APPENDIX I

MULTIPURPOSE DEVELOPMENT OF THE PROJECT

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CHAPTER I AGGREGATE PRODUCTION IN LAOAG RIVER

1.1 General

Dike construction, river dredging and their combination are the major alternative works for flood control of the Laoag River in addition to sabo works. River dredging is more preferable to minimize flood risk.

The dredging of approximately 20 million m^3 and 30 million m^3 is necessary for the tributaries in the alluvial fans and for the Laoag Main River, respectively, to solve the existing flood problems. In addition, periodic dredging of some volume may be necessary to maintain the design riverbed elevation.

However, spoil banks which can accommodate such large volumes of sands/gravel are not available in the Laoag River Basin except the sea or the sand dunes in the seacoast. On the other hand, the dredged sands/gravel can be used for construction materials, resulting in savings on dredging cost as well as exploitation of the natural river resources.

The feasibility of aggregate production in the river is discussed in the following sections.

1.2 Aggregate Demand of Project Area

The current and future demand of aggregate (sand and gravel) in Ilocos Norte Province was estimated by the Bureau of Mines and Geo-Sciences Development Service, DENR Region I in August, 1995, as summarized below.

Aggregate Demand in Ilocos Norte

(Unit: thousand m^3)

Year	Demand	Year	Demand
1995	724	2001	917
1996	757	2002	949
1997	789	2003	981
1998	821	2004	1,013
1999	853	2005	1,045
2000	885		

Aggregate demand in Ilocos Norte is projected to increase up to $1,208\times10m^3$ in 2010 and $1,383\times10m^3$ in 2015 by extrapolating the above increasing trend. The above aggregate requirements will come from many demand centers widely distributed over the Province, and each demand center will be supplied from the nearest river to minimize the aggregate supply cost.

The lower reaches of the Laoag River is expected to supply the aggregates to such demand centers as Laoag City, San Nicolas, Sarrat and Batac. The Bongo River is expected to provide to Dingras, Marcos, Espiritu and Nueva Era. However, the rivers of Cura/Labugaon, Solsona, Madongan and Papa in the alluvial fan are expected to supply only the Municipality of Solsona and its surrounding areas.

The major aggregate demand in the Laoag River Basin will be generated in the road and other infrastructure construction. The total length of existing roads including national, provincial, municipal and barangay roads in Solsona and the surrounding areas (the flood prone areas of the four rivers) is estimated at 500 km. Most of these roads need to be improved (banking, widening and paving). Further, new road networks will be constructed in these areas in the future.

Aggregate requirement for road improvement and construction is roughly estimated as follows.

Improvement of Existing Road (5 m × 0.5 m × 500 km)	:	1.25 million m^3
Construction of New Road (5 m × 1.0 m × 250 km)	:	1.25 million m^3

The total aggregate demand for these areas in the future is roughly estimated at 3.0 to 4.0 million m^3, taking into account some additional demand for the other infrastructures and for private uses.

Average annual aggregate demand to be supplied from the alluvial fan rivers is calculated at 0.10 million m^3/year by assuming that the above infrastructure improvements will be completed within 30-40 years. Similarly, the annual aggregate demand from the Laoag Main River is not so large, either.

1.3 Export of Aggregate

The local aggregate demand for the Laoag River is very small compared to the production volume. Therefore, exportation of the aggregate is discussed in this Section. The potential markets of the aggregate export are Manila, Taiwan and Japan.

1.3.1 Aggregate Demand of the Export Area

The aggregate demands of Metro Manila and the neighboring CALABARZON area were estimated by the Mines and Geo-Sciences Development Service, DENR, Region IV-A in August, 1995. Those demands are summarized as follows.

Aggregate Demand in Metro Manila and CALABARZON

(Unit: thousand m^3)

Year	Metro Manila	CALABARZON	Total
1995	108,593	24,211	132,804
1996	117,628	26,056	143,684
1997	127,415	28,042	155,456
1998	138,016	30,178	168,194

Note: CALABARZON covers the Cavite, Laguna, Batangas, Rizal and Quezon provinces adjacent to Metro Manila.

The annual increase rate of the total demand during 1995-1998 is 8.19%. The total aggregate demand in the future will grow up to 197 million m^3 in 2000, 292 million m^3 in 2005, 433 million m^3 in 2010 and 641 million m^3 in 2015, provided that the demand continues to increase at the rate of 8.19%.

On the other hand, the demand of cement is also expected to increase at a high rate in the future. According to the Philippine Construction Industry Report by the Construction Industry Authority of the Philippines in 1995, the total demand for cement in the whole country is estimated as follows.

Cement Demand in Philippines

(Unit: million ton)

Year	Demand	Year	Demand
1990	7.35	1996	13.83
1991	6.94	1997	16.59
1992	7.35	1998	19.08
1993	8.04	1999	21.94
1994	9.61	2000	25.23
1995	11.52		

These demands are considered to occur mostly in Metro Manila and its surrounding areas. This cement demand projection also indicates that the aggregate demand in Metro Manila and its surrounding areas will increase more in the future.

On the other hand, the existing supply capacity of aggregate is limited. The above-mentioned DENR report recommends to encourage the opening of new quarry areas.

The existing supply and demand balance of aggregate in Taiwan is severe and it imports a considerable quantity from China. The existing supply and demand balance in Japan, especially in Tokyo Metropolitan area is also severe. Approximately 1.4 million m^3 of aggregate was imported to Japan from China, Taiwan, North Korea and other countries in 1995. Among them, China is the largest supplier. The aggregate import of Japan is expected to further increase due to exhaustion of domestic quarry sites.

1.3.2 Port of Shipment

Two (2) ways of shipment can be considered. One is to use the existing Currimao Port. Another is to construct a new Laoag Port. These ports should have the capacity to dock vessels of 30,000 to 50,000 tons.

The Currimao Port with a water depth of approximately 24 feet is located 25-30 km southward from Laoag City. It can dock a ship of 8,000-10,000 tons at present. The Philippine Government has a plan to enlarge the capacity of the port in the near future.

The new Laoag Port of pier type will be constructed at the right side of the river mouth of Laoag. The pier should be extended approximately 1.5 km offshore to have a sufficient water depth (15 m).

1.3.3 Export Prices of Aggregate

The export prices of aggregate are estimated below at the currency exchange rate of $1.00 = Peso 26.00 = Yen 105, and unit weight of aggregate is 1.0 m^3 = 1.6 tons.

(1) Export to Manila

The existing market price of aggregate at construction sites in Metro Manila is estimated at $7 to $9/ton as of March, 1996. However, a considerable amount of inland transportation and shipping cost are involved. Therefore, assuming that inland transportation and shipping cost is $6 to $7/ton, the FOB price at the loading port (Currimao or Laoag Port) should be $1 to $2/ton or lower to make the export feasible.

(2) Export to Taiwan (Taipei)

The market price of aggregates in Taipei is not so high because large amounts of aggregates are supplied from China. The existing upper limit price of CIF at Taipei for aggregate import is estimated at $6 to $8/ton. Therefore, assuming that shipping cost is $5 to $6/ton, the FOB price at the loading port should be $1 to $2/ton or lower to make the export feasible.

(3) Export to Japan (Tokyo)

The existing market price of aggregates at construction sites in Tokyo is estimated to be $27 to $30/ton as of May, 1996. The existing upper limit of CIF price at Tokyo Port for aggregate import is considered to be $15 to $16/ton. Therefore, assuming that shipping cost is approximately $12/ton, the FOB price at the loading port should be $3 to 4/ton or lower to make the export feasible.

1.4 Aggregate Production and Transportation Plan

Aggregate production in the tributaries of the alluvial fan and lower reaches of Laoag River is discussed in this Section, because river dredging, a measure necessary for flood control and aggregate production, may enable it to be economically feasible.

The size of sand and gravel for concrete material in Japan is 0.5 and 40 mm, respectively. According to the JICA field test, the ratio of riverbed materials with a size of 0.5 to 40 mm is 75% in the alluvial fan and 90% in the Laoag lower reaches. Therefore, 75% of the riverbed materials in the alluvial fan and 90% of the riverbed materials in the Laoag lower reaches can be used for concrete material after sieving or screening.

The following five (5) cases are compared. In this study, yearly working day is assumed as 300 days.

(1) Case I

Production Site	:	Tributaries in alluvial fan
Dredging Volume of Riverbed	:	1,000,000 m^3/year (3,300 m^3/day)
Production Volume of Aggregate	:	750,000 m^3/year (2,500 m^3/day)
Loading Port	:	Currimao Port
Inland Transportation	:	Production site to loading port by dump truck

(2) Case II-A

Production Site	:	Tributaries in alluvial fan
Dredging Volume of Riverbed	:	1,000,000 m^3/year (3,300 m^3/day)
Production Volume of Aggregate	:	750,000 m^3/year (2,500 m^3/day)
Loading Port	:	Laoag Port
Inland Transportation	:	Production site to loading port by dump truck

(3) Case II-B

Production Site	:	Tributaries in alluvial fan
Dredging Volume of Riverbed	:	2,000,000 m^3/year (6,700 m^3/day)
Production Volume of Aggregate	:	1,500,000 m3/day (5,000 m3/day)
Loading Port	:	Laoag Port
Inland Transportation	:	Production site to loading port by belt conveyor

(4) Case III-A

Production Site	:	Lower reaches of Laoag River (downstream of Laoag city)
Dredging Volume of Riverbed	:	1,000,000 m^3/year (3,300 m^3/day)
Production Volume of Aggregate	:	900,000 m^3/year (3,000 m^3/day)
Loading Port	:	Laoag Port
Inland Transportation	:	Production site to loading port by dump truck

(5) Case III-B

Production Site	:	Lower reaches of Laoag River (downstream of Laoag city)
Dredging Volume of Riverbed	:	2,000,000 m^3/year (6,700 m^3/day)
Production Volume of Aggregate	:	1,800,000 m^3/year (6,000 m^3/day)
Loading Port	:	Laoag Port
Inland Transportation	:	Production site to loading port by belt conveyor

The above inland transportation routes are shown in Fig. I.1.1.

