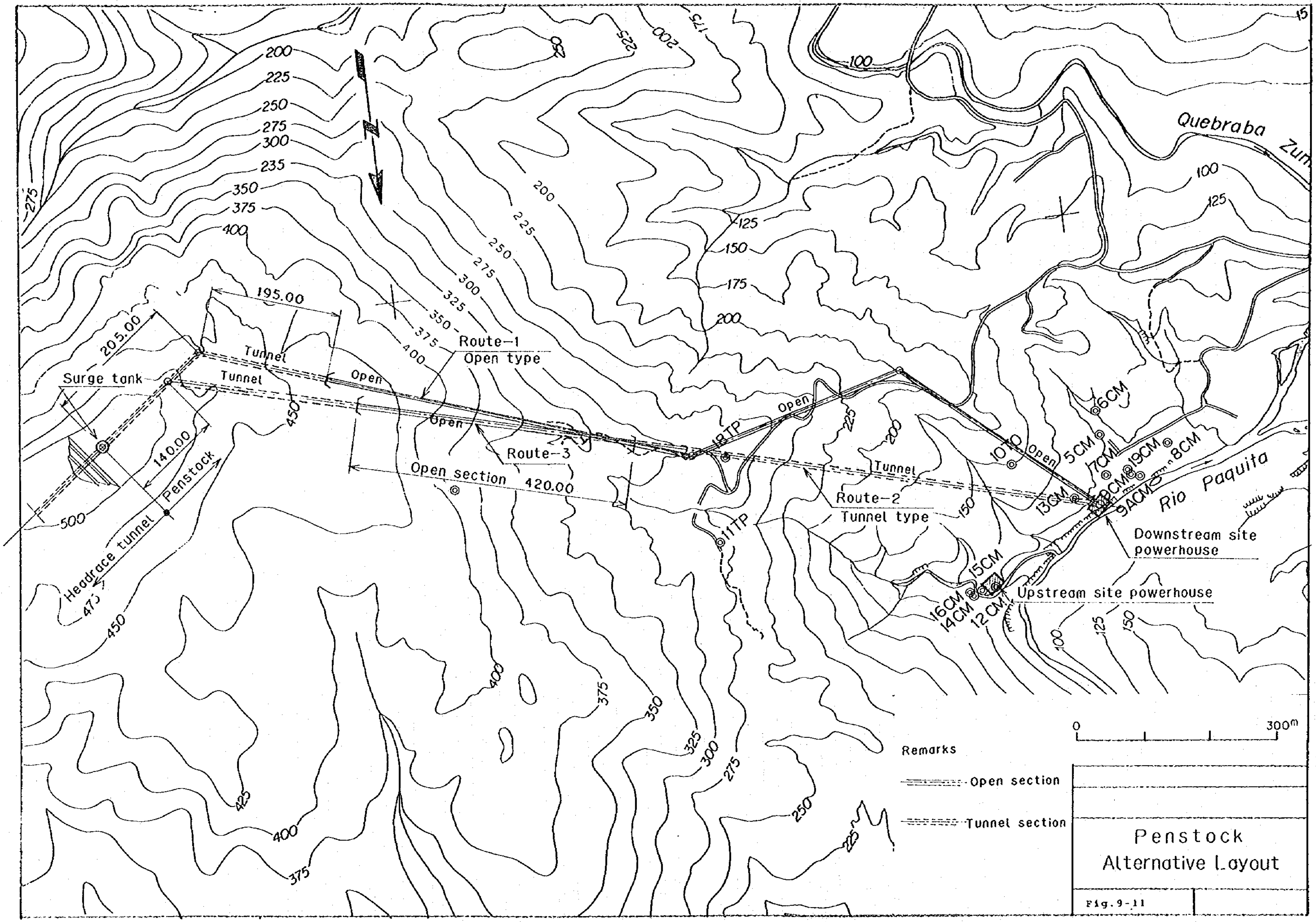



**Fig. 9-10 Headrace Tunnel Layout**




Penstock
Alternative Layout

Fig. 9-11

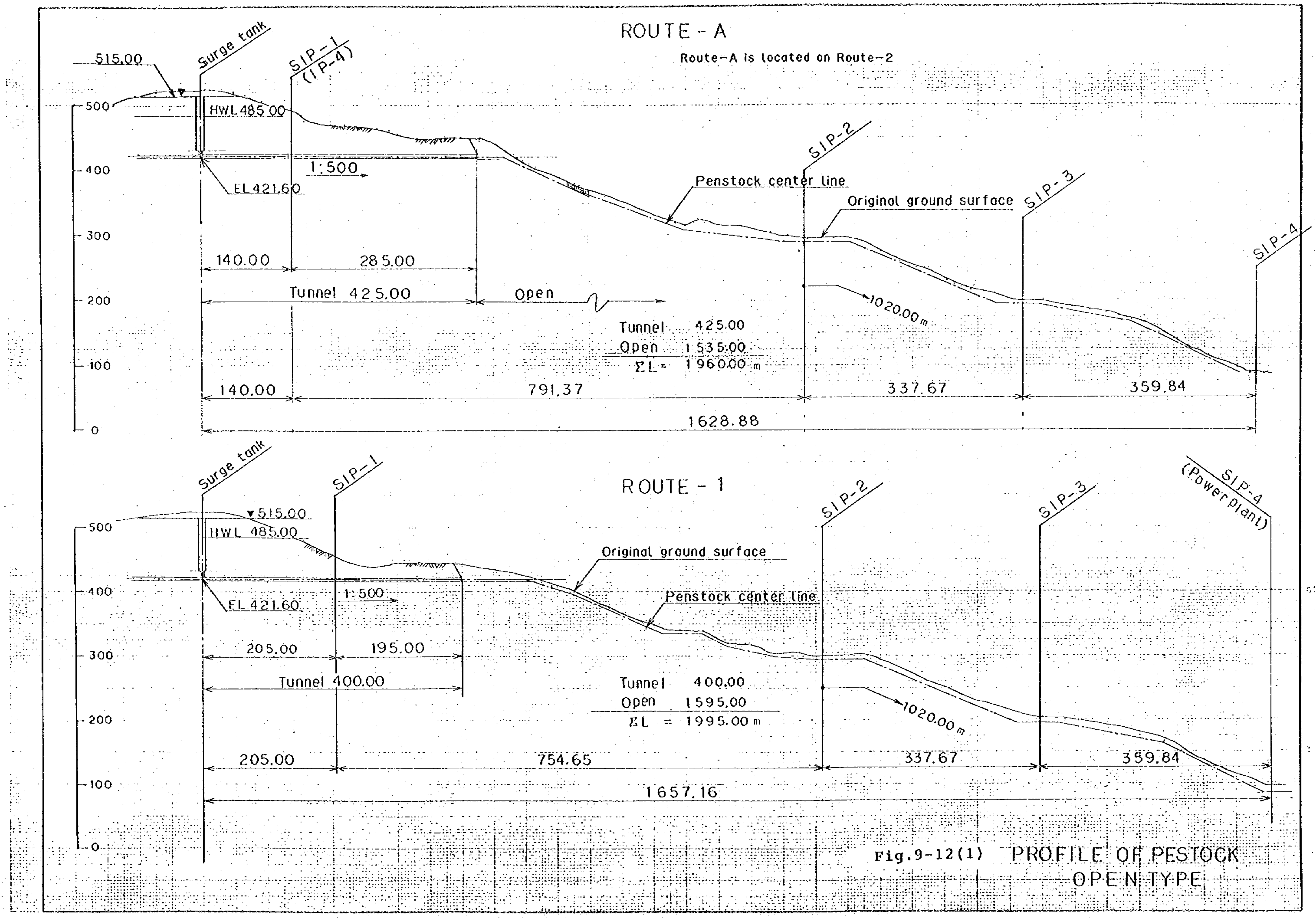



Fig.9-12(1) PROFILE OF PESTOCK OPEN TYPE

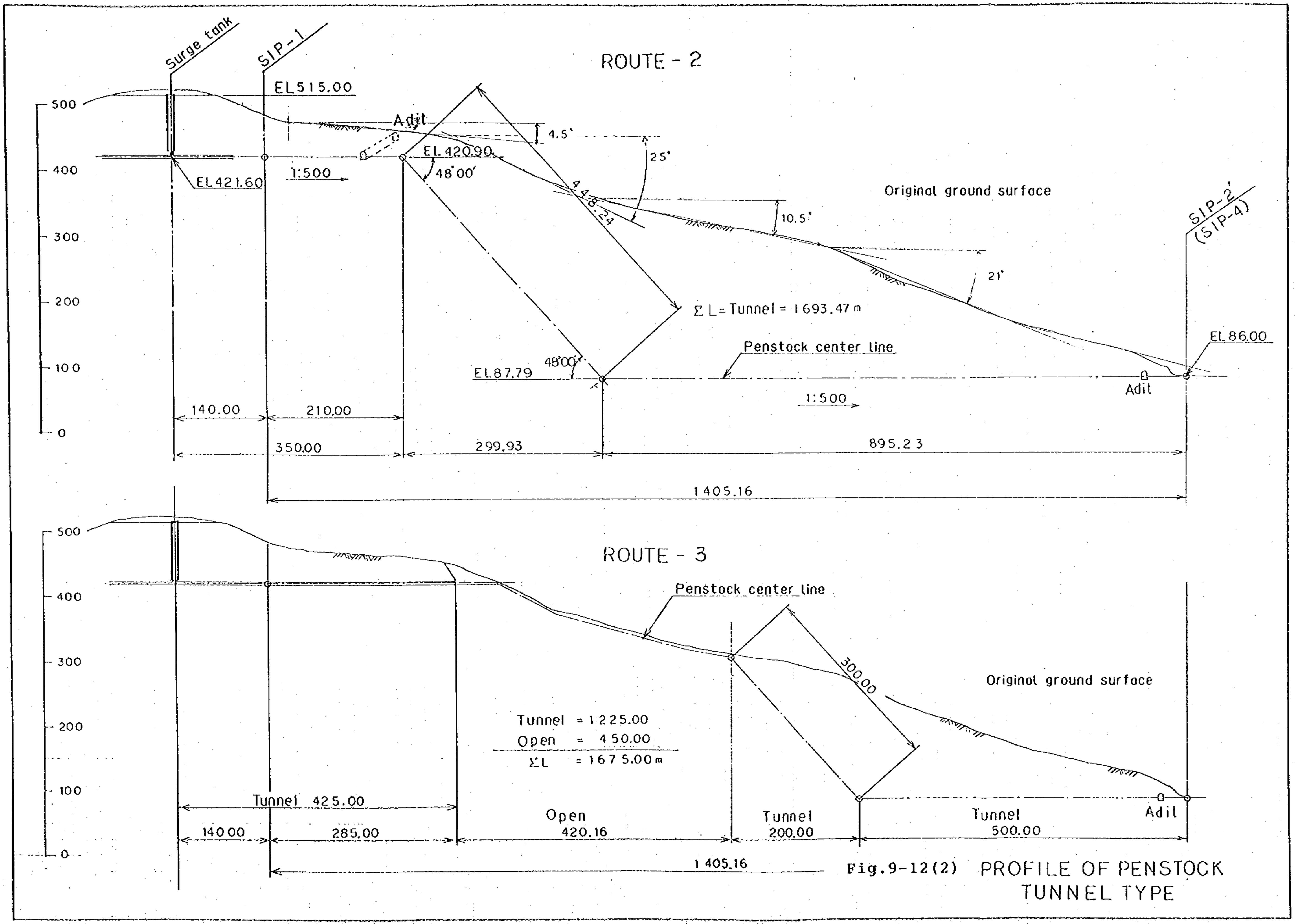
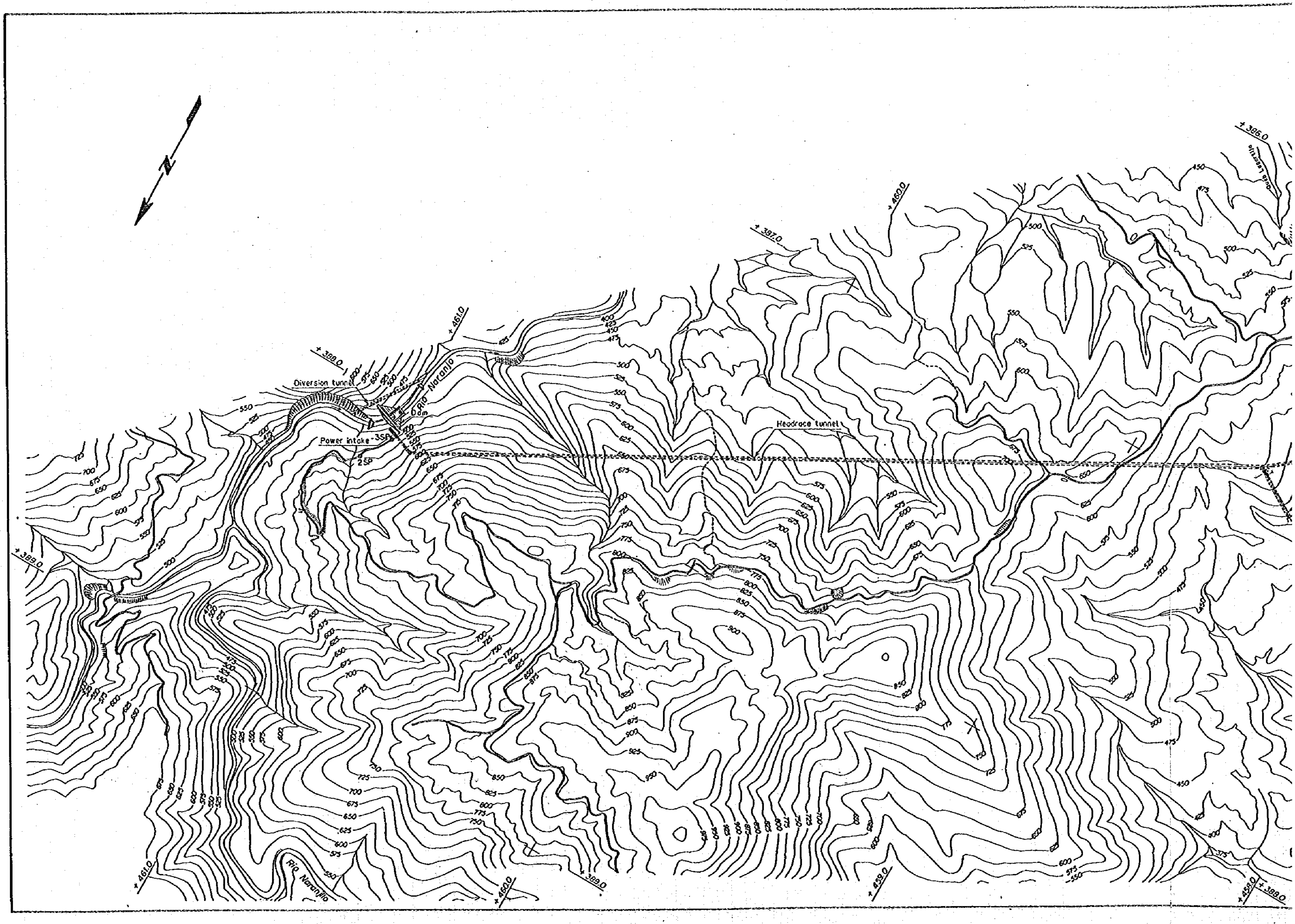
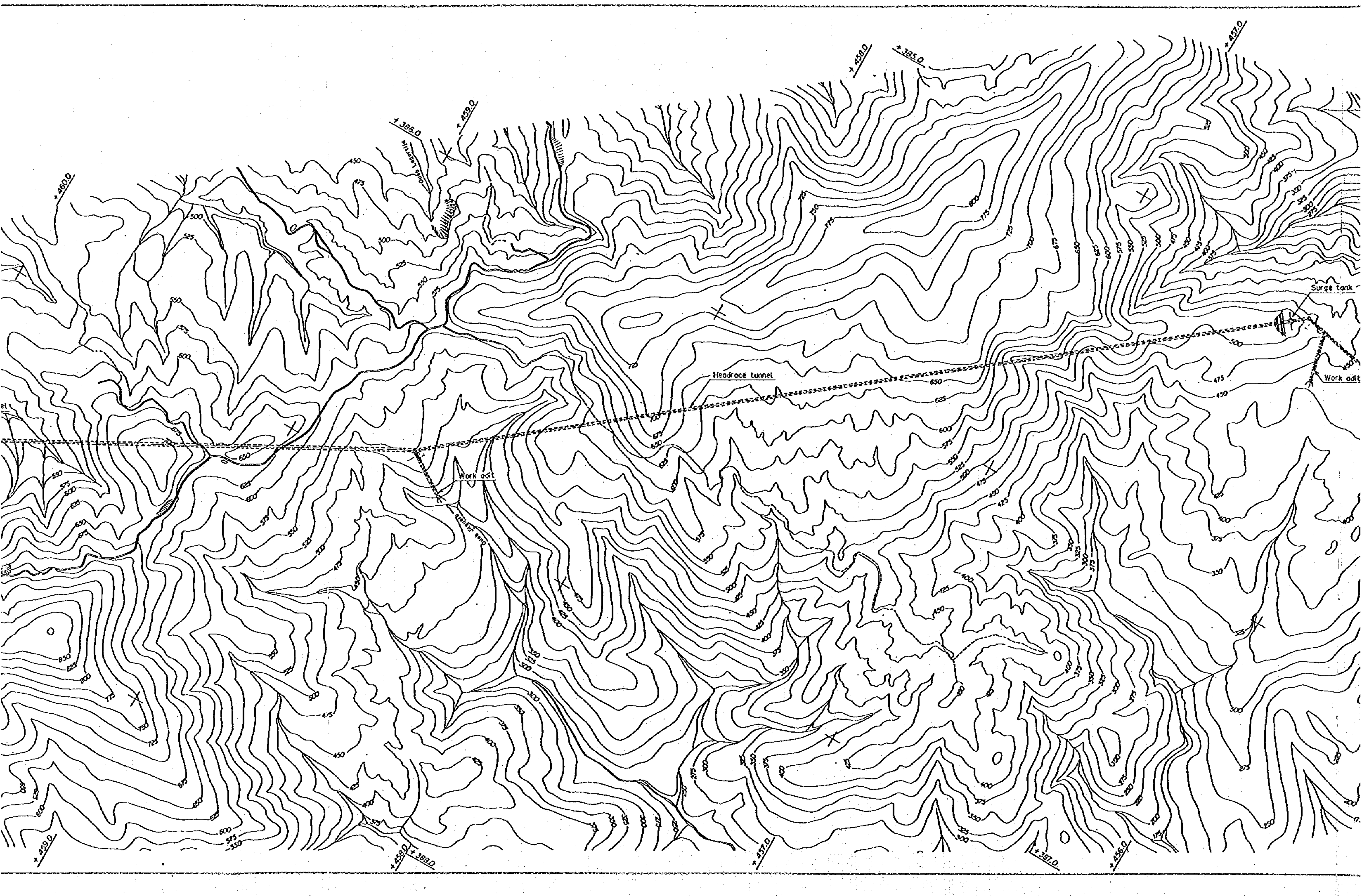



