

Tabla 8.2 Costo Economico de Sistema FV (SHS)

System Size	55	Watt
System Cost per Watt	12	US\$
System Cost (Excluding Charge Controller & Battery)	538	US\$
Domestic Part	290	US\$
Imported Part	248	US\$
Installation Cost per System	69	US\$
(Including Labor Cost and Transportation Cost)		
Cost of the Charge Controller	60	US\$
Battery Cost	78	US\$
Cost of Distilled Water for Battery	0.59	US\$/Litter
Annual Operation and Maintenance (% of Initial Investment Costs)	1	%
Required Number of Battery	1	Piece
Required Volume of Distilled Water for the Battery	0.08	Litter/Battery·Month
Annually Generated Amount of Electricity	70	kWh/Y
Life Time of the System	20	Years
Life Time of the Charge Controller	5	Years
Life Time of the Battery	4	Years
No. of Households	200	
Discount Rate	10	%
CRF (20 Years)	0.1175	
Exchange Rate	6.53	Bs/US\$
	120.5	Yen/US\$
Tax Rate		
Imported Products:		
PV System (10% import tax and 14.94% Effective VAT)	24.94	%
Domestic Products:		
Value Added Tax	13	%
Transaction Tax	3	%
Agency Transaction Fee for the Imported Products	10	%
1) Annualized Investment Cost per kWh		
The cost of the PV system including the installation cost will be	607	US\$
Annualized investment cost will be		
Total system cost x CRF =	71	US\$
Annualized investment cost per kWh will be	1.02	US\$/kWh
2) Annual Cost of the Charge Controller, Battery and Distilled Water		
Charge controller replacement cost per year will be		
Controller cost / controller life =	12.1	US\$
Annual charge controller cost per kWh will be	0.17	US\$/kWh
Battery cost per year will be		
Battery cost / battery life =	19.4	US\$/Y
Annual battery cost per kWh will be	0.28	US\$/kWh
Required amount of distilled water per year will be		
0.08 litter/battery·month x 1 piece x 12 months/Y =	0.96	Litter
Annual cost of the distilled water will be		
0.96Litter x US\$0.59/Litter =	0.56	US\$
Annual cost of the distilled water per kWh will be	0.01	US\$/kWh
Thus, annual cost of the charge controller, battery and distilled water per kWh will be	0.46	US\$/kWh
3) Operation and Maintenance Cost per kWh		

Annualized OM cost per kWh will be (PV system cost x 2.5%) / power generation =	0.09	US\$/kWh
4) Total annualized cost of the PV System per kWh		
Total annualized cost of the PV System per kWh will be 1) + 2) + 3) =	1.6	US\$/kWh

Source: JICA Study Team

Tabla 8.3 Costo Economico de Micro-Central Hidroelectrica

<u>Micro-hydro Power:</u>		
Cost of Micro-hydro per kW	2,500	US\$
Installed capacity (kW)	30	kW
Cost of the Micro-hydro:	75,000	US\$
Civil works (including engineering)	45,000	US\$
Electromechanical equipment	30,000	US\$
2 Substations	10,000	US\$
Annual Electricity Generation	87,600	kWh/Year
OM Cost of the Electromechanical Equipment (% of investment)	2.0	%
OM Cost of the Civil Engineering (% of investment)	0.5	%
OM Cost of the Substations (% of investment)	2.0	%
Life Time of the Micro-hydro system	20	Years
Life Time of the Substations	20	Years
<u>Distribution Lines:</u>		
Cost of Primary Distribution Line per km	3,083	US\$/km
Cost of Secondary Distribution Line per km	3,409	US\$/km
Length of Primary Distribution Line	3	Km
Length of Secondary Distribution Line	3	Km
OM Cost of the Distribution Lines (% of investment)	2.5	%
Life Time of the Distribution Lines	20	Years
Discount Rate	10	%
CRF (20 Years)	0.1175	
Exchange Rate	6.53	Bs/US\$
	120.5	Yen/US\$
<u>Tax Rate</u>		
Imported Products:		
Hydraulic turbine and substations (5% Import Tax and 14.94% Effective VAT)	19.94	%
Domestic Products:		
Value Added Tax	13	%
Transaction Tax	3	%
Agency Transaction Fee for the Imported Products	10	%
1) Investment Cost of Micro-hydro		
Total initial investment cost of micro-hydro system including 2 substations is	85,000	US\$
Annualized investment cost will be US\$85000 x CRF =	9,988	US\$
Annual electricity generation will be	87,600	kWh/Year
Thus, annualized investment cost per kWh of the system will be	0.11	US\$/kWh
2) Cost of the Distribution Lines		
Total costs of the distribution lines will be	19,477	US\$
Annualized distribution line costs will be US\$19477 x CRF =	2,289	US\$
Annualized distribution line costs per kWh will be	0.03	US\$/kWh
3) Operation and Maintenance Cost		
Annual OM Cost of the micro-hydro system will be		
OM cost for the electromechanical equipment (2%)	600	US\$
OM cost for civil engineering (0.5%)	225	US\$
OM cost of the distribution lines (2.5%)	487	US\$
OM cost of the substations (2%)	200	US\$

Total OM cost per annual will be	1,512	US\$
Thus, total annual OM cost per kWh will be	0.02	US\$/kWh
4) Total Cost of the Micro-hydro System per kWh		
Thus, total Cost of the Micro-hydro System per kWh will be 1) + 2) + 3) =	0.16	US\$/kWh

Source: UMSA and JICA Study Team

Tabla 8.4 Costo Economico de Energia Eolica

Wind PV Hybrid System:

Installed Capacity: Wind 40 kW, PV 10kWp	50	kW
Cost of Wind Power (wind turbine, tower, etc.) and PV: Wind Power US\$200,000 (\$5,000 x 40 kW), PV US\$100,000 (\$10,000 x 10 kW) (The above costs include costs of installation materials, installation and transportation.)	300,000	US\$
Control House	10,000	US\$
Cost of Inverter & Converter	11,800	US\$
Cost of Batteries	4,000	US\$
OM cost of Wind PV Hybrid System (% of investment cost)	3	%
Annual Electricity Generation	87,600	kWh/Y
Life Time of the Wind PV Hybrid System and Control House	20	Years
Life Time of the Inverter and Converter	10	Years
Replacement Period of the Batteries	6	Years

Distribution Lines:

Cost of Primary Distribution Line per km	3,083	US\$/km
Cost of Secondary Distribution Line per km	3,409	US\$/km
Length of Primary Distribution Line	3	Km
Length of Secondary Distribution Line	3	Km
OM Cost of Distribution Lines (% of investment cost)	2.5	%
Life Time of the Distribution Lines	20	Years

Discount Rate	10	%
CRF (20 Years)	0.1175	
CRF (10 Years)	0.1627	
Exchange Rate	6.53	Bs/US\$
	120.5	Yen/US

Tax Rate

<u>Imported Products:</u>		
Wind Power System, Inverter, Converter (5% Import Tax, 14.94% Effective VAT)	19.94	%
PV System (10% Import Tax and 14.94% Effective VAT)	24.94	%
<u>Domestic Products:</u>		
Value Added Tax	13	%
Transaction Tax	3	%
Agency Transaction Fee for Imported Products	10	%

1) Investment Cost

The investment cost of the Wind PV Hybrid System and the control house will be	310,000	US\$
Annualized investment cost of the system will be US\$310000 x CRF =	36,412	US\$
The investment cost of the Inverter and Converter will be	11,800	US\$
Annualized investment cost of the Inverter and Converter will be US\$11800 x CRF =	1,920	US\$
Total costs of the distribution lines will be	19,476	US\$
Annualized investment cost of the distribution lines will be US\$19476 x CRF =	2,288	US\$
Annual cost of batteries will be Cost of batteries/life time of the batteries =	667	US\$
Total annualized investment cost of the Wind PV Hybrid System will be	41,287	US\$

Annual electricity generation will be	87,600	kWh
Therefore, annualized investment cost of the Wind PV Hybrid System will be	0.47	kWh
2) Operation and Maintenance Cost		
Annual OM cost of the Wind PV Hybrid System (3% of investment) will be	9,354	US\$
Annual OM cost of distribution lines (2.5% of investment) will be	256	US\$
Thus, total annual OM cost will be	9,610	US\$
Annual OM cost per kWh will be	0.11	US\$/kWh
3) Total annualized cost per kWh of the Wind PV Hybrid System		
Thus, annualized cost per kWh of the Wind PV Hybrid System will be 1) + 2) =	0.58	US\$/kWh

Source: JICA Study Team

Tabla 8.5 Costo Economico de Generador de Diesel

Diesel Generator:		
Cost of Diesel Generator	22,500	US\$
Generation Capacity	30	kW
Cost of Generator per kW	750	US\$/kW
Cost of Automatic Transfer Switch	1,910	US\$
Cost of Protection Box	917	US\$
Building	1,500	US\$
OM Cost of Generator (% of investment cost)	5	%
Operation Hour per Day	10	Hours/Day
Generated Power	87,600	kWh/Year
Life Time of the Generator	10	Years
Diesel Oil Cost per Litter (including transportation cost)	3.1	Bs/Litter
Fuel Consumption	17,228	Litter/Year
Diesel Fuel Cost	8,188	US\$/Year
Distribution Lines:		
Cost of Secondary Distribution Line per km	3,409	US\$/km
Length of Secondary Distribution Line	3	Km
OM Cost of Distribution Lines (% of investment cost)	2.5	%
Life Time of the Distribution Lines	20	Years
Discount Rate	10	%
CRF (10 Years)	0.1627	
CRF (20 Years)	0.1175	
Exchange Rate	6.53	Bs/US\$
	120.5	Yen/US\$
Tax Rate		
Imported Products:		
Diesel Generator (10% import tax and 14.94% Effective VAT)	24.94	%
Automatic Transfer Switch and Protection Box (5% import tax and 14.94% Effective VAT)	19.94	%
Domestic Products:		
Value Added Tax	13	%
Transaction Tax	3	%
Agency Transaction Fee for the Imported Products	10	%
1) Investment Cost		
Total investment cost of the diesel generator, automatic transfer switch, protection box and building will be	26,827	US\$
Annualized investment cost of the diesel generator will be US\$26827 x CRF =	4,366	US\$
Total costs of the distribution line will be	10,227	US\$
Annualized distribution line costs will be Total distribution line cost x CRF =	1,202	US\$/Year
Thus, annualized investment cost per kWh will be	0.06	US\$/kWh
2) Operation and Maintenance Cost		
Annual OM cost of the diesel generator will be Investment cost of the diesel generator x 5% =	1,341	US\$
Annual OM cost of the distribution line will be		

Investment cost of the distribution lines x 2.5% =	256	US\$/Year
Annual OM cost per kWh will be	0.02	US\$/kWh
3) Fuel Cost		
Total fuel cost per kWh will be	0.09	US\$/kWh
4) Total Annualized Cost of the Diesel Generator		
Total annualized cost of the diesel generator per kWh will be (1) + (2) + (3) =	0.18	US\$/kWh

Source: JICA Study Team

Tabla 8.6 Proyectos Prioritarios de Micro Centrales Hidroeléctricas en La Paz y Oruro (Plan 2002 - 2011)

La Paz

Priority Ranking No.	Proposed Implementation Schedule (Year of Year)	Name of Project	Province	Cantón	No. of Benef. Families by MHP		Installed Capacity (kW)	Investment Cost (MHP) (USD)	kW Cost (MHP) (USD/kW)	MHP		Study Conducted by	Stage of Project
					a	b				Annual Energy (kWh/Year)	Annualized Investment + O&M Cost per kWh (MHP) (USD/kWh)		
1	2002 - 2006	Apolo (Rio Machariapu) Phase - I	F. Tamayo	Apolo, Santa Cruz del Valle Azenzo & Aiza	1,100	350	2,000,000	5,714	970,900	0.28	JICA Study Team	2	
2	2002 - 2006	San José de Chupimayoma	Ibarra	San José de Chupimayoma	80	40	70,200	1,755	110,960	0.09	NF-Alisei (Italia), EU, Alcaldía, Munc., Prefectura	2	
3	2002 - 2006	San Miguel	Ibarra	San Buen Venura	80	25	66,900	2,676	69,350	0.13	NF-Alisei (Italia), EU, Alcaldía, Munc., Prefectura	2	
4	2002 - 2006	25 de Mayo	Ibarra	San Buen Venura	350	25	65,000	2,600	69,350	0.13	EU, NF, Prefectura, Alcaldía	1	
5	2002 - 2006	Yamayo	S. Yungas	Yamayo	230	85	183,561	2,086	244,112	0.10	UMSA-BDH	3	
6	2002 - 2006	Colopampa-Santa Rosa	S. Yungas	Colopampa Grande	580	100	270,512	1,691	443,840	0.08	UMSA-BDH	3	
7	2002 - 2006	Calisaya	S. Yungas	Calisaya	80	25	34,300	1,372	69,350	0.07	NF-Alisei (Italia), EU, Alcaldía, Munc., Prefectura	2	
8	2002 - 2006	Chirra	S. Yungas	Chirra	200	50	80,000	1,600	138,700	0.08	ECOTEC	1	
9	2002 - 2006	Pichari	S. Yungas	San José	162	48	100,000	2,083	133,152	0.10	ECOTEC	1	
9	2002 - 2006	Centro Tococoni	S. Yungas	Villa Barrientos	828	60	174,723	5,090	166,440	0.14	UNDP	3	
11	2002 - 2006	Suches	F. Tamayo	Suches	140	100	200,000	2,000	277,400	0.10		1	
12	2002 - 2006	Curva - Caslaya (Rio Opimayaya)	B. Saavedra	Curva	170	45	112,500	2,500	124,830	0.12	JICA Study Team	1	
13	2002 - 2006	Palmar	S. Yungas	Chamaca	150	40	70,000	1,750	110,960	0.09	ECOTEC	1	
13	2002 - 2006	Villa el Carmen	Caranavi	Rosario Entre Rios	90	40	68,100	1,703	110,960	0.08	NF-Alisei (Italia), EU, Alcaldía, Munc., Prefectura	2	
15	2007 - 2011	Calama	Caranavi	Calama	170	50	175,204	3,504	138,700	0.17	UMSA-BDH	3	
16	2007 - 2011	Ulla Ulla	F. Tamayo	Ulla Ulla	60	20	50,000	2,500	55,480	0.12		1	
17	2007 - 2011	Chairo	Nor Yungas	Pecolito	100	40	56,170	1,404	110,960	0.07	NF-Alisei (Italia), EU, Alcaldía, Munc., Prefectura	2	
18	2007 - 2011	Pocoaymo (Pocoaymo, Vilqueo, Choquepata)	Mimicsa	Tinani	102	25	53,842	2,154	69,350	0.11	Comunidad de Pocoaymo, UMSA-BDH	1	
19	2007 - 2011	Incaic-Delicias	S. Yungas	Palos Blancos	84	60	141,140	2,352	166,440	0.11	VMEB/PNUD/Sotésocio SRL, PROPER, Misión Alianza Noruzga (MAN)	1	
20	2007 - 2011	Litllajun	J. Manuel Pando	Santiago de Machaca	10	8	8,485	1,061	22,192	0.05		1	
21	2007 - 2011	Incahuasi	Caranavi	Incahuasi de Chufo Kachi	70	30	150,000	5,000	83,220	0.24	Munc. De Caranavi, UMSA-BDH	1	
21	2007 - 2011	Porom	Larecaja	Santa Rosa de Chullani	350	300	200,000	1,000	832,200	0.05	ECOTEC	1	
23	2007 - 2011	Pedilla-Thrumayo	Nor Yungas	Coroico	220	20	39,450	1,973	55,480	0.10	EU, Prefectura, Alcaldía	1	
24	2007 - 2011	Villa Barrientos	S. Yungas	Villa Barrientos	100	23	50,000	2,174	63,802	0.11	ECOTEC	1	
25	2007 - 2011	Huamillas Coroico (Rehabilitación)	Nor Yungas	Coroico	978	205	279,000	1,361	568,676	0.07	UMSA-BDH	1	
26	2007 - 2011	Oro Verde	Caranavi	Sumpi Alto Beni	60	25	52,000	2,080	69,350	0.10	NF-Alisei (Italia), EU, Alcaldía, Munc., Prefectura	2	
26	2007 - 2011	Cotosi - Queñi	Caracheo	Mocococo	137	5	20,550	4,110	13,870	0.20	ORPA, Kham Wayra y PROPER	1	
28	2007 - 2011	Nueva Esperanza	Caranavi	Nueva Esperanza	65	30	78,000	2,600	83,220	0.13	Munc. De Caranavi, UMSA-BDH	1	
29	2007 - 2011	Mocori	Nor Yungas	Miltubaya	22	8.8	29,600	3,364	24,411	0.16	UMSA-BDH	1	
30	2007 - 2011	Illimani	Caranavi	Alto Illimani	60	20	58,000	2,900	55,480	0.14	Munc. De Caranavi, UMSA-BDH	1	
-	2007 - 2011	Apolo (Rio Machariapu) Phase - II	F. Tamayo	Apolo, Santa Cruz del Valle Azenzo & Aiza	900	350	2,000,000	5,714	970,900	0.28	JICA Study Team	2	
					321 W/HH	11,783	3,788	12,396,207	2,728				
Sub-Total 2002 - 2006							4,240	1,096	3,496,000				
Sub-Total 2007 - 2011							3,490	1,220	3,541,000				
TOTAL (2002 - 2011)							7,730	2,316	7,037,000				

Average Installed Capacity per Household in the Selected MHP Projects (La Paz) = 300 W/HH

Note: The total number was rounded.

910 [US\$/HH]

Oruro

1	2002 - 2006	Tambo Quemado	Sajama	Chacacomani	69	62	239,700	3,866	171,988	0.19	JICA Study Team, ECOTEC	2	
2	2007 - 2011	Juro - Vilayo (Rio Pacobun, Est Vilayo)	Altiplano	Negritos / Juro	80	15	52,500	3,500	41,610	0.17	JICA Study Team	1	
3	2007 - 2011	Sajama (Rio Jachcha Huacollo)	Sajama	Sajama	60	25	75,000	3,000	69,350	0.13	ECOTEC, JICA Study Team	1	
					314 W/HH	2,065	649	3,976,672					
									US\$				
Sub-Total 2002 - 2006							69	62	240,000				
Sub-Total 2007 - 2011							140	40	128,000				
TOTAL (2002 - 2011)							209	102	368,000				

Average Installed Capacity per Household in the Selected MHP Projects (Oruro) = 488 W/HH

Note: The total number was rounded.

1,761 [US\$/HH]

Source: JICA Study Team

Note: *1) Column 'c', 'f', 'g'; Italic numbers are assumed.

*2) Column 'e' & 'h': For the estimation of annual energy of the MHP, following parameter are used.

Effective Operation Hour (Days/year) for Estimation of kWh (hours/year)	= 3
Plant Factor for MHP	= 0.95
n: Life Time of the System (Year)	= 20
R: Discount Rate (%)	= 10%
CRF (Capital Recovery Factor) = $R(1+R)^n / ((1+R)^n - 1)$	= 0.1175
OM Cost for MHP (% of total investment)	= 1.8%

Note *: The Apolo micro-hydro power project is one project, but is divided into two in this table for incorporating annual investment plan.