1.5 Estimate of Aggregate Production Cost

The aggregate production costs of the above five (5) cases are estimated as follows.

1.5.1 Case I

(1) Production System

(a) Excavation
(b) Sieving
(c) Truck Transportation (Production site to Currimao Port)
(d) Ship Loading

(2) Excavation

(a)	Equipment		
	-Backhoe (0.6 m^3)	:	6 sets
	-Dump Truck (11 ton, 6 m^3)	:	12 sets
(b)	Cost		
	-Equipment Purchase	:	$1,980,000
	-Annual Equipment Maintenance	:	$116,000
	-Annual Fuel	:	$238,000
	-Annual Labor	:	$54,000
	-Other Annual Expenses	:	$12,000

(3) Sieving

(a) Equipment

-Sieving Machine and Generator	:	6 sets

(b) Cost

-Equipment Purchase	:	$900,000
-Annual Equipment Maintenance	:	$69,000
-Annual Fuel	:	$105,000
-Annual Labor	:	$90,000
-Other Annual Expenses	:	$16,000

(4) Transportation (One-way distance, 45 km)

(a) Equipment

-Wheel Loader (2 m^3)	:	10 sets
-Dump Truck (11 ton, 6 m^3)	:	140 sets

(b) Cost

-Bypass Road Construction (San Nicolas, Batac)		$4,000,000
-Equipment Purchase	:	$15,700,000
-Annual Road Maintenance	:	$100,000
-Annual Equipment Maintenance	:	$1,033,000
-Annual Fuel	:	$1,989,000
-Annual Labor	:	$450,000
-Other Annual Expenses	:	$18,000

(5) Ship Loading

(a) Equipment

- Belt Conveyor System, 1000 ton/hr.	:	1,500 m

(b) Cost

-Steel Framework	:	$600,000
-Civil Works (Stockyard)	:	$500,000
-Equipment Purchase	:	$3,400,000
-Annual Equipment Maintenance	:	$68,000
-Annual Electricity	:	$118,000
-Annual Labor	:	$60,000
-Other Annual Expenses	:	$14,000

(6) Management

(a)	Management Works	:	Field and headquarters management
(b)	Annual Cost	:	$1,000,000

1.5.2 Case II-A

(1) Production System

(a) Excavation
(b) Sieving
(c) Truck Transportation (Production site to Laoag Port)

(d) Ship Loading

(2) Excavation [Same as Case I]

(a) Equipment

-Backhoe (0.6 m^3)	:	6 sets
-Dump Truck (11 ton, 6 m^3)	:	12 sets

(b) Cost

-Equipment Purchase	:	$1,980,000
-Annual Equipment Maintenance	:	$116,000
-Annual Fuel	:	$238,000
-Annual Labor	:	$54,000
-Other Annual Expenses	:	$12,000

(3) Sieving [Same as Case I]

(a) Equipment

-Sieving Machine and Generator	:	6 sets

(b) Cost

-Equipment Purchase	:	$900,000
-Annual Equipment Maintenance	:	$69,000
-Annual Fuel	:	$105,000
-Annual Labor	:	$90,000
-Other Annual Expenses	:	$16,000

(4) Transportation (One-way distance, 30 km)

(a) Equipment

-Wheel Loader (2 m^3)	:	10 sets
-Dump Truck (11 ton, 6 m^3)	:	90 sets

(b) Cost

-Road Construction (Bridge, Sarrat & Laoag Bypass)	:	$ 3,000,000
-Equipment Purchase	:	$11,200,000
-Annual Road Maintenance	:	$100,000
-Annual Equipment Maintenance	:	$712,000
-Annual Fuel	:	$1,388,000
-Annual Labor	:	$300,000
-Other Annual Expenses	:	$10,000

(5) Ship Loading

(a)	Equipment	:	Belt Conveyor System (1000 ton/hr, 1,500 m)
(b)	Cost		
	-Civil Works (1.5 m pier, Stockyard)	:	$5,500,000
	-Steel Framework	:	$600,000
	-Equipment Purchase	:	$3,400,000
	-Annual Equipment Maintenance	:	$68,000
	-Annual Electricity	:	$118,000
	-Annual Labor	:	$60,000
	-Other Annual Expenses	:	$14,000

(6) Management [Same as Case I]

(a)	Management Works	:	Field and headquarters management
(b)	Annual Cost	:	$1,000,000

1.5.3 Case II-B

(1) Production System

(a) Excavation
(b) Sieving
(c) Truck Transportation (Production site to Dingras)
(d) Belt Conveyor Transportation (Dingras to Laoag Port)
(e) Ship Loading

(2) Excavation

(a)	Equipment		
	-Backhoe (0.6 m^3)	:	12 sets
	-Dump Truck (11 ton, 6 m^3)	:	24 sets
(b)	Cost		
	-Equipment Purchase	:	$3,960,000
	-Annual Equipment Maintenance	:	$232,000
	-Annual Fuel	:	$476,000
	-Annual Labor	:	$108,000
	-Other Annual Expenses	:	$24,000

(3) Sieving

(a)	Equipment		
	-Sieving Machine and Generator	:	12 sets
(b)	Cost		
	-Equipment Purchase	:	$1,800,000
	-Annual Equipment Maintenance	:	$138,000
	-Annual Fuel	:	$210,000
	-Annual Labor	:	$180,000
	-Other Annual Expenses	:	$32,000

(4) Truck Transportation (One-way distance, 5 km)

(a)	Equipment		
	-Wheel Loader (2 m^3)	:	20 sets
	-Dump Truck (11 ton, 6 m^3)	:	50 sets
(b)	Cost		
	-Equipment Purchase	:	$10,700,000
	-Annual Road Maintenance	:	$588,000
	-Annual Equipment Maintenance	:	$1,033,000
	-Annual Fuel	:	$1,214,000
	-Annual Labor	:	$210,000
	-Other Annual Expenses	:	$28,000

(5) Belt Conveyor Transportation (One-way distance, 25 km)

(a)	Equipment	:	Belt Conveyor System (1000 ton/hr. 25,000 m)
(b)	Cost		
	-Civil Works (Bridge, Others)	:	$1,000,000
	-Steel Framework	:	$9,500,000
	-Equipment Purchase	:	$29,500,000
	-Annual Equipment Maintenance	:	$590,000
	-Annual Electricity	:	$1,806,000
	-Annual Labor	:	$60,000
	-Other Annual Expenses	:	$14,000

(6) Ship Loading

(a)	Equipment	:	Belt Conveyor System (2000 ton/hr. 1,500 m)
(b)	Cost		
	-Civil Works (1.5 km pier, Stockyard)	:	$5,500,000
	-Steel Framework	:	$1,100,000
	-Equipment Purchase	:	$4,100,000
	-Annual Equipment Maintenance	:	$82,000
	-Annual Electricity	:	$151,000
	-Annual Labor	:	$90,000
	-Other Annual Expenses	:	$17,000

(7) Management

(a)	Management Works	:	Field and headquarters management
(b)	Annual Cost	:	$1,500,000

1.5.4 Case III-A

(1) Production System

(a) Excavation
(b) Sieving

(c) Truck Transportation (Production site to Laoag Port)
(d) Ship Loading

(2) Excavation [Same as Case I]

(a) Equipment

-Backhoe (0.6 m^3)	:	6 sets
-Dump Truck (11 ton, 6 m^3)	:	12 sets

(b) Cost

-Equipment Purchase	:	$1,980,000
-Annual Equipment Maintenance	:	$116,000
-Annual Fuel	:	$238,000
-Annual Labor	:	$54,000
-Other Annual Expenses	:	$12,000

(3) Sieving [Same as Case I]

(a) Equipment

-Sieving Machine and Generator	:	6 sets

(b) Cost

-Equipment Purchase	:	$900,000
-Annual Equipment Maintenance	:	$69,000
-Annual Fuel	:	$105,000
-Annual Labor	:	$90,000
-Other Annual Expenses	:	$16,000

(4) Truck Transportation (One-way distance, 5 km)

(a) Equipment

-Wheel Loader (2 m^3)	:	12 sets
-Dump Truck (11 ton, 6 m^3)	:	30 sets

(b) Cost

-Road Construction	:	$1,000,000
-Equipment Purchase	:	$6,420,000
-Annual Road Maintenance	:	$100,000
-Annual Equipment Maintenance	:	$352,000
-Annual Fuel	:	$729,000
-Annual Labor	:	$126,000
-Other Annual Expenses	:	$13,000

(5) Ship Loading

(a)	Equipment	:	Belt Conveyor System (1000 ton/hr. 1,500 m)
(b)	Cost		
	-Civil Works (1.5 km pier, Stockyard)	:	$5,500,000
	-Steel Framework	:	$600,000
	-Equipment Purchase	:	$3,400,000
	-Annual Equipment Maintenance	:	$68,000
	-Annual Electricity	:	$137,000
	-Annual Labor	:	$60,000
	-Other Annual Expenses	:	$15,000

(6) Management [Same as Case I]

(a)	Management Works	:	Field and headquarters management
(b)	Annual Cost	:	$1,000,000

1.5.5 Case III-B

(1) Production System

(a) Excavation
(b) Sieving
(c) Belt Conveyor Transportation (Production site to Laoag Port)
(d) Ship Loading

(2) Excavation (including 1 km transportation)

(a)	Equipment		
	-Backhoe (0.6 m^3)	:	12 sets
	-Dump Truck (11 ton, 6 m^3)	:	35 sets
(b)	Cost		
	-Equipment Purchase	:	$4,950,000
	-Annual Equipment Maintenance	:	$303,000
	-Annual Fuel	:	$609,000
	-Annual Labor	:	$141,000
	-Other Annual Expenses	:	$17,000

(3) Sieving [Same as Case II-B]

(a)	Equipment		
	-Sieving Machine and Generator	:	12 sets
(b)	Cost		
	-Equipment Purchase	:	$1,800,000
	-Annual Equipment Maintenance	:	$138,000
	-Annual Fuel	:	$210,000
	-Annual Labor	:	$180,000
	-Other Annual Expenses	:	$32,000

(4) Belt Conveyor Transportation (One-way distance, 5 km)

(a)	Equipment	:	Belt Conveyor System (1000 ton/hr) 5,000 m (Main) 1,000 m (Sub)
(b)	Cost		
	-Civil Works	:	$1,000,000
	-Steel Framework	:	$2,500,000
	-Equipment Purchase	:	$8,500,000
	-Annual Equipment Maintenance	:	$170,000
	-Annual Electricity	:	$462,000
	-Annual Labor	:	$60,000
	-Other Annual Expenses	:	$18,000

(5) Ship Loading

(a)	Equipment	:	Belt Conveyor System (2000 ton/hr. 1,500 m)
(b)	Cost		
	-Civil Works (1.5 km pier, Stockyard)	:	$5,500,000
	-Steel Framework	:	$1,100,000
	-Equipment Purchase	:	$4,100,000
	-Annual Equipment Maintenance	:	$82,000
	-Annual Electricity	:	$176,000
	-Annual Labor	:	$90,000
	-Other Annual Expenses	:	$12,000

(7) Management [Same as Case II-B]

(a)	Management Works	:	Field and headquarters management
(b)	Annual Cost	:	$1,500,000

The above estimated costs are summarized as follows.