Fig.9-12(2) PROFILE OF PENSTOCK TUNNEL TYPE


Diversion tunnel
Power intake
Dam
Rio Naranjo
Headrace tunnel
Rio Naranjo
+ 388.0
+ 461.0
+ 387.0
+ 460.0
+ 386.0
+ 389.0
+ 461.0
+ 460.0
+ 389.0
+ 459.0
+ 458.0
+ 388.0


+ 460.0
+ 386.0
+ 459.0
+ 458.0
+ 385.0
+ 457.0
Surge tank
Work adit
Headrace tunnel
Work adit
+ 459.0
+ 458.0
+ 388.0
+ 457.0
+ 387.0
+ 456.0


0 500m

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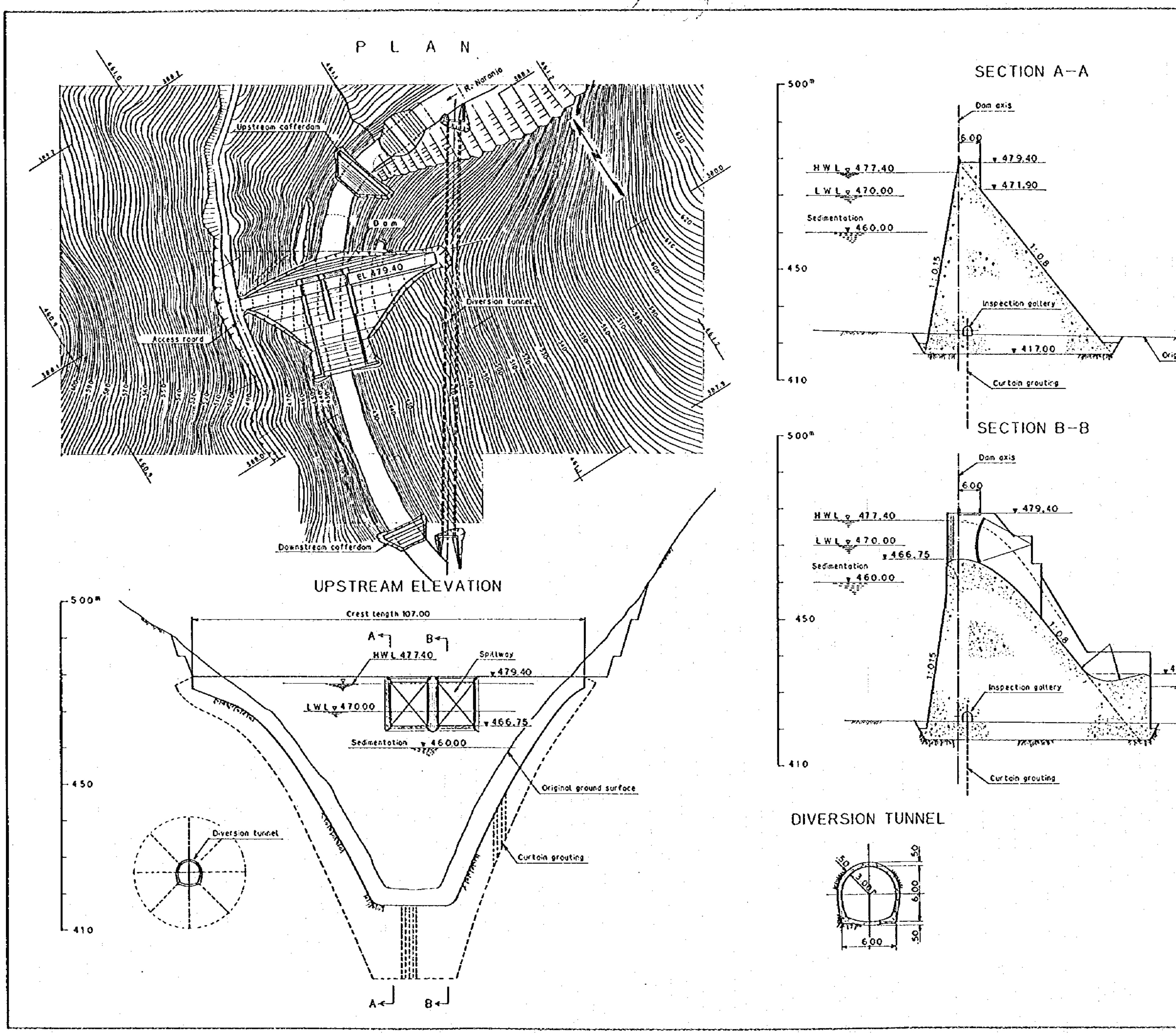
LOS LLANOS HYDROELECTRIC POWER DEVELOPMENT PROJECT

GENERAL PLAN

Fig.9-13 | Date:

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LOS LLANOS HYDROELECTRIC POWER DEVELOPMENT PROJECT

Los Llanos Dam

Plan and Sections

Fig.9-14

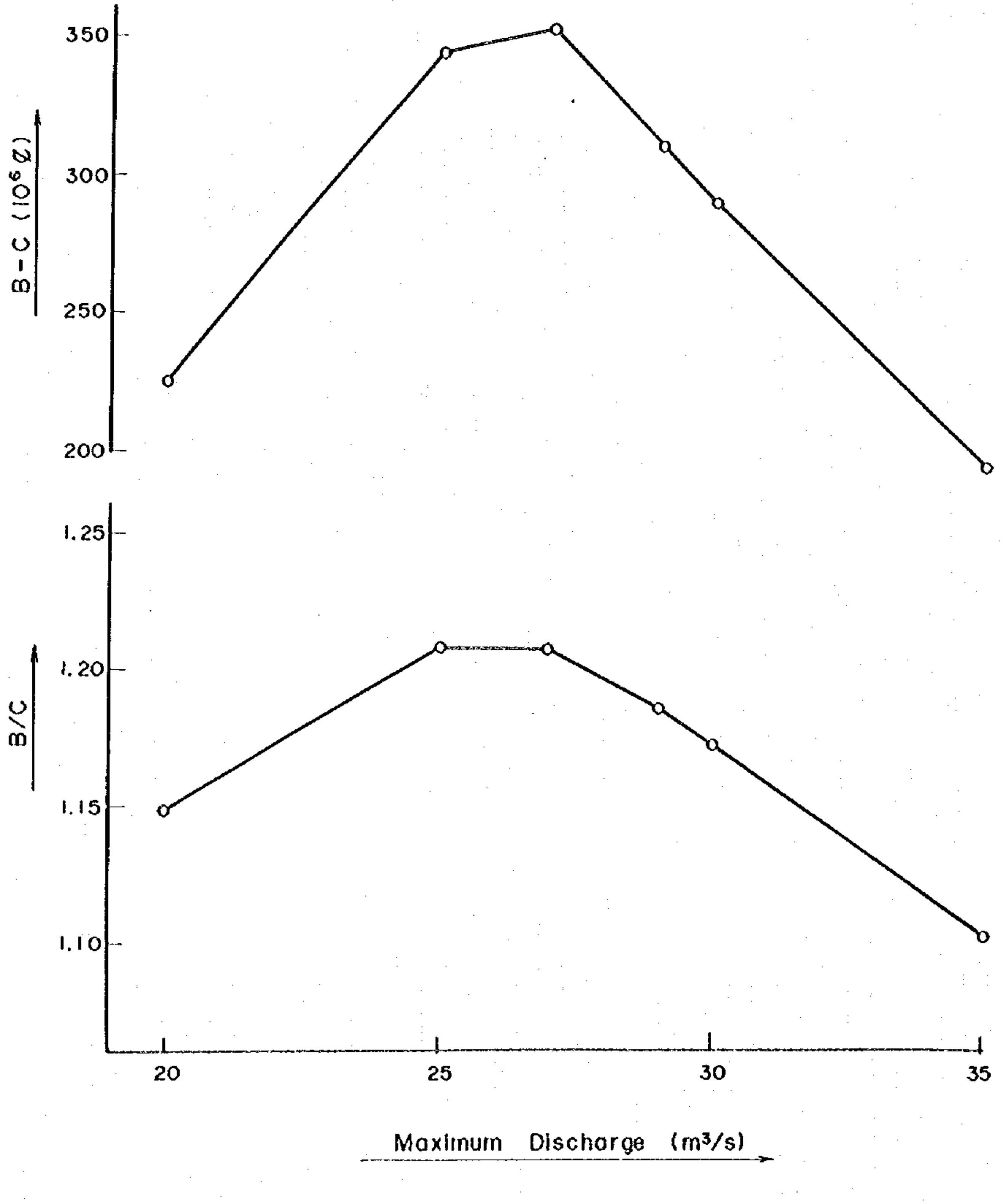


Fig. 9-15 Study on Maximum Discharge

## Table 9-1 Project Outline of Naranjo River Basin

| Item | Reyes | Milagro | Los Llanos | Los Llanos-A | Nara |
|---|---|---|---|---|---|
| Catchment Area ($km^2$) | 68.0 | 27.0 | 143.7 | 143.7 | 28.0 |
| Annual Inflow ($m^3$/sec) | 6.08 | 2.94 | 18.05 | 18.05 | 4.08 |
| High Water Level (EL. m) | 880 | 1,310 | 485 | 485 | 615 |
| Low Water Level (EL. m) | 840 | 1,310 | 475 | 475 | 615 |
| Effective Storage Capacity ($10^6$ $m^3$) | 23.8 | 0 | 1.5 | 1.5 | 0 |
| Tail Water Level (EL. m) | 600 | 690 | 84 | 300 | 135 |
| Gross Head (m) | 280 | 620 | 401 | 185 | 480 |
| Effective Head (m) | 255 | 577 | 365 | 167 | 432 |
| Maximum Discharge ($m^3$/sec) | 10.8 | 6.3 | 31.0 | 31.0 | 6.2 |
| Installed Capacity (MW) | 23.3 | 30.8 | 95.8 | 43.7 | 22.7 |
| | | | | | |
| Main Facilities | | | | | |
| Dam Type | Rockfill | Concrete Gravity | Concrete Gravity | Concrete Gravity | Concrete Gravity |
| Height x Length | 113 m x 250 m | 10 m x 70 m | 53 m x 105 m | 53 m x 105 m | 10 m x 100 m |
| Headrace (D x L) | 2.4 m x 3,600 m | 2.4 m x 4,000 m | 3.2 m x 5,900 m | 3.2 m x 2,400 | 2.4 m x 2,800 m |
| Surge Tank (D x H) | 9.1 m x 55 m | Head Tank | 8.0 m x 92 m | 8.0 m x 80 m | Head Tank |
| Penstock Type | Open | Open | Open | Open | Open |
| D x L | 1.5 m x 600 m | 1.2 m x 1,100 m | 2.75 m x 1,465 m | 2.75 m x 1,160 m | 1.2 m x 1,550 m |
| Powerhouse Type | Open | Open | Open | Open | Open |
| Type of Turbine | Pelton | Pelton | Pelton | Pelton | Pelton |

## Table 9-2 Estimation of Electric Energy Generation

| Item | Unit | Los Reyes | Milagro | Nara | Los Llanos | Los Llanos-A |
|---|---|---|---|---|---|---|
| Average Inflow | $m^3$/s-d | 6.08 | 2.94 | 4.08 | 18.05 | 18.05 |
| Maximum Discharge | $m^3$/s | 10.80 | 6.30 | 6.20 | 31.00 | 31.00 |
| Effective Storage Capacity | $10^6m^3$ | 23.80 | 0 | 0 | 1.50 | 1.50 |
| Available Discharge | $m^3$/s-d | 6.06 | 2.85 | 3.63 | 16.73 | 16.73 |
| Over Flow | $m^3$/s-d<br>$10^6m^3$ | 0.02<br>0.6 | 0.09<br>2.8 | 0.45<br>14.2 | 1.32<br>41.6 | 1.32<br>41.6 |
| Firm Discharge | $m^3$/s-d | 3.48* | 0.62 | 0.64 | 3.29 | 3.29 |
| Firm Power Discharge | $m^3$/s | 10.80* | 0.62 | 0.64 | 13.16* | 13.16 |
| Maximum Output | MW | 23.3 | 30.8 | 22.7 | 95.8 | 43.7 |
| Firm Power | MW | 22.1 | 2.9 | 2.3 | 39.5 | 18.1 |
| Annual Energy (Monthly base) | GWh | 108.9 | 120.9 | 115.3 | 448.7 | 205.3 |
| Available Energy | GWh | 108.9 | 114.9 | 109.5 | 426.3 | 195.0 |

Note: The value of firm discharge at Los Reyes is to be regulated by reservoir operation.

