Table III–2–5–2 PICOP's Test Data

	Linerboard LUKP	Corrugating Medium LUKP
Kappa No.	50–55	60–68
Freeness (CSF) (mℓ)	400	300
Burst Index (kPa m^2/g)	4.2–4.6	4.4
Tear Index (mN m^2/g)	7.6–9.0	8.4
Breaking Length (km)	7.8–8.9	8.6

(2) Quality of containerboard

(a) Sample of kraft linerboard and corrugating medium which were brought back by the Team to Japan were tested in the Laboratory of Honshu Paper Co., Ltd. and the results are shown in Table III–2–6.

Test data of linerboard and corrugating medium made by Japanese suppliers are shown herewith for reference.

i) Basis weight

As indicated in Table III 2–6, the actual basis weights are substantially greater than the standard on all linerboards made by PICOP. However they are within a basis weight allowance of JIS (±5%).

The basis weights of corrugating medium fulfill mostly the standards.

ii) Strength properties

Fig. III–2–7 is a bar graph in which the major quality characteristics are compared between PICOP and two representing Japanese companies.

The quality of PICOP's 220 g/m² linerboard is almost the same as that of prevailing in the Japanese market.

On the 160 g/m² corrugating medium, the PICOP's product is superior to the Japanese company B on the ring crush index and burst index.

(b) Moisture profile

i) Moisture content after press

Moisture fructuation of the web after press is remaining with the range of ±1%, however, average moisture content is as high as 66%.

ii) Moisture content on reel

Fig. III–2–8 shows that the fructuation of moisture content on reel is as much as the range of ±3%, which also exceeds JIS moisture allowance of ±1.5%.

Table III-2-6 Test Data of PICOP's Linerboard & Corrugating Medium

TEST ITEM \ PICOP's SAMPLE			3	4	5	6	7	1	2	REFERENCE DATA IN JAPAN	
			LB 125 g/m²	LB 160 g/m²	LB 185 g/m²	LB 200 g/m²	LB 230 g/m²	CM 115 g/m²	CM 160 g/m²	LB of A 220 g/m²	CM of B 160 g/m²
Basis Weight		g/m²	129.2	166.3	195.3	208.5	246.3	117.7	163.9	220.1	160.1
Thickness		mm	0.173	0.244	0.294	0.306	0.368	0.225	0.316	0.305	0.297
Density		g/cm³	0.75	0.68	0.66	0.68	0.67	0.52	0.52	0.72	0.54
Burst Strength		kg/cm²	4.52	5.30	6.08	7.10	7.32	2.62	3.16	6.77	1.91
Brust Index		–	3.50	3.19	3.11	3.41	2.97	2.23	1.93	3.08	1.19
Ring Crush	MD	kg	24.8	37.1	43.7	47.9	52.8	22.1	35.8	45.0	29.9
	CD	kg	19.0	27.9	32.4	32.4	37.6	17.0	27.5	33.0	22.3
Ring Crush Index	MD	–	19.2	22.3	22.4	23.0	21.4	18.8	21.8	20.4	18.7
	CD	–	14.7	16.8	16.6	15.5	15.3	14.4	16.8	15.1	13.9
Tensile Strength	MD	kg	13.5	17.2	19.6	24.2	26.2	11.2	14.9	22.4	–
	CD	kg	6.08	7.63	8.75	9.30	10.6	4.58	7.54	9.1	–
Stretch	MD	%	2.3	2.0	2.0	2.1	2.0	1.8	2.1	2.1	–
	CD	%	4.5	5.1	4.0	5.2	4.2	3.5	3.5	4.0	–
Tensile Breaking Length	MD	km	6.97	6.90	6.69	7.74	7.09	6.34	6.06	6.78	–
	CD	km	3.14	3.06	2.99	2.97	2.87	2.59	3.07	2.67	–
Concora Crush	CD	kg	–	–	–	–	–	24.5	32.7	–	–
Concora Crush Index	CD	–	–	–	–	–	–	20.8	20.0	–	–
Moisture Content		%	9.3	9.2	9.1	9.1	9.0	9.4	9.2	9.1	8.4

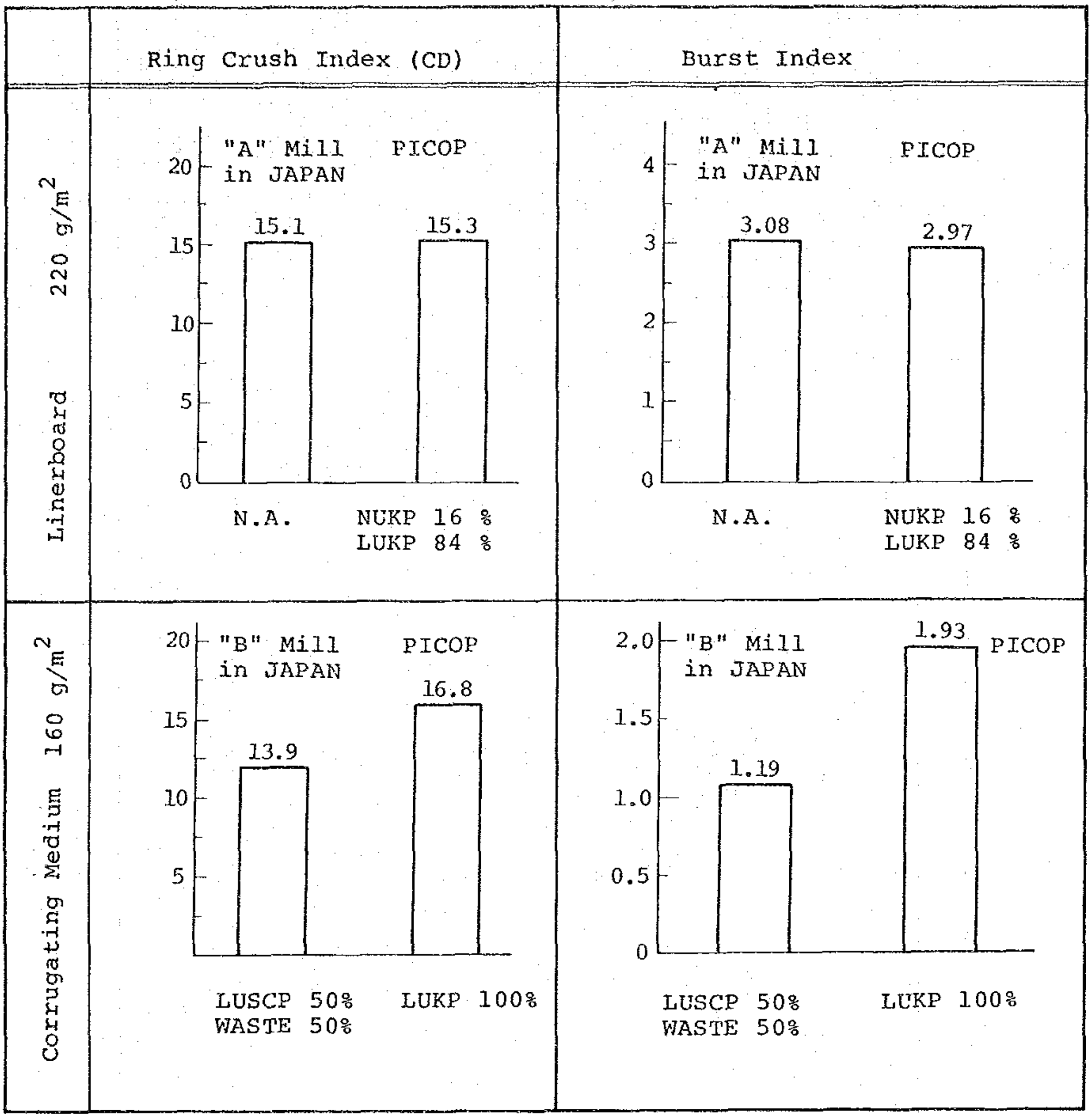
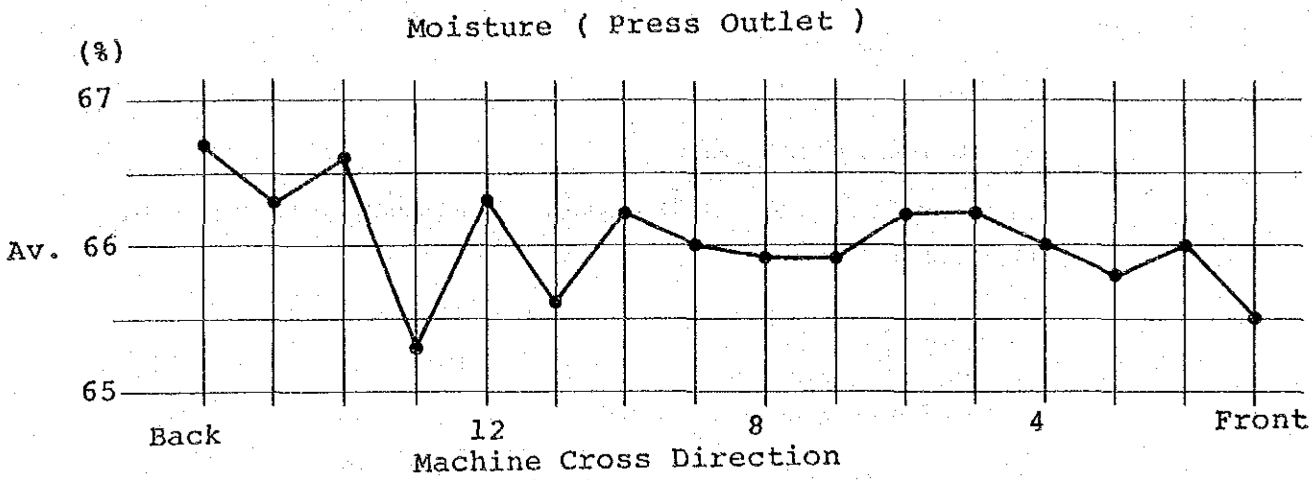
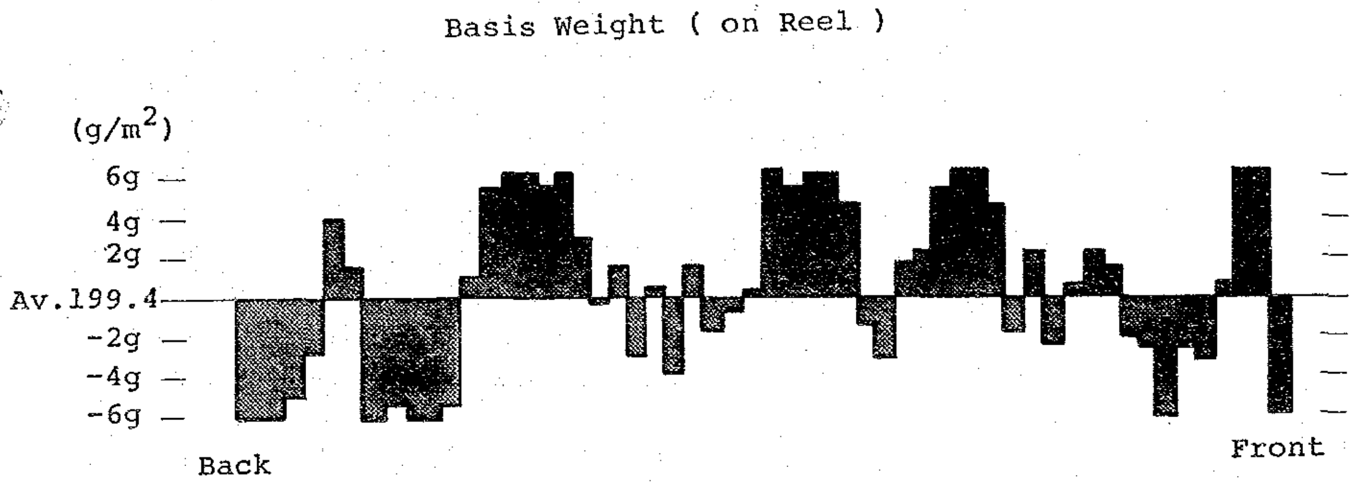


Fig. III–2–7 Comparison of Major Strength Properties of Containerboard





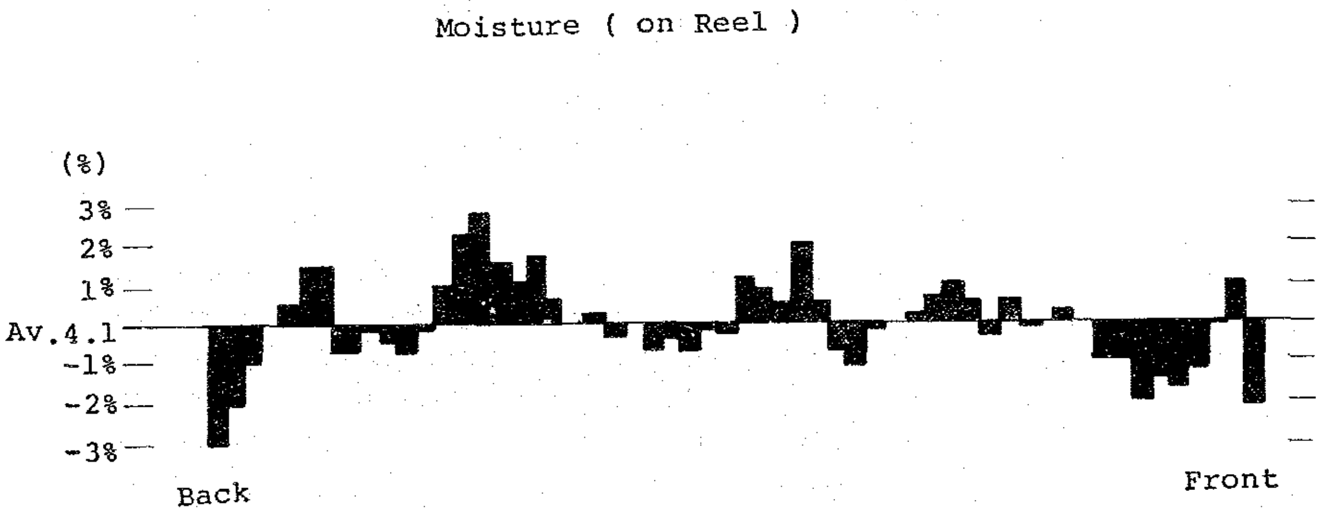


Fig. III-2-8 Profiles (No. 2 Paper Machine)

2-2-7 Recausticizing and Lime Kiln

The process is composed of Dorr Oliver recausticizing system and rotary kiln for lime calcination.

1) Recausticizing

(1) Outline of equipment

The following items are installed:

Green liquor clarifier	(9.7mD x 6mH, 440m^3)	2 units
Lime slaker with classifier		1 unit
Causticizer	(20m^3)	4 units
White liquor clarifier	(9.7mD x 6mH, 440m^3)	1 unit
Primary lime mud washer	(10.5mD x 6mH, 520m^3)	1 unit
Secondary lime mud washer	(10.5mD x 6mH, 520m^3)	1 unit
Green liquor storage tank	(9.2mD x 6mH, 400m^3)	1 unit
White liquor storage tank	(9.7mD x 6mH, 440m^3)	2 units
Weak liquor storage tank	(9.2mD x 6mH, 400m^3)	1 unit
Lime mud storage tank	(4.1mD x 6mH, 80m^3)	1 unit
Lime mud filter	(1.5mD x 2mL, 9.4m^2)	2 units
Dregs filter	(1.25mD x 1.75mL, 9.4m^2)	1 unit

Note: a) Clarifier and mud washer are all dieselized for emergency.
b) No. 3 causticizer stopping due to agitator blade corrosion.

(2) Output in recent three months

White liquor output:

Average: 545 m^3/d (60 t active alkali/d)
Max. : 682 m^3/d (75 t active alkali/d)

(3) Operation

a) The dregs was directly washed out at dregs filter as there was no dregs washer. The filter was not maintained well, as filter cloth wrinkled and truned over at its edges. Concentrated dregs by the filter was dripping out and accumulated around the sewer mouth. Alkali loss accompanied with the dregs is supposed to be considerable.

b) Suspended solids content in white liquor was measured as 130 mg/l and poor sedimentation of lime mud in white liquor clarifier or in lime mud washer were reported. Low clarity of green liquor, excess charge of calcined lime, high causticity (*), etc. are supposed to be the cause of the difficulty. Search for true reason should be made under strengthened supervision to prevent their rakes from unexpected stops.

* Note: According to PICOP's data file, causticity of white liquor is 84.6% at total alkali content of 124 g/l as Na_2O. This condition is close to equilibrium causticity.

2) Lime Kiln

(1) Outline of equipment

Number of unit:			One unit
Type of unit	:	Long type rotary kiln	
Dimension	:	Outer diameter	2.436 m
		Inner diameter	2.136 m
		Total length	69 m

Ordinary quality of firebricks but no thermal insulation bricks are used. Conventional type of calcined lime shaking cooler is installed but no heat recovery system.

(2) Output in recent three months

Calcined lime output:

Average	:	70 t/d
Max.	:	100 t/d
Available CaO	:	85 ± 2% (target)

(3) Operation

a) Heavy oil consumption in recent three months averaged 223 liters per ton of calcined lime. It is rather high compared with new practice on those kiln which equipped with heat recovery type cooler for calcined lime and with heat insulation brick.

b) Some extent of slide off of the body due to miss adjustment of the trunnion rollers, or some extent of draft variation have recorded however lead to no serious problems.

2–2–8 Evaporator

1) Outline of equipment

		No. 1 Line		No. 2 Line (stand-by)	
Type		LTV		LTV	
Manufacturer		IHI-Swenson		Swenson	
Feed black liquor					
Flow rate	t/h		131.6		65.0
Concentration	% DS		12		12
Product black liquor					
Flow rate	t/h		31.6		15.6
Concentration	% DS		50		50
Evaporation	t/h		100		49.4
Heating surface area	m^2	1V	675	1V	270
		2V	675	2V	530
		3V	760	3V	706
		4V	760		
		5V	760		
		6V	760		
Number of effects (design)			6		3

Note: LTV; long tube vertical type
V ; vessel

2) Operating data (1983)

Feed black liquor			
Flow rate	t/h	129.5	
Concentration	% DS	12	
Product black liquor			
Flow rate	t/h	38.9–37.9	
Concentration	% DS	40–41	40–41
Evaporation	t/h	90.6–91.6	
Number of effects		5	3
Operating time	h/yr	7,176	2,580

3) Cleaning

Hot water cleaning (Steam heating)	2 h/d
Mechanical cleaning	10 h/d
Caustic cleaning	necessary to soften scales adhering to tubes instead of acid cleaning

4) Utility consumption

Electric power	245 kWh/t-Na_2O (as A.A in WL)
Steam	9.5 t/t Na_2O (as A.A in WL)
Mill water	5.0 m^3/t-Na_2O (as A.A in WL)

Note: WL ; white liquor
A.A ; active alkali

5) Present situation and problems

(1) Dry solid concentration of product of 40 – 41% is very low and not suitable for utilizing black liquor energy and stable operation of recovery boiler.

(2) Despite low concentration of product, long cleaning time for hot water cleaning and mechanical cleaning is necessary, so operating time of No. 1 line evaporator (6 bodies 6 effects) decreases.

No. 2 line evaporator (3 bodies 3 effects, stand-by) which has low heat economy was in operation for 2,580 hrs in 1983 in order to maintain catch-up capacity, and incurred low heat economy as a whole.

(3) The main reason of operating troubles may be that scaling and plugging of black liquor easily occure in the tubes of evaporator in course of concentration of black liquor. It seems difficult that black liquor is concentrated up to 50% through tubular (LTV) evaporator without forced circulation.

2–2–9 Kraft Chemical Recovery Process

1) Na-S balance
Na-S balance is shown in Table III–2–7.
Soda recovery efficiency is shown in Table III–2–8.

2) Present situation and problems
Soda recovery efficiency is less than 90% and very low as compared with those of modern kraft pulp mills, so there is room of cost reduction by improvement of recovery efficiency. Soda losses are mainly composed of those of recovery boiler, the cause and the sources of the other losses should be investigated.