Tabla 8.7 Selección de Proyectos Prioritarios de Energía Eólica

La Paz

Cantons in high wind potential area	Population	Population for Project	Existing grid or the plan	Result
1 OKORURO	339	suitable	no	selected
2 CHINOCABI	264	suitable	no	selected
3 E.ABAROA	116	suitable	no	selected
4 GREAL PEREZ	159	suitable	no	selected
5 LADISLAO CABRERA	237	suitable	no	selected
6 RIO BLANCO	287	suitable	no	selected
7 CATAORA	278	suitable	no	selected
8 PAIRUMANI GRANDE	124	suitable	no	selected
9 POJO PAJCHIRI	221	suitable	no	selected
10 CHARANA	1016	suitable	no	selected
11 CARACOLLO	61	not suitable	no	not selected
12 THOLA COLLO	87	not suitable	no	not selected

Oruro

Cantons in high wind potential area	Population	Population for Project	Existing grid or the plan	Result
1 SAJAMA	449	suitable	existing	not selected
2 LAGUNAS	235	suitable	no	selected
3 COPASA	685	suitable	no	selected
4 CARANGAS	152	suitable	existing	not selected
5 CARIPE	208	suitable	no	selected
6 CHACHACOMANI	476	suitable	no	selected
7 VILLA ROSARIO	96	not suitable	no	not selected

Source: JICA Study Team

Tabla 8.8 Numero de Beneficiarios Nuevos por Fuente de Energia

	Phase 1					Phase 2				
	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
La Paz										
	2,851	2,758	2,863	2,975	3,156	3,354	3,349	3,462	3,676	3,771
Renewable Energy	1,080	923	962	1,005	1,116	1,403	1,328	1,368	1,506	1,523
PV	180	73	68	95	244	671	584	794	610	703
Micro-hydro	900	800	844	860	836	700	680	500	850	760
Wind	0	50	50	50	36	32	64	74	46	60
Grid	1,771	1,835	1,901	1,970	2,040	1,951	2,021	2,094	2,170	2,248
Oruro										
	1,739	1,663	1,665	1,732	1,810	2,023	2,028	2,278	2,286	2,445
Total	606	490	450	474	506	865	829	1,036	998	1,112
Renewable Energy	606	415	377	401	436	785	767	1,036	938	1,112
PV	0	45	0	0	0	80	0	0	60	0
Micro-hydro	0	30	73	73	70	0	62	0	0	0
Wind	0	0	0	0	0	0	0	0	0	0
Grid	1,133	1,173	1,215	1,259	1,304	1,158	1,199	1,243	1,288	1,334

Source: VMEH and JICA Study Team

Tabla 8.9 Taza de Electrificación Rural en La Paz y Oruro (%)

La Paz	Phase 1						Phase 2				
	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	
Total No. of Rural Households	232,629	232,398	232,197	232,021	231,879	231,773	231,700	231,663	231,649	231,669	
Existing No. of HHs with Electricity	70,673	73,379	76,010	78,762	81,640	84,712	87,991	91,276	94,681	98,307	
New Beneficiary HHs with Electricity	2,851	2,758	2,863	2,975	3,156	3,354	3,349	3,462	3,676	3,771	
Decrease in No. of Electrified HHs by Diesel	-145	-127	-111	-97	-85	-74	-65	-57	-50	-43	
Total No. of Rural HHs with Electricity	73,379	76,010	78,762	81,640	84,712	87,991	91,276	94,681	98,307	102,034	
Rural Electrification Rate (%)	31.5%	32.7%	33.9%	35.2%	36.5%	38.0%	39.4%	40.9%	42.4%	44.0%	

Oruro	Phase 1						Phase 2				
	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	
Total No. of Rural Household	61,981	61,694	61,410	61,126	60,846	60,568	60,290	60,015	59,743	59,473	
Existing No. of HHs with Electricity	10,268	11,973	13,607	15,246	16,955	18,746	20,751	22,765	25,029	27,303	
New Beneficiary HHs with Electricity	1,739	1,663	1,665	1,732	1,810	2,023	2,028	2,278	2,286	2,445	
Decrease in No. of Electrified HHs by Diesel	-34	-30	-26	-23	-20	-17	-15	-13	-12	-10	
Total No. of Rural HHs with Electricity	11,973	13,607	15,246	16,955	18,746	20,751	22,765	25,029	27,303	29,739	
Rural Electrification Rate (%)	19.3%	22.1%	24.8%	27.7%	30.8%	34.3%	37.8%	41.7%	45.7%	50.0%	

Source: VMEH and JICA Study Team

Tabla 8.10 Inversion Anual Total para Electrificación Rural por Fuente de Energía (US\$)

	Phase 1										Phase 2				
	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2009	2010	2011		
Total	2,725,000	2,823,000	2,925,000	3,030,000	3,139,000	3,252,000	3,369,000	3,490,000	3,616,000	3,746,000					
Renewable Energy	954,000	988,000	1,024,000	1,060,000	1,099,000	1,301,000	1,348,000	1,396,000	1,446,000	1,498,000					
PV	144,000	58,000	54,400	76,000	195,400	536,600	467,200	635,200	487,800	562,000					
Micro-hydro	810,000	720,000	759,600	774,000	752,400	630,000	612,000	450,000	765,000	684,000					
Wind	0	210,000	210,000	210,000	151,200	134,400	268,800	310,800	193,200	252,000					
Grid	1,771,000	1,835,000	1,901,000	1,970,000	2,040,000	1,951,000	2,021,000	2,094,000	2,170,000	2,248,000					

	Phase 1										Phase 2				
	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2009	2010	2011		
Total	1,618,000	1,676,000	1,736,000	1,798,000	1,863,000	1,930,000	1,999,000	2,071,000	2,146,000	2,223,000					
Renewable Energy	483,000	502,800	520,800	539,400	558,900	772,000	799,600	828,400	858,400	889,200					
PV	483,000	331,800	301,800	320,400	348,900	628,000	613,600	828,400	750,400	889,200					
Micro-hydro	0	81,000	0	0	0	144,000	0	0	108,000	0					
Wind	0	90,000	219,000	219,000	210,000	0	186,000	0	0	0					
Grid	1,133,000	1,173,200	1,215,200	1,258,600	1,304,100	1,158,000	1,199,400	1,242,600	1,287,600	1,333,800					

Source: VMEH and JICA Study Team

Tabla 8.11 Numero de Beneficiarios Total por Fuente de Energia, La Paz

	Phase 1										Phase 2				
	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2008	2009	2010	2011	
PV	Total	1,073	1,146	1,214	1,309	1,553	2,224	2,808	3,602	4,211	4,914				
	Share	1.5%	1.5%	1.5%	1.6%	1.8%	2.5%	3.1%	3.8%	4.3%	4.8%				
Micro-hydro	Total	2,195	2,995	3,839	4,699	5,535	6,235	6,915	7,415	8,265	9,025				
	Share	3.0%	3.9%	4.9%	5.8%	6.5%	7.1%	7.6%	7.8%	8.4%	8.8%				
Wind	Total	0	50	100	150	186	218	282	356	402	462				
	Share	0.0%	0.1%	0.1%	0.2%	0.2%	0.2%	0.3%	0.4%	0.4%	0.5%				
Total	Total	3,268	4,191	5,153	6,158	7,274	8,677	10,005	11,373	12,878	14,401				
	Share	4.5%	5.5%	6.5%	7.5%	8.6%	9.9%	11.0%	12.0%	13.1%	14.1%				
Renewable Energy	Total	69,102	70,937	72,838	74,808	76,848	78,799	80,820	82,914	85,084	87,332				
	Share	94.2%	93.3%	92.5%	91.6%	90.7%	89.6%	88.5%	87.6%	86.5%	85.6%				
Grid Extension	Total	1,010	883	772	675	591	516	452	395	345	302				
	Share	1.4%	1.2%	1.0%	0.8%	0.7%	0.6%	0.5%	0.4%	0.4%	0.3%				
Diesel	Total	73,379	76,010	78,762	81,640	84,712	87,991	91,276	94,681	98,307	102,034				
	Share	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%				

Source: VMEH and JICA Study Team

Tabla 8.12 Numero de Beneficiarios Total por Funete de Energia, Oruro

	Phase 1						Phase 2				
	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	
PV	Total	2,355	2,770	3,147	3,548	3,984	4,769	5,536	6,571	7,509	8,621
	Share	19.7%	20.4%	20.6%	20.9%	21.3%	23.0%	24.3%	26.3%	27.5%	29.0%
Micro-hydro	Total	365	410	410	410	410	490	490	490	550	550
	Share	3.0%	3.0%	2.7%	2.4%	2.2%	2.4%	2.2%	2.0%	2.0%	1.8%
Wind	Total	0	30	103	176	246	246	308	308	308	308
	Share	0.0%	0.2%	0.7%	1.0%	1.3%	1.2%	1.4%	1.2%	1.1%	1.0%
Total Renewable Energy	Total	2,720	3,210	3,660	4,134	4,640	5,505	6,334	7,369	8,367	9,479
	Share	22.7%	23.6%	24.0%	24.4%	24.8%	26.5%	27.8%	29.4%	30.6%	31.9%
Grid Extension	Total	9,016	10,190	11,405	12,663	13,968	15,126	16,325	17,568	18,855	20,189
	Share	75.3%	74.9%	74.8%	74.7%	74.5%	72.9%	71.7%	70.2%	69.1%	67.9%
Diesel	Total	237	207	181	158	138	121	106	93	81	71
	Share	2.0%	1.5%	1.2%	0.9%	0.7%	0.6%	0.5%	0.4%	0.3%	0.2%
Total	Total	11,973	13,607	15,246	16,955	18,746	20,751	22,765	25,029	27,303	29,739
	Share	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%

Source: VMEH and JICA Study Team

Tabla 8.13 Consumo de Electricidad Calculada por Fuente de Energia, La Paz (kWh)

	Phase 1										Phase 2			
	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2009	2010	2011	
PV	Total	69,745	74,458	78,878	85,053	100,929	144,528	182,488	234,098	273,731	319,394			
	Share	0	0	0	0	0	0	0	0	0	0			
Micro-hydro	Total	523,500	778,500	1,025,100	1,280,700	1,535,100	1,765,500	1,972,500	2,149,500	2,352,000	2,593,500			
	Share	2.4%	3.5%	4.5%	5.4%	6.2%	6.9%	7.5%	7.9%	8.4%	8.9%			
Wind	Total	0	7,500	22,500	37,500	50,400	60,600	75,000	95,700	113,700	129,600			
	Share	0.0%	0.0%	0.1%	0.2%	0.2%	0.2%	0.3%	0.4%	0.4%	0.4%			
Total Renewable Energy	Total	593,245	860,458	1,126,478	1,403,253	1,686,429	1,970,628	2,229,988	2,479,298	2,739,431	3,042,494			
	Share	2.8%	3.9%	4.9%	5.9%	6.8%	7.7%	8.5%	9.1%	9.8%	10.5%			
Grid Extension	Total	20,464,808	21,005,708	21,566,108	22,146,758	22,748,258	23,346,908	23,942,708	24,559,958	25,199,558	25,862,258			
	Share	95.7%	94.8%	94.0%	93.2%	92.4%	91.6%	91.0%	90.4%	89.8%	89.2%			
Diesel	Total	324,680	283,928	248,291	217,126	189,874	166,042	145,201	126,976	111,039	97,102			
	Share	1.5%	1.3%	1.1%	0.9%	0.8%	0.7%	0.6%	0.5%	0.4%	0.3%			
Total	Total	21,382,733	22,150,093	22,940,876	23,767,137	24,624,561	25,483,578	26,317,897	27,166,232	28,050,028	29,001,854			
	Share	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%			

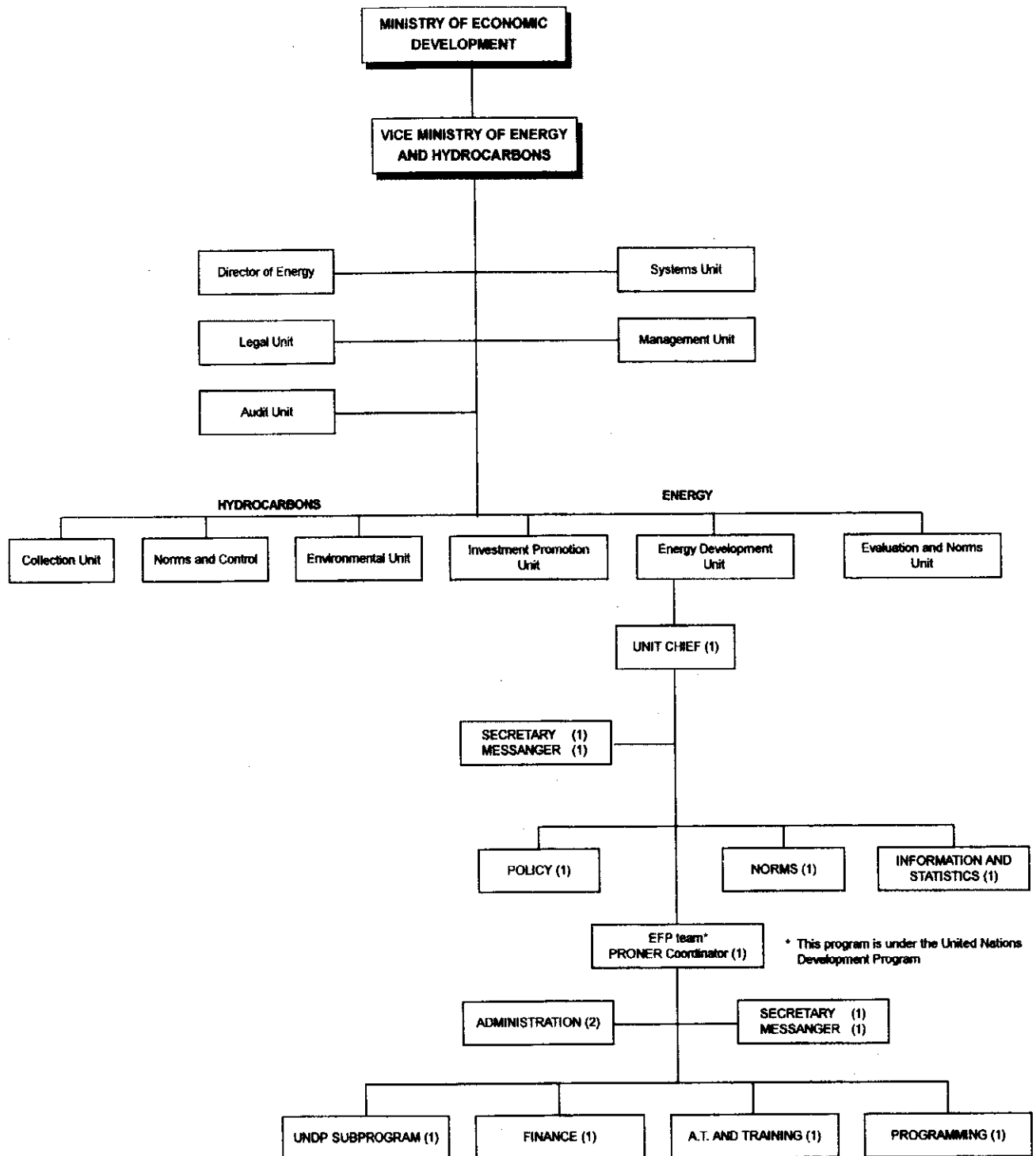
Source: VMEH and JICA Study Team

Tabla 8.14 Consumo de Electricidad Calculada por Fuente de Energia, Oruro (kWh)

	Phase 1										Phase 2										
	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	
PV	Total	153,091	180,050	204,571	230,604	258,952	309,977	359,832	427,139	488,109	560,357										
	Share	5.3%	5.5%	5.6%	5.7%	5.8%	6.3%	6.7%	7.4%	7.8%	8.4%										
Micro-hydro	Total	109,500	116,250	123,000	123,000	123,000	135,000	147,000	147,000	156,000	165,000										
	Share	3.8%	3.6%	3.4%	3.0%	2.7%	2.7%	2.8%	2.5%	2.5%	2.5%										
Wind	Total	0	4,500	19,950	41,850	63,300	73,800	83,100	92,400	92,400	92,400										
	Share	0.0%	0.1%	0.9%	1.0%	1.4%	1.5%	1.6%	1.6%	1.5%	1.4%										
Total Renewable Energy	Total	262,591	300,800	347,521	395,454	445,252	518,777	589,932	666,539	736,509	817,757										
	Share	9.1%	9.3%	9.5%	9.7%	9.9%	10.5%	11.0%	11.5%	11.8%	12.2%										
Grid Extension	Total	2,334,980	2,880,910	3,239,170	3,610,240	3,994,645	4,363,960	4,717,570	5,083,870	5,463,400	5,856,610										
	Share	88.2%	88.7%	88.9%	89.0%	89.1%	88.7%	88.3%	88.0%	87.8%	87.4%										
Diesel	Total	76,117	66,563	58,209	50,902	44,513	38,976	34,041	29,768	26,032	22,764										
	Share	2.6%	2.0%	1.6%	1.3%	1.0%	0.8%	0.6%	0.5%	0.4%	0.3%										
Total	Total	2,873,688	3,248,273	3,644,899	4,056,596	4,484,410	4,921,663	5,341,542	5,780,177	6,225,941	6,697,131										
	Share	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%										

Source: VMEH and JICA Study Team

FIGURAS

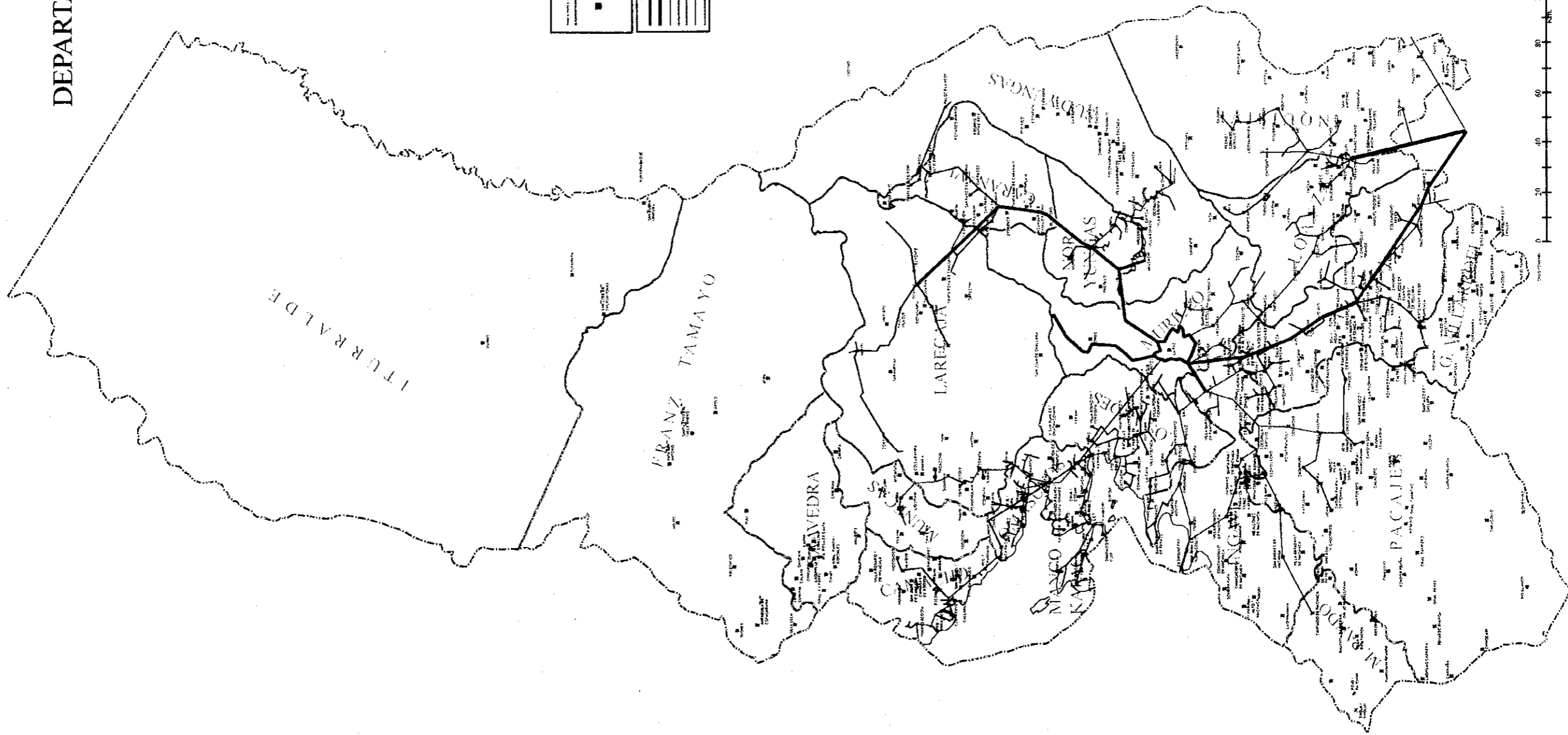
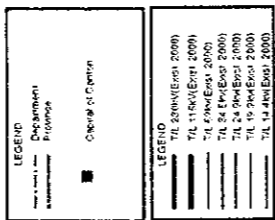