## Table 9-3 (1) Energy Production of Los Reyes Scheme

Installed Capacity: 23.3 MW  Power Efficiency : 0.84
Maximum Discharge : 10.80 m^3/s  Effective Storage Capacity 23.8 * 10^6 m^3
Effective Head : 249.00 m

Unit : GWh

| Year | May | Jun. | Jul. | Aug. | Sept. | Oct. | Nov. | Dec. | Jan. | Feb. | Mar. | Apr. | Average |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1970 | 0.0 | 0.0 | 0.0 | 14.3 | 16.5 | 16.5 | 12.9 | 7.7 | 6.8 | 3.6 | 3.8 | 4.9 | 86.9 |
| 1971 | 16.5 | 16.5 | 16.5 | 16.5 | 16.5 | 16.5 | 15.1 | 7.2 | 7.2 | 7.2 | 7.2 | 7.2 | 149.8 |
| 1972 | 9.8 | 8.1 | 7.8 | 9.8 | 11.7 | 16.5 | 13.6 | 6.3 | 6.3 | 6.3 | 6.3 | 6.3 | 108.6 |
| 1973 | 6.3 | 16.3 | 14.6 | 16.5 | 16.5 | 16.5 | 12.3 | 9.2 | 8.4 | 3.4 | 2.6 | 2.9 | 125.4 |
| 1974 | 9.8 | 16.5 | 11.1 | 12.7 | 16.5 | 16.5 | 13.0 | 4.8 | 4.8 | 4.8 | 4.8 | 4.8 | 119.8 |
| 1975 | 10.4 | 11.5 | 12.3 | 16.3 | 16.5 | 16.5 | 16.5 | 5.6 | 5.6 | 5.6 | 5.6 | 5.6 | 127.9 |
| 1976 | 5.0 | 8.6 | 6.7 | 7.3 | 12.7 | 15.7 | 9.6 | 4.5 | 2.5 | 1.9 | 1.7 | 2.1 | 78.2 |
| 1977 | 5.1 | 8.6 | 6.0 | 13.5 | 15.5 | 16.5 | 14.3 | 6.2 | 3.0 | 3.0 | 3.0 | 5.1 | 99.7 |
| 1978 | 7.0 | 12.2 | 12.3 | 14.8 | 16.5 | 16.5 | 13.5 | 6.5 | 4.4 | 4.4 | 4.4 | 4.4 | 116.9 |
| 1979 | 10.9 | 12.2 | 11.1 | 13.5 | 16.5 | 16.5 | 13.3 | 6.7 | 5.0 | 5.0 | 5.0 | 5.0 | 120.4 |
| 1980 | 7.6 | 11.6 | 11.8 | 11.8 | 13.6 | 16.1 | 16.5 | 7.2 | 4.0 | 2.6 | 2.4 | 4.6 | 109.7 |
| 1981 | 16.4 | 16.5 | 11.8 | 15.6 | 11.5 | 15.5 | 13.2 | 5.4 | 4.4 | 3.8 | 3.8 | 3.8 | 121.5 |
| 1982 | 12.3 | 8.5 | 8.6 | 8.6 | 11.2 | 13.6 | 7.1 | 3.2 | 2.0 | 1.9 | 2.3 | 2.6 | 81.8 |
| 1983 | 3.7 | 8.1 | 6.2 | 8.3 | 14.5 | 16.5 | 16.5 | 8.6 | 4.1 | 4.1 | 4.1 | 4.1 | 98.9 |
| 1984 | 10.9 | 14.0 | 16.2 | 13.0 | 16.2 | 16.5 | 14.8 | 4.9 | 2.3 | 2.3 | 2.3 | 2.3 | 115.5 |
| 1985 | 6.3 | 10.3 | 10.8 | 15.6 | 16.5 | 16.5 | 14.8 | 10.3 | 4.0 | 4.4 | 4.4 | 4.4 | 118.2 |
| 1986 | 8.1 | 10.9 | 10.3 | 8.8 | 11.1 | 16.5 | 10.5 | 4.5 | 2.5 | 1.7 | 2.1 | 2.4 | 89.5 |
| 1987 | 7.9 | 9.3 | 12.2 | 15.0 | 11.1 | 12.1 | 9.1 | 5.0 | 2.7 | 1.7 | 1.5 | 1.8 | 89.4 |
| 1988 | 6.2 | 11.9 | 12.4 | 16.5 | 16.5 | 16.5 | 9.5 | 4.6 | 5.2 | 5.2 | 5.2 | 5.2 | 115.1 |
| 1989 | 6.8 | 8.3 | 8.4 | 12.9 | 16.5 | 14.3 | 10.2 | 9.4 | 4.2 | 3.3 | 3.3 | 3.3 | 100.8 |
| 1990 | 9.8 | 12.3 | 12.7 | 12.9 | 14.1 | 16.5 | 13.5 | 7.9 | 5.9 | 3.8 | 3.8 | 3.8 | 116.8 |
| 1991 | 7.5 | 11.8 | 11.0 | 11.1 | 12.3 | 14.3 | 10.2 | 6.4 | 3.1 | 2.6 | 1.6 | 1.9 | 93.7 |
| 1993 | 9.0 | 7.8 | 8.4 | 13.6 | 16.5 | 16.5 | 9.5 | 4.8 | 2.7 | 3.1 | 3.1 | 3.1 | 98.1 |
| Total | 193.1 | 251.6 | 239.3 | 284.5 | 320.0 | 348.6 | 276.5 | 139.0 | 94.2 | 82.0 | 80.3 | 86.5 | 2395.7 |
| Average | 8.8 | 11.4 | 10.9 | 12.9 | 14.5 | 15.8 | 12.6 | 6.3 | 4.3 | 3.7 | 3.6 | 3.9 | 108.9 |
| Min. | 3.7 | 7.8 | 6.0 | 7.3 | 11.1 | 12.1 | 7.1 | 3.2 | 2.0 | 1.7 | 1.5 | 1.8 | 78.2 |
| Max. | 16.5 | 16.5 | 16.5 | 16.5 | 16.5 | 16.5 | 16.5 | 10.3 | 8.4 | 7.2 | 7.2 | 7.2 | 149.8 |

## Table 9-3 (2) Energy Production of Milagro Scheme

Installed Capacity: 30.8 MW
Maximum Discharge : 6.30 m^3/s
Effective Head : 577.00 m

Power Efficiency : 0.84
Effective Storage Capacity 0 * 10^6 m^3

Unit : GWhr

| Year | May | Jun. | Jul. | Aug. | Sept. | Oct. | Nov. | Dec. | Jan. | Feb. | Mar. | Apr. | Average |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1970 | 0.0 | 0.0 | 0.0 | 16.0 | 20.1 | 22.3 | 14.4 | 8.6 | 7.6 | 4.1 | 4.3 | 5.5 | 102.8 |
| 1971 | 19.4 | 22.3 | 20.1 | 22.3 | 22.3 | 22.3 | 16.8 | 7.3 | 6.7 | 3.4 | 2.3 | 4.8 | 169.8 |
| 1972 | 11.0 | 9.0 | 8.7 | 11.0 | 13.0 | 18.8 | 15.2 | 7.8 | 3.5 | 2.4 | 2.1 | 3.5 | 106.1 |
| 1973 | 7.0 | 18.2 | 16.4 | 22.3 | 22.3 | 22.3 | 13.7 | 10.3 | 9.4 | 3.8 | 2.5 | 3.3 | 151.4 |
| 1974 | 11.0 | 19.5 | 12.4 | 14.2 | 19.7 | 22.3 | 14.5 | 5.5 | 3.3 | 2.3 | 2.3 | 2.7 | 129.7 |
| 1975 | 11.6 | 12.9 | 13.7 | 18.3 | 22.3 | 22.3 | 20.7 | 8.1 | 4.2 | 2.2 | 1.7 | 2.0 | 140.0 |
| 1976 | 5.5 | 9.6 | 7.4 | 8.1 | 14.2 | 17.6 | 10.7 | 5.0 | 2.8 | 2.1 | 1.9 | 2.4 | 87.5 |
| 1977 | 5.7 | 9.6 | 6.8 | 15.1 | 17.3 | 20.8 | 15.9 | 7.0 | 3.2 | 2.2 | 2.1 | 5.7 | 111.4 |
| 1978 | 7.9 | 13.6 | 13.8 | 16.5 | 20.0 | 22.3 | 15.1 | 7.2 | 3.8 | 2.6 | 2.3 | 4.3 | 129.3 |
| 1979 | 12.2 | 13.6 | 12.4 | 15.1 | 21.7 | 22.3 | 14.9 | 7.4 | 5.0 | 3.0 | 2.1 | 3.4 | 133.1 |
| 1980 | 8.5 | 12.9 | 13.2 | 13.2 | 15.2 | 18.0 | 19.8 | 8.0 | 4.4 | 3.0 | 2.6 | 5.2 | 123.9 |
| 1981 | 18.4 | 21.2 | 13.2 | 17.4 | 12.9 | 17.3 | 14.8 | 6.0 | 4.9 | 2.9 | 3.0 | 4.0 | 135.9 |
| 1982 | 13.8 | 9.5 | 9.6 | 9.6 | 12.5 | 15.2 | 8.0 | 3.5 | 2.3 | 2.1 | 2.5 | 2.9 | 91.5 |
| 1983 | 4.2 | 9.0 | 6.9 | 9.2 | 16.2 | 20.3 | 20.2 | 9.6 | 4.7 | 3.8 | 3.1 | 3.3 | 110.7 |
| 1984 | 12.1 | 15.6 | 18.1 | 14.5 | 18.1 | 20.9 | 16.6 | 5.5 | 2.6 | 1.9 | 1.5 | 1.8 | 129.1 |
| 1985 | 7.0 | 11.6 | 12.1 | 17.5 | 19.7 | 22.3 | 16.6 | 11.6 | 4.5 | 2.4 | 1.8 | 2.5 | 129.4 |
| 1986 | 9.0 | 12.1 | 11.6 | 9.9 | 12.5 | 19.3 | 11.8 | 5.0 | 2.8 | 1.9 | 1.5 | 2.7 | 100.1 |
| 1987 | 8.8 | 10.4 | 13.7 | 16.8 | 12.4 | 13.6 | 10.2 | 5.6 | 3.0 | 1.9 | 1.6 | 2.0 | 100.0 |
| 1988 | 6.9 | 13.3 | 13.9 | 21.1 | 22.3 | 22.3 | 10.7 | 5.2 | 3.0 | 1.7 | 1.3 | 1.8 | 123.4 |
| 1989 | 7.6 | 9.3 | 9.4 | 14.5 | 20.8 | 16.0 | 11.4 | 10.5 | 4.7 | 2.7 | 2.4 | 3.5 | 112.7 |
| 1990 | 10.9 | 13.7 | 14.2 | 14.4 | 15.7 | 22.3 | 15.1 | 8.8 | 6.6 | 3.0 | 2.1 | 3.4 | 130.3 |
| 1991 | 8.4 | 13.2 | 12.3 | 12.4 | 13.7 | 15.9 | 11.5 | 7.1 | 3.4 | 2.9 | 1.8 | 2.1 | 104.8 |
| 1993 | 10.1 | 8.8 | 9.4 | 15.2 | 22.3 | 18.6 | 10.7 | 5.3 | 3.0 | 2.0 | 1.8 | 2.6 | 109.8 |
| Total | 216.9 | 289.1 | 269.4 | 328.6 | 387.0 | 432.7 | 314.6 | 157.6 | 91.9 | 56.2 | 46.4 | 69.6 | 2660.0 |
| Average | 9.9 | 13.1 | 12.2 | 14.9 | 17.6 | 19.7 | 14.3 | 7.2 | 4.2 | 2.6 | 2.1 | 3.2 | 120.9 |
| Min. | 4.2 | 8.8 | 6.8 | 8.1 | 12.4 | 13.6 | 8.0 | 3.5 | 2.3 | 1.7 | 1.3 | 1.8 | 87.5 |
| Max. | 19.4 | 22.3 | 20.1 | 22.3 | 22.3 | 22.3 | 20.7 | 11.6 | 9.4 | 4.1 | 4.3 | 5.7 | 169.8 |

## Table 9-3 (3) Energy Production of Los Llanos Scheme (1)

Installed Capacity: 95.8 MW
Maximum Discharge : 31.00 m^3/s
Effective Head : 365.00 m
Power Efficiency : 0.84
Effective Storage Capacity 1.5 * 10^6 m^3

Unit : GWh

| Year | May | Jun. | Jul. | Aug. | Sept. | Oct. | Nov. | Dec. | Jan. | Feb. | Mar. | Apr. | Average |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1970 | 0.0 | 0.0 | 0.0 | 62.0 | 69.3 | 69.3 | 55.9 | 33.4 | 29.6 | 15.8 | 16.7 | 21.3 | 373.4 |
| 1971 | 69.3 | 69.3 | 69.3 | 69.3 | 69.3 | 69.3 | 65.5 | 28.5 | 26.1 | 13.1 | 9.0 | 18.5 | 576.4 |
| 1972 | 42.8 | 35.2 | 34.0 | 42.8 | 50.7 | 69.3 | 59.3 | 30.3 | 13.5 | 9.2 | 8.3 | 13.5 | 408.9 |
| 1973 | 27.3 | 69.3 | 63.7 | 69.3 | 69.3 | 69.3 | 53.3 | 40.0 | 36.7 | 14.9 | 9.8 | 12.8 | 535.6 |
| 1974 | 42.6 | 69.3 | 48.1 | 55.4 | 69.3 | 69.3 | 56.4 | 21.3 | 12.7 | 9.1 | 8.9 | 10.7 | 473.2 |
| 1975 | 45.1 | 50.1 | 53.3 | 69.3 | 69.3 | 69.3 | 69.3 | 31.7 | 16.5 | 8.7 | 6.6 | 7.8 | 497.0 |
| 1976 | 21.5 | 37.4 | 28.9 | 31.5 | 55.3 | 68.3 | 41.6 | 19.6 | 10.9 | 8.3 | 7.5 | 9.1 | 340.1 |
| 1977 | 22.0 | 37.5 | 26.3 | 58.8 | 67.3 | 69.3 | 62.0 | 27.1 | 12.4 | 8.7 | 8.1 | 22.2 | 421.7 |
| 1978 | 30.6 | 53.0 | 53.6 | 64.2 | 69.3 | 69.3 | 58.5 | 28.1 | 14.7 | 10.1 | 8.8 | 16.8 | 477.0 |
| 1979 | 47.3 | 53.0 | 48.4 | 58.7 | 69.3 | 69.3 | 57.8 | 28.9 | 19.5 | 11.6 | 8.0 | 13.3 | 485.2 |
| 1980 | 33.1 | 50.3 | 51.4 | 51.2 | 59.1 | 69.3 | 69.3 | 31.2 | 17.3 | 11.5 | 10.1 | 20.1 | 473.7 |
| 1981 | 69.3 | 69.3 | 51.2 | 67.7 | 50.1 | 67.3 | 57.4 | 23.5 | 19.2 | 11.3 | 11.5 | 15.4 | 513.2 |
| 1982 | 53.6 | 37.0 | 37.5 | 37.4 | 48.6 | 59.1 | 31.0 | 13.7 | 8.8 | 8.2 | 9.9 | 11.1 | 356.0 |
| 1983 | 16.2 | 35.1 | 27.0 | 35.9 | 63.2 | 69.3 | 69.3 | 37.4 | 18.4 | 15.0 | 12.2 | 12.7 | 411.6 |
| 1984 | 47.2 | 60.8 | 69.3 | 56.4 | 69.3 | 69.3 | 64.4 | 21.5 | 10.0 | 7.2 | 5.7 | 6.8 | 487.9 |
| 1985 | 27.3 | 45.0 | 47.0 | 68.0 | 69.3 | 69.3 | 64.4 | 45.0 | 17.4 | 9.3 | 6.9 | 9.6 | 478.5 |
| 1986 | 35.2 | 47.2 | 45.0 | 38.4 | 48.4 | 69.3 | 45.8 | 19.6 | 10.7 | 7.5 | 6.0 | 10.4 | 383.6 |
| 1987 | 34.3 | 40.5 | 53.2 | 65.4 | 48.1 | 52.8 | 39.7 | 21.7 | 11.7 | 7.5 | 6.4 | 7.7 | 388.9 |
| 1988 | 26.9 | 51.9 | 54.0 | 69.3 | 69.3 | 69.3 | 41.5 | 20.1 | 11.8 | 6.5 | 4.9 | 6.9 | 432.3 |
| 1989 | 29.4 | 36.0 | 36.6 | 56.2 | 69.3 | 62.3 | 44.4 | 40.8 | 18.4 | 10.6 | 9.1 | 13.6 | 426.8 |
| 1990 | 42.4 | 53.4 | 55.4 | 56.0 | 61.1 | 69.3 | 58.7 | 34.4 | 25.7 | 11.5 | 8.3 | 13.3 | 489.5 |
| 1991 | 32.6 | 51.2 | 48.0 | 48.4 | 53.4 | 62.0 | 44.6 | 27.7 | 13.3 | 11.2 | 7.1 | 8.3 | 407.7 |
| 1993 | 39.3 | 34.1 | 36.5 | 59.1 | 69.3 | 69.3 | 41.4 | 20.8 | 11.9 | 7.7 | 7.2 | 10.2 | 406.8 |
| Total | 835.4 | 1085.9 | 1037.6 | 1228.8 | 1367.7 | 1480.6 | 1195.7 | 612.8 | 357.4 | 218.7 | 180.4 | 270.8 | 9871.8 |
| Average | 38.0 | 49.4 | 47.2 | 55.9 | 62.2 | 67.3 | 54.3 | 27.9 | 16.2 | 9.9 | 8.2 | 12.3 | 448.7 |
| Min. | 16.2 | 34.1 | 26.3 | 31.5 | 48.1 | 52.8 | 31.0 | 13.7 | 8.8 | 6.5 | 4.9 | 6.8 | 340.1 |
| Max. | 69.3 | 69.3 | 69.3 | 69.3 | 69.3 | 69.3 | 69.3 | 45.0 | 36.7 | 15.8 | 16.7 | 22.2 | 576.4 |

