E-1.4. Irrigation System Improvement for the Priority Area

(1) Present Irrigation System

The irrigation water source for the Project is the Ngu Huyen Khe river, supplementing the water from the Duong river through Long Tuu intake when the water is insufficient in the Ngu Huyen Khe river. The water is taken by Trinh Xa pumping station and diverted to the north and south main canals.

The irrigation water for the Project area is distributed through the South main canal of Trinh Xa irrigation system, supplementing the water from Tan Chi pumping station to the downstream area of N4 secondary canal. While, Tri Phuong pumping station supplies the irrigation water for Canh Hung area with the excess water in the its drainage area.

In addition to the said two station, there are about 19 irrigation pumping stations and 18 dual purpose pumping stations for irrigation and drainage built and operated by the communes and/or villages to pump up the water from the secondary and tertiary canal of Trinh Xa irrigation system and/or drainage canals, creeks, ponds etc. (See Figure E-1.4.1. and Table E-1.4.1.). Where no pumping stations are built, use of portable pumps and practice of manually drawing up with a big scoop are noticeable.

In Trinh Xa pumping station, pumps built in 1962 are still used presently, of which eight (6) units out of totally installed eight (8) units are operational. Though present pump capacity is reported to be 2.5 cu.m/sec, it shall be verified by the survey. The water pumped up are distributed to three ways, drainage, North and South main irrigation canals by operation of gates provided in the discharge tank.

Present canal network of Trinh Xa South irrigation system is shown in Figure E-1.4.2. The south main canal is unlined and equipped with many check structures. Many gates of check and off-take structures are timeworn, moved out, not operational and/or difficult in operation and not in condition to regulate the water in quantity. Therefore, the most water pumped up from Trinh Xa pumping station are wasted in the upstream reaches. Due to absence of adequate maintenance works, it may be noted that the canals are not well-shaped, turnouts are collapsed and mainte-

nance roads are not passable in the long reaches. The gates of check structures are timeworn and not operational in the most gates as well as the gate of turnouts.

The most secondary canals are deteriorated and equipped without check structures. Except major secondary canals, the water diverted from the main canal flows down to the lower-bedded canal, like a drainage canal, without an adequate water head necessary to irrigate the lands in their commanded area. In the tertiary level, the irrigation canals interconnected with each other, like the meshes of net, and may be used as a dual purposes for irrigation and drainage and are not equipped with check structure. Thereby, farmers draw up the water manually by using water-proof scoop to irrigate their land and spend much working time for this drawing up.

Bac Duong Irrigation Enterprise has responsible for the water management. As the report of actually irrigated area for the Project Area is not available, the irrigated area in Tien Son district is reported to be about 6,740 ha for the winter/spring paddy and 7,020 ha for the summer paddy on the average for the latest five (5) years, which correspond to be 74 % and 82 % of the total cultivated land area with the winter/spring and the summer paddy in the district, respectively. As reported that the irrigation water has been supplied by the extension of pump operation, it is seemed that the water management means to make the schedule of pump operation with inadequate consideration in the water head, assuming that paddy lands are served by second and/or third stage pumping irrigation system.

(2) Irrigation Plan

The project would be integrated with the irrigation component to supply the water to the land to be reclaimed by the drainage improvement where are presently not planted with crops due to the water logging and the land where are insufficient in the irrigation water, expecting the increase of production yield with lower investment costs. In addition, an effective water management at the field would be practicable and ensure a high production. Furthermore, farmers would be relieved from a heavy water-lifting work, by upgrading of the irrigation system which would enable the water supply to serve directly from the canals.

The water requirement for the design of canals and structures would be proposed to be 1.3 lit/sec/ha, considering present paddy land of some 5,400 ha, proposed cropping pattern and peak diversion water requirement estimated previously.

(3) Proposed Irrigation System and Works

Most land in the Project Area would be irrigated by the canal system, as reviewed the water level available in the existing Trinh Xa South main canal. Thereby, the land area currently irrigated by the second stage pumping system would be gradually suspended and transformed to the canal irrigation system. Nevertheless, the some land area, which would be necessary to improve the a large scale of canal system in its upstream area and required in a vast cost, will be remained as the second stage pumping irrigation system, such as Canh Hung, Xom Chua, Thon Kien, Phuong Hoang, Kien Ap and Minh Dao-2. The existing irrigation canals network would be followed in the planning but modified in the some canals to ensure the water supply for the second stage pumping area (See Figure E-1.4.3.).

The South Trinh Xa Main Canal would be improved, focusing on the implementation of effective water management. The improvement would be made from the beginning point of the canal at Trinh Xa pumping station up to Hap Linh gate at Sta. 17+520. All regulating gates would be replaced with new gates to make it operational. The gates of turnout would also be provided or replaced with new ones to divert the water adequately. Nevertheless, the rehabilitation/improvement of the Main Canal would be studied further, taking the master plan of irrigation into account.

The secondary and tertiary canals would be improved and/or upgraded up to the point which has a commanded area of not less than 50 ha. These canals would be lined with bricks for the major canals which have a canal length of more than 2 km and/or a commanded area of not less than 150 ha. Others remained and farm ditches would be unlined. Check structures would be proposed, if necessary for effective water management.

TABLE E-1.1.1. IRRIGATION SERVICE AREA FOR EACH PUMPING STATION

Name of Station	Pumps Type	Pumps Nos.	Dischrge (cu.m/s)	Service Area(ha)	Remarks
[Trinh Xa Pumping Irriagtion System]					
Noi Due	H-MV 300	4	0.89	384	Irr. only
Phu Lam	H-MV 300	6	1.33	297	15-unit in total
Tan Chi	H-MV 300	8	1.78	601	68-unit in total
Tri Phuong	H-MV 300	2	0.44	200	14-unit in total
Trinh Xa	V-A 870	8	11.71	8,763	Irr.Q for 16,045 ha
Y Na	H-MV 300	2	0.22	25	Irr. only
Subtotal	6-Station	30	16.37	10,270	
[Kim Doi Area Irrigation System]					
Cau Tien	H-MV 300	1	0.22	75	Irr. only
Cach Bi	H-MV 300	5	1.11	500	Irr. only
Kieu Luong	H-MV 300	4	0.89	710	Irr. only
Kim Doi	V-A 870	2	5.00	3,185	5-unit in total
Que Tan	H-MV 300	1	0.22	105	7-unit in total
Thai Hoa	H-MV 300	21	4.67	2,220	Irr. & Drainage
Xuan Thuy	H-MV 300	1	0.22	85	Irr. only
Sub-total	8-Station	35	12.33	6,880	
[Dong Sai Irrigation System]					
Dong Sai	H-MV 300	4	0.89	570	Irr. only
[Xuan Vien Pumping Irrigation System]					
Huu Chap	H-MV 300	1	0.22	70	20-unit in total
Xuan Vien	H-MV 300	10	2.22	900	Irr. & Drainage
Sub-total	2-Station	11	2.44	970	
[Total for Bac Duong Irrigation System]					
Total	16-station	80	32.03	18,690	
[Dong Anh Area Irrigation System]					
Dong Dau	H-MV 300	1	0.28	190	Irr. only
Loc Ha	H-MV 300	3	0.83	240	Irr. only
Lai Da	H-MV 300	1	0.22	110	Irr. only
Total	3-Station	5	1.33	540	
[Gia Lam Area Irrigation System]					
Cong Thon	H-MV 300	11	2.52	1,400	Irr. only
Thinh Lien	H-MV 300	4	0.65	(400)	15-unit in total
Lien Dam	H-MV 300	3	0.67	490	10-unit in total
Total	3-Station	18	3.84	1,890	
Grand Total	22-Station	103	37.20	21,120	11-station Irr.only

Source: Bac Duong, Dong Anh and Gia Lam Irrigation Enterprises

Note: H-MV 300; Horizontal Axix Mixed Flow Volute Pump x 300mm (Bore)
V-A 870; Vertical Axis Axial Flow Pump x 870mm (Bore)
* Service area of Trinh Xa station is estimated as the area directly irrigated
**Parenthesized area is shown as an area of two-stage pump

TABLE E-1.1.2. LIST OF MAIN IRRIGATION CANALS

No.	Name of Canals	Length (m)	Width (m)	W. Depth (m)	Flow Q* (cumec)	Service Area (ha)	Remarks
1	Long Tuu	11,300	20.00	2.00	10.80		B=41.5m, s=1/50,000
2	Trinh Xa South						
2.1	Upper Reach	11,300	12.90	2.30	13.80		B=23.3m, s=1/26,300
2.2	Middle Reach	12,500	10.00	2.30	7.00		B=20.4m, do.
2.3	Lower Reach	9,700	8.00	2.30	3.50		B=18.2m, do.
	Sub-total	33,500				16,045	
3	Cong Thon	2,250	4.50	2.50	7.09	1,400	B=12.0m, s=1/10,000
	Total for 2 & 3	35,750				17,445	

Source : Bac Duong and Gia Lam Irrigation Enterprises

TABLE E-1.1.3. LIST OF SECONDARY IRRIGATION CANALS

No.	Name of Canals	Length (m)	Width (m)	Hight (m)	Flow Q* (cumec)	Design Area (ha)	Remarks
Trinh Xa South Main Canal							
1	B2	10,000	1.50	1.70	1.41	3,100	
2	B1	1,450	0.80	1.50	0.75	205	
3	Trinh Nguyen Ta	600	0.60	1.20	0.35	60	
4	Dau Dot	1,650	0.70	1.20	0.37	58	
5	B2'	1,140	0.70	1.00	0.21	60	
6	Cong Thon	4,700	3.00	2.50	5.41		For Gia Lam System
7	Day Gang	852	0.70	1.70	1.01	18	
8	N3A	3,500	0.80	1.10	0.31	170	
9	Dong Bong	1,060	0.70	1.50	0.71	26	
10	Noi Loc	700	0.60	1.00	0.20	28	
11	N3B	1,960	0.80	1.40	0.61	134	
12	N4	5,500	0.80	1.10	0.31	675	
13	N11	1,000	0.60	0.80	0.10	87	
14	N5	2,430	0.70	0.90	0.15	190	
15	N13	3,000	0.70	0.90	0.15	203	
16	Cau Nga Tu	1,400	0.80	1.30	0.50	60	
17	N15	2,000	1.00	1.40	0.68	150	
18	Nam Nui Che	4,650	0.80	1.00	0.23	177	
19	Ban Thong	700	0.60	0.90	0.14	43	
20	Nguhia Trang	4,000	0.80	1.00	0.23	234	
21	Nghia Trang	480	0.70	0.90	0.15	48	
22	Che Doc	450	0.60	0.90	0.14	24	
23	K10 Van Tuong	3,200	0.70	1.00	0.21	218	
24	Thuong Lam	900	0.70	1.00	0.21	60	
25	Benh Vien	1,000	0.70	1.00	0.21	53	
26	N6	13,000	1.80	1.70	1.56	2,400	
27	Hoai Trung	350	0.60	0.80	0.10	50	
28	Hoai Thi	1,080	0.70	1.00	0.21	65	
29	Lang Tuong	500	0.60	0.80	0.10	47	
30	M22	327	0.60	0.80	0.10	154	

Source : Bac Duong Irrigation Enterprise
:*Estimated, Free Board =0.3m, ss=1:1.5, n=0.03, s=1/10,000

TABLE E-1.1.3. LIST OF SECONDARY IRRIGATION CANALS (Continued)

No.	Name of Canals	Length (m)	Width (m)	Hight (m)	Flow Q* (cumec)	Design Area (ha)	Remarks
Trinh Xa South Main Canal							
31	N1	8,500	1.00	1.20	0.44	1,050	
32	M24	400	0.60	0.80	0.10	50	
33	M25	1,600	0.80	1.00	0.23	80	
34	N8	5,200	0.80	1.10	0.31	434	
35	M27	1,180	0.80	1.00	0.23	229	
36	N35	1,600	0.80	0.90	0.17	130	
37	N9	300	0.60	0.80	0.10	28	
38	N23	2,000	0.80	1.00	0.23	383	
39	N9A	2,000	0.70	0.90	0.15	80	
40	N23'	2,700	0.80	1.00	0.23	196	
41	N34	3,800	0.80	1.00	0.23	233	
42	Thai Hoa	3,500	8.00	2.40	10.24	1,137	
43	N36	4,000	1.00	1.20	0.44	400	
44	N42	2,500	0.70	0.90	0.15	134	
45	Kim Doi	9,200	2.00	2.20	3.16	1,915	
46	N49	1,750	0.70	0.90	0.15	159	
47	N43	800	0.60	0.80	0.10	90	
48	N51	2,300	0.70	0.90	0.15	98	
49	N44	800		0.80	0.04	40	
50	N53	1,400	0.60	0.80	0.10	70	
51	N48	1,000	0.60	0.80	0.10	52	
53	N50	1,000	0.60	0.80	0.10	50	
55	N52	800	0.60	0.80	0.10	20	
57	N54	2,000	0.70	0.90	0.15	130	
59	M56	2,000	0.70	0.90	0.15	60	
	Total	135,909				16,045	

Source : Bac Duong Irrigation Enterprise

:*Estimated, Free Board =0.3m, ss=1:1.5, n=0.03, s=1/10,000

FIGURE E-1.1.1. GENERAL MAP OF PRESENT IRRIGATION SYSTEM IN THE STUDY AREA

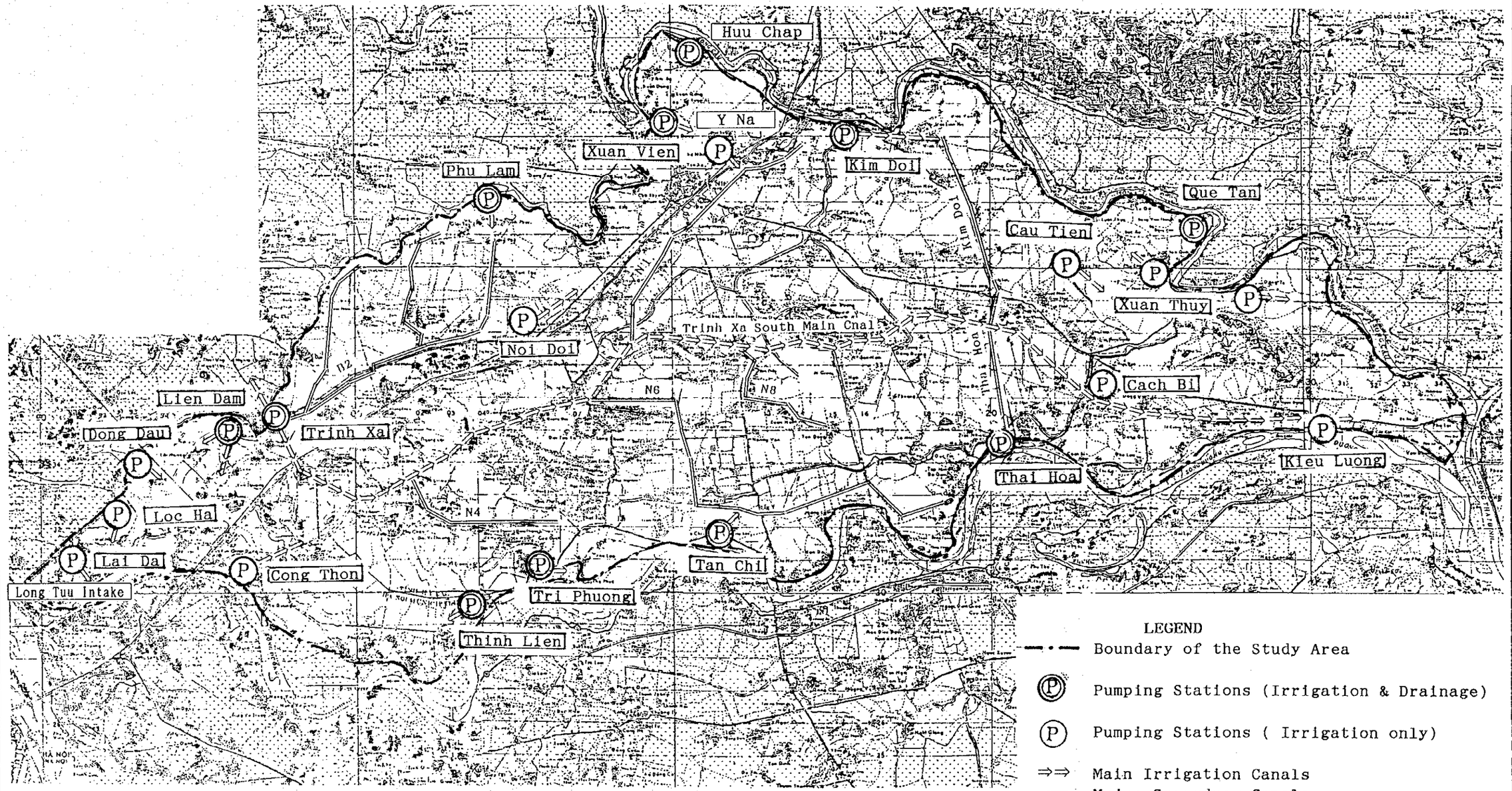


TABLE E-1.2.1. DROUGHT IN BAC DUONG IRRIGATION AREA (ha)

Year	Area	Year	Area	Year	Area
1980	3,200	1986	13,915	1992	3,895
1981	5,000	1987	7,896		
1982	660	1988	4,500	Max.	9,900
1983	9,900	1989	2,578	Min.	660
1984	8,300	1990	3,510	Average	5,355
1985	13,687	1991	6,870	Std.Var.	2,679

Source : Bac Duong Irrigation Enterprise

TABLE E-1.2.2. IRRIGATED AREA FOR THE LATEST FIVE YEARS IN SOUTH BAC DUONG AREA

No.	District/ Stations	1989 (ha)	1990 (ha)	1991 (ha)	1992 (ha)	1993 (ha)	Average (ha)
For Winter and Spring Crops							
TIEN SON							
1	Tri Phuong	156	161	101	101	157	135
2	Noi Due	360	302	302	284	285	307
3	Phu Lam	400	578	576	570	612	547
4	Tan Chi	485	588	550	586	609	564
5	Trinh Xa	7,262	6,501	6,816	6,793	6,329	6,740
QUE VO							
1	Cach Bi	553	403	525	501	331	463
2	Dong Sai	233	224	236	280	253	245
3	Hien Luong	0	0	0	33	30	13
4	K.Luong & C.Cau	675	684	676	672	489	639
5	Kim Doi	1,515	1,612	1,518	1,280	1,317	1,448
6	Que Tan	90	56	183	400	417	229
7	Thai Hoa	639	676	683	578	608	637
8	Trinh Xa	1,003	901	967	833	769	895
9	Viet Thong	80	80	80	85	81	81
BAC NINH							
1	X.Vien & H.Chap	132	118	118	120	146	127
2	Trinh Xa	886	735	740	585	697	729
3	Y Na	42	36	38	39	25	36
Sub-total		14,511	13,655	14,109	13,740	13,155	13,834
Irrigation Rate (%)		77.64	73.06	75.49	73.52	70.39	74.02

Source : Bac Duong Irrigation Enterprise

TABLE E-1.2.2. IRRIGATED AREA FOR THE LATEST FIVE YEARS IN SOUTH BAC DUONG AREA (CONTINUED)

