KINGDOM OF THAILAND
MINISTRY OF INTERIOR
PUBLIC WORKS DEPARTMENT

FEASIBILITY STUDY ON THE NONG KHO–LAEM CHABANG WATER PIPELINE PROJECT

SUPPORTING REPORT

MARCH 1984

JAPAN INTERNATIONAL COOPERATION AGENCY

KINGDOM OF THAILAND
MINISTRY OF INTERIOR
PUBLIC WORKS DEPARTMENT

FEASIBILITY STUDY
ON
THE NONG KHO--LAEM CHABANG WATER PIPELINE PROJECT

SUPPORTING REPORT

MARCH 1984

JAPAN INTERNATIONAL COOPERATION AGENCY

LIST OF REPORTS

MAIN REPORT

SUPPORTING REPORT

I TOPOGRAPHIC SURVEY

II HYDROLOGY

III GEOLOGY AND SOIL MECHANICS

IV WATER DEMAND PROJECTION

V ENGINEERING DATA AND PRICED BILL OF QUANTITY

ABBREVIATION AND LOCAL TERMS

A. ABBREVIATION OF MEASURES

(1) Length	mm	=	millimetre
	cm	=	centimetre
	m	=	metre
	km	=	kilometre
(2) Area	m^2	=	square metre
	ha	=	hectare = 10^4 m^2
	km^2	=	square kilometre = 10^6 m^2
	rai	=	0.16 ha
(3) Volume	lit, l	=	litre = 1,000 cm^3
	kl	=	kilolitre = 1 m^3
	MCM	=	million cubic metres = 1,000,000 m3
(4) Weight	mg	=	milligramme
	g	=	gramme
	kg	=	kilogramme
	t	=	ton = 1,000 kg
	qwt	=	quintal = 100 kg
(5) Time	s	=	second
	min	=	minute
	h	=	hour
	d	=	day
	yr	=	year
(6) Money	฿	=	Baht (unit of Thai Currency, US$ 1 = ฿ 23.0 = ¥ 230)
	US$	=	US dollar
	¥	=	Japanese Yen

(7) Electric Measures

kV	=	kilovolt
kW	=	kilowatt
MW	=	megawatt = 1,000 kW
kWh	=	kilowatt hour
kVA	=	kilovolt ampere

(8) Other Measures

Alk.	=	alkalinity
mmho	=	micromho = conductance
ppm	=	parts per million
ppb	=	parts per billion
%	=	per cent
PS	=	0.736 kW
pH	=	scale for acidity
RSC	=	residual sodium carbonate
SAR	=	sodium adsorption ratio
SSP	=	soluble sodium percentage
TH.	=	total hardness
o	=	degree
'	=	minute
"	=	second
^{o}C	=	degree centigrade

(9) Derived Measures Based on the Same Symbols

m^3/s	=	cubic metre per second
t/ha	=	ton per hectare
MCM/yr	=	million cubic metre per year
lcd	=	litre per capita per day

B. OTHER ABBREVIATIONS

ASTM	=	American Society for Testing and Material
GDP	=	gross domestic product
GRP	=	gross regional product

El.	=	elevation
H.W.L.	=	high water level
L.W.L.	=	low water level
SD	=	sanitary district
DA	=	development area
NDA	=	non-development area
FOB	=	free on board
CIF	=	cost, insurance and freight

C. ABBREVIATION OF ORGANIZATIONS

DCD	Department of Community Development
DH	Department of Health
DOLA	Department of Local Administration
EGAT	Electricity Generation Authority of Thailand
IEAT	Industrial Estate Authority of Thailand
JICA	Japan International Cooperation Agency
LDD	Land Development Department
MD	Meteorology Department
MOI	Ministry of Industry
MWWA	Metropolitan Water Works Authority
NEB	National Environment Board
NESDB	National Economic and Social Development Board
NHA	National Housing Authority
NSO	National Statistical Office
OARD	Office of Accerelated Rural Development
OECF	Overseas Economic Cooperation Fund (Japan)
PAT	Port Authority of Thailand
PEA	Provincial Electricity Authority
PWD	Public Works Department
PWWA	Provincial Water Works Authority

RID	Royal Irrigation Department
SRT	State Railway of Thailand
TAT	Tourism Authority of Thailand
TCPD	Town and City Planning Department
WHO	World Health Organization

D. LOCAL TERMS

Changwat	Province
Amphoe	District (Township)
Tambon	Township (Town)
Muban	Village
Muang	Administrative Center of Province
King Amphoe	Sub-district
Mae Nam	River
Khwae	Main tributary of a river
Huai	Stream, creek or small tributary
Khlong	Canal
Khao	Mountain