## Table 9-3 (4) Energy Production of Los Llanos Scheme (A)

Installed Capacity: 95.8 MW
Maximum Discharge : 31.00 m^3/s
Effective Head : 167.00 m

Power Efficiency : 0.84
Effective Storage Capacity 1.5 * 10^6 m^3

Unit : GWh

| Year | May | Jun. | Jul. | Aug. | Sept. | Oct. | Nov. | Dec. | Jan. | Feb. | Mar. | Apr. | Average |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1970 | 0.0 | 0.0 | 0.0 | 28.4 | 31.7 | 31.7 | 25.6 | 15.3 | 13.6 | 7.2 | 7.6 | 9.7 | 170.8 |
| 1971 | 31.7 | 31.7 | 31.7 | 31.7 | 31.7 | 31.7 | 30.0 | 13.0 | 11.9 | 6.0 | 4.1 | 8.5 | 263.7 |
| 1972 | 19.6 | 16.1 | 15.6 | 19.6 | 23.2 | 31.7 | 27.1 | 13.9 | 6.2 | 4.2 | 3.8 | 6.2 | 187.1 |
| 1973 | 12.5 | 31.7 | 29.1 | 31.7 | 31.7 | 31.7 | 24.4 | 18.3 | 16.8 | 6.8 | 4.5 | 5.8 | 245.1 |
| 1974 | 19.5 | 31.7 | 22.0 | 25.4 | 31.7 | 31.7 | 25.8 | 9.7 | 5.8 | 4.1 | 4.1 | 4.9 | 216.5 |
| 1975 | 20.7 | 22.9 | 24.4 | 31.7 | 31.7 | 31.7 | 31.7 | 14.5 | 7.5 | 4.0 | 3.0 | 3.6 | 227.4 |
| 1976 | 9.9 | 17.1 | 13.2 | 14.4 | 25.3 | 31.2 | 19.0 | 9.0 | 5.0 | 3.8 | 3.4 | 4.2 | 155.6 |
| 1977 | 10.1 | 17.2 | 12.0 | 26.9 | 30.8 | 31.7 | 28.4 | 12.4 | 5.7 | 4.0 | 3.7 | 10.2 | 192.9 |
| 1978 | 14.0 | 24.2 | 24.5 | 29.4 | 31.7 | 31.7 | 26.8 | 12.9 | 6.7 | 4.6 | 4.0 | 7.7 | 218.3 |
| 1979 | 21.7 | 24.2 | 22.2 | 26.9 | 31.7 | 31.7 | 26.4 | 13.2 | 8.9 | 5.3 | 3.7 | 6.1 | 222.0 |
| 1980 | 15.1 | 23.0 | 23.5 | 23.4 | 27.0 | 31.7 | 31.7 | 14.3 | 7.9 | 5.3 | 4.6 | 9.2 | 216.7 |
| 1981 | 31.7 | 31.7 | 23.4 | 31.0 | 22.9 | 30.8 | 26.3 | 10.7 | 8.8 | 5.2 | 5.3 | 7.1 | 234.8 |
| 1982 | 24.5 | 16.9 | 17.1 | 17.1 | 22.2 | 27.0 | 14.2 | 6.3 | 4.0 | 3.8 | 4.5 | 5.1 | 162.9 |
| 1983 | 7.4 | 16.1 | 12.3 | 16.4 | 28.9 | 31.7 | 31.7 | 17.1 | 8.4 | 6.8 | 5.6 | 5.8 | 188.3 |
| 1984 | 21.6 | 27.8 | 31.7 | 25.8 | 31.7 | 31.7 | 29.5 | 9.8 | 4.6 | 3.3 | 2.6 | 3.1 | 223.2 |
| 1985 | 12.5 | 20.6 | 21.5 | 31.1 | 31.7 | 31.7 | 29.5 | 20.6 | 8.0 | 4.3 | 3.2 | 4.4 | 218.9 |
| 1986 | 16.1 | 21.6 | 20.6 | 17.6 | 22.2 | 31.7 | 21.0 | 9.0 | 4.9 | 3.4 | 2.7 | 4.7 | 175.5 |
| 1987 | 15.7 | 18.5 | 24.3 | 29.9 | 22.0 | 24.1 | 18.1 | 9.9 | 5.4 | 3.4 | 2.9 | 3.5 | 177.9 |
| 1988 | 12.3 | 23.7 | 24.7 | 31.7 | 31.7 | 31.7 | 19.0 | 9.2 | 5.4 | 3.0 | 2.2 | 3.1 | 197.8 |
| 1989 | 13.5 | 16.5 | 16.7 | 25.7 | 31.7 | 28.5 | 20.3 | 18.7 | 8.4 | 4.9 | 4.2 | 6.2 | 195.3 |
| 1990 | 19.4 | 24.4 | 25.3 | 25.6 | 28.0 | 31.7 | 26.9 | 15.7 | 11.7 | 5.3 | 3.8 | 6.1 | 224.0 |
| 1991 | 14.9 | 23.4 | 22.0 | 22.1 | 24.4 | 28.4 | 20.4 | 12.7 | 6.1 | 5.1 | 3.2 | 3.8 | 186.6 |
| 1993 | 18.0 | 15.6 | 16.7 | 27.1 | 31.7 | 31.7 | 19.0 | 9.5 | 5.4 | 3.5 | 3.3 | 4.7 | 186.1 |
| Total | 382.2 | 496.8 | 474.7 | 562.2 | 625.8 | 677.4 | 547.1 | 280.4 | 163.5 | 100.1 | 82.6 | 123.9 | 4516.7 |
| Average | 17.4 | 22.6 | 21.6 | 25.6 | 28.4 | 30.8 | 24.9 | 12.7 | 7.4 | 4.5 | 3.8 | 5.6 | 205.3 |
| Min. | 7.4 | 15.6 | 12.0 | 14.4 | 22.0 | 24.1 | 14.2 | 6.3 | 4.0 | 3.0 | 2.2 | 3.1 | 155.6 |
| Max. | 31.7 | 31.7 | 31.7 | 31.7 | 31.7 | 31.7 | 31.7 | 20.6 | 16.8 | 7.2 | 7.6 | 10.2 | 263.7 |

## Table 9-3 (5) Energy Production of Nara Scheme

Installed Capacity: 22.7 MW | Power Efficiency : 0.84
Maximum Discharge : 6.20 m^3/s | Effective Storage Capacity 0 * 10^6 m^3
Effective Head : 432.00 m

Unit : GWh

| Year | May | Jun. | Jul. | Aug. | Sept. | Oct. | Nov. | Dec. | Jan. | Feb. | Mar. | Apr. | Average |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1970 | 0.0 | 0.0 | 0.0 | 16.4 | 16.4 | 16.4 | 15.0 | 8.9 | 7.9 | 4.2 | 4.5 | 5.7 | 95.4 |
| 1971 | 16.4 | 16.4 | 16.4 | 16.4 | 16.4 | 16.4 | 16.4 | 7.6 | 7.0 | 3.5 | 2.4 | 4.9 | 140.3 |
| 1972 | 11.5 | 9.4 | 9.1 | 11.5 | 13.6 | 16.4 | 15.9 | 8.1 | 3.6 | 2.5 | 2.2 | 3.6 | 107.3 |
| 1973 | 7.3 | 16.4 | 16.4 | 16.4 | 16.4 | 16.4 | 14.3 | 10.7 | 9.8 | 4.0 | 2.6 | 3.4 | 134.1 |
| 1974 | 11.4 | 16.4 | 12.9 | 14.8 | 16.4 | 16.4 | 15.1 | 5.7 | 3.4 | 2.4 | 2.4 | 2.9 | 120.2 |
| 1975 | 12.1 | 13.4 | 14.3 | 16.4 | 16.4 | 16.4 | 16.4 | 8.5 | 4.4 | 2.3 | 1.8 | 2.1 | 124.4 |
| 1976 | 5.8 | 10.0 | 7.7 | 8.4 | 14.8 | 16.4 | 11.1 | 5.2 | 2.9 | 2.2 | 2.0 | 2.4 | 89.1 |
| 1977 | 5.9 | 10.0 | 7.0 | 15.7 | 16.4 | 16.4 | 16.4 | 7.3 | 3.3 | 2.3 | 2.2 | 5.9 | 108.9 |
| 1978 | 8.2 | 14.2 | 14.3 | 16.4 | 16.4 | 16.4 | 15.7 | 7.5 | 3.9 | 2.7 | 2.4 | 4.5 | 122.6 |
| 1979 | 12.7 | 14.2 | 13.0 | 15.7 | 16.4 | 16.4 | 15.5 | 7.7 | 5.2 | 3.1 | 2.1 | 3.6 | 125.6 |
| 1980 | 8.8 | 13.5 | 13.8 | 13.7 | 15.8 | 16.4 | 16.4 | 8.4 | 4.6 | 3.1 | 2.7 | 5.4 | 122.5 |
| 1981 | 16.4 | 16.4 | 13.7 | 16.4 | 13.4 | 16.4 | 15.4 | 6.3 | 5.1 | 3.0 | 3.1 | 4.1 | 129.7 |
| 1982 | 14.3 | 9.9 | 10.0 | 10.0 | 13.0 | 15.8 | 8.3 | 3.7 | 2.3 | 2.2 | 2.6 | 3.0 | 95.2 |
| 1983 | 4.3 | 9.4 | 7.2 | 9.6 | 16.4 | 16.4 | 16.4 | 10.0 | 4.9 | 4.0 | 3.3 | 3.4 | 105.4 |
| 1984 | 12.6 | 16.3 | 16.4 | 15.1 | 16.4 | 16.4 | 16.4 | 5.8 | 2.7 | 1.9 | 1.5 | 1.8 | 123.3 |
| 1985 | 7.3 | 12.0 | 12.6 | 16.4 | 16.4 | 16.4 | 16.4 | 12.0 | 4.7 | 2.5 | 1.9 | 2.6 | 121.1 |
| 1986 | 9.4 | 12.6 | 12.0 | 10.3 | 13.0 | 16.4 | 12.3 | 5.2 | 2.9 | 2.0 | 1.6 | 2.8 | 100.5 |
| 1987 | 9.2 | 10.8 | 14.2 | 16.4 | 12.9 | 14.1 | 10.6 | 5.8 | 3.1 | 2.0 | 1.7 | 2.0 | 103.0 |
| 1988 | 7.2 | 13.9 | 14.4 | 16.4 | 16.4 | 16.4 | 11.1 | 5.4 | 3.2 | 1.7 | 1.3 | 1.8 | 109.3 |
| 1989 | 7.9 | 9.6 | 9.8 | 15.0 | 16.4 | 16.4 | 11.9 | 10.9 | 4.9 | 2.8 | 2.4 | 3.7 | 111.8 |
| 1990 | 11.4 | 14.3 | 14.8 | 15.0 | 16.4 | 16.4 | 15.7 | 9.2 | 6.9 | 3.1 | 2.2 | 3.6 | 128.8 |
| 1991 | 8.7 | 13.7 | 12.8 | 12.9 | 14.3 | 16.4 | 11.9 | 7.4 | 3.6 | 3.0 | 1.9 | 2.2 | 108.9 |
| 1993 | 10.5 | 9.1 | 9.8 | 15.8 | 16.4 | 16.4 | 11.1 | 5.6 | 3.2 | 2.1 | 1.9 | 2.7 | 104.6 |
| Total | 219.3 | 282.0 | 272.7 | 314.9 | 340.3 | 358.0 | 310.5 | 164.0 | 95.6 | 58.5 | 48.3 | 72.5 | 2536.5 |
| Average | 10.0 | 12.8 | 12.4 | 14.3 | 15.5 | 16.3 | 14.1 | 7.5 | 4.3 | 2.7 | 2.2 | 3.3 | 115.3 |
| Min. | 4.3 | 9.1 | 7.0 | 8.4 | 12.9 | 14.1 | 8.3 | 3.7 | 2.3 | 1.7 | 1.3 | 1.8 | 89.1 |
| Max. | 16.4 | 16.4 | 16.4 | 16.4 | 16.4 | 16.4 | 16.4 | 12.0 | 9.8 | 4.2 | 4.5 | 5.9 | 140.3 |

## Table 9-4 Study on Project Site

| Item | Reyes | Milagro | Los Llanos | Los Llanos-A | Nara |
|---|---|---|---|---|---|
| Effective Storage Capacity ($10^6$ $m^3$) | 23.8 | 0 | 1.5 | 1.5 | 0 |
| Installed Capacity (MW) | 23.3 | 30.8 | 95.8 | 43.7 | 22.7 |
| Firm Power (MW) | 22.1 | 2.9 | 39.5 | 18.1 | 2.3 |
| Annual Available Energy (GWh) | 108.9 | 114.9 | 426.3 | 195.0 | 109.5 |
| Investment Cost ($10^6$¢) | 15,613 | 4,971 | 14,139 | 9,866 | 4,472 |
| Annual Cost (C) ($10^6$¢) | 2,030 | 646 | 1,838 | 1,283 | 581 |
| Annual Benefit (B1) ($10^6$¢) | 621 | 398 | 1,839 | 841 | 374 |
| " (B2) ($10^6$¢) | | | | | |
| Benefit Cost Ratio (B1/C) | 0.306 | 0.616 | 1.001 | 0.655 | 0.644 |
| " (B2/C) | | | | | |
| Unit Cost of Energy (¢/kWh) | 18.64 | 5.62 | 4.31 | 6.58 | 5.31 |

## Table 9-5 Project Outline of Los Llanos Scheme

| Item | Los Llanos | Los Llanos (A) | Los Llanos (B) |
|---|---|---|---|
| Catchment Area ($km^2$) | 143.7 | 143.7 | 143.7+31.0 |
| Annual Inflow ($m^3$/sec) | 18.05 | 18.05 | |
| High Water Level (EL. m) | 485 | 485 | 485 |
| Low Water Level (EL. m) | 475 | 475 | 475 |
| Effective Storage Capacity ($10^6$ $m^3$) | 1.5 | 1.5 | 1.5 |
| Tail Water Level (EL. m) | 84 | 300 | 200 |
| Gross Head (m) | 401 | 185 | 285 |
| Effective Head (m) | 365 | 167 | 242 |
| Maximum Discharge ($m^3$/sec) | 31.0 | 31.0 | 40.0 |
| Installed Capacity (MW) | 95.8 | 43.7 | 82.0 |
| | | | |
| Main Facilities | | | |
| Dam Type | Concrete Gravity | Concrete Gravity | Concrete Gravity |
| Height x Length | 53 m x 105 m | 53 m x 105 m | 53 m x 105 m |
| Headrace (D x L) | 3.2 m x 5,900 m | 3.2 m x 2,400 m | 3.2 m x 5,300 m<br>3.6 m x 2,400 m |
| Surge Tank (D x H) | 8.0 m x 92 m | 8.0 m x 80 m | 8.0 m x 92 m |
| Penstock Type | Open | Open | Open |
| D x L | 2.75 m x 1,465 m | 2.75 m x 1,160 m | 3.0 m x 2,100 m |
| Powerhouse Type | Open | Open | Open |
| Type of Turbine | Pelton | Pelton | Pelton |

Table 9-6 Basic Development Plan of Los Llanos Project

| Item | Los Llanos (1) | Los Llanos (A) | Los Llanos (B) |
|---|---|---|---|
| Effective Storage Capacity ($10^6$ $m^3$) | 1.5 | 1.5 | 1.5 |
| Installed Capacity (MW) | 95.8 | 43.7 | 82.0 |
| Firm Power (MW) | 66.1 | 30.3 | 39.1 |
| Annual Available Energy (GWh) | 382.8 | 175.1 | 308.6 |
| Firm Energy (GWh) | 120.7 | 55.2 | 83.0 |
| Secondary Energy (GWh) | 262.1 | 119.9 | 225.6 |
| Investment Cost ($10^6$¢) | 14,139 | 9,866 | 17,143 |
| Annual Cost (C) ($10^6$¢) | 1,838 | 1,283 | 2,229 |
| Annual Benefit (B) ($10^6$¢) | 1,949 | 892 | 1,373 |
| Benefit Cost Ratio (B/C) | 1,060 | 0.695 | 0.616 |
| Unit Cost of Energy (¢/kWh) | 4.80 | 7.33 | 7.23 |