No.	District/ Stations	1989 (ha)	1990 (ha)	1991 (ha)	1992 (ha)	1993 (ha)	Average (ha)
For Summer Crops							
TIEN SON							
1	Tri Phuong	188	138	108	120	118	134
2	Noi Due	306	164	319	349	349	297
3	Phu Lam	572	237	569	558	569	501
4	Tan Chi	497	381	666	601	644	558
5	Trinh Xa	7,104	3,029	7,038	7,028	6,909	6,222
QUE VO							
1	Cach Bi	297	228	304	291	330	290
2	Dong Sai	0	0	0	22	0	4
3	Hien Luong	0	40	0	18	24	16
4	K.Luong & C.Cau	262	336	302	311	327	308
5	Kim Doi	1,271	989	1,356	1,240	1,302	1,232
6	Que Tan	254	253	252	246	369	275
7	Thai Hoa	549	346	546	545	580	513
8	Trinh Xa	319	229	417	480	480	385
9	Viet Thong	60	60	60	61	66	61
BAC NINH							
1	X.Vien & H.Chap	128	90	122	122	143	121
2	Trinh Xa	750	407	730	697	700	657
3	Y Na	36	32	34	35	25	32
Sub-tptal		12,593	(6,959)	12,823	12,724	12,935	12,769
Irrigation Rate (%)		67.38	(37.23)	68.61	68.08	69.21	68.32
Total for Yearlong Cropping							
TIEN SON							
1	Tri Phuong	344	299	209	221	275	270
2	Noi Due	666	466	621	633	634	604
3	Phu Lam	972	815	1,145	1,128	1,181	1,048
4	Tan Chi	982	969	1,216	1,187	1,253	1,121
5	Trinh Xa	14,366	9,530	13,854	13,821	13,238	12,962
QUE VO							
1	Cach Bi	850	631	829	792	661	753
2	Dong Sai	233	224	236	302	253	250
3	Hien Luong	0	40	0	51	54	29
4	K.Luong & C.Cau	937	1,020	978	983	816	947
5	Kim Doi	2,786	2,601	2,874	2,520	2,619	2,680
6	Que Tan	344	309	435	646	786	504
7	Thai Hoa	1,188	1,022	1,229	1,123	1,188	1,150
8	Trinh Xa	1,322	1,130	1,384	1,313	1,249	1,280
9	Viet Thong	140	140	140	146	147	143
BAC NINH							
1	X.Vien & H.Chap	260	208	240	242	289	248
2	Trinh Xa	1,636	1,142	1,470	1,282	1,397	1,385
3	Y Na	78	68	72	74	50	68
T o t a l		27,104	(20,614)	26,932	26,464	26,090	26,648
Irrigation Rate (%)		72.51	(55.15)	72.05	70.80	69.80	71.29

Note : Parenthesized are extremely low values
Source : Bac Duong Irrigation Enterprise

TABLE E-1.2.3. IRRIGATED AREA FOR THE LATEST FIVE YEARS IN DONG ANH AREA

No.	District/ Stations	1989 (ha)	1990 (ha)	1991 (ha)	1992 (ha)	1993 (ha)	Average (ha)
For Spring Crops							
1	Dong Hoi	209	205	227	279	279	240
2	Duc Tu	380	366	366	198	198	302
3	Mai Lam	194	164	160	246	246	202
4	Xuan Canh	167	191	191	209	209	193
5	Viet Hung	27	24	24	24	24	25
	T o t a l	977	950	968	956	956	961
Irrigation Rate (%)		90.21	87.72	89.38	88.27	88.27	88.77

Note : Area covered 1,083 ha along the Ngu Huyen Khe river
Source : Dong Anh Irrigation Enterprise

TABLE E-1.2.4. IRRIGATED AREA FOR THE LATEST FIVE YEARS IN GIA LAM AREA

No.	District/ Stations	1989 (ha)	1990 (ha)	1991 (ha)	1992 (ha)	1993 (ha)	Average (ha)
For Summer Crops							
1	Cong Thon	1,326	1,298	1,365	1,258	1,387	1,327
2	Thinh Lien	418	415	405	310	403	390
3	Lien Dam	446	451	450	451	470	454
	T o t a l	2,190	2,164	2,220	2,019	2,260	2,171
Irrigation Rate (%)		95.63	94.50	96.94	88.17	98.69	94.79

Note : Cong Thon area includes the directly irrigated area and 2-stage pumping area (Thinh Lien)
: The service area to be revised because of withdrawal of some area (about 140 ha) along the Duong river
Source : Gia Lam Irrigation Enterprise

TABLE E-1.3.1. MONTHLY RAINFALL AT BAC NINH STATION

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Dry S.	Wet S.	Year
1983	39.5	7.0	63.3	104.3	73.8	110.0	93.0	269.3	250.7	257.1	30.0	20.0	264.1	1083.9	1318.0
1984	0.0	10.2	9.8	178.5	83.2	303.4	188.4	416.8	162.9	171.3	151.2	2.6	352.3	1477.2	1678.3
1985	11.6	44.4	40.4	116.8	130.5	100.6	114.9	431.4	522.5	124.3	41.8	0.0	255.0	1466.0	1679.2
1986	1.1	4.9	4.3	140.5	301.4	437.2	433.4	149.9	206.0	119.7	31.3	19.1	201.2	1678.9	1848.8
1987	0.4	15.8	53.8	68.6	136.7	134.1	222.1	411.1	227.8	270.6	70.0	0.0	208.6	1472.4	1611.0
1988	21.4	55.3	15.4	13.3	206.5	237.5	219.9	194.9	57.3	237.9	5.1	0.0	110.5	1159.1	1264.5
1989	60.5	1.9	88.0	40.1	282.6	251.9	290.2	93.3	178.5	183.9	3.3	1.3	195.1	1283.7	1475.5
1990	28.3	71.2	152.0	80.7	163.1	236.0	374.0	177.0	285.9	187.6	103.2	3.1	438.5	1526.8	1862.1
1991	1.0	7.5	79.1	47.2	204.8	444.2	248.0	179.2	100.0	26.1	62.0	18.2	215.0	1264.3	1417.3
1992	106.7	45.9	50.4	20.2	93.0	436.4	235.8	54.3	127.5	0.0	23.8	38.3	285.3	970.8	1232.3
Ave.	27.1	26.4	55.7	81.0	167.6	269.1	242.0	237.7	211.9	157.9	52.2	10.3	252.6	1338.3	1538.7

TABLE E-1.3.2. MONTHLY EFFECTIVE RAINFALL FOR PADDY (Unit:mm)

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	W/S C.	Sum.C.	Year
1983	14.6	1.6	27.7	21.8	84.2	64.3	36.1	131.9	143.8	109.4	32.0	5.6	135.3	376.1	673.0
1984	0.0	0.0	1.3	55.9	89.8	101.0	94.9	156.2	62.4	129.0	82.4	4.4	147.0	414.5	777.3
1985	1.5	18.8	7.8	77.4	65.8	52.6	68.2	108.3	131.2	34.0	52.5	0.0	169.8	360.3	618.1
1986	0.0	0.0	0.0	73.7	109.2	163.7	167.1	116.7	107.2	50.0	32.2	11.3	182.9	554.7	831.1
1987	0.0	3.8	25.4	34.3	46.4	103.4	84.7	136.1	116.8	129.0	58.4	0.0	109.9	441.0	738.3
1988	3.2	14.9	0.0	0.0	57.6	122.4	162.9	122.2	31.1	107.5	0.0	0.0	72.5	438.6	621.8
1989	37.4	0.0	37.3	15.3	68.0	158.4	171.1	53.1	89.0	114.9	0.0	0.0	120.6	471.6	744.5
1990	6.9	33.4	92.5	39.8	54.3	130.8	133.3	154.2	65.7	87.9	88.6	0.0	220.0	484.0	887.4
1991	0.0	0.0	8.6	34.0	117.0	145.0	126.3	95.1	60.0	10.3	34.3	5.9	159.6	426.4	636.5
1992	65.0	18.3	6.2	4.4	51.0	119.0	171.1	64.7	60.1	3.0	10.7	22.1	198.9	298.9	595.6
Ave.	12.9	9.1	20.7	35.7	74.3	116.1	121.6	113.9	86.7	77.5	39.1	4.9	151.7	426.6	712.4

Notr: Computed based on daily raifall at Bac Ninh station

TABLE E-1.3.3. MONTHLY EFFECTIVE RAINFALL FOR UPLAND (Unit:mm)

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	W/S C.	Sum.C.	Year
Ave.	17.0	17.0	42.0	45.0	107.0	120.0	120.0	120.0	120.0	99.0	34.0	8.0	686.0	163.0	849.0

Note: Applied Table 34, Crop Water Requirement, FAO, 1977

TABLE E-1.3.4. UNIT DIVERSION WATER REQUIREMENT FOR WINTER/SPRING PADDY IN LEADING 5 YEARS

Year	Decemver		January		February		March		April		May		Total
	1	2	1	2	1	2	1	2	1	2	1	2	/Max.
1983		0.42	0.33	0.64	0.82	0.75	0.65	0.89	1.03	0.98	0.64	0.25	1.03
1985		0.40	0.43	0.63	0.82	0.39	1.04	0.90	0.90	0.26	1.12	0.17	1.14
1987		0.40	0.43	0.64	0.79	0.80	0.86	0.81	0.95	0.91	0.98	0.25	0.98
1988		0.40	0.43	0.61	0.82	0.51	1.11	0.96	1.21	1.07	0.92	0.23	1.21
1992		0.40	0.14	0.47	0.66	0.74	1.11	0.87	1.14	1.07	1.10	0.21	1.14

Note : Marked value is third place from the leading value

TABLE E-1.3.5. UNIT DIVERSION WATER REQUIREMENT FOR SUMMER PADDY IN 5 YEARS

Year	May		June		July		August		September		Total
	1	2	1	2	1	2	1	2	1	2	/Max.
1983		0.28	0.58	0.74	1.68	1.26	0.67	0.54	0.27	0.16	1.68
1985		0.12	0.75	0.75	1.65	0.91	1.08	0.27	0.45	0.12	1.65
1987		0.27	0.10	1.08	1.24	0.58	0.09	1.16	0.15	0.09	1.24
1988		0.23	0.26	0.49	0.44	0.54	0.35	0.80	0.69	0.31	0.80
1992		0.15	0.23	0.30	0.34	0.27	0.63	1.33	0.83	0.03	1.33

Note : Marked value is third place from the leading value

TABLE E-1.3.6. UNIT WATER REQUIREMENT FOR UPLAND CROPS

(1988)	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
Eo	2.1	2.2	2.6	3.4	5.1	5.1	5.4	4.8	4.5	3.7	2.9	2.4	44.2
ETo	68	65	85	107	166	161	176	156	142	120	91	78	1415
Eff.R	17	17	42	45	107	120	120	120	120	99	34	8	849
F.W.R.	51	48	43	62	59	41	56	36	22	21	57	70	566
D.W.R.	0.40	0.41	0.33	0.50	0.46	0.33	0.44	0.28	0.18	0.17	0.46	0.55	

Unit : mm, except Unit-Q (lit/sec/ha)

TABLE E-1.3.7. UNIT WATER REQUIREMENT FOR WINTER/SPRING CROPS (1992)

Month	Decemver		January		February		March		April		May		Total
(1992)	1	2	1	2	1	2	1	2	1	2	1	2	/Max.
Eff.R.		0.0	40.3	24.6	16.3	2.0	0.0	6.2	4.4	0.0	2.8	48.2	
Soak		120	120	120	120								120
Puddle				70	70	70	70						70
L.P.		30.0	9.9	35.2	39.4	16.5	17.5						148.4
ETo					33.0	28.6	39.0	41.6	51.0	51.0	76.5	81.6	
Crop					6.1	18.4	39.3	47.3	61.8	52.2	62.2	20.4	307.6
Perco.					3.8	11.4	20.6	24.0	22.5	22.5	16.9	6.0	127.6
Eff.R					2.7	1.2	0.0	6.2	4.4	0.0	2.1	12.1	28.6
W.R.					7.1	28.6	60.0	65.1	79.9	74.7	76.9	14.4	406.6
T-W.R.		30.0	9.9	35.2	46.4	45.1	77.5	65.1	79.9	74.7	76.9	14.4	79.9
Unit-Q		0.40	0.14	0.47	0.66	0.74	1.11	0.87	1.14	1.07	1.10	0.21	1.14

Unit : mm, except Unit-Q (lit/sec/ha)

TABLE E-1.3.8. UNIT WATER REQUIREMENT FOR SUMMER CROPS (1992)

Month	May		June		July		August		September		Total
(1992)	1	2	1	2	1	2	1	2	1	2	/Max.
Eff.R.		48.2	43.8	75.2	82.8	88.3	55.6	9.1	12.0	48.1	
Puddle		70	70								70
L.P.		10.9	0.0								10.9
ETo			76.5	76.5	81.0	86.4	72.0	76.8	64.0	34.8	
Crop.			21.0	63.1	89.1	94.0	76.5	78.7	47.2	8.3	477.9
Perco.			5.6	16.9	22.5	24.0	22.5	24.0	16.9	5.6	138.0
Eff.R			11.0	56.4	82.8	88.3	55.6	9.1	9.0	12.0	324.2
W.R.			15.7	23.6	28.8	29.7	43.4	93.6	55.1	1.9	291.7
T-W.R.		10.9	15.7	23.6	28.8	29.7	43.4	93.6	55.1	1.9	93.6
Unit-Q		0.15	0.24	0.36	0.44	0.42	0.66	1.33	0.83	0.03	1.33

Unit : mm, except Unit-Q (lit/sec/ha)

TABLE E-1.3.9. PROPOSED IRRIGATION AREA IN THE STUDY AREA (Unit:ha)

Irr.Block	Paddy	Nursary	Upland	Total	W-S Paddy	S-Paddy
(Trinh Xa)	17,940	940	940	19,820	15,210	14,020
(Kim Doi)	1,340	90	110	1,540	1,140	1,050
(Que Tan)	200	20	0	220	170	160
(Dong Sai)	570	40	0	610	480	450
(Xuan Vien)	970	70	30	1,070	820	760
Bac Doung	21,020	1,160	1,080	23,260	17,820	16,440
Dong Anh	570	50	0	620	480	440
Gia Lam	1,900	70	520	2,490	1,610	1,480
Total	23,490	1,280	1,600	26,370	19,910	18,360

TABLE E-1.4.1. LIST OF PUMPING STATIONS OPERATED BY COMMUNES/VILLAGES IN THE PROJECT AREA

No.	Name of Commune	Name of Station	Location	Purposes	Specifications (BorexKwxNos.)	Q (Cm/h)	Related Creeks/Canals For Irrigation	Related Creeks/Canals For drainage
1		Thi Thon	Thi Thon	Irrigat'n	200mm x14kw x1	380	Tao Khe Creek	
					250mm x20kw x1	540		
2	Han Quang	Quang Lam	Quang Lam	Combine	300mm x33kw x2	2000	N6 Canal	N6 Canal
3		Han Da	Han Da	Combine	200mm x14kw x2	760	N6 Canal	Tao Khe Creek
					250mm x20kw x1	540		
4		Dong Quan	Dong Quan	Drainage	300mm x33kw x4	4000		Ten Creek
5		Dau Xuan Hoi	Xuan Hoi Village	Combine	300mm x33kw x4	4000	D.Trung (pond)	Dong Co
6	Lac Ve	Ve Huong	Ve Huong	Drainage	300mm x33kw x1	1000		4-Xa Canal
7		Trang	Trang Pond	Drainage	300mm x33kw x2	2000		4-Xa Canal
8		Lac Ve	Lac Ve	Combine	200mm x14kw x3	1140	D.Trung (pond)	4-Xa Canal
9		Chi Ho	Chi Ho	Combine	250mm x20kw x1	540	Drainage Canal	Tao Khe Creek
					300mm x33kw x1	1000		
10		Chi Trung	Chi Trung	Combine	250mm x20kw x1	540	N6 Canal	Tao Khe Creek
	Tan Chi				300mm x33kw x1	1000		
11		Chi Noi	Chi Noi	Drainage	300mm x33kw x2	2000		Tao Khe Creek
12		Chi Dong	Chi Dong	Combine	300mm x33kw x1	1000	Tao Khe Creek	Tao Khe Creek
13		Van Trung	Van Trung	Combine	300mm x33kw x1	1000	Tao Khe Creek	Tao Khe Creek
14		Cua Chien	Cua Chien	Drainage	200mm x14kw x1	380		4-Xa Canal
					300mm x33kw x1	1000		
15	Hop Linh	Cho Va	Cho Va	Drainage	300mm x33kw x1	1000		4-Xa Canal
16		Dong Mu	Dong Mu	Drainage	200mm x14kw x1	380		Tao Khe Creek
					300mm x33kw x1	1000		

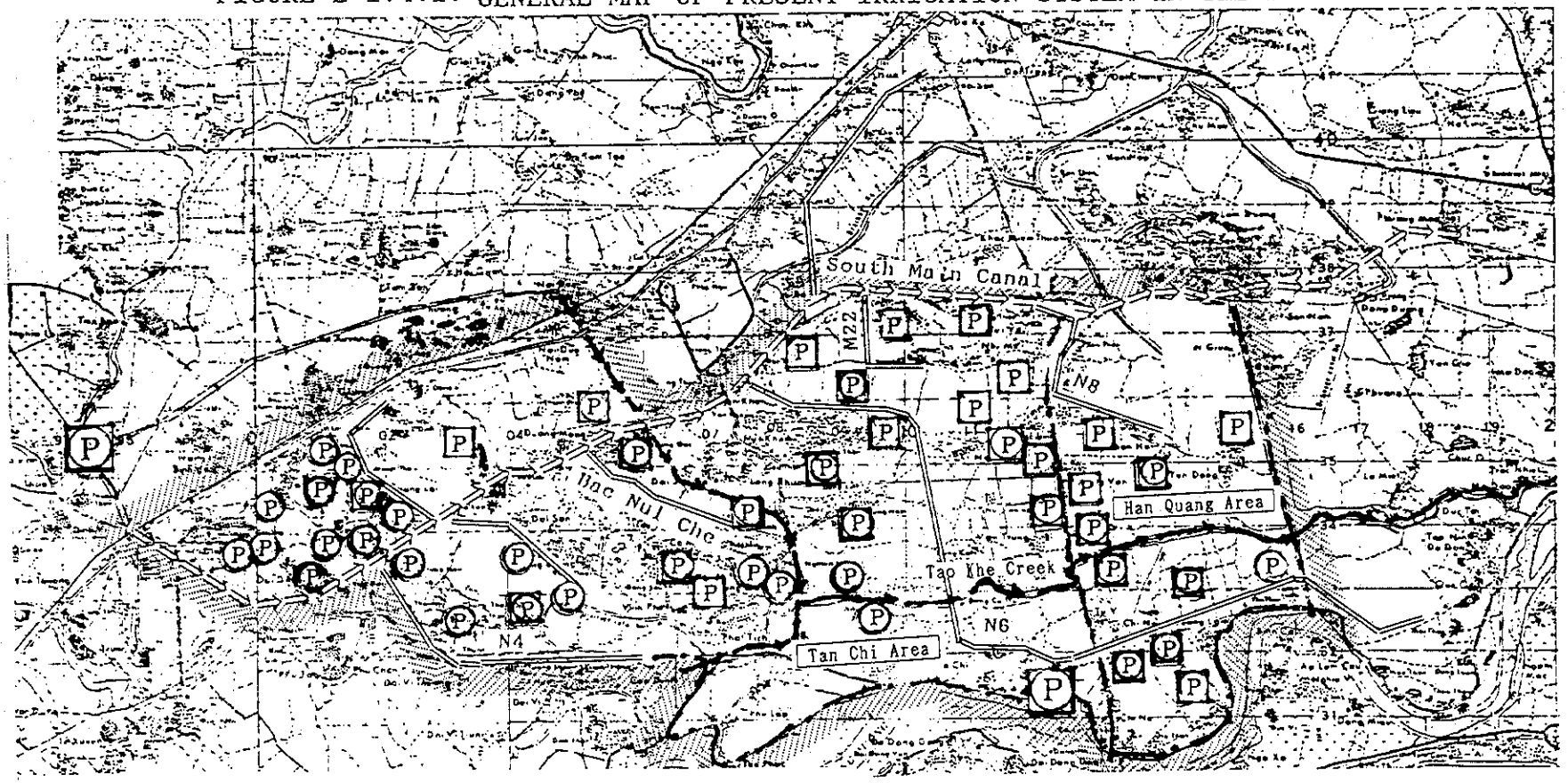
Source : Institute of Water Resources Planning and Management, MWR

TABLE E-1.4.1. LIST OF PUMPING STATIONS OPERATED BY COMMUNES/VILLAGES IN THE PROJECT AREA(Cont'ed)