(Unit: $1,000)

Works	Case I	Case II-A	Case II-B	Case III-A	Case III-B
Excavation					
-Construction	-	-	-	-	-
-Equipment Purchase	1,980	1,980	3,960	1,980	4,950
-Annual O/M	420	420	840	420	1,070
Sieving					
-Construction	-	-	-	-	-
-Equipment Purchase	900	900	1,800	900	1,800
-Annual O/M	280	280	560	280	560
Truck Transportation					
-Construction	4,000	3,000	-	1,000	-
-Equipment Purchase	15,700	11,200	10,700	6,420	-
-Annual O/M	3,590	2,510	2,040	1,320	-
Belt Conveyor Transport.					
-Construction	-	-	10,500	-	3,500
-Equipment Purchase	-	-	29,500	-	8,500
-Annual O/M	-	-	2,470	-	710
Ship Loading					
-Construction	1,100	6,100	6,600	6,100	6,600
-Equipment Purchase	3,400	3,400	4,100	3,400	4,100
-Annual O/M	260	260	340	280	360
Management					
-Annual Management	1,000	1,000	1,500	1,000	1,500

Exchange Rate: $1.00 = P26.00 = ¥105

1.6 Financial Evaluation

1.6.1 Present Value of Aggregate Production Cost

The present aggregate production costs for the above five (5) cases are calculated on condition that discount rate is 15%. The calculation results are summarized below.

(Unit: $1,000)

Works	Case I	Case II-A	Case II-B	Case III-A	Case III-B
Excavation	4,810	4,810	9,619	4,810	12,129
Sieving	2,482	2,482	4,964	2,482	4,964
Truck Transportation	43,026	30,541	24,735	16,239	-
Belt Conveyor Transport.	-	-	53,935	-	15,729
Ship Loading	5,988	10,335	11,948	10,444	12,055
Management	5,433	5,433	8,162	5,433	8,162
Total	61,739	53,601	113,363	39,408	53,039

Further, the present cost of each production work including management cost is obtained as follows.

(Unit: $1,000)

Works	Case I	Case II-A	Case II-B	Case III-A	Case III-B
Excavation	5,274	5,353	10,365	5,579	14,335
Sieving	2,721	2,762	5,349	2,879	5,867
Truck Transportation	47,178	33,986	26,654	18,836	-
Belt Conveyor Transport.	-	-	58,120	-	18,590
Ship Loading	6,566	11,500	12,875	12,114	14,247
Total	61,739	53,601	113,363	39,408	53,039

For details, see Tables I.1.1, I.1.2, I.1.3, I.1.4 and I.1.5.

1.6.2 Present Value of Aggregate Production

The present value of aggregate production for the above five (5) cases is calculated under the discount rate of 15%.

The calculation results are summarized below.

(Unit: thousand ton)

Item	Case I	Case II-A	Case II-B	Case III-A	Case III-B
Yearly Production	1,200	1,200	2,400	1,440	2,880
Present Value of Production	6,531	6,531	13,062	7,839	15,678

For details, see Table I.1.6.

1.6.3 Unit Aggregate Production Cost

The unit aggregate production costs of the five (5) cases are estimated as follows.

(1)	Case I	:	\$9.45/ton	(= 61,739 / 6,531)	or \$15.12/m^3
(2)	Case II-A	:	\$8.21/ton	(= 53,601 / 6,531)	or \$13.14/m^3
(3)	Case II-B	:	\$8.68/ton	(= 113,363 / 13,062)	or \$13.89/m^3
(4)	Case III-A	:	\$5.03/ton	(= 39,408 / 7,839)	or \$8.05/m^3
(5)	Case III-B	:	\$3.38/ton	(= 53,039/ 15,678)	or \$5.41/m^3

Note: Unit Weight of Aggregate : 1.0 m^3 = 1.6 ton

These are broken down into each work item as shown below.

(Unit: $/ton)

Works	Case I	Case II-A	Case II-B	Case III-A	Case III-B
Excavation	0.81 (1.30)	0.82 (1.31)	0.79 (1.26)	0.71 (1.14)	0.91 (1.46)
Sieving	0.42 (0.67)	0.42 (0.67)	0.41 (0.66)	0.37 (0.59)	0.37 (0.59)
Truck Transport.	7.22(11.55)	5.21 (8.34)	2.04 (3.27)	2.40 (3.84)	-
Belt Conveyor Transport.	-	-	4.45 (7.12)	-	1.19 (1.90)
Ship Loading	1.00 (1.60)	1.76 (2.82)	0.99 (1.58)	1.55 (2.48)	0.91 (1.46)
Total	9.45(15.12)	8.21(13.14)	8.68(13.89)	5.03 (8.05)	3.38 (5.41)

Note : Figures in parentheses are in \$/m^3

1.6.4 Cost Allocation for Flood Control and Aggregate Production

The unit aggregate production costs are allocated for the flood control project and aggregate production on the following assumptions.

Item	Flood Control	Aggregate Production
Excavation	50%	50%
Sieving	0%	100%
Truck Transport.	50%	50%
Belt Conveyor Transport.	50%	50%
Ship Loading	0%	100%

The allocated unit costs for flood control and aggregate production in the five (5) cases are calculated as follows.

(Unit: $/ton)

Project	Case I	Case II-A	Case II-B	Case III-A	Case III-B
Flood Control	4.02 (6.43)	3.02 (4.83)	3.65 (5.84)	1.56 (2.50)	1.06(1.70)
Aggregate Product.	5.43 (8.69)	5.19 (8.31)	5.03 (8.05)	3.47 (5.55)	2.32(3.71)
Total	9.45 (15.12)	8.21 (13.14)	8.68 (13.89)	5.03 (8.05)	3.38(5.41)

Note: Figures in parentheses are in $/m³

1.7 Conclusion

(1) Aggregate demand in the Laoag River Basin is small. Annual demand in the alluvial fan area in future is estimated to be 100, 000 m^3/year at most.

(2) Aggregate demand in the Manila Metropolitan Area will much increase in the future, requiring the development of new aggregate resources. However, aggregate supply from the Laoag River is not economical.

(3) Taiwan is not always attractive as a market for the aggregate exportation from the Laoag River. It imports aggregates from China.

(4) Japan is the only prospective market for aggregate exportation from the Laoag River at present. Japan imports a considerable amount of aggregate from the neighboring countries. However, the aggregate export from the Laoag River to Japan is considered financially feasible only in case the aggregates are produced in the lower reaches and shipped from the newly constructed Laoag Port. Aggregate exportation from the alluvial fan areas is not feasible.

(5) Dredging in the lower reaches of the Laoag River is effective for flood control. However, it is not given priority in the overall flood control plan of the basin for the time being. Therefore, the multipurpose dredging project consisting of flood control and aggregate production may not be realized in the near future. The single purpose project of aggregate production in the lower reaches is considered feasible only in the case of large scale production. However, more detailed studies on aggregate production method, production cost, shipping cost and market price are necessary to form a final conclusion on the commercial feasibility of the aggregate exportation from the Laoag Lower Reaches.

CHAPTER II IRRIGATION WATER SUPPLY OF SABO DAM

2.1 Proposed Sabo Dam

The following eight (8) major sabo dams are proposed in this study.

River	Dam	Catchment Area (km^2)	Height (m)	Sedimentation Volume (10 m^3)	Level Sediment Storage (10 m^3)	Water Storage Volume (10 m^3)
Cura	Cura No. 1	68.2	6.5	391	98	34
	Cura No. 2	63.1	4.5	150	38	13
Labugaon	Labugaon No. 1	100.5	10.0	1,043	261	91
	Labugaon No. 2	90.9	7.0	511	128	45
Solsona	Solsona No. 1	72.2	10.0	233	58	20
	Solsona No. 2	68.2	10.0	233	58	20
Madongan	Madongan	153.8	7.0	2,192	548	192
Papa	Papa	51.4	7.0	707	177	62
	Total			5,460	1,366	477

Location of the sabo dams is shown in Fig. I.2.1.

A single purpose sabo dam is generally constructed on the riverbed as a floating type structure in case the riverbed is covered by thick sediment deposits. Further, the dam is provided with some drain holes. Hence, no water is stored in the dam.

However, the proposed sabo dams can be developed for irrigation water supply by constructing cutoff walls on the foundations and providing drain holes with control gates.

The storage capacity of the above sabo dams is estimated as shown in the above table by assuming the void ratio of sediment storage in the sabo dams as 35%. The stored water can be supplied for irrigation use in the alluvial fan areas.

2.2 INIP-I Irrigation Plan

(1) General

The Ilocos Norte National Irrigation Project Phase-I (INIP-I) covering an area of 10,200 ha was completed in 1987. The project area is irrigated by the river runoff of the Labugaon, Solsona, Madongan, Papa and Nueva Era (Bongo) through the respective diversion dams. The irrigation areas governed by the respective diversion dams are as shown below.