SUPPORTING REPORT I

TOPOGRAPHIC SURVEY

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

1. INTRODUCTION

The topographic survey, consisting of traverse survey, route survey and topographic mapping, was carried out during the period from September 10 to November 24, 1983 by the PWD's surveying crew under a technical guidance of Survey Guidance Engineer of JICA Study Team. For smooth performance of the works, technical specifications were prepared by the Survey Guidance Engineer prior to commencement of the works. During the course of work, the Survey Guidance Engineer conducted a lecture on theory and practice on topographic survey and on-the-job trainning for the PWD's surveyors as a part of transfer of knowledge.

In addition to the above topographic survey, a survey on right of way and land price was carried out by a task force of the PWD in order to estimate the land acquisition cost and to grasp the right of way along the prospective raw water pipeline route. The survey result was delivered to the JICA Study Team in November 28, 1983.

2. AVAILABLE SURVEY DATA

2.1 Topo-maps and Aerial-photos

The under-listed topographic maps and aerial-photos have been made available through the PWD.

	Scale	Contour intervals (m)	Covering area	Data source
Topographic map	1/2,000	5	Laem Chabang	TCPD
Topopraphic map/1	1/4,000	5	Laem Chabang	TCPD
Topographic map/1	1/10,000	5	Laem Chabang	TCPD
Topographic map	1/10,000	1	Nong Kho reservoir	RID
Topographic map	1/2,000	1	Nong Kho damsite	RID
Aerial-photo	1/15,000	-	Study Area	RTSD

2.2 Coordinates and Datum Level

For construction of Nong Kho dam, 6 basic control points had been installed by the RID, of which 4 points, Nos 1, 2, 5 and 6 are still existing. However their true coordinates are not exactly known, because they have been moved in a number of times during construction of Nong Kho dam. According to the result of check survey, a control point No. 2 precisely shows the original coordinates and its bearing toward the point No. 5 is nearly the same with the original. Therefore, the control point No. 2 is adopted as basic coordinates point of the project. The coordinates and bearing at the control point No. 2 are as follows.

/1 : Reproduced from topographic maps in a scale of 1 to 2,000

Coordinates : N = 80,122.680

E = 11,502.948

Bearing (No.2 - No.5) : 139°26'25"

The locations of the control points Nos. 2 and 5 are shown in Fig. 1.

The datum level of the project is baed on the following two bench marks.

Bench Marks	Established by	Elevation (m)
BM No. 2	RID	69.923
BM 1413	RTSD	22.379

The locations of the above two bench marks as shown in Fig. 1.

3. TOPOGRAPHIC SURVEY

3.1 Traverse Survey

The purposes of the traverse survey are (i) to provide a geometric data and (ii) to facilitate a route survey. It is foreseen that the raw water pipeline will be aligned mostly along the existing roads. Thus the traverse network is arranged along the most prospective pipeline routes as shown in Fig. 2.

The number of traverse station is 112 and total length is 27 km. Out of 112 traverse stations, 20 traverse stations have been provided with permanent monument for future detailed survey and construction. The locations of the permanent monuments are shown in Fig. 1 and in more detail Reference Data, which is attached to this supporting report.

(1) Angle Observation

Horizontal angle observation was conducted in two full series by means of direction method. The first and second series were conducted at initial headings "0^{o}" and "90^{o}" respectively. A series observation consisted of observations at positions of "R" and "L"; in position "R" sighting was made in order of the first direction and the second direction and in position "L" it was vice versa.

For Angle observation, theodolite, Nikon NT-5 with a calibration of one second was used.

(2) Distance Measurement

The distance measurement was carried out by using an electro optical distance meter and reflection of prism type. It was conducted at least 4 times for each measuring line and maximum tolerance among measurements was limited to 10 mm.

(3) Allowable Error

a. Horizontal angle

Between 1st and 2nd readings;	30"
Between 1st and 2nd series;	20"

b. Vertical angle

Constant error;	30"

c. Error of closure in closed traverse

Horizontal angle;	$10" + 10"/\sqrt{n}$
(n = number of traverse station)	

d. Coordinates; $10 \text{ cm} + 10 \text{ cm} /\sqrt{s}$ and 1/5,000, in terms of ratio of closure

(s = total length of traverse)

(4) Actual survey result

Total length of traverse;	27 km
Number of traverse station;	112
Error of closure	
Horizontal angle;	0° - 01' - 06"
Coordinates;	1.26 m
Ratio of closure;	1/18, 132

The result of the traverse survey is compiled in Table 1. The coordinates of the permanent stations are shown in Fig. 2.