Source: VMEH

Figura 2.1 Organización de Viceministerio de Energía e Hidrocarburos (VMEH)

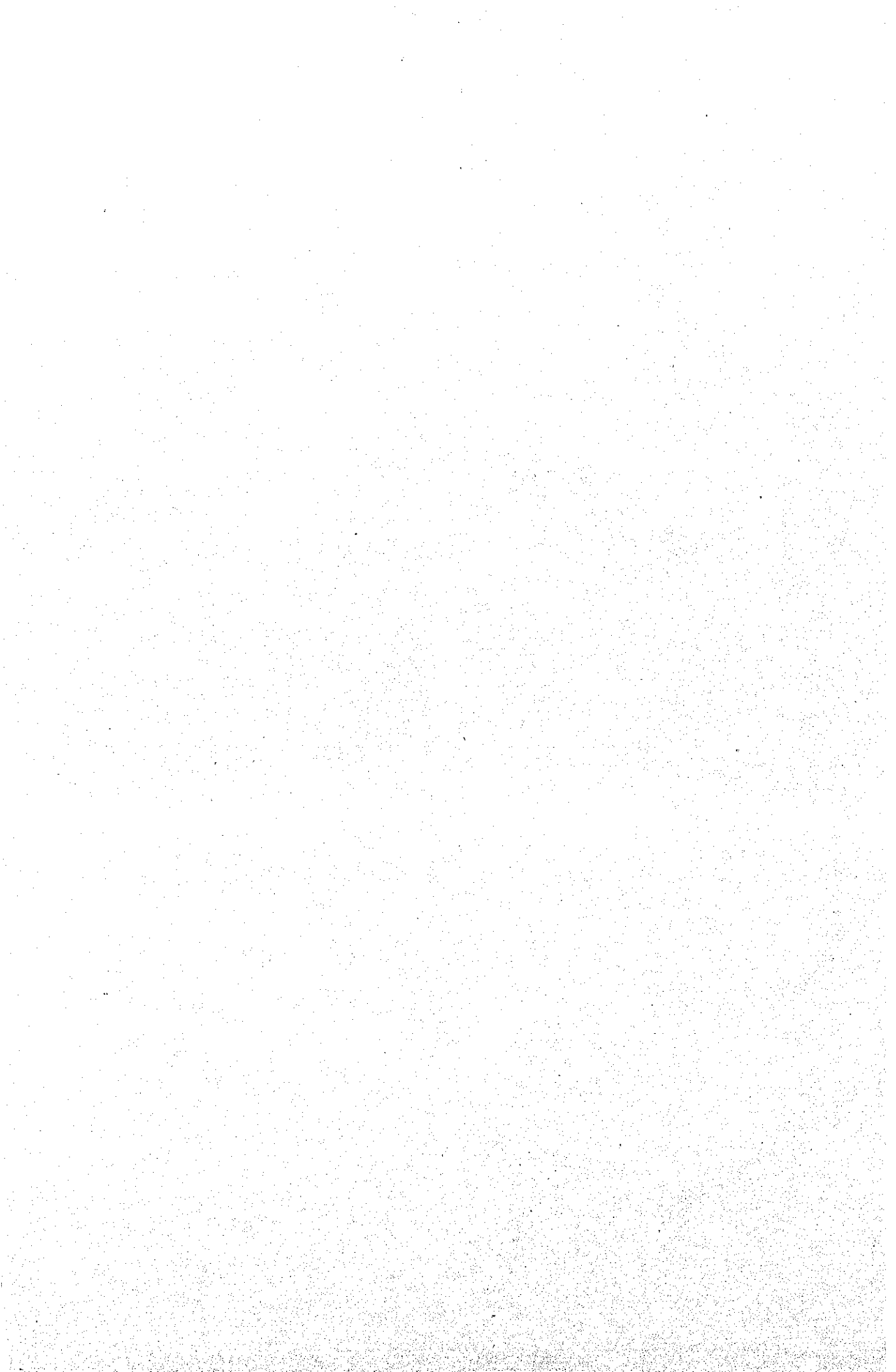


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Figura 4.1
Lineas de Transmision (La Paz)
(as of Early 2001)



DEPARTAMENTO DE ORURO



LEGEND	
	Departamento
	Municipio
	Canton
	Capital y Centros

LEGENDA de Transmision Linea	
	T1, 20KV (Ene 2001)
	T2, 11KV (Ene 2001)
	T3, 5KV (Ene 2001)
	T4, 20KV (Ene 2001)
	T5, 11KV (Ene 2001)
	T6, 5KV (Ene 2001)

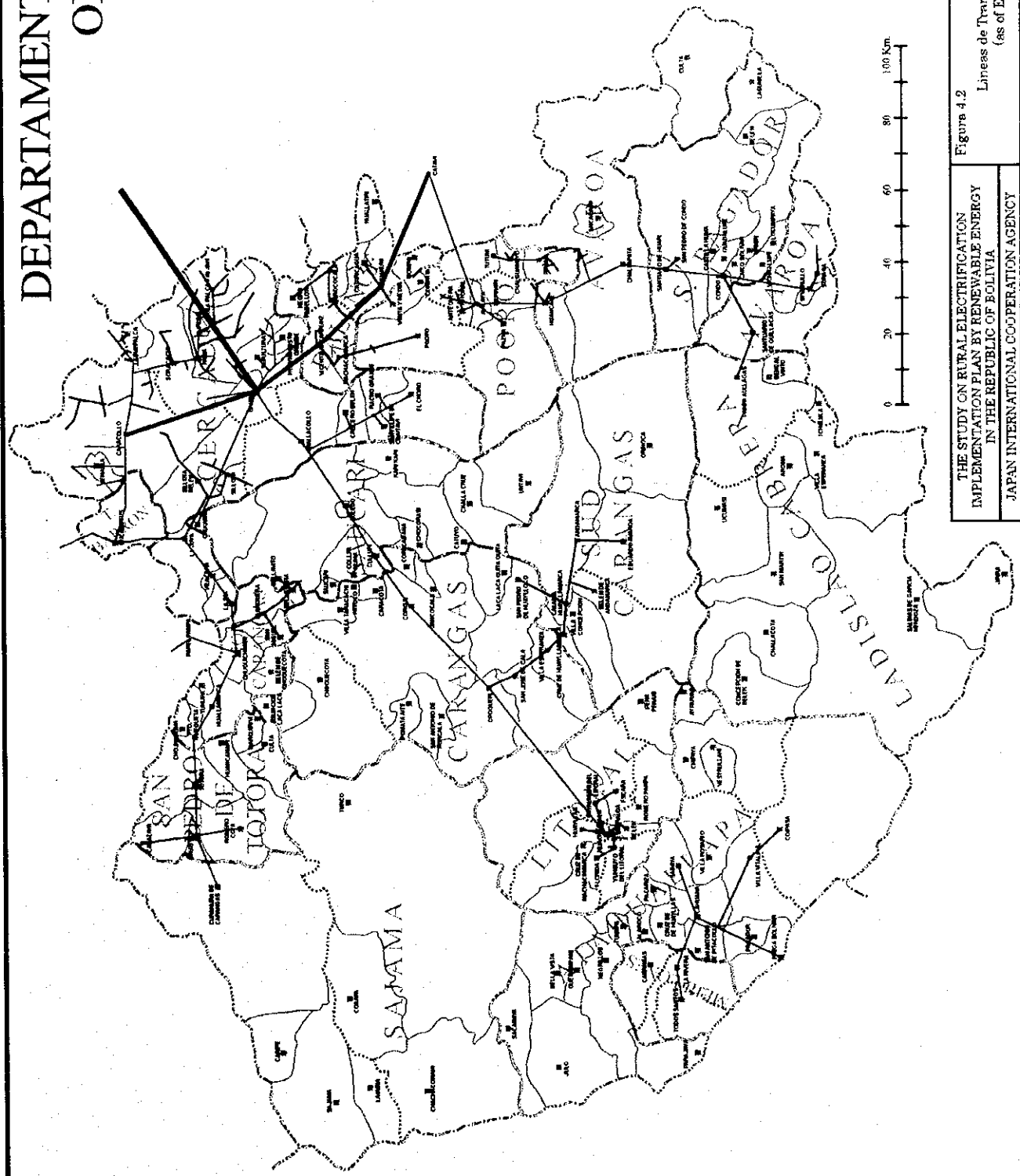
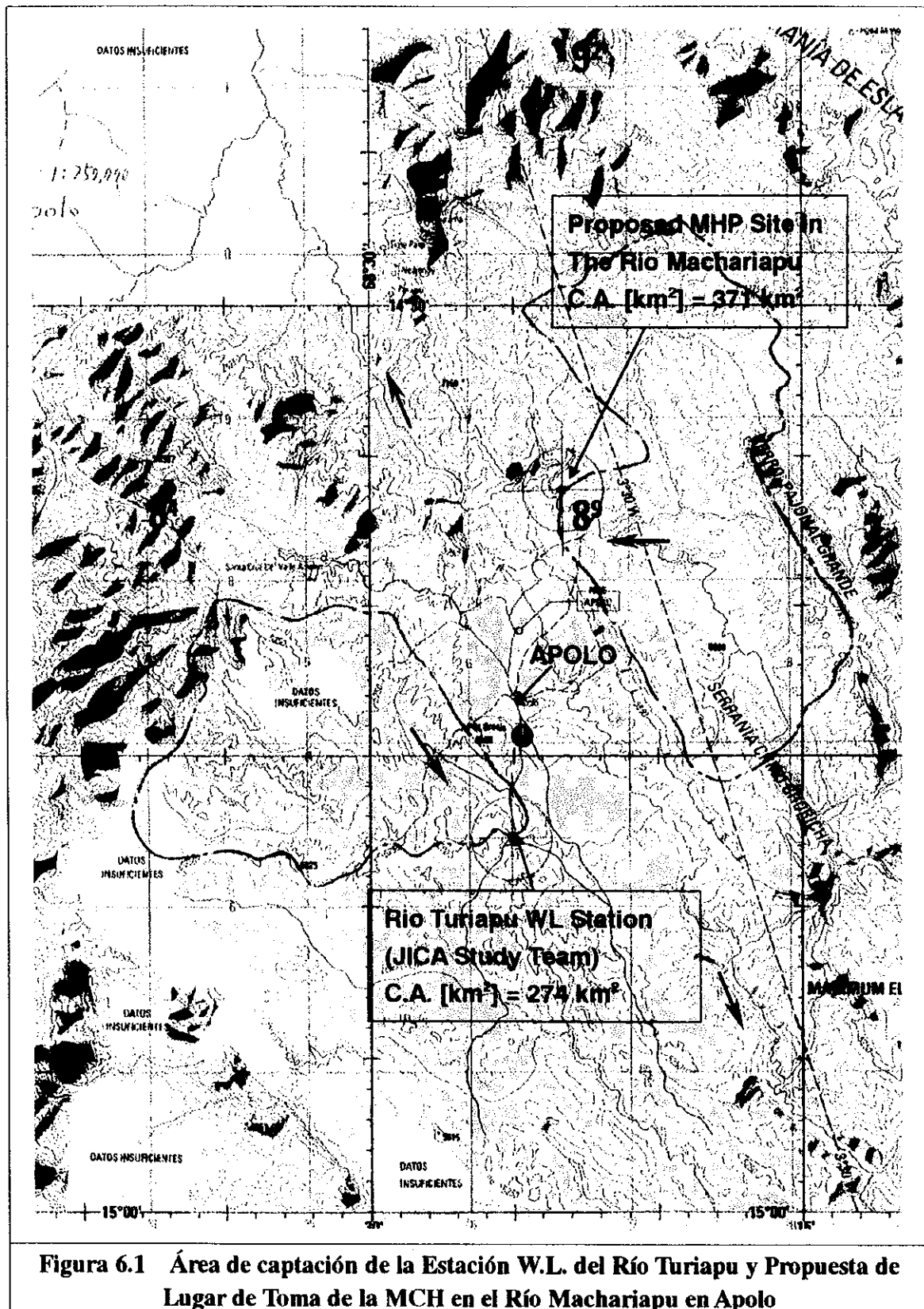
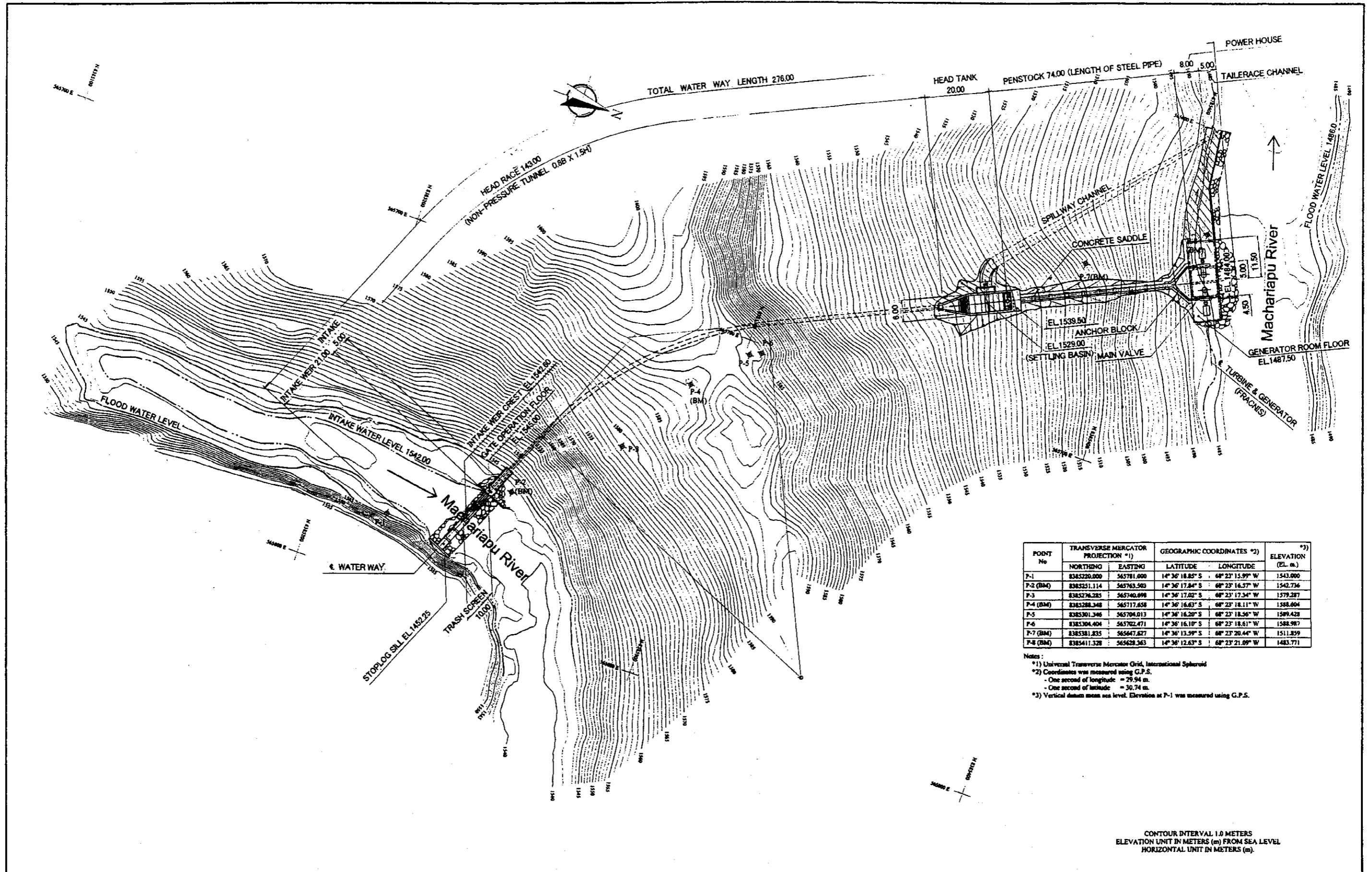


Figure 4.2
Lines de Transmission (Oruro)
(as of Early 2001)