Table III-2-7 Na-S Chemical Balance

Point and Type of Discharge	Total loss kg/UKP.BDt		Point and Type of Make-up	Total Make-up kg/UKP.BDt	
	Na as Na_2SO_4	S as S		Na as Na_2SO_4	S as S
Recovery Boiler			Recovery Boiler	66.6	15.0
Main Dissolving Tank	24.0	8.92			
Stack gas	13.2	4.86			
Recausticizing Plant	6.3	0.26			
KP Mill - Bound Soda	8.2	0.34			
- Sewer Loss	6.3	0.26			
Evaporator	8.6	0.36			
Total	66.6	15.0	Total	66.6	15.0

Table III-2-8 Soda Recovery Efficiency

WL (White liquor, as Na_2O) Consumption (1983)

Pulp (UKP)	Actual Consumption A.A as Na_2O t/yr	Usage Rate kg A.A as Na_2O/UKP.BDt
UKP (EBK - STD)	8,984	229
(KF - FAL)	35	230
(KF - LB)	6,720	249
(KF - CM)	4,778	200
Total	20,517	(Average) 227

WL Composition

	as Na_2O g/l
Na_2S	22.4
NaOH	86.1
Na_2CO_3	15.7
Na_2SO_4	2.3
Total Soda	126.5

	as Na_2O g/l
Active Alkali (A.A)	108.5
Total Alkali (T.A)	124.2

Soda Recovery Efficiency

Soda loss (according to Na-S Balance) = 66.6 x 62/142 = 29.0 kg as Na_2O/UKP.BDt

Soda recovery efficiency = [1 - 29.0/(227 x 126.5/108.5)] x 100 = 89.0 %

2–2–10 Power Plant

1) Recovery boiler

(1) Outline of equipment

Type		CER with cascade evaporator
Manufacturer		Mitsubishi Heavy Industries (MHI)
Design capacity		408 DSt/d
Steam generation		60 t/h
Steam condition	Pressure	91 kg/cm²G
	Temperature	482 °C

(2) Operating data (1983)

		Design	Actual
Receiving black liquor			
Concentration	%DS	50	41
Flow rate	m^3/h	27.5	35
Spraying black liquor			
Concentration	%DS	68	62
Flow rate	m^3/h	18	21
Reduction rate of smelt	%	95	90–95
High heating value of black liquor	kcal/DSkg	3,722	3,530–3,350
Washing of cascade evaporator			18 h/wash (every 15 days)
Operating time			8,210 h/yr

2) Power boiler

(1) Outline of equipment

Type		Front oil firing
Manufacturer		Ishikawajima-harima Heavy Industries (IHI)
Steam generation		182 t/h
Steam condition	Pressure	91 kg/cm²G
	Temperature	482 °C

(2) Operating data (1983)

Steam generation	110 t/h
Operating time	7,420 h/yr

3) No 1 Bark boiler

(1) Outline of equipment

Type		Inclined grate with pin hole
Manufacturer		Ishikawajima-harima Heavy Industries (IHI)
Wood fuel (Solid)		623 m^3/d
Steam generation		114 t/h
Steam condition	Pressure	91 kg/cm^2G
	Temperature	482 °C

(2) Operating data (1983)

Steam generation	57 t/h
Operating time	8,452 h/yr
Wood fuel (Solid)	163,893 m^3/yr
Bunker C oil	16,916 kl/yr

4) No. 2 Bark boiler

(1) Outline of equipment

Type		Horizontal stoker
Manufacturer		Ishikawajima-harima Heavy Industries (IHI)
Wood fuel (Solid)		623 m^3/d
Steam generation		114 t/h
Steam condition	Pressure	91 kg/cm^2G
	Temperature	482 °C

(2) Operating data (1983)

Steam generation	88 t/h
Operating time	8,452 h/yr
Wood fuel	304,417 m^3/yr
Bunker C oil	2,496 kl/yr

5) Boiler feedwater plant

(1) Outline of equipment

Water treatment (Flocculation and sedimentation)	1 unit	260 m^3/h
Deionizing equipment	3 units	3x130 m^3/h
Polisher (mixed bed)	3 units	3x130 m^3/h
Iron filter	1 unit	60 t/h
Deaerator	1 unit	430 t/h

(2) Operating data (1983)

Flow of deionized water	210 – 230 m^3/h
Flow of deaerator	294 t/h
Water quality of deionized water (SiO_2)	0.01 ppm

6) 20 MW turbine generator

– Outline of equipment

Type	Extraction and back pressure		
Manufacturer	Toshiba		
Capacity			20 MW
Steam condition	Main steam	pressure	87.5 kg/cm^2G
		temperature	477 °C
		max. flow	236 t/h
	Extraction	pressure	28.7 kg/cm^2G
		max. flow	91 t/h
	Back	pressure	10.5 kg/cm^2G
		max. flow	192 t/h

7) 30 MW turbine generator

– Outline of specification

Type	Extraction and condensing		
Manufacturer	Toshiba		
Capacity			30 MW
Steam condition	Main steam	pressure	87.5 kg/cm^2G
		temperature	477 °C
		max. flow	154 t/h
	Extraction	pressure	3.5 t/h
		max. flow	91 t/h
	Condensing	pressure	684 mmHg Vac.
		max. flow	132 t/h

8) Diesel generators (Pielstock)

– Specification 2 units x 11.5 MW

9) Present situation and problems

(1) Bislig Mill has efficient and sufficient equipment for steam and power generation, which will contribute to future mill expansion.

(2) The most serious problem is unstability of main steam pressure of power plant. Energy of generated steam from boilers is not effectively utilized for power generation. And it is not desirable on safety that pressure parts are severely affected by wide range fluctuation of main steam pressure. It seems that unstability of main steam pressure is caused by defect of automatic oil combustion control (ACC) system of power boiler and insufficient capability of ACC system of No. 1 bark boiler (or No. 2 bark boiler). Prompt improvement of ACC or power boiler will be expected for energy conservation and safety.

(3) Boilers have suffered from corrosion trouble and failure of superheater tubes and have been obliged to decrease operating time because of high pressure and temperature of generated steam.

(4) Heavy oil consumption for auxiliary firing at recovery boiler is too much (3,761 kl/yr in 1983), because concentration of black liquor from the evaporator is very low and low load of recovery boiler necessitates additional firing of heavy oil.

2–2–11 NPC Power Receiving (Substation)

1) Outline of equipment

Capacity	40	MVA
Voltage and frequency	138kV/60	Hz
Transformer	138kV/13.8	kV

2) Contract of power receiving (1984)

Allowable max. demand	23	MW
Allowable max. energy	13,248	MWh/month

3) Voltage variation — −4.35 – 0.72% (13.2 – 13.9 kV)

4) Frequency variation — −1.0 – 0.83 % (59.4 – 60.5 Hz)

5) Single line diagram of electrical power system
The diagram above is shown in Fig. III–2–9.

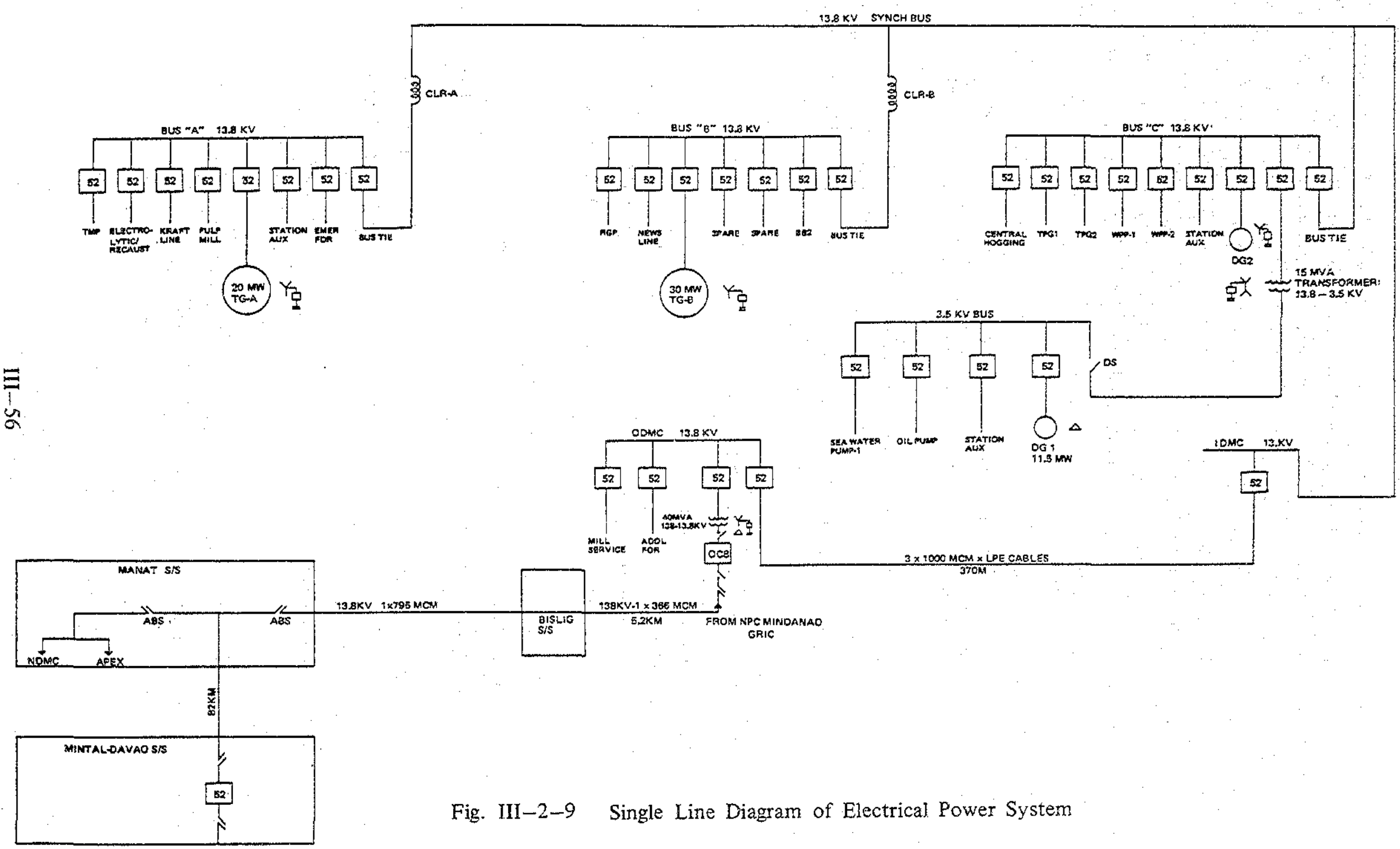


Fig. III–2–9 Single Line Diagram of Electrical Power System

6) Present situation and problems

Cheap purchased power from NPC (National Power Corporation) has contributed to energy cost reduction from the middle of Decenber in 1983. Bislig Mill has suffered from voltage and frequency fluctuations through parallel running between NPC and in-plant power generation.

The fluctuations cause decreasing efficiency of No. 1 paper machine. On the other hand, Mindanao grid is under construction to complete the loop, so the Mill will be released from the fluctuations in the middle of 1985. Allowable demand will be increased up to the capacity of power receiving. The increased allowable demand will contribute to further energy cost reduction.

2–2–12 Mill Water Equipment

1) Waterintake and transportation of river water

(1)	Water source river		Borboanan River (Source 300,000	m^3/d)
(2)	Waterintake pump	2 units	38 m^3/min x 450 Diesel-engine drive	HP
(3)	Water pipeline		660$^\phi$ x 4	km
(4)	Bagnan Reservior (Water source)		Capacity 1,350,000 Available 1,000,000	m^3 m^3
(5)	Transit water pump	3 units	20.8 m^3/min x 220 Diesel-engine drive	HP
		1 unit	18.9 m^3/min x 270 Diesel-engine drive	HP
(6)	Water transportation line	pipeline canal	660$^\phi$ x 1.9 4.0	km km
(7)	Comawas Reservoir (transit reservoir)		7,500	m^3
(8)	Transit water pump	3 units	18.9 m^3/min x 200	kW
(9)	Water pipeline		660$^\phi$ x 3.7	km

2) Mill water equipment

(1)	Mill water reservoir		15,000	m^3
(2)	Mill water pump	3 units	18.9 m^3/min x 200	kW
(3)	Fire fighting pumps	1 unit	Motorized	
		1 unit	Diesel-engine drive	
(4)	Cooling water pump (Sea water)	4 units		
	Water use		30 MW turbine, evaporator and diesel generator	

3) Water flow

The flow diagram is shown in Fig. III–2–10.

4) Water quality data

Quality of river and mill water is shown in Table III–2–9.

5) Present situation and problems

Bislig Mill has sufficient water source, huge water source reservoir, transit water reservoir and mill site reservoir, those have enough capacity to supply water in case of mill expansion.

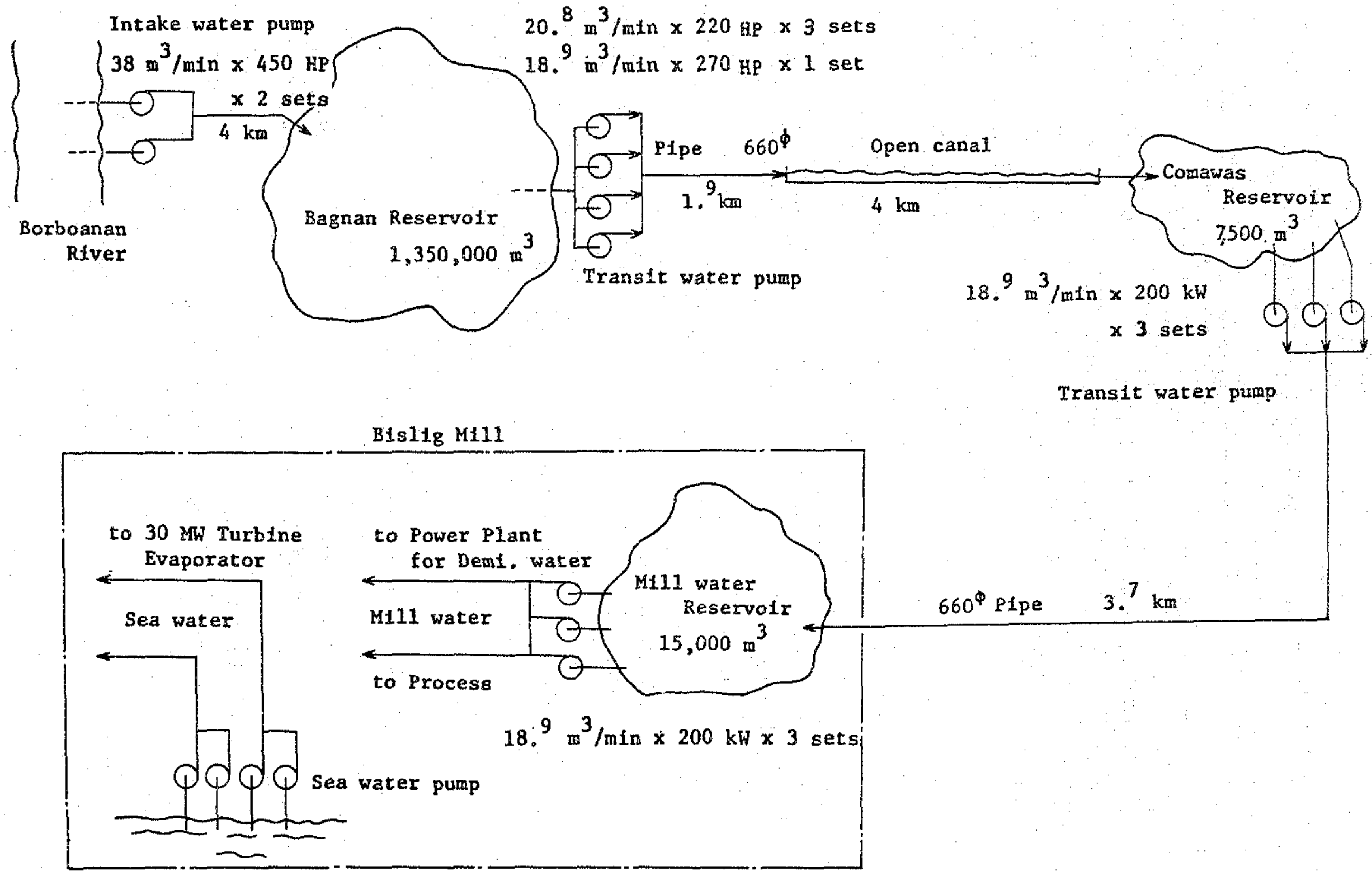


Fig. III–2–10 Flow of River and Mill Water

Table III-2-9 Quality of River and Mill Water

			River Water	Mill Water
1.	PH		7.4 – 8.6	7.0 – 8.5
2.	Total Hardness as $CaCO_3$	ppm	36 – 136	70 – 140
3.	Total Air (CO_2) as $CaCO_3$	ppm	41 – 126	93 – 112
4.	Chlorides as NaCl	ppm	1 – 8	0 – 30
5.	SiO_2	ppm	5 – 20	1 – 16
6.	Iron	ppm	0.31 – 0.52	0.24 – 1.84
7.	Conductivity	mho/cm	65 – 136	100 – 160

2–2–13 Utility

1) Electric power

(1) Electric power system

NPC power receiving	138	kV,	60 Hz
Power generation	13.8	kV,	60 Hz
High voltage line (HV)	2,300	V,	60 Hz
Low voltage line (LV)	440	V,	60 Hz
Control	110	V DC/AC,	60 Hz
Motor HV	not less than		132 kW
LV	less than		132 kW

(2) Electric power cost (Aug. 1984)

– Power generation cost 0.9382 P/kWh
– Purchased power 0.4095 P/kWh
– Total electric power cost 0.7430 P/kWh

(3) Power Balance

Typical power balance is shown in Table III–2–10.

2) Steam

(1) Steam condition

– Generated steam from boilers	1,300 psig x 482°C
	(91 kg/cm²G)
– Inlet steam of turbines	1,250 psig x 477°C
	(87.5 kg/cm²G)
– 405 psig steam	410 psig x 349°C
	(28.7 kg/cm²G)
– 20 MW turbine, back steam	150 psig x 250°C
	(10.5 kg/cm²G)
– 30 MW turbine, extraction steam	50 psig x 160°C
	(3.5 kg/cm²G)
– Medium pressure process steam	145 psig x 244°C
	(10.2 kg/cm²G)
– Low pressure process steam	45 psig x 154°C
	(3.2 kg/cm²G)

(2) Steam balance and steam flow

Typical steam balance and steam flow are shown in Table III–2–11 and Fig. III–2–11 respectively.

3) Mill water

(1) Mill water balance

Typical mill water balance is shown in Table III–2–12.

(2) Mill water cost (Aug., 1984) 0.95 P/m³

4) Utility unit consumption

Utility unit consumption is shown in Table III–2–13.

Table III-2-10 Typical Electric Power Balance

	Generated power Purchased power	Distribution
	kW	kW
1. 20 MW Turbine Generator 30 MW Turbine Generator NPC	13,700 10,050 14,200	
2. TPMD Plants		3,850
3. Wood preparation plants		1,940
4. Pulp Mill Cooking, Screening & Washing Bleach Plants RGP/TMP Plant		(14,020) 1,950 220 11,850
5. Paper Mill Newsprint Machine Board Machine		(9,750) 6,700 3,050
6. Chemical Plant Electrolytic Plant Recaust. & Kiln Evaporator		(2,200) 1,785 260 155
7. Power plant Power boiler Bark boilers Recovery boiler 20 MW & 30 MW T/G Feedwater Mill water		(5,085) 160 1,845 460 360 1,360 900
8. Mill service		1,105
Total	37,950	37,950

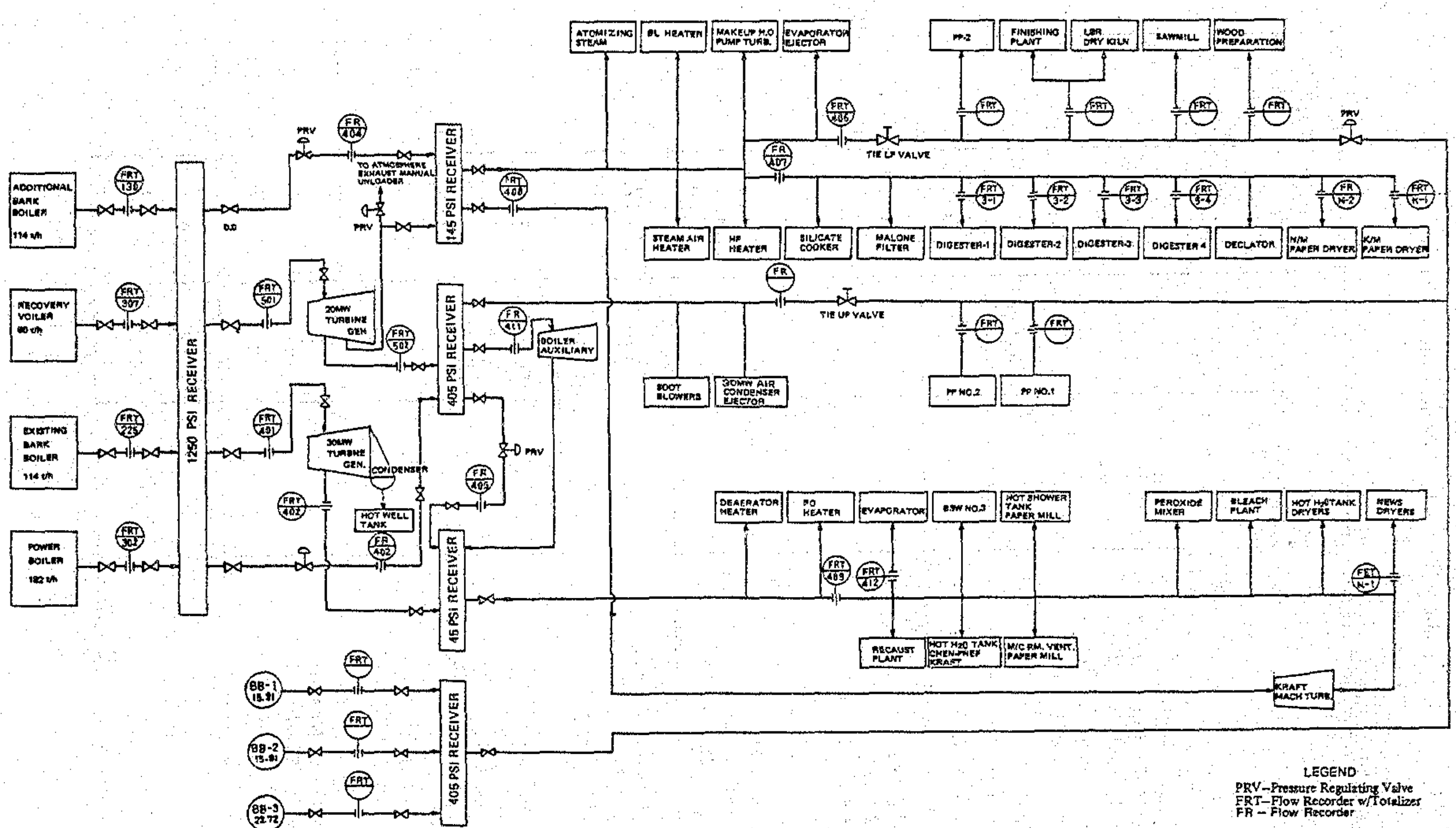


Fig. III–2–11 Steam Flow

Table III-2-11 Typical Steam Balance

	Steam Generation t/h	Steam Distribution 405# t/h	145# t/h	45# t/h	Total t/h
1. Steam Generator					
Power boiler	89				
Bark boiler No.1	57				
Bark boiler No.2	88				
Recovery boiler	45				
2. TPMD		16.9	7.1	-	24.0
3. Wood Preparation		-	10.0	-	10.0
4. Pulp Mill			(13.5)	(8.0)	(21.5)
Cooking		-	13.5	4.9	18.4
Bleach Plant		-	-	1.3	1.3
RGP/TMP		-	-	1.8	1.8
5. Paper Mill			(35.3)	(19.7)	(55.0)
Newsprint Machine		-	6.7	18.1	24.8
Board Machine		-	28.6	1.6	30.2
6. Chemical Plant			(1.2)	(27.9)	(29.1)
Recaust. & Kiln		-	-	0.8	0.8
Evaporator		-	1.2	27.1	28.3
7. Power Plant		(6.4)	(35.6)	(97.4)	(139.4)
Boilers		6.2	21.1	3.5	30.8
30 MW T/G		0.2	-	-	0.2
Relief to Atmosphere		-	1.8	1.3	3.1
Feed water heating		-	12.7	52.3	65.0
30 MW T/G Condensing Steam		-	-	40.3	40.3
8. Turbine Drive					
Power Plant		[61.6]	-	[61.6]	-
Board Machine		-	[15.7]	[15.7]	-
		[84.9]	[118.4]	[75.7]	[279.0]
Total	279	23.3	102.7	153.0	279.0

Table III-2-12 Typical Mill Water Balance

Mill water distribution		Flow rate m^3/h
1.	Wood preparation Plant	(162)
	Debarker	103
	Chipper	59
2.	Pulp Mill	(1,036)
	Cooking, Screening & Washing	354
	Bleach Plant	305
	RGP/TMP Plant	377
3.	Paper Mill	(645)
	Newsprint Machine	372
	Board Machine	273
4.	Chemical Plant	(76)
	Electrolytic Plant	8
	Recaust. & Kiln Evaporator	68
5.	Power Plant	223
6.	Other	14
	Total	2,156

Table III-2-13 Utility Unit Consumption

		NP	LB	CM	RGP/TMP	SBKP	EBK	KF-CM	KF-LB
1.	Electric Power (kWh/t or BDt)	715	435	451	2,718	63	187	187	188
2.	Steam 145 psig	0.749	2.939	3.007			1.607	0.975	1.114
	(145-45)	-	(1.747)	(1.993)			-	-	-
	45	2.103	0.200	0.200	0.449	0.349	0.462	0.459	0.476
	(t/t or BDt) Total	2.852	3.139	3.207	0.449	0.349	2.069	1.434	1.590
3.	Mill water (m^3/t or BDt)	41.5	32.9	34.0	88.1	80.6	32.1	32.6	32.0

Notes ; NP : Standard Newsprint
LB : Liner Board
CM : Corrugating Medium
EBK : Eeasily Bleachable Kraft
KF-CM : Kraft Furnish for Corrugating Medium
KF-LB : Kraft Furnish for Liner Board

2–2–14 Environment

1) Effluent

(1) Water quality and flow of effluent

Effluent quality and flow are shown in Table III–2–14.