Labugaon	:	1,560 ha
Solsona	:	2,140 ha
Madongan	:	3,190 ha
Papa	:	2,560 ha
Nueva Era	:	750 ha
Total	:	10,200 ha

For location of the diversion dams and irrigation areas, see Fig. I.2.1.

(2) Diversion Water Requirement

This irrigation project plans to crop rice for all the irrigated areas in wet season, while in dry season, to harvest rice for 90% of the irrigated area and upland crop for the remaining 10%.

The monthly diversion water requirement of the above crops in wet and dry seasons is estimated as follows.

Wet Season

	May	June	Jul.	Aug.	Sept.	Oct.	Total
(mm)	-	-	91.0	78.2	184.2	258.3	611.7

Dry Season

	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Total
(mm)	113.1	322.5	477.8	450.5	296.8	146.4	1,807.1

(3) Design Irrigable Area

The water requirements mentioned above are not all satisfied due to shortage of river runoff. Even in wet season, some areas cannot be irrigated. According to the INIP-I Plan, the irrigable areas in the design drought year with a 5-year probability (the year 1969) are estimated as follows.

Diversion Dam	Project Area (ha)	Irrigable Area (ha)	
		Wet Season	Dry Season
Labugaon	1,560	1,560	780
Solsona	2,140	2,140	610
Madongan	3,190	2,290	720
Papa	2,560	1,340	400
Nueva Era	750	750	450
Total	10,200	8,080	2,960

The periods of water shortage in wet and dry seasons are estimated as shown below.

Diversion Dam	Water Shortage Period			
	Wet Season		Dry Season	
Labugaon	-		Dec. 20 - Feb. 28	(70 days)
Solsona	-		Nov. 01 - Feb. 28	(120 days)
Madongan	Aug. 21-30	(10 days)	Nov. 10 - Feb. 28	(110 days)
Papa	Aug. 11 - Sept. 10	(30 days)	Oct. 20 - Feb. 28	(130 days)
Nueva Era	-		Dec. 21 - Feb. 28	(90 days)

2.3 Estimation of Water Shortage

Unit water shortage of diversion (m^3/ha) in each sub-project area in the design drought year is estimated below based on the above diversion water requirements and water shortage periods.

(1) Wet Season

Madongan	:	78.2 mm × 1/3 = 26.1 mm = 261 m^3/ha
Papa	:	78.2 mm × 2/3 + 184.2 mm × 1/3 = 113.5 mm = 1,135 m^3/ha

(2) Dry Season

Labugaon	:	477.8 mm × 1/3 + 450.5 mm + 296.8 mm = 906.6 mm = 9,066 m^3/ha
Solsona	:	322.5 mm + 477.8 mm + 450.5 mm + 296.8 mm = 1,547.6 mm = 15,476 m^3/ha
Madongan	:	322.5 mm × 2/3 + 477.8 mm + 450.5 mm + 296.8 mm = 1,440.1 mm = 14,401 m^3/ha
Papa	:	113.1 mm × 1/3 + 322.5 mm + 477.8 mm + 450.5 mm + 296.8 mm = 1,585.3 mm = 15,853 m^3/ha
Nueva Era	:	477.8 mm × 1/3 + 450.5 mm + 296.8 mm = 906.6 mm = 9,066 m^3/ha

2.4 Irrigation Water Supply Development of Sabo Dam

(1) Water Source Development

There are two (2) kinds of water sources development for irrigation water supply by the proposed sabo dams. One is to release the stored water in the reservoir during dry period. The water storage of the respective sabo dams are as shown in Section 2.1.

The other is to exploit the underground river water which flow as waste. Some water flow under the riverbeds of the existing diversion dams. Construction of cutoff walls in the sabo dams will stop this underground river flow and convert it into surface river flow. This converted surface river water can be taken by the existing diversion dams located just downstream of the sabo dams.

The existing underground river flow is calculated by the following Darcy's Formula.

$$Q = kAI$$

where,
- Q : discharge (cm^3/s)
- k : permeability coefficient of riverbed materials (10^{-1} cm/s)
- A : underground river flow area (cm^2)
- I : hydraulic gradient of underground river flow

The existing underground river flow at the sabo dam sites is calculated as follows.

Sabo Dam	Flow Area (m^2)	Gradient (%)	Discharge (l/s)
Cura No. 1	720	1.08	8
Labugaon No. 1	450	1.15	5
Solsona No. 1	0	2.58	0
Madongan	880	1.52	13
Papa	1,230	2.08	26
Total			52

(2) Extension of Irrigable Area

Additional areas of 871 ha in wet season and 59 ha in dry season will be irrigated in the INIP-I area by releasing the stored water in the proposed sabo dams in drought period. Extension of the irrigable area in each sub-project is estimated as follows.

River	Wet Season (ha)		Dry Season (ha)	
	Stored Water	Ground-water	Stored Water	Ground-water
Labugaon	not necessary	not necessary	15	3
Solsona	not necessary	not necessary	3	0
Madongan	736	43	13	7
Papa	55	37	4	14
Total	791	80	35	24

Further, the Cura sabo dam will also be able to supply irrigation water to at least 10 ha of the existing Cura National Irrigation Project area (676 ha) in dry season.

Then, the proposed sabo dams with a cutoff wall will be able to extend the irrigable area in the alluvial fan by approximately 870 ha in wet season and 70 ha in dry season.

(3) Cost

All the irrigation facilities including diversion dam, distribution networks and other farm facilities are already completed. Therefore, the required cost for this project is only the construction cost for the cutoff wall and outlet gate of the sabo dams, and part of the O/M cost for the existing irrigation facilities.

A cutoff wall made of concrete is constructed for all the proposed sabo dams. The cutoff volume and the construction cost of cutoff wall and outlet gate are estimated below.

Sabo Dam	Cutoff Wall (m^2)	Const. Cost (million ₱)
Cura No. 1	720	7.1
Cura No. 2	270	2.6
Labugaon No. 1	450	4.5
Labugaon No. 2	630	6.1
Solsona No. 1	0 (rock foundation)	1.6
Solsona No. 2	0 (rock foundation)	2.4
Madongan	880	10.0
Papa	1,230	10.8
Total		45.1

Annual O/M cost for the existing irrigation facilities is estimated at 1.4 million pesos by assuming cost at ₱3,000/ha/year (= (870+70) ha × 1/2 × ₱3,000).

(4) Benefits

Annual irrigation benefits generated from the sabo dams are estimated, based on the following assumptions.

(a) In wet season, the project will irrigate 870 ha of paddy field which is rainfed at present due to lack of river water although the irrigation networks were already completed.

(b) In dry season, the project will irrigate 70 ha of farm land to cultivate paddy for 90 % portion and upland crop (garlic) for the remaining 10 %. For percentages of paddy and upland crop, refer to INIP-I plan.

The annual irrigation benefits of the project in financial and economic terms are estimated as follows.

Item	Wet Season	Dry Season	
	Paddy	Paddy	Garlic
Productive Area (ha)	870	63	7
With Project			
Production (ton/ha)	3.8	4.2	3.0
Farm Gate Price (P/ton)	8,000	8,000	110,000
	(6,000)	(6,000)	(90,200)
Production Cost (P/ha)	17,970	17,970	45,650
	(14,735)	(14,735)	(37,433)
Annual Benefit (thousand P)	10,814	985	1,990
	(7,017)	(659)	(1,632)
With Project			
Production (ton/ha)	2.4	-	-
Farm Gate Price (P/ton)	8,000	-	-
	(6,000)		
Production Cost (P/ha)	14,761	-	-
	(12,104)		
Annual Benefit (thousand P)	3,862	-	-
	(1,998)		
Net Annual Benefit (thousand P)	6,952	985	1,990
	(5,019)	(659)	(1,632)
Unit Net Annual Benefit (P/ha)	7,991	15,632	284,286
	(5,769)	(10,460)	(233,143)

Note : 1) without parentheses : financial terms
2) with parentheses : economic terms

For production, farm gate price and production cost in the above table, see Appendix C Chapter 5.

The total net annual benefit of the project is approximately 9.9 million pesos in financial terms and 7.3 million pesos in economic terms.

(5) Economic Evaluation

The economic construction cost and annual O&M cost of the project are estimated to be 37.0 million pesos and 1.1 million pesos by assuming the conversion factor of financial cost to economic cost as 0.82. On the other hand, the economic annual benefit of the project is 7.3 million pesos as mentioned before.

The present value of the economic cost and benefit of the project are calculated to be 42.5 million pesos and 36.8 million pesos respectively under the following conditions.

(a) Discount rate : 15 %, project life : 50 years

(b) Construction period of the sabo dam is 3 years. The cutoff wall will be construction in the first year of the construction period of the sabo dam.

The benefit and cost ratio (B/C) of the project is 0.87. The project is economically not feasible. Hence, the irrigation water supply development of the sabo dams is not proposed.

CHAPTER III HYDROPOWER DEVELOPMENT OF SABO DAM

3.1 General

The following eight (8) sabo dams are proposed for hydropower development in this study.

River	Dam	Catchment Area (km^2)	Height (m)	Elevation of Dam Crest (m)
Cura	Cura No. 1	68.2	6.5	EL. 116.3
Cura	Cura No. 2	63.1	4.5	EL. 140.5
Labugaon	Labugaon No. 1	100.5	10.0	EL. 124.4
Labugaon	Labugaon No. 2	90.9	7.0	EL. 162.2
Solsona	Solsona No. 1	72.2	10.0	EL. 148.6
Solsona	Solsona No. 2	68.2	10.0	EL. 191.1
Madongan	Madongan	153.8	7.0	EL. 129.3
Papa	Papa	51.4	7.0	EL. 143.8

Location of the sabo dams is shown in Fig. I. 2.1.

Similar to the irrigation water supply discussed in Chapter II, the proposed sabo dams can be used as hydropower intakes by constructing cutoff walls in the riverbeds and by closing the drainholes.

