SECTOR F

MONITORING OF PILOT WORKS

THE STUDY ON MEKONG RIVERBANK PROTECTION AROUND VIENTIANE MUNICIPALITY IN THE LAO PEOPLE'S DEMOCRATIC REPUBLIC

FINAL REPORT
VOLUME 4
-SUPPORTING REPORT-

SECTOR F

MONITORING OF PILOT WORKS

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MONITORING OF PILOT WORKS

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a) Comparison of topographic survey results

Successive topographic surveys of riverbank profile had been conducted 3 times along lines as shown in Figure 1.1(1/3)-(3/3). First survey was done on February 2002, before construction work started. Second survey was done on June 2003, just after the completion of the construction work of the riverbank protection work. And the third one was done on January 2004 after the first flood season for the structure since its completion.

Along each cross sectional line, the profiles of riverbank and riverbed near the bank are compared in the same line as shown in Figure 1.2(1/6)-(6/6). By comparing the cross sectional profiles in different time, monitoring results on the variation of riverbank protection work and riverbank and riverbed are summarized as shown in Table 1.1.

Table 1.1 Comparison of Cross Sectional Profile near Riverbank at Ban Dongphosi Site

Location	Riverbank Structure	Monitoring Results
Line No.0+00 – No. 1+00	Existing riverbank protection work for the Friendship Bridge	Slightly small variation of profile is found, presumably small scale of local sedimentation and scoring.
Line No.1+20 – No. 2+00	Cobble stone with Willow Branch work + Riprap foundation work	No remarkable changes after the construction work are found.
Line No.2+20 – No. 4+20	Cobble stone with Willow Branch work + Riprap foundation work + SODA Mattress	No remarkable changes on the slope and the foundation part are found. Slightly small variation of the profile on the foot protection work are found, presumably due to un-even surface of SODA Mattress covered by ripraps.
Line No.4+40 – No. 5+60	Cobble stone with Willow Branch work + Riprap foundation work + SODA Mattress + Covering Stones	Covering riprap part is reduced on Line No.4+40 and increased on Line No.5+40. Front slopes of foundation along lines No.5+00, 5+60 are seemed to subside following the SODA mattress before.
Line No.5+80 – No. 6+60	Cobble stone with Willow Branch work + Riprap foundation work + SODA Mattress	Toe of the slope is slightly scored on Line No.6+00. At the foot protection part, riprap seems to be lost along lines of No.6+00, 6+20 and 6+60.
Line No.6+80 – No. 7+40	Cobble stone with Willow Branch work + Riprap foundation work	Slopes along Line No.7+00 – No.7+20 slightly subsided, especially on Line No.7+20. Foundation part is kept as the original profile.
Line No.7+60 – No. 8+40	Existing riverbank protection work in front of Culture Park	Toe of the slopes has subsided with a steep angle along lines of No.7+60 – No.7+80.