(2) Regulation of effluent discharge

NPC (National Pollution Control Commission) regulation and actual data of effluent are shown in Table III–2–15.

2) Dust and gas

Data of emission concentration and NPC regulation are as follows.

		Actual data	NPC regulation
Dust	mg/scm	600 – 1,340	max. 500
SO_2	mg/scm	500 – 1,250	1,500
H_2S	mg/scm	15	15

Notes: a) Figures above to be measured at emission point (stack)
b) scm: standard cubic meter (0°C, atmosphere)

3) Present situation and problems are described in the clause III–2–7–10.

2–2–15 Chemicals and Fuel Oil

1) Chemicals

Chemicals price and annual consumption are shown in Table III–2–16.

2) Fuel oil

Fuel oil price and annual consumption are shown in Table III–2–17.

Table III–2–14 Typical Effluent Flow and Pollutant Load

	Flow m^3/d	BOD_5 mg/l	BOD_5 Load kg/d	Suspended Solid mg/l	pH
1. Pulp Mill 1	6,439	305	1,963		
2	1,369	65	89		
2. RGP/TMP 1	590	630	1,385		
2	1,608				
3. Newsprint 1	4,000	361	2,652		
2	3,346				
4. Board	6,611	203	1,342		
5. Recausticizing	1,779				
6. Evaporator	588	469	1,945		
7. Recovery boiler	1,780				
8. Sea water for Cooling	16,500	-	-		
9. Main Sewer Outfall	44,610	210	9,376	460	7.4

Table III–2–15 Effluent Discharge Regulation and Actual Data

		Actual Data	NPC Regulation
1. Color	Units	250 - 500	less than 300
2. pH		7.4	5.5 - 9.0
3. Temperature	^oC	31	less than 40
4. Suspended Solids	mg/l	320 - 500	less than 400
5. BOD_5	mg/l	200 - 500	less than 500
6. Mercury	mg/l	0.00038	less than 0.01
7. Oil/Greese	mg/l	1.66	less than 15

Table III-2-16 Chemicals

		Unit Price P/t	Consumption t/yr
Sodium chloride	Nacl	523	6,300
Limestone	$CaCO_3$	16	4,155
Salt cake	Na_2SO_4	2,808	5,367
Washer additive		30,763	22
Pitch disp.		49,358	36
Chlorine (Own made)	Cl_2	4,729	1,777
Caustic soda (Own made)	NaOH	2,949	1,963
Hypochlorite (Own made)	NaClO	7,752	750
Sodium sulfite	Na_2SO_3	4,277	182
Hydrogen peroxide	H_2O_2	37,683	307
Sulfur dioxide	SO_2	20,202	216
Magnesium sulfate	$MgSO_4$	3,475	6.2
Sodium silicate	Na_2SiO_3	3,853	231
Coco oil		15,506	139
Sulfuric Acid	H_2SO_4	1,910	84
Alum		3,016	1,264
Rosin size		36,681	148
Slimicide			
Wet strength agant		23,077	63
Acetic acid		29,840	4.1
M. Violet		523,226	6.5
Rhoda. Red		455,007	0.6
Methyl Blue		315,380	0.3
Nosh size		36,680	125
Wetstreg		24,740	63
CATO 15		28,776	126
Favamyl		13,687	13
Hydrazine	N_2H_4	122,868	0.6
Trisodium phosphate	Na_3PO_4	4,289	1.4
Disodium phosphate	Na_2HPO_4	9,875	1.3
Hydrochloric acid (as 100%)	HCl	4,396	69

Table III-2-17 Fuel Oil

	1983		1984 (Projected)	
	Price P/kl	Consumption kl/yr	Price P/kl	Consumption kl/yr
1. Bunker C oil	2,562		4,758	
Power boiler		58,126		44,556
No.1 Bark boiler		16,916		10,177
No.2 Bark boiler		2,496		2,462
Recovery boiler		3,761		2,684
Sub total		(81,299)		(59,879)
Lime kiln		4,686		5,193
Sub total		(85,985)		(65,072)
Diesel generator		8,734		-
Total		94,719		65,072
2. Diesel oil	3,247		6,129	
Diesel generator		239		-
Water source pumps		6,300		6,270
Total		6,539		6,270

2–3 Maintenance System

2–3–1 Machine Shop

In the industrialized developed countries, there are many instances where the repair and maintenance works are dependent on the other affiliated companies. However in Bislig Mill they have to provide their own activities on maintenance as there is no facilities to be utilized in the area.

1) Major machines installed are as follows:

Lathe	10 units
Milling machine	4 units
Shaper	2 units
Drill	3 units
Planer	1 unit
Universal milling machine	1 unit
Boring machine	1 unit
Band saw	2 units
Roll grinder	2 units

Number of employees required for the work is 180. Practically all repairs and manufacturing of parts can be done by this machine shop. Boiler tube welding is worked out by the welders in this machine shop as well.

The relining of rubber rolls is conducted by a Japanese manufacturer. The time needed for relining is about six months including transportation. Therefore, they have a spare roll for each type of rubber roll, and four rolls are sent to Japan at a time for relining.

2) They have enough equipment for electrical repair work and can rewind coils of motors.

In addition, they have forging and woodwork equipment.

The average repair work and modification in this mill can be well performed by this maintenance shop.

2–3–2 Maintenance System

The maintenance is adopting a similar system to that of average pulp and paper mills in Japan.

1) All equipment is periodically checked based on a check list.

Experienced persons handle this work, and they check equipment, discover irregularities and confirm normal operation. Minor repairs and adjustments are done on the spot.

These activities are done at predetermined intervals during the work of 24 h/d.

2) Apart from the preventive maintenance above, there are additional number of personnel related to lubrication.

A lubrication manual (adequate lubrication frequency, adequate lubrication oil and adequate quantity are described) is provided, and the lubrication work is conducted at predetermined intervals as described in the manual.

2–3–3 Plan of Shutdown

1) Shutdown planning in small scale
A Maintenance Planning Meeting is held daily based on the results and problems discovered by the maintenance team and requests from the manufacturing department. Planners, operators and machine shop personnel attend this meeting and discuss repair items, repair schedule, operation stoppage plan and other items.

2) Shutdown planning in mill scale
By the preliminary meeting five months prior to the shutdown, conceptual shutdown plan is discussed, which followed by a meeting one month before the shutdown and makes preparations for it including material arrangement and a meeting is held a week or two before the shutdown to confirm.

3) Planning of repair work and scheduling of shutdown time are conducted by the maintenance planning section.

2–3–4 The Team's View on the Maintenance

There are little problem in relation to planning and conducting execution of the repair work. It is acknowledged that the efforts have been made on the technical education through seminars and on-the-job training.

However, on the actual maintenance aspect of the mill equipment, several insufficient instances such as steam leaks, excess cooling water etc. were observed on the mill visit. On the other hand, those corroded foundation of vacuum evaporator support should be fixed by urgent repair. It is understandable that there are difficulties on the maintenance of equipment due to the insufficient budget allocation and materials, however, thorough maintenance shall be completed for the sake of extending equipment life.

Complete maintenance of utilities combined direct saving of cost as well as further efforts on the checking system are requested.

2–4 Quality Control System

1) Quality standards
Company standards are well established for each product grade and basis weight, and this information is clearly noted on order sheets and quality inspection reports.

2) Quality inspection
The development and technical service section engages in daily quality inspections. The data obtained is statistically processed, and since marks such as X, σ, R, etc. are recorded for each lot, the records are very useful for data analysis.

3) Measuring equipment
The development and technical service section takes good care of all quality measuring equipment and the personnel engaged in taking measurements are will educated and trained.

4) Basis weight and moisture content continuous measuring instrument
The latest BM meter made by Accuray is installed at No. 1 PM and No. 2 PM respectively, and the machine operator adjusts the operation while watching the display on CRT (cathode ray tube).

5) The measuring method of edgewise compression of corrugating medium has been developed and put into use based on a Canadian measuring method and they have added an adaptor of their own invention. The positive attitude of the personnel is quite noticeable.

6) Quality information from users
Quality information from users is obtained during periodic visits by the technical service personnel of PICOP Trading Corp. This information is effectively fed back to the manufacturing department.

7) Data related to operation status
CORPLAN is in charge of recording and analyzing data related to the operation, such as machine efficiency, downtime, and records are systematically kept. We were able to refer to old data as we needed.

Various graphs, such as describing machine efficiency, or representing cost control, are displayed on the paper machine office wall.

8) Employee participation

Work responsibility is clearly defined and understood. We did not notice evidence of campaigns aimed at quality consciousness or control through setting targets, and this is probably due to differences in national work concepts. We think that encouraging employees to make proposals for improvement would help increase participation.

2–5 Production Control System

1) Mill organization

When Pulp and Paper Manufacturing Division (PPMD) has established, the mill management was carried out with the supervision of the International Paper Co. in U.S.A., and necessary function to the production control has been established since then.

Most of the necessary information is delivered to the Study Team from CORPLAN promptly on the request. There were numerical discrepancies at times among the data delivered, and improved abilities in terms of data checking and analysis seemed to be necessary. Several engineers who have experienced and trained in the overseas mills are posted at department managers. Therefore average level of mill management is said to be attained by existing organization.

As to the production statistics, operation efficiency and unit consumption of utilities, separate description is to be shown in this report some views on the productivity and annual operating days are stated in the following.

2) Productivity

It is understandable for PICOP to need an additional man power for repairing work and product transport in long distance due to the remote mill location. However, there is room to be rationalized in the productivities, and every efforts should be made to reduce production costs as far as there is any possibilities.

The comparison is made in the following operation figures of Oji Paper Co. and PICOP.

Table III-2-18 Comparison of Productivity

	Oji (1983)	PICOP (1983)	Oji/PICOP ratio
Employees (person)	5,665	1,859*	3.05
Paper Production (t/yr)	1,941,600	139,789	13.9
Paper Sales (1,000 US$)	1,483,000	73,629	20.1
Productivity (t/yr/person)	342.7	75.2	4.6
Sales per person (1,000 US$/yr person)	261.8	39.6	6.6

* Breakdown of number of employees in PICOP is as follows:

Pulp plant	100
Paper plant	128
Chemicals recovery plant	65
Finishing	130
Sub total	423
Supporting Divisions	1,031
Total	1,454
Administration	405
Grand total	1,859

405 for administration are allocated by PICOP in relation to the magnitudes of work where total administration staff are counted 1,213.

According to the comparison, Oji is 4.6 times of PICOP in the productivity. Of course it must be recognized that there is some benefits due to the production scale affecting condition of Oji. However, total number of employees for the work of administration, financial, materials procurements, marketing, and personnel for five mills and head office of Oji are 1,074. PICOP's 1,213 as a indirect portion for the manufacture is too much. At the same time, balance of 808 after allocated 405 to the pulp and paper division are for the log sales and timber processing division. The basis of this allocation needs to review.

PICOP has attained social contribution by means of employment of local labourer, nevertheless, it is requested for the survival of the company that the reconsideration of standard number of operators in the mill process as well as the indirect manufacturing man power.

3) Annual operation days of the newsprint machine
Official operation days per annum are said to be 350 days, however this is the planned days and actual in 1983, for example, was 336 days deducted by unscheduled shutdown of 14 days.

The main reason for unscheduled shutdown above were run out of wood chip and electric power supply. In other words, pulping division and power generating division have committed unefficiency of the whole mill production. Therefore, enough caution has to be paid so that planned operation day can be maintained throughout the year.

2–6 Education and Training

1) The top management of PICOP has well recognized the importance of engineering and technical skill on the view point of the actual operation and the safety.

Consequently the management has applied following training programs to the mill operators,

(a) Schooling by means of textbooks and slide.
(b) On-the-job training by means of the operation manuals.

There are no difference with the training systems adopted by the common manufacturers in Japan. As to the level of the operator's skill, fairly good proofs have been observed in terms of No. 1 paper machine speed running as high as 700 m/min by hardwood pulp only.

The operator's skill gave the Study Team advanced impression to the other Southeast Asian mills.

2) To the mill management, inclusive managers of operating departments, who have trained in the overseas firms from six months to about two years period, have been disposed. Those who met with the Study Team have shown keen attitudes in absorbing technical advices from visitors. In the research, there provided by the overseas technical periodicals and reports, people are seemingly served by the average documentary knowledges.

Some Tappi subscribers and other volantary technical personnel are said to send their delegates to the annual international conferences.

On the request of PICOP during the stay of the Study Team, Mr. Amamiya, one of the Team member, rendered lecture on energy conservation and paper machine furnish to PICOP's young engineers.

Many questions and comments were appeared after the lecture. They wanted to have an opportunity of training by those of developped countries.

At the moment PICOP is also executing operational rationalization in accordance with the engineering consultant of U.S.A.

3) It is acknowledged that the company is challenging to increase in production, however, consideration should be paid to the quality of the products. Similarly, the efforts in increasing the machine speed are resulting frequent sheet breaks and low paper machine efficiency. Further consideration is needed in terms of improved unit consumption and financial viability.

To the educational and training aspect of the operation, economical view point should be included as soon as possible.

4) The state of maintenance to the machinery and equipment is far from the satisfaction. As the matter of fundamental policy of the education, cost consciousness and true recognization of the unit consumption have to be emphasized, and thus overall maintenance level of the mill equipments are also expected to improve.

5) Conclusion

It is well perceived that those who belong to the technical concerns in PICOP are willing to learn from abroad and catch up to the developed countries.

In order to effectuate the renovation work, PICOP is expected to proceed further education and training on the production and maintenance aspect in the developed industrialized countries.

2–7 Recommendation

While number of recommendation are shown in the description of the diagnosis of each department, important points are summarized in this section.

2–7–1 Kraft Pulping Plant

1) Saving of bleaching chemicals

As stated in the paragraph of III–2–2–2, the Kappa number of unbleached kraft pulp (EBK) for bleaching is held as high as 27 – 30 which is equivalent to that of softwood pulp and incurs high consumption of bleaching chemicals.

This clause includes discussion on the possibility of bleaching chemicals saving by modifying the operating condition and flow on EBK production as follows.

- To reduce Kappa number of EBK to reasonable level of ordinary bleachable pulp
- To install secondary knotters (vibrating screen) newly
  The secondary knotters are installed to recover good fiber from rejects of the primary knotters and secondary screen
- To recover rejects of the secondary knotters to the No. 2 blow tank (for lauan pulp)

When the above modification is executed, the production capacity of digesting plant can be increased since recooking of knots and screen rejects is ceased completely.

The economic calculation of above modification is examined hereinafter. Saving of bleaching chemicals is expected on the one hand, and increased concumption of falcata chip and fixed cost increase by installing secondary knotters should be considered on the other hand. In this calculation it is assumed tentatively that knots and secondary screen rejects from EBK production are mixed with blown pulp of KF–LB grade. The calculation bases are placed as follows:

(1) Premise

a) Pulp production (Current operation base)

Semi-bleached kraft pulp	100	BDt/d
Unbleached kraft pulp for linerboard (KF–LB)	84	BDt/d
Unbleached kraft pulp for corrugating medium (KF–CM)	68	BDt/d

b) Operating days per annum

EBK production	350	d
KF–LB and KF–CM production	340	d

c) Pulping yield

SBKP yield	at current operation	90	%
	after modification	93.5	%
Cooking yield			
EBK	at current operation	55.2	%
	after modification	53	%
KF–LB		51.6	%
KF–CM		57	%
Rejects rate after modification		5.9	%

Note: Rejects rate is defined by the formula as below.

$$\frac{\text{Amount of rejects from 2ry knotters}}{\text{Amount of pulp fed to 1ry knotters}} \times 100\ (\%)$$

d) Unit consumption of bleaching chemicals

Chemicals	After Modification	Current Operation
Chlorine	40 kg/BDt	55 kg/BDt
Caustic soda	28 kg/BDt	35 kg/BDt
Sodium hypochlorite (as available chlorine)	16 kg/BDt	23 kg/BDt

Note: The above consumption figures after modification include about 10% allowances against typical consumption figures in producing bleached kraft pulp from Japanese hardwood, where brightness of pulp after C–E–H sequence will be at the level of 60 – 70%.

e) Density of woodchip

Falcata	265 BDkg/m^3
Lauan	373 BDkg/m^3

f) Unit price

Falcata chip	P 351	$/m^3$
Lauan chip	P 289	$/m^3$
Chlorine	P 2,949	/t
Caustic soda	P 4,729	/t
Sodium hypochlorite	P 7,751	/t

(2) Cost calculation

a) Wood cost

a)–1 Wood consumption by the species

– on current operation

Falcata for EBK: 100x350/(0.90x0.552x0.265)
= 265,900 m^3/yr

Lauan for KF–LB: 84x340/(0.516x0.373) = 148,400 m^3/yr

Lauan for KF–CM: 68x340/(0.57x0.373) = 108,700 m^3/yr

Falcata chip	265,900	m^3/yr
Lauan chip	257,100	m^3/yr
Total	523,000	m^3/yr

– after modification

Falcata for EBK: 100x350/(0.935x0.941x0.53x0.265)
= 283,300 m^3/yr

Rejects from 2ry knotters:
100x350x0.059/(0.935x0.941) = 2,347 BDt/yr

Lauan for KF–LB: Provided that total rejects of 2,347 BDt/yr are to be recovered in KF–LB line.
[(84x340)–2,347]/(0.516x0.373) = 136,200 m^3/yr

Lauan for KF–CM: 108,700 m^3/yr

Therefore,

Falcata chip	283,300	m^3/yr
Lauan chip	244,900	m^3/yr
Total	528,200	m^3/yr

– increase in wood consumption

Falcata chip	283,300 – 265,900	= 17,400 m³/yr
Lauan chip	244,900 – 257,100	= –12,200 m³/yr
Total		5,200 m³/yr

a)–2 Wood cost

Wood cost increases about 2,581 thousand Pesos (US$143,000) per annum.

Increase in falcata chip	17,400 x P351/m³	= P6,107,000/yr
Decrease in lauan chip	12,200 x P289/m³	= P3,526,000/yr
Increase in wood cost	6,107,000 – 3,526,000	= P2,581,000/yr

b) Bleaching chemicals cost

b)–1 Bleaching chemicals consumption

– on current operation

Chlorine	100x350x55/1000	= 1,925	t/yr
Caustic soda	100x350x35/1000	= 1,225	t/yr
Sodium hypochlorite	100x350x23/1000	= 805	t/yr

– after modification

Chlorine	100x350x40/1000	= 1,400	t/yr
Caustic soda	100x350x28/1000	= 980	t/yr
Sodium hypochlorite	100x350x16/1000	= 560	t/yr

– reduction in bleaching chemicals

Chlorine	1,925 – 1,400	= 525	t/yr
Caustic soda	1,225 – 980	= 245	t/yr
Sodium hypochlorite	805 – 560	= 245	t/yr

b)–2 Cost of bleaching chemicals

The annual cost of bleaching chemicals can be reduced as much as 4.6 million Pesos (US$ 256 thousand).

Chlorine	525 x P2,949/t	= P1,548,000/yr
Caustic soda	245 x P4,729/t	= P1,159,000/yr
Sodium hypochlorite	245 x P7,751/t	= P1,899,000/yr
Total		P4,606,000/yr

c) Difference in variable cost

The proposed saving of annual variable cost by this modification is estimated as about 2 million Pesos (US$112 thousand) and shown as underneath,

Saving of annual variable cost
= Saving of annual bleaching chemicals cost
– Increase in annual wood cost
= P 4,606,000 – P 2,581,000
= P 2,025,000

Meantime, actual saving will be rather more than the calculation above in view of higher estimation of chemicals unit consumption under the changed bleaching operation.

Short pay-back period for cost of secondary knotter installation can be expected by the proposed profit of saving above.

2) Increase in black liquor concentration to be fed to vacuum evaporator

As stated in foregoing paragraph, concentration of black liquor to be fed to vacuum evaporator is as low as 11 to 12%. Such low concentration is due to the facts that producing rather high yield of pulp and adopting direct steam heating in the digesters. The latter problem will be solved by introducing indirect heating in future. Furthermore, for the concepts to introduce a computer control system in the cooking process, indirect heating is inevitably requested in achieving accurate H-factor control.