3.2 Route Survey

3.2.1 Staking

The traverse line has been treated as hypothetic center line of raw water pipeline in order to expedite the surveying works. Chain pegs were staked at intervals of 50 m along the hypothetic center line by using the theodolite and steel measuring tape. In addition, plus pegs were also installed at such locations as both sides of road, railway, drain and stream, change in slopes, etc.

3.2.2 Longitudinal Profile Survey

All stakes and traverse stations were level-surveyed. Their elevations were calculated based on the datum levels given in Chapter 2.

The levelling was conducted by means of round levelling method. An allowable error has been set forth below.

Round levelling ; $20 \text{ mm} \sqrt{S}$

Link ; $20 \text{ mm} \sqrt{S}$

(S = total length of levelling)

The result of the round levellings is within the above limit. The difference between, BM No. 2 and BM 1413 is 47.544 m, while it is 47.685 m according to the survey results. A closing error is, therefore, 0.141 m, exceeding the allowable limit by 0.037 m. It is however advisable to conduct the levelling between BM No. 2 and BM 1413 in order to confirm accuracy of BM No. 2. According to the RID, BM No. 2 was established in conjuction with a bench mark in the Bang Phra damsite.

3.2.3 Cross-sectional Survey

The cross-sectional survey awas conducted at each stake and its extent covers 50 m to the left and right sides from a center of existing road.

3.3 Topographic Mapping

The topographic maps were prepared along the pipeline routes and major structure sites.

(1) Pipeline Route

The topographic map was prepared in a scale of 1 to 2,000 with 0.5 m contour intervals. The mapping area is approximately 270 ha and is compiled in 20 sheets. The mapping was made mainly by plane table survey.

(2) Major Structure Sites

The surveyed major structure sites are the Khlong Yai and Huai Lek rivers crossing, railway crossing and receiving well. The former three sites were mapped in a scale of 1 to 200 with 0.5 m contour intervals and the latter in a scale of 1 to 1,000 with 0.5 m contour intervals. The topographic maps are prepared all for structure sites, excepting the Khlong Yai river.

4. RIGHT OF WAY AND LAND PRICE SURVEY

4.1 General

The right of way along existing roads and land price were surveyed by the PWD's task force in accordance with mutual agreement between the PWD and the Study Team. The result of the survey is reported in this chapter referring to the PWD's report.

The data and information on right of way and land acquisition cost have been obtained from 10 village chiefs, who are listed up in Table 2.

4.2 Right of Way

The right of way was investigated along existing roads, along which the raw water pipeline will be aligned. A width of the right of way is 6 - 8 m. For construction of the raw water pipeline, land expropriation is therefore required.

4.3 Land Price

The land acquisition cost along the Middle and South Routes was obtained from village chiefs listed in Table 2. Fig. 4 shows the land price per rai.

The compensation cost was also obtained for tree crops and upland crops as tabulated below.

Items	Compensation Cost (฿/Rai)
Cassava	80,000
Sugarcane	20,000
Coconut tree	70,000
Papaya, orange, etc.	30,000

TABLES

Table 1 RESULTS OF TRAVERSE SURVEY (1/7)

REACH: BM NO.2 - TP4

STATION	X	Y	H	S	A
BM.NO2	80122.680	11502.948	69,923		
				1649.686	139 36 34
A	78866.204	12571.935			
				37.514	229 08 16
IP1	78841.561	12543.564	58,668		
				142.362	229 22 32
IP2	78748.969	12435.512	59,024		
				881.359	319 24 26
IP3	79418.232	11862.030	56,403		
				806.945	220 34 01
IP4	78805.239	11337.245	56,268		

Table 1 RESULTS OF TRAVERSE SURVEY (2/7)

REACH: TR4-TP215J, along South Route (1)