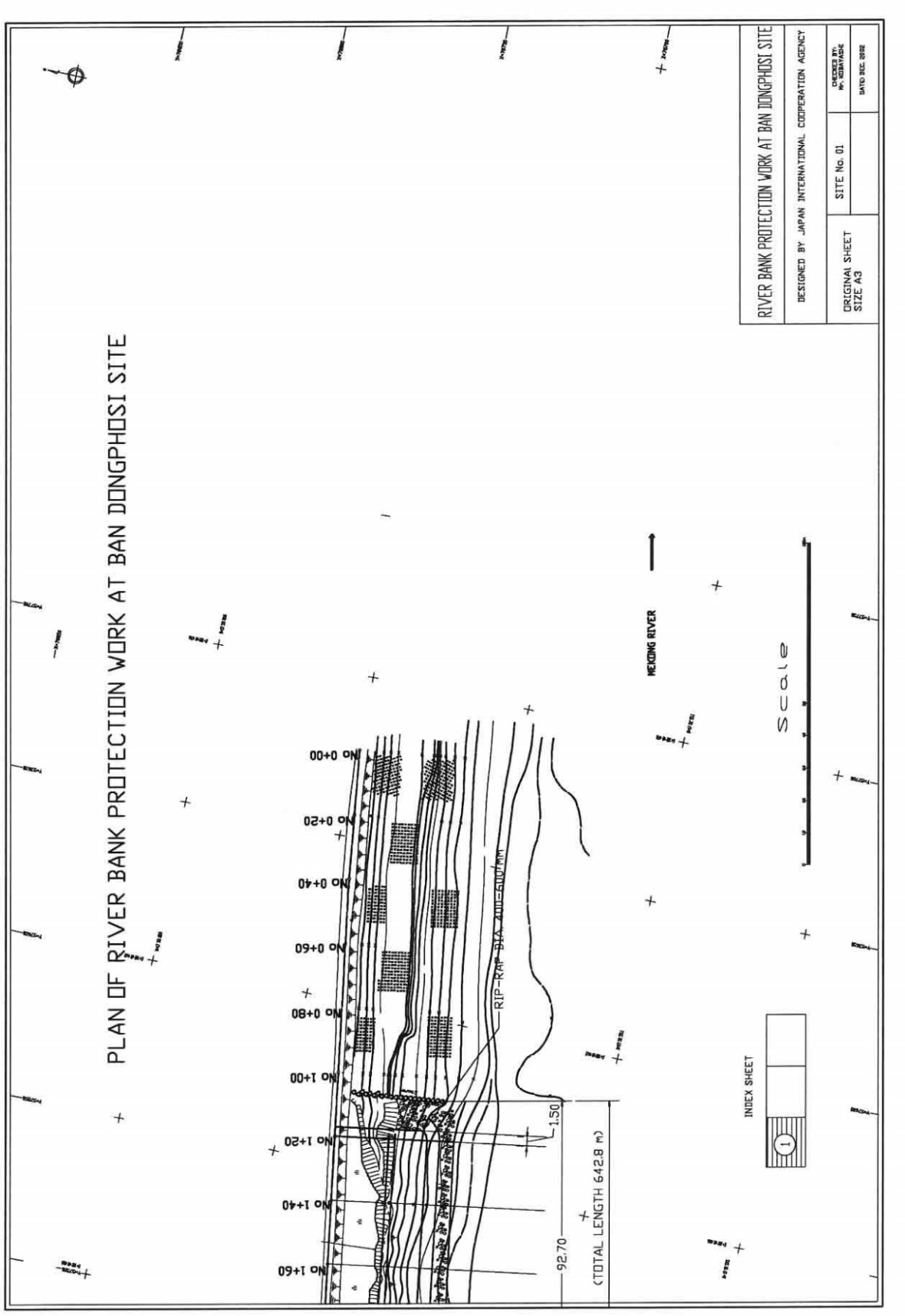


Figure 1.1(1/3) Location of Topographic Survey Lines at Ban Dongphosi Site

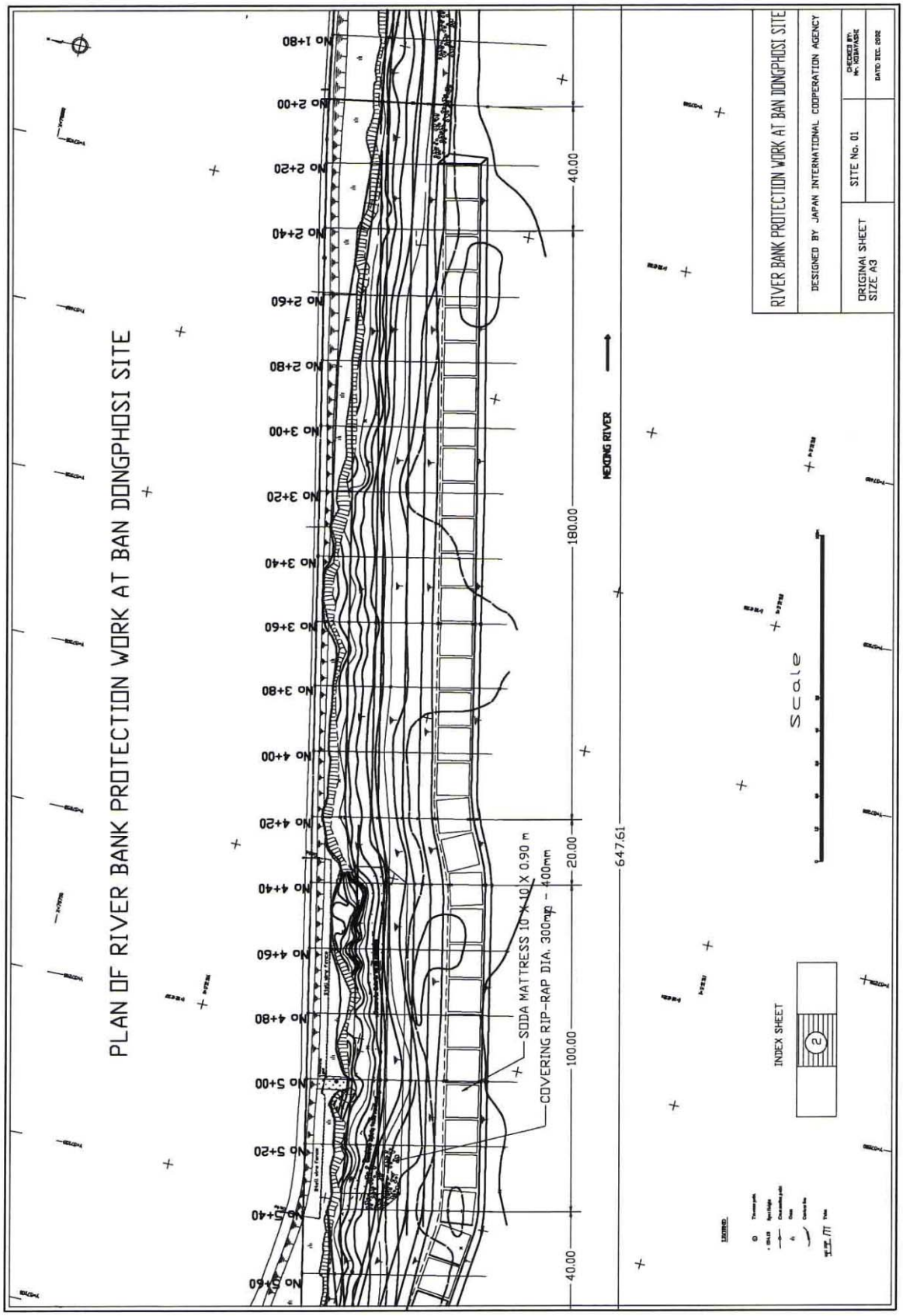


Figure 1.1(2/3) Location of Topographic Survey Lines at Ban Dongphosi Site

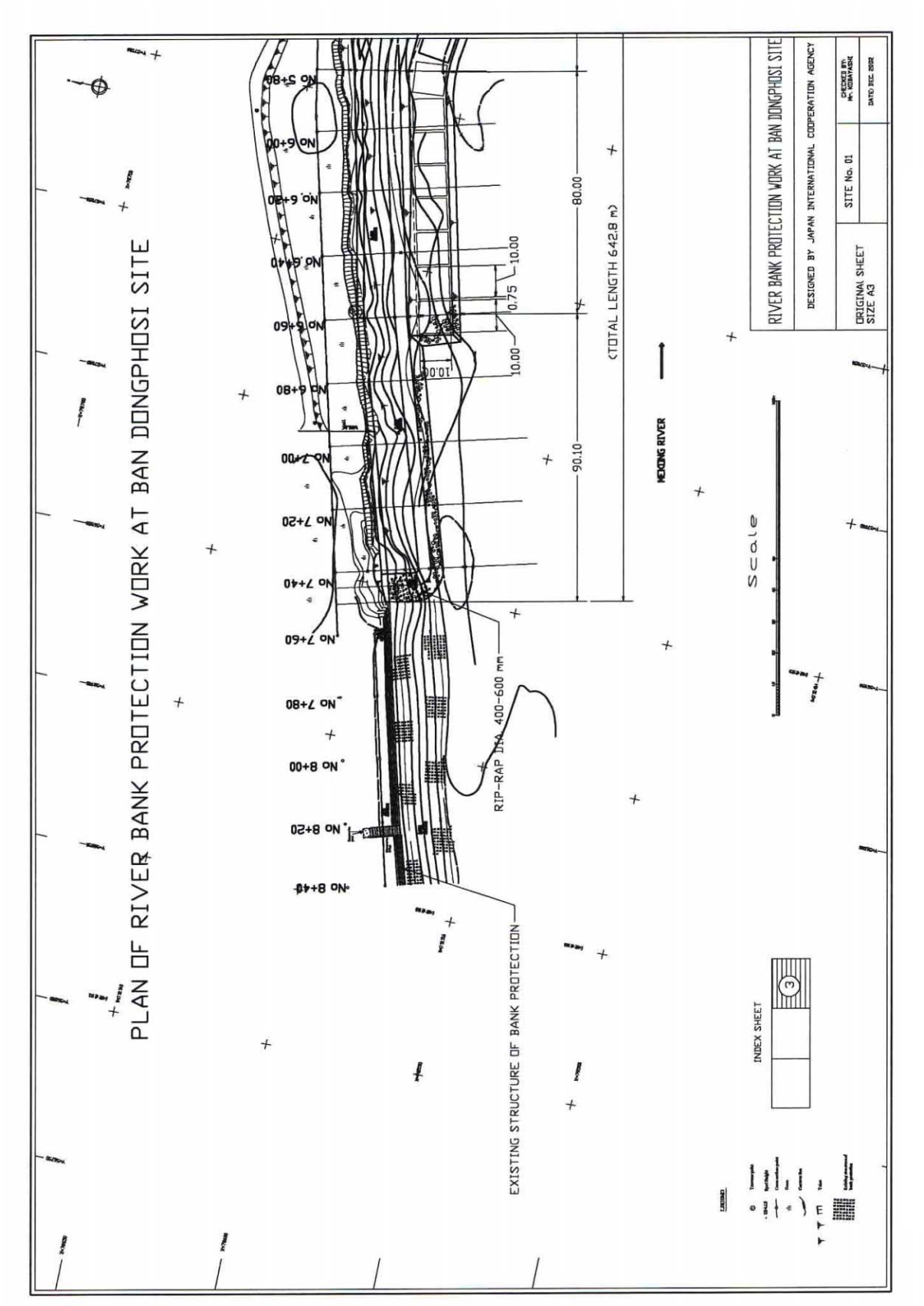


Figure 1.1(3/3) Location of Topographic Survey Lines at Ban Dongphosi Site

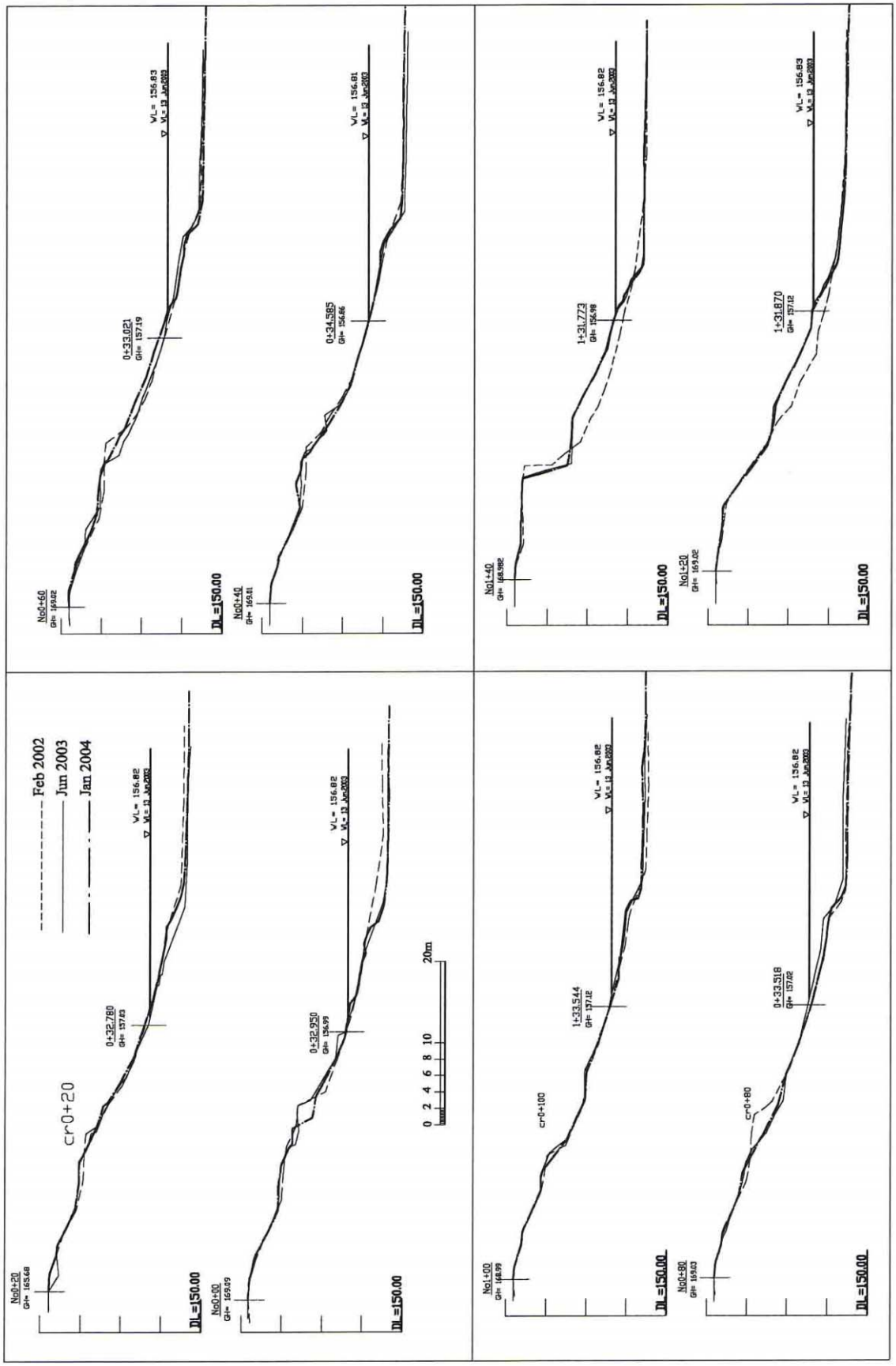


Figure 1.2(1/6) Comparison of Riverbank Profiles at Ban Dongphosi Site

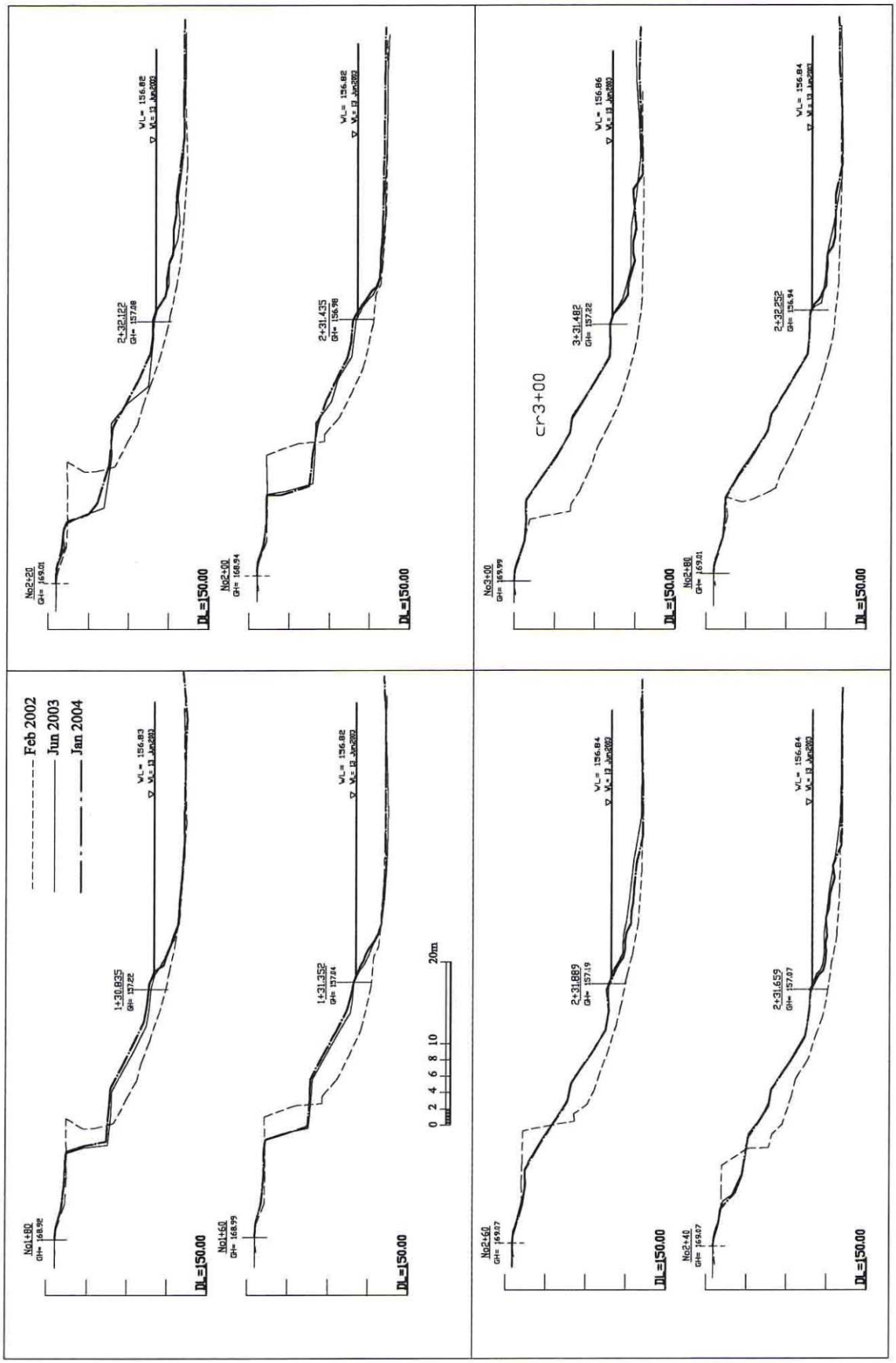


Figure 1.2(2/6) Comparison of Riverbank Profiles at Ban Dongphosi Site

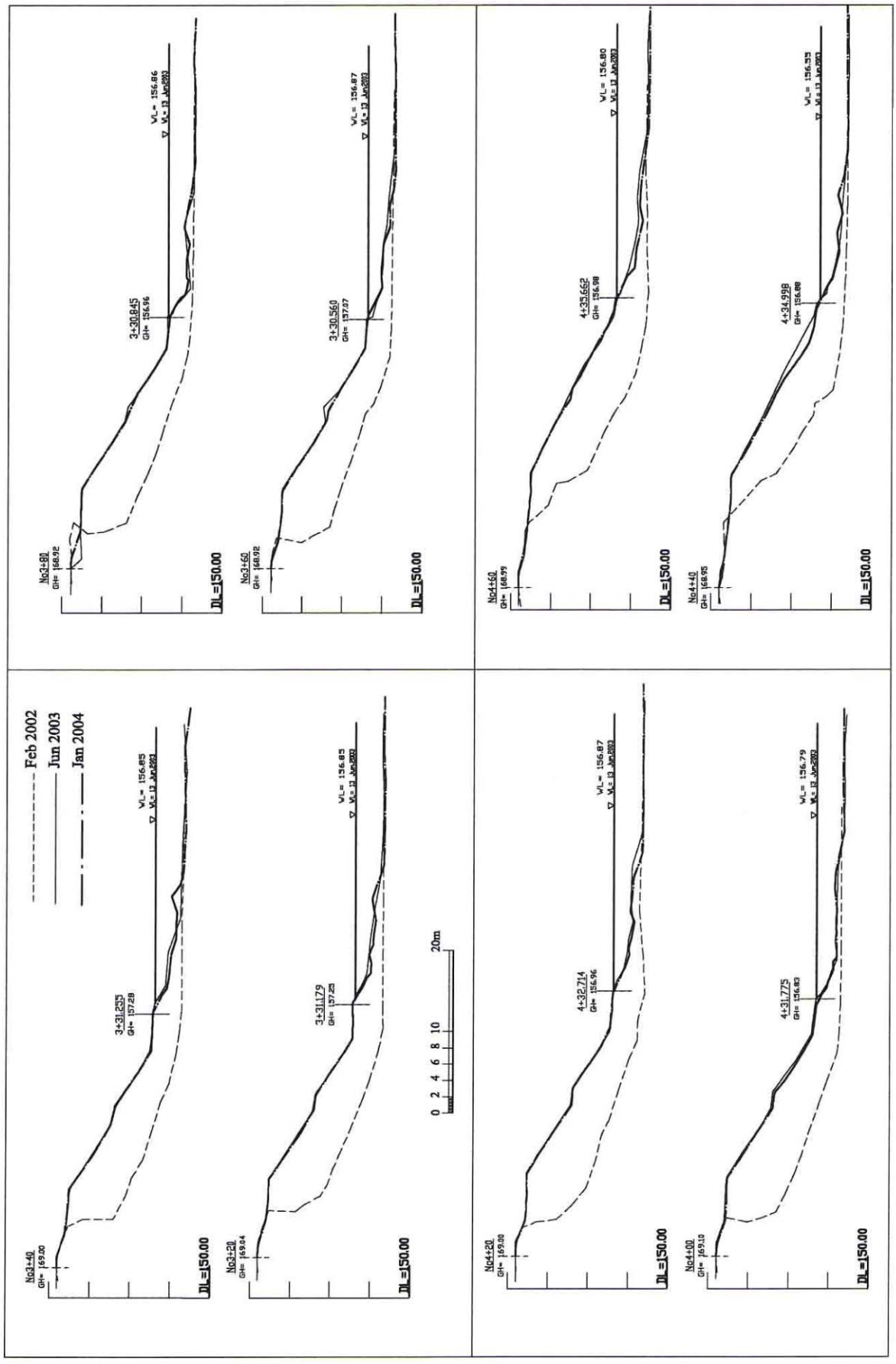


Figure 1.2(3/6) Comparison of Riverbank Profiles at Ban Dongphosi Site

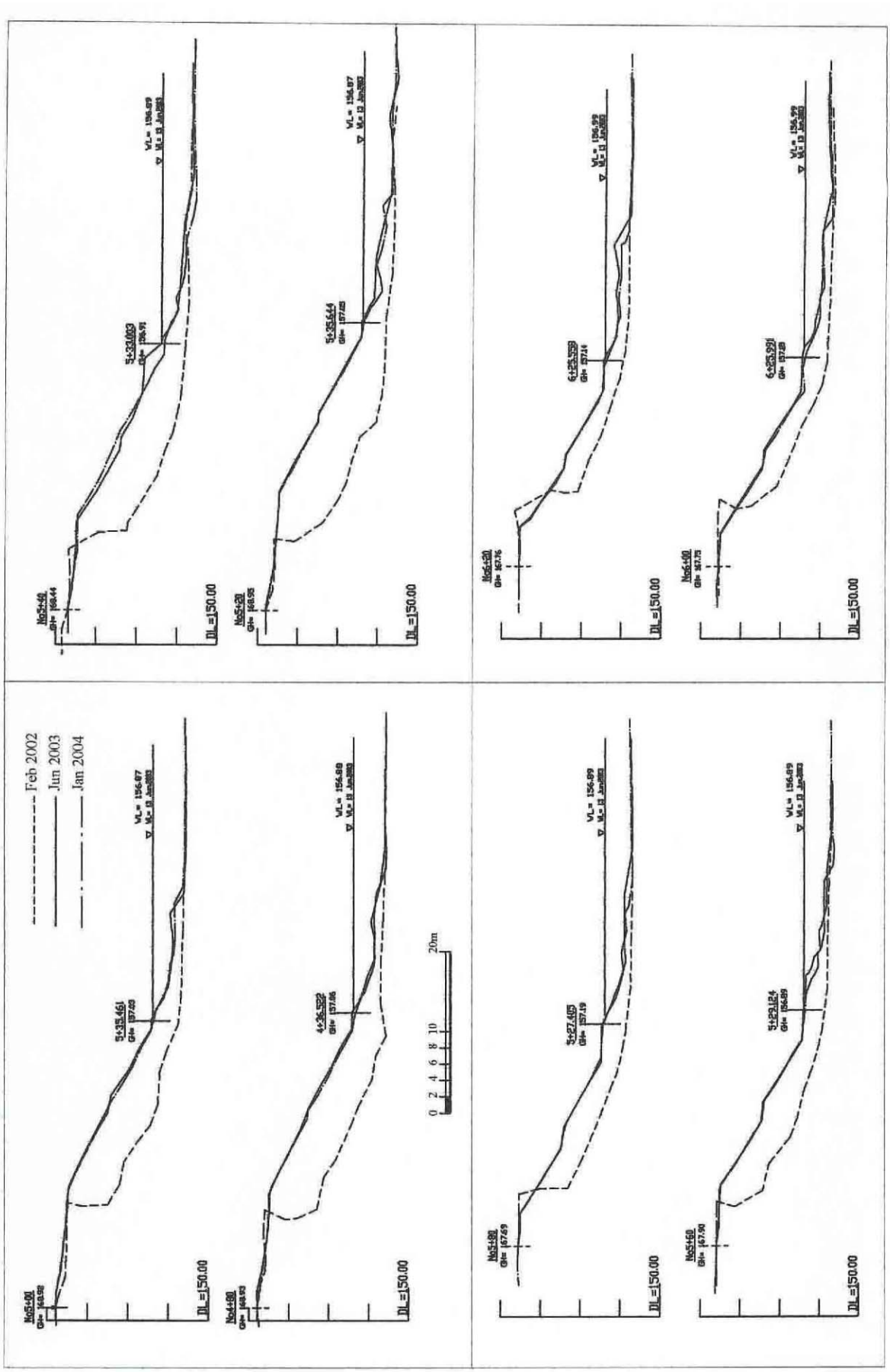


Figure 1.2(4/6) Comparison of Riverbank Profiles at Ban Dongphosi Site

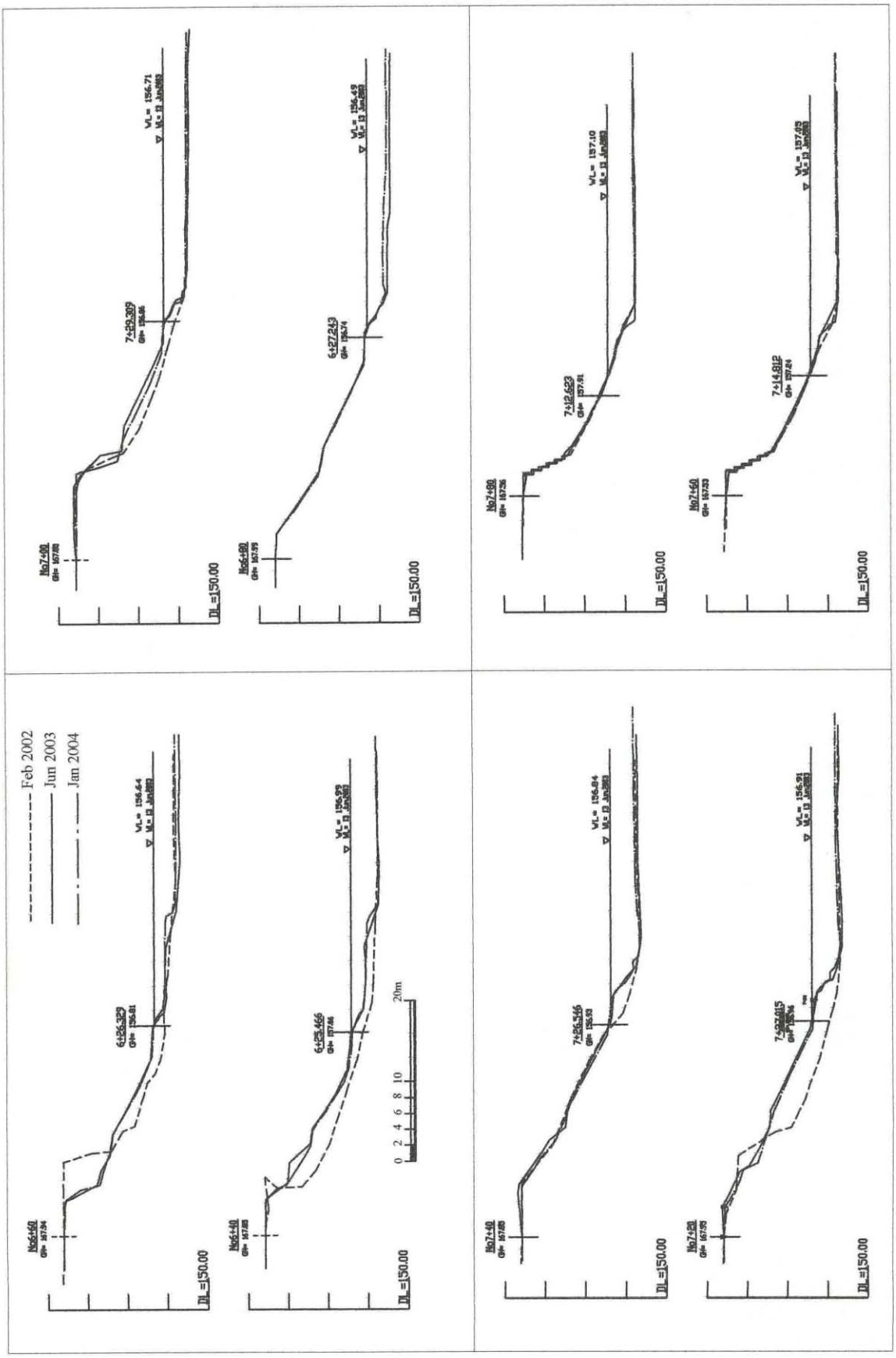


Figure 1.2(5/6) Comparison of Riverbank Profiles at Ban Dongphosi Site

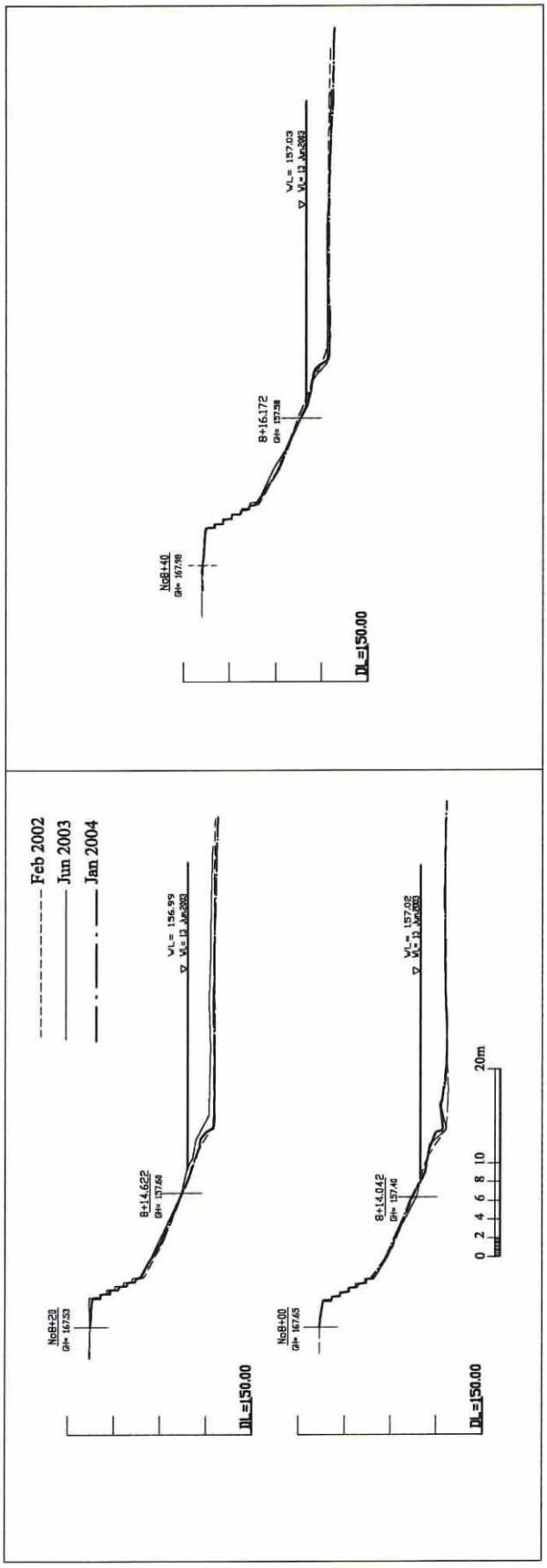


Figure 1.2(6/6) Comparison of Riverbank Profiles at Ban Dongphosi Site

b) Visual observation

Cobble Stone with Willow Branch Work as a slope protection work and riprap foundation work have kept almost their original formation, except slightly small scale of riprap stone movement on the slope around the whole area and local scoring at the toe of the slope along Line No.5+40 – No.5+52 with depth of approximately 0.4m and width and length of approximately 2m an 12m, respectively as shown in Figure 1.3. The latter part falls in the transition of cross sectional profile with slight weakness against erosion presumably due to increase of gap between the toe of the slope protection work and the riprap foundation work around the area.