Among the above sabo dams, Labugaon No. 1, Madongan and Papa are constructed only 50-200 m upstream of the existing irrigation diversion dams. There is no space to construct a hydropower station between sabo dam and diversion dam because mountains rise abruptly from the riverbank. Similarly, no space is identified for the construction of the Labugaon No. 2 hydropower station. The Cura No. 1 sabo dam cannot harness a sufficient hydraulic head. The exploitable effective head is only 6.0 m. The Cura No. 2 sabo dam also cannot exploit a sufficient hydraulic head compared to the water conveyance distance.

Therefore, the hydropower development of the Solsona No. 1 and Solsona No. 2 sabo dams are discussed in this study.

3.2 Solsona No. 1 Hydropower Development

(1) River Runoff at Dam Site

Monthly runoff at the Solsona irrigation diversion dam site (C.A. = 79.0 km^2) during the period 1960-1970 is shown in Table I.3.1 (refer to INIP-I Plan). From these monthly runoff data, the river runoff corresponding to each exceeding percentage (%) is estimated as follows.

Exceeding (%)	90	80	70	60	50	40	30	20	10	0
Runoff (m^3/s)	0.90	1.60	2.20	3.10	4.50	5.50	7.20	11.7	14.5	35.7

The Solsona No. 1 sabo dam is proposed at approximately 2.0 km upstream of the irrigation dam. The sabo dam covers a catchment area of 72.2 km^2 or 91.4% of that of the irrigation diversion dam. Therefore, the river runoff corresponding to each exceeding percentage (%) at the sabo dam site is calculated as follows.

Exceeding (%)	90	80	70	60	50	40	30	20	10	0
Runoff (m^3/s)	0.80	1.50	2.00	2.80	4.10	5.00	6.60	10.6	13.2	32.5

(2) Hydropower Development System

The river water is taken from the sabo dam with a crest elevation of EL. 148.6 m, and discharged to the river just upstream of the existing irrigation diversion dam with a normal intake water level of 110.3 m. The hydraulic head between both sites is exploited by a runoff type system consisting of the following water conveyance measures.

Sabo dam → Intake → Headrace channel → Headrace tunnel → Head tank → Penstock → Power house → Tailrace channel

The flow distance is as follows.

Headrace Channel	:	1,200 m (1/1,000 slope)
Headrace Tunnel	:	1,000 m (1/1,000 slope)
Penstock	:	200 m

Layout of the above system is shown in Fig. I.3.1.

(3) Water Head

The water head for the hydropower development is estimated as follows.

Crest Elevation of Sabo Dam	:	EL. 148.6 m
Normal Water Level of Diversion Dam	:	EL. 110.3 m
Tail Water Level	:	EL. 110.5 m

From the above, the gross head is assumed to be 38.1 m.

The total head loss is estimated to be 4.1 m with the following breakdown.

Headrace Channel/Tunnel	:	2,200 m / 1,000 = 2.2 m
Penstock Loss	:	1.0 m
Others	:	0.9 m.

Therefore, the effective hydraulic head comes to 34.0 m.

(4) Maximum Output and Annual Energy Production

The maximum output and annual energy production for the following five (5) alternative developments are estimated, as shown below.

Case A	:	Maximum harnessed discharge for hydropower development is assumed as 1.50 m^3/s (80% discharge).
Case B	:	Maximum discharge is 2.00 m^3/s (70% discharge)
Case C	:	Maximum discharge is 2.80 m^3/s (60% discharge)
Case D	:	Maximum discharge is 4.10 m^3/s (50% discharge)
Case E	:	Maximum discharge is 5.00 m^3/s (40% discharge)

The maximum output and annual energy production are calculated based on the following formula.

Maximum Output, $P_{max} = 9.8 \times Q_{max}\, He \times \eta$

Annual Energy Production, $E = 24hr \times 365day \times P_{max} \times \Sigma Q / Q_{max} \times 365day \times \alpha$

where,

P_{max} : Maximum output (kw)
Q_{max} : Maximum harnessed discharge (m^3/s)
He : Effective head (m)
η : Integrated efficiency of turbine and generator (0.84)
E : Annual energy production (kwh)
ΣQ : Annual harnessed discharge ($m^3/s \cdot day$)
α : Coefficient concerning lowering of turbine and generator efficiency (0.95)

The estimated maximum output and annual energy production of the above five (5) alternative developments are summarized below.

	Case A	Case B	Case C	Case D	Case E
Maximum Output (kw)	420	560	784	1,148	1,399
Annual Harnessed Discharge ($m^3/s \cdot day$)	495	632	821	1,082	1,230
Annual Energy Production (Mwh)	3,160	4,035	5,241	6,907	7,847

(5) Construction Cost

The construction costs of the above five (5) developments are roughly estimated as below.

(Unit: ₱1000)

Work Item	Case A	Case B	Case C	Case D	Case E
Direct Cost	93,000	103,000	120,000	140,000	171,000
Civil Works	57,000	60,000	67,000	73,000	95,000
Turbine/Generator	31,000	38,000	48,000	62,000	71,000
Distribution Line	3,000	3,000	3,000	3,000	3,000
Land Acquisition	2,000	2,000	2,000	2,000	2,000
Indirect Cost	28,000	31,000	36,000	42,000	51,000
Total	121,000	134,000	156,000	182,000	222,000

Note: Indirect cost is assumed as 30% of direct cost.

(6) Optimum Development Plan

The construction costs per kwh of the above five (5) developments are compared as follows.

	Case A	Case B	Case C	Case D	Case E
Const. Cost per kwh (Pesos/kwh)	38.3	33.2	29.8	26.4	28.3

Among the above developments, only Case A can provide electricity through an independent distribution system. It can distribute electricity with an assurance of 80%. However, the power output is small and electricity generation cost is high compared with the other plans.

All the other plans must be integrated into the existing electricity distribution networks, because they will not be able to supply full power to the users in dry season but when combined they will produce much energy.

On the other hand, the existing electricity networks are well developed covering almost all the local users. Integration into the existing system is considered easy and any independent system is not necessary. Therefore, Case D is considered the optimum.

The salient features of the hydropower development of Solsona No. 1 sabo dam is proposed as follows.

Effective Head	:	34.0 m
Maximum Discharge for Hydropower	:	4.10 m^3/s
Installed Capacity	:	1,200 kw
Expected Annual Energy Production	:	6,907 Mwh
Construction Cost	:	₱182 million

For breakdown of the construction cost, see Table I.3.2.

3.3 Solsona No. 2 Hydropower Development

(1) River Runoff at Dam Site

The Solsona No. 2 sabo dam is located 1.5 km upstream of Solsona No. 1 sabo dam, covering a drainage area of 68.2 km^2 or 86.3% of that of the irrigation diversion dam. Therefore, the river runoff corresponding to each exceeding percentage (%) at the sabo dam site is estimated as follows.

Exceeding (%)	90	80	70	60	50	40	30	20	10	0
Runoff (m^3/s)	0.80	1.40	1.90	2.70	3.90	4.80	6.20	10.1	12.5	30.8

(2) Hydropower Development System

The river water is withdrawn from the sabo dam with a crest elevation of 191.1 m and discharged to the river at the same location as the Solsona No. 1 hydropower development system. The hydraulic head between both sites is developed by a runoff type system consisting of the following water transmission measures.

Sabo dam --> Intake --> Headrace tunnel (1) --> Headrace channel --> Headrace tunnel (2) --> Head tank --> Penstock --> Powerhouse --> Tailrace channel

The flow distance is as follows.

Headrace Tunnel (1)	:	1,500 m (1/1,000 slope)
Headrace Channel	:	700 m (1/1,000 slope)
Headrace Tunnel (2)	:	1,500 m (1/1,000 slope)
Penstock	:	300 m

Layout of the above system is shown in Fig. I. 3. 1.

(3) Water Head

The water head for the hydropower development is estimated as follows.

Crest Elevation of Sabo Dam	:	EL. 191.1 m
Normal Water Level of Diversion Dam	:	EL. 110.3 m
Tail Water Level	:	EL. 110.5 m

From the above, the gross head is assumed to be 80.6 m.

The total head loss is assumed to be 5.6 m with the following breakdown.

Headrace Tunnel/Channel Loss	:	3,700 m / 1,000 = 3.7 m
Penstock	:	1.0 m
Others	:	0.9 m

Therefore, the effective hydraulic head comes to 75.0 m.

(4) Maximum Output and Annual Energy Production

The maximum output and annual energy production for the following five (5) alternative developments are estimated in the same way as Solsona No. 1 hydropower development.

Case A	:	Maximum discharge is 1.40 m^3/s (80% discharge)
Case B	:	Maximum discharge is 1.90 m^3/s (70% discharge)
Case C	:	Maximum discharge is 2.70 m^3/s (60% discharge)
Case D	:	Maximum discharge is 3.90 m^3/s (50% discharge)
Case E	:	Maximum discharge is 4.80 m^3/s (40% discharge)

The estimated maximum output and annual energy production of the five (5) developments are summarized as follows.

	Case A	Case B	Case C	Case D	Case E
Maximum Output (kw)	864	1,173	1,667	2,408	2,964
Annual Harnessed Discharge (m^3/s·day)	464	601	790	1,031	1,179
Annual Energy Production (Mwh)	6,529	8,460	11,121	14,514	16,599

(5) Construction Cost

The construction costs of the above five (5) developments are roughly estimated as follows.

(Unit: ₱1000)

Work Item	Case A	Case B	Case C	Case D	Case E
Direct Cost	168,000	183,000	203,000	227,000	288,000
Civil Works	125,000	130,000	136,000	143,000	191,000
Turbine/Generator	38,000	48,000	62,000	79,000	92,000
Distribution Line	3,000	3,000	3,000	3,000	3,000
Land Acquisition	2,000	2,000	2,000	2,000	2,000
Indirect Cost	50,000	55,000	61,000	68,000	86,000
Total	218,000	238,000	264,000	295,000	374,000

Note: Indirect cost is assumed as 30% of direct cost.

(6) Optimum Development Plan

The construction costs per kwh of the five (5) developments are compared as follows.

	Case A	Case B	Case C	Case D	Case E
Const. Cost per kwh (₱/kwh)	33.4	28.1	23.7	20.3	22.5

Case D is regarded optimum based on the same consideration as the Solsona No. 1 sabo dam.