STATION	X	Y	H	S	A
TP4	78805.239	11337.245	56,268		
				83.101	191 25 58
TP5	78723.787	11320.773	56,274		
				225.130	203 20 58
TP6	78517.094	11231.545	53,199		
				263.536	189 03 09
TP7	78256.841	11190.080	50,598		
				485.337	214 24 30
TP8	77856.423	10915.822	46,818		
				135.466	204 10 18
TP9	77732.834	10860.352	46,265		
				92.218	186 21 28
TP10	77641.183	10850.140	45,788		
				141.278	160 21 12
TP11	77508.130	10897.640	45,536		
				135.340	197 33 01
TP12	77379.090	10856.829	46,043		
				609.831	218 47 11
TP13	76903.735	10474.820	44,519		
				245.983	207 49 03
TP14	76686.178	10360.030	43,355		
				135.265	191 24 04
TP15	76553.582	10333.291	41,041		
				60.819	179 42 29
TP16	76492.764	10333.601	40,603		
				145.805	162 59 40
TP17	76353.334	10376.244	42,609		
				158.073	152 17 23
TP18	76213.390	10449.748	43,092		
				160.848	175 17 52
TP19	76053.083	10462.934	42,629		
				124.931	214 09 51
TP20	75949.711	10392.777	43,799		
				151.338	198 51 11
TP21	75806.492	10343.873	43,933		
				57.665	169 50 49
TP22	75749.730	10354.038	43,891		
				127.231	140 54 34
TP23	75650.980	10434.263	44,445		
				54.021	177 38 18
TP24	75597.005	10436.489	44,862		
				229.829	258 43 53
TP25	75552.094	10211.091	43,751		
				71.259	247 01 28
TP26	75524.279	10145.485	43,257		

Table 1 RESULTS OF TRAVERSE SURVEY (3/7)

REACH: TR4-215J, along South Route (2)

STATION	X	Y	H	S	A
IP26	75524.279	10145.485	43,257		
				130.668	226 17 58
IP27	75434.002	10051.017	42,427		
				107.718	273 32 18
IP28	75440.650	9943.504	42,701		
				84.961	280 28 48
IP29	75456.104	9859.960	41,992		
				79.571	312 51 01
IP30	75510.219	9801.624	41,348		
				61.801	266 38 04
IP31	75506.591	9739.930	40,803		
				81.582	246 08 42
IP32	75473.597	9665.317	40,502		
				215.401	237 36 12
IP33	75358.190	9483.441	39,901		
				64.736	256 00 36
IP34	75342.540	9420.625	39,336		
				228.626	279 05 02
IP35	75378.636	9194.866	42,188		
				292.212	277 08 17
IP36	75414.946	8904.919	41,147		
				208.363	301 10 02
IP37	75522.782	8726.631	39,431		
				59.232	284 26 37
IP38	75537.556	8669.271	39,526		
				145.184	266 13 07
IP39	75527.981	8524.403	38,289		
				85.711	236 21 05
IP40	75480.489	8453.053	38,343		
				139.656	282 47 50
IP41	75511.423	8316.866	39,766		
				365.490	264 36 53
IP42	75477.130	7952.988	46,321		
				190.566	265 12 40
IP43	75461.221	7763.087	44,790		
				255.691	267 27 43
IP44	75449.905	7507.647	39,042		
				385.876	266 06 08
IP45	75423.674	7122.664	35,699		
				249.108	265 22 47
IP46	75403.608	6874.365	35,404		
				197.906	259 36 49
IP47	75367.928	6679.702	33,542		
				278.429	270 21 02
IP48	75369.631	6401.278	28,868		

Table 1 RESULTS OF TRAVERSE SURVEY (4/7)

REACH: TP4-215J, along South Route (3)

STATION	X	Y	H	S	A
IP48	75369.631	6401.278	28,868		
				140.445	256 38 41
IP50	75337.190	6264.631	27,432		
				118.831	205 54 02
IP51	75230.295	6212.724	27,064		
				64.455	228 22 32
IP52	75187.481	6164.543	26,520		
				50.074	203 20 35
IP53	75141.506	6144.702	26,343		
				150.592	199 52 45
IP54	74999.888	6093.495	25,533		
				89.295	222 39 44
IP55	74934.224	6032.982	25,044		
				75.218	219 16 42
IP56	74875.999	5985.362	24,765		
				299.501	194 54 32
IP57	74586.580	5908.305	24,423		
				275.727	268 27 50
IP58	74579.189	5632.677	23,672		
				1323.820	275 38 42
IP59	74709.409	4315.277	18,560		
				492.214	307 38 58
IP60	75010.067	3925.560	18,597		
				201.562	266 12 23
IP61A	74996.725	3724.340	18,125		
				279.932	282 32 39
IP62A	75057.524	3451.090	17,746		
				686.429	276 47 05
IP215J	75138.619	2769.468	15,584		

Table 1 RESULTS OF TRAVERSE SURVEY (5/7)

REACH: TP4-TP215J, along Middle Route (1)