**Table 9-7 Project Outline of Los Llanos Projects**

| Item | Los Llanos (1) | Los Llanos (2) | Los Llanos (3) | Los Llanos (4) |
|---|---|---|---|---|
| Catchment Area ($km^2$) | 143.7 | 143.7 | 143.7 | 143.7 |
| Annual Inflow ($m^3$/sec) | 18.05 | 18.05 | 18.05 | 18.05 |
| High Water Level (EL. m) | 485 | 570 | 540 | 525 |
| Low Water Level (EL. m) | 475 | 505 | 475 | 475 |
| Effective Storage Capacity ($10^6$ $m^3$) | 1.5 | 22.5 | 9.5 | 5.0 |
| Tail Water Level (EL. m) | 84 | 84 | 84 | 84 |
| Gross Head (m) | 401 | 486 | 456 | 441 |
| Effective Head (m) | 365 | 447 | 417 | 403 |
| Maximum Discharge ($m^3$/sec) | 31.0 | 31.0 | 31.0 | 31.0 |
| Installed Capacity (MW) | 95.8 | 117.3 | 109.5 | 105.9 |
| | | | | |
| Main Facilities | | | | |
| Dam Type | Concrete Gravity | Concrete Gravity | Concrete Gravity | Concrete Gravity |
| Height x Length | 53 m x 105 m | 138 m x 275 m | 108 m x 215 m | 93 m x 190 m |
| Headrace (D x L) | 3.2 m x 5,900 m | 3.2 m x 5,900 m | 3.2 m x 5,900 m | 3.2 m x 5,900 m |
| Surge tank (D x H) | 8.0 m x 92 m | 8.0 m x 150 m | 8.0 m x 150 m | 8.0 m x 131 m |
| Penstock Type | Open | Open | Open | Open |
| D x L | 2.75 m x 1,465 m | 2.75 m x 1,465 m | 2.75 m x 1,465 m | 2.75 m x 1,465 m |
| Powerhouse Type | Open | Open | Open | Open |
| Type of Turbine | Pelton | Pelton | Pelton | Pelton |

## Table 9-8 (1) Energy Production of Los Llanos Scheme (1)

Installed Capacity: 95.8 MW
Maximum Discharge : 31.00 m^3/s
Effective Head : 365.00 m
Power Efficiency : 0.84
Effective Storage Capacity 1.5 * 10^6 m^3
Firm Discharge 3.91 m^3/s-d

Unit : GWh

| Year | May | Jun. | Jul. | Aug. | Sept. | Oct. | Nov. | Dec. | Jan. | Feb. | Mar. | Apr. | Average |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1971 | 49.3 | 58.1 | 54.3 | 66.1 | 66.5 | 64.9 | 50.0 | 26.2 | 24.4 | 13.1 | 10.3 | 17.7 | 500.9 |
| 1972 | 36.3 | 30.2 | 30.4 | 36.6 | 40.7 | 54.7 | 46.2 | 27.6 | 14.3 | 9.5 | 9.6 | 13.3 | 349.5 |
| 1973 | 25.0 | 53.0 | 49.7 | 53.4 | 65.0 | 68.7 | 41.9 | 34.7 | 32.2 | 13.9 | 11.0 | 13.2 | 461.7 |
| 1974 | 36.3 | 54.7 | 40.2 | 43.4 | 54.9 | 67.5 | 43.8 | 20.7 | 13.7 | 9.4 | 10.2 | 11.4 | 406.1 |
| 1975 | 37.3 | 39.7 | 43.8 | 53.7 | 57.6 | 66.3 | 54.3 | 28.7 | 16.8 | 9.4 | 8.0 | 8.8 | 424.4 |
| 1976 | 20.3 | 31.8 | 26.7 | 28.6 | 42.5 | 50.8 | 34.6 | 19.4 | 12.0 | 8.7 | 8.8 | 10.0 | 294.3 |
| 1977 | 20.8 | 31.5 | 24.7 | 46.4 | 49.5 | 58.7 | 48.0 | 25.2 | 13.4 | 9.0 | 9.5 | 17.8 | 354.4 |
| 1978 | 27.8 | 42.1 | 44.1 | 50.8 | 57.4 | 62.3 | 45.6 | 26.0 | 15.4 | 10.2 | 10.1 | 16.1 | 407.9 |
| 1979 | 40.1 | 41.9 | 40.5 | 46.7 | 55.8 | 60.1 | 44.3 | 26.6 | 19.1 | 11.9 | 9.4 | 13.5 | 409.9 |
| 1980 | 29.5 | 39.0 | 40.6 | 42.3 | 45.7 | 54.7 | 56.0 | 28.4 | 17.5 | 11.4 | 11.3 | 18.7 | 395.0 |
| 1981 | 54.8 | 56.5 | 42.5 | 52.2 | 40.2 | 53.0 | 43.2 | 22.5 | 19.0 | 11.2 | 12.6 | 15.4 | 423.2 |
| 1982 | 43.4 | 31.6 | 32.8 | 32.9 | 38.7 | 47.2 | 27.3 | 14.5 | 10.1 | 8.6 | 11.1 | 11.8 | 310.0 |
| 1983 | 16.4 | 30.1 | 25.2 | 31.7 | 48.7 | 59.5 | 54.9 | 32.6 | 18.4 | 14.5 | 13.2 | 13.1 | 358.3 |
| 1984 | 37.6 | 47.2 | 54.9 | 46.0 | 53.0 | 61.6 | 48.7 | 20.8 | 11.2 | 7.8 | 7.1 | 7.8 | 403.7 |
| 1985 | 25.2 | 37.0 | 39.4 | 51.8 | 57.0 | 64.5 | 47.1 | 38.0 | 17.6 | 9.6 | 8.3 | 10.4 | 405.9 |
| 1986 | 27.8 | 38.4 | 38.2 | 33.6 | 39.3 | 57.8 | 37.6 | 19.4 | 11.9 | 8.1 | 7.4 | 11.1 | 330.4 |
| 1987 | 30.6 | 33.9 | 43.8 | 51.9 | 39.1 | 43.4 | 33.2 | 21.0 | 12.8 | 8.4 | 7.8 | 8.7 | 334.5 |
| 1988 | 24.9 | 40.0 | 44.3 | 60.4 | 63.0 | 63.2 | 34.4 | 19.8 | 12.8 | 7.1 | 6.3 | 7.9 | 384.0 |
| 1989 | 27.0 | 30.8 | 32.3 | 45.8 | 58.7 | 49.8 | 36.6 | 35.0 | 18.4 | 10.7 | 10.5 | 13.8 | 369.4 |
| 1990 | 36.3 | 42.5 | 44.6 | 45.4 | 47.5 | 62.2 | 45.4 | 30.6 | 24.2 | 11.4 | 9.7 | 13.6 | 413.4 |
| 1991 | 29.3 | 41.0 | 40.3 | 39.7 | 42.5 | 49.2 | 36.5 | 25.5 | 14.2 | 11.5 | 8.5 | 9.3 | 347.6 |
| 1992 | 15.5 | 38.7 | 45.0 | 35.3 | 56.0 | 57.3 | 42.0 | 26.2 | 13.1 | 9.3 | 9.2 | 11.6 | 359.0 |
| 1993 | 37.8 | 41.4 | 38.4 | 42.5 | 57.6 | 49.7 | 30.6 | 21.6 | 13.6 | 9.6 | 9.0 | 8.5 | 360.2 |
| Total | 729.4 | 931.3 | 916.5 | 1,037.0 | 1,177.2 | 1,327.1 | 982.1 | 590.8 | 375.9 | 234.1 | 218.8 | 283.6 | 8,803.8 |
| Average | 31.7 | 40.5 | 39.8 | 45.1 | 51.2 | 57.7 | 42.7 | 25.7 | 16.3 | 10.2 | 9.5 | 12.3 | 382.8 |
| Min. | 15.5 | 30.1 | 24.7 | 28.6 | 38.7 | 43.4 | 27.3 | 14.5 | 10.1 | 7.1 | 6.3 | 7.8 | 294.3 |
| Max. | 54.8 | 58.1 | 54.9 | 66.1 | 66.5 | 68.7 | 56.0 | 38.0 | 32.2 | 14.5 | 13.2 | 18.7 | 500.9 |

Annual Energy Production
- Total Energy Et = 382.8 GWh
- Firm Energy Ef = 120.7 GWh
- Secondary Energy Es = 262.1 GWh

Firm Power Output Pf = 66.1 MW (Peak Time 5 hr)

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## Table 9-8 (2) Energy Production of Los Llanos Scheme (2)

Installed Capacity: 117.3 MW
Maximum Discharge : 31.00 m^3/s
Effective Head : 447.00 m

Power Efficiency : 0.84
Effective Storage Capacity 22.5 * 10^6 m^3
Firm Discharge 5.91 m^3/s-d

Unit : GWh

| Year | May | Jun. | Jul. | Aug. | Sept. | Oct. | Nov. | Dec. | Jan. | Feb. | Mar. | Apr. | Average |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1971 | 60.3 | 71.2 | 66.5 | 80.9 | 81.4 | 79.5 | 61.3 | 32.1 | 29.9 | 16.0 | 12.6 | 21.7 | 613.4 |
| 1972 | 44.5 | 37.0 | 37.2 | 44.8 | 49.9 | 66.9 | 56.6 | 33.8 | 17.6 | 11.6 | 11.8 | 16.3 | 428.0 |
| 1973 | 30.6 | 64.9 | 60.8 | 65.4 | 79.6 | 84.1 | 51.3 | 42.5 | 39.4 | 17.1 | 13.5 | 16.2 | 565.4 |
| 1974 | 44.5 | 67.0 | 49.2 | 53.2 | 67.2 | 82.7 | 53.7 | 25.3 | 16.7 | 11.5 | 12.5 | 13.9 | 497.4 |
| 1975 | 45.7 | 48.7 | 53.7 | 65.7 | 70.6 | 81.2 | 66.5 | 35.2 | 20.5 | 11.5 | 9.8 | 10.8 | 519.8 |
| 1976 | 24.8 | 38.9 | 32.7 | 35.0 | 52.1 | 62.3 | 42.4 | 23.7 | 14.7 | 10.7 | 10.8 | 12.3 | 360.4 |
| 1977 | 25.5 | 38.6 | 30.2 | 56.8 | 60.7 | 71.9 | 58.7 | 30.9 | 16.4 | 11.1 | 11.6 | 21.8 | 434.0 |
| 1978 | 34.0 | 51.6 | 54.0 | 62.2 | 70.3 | 76.3 | 55.8 | 31.8 | 18.9 | 12.5 | 12.4 | 19.8 | 499.5 |
| 1979 | 49.1 | 51.3 | 49.6 | 57.2 | 68.4 | 73.7 | 54.2 | 32.6 | 23.4 | 14.5 | 11.5 | 16.5 | 502.0 |
| 1980 | 36.1 | 47.8 | 49.7 | 51.8 | 56.0 | 66.9 | 68.5 | 34.7 | 21.4 | 13.9 | 13.8 | 22.9 | 483.7 |
| 1981 | 67.1 | 69.2 | 52.0 | 63.9 | 49.3 | 64.9 | 52.9 | 27.5 | 23.3 | 13.8 | 15.4 | 18.8 | 518.3 |
| 1982 | 53.2 | 38.7 | 40.2 | 40.3 | 47.4 | 57.8 | 33.5 | 17.8 | 12.3 | 10.6 | 13.6 | 14.5 | 379.7 |
| 1983 | 20.0 | 36.9 | 30.8 | 38.8 | 59.7 | 72.9 | 67.2 | 39.9 | 22.6 | 17.8 | 16.2 | 16.0 | 438.8 |
| 1984 | 46.1 | 57.8 | 67.2 | 56.3 | 64.9 | 75.4 | 59.6 | 25.5 | 13.7 | 9.6 | 8.7 | 9.6 | 494.4 |
| 1985 | 30.8 | 45.3 | 48.2 | 63.5 | 69.9 | 79.0 | 57.7 | 46.5 | 21.5 | 11.7 | 10.2 | 12.8 | 497.1 |
| 1986 | 34.1 | 47.1 | 46.8 | 41.2 | 48.1 | 70.7 | 46.0 | 23.7 | 14.5 | 9.9 | 9.0 | 13.6 | 404.7 |
| 1987 | 37.4 | 41.5 | 53.6 | 63.6 | 47.9 | 53.2 | 40.7 | 25.8 | 15.6 | 10.2 | 9.5 | 10.6 | 409.7 |
| 1988 | 30.5 | 49.0 | 54.2 | 73.9 | 77.1 | 77.5 | 42.1 | 24.2 | 15.7 | 8.7 | 7.7 | 9.6 | 470.2 |
| 1989 | 33.1 | 37.7 | 39.6 | 56.1 | 71.9 | 61.0 | 44.8 | 42.9 | 22.5 | 13.1 | 12.8 | 16.9 | 452.4 |
| 1990 | 44.5 | 52.1 | 54.7 | 55.5 | 58.2 | 76.2 | 55.5 | 37.5 | 29.6 | 13.9 | 11.8 | 16.7 | 506.3 |
| 1991 | 35.9 | 50.3 | 49.4 | 48.7 | 52.1 | 60.2 | 44.7 | 31.2 | 17.4 | 14.1 | 10.4 | 11.4 | 425.7 |
| 1992 | 19.0 | 47.3 | 55.1 | 43.2 | 68.5 | 70.2 | 51.5 | 32.0 | 16.0 | 11.3 | 11.3 | 14.2 | 439.7 |
| 1993 | 46.3 | 50.7 | 47.0 | 52.0 | 70.6 | 60.8 | 37.4 | 26.4 | 16.7 | 11.8 | 11.0 | 10.4 | 441.1 |
| Total | 893.3 | 1,140.6 | 1,122.5 | 1,269.9 | 1,441.6 | 1,625.2 | 1,202.7 | 723.6 | 460.3 | 286.7 | 267.9 | 347.3 | 10,781.7 |
| Average | 38.8 | 49.6 | 48.8 | 55.2 | 62.7 | 70.7 | 52.3 | 31.5 | 20.0 | 12.5 | 11.6 | 15.1 | 468.8 |
| Min. | 19.0 | 36.9 | 30.2 | 35.0 | 47.4 | 53.2 | 33.5 | 17.8 | 12.3 | 8.7 | 7.7 | 9.6 | 360.4 |
| Max. | 67.1 | 71.2 | 67.2 | 80.9 | 81.4 | 84.1 | 68.5 | 46.5 | 39.4 | 17.8 | 16.2 | 22.9 | 613.4 |

Annual Energy Production
- Total Energy Et = 468.8 GWh
- Firm Energy Ef = 190.6 GWh
- Secondary Energy Es = 278.2 GWh

Firm Power Output Pf = 104.4 MW (Peak Time 5 hr)

# Table 9-8 (3) Energy Production of Los Llanos Scheme (3)

Installed Capacity: 109.5 MW
Maximum Discharge : 31.00 m^3/s
Effective Head : 417.00 m

Power Efficiency : 0.84
Effective Storage Capacity 9.5 * 10^6 m^3
Firm Discharge 5.48 m^3/s-d