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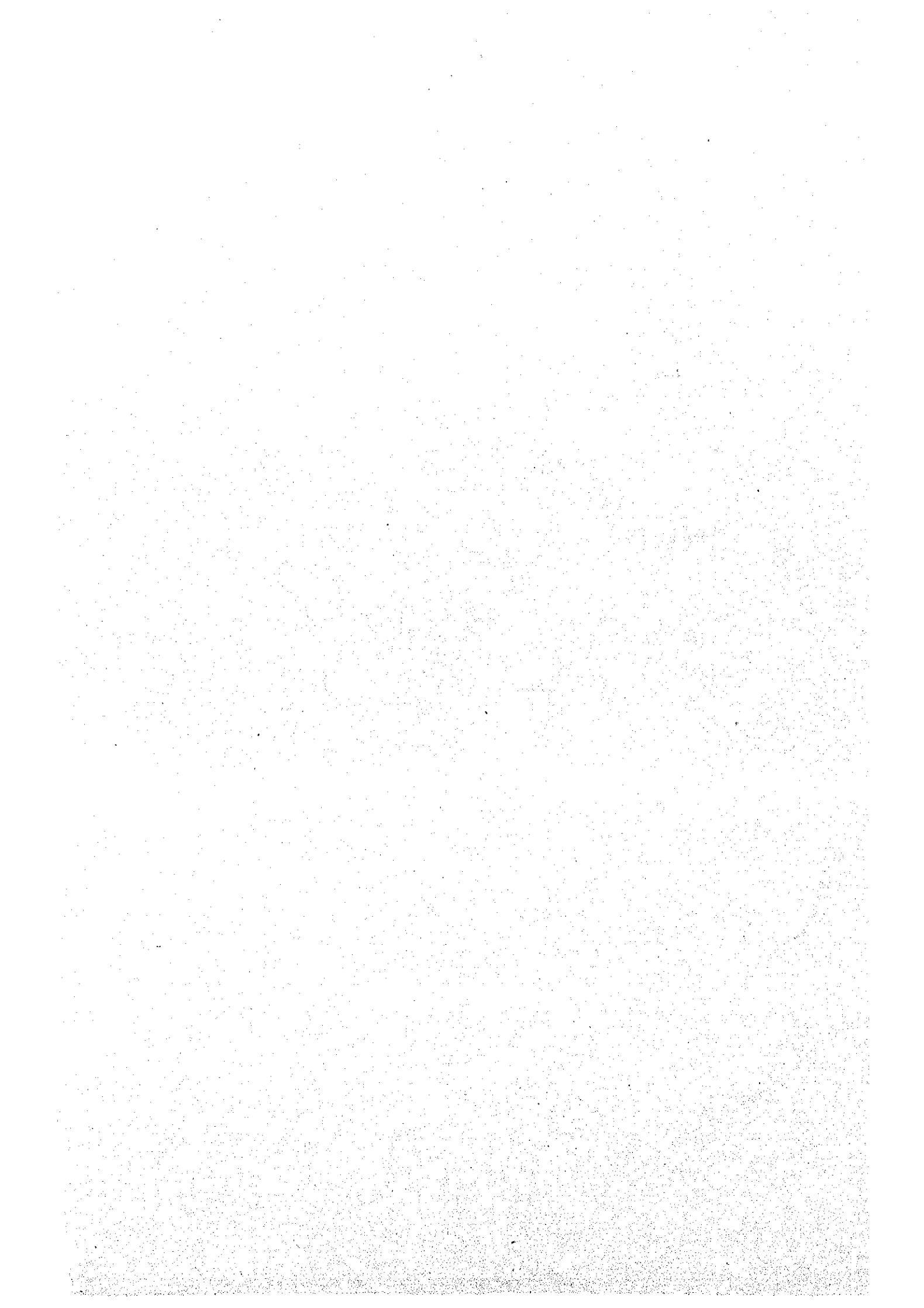
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 APOLO / FRANZ TAMAYO PROVINCE
 LA PAZ DEPARTMENT
 MACHARIAPU RIVER

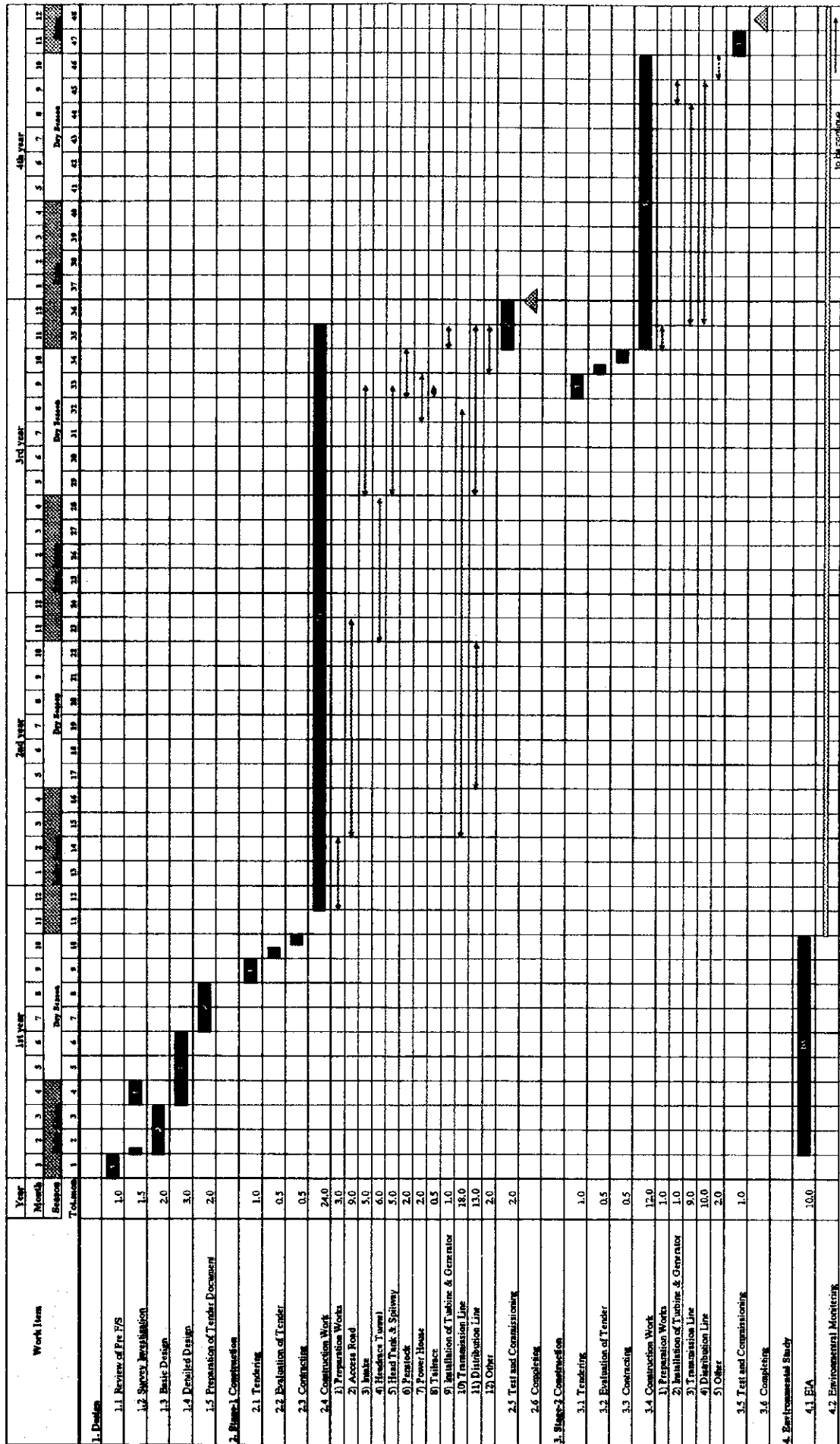
Figura 6.2 Plano de la MCH de Apolo
 (Río Machariapu)

SCALE:
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DATE:
 JULY - 2001

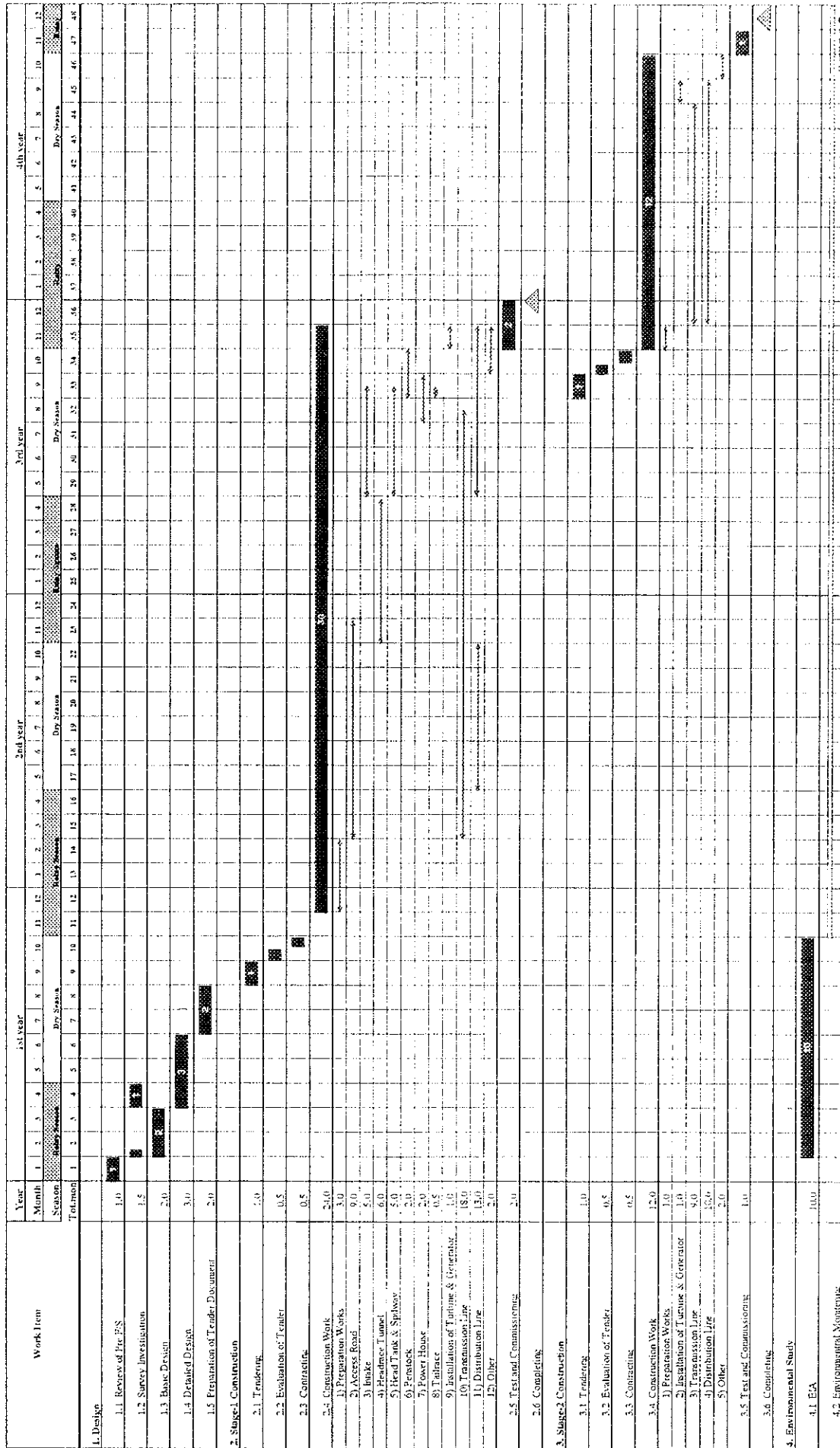
SHEET:
 1 / 1





Note:
 Construction Stage-1: Preparation works, Construction of Access road, Jinks weir, Jinks, Headrace Tunnel, Headrack, Penstock, Spillway, Powerhouse, Tailrace, Maintenance Service Road, etc.
 Installation of Turbine & Generator (350kW x 1 set), Electric facilities, Transmission & Distribution Line (311 m= Block 'A' (Apolo town) and Block 'B')
 Construction Stage-2: Installation of additional Turbine & Generator (350kW x 1 set), Transmission & Distribution Line (Block 'C', 'D', 'E', 'F' & 'G')

Figura 6.3 Programa de Implementación Propuesto para el Proyecto de la MCH de Apolo



Note: Construction Stage-1: Preparation works, Construction of Access road, Intake weir, Intake, Headrace Tunnel, Headrace, Penstock, Spillway, Powerhouse, Tailrace, Maintenance Service Road, etc.
 Installation of Turbine & Generator (350kW x 1 set), Electric facilities, Transmission & Distribution Line (Site 222-Block 'A' (Apolo town) and Block 'B')
 Installation of additional Turbine & Generator (350kW x 1 set), Transmission & Distribution Line (Block 'C', 'D', 'E', 'F' & 'G')

Figura 6.3 Programa de Implementación Propuesto para el Proyecto de la MCH de Apolo

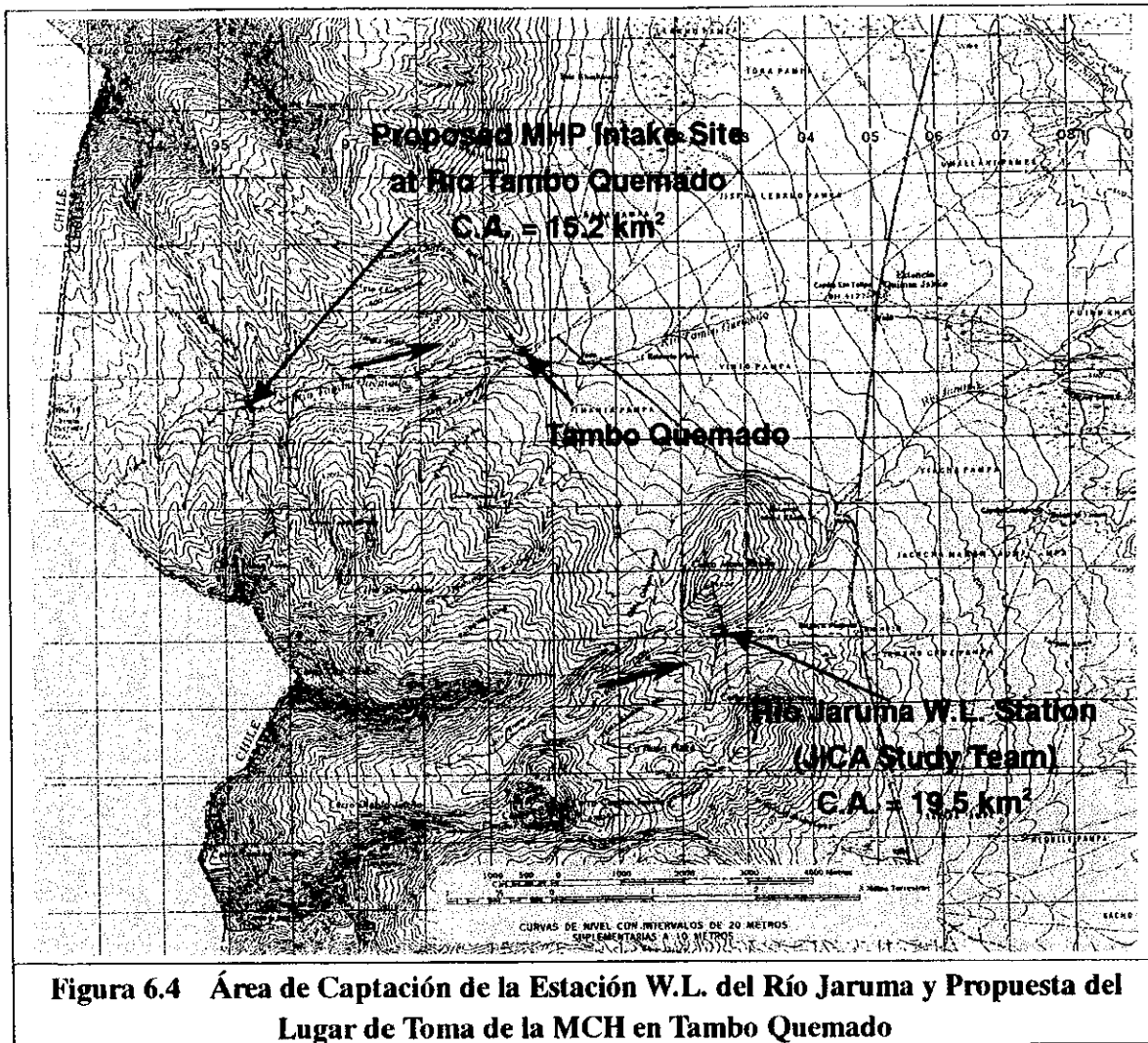
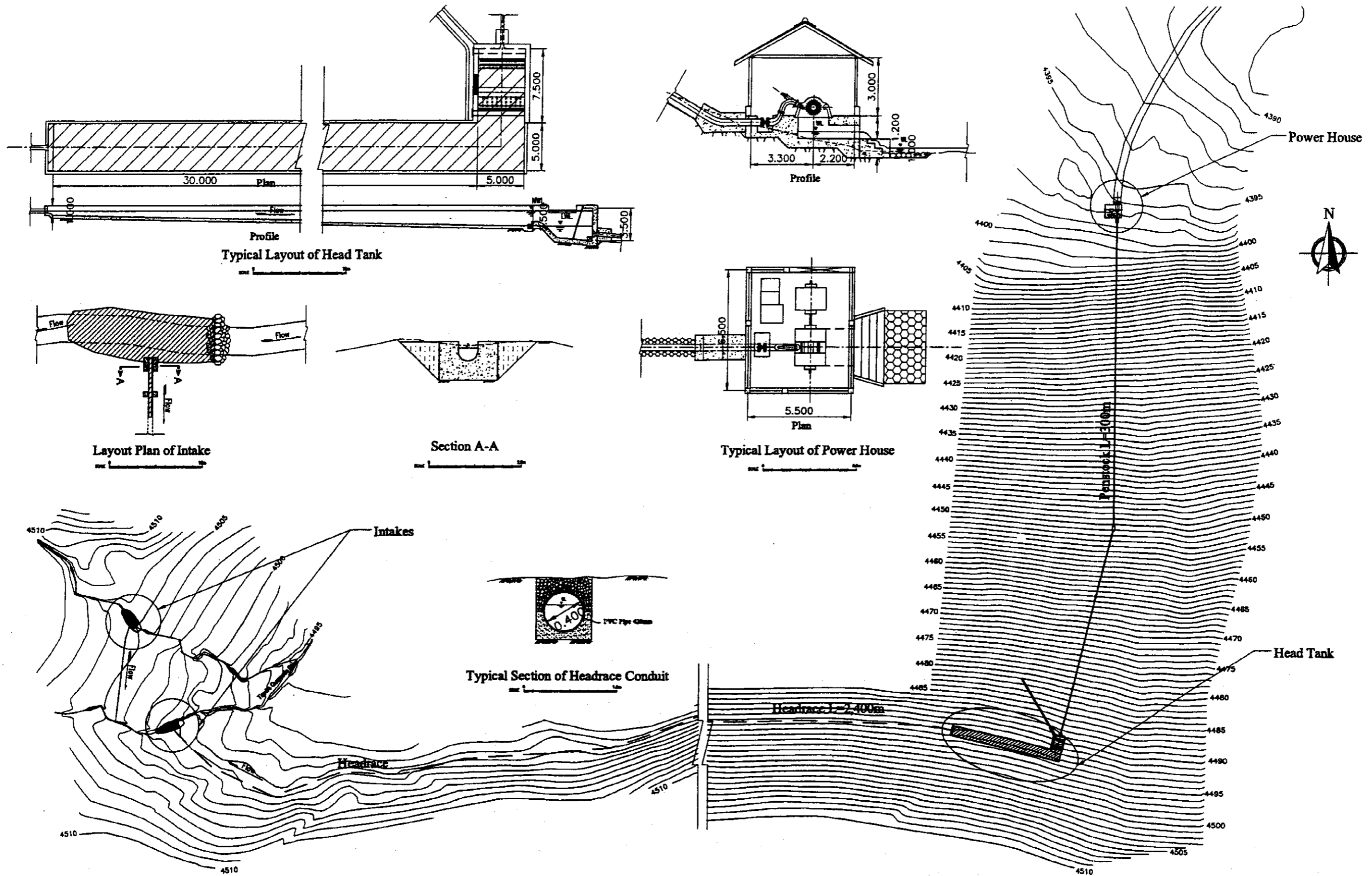


Figura 6.4 Área de Captación de la Estación W.L. del Río Jaruma y Propuesta del Lugar de Toma de la MCH en Tambo Quemado