In obtaining a high black liquor concentration it is necessary to maintain precise adjustment of hot shower water usage in washing process as well as sealing water usage through screening and washing processes in addition to the principal countermeasures stated above.

In Bislig Mill, it is observed that the pH control has been carried out on accompanied filtrate to outcoming pulp mat of fourth stage washer (target pH: under 9.4). Unfortunately it was seemed that correct amount of hot water for washing was not grasped, when the Study Team was in site. By confirming correct dilution factor and proper washing water adjustment, effective rise in black liquor concentration can also be attained.

3) Installation of chip weigher

Quantity of wood chip input to the digesters is adjusted by ehe measures. The fluctuation in digester input and resulted pulp qualities can not be controlled as long as existing way may be continued.

It is desirable to install a chip weigher and maintain input amount within controllable range.

4) Installation of steam packer
There is an increased trend for falcata chip of low density. It is also recommended to install steam packer in order to increase chip filling rate in the digester and improve pulp output.

5) Energy saving
Today reportedly in Sweden, there is improved digester operation attaining big amount of energy saving where black liquor is extracted from the digester just prior gas relief or blow and utilized to pre-heat cooking liquor (at 130°C).

In future when PICOP will have some money to spare, the energy saving above should be introduced at the first priority.

2–7–2 RGP/TMP Plant

1) Midification of process flow
This discussion premises the installation of TMP secondary refiner at the end of 1984. The refiner will be adopted pressurized type in order to convert as primary refiner in case of plate change in primary refiner.

Meanwhile, the primary refiners for RGP are double disc refiners which have two discs rotating opposit directions each other and are comparatively hard in chip feed than in single disc refiner.

Consequently, it should not be recommended to use double disc refiner for primary refining of Falcata in that difficulties of chip feed in addition to the low density of Falcata cause very poor output in RGP.

Recommendation is as follows:
Use two single disc refiners of TMP as the TMP primary stage. And convert existing two double disc refiners of RGP as the TMP secondary stage. Remaining two double disc refiners in place of RGP secondary stage should be rearranged so that either secondary can handle the stock from either primary.

The recommended flows are shown in Fig. III–2–12.

TMP output increases double and RGP decreases by half as whole, however, it is doubtful to increase output of weaker pulp TMP and to reduce stronger pulp RGP on the existing pulp quality basis.

As to the discussion whether to be oriented to improve TMP qualities or to abandon TMP shall be described later, the advantages by the recommended flow modification are stated herein.

Stabilization of RGP and TMP qualities:

As the result of flow modification, installed capacities for primary and secondary stages become balanced so that surplus capacities available in adjusting power allocation of both stages can improve fluctuation in the quality of pulp.

In case any of secondary refiner is subject to plate change, there will be complete backup by remaining secondary, and minimize a chance shive to be contained in machine furnish.

The output by the recommendation is 80 BDt/d in TMP, 50 BDt/d in RGP and 130 BDt/d in the aggregate. This is 10 BDt/d low than 140 BDt/d of intermediate step, however, can afford to supply (127 BDt/d*[1]) the demand until the execution of renovation work.

Note: *[1] pulp consumption and paper production
before renovation (from 1985 to 1988) is as follows:
(refer to Table V–5–2)
Paper production x conversion factor x combination rate = RGP/TMP consumption
238 t/d x 0.97 x 0.55 = 127 BDt/d

2) Qualities of pulp

As stated in the foregoing paragraph, qualities of TMP is extremely poor. When separate refining line is completed by installing an additional refiner to TMP secondary stage, there are increased needs of investigating real characteristics in refining Falcata in terms of commercial scale operation. Particurally, preheating, plate pattern and additives of chemicals are crucial conditions .

It is recommended if there were little possibilities in improving pulp qualities, heating steam should be stopped and RGP type of operation can be proceeded.

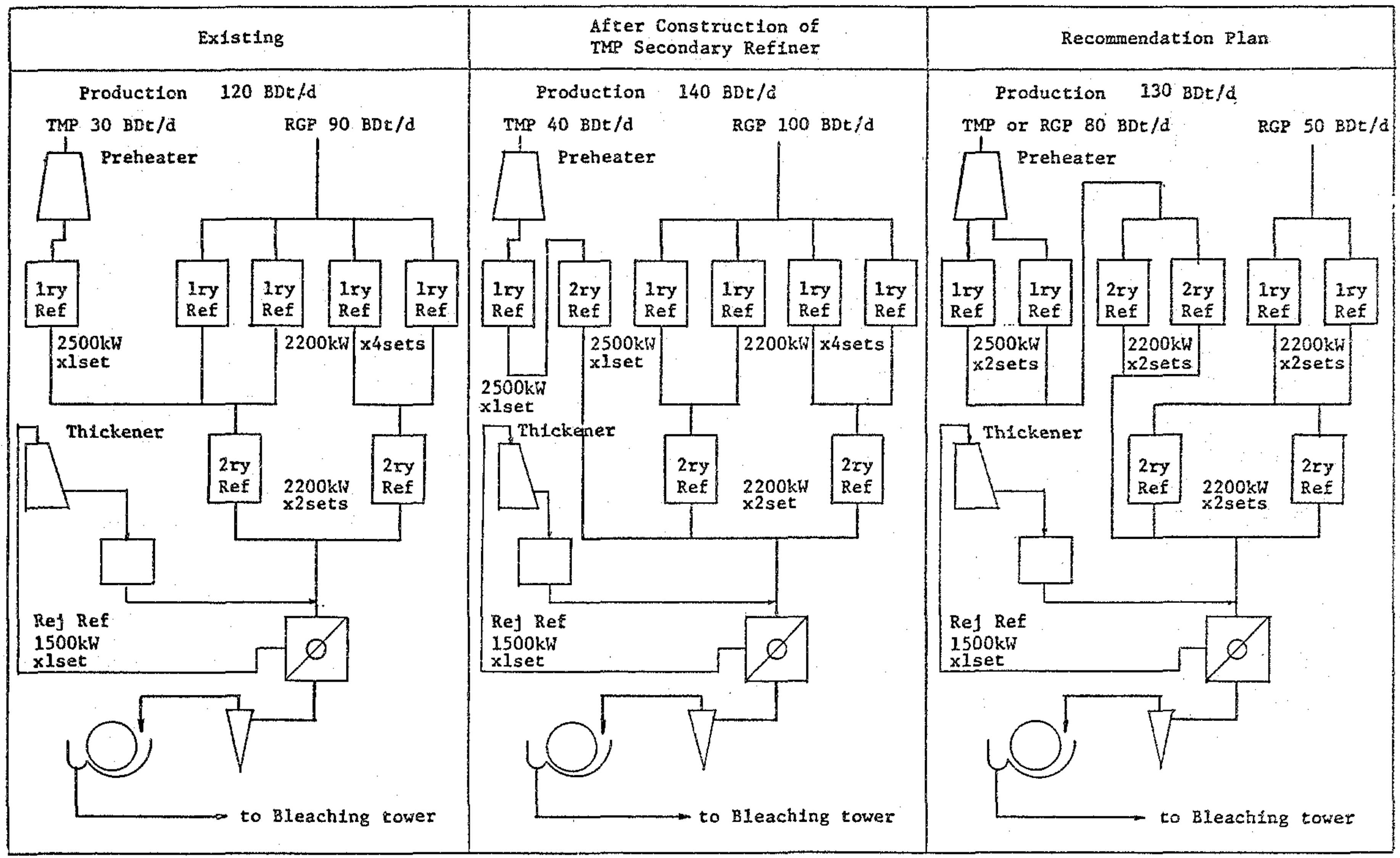


Fig. III–2–12 Draft Plan of RGP/TMP Flow

3) Installation of refiner power recorder

Precise power adjustment on the refining can be expected by means of power recorder installed at each refiner. The fluctuation in pulp quality thus may be minimized.

4) Installation of chip weigher

For the accurate materials control, the weight of incoming chip to RGP, TMP plant should be measured by weight meter installed on the chip feed conveyor.

5) The strength of hardwood RGP and TMP is inherently poor. By the renovation project in future, sufficient discussion have to be made as to the conversion into CTMP and improved result of pulp quality and power consumption.

2–7–3 No. 1 Paper Machine

1) Improvement on paper machine efficiency

(1) By means of blending softwood pulp:

The paper machine efficiency can be improved even in existing state by means of blending softwood pulp into the furnish, thus increased wet web strength can reduce sheet break and increase output at present machine speed. Providing blending rate of softwood pulp as 7% and improved efficiency as 85%, the output increase can easily pay to the cost of purchased pulp.
(refer to Appendix A–3)

Nevertheless cross profile of basis weight and moisture remain poor.

(2) By means of equipment modification:

As to the equipment modification, the description in the renovation project and quality improvement are to be shown in this report.

2) Quality improvement

(1) Basis weight profile

The existing mechanism of adjusting slice lip is unable one thirds of drive side across the width. Replacing lips and the adjusting device is supposed to be necessary, however, whole replacement of stockinlet is recommended in view of speed-up plan in hand.

(2) Moisture profile after press part

The existing moisture profiles at 2nd press outlet and 3rd press outlet are shown in Fig. III–2–13. The 2nd press outlet moisture fluctuates much in cross direction.

The 3rd press outlet moisture is 60.4 – 61.9%, average 61.4%, very high as moisture level, but the fluctuation (1.5%) is reasonable. However as back side dewatering is exceedingly good, this result incur further over dry in dryer section.

Therefore, the existing press roll crown should be reviewed and reground in order to have a better moisture profile. Installation of steaming box on the No. 1 suction press roll is recommended so that improved dewatering and moisture profile are expected to be attained. Steam consumption in dryer part can be reduced.

(3) Moisture profile after dryer part

Modification of existing open dryer hood should be adopted, so as to totally enclosed on the operating floor and on the basement floor.

In addition, assisting drying device of hot air blowing rolls are necessary to improve ventilation in pocket and canvas dryness. Furthermore following item should be discussed to introduce for the improved heat transfer.

- to adjust fitting of rotary siphon mouth piece for condensate and to adjust the position of rotary siphon.

- to fit dum rings at both ends of dryer cylinders.

- to fit spoiler bars for condensate.

The expected improvement of steam unit consumption may be more than 20% by the adoption of the totally enclosed hood with heat recovery system (refer to Fig. III–2–14).

(4) Smoothness of paper

Improvement of smoothness is increasing market demand in these days in that the final use is expanding from newsprint to computer form paper, register paper, Xerox paper etc.

Consequently existing solid king roll of calender should be replaced with crown controllable roll and also nip pressure adjusting device should be introduced. For the further demand of smoothness in future it may be

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Time 10:45 am

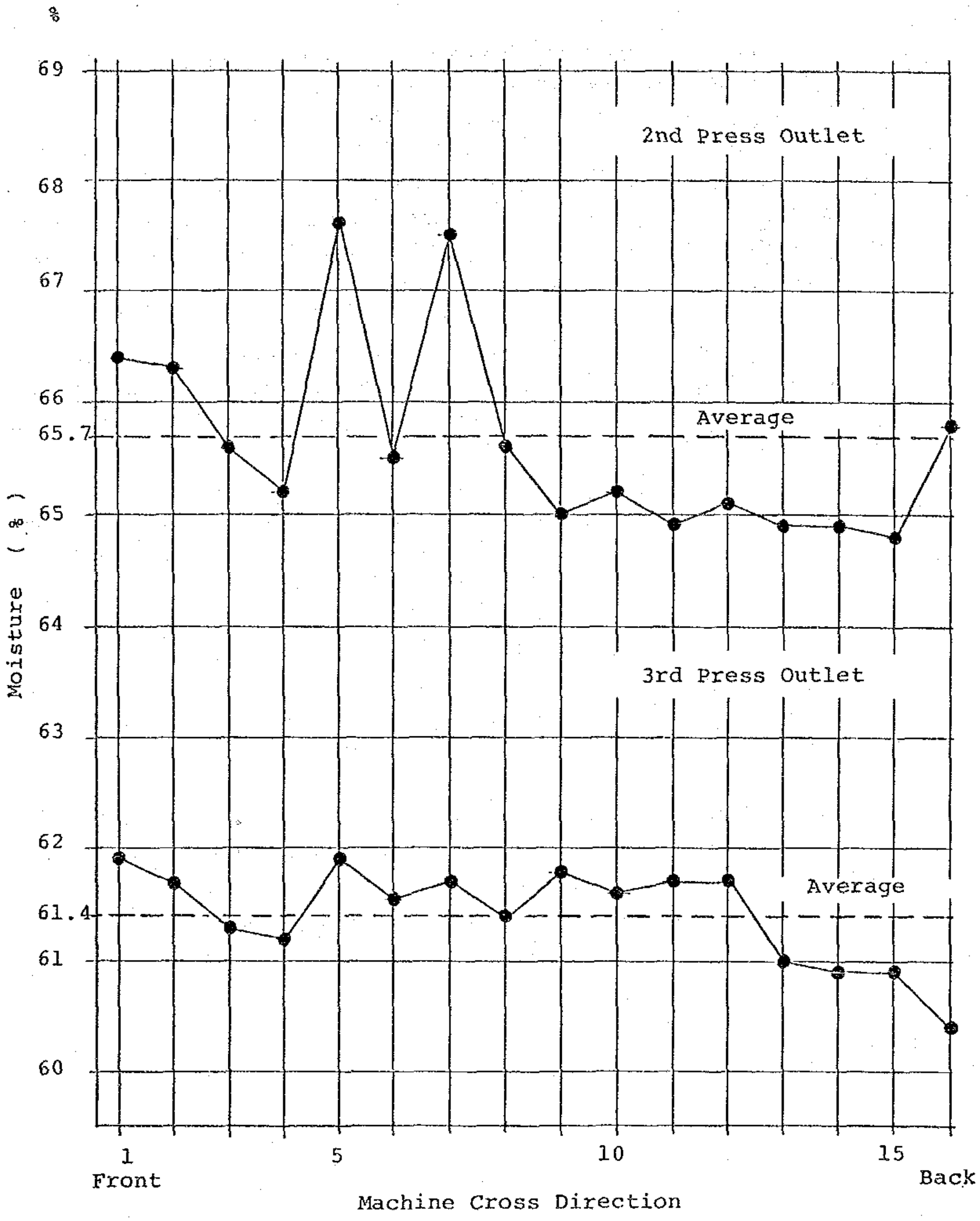


Fig. III–2–13 Moisture Profile at Press Part

No. 1 Paper Machine

considered to install breaker stack between dryers.

The priority of the items above should be placed to those effective speed-up and/or increase production, however, item (2) and (3) are of more payable and therefore part of those should be executed promptly.

3) Improvement of tearing strength of LSBKP

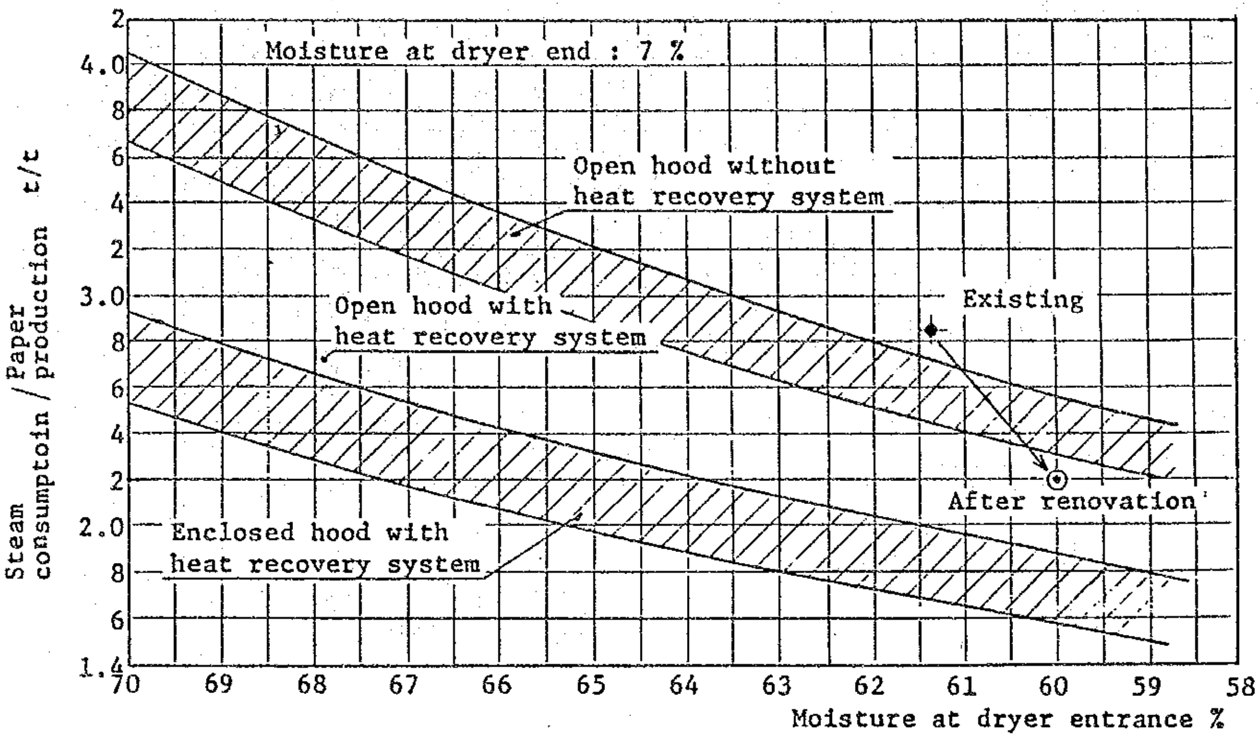
At the moment, breaking length of LSBKP is deliberately developed by dropping freeness level from 440 – 460 ml to 280 – 290 ml in the stock preparation plant.

Whether improved breaking length or improved tearing strength may connect to effective improvement in paper strength will be discussed in the paragraph of renovation program, however, the Study Team would prefer to recommend the latter.

In view of relationship between freeness and tear factor of LSBKP according to PICOP's test data (indicated in Fig. III–2–15), tear factor is to be improved 20% by the freeness change from 290 ml to 450 ml.

Also according to the fibre classification (indicated in Table III–2–20), the characteristics of Falcata pulp does not contain long fibres and if freeness level is adjusted to 450 ml level, it will not make adverse effect on printing at user's press room.

Therefore, if once gradual freeness raise with cautious observation to the market reaction up to 450 ml may be succeeded, tearing strength of paper will increased, drainage on the Fourdrinier will be improved, and decreased sheet break to take place. Saving in refining power will be also is expected.



P I C O P

	Moisture at dryer entrance	Unit consumption of steam
Existing	61.4 %	2.85 t/t *1
After renovation	60 %	2.2 t/t

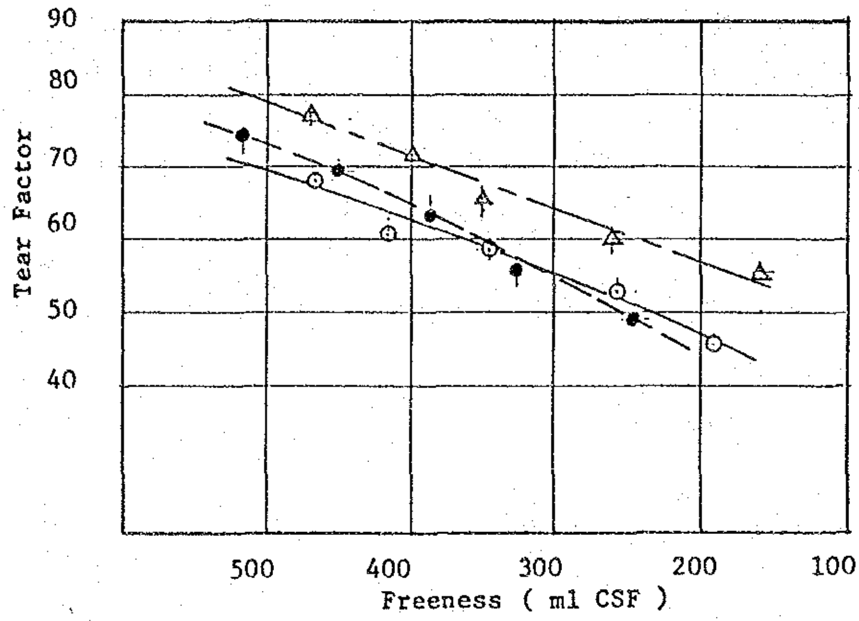
Improved rate of unit consumption of steam :
(2.85 - 2.2)/2.85 x 100 = 23 %

Actual data of " O " company in Japan
Unit consumption of steam : 1.5~2.0 t/t

*1 Unit consumption of steam after renovation in PICOP is estimated 10 % more than average value in Japan.

Fig. III-2-14 Comparison Figure of Steam Consumption of Paper Machine

TEAR FACTOR



BREAKING LENGTH

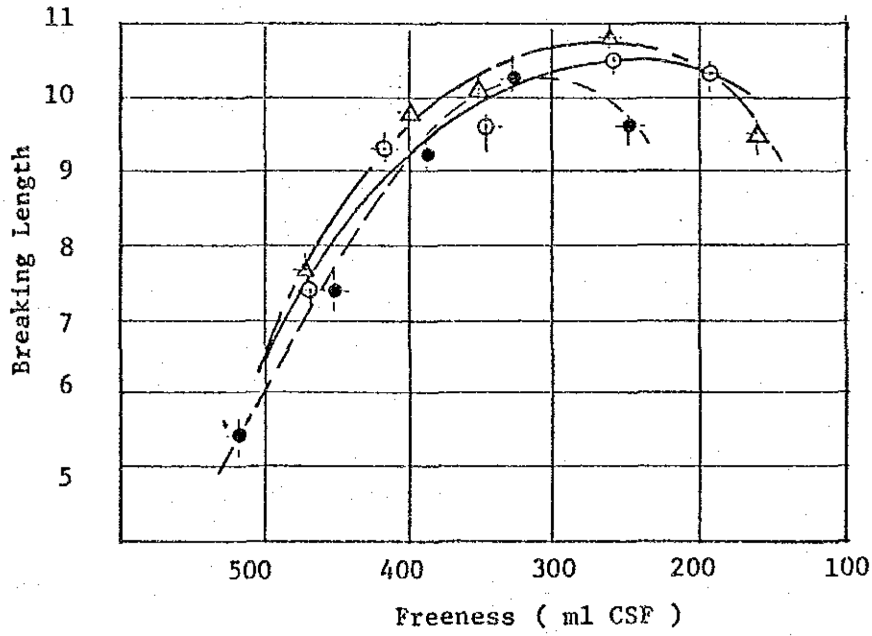


Fig. III–2–15 Relation of Freeness vs T.F. & B.L.