STATION	X	Y	H	S	A
TP4	78805.239	11337.245	56,268		
				114.980	232 52 27
TP101	78735.841	11245.370	56,017		
				104.872	250 29 10
TP102	78700.810	11145.722	54,418		
				344.074	271 42 59
TP103	78711.115	10802.802	55,729		
				249.848	272 48 40
TP104	78723.368	10553.255	55,693		
				825.314	272 52 52
TP105	78764.850	9728.984	55,987		
				448.479	272 56 07
TP106	78787.816	9281.093	52,965		
				594.377	255 24 22
TP200	78638.054	8705.893	43,703		
				220.539	276 49 24
TP201	78664.256	8486.916	43,290		
				145.600	277 31 49
TP202	78683.337	8342.572	41,345		
				87.105	265 10 15
TP203	78676.004	8255.776	41,991		
				481.001	258 53 25
TP204	78583.315	7783.790	41,330		
				581.480	267 33 02
TP205	78554.190	7102.933	34,385		
				197.501	278 19 16
TP206	78582.773	6907.511	38,374		
				257.176	283 41 28
TP207	78643.643	6657.642	40,405		
				256.510	282 36 26
TP208	78699.631	6407.317	38,621		
				322.499	218 02 54
TP209	78445.666	6208.553	39,665		
				155.555	263 34 15
TP210	78428.248	6053.976	38,234		
				729.202	259 25 24
TP212	78294.404	5337.163	25,070		
				136.224	259 30 48
TP213	78269.610	5203.214	21,859		
				289.560	197 43 27
TP214	77993.794	5115.062	20,598		
				426.324	184 42 20
TP215	77568.907	5080.088	20,484		
				95.464	210 51 52
TP216	77486.962	5031.114	20,926		

Table 1 RESULTS OF TRAVERSE SURVEY (6/7)

REACH: TP4-TP215J, along Middle Route (2)

STATION	X	Y	H	S	A
TP216	77486.962	5031.114	20,926		
				197.292	201 21 50
TP217	77303.227	4959.243	21,509		
				210.422	227 03 26
TP218	77159.873	4805.207	21,250		
				311.196	234 55 39
TP219	76981.056	4550.516	21,395		
				185.230	248 51 11
TP220	76914.232	4377.760	20,707		
				104.848	242 17 19
TP221	76865.476	4284.938	20,565		
				221.551	211 43 37
TP222	76677.033	4168.431	20,493		
				505.389	192 28 41
TP223	76183.582	4059.233	20,582		
				296.979	248 12 19
TP224	76073.319	3783.482	19,282		
				76.154	281 22 22
TP66	76088.336	3708.823	19,332		
				480.479	195 04 23
TP65	75624.391	3583.864	18,680		
				118.119	291 48 04
TP64	75568.259	3474.193	18,320		
				171.528	219 13 00
TP63	75536.366	3365.744	18,041		
				117.326	213 57 21
TP62	75438.048	3300.211	17,736		
				91.417	229 54 00
TP61	75379.164	3230.284	17,525		
				405.394	238 55 28
TP60	75169.912	2883.069	16,140		
				117.832	254 35 57
TP215J	75138.619	2769.468	15,584		

Table 1 RESULTS OF TRAVERSE SURVEY (7/7)

REACH: TP215J-TP239-4

STATION	X	Y	H	S	A
TP215J	75138.619	2769.468	15.584		
				349.227	275 39 35
TP236	75173.060	2421.943	24.592		
				319.125	286 08 21
TP237	75261.767	2115.395	31.631		
				252.600	276 28 11
TP238	75290.229	1864.404	30.735		
				62.289	255 31 00
TP239	75285.360	1802.306	30.103		
				446.228	250 45 41
TP240	75138.327	1380.998	33.102		
				64.732	70 45 42
TP239-1	75159.656	1442.115	32.098		
				345.226	283 28 35
TP239-2	75240.109	1106.394	41.489		
				173.772	28 17 14
TP239-3	75393.130	1188.743	44.216		
				186.477	28 17 14
TP239-4	75557.338	1277.113	44.817		

Table 2. LIST OF VILLAGE CHIEFS

	Names	Villages
1.	Mr. Wichai Hitacharee	Moo 1, Tambon Nong Kham
2.	Mr. Sure Samrit	Moo 3, Tambon Nong Kham
3.	Mr. Pruang Bunprasart	Moo 5, Tambon Nong Kham
4.	Mr. Sombun Phetphloi	Moo 9, Tambon Nong Kham
5.	Mr. Tuan Prapnarong	Moo 1, Tambon Bung
6.	Mr. Ying Sukcharoen	Moo 3, Tambon Bung
7.	Mr. Nonthawat Yeamphaeng	Moo 5, Tambon Bung
8.	Mr. Chalieu Chueprathom	Moo 6, Tambon Bung
9.	Mr. Mongkhon Phanthusunthorn	Moo 9, Tambon Thung Sukhla
10.	Mr. Yiam Phummuang	Moo 10, Tambon Thung Sukhla