Unit : GWh

| Year | May | Jun. | Jul. | Aug. | Sept. | Oct. | Nov. | Dec. | Jan. | Feb. | Mar. | Apr. | Average |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1971 | 56.3 | 66.4 | 62.0 | 75.5 | 76.0 | 74.1 | 57.2 | 29.9 | 27.9 | 14.9 | 11.8 | 20.2 | 572.2 |
| 1972 | 41.5 | 34.5 | 34.7 | 41.8 | 46.5 | 62.4 | 52.8 | 31.6 | 16.4 | 10.8 | 11.0 | 15.2 | 399.3 |
| 1973 | 28.6 | 60.6 | 56.8 | 61.0 | 74.2 | 78.4 | 47.9 | 39.6 | 35.8 | 15.9 | 12.6 | 15.1 | 527.4 |
| 1974 | 41.5 | 62.5 | 45.9 | 49.6 | 62.7 | 77.1 | 50.1 | 23.6 | 15.6 | 10.7 | 11.7 | 13.0 | 464.0 |
| 1975 | 42.6 | 45.4 | 50.1 | 61.3 | 65.8 | 75.7 | 62.0 | 32.8 | 19.1 | 10.7 | 9.2 | 10.1 | 484.9 |
| 1976 | 23.2 | 36.3 | 30.5 | 32.6 | 48.6 | 58.1 | 39.5 | 22.1 | 13.7 | 10.0 | 10.1 | 11.5 | 336.2 |
| 1977 | 23.8 | 36.0 | 28.2 | 53.0 | 56.6 | 67.1 | 54.8 | 28.8 | 15.3 | 10.3 | 10.8 | 20.3 | 404.9 |
| 1978 | 31.7 | 48.1 | 50.4 | 58.0 | 65.6 | 71.2 | 52.1 | 29.7 | 17.6 | 11.6 | 11.5 | 18.4 | 466.0 |
| 1979 | 45.8 | 47.9 | 46.3 | 53.4 | 63.8 | 68.7 | 50.6 | 30.4 | 21.8 | 13.5 | 10.7 | 15.4 | 468.3 |
| 1980 | 33.7 | 44.6 | 46.4 | 48.4 | 52.2 | 62.4 | 63.9 | 32.4 | 20.0 | 13.0 | 12.9 | 21.4 | 451.3 |
| 1981 | 62.6 | 64.6 | 48.5 | 59.6 | 46.0 | 60.6 | 49.3 | 25.7 | 21.8 | 12.8 | 14.4 | 17.6 | 483.5 |
| 1982 | 49.6 | 36.1 | 37.5 | 37.6 | 44.2 | 53.9 | 31.2 | 16.6 | 11.5 | 9.9 | 12.6 | 13.5 | 354.2 |
| 1983 | 18.7 | 34.4 | 28.8 | 36.2 | 55.7 | 68.0 | 62.7 | 37.2 | 21.1 | 16.6 | 15.1 | 15.0 | 409.4 |
| 1984 | 43.0 | 53.9 | 62.7 | 52.6 | 60.6 | 70.4 | 55.6 | 23.8 | 12.8 | 8.9 | 8.1 | 8.9 | 461.2 |
| 1985 | 28.8 | 42.3 | 45.0 | 59.2 | 65.2 | 73.7 | 53.8 | 43.4 | 20.1 | 10.9 | 9.5 | 11.9 | 463.8 |
| 1986 | 31.8 | 43.9 | 43.7 | 38.4 | 44.9 | 66.0 | 42.9 | 22.1 | 13.5 | 9.2 | 8.4 | 12.6 | 377.5 |
| 1987 | 34.9 | 38.7 | 50.0 | 59.3 | 44.7 | 49.6 | 38.0 | 24.0 | 14.6 | 9.5 | 8.9 | 9.9 | 382.2 |
| 1988 | 28.4 | 45.7 | 50.6 | 69.0 | 71.9 | 72.3 | 39.3 | 22.6 | 14.6 | 8.1 | 7.2 | 9.0 | 438.7 |
| 1989 | 30.9 | 35.2 | 36.9 | 52.3 | 67.1 | 56.9 | 41.8 | 40.0 | 21.0 | 12.2 | 11.9 | 15.8 | 422.0 |
| 1990 | 41.5 | 48.6 | 51.0 | 51.8 | 54.3 | 71.1 | 51.8 | 35.0 | 27.6 | 13.0 | 11.1 | 15.6 | 472.3 |
| 1991 | 33.5 | 46.9 | 46.1 | 45.4 | 48.6 | 56.2 | 41.7 | 29.1 | 16.2 | 13.1 | 9.7 | 10.7 | 397.1 |
| 1992 | 17.7 | 44.2 | 51.4 | 40.3 | 63.9 | 65.5 | 48.0 | 29.9 | 14.9 | 10.6 | 10.5 | 13.2 | 410.2 |
| 1993 | 43.2 | 47.3 | 43.8 | 48.5 | 65.8 | 56.8 | 34.9 | 24.6 | 15.6 | 11.0 | 10.3 | 9.7 | 411.5 |
| Total | 833.3 | 1,064.0 | 1,047.1 | 1,184.7 | 1,344.9 | 1,516.1 | 1,122.0 | 675.0 | 429.4 | 267.4 | 250.0 | 324.0 | 10,058.1 |
| Average | 36.2 | 46.3 | 45.5 | 51.5 | 58.5 | 65.9 | 48.8 | 29.3 | 18.7 | 11.6 | 10.9 | 14.1 | 437.3 |
| Min. | 17.7 | 34.4 | 28.2 | 32.6 | 44.2 | 49.6 | 31.2 | 16.6 | 11.5 | 8.1 | 7.2 | 8.9 | 336.2 |
| Max. | 62.6 | 66.4 | 62.7 | 75.5 | 76.0 | 78.4 | 63.9 | 43.4 | 36.8 | 16.6 | 15.1 | 21.4 | 572.2 |

Annual Energy Production

| | | |
|---|---|---|
| Total Energy | Et = | 437.3 GWh |
| Firm Energy | Ef = | 164.8 GWh |
| Secondary Energy | Es = | 272.5 GWh |

Firm Power Output Pf = 90.3 MW (Peak Time 5 hr)

# Table 9-8 (4) Energy Production of Los Llanos Scheme (4)

Installed Capacity: 105.9 MW — Power Efficiency : 0.84
Maximum Discharge : 31.00 m^3/s — Effective Storage Capacity 5 * 10^6 m^3
Effective Head : 403.00 m — Firm Discharge 5.12 m^3/s-d

Unit : GWh

| Year | May | Jun. | Jul. | Aug. | Sept. | Oct. | Nov. | Dec. | Jan. | Feb. | Mar. | Apr. | Average |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1971 | 54.4 | 64.2 | 60.0 | 72.9 | 73.4 | 71.7 | 55.3 | 28.9 | 26.9 | 14.4 | 11.4 | 19.6 | 553.0 |
| 1972 | 40.1 | 33.4 | 33.5 | 40.4 | 45.0 | 60.4 | 51.0 | 30.5 | 15.8 | 10.5 | 10.6 | 14.7 | 385.9 |
| 1973 | 27.6 | 58.5 | 54.9 | 59.0 | 71.7 | 75.8 | 46.3 | 38.3 | 35.5 | 15.4 | 12.2 | 14.6 | 509.7 |
| 1974 | 40.1 | 60.4 | 44.3 | 47.9 | 60.6 | 74.5 | 48.4 | 22.8 | 15.1 | 10.3 | 11.3 | 12.5 | 448.4 |
| 1975 | 41.2 | 43.9 | 48.4 | 59.2 | 63.6 | 73.2 | 60.0 | 31.7 | 18.5 | 10.4 | 8.9 | 9.7 | 468.6 |
| 1976 | 22.4 | 35.1 | 29.5 | 31.5 | 47.0 | 56.1 | 38.2 | 21.4 | 13.3 | 9.6 | 9.7 | 11.1 | 324.9 |
| 1977 | 23.0 | 34.8 | 27.2 | 51.2 | 54.7 | 64.8 | 52.9 | 27.8 | 14.8 | 10.0 | 10.4 | 19.6 | 391.3 |
| 1978 | 30.7 | 46.5 | 48.7 | 56.1 | 63.4 | 68.8 | 50.3 | 28.7 | 17.0 | 11.2 | 11.1 | 17.8 | 450.3 |
| 1979 | 44.3 | 46.3 | 44.7 | 51.6 | 61.6 | 66.4 | 48.9 | 29.4 | 21.1 | 13.1 | 10.4 | 14.9 | 452.6 |
| 1980 | 32.6 | 43.1 | 44.8 | 46.7 | 50.5 | 60.4 | 61.8 | 31.3 | 19.3 | 12.5 | 12.5 | 20.7 | 436.1 |
| 1981 | 60.5 | 62.4 | 46.9 | 57.6 | 44.4 | 58.5 | 47.7 | 24.8 | 21.0 | 12.4 | 13.9 | 17.0 | 467.3 |
| 1982 | 47.9 | 34.9 | 36.2 | 36.3 | 42.8 | 52.1 | 30.2 | 16.0 | 11.1 | 9.5 | 12.2 | 13.1 | 342.3 |
| 1983 | 18.1 | 33.3 | 27.8 | 35.0 | 53.8 | 65.7 | 60.6 | 36.0 | 20.3 | 16.0 | 14.6 | 14.5 | 395.6 |
| 1984 | 41.6 | 52.1 | 60.6 | 50.8 | 58.5 | 68.0 | 53.7 | 23.0 | 12.4 | 8.6 | 7.8 | 8.6 | 445.7 |
| 1985 | 27.8 | 40.8 | 43.5 | 57.2 | 63.0 | 71.3 | 52.0 | 41.9 | 19.4 | 10.6 | 9.2 | 11.5 | 448.2 |
| 1986 | 30.7 | 42.4 | 42.2 | 37.1 | 43.4 | 63.8 | 41.5 | 21.4 | 13.1 | 8.9 | 8.1 | 12.2 | 364.9 |
| 1987 | 33.8 | 37.4 | 48.3 | 57.3 | 43.2 | 47.9 | 36.7 | 23.2 | 14.1 | 9.2 | 8.6 | 9.6 | 369.4 |
| 1988 | 27.5 | 44.2 | 48.9 | 66.6 | 69.5 | 69.8 | 38.0 | 21.8 | 14.2 | 7.9 | 6.9 | 8.7 | 424.0 |
| 1989 | 29.9 | 34.0 | 35.7 | 50.6 | 64.8 | 55.0 | 40.4 | 38.7 | 20.3 | 11.8 | 11.5 | 15.3 | 407.8 |
| 1990 | 40.1 | 47.0 | 49.3 | 50.1 | 52.5 | 68.7 | 50.1 | 33.8 | 26.7 | 12.5 | 10.7 | 15.0 | 456.5 |
| 1991 | 32.4 | 45.3 | 44.5 | 43.9 | 47.0 | 54.3 | 40.3 | 28.1 | 15.7 | 12.7 | 9.3 | 10.3 | 383.8 |
| 1992 | 17.1 | 42.7 | 49.7 | 38.9 | 61.8 | 63.3 | 46.4 | 28.9 | 14.4 | 10.2 | 10.2 | 12.8 | 396.4 |
| 1993 | 41.7 | 45.7 | 42.4 | 46.9 | 63.6 | 54.9 | 33.8 | 23.8 | 15.0 | 10.6 | 9.9 | 9.4 | 397.7 |
| Total | 805.4 | 1,028.3 | 1,012.0 | 1,144.9 | 1,299.7 | 1,465.2 | 1,084.3 | 652.3 | 415.0 | 258.5 | 241.6 | 313.2 | 9,720.4 |
| Average | 35.0 | 44.7 | 44.0 | 49.8 | 56.5 | 63.7 | 47.1 | 28.4 | 18.0 | 11.2 | 10.5 | 13.6 | 422.6 |
| Min. | 17.1 | 33.3 | 27.2 | 31.5 | 42.8 | 47.9 | 30.2 | 16.0 | 11.1 | 7.9 | 6.9 | 8.6 | 324.9 |
| Max. | 60.5 | 64.2 | 60.6 | 72.9 | 73.4 | 75.8 | 61.8 | 41.9 | 35.5 | 16.0 | 14.6 | 20.7 | 553.0 |

Annual Energy Production
- Total Energy Et = 422.6 GWh
- Firm Energy Ef = 148.7 GWh
- Secondary Energy Es = 273.9 GWh

Firm Power Output Pf = 81.5 MW (Peak Time 5 hr)

## Table 9-9 Investment Cost (Millions of Colones)

| Item | Los Llanos (1) | Los Llanos (2) | Los Llanos (3) | Los Llanos (4) | Los Llanos (A) | Los Llanos (B) |
|---|---|---|---|---|---|---|
| 1. Reservoir | 16.7 | 136.4 | 66.5 | 55.0 | 16.7 | 16.7 |
| 2. Access | 138.5 | 138.5 | 138.5 | 138.5 | 138.5 | 120.7 |
| 3. Temporary Installations (Main Civil Works x 0.06) | 304.6 | 1,090.7 | 663.7 | 544.1 | 219.3 | 379.9 |
| 4. Main Civil Works | | | | | | |
| Diversion Works | 172.8 | 172.8 | 172.8 | 172.8 | 172.8 | 172.8 |
| Dam | 1,665.5 | 13,640 | 6,650 | 5,501.2 | 1,665.5 | 1,665.5 |
| Power Intake | 298.3 | 846 | 846 | 323.0 | 298.3 | 298.3 + 276.4 |
| Headrace Tunnel | 1,826.1 | 2,215 | 2,153 | 1,831.3 | 751.2 | 2,619.5 |
| Surge Tank | 129.6 | 195 | 195 | 195.0 | 112.7 | 128.4 |
| Penstock | 245.6 | 245.6 | 245.6 | 245.6 | 194.5 | 434.4 |
| Powerhouse and Switchyard | 738.0 | 863.6 | 799.6 | 799.6 | 460.2 | 738.8 |
| Sub-total | 5,075.9 | 18,178 | 11,062 | 9,068.5 | 3,655.2 | 6,331.1 |
| 5. Hydraulic Equipment | | | | | | |
| Spillway gate | 149.4 | 149.4 | 149.4 | 149.4 | 149.4 | 149.4 |
| Outlet works | 34.2 | 34.2 | 34.2 | 34.2 | 34.2 | 34.2 |
| Intake gate | 34.9 | 34.9 | 34.9 | 34.9 | 34.9 | 34.9 + 14.3 |
| Draft gate | 6.5 | 6.5 | 6.5 | 6.5 | 6.5 | 6.5 |
| Penstock | 1,663.2 | 2,031.8 | 1,915.2 | 1,665.6 | 658.4 | 2,308.2 |
| Bridge at Spillway | 24.3 | 24.3 | 24.3 | 24.3 | 24.3 | 24.3 |
| Sub-total | 1,912.5 | 2,281.1 | 2,164.5 | 1,914.9 | 907.7 | 2,571.8 |
| 6. Electromechanical Equipment | 2,440.0 | 2,600 | 2,550 | 2,550 | 1,960 | 2,550.0 |
| 7. Transmission Works | - | - | - | - | - | - |
| a. Total Direction Cost (DC) | 9,888.2 | 24,424.7 | 16,645.2 | 14,271.0 | 6,897.4 | 11,970.2 |
| b. Engineering and ADM (0.14 x a) | 1,384.3 | 3,419.5 | 2,330.3 | 1,997.5 | 965.6 | 1,675.8 |
| c. Contingencies | | | | | | |
| Civil Works (0.25 x MC) | 1,269.0 | 4,544.5 | 2,765.5 | 2,267.1 | 913.8 | 1,582.8 |
| Electromechanical Eq. (0.15 x EM + HE) | 652.9 | 732.2 | 707.2 | 669.7 | 430.2 | 768.3 |
| Engineering (0.15 x b) | 207.6 | 390.1 | 349.8 | 299.7 | 145.0 | 251.9 |
| Sub-total | 2,129.5 | 5,666.8 | 3,822.5 | 3,236.5 | 1,489.0 | 2,603.0 |
| A. Total (a + b + c) | 13,402 | 33,511 | 22,798 | 19,505 | 9,352 | 16,249 |
| B. Institute Expense (0.055 x A) | 737 | 1,843 | 1,254 | 1,073 | 514 | 894 |
| C. Grand Total | 14,139 | 35,354 | 24,052 | 20,578 | 9,866 | 17,143 |

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## Table 9-10 Basic Development Plan of Los Llanos Project

| Item | Los Llanos (1) | Los Llanos (2) | Los Llanos (3) | Los Llanos (4) |
|---|---|---|---|---|
| Effective Storage Capacity ($10^6$ $m^3$) | 1.5 | 22.5 | 9.5 | 5.0 |
| Installed Capacity (MW) | 95.8 | 117.3 | 109.5 | 105.9 |
| Firm Power (MW) | 66.1 | 104.4 | 90.3 | 81.5 |
| Annual Available Energy (GWh) | 382.8 | 468.8 | 437.3 | 422.6 |
| Firm Energy (GWh) | 120.7 | 190.6 | 164.8 | 148.7 |
| Secondary Energy (GWh) | 262.1 | 278.2 | 272.5 | 273.9 |
| Investment Cost ($10^6$¢) | 14,139 | 35,354 | 24,052 | 20,578 |
| Annual Cost (C) ($10^6$¢) | 1,838 | 4,596 | 3,127 | 2,675 |
| Annual Benefit (B) ($10^6$¢) | 1,949 | 2,744 | 2,452 | 2,281 |
| Benefit Cost Ratio (B/C) | 1,060 | 0.597 | 0.784 | 0.853 |
| Unit Cost of Energy (¢/kWh) | 4.80 | 9.80 | 7.15 | 6.33 |