No.	Name of Commune	Name of Station	Location	Purposes	Specifications (BorexKwxNos.)	Q (Cm/h)	Related Creeks/Canals For Irrigation	For drainage
17	Khac Niem	Dau Tien Trong	Coi Pond	Drainage	300mm x33kw x1	1000		4-Xa Canal
18		Lang Dong	Lang Dong	Combine	200mm x14kw x1	380	D.Trung (pond)	4-Xa Canal
19	Hien Van	Thon Kieu	Man	Combine	300mm x33kw x1	1000	Cau Nau Dr. C.	Cau Nau Dr. C.
20		Ngang Noi	Ngang Noi	Drainage	300mm x33kw x2	2000		Cau Nau-2 Dr.C
21		Nguyen Kham	Dong Nguyen	Combine	300mm x33kw x1	1000	N6 Canal	N6 Canal
22	Dinh Bang	Goc Sua	Goc Sua	Irrigat'n	300mm x33kw x2	2000	N3B Canal	
23		Hien Do	Hien Do	Irrigat'n	250mm x20kw x1	540	South M.C.	
					300mm x33kw x1	1000		
24	Tan Hong	Dai Dinh-1	Dai Dinh	Irrigat'n	300mm x33kw x1	1000	South M.C.	
25		Trung Hoa	Trung Hoa	Irrigat'n	300mm x33kw x1	1000	South M.C.	
26		Dong Soi	Dong Soi	Irrigat'n	300mm x33kw x1	1000	South M.C.	
27		Cho La	Cho La	Irrigat'n	250mm x20kw x1	540	N13 Canal	
28		Noi Chi	Noi Chi	Irrigat'n	250mm x20kw x1	540	South M.C.	
29		Dam Phu Luu	Dam Phu Luu	Irrigat'n	250mm x20kw x1	540	South M.C.	
					300mm x33kw x1	1000		
30		Hoa Phu	Hoa Phu	Irrigat'n	250mm x20kw x1	540	South M.C.	
31		Phu Luu	Phu Luu	Irrigat'n	300mm x33kw x1	1000	South M.C.	
32		Duong Noi	Duong Noi	Combine	300mm x33kw x1	1000	N13 Canal	
33		Cum Nghien	Cum Nghien	Irrigat'n	300mm x33kw x2	2000	N13 Canal	
34	Hoan Son	Dai Son-1	Don Son Vilag.	Irrigat'n	300mm x33kw x1	1000	Cau Ngatu C.	
35		Dai Son-2	Don Son Vilag.	Irrigat'n	300mm x33kw x1	1000	Cau Ngatu C.	
36		Mong Nui	Mong Nui Vilag.	Drainage	300mm x33kw x1	1000	6-Xa Dr. C.	
37	Lien Bao	Honi Thi	Honi Thi	Drainage	300mm x33kw x1	1000		South M.C.
38		Che	Lang Che	Combine	300mm x33kw x1	1000	South M.C.	South M.C.
39		Doc	Thon Doc	Combine	300mm x33kw x1	1000	South M.C.	Trinh Xa Dr.C.
40	Dai Dong	Huc	Huc	Combine	300mm x33kw x2	2000	Hoan Son Dr.C.	Hoan Son Dr.C.
41		Xom To	Xom To	Irrigat'n	250mm x20kw x1	540	Xom To Pond	
42	Phat Tich	Co Mieu	Co Mieu	Combine	250mm x20kw x2	1080	Drainage C.	Drainage C.
43		Phat Tich	Phat Tich Vilag.	Irrigat'n	250mm x20kw x1	540	Drainage C.	
					300mm x33kw x1	1000		
44		Nui Dat	Nui Dat	Irrigat'n	250mm x20kw x2	1080	Drainage C.	
45		Ngo Xa	Ngoi	Irrigat'n	300mm x33kw x1	1000		Drainage C.
46	Minh Dao	Nghia Chi	Sua Brdg.	Irrigat'n	300mm x33kw x2	2000	Tao Khe Creek	
47	Viet Doan	Dong Son	Goc Sua	Combine	300mm x33kw x2	2000	Drainage C.	Drainage C.
48		Long Van	Dong Ngay	Combine	300mm x33kw x1	1000	Drainage C.	Drainage C.
49		Lien Ap	Lien Ap Vilag.	Irrigat'n	250mm x20kw x1	540	Drainage C.	
				Irrigat'n	300mm x33kw x1	1000		

Source : Institute of Water Resources Planning and Management, MWR

FIGURE E-1.4.1. GENERAL MAP OF PRESENT IRRIGATION SYSTEM IN THE PROJECT AREA



LEGEND

- Boundary of the Project Area
- (P) Pumping Stations (Irrigation & Drainage) Operated by Bac Duong Irrigation Enterprise
- ⇒⇒ Main canal
- ═══ Secondary Canals

Pumping Stations operated by Communes:

- (P) For Irrigation only
- [P] For Irrigation and Drainage
- P For Drainage Only

FIGURE E-1.4.2. SCHEMATIC DIAGRAM OF EXISTING TRINH XA SOUTH MAIN CANAL SYSTEM FOR TAN CHI AND HAN QUANG AREA

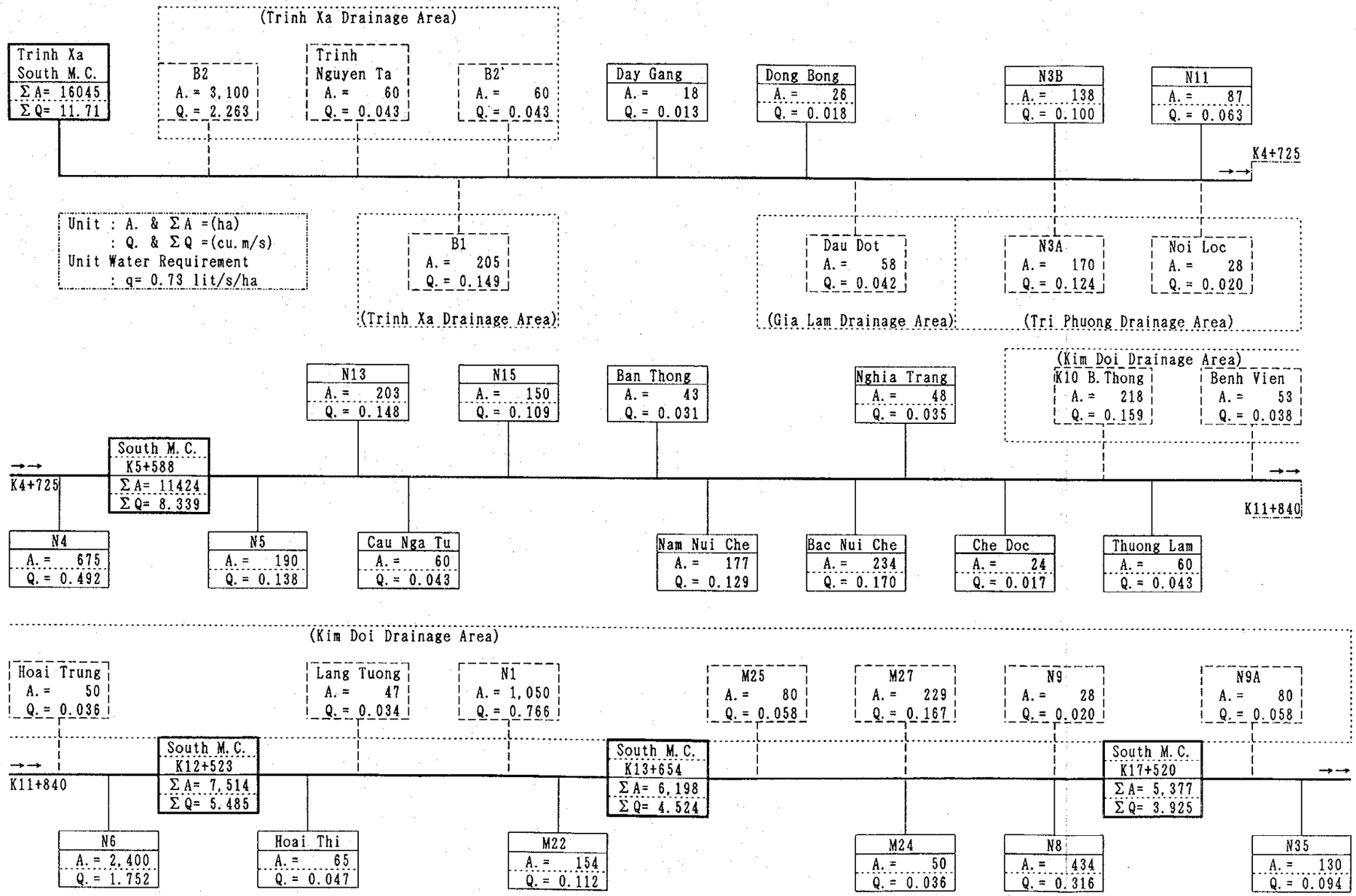
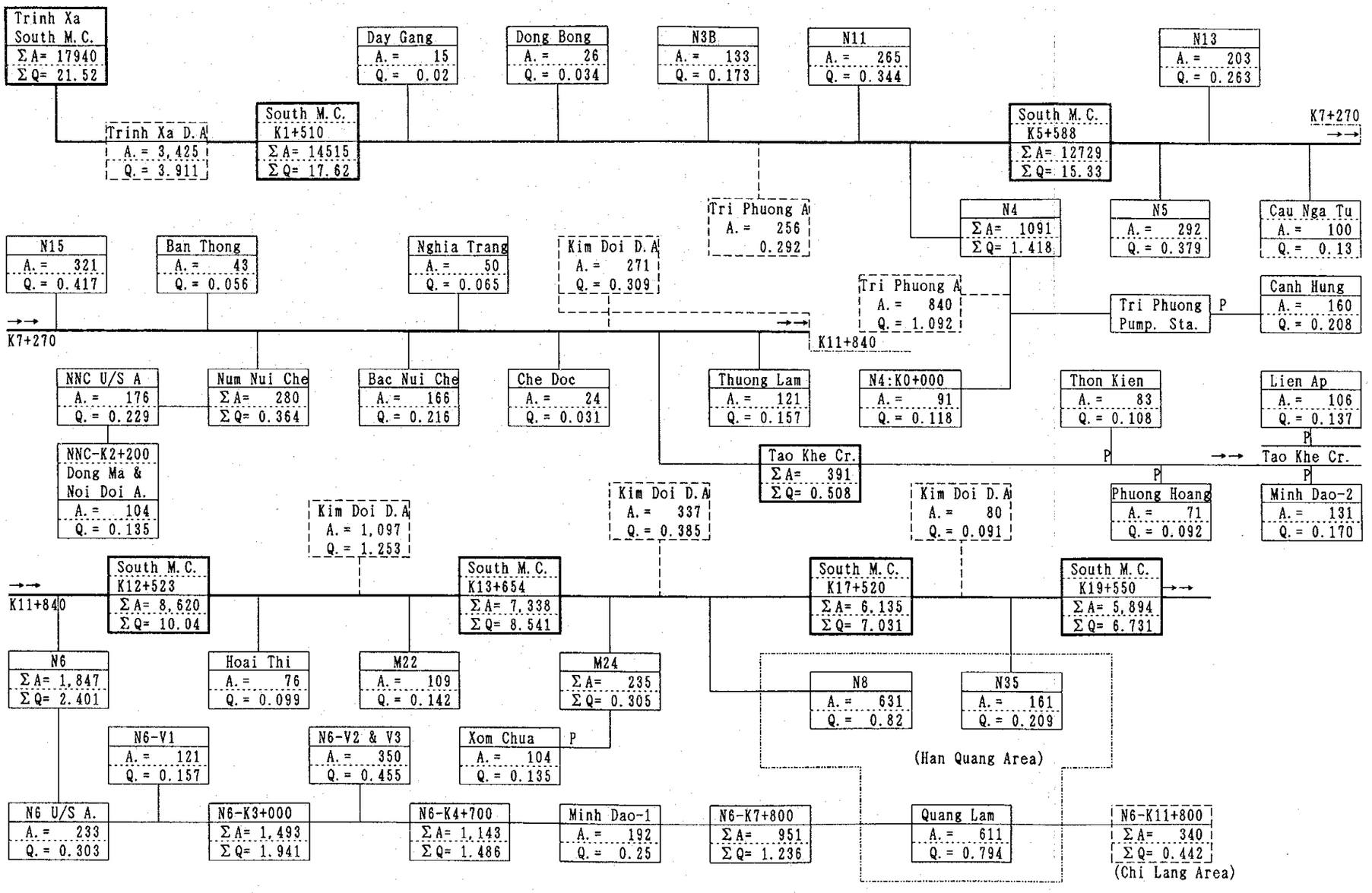


FIGURE E-1.4.3. SCHEMATIC DIAGRAM OF PROPOSED IRRIGATION SYSTEM FOR TAN CHI AND HAN QUANG AREAS



Note : Unit of A & ΣA=(ha); Q & ΣQ=(cu.m/sec) and P are Pumping Irrigation proposed
Unit Water Requirement q = 0.73 lit/s/ha w/o Project, q=1.3 lit/s/ha w/ Project

: w/i Project A. : outside Project A.

E-2. Drainage System

E-2.1. Existing System and Facilities

(1) Existing Drainage System

General

The drainage system areas in the Study Area (A=40,020 ha), included a land area of some 410 ha outside the surrounding river levee in Gia Lam district, are bounded by the rivers, roads, irrigation canals, polder dikes, etc. for each drainage area equipped with pumping station and can be grouped into the following five (5) drainage system areas, taking into account the main drainage canal system and/or the rivers to discharge (see Figure E-2.1.1 and Table E-2.1.1.), as follows:

*Ngu Huyen Khe river drainage system area (A=5,850 ha);
*Duong river upstream drainage system area (2,620 ha);
*Kim Doi creek drainage system area (6,510 ha);
*Tao Khe creek drainage system area (17,000 ha); and
*Drainage system area along the Cau river (7,630 ha).

Ngu Huyen Khe River Drainage System Area consists of Trinh Xa and Phu Lam pumping drainage areas discharged the water to the Ngu Huyen Khe river, and Lien Dam, Dong Dau, Loc Ha and Lai Da pumping drainage area drained the excess water to the Ngu Huyen Khe and Long Tuu diversion canal. The capacity of Trinh Xa pumping station (2.5 cu.m/sec x 8 units) was planned mainly for the irrigation purpose to serve a land area of 27,400 ha so that the pump capacity may be bigger against its drainage area. The total capacity of pumps is reported to be 20.0 cu.m/sec or 6.23 lit/sec/ha in a total discharge of drainage pumps per unit area (hereinafter said as drainage coefficient) at present. However, the present capacity may be reduced because the pumps have operated for the period of over 30 years. This discharge capacity is big depending on a capacity of Trinh Xa pumps, while other pumping stations are small, as 2.35-4.88 lit/sec/ha. On the other hand, Dong Dau pumping station is under renovation and expected to be operated in 1995.

The Ngu Huyen Khe river originate from Thiep pond in Dong Anh district, Ha Noi, and runs towards the south-east and joins the Cau river at Dang Xa in Yen Phong district, after turning its

direction to the north-east at Dai Tu commune in Dong Anh district. A total drainage area is some 16,200 ha including the gravitational drainage area in the upstream and pumping drainage area along the river. The Ngu Huyen Khe river is connected with the Duong river to the west through Long Tuu diversion canal with intake gates. However, this canal is mainly used as the diversion canal to convey the supplemental irrigation water to Trinh Xa pumping station but not for the drainage purpose.

Dang Xa pumping station has been constructed at the confluence of the Ngu Huyen Khe and Cau rivers to discharge the river water to the Cau river, when a gravitational drainage of Ngu Huyen Khe river is unavailable. When the water level of the Ngu Huyen Khe river is over 5.5 m at Dang Xa, the Drainage sluice is closed and then Dang Xa pumps are operated. On the other hand, according to the Operation, Management and Development Rule for Bac Duong Irrigation System, when the water level of the Ngu Huyen Khe river is higher than 6.5 m in an elevation at Trinh Xa pumping station, all drainage sluices are closed and all pumps are also stopped in their operation to prevent the levee of the Ngu Huyen Khe river with a top levee elevation of 7.0 m from over-flowing and collapse. It is reported that the number of days to stop in the pump operation under the this rule is about several days every year. Furthermore, in the case of water level raising over 7.0 m, The excess water in the river are delivered to the farm land by opening of the drainage sluices and operation of irrigation pumps. As a matter of fact, such emergency case have been recorded in 1978,1980 and 1985, which brought about serious social problems in the area.

Duong River Upstream Drainage System Area, which is located on the west of the Study Area and has a drainage area of some 2,620 ha, is situated in the most upstream area of Tao Khe creek drainage system from a standpoint of gravitational drainage. According to the Operation and Management Rule for Bac Duong Irrigation System, Thinh Lien sluice is closed to block the water way to the Tao Khe creek and the drainage is managed only by the pumps built within the area from 15 June to 15 November. In turn, for the remaining period, the excess water in this drainage area is drained by opening of Thinh Lien sluice to the Cau river through the Tao Khe creek.

The area is equipped with three pumping stations, Duong Ha, Phu Dong and Thinh Lien stations, built in 1969-89 and managed by

Gia Lam Irrigation Enterprise, of which Thinh Lien station is under construction to increase its drainage capacity (0.64 cu.m/sec x9). A total drainage capacity installed in three stations is 14.7 cu.m/sec at present, corresponding to 5.62 lit/sec /ha. The drainage area is divided to sub-drainage areas for each pumping station. The incoming and out-going water among the sub-drainage areas are controlled by the sluices. Since the operation rule of these sluices rule has not been set up yet, the drainage water control rule is expected to be prepared for effective operation of pumps for the regional drainage. The excess waters are pumped up to the Duong river. Nevertheless, the pumps operation are suspended for 3-5 days for a year due to the warning water level of the Duong river. On the other hand, the increase of runoff water, which is equivalent to about 30 % of a total drainage quantity at present, caused by the urbanization of the area along the national highway 1A results in the increase of pump operation hours. The Enterprise claims that the increase of operation and maintenance costs bring about the balance due in the finance. These are the urgent problems to be solved, reportedly.

Kim Doi Creek Drainage System Area is situated in the northeast of the Study Area and has a drainage area of some 6,510 ha. Kim Doi pumps (2.5 cu.m/sec x5), which have been used for dual purposes of irrigation and drainage, may have lower in an actual capacity than the reported ones since it operated over 25 years.

The upstream area from the Van sluice has originally been planned as a part of Tao Khe creek drainage system but transferred into the Kim Doi creek drainage system area by constructing Van sluice because of difficulty to drain the excess water to Tao Khe creek drainage system area. According to the operation rule, Van sluice can be discharge the water to the downstream by about 30 % of Kim Doi pumps and/or out-flowing capacity of Kim Doi sluice when The pumps and/or sluice is operated. However, this upstream area (about 2,000 ha) is poor in the drainage and suffered from a persistent inundation every year.

Tao Khe Creek Drainage System Area, which has the Tao Khe creek, as a main drainage canal, running from the west to the east in the middle of its drainage area, is equipped with Tri Phuong, Tan Chi and Thai Hoa pumping stations along the Duong river and Hien Luong pumping station on the Cau river. These were constructed long time ago except Thai Hoa station (1986), such as

Tri Phuong and Hien Luong stations in 1966 and Tan Chi station in 1975. A total discharge capacity is estimated to be 45.4 cu.m/sec or 2.67 lit/sec/ha in a drainage coefficient but may be lower in an actual discharge capacity. While, Tri Phuong pumping station is under construction to improve its drainage capacity from 3.11 cu.m/sec to 5.33 cu.m/sec.

The drainage in the area is mainly provided by the pumping system, a gravitational drainage is available through Hien Luong sluice in the dry season. The area can be sub-divided for each pumping station based on the topography, roads, irrigation canals polder dikes and other control structures/facilities, but the drainage water have been hardly controlled due to the inundation problem in the downstream and failure in drainage sluices. Moreover, there are a great number of pumping stations and/or drainage sluices/conduits provided and operated by the communes and/or villages for each small area. It learned that the drainage system of Tao Khe creek drainage area is very complicated in the drainage water flow because of unsystematical operation of such pumps and sluices. Thereby, the drainage water flow are hardly defined as well as boundary of sub-drainage area.

Most drainage control sluices are hardly operated and/or not operational to control the excess water to the downstream area. It seems that the excess water in the upstream area can be flown down to the downstream area without the control except Tram Sluice (bridge). Tram sluice is located at the most downstream of Tan Chi area on the Tao Khe creek. Its operation is determined based on the rainfall, drainage capacity of pumps and inundation status in the Tan Chi area and the downstream area. Under these circumstance, it is learned that the water logging is caused by not only the lower capacity of existing pumps but also increase of water quantity to the downstream due to inoperative drainage sluices, and difficulty in application of sluice operation rule, lower capacity of drainage canal resulted in flooding and local inundation, and so on.

Drainage System Area Along The Cau River involves the pumping drainage area along the Cau and Pha Lai rivers and is equipped with Xuan Vien, Huu Chap, Viet Thong, Que Tan, Chau Cau and Pha Lai pumping stations. These stations have been built in 1976-86, except Pha Lai and Xuan Vien stations (1966-67). A total drainage capacity is 21.2 cu.m/sec and corresponds to 2.78 lit/sec/ha in a drainage coefficient. Within the area of Bac Ninh

town in the north-east of the Study Area, Co Me new pumping station is under construction with finance support of the province.