SCALE 0 100m

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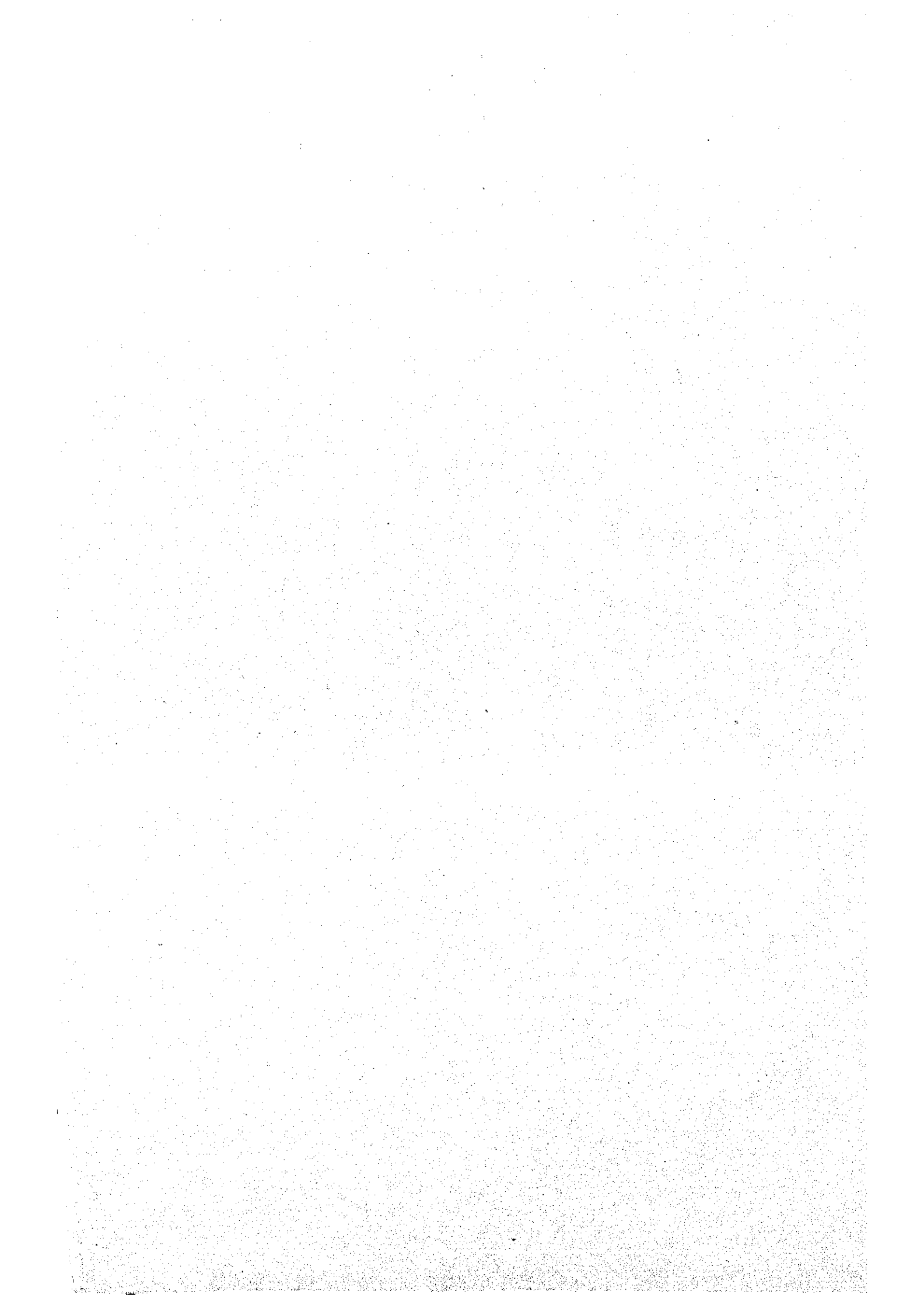
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TAMBO QUEMADO / SAJAMA PROVINCE
ORURO DEPARTAMENT

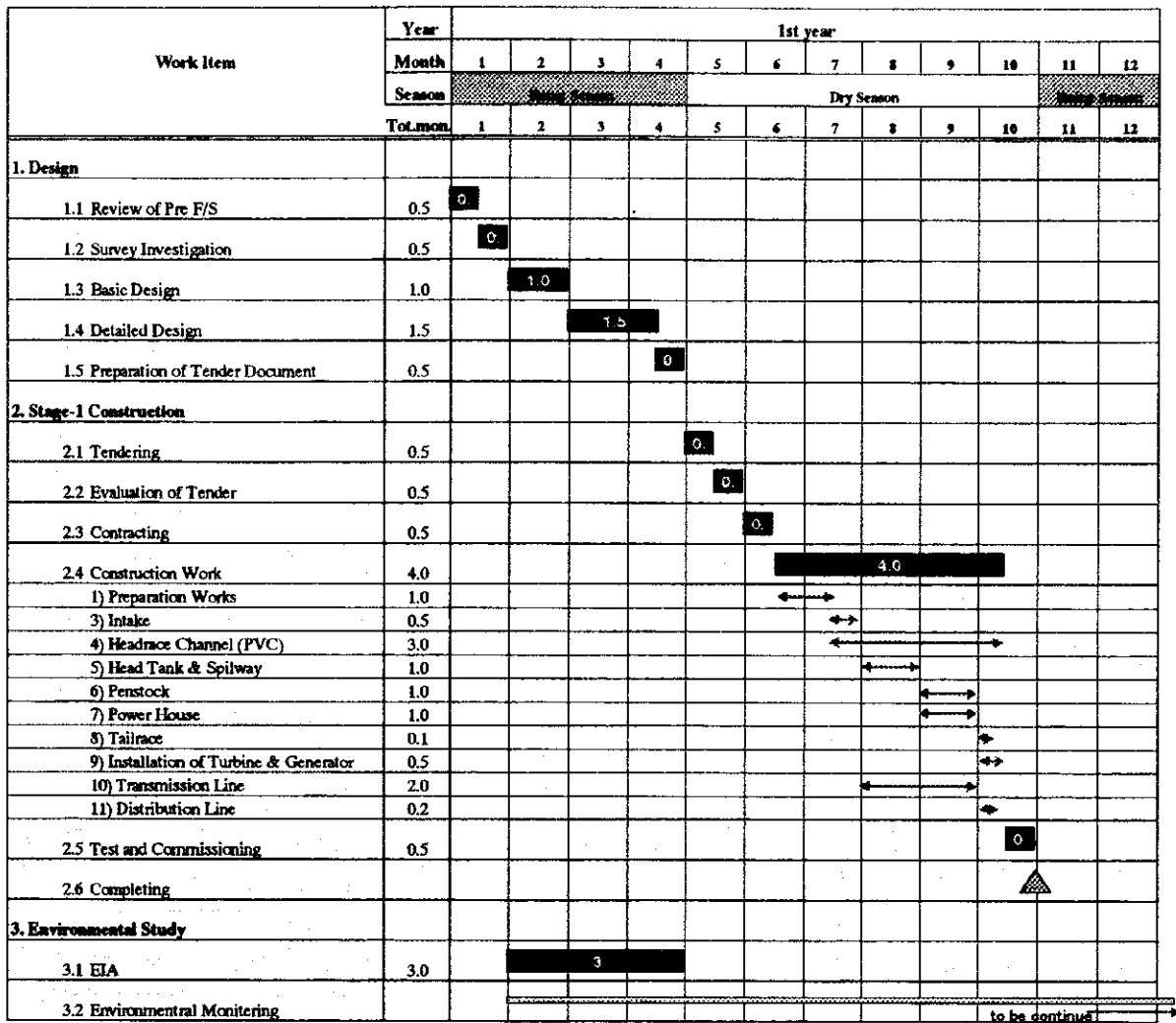
Figura 6.5
Plano de la MCH de Tambo Quemado

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DATE:
Feubary- 2001

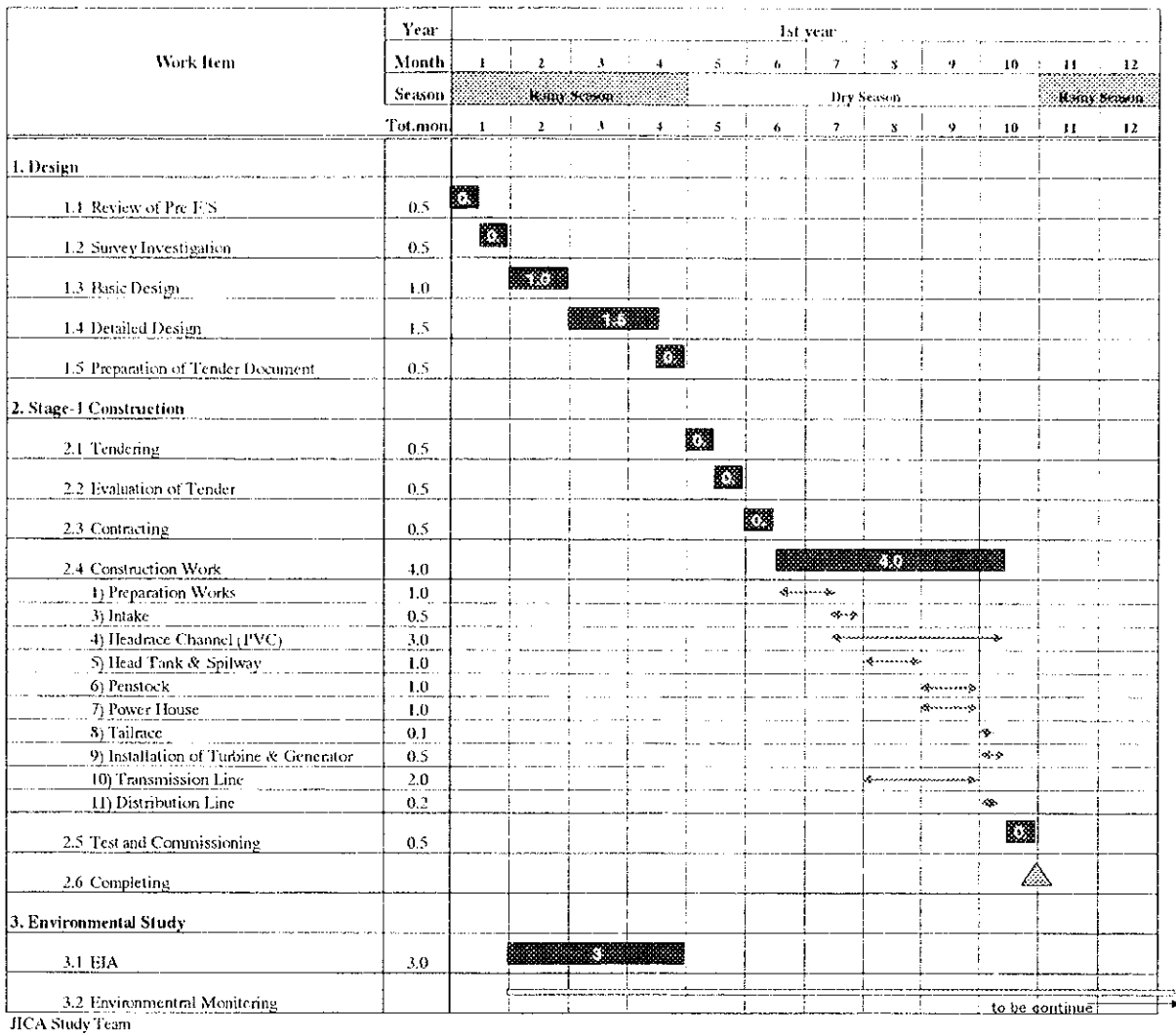
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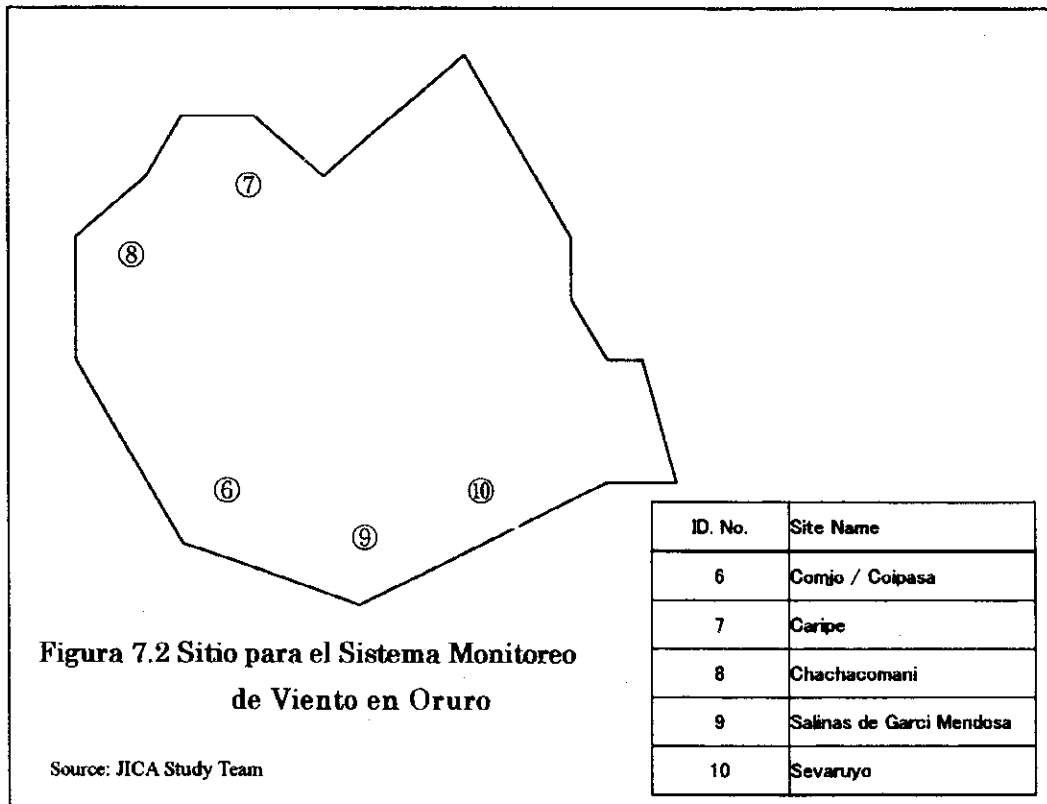
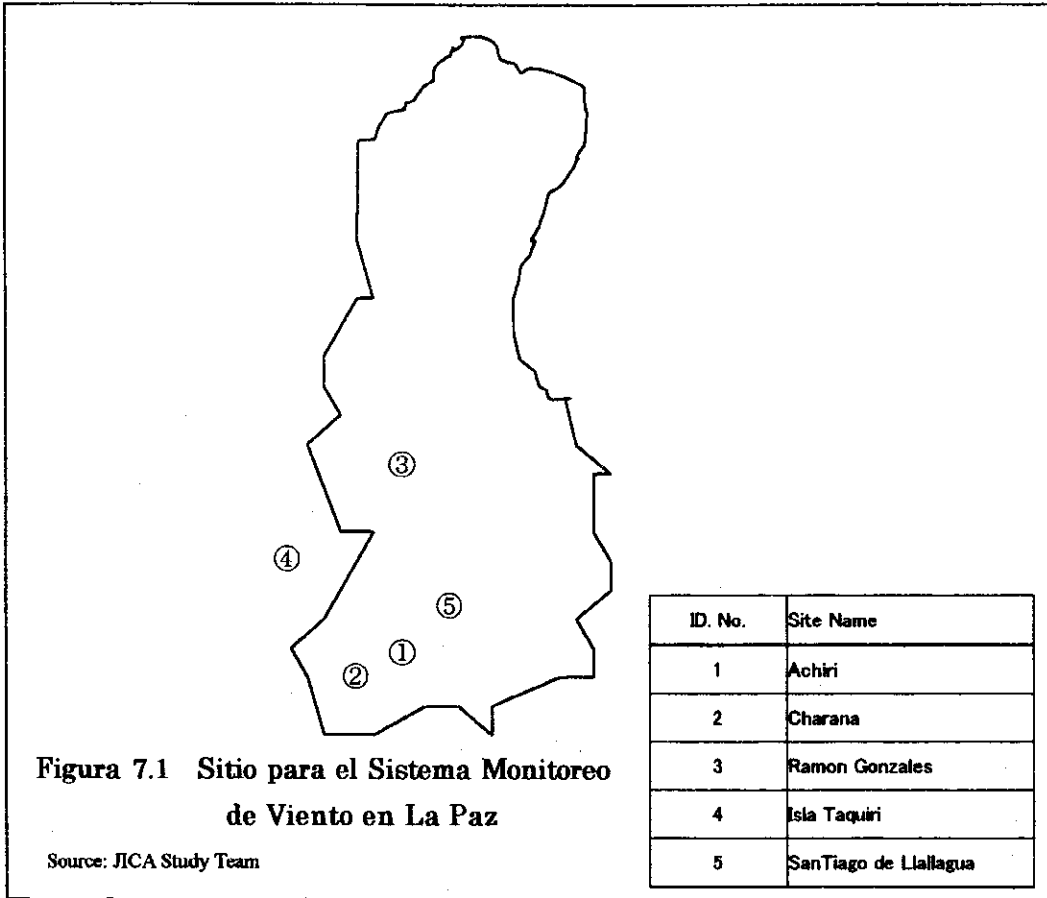
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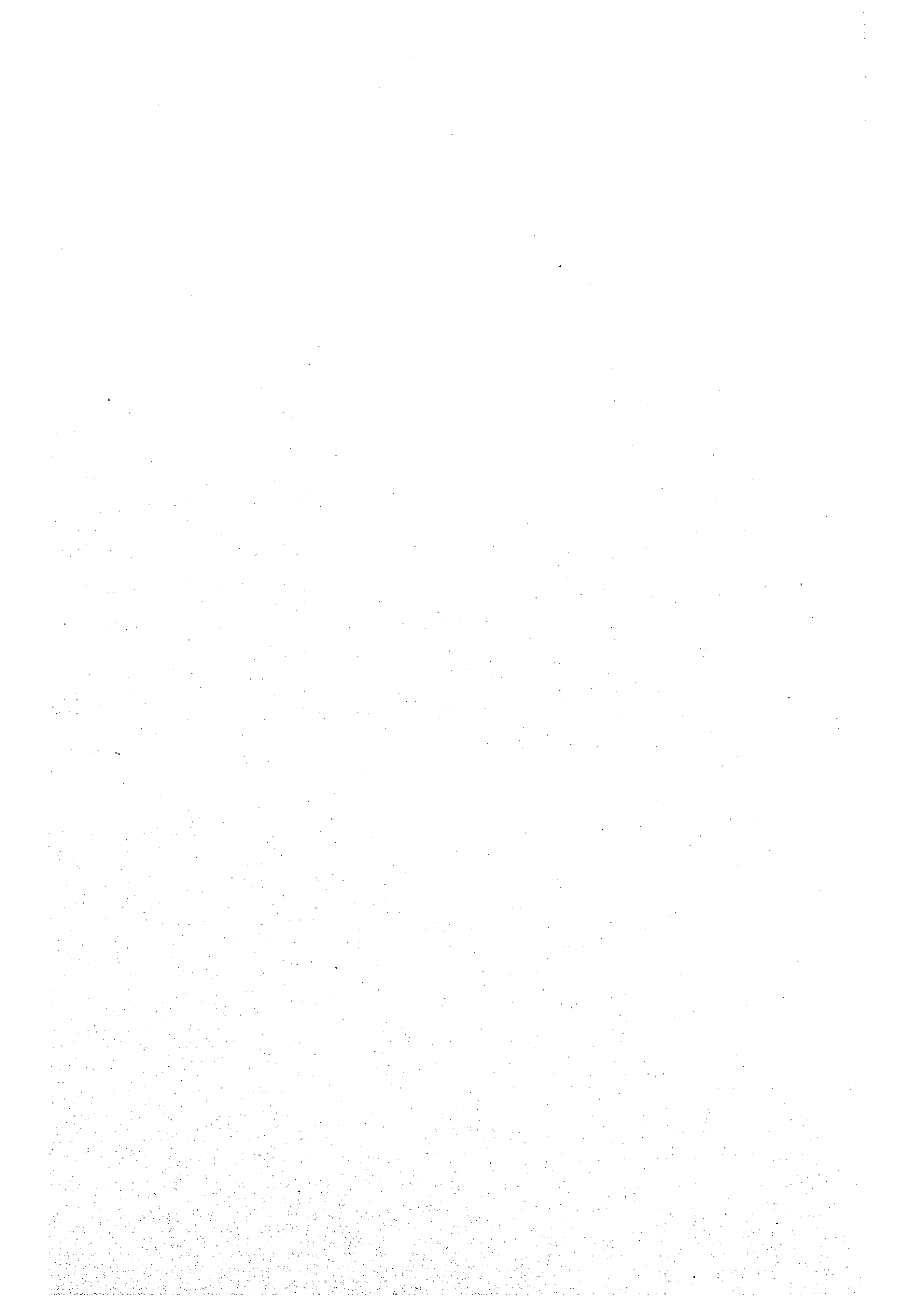
Figura 6.6 Programa de Implementación Propuesto para el Proyecto de la MCH de Tambo Quemado