As for the foot protection work, part of SODA mattress exposes its naked wooden basket frame in the low water as shown in Figure 1.4. Gaps between SODA mattress and the riprap foundation work are found, that could lessen the function of foot protection work.

Figure 1.3 Local Scoring at the toe of Slope Protection Work

Figure 1.4 Ripraps on SODA Mattress Work

c) Feedbacks to design

Through the monitoring works, the followings are derived for feedbacks to the design:

- Connection part between the toe of the slope protection work and the foundation work could be weak against local erosion in the flood season. To avoid this, enforcement with ripraps on the part will be effective.
- As for the foot protection work, supply of ripraps will be effective if further deformation of the foundation work is detected through successive monitoring works.

1.1.2 Wat Chom Cheng Site

a) Comparison of topographic survey results

Successive topographic surveys of riverbank profile around Wat Chom Cheng Site had been conducted 3 times along lines as shown in Figure 1.5. First survey was done on February 2002, before construction work started. Second survey was done on June 2003, just after the completion of the construction work of the riverbank protection work. And the third one was done on January 2004 after the first flood season for the structure since its completion.

Along each cross sectional line, the profiles of riverbank and riverbed near the bank are compared in the same figure as shown in Figure 1.6(1/3)-(3/3). By comparing the cross sectional profiles in different time, monitoring results on the variation of riverbank protection work and riverbank and riverbed are summarized as shown in Table 1.2.

Table 1.2 (1/2) Comparison of Cross Sectional Profile near Riverbank at Wat Chom Cheng Site