(2) Drainage Facilities

Pumping Station

In the Study Area, 20 drainage pumping stations with a total discharge capacity of about 123.59 cu.m/sec have been operated, of which 8 stations were built before 1970, 4 stations in 1970s and 8 stations in 1980s. The oldest station is Trinh Xa stations in 1962, followed by Hien Luong, Pha Lai, Kim Doi and Tri Phuong stations in 1966, as shown in Table E-2.1.2. The average operation hours per pump unit was estimated at about 710 hr per year for the selected 15 stations, while 600 to 700 hr/unit per year were assumed to be operated for the drainage purpose (see Table E-2.1.4.).

Among 337 units of major pumps, which are used for the irrigation and drainage purposes, 267 units or 79 % of total pump units are currently operational and 93 units or 28 % of total pump units are requested to be repaired (See Table E-2.1.3.). Those repairs are reported to fit and/or replace the bolts for coupling between pump and motor axes due to bolts broken and replace the coils of motors due to overheating. In fact, The extreme amplitude of vibration have been measured for two (2) of three (3) pump units inspected in Tan Chi pumping Station, while temperature of motors have been normal.

The vibration, in general, result from mis-alignment of pump and motor shaft center, unbalanced movement of rotors, deflection of shaft, bearing damaged/degraded, impeller of blade damaged and so on. It was found that there were no particular relation between these damages and the operation time elapsed. However, It is uncertain whether these causes originate in manufacturing or installation. The revolution per minute is generally high in a pump of Vietnamese made so that pump bring about a high rate of discharge capacity and require a high output of motor. This high revolution rate may result in the said damages. On the other hand, as to the overheating of motor, it is not clear what is the cause of overheating, except defective lubrication of oils/grease. As motors were selected to fit with the output and revolution per minute required by the pump and add minimum 10 %

allowance to its output, the overheating, in general, seldom occurs. Either way, further evaluation may be required in the specifications and quality of materials.

The type of pumps in Tan Chi pumping station is reported to be 12HT-40 with a design discharge of 1,000 cu.m/hr and a discharge bore of 300 mm, which installed by 318 units in the study area. This type may be defined as horizontal axis mixed flow volute type. This design discharge is very big for a bore of 300 mm. On the other hand, the present discharge is 800 cu.m/sec, reportedly. To confirm the actual discharge, the water discharge measurement by the current meter have been carried out at the discharge canal of tan Chi pumping station in the course of the study and disclosed to be 10 cu.m/min or 600 cu.m/hr at a total head of about 6 m or 75 % of discharge reported.

The pump efficiency of Vietnamese made may be about 58 % for HL 900-9 (300mm x33kw), as seen in the brochure of Pump Manufacturing Plant in Hai Hung. This efficiency may be lower, as seen in general efficiency of 68 %. This difference may bring out high power rate. For instance, the electric charge/unit per year for this type of pump is estimated at about 8.8 million Dong (US$ 802) in an efficiency of 58 % and 7.7 million Dong (US$ 704) in an efficiency of 68 %, assuming that 710 hour/year operation and 376 Dong/kw. This difference of 1.1 million Dong (US$ 98) is equivalent to 10.8 million Dong (US$ 962) at a present value with 8 % discount rate of and 20 years life time or about 30 % of the total prices for pump and motor.

Recently, vertical axis axial flow type pumps are manufacturing in Vietnam up to a bore of 1,000 mm, as shown in the said brochure. The pump of this type with a bore of 500 mm have been installed in Dong Anh and Gia Lam drainage area but its efficiency are still lower. It is expected to be improved in the specifications.

Drainage Sluices

Main drainage sluices are Hien Luong, Kim Doi and Dang Xa sluices, which are operated for the gravitational drainage to the Cau river for the dry season. On the other hand, Kim Doi and Thai Hoa sluices can operate with the condition for irrigation, in case the excess water are insufficient. A number of sluices are built in the Study Area to retain the irrigation water in the

creeks/drainage canals and drain the excess water to the downstream but most of them are not well operational. Some drainage sluices, such as Thinh Lien, Tram and Van sluices, can be operated with the conditions stipulated in the operation, management and development rules for Bac Duong irrigation system, as stated previously. Major sluices are tabulated in Table E-2.1.5.

Drainage Canals

Main drainage canals are the Tao Khe and Kim doi creek within the Study Area (See Table E-2.1.6.). A number of canals join with the said creels but be low in a canal density, as 3.1 m/ha in the major secondary canals (See Table E-2.1.7.). Most canals including the Tao Khe and Kim Doi creels are deteriorated and low in the flow capacity due to siltaion. By urbanizing the land along the highway, it is regretted for drainage canals to reduce flow area due to reclamation.

E-2.2. Present Drainage and Inundation

In the study Area, about 21 drainage pumping stations built in 1962-81 exist and operate to drain the excess water in the rainy season, June to October, where the river water levels are high. Specially in the month of July to September, due to much rainfall, increase of runoff water, shortage of drainage pump capacities, under-development of drainage canal networks and so on, the inundation damage to crops is in routine and suspension of summer cropping land is increasing every year. While, the gravitational drainage is employed during the month of November to May, where the water levels in the river are lower.

The inundated area, according to the Bac Duong Irrigation Enterprise, occurs every year and spreads to a land area of some 5,200 ha with the land area of some 2,560 ha failed in crops on an average for the latest 14 years. In the year of 1985 suffered heavy damages, The damages are reported to be a cropped land of some 11,900 ha is the inundated area, of which 9,200 ha was failed in the harvest (See Table E-2.2.1.). In Tien Son district the area below 4.0 m in an elevation are usually inundated and the flood water depth in Que Vo district is deeper due to the incoming water from the outside not area, reportedly. The damages extend to not only crop damages and lower yielding but also the collapse of road and polder dikes, worsening of ecological condi-

tions, living environment, transportation and so on.

The increase of runoff water is caused by urbanization of the land along the highway, nude mountains and hills, increase of domestic wasted-water, and so on. The flood is brought from not only such incremental runoff discharge but also under-developed drainage networks, lack of farm drains, dual purposes canals for irrigation and drainage, insufficient capacity of culverts, sluices and pumps, etc., decrease in the number of operational pump units and so on. The inundated area are expanded by inadequate farm management to keep the deep water in the paddy field, insufficient control and management of drainage system, improper system of data and information collection, notification, etc. The suspension in pump operation due to electric failure and warning water level set up to prevent the river levee from collapse are an external factor for inundation problem.

E-2.3. Drainage Improvement in the Future

General

The improvement plan aims to enhance the land productivity by reducing the persistent water-logging area and improving the rural living environment through renovation of existing pumps, construction of pumping station, improvement/upgrading of canal flow capacity. The present subject is focused on the inundation prevention. The drainage water control and village drainage will be tackled in the future, according to the land use.

For the drainage study, 3 days consecutive rainfall over the Study Area with a return period of 10 years has been adopted. The designed inundation water depth and duration are set up to employ crop damages within 10 % of the yield; that is, the inundated period with a water depth of over 24.6 cm on the datum land which corresponds to about 10 % of beneficial land area within a day and the period with a water depth of 15.9 cm on the datum land will be within 3 days . As a result of the drainage analysis, the drainage pump discharge capacity per unit area (herein after said as drainage coefficient) shall be upgraded from 2.5-4.9 lit/sec/ha at present to 4.7-5.6 lit/sec/ha in the future. For improvement of drainage pumps, A priority, in principal, will be given to restoration of existing ones and followed to additional ones to meet the required drainage discharge. Neverthe-

less, alternatives to replace with new ones will be suggested from an engineering point of view.

The drainage schemes for the Study Area worked out by grouping into five (5) development blocks; that is, Dong Anh & Gia Lam drainage block, Trinh Xa & Xuan Vien drainage block, Tao Khe creek drainage block, Kim Doi creek drainage block, and Chau Cau & Pha Lai drainage block (Table E-2.3.1.).

Dong Anh & Gia Lam Drainage Block

For Dong Anh area, present drainage coefficient of 3.57 lit/sec/ha on an average will be increased to 5.03 lit/sec/ha. The required drainage discharge to Dong Dau pumping station will meet a discharge capacity of pumps under construction. As the drainage discharge for Loc Ha and Lai Da pumping station will be require a little more than the discharge capacity of existing ones, additional pumps will be selected to be the same type of existing ones from a standpoint of easy operation and maintenance. For Lai Da area, an increased quantity of drainage discharge due to seepage water through the levee of the Duong river will be accommodated within the proposed pump discharge capacity. In addition, it is suggested to verify the cause of seepage water through the levee as soon as possible and take the adequate measures, if necessary.

In Gia Lam area, present drainage coefficient for each pumping station, including the renewed stations, is comparatively high as 4.04-6.38 lit/sec/ha so that a large scale improvement works for the stations will not be provided, as required a drainage coefficient of 5.62 lit/sec/ha in the drainage plan. Lien Dam pumping station is under construction but a little insufficient to the required drainage discharge. Therefore, it will be required to add one more unit in the same type, considering inter-exchangeability of parts. The discharge capacity of Dong Ha and Phu Duong pumping station will meet the required drainage discharge under the existing number of pump units. Nevertheless, it will be suggested for all pump units to repair completely. Thinh Lien, which is under construction, will has enough capacity for the required drainage discharge.

Trinh Xa & Xuan Vien Drainage Block

The pumping stations on the Ngu Huyen Khe river in Trinh Xa

drainage area and on the Cau river in Xuan Vien drainage area are generally old in the year of installation and uncertain in the actual discharge capacity. Huu Chap pumping station is comparatively good in the maintenance but may be required to inspect and repair all pumps for ensuring the discharge capacity. An insufficient quantity of discharge against the requirement will be shouldered by Co Me pumping station which is new and under construction. Xuan Vien Pumping station has been operated for over 26 years and be costly in the maintenance as compared to others. Thereby, All pumps are planned to replace with new ones (300mm x55kw) to meet the required drainage discharge.

Trinh Xa pumping station may need to repair 5 units out off the total 8 units to meet the requirement, as reported to be 20 cu.m/sec in the total discharge pump capacity. However, this type of pump (870mm x320kw) is questionable in the discharge capacity in consideration of bore, total head, type (Axial Flow), etc., even though a discharge capacity of pump per unit is reported to be 2.5 cu.m/sec, as stated previously. The repair costs are also high. Therefore, further study will be required for use of existing ones by repairing. Furthermore, Trinh Xa pumping station shall be reviewed from both irrigation and drainage point of view, as used it also for the irrigation purpose.

Phu Lam pumping station, which takes charge of drainage for a portion of Trinh Xa drainage system area, will be deficient in the pump discharge capacity to the requirement in its allotted area. The plan is devised to provide repair of all pumps rather than construction of additional ones and transfer a land area of some 140 ha to the drainage area of Trinh Xa pumping station which is expected to be more than enough discharge capacity as stated in the previous section. In any case, it is advisable to conduct further study before the project implementation.

Tao Khe Creek Drainage Block

In Tao Khe creek drainage system area, there are four(4) pumping station along the creek. Among them, New Tri Phuong station is under construction, assuming that old ones may be abolished. This new pumping station will mitigate the present drainage problems but be still required to add four (4) units of the same type of pumps (300mm x33kw) and/or to use the existing ones by making repair/improvement of pumps and building in order to meet the drainage requirement.

Tan Chi pumping drainage area will be required to be 4.85 lit/sec/ha in the drainage coefficient, in case of independent drainage scheme by closing Cham sluice. To meet the requirement, 68 units of existing pumps will be completely restored/improved and additional four units of pumps (1,350mm x500kw) will be procured. On the other hand, as an alternative scheme, the procurement of eight (8) units of pumps (1,350 x500kw) will be proposed from a standpoint of operation and maintenance after the construction.

Han Quang area drains the excess water to Hien Luong area through La Miet sluice. In case of independent drainage scheme by closing Tram and La Miet sluices, the area will be required to provide five (5) units of pumps (1,000 mm x320kw) with a total discharge capacity of 10 cu.m/sec. In Hien Luong area which will have no incoming inflow from Han Quang area, the excess water will be discharge by Thai Hoa and Hien Luong pumping stations.

Thai Hoa pumping station, which receive the excess water in the upstream area, will be required to discharge 6.83 cu.m/sec in its pumping capacity but will be improved in its original discharge capacity by repairing/restoring the existing ones and the remaining discharge (2.16 cu.m/sec) will be left to Hien Luong station. Therefore, at Hien Luong pumping station, the required drainage discharge become to be 26.5 cu.m/sec.

The improvement scheme of Hien Luong pumping station is to repair the existing ones and add four (4) units of pumps (800mm x132kw). However, seeing that the reported discharge capacity of existing ones is questionable, as mentioned previously, it is suggested to conduct further investigation on the actual capacity of pumps prior to the project implementation.

Que Tan pumping station will be improved from 2.22 lit/sec/ha to 4.83 lit/sec/ha in the drainage coefficient. To meet this requirement, existing pumps will be adequately repaired and provided with new six (6) units of pumps (300 x33kw).

Kim Doi Creek Drainage Block

The Kim Doi creek is provided with the pumping station with five (5) units of pumps (870mm x320kw) at the end of the creek. At present, four (4) pump units among them are operational, which a total discharge capacity is reported to be 10 cu.m/sec or 1.54

lit/sec/ha in a drainage coefficient. In the improvement plan, the existing pumps will be repaired, expecting a total discharge of 12.5 cu.m/sec, and added by six (6) units of pumps (1,350mm x350kw) to meet the required drainage coefficient of 5.45 lit/sec/ha. In addition, the improvement of Van sluice shall be included in this plan. For the best scheme, the exact discharge capacity of existing Kim Doi pumps shall be verified.

Viet Thong pumping station has also to improve the drainage capacity from 3.56 cu.m/sec to 5.50 cu.m/sec in a total discharge capacity or 3.27 lit/sec/ha to 5.05 lit/sec/ha in a drainage coefficient. In addition to the repair of existing pumps (300 mm x33kw x8), three (3) units of new pumps (600mm x75kw) will be required.

Chau Cau & Pha Lai Drainage Block

For the pumping station built on the Cau river, present drainage coefficient is low as 1.98-3.27 lit/sec/ha will be improved to 4.06-5.18 lit/sec/ha , as required. In line with this schemes, every existing pumps will be repaired/improved and added by seven (7) units of pumps (600mm x75kw) for Chau Cau station and two (2) units of pumps (1000mm x320) for Pha Lai station will be additionally procured. Furthermore, the improvement of discharge channel to the Duong river will be necessary for Chau Cau station to separate the drainage water from Pha Lai area and the improvement of levees along the Cau river will be initiated for Pha Lai area.

Improvement of Drainage Canals and Structures

Along with such improvement of drainage pumping stations, dredging of leading Tao Khe and Kim Doi creeks, and improvement/construction of drainage/control sluices, excavation/reshaping or construction of drainage canals, re-arrangement of drainage canal networks for every drainage area shall be implemented to solve the drainage problems. Furthermore, the excellent drainage improvement will be expected by solving the suspension of pump operation confined by the warning water levels, the river flow capacities and impact to the downstream reaches, power supply interruption, etc. Specially, the improvement of Ngu Huyen Khe river and drainage in its basin will bring about delightful living environment without unrest due to flood.

E-2.4. Selection of Priority Area

(1) Regional Drainage Schemes

The regional drainage system, which the Ngu Huyen Khe river, Kim Doi creek and Tao Khe creek are considered as a main drainage canal for each drainage area based on the topography, is an ideal system from an engineering and economic point of view. However, main drainage canals and pumping stations become large scale, improvement /upgrading of secondary and tertiary canal are imperative, and a big regulating pond in front of pumping station is required from a standpoint of hydraulics and water control. As a result, it has demerit, such as the costs are huge, construction period is longer, and delay in benefit generation. Furthermore,the problems/constraint, such as soils in the presently poor drainage area, water supply from the drainage canals, impact due to rapid change of drainage events and so on, shall be taken into consideration.

(2) Decentralization Drainage Schemes

This scheme, like a present improvement scheme, is a method to improve a drainage by construction of pumping station for the poor drainage area surrounded by polder dikes. However, the drainage improvement is limited to the selected area, imbalance improvement is employed in the area, and total investment costs to the area as well as operation and maintenance costs become high. On the other hand, scale of the project would be appropriate for the implementation and faster benefits would be expected. The drainage operation rule between the areas has been concluded at present to moderate imbalance drainage constraint. As the gravitational drainage is prevalent in the dry season, the drainage water is discharged through the said three river/creeks to the Cau river. Therefore, the decentralization drainage scheme is considered as a part of stage improvement of the regional drainage scheme.

(3) Evaluation of Alternative Schemes

The drainage schemes for the Study Area have been worked out to evaluate the inundation events and project feasibility, grouping the Area into five (5) development blocks; that is, Dong Anh & Gia Lam drainage block, Trinh Xa & Xuan Vien drainage block, Tao Khe creek drainage block, Kim Doi creek drainage block and

Chau Cau & Pha Lai drainage block, based on the design rainfall and drainage planning criteria stated previously. Thereof, the project benefits have been estimated only for a net value of crop damages prevention in the future without project, as shown in Table E-2.4.1.

Dong Anh & Gia Lam Drainage Block

Gia Lam area would not persist in the additional drainage pumps for the time, except repair/replacement of pumps in some stations, because the existing pumps have been renovated/planned to be improved and the inundation damages are small, as compared to the areas in Ha Bac province. Dong Anh area is high in the frequency of inundation and necessary to add some pumps in each station, expecting higher project effects, as compared to Gia Lam area. However, for the entire block included Dong Anh and Gia Lam area, the projects would be lower in the urgency and feasibility.

Trinh Xa & Xuan Vien Drainage Block

Trinh Xa & Xuan Vien drainage block is moderately good in the present inundation events as compared to the other blocks. The repair/replacement of existing pumps would be required but low in the project feasibility. In either way, the priority should be given to the improvement of the Ngu Huyen Khe river and measurement to the warning water level for suspension of pump operation in the Cau river rather than the drainage improvement for the inland area.

Tao Khe Creek Drainage Block

Tao Khe creek drainage block would be the highest in the economic internal rate of return for the project (EIRR) and followed to Chau Cau & Pha Lai drainage block in the ratio of inundated area to the agricultural land area. Tri Phuong and Que Tan drainage areas have discharged the excess water to the Duong and Cau rivers, respectively. Que Tan area would be improved with high EIRR, while the improvement of Tri Phuong pumping station is on-going with relatively high EIRR.

Under such circumstance, the regional drainage scheme for Tao Khe creek drainage area as a stream line of Tan Chi area in the upstream to Hien Luong area in the downstream have been studied. In this scheme, it is turned out that the operation of Tram

sluice would be greatly influenced in the Tao Khe area drainage improvement scheme. Tram sluice has an enough capacity to drain the excess water in the Tan Chi pumping drainage area, upstream from the Tram sluice. When the gates are fully opened, the inundation would take place in the downstream area. In other words, the excess water in the Tan Chi pumping area had better drain to the downstream area with regulation of Tram sluice, improving drainage canals, and providing additional pumping station at Hien Luong rather than construction of additional pumping station in the Tan Chi area or Han Quang area. This scheme would be low in the project costs per hectare and comparatively high in EIRR, as shown in Table E-2.4.2. However, the drainage control would depend on the operation drainage sluices, as existed two (2) drainage sluices at Tram and La Miet on the Tao Khe creek.

In the view of the decentralization drainage, it is recommended to make plans of separated drainage for Tan Chi area and Combined drainage for Tan Chi and/or Han Quang areas, to avoid social problems in these drainage control and sluices operation. Both plan would be of urgency in large inundation damages and expected at high project benefits. Moreover it is expected to mitigate the drainage damages in Hien Luong area by diverting the runoff discharge at Tan Chi or Han Quang (See Table E-2.4.3.).

Kim Doi Creek Drainage Block

The Kim Doi area is commonly suffered from poor drainage in the upstream area of Van sluice so that both the additional pumping station and widening of Van sluice's bay are required for the drainage improvement, and suggested to improve urgently from a standpoint of solving heavy inundation problem in the upstream area. Seeing that the high EIRR estimated from the present inundation damages might be unexpectable, the project should be formulated by expecting the agricultural effects from increase of cropping intensity and integrating with the irrigation component. Thereof, Viet Thong area is expected to implement the project with high EIRR urgently.

Chau Cau & Pha Lai Drainage Block

Chau Cau & Pha Lai drainage block is hasten to implement the drainage improvement. The EIRR would be high in Chau Cau area but low in Pha Lai area because of the river dike improvement in parallel with the inland drainage improvement.