## Table 9-11 Monthly Average Inflow at the Intake Channel Site (without Project)

Catchment Area : 230 km^2

Unit : m^3/s

| Year | May | Jun. | Jul. | Aug. | Sept. | Oct. | Nov. | Dec. | Jan. | Feb. | Mar. | Apr. | Average |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1971 | 56.93 | 89.36 | 59.22 | 85.50 | 102.48 | 74.61 | 49.52 | 21.52 | 19.73 | 9.88 | 6.81 | 13.97 | 49.13 |
| 1972 | 32.36 | 26.58 | 25.71 | 32.34 | 38.36 | 55.20 | 44.84 | 22.93 | 10.23 | 6.97 | 6.25 | 10.19 | 26.00 |
| 1973 | 20.64 | 53.45 | 48.17 | 72.48 | 79.14 | 91.98 | 40.31 | 30.23 | 27.78 | 11.24 | 7.39 | 9.64 | 41.04 |
| 1974 | 32.21 | 57.43 | 36.39 | 41.90 | 57.84 | 81.70 | 42.68 | 16.08 | 9.62 | 6.85 | 6.76 | 8.05 | 33.13 |
| 1975 | 34.12 | 37.84 | 40.32 | 53.75 | 70.54 | 69.15 | 60.76 | 23.95 | 12.45 | 6.59 | 5.02 | 5.91 | 35.03 |
| 1976 | 16.29 | 28.27 | 21.87 | 23.85 | 41.84 | 51.62 | 31.44 | 14.83 | 8.22 | 6.29 | 5.66 | 6.90 | 21.42 |
| 1977 | 16.61 | 28.36 | 19.86 | 44.45 | 50.90 | 61.08 | 46.89 | 20.52 | 9.38 | 6.57 | 6.16 | 16.76 | 27.29 |
| 1978 | 23.14 | 40.06 | 40.51 | 48.54 | 58.90 | 69.36 | 44.25 | 21.25 | 11.15 | 7.59 | 6.65 | 12.70 | 32.01 |
| 1979 | 36.25 | 40.05 | 36.61 | 44.39 | 63.93 | 69.62 | 43.68 | 21.88 | 14.71 | 8.78 | 6.07 | 10.10 | 33.01 |
| 1980 | 25.00 | 38.02 | 38.87 | 38.67 | 44.65 | 52.83 | 58.11 | 23.61 | 13.08 | 8.68 | 7.62 | 15.17 | 30.36 |
| 1981 | 54.11 | 62.29 | 38.75 | 51.19 | 37.86 | 50.88 | 43.37 | 17.74 | 14.51 | 8.58 | 8.71 | 11.64 | 33.30 |
| 1982 | 40.51 | 28.00 | 28.33 | 28.31 | 36.71 | 44.70 | 23.46 | 10.35 | 6.61 | 6.22 | 7.47 | 8.41 | 22.42 |
| 1983 | 12.22 | 26.57 | 20.37 | 27.14 | 47.74 | 59.80 | 59.38 | 28.24 | 13.91 | 11.30 | 9.25 | 9.63 | 27.13 |
| 1984 | 35.68 | 45.96 | 53.18 | 42.64 | 53.12 | 61.56 | 48.66 | 16.26 | 7.55 | 5.47 | 4.28 | 5.14 | 31.63 |
| 1985 | 20.64 | 34.03 | 35.54 | 51.39 | 57.96 | 74.21 | 48.72 | 34.04 | 13.15 | 7.05 | 5.24 | 7.25 | 32.44 |
| 1986 | 26.59 | 35.73 | 34.01 | 29.02 | 36.63 | 56.89 | 34.65 | 14.83 | 8.09 | 5.70 | 4.52 | 7.83 | 24.54 |
| 1987 | 25.91 | 30.64 | 40.20 | 49.47 | 36.39 | 39.88 | 30.00 | 16.39 | 8.84 | 5.70 | 4.84 | 5.80 | 24.51 |
| 1988 | 20.37 | 39.24 | 40.79 | 62.18 | 84.48 | 73.65 | 31.40 | 15.19 | 8.91 | 4.90 | 3.70 | 5.19 | 32.50 |
| 1989 | 22.23 | 27.23 | 27.66 | 42.49 | 61.19 | 47.14 | 33.55 | 30.83 | 13.87 | 8.04 | 6.93 | 10.32 | 27.62 |
| 1990 | 32.08 | 40.36 | 41.87 | 42.35 | 46.21 | 66.03 | 44.38 | 25.99 | 19.40 | 8.70 | 6.29 | 10.07 | 31.98 |
| 1991 | 24.67 | 38.71 | 36.28 | 36.57 | 40.40 | 46.88 | 33.68 | 20.92 | 10.07 | 8.44 | 5.34 | 6.29 | 25.69 |
| 1992 | 11.41 | 36.31 | 41.54 | 30.79 | 58.92 | 56.53 | 39.81 | 21.56 | 9.09 | 6.69 | 6.38 | 9.38 | 27.37 |
| 1993 | 29.74 | 25.78 | 27.57 | 44.71 | 65.47 | 54.74 | 31.32 | 15.69 | 8.97 | 5.83 | 5.42 | 7.69 | 26.91 |
| Total | 649.72 | 910.27 | 833.62 | 1024.10 | 1271.69 | 1410.05 | 964.87 | 484.84 | 279.30 | 172.04 | 142.74 | 214.05 | 696.44 |
| Average | 28.25 | 39.58 | 36.24 | 44.53 | 55.29 | 61.31 | 41.95 | 21.08 | 12.14 | 7.48 | 6.21 | 9.31 | 30.28 |
| Min. | 11.41 | 25.78 | 19.86 | 23.85 | 36.39 | 39.88 | 23.46 | 10.35 | 6.61 | 4.90 | 3.70 | 5.14 | 21.42 |
| Max. | 56.93 | 89.36 | 59.22 | 85.50 | 102.48 | 91.98 | 60.76 | 34.04 | 27.78 | 11.30 | 9.25 | 16.76 | 49.13 |

## Table 9-12 Monthly Average Inflow at the Intake Channel Site (with Project)

Catchment Area : 230 km^2

Unit : m^3/s

| Year | May | Jun. | Jul. | Aug. | Sept. | Oct. | Nov. | Dec. | Jan. | Feb. | Mar. | Apr. | Average |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1971 | 30.87 | 58.36 | 32.31 | 54.50 | 71.48 | 43.61 | 26.26 | 9.73 | 8.74 | 3.62 | 2.19 | 5.68 | 28.95 |
| 1972 | 15.91 | 12.57 | 12.08 | 15.90 | 19.47 | 29.79 | 23.39 | 10.51 | 3.80 | 2.26 | 1.94 | 3.77 | 12.62 |
| 1973 | 9.24 | 28.70 | 25.42 | 41.48 | 48.14 | 60.98 | 20.64 | 14.67 | 13.26 | 4.29 | 2.45 | 3.51 | 22.73 |
| 1974 | 15.83 | 31.19 | 18.29 | 21.60 | 31.44 | 50.70 | 22.08 | 6.78 | 3.50 | 2.21 | 2.17 | 2.76 | 17.38 |
| 1975 | 16.95 | 19.16 | 20.65 | 28.88 | 39.54 | 38.62 | 33.28 | 11.08 | 4.90 | 2.09 | 1.42 | 1.79 | 18.20 |
| 1976 | 6.89 | 13.54 | 9.92 | 11.03 | 21.56 | 27.56 | 15.37 | 6.12 | 2.83 | 1.96 | 1.69 | 2.23 | 10.06 |
| 1977 | 7.06 | 13.59 | 8.81 | 23.15 | 27.11 | 33.48 | 24.64 | 9.17 | 3.38 | 2.08 | 1.90 | 7.14 | 13.46 |
| 1978 | 10.63 | 20.49 | 20.76 | 25.65 | 32.11 | 38.75 | 23.03 | 9.57 | 4.25 | 2.55 | 2.12 | 5.03 | 16.24 |
| 1979 | 18.21 | 20.48 | 18.42 | 23.11 | 35.29 | 38.92 | 22.68 | 9.93 | 6.06 | 3.10 | 1.87 | 3.73 | 16.82 |
| 1980 | 11.67 | 19.27 | 19.77 | 19.65 | 23.27 | 28.31 | 31.61 | 10.89 | 5.22 | 3.05 | 2.56 | 6.30 | 15.13 |
| 1981 | 29.11 | 34.25 | 19.70 | 27.29 | 19.17 | 27.10 | 22.49 | 7.66 | 5.95 | 3.00 | 3.07 | 4.49 | 16.94 |
| 1982 | 20.76 | 13.38 | 13.57 | 13.56 | 18.48 | 23.30 | 10.80 | 3.85 | 2.10 | 1.93 | 2.49 | 2.93 | 10.60 |
| 1983 | 4.78 | 12.56 | 9.09 | 12.89 | 25.16 | 32.67 | 32.41 | 13.52 | 5.64 | 4.32 | 3.32 | 3.50 | 13.32 |
| 1984 | 17.87 | 24.07 | 28.53 | 22.05 | 28.49 | 33.79 | 25.73 | 6.87 | 2.53 | 1.61 | 1.12 | 1.47 | 16.18 |
| 1985 | 9.24 | 16.89 | 17.79 | 27.42 | 31.52 | 43.21 | 25.77 | 16.90 | 5.25 | 2.30 | 1.51 | 2.39 | 16.68 |
| 1986 | 12.57 | 17.90 | 16.88 | 13.97 | 18.44 | 30.84 | 17.26 | 6.12 | 2.77 | 1.70 | 1.21 | 2.66 | 11.86 |
| 1987 | 12.19 | 14.91 | 20.57 | 26.23 | 18.29 | 20.38 | 14.54 | 6.94 | 3.13 | 1.70 | 1.34 | 1.75 | 11.83 |
| 1988 | 9.09 | 19.99 | 20.93 | 34.18 | 53.48 | 42.65 | 15.35 | 6.31 | 3.16 | 1.37 | 0.89 | 1.49 | 17.41 |
| 1989 | 10.12 | 12.94 | 13.19 | 21.96 | 33.55 | 24.79 | 16.61 | 15.02 | 5.63 | 2.75 | 2.24 | 3.84 | 13.55 |
| 1990 | 15.75 | 20.67 | 21.58 | 21.87 | 24.22 | 36.63 | 23.11 | 12.23 | 8.56 | 3.06 | 1.96 | 3.72 | 16.11 |
| 1991 | 11.49 | 19.68 | 18.23 | 18.40 | 20.69 | 24.63 | 16.69 | 9.39 | 3.72 | 2.94 | 1.55 | 1.96 | 12.45 |
| 1992 | 4.38 | 18.24 | 21.38 | 15.00 | 32.12 | 30.62 | 20.34 | 9.74 | 3.25 | 2.14 | 2.00 | 3.38 | 13.55 |
| 1993 | 14.39 | 12.11 | 13.14 | 23.31 | 36.26 | 29.50 | 15.30 | 6.57 | 3.19 | 1.76 | 1.58 | 2.59 | 13.31 |
| Total | 314.99 | 474.95 | 421.02 | 543.06 | 709.32 | 790.83 | 499.38 | 219.59 | 110.80 | 57.79 | 44.58 | 78.10 | 355.37 |
| Average | 13.70 | 20.65 | 18.31 | 23.61 | 30.84 | 34.38 | 21.71 | 9.55 | 4.82 | 2.51 | 1.94 | 3.40 | 15.45 |
| Min. | 4.38 | 12.11 | 8.81 | 11.03 | 18.29 | 20.38 | 10.80 | 3.85 | 2.10 | 1.37 | 0.89 | 1.47 | 10.06 |
| Max. | 30.87 | 58.36 | 32.31 | 54.50 | 71.48 | 60.98 | 33.28 | 16.90 | 13.26 | 4.32 | 3.32 | 7.14 | 28.95 |

## Table 9-13 (1) Outline of Los Llanos Project (I)

| Item | | | CASE I-1 | CASE I-2 | CASE I-3 | CASE I-4 |
|---|---|---|---|---|---|---|
| High Water Level | | (EL. m) | 475.5 | 476.8 | 478.0 | 479.2 |
| Low Water Level | | (EL. m) | 470.0 | 470.0 | 470.0 | 470.0 |
| Effective Storage Capacity (1) | | ($10^3$ $m^3$) | 484 | 605 | 726 | 847 |
| Effective Storage Capacity (2) | | ($10^3$ $m^3$) | 0 | 0 | 0 | 0 |
| Tail Water Level | | (EL. m) | 84.0 | 84.0 | 84.0 | 84.0 |
| Gross Head | | (m) | 388.8 | 389.4 | 390.0 | 390.6 |
| Effective Head | | (m) | 353.8 | 354.4 | 354.9 | 355.4 |
| Maximum Discharge | | ($m^3/s$) | 20 | 25 | 30 | 35 |
| Installed Capacity | | (MW) | 60 | 75 | 90 | 105 |
| Firm Power Output | | (MW) | 60 | 75 | 78.7 | 78.8 |
| Annual Available Energy | | (GWh) | 338 | 365 | 379 | 386 |
| Firm Energy | | (GWh) | 102 | 102 | 102 | 103 |
| Secondary Energy | | (GWh) | 236 | 263 | 277 | 283 |
| Main Facilities | | | | | | |
| Dam | Type | | Concrete Gravity | Concrete Gravity | Concrete Gravity | Concrete Gravity |
| | Height x Length | | 60.5 x 107 | 61.8 x 108 | 63.0 x 109 | 64.2 x 110 |
| Headrace | (D x L) | | 2.8 x 5,600 | 3.0 x 5,600 | 3.2 x 5,600 | 3.4 x 5,600 |
| Surge Tank | (D x H) | | 8.0 x 55 | 8.0 x 55 | 8.0 x 55 | 8.0 x 55 |
| Penstock | Type | | Tunnel | Tunnel | Tunnel | Tunnel |
| | D x L | | 2.3 x 1,650 | 2.5 x 1,650 | 2.7 x 1,650 | 2.9 x 1,650 |
| Powerhouse | Type | | Open | Open | Open | Open |
| | Type of Turbine | | Pelton | Pelton | Pelton | Pelton |

## Table 9-13 (2) Outline of Los Llanos Project (II)

| Item | | | CASE II-1 | CASE II-2 | CASE II-3 | CASE II-4 |
|---|---|---|---|---|---|---|
| High Water Level | | (EL. m) | 523.0 | 523.4 | 523.8 | 524.2 |
| Low Water Level | | (EL. m) | 506.0 | 506.0 | 506.0 | 506.0 |
| Effective Storage Capacity (1) | | ($10^3$ $m^3$) | 484 | 605 | 726 | 847 |
| Effective Storage Capacity (2) | | ($10^3$ $m^3$) | 5,000 | 5,000 | 5,000 | 5,000 |
| Tail Water Level | | (EL. m) | 84.0 | 84.0 | 84.0 | 84.0 |
| Gross Head | | (m) | 430.5 | 430.7 | 430.9 | 431.1 |
| Effective Head | | (m) | 391.8 | 391.9 | 392.1 | 392.3 |
| Maximum Discharge | | ($m^3/s$) | 20 | 25 | 30 | 35 |
| Installed Capacity | | (MW) | 66 | 83 | 100 | 116 |
| Firm Power Output | | (MW) | 66 | 83 | 93.7 | 93.7 |
| Annual Available Energy | | (GWh) | 399 | 426 | 435 | 436 |
| Firm Energy | | (GWh) | 120 | 120 | 120 | 120 |
| Secondary Energy | | (GWh) | 279 | 306 | 315 | 316 |
| Main Facilities | | | | | | |
| Dam | Type | | Concrete Gravity | Concrete Gravity | Concrete Gravity | Concrete Gravity |
| | Height x Length | | 108.0 x 194 | 108.4 x 195 | 108.8 x 195 | 109.2 x 196 |
| Headrace | (D x L) | | 2.8 x 5,520 | 3.0 x 5,520 | 3.2 x 5,520 | 3.4 x 5,520 |
| Surge Tank | (D x H) | | 8.0 x 77 | 8.0 x 77 | 8.0 x 77 | 8.0 x 77 |
| Penstock | Type | | Tunnel | Tunnel | Tunnel | Tunnel |
| | D x L | | 2.3 x 1,720 | 2.5 x 1,720 | 2.7 x 1,720 | 2.9 x 1,720 |
| Powerhouse | Type | | Open | Open | Open | Open |
| | Type of Turbine | | Pelton | Pelton | Pelton | Pelton |