Location	Riverbank Structure	Monitoring Results
Line No.0+00	None	No remarkable variation of the riverbank profiles is found on the slope, but scoring of approximately 0.7 - 1.0m deep is at the foot part of the slope.
Line No.0+20	None	Accretion of approximately 0.5m thick is found on the slope, but slight scoring is at the foot of it.
Line No.0+40	None	Accretion of approximately 0.5m thick is found on the slope, but slight scoring is at the foot of it.
Line No.0+60	None	No remarkable variation of the profiles is found.
Line No.0+80	None	Accretion of approximately 0.5m thick is found on the slope, but slight scoring is at the foot of it.
Line No.1+00 – No.1+20	None	Accretion of approximately 0.6 – 0.8m thick is found at the foot of the slope.
Line No.1+40	Wooden Pile Dike Groyne	No remarkable variation of the profiles is found after completion of the work, except a slight accretion at the toe of the slope with approximately 0.5 – 1.0m thick.
Line No.1+60	None	Slight accretion on the whole slopes and scoring of approximately 0.4 – 0.6m deep at the foot of the slope are found.
Line No.1+80	None	No remarkable variation of the profiles is found after completion of the work, except a slight accretion at the toe of the slope with approximately 0.6m thick.
Line No.2+00	Wooden Pile Dike Groyne + SODA Mattress	Accretion and subsidence are found on the upper part of slope and middle part of slope, respectively. At the foot of the slope, wide range of sedimentation is found with approximately 0.6 – 0.8m thick.
Line No.2+20	None	On the middle part and the foot part of the slope is found accretion of approximately 0.4 – 0.6m thick.
Line No.2+40	None	On the middle part and the foot part of the slope is found accretion of approximately 0.6 – 1.1m thick.