The salient features of the proposed hydropower development of the Solsona No. 2 sabo dam are summarized as follows.

Effective Head	:	75.0 m
Maximum Discharge for Hydropower	:	3.90 m^3/s
Installed Capacity	:	2,400 kw
Expected Annual Energy Production	:	14,514 Mwh
Construction Cost	:	₱295 million

For breakdown of the construction cost, see Table I.3.2.

3.4 Project Evaluation

(1) General

The economic efficiency of the proposed Solsona No. 1 and Solsona No. 2 hydropower developments are compared to that of diesel power development in terms of the present value of kwh cost.

The present value of kwh cost is calculated based on the following assumptions.

(a)	Hydropower Plant		
	-Construction Period	:	1 year
	-Annual O&M Cost	:	2.0% of construction cost
	-Economic Life	:	50 years
(b)	Diesel Power Plant		
	-Construction Period	:	1 year
	-Construction Cost	:	₱40,000/kw
	-Annual O&M Cost	:	2.5% of construction cost
	-Fuel Cost	:	₱1.50/kwh
	-Lubricant Cost	:	₱0.10/kwh
	-Economic Life	:	20 years
(c)	Discount Rate	:	15%

(2) Initial and Annual Costs

(a)	Solsona No. 1 Hydropower		
	-Initial Cost	:	₱182 million
	-Annual Cost	:	₱3.64 million (=₱182 million × 2.0%)
(b)	Solsona No. 1 Diesel Power		
	-Initial Cost	:	₱48 million (=1,200 kw × ₱ 40,000/kw)
	-Annual O&M Cost	:	₱1.20 million (=₱48 million × 2.5 %)
	-Annual Fuel Cost	:	₱10.36 million (=6,907 Mwh × ₱ 1.50/kwh)
	-Annual Lubricant Cost	:	₱0.69 million (=6,907 Mwh × ₱ 0.10/kwh)
(c)	Solsona No. 2 Hydropower	:	
	-Initial Cost	:	₱295 million
	-Annual Cost	:	₱5.9 million (=₱295 million × 2.0%)
(d)	Solsona No. 2 Diesel Power		
	-Initial Cost	:	₱96 million (=2,400 kw × ₱ 40,000/kw)
	-Annual O&M Cost	:	₱2.4 million (=₱96 million × 2.5 %)
	-Annual Fuel Cost	:	₱21.77 million (=14,514 Mwh × ₱ 1.50/kwh)
	-Annual Lubricant Cost	:	₱1.45 million (=14,514 Mwh × ₱ 0.10/kwh)

(3) Annual Energy Production

Solsona No. 1 Hydropower	:	6,907 Mwh
Solsona No. 1 Diesel	:	6,907 Mwh
Solsona No. 2 Hydropower	:	14,514 Mwh
Solsona No. 2 Diesel	:	14,514 Mwh

(4) kwh Cost

The kwh costs of the hydropower and diesel power developments are obtained by calculating the present value of their cost and energy production respectively. The results are summarized below.

Present Value	Solsona No. 1		Solsona No. 2	
	Hydro-power	Diesel	Hydro-power	Diesel
Cost (million ₱)	179.32	115.77	290.71	238.10
Energy Production (Mwh)	39,997	39,997	84,050	84,050
kwh Cost (₱/kwh)	4.48	2.89	3.46	2.83

For details, see Table I.3.3.

(5) Conclusion

As evident from the above table, Solsona No. 1 hydropower development project is not economically feasible. On the other hand, Solsona No. 2 is considered prospective from the following points.

(a) The kwh cost is close to that of diesel alternative.
(b) Hydropower is clean energy.
(c) It can save the import of fossil fuel.

However, it may not be able to generate power in dry periods due to shortage of river water although it can produce a large quantity of energy annually. Hence, it cannot distribute stable energy to the users until it is integrated into the other power system.

TABLES

Table I.1.1 Present Value of Aggregate Production Cost (Case I)

(unit : thousand $)

Year	Excavation		Sieving		Truck Transportation			Ship Loading			Management
	Equipment	O/M	Equipment	O/M	Const.	Equipment	O/M	Const.	Equipment	O/M	
Cost	1,980	420	900	280	4,000	15,700	3,590	1,100	3,400	260	1,000
1	1,722		783		3,478	13,652		957	2,957		
2		318		212			2,715			197	756
3		276		184			2,360			171	658
4		240		160			2,053			149	572
5		209		139			1,785			129	497
6		182		121			1,552			112	432
7		158		105			1,350			98	376
8	647	137		92		5,132	1,174			85	327
9	−65	119		80		−513	1,021			74	284
10		104		69			887			64	247
11		90	193	60			772		731	56	215
12		79	−19	52			671		−73	49	187
13		68		46			583			42	163
14		59		40			507			37	141
15	243	52		34		1,929	441			32	123
16	−24	45		30		−193	384			28	107
17		39		26			334			24	93
18		34		23			290			21	81
19		30		20			252			18	70
20		26		17			219			16	61
21		22		15			191			14	53
Total	2,523	2,287	957	1,525	3,478	20,007	19,541	957	3,615	1,416	5,443

Note: − : remaining value

Table I.1.2 Present Value of Aggregate Production Cost (Case II-A)

(unit : thousand $)

Year	Excavation		Sieving		Truck Transportation			Ship Loading			Management
	Equipment	O/M	Equipment	O/M	Const.	Equipment	O/M	Const.	Equipment	O/M	
Cost	1,980	420	900	280	3,000	11,200	2,510	6,100	3,400	260	1,000
1	1,722		783		2,609	9,739		5,304	2,957		
2		318		212			1,898			197	756
3		276		184			1,650			171	658
4		240		160			1,435			149	572
5		209		139			1,248			129	497
6		182		121			1,085			112	432
7		158		105			944			98	376
8	647	137		92		3,661	821			85	327
9	-65	119		80		-366	713			74	284
10		104		69			620			64	247
11		90	193	60			540		731	56	215
12		79	-19	52			469		-73	49	187
13		68		46			408			42	163
14		59		40			355			37	141
15	243	52		34		1,376	308			32	123
16	-24	45		30		-138	268			28	107
17		39		26			233			24	93
18		34		23			203			21	81
19		30		20			176			18	70
20		26		17			153			16	61
21		22		15			133			14	53
Total	2,523	2,287	957	1,525	2,609	14,272	13,660	5,304	3,615	1,416	5,443

Note : - : remaining value

Table I.1.3 Present Value of Aggregate Production Cost (Case II-B)

(unit : thousand $)

Year	Excavation		Sieving		Truck Transportation		Belt Conveyor Transportation			Ship Loading			Management
	Equipment	O/M	Equipment	O/M	Equipment	O/M	Const.	Equipment	O/M	Const.	Equipment	O/M	
Cost	3,960	840	1,800	560	10,700	2,040	10,500	29,500	2,470	6,600	4,100	340	1,500
1	3,444		1,566		9,304		9,130	25,652		5,739	3,565		
2		636		424		1,542			1,868			257	1,134
3		552		368		1,342			1,624			224	986
4		480		320		1,166			1,412			194	858
5		418		278		1,014			1,228			169	746
6		364		242		882			1,068			147	648
7		316		210		766			929			128	564
8	1,294	274		184	3,498	666			807			111	490
9	-129	238		159	-350	580			702			97	426
10		208		138		504			611			84	371
11		180	386	120		438		6,341	531		881	73	322
12		158	-39	104		382		-634	462		-88	64	280
13		136		92		332			401			55	244
14		118		80		288			349			48	212
15	486	104		68	1,314	250			304			42	184
16	-49	90		60	-131	218			264			36	160
17		78		54		190			230			32	139
18		68		46		164			200			27	121
19		59		40		144			174			24	105
20		52		34		124			151			21	92
21		44		30		108			131			18	80
Total	5,046	4,573	1,913	3,051	13,635	11,100	9,130	31,359	13,446	5,739	4,358	1,851	8,162

Note : - : remainig value

Table I.1.4 Present Value of Aggregate Production Cost (Case III-A)

(unit : thousand $)

Year	Excavation		Sieving		Truck Transportation			Ship Loading			Management
	Equipment	O/M	Equipment	O/M	Const.	Equipment	O/M	Const.	Equipment	O/M	
Cost	1,980	420	900	280	1,000	6,420	1,320	6,100	3,400	280	1,000
1	1,722		783		870	5,583		5,304	2,957		
2		318		212			998			212	756
3		276		184			868			184	658
4		240		160			755			160	572
5		209		139			656			139	497
6		182		121			571			121	432
7		158		105			496			105	376
8	647	137		92		2,099	432			92	327
9	-65	119		80		-210	375			80	284
10		104		69			326			69	247
11		90	193	60			284		731	60	215
12		79	-19	52			247		-73	52	187
13		68		46			215			46	163
14		59		40			187			40	141
15	243	52		34		789	162			34	123
16	-24	45		30		-79	141			30	107
17		39		26			123			26	93
18		34		23			107			23	81
19		30		20			93			20	70
20		26		17			81			17	61
21		22		15			70			15	53
Total	2,523	2,287	957	1,525	870	8,182	7,187	5,304	3,615	1,525	5,443

Note : - : remaining value

Table I.1.5 Present Value of Aggregate Production Cost (Case III-B)

(unit : thousand $)

Year	Excavation		Sieving		Belt Conveyor Transport.			Ship Loading			Management
	Equipment	O/M	Equipment	O/M	Const.	Equipment	O/M	Const.	Equipment	O/M	
Cost	4,950	1,070	1,800	560	3,500	8,500	710	6,600	4,100	360	1,500
1	4,304		1,566		3,043	7,391		5,739	3,565		
2		809		424			537			272	1,134
3		704		368			467			237	986
4		612		320			406			206	858
5		532		278			353			179	746
6		463		242			307			156	648
7		402		210			267			135	564
8	1,618	350		184			232			118	490
9	−162	304		159			202			102	426
10		264		138			176			89	371
11		230	386	120		1,589	153		881	77	322
12		200	−39	104		−159	133		−88	67	280
13		174		92			115			59	244
14		151		80			100			51	212
15	608	131		68			87			44	184
16	−61	114		60			76			38	160
17		99		54			66			33	139
18		86		46			57			29	121
19		75		40			50			25	105
20		65		34			43			22	92
21		57		30			38			19	80
Total	6,307	5,822	1,913	3,051	3,043	8,821	3,865	5,739	4,358	1,958	8,162