FIGURES

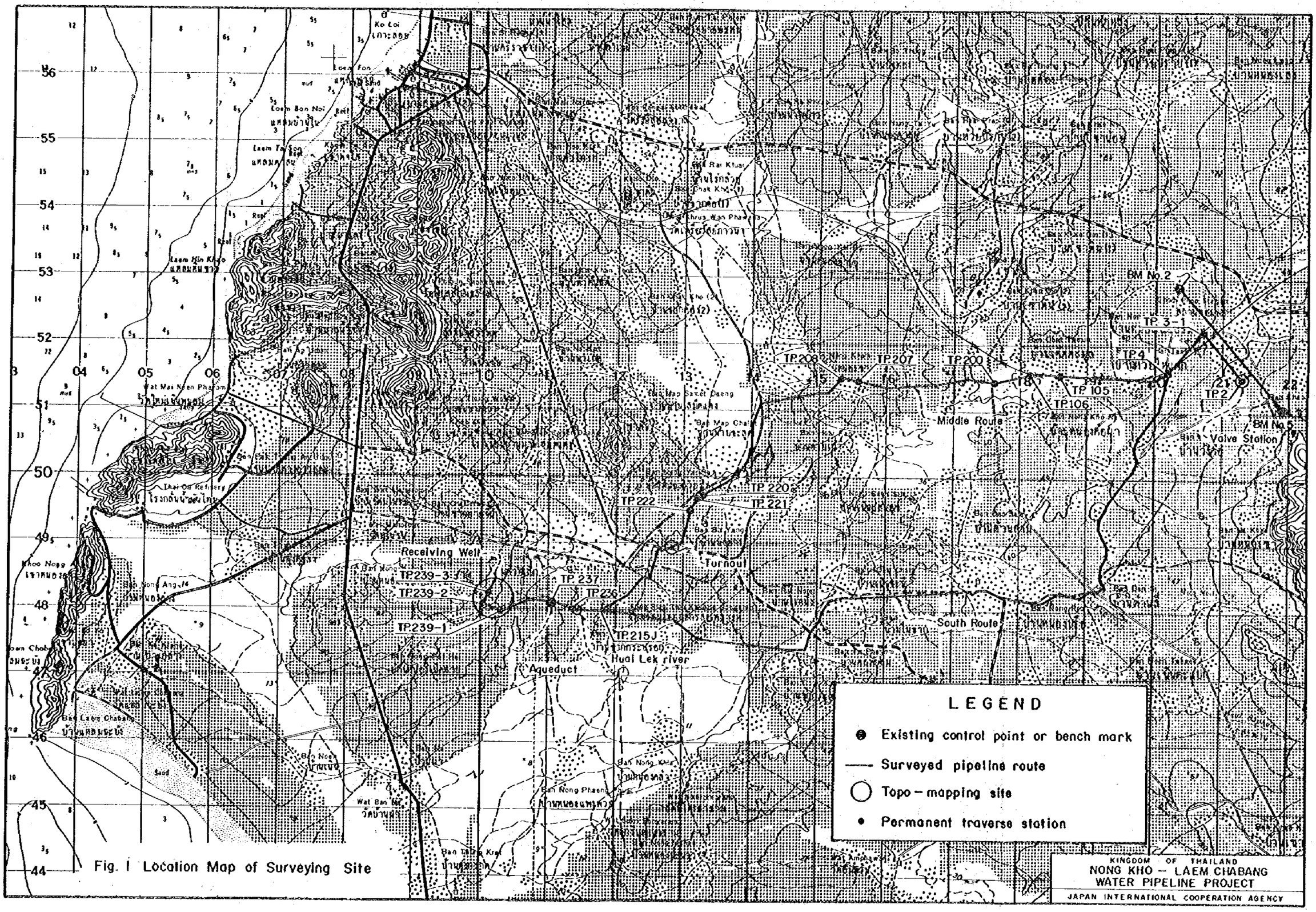