Table 1.2 (2/2) Comparison of Cross Sectional Profile near Riverbank at Wat Chom Cheng Site

Location	Riverbank Structure	Monitoring Results
Line No.2+60	Wooden Pile Dike Groyne	Accretion approximately 0.5 – 0.7m thick at the foot of the slope is found.
Line No.2+80	None	Ditto.
Line No.3+00	Wooden Pile Dike Groyne + SODA Mattress	Approximately 0.5 – 0.7m thick accretions is found at the lower part of the slope. Tip of SODA Mattress seems to subside approximately 0.5m.
Line No.3+20	None	Wide range of accretion is found on the upper part and lower part of the slope.
Line No.3+40	Wooden Pile Dike Groyne	Ditto.
Line No.3+60	None	Much amount of sedimentation at lower part of the slope is found with thickness of approximately 1.0m. Upper part of the slope seems to change its profile slightly uniform slope through the previous flood season.
Line No.3+80	Wooden Pile Dike Groyne + SODA Mattress	Accretions at the foot and upper part of the slope are found with thickness of approximately 0.5 – 1.0m.
Line No.4+00	None	Natural riverbank slope variation is found without effect of Wooden Pile Dike Groyne Works. Variation ranges approximately 0.5 – 0.8m.

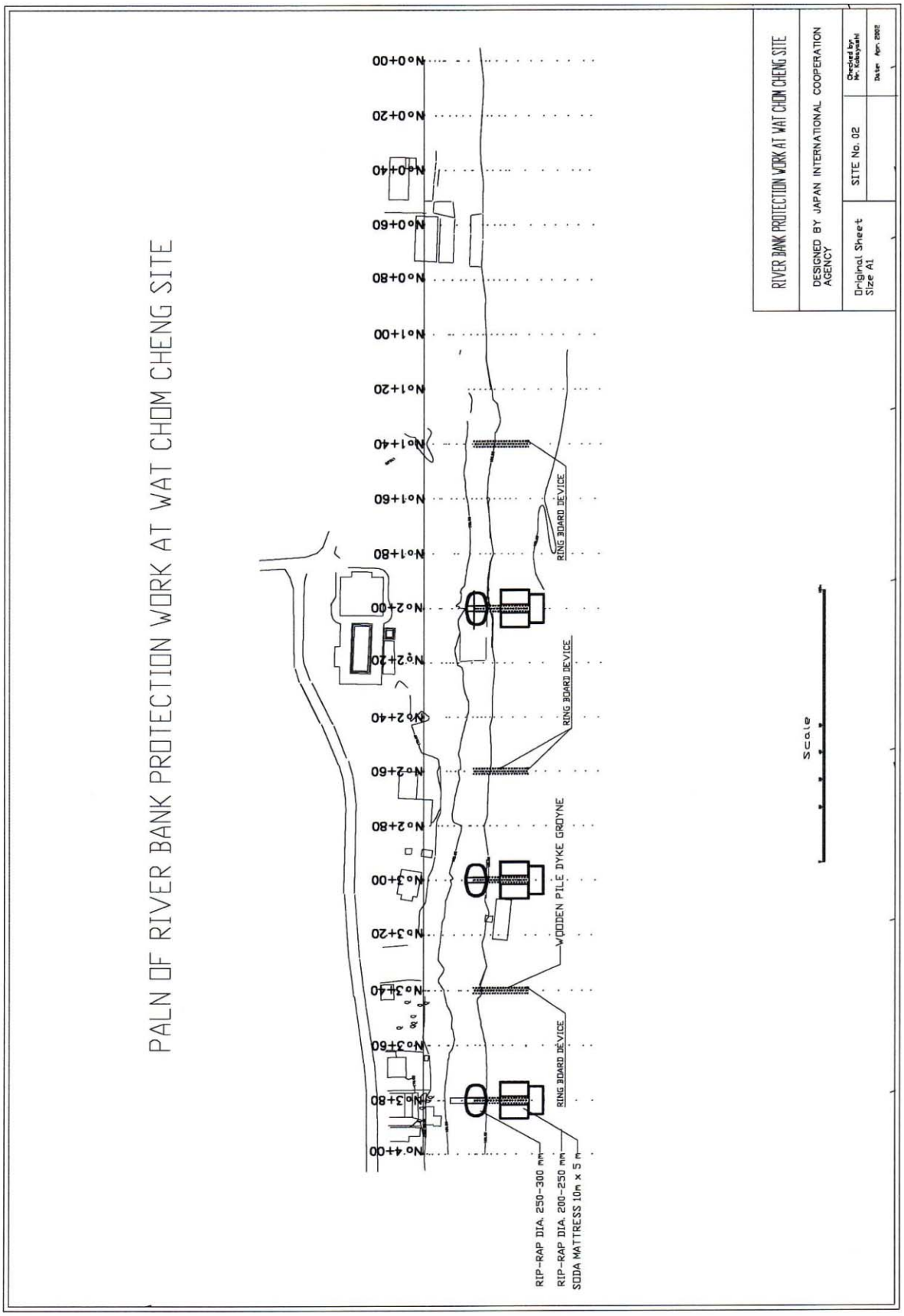


Figure 1.5 Location of Topographic Survey Lines at Wat Chom Cheng Site

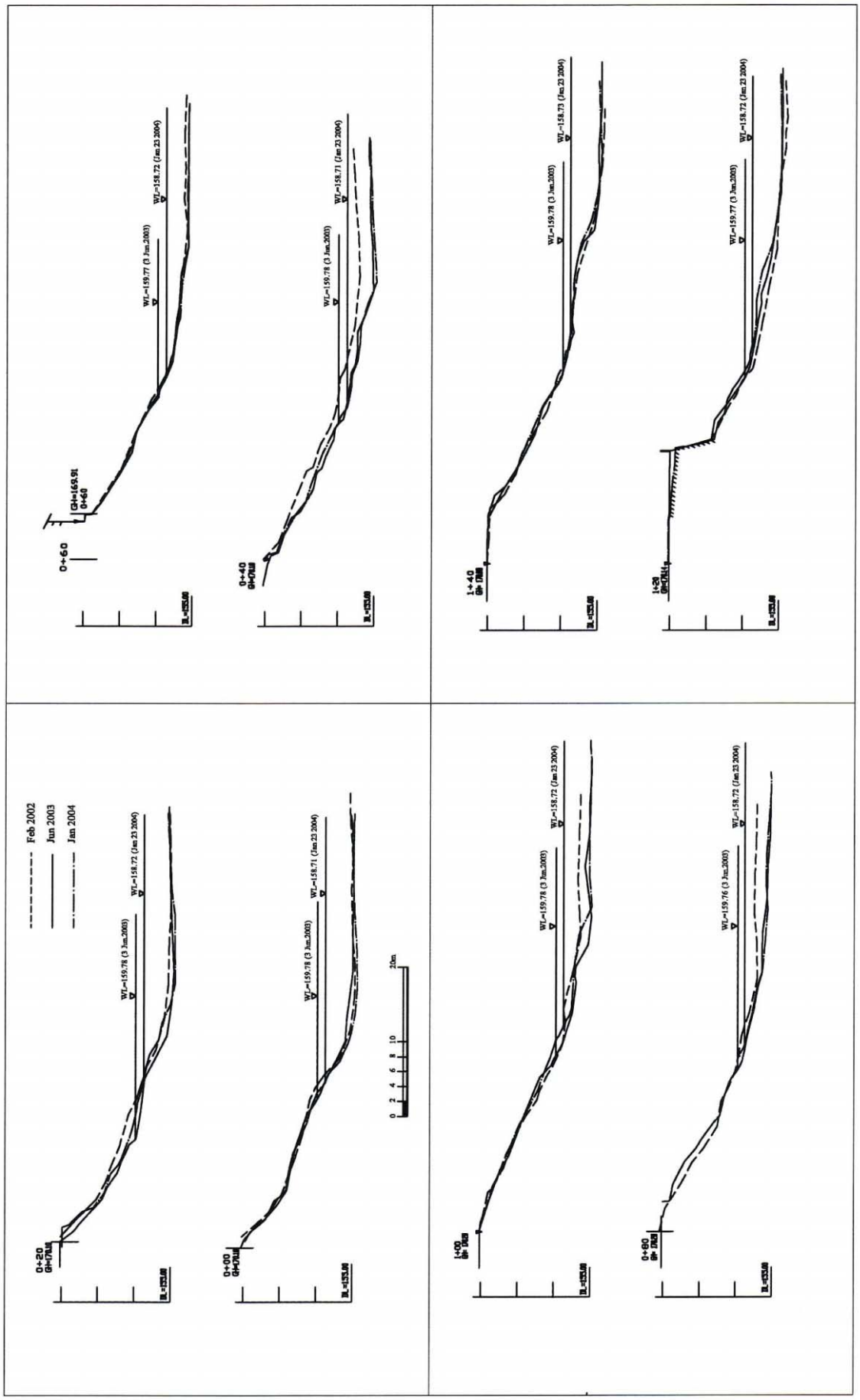


Figure 1.6(1/3) Comparison of Riverbank Profiles at Wat Chom Cheng Site

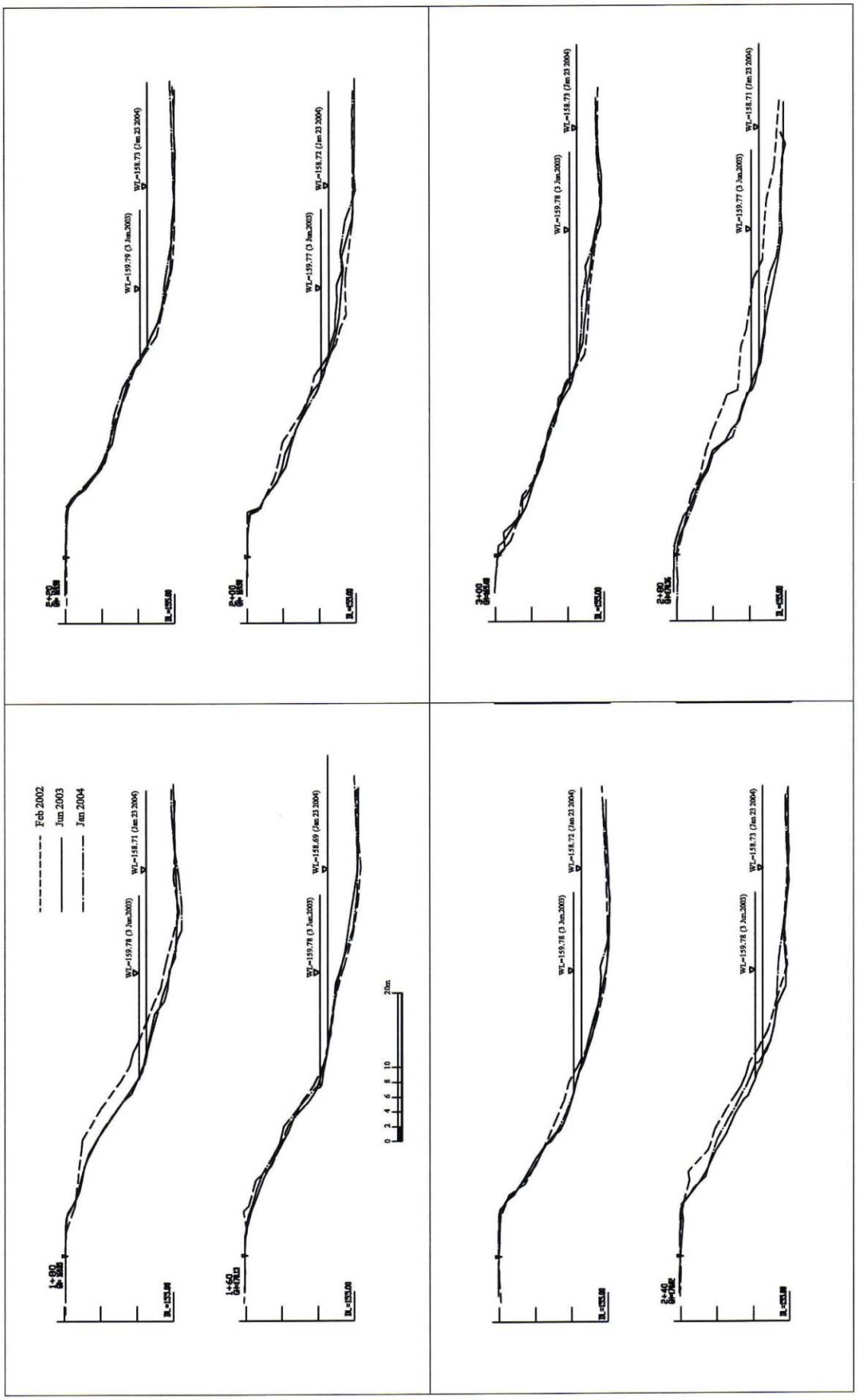


Figure 1.6(2/3) Comparison of Riverbank Profiles at Wat Chom Cheng Site

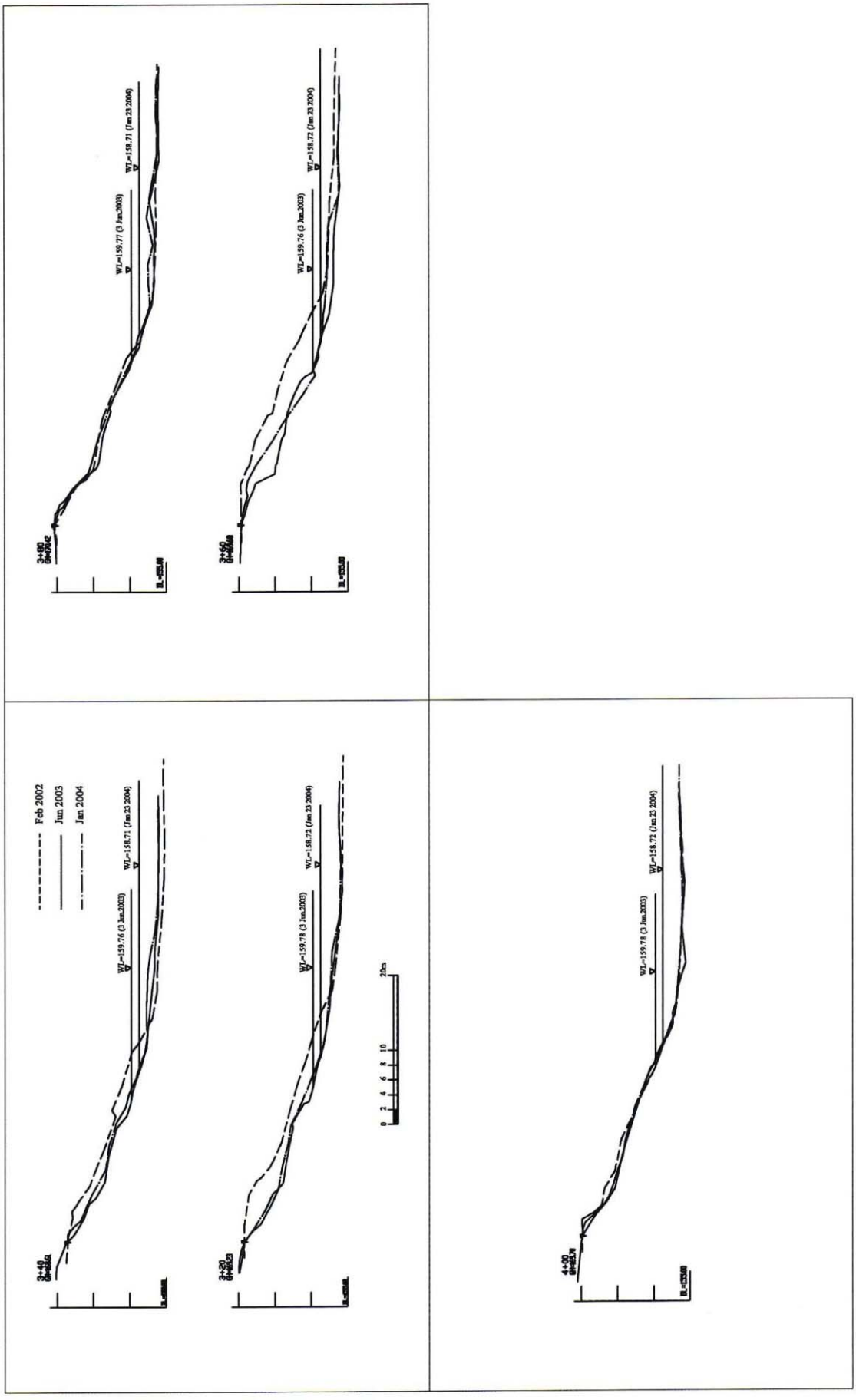


Figure 1.6(3/3) Comparison of Riverbank Profiles at Wat Chom Cheng Site

b) Visual observation

Amount of soil sedimentation is found between wooden pile groynes as shown in Figure 1.7. Especially the sedimentation occurs just downstream of the groyne works. No remarkable changes of the wooden piles are observed with respect to; a) Deformation of wooden piles, b) Deterioration of wood pile not only with tin-plate cap, but also without cap. Slight inclination of wooden piles presumably due to soil mass movement induced by drained water are found at Line No.3+40 as shown in Figure 1.8.

Figure 1.7 Sedimentation between Wooden Pile Dike Groyne Works

Figure 1.8 Inclination of Wooden Piles at Line No.3+40

c) Ring board device

Ring board devices were installed to detect the maximum scoring depth during flood period as shown in Figure 1.5. The results are as summarized in Table 1.3. Maximum local scoring depth successfully recorded at the middle of the groyne on Line No.2+60 is approximately 0.6m through the flood period in 2003.

Table 1.3 Ring Board Device Measurement Results

Line	Location	L1		L3		⊿Z1	⊿Z3
		Apr.2002	Dec15'03	Installation	Dec15'03		
1+40	Tip	2.21	2.06	1.95	1.75	0.15	0.2
2+60	Tip	4.26	3.17	4.2	Lost	1.09	N.A.
	Middle	1.19	1.4	1.17	1.77	-0.21	-0.6
3+40	Tip	3.01	2.4	2.93	Lost	0.61	N.A.
	Middle	2.65	2.1	2.7	5.92(?)	0.55	N.A.

L1, L3: (Top elevation of wooden pile) - (Riverbed elevation) Unit:m

⊿Z1: Sediment thickness after installation of wooden pile groyne

⊿Z3: Maximum vertical shift of ring board (up: +, down: -)

N.A.:Data not available

d) Feedbacks to design

The followings are derived through the monitoring:

- Wooden Pile Dike Groyne Work is effective at the site where accretion almost balances to degradation through a flood period and riverbed consists of sand and silt material.
- Appropriate interval of groynes will be 3 times of groyne length for the site.

1.1.3 Sibounheuang Site

a) Comparison of topographic survey results

Successive topographic surveys of riverbank profile around Sibounheuang Site had been conducted 3 times along lines as shown in Figure 1.9. First survey was done on February 2002, before construction work started. Second survey was done on June 2003, just after the completion of the construction work of the riverbank protection work. And the third one was done on January 2004 after the first flood season for the structure since its completion.

Along each cross sectional line, the profiles of riverbank and riverbed near the bank are compared in the same figure as shown in Figure 1.10(1/3)-(3/3). By comparing the cross sectional profiles in different time, the variation of riverbank protection work and riverbank and riverbed are derived as shown in Table 1.4.

Table 1.4 Comparison of Cross Sectional Profile near Riverbank at Sibounheuang Site

Location	Riverbank Structure	Monitoring Results
Line No.0+00	None	Slightly large recession at the lower part of slope is found.
Line No.0+20	None	Recession of steep slope is found.
Line No.0+40	None	Recession of steep slope and accretion at the foot of slope are found.
Line No.0+60	Cobble Stone with Willow Branch Work + Log Hurdle Work + SODA Mattress	No remarkable change is found.
Line No.0+80		Recession of upper part of steep slope is found. Tip of the foot protection work is seemed to subside.
LineNo.1+00 – No.1+20		Accretion at the foot of foundation is found. Tip of the foot protection work is seemed to subside.
Line No.1+40		Recession of steep slope and accretion at the foot of slope are found. And tip of the foot protection work is seemed to subside.
Line No.1+60		Ditto.
Line No.1+80		No remarkable change in the profiles is found.
Line No.2+00		Amount of sediment is found at the lower part of slope.
LineNo.2+20 – No.3+00	Riverbank protection work done by IDI Japan.	Riverbank slope is almost stable in the range of riverbank protection work, except on Line No.2+60, where upper part of slope collapsed in flood season of 2003