Note : − : remaining value

Table I.1.6 Present Value of Aggregate Production

(unit : thousand ton)

Year	Case I	Case II-A	Case II-B	Case III-A	Case III-B
Yearly Production	1,200	1,200	2,400	1,440	2,880
1					
2	907	907	1,814	1,089	2,178
3	789	789	1,578	947	1,894
4	686	686	1,372	823	1,646
5	597	597	1,194	716	1,432
6	519	519	1,038	623	1,246
7	451	451	902	541	1,082
8	392	392	784	471	942
9	341	341	682	409	818
10	297	297	594	356	712
11	258	258	516	310	620
12	224	224	448	269	538
13	195	195	390	234	468
14	170	170	340	204	408
15	147	147	294	177	354
16	128	128	256	154	308
17	112	112	224	134	268
18	97	97	194	116	232
19	84	84	168	101	202
20	73	73	146	88	176
21	64	64	128	77	154
Total	6,531	6,531	13,062	7,839	15,678

Table I. 3.1 Monthly Runoff at Solsona Diversion Dam Site (C.A. = 79.0 km2)

(unit : m3/s)

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1960	3.61	3.91	1.33	0.96	1.62	6.81	5.42	14.32	5.96	12.69	2.52	2.49
1961	1.96	1.01	0.90	0.61	2.94	5.50	23.41	17.14	14.19	10.02	3.91	2.91
1962	1.97	1.31	0.66	0.78	1.61	8.49	18.63	17.97	18.63	9.24	4.75	3.13
1963	2.07	1.88	0.67	0.65	0.58	14.17	14.21	10.89	15.34	4.78	2.43	3.30
1964	1.79	1.81	1.15	0.87	4.85	18.58	8.19	22.86	26.50	9.84	14.58	12.15
1965	4.36	2.15	0.96	1.69	4.89	19.52	12.69	8.64	11.71	5.38	2.91	2.55
1966	1.16	0.77	0.37	0.27	5.05	6.81	5.67	18.93	13.05	3.36	12.85	5.22
1967	6.85	4.53	2.60	2.34	2.22	12.79	35.70	7.13	7.31	7.86	7.20	6.54
1968	3.57	1.80	0.82	1.40	3.85	12.04	14.51	13.16	11.68	4.46	2.39	2.22
1969	1.53	0.96	0.50	0.56	2.00	5.93	11.35	4.69	10.10	8.08	4.43	3.15
1970	1.64	1.38	1.55	2.32	4.72	6.08	3.86	5.43	5.86	4.81	6.69	6.62
Mean	2.77	1.96	1.05	1.13	3.12	10.26	13.97	12.83	12.76	6.82	5.88	4.57

Table I.3.2 Construction Cost of Solsona No.1 and No.2 Hydropower Development

(unit : thousand P)

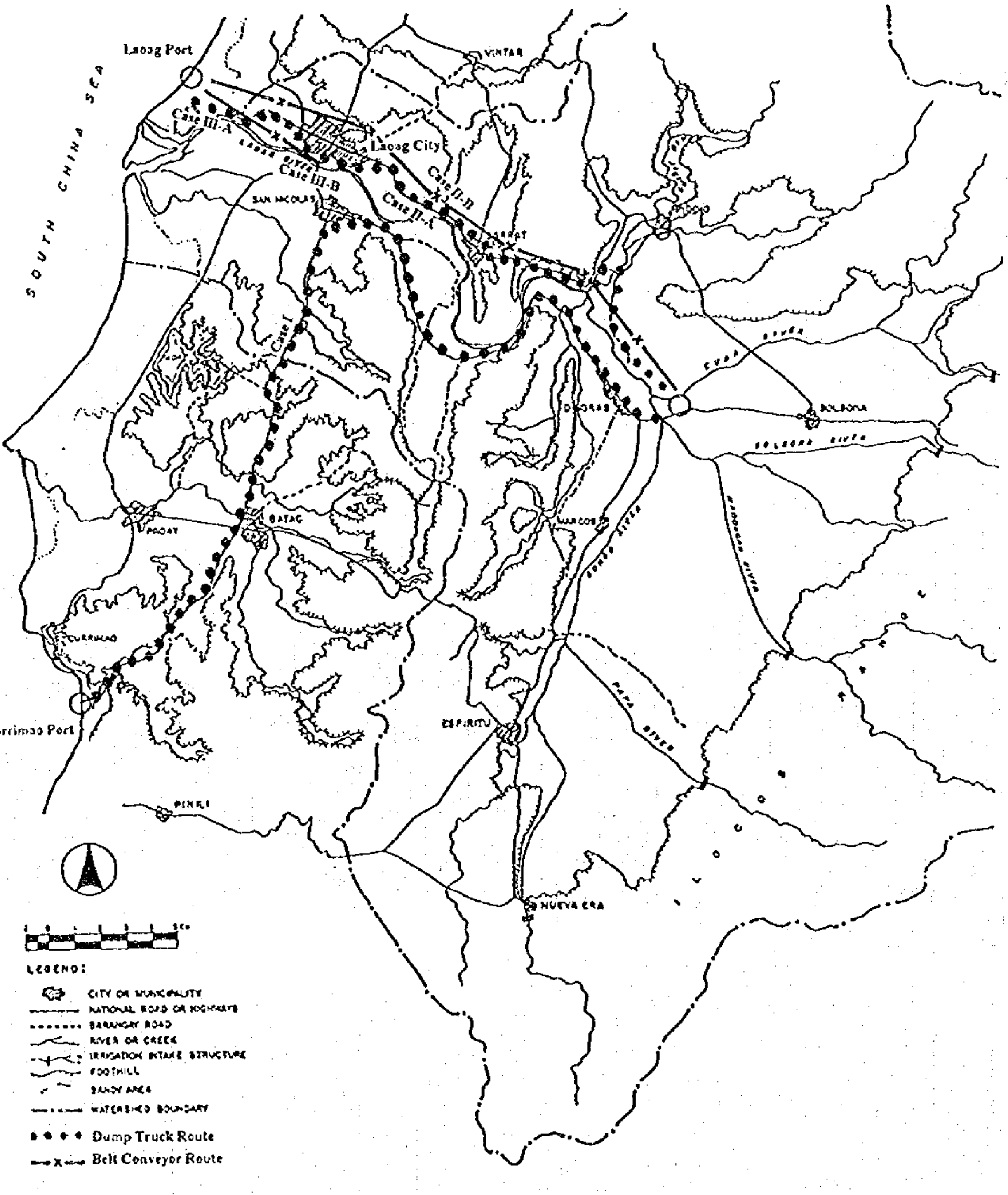
Work Item	Solsona No.1			Solsona No.2		
	Quantity	Unit Cost	Cost	Quantity	Unit Cost	Cost
Direct Cost			140,000			227,000
1. Civil Works			73,000			143,000
1) Preparatory Works	1 l.s.		3,000	1 l.s.		3,000
2) Intake(Sabo Dam)	1 l.s.		0	1 l.s.		0
3) Headrace Channel	2.0x2.0m, 1,200m	10,000 P/m	12,000	2.0x2.0m, 700m	10,000 P/m	7,000
4) Headrace Tunnel	dia.1.8m, 1,000m	34,000 P/m	34,000	dia.1.8m, 3,000m	34,000 P/m	102,000
5) Head Tank	1 l.s.		10,000	1 l.s.		10,000
6) Penstock	dia.1.6m, 200m	35,000 P/m	7,000	dia.1.4m, 300m	40,000 P/m	12,000
7) Power House	1 l.s.		6,000	1 l.s.		8,000
8) Tailrace Channel	1 l.s.		1,000	1 l.s.		1,000
2. Turbine/Generator	1,200 kw		62,000	2,400 kw		79,000
3. Distribution Line	1 l.s.		3,000	1 l.s.		3,000
4. Land Acquisition	1 l.s.		2,000	1 l.s.		2,000
Indirect Cost			42,000			68,000
Total			182,000			295,000

Note: 1) Indirect cost is assumed as 30 %of direct cost.
2) Exchange rate : 1.0 $ = 26 P = 105 Y