Table III-2-20 Kraft Pulp Quality

	Philippines	Test Data in Japan		
	PICOP Data	PICOP Sample		Actual Data in Japan
Beating Condition	After Beating	After Beating	Before Beating	Without Beating
Wood	Falcata	Falcata	Falcata	Hardwood
Freeness	290 mlCSF	266 mlCSF	470 mlCSF	430 mlCSF
Basis weight		61.1 g/m^2	60.9 g/m^2	59.9 g/m^2
Density	0.91 g/ml	0.85 g/ml	0.69 g/ml	0.63 g/ml
Breaking length	10.15 km	6.76 km	5.36 km	5.73 km
Tear factor	57.82	89.2	107.6	115
Brightness	B*1 50% GE	UB*2 24.6%HU*5	UB 30.4% HU	B 81.8 % HU
Opacity	B 93.3%	UB 92.0%	UB 98.3%	B 76.6 %
Scattering coefficient	-	UB 222.7	UB 405.9	B 358.3
Fractionation				
24 mesh on %			1.6	13.3
42 mesh on %			42.0	22.9
80 mesh on %			37.7	27.9
150 mesh on %			5.6	10.9
150 mesh pass %			13.1	25.9
Shives				
Alfthan *3			14 counts/20g	5 counts/20g
STFI *4				
Σ (1-16)			19 fibers/g	10 fibers/g
Long shives			4 fibers/g	1 fibers/g

*1 Bleached
*2 Unbleached
*3 Counts of shive that cannot pass through 0.18 mm slit.
*4 Length & width of each fiber is measured by optical method, Long shive means above 3 mm fiber length & 0.075 mm fiber width.
*5 Hunter brightness meter

2–7–4 No. 2 Paper Machine

1) Improvement of steam unit consumption

Current moisture content of the web after press is 66% which incurs exceeding dryer steam consumption. By strengthening the press function, low moisture content of web before drying and improved steam consumption can be expected.

Comparison are made below with current PICOP condition and instances in Japanese mills.

	Current PICOP condition	Instances in Japanese mills
Web moisture after press	66 %	55 - 58 %
Paper machine eff.	83.5 %	> 90 %
Steam unit consumption	3.14-3.24 t/t-product	1.7-2.0 t/t-product

2) Increase of finished moisture content

Current moisture contents of finished product are ranging between 5 and 7%. This is lower than JIS which is indicating 7.5 ± 1.5% for linerboard, 8.5 ± 1.5% for corrugating medium.

Therefore it is desirable to increase about one percent in average moisture content of the product under adjusting cross profile.

2–7–5 Recausticizing and Lime Kiln

1) Saving of fuel oil in lime calcination

As stated in the description of III–2–2–7, fuel oil consumption in lime calcination is high.

By the installation of calcined lime cooler as well as the adoption of heat insulating brick, outstanding saving of fuel oil can be achieved.

Note: 1) Unit consumption of fuel oil in lime calcination in Bislig mill: 223 l/t-calcined lime

2) Latest operation in a Japanese mill:

Type of kiln :	Short type with flash dryer
Unit consumption:	180 – 187 l/t-available CaO
	(153 – 159 l/t-calcined lime)

3) Operation in a Brazilian BKP mill:

Type of kiln :	Long type with satelite cooler
Unit consumption:	155 – 165 l/t-calcined lime

2) Saving soda loss by means of dregs washing tank
Description has been shown in III–2–2–7.

3) Compressed air cleaning of lime mud filters
Two lime mud washing filters in Bislig Mill have been cleaned almost once a week by hydrochloric acid. The work will be reduced greatly by the adoption of automatic filter cloth cleaning device using compressed air.

2–7–6 Evaporator

1) It is desirable that black liquor concentration of product is about 55% DS, taking account of utilizing black liquor energy in combination with recovery boiler with cascade evaporator.

2) If further concentration rise of black liquor product is difficult because of scaling and plugging trouble, and then evaporator necessitates long cleaning time of tubes, adoption of plate type (falling film type) evaporator is recommended.

3) Modernization of evaporator
As a concept of existing evaporator modernization, the following plans will be considered.

(1) Evaporator will compose of two (2) lines of six (6) effects evaporator by adding three (3) long tube vertical (LTV) type bodies to No. 2 (stand-by) line, and improvement of heat economy and concentration rise of black liquor product will be achieved.

(2) The evaporator will converted into new six (6) effects evaporator by adding new plate type bodies to the existing evaporator, concentration rise (up to about 55% DS) of product and sufficient improvement of heat economy will be attained.

Making comparison between countermeasures above, the latter will be recommended, because LTV type evaporator has limitation of concentration (max. about 50%) and can not get rid of scaling trouble and plugging trouble, and because plate type evaporator can eliminate serious scaling and plugging trouble, especially on high dry solid concentration.

4) If the modernization above can achieve concentration rise of product, increase in generated steam and decrease in oil consumption of auxiliary firing at recovery boiler will be expected.

2-7-7 Kraft Chemical Recovery Process

1) As to actual breakdown of soda losses, the fact that losses at recovery boiler share the major portion of total losses is doubtful, the cause and other sources of losses should be fully investigated.

2) For the purpose of decreasing soda losses at recovery boiler, it is recommended that low efficiency wet-bottom type electrostatic precipitator, suffering from corrosion trouble, should be converted into high efficiency dry-bottom type and also wet cyclone scrubber should be installed at exhaust stack of dissolving tank.

2-7-8 Power Plant

1) Stabilization of main steam pressure
Wide range fluctuation of main steam pressure lowers power generation efficiency because of defect of automatic combustion control system (ACC) at power boiler. Now improvement and renewal of ACC is under contemplation. When improving and renewing, fairly sophisticated control system, for example feed-forward control utilizing programmable controller with micro-computor, is recommended.

2) Countermeasures for superheater tube corrosion
Boilers suffer from corrosion of superheater tube at the moment, adoption of superior corrosion-resistant material is suggested. It is recommendable to convert tangential injection of secondary combustion air into parallel injection in recovery boiler in order to have uniform gas flow and to make superheater tube temperature even.

3) Utilization of woodfuel
Utilization of woodfuel has been promoted as alternative fuel of heavy

oil in the activity of Energy Conservation Program at the moment. Supply and maintaining of woodfuel and searching for new alternative fuel such as Ipil-ipil will be expected in future.

4) Utilization of purchased power
In-plant power generation should be shifted to purchased power by minimizing condensing power generation of 30 MW turbine, taking account of process steam amount and steam load fluctuation, because power cost of condensing power generation is much higher than purchased power cost due to expensive fuel oil (bunker C oil).

5) Operation of power plant without power boiler
If Activity of Energy Conservation Program has an effect on sufficient decrease of process steam, operation of power plant without power boiler may be realized, taking account of steam load fluctuation. At that time, swing boiler will change to No. 2 bark boiler (or No. 1 boiler) from power boiler, and condensing power generation by 30 MW turbine generator will be minimized, keeping power balance of mill. This case will contribute to sufficient reduction of energy cost.

2–7–9 Utility

1) Utilization of purchased power
There are many dieselized pumps used for waterintake and water supply at the moment, they are suggested to be converted into motor-driven pump for energy cost reduction

In case Mindanao grid of NPC is completed to make the loop network of electric power transmission in the middle of 1985, allowable max. power demand will be able to increase. Therefore further reduction of energy cost will be expected, utilizing cheap purchased power.

2) Mill water saving
Mill water unit consumption of products (newsprint and containerboard) is about 130 m^3/t-products. It is suggested that the present equipment of waterintake and mill water supply will be able to cope with the situation after renovation, including saving of mill water consumption in the existing processes.

Target figure of mill water unit consumption after renovation plan will be 95–100 m^3/t–products.

3) Energy saving

In general, figures of process steam unit consumption are fairly high, especially for evaporator, therefore improvement of unit consumption is necessary.

It is suggested that increase amount of process steam consumption in renovation plan will be compensated by energy saving of existing equipment.

Main countermeasures of energy saving are as follows:

(1) Improvement of dryer drainage of paper machine
(2) Total enclosure of dryer of paper machine with heat recovery system
(3) Improvement of dewatering at press part of paper machine
(4) Improvement of heat economy of evaporator
(5) Improvement of recovery of process steam condensate
(6) Reduction of steam exhausted to atmosphere (caused by defect of main pressure control system of power plant)
(7) Improvement of process heat recovery such as blow heat recovery of batch digesters, etc. (reduction of process steam for hot water heating)

2–7–10 Environment

In general, environmental figures (concentration of effluent, dust and gas) of Bislig Mill are not good, compared with those of industrialized country, improvement of environment will be expected.
The following countermeasures, which contribute to cost reduction, especially should be put in practice at early stage, because pollutant load will increase due to production increase after the renovation work.

1) Countermeasures for decrease of effluent pollutant load, which contribute to improvement of production yield of pulp and paper

2) Countermeasures for decrease of process effluent amount

3) Countermeasures for decrease of dust emission at recovery boiler (improvement of efficiency of electrostatic precipitator, installation of wet cyclone scrubber at stack of dissolving tank)

Pollution of Bislig Bay by mill effluent discharge may not be serious at the moment, but it is recommended that installation of activated sludge process and flocculation/sedimentation treatment equipment for effluent should be studied taking view of future.

2–7–11 Quality Control and Production Control

1) With regard to the operation and quality of the products, a great deal of information and data have been collecting. It is important to utilize those information and data applying back to the actual operation.

Personnel factor is attached importance to quality control and the following is regarded as keys of execution:

(1) to indicate problems clearly (clear target)
(2) to render operators creative attitudes
(3) to render operators prompt report on results

As to the actual implementation of quality control, for example, the following procedure may be taken. While there is a big problem of web break on the No. 1 paper machine, management should lift target as definitely as possible. Then the target should be indicated somewhere good place of well watched by the employees such as on a notice board or on the training session. Next step is to be indicated by the down time graph on the similar place of notice, and plot the results of a certain day within the day. Probably, for the first time people do not react as if the issue is direct concern of themselves, however, in due course, the opinion in the form of suggestion are to be offered.

Thus the beginning of collecting real information from the operation must be obtained by the management which is not expected by mere cumulation of technical data.

2) An attitude towards the productivity increase
The detail is stated in III–2–2–5, however, the efforts should be requested in reviewing standard number of operators and finally to attain rationalized man-power allocation.

Several recommendations have been stated in the preceding description, however, it will be difficult to introduce all items of recommendations in renovation project this time in that financial situation in PICOP does not allow big investment at once.

Consequently, as a renovation program, selected items of improvement which will be most effective for the interim recovery are summarized and stated hereafter in "V. Renovation Plan".

The excess items of the recommendations also would be better to be adopted as sooner the PICOP's improvement may attain.

3. Present Situation of Iligan Mill

3–1 Outline of Mill

1) Location : Maria Cristina, Balo-i, Lanao del Norte, Mindanao
2) Site area : 24 ha
3) Major products : Linerboard
   Corrugating medium
   Abaca pulp (not included in this investigation)

4) History

This paper mill was constructed as the Cristina Mill of the Rustan Pulp and Paper Mills, Inc. in 1968.

The pulp equipment was supplied by Kawasaki Heavy Industries, Ltd. (only the M & D digester was made by Mitsubishi Heavy Industries, Ltd.) and entered into operation in 1968. The board machine was supplied by Kobayashi Mfg. Co., installed in 1970 and entered into operation in 1972.

In 1977, Rustan Pulp and Paper Mills, Inc. merged with PICOP, and the Cristina Mill became Iligan Mill of PICOP.

Since 1980, Iligan Mill has not been operating.

5) Major equipment capacities

(1) M & D digester for LUKP
   Designed capacity : 70 BDt/d
   Actual production : 45 BDt/d (February, 1979)

(2) Disintegration of purchased pulp, own pulp, waste paper and stock preparation equipment
   a) NUKP line : 45 BDt/d
   b) LUKP line : 90 BDt/d
   c) Corrugated waste line : 60 BDt/d
   d) News waste line : 22 BDt/d

(3) Board machine

Ultraformer V type, 6-cylinder, multicylinder dryer, on-machine coater

– Trim : 2.2 m

– Designed capacity (theoretical production)

125 g/m² x 160 m/min	:	63.5 t/d (corrugating medium)
225 g/m² x 147 m/min	:	104.8 t/d (linerboard)
325 g/m² x 102 m/min	:	105.0 t/d (linerboard)

– Actual production (February, 1979)

185 – 339 g/m² (7 grades): 72.1 t/d (linerboard)

3–2 Condition of Existing Equipment

In spite of the fact that the Mill has been shut down for about four years, the equipment and facilities are in a fairly good condition. Especially, the equipment related to the board machine would become functional again if partial renovation and repair are undertaken. The wood preparation equipment like the chipper and chip screen, some pumps, two double disk refiners and one centri-sorter have been transferred to Bislig Mill.

1) Drum barker

This has gathered excessive rust and cannot be reused.

2) M & D digester

(1) The main body is made of mild steel and the outside has gathered much rust.

(2) Abrasion and rust inside the digester, the condition of the flight conveyor and the condition of the rotary valve could not be checked.

(3) Since the main body is made of mild steel, it is difficult to use this digester for the preprocessing equipment of the CTMP plant for the renovation of Bislig Mill.

3) Stock preparation equipment

(1) There are four pulpers to process purchased pulp and waste paper, and all four can be reused. However, the rotors have been worn excessively on all four pulpers and they must be replaced for reuse.

(2) The stock preparation equipment including five refiners seems to be in a good condition as far as the outside appearance is concerned.

4) Board machine and coater

(1) The six cylinders of the Ultraformer were removed and are stored separately in the same room. Rustproofing was done to the stand and bearing housing and they are in good condition. Scales and paper waste are sticking to the center shaft and spoke section, and a thorough cleaning is necessary to reuse them. The flow box of the Ultraformer is generally in good condition and can be used again if the slice lip is replaced and a few other parts are repaired. All frames are in good condition.

(2) All rolls of the baby press and main press were removed and stored in wooden cases. Rolls lined with rubber need relining, but the shell itself is reusable. The frame of the press part and its accessories are in almost perfect condition. However, when reusing the board machine, in order to reduce production costs by improving steam consumption, the press part must be rebuilt, and there seems little possibility of re-using the existing press part.

(3) 50 dryer cylinders coated with rustproof-oil on the surface are in almost perfect condition. The built-in parts of the siphon tubes and bellows and the cylinder internal walls could not be checked. The dryer hood is in an almost perfect state although the plated layer has partially peeled off, but it seems reusable.

(4) The coater has never been used for actual production since this board machine came into operation, and it is almost like new. It seems that it can be used satisfactorily if the rod of the bar coater is replaced and the nozzle section of air knife coater is adjusted and checked.

(5) Electrical parts including the motor

All motors in the Mill are wrapped with vinyl sheets and judging from the outside observation, it seems that they are in good condition. However, it is observed that the vinyl sheet had peeled off in some places, and since it has not been used for a long time, all of them must be dried and have insulation testing before they are reused.

(6) Instruments and instrument panels

While almost all panels are wrapped with vinyl sheets and the preservation state is good, but they must be inspected in detail before determining whether or not they can be used.

(7) Roll and rotary machine bearings
Any bearings could not be observed or checked. They must be closely checked before they are actually used.

3–3 Operating Conditions before Ceasisng Mill Operation

1) Board machine design values

Grade	Range of basis weight
Linerboard	225 – 325 g/m^2
Corrugating medium	125 g/m^2
Coated board	250 – 600 g/m^2

2) The actual production was linerboard only in a range of 185 – 337 g/m^2. Although this board machine is equipped with an on-machine coater, coated board has never been produced.

3) Unit consumption of raw materials and chemicals (per ton of product)

(1) Pulp	1.02	BDt/t	(Average furnish combination)
NUKP	0.63	BDt/t	62.0%
LUKP	0.22	BDt/t	21.8%
Corrugated board waste	0.16	BDt/t	16.2%
Broke	0.01	BDt/t	

(2) Chemicals

Alum	22.5	kg/t as $Al_2(SO_4)_3 \cdot 14H_2O$
Rosin size	3.16	kg/t as solid
Sulfuric acid	3.22	kg/t as H_2SO_4
Web strength increasing agent	6.46	kg/t as solid

4) Unit consumption of utilities (per ton of product)

– Steam	3.22	t/t
– Electric power	800	kWh/t
– Water	200	t/t

5) Qualities of products
The table below shows the major linerboard qualities in the typical basis weight.

Nominal Basis Weight	Actual Basis Weight		Burst Strength				Burst Index		Water Absorption Degree (Cobb's Method)	
			Top		Bottom					
	Ave.	S.D.	Ave.	S.D.	Ave.	S.D.	Top	Bottom	Top	Bottom
g/m^2	g/m^2		kg/cm^2				$(kg/cm^2/g/m^2)$ x100		g/m^2-min	
185	184.4	6.34	6.71	0.481	6.61	0.428	3.64	3.58	33.9	124.0
205	206.7	4.46	7.64	0.497	7.49	0.503	3.70	3.62	35.6	129.8
337	336.4	10.16	10.84	0.942	9.77	0.827	3.22	2.90	34.4	108.5

Note: Ave. : Average
S.D. : Standard Deviation

3–4 Background for Ceasing Mill Operation

The Iligan Mill stopped the operation for the following reasons and it is not operated since then.

1) The lauan wood resources that Iligan Mill needed has been exhausted and became unavailable in the mill district.

As the measures to solve the situation, Iligan Mill continued the operation for a while using chips brought in from Bislig Mill, but as an essential result, the raw material cost increased and the Mill could not continue long-term operation.

PICOP has no forest concession for wood supply in this district at the moment.

2) Increase of manufacturing cost

(1) The wet-web out of the press part had extremely high moisture content (approx. 68%) and was causing high steam consumption.

(2) The quality variation in the machine direction was large, and there were heaps of rejected final products because of poor burst strength. This caused increasing unit consumption of electric power and steam.

The following shows comparison of utility unit consumption between Iligan Mill and average Japanese Mills.

		Iligan Mill	Average Japanese-Mill
Steam	t/t-paperboard	3 – 5	1.7 – 2.0
Power	kWh/t-paperboard	900 – 1000	500 – 700

3) There was not enough demand for products of heavy basis weight that were suitable for the board machine, and the machine could not be operated efficiently.

4) Accordingly, if the board machine is to be operated, the following countermeasures are essential.

(1) Selection of mill location where pulpwood are easily available.

(2) Efforts in producing light weight paperboard.

(3) Rebuilding the press part to reduce the moisture content of wet-web out of the press part to the level of no higher than 58%.

(4) To take measures to obtain the required quality (especially burst strength), thereby reducing the reject rate.

3–3 Reviews on Iligan Mill Plan

The Study Team is of the following opinions with regard to renovation plan based on the diagnosis conducted in field survey.

1) Applicability of Iligan machine

(1) No. 2 PM of Bislig Mill is a Fourdrinier type having a secondary slice but the board machine of Iligan Mill is an Ultraformer with six cylinders.

(2) Since the board machine of Iligan Mill is a multilayer former, it has a better applicability to the production of thick boards of 400 g/m^2 or heavier than the Fourdrinier type. However, the basis weight range of linerboard produced by PICOP is 160 to 200 g/m^2. Also, the linerboard for banana carton, which imported linerboard is used at present, are in a range of 280 to 300 g/m^2. As to linerboard of the basis weight in such a range, the Fourdrinier type like No. 2 PM in Bislig Mill is more suitable, because of stronger binding in the thickness direction obtainable with fewer layers, and its high productivity.

(3) However, the quality data of Iligan Mill in February, 1979 indicates that its quality level is almost equal to that of current Bislig Mill products in the range of 160 to 200 g/m^2, therefore it seems that the board machine in Iligan Mill can get the same quality as No. 2 PM of Bislig Mill.

(4) Existing part of the board machine in Iligan Mill was causing a higher moisture content (about 68%) of wet-web out of the press part, and this incurred excessively large steam consumption (unit consumption of steam 3.22 t/t product, actual data in February, 1979), raising production costs. Therefore, if the board machine in Iligan Mill is reused, the press part must be completely rebuilt.

2) Reviews on location

(1) Restart of Iligan Mill

Iligan Mill is not operating since 1980 because of the shortage of hard wood resources as main raw materials, and there is no future prospect of wood supply. Also, since the equipment has partially been transferred for reuse and employees have been transferred to Bislig Mill, it can be concluded that Mill would be very difficult to resume the operation in the Iligan district.

(2) Operation in Manila district

a) Inhabitants oppose to new paper mill from the viewpoint of environmental protection and purchasing the necessary land is extremely difficult. Also, the land acquisition cost is expensive.

b) While a mill in this district will have an advantage in transporting waste paper, large supply sources of waste paper have entered into special supply agreement with paper manufacturers and there are no room to newcomer for join purchasing. Accordingly, the mill will have to depend on imports for the supply of waste paper.

Any place in the Philippines is possible to say same in this aspect as long as it is in a port area.

c) The ratio of thermal power generation is high in Luzon Island and the electric power cost is high.

d) Acquiring a forest concession is difficult.

For these reasons, the Study Team considers that transfer of Iligan Mill to Manila district is difficult.

(3) Transfer to Bislig Mill

a) Iligan board machine will be installed adjacent to No. 1 and No. 2 paper machines.

b) Water and electric power sources as utility are available.

c) PICOP has owned sufficient forest concessions around the Bislig Mill, and the pulp supply which is cheaper than waste paper is available for containerboard production.

d) Since utility division and research & technical services can be utilized in common, the plan of transferring to Bislig Mill is supposed to be economical.

Based on these reviews, the Study Team has determind to take up this plan for the renovation plan.

However, Iligan board machine has the following problems.

- Since the trim of the machine was matched with the corrugator trim (2,200 mm) in the Manila district, the board machine is not advantageous for production of other paperboard than containerboard.

- Since the machine is suitable for production of heavy basis weight board of 300 to 600 g/m², it cannot demonstrate its productivity sufficiently on production of 115–240 g/m² linerboard and corrugating medium consumed mainly at the moment.