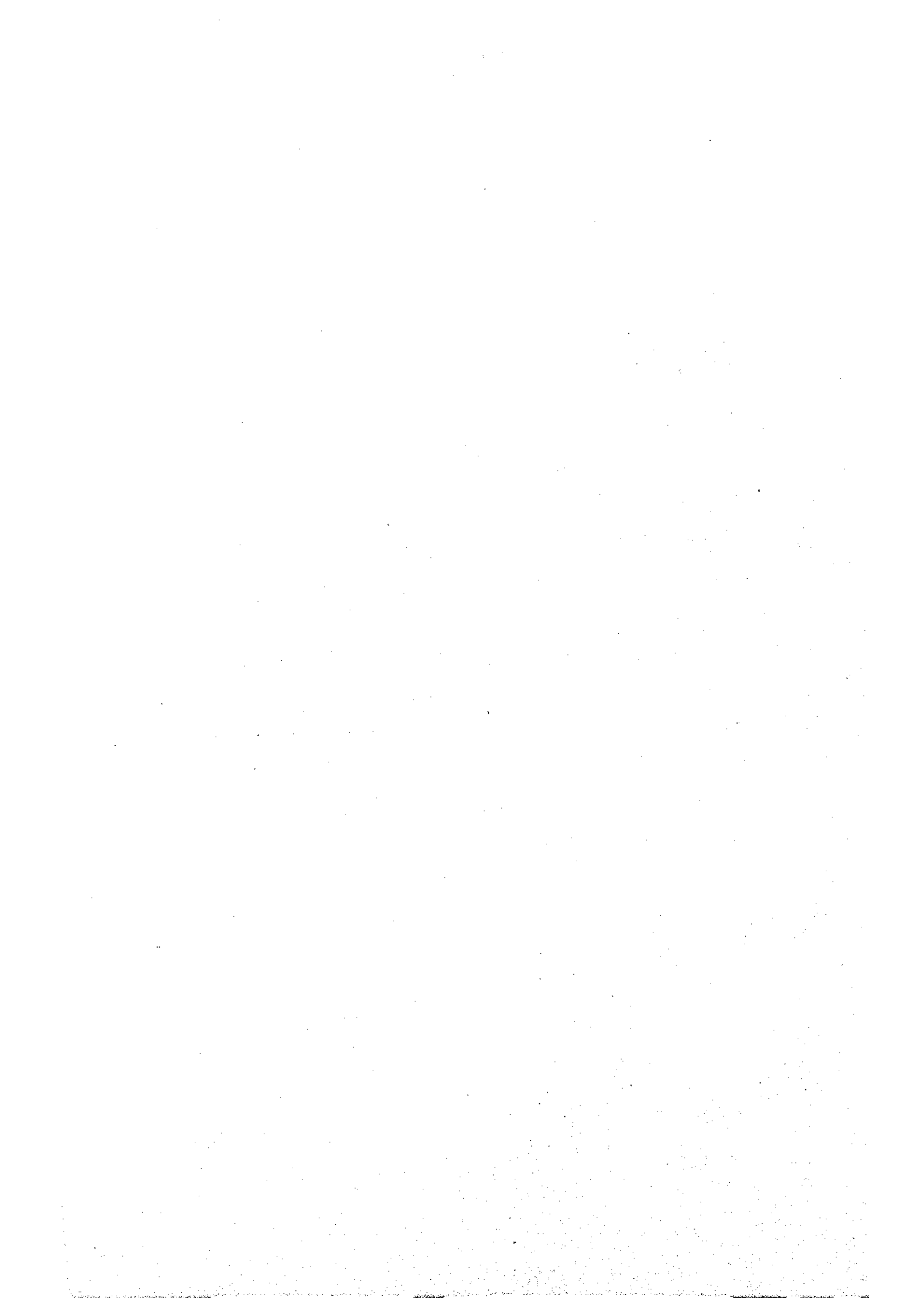


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Figura 6.6 Programa de Implementación Propuesto para el Proyecto de la MCH de Tambo Quemado







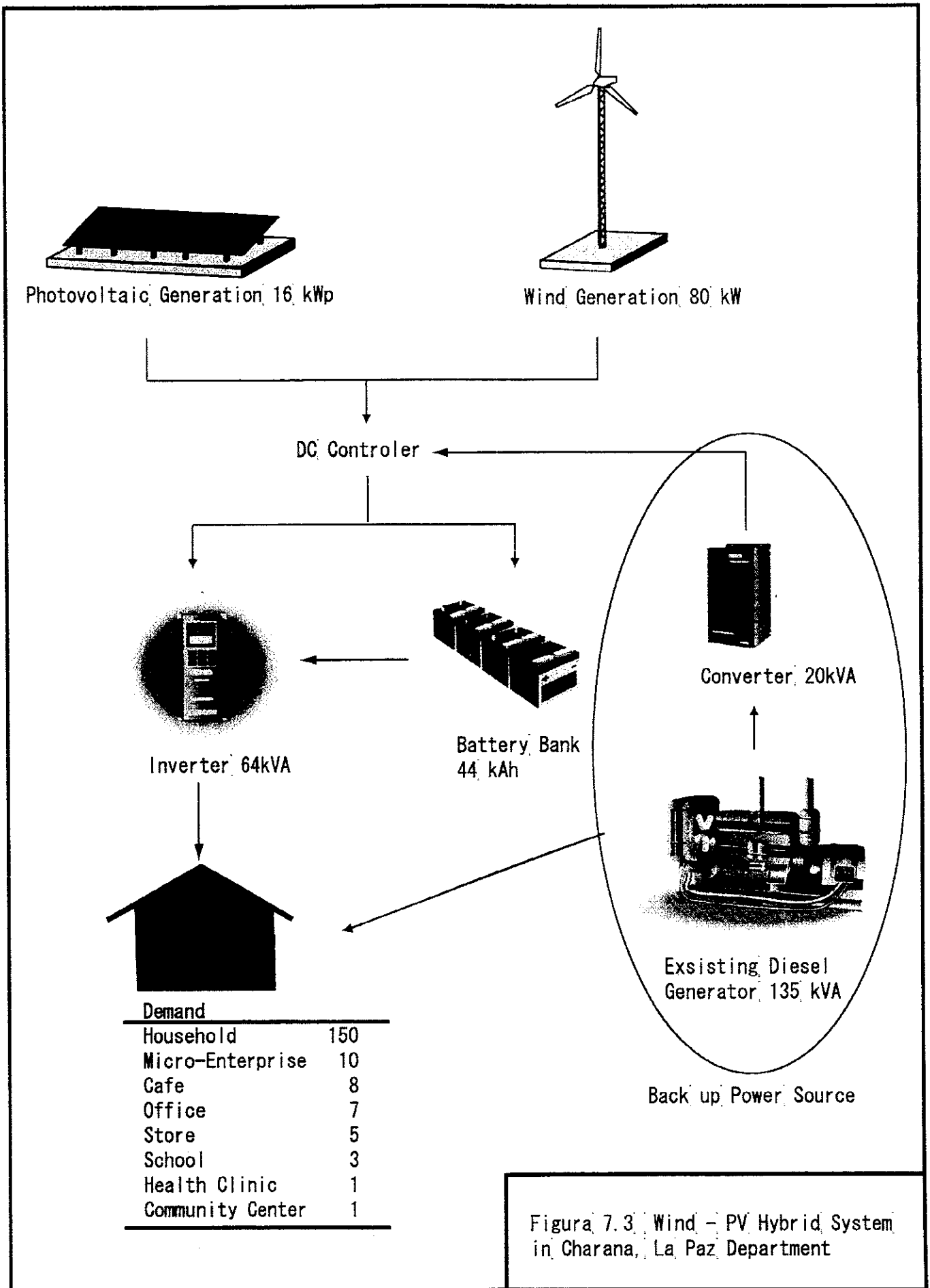


Figura 7.3 Wind - PV Hybrid System in Charana, La Paz Department

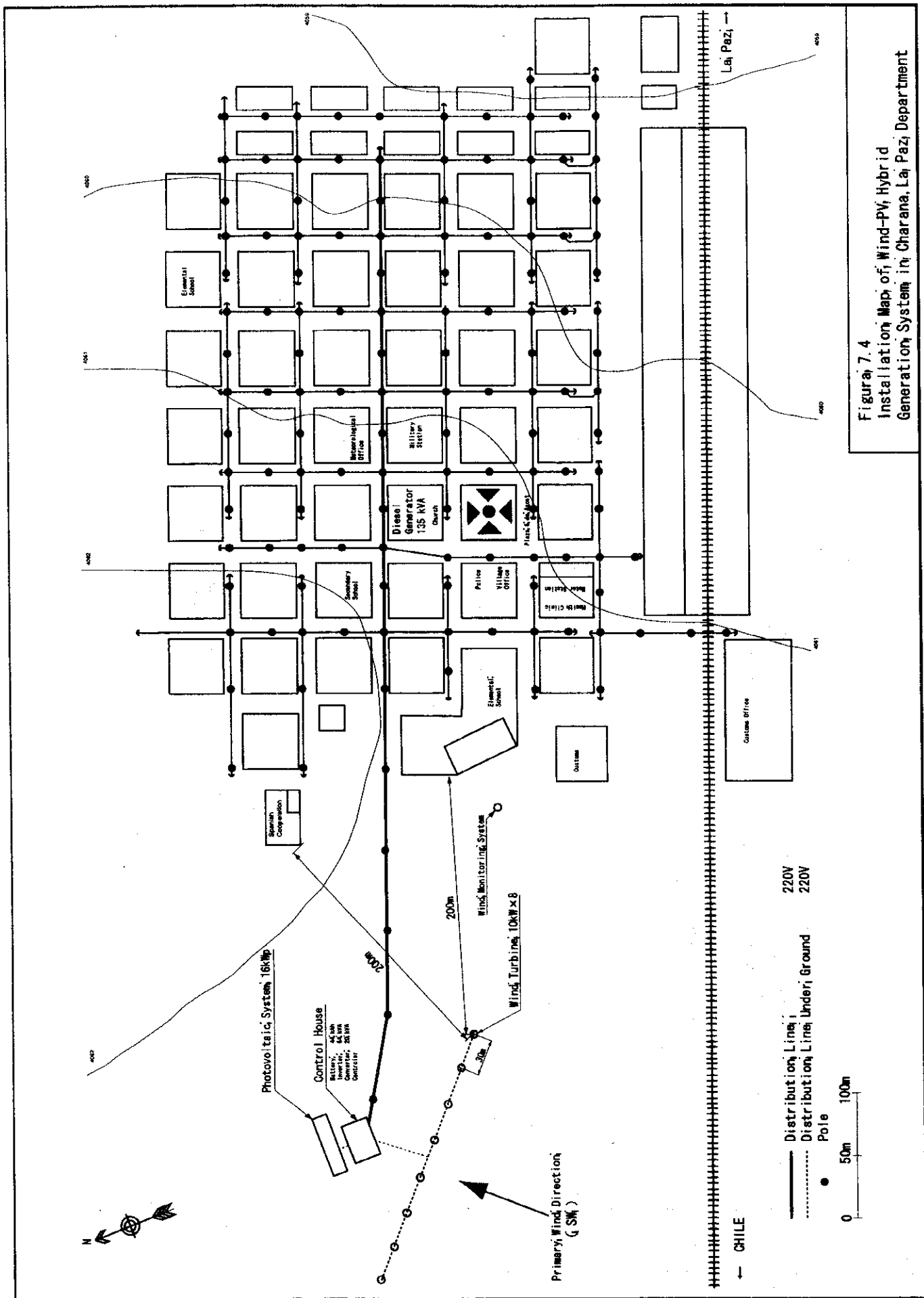
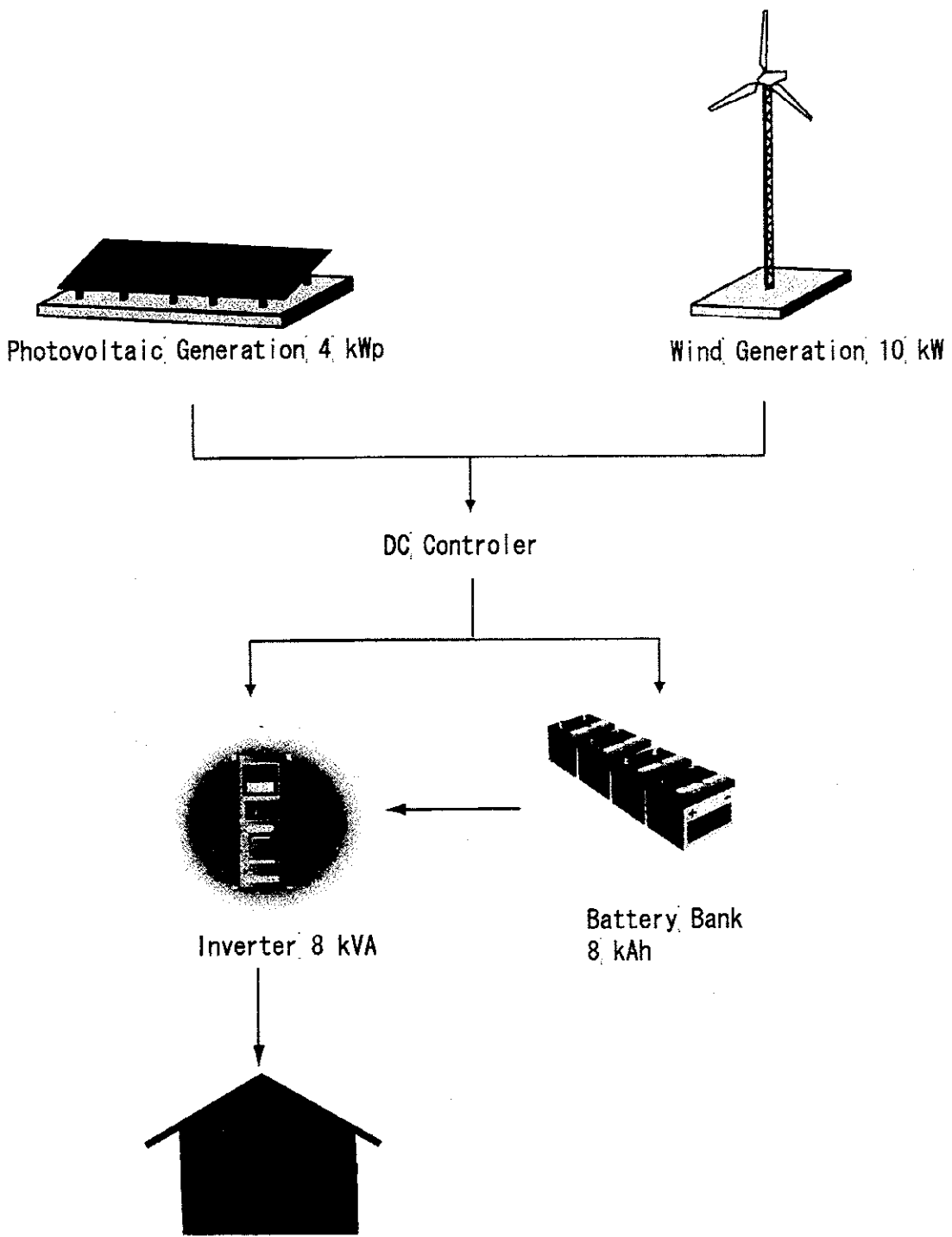


Figure 7.4
Installation Map of Wind-PV Hybrid
Generation System in Charana, La Paz, Department