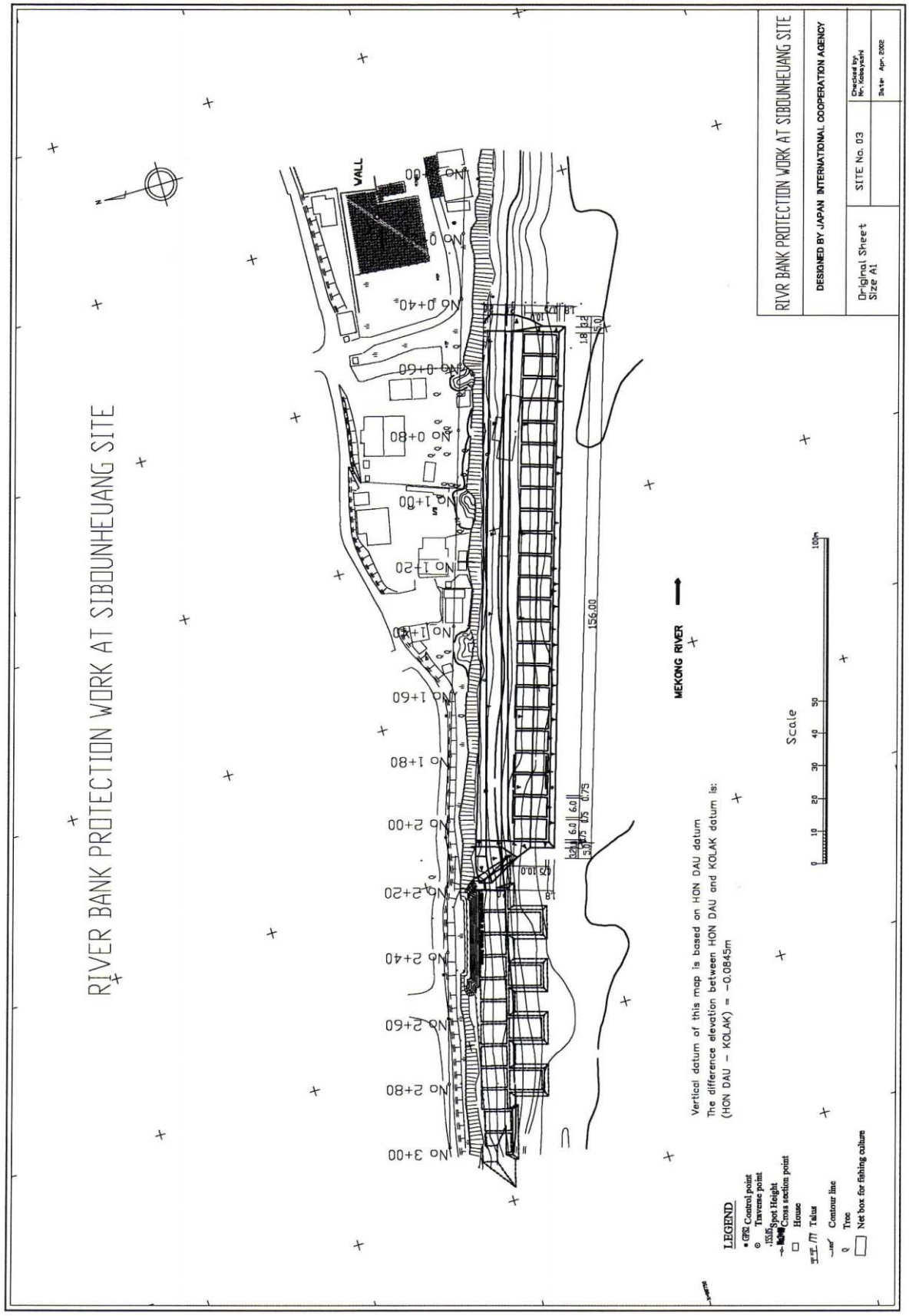


Figure 1.9 Location of Topographic Survey Lines at Sibounheuang Site

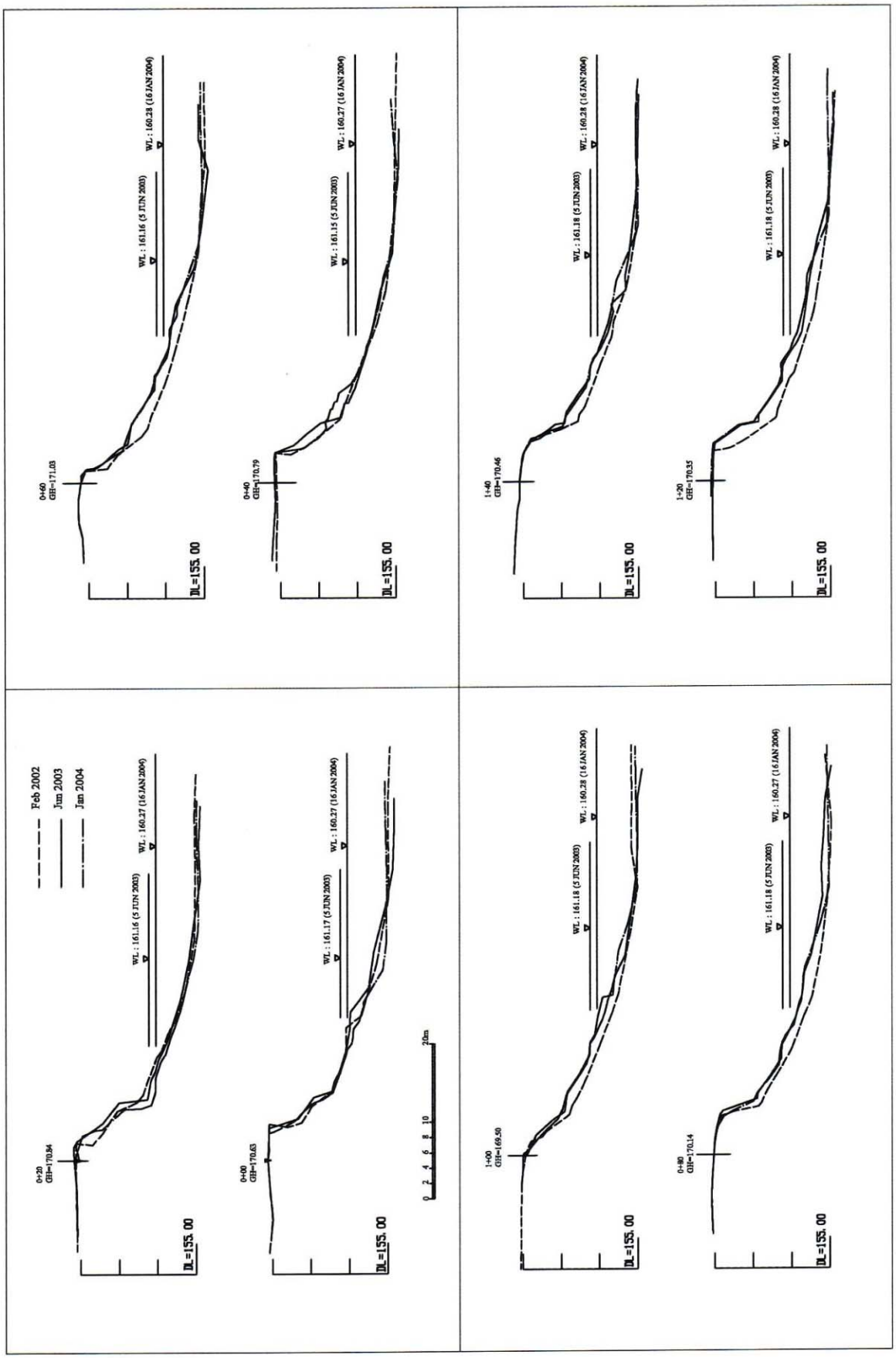


Figure 1.10(1/2) Comparison of Riverbank Profiles at Sibounheuang Site

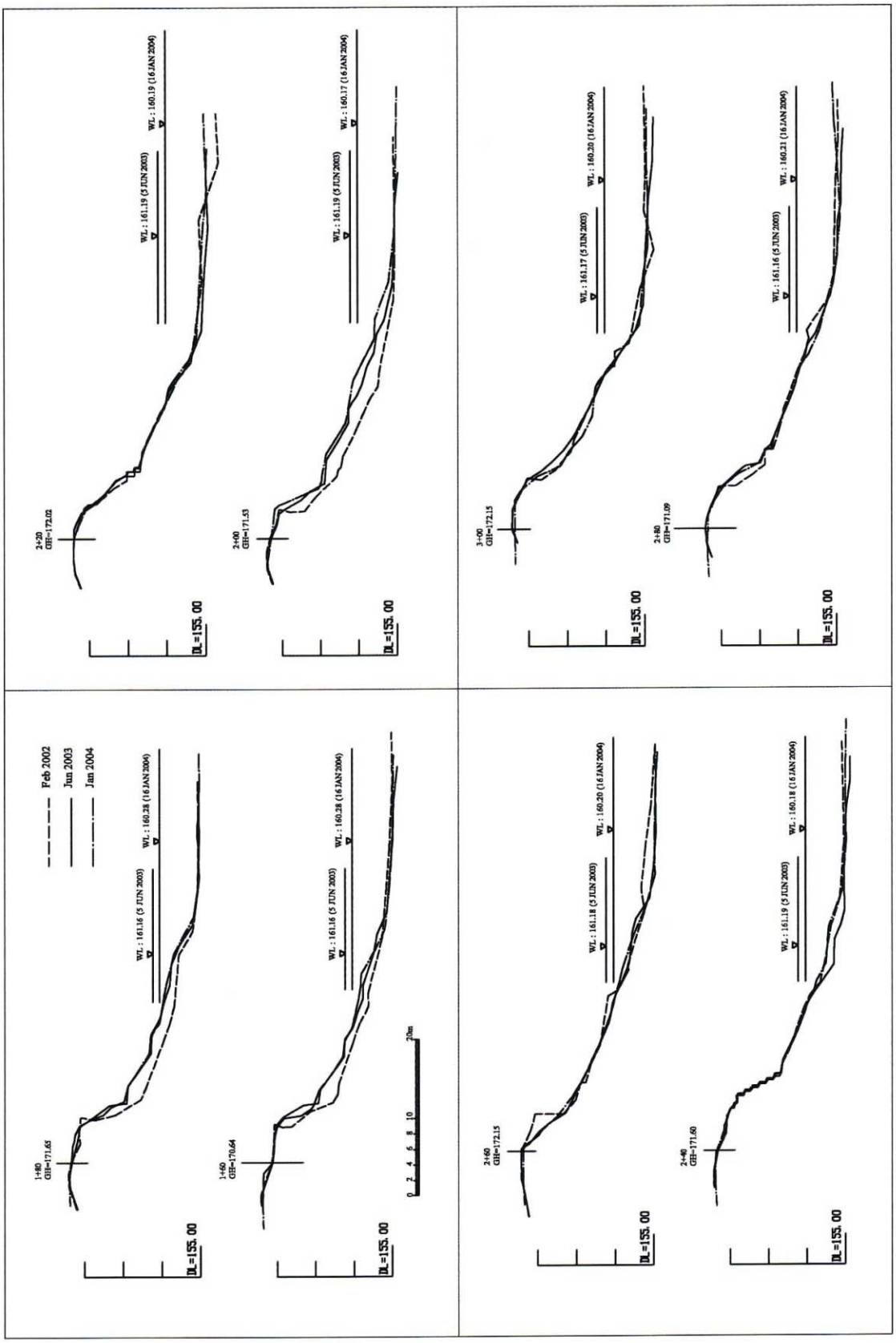


Figure 1.10(2/2) Comparison of Riverbank Profiles at Sibounheuang Site

b) Visual observation

Amount of soil sedimentation is found on the flat top of slope covering work and also flat foundation work as shown in Figure 1.11. Between riprap stones fine sediment materials are found as shown in Figure 1.12.

No remarkable changes of the riverbank protection work at the site is observed with respect to,

- Deformation of the profile
- Local scoring causing movement / loss of ripraps.

Upper part of the slope, natural steep slope, seems to relatively stable to have some scattering vegetation growing on the part of it.

Figure 1.11 Downstream View at Sibounheuang Site

Figure 1.12 Sediment Material under the Slope Covering Riprap at Sibounheuang Site

c) Feedbacks to design

The followings are derived through monitoring works:

- Protecting the lower part of the steep slope will be effective around the site to mitigate the setbacks of the cliffy riverbank caused by successive erosion during flood period.
- Width of foot protection work is to be adjusted in accompanying the deformation / subsidence of SODA mattress through successive monitoring works.

1.2 Hydraulic Condition

Monitoring surveys on hydraulic condition to investigate characteristics of river flow and the effect of the pilot works have been executed according to the program shown as Table 1.5.

Table 1.5 Monitoring Program

Monitoring Items	Site	Nos	Interval	2001	2002		2003		2004	
				Dry season	Rainy season	Dry season	Rainy season	Dry season	Rainy season	Dry season
River water stage	All Sites		Everyday	———						
Flow velocity and direction	All Sites	6		–	–	–	–	–	–	
Construction of pilot works						———				

——— : Executed

The daily water levels of each construction site other than Sibounheuang Site have been observed with the water gauge, which the study team set up by operating directly. The water levels of Sibounheuang Site have been referred to the data measured by the water gauge that had already existed.

In addition, horizontal and vertical distribution of flow velocity and direction around the pilot works in the time of a different water level, that is, the dry season and the rainy season, before and after the construction of the bank protection works, have been measured to grasp the change in a local flow field in the effect of the flow velocity decrease and the effect of the water splash etc.

Detailed results of measuring flow velocity and direction were basically similar to the measurement executed in the first survey results.

The variation of water level and discharge are estimated based on the data of the water level and discharge gauging station of Vientiane KM4.

(1) River Water Level

River water levels at Ban Dongphosi Site and Wat Chom Cheng Site have been observed by reading the water gauges settled at each site every day.

The water level variations obtained by the survey at each site including the data of Sibounheuang Site are shown in Figure 1.13.

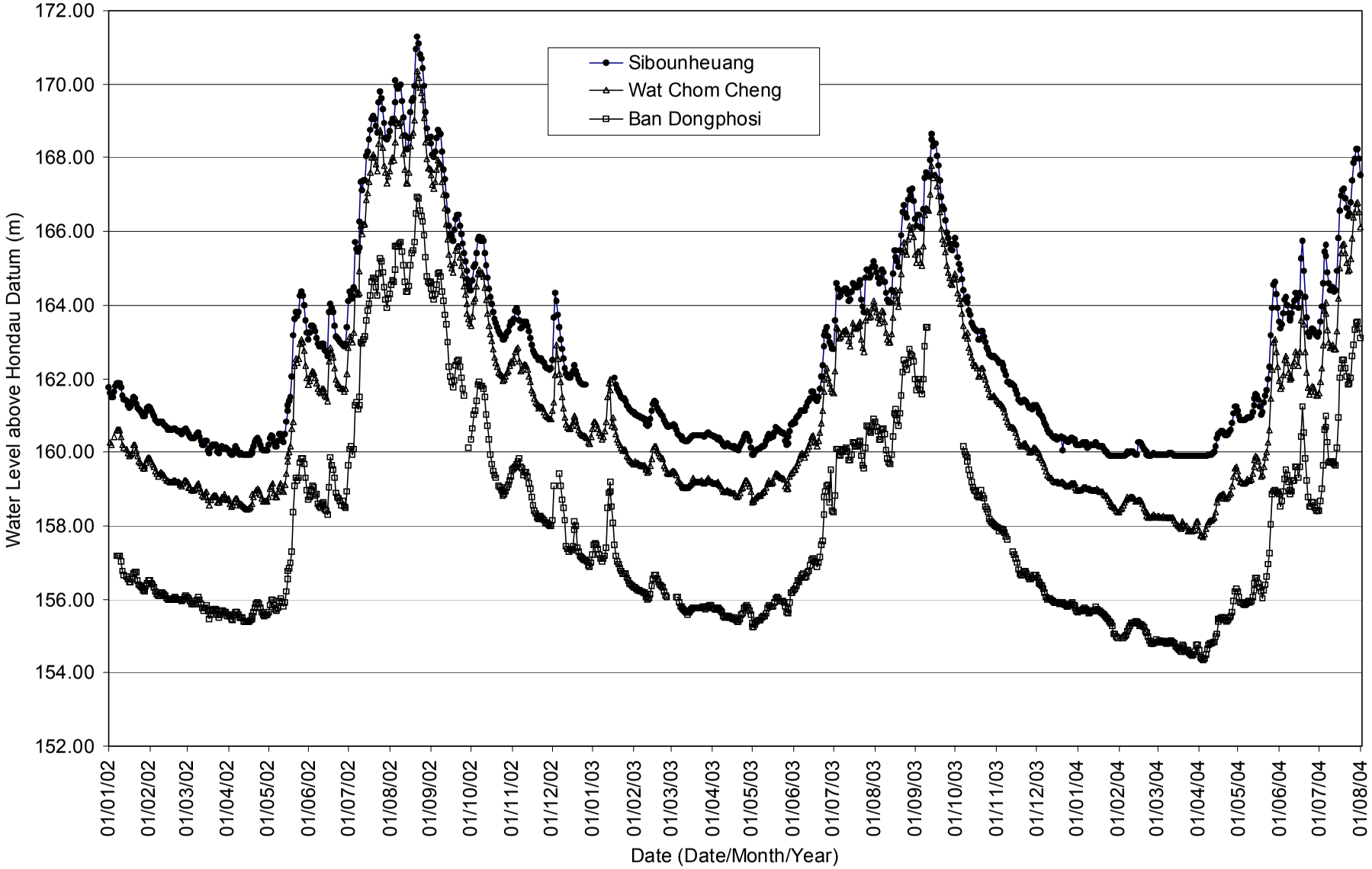


Figure 1.13 Water Level Variation at Pilot Work Sites

(2) Flow Velocity and Direction

Flow velocity and direction have been carried out at three Pilot Work sites to obtain current speed and direction for the monitoring of the Pilot Works.

The amount of measuring point of each site per unit survey is as follows.

Ban Dongphosi Site	:	9 lines × 20 points/line = 180 points
Wat Chom Cheng Site	:	3 lines × 20 points/line = 60 points
Sibounheuang Site	:	3 lines × 20 points/line = 60 points

Table 1.6 shows the hydraulic conditions at each site on the measuring dates respectively. There were six opportunities of measuring at each site. The three of them were executed in rainy season, and the rest were in dry season.

Figures 1.14 to Figure 1.16 show the plane distributions of measured flow velocity and distribution at each site respectively.

From these figures, following matters are understood.

a) Flow velocities have become relatively small after construction of Pilot Works. This tendency is clear especially at Wat Chom Cheng Site. This is considered due to the effect of groynes and rip-rap stones.

b) Flow directions have become relatively uniform after construction of Pilot Works. This is considered due to effects of the straightened topographical features.

c) Above mentioned effects are corresponding to the ones expected in the beginning of this project.

d) As understood from the measurement data of Sibounheuang Site in October 2002, flow velocity becomes comparatively large at the time of not-so-large discharge. This phenomenon is regarded as the one by the change in geographical features in the surrounding and the change in the direction of current that comes from the upstream. And this suggests that attention should be paid on the flow at the discharge smaller than design discharge.

Table 1.7 shows section average velocity (v_m) and velocity concentration ratio (v_{toe} / v_m) corresponding to each measuring opportunity. Where riverside part average velocities (v_{toe}) are calculated by plane weighted velocities of whole field measurement area without considering depth difference in respective measuring points.

Judging from the changes of velocity concentration ratio (v_{toe} / v_m) at each site, it is obvious that value of v_{toe} / v_m have become smaller after construction of Pilot Works. This means the main current part of the flow shifted in a direction away from the riverside after constructing the Pilot Works.

Moreover, it is understood that, in Volume 3 (Manual for Riverbank Protection, Sector A : Planning & Design), the equation (2-1-3) and the calculation values of correction factor α (= v_{toe} / v_m) indicated in Table 2.1.2 are appropriate by comparing with the calculation values indicated in Table 1.7 of this section.

However, the value of v_{toe} / v_m at Ban Dongphosi Site is overall small in Table 1.7, being compared with the value in corresponding section, 1.29, which is calculated by the equation (2-1-3). One of the causes of this is considered to be the accuracy of v_m obtained by the non-uniform flow calculation.