Therefore, it is recommended that the existing Ultraformer is remodeled to a High-speed Ultraformer when the board machine is transferred to Bislig Mill.

(4) Coater

For the following reasons, the Study Team recommends that the coater of Iligan Mill should not be transferred.

a) The use of coater being planned at the moment is coating of corrugated board surface for export. However, if the production amount is small, coating on a corrugator, as is done at the moment, is more economical and adequate.

b) Installation of a coater at Bislig Mill should be planned when orders become large enough.

c) Since Iligan Mill coater is for white board, it is a wet-on-wet type of bar coater and air-knife coater. However, a combination of bar coater and simple dryer is good enough for coating on linerboard only.

d) The opinions of experts in Manila are rather pessimistic on the growth of white board demand.

Thus, it is concluded that the coater of Iligan Mill is not matching the current market needs at the moment.

IV. WOOD RESOURCES

IV. WOOD RESOURCES

1. Supply Source

1-1 General

PICOP has four main wood supply sources as follows.

a) Forest concessions
b) Industrial tree plantation
c) Agro-Forestry
d) Wood procurement division

1-1-1 Forest Concessions and Industrial Tree Plantation

PICOP has two forest concessions and one industrial tree plantation license near Bislig Mill.

Concession	Area coverage	Year granted	Year renewed
TLA-43	78,645 ha	1952	1977
PTLA-47	49,657	1957	1981
ITPLA-96	54,380	1982	–
Total	182,682		

Table IV-1 shows the present utilization of forest lands, and Fig. IV-1 shows their location and forest type.

It is easy to do logging operation and to develop plantation in PICOP's forest concessions and industrial tree plantation areas, which locate at the altitude between about 200 and 400 meters in hilly terrain. Soil is of sandy loam with effective depth of 0.6 – 1.0 meters.

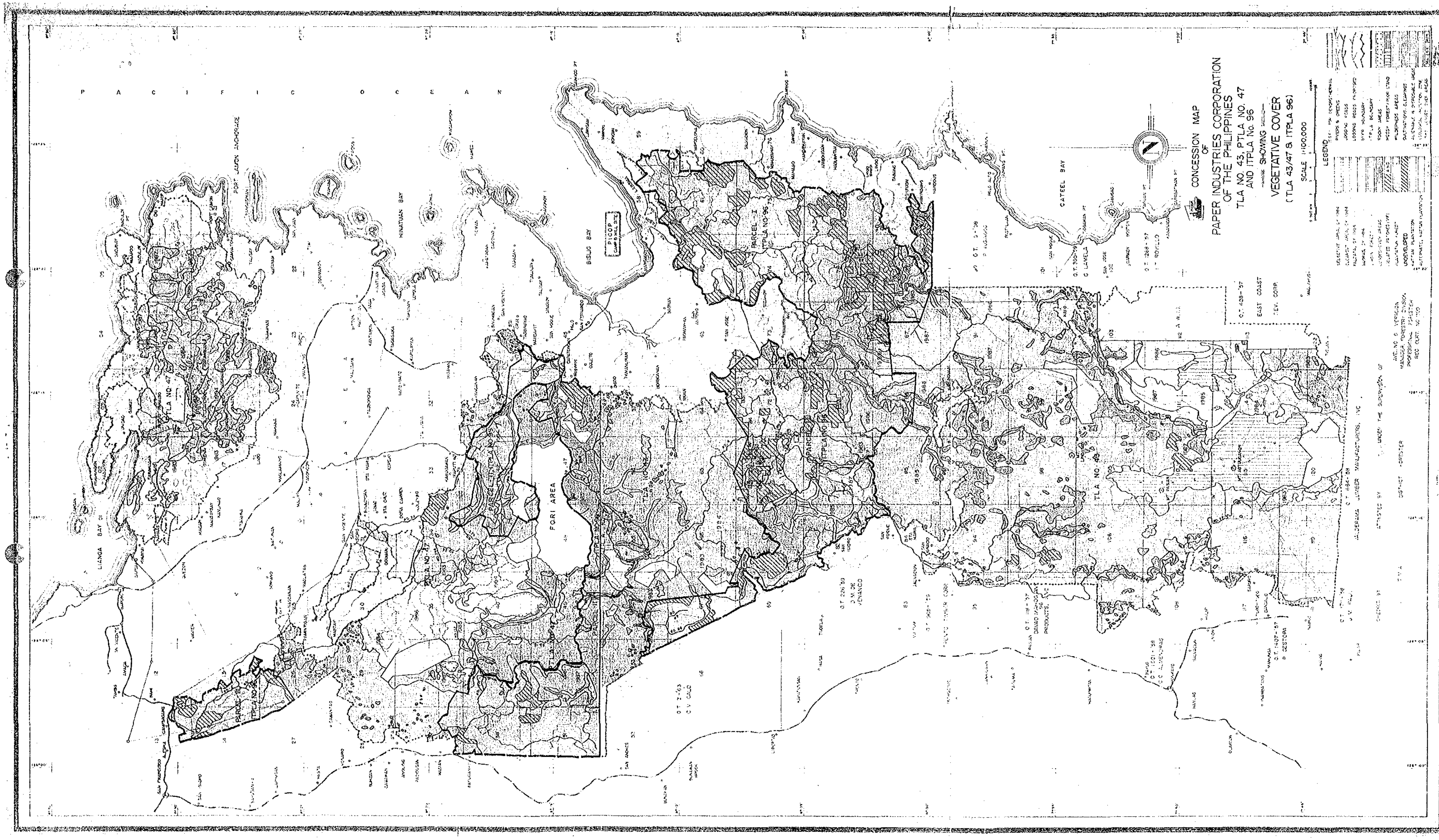
PICOP's forest areas are included within the most beautiful forest areas in Mindanao, and also judging from the present state of growth in the plantation, there seem few unproductive areas.

The following show yearly rainfalls.

Table IV-1 Forest Resource Base (in Hectares)

As of Dec. 1983

Particular	TLA-43	PTLA-47	Sub-Total	ITPLA-96	Total
Operable Areas					
1. Virgin Forest	4,723	5,296	10,019	-	10,019
2. Second Growth Forest	53,949	14,693	68,642	19,678	88,320
3. Plantation					
Falcata			2,476	18,287	20,763
Bagras			1,165	9,462	10,627
Ipil-ipil			1,140	-	1,140
Pines			164	845	1,009
Mixed			2,467	500	2,967
Sub-Total	3,047	4,365	7,412	29,094	36,506
4. For Development	1,399	2,007	3,406	282	3,688
5. Kaingin	1,520	3,748	5,268	500	5,768
Total Operable	64,638	30,109	94,747	49,554	144,301
Inoperable Areas					
1. Subdivided Land	-	3,089	3,089	-	3,089
2. Kaingin	651	5,623	6,274	-	6,274
3. FORI Experiment Areas	-	3,258	3,258	-	3,258
4. Roads	2,608	1,368	3,976	1,010	4,986
5. NPC Transmission Lines	-	-	-	130	130
6. PNOC Areas	-	-	-	350	350
7. Ecological Areas					
Protection Areas	4,537	3,450	7,987	3,336	11,323
Mossy Forest	5,720	-	5,720	-	5,720
Rocky Areas	491	2,670	3,161	-	3,161
Water Shed	-	90	90	-	90
Total Inoperable	14,007	19,548	33,555	4,826	38,381
Total Concession Areas	78,645	49,657	128,302	54,380	182,682


CONCESSION MAP OF PAPER INDUSTRIES CORPORATION OF THE PHILIPPINES
TLA NO. 43, PTLA NO. 47 AND ITPLA No. 96
SHOWING
VEGETATIVE COVER
(TLA 43/47 & ITPLA 96)
SCALE 1:100,000
LEGEND
PACIFIC OCEAN
BISLIG BAY
HINATUAN BAY
LIANGA BAY
CATEEL BAY
FORI AREA
TLA NO. 43

5,133	mm in	1981
4,232	"	1982
2,392	"	1983
3,919	"	average

The rainfall in 1983 was not such as previous years, but it did not cause any trouble in growth after planting. In general, there are relatively a few rainy days from May through September.

Monthly mean temperatures vary from 22°C to 28°C throughout the year. It is said that Bislig has seldom been hit by typhoon, but in 1982 Typhoon Akang hit the forest areas and caused serious damages to plantations.

It was the first typhoon on record to hit Bislig.

The extent of the damages will be explained later on.

Damages by insects and diseases are slight, so there is no need of medical spray.

1–1–2 *Agro-Forestry and Wood Procurement Division*

In the name of Agro-Forestry development program, PICOP has entered into marketing agreement with nearly 5,300 farmers including Kaingineros within a 100-kilometer radius centering on Bislig Mill, covering about 20,000 hectares in area.

PICOP provides Falcata seedlings at cost, payable at harvest 6 to 8 years later and guarantees to buy all the wood produced.

PICOP is planning to encourage agro-forestry farmers to raise Ipil-ipil, faster growing fuelwood trees, along with Falcata in the near future.

Actual procurement of Falcata produced by agro-forestry farmers totalled 1,241,000 m^3 from 1980 to 1984, amounting to 64% of all Falcata supply volume during the same period and playing an important role in the supply of raw material for newsprint at Bislig Mill. PICOP also purchased in 1983 up to 346,000 m^3 of Falcata from agro-forestry farmers, including Falcata damaged by Typhoon Akang in 1982, in order to extend helping hands to farmers who suffered the damages by Typhoon Akang.

PICOP's harvesting plan shows that virgin forest will have been cut over until 1988 and log harvest from second growth forest will follow, resulting in a sharp decline in yearly harvest volume from its forest concessions, and that the supply volume of Falcata from both industrial tree plantation and agro-forestry will drop from 1985 to 1988, as a result of the damages caused by Typhoon Akang.

In order to meet such circumstances, PICOP established Wood Procurement Division to start purchasing pulpwood from forest concession holders throughout Mindanao from 1983 onward. There is a chance for PICOP to buy pulpwood since forest concession holders are selling their logs like PICOP selling logs. And PICOP will be able to purchase even Falcata from forest concession holders because the Bureau of Forest Development has been encouraging them to plant Falcata on poorer natural regeneration areas since early times. Procured pulpwood are mainly transported by barges.

1–2 Natural Forest (Virgin Forest and Second Growth Forest)

Table IV–2 shows the summary of Table IV–1 and the comparison of forest land utilization between in 1983 and in 1988.

Table IV–2 Comparison of Forest Land Utilization (in Hectares)

Particular	As of End 1983			As of End 1988			Difference
	TLA-43 PTLA-47	ITPLA-96	Total	TLA-43 PTLA-47	ITPLA-96	Total	
Operable Areas							
Virgin Forest	10,019	-	10,019	-	-	-	-10,019
2nd Growth Forest	68,642	19,678	88,320	69,826	-	69,826	-18,494
Plantation	7,412	29,094	36,506	24,921	49,554	74,475	37,969
For Development	3,406	282	3,688	-	-	-	- 3,688
Kaingin	5,268	500	5,768	-	-	-	- 5,768
Total	94,747	49,554	144,301	94,747	49,554	144,301	-
Inoperable Areas	33,555	4,826	38,381	33,555	4,826	38,381	-
Total Areas	128,302	54,380	182,682	128,302	54,380	182,682	-

There are only 10,019 hectares of virgin forest, supply sources of superior quality logs with large diameter, as of the end of 1983 and there will be no virgin forest as of the end of 1988 as shown in Table IV–2.

After virgin forest being cut over, only second growth forest could produce superior quality logs, but production volume per hectare drops remarkably as shown in Table IV–3.

Table IV–3 Comparison of Production Volume per Hectar (in m^3/ha)

Particular	Virgin Forest	2nd Growth Forest	Difference	Remarks
Sawtimber	83	48	-35	Virgin Forest : Resusltsin 1983 and 1984.
Pulpwood	57	24	-33	
Fuelwood	11	17	6	2nd Growth Forest : Expecting Volume from 1988 onward.
Total	151	89	-62	

The Bureau of Forest Development has forced forest concession holders to abide by selective logging system to secure the next harvest of second growth forest after 25 to 35 years, but Table IV–3 shows that the regeneration of natural forest does not go well as expected.

Timber Stand Improvement allows to extract pulpwood and fuelwood only, aimed at better growth of useful species in second growth forest.

If there are some second growth forests being hopeless in their natural regeneration, such second growth forests will be clearcut and converted into plantations with fast growing species.

It is expected to clearcut up to 28,513 hectares and convert them into the above plantations from 1984 to 1988.

1–3 Plantation (Industrial Tree Plantation and Agro-Forestry)

PICOP also has plantations outside the boundary of ITPLA–96 because PICOP had been continuing to establish plantations both inside and outside of the boundary of ITPLA–96 until the industrial tree plantation was granted in 1982.

Therefore, PICOP is collectively managing plantations both inside and outside of the boundary of ITPLA–96 under the classification of Industrial Tree Plantation. So this report follows PICOP's classification hereafter.

1-3-1 Planted Areas in Industrial Tree Plantation

Table IV-4 shows planted areas as of end 1983 and as of end 1988 by species.

Table IV-4 Comparison of Planted Areas by Species (in Hectares)

Species	As of End 1983			As of End 1988			Difference
	TLA-43 PTLA-47	ITPLA-96	Total	TLA-43 PTLA-47	ITPLA-96	Total	
Falcata	2,476	18,287	20,763	2,476	23,718	26,194	5,431
Bagras	1,165	9,462	10,627	1,165	25,000	26,165	15,538
Ipil-ipil	1,140	-	1,140	20,000	-	20,000	18,860
Pines	164	845	1,009	164	336	500	- 509
Mixed	2,467	500	2,967	1,116	500	1,616	-1,351
Total	7,412	29,094	36,506	24,921	49,554	74,475	37,969

Planted areas at the end of 1988 when PICOP completes its plantation establishment program, are expected to become almost two times as wide as planted areas at the end of 1983.

The following forest lands are to be converted into increased plantation areas. (Refer to Table IV-2)

	(ha)
Decreased virgin forest	10,019
Decreased second growth forest	18,494
Land for development	3,688
Kaingin	5,768
Total:	37,969

1-3-2 Planted Species

The following are outlined history of PICOP's silviculture activity.

The first experimental tree plantations were established in the early 1950's, consisting of trial plantings of Benguet Pine (Pinus insularis), Mindoro Pine (Pinus Merkusii) and Caribbean Pine (Pinus caribaea) in an attempt to give a planning pulp and paper mill a supply of long fiber believed essential for the production of pulp and paper.

These experimental plantations failed because the roots of trees were attacked by fungus after a very wet rainy season, which caused to kill most of them.

For the purpose of supplying long fiber from plants other than trees, also in the early 1950's the first study on the possibility of large scale Abaca plantations and studies on growing Kenaf and Ramie were carried out, and in the late 1950's trial planting of various species of bamboo were made. But these trials led to the conclusion that only trees could supply fiber needed for manufacturing pulp and paper.

It was assumed that the naturally regenerating lauan forests would give enough wood to sustain all of PICOP's proposed manufacturing operations, including a pulp and paper mill with a capacity of about 200 tons per day.

The pulp and paper mill would get its raw materials from forest waste generated from the harvesting of primary timber and milling waste from timber manufacturing operations.

By the middle 1960's, the capacity of the mill was increased to 400 tons per day with the addition of newsprint. It became clear that the volume of wood that could be available from the natural regeneration of the lauan forests would not be as large as was originally predicted.

One of the main reasons was that the technical information on the regeneration of Philippine lauan forests developed by the Bureau of Forest Development in limited areas under very favorable conditions, the only data available at that time, was not fully applicable to Bislig conditions.

Consequently, PICOP had to get additional sources of wood to go with the pulp and paper project, and it was decided that the best sources would be the additional waste wood that would be generated by clearcutting poorly stocked regenerating natural forests in the process of converting these into tree plantations, and eventually the wood that would become available from fast growing industrial tree plantations.

Under such circumstances, a considerable number of species were studied on the suitability for this purpose. By the second half of the sixties it became evident that PICOP had to make a decision on what species to plant in bulk, otherwise, PICOP would not have the wood when PICOP needs it in the eighties. PICOP decided on the following species.

a) Falcata (Albizzia Falcataris)

This tree had good and rapid growth characteristics and acceptable fiber specifications. It grew well in Mindanao where numerous trees of varied ages could be found, although it had not been grown on a plantation scale.

Falcata has been found to be a good pulpwood for mechanical pulp, but because of its very low density, it gives a very poor recovery for chemical pulp. Lately, it has been established that the density of this species improves rapidly with age (260 kg/m^3 at the age of 8 and 295 kg/m^3 at the age of 10).

From the very beginning, it was decided that PICOP would concentrate on pine and bagras, which are more difficult to grow and have a longer rotation, leaving Falcata, which has a shorter rotation and is much lighter, to the tree farmers.

In as much as Falcata is a coppicing species which throws shoots from its established root structure after harvesting (of which a dominant shoot is allowed to become the stem of a second rotation tree by pruning away less vigorous shoots), subsequent rotations do not require the planting of new seedlings. This early start should allow plantation trees to reach harvestable age much earlier. Up to 3 re-growths can be expected from each falcata stump.

b) Bagras (Eucalyptus Deglupta)

This tree grew well in certain locations in Papua-New Guinea, and they have already had 20 year old plantations. The location of these in Papua-New Guinea was at about the same number of degrees of latitude south of the equator as Bislig is north. It has good prospects for sawtimber and was known to make good pulp. Growth data from Papua-New Guinea showed good growth patterns.

It was known that Bagras was native of the Philippines, but at that time it was not known that Bagras was also native of Bislig. It was only after PICOP had established the first Bagras plantation at Bislig that PICOP found out that Bagras was growing in the area. Now PICOP has provenance trial plantations of Bagras.

A serious infestation problem was encountered with Bagras which was later successfully diagnosed as an attack by a sort of beetle. As it was found out that the New Guinea variety was more susceptible to attack than the local variety, it was decided to switch all plantations of the New Guinea variety to the local variety.

Bagras has shown good possibilities for the production of plywood and sawn timber. It gives an indifferent mechanical pulp, inferior to that of Albizzia Falcataris, but should give a satisfactory chemical pulp.

c) Pine (Pinus caribaea)
PICOP wanted to supply long fiber believed essential for the production of newsprint and linerboard from its own pine plantations and started trial plantations of several pine species but failed except Pinus caribaea.

Pine plantations are still young to give conclusive data, but the performance of pine plantations can only be described as poor to fair. However, PICOP stopped planting Pinus caribaea from 1980 forward.

d) Ipil-ipil (Leucaena Leucocephala)
PICOP is planning to establish a large scale of Ipil-ipil plantation both in industrial tree plantation and in agro-forestry for the purpose of supplying fuelwood on a 4 year cycle, expecting up to 3 re-growths from each Ipil-ipil stump.

In this connection, Ipil-ipil of one cubic meter is said to have calorific power equivalent to fuel oil of 185 liters.

e) Mixed
Mixed plantations consist of Falcata and Bagras, but PICOP stopped establishing mixed plantation from 1983 forward because Falcata which grows faster than Bagras overtopped Bagras in a few years after planting, resulting in death of Bagras.

1–3–3 Expecting Yield Volume by Species
Table IV–5 shows both expecting yield volume and mean annual increment by species, based on more than 10 years of research studies by PICOP (Refer to Fig. IV–2).