Demand	
Household	30
Cafe	3
Store	2
School	1
Health Clinic	1
Community Center	1

Figura 7.5
Wind - PV Hybrid System
in Caripe, Oruro Department

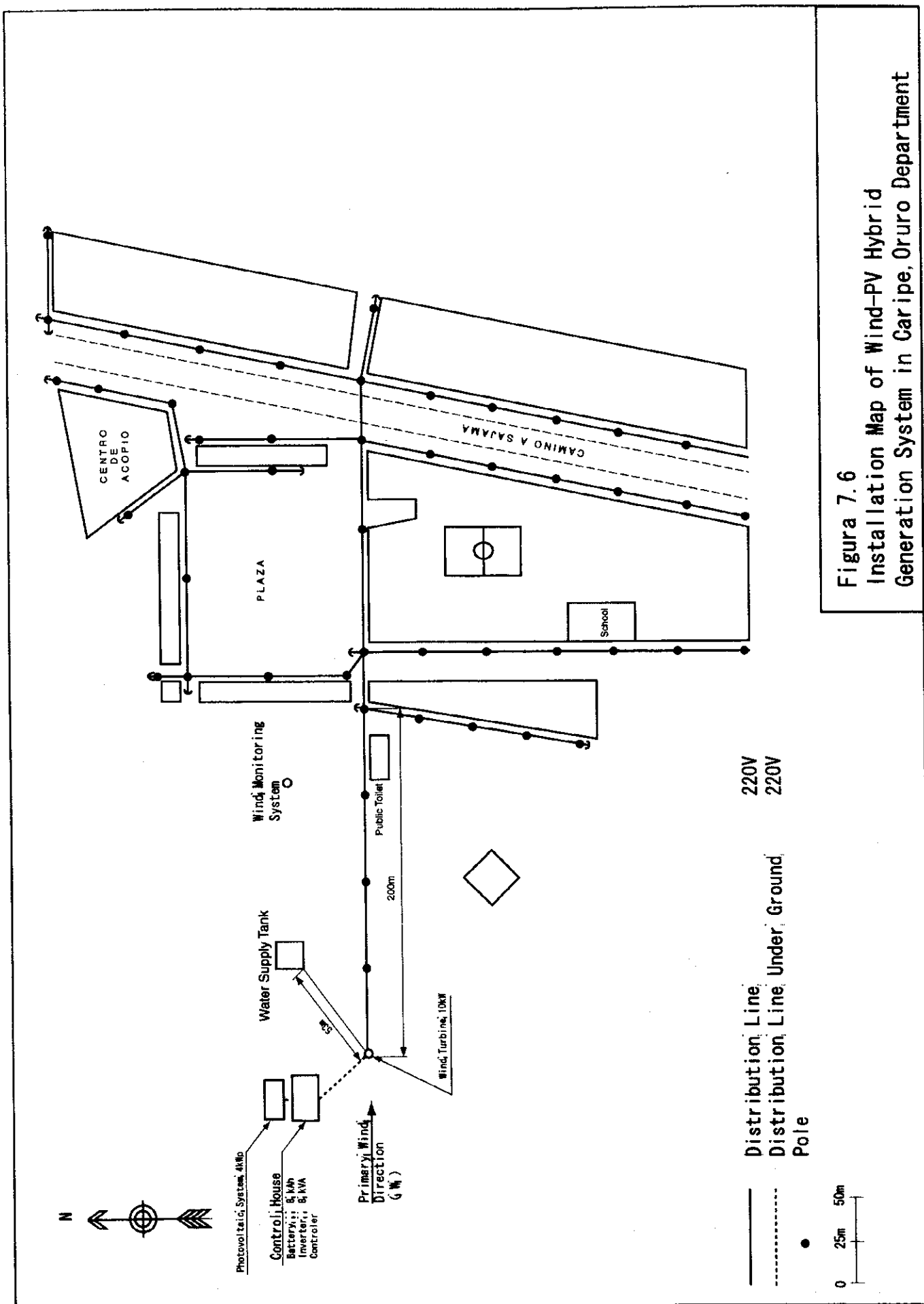
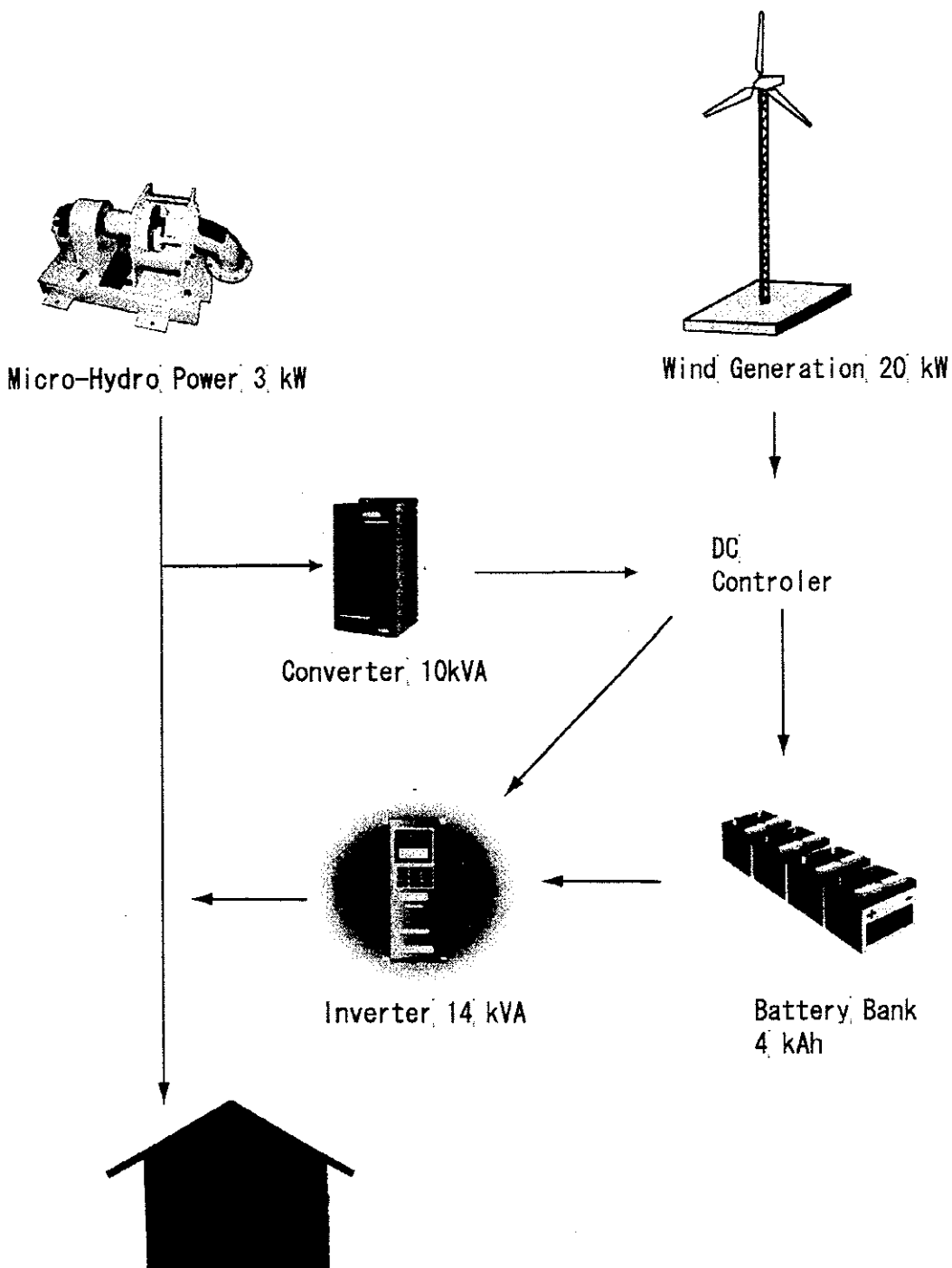


Figura 7.6
 Installation Map of Wind-PV Hybrid
 Generation System in Caripe, Oruro Department



Demand	
Household	70
Cafe	3
Store	4
School	1
Health Clinic	1
Community Center	1

Figura 7.7
 Wind - Micro Hydro Hybrid System
 in Chachacomani, Oruro Department

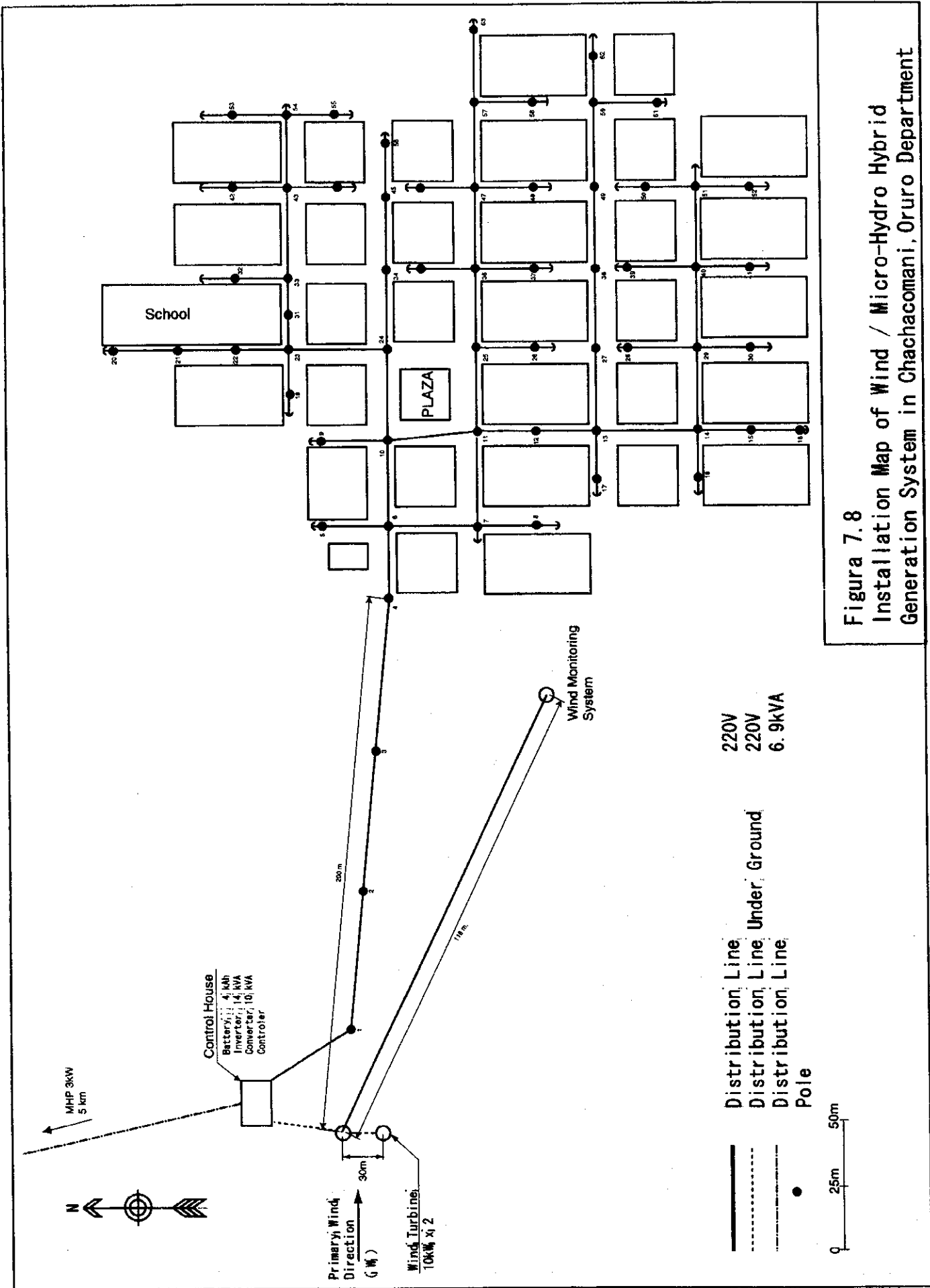
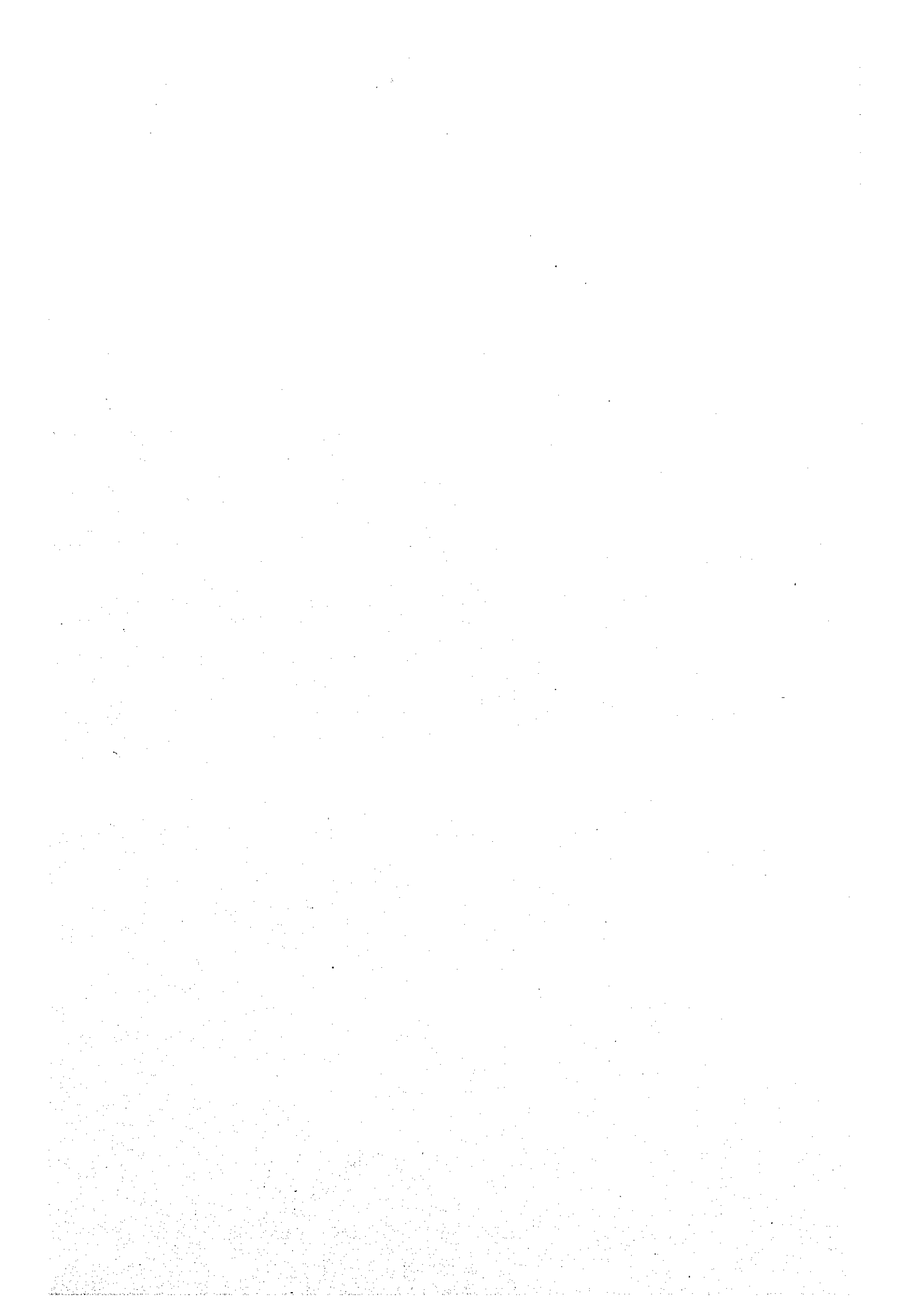
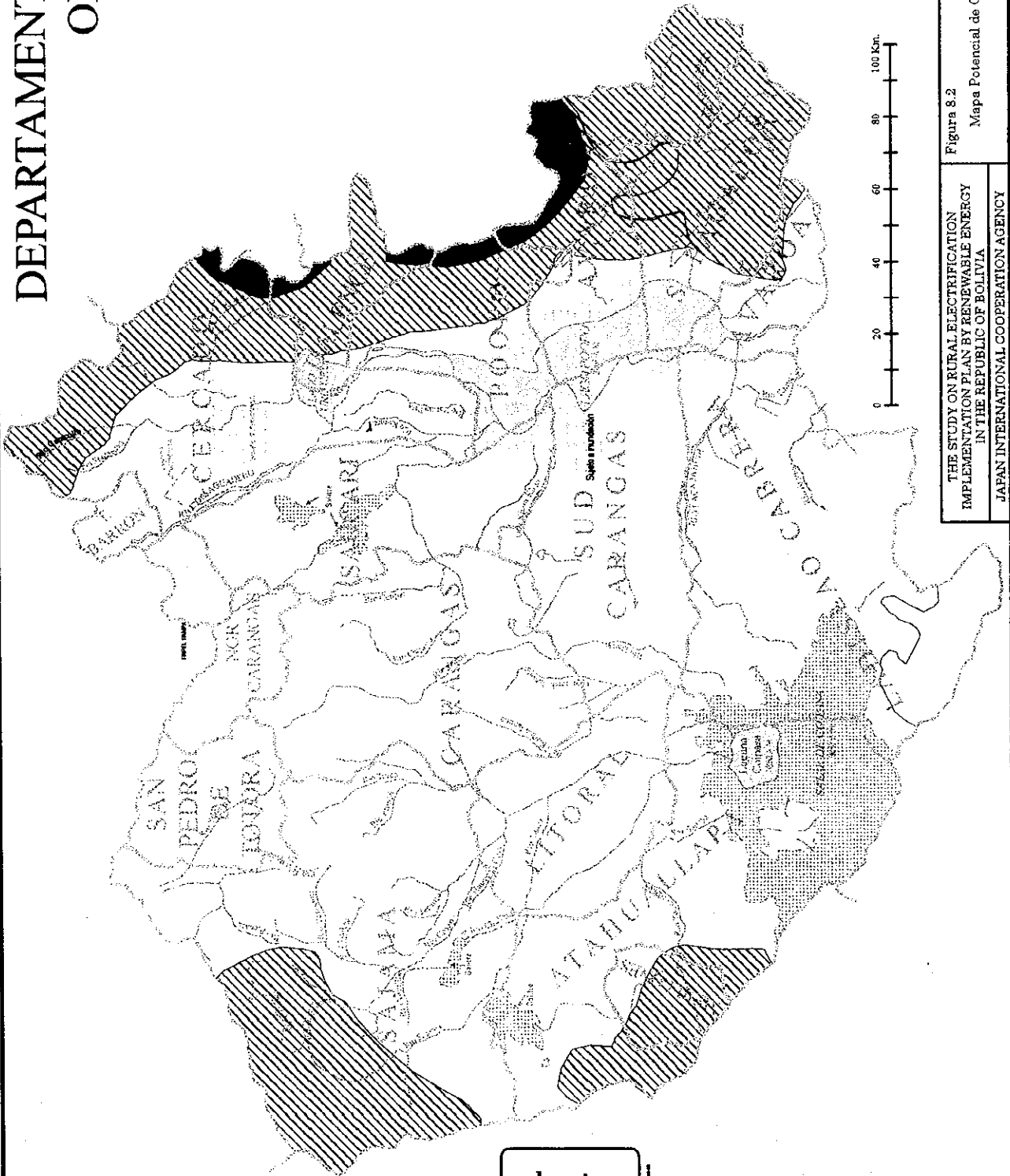


Figura 7.8
 Installation Map of Wind / Micro-Hydro Hybrid
 Generation System in Chachacomani, Oruro Department