E-2.5. Drainage Improvement for the Priority Area

(1) Present Drainage System

The Project Area is surrounded by Kim Doi and Trinh Xa drainage area on the north, Tri Phuong drainage area on the west, the Duong river on the south and Hien Luong drainage area on the east. The boundary line is drawn down, starting the crossing point of South main canal and the national railway, clockwise through the national railway, Trinh Xa drainage canal, the south main canal, the Ten creek, the Duong river, No.4 secondary canal, and South main canal up to the starting point. Tan Chi and Han Quang drainage area are separated by the provincial road No.38 to the west and the east, respectively (See Figure E-2.5.1.). The excess water in Tan Chi drainage area are collected to the Tao Khe creek and flows down to Han Quang drainage area through Tram sluice in the dry season and discharge to the Duong river by Tan Chi pumping station in the rainy season, in principal. The excess water in Canh Hung area on the Duong river drains to the Tao Khe creek within Tan Chi area through the sluiceway. Han Quang area is situated in the upstream of Hien Luong drainage area and its excess water flows down through Tao Khe creek and discharges to the Cau river through the sluiceway in the dry season and by pumps in the rainy season at Hien Luong.

Tan Chi pumping station has been constructed in 1975 with 68 units of pumps (300mm x33kw), of which eight (8) units have also been used for irrigation purpose. Average pump operation hour per annum is about 41,000 hour-unit, of which about 80 % is operated for the drainage purpose for the months mostly from June to October, as seen in Table E-2.5.1. A drainage rate is estimated to be about 4,200 cu.m/ha or 420 mm per annum.

The pump discharge capacity is reported to be 800 cu.m/hr per one unit or 15.11 cu.m/sec in the total. However, it is learned that the actual discharge capacity per one unit has been decreased to 600 cu.m/hr or 75 % of the reported one at present, according to the discharge measurement at the delivery canal. In addition, the operation of pumps is managed in 50 units more or less, because of machine troubles and electric motors failed in the continuous operation. It is reported that major troubles are broken in bolts of coupling between pump and motor and overheating of motor.

Main drainage canal is Tao Khe creek, branched to the pumping station through the diversion canal (L=1,300m) and equipped with Tram drainage sluice (B=2.00m, 2 bays) at the downstream end of Tan Chi area. The Tao Khe creek is disordered in the cross-section and its flow capacity is estimated to be about 7 cu.m/sec. Tram sluice has an enough capacity to drain the excess water in Tan Chi area but regulated in its gate opening height, taking into account the inundation state in the downstream area. Major secondary drainage canals are Trinh Xa drainage canal, Cau Nau drainage canal and Phat Tich drainage canal. Each drainage canal equips with control sluiceway at the confluence with Tao Khe creek but not operational.

In Han Quang area, no pumping station exists. The excess water are flown down to the Tao Khe creek directly in the southern area and through the Ten creek in the northern area and discharge to the Cau river, via. the Tao Khe creek, through Hien Luong sluice in the dry season and by the pumping station in the wet season. At the downstream end of the area. La Miet sluice is built but not operational. The tan creek has also an irregular shape in the cross-section and with lower dikes.

The lands with an elevation of below 4.0 m have frequently inundated, as caused by insufficient flow capacity of the Tao Khe creek and decrease of pump discharge capacity. Local inundation have taken place in the lower land commonly due to an inadequate drainage network, insufficient capacity of conduit. etc. Those low-lying land are surrounded with small polder dike to prevent the incoming flow from the outside area and equipped with pumps. In the Project Area, 12 drainage pumping stations and 18 dual purpose pumping stations are operated and maintained by the communes and/or villages but claimed in lower drainage capacity. According to the report of Bac Duong Irrigation Enterprise, annual inundated and damaged in Tien Son district are about 3,460 ha and 1,730 ha on the average for the latest 13 years, and correspond to 32 % and 16 % of total agricultural land in the district, respectively.

(2) Basic Concept to Drainage Improvement

Agriculture is a leading industry in the Project Area. The upgrading of land productivity by intensive agriculture is the most essential subject in the district economic development, as indicated a dense population (1,330 persons/sq.km-1993), a big

share of agricultural population (about 80 % of total households in farmers' household) and a small farm size (about 0.2 ha/farm on the average). In the Project Area, main problem to the increase of land productivity is the inundation which have taken place every year. Little production due to rainfall calamity have brought about loss of the willingness to cultivate and the status unable to ensure the minimum income necessary for the life to the farmers with a small land size. An inundation constraint to the peoples gaining the income mostly from agriculture in the Project Area become a big object of public concern in the district. Consequently, The solution of inundation problems is required urgently in the Project Area.

A direct objectives of farmland drainage is to drain the excess water on land surface (surface drainage) and the excess moisture in soils (subsurface drainage). For the Project Area, the surface drainage is presently required. In either way, it might as well initiate the removal of water logging (storm drainage) and gradually follow the ordinary drainage after completion of irrigation systems. The sub-surface drainage is ignored so that the introduction of diversified crops might be limited in the variety due to groundwater table. However, more variety of diversified crops might be cropped on the high ridges by utilizing rich manpower. Aside from such farmland drainage, in the light of present canals used for irrigation and drainage purposes, the excess water from residential and commercial land would be tackled in the future from a standpoint of water quality and environmental aspects.

The present water logging is caused not only by the decrease of drainage capacity of Tan Chi pumping station due to deterioration but also by the increase of runoff discharges from the urbanization along the highway, deforestation of mountains and hills, increase of domestic wasted-water. In addition, the under-arrangement of systematic drainage canal network, insufficient flow capacity of canals due to sedimentation, absence of water management/control of irrigation and drainage canals, deficient sectional area of drainage conduits/sluiceways, deep water keeping in the field, etc. might support the present water logging.

Under the above view, the project aims to solve the persistent water logging problem in the farmland, enhance land productivity in the area, stabilize agricultural production and upgrade the rural life in the project area through construction and/or

improvement of drainage pumping stations, rehabilitation and/or improvement of drainage sluiceway and canals, upgrading/extension of power transmission lines.

(3) Proposed Drainage Improvement

Drainage System

The improvement of drainage system have been worked out for the drainage system for Tan Chi area (A=6,420 ha) and combined Tan Chi and Han Quang area (A=8,540 ha), as reported that the study for Han Quang area was completed by the Ministry of Water Resources. Tan Chi drainage area has been divided into six (6) sub-drainage areas for Trinh Xa No.6 secondary canal, Phat Tich area in the upstream of Tao Khe creek, Cau Nau canal joined with Tao Khe creek at Cham sluice, the area directly drained to Trinh Xa drainage canal, Canh Hung area drain to Tao Khe creek and the area directly drained to Tao Khe creek, as examined the local water logging due to insufficient capacity of drainage sluiceways and/or conduits. While, Trinh Xa drainage joins with Tao Khe creek at Ba Cay. These sub-drainage areas are equipped with the drainage sluiceway/conduits at the downstream end of the canals. In Han Quang area, sub-drainage areas are consist of the systems for the areas directly drained to Tao Khe creek and through Tan creek and join each others at the downstream end of the area. The excess waters in Tan Chi area flow down to Han Quang area through Cham sluice.

Runoff and Drainage

Within and in vicinity of the Project Area, six (6) rainfall observation stations are located, which have only daily rainfall records observed at 7:00 a.m. every day for the period of 33 years (1960-92). Since the rainfall records at Tu Son station within the Project Area were available only for 22 years and the rainfall among the stations were poorly correlated, area rainfalls have been calculated by Thiessen Method, to determine the rainfalls for the Project. The probability of rainfalls have been calculated by Iwai-Kadoya method, following the probability of exceedance in the logarithm normal distribution. for the design rainfall, a consecutive three (3) days rainfall of 248.1 mm with 1/10 year probability has been adopted. The hyetogragh daily pattern, which was of frequent occurrence in the last records, has been allotted for the probable daily maximum rainfall in the

second day, the rainfall in the first day subtracted the probable daily maximum rainfall from the probable consecutive two (2) days rainfall, and the rainfall in the third day subtracted the probable consecutive 2 days rainfall from the probable consecutive 3 days rainfall, as follows:

First Day	Second Day	Third Day	Total
49.0 mm	182.9 mm	16.2 mm	248.1 mm

For the runoff analysis in the study area, the rainwater flow method has been applied, which is complicated in calculation but be the most applicable method corresponding with the various physical conditions, since the runoff discharge records/data actually observed and hydraulic data/information on the flood events were scarcely available within the area. Prior to the runoff calculation, the hyetograph of design rainfalls has been modified to the hyetograph of hourly rainfall by applying Sherman type, as the rainfalls in the Project Area are generally intensified in the relatively short time. The equivalent roughness, which is equivalent to roughness coefficient of Manning formula applied to the flow on the saturated land, have been determined to be 0.6 for mountainous land, 1.0 for paddy field, 0.4 for upland field and 0.025 for residential area. The gradient of rivers/creeks/channels and slope of land have been decided based on the 1/10,000 topographical maps. the river flow factors (K & P values) for each creek and drainage channels have been estimated by the cross-section of existing water ways.

The base flow might consist of wasted-water of irrigation and domestic water, while the rainfall losses might be involved in the initial losses, seepage losses and retention in the area. Considering that the drainage problems are taken place only in the rainy season, and that the antecedent rainfall to the 3-day consecutive rainfall might be expected to be substituted for the initial losses, it is assumed that the base flows are negligibly small and rainfall losses ignore.

For drainage analysis, the series of reservoir model, which is the method to flow down the drainage water in the blocks, regarded as a reservoir, to the other blocks, regulating by the hydraulic structures, such as sluice gate, culverts, etc. The drainage discharge depends on the flow capacity of the hydraulic structure and the difference at the upstream and downstream of the structures. Seeing that the water logging area depends on the

topography of land, the land slope have been evaluated, based on the topographical maps with a scale of 1/10,000 indicating every 1.0 meter contour line supplemented to 0.5 m by the survey in the course of the study. An area and volume every 0.5 meter in an elevation have been computed for drainage analysis, which would be regarded as an area and volume of flooded water. The datum elevation of land, which is covered about 10 % of the benefited area for the respective blocks, have been determined to express the inundated depth and area under the design rainfall. The design criteria for drainage improvement, which the inundated period should not exceed one day (24 hr.) in a water depth of 0.246 m and/or three (3) days (72 hr.) in a water depth of 0.159 m, assuming that the growing of paddy may be tilling to booting stage in which inundation has frequently taken place for the month of July through September, have been applied.

The drainage analyses, which have integrated the drainage model with the runoff discharges mentioned previously, have been made by using computer. In the calculation, Cham sluice was closed and the excess water were discharged by the existing and additional/new pumps at Tan Chi in case of individual drainage scheme, and Cham sluice was opened and the excess water were discharged by existing Tan Chi pumping station and new pumps to be installed in Han Quang in case of the combined scheme for Tan Chi and Han Quang area. For the above two (2) schemes, a drainage coefficient of 4.85 lit/sec/ha for the Tan Chi individual scheme and 4.82 lit/sec/ha for the combined scheme would be proposed and the required drainage discharges are shown as follows:

Scheme	Ex.Drainage (cu.m/s)	Add.Drainage (cu.m/s)	Total (cu.m/s)
Tan Chi individual	15.11	16.0	31.11
Combined Drainage	15.11	26.0	41.11

Proposed Drainage System

Tan Chi pumping station would be replaced with new pumps and transformer facilities, and improved in the structures and buildings of the station, because the existing pumping station have arrived at the time of replacement from a mechanical and engineering point of view. Additional pumping station would be constructed in Tan Chi or Han Quang, in accordance with the alternative study. In the case of increasing a drainage capacity of Tan Chi station, new pumping station would be constructed to

meet the requirement summed up the replacement and additional pump's discharge capacities.

The major control gates, such as Tram sluice, La Miet sluice, Ba Cay sluice and others necessary for water control would be improved to make it operational. Other sluiceways would be also improved to convey the excess water effectively. The bridges and conduit, if those are a bottle neck in the drainage water passage, would be enlarged into the adequate size.

The existing drainage canals included Tao Khe and Tan creeks would be improved to meet the increased drainage requirement. Construction of new drainage canals would also be required to solve local waterlogging area due to depressed land or absence of adequate drainage canal network, as shown in Figure E-2.5.2.

TABLE E-2.1.1. DRAINAGE AREA FOR EACH PUMPING STATION

Name of Station	Pumps Type	Pumps Nos.	Discharge (cu.m/s)	Drainage Area (ha)	Remarks
[Ngu Huyen Khe Drainage System]					
Trinh Xa	V-A 870	8	20.00	3,210	Irr. & Drainage
Phu Lam	H-MV 300	15	3.33	850	Do.
Lien Dam	H-MV 300	10	2.22	830	Do.
Dong Dau	V-A 500	4	2.00	410	Renovating
Loc Ha	V-A 500	2	1.17	280	
Lai Da	V-A 500	2	1.00	270	
Sub-total	6-station	41	29.72	5,850	
[Duong River Upstream Area Drainage System]					
Dong Ha	H-MV 300	30	6.67	1,100	
Phu Dong	H-MV 300	25	5.56	780	
Thinh Lien	H-MV 300	15	2.50	740	I&D, Improving
Tri Phuong	H-MV 300	14	3.13	1,480	I&D, Improving
Sub-total	4-station	84	17.86	4,100	
[Kim Doi Creek Dainage System]					
Kim Doi	V-A 870	5	12.50	6,510	Irr. & Drainage
[Tao Khe Creek Drainage System]					
Tan Chi	H-MV 300	68	15.11	6,420	Irr. & Drainage
Thai Hoa	H-MV 300	21	4.67	1,530	Do.
Hien Luong	V-A 870	9	22.50	7,570	
Sub-total	3-station	98	42.28	15,520	
[Drainage System along the Cau River]					
Xuan Vien	H-MV 300	10	2.22	570	Irr. & Drainage
Huu Chap	H-MV 300	20	4.44	1,350	Do.
(Co Me)	H-MV 300	(10)	(2.22)		Under Construction
Viet Thong	H-MV 300	16	3.56	1,090	
Que Tan	H-MV 300	7	1.56	600	Irr. & Drainage
Chau Cau	H-MV 300	20	4.44	1,680	
Pha Lai	V-A 870	2	5.00	2,340	
Sub-total	6-station	75	21.22	7,630	
Total	20-station	303	123.58	39,610	

Source: Bac Duong, Dong Anh and Gia Lam Irrigation Enterprises
Note: H-MV 300; Horizontal Axis Mixed Flow Volute Pump x 300mm (Bore)
V-A 870; Vertical Axis Axial Flow Pump x 870mm (Bore)
Drainage Area estimated based on 1/10,000 topographical maps

TABLE E-2.1.2. LIST OF PUMPING FACILITIES IN THE STUDY AREA

Name of Station	Related River etc.	Pump & Motor				Unit(q) & Total(Q)			Transformers (KVA)	Constructed in
		Type	D(mm)	KW	Nos.	H.(m)	q(cu.m/h)	Q(cu.m/s)		
[Ngu Huyen Khe Drainage System]										
Dang Xa	Cau river	H-A	600	75	34	3.9	3,200	30.22	3x1000	1984
Trinh Xa	N.H.K.river	V-A	870	320	8	5.6	9,000	20.00	2x1800 & 180	1962
Phu Lam	N.H.K.river	H-MV	300	33	15	5.0	800	3.33	560 & 180	1982
Lien Dam	N.H.K.river	H-MV	300	33	10	4.5	800	2.22	880	1968
		(V-A)	(500)	(37)	(8)		(1,900)	(4.24)		(1995)
Dong Dau	N.H.K.river	H-MV	300	33	4	3.0	900	0.89	320	1989
		(V-A)	(500)	(37)	(4)		(1,800)	(2.00)		(1994)
Loc Ha	Long Tuu C.	V-A	500	37	2	2.5	2,100	1.17	480	1989
Lai Da	Long Tuu C.	V-A	500	33	2	2.5	1,800	1.00	400	1987
[Duong River Upstream Drainage System]										
Duong Ha	Duong river	H-MV	300	30	30	6.0	800	6.67	2x560	1988
Phu Dong	Duong river	H-MV	300	33	25	6.0	800	5.19	2x560	1974
Thinh Lien	Duong river	H-MV	300	33	15	6.0	800	2.49	2x560	1969
		(V-A)	(600)	(37)	(9)	6.0	2,300	(5.75)		1994
[Kim Doi Creek Drainage System]										
Kim Doi	Cau river	V-A	870	320	5	4.8	9,000	12.50	2x1800	1966
[Tao Khe Creek Drainage System]										
Tri Phuong	Duong river	H-MV	300	33	14	5.8	800	3.13	560	1966
		(H-MV)	(300)	(33)	(24)	5.8	(800)	(5.33)		(1995)
Tan Chi	Duong river	H-MV	300	33	68	5.6	800	15.11	2x1000 & 320	1975
Thai Hoa	Duong river	H-MV	300	33	21	6.6	800	4.67	560 & 180	1986
Hien Luong	Cau river	V-A	870	320	9	5.5	9,000	22.50	2x1800 &1100	1966

Note : H-MV; Horizontal Axis Mixed Flow Volute Type
H-A; Horizontal Axis Axial Flow Type
V=A; Vertical Axis Axial Flow Type
Parenthesized are under construction

TABLE E-2.1.2. LIST OF PUMPING FACILITIES IN THE STUDY AREA (Continued)

Name of Station	Related River etc.	Pump & Motor Type	D(mm)	KW	Nos.	Unit(q) & Total(Q) H.(m)	q(cu.m/h)	Q(cu.m/s)	Transformers (KVA)	Constructed in
[Drainage System Along the Cau River]										
Xuan Vien	Cau river	H-MV	300	33	10	5.5	800	2.22	560	1967
Huu Chap	Cau river	H-MV	300	33	20	5.5	800	4.44	560 & 320	1977
(Co Me)	Cau river	(H-MV)	(300)	(33)	(10)		(800)			
Viet Thong	Cau river	H-MV	300	33	16	5.3	800	3.56	560 &180	1980
Que Tan	Cau river	H-MV	300	33	7	5.8	800	1.56	320	1984
Chau Cau	Duong river	H-MV	300	33	20	6.1	800	4.44	560 & 320	1976
Pha Lai	Duong river	V-A	870	33	2	5.7	9,000	5.00		1966
[Pumps for Irrigation Only]										
Noi Due	Trinh Xa C.	H-MV	300	33	4	4.0	800	0.89		
Xuan Thuy	Drainage C.	H-MV	300	33	1	3.0	800	0.22		
Dong Sai	Drainage C.	H-MV	300	33	4	3.0	800	0.89		1976
Cau Tien	Drainage C.	H-MV	300	33	1	3.0	800	0.22		
Cach Bi	Tao Khe Cr.	H-MV	300	33	5	3.0	800	1.11		
Kien Luong	Duong river	H-MV	300	33	4	4.8	800	0.89		1977
Y Na	Drainage C.	H-MV	300	33	2	3.0	800	0.44		1982
Dong Dau	N.G.K.river	H-MV	300	33	1	3.0	800	0.22		
Loc Ha	Long Tuu C.	H-MV	300	33	3	2.5	800	0.67		
Lai Da	Long Tuu C.	H-MV	300	33	1	2.5	800	0.22		
Cong Thon	Duong river	H-MV	300	33	11	6.0	800	2.44		1982

Note : H-MV; Horizontal Axis Mixed Flow Volute Type
H-A; Horizontal Axis Axial Flow Type
V=A; Vertical Axis Axial Flow Type
Parenthesized are under construction