If we expect maximum yield volume per hectare from the plantation, we have to harvest the plantation at the age that its mean annual increment is at the maximum. On the other hand, if we expect the better productivity in logging operation, we have to harvest the older plantation because it is easy

Table IV–5 Expecting Yield Volume and Mean Annual Increment

Age	Falcata				Bagras				Ipil-ipil	
	No Thinning		With Thinning		No Thinning		With Thinning		No Thinning	
	E.Y.V.	M.A.I.	E.Y.V.	M.A.I.	E.Y.V.	M.A.I.	E.Y.V.	M.A.I.	E.Y.V.	M.A.I.
	m³/ha	m³/yr	m³/ha	m³/yr	m³/ha	m³/yr	m³/ha	m³/yr	m³/ha	m³/yr
1										
2	36	18.0	36	18.0						
3	64	21.3	64	21.3					50	16.7
4	96	24.0	96	24.0					60	15.0
5	134	26.8	134	26.8						
6	172	28.7	126 +46	28.7	94	15.7	94	15.7		
7	211	30.1	173	32.4	122	17.4	122	17.4		
8	242	30.3	224	35.7	150	18.8	105 +45	18.8		
9	269	29.9	260	36.6	169	18.8	120	18.9		
10	298	29.8	298	37.5	190	19.0	145	20.1		
11	320	29.1	320	36.8	215	19.5	182	22.1		
12					240	20.0	220	23.9		
13					262	20.2	252	24.9		
14					273	19.5	272	25.0		
15					280	18.7	280	24.3		

E.Y.V. : Expecting Yield Volume
M.A.I. : Mean Annual Increment

Volume thinned out : Falcata, 46 m³/ha at age of 6
" : Bagras, 45 " 8

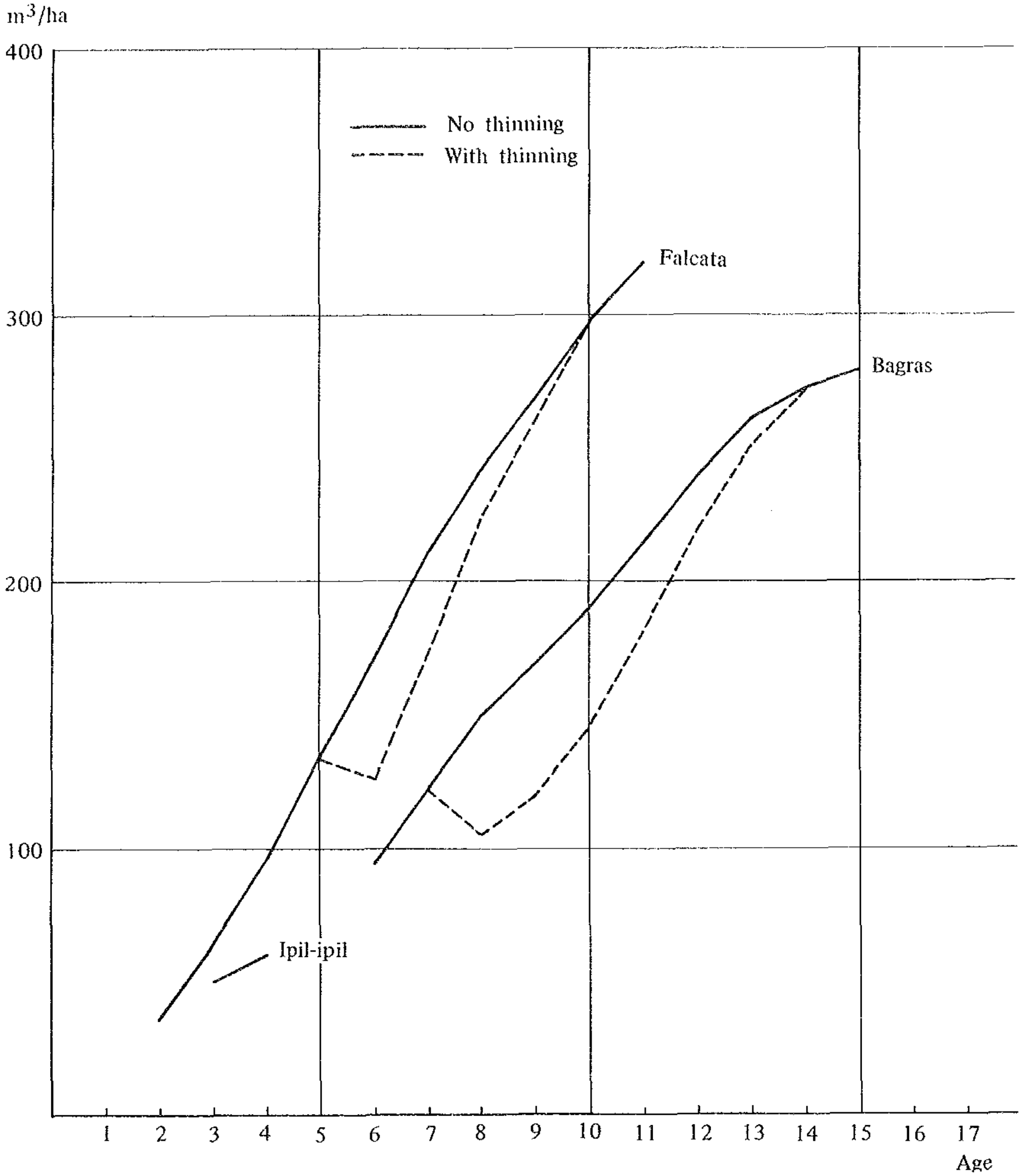
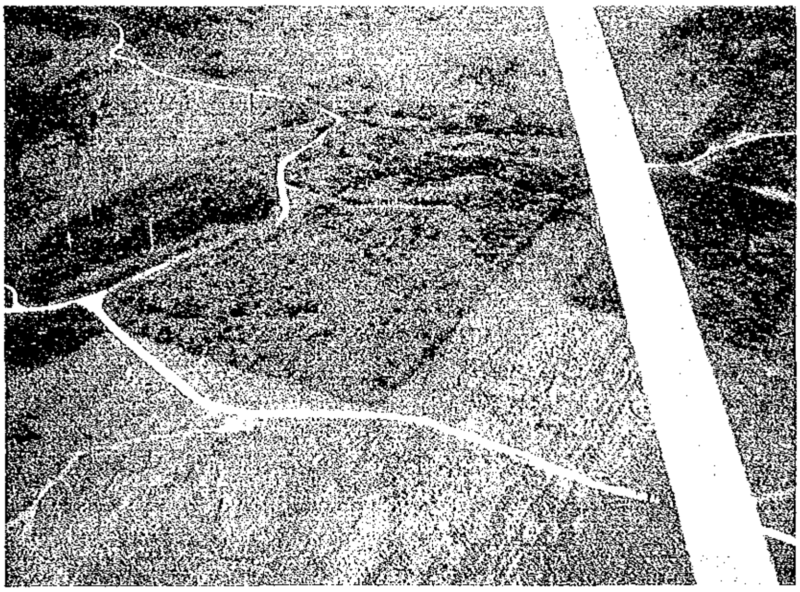
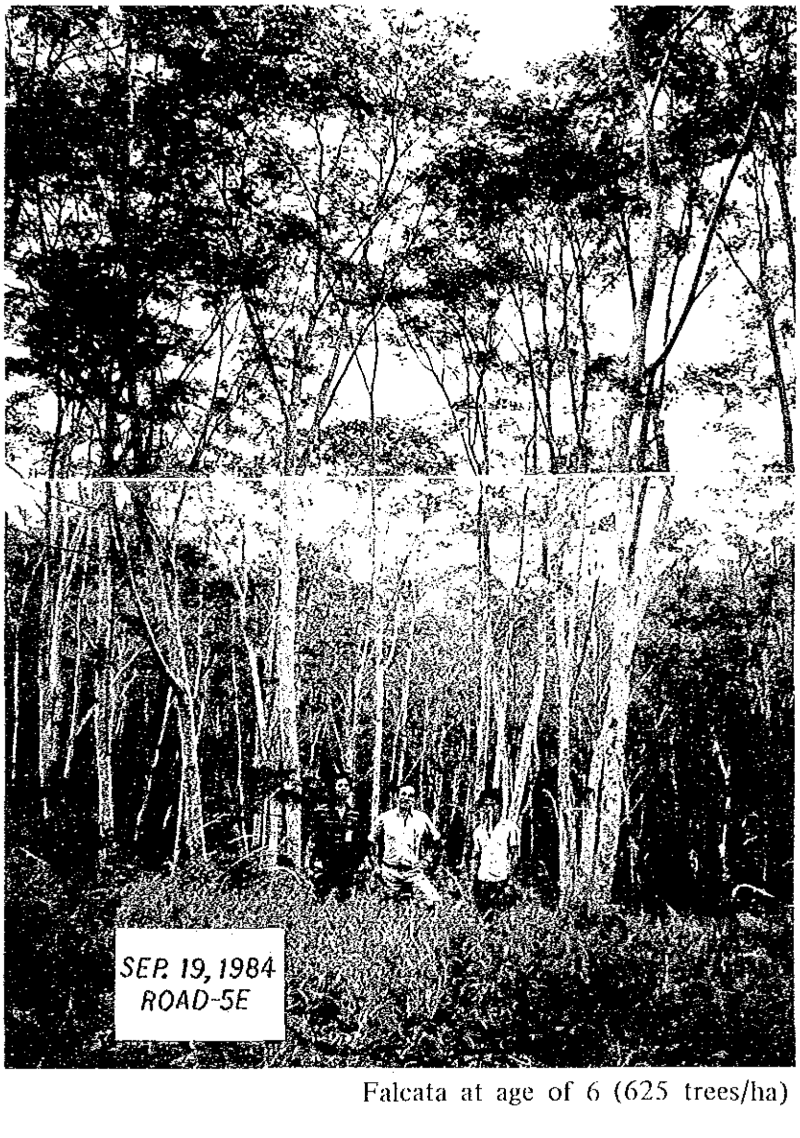


Fig. IV–2 Expecting Yield Volume



Industrial tree plantation



Falcata at age of 6 (625 trees/ha)

for us to get better productivity through the logging of larger sized trees.

PICOP has made the planting and harvesting plans of industrial tree plantation at the harvesting ages shown in the following table.

Presumably the harvesting ages of both Falcata and Ipil-ipil are reasonable, but the harvesting age of Bagras seems to be too young from the viewpoint of increment.

Species	Age of max. mean annual increment		Age adopted in PICOP's plan
	No thinning	With thinning	
	years	years	years
Falcata	8	10	7 - 8 - 9
Bagras	13	14	7 - 8
Ipil-ipil	3	-	3 - 4

1–3–4 Storm Damage

In March, 1982, an unseasonal Typhoon Akang (the first on 40 years record) cut a swath of destruction across the plantations in the vicinity of Bislig. (Refer to Table IV–6). Both company-owned and farmer-owned stands were struck.

The severe damage occurred in Falcata timber stands in the 4-year and upward age class trees which were approaching their harvesting age.

49% of Falcata plantations established before the Typhoon, corresponding to up to 61% of Falcata plantations in the 4-year and upward age, were damaged.

More than 70% of the damage were in the "snapping" of the brittle tops rather than the uprooting of the tree. For this reason many trees remain standing; new branches have sprouted from the broken tops to keep the tree alive, and a little additional growth can be expected in the future.

However, nearly 30% of the damaged plantations were in trunk-breaking, so these were salvaged and replanted.

Meanwhile, 54% of Bagras plantations established before the Typhoon, including even the youngest plantations, were damaged.

And the damage of the plantations in the 7-year and upward age class trees were serious.

The extent of the damage of Bagras was almost the same as that of Falcata.

A normal growth of damaged plantation could not be expected in the future, but the damaged Bagras could be available for pulpwood.

The route of high wind could be clearly distinguished at a glance after the Typhoon, because the damage occured along the route of high wind. But the damage was so quickly recovered that the study team could not search the damaged areas through air surveys made in September, 1984.

As a matter of fact, it is impossible to take countermeasure against typhoon because nobody can predict when it comes.

PICOP has clear policy that PICOP will purchase or import pulpwood and chips to operate the Mill, in case the lack of raw material brought by typhoon causes the Mill to close down.

It is well understood that the above-mentioned measure would be one of practical solutions, because Bislig has good harbor.

Table IV–6 Damage caused by Typhoon Akang (March, 1982)

Year	Age	Falcata				Bagras				Mixed				Pine				Total			
		Areas Planted (1)	Areas Damaged (2)	(2)/(1) x 100	A.P.	Areas Planted (1)	Areas Damaged (2)	(2)/(1) x 100	A.P.	Areas Planted (1)	Areas Damaged (2)	(2)/(1) x 100	A.P.	Areas Planted (1)	Areas Damaged (2)	(2)/(1) x 100	A.P.	Areas Planted (1)	Areas Damaged (2)	(2)/(1) x 100	A.P.
		ha	ha	%	%	ha	ha	%	%	ha	ha	%	%	ha	ha	%	%	ha	ha	%	%
1971	11	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
72	10	–	–	–	–	385.53	325.00	84.3	84.3	–	–	–	–	60.88	2.00	3.3	3.3	446.41	327.00	73.3	73.3
73	9	2,126.19	660.00	31.0	31.0	428.64	344.00	80.3	82.6	–	–	–	–	118.26	17.00	14.4	10.6	2,673.09	1,021.00	38.2	43.2
74	8	2,253.50	1,919.00	85.2	58.9	302.00	302.00	100.0	87.0	–	–	–	–	30.94	27.00	87.3	21.9	2,586.44	2,248.00	86.9	63.0
75	7	1,650.59	872.00	52.8	57.2	466.93	461.00	98.7	90.5	–	–	–	–	27.48	9.00	32.8	23.2	2,145.00	1,342.00	62.6	62.9
76	6	1,590.25	526.00	33.1	52.2	162.51	55.00	33.8	85.2	–	–	–	–	49.68	2.00	4.0	19.8	1,802.44	583.00	32.3	57.2
77	5	1,035.50	741.00	71.6	54.5	1,503.30	36.36	2.4	46.9	354.37	–	–	–	544.02	7.00	1.3	7.7	3,437.19	784.36	22.8	48.2
78	4	3,119.91	2,499.00	80.1	61.3	2,565.78	1,211.00	47.2	47.0	436.91	–	–	–	148.76	32.00	21.5	9.8	6,271.36	3,742.00	59.7	51.9
79	3	1,031.98	–	–	56.3	1,446.12	603.00	41.7	46.0	503.13	–	–	–	24.39	10.00	41.0	10.6	3,005.62	613.00	20.4	47.7
80	2	411.71	–	–	54.6	1,106.99	1,027.00	92.8	52.2	274.61	–	–	–	3.91	–	–	10.5	1,797.22	1,027.00	57.1	48.4
81	1	1,395.71	–	–	49.4	929.62	635.00	68.3	53.8	313.34	–	–	–	0.24	–	–	10.5	2,638.91	635.00	24.1	46.0
Total		14,615.34	7,217.00	49.4		9,297.42	4,999.36	53.8		1,882.36	–	–	–	1,008.56	106.00	10.5		26,803.68	12,322.36	46.0	

A.P.: Accumulated Damage Percent = $\sum_{1971}^{n}$ (Areas Damaged) / $\sum_{1971}^{n}$ (Areas Planted)

2. Wood Supply Plan

PICOP's wood supply plan (from 1984 to 1994) and the result (from 1980 to 1983, including estimates by Study Team) are briefly described by main wood supply sources in this chapter.

Details of wood supply plan are cescribed in attached Appendixes.

2–1 Natural Forest (Refer to Appendix IV–1)

Output of natural forest will drop sharply in the future to less than one third of present output.

(in 1,000m^3)

Wood species	1980 - 1984 (1) ave. yearly output		1985 - 1989 (2) ave. yearly output		1990 - 1994 (3) ave. yearly output	
		(1)/(1)		(2)/(1)		(3)/(1)
Sawtimber	484	100	235	49	113	23
Pulpwood	344	100	216	63	75	22
Fuelwood	108	100	218	202	69	64
Total	936	100	669	71	257	27

It seems impossible to increase average yearly output to more than the volume shown in the table because allowable cutting volume should be authorized by the Bureau of Forest Development beforehand.

2–2 Industrial Tree Plantation (Refer to Appendix IV–2, IV–3, IV–4, IV–5, IV–6)

Output of industrial tree plantation will rise sharply in the future as shown in the table.

(in 1,000m^3)

Species	1980 - 1984 (1) ave. yearly output		1985 - 1989 (2) ave. yearly output		1990 - 1994 (3) ave. yearly output	
		(1)/(1)		(2)/(1)		(3)/(1)
Falcata	148	100	85	57	427	289
Bagras	9	100	27	300	174	1933
Ipil-ipil	-		63		264	
Total	157	100	175	111	865	551

When planting and harvesting plans of industrial tree plantation shown in attached Appendixes were made, PICOP excluded both areas damaged by Typhoon Akang and areas harvested until 1983.

These areas of Falcata are totalling up to 9,412 hectares (7,217 + 2,195: refer to Appendix IV–2), and these of Bagras are totalling up to 5,121 hectares (5,000 + 121: refer to Appendix IV–3).

As mentioned in IV–1–3–4 "Storm Damage", the damage caused by Typhoon Akang was not so serious, and also the damaged plantations have been recovering their growth through replantation or rehabilitation measures.

Particulary, since Falcata is a coppicing species it is certain that at least Falcata Plantations damaged by Typhoon Akang must considerably recover their additional growth.

However, PICOP has excluded plantation areas damaged by Typhoon Akang from PICOP's wood supply plan. And, the ages of both Falcata and Bagras plantations in PICOP's harvesting plans are counted one year younger than actual plantation ages where the plantations are to be cut, that is, actual 8 year old plantation is described as 7 year old plantation. Also, the expecting yield volume of 7 years old is employed instead of volume of 8 years old, in accordance with the age described in PICOP's harvesting plan. Furthermore, the expecting yield volume used in harvest plans are the volumes that had been obtained by multiplying volumes listed in Table IV–5 "Expecting Yield Volume and Mean Annual Increment" by some safety factors. It should be noted that PICOP underestimates the output from its industrial tree plantation.

By taking into account the above points, PICOP's harvesting plans have become safer and steadier volume from the viewpoint of wood supply plan. And, as mentioned in IV–2–6 "Total Wood Supply Plan and Total Wood Requirement", PICOP will be able to supply the wood volume required under both Renovation Plan A and Renovation Plan B by adjusting PICOP's present wood supply plan slightly. Therefore, the wood supply plan which was submitted during the field surveys has been used in this report as it is, to avoid any confusions. However, it is necessary for PICOP to make new wood supply plans to meet Renovation Plan A and B in consideration of the above-mentioned points.

As mentioned in IV–1–3–1 "Planted Areas in Industrial Tree Plantation", PICOP intends to complete its industrial tree plantation development program until the end of 1988.

PICOP's industrial tree plantation theoretically has the potential to supply the volume by species shown in the following table if the plantation continues to grow on the cycles shown in the following table after the completion of its plantation development program.

Species	Areas Planted	Rotation Age	Mean Annual Increment No Thinning	Potential Supply Volume
	ha	years	m^3/ha/yr	1,000m^3/year
Falcata	26,194	8	30.3	794
Bagras	26,165	8	18.8	492
Ipilk-ipil	20,000	4	15.0	300
Total	72,359			1,586

Comparing potential supply volume in the above table with average yearly output (from 1990 to 1994) in the previous table, it is obvious that there is considerable room to increase supply volume as far as PICOP's wood supply plan of industrial tree plantation is concerned.

2–3 Agro-Forestry (Refer to Appendex IV–7, IV–8)

The wood supply plan has also excluded harvested areas of agro-forestry until the end of 1983 like the case of industrial tree plantation.

Since tree farmers of agro-forestry have planted only Falcata which has reproductive power from stump, cut-over areas should reproduce Falcata stands naturally.

It is estimated that about 10,000 hectares are not included in PICOP's harvesting plan of agro-forestry.

(in 1,000 m^3)

Species	1980 - 1984 (1) ave. yearly output		1985 - 1989 (2) ave. yearly output		1990 - 1994 (3) ave. yearly output	
		(1)/(1)		(2)/(1)		(3)/(1)
Falcata	248	100	293	118	182	73
Ipil-ipil	–		6		121	
Total	248	100	299	121	303	122

2–4 Wood Procurement Division (Refer to Table IV–7)

Only shortage of veneer logs and Falcata pulpwood is to be supplemented by wood procurement.

Judging from fuelwood consumptions in 1980 and 1981, considerable volume of fuelwood ought to have been procured, but Study Team can not make clear how many cubic meters of fuelwood PICOP had bought.

2–5 Mill-waste

Mill-wastes generated from timber manufacturing operations such as saw mill, plywood plants, wood processing plant and so on is fully utilized as fuel except veneer cores.

Although Study Team had not obtained PICOP's estimation of mill-waste, volume of mill-waste has been estimated as follows.

1) Generation rate of mill-waste has been calculated through Log Flow in 1983 by timber manufacturing operations.

2) Based upon the generation rate calculated in the above 1), the final generation rate has been decided as shown in the following table, taking log quality and process improvement in the future into consideration.

3) Volume of mill-waste has been obtained by multiplying the final generation rate by the volume of generation source.

(Refer to Table IV–7, in which volume of mill-waste is described as produced fuelhog).

	Source of waste generation	– 1984	1985–1987	1988 –
		%	%	%
Plywood plants	Consumed veneer logs	38–25	25	21
Sawmill	Consumed saw logs	54.2–51.7	51.3	48.3
Wood preparation plant & Woodyard	Total supplied logs	3.6	3.6	3.6
Bark	Total supplied logs except Falcata from agro-forestry	3.2	3.2	3.2

Good quality logs will be distributed to plywood plants and sawmill because PICOP is planning to stop log sales including export from 1988 onward. Therefore, processing yield percentage will be improved and waste generation rate will be decreased.

2–6 Total Wood Supply Plan and Total Wood Requirement

Table IV–7 "Wood Supply Plan" shows the grand total from 2–1 to 2–5. Table IV–8–A "Wood Requirement (A)" shows total wood requirement when Renovation Plan A is carried out.

Table IV–8–B "Wood Requirement (B)" shows total wood requirement when Renovation Plan B is carried out.

And wood assortments are divided as follows.

Sawtimber: Logs for export and domestic sales and veneer logs.
Falcata: Pulpwood for newsprint, namely, for white chips.
Others : The sum of pulpwood for red chips, fuelwood and logs for sawmill. (Necessary volume of logs for sawmill shall be selected from all logs that come to wood preparation plant, except sawtimber.)

Table IV–8–A shows that PICOP will be able to supply wood requirement when Renovation Plan A is carried out, although it is necessary to adjust potential of wood fuel to dividing equally. Since total log requirement in the table does not include the consumption of wood fuel, the sum of excessive supply and produced fuelhog is described as potential of wood fuel in the table.

Table IV–8–B shows the demand and supply of woods when Renovation Plan B is carried out.

In this case, the total of nearly 269,000 m^3 will be short of "Others" including pulpwood for red chips from 1989 to 1991.

However, supply from 1985 to 1988 is nearly 574,000 m^3 in excess of requirement during the same period.

So it is possible to offset the shortage by postponing the cutting of excessive supply from 1985 to 1988.

Consequently, PICOP will be able to supply wood requirement through slight adjustment of its wood supply plan when Renovation plan B is carried out.