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LEGEND

	Hydroelectric Potential
	Low
	Medium
	High

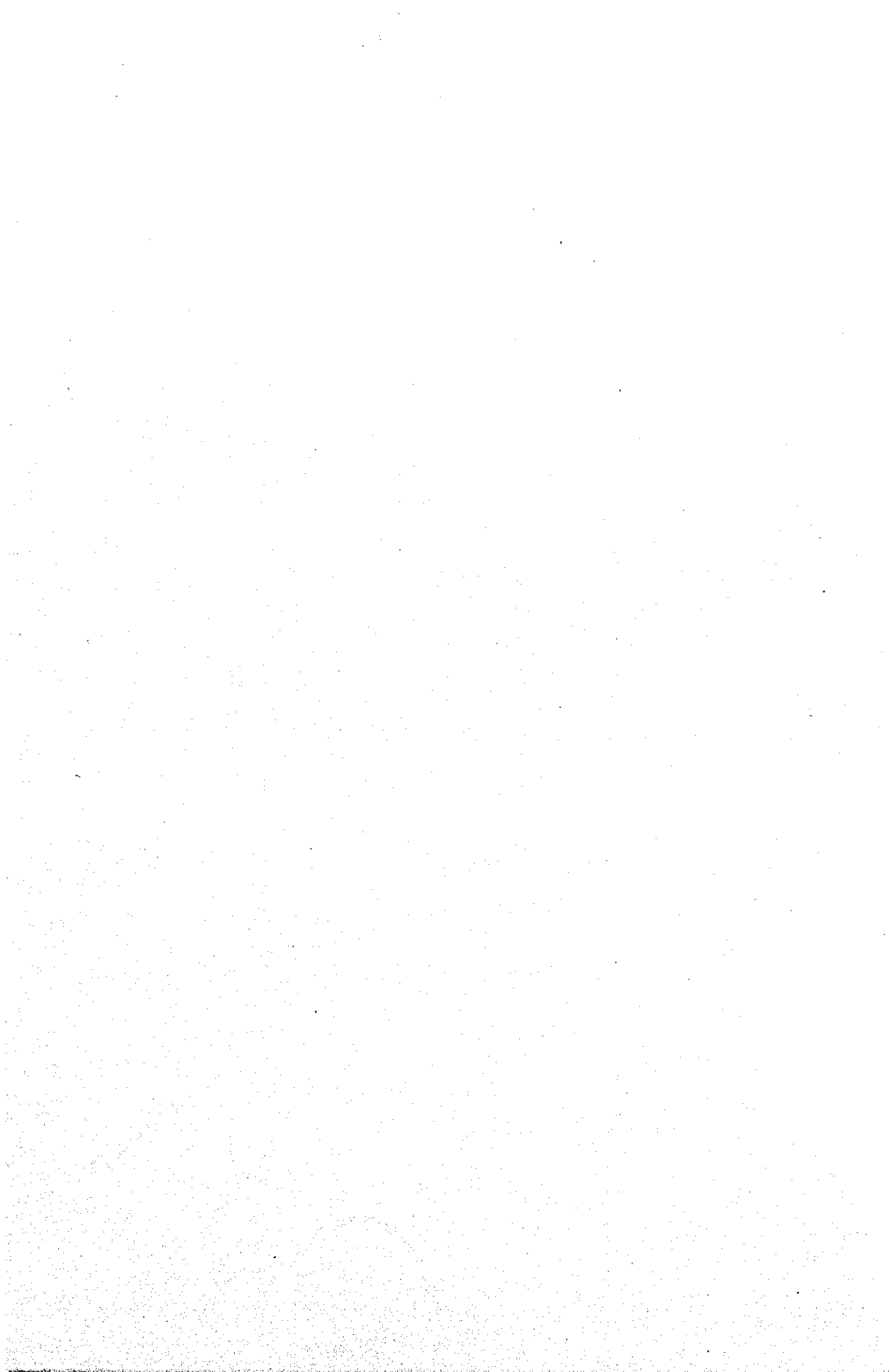
Source: I.A.C.I. Study Team

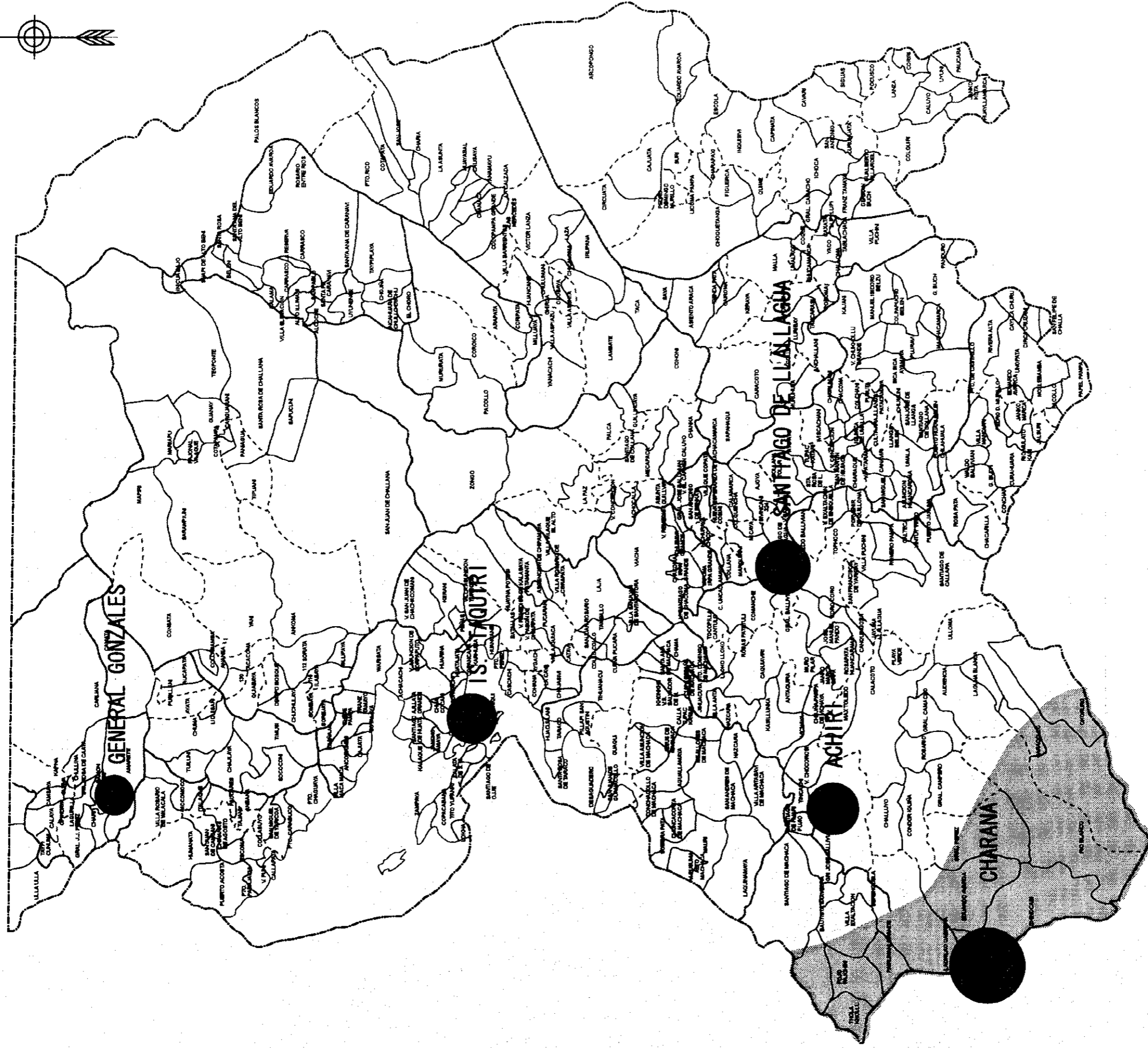


Figura 8.2
Mapa Potencial de Centrales Hidroeléctricas (Oruro)

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LEGEND

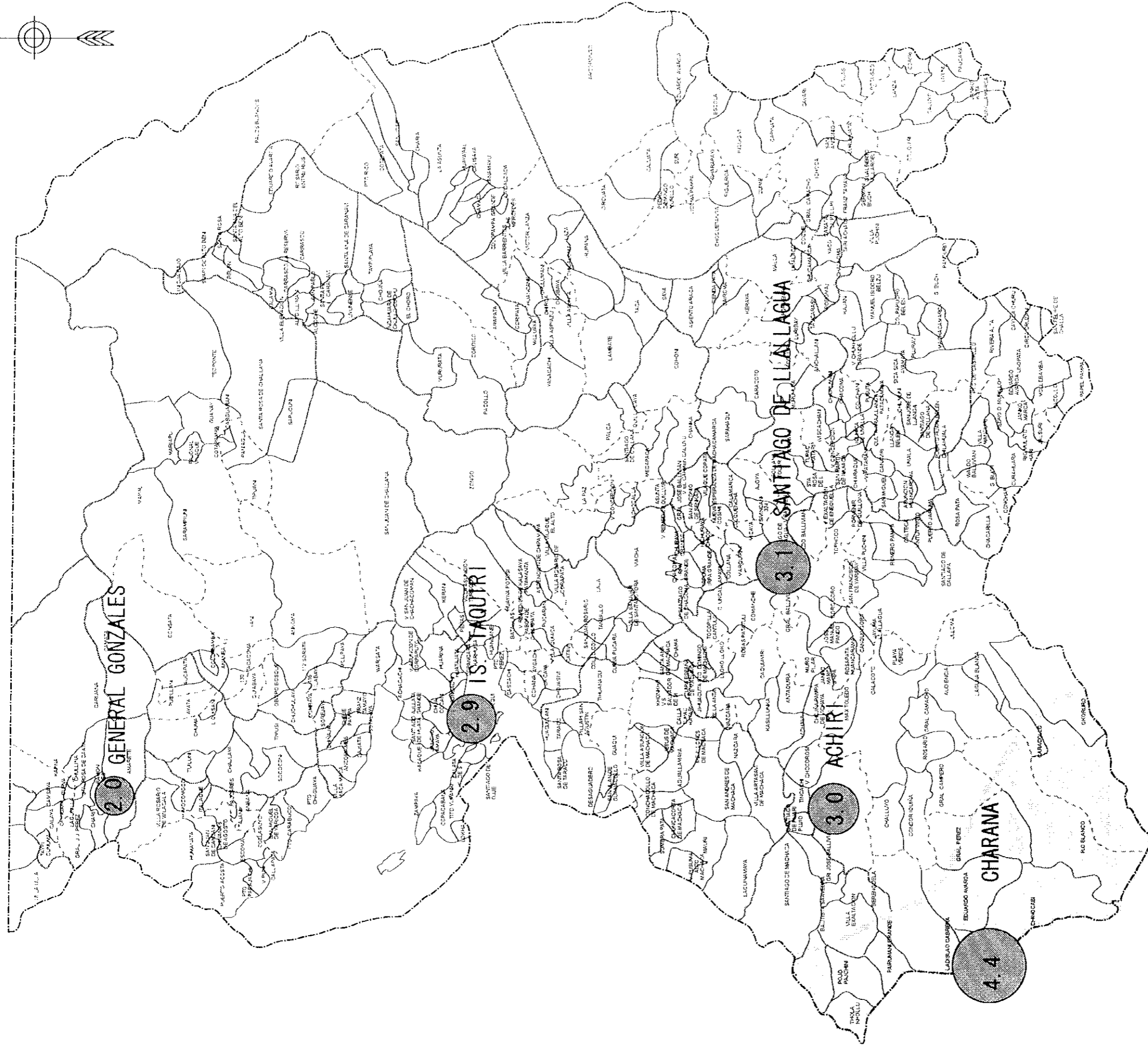
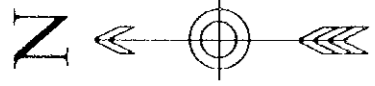
4.5 Annual Average Wind Speed (m/s)
20 meters above ground level

> 4.0 m/s (High Potential Area)



Figura 8.3 Mapa de Energia Eolica Potencial
La Paz

JICA Study Team



LEGEND

4.5 Annual Average Wind Speed (m/s)
20 meters above ground level

> 4.0 m/s (High Potential Area)

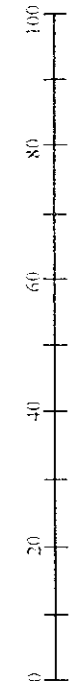
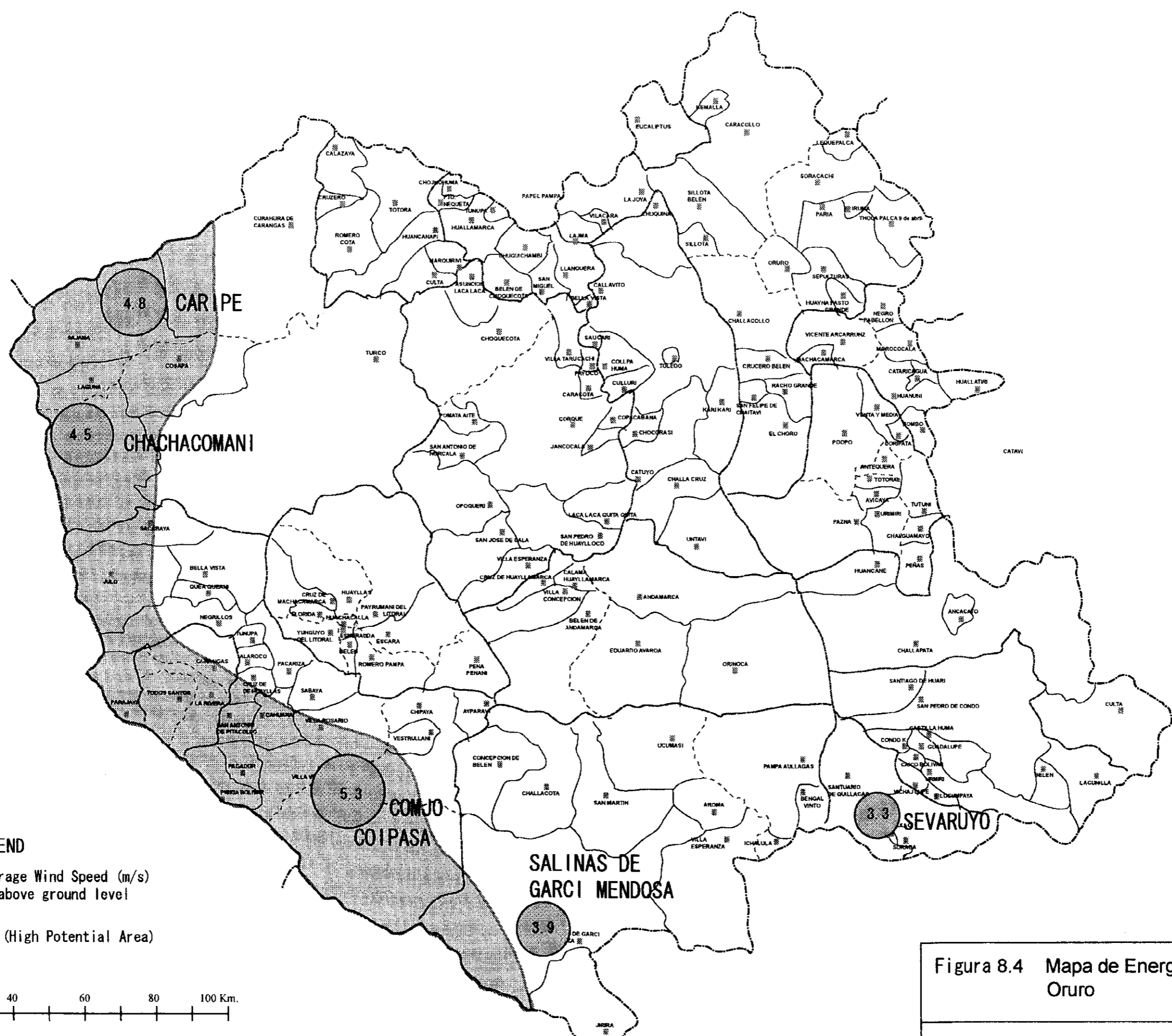


Figura 8.3 Mapa de Energia Eolica Potencial
La Paz

JICA Study Team



LEGEND

- 4.5 Annual Average Wind Speed (m/s) 20 meters above ground level
- > 4.0 m/s (High Potential Area)

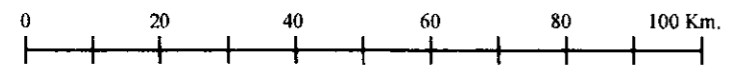
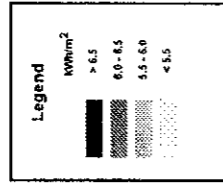
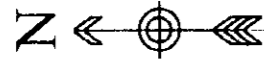


Figura 8.4 Mapa de Energia Eolica Potencial Oruro

JICA Study Team

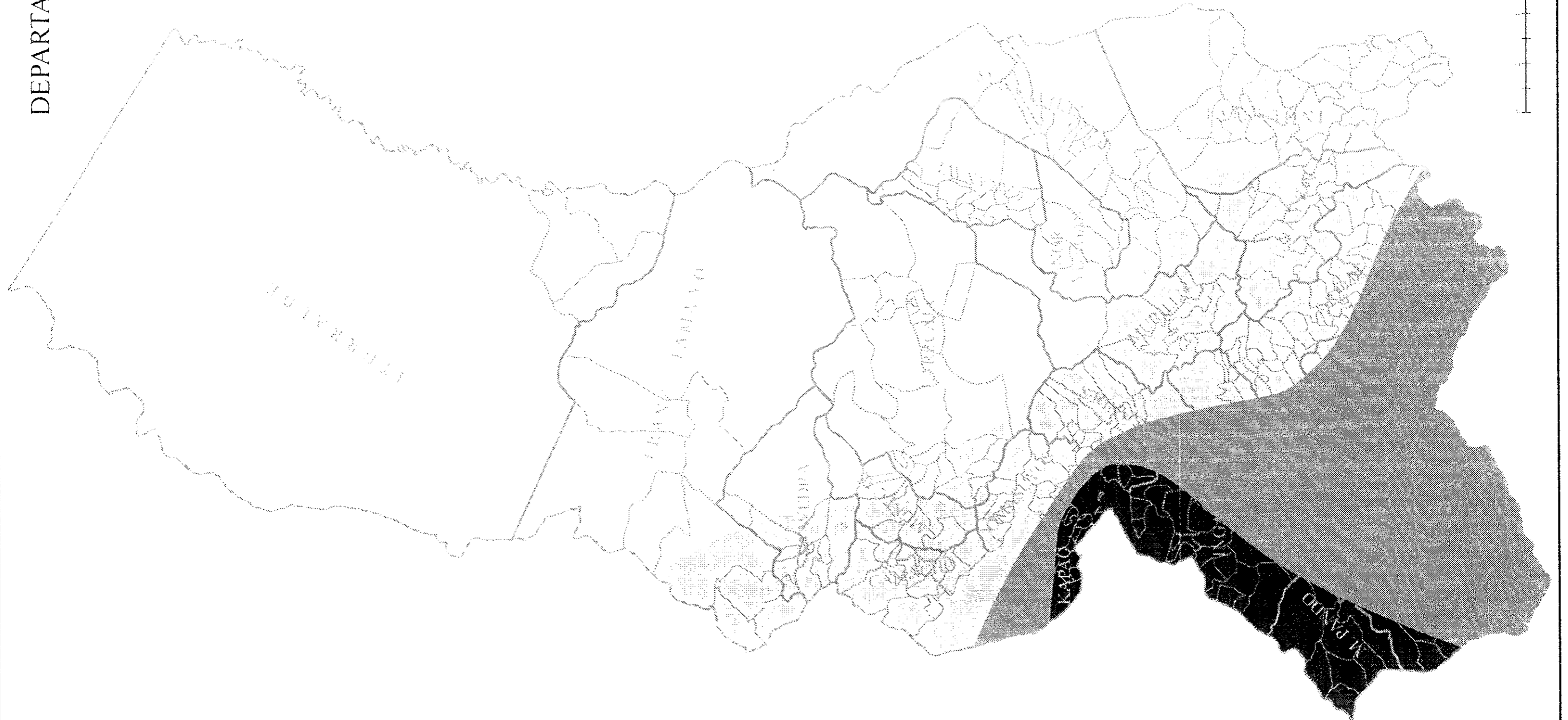
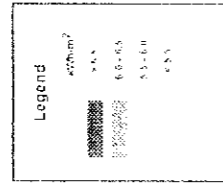
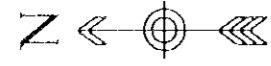
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JAPAN INTERNATIONAL COOPERATION AGENCY

Figura 8.5
Mapa de Energia Fotovoltaico Potencial, La Paz
(2002-2006, 2007-2011)

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