Table I.3.3 Present Value of Cost and Energy Production

Year	Solsona No.1					Solsona No.2				
	Hydro		Diesel		Energy	Hydro		Diesel		Energy
	Initial(mil.P)	Annual(mil.P)	Initial(mil.P)	Annual(mil.P)	(Mwh)	Initial(mil.P)	Annual(mil.P)	Initial(mil.P)	Annual(mil.P)	(Mwh)
	182	3.64	48	12.25	6,907	295	5.9	96	25.62	14,514
1	158.26		41.74			256.52		83.48		
2		2.75		9.26	5,223		4.46		19.37	10,975
3		2.39		8.05	4,541		3.88		16.85	9,543
4		2.08		7.00	3,949		3.37		14.65	8,298
5		1.81		6.09	3,434		2.93		12.74	7,216
6		1.57		5.30	2,986		2.55		11.08	6,275
7		1.37		4.61	2,597		2.22		9.63	5,456
8		1.19		4.00	2,258		1.93		8.38	4,745
9		1.03		3.48	1,963		1.68		7.28	4,126
10		0.90		3.03	1,707		1.46		6.33	3,588
11		0.78		2.63	1,485		1.27		5.51	3,120
12		0.68		2.29	1,291		1.10		4.79	2,713
13		0.59		1.99	1,123		0.96		4.16	2,359
14		0.51		1.73	976		0.83		3.62	2,051
15		0.45		1.51	849		0.73		3.15	1,784
16		0.39		1.31	738		0.63		2.74	1,551
17		0.34		1.14	642		0.55		2.38	1,349
18		0.29		0.99	558		0.48		2.07	1,173
19		0.26		0.86	485		0.41		1.80	1,020
20		0.22	2.93	0.75	422		0.36	5.87	1.57	887
21		0.19		0.65	367		0.31		1.36	771
22		0.17		0.57	319		0.27		1.18	671
23		0.15		0.49	277		0.24		1.03	583
24		0.13		0.43	241		0.21		0.90	507
25		0.11		0.37	210		0.18		0.78	441
26		0.10		0.32	182		0.16		0.68	383
27		0.08		0.28	159		0.14		0.59	333
28		0.07		0.24	138		0.12		0.51	290
29		0.06		0.21	120		0.10		0.45	252
30		0.05		0.19	104		0.09		0.39	219
31		0.05		0.16	91		0.08		0.34	191
32		0.04		0.14	79		0.07		0.29	166
33		0.04		0.12	69		0.06		0.25	144
34		0.03		0.11	60		0.05		0.22	125
35		0.03		0.09	52		0.04		0.19	109
36		0.02		0.08	45		0.04		0.17	95
37		0.02		0.07	39		0.03		0.15	82
38		0.02		0.06	34		0.03		0.13	72
39		0.02		0.05	30		0.03		0.11	62
40		0.01	0.18	0.05	26		0.02	0.36	0.10	54
41		0.01		0.04	22		0.02		0.08	47
42		0.01		0.03	19		0.02		0.07	41
43		0.01		0.03	17		0.01		0.06	36
44		0.01		0.03	15		0.01		0.05	31
45		0.01		0.02	13		0.01		0.05	27
46		0.01		0.02	11		0.01		0.04	23
47		0.01		0.02	10		0.01		0.04	20
48		0.00		0.01	8		0.01		0.03	18
49		0.00		0.01	7		0.01		0.03	15
50		0.00		0.01	6		0.01		0.02	13
Total	158.26	21.06	44.85	70.92	39,997	256.52	34.19	89.71	148.39	84,050

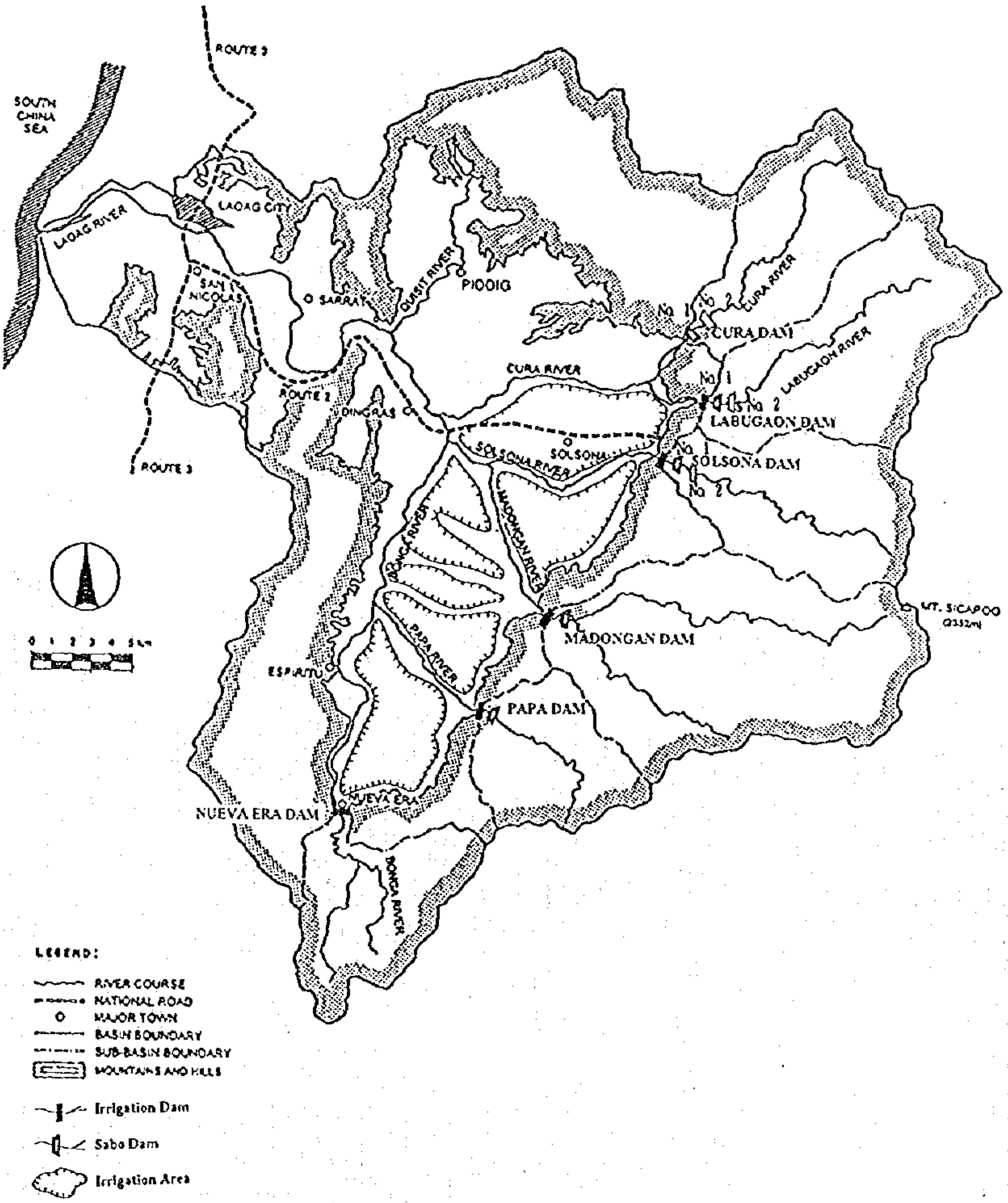
FIGURES



THE STUDY ON SABO AND FLOOD CONTROL IN THE LAOAG RIVER BASIN

JAPAN INTERNATIONAL COOPERATION AGENCY

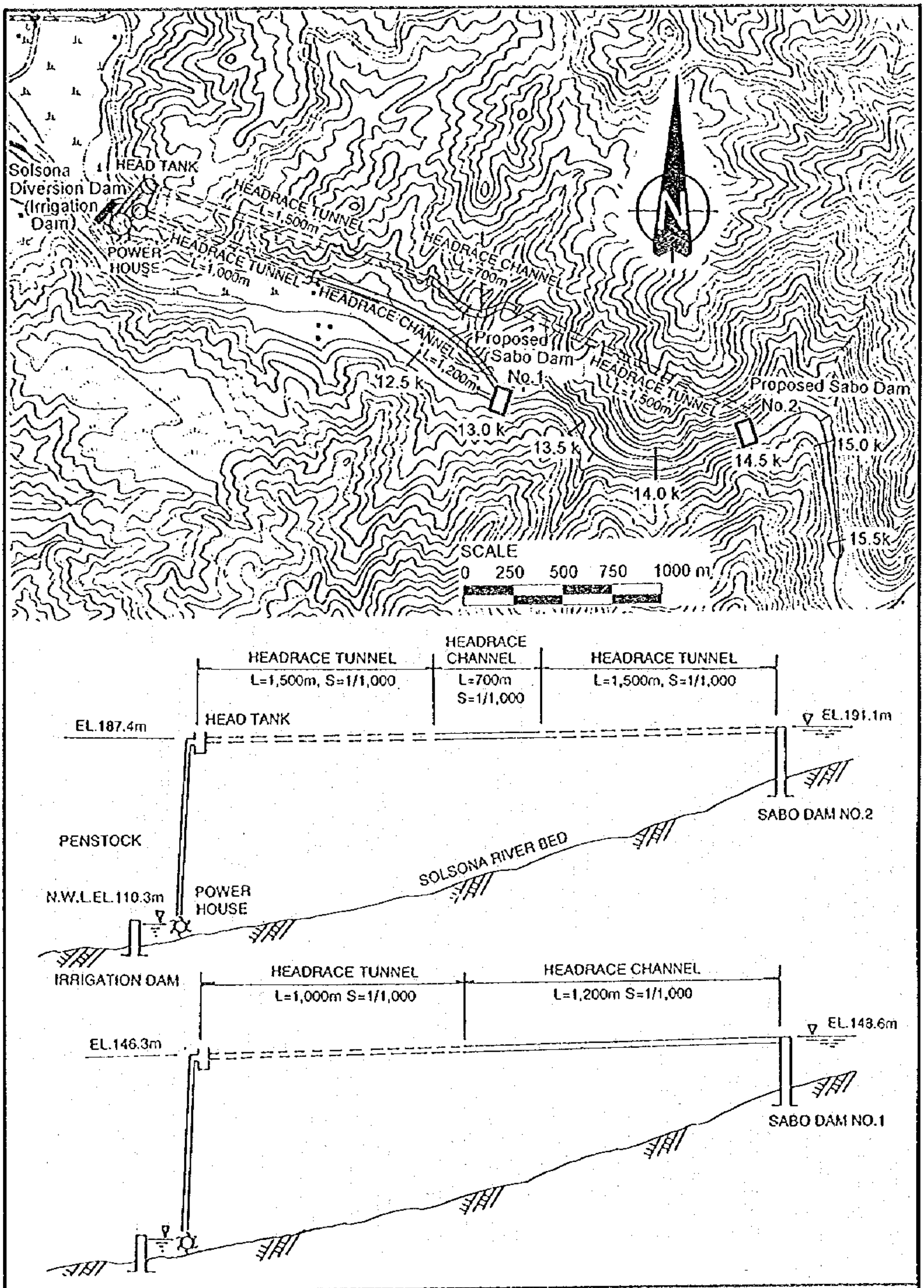
Fig. I.1.1
Aggregate Transportation Route



THE STUDY ON SABO AND FLOOD CONTROL IN THE LAOAG RIVER BASIN

JAPAN INTERNATIONAL COOPERATION AGENCY

Fig. I.2.1
Location of Sabo and Irrigation Dam



THE STUDY ON SABO AND FLOOD CONTROL IN THE LAOAG RIVER BASIN JAPAN INTERNATIONAL COOPERATION AGENCY	Fig. I.3.1 Layout of Solsona No.1 and No.2 Hydropower Development System