It is considered that to measure the flow velocity distribution in all section area in an appropriate section at several stages of discharge to clarify the relation between water level and discharge is one of good way to improve the evaluation accuracy of v_m.

Table 1.6 General Condition

Site	No.	Date	Average Discharge [1] (m^3/s)	Average Water Level [2] (EL.m) [4]	Average Velocity [3] v_m (m/s)
Ban Dongphosi	Jan-02	23/01 to 25/01	1,900	156.39	1.04
	Oct-02	25/10 to 02/11	4,300	159,36	1.45
	Jun-03	03/06 to 07/06	2,000	156.60	1.07
	Sep-03	08/09 to 12/09	12,200	163.54	2.08
	Dec-03	24/12 to 26/12	1,300	154.59	0.89
	Aug-04	21/08 to 23/08	12,600	163.70	2.11
Wat Chom Cheng	Jan-02	16/01	2,000	160.04	0.53
	Oct-02	30/10	4,500	161.57	0.85
	Jun-03	08/06 to 09/06	2,000	159.99	0.53
	Sep-03	13/09 to 14/09	13,700	167.76	1.52
	Dec-03	23/12	1,300	158.46	0.41
	Aug-04	19/08	11,800	166.92	1.41
Sibounheuang	Jan-02	12/01 to 15/01	2,100	161.42	0.80
	Oct-02	29/10	4,400	163.43	1.22
	Jun-03	10/06 to 11/06	2,100	161.56	0.80
	Sep-03	15/09 to 16/09	13,400	168.66	2.12
	Dec-03	22/12	1,300	159.46	0.59
	Aug-04	17/08	11,400	167.48	1.99

1) Derived from the water level at Vientiane KM4 2) Measured at each site

3) Estimated by non-uniform flow calculation 4) above M.S.L. Ko Lak Datum.

Table 1.7 Average Velocity and Velocity Concentration Ratio

Site	No.	v_m (m/s)	v_{toe} (m/s)	v_{toe} / v_m
Ban Dongphosi	Jan-02	1.04	0.77	0.74
	Oct-02	1.45	1.12	0.77
	Jun-03	1.07	0.41	0.38
	Sep-03	2.08	0.79	0.38
	Dec-03	0.89	0.70	0.79
	Aug-04	2.11	0.78	0.37
Wat Chom Cheng	Jan-02	0.53	0.69	1.30
	Oct-02	0.85	1.02	1.20
	Jun-03	0.53	0.35	0.66
	Sep-03	1.52	0.61	0.40
	Dec-03	0.41	0.48	1.17
	Aug-04	1.41	0.56	0.40
Sibounheuang	Jan-02	0.8	0.82	1.03
	Oct-02	1.22	1.76	1.44
	Jun-03	0.8	0.58	0.73
	Sep-03	2.12	0.97	0.46
	Dec-03	0.59	0.70	1.19
	Aug-04	1.99	0.77	0.39

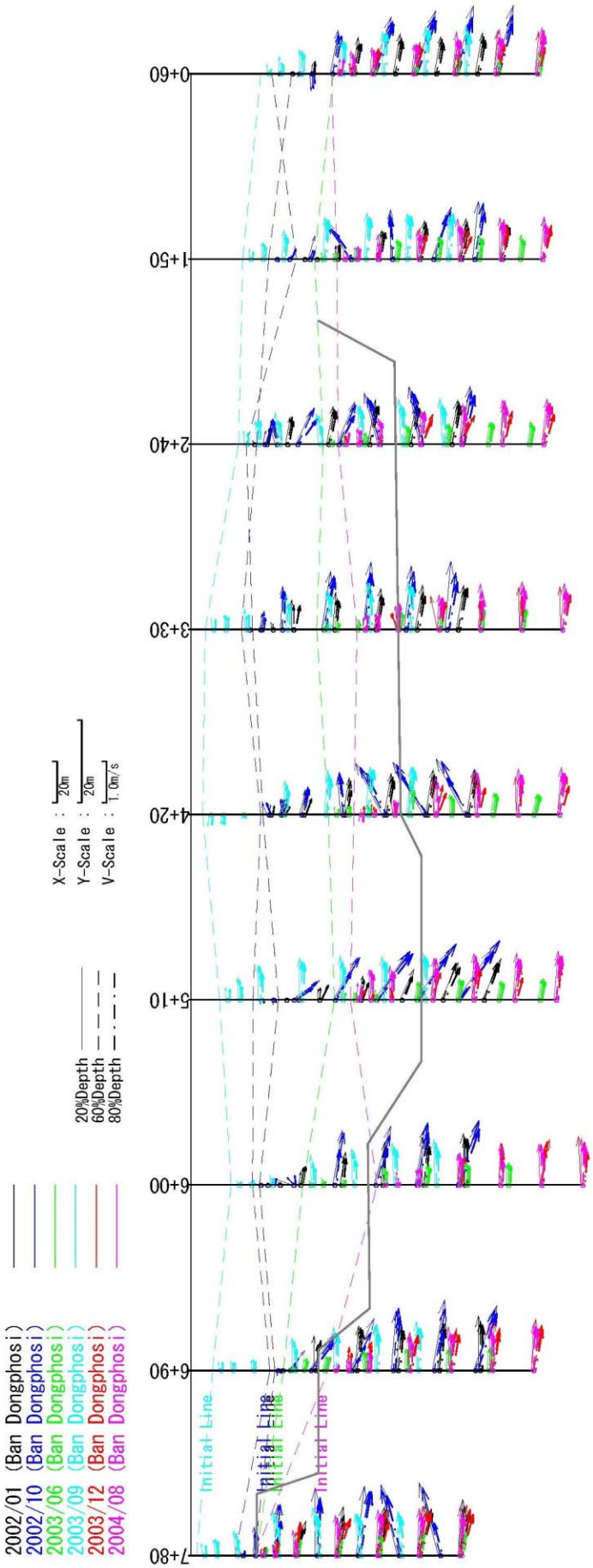


Figure 1.14 Plane Distribution of Flow Velocity and Direction (Ban Dongphosi Site)

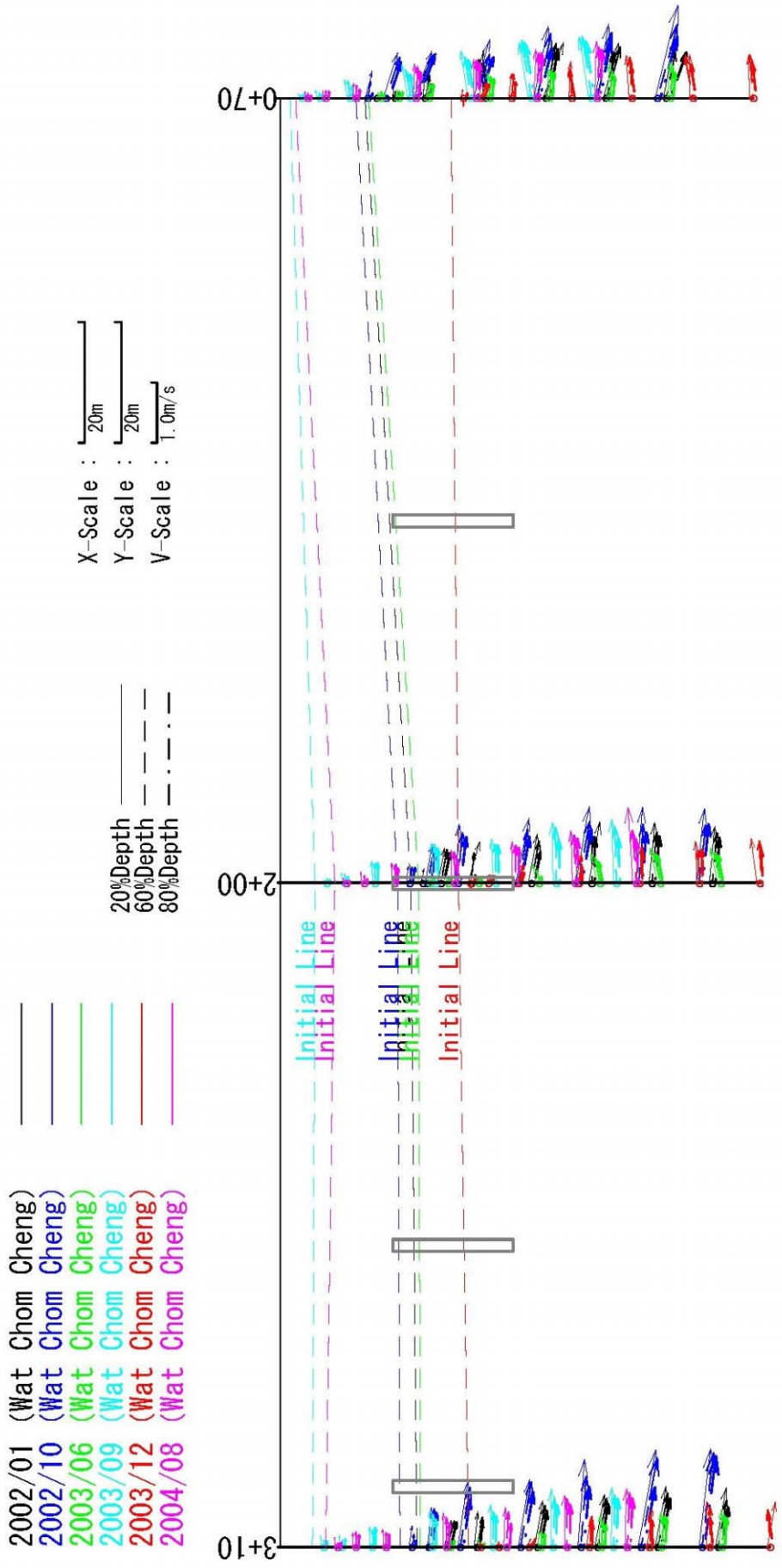


Figure 1.15 Plane Distribution of Flow Velocity and Direction (Wat Chom Cheng Site)

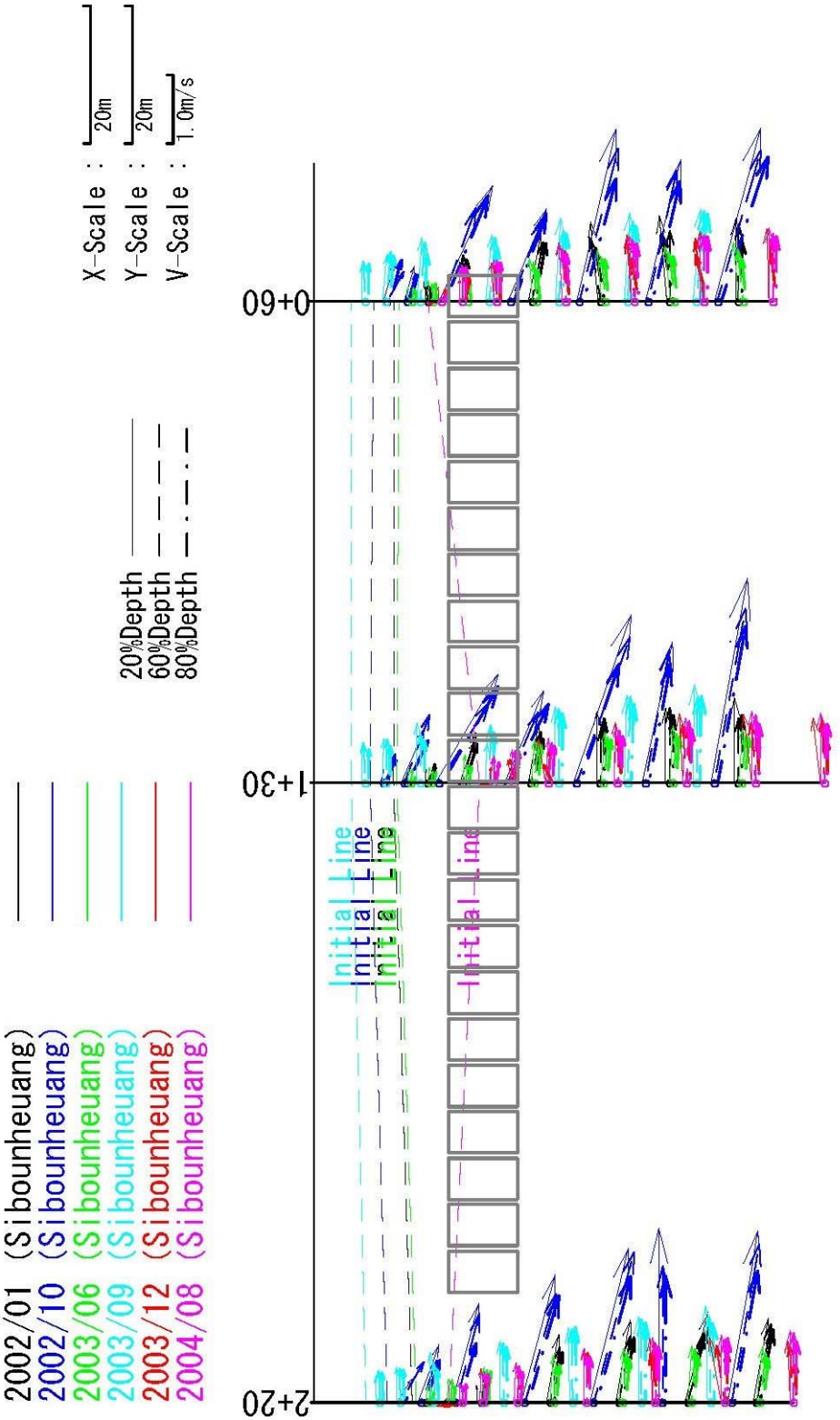


Figure 1.16 Plane Distribution of Flow Velocity and Direction (Sibounheuang Site)

1.3 Vegetation Condition

1.3.1 Objective

- To monitor the survival rate and growth performance of planted willow (stump directly planting, seedling and seed sowing).
- To assess the growth performance of the two species in terms of root system, height, branches, and stem.
- To find the suitable planting method and species for riverbank protection.