## Table 9-14 Development Plan of Los Llanos Project

| Item | | CASE I (Regulation Type) | | | | CASE II (Reservoir Type) | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | CASE I-1 | CASE I-2 | CASE I-3 | CASE I-4 | CASE II--1 | CASE II-2 | CASE II-3 | CASE II-4 |
| Effective Storage Capacity | ($10^3$ $m^3$) | 484 | 605 | 726 | 847 | 484 + 5000 | 605 + 5,000 | 726 + 5,000 | 847 + 5,000 |
| Installed Capacity | (MW) | 60 | 75 | 90 | 105 | 66 | 83 | 100 | 116 |
| Firm Power | (MW) | 60 | 75 | 78.7 | 78.8 | 66 | 83 | 93.7 | 93.7 |
| Annual Available Energy | (GWh) | 338.1 | 365.5 | 379.4 | 385.9 | 399 | 426 | 435 | 436 |
| Firm Energy | (GWh) | 102.1 | 102.3 | 102.4 | 102.6 | 120 | 120 | 120 | 120 |
| Secondary Energy | (GWh) | 236.0 | 263.2 | 277.0 | 283.3 | 279 | 306 | 315 | 316 |
| Investment Cost | ($10^6$ ¢) | 11,623<br>(16,124) | 12,687<br>(17,188) | 13,734<br>(18,235) | 14,590<br>(19,091) | 18,838 | 19,439 | 20,641 | 21,443 |
| Annual Cost (C) | ($10^6$ ¢) | 1,604<br>(2,096) | 1,742<br>(2,234) | 1,878<br>(2,371) | 1,990<br>(2,482) | 2,449 | 2,527 | 2,683 | 2,788 |
| Annual Benefit (B) | ($10^6$ ¢) | 1,735 | 1,992 | 2,073 | 2,090 | 1,987 | 2,267 | 2,424 | 2,426 |
| Benefit Cost Ratio (B / C) | | 1.082<br>(0.828) | 1.144<br>(0.892) | 1.104<br>(0.874) | 1.050<br>(0.842) | 0.811 | 0.897 | 0.903 | 0.870 |
| (B−C) | ($10^6$ ¢) | 131<br>(△361) | 250<br>(△242) | 195<br>(△298) | 100<br>(△392) | △462 | △260 | △259 | △362 |
| Unit Cost of Energy | (¢/kWh) | 4.74 | 4.77 | 4.95 | 5.16 | 6.14 | 5.93 | 6.17 | 6.39 |

Remark : ( ) means CASE I'

## Table 9-15 Study on Turbine Type

| Item | | Pelton Turbine | Francis Turbine |
|---|---|---|---|
| Maximum Discharge | Q ($m^3$/s) | 27 | 27 |
| Effective Head | H (m) | 356.9 | 359.4 |
| Installed Capacity P=9.8 QHηtηg | (kW) | 9.8 x 27 x 356.9 x 0.884 x 0.971 = 81,000 | 9.8 x 27 x 359.4 x 0.922 x 0.971 = 85,000 |
| Firm Power | (kW) | 78.8 | 82.7 |
| Annual Available Energy | (GWh) | 371.1 | 389.4 |
| Firm Energy | (GWh) | 102.3 | 107.3 |
| Secondary Energy | (GWh) | 268.8 | 282.1 |
| Investment Cost | ($10^6$ ¢) | 12,122 | 11,652 |
| Main Civil Works | ($10^6$ ¢) | 4,360 | 4,498 (Surge Tank) |
| | | | 138 |
| Electromechanical Eq | ($10^6$ ¢) | 2,186 | 1,697 |
| Others | ($10^6$ ¢) | 5,576 | 5,457 |
| Annual Cost | ($10^6$ ¢) | 1,669 | 1,608 |
| Annual Benefit | ($10^6$ ¢) | 2,053 | 2,155 |
| Benefit Cost Ration | (B/C) | 1.23 | 1.34 |
| (B-C) | ($10^6$ ¢) | 384 | 547 |
| Unit Cost Energy | (¢/kWh) | 4.50 | 4.13 |

## Table 9-16 Standard Alternative Thermal Power Plant

| Item | Unit | Description | |
|---|---|---|---|
| Type | - | Gas Turbine | Diesel (Slow Speed Internal Combustion Engine) |
| Installed Capacity | MW | 42 MW | 40 MW |
| Annual Plant Factor | % | 30 | 80 |
| Thermal Efficiency | % | 27.23 | 34.32 |
| Annual Energy Production | GWh | 110 | 280 |
| Construction Cost (Interest during Construction included) | $ | 25,729,200 | 74,136,000 |
| Service Life | year | 15 | 25 |
| Construction Period | year | 2 | 2 |
| Capital Recovery Factor | - | 0.14682 | 0.12750 |
| Diesel Calorific Value | kcal/kg | 10,248 | - |
| Bunker Calorific Value | kcal/kg | - | 10,207 |
| Fuel Consumption Rate $\left[\frac{860\,\text{kcal / kWh}}{\text{Thermal Efficiency} \times \text{Colorific Value}}\right]$ | kg/kWh | 0.308 | 0.246 |
| O & M Cost | % | 3.58 | 2.02 |
| Unit Fuel Cost | $/l (1994 CIF) | 0.1478 (Diesel) | 0.0743 (Bunkeroil) |

| Type | | Gas Turbine | | Diesel (Slow Speed Internal Combustion Engine) | |
|---|---|---|---|---|---|
| Annual Cost | Unit | Fixed Cost | Variable Cost | Fixed Cost | Variable Cost |
| Capital Recovery | $10^6$ $ | 3,778 | - | 9,452 | - |
| O & M Cost | $10^6$ $ | 0.829 (90%) | 0.092 (10%) | 1.348 (90%) | 0.150 (10%) |
| Fuel Cost | $10^6$ $ | - | 6.019 [1] | - | 5.212 [2] |
| Total | $10^6$ $ | 4.607 | 6.111 | 10.773 | 5.362 |
| Annual Cost at Receiving end | | | | | |
| kW Cost | $/kW | [3] kW value | | 236.14 $/kW | |
| kWh Cost | $/kWh | [4, 5] Firm energy value<br>Secondary energy value | | 0.0313 $/kWh<br>0.0204 $/kWh | |

1) $110 \times 10^6 \times 0.308/0.832 \times 0.1478 = 6.019 \times 10^6$ \$

2) $280 \times 10^6 \times 0.246/0.982 \times 0.0743 = 5.212 \times 10^6$ \$

Adjustment Factor for kW & kWh

| Item | kW (%) | kWh (%) |
|---|---|---|
| Loss of Station Service | 6 | 6 |
| Loss of Stoppage | 4 | - |
| Loss of Repair | 12 | - |
| Loss of Transmission | 0 | 0 |

$$\text{kW Adjustment Factor} = \frac{1}{(1-0.06)\times(1-0.04)\times(1-0.12)\times(1-0.0)} = 1.259$$

$$\text{kWh Adjustment Factor} = \frac{1}{(1-0.06)\times(1-0.0)} = 1.064$$

3) $$\frac{(4.607+10.773)\times 10^6}{(42+40)\times 1{,}000} \times 1.259 = 236.14 \text{ \$/kW}$$

4) $$\frac{(6.111+5.362)\times 10^6}{(110+280)\times 10^6} \times 1.064 = 0.0313 \text{ \$/kW}$$

5) $$\frac{5.362\times 10^6}{280\times 10^6} \times 1.064 = 0.0204 \text{ \$/kW}$$

Firm energy value synthesized costs of both the gas turbine generator and the diesel engine generator. The secondary energy value was estimated from the diesel engine generator cost considering reducing the operation during high stream flow season, because in this season, the energy will be produced by the hydroelectric power stations instead of the diesel engine generator plants.

## Table 9-17 Result of Optimum Development Plan

| | | |
|---|---|---|
| High Water Level | | EL. 477.4 m |
| Low Water Level | | EL. 470.0 m |
| Effective Storage Capacity | | $653 \times 10^3$ $m^3$ |
| Effective Head | | 359.4 m |
| Installed Capacity | | 85 MW |
| Firm Power Output | | 82.7 MW |
| Annual Available Energy | | 389 Gwh |
| Firm Energy | | 107 Gwh |
| Secondary Energy | | 282 Gwh |
| Investment Cost | | $151,763 \times 10^3$ US$ |
| Annual Cost | (C) | $19,729 \times 10^3$ US$ |
| Annual Benefit | (B) | $28,631 \times 10^3$ US$ |
| Benefit Cost Relation | (B - C) | 8,902 |
| Unit Cost of Energy | | 0.05 US$/kwh |

# Chapter 10 Power Transmission Plan

# Chapter 10 Power Transmission Plan

## CHAPTER 10 POWER TRANSMISSION PLAN

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# CHAPTER 10 POWER TRANSMISSION PLAN AND POWER SYSTEM ANALYSIS

## 10.1 Outline of Power Transmission System

The power transmission system of Costa Rica is a 230 kV system interconnected to that of Nicaragua and Panama. The system exchanges power on a mutual basis with certain neighboring countries.

The domestic power transmission system consists of 230 kV and 138 kV transmission lines. As of January 1995, the total lengths were 880 km and 704 km respectively.

The transmission system in the central mountain area surrounding the city of San Jose, which is the largest load area in Costa Rica, is a 138 kV ring system providing high system reliability.

However, there is a plan to form a large 500 kV power transmission system (SIEPAC) interconnecting five central American countries and Panama. This system is projected to come on line somewhere between the years 2000 and 2003.

The projected SIEPAC route would pass along the Costa Rican Pacific coast and connect to a substation to be installed in the San Rafael area at Parrita town near the Los Llanos Hydropower Station. It will then be linked to the metropolitan ring system via the Pirris Power Station (to start operation in 2003).

Fig. 10-1 shows the 230 kV and 138 kV power transmission system (scheduled for 2015) in Costa Rica.

## 10.2 Power Transmission Line Route

### 10.2.1 Project Conditions

(1) The ICE plans to transmit the power generated at the Los Llanos Power Station to the metropolitan area of San Jose, the largest load center in Costa Rica, via the Pirris Hydropower Station (128 MW, scheduled for commissioning around 2003).

(2) The 500 kV Central American Interconnected Power Transmission Line (SIEPAC) is scheduled for completion and interconnection with the Pirris Power Station via a 500 kV substation at San Rafael Sur near Parrita town, around 2003 when the Pirris Power Station is to start operation. As the Los Llanos Power Station is scheduled for commissioning in 2004, completion of the SIEPAC project is expected when the Los Llanos Power Station is in actual operation.

(3) In this way, the power transmission line from Los Llanos Power Station will be connected to the 500 kV Substation at San Rafael (Parrita) because it is nearest to the Los Llanos Power Station Site.

The power transmission from the projected Savegre Power Station (165 MW) is also to be taken into consideration.

Fig. 10-2 shows the power transmission system in the vicinity of the Los Llanos Power Station.

### 10.2.2 Site Survey

#### (1) Power Transmission Line Route

For the transmission line route from Los Llanos Power Station to San Rafael (Parrita) Substation, there are three alternatives: One is an almost straight route crossing the Rio Paquita at the power station and traversing the mountain areas (Alternative Route A). Although the shortest, it traverses a mountain area. The other is a route running to the right of the Rio Paquita to the plains and to San Rafael (Parrita) and running parallel to SIEPAC is also conceivable (Alternative Route B).

Another possible route is one that, after arrival at the plains, would traverse the palm plantations, and run along National Highway 239 to San Rafael (Parrita) (Alternative Route C).

#### (2) Switchyard Site

As the grazing land to the left of the river downstream from the projected power station is sufficiently flat for its construction, a switchyard will be located there.

The transmission line would cross the Río Paquita to the right bank. However, as the river is only about 100 m wide, connection of the transmission line to this station is easy and there are no topographical problems in locating the switchyard there.

### (3) Interconnection Substation Site (San Rafael Site)

Located midway between Paquita town and Damas town, this site is presently grazing. It is flat, situated approximately 10 km from the Pacific Ocean and located on the SIEPAC route. It is approximately 2 km from the trunk highway to the mountains site. For this reason, an access road will have to be repaired from that highway, but no special problem is conceivable for transporting heavy objects to the site.

Although the details remain to be determined, the substation will step down the voltage from 500 kV to 230 kV and be connected by two circuits to the Pirris Power Station (128 MW, scheduled for operation start in 2003).

## 10.2.3 Selection of Transmission Line Route

The following factors were taken into consideration In the selection of the transmission line route in view of the requirement to maintain harmony with the natural and social environments and because of the technical feasibility involved:

### a) Harmony with the natural environment

- No damage to the natural view such as natural parks and scenic pots
- No trespassing into the growing areas of valuable animals and plants
- Minimization of tree felling in natural and artificial forests

### b) Harmony with the social environment

- No trespassing into residential and public facilities
- No trespassing into cultural properties and historic remains
- No trespassing into high-productivity land and hard to recover land (No trespassing into palm plantations)
- Coordination with regional development schemes

c) **Harmony with the technology**

- High facility safety
- Low construction cost
- Easy construction work
- Work completion according to schedule
- Easy maintenance
- Short line length

In view of the above factors, considering the natural and social environments along the routes, the following three alternative routes (A, B and C) were studied:

Fig. 10-3 shows the Alternative of Transmission Line Route.

**(1) Alternative Route A**

This route connects the Los Llanos Power Station to the San Rafael (Parrita) Substation by a straight line.

This route almost entirely traverses steep mountain areas, and the construction involves many problems including the transport of the construction materials and maintenance after operation start.

This route provides the shortest length (approx. 20 km).

**(2) Alternative Route B**

This route crosses the Rio Paquita at the Los Llanos switchyard and runs to the plains along the right bank of the Rio Paquita. After crossing the Rio Paquita, the route immediately climbs the mountain and runs through mountainous areas for approximately 6 km.

After entering the plains, it runs along the foot of the mountains to San Antonio Village via Parrita, in order to avoid traversing the palm plantation which extends into the plain, to subsequently terminate at the San Rafael (Parrita) Substation.

The route traverses the plains between Parrita and San Rafael in a straight line. These plains are farmland with no palm or banana plantations, or other objects requiring a detour. Although there is no material transport road along the transmission line route, there are many roads allowing motor vehicle travel, so that both material transportation and maintenance after operation start of the line are considered very easy.

This alternative route provides a length for the transmission line of approximately 22 km.

### (3) Alternative Route C

With this alternative, the transmission line comes onto the plains along the same route as Route B. However, upan reaching the plains, it leads straight to trunk highway R239 which it then runs along close to the San Rafael (Parrita) Substation for eventual connection to the San Rafael (Parrita) Substation. Since this route runs along the existing roads, it is the most advantageous for material transportation and maintenance after operation start.

However, it does traverse the palm plantation area and intersects the 500 kV transmission line. With this, its length is approximately 25 km, the longest of the three alternatives.

### (4) Comparison of the Alternatives

Comparison of the three alternative routes (A, B and C) is shown below.

| | Route A | Route B | Route C |
|---|---|---|---|
| Transmission line length | ◎(20 km) | O(22 km) | △(25 km) |
| Traversing mountain area | △ | O | ◎ |
| Transmission line intersection | O | ◎ | △ |
| Traversing palm plantation | ◎ | O | △ |
| Material transportation | △ | O | ◎ |
| Maintenance convenience | △ | O | ◎ |
| Construction cost (relative to Route B ) | △ 1.5 | ◎ 1.0 | O 1.0 |
| Minimized felling of natural and afforestation trees | △ | ◎ | △ |
| Short distance | ◎ | O | △ |
| Overall evaluation | O | ◎ | △ |

### (5) Result of Study

On the basis of the overall study of the three routes, A, B and C, including the technical and economical evaluations, Route B was selected as the route for the projected transmission line.