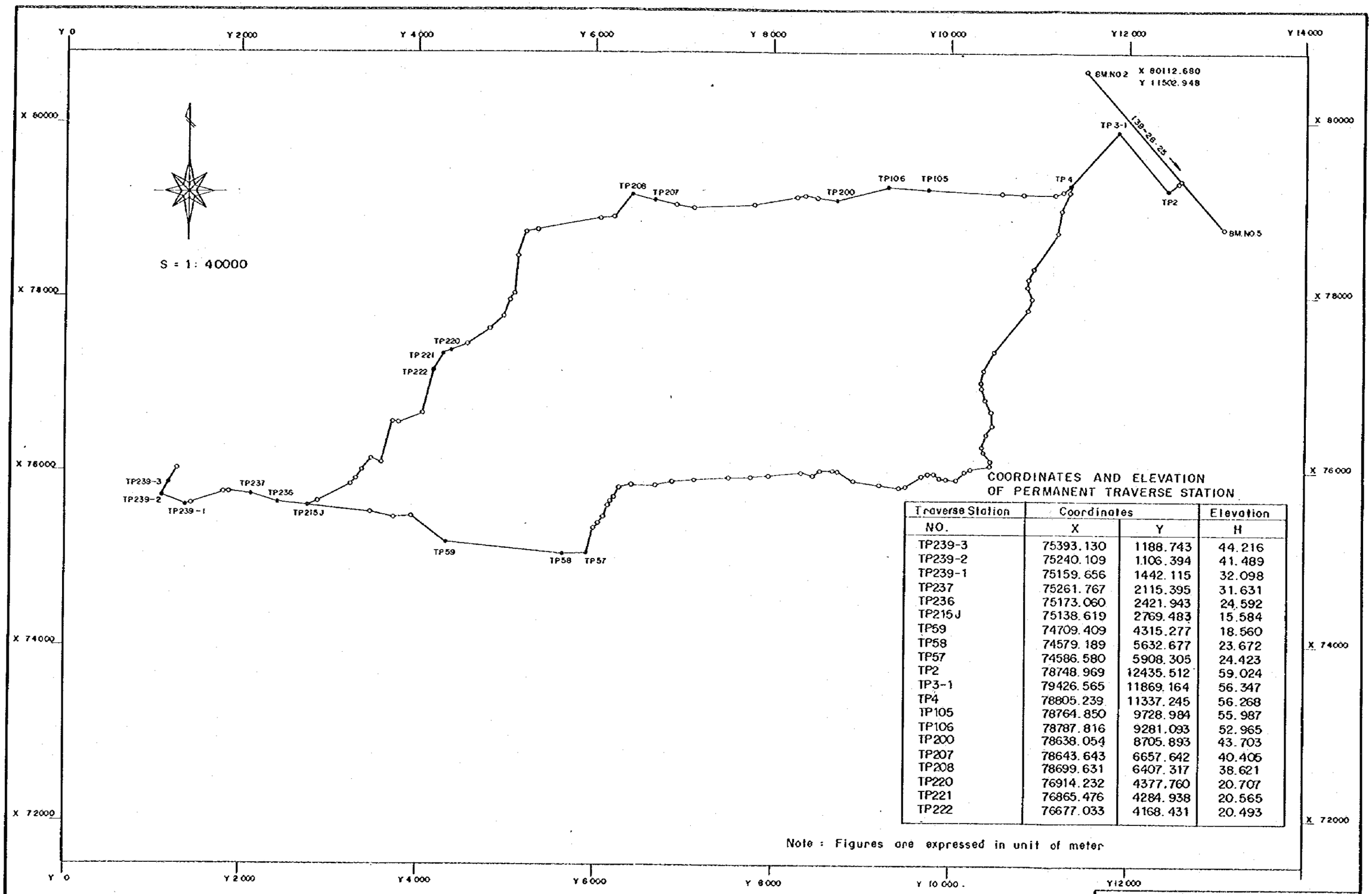