1.3.2 Monitoring Items and Schedule

Table 1.8 shows the monitoring items and schedule of vegetation in Ban Dongphosi site.

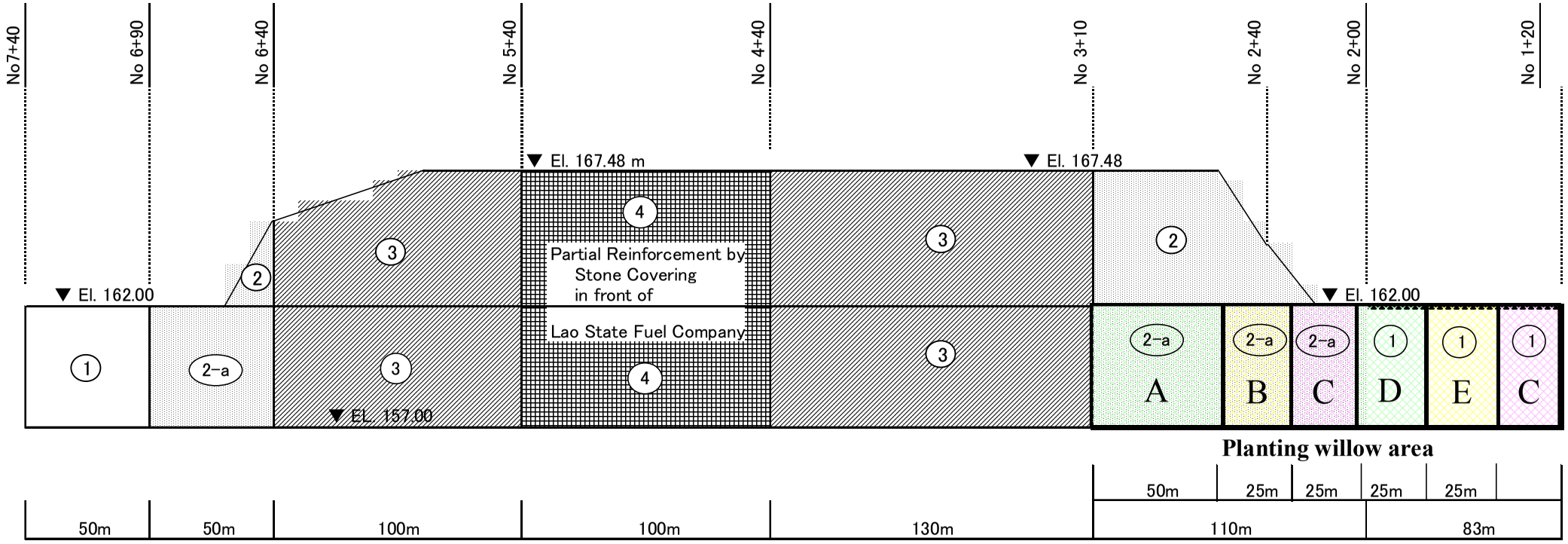
Table 1.8 Monitoring Items and Schedule

Monitoring Items	Unit	Q'ty	2003												2004											
			1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12
Planting willow	Time	2						■						■												
Growth situation of willow	Time	1												■	■											
Photograph of planted willow (0nce/1M)	Time	3						■						■		■										
Distribution of vegetation	Time	1																	■							

1.3.3 Execution of Planting Willow

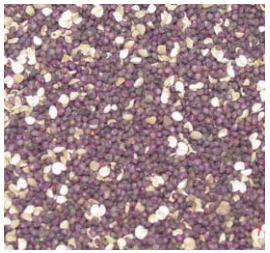
Test planting was conducted in Ban Dongphosi site by the stump directly planting, by the seedling prepared in the nursery and by seed sowing into the gap of stones. Willows were collected from two species namely: Khai Nun *(Eugenia fluviatilis)* and Kok Khai *(Polyalthia corticosa)*.

Figure 1.17 shows the completed design of planting willow and Figure 1.18 shows the situation of willow planting. Referring the planting willow grown in the pollybag, there were two small blocks for testing the two species (*Polyalthia corticosa and Eugenia fluviatilis species)*. Moreover there were two small blocks for stump directly planting by using also two species.



Seedling (grown in polybag)

Stump
(To use just after cutting)



Seed (Kok Khai)

Legend

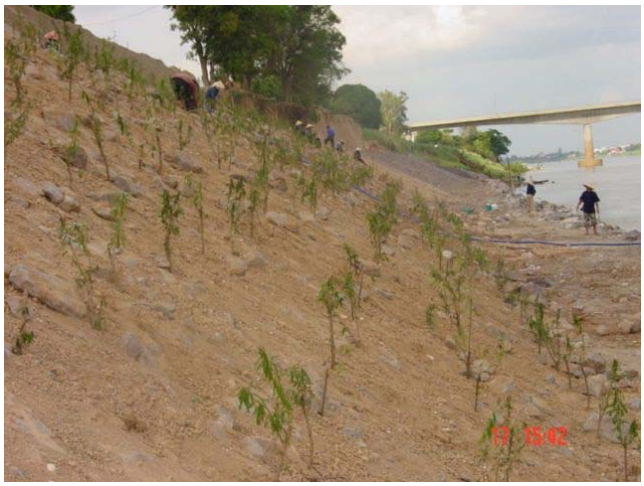
Base Condition

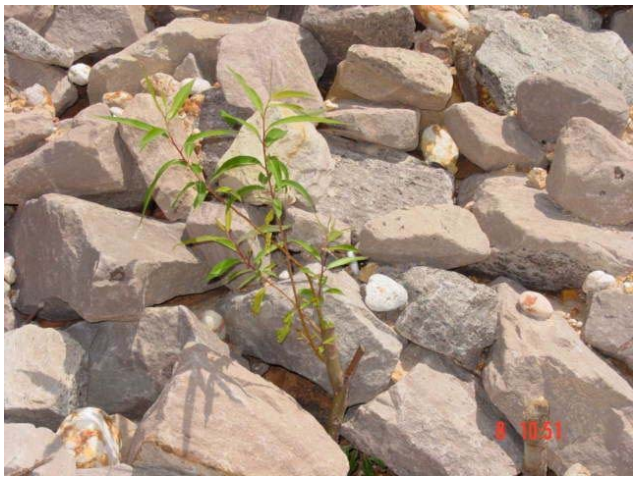
① No willow included Sikisoda with out covering soil
② Willow included Sikisoda without covering soil
2-a Willow included Sikisoda with covering soil
③ Willow included Sikisode with covering soil
④ Willow included Sikisoda with covering stones

Method of Planting Willow

A	Seedling before rainy season
B	Stump directry planting before rainy season
C	Sowing seed before rainy season
D	Seedling after rainy season
E	Stump directry planting after rainy season

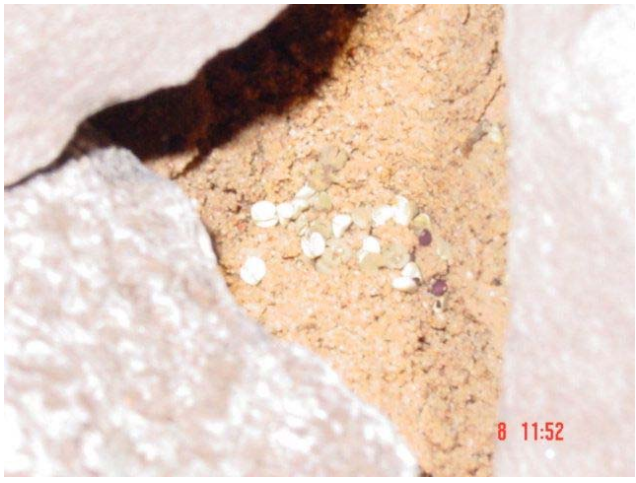
Figure 1.17 Completed Design of Planting Willow





Seedling (willow grown in lollygag)

Stump directly planting



Seed sowing

Figure 1.18 Situation of Planting Willow

1.3.4 Result and Discussion

Table 1.9 shows survival rate and growth performance of the planted willow.

(1) Survival Rate

Planting by seedling was conducted with the total of 500 seedlings, in which there were 164 survived (32.8%).

For the stump directly planting, 250 stumps were planted, in which there were only 6 survived (2.4%). The too low percentage is presumably due to the site condition of the slope with the stone, that is hardly to keep the moisture leading to the stump drying up and death.

Regarding the seed sowing into the gap of stone, this method was failed.

(2) Growth Performance

The 6 trees survived from 250 stumps planted were measured. It was shown that the mean height was 16.2 cm and mean diameter was 2.6 cm.

Planting of seedling was the highest survival rate compared to other methods. Measurement was done for all survived seedlings. The results indicated that the mean height was 20.5 cm while 2.9 cm was the mean diameter. In terms of branch, an average branch number per tree was 4 and the mean length was 33 cm. Table 1.9 shows the growth performance of the willow planted in terms of height, diameter and branches with three different methods of planting.

(3) Root Growth Performance

The results of root system in each site were quite different due to the method of planting. The root system of the planting by seedling is stronger than the stump directly planting and survival rate of the former is higher. Moreover, difference of the soil conditions was also one of the reasons that make the root system different. As for the planting in the construction site, the soil was brought from other places and compacted there, the root system therefore will follow the gap of stones, and the main root was shorter than the other places and the small root was lesser than the other sites as shown in Table 1.9.

(4) Distribution of vegetation

The distribution of vegetation just before rainy season 2004 is shown in Figure 1.20-22. Many species grow on riverbank protection works. The growth situation of vegetation is is effective for riverbank protection.

Table 1.9 Growth Performance of Planted Willow

Items	Planting Methods				
	Seedling		Stump Directly		Seed Sowing
Survival Rate	32.8%		2.4%		Fail
Growth Performance	D (cm)	H (cm)	D (mm)	H (cm)	Fail
	2.9	20.5	3.4	16.2	
Root System growing from12/03/03 to 16/01/04	Main root	Small root	Main root	Small root	Fail
	No.=3-9 roots D=0,1-0,9 Cm Length=5-47cm	No.= 16-75 roots D=very small Length=0.1-13 cm	No.= 1-7 roots D= 0,1-0,9 Cm Length= 5-48 cm	No.=5-37 roots D=very small Length=0.1-12 cm	

Situation of willow survived (Seedling) Dec/2003

Situation of willow survived (Stump directly planting) Dec/2003

Growth Situation of willow
(Seedling, Kok khai) Jan/2004

Growth Situation of Willow Root
(Seedling, Kok khai) Jan/2004

Growth Situation of Willow
(Stump directory planting, khai Nun) Jan/2004

Growth Situation of Willow Root
(Stump directory planting, khai Nun) Jan/2004

Figure 1.19 Growth Performance of Willow in Dongphosi Site

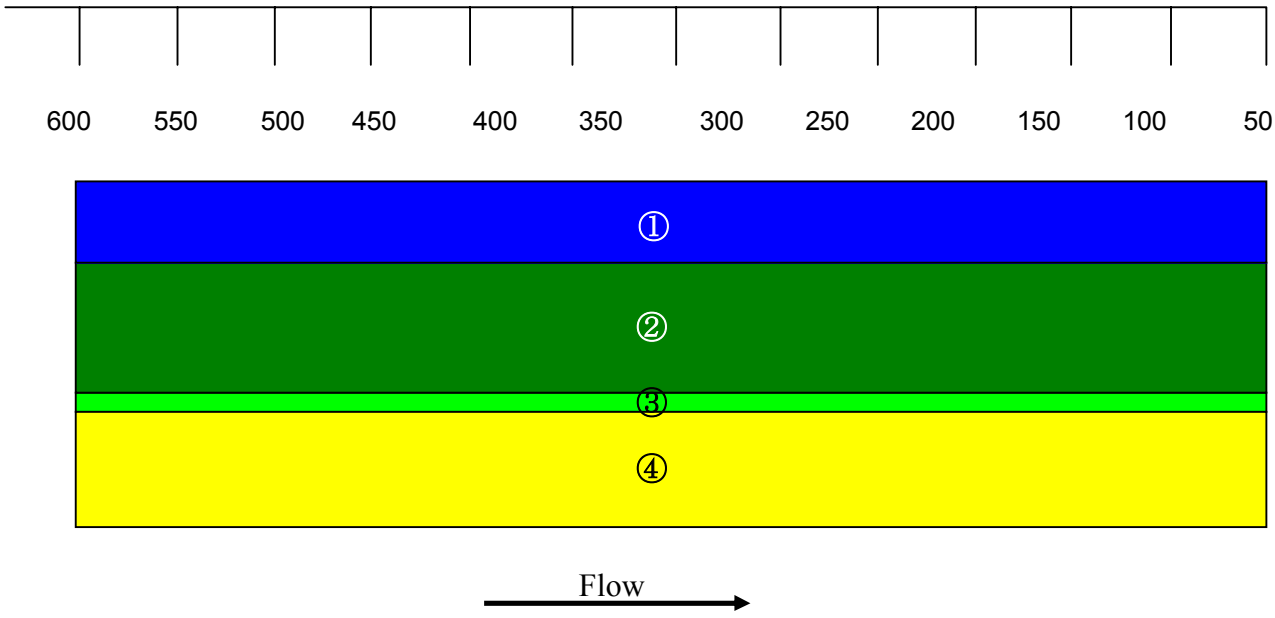