TABLE E-2.1.3. PRESENT STATUS OF PUMPS IN SOUTH BAC DUONG AREA

Name of Station	Pump Type	Installed		Operational		To Be Repaired(No)		
		Nos.	Q(cumec)	Nos.	Q(cumec)	Pump	Motor	Trans.
[Ngu Huyen Khe Drainage System]								
Dang Xa	H-A 600	34	30.22	23	20.44	-	-	-
Trinh Xa	V-A 870	8	20.00	6	15.00	-	-	-
Phu Lam	H-MV 300	15	3.33	9	2.00	6	4	1
Lien Dam	H-MV 300	10	2.22	10	2.22	-	-	-
	(V-A 500)	(8)	(4.04)			Under Const.		
Dong Dau	H-MV 300	4	0.89	4	0.89	-	-	-
	(V-A 500)	(4)	(2.00)			Under Const.		
Loc Ha	V-A 500	2	1.17	2	1.17	-	-	-
Lai Da	V-A 500	2	1.00	2	1.00	-	-	-
Sub-total	7-station	75	58.83	56	42.72	6	4	1
[Duong River Upstream Drainage System]								
Duong Ha	H-MV 300	30	6.67	22	4.44	-	-	-
Phu Dong	H-MV 300	25	5.19	24	4.98	24	8	2
Thinh Lien	H-MV 300	15	2.49	15	3.90	-	-	-
	(V-A 600)	(9)	(5.75)			Under Const.		
Sub-total	4-station	70	14.35	61	13.32	24	8	2
[Kim Doi Creek Drainage System]								
Kim Doi	V-A 870	5	12.50	4	10.00	2	-	-
[Tao Khe Creek Drainage System]								
Tri Phuong	H-MV 300	14	3.13	9	2.00	5	3	-
	(H-MV 300)	(24)	(5.33)			Under Const.		
Tan Chi	H-MV 300	68	15.11	52	11.56	20	10	-
Thai Hoa	H-MV 300	21	4.67	15	3.33	8	2	-
Hien Luong	V-A 870	9	22.50	8	20.00	2	-	-
Sub-total	4-station	112	45.41	84	36.89	35	15	-
[Drainage System Along the Cau River]								
Xuan Vien	H-MV 300	10	2.22	8	1.78	3	1	-
Huu Chap	H-MV 300	20	4.44	15	3.33	3	1	1
(Co Me)	(H-MV 300)	(10)				Under Constructio		
Viet Thong	H-MV 300	16	3.56	16	3.56	8	2	2
Que Tan	H-MV 300	7	1.56	6	1.33	4	1	-
Chau Cau	H-MV 300	20	4.44	15	3.33	8	2	-
Pha Lai	V-A 870	2	5.00	2	5.00	-	-	-
Sub-total	7-station	75	21.22	62	18.34	26	7	3
Total for Major Pumps		337	152.31	267	121.27	93	34	6
[Pumps for Irrigation Only]								
Noi Due	H-MV 300	4	0.89	4	0.89	3	1	-
Xuan Thuy	H-MV 300	1	0.22	1	0.22	-	-	-
Dong Sai	H-MV 300	4	0.89	4	0.89	2	-	-
Cau Tien	H-MV 300	1	0.22	1	0.22	-	-	-
Cach Bi	H-MV 300	5	1.11	5	1.11	3	2	-
Kien Luong	H-MV 300	4	0.89	4	0.89	2	-	-
Y Na	H-MV 300	2	0.44	2	0.44	1	-	-
Dong Dau	H-MV 300	1	0.22	1	0.22	-	-	-
Loc Ha	H-MV 300	3	0.67	3	0.67	-	-	-
Lai Da	H-MV 300	1	0.22	1	0.22	-	-	-
Cong Thon	H-MV 300	11	2.44	11	2.44	-	-	-
Sub-total	11-station	37	45.21	37	45.21	11	3	-
Grand Total		374	197.52	304	166.48	104	7	6

Sourse : Bac Duong, Dong Anh and Gia Lam Irrigation Enterprises

TABLE E-2.1.4. AVERAGE PUMP OPERATION HOUR PER UNIT (hr./unit)

Station	P.Nos.	1989	1990	1991	1992	1993	Average
Phu Lam	15	670.7	737.9	868.3	734.7	581.5	718.6
Tri Phuong	14	385.5	443.6	420.8	527.1	545.3	464.5
Noi Due	4	915.4	725.9	701.7	936.1	841.3	824.1
Tan chi	68	563.9	531.3	472.3	547.7	475.8	518.2
Thai Hoa	21	1,150.4	574.2	811.2	603.2	621.6	752.1
Cach Bi	5	1,512.8	1,080.1	1,290.8	1,139.7	1,113.0	1,227.3
Chau Cau	20	521.6	414.8	697.8	546.5	731.4	582.4
Que Tan	7	603.7	367.1	846.7	851.3	755.2	684.8
Viet Thong	16	410.6	664.8	940.9	518.8	595.8	626.2
Kim Doi	5	731.8	888.7	1,056.9	903.1	701.2	856.3
Hien Luong	9	320.9	371.3	512.1	336.6	358.5	379.9
Pha Lai	2			271.3	128.0	192.6	197.3
Xuan Vien	10	1,035.2	34.7	769.1	799.7	682.6	664.3
Huu Chap	20	403.7	625.4	384.6	328.2	354.1	419.2
Dong Xa	34	406.6	390.9	195.2	345.4	147.7	297.2
Trinh Xa	8	4,962.5	3,798.4	1,146.2	1,583.3	1,205.6	2,539.2
Average		973.0	776.6	711.6	676.8	619.0	734.5

Note : Estimated by O&M costs for Bac Duong Irrigation Enerprise

TABLE E-2.1.5. LIST OF MAJOR DRAINAGE SLUICES IN SOUTH BAC DUONG AREA

No.	Name of Sluices	Related River/c	D/S WL(m)		Drainage Area(ha)	Drain. Q(cumec)	Gate			Land El. (m)	Sill El. (m)
			HWL	LWL			B (m)	H (m)	Nos.		
G 1	Thinh Lien	Tao Khe Cr.	5.26	2.90	2,620	1.91	0.96	2.26	2	4.30	3.49
G 2	Xom Ga	Tao Khe Cr.	5.00	3.56			1.87	1.96	1		2.95
G 3	Ba Cay	Trinh Xa C.	4.94	2.90	2,210	5.06	2.00	1.72	2	3.15	2.12
G 4	Tram	Tao Khe Cr.	4.72	1.70	10,520	6.83	2.40	2.64	2	2.90	1.74
G 5	La Miet	Tao Khe Cr.	4.83	1.60	12,640	11.66	1.60	1.70	3	2.20	0.22
G 6	Tay	Ten Creek	4.80	2.00	730	19.44	2.40	1.85	2	2.20	-1.10
						8.10	2.00	2.75	1	2.20	-1.10
G 7	Cong Ba	Kim Doi Cr.	4.75	2.00			1.15	2.7	2		
G 8	Van	Kim Doi Cr.	4.65	1.60	2,370	9.26	2.05	2.30	2	3.45	1.61
G 9	Duong Sat		4.81	2.52			1.98	2.00	2		0.66
G10	Noi Due	Trinh Xa C.	4.80	2.95	3,210	4.38	1.00	1.97	3	2.00	0.81
G11	Lien Mao	6-Xa Dr. C.	4.76	1.60	730		2.00	1.50	3	4.65	0.54
G12		Trinh Xa C.	4.80	2.35			1.35	1.55	1		1.88
G13	Duong Mong	Trinh Xa C.	4.80	2.52	150		ϕ.85		1		
G14	6-Xa	Trinh Xa C.	4.83	2.51	1,377		1.02	1.33	2		1.51
G15	Canh Hung	Tao Khe Cr.	4.76	3.15	270		0.85	3.1	1		2.36
G16	Thai Hoa	Duong R.	9.00	1.40	1,530	10.79	1.40	1.55	2	2.00	-1.14
G17	Hien Luong	Cau R.	7.22	0.65	19,620	19.32	1.60	2.50	3	2.00	-1.28
G18	Kim Doi	Cau R.	7.30	0.50	6,420	12.22	2.00	2.45	2	2.10	-0.39
G19	Dang Xa	Cau R.	7.36	0.80	16,790	40.67	2.00	2.15	2	2.00	-0.66
							2.82	2.15	3		-0.66

Surveyed

TABLE E-2.1.6. LIST OF MAJOR RIVER AND CREEKS

No.	Name of Canals	Length (m)	Width (m)	W. Depth (m)	Flow Q* (cumec)	Drainage Area (ha)	Remarks
1	Ngu Huyen Khe R.	20,950	20.00	6.50	109.30	16,200	B=90m, s=1/50,000
2	Tao Khe Creek						
2.1	Upper Reach	17,500	12.90	1.20	7.00		B=17.2m, s=1/7,500
2.2	Middle Reach	3,830	13.00	2.20	24.60		B=22.0m, s=1/5,400
2.3	Lower Reach	13,670	13.20	3.70	29.90		B=26.3m, s=1/23,600
	Total	35,000				17,740	
3	Kim Doi Creek						
3.1	Upper Reach	9,070	9.40	1.60	7.00		B=12.7m, s=1/9,600
3.2	Lower Reach	70,100	8.00	1.60	3.90		B=14.4m, s=1/30,000
	Total	79,170				6,510	

Source : Bac Duong Irrigation Enterprise

TABLE E-2.1.7. LIST OF MAJOR DRAINAGE CANALS

No.	Name of Canals	Length (m)	Width (m)	Hight (m)	Flow Q* (cumec)	Drainage Area (ha)	Remarks
	Ha Bac Province Area (Bac Duong Irr. Enterprise)						
1	KT Trinh Xa	15,000	6.00	3.00	14.79	15,000	
2	KT Phat Tich	6,500	4.00	2.50	7.96	3,000	
3	KT 6 XA	6,200	3.50	2.00	4.62	1,045	
4	KT 3 XA	2,500	3.00	1.70	3.01	372	
5	KT 4 XA	6,600	4.00	1.70	3.61	1,064	
6	KT Cau Nau	3,500	4.00	2.50	7.96	206	
7	KT Lien Ap	1,100	1.50	1.80	2.43	200	
8	KT KKV2	1,100	1.50	1.80	2.43	200	
9	KT KKV1	1,100	1.50	1.80	2.43	200	
10	T7	1,750	1.50	2.00	3.10	257	
11	T9	3,400	1.80	2.20	4.13	394	
12	KT Phu Lam	3,500	2.50	2.80	8.12	1,139	
13	KD2	11,000	3.50	2.00	4.62	1,080	
14	KD3	700	1.20	1.60	1.71	57	
15	KD1	900	1.20	1.50	1.47	200	
16	KD5	800	2.00	1.50	1.85	125	
17	KD6	1,600	1.80	1.70	2.31	212	
18	KD9	4,000	5.00	1.70	4.22	209	
19	KD8	1,500	2.00	1.60	2.12	238	
20	KD11	1,500	1.80	1.70	2.31	150	
21	KD12	1,500	1.20	1.60	1.71	100	
22	HL1	1,200	2.00	1.50	1.85	104	
23	HL6	2,500	1.80	1.80	2.62	550	
24	HL5	4,700	3.50	2.00	4.62	2,090	
25	HL9	1,500	1.20	1.50	1.47	160	
26	HL15	4,000	2.50	1.80	3.07	1,200	
27	HL17	4,050	2.70	1.90	3.59	980	
28	HL18	2,500	2.00	1.70	2.42	810	
29	HL2	1,500	1.50	1.60	1.86	260	
30	HL13	1,000	1.00	1.40	1.18	100	
	Sub-total	98,700				31,702	
	Gia Lam Area						
1	Phu Dong	1,254	6.80	2.40	9.35	523	B=14.0
2	Gien Thong	1,202	4.80	2.40	7.19	251	B=12.0m
3	Duong Ha	1,140	4.70	3.10	11.78	895	B=14.0m
4	Dien Vy	1,450	6.80	2.00	6.67	360	B=12.8m
5	Lai Hoang	1,245	2.00	2.00	2.88	121	B=8.0m
	Sub-total	6,291				2,150	
	Total	104,991				33,852	

Source : Bac Duong and Gia Lam Irrigation Enterprises
:*Estimated, ss=1:2.0, n=0.03, s=1/15,000

FIGURE E-2.1.1. GENERAL MAP OF PRESENT DRAINAGE SYSTEM IN THE STUDY AREA

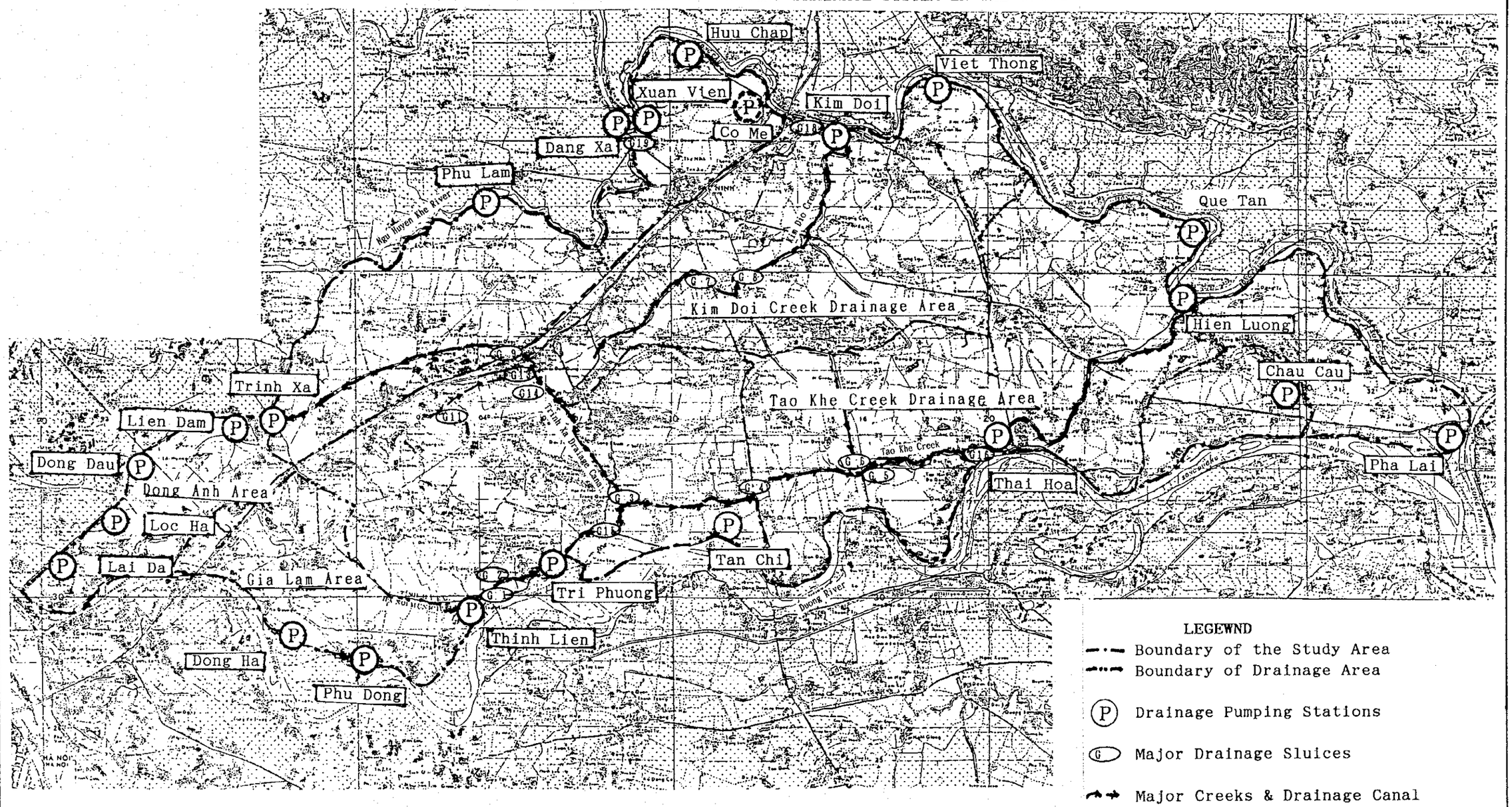


TABLE E-2.2.1. INUNDATED AND CROP-DAMAGED AREA IN SOUTH BAC DUONG AREA

Year	Yen Phong District		Tien Son District		Que Vo District		Bac Ninh Town		T o t a l	
	Inundated Area	Failure of Crops	Inundated Area	Failure of Crops	Inundated Area	Failure of Crops	Inundated Area	Failure of Crops	Inundated Area	Failure of Crops
1980	656	127	7,130	6,190	615	574	223	174	8,624	7,065
1981	108	10	0	0	85	37	137	50	330	97
1982	230	54	2,446	412	462	105	387	76	3,525	647
1983	171	50	2,065	1,623	2,143	120	213	76	4,592	1,869
1984	126	65	431	236	331	111	198	38	1,086	450
1985	400	82	6,461	5,181	4,090	3,060	919	832	11,870	9,155
1986	377	269	4,543	1,100	3,108	2,206	761	621	8,789	4,196
1987	129	14	505	116	1,630	220	255	0	2,519	350
1988	25	0	218	72	300	120	187	0	730	192
1989	220	103	2,598	60	320	130	319	80	3,457	373
1990	255	103	6,100	4,200	2,823	1,013	725	493	9,903	5,809
1991	169	40	5,728	3,698	543	144	334	194	6,774	4,076
1992	165	42	6,644	919	0	0	257	162	7,066	1,123
1993	155	0	3,583	421	0	0	35	0	3,773	421
Average	228	69	3,461	1,731	1,175	560	354	200	5,217	2,559
St.Var.	153	68	2,536	2,064	1,295	900	251	251	3,518	2,877

Source : Bac Duong Irrigation Enterprise

Note:Yen Phong District covered Hoa Long, Van An, Khuc Xuyen and Phong Khe commues only

TABLE E-2.3.1. MASTER PLAN OF DRAINAGE IMPROVEMENT IN SOUTH BAC DUONG AREA

Dev'p	Drainage System		Instal'd	Present Drainage		Required Drain.		Proposed Plan	
B.No.	Pump.Sta.	Area(ha)	Q(cumec)	Q(cumec)	(l/s/ha)	Q(cumec)	(l/s/ha)	Q(cumec)	Improvement of Main Facility
1	Dien Dam	830	2.22	2.22	2.67	4.17	5.02	4.00 0.50	New V-A 500x37kw x8 and Add 1 more unit
	Dong Dau	410	2.00	2.00	4.88	2.06	5.02	2.11	New V-A 500x37kw x4 Operating in 1995
	Loc Ha	280	1.17	1.17	4.18	1.41	5.04	1.75	Add V-A 500x37kw x1
	Lai Da	270	1.00	1.00	3.70	1.36	5.04	1.50	Add V-A 500x37kw x1 Incl. seepage water
	Subtotal	1,790	6.39	6.39	3.57	9.00	5.03	9.86	
	Dong Ha	1,100	6.67	4.44	4.04	6.18	5.62	6.67	Repare H-MV 300x30kw x30
	Phu Dong	780	5.56	4.98	6.38	4.39	5.62	6.38	Repare H-MV 300x33kw x20
	Thinh Lien	740	2.50	3.33	4.50	4.16	5.62	5.75	New V-A 600x75kw x9 Operationg in 1995
	Subtotal	2,620	14.73	12.75	4.87	14.73	5.62	18.80	
	Total	4,410	21.12	19.14	4.34	23.73	5.38	28.66	
2	Huu Chap	1,350	4.44	3.33	2.47	6.33	4.69	4.44	Repare H-MV 300x33kw x20
	Co Me							2.22	New H-MV 300x33kw x10
	Xuan Vien	570	2.20	1.78	3.12	2.67	4.69	2.78	Replace w/ H-MV 300x55kw x10
	Subtotal	1,920	6.64	5.11	2.66	9.00	4.69	9.44	
	Phu Lam	850	3.33	2.00	2.35	3.98	4.68	3.33	Repare H-MV 300x33kw x15 and Revise 140ha to Trinh Xa Area
	Trinh Xa	3,210	20.00	15.00	4.67	15.02	4.68	17.50	Repare V-A 870x320kw x7 for drainage purpose only
	Subtotal	4,060	23.33	17.00	4.19	19.00	4.68	20.83	
	Total	5,980	29.97	22.11	3.70	28.00	4.68	30.27	

Note : New ; under Construction
H-MV; Horizontal axis - Mixed flow Volute type pump
V-A ; Vertical axis - Axial flow type pump
300 ; Bore in m/m, x2 ; Numbers of pump units

TABLE E-2.3.1. MASTER PLAN OF DRAINAGE IMPROVEMENT IN SOUTH BAC DUONG AREA (continued)

Dev'p B.No.	Drainage System Pump.Sta.	Area(ha)	Instal'd Q(cumec)	Present Drainage Q(cumec)	(l/s/ha)	Required Drain. Q(cumec)	(l/s/ha)	Proposed Plan Q(cumec)	Improvement of Main Facility
3	Tri Phuong	1,480	3.13	2.00	1.35	6.50	4.39	5.33	New H-MV 300x33kw x24 and
								1.22	Add H-MV 300x55kw x4
	Tan Chi	6,420	15.11	11.56	1.80	31.11	4.85	15.11	Repare H-MV 300x33kw x68
								16.00	Add V-A 1350x450kw x4
	Han Quang	2,120	0.00	0.00	0.00	10.00	4.72	10.00	Provide V-A 1000x320kw x5
	Thai Hoa	1,530	4.67	3.33	2.18	6.83	4.46	4.67	Repare H-MV 300x33kw x 21
	Hien Luong	5,450	22.50	20.00	3.67	24.34	4.47	22.50	Repare V-A 870x320kw x9
								4.00	Add V-A 800x132kw x3
	Subtotal	6,980	27.17	23.33	3.34	31.17	4.47	31.17	
	Que Tan	600	1.56	1.33	2.22	2.90	4.83	1.56	Repare H-MV 300x33kw x7
								1.34	Add H-MV 300x33kw x6
	Total	17,600	46.97	38.22	2.17	81.68	4.64	81.73	
4	Kim Doi	6,510	12.50	10.00	1.54	35.50	5.45	12.50	Repare V-A 870x320kw x5
								23.00	Add V-A 1350x350kw x6
	Viet Thong	1,090	3.56	3.56	3.27	5.50	5.05	3.56	Repare H-MV 300x33kw x16
								2.00	Add V-A 600x75kw x3
	Total	7,600	16.06	13.56	1.78	41.00	5.39	41.06	
5	Chau Cau	1,680	4.44	3.33	1.98	8.70	5.18	4.44	Repr.H-MV 300x33kw x8
								4.47	Add V-A 600x75kw x7
	Pha Lai	2,340	5.00	5.00	2.14	9.50	4.06	5.00	
								4.50	Add 1000x320kw x2
	total	4,020	9.44	8.33	2.07	18.20	4.53	18.41	
Grand Total		39,610	123.56	101.36	2.56	192.61	4.86	200.13	

Note : New ; under Construction
H-MV; Horizontal axis - Mixed flow Volute type pump
V-A ; Vertical axis - Axial flow type pump
300 ; Bore in m/m, x2 ; Numbers of pump units

TABLE E-2.4.1. EVALUATION OF IMPROVEMENT SCHEMES FOR EACH DRAINAGE AREA

Dev. Blk. No.	Drainage System	Drainage Area		Inundated		Inundated hr.		Inundated %		Damage Prevent		Project Costs ($'000)	IRR (%)
		Gross (ha)	Agri. (ha)	Area (ha)	Depth (m)	>0.16 (hr)	>0.25 (hr)	Gross (%)	Agri. (%)	Area (ha)	Amout ($'000)		
1	Dong Anh	1,790	1,080	425	0.59	95	85	23.7	39.4	281	94.5	2,041	3.63
	Gia Lam	2,620	1,740	401	0.25	43	0	15.3	23.0	265	89.1	2,934	1.52
	Sub-total	4,410	2,820	826				18.7	29.3	546	183.6	4,975	2.44
2	Xuan Vien	1,920	1,230	354	0.41	84	68	18.4	28.8	234	78.7	1,796	3.33
	Trinh Xa	4,060	2,880	582	0.18	31	0	14.3	20.2	451	151.7	4,329	2.19
	Sub-total	5,980	4,110	936				15.7	22.8	685	230.4	6,125	2.54
3	Tri Phuong	1,480	1,180	458	0.71	117	99	30.9	38.8	303	101.9	1,796	3.33
	Tan Chi	(6,420)	(4,250)	(1,937)	(0.65)	(108)	(97)	(30.2)	(45.6)	(1,283)	(431.5)	(8,662)	(3.79)
	Han Quang*	8,540	5,650	2,710	0.85	110	99	31.7	48.0	1,792	607.6	11,640	4.05
	Hien Luong	6,980	4,520	977	0.24	77	0	14.0	21.6	646	217.2	7,424	1.25
	Que Tan	600	390	227	0.73	106	97	37.8	58.2	150	50.4	606	7.46
	Sub-total	17,600	11,740	4,372				24.8	37.2	2,891	977.1	21,466	3.28
4	Kim Doi	6,510	5,690	1,787	1.24	113	108	27.5	31.4	1,182	397.5	10,981	2.15
	Viet Thong	1,090	710	353	0.7	109	99	32.4	49.7	233	78.4	1,052	6.64
	Sub-total	7,600	6,400	2,140				28.2	33.4	1,415	475.9	12,033	2.63
5	Chau Cau	1,680	1,080	502	0.72	110	101	29.9	46.5	332	111.7	1,881	5.10
	Pha Lai	2,340	1,510	680	0.32	79	50	29.1	45.0	450	151.3	5,801	0.75
	Sub-total	4,020	2,590	1,182				29.4	45.6	782	263.0	7,682	2.02
	Total	39,610	27,660	9,456				23.9	34.2	6,319	2130.0	52,281	

TABLE E-2.4.2. REGIONAL DRAINAGE SCHEMES FOR TAO kHE CREEK DRAINAGE AREA

No.	Drainage System	Drainage Area		Inundated		Required Q.		Inundated %		Damage Prevent		Project Costs ($'000)	IRR (%)
		Gross (ha)	Agri. (ha)	Area (ha)	Depth (m)	Exist. (cumec)	Add. (cumec)	Gross (%)	Agri. (%)	Area (ha)	Amout ($'000)		
1	w/ Tan Chi	15,520	10,170	3,473	0.46	42.28	14.00	22.4	34.1	2299	773.2	15,035	3.68
2	w/o Tan Chi	9,100	5,920	2,054	0.46	27.17	6.00	22.6	34.7	1360	457.3	9,664	3.51

TABLE E-2.4.3. ADDITIONAL BENEFITS IN THE DOWNSTREAM AREA WITH PROJECT

No.	Case Study	Drainage Area		Inundated Area			Inundated %		Damage Prevent		IRR (%)
		Gross (ha)	Agri. (ha)	w/o P. (ha)	w/ P. (ha)	(-) A. (ha)	Gross (%)	Agri. (%)	Area (ha)	Amout ($'000)	
1	Only Tan Chi	9,100	5,920	2,054	1,574	480	22.6	34.7	318	106.9	5.08
2	Combined	6,980	4,520	1,179	977	202	16.9	26.1	134	45.0	4.46

TABLE E-2.5.1.OPERATION RECORD OF TAN CHI PUMPING STATION (unit : pump unit-hour)

For Irrigation

year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
1990	1,786	1,502	360	515	853	210	0	0	0	662	0	0	5,888
1991	2,306	2,212	397	781	105	0	0	386	0	0	1,274	42	7,503
1992	2,033	1,123	881	1,274	691	629	0	0	0	502	815	0	7,948
1993	2,470	1,608	867	635	0	1,096	794	493	0	0	369	380	8,712
Average	2,149	1,611	626	801	412	484	199	220	0	291	615	106	7,513

For Drainage

year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
1990	0	0	2,516	302	0	155	20,512	9,873	7,238	0	0	0	40,596
1991	0	0	0	0	0	0	17,805	7,440	2,816	829	0	0	28,890
1992	0	0	0	0	0	1,224	29,187	5,858	1,732	0	0	0	38,001
1993	0	0	0	0	6,124	0	3,522	8,014	6,284	3,455	0	0	27,399
Average	0	0	629	76	1,531	345	17,757	7,796	4,518	1,071	0	0	33,722

Total Operation

year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
1990	1,786	1,502	2,876	817	853	365	20,512	9,873	7,238	662	0	0	46,484
1991	2,306	2,212	397	781	105	0	17,805	7,826	2,816	829	1,274	42	36,393
1992	2,033	1,123	881	1,274	691	1,853	29,187	5,858	1,732	502	815	0	45,949
1993	2,470	1,608	867	635	6,124	1,096	4,316	8,507	6,284	3,455	369	380	36,111
Average	2,149	1,611	1,255	877	1,943	829	17,955	8,016	4,518	1,362	615	106	41,234

Source : Bac Duong Irrigation Enterprise

FIGURE E-2.5.1. GENERAL MAP OF PRESENT DRAINAGE SYSTEM IN THE PROJECT AREA

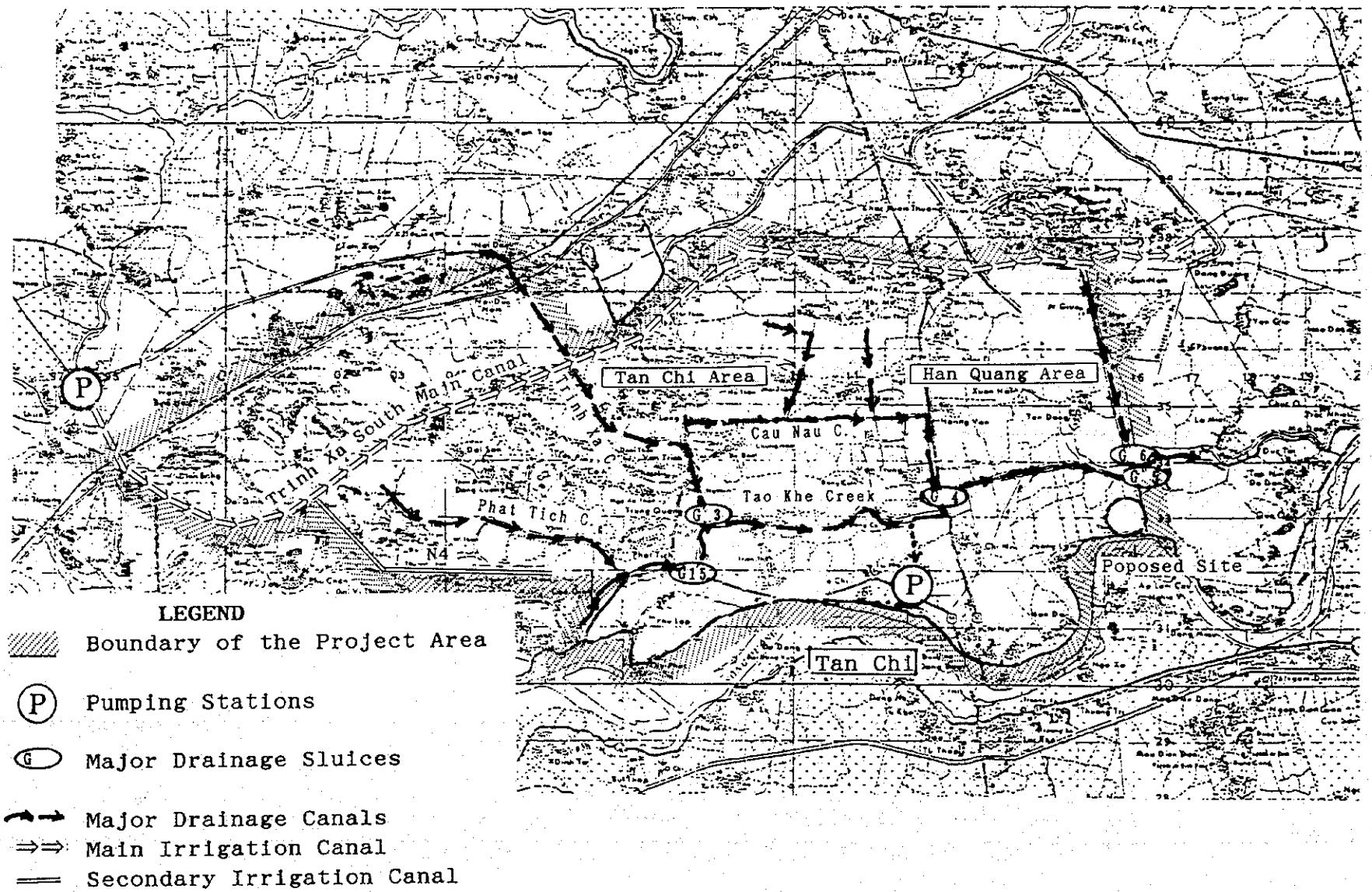
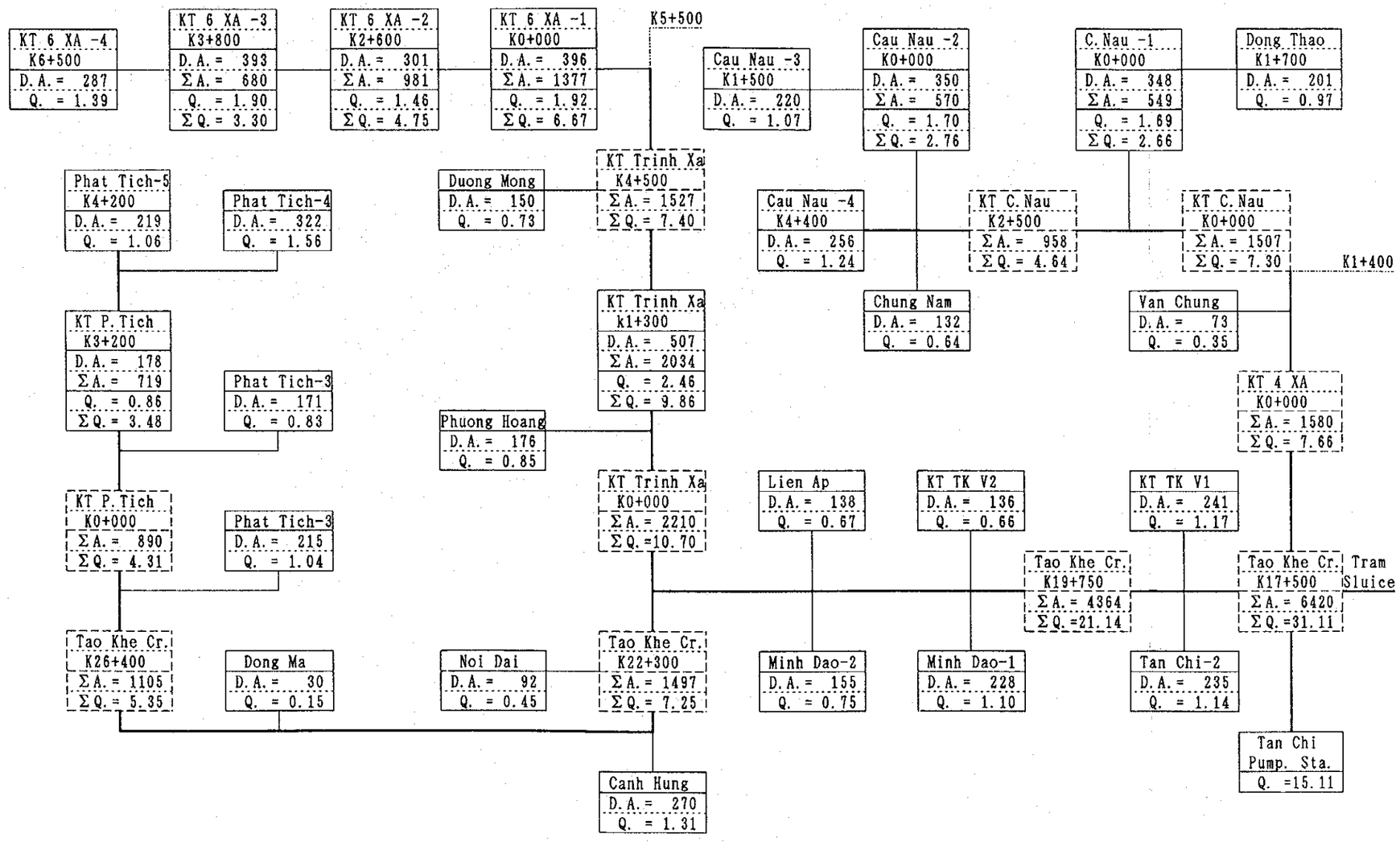
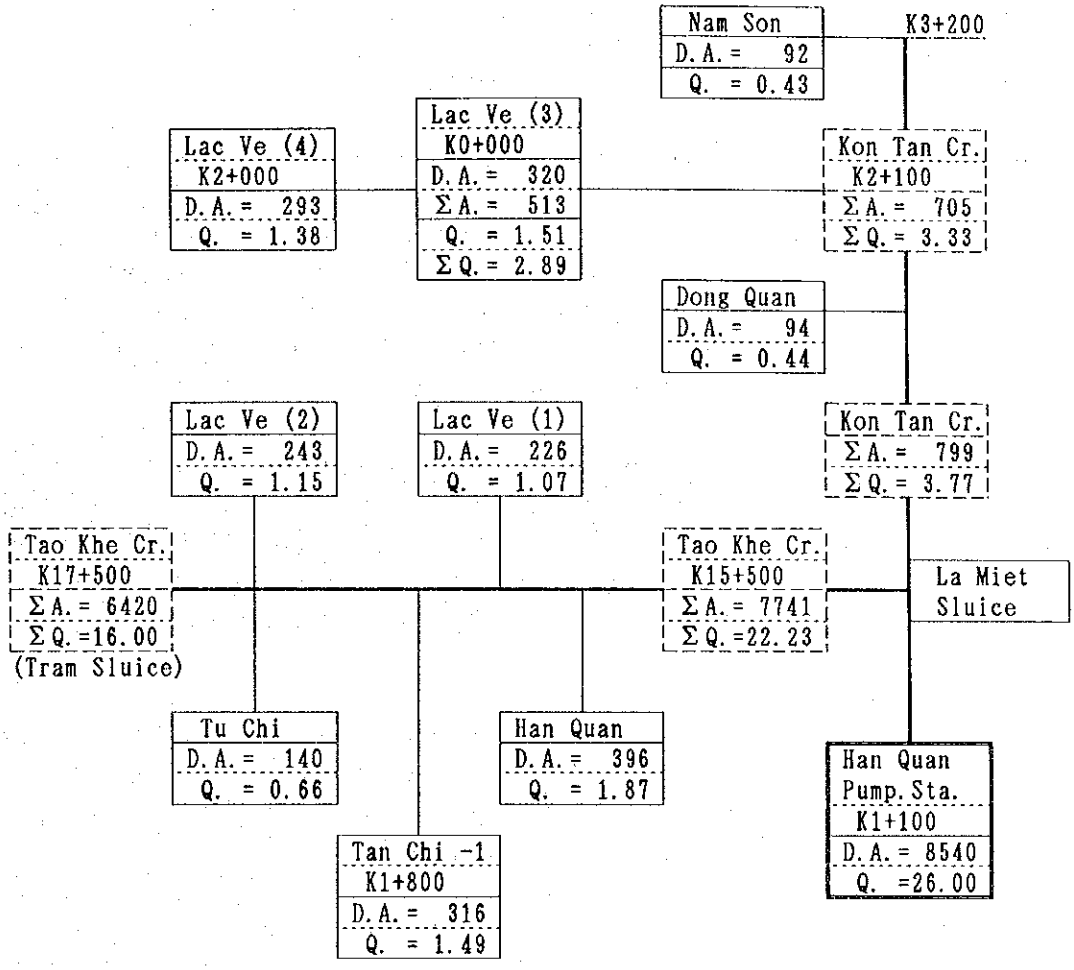


FIGURE E-2.5.2. SCHEMATIC DIAGRAM OF DRAINAGE CANAL SYSTEM IN TAN CHI AREA



Note : D.A. & ΣA.=(ha); Q. & ΣQ.=(cu.m/sec)

FIGURE E-2.5.3.
SCHEMATIC DIAGRAM OF DRAINAGE CANAL SYSTEM IN HAN QUANG AREA



Note : D.A. & ΣA.=(ha); Q. & ΣQ.=(cu.m/sec)

E-3. Operation and Maintenance

E-3.1. Organization and Management

(1) Present Organization and Management

The organization have been established under the provincial government for the operation and maintenance of the irrigation and drainage facilities extended over two more districts, and under the district government for those within one district. Bac Duong, Dong Anh and Gia Lam Irrigation Enterprises are connected to the operation and maintenance (O&M) of the irrigation and drainage systems in the Study Area.

Bac Duong Irrigation Management Enterprise have managed and operated for irrigation and drainage services since 1964 and maintains 33 pumping stations, about 150 km length of main irrigation and drainage canals, and sluices for irrigation and drainage. The service area is some 32,700 ha, extending over three districts and one town.

The Enterprise is under the administration of Water Resources Services in Ha Bac provincial government, and has a main office in Tu Son, Tien Son district. Under the Director, one Board and five (5) Divisions are organized, of which four (4) divisions in charge of the operation and maintenance works for each district area are provided with offices in the respective district and the staffs together with the provincial government staff under the Director appointed by the provincial government. The staffs of Head Works Irrigation Division are in the quarter of Trinh Xa pumping Station. Therefore, the staffs for Board of General Management serve are in Tu Son office. Board of General Management has three (3) section of Planning & Technology, Personnel & Administration and Finance, and four (4) Team of Investigation, Repair & Rehabilitation, K4 and Work Management, as shown in Figure E-3.1.1. The communication is kept up by radio among the Board/Divisions and by telephone to every pumping stations.

The organization of Dong Anh and Gia Lam Irrigation Enterprises under the respective district government and are similar to those of Bac Duong Irrigation Enterprise. the working teams are arranged instead of District O&M Divisions.

The water fee have been collected from the farmers, which are estimated based on the 5 year's average paddy production yield and actual achievement of water supply and collected by cash or in kind through farmers' cooperatives since 1987 in Bac Duong Enterprise. Other Enterprises have settle the fee similar to Bac Duong Enterprise in cash. The O&M expenditure for irrigation and maintenance have been managed by these water fee Each enterprise is managed by the independent profit system but can not be paid for all O&M expenses by the collected water fee, as shown in Table E-3.1.1. to Table E-3.1.3. The balance due is financed by the payable account to the electric company and/or the bank loan. Particularly in Bac Duong Irrigation Enterprise, the collected water fee corresponds to about 42 % of O&M costs. The remaining 58 % is remained as the payable account to the electric company. these unpaid amount is accumulated to about several times the annual revenue to be collected as water fee, reportedly.

As evaluated the O&M costs, water costs per one (1) cu.m pumped up have been estimated to be 21 Dong on an average, which are lower in the large scale capacity pumps (17 Dong) and high in the small capacity pumps (25 Dong), as shown in Table E-3.1.4. Repair costs per operation hour have also been estimated at about 5,000 Dong on the average, considerably high in Noi Due and Hien Luong pumping Stations, as shown in Table E-3.1.5.

E.3.2. Water Control for Drainage System

The drainage sluices in the Study Area may have dual purposes to retain the water for irrigation and drain the excess water to the downstream. Even so, most of them are not operational. For the drainage control, some drainage sluices, specially in Tram and Van sluices, are operated in accordance with the Operation, Management and Development for Bac Duong Irrigation System, as mentioned previously. However, it seems that the gate operation are hardly performed in practice due to absence of gate operation manual.

The drainage pumps, in general, have been operated by the planned water levels of gauging staff installed nearby the station. Furthermore, the pumps can be operated when daily rainfall exceed 100 mm and storm warning is issued. On the other hand, the pumps operation shall be stopped when the river water level is

exceed over the warning water level No.3 which are designated to the major rivers, for instance; 11.50 m at Thoung Cat gauging station on the Duong river, 5.80 m at Dap Cau gauging station on the Cau river and 5.50 m at Pha Lai gauging station on the Thai Binh river.

E.3.3. Water Management for Irrigation System

The water management by the operation of Trinh Xa pumping station is practiced by the supply-oriented water control system in accordance with the cropping pattern prepared by the agricultural section of the respective districts. According to Bac Duong Irrigation Enterprise, Trinh Xa pump is operating for the months January to May for the spring crops, June to July for transplanting of the summer paddy, October for the summer paddy and November to December for the winter crops. However, no operation manual is provided taking into account effective rainfall, conveyance losses, and so on. The information of water supply given to the farmers is seemed to be very limited. The pumping stations other than Trinh Xa station are currently operated within the limited time (6,000 - 10,000 KWH) decided based on the averaged operation hours in the latest year. Bac Duong Irrigation Enterprise is expected to maintain a total power consumption within 14 million KWH.

E.3.4. Propose Operation and Maintenance

(1) Proposed Organization and Management

Present organizations, will be principally supported but recommended gradually to transfer from the government leading organization to beneficiaries participant ones. The irrigation enterprise/water resources enterprises are organized under the province and/or district and directors are appointed for them. The operation and management policies of the enterprise will be decided by the board/committee, which will be composed of representatives of agencies concerned, and implemented by the director of the enterprise. Under the director, divisions, which take charge of the planning/technical, financial, administrative, operation and maintenance, mechanical matters will be arranged. For Bac Duong Enterprise, the operation and maintenance offices will be maintained. Every divisions/offices will be sufficiently

staffed depending on a volume of the works. The superintendent will be appointed for each irrigation and/or drainage pumping station together with operators depending on the number of pump units.

The director for the enterprise will rest with all technical and administrative matters with support of every division staffs. The planning/technical division will prepare operation plan of pumps based on the request of water supply from each district operation and maintenance office and inform the plan to each pumping station every week, and also prepare the guideline and operation rules necessary for operation and maintenance. The operation and maintenance division/office will provide the services to inspect whether the water management and drainage control are operated properly and report those status to the director, and take appropriate measures and/or instruct those to the gatekeeper, if any.

After the completion of priority project for Tan Chi and/or Han Quang area, the organization would follow the present organization of Bac Duong Irrigation Enterprise in principal, since the Project area is situated within its management area.

Planning & Technical Division deal with the Planning and management of operation and maintenance works in the entire Bac Duong area at present and is expected to continue those works and conduct the planning of irrigation water management, drainage water control and facilities' maintenance as well as monitoring and management of pumps and sluices as a day-to-day activity after the Project. The superintendents for each pumping station and gate-keepers for each sluice would be appointed. The communication would be kept up by telephone between the main office and pumping stations and to the gate-keepers through Operation and Maintenance Division in Tien Son district. In order to implement adequate and effective irrigation and drainage water management, the inspection/communication team would be organized in the Tien Son office, which should be mobilized. The team would serve to monitor the present state of facilities and operation of irrigation/drainage sluices, and check the offtake water discharge from the main/secondary canals, and provide the instruction/guidance of proper gate operation to the gate-keepers, as a daily works.

(2) Water Control for Drainage System

Paddy field have a substantial function to control the runoff discharge by retaining the rain water in the field. In fact, it is allowed to keep the water in the depth of 20-30 cm temporary, depending on the crop growing stages. Runoff of rainfall is first controlled by paddy field, farm drains and conduits, where no deep water is keeping in the field. The excess water is also controlled by the drainage regulating sluice not to concentrate the inundation into the limited area. in other words, rain water is distributed every paddy fields within an allowable water depth. Taking into account these functions of paddy field area, drainage water control will be planned. In addition, the farmers and drainage water masters concerned will be trained on the field drainage water control.

The review of present water control and pump operation rules as well as the strengthening of data/ information collection and evaluation system will be proposed to execute effective water control and reduce the pump operation costs. In order to achieve these strategies, the water gauges and/or staves will be installed at the confluences of creeks/main drainage canals and major drainage canals and other places necessary for drainage pump operation, which those will contribute to the adequate and effective operation of drainage pumps. The water level in the creeks and main canals will be controlled at about 50 cm below the fields, to react to the local spot rainfall. After the project, the new operation rule of drainage sluices shall be set up by review of present rules and agreements. Moreover, The monitoring system strictly to watch over the implementation of the rules shall be strengthened, because the miss operation of the irrigation cum. drainage sluices and regulating sluices on the creeks bring about inundation problems in the downstream.

Under the project for the priority area, The centralized network to collect the water levels, by installation of water gauges/staffs on the creeks, major drainage canals and drainage sluices, is proposed to instruct the operation of drainage pumps and sluices adequately. Inasmuch as it has less possibility to provide the regulating pond to meet a capacity of the drainage pumps in the immediate upstream, the operation of pumps might depend on the water levels of the gauges/staffs mentioned previously in the initial operation stage. The drainage sluices would

also be properly operated depending on the water levels in the downstream and pump operation. Specially for the operation of Cham sluice it is necessary to send correct instruction so as not to meet an inundation damages in the downstream. For executing adequate drainage control, the operation manuals for drainage sluices and pumps should be prepared.

(3) Water Management for Irrigation System

The water management at the field is one of major factors in the increase of paddy production. The water supply is variable in the crop growing stages. The water depth shall be practically a few centimeters in the field except it is retained in about 5 centimeters for 2 to 3 weeks after transplantation. As seen in the Study Area, A deep water in the field bring about checking of paddy growing in the tilling stage and inundation even by a little rainfalls. A good harvest will be expected in the wetted field. Specially in the summer crops season, the paddy field is well drained in the surface water. Although such water management in the filed will be practiced by farmer, training/education on the proper field water management shall be conducted.

The irrigation water shall be supplied timely in the request and adequately in the required quantity to the field through the turnout and farm ditches. To implement the proper and effective water management, the improvement/provision of water management facilities included communication system will be provided. Mobilization of staffs are also enhanced. Furthermore, it is required to arrange the supervision system for the effective operation and maintenance of the regulating facilities. The training on the proper operation and maintenance will be precisely required. Aside from the above, in the water supply schedule, the water users will recognize well the water supplied from the pumping station and/or canals, when the water supply system is modified to the demand-oriented water control. The water supply method, which is practiced to supply the diversion water estimated based on the request of the farmers through the district operation and maintenance office one week before the water is demanded, is recommended.

For the irrigation water management under the priority project for Tan Chi and/or Han Quang Area to supply the water with adequate quantity in time for the requirement, Trinh Xa pumping station would be operated under the demand-oriented

supply system by perceiving a necessary quantity of the water one week before the supply. The regulating sluices and turnout gates would also be operated properly. Therefore, the system to properly notify the water supply schedule to the staffs concerned is imperative. The system to reply with the rainfall in the water supply should be established, when it is rain able to effectively use for the irrigation. On the other hand, the illegal water use by the farmers should be strictly prohibited. In order to implement the adequate and effective water management, preparation of water management manuals included operation of regulating sluices and turnout gates and education/training to the staffs concerned would be required. In addition, by undertaking the education to farmers, more effective water management would be expected.

(4) Operation and Maintenance of the Structures

The operation and maintenance of the facilities will be responsible by the Enterprises for the major facilities and by the water users for the facilities below the secondary canals, as stated previous section on the organization and management. The maintenance of facilities will be implemented by preparing the maintenance manual stipulated the scope of the works, activities, method etc. The maintenance works consist of day-to-day works and periodical maintenance works. The inspectors should observe the state and operation of the facilities, as a day-to-day activity. If it is necessary for the repair, he should take prompt action to report to the chief and restore those structures with assistance of staffs concerned. Specially, it is required to pay close attention to the pumping equipment.

The periodical maintenance works, which are recommended to be executed principally by the contract basis depending on the quantity of the works, shall be carried out properly. Those repair should be carried out with advice of supervisor/experts, because an incomplete repair and/or un-skilled service might bring about a heavy damages in the near future. The repair/restoration of the irrigation facilities would be implemented in a spare time during the winter/spring crop season, while the repair of drainage facilities would be done in the months of March to May before the rainy season. In order to implement proper maintenance works, it is integral to provide maintenance manual for the facilities and pumping equipment as well as training/education to the staffs concerned.

After the completion of the project for priority area, the Province/Enterprise would take the initiative in every operation and maintenance of the project facilities for the time being. In future, it is advised that the operation and maintenance of major facilities, such as Trinh Xa pumping station, Tan Chi pumping station and main irrigation and drainage canals and structures including the Tao Khe creek, should be under Bac Duong Enterprise but the small scale pumping stations and small canals below the secondary canals for irrigation and drainage should be operated and maintained by the farmers concerned. For this institutional set-up, the farmers' association would be developed to shoulder a part of the system operation and maintenance, aiming to make the farmers understand necessity of operation and maintenance and common use of the facilities among them. By this arrangement, the expenses of the Enterprise might be reduced but the financial assistance to the farmers' association might be required.

The costs necessary for the operation and maintenance would be managed within the amount collected as a water fee from the farmers, while some financial assistance of the government might be necessary in case of huge construction costs required. The repair/remedy of the facilities damaged by calamity would be carried out directly by the provincial/district government and/or by the farmers concerned with supply of fund and/or materials from the government, depending to the scope of the responsible management.

In the future, the operation and maintenance of facilities will be responsible by the enterprises for major facilities, such as large scale irrigation/ drainage pumping station, main irrigation/drainage canals and structures, major secondary canals, and by farmers' association, which will be organized for operation and maintenance of the small scale pumping station, for the remaining secondary irrigation/drainage canals and farm ditches/drains and other small structures. By this arrangement, the expenses of the enterprise will be reduced but the financial assistance to the farmers' association may be required.

TABLE E-3.1.1. OPERATION AND MAINTENANCE COSTS OF BAC DUONG IRRIGATION ENTERPRISE (1989-93)

Items	1989		1990		1991		1992		1993*	
	Amount (M.Dong)	Rate (%)	Amount (M.Dong)	Rate (%)	Amount (M.Dong)	Rate (%)	Amount (M.Dong)	Rate (%)	Amount (M.Dong)	Rate (%)
Expenditure										
Salary & Ins.	135.0	4.6	138.4	5.1	163.8	2.3	292.9	3.9	603.4	5.0
Elect.Charge	1,993.9	68.7	1,851.6	68.5	4,143.1	58.6	5,058.6	67.9	4,274.7	35.2
Struct.Repair	274.6	9.5	201.0	7.4	828.4	11.7	1,007.6	13.6	2,737.8	22.6
E & M Repair	144.1	5.0	244.1	9.0	631.9	8.9	670.0	9.0	994.2	8.2
Other Costs	354.6	12.2	269.1	10.0	1,304.8	18.5	416.3	5.6	3,518.4	29.0
T o t a l	2,902.2	100.0	2,704.2	100.0	7,072.0	100.0	7,445.4	100.0	12,128.5	100.0
Revenue										
Collected Fee	859.9	29.6	895.2	33.1	2,547.1	36.0	4,815.2	64.7	5,365.5	44.2
Balance	-2,042.3	-70.4	-1,809.0	-66.9	-4,524.9	-64.0	-2,630.2	-35.3	-6,763.0	-55.8

Source : Bac Duong Irrigation Enterprise
Note : * Provisional Estimates

TABLE E-3.1.2. OPERATION AND MAINTENANCE COSTS OF DONG ANH IRRIGATION ENTERPRISE (1989-93)

Items	1989		1990		1991		1992		1993	
	Amount (M.Dong)	Rate (%)	Amount (M.Dong)	Rate (%)	Amount (M.Dong)	Rate (%)	Amount (M.Dong)	Rate (%)	Amount (M.Dong)	Rate (%)
Expenditure										
Salary	55.5	6.8	94.8	9.7	236.3	10.1	264.7	8.2	372.2	12.7
Elect.Charge	414.3	50.6	396.4	40.6	770.8	32.8	1,691.7	52.4	1,574.5	53.6
Contract Repair	86.0	10.5	105.2	10.8	721.9	30.7	393.4	12.2	0.0	0.0
Annual Repair	17.2	2.1	198.9	20.3	226.3	9.6	278.2	8.6	415.7	14.1
	44.0	5.4	83.3	8.5	40.2	1.7	153.1	4.7	153.1	5.2
Facility Costs	28.3	3.4	16.8	1.7	65.2	2.8	91.7	2.8	98.9	3.4
Other Costs	173.8	21.2	82.0	8.4	289.3	12.3	357.5	11.1	322.7	11.0
Total	819.1	100.0	977.4	100.0	2,350.0	100.0	3,230.3	100.0	2,937.1	100.0
Revenue										
Collected Fee	753.7	92.0	1,027.0	105.1	2,363.4	100.6	2,797.7	86.6	2,724.2	92.8
Balance	-65.4	-8.0	49.6	5.1	13.4	0.6	-432.6	-13.4	-212.9	-7.2

Source : Dong Anh Irrigation Enterprise

TABLE E-3.1.3. OPERATION AND MAINTENANCE COSTS OF GIA LAM IRRIGATION ENTERPRISE (1989-93)

Items	1989		1990		1991		1992		1993	
	Amount (M.Dong)	Rate (%)	Amount (M.Dong)	Rate (%)	Amount (M.Dong)	Rate (%)	Amount (M.Dong)	Rate (%)	Amount (M.Dong)	Rate (%)
Expenditure										
Salary & Ins.	47.4	11.0	113.1	16.4	180.4	12.6	160.0	6.7	261.1	11.5
Elect.Charge	255.4	59.5	229.2	33.2	575.3	40.3	1,373.5	57.2	1,162.5	51.3
Struct.Repair	34.9	8.1	63.4	9.2	108.2	7.6	196.9	8.2	177.4	7.8
E & M Repair	43.2	10.1	67.9	9.8	88.0	6.2	181.5	7.5	119.8	5.3
Other Costs	48.4	11.3	217.5	31.4	474.2	33.3	489.1	20.4	546.5	24.1
Total	429.3	100.0	691.1	100.0	1,426.1	100.0	2,401.0	100.0	2,267.3	100.0
Revenue										
Collected Fee	540.7	125.9	735.0	106.4	1,575.1	110.4	1,894.5	78.9	1,974.7	87.1
Balance	111.4	25.9	43.9	6.4	149.0	10.4	-506.5	-21.1	-292.6	-12.9

Source : Gia Lam Irrigation Enterprise

TABLE E-3.1.4. WATER COSTS PER CU.M (Unit:Dong/cu.

Station	1989		1990		1991		1992		1993
	Cu'nt.	'93 P.	Cu'nt.	'93 P.	Cu'nt.	'93 P.	Cu'nt.	'93 P.	Cu'nt.
Phu Lam	6.4	19.5	6.2	17.3	15.0	15.9	19.9	18.6	36.0
Tri Phuong	8.9	27.2	6.1	17.0	19.9	21.1	36.7	34.4	42.3
Noi Due	11.0	33.7	8.8	24.5	30.6	32.4	20.7	19.4	116.1
Tan Chi	4.6	14.0	8.4	23.6	14.8	15.7	18.7	17.6	31.7
Thai Hoa	5.0	15.3	6.1	17.1	12.3	13.0	21.0	19.7	44.6
Cach Bi	5.0	15.3	5.8	16.3	11.6	12.3	21.0	19.7	45.0
Chau Cau	5.4	16.7	8.2	23.0	4.8	5.1	35.8	33.6	41.4
Que Tan	4.5	13.7	5.3	14.8	10.3	10.9	21.4	20.1	46.9
Viet Thong	4.3	13.2	4.5	12.6	9.7	10.3	34.2	32.1	35.6
Kim Doi	4.6	14.2	5.0	14.1	8.8	9.3	13.9	13.0	35.3
Hien Luong	4.1	12.7	4.0	11.2	8.2	8.7	17.2	16.2	31.5
Pha Lai					9.3	9.9	16.2	15.2	31.3
Xuan Vien	5.0	15.2	5.9	16.5	11.6	12.3	21.6	20.3	48.2
Huu Chap	4.7	14.5	4.8	13.5	10.7	11.4	19.1	17.9	29.6
Dang Xa	2.6	8.0	3.2	8.9	6.2	6.6	11.1	10.4	26.5
Trinh Xa	13.5	41.5	5.1	14.4	14.2	15.1	21.0	19.7	43.9
Average	6.0	18.3	5.8	16.3	12.4	13.1	21.8	20.5	42.9

TABLE E-3.1.5. REPAIR COSTS PER OPERATION HOUR (Unit:Dong/hr)

Station	1989		1990		1991		1992		1993	Ave.
	Cu'nt.	'93 P.	Cu'nt.	'93 P.	Cu'nt.	'93 P.	Cu'nt.	'93 P.	Cu'nt.	(per hr)
Phu Lam	1,045	3,207	573	1,609	222	236	717	673	3,897	1,924
Tri Phuong	2,708	8,307	437	1,227	2,899	3,074	10,356	9,719	12,112	6,888
Noi Due		8,659	1,656	4,652	11,467	12,516	856	804	40,174	13,361
Tan Chi	141	433	2,857	8,027	4,175	4,425	545	511	3,377	3,355
Thai Hoa	51	157	11	30	234	248	625	587	1,920	588
Cach Bi	78	240	6	18	328	348	498	468	4,369	1,089
Chau Cau	65	199	982	2,760	526	558	8,512	7,988	2,633	2,828
Que Tan	133	407	51	143	392	415	1,193	1,120	9,140	2,245
Viet Thong	98	302	8	22	546	579	13,221	12,407	1,571	2,976
Kim Doi	5,993	18,381	6,843	19,228	3,652	3,871	3,995	2,810	3,863	9,631
Hien Luong	1,207	3,703	2,305	6,476	4,800	5,089	31,988	30,019	22,436	13,545
Pha Lai					9,416	9,981	8,906	8,358	13,159	6,300
Xuan Vien	590	1,809	5,573	15,661	384	407	940	882	13,575	6,467
Huu Chap	361	1,106	219	615	544	577	621	583	762	729
Dang Xa	424	1,301	935	2,629	1,839	1,949	2,954	2,772	12,251	4,180
Trinh Xa	828	2,538	1,274	3,681	9,121	9,669	5,760	5,406	1,037	4,466
Average	980	3,383	1,582	4,452	3,159	3,371	5,730	5,319	9,142	5,036

FIGURE E-3.1.1. ORGANIZATION CHART OF BAC DUONG IRRIGATION ENTERPRISE