Fig. I Location Map of Surveying Site



COORDINATES AND ELEVATION
OF PERMANENT TRAVERSE STATION

Traverse Station	Coordinates		Elevation
NO.	X	Y	H
TP239-3	75393.130	1188.743	44.216
TP239-2	75240.109	1106.394	41.489
TP239-1	75159.656	1442.115	32.098
TP237	75261.767	2115.395	31.631
TP236	75173.060	2421.943	24.592
TP215J	75138.619	2769.483	15.584
TP59	74709.409	4315.277	18.560
TP58	74579.189	5632.677	23.672
TP57	74586.580	5908.305	24.423
TP2	78748.969	12435.512	59.024
TP3-1	79426.565	11869.164	56.347
TP4	78805.239	11337.245	56.268
TP105	78764.850	9728.984	55.987
TP106	78787.816	9281.093	52.965
TP200	78638.054	8705.893	43.703
TP207	78643.643	6657.642	40.405
TP208	78699.631	6407.317	38.621
TP220	76914.232	4377.760	20.707
TP221	76865.476	4284.938	20.565
TP222	76677.033	4168.431	20.493

Note : Figures are expressed in unit of meter

Fig. 2 Traverse Network

KINGDOM OF THAILAND
NONG KHO -- LAEM CHABANG
WATER PIPELINE PROJECT
JAPAN INTERNATIONAL COOPERATION AGENCY

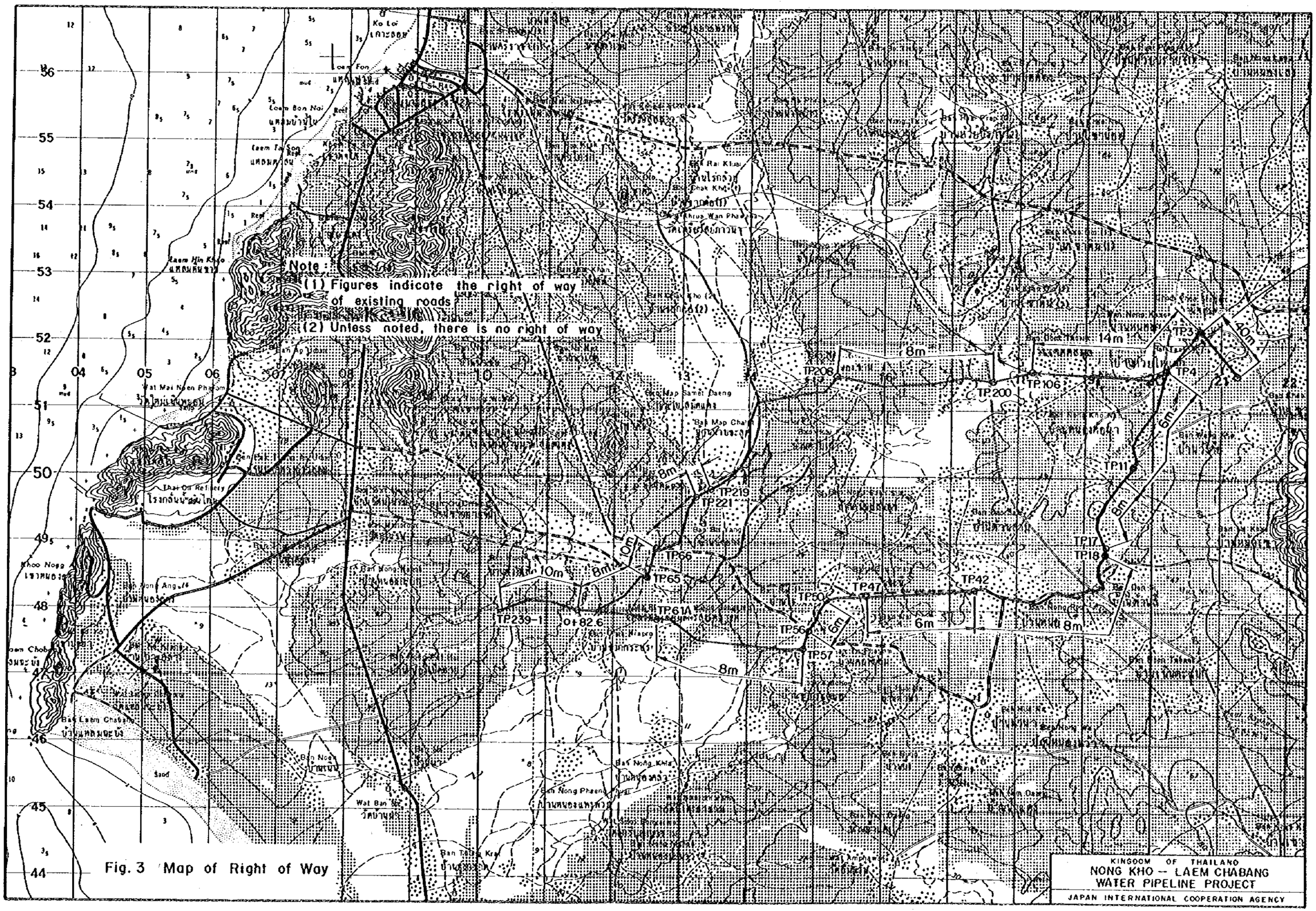


Fig. 3 Map of Right of Way

Note : Figures indicate land price in Baht per rai

Fig. 4 Map of Land Price

KINGDOM OF THAILAND
NONG KHO – LAEM CHABANG
WATER PIPELINE PROJECT
JAPAN INTERNATIONAL COOPERATION AGENCY