Table IV–7 Wood Supply Plan

(in 1,000 m³)

	1980	1981	1982	1983	1984	Sub-total	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	Sub-total
Natural Forest																	
Sawtimber	686	500	436	447	351	2,420	305	278	310	171	113	113	113	113	113	113	1,742
Pulpwood (red)	373	354	308	328	356	1,719	323	275	297	107	75	75	75	75	75	75	1,452
Fuelwood	28	85	74	197	157	541	246	340	352	84	69	69	69	69	69	69	1,436
Sub-total	1,087	939	818	972	864	4,680	874	893	959	362	257	257	257	257	257	257	4,630
Industrial Tree Plantation																	
Falcata	40	55	289	197	158	739	54	86	115	55	113	425	438	458	445	368	2,557
Pulpwood (red)	-	10	12	20	1	43	-	10	7	61	56	62	41	205	218	344	1,004
Fuelwood	-	-	-	-	-	-	-	-	7	111	195	215	227	365	261	253	1,634
Sub-total	40	65	301	217	159	782	54	96	129	227	364	702	706	1,028	924	965	5,195
Agro-Forestry																	
Falcata	175	178	244	346	270	1,213	252	191	180	444	398	185	200	179	175	172	2,376
Fuelwood	7	21	-	-	-	28	-	-	-	-	30	60	90	122	152	182	636
Sub-total	182	199	244	346	270	1,241	252	191	180	444	428	245	290	301	327	354	3,012
Total																	
Sawtimber	686	500	436	447	351	2,420	305	278	310	171	113	113	113	113	113	113	1,742
Falcata	215	233	533	543	428	1,952	306	277	295	499	511	610	638	637	620	540	4,933
Pulpwood (red)	373	364	320	348	357	1,762	323	285	304	168	131	137	116	280	293	419	2,456
Fuelwood	35	106	74	197	157	569	246	340	359	195	294	344	386	556	482	504	3,706
Total	1,309	1,203	1,363	1,535	1,293	6,703	1,180	1,180	1,268	1,033	1,049	1,204	1,253	1,586	1,508	1,576	12,837
Wood Procurement																	
Sawtimber	-	-	-	-	-	-	-	-	-	-	25	25	14	33	47	47	191
Falcata	-	-	-	-	6	6	144	173	156	-	-	-	-	-	-	-	473
Pulpwood (red)	-	-	-	75	75	150	-	-	-	-	-	-	-	-	-	-	-
Sub-total	-	-	-	75	81	156	144	173	156	-	25	25	14	33	47	47	664
Grand Total																	
Sawtimber	686	500	436	447	351	2,420	305	278	310	171	138	138	127	146	160	160	1,933
Falcata	215	233	533	543	434	1,958	450	450	451	499	511	610	638	637	620	540	5,406
Others	408	470	394	620	589	2,481	569	625	663	363	425	481	502	836	775	923	6,162
Total	1,309	1,203	1,363	1,610	1,374	6,859	1,324	1,353	1,424	1,033	1,074	1,229	1,267	1,619	1,555	1,623	13,501
Produced Fuelhog	216	168	156	226	202	968	232	165	162	146	139	155	154	194	202	206	1,755

Table IV–8–A Wood Requirement (A) (in 1,000 m^3)

	1980	1981	1982	1983	1984	Sub-total	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	Sub-total
Log Sales																	
Export --- Lauan	132	100	76	113	66	487	77	43	35	-	-	-	-	-	-	-	155
Local	116	112	136	129	60	553	17	-	-	-	-	-	-	-	-	-	17
Sub-total	248	212	212	242	126	1,040	94	43	35	-	-	-	-	-	-	-	172
Export --- Falcata	-	9	23	24	-	56	-	-	-	-	-	-	-	-	-	-	-
Total	248	221	235	266	126	1,096	94	43	35	-	-	-	-	-	-	-	172
Plywood Mill	333	219	117	157	167	993	175	115	101	169	138	138	127	146	160	160	1,429
Sawmill	29	27	67	138	129	390	208	99	90	114	101	101	97	122	140	140	1,212
Pulp Mill																	
Falcata	214	224	328	400	450	1,616	450	450	450	324	451	494	507	507	507	507	4,647
Red chips	530	499	187	262	296	1,774	296	296	296	247	321	340	340	340	340	340	3,156
Total	744	723	515	662	746	3,390	746	746	746	571	772	834	847	847	847	847	7,803
Total Log Requirement																	
Logs for Sales & Plymill	581	431	329	399	293	2,033	269	158	136	169	138	138	127	146	160	160	1,601
Falcata	214	233	351	424	450	1,672	450	450	450	324	451	494	507	507	507	507	4,647
Others	559	526	254	400	425	2,164	504	395	386	361	422	441	437	462	480	480	4,368
Total	1,354	1,190	934	1,223	1,168	5,869	1,223	1,003	972	854	1,011	1,073	1,071	1,115	1,147	1,147	10,616
Total Log Supply																	
Logs for Sales & Plymill	686	500	436	447	351	2,420	305	278	310	171	138	138	127	146	160	160	1,933
Falcata	215	233	533	543	434	1,958	450	450	451	499	511	610	638	637	620	540	5,406
Others	408	470	394	620	589	2,481	569	625	663	363	425	481	502	836	775	923	6,162
Total	1,309	1,203	1,363	1,610	1,374	6,859	1,324	1,353	1,424	1,033	1,074	1,229	1,267	1,619	1,555	1,623	13,501
Difference																	
Logs for Sales & Plymill	105	69	107	48	58	387	36	120	174	2	-	-	-	-	-	-	332
Falcata	1	-	182	119	Δ 16	286	-	-	1	175	60	116	131	130	113	33	759
Others	Δ 151	Δ 56	140	220	164	317	65	230	277	2	3	40	65	374	295	443	1,794
Total (1)	Δ 45	13	429	387	206	990	101	350	452	179	63	156	196	504	408	476	2,885
Produced Fuelhog (2)	216	168	156	226	202	968	232	165	162	146	139	155	154	194	202	206	1,755
Potential of Wood Fuel (3)=(1)+(2)	171	181	585	613	408	1,958	333	515	614	325	202	311	350	698	610	682	4,640
Actual consumption of wood fuel (4)	433	503	518	554													
(3) - (4)	Δ 262	Δ 322	67	59													

Table IV–8–B Wood Requirement (B)

(in 1,000 m^3)

	1980	1981	1982	1983	1984	Sub-total	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	Sub-total
Log Sales																	
Export --- Lauan	132	100	76	113	66	487	77	43	35	-	-	-	-	-	-	-	155
Local	116	112	136	129	60	553	17	-	-	-	-	-	-	-	-	-	17
Sub-total	248	212	212	242	126	1,040	94	43	35	-	-	-	-	-	-	-	172
Export --- Falcata	-	9	23	24	-	56	-	-	-	-	-	-	-	-	-	-	-
Total	248	221	235	266	126	1,096	94	43	35	-	-	-	-	-	-	-	172
Plywood Mill	333	219	117	157	167	993	175	115	101	169	138	138	127	146	160	160	1,429
Sawmill	29	27	67	138	129	390	208	99	90	114	101	101	97	122	140	140	1,212
Pulp Mill																	
Falcata	214	224	328	400	450	1,616	450	450	450	324	451	494	507	507	507	507	4,647
Red chips	530	499	187	262	296	1,774	296	296	296	247	387	494	497	497	497	497	4,004
Total	744	723	515	662	746	3,390	746	746	746	571	838	988	1,004	1,004	1,004	1,004	8,651
Total Log Requirement																	
Logs for Sales & Plymill	581	431	329	399	293	2,033	269	158	136	169	138	138	127	146	160	160	1,601
Falcata	214	233	351	424	450	1,672	450	450	450	324	451	494	507	507	507	507	4,647
Others	559	526	254	400	425	2,164	504	395	386	361	488	595	594	619	637	637	5,216
Total	1,354	1,190	934	1,223	1,168	5,869	1,223	1,003	972	854	1,077	1,227	1,228	1,272	1,304	1,304	11,464
Total Log Supply																	
Logs for Sales & Plymill	686	500	436	447	351	2,420	305	278	310	171	138	138	127	146	160	160	1,933
Falcata	215	233	533	543	434	1,958	450	450	451	499	511	610	638	637	620	540	5,406
Others	408	470	394	620	589	2,481	569	625	663	363	425	481	502	836	775	923	6,162
Total	1,309	1,203	1,363	1,610	1,374	6,859	1,324	1,353	1,424	1,033	1,074	1,229	1,267	1,619	1,555	1,623	13,501
Difference																	
Logs for Sales & Plymill	105	69	107	48	58	387	36	120	174	2	-	-	-	-	-	-	332
Falcata	1	-	182	119	Δ 16	286	-	-	1	175	60	116	131	130	113	33	759
Others	Δ 151	Δ 56	140	220	164	317	65	230	277	2	Δ 63	Δ 114	Δ 92	217	138	286	946
Total (1)	Δ 45	13	429	387	206	990	101	350	452	179	Δ 3	2	39	347	251	319	2,037
Produced Fuelhog (2)	216	168	156	226	202	968	232	165	162	146	139	155	154	194	202	206	1,755
Potential of Wood Fuel (3)=(1)+(2)	171	181	585	613	408	1,958	333	515	614	325	136	157	193	541	453	525	3,792
Actual consumption of wood fuel (4)	433	503	518	554													
(3) - (4)	Δ 262	Δ 322	67	59													

3. Pulpwood Cost

3–1 Present Pulpwood Cost

All logs are supplied to Bislig from

a) natural forest (virgin forest and second growth forest)
b) industrial tree plantation
c) agro-forestry
d) wood procurement division.

Logs from natural forest and industrial tree plantation shall be logged out by PICOP itself, namely logs produced by Company Logging Operation. Plantation development cost in industrial tree plantation and agro-forestry shall correspond with stumpage cost in natural forest.

Logs from agro-forestry are usually purchased at roadside and their delivery costs at mill woodyard are lower than those of logs from industrial tree plantation because tree farmers of agro-forestry plant seedlings and harvest trees by themselves.

Meanwhile, procured logs are higher than any other logs because they have to be transported on barges from Davao, Iligan, etc. to Bislig.

Table IV–9 shows actual cost of logs from natural forest from January to May, 1984, and estimated cost of logs to be produced from natural forest from January to December, 1984.

Table IV–10 shows the same costs in industrial tree plantation.

Estimated costs in both tables were made by Study Team. (Refer to Appendix IV–9, IV–12, IV–14, IV–15.)

Table IV-9 Cost of Logs from Natural Forest (in US$/m³)

	Actual cost Jan. - May 1984	Estimated cost Jan. - Dec. 1984
Virgin forest/ Natural forest	42 %	37.5 %
	US$/$m^3$	US$/$m^3$
Operating costs		
Extraction expenses (Felling - Yarding)	3.62	3.67
Loading & Hauling	4.73	4.66
Sub-total	8.35	8.33
Other costs		
Road cost	1.28	
Overhead	4.07	
Silvicultural fees	0.13	
Sub-total	5.48	5.48
Total	13.83	13.81

Comparing with second growth forest, virgin forest is cheaper in extraction expenses, but higher in road cost, loading and hauling costs.

1 US$ = 14 Peso in Jan. - May, 1984.

Table IV–10 Cost of Logs from Industrial Tree Plantation (in US$/m³)

	Actual cost Jan. - May 1984	Estimated cost Jan. - Dec. 1984
	US$/$m^3$	US$/$m^3$
Operating costs		
Extraction expenses	4.66	4.66
Loading & Hauling	4.90	4.63
Sub-total	9.56	9.29
Other costs		
Road cost	1.17	
Overhead	3.83	
Stumpage cost	1.87	
Sub-total	6.87	6.87
Total	16.43	16.16

Since road cost and overhead per unit volume are even among wood assortment such as sawtimber, pulpwood and fuelwood produced by Company Logging Operation, average pulpwood cost to be supplied in 1984 is estimated as shown in Table IV–11.

Table IV–11 Pulpwood Delivery Cost at Mill Woodyard in 1984

	Output of pulpwood 1,000m^3	Delivery costs at woodyard US$/$m^3$
Natural forest	356	13.8
Industrial tree plantation	159	16.2
Agro-Forestry	270	13.9
Wood procurement div.	81	19.4
Total	866	14.8

1 US$ = 18 Pesos

Table IV–11 shows actual pulpwood delivery cost at mill woodyard, gathered by the Woods Group. But PICOP delivers logs to timber manufacturing operations at the costs set up on the basis of market prices by wood assortment. Therefore, each of timber manufacturing operations is receiving logs at the cost which is nearly the level of market price. In this connection, the present delivery costs of chips are as follows:

white chip : 351 P/m^3 (19.50 US$/$m^3$)
red chip : 289 P/m^3 (16.10 US$/$m^3$)

And the above prices are used in the chapter "Financial and Economic Analysis"

3–2 Cost Analysis

3–2–1 Operating Cost

(1) Condition of stand on logging operation (Refer to Appendix IV–18)
Present and future harvesting volume per year, standard condition on logging operation and standard harvesting volume per hectare are shown in Table IV–12, IV–13 and IV–14 respectively, based upon the data submitted by PICOP and the spot survey results made by Study Team. The following are distinctive in PICOP's logging operations.

1) A network of all-weather roads covers the whole forest land and the roads are well maintained, using lots of ballast produced from nearby quarries in the forest. So logging operation can be performed throughout the year by heavy U.S. made machinery and equipment (such as highlead system and tractors), thanks to densely developed forest road network against abundant rainfall. (Refer to Appendix IV–13).

2) Forest workers work more than 300 days in a year, 10 hours a shift in felling and yarding operations and two-shift a day in loading and hauling operations.

3) Forest workers are well trained and inexpensive under piece-rate wage. Lots of staff and computers are utilized for strict management.

4) Since logging machinery and equipment is well repaired and maintained in PICOP owned work shop, machines are utilized very efficiently.

(2) Logging systems
Flow charts of logging operations in both natural forest and industrial tree plantation could be simplified as shown in Table IV–15 and IV–16.

(3) Logging cost
Table IV–19 and IV–10 are estimates of logging costs in both natural forest and insutrial tree plantation based upon Table IV–15 and IV–16. (Details of estimates are calculated in Appendix IV–14 and IV–15.)

Table IV-12 Harvesting Volume in 1984, 1987 and 1992

Forst type	logging system	Wood assortment	1984			1987			1992		
			ha	m^3/ha	$1,000m^3$	ha	m^3/ha	$1,000m^3$	ha	m^3/ha	$1,000m^3$
Natural Forest Virgin Forest	Selective Logging	Sawtimber		69	173		64	130			
		Pulpwood		49	124		39	79			
		Fuelwood		11	27		14	29			
		Total	2,500	129	324	2,036	117	238	–	–	–
Second Growth Forest	Selective Logging	Sawtimber								48	113
		Pulpwood								24	55
		Fuelwood								17	39
		Total	–	–	–	–	–	–	2,331	89	207
"	Timber Stand Improvement	Pulpwood					20	20		20	20
		Fuelwood			2		30	30		30	30
		Total			2	1,000	50	50	1,000	50	50
"	Clearcut	Sawtimber		59	178		56	180			
		Pulpwood		77	232		62	198			
		Fuelwood		43	128		92	293			
		Total	3,000	179	538	3,187	210	671	–	–	–
Total		Sawtimber		64	351		50	310		34	113
		Pulpwood		65	356		48	297		22	75
		Fuelwood		28	157		56	352		21	69
		Total	5,500	157	864	6,223	154	959	3,331	77	257
Industrial Tree Plantation	Clearcut	Falcata	2,042	77	158	1,294	89	115	2,878	159	458
		Pulpwood	34	19	1	175	40	7	1,660	123	205
		Fuelwood	–	–	–	120	60	7	6,824	53	365
		Total	2,076	77	159	1,589	81	129	11,362	90	1,028
Agro-Forestry	Clearcut	Falcata			270	1,024	176	180	1,054	170	179
		Fuelwood			–	–	–	–	2,025	60	122
		Total			270	1,024	176	180	3,079	98	301
Wood Procurement		Sawtimber			–			–			33
		Falcata			6			156			–
		Pulpwood			75			–			–
		Total			81			156			33
Grand Total		Sawtimber			351			310			146
		Falcata			434			451			637
		Pulpwood			432			304			280
		Fuelwood			157			359			556
		Total			1,374			1,424			1,619

Table IV−13 Stand Condition on Logging Operation

Forest Type	Logging system	Slope class distribution: Areas	Slope class distribution: Slope	1985 .... 1994: Cutting areas	1985 .... 1994: Output per ha.	1985 .... 1994: Total output	Average tree size: DBH	Average tree size: Height	Average tree size: Available Volume	Average tree size: No. of trees per ha.	Hauling Distance	Wood Assortment: Sawtimber	Wood Assortment: Pulpwood	Wood Assortment: Fuelwood
		%	%	ha	m^3/ha	1,000m^3	cm	m	m^3/tree	No./ha	km	%	%	%
Natural Forest														
Virgin Forest	Selective logging	100	over 30	7,271	104	753	90	(30)	7	15	46	54	32	14
Second Growth Forest	ditto			16,317	89	1,449	80	(30)	6	15	42	55	26	19
ditto	Timber Stand Improvement	30 70	less 30 over 30	10,000	50	500	40	(15)	1.0	50	42	-	40	60
ditto	Clearcut			9,587	201	1,928	45	(15)	1.3	155	42	28	33	39
Total				43,175	107	4,630						38	31	31
Industrial Tree Plantation														
Falcata	Clearcut			18,310	140	2,557	24	19	0.31	450	30	-	100	-
Bagras	ditto	50	less 30	12,092	83	1,004	21	18	0.19	430	30	-	100	-
Ipil-ipil, etc.	ditto	50	over 30	30,253	54	1,634	12	10	0.03	1,800	30	-	-	100
Total				60,655	86	5,195						-	68	32
Agro-Forestry														
Falcata	Clearcut	50	less 30	14,757	161	2,376	22	17	0.21	750	67	-	100	-
Ipil-ipil	ditto	50	over 30	10,575	60	636	12	10	0.03	2,000	67	-	-	100
Total				25,332	119	3,012						-	79	21
Grand-Total				129,162	99	12,837						14	57	29
Wood Procurement						664	25	20	0.35			29	71	-

Note: ( ) under main branch

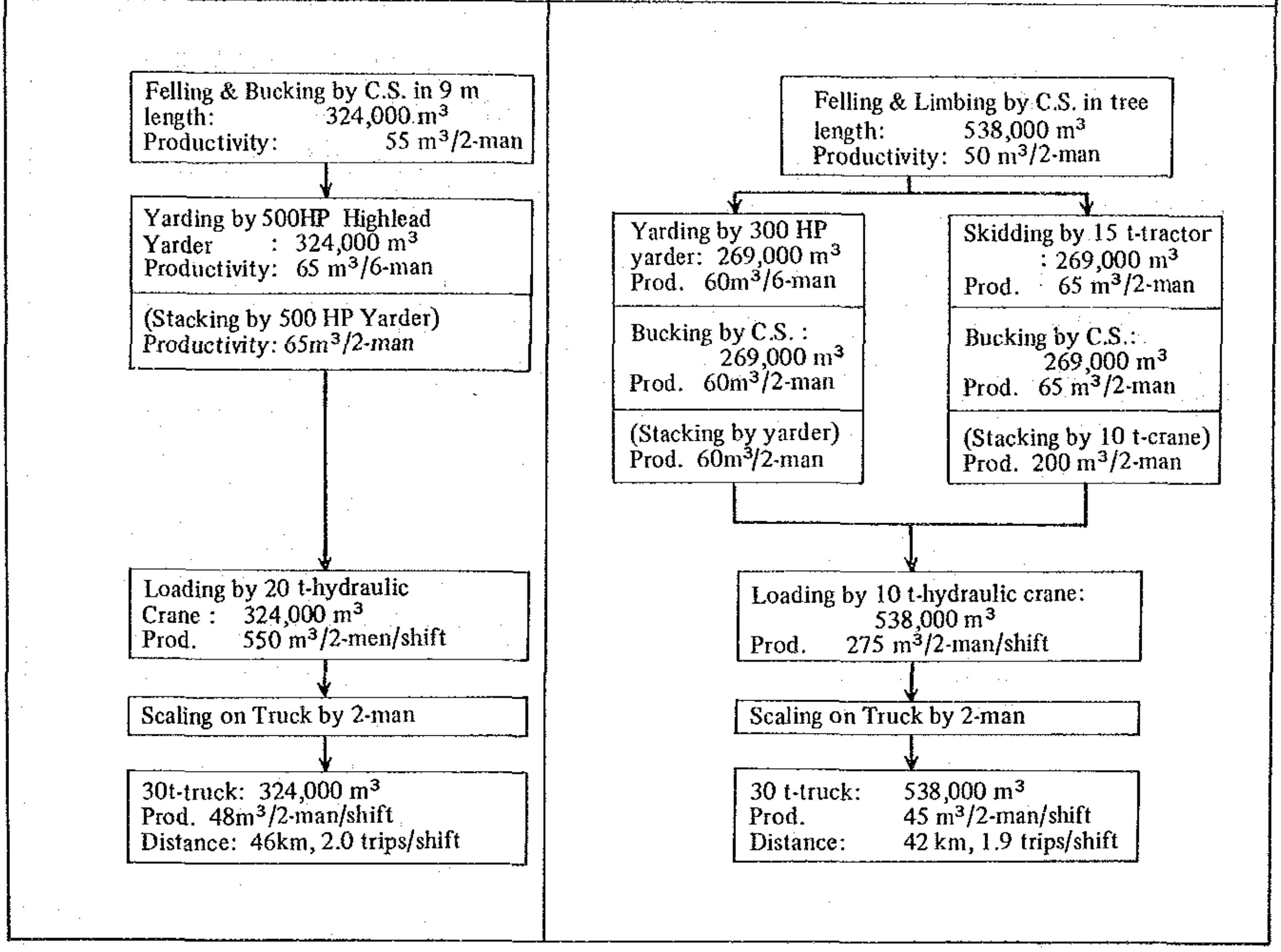
Table IV-14 Standard Harvesting Volume per Hactar (no thinning)

	Bagras	Falcata		Pine	Mixed	Ipil-ipil	
	ITP	ITP	Agro-F	ITP	ITP	ITP	Agro-F
Planting interval (m)	3x3	3x3	3x3	4x3	4x3	2x2	
No. of planting trees (No./ha)	1,111	1,111	1,111	833	833	2,500	
Cutting age (years)	8	8	6	15	8	4	
Percentage of remaining trees up to cutting age	0.7	0.7	0.72	0.6	0.7	0.8	
No. of remaining trees up to cutting age (No./ha)	777	777	800	500	583	2,000	
DBH (cm)	20.5	24	21.5	25	23.5	12	
Height/DBH	0.85	0.79	0.79	0.74	0.83	0.79	
Height (m)	17.5	19	17	18.5	19.5	9.5	
Breast height form factor	0.44	0.44	0.44	0.43	0.44	0.44	
Standing tree volume including bark (m^3)	0.251	0.379	0.271	0.39	0.372	0.047	
Utilization percent (up to 7 cm top diameter)	0.77	0.82	0.79	0.77	0.82	0.64	
Available volume (m^3)	0.193	0.311	0.214	0.3	0.305	0.03	
Output per ha (m^3/ha)	150	242	172	(150)		60	
Expecting yield in 1992 in PICOP's plan (m^3/ha)	125	242	170		178	53	60

ITP : Industrial Tree Plantation
Agro-F : Agro-Forestry
DBH : Diameter Breast Height

Table IV–15 Flow Chart of Logging Operation in Natural Forest in 1984

Forest type Cutting system Cutting areas m^3/ha Output Available volume per tree Volume per log	Virgin forest Selective 2,500 ha 129 m^3/ha 324,000 m^3 7 m^3/tree L 9 m 2.3 m^3/Piece	Second growth forest Clearcut including T.S.I. 3,000 ha 179 m^3/ha 538,000 m^3 1.3 m^3/tree L 9 m 0.8 m^3/piece



C.S. : Chain Saw
Prod. : Productivity

10 working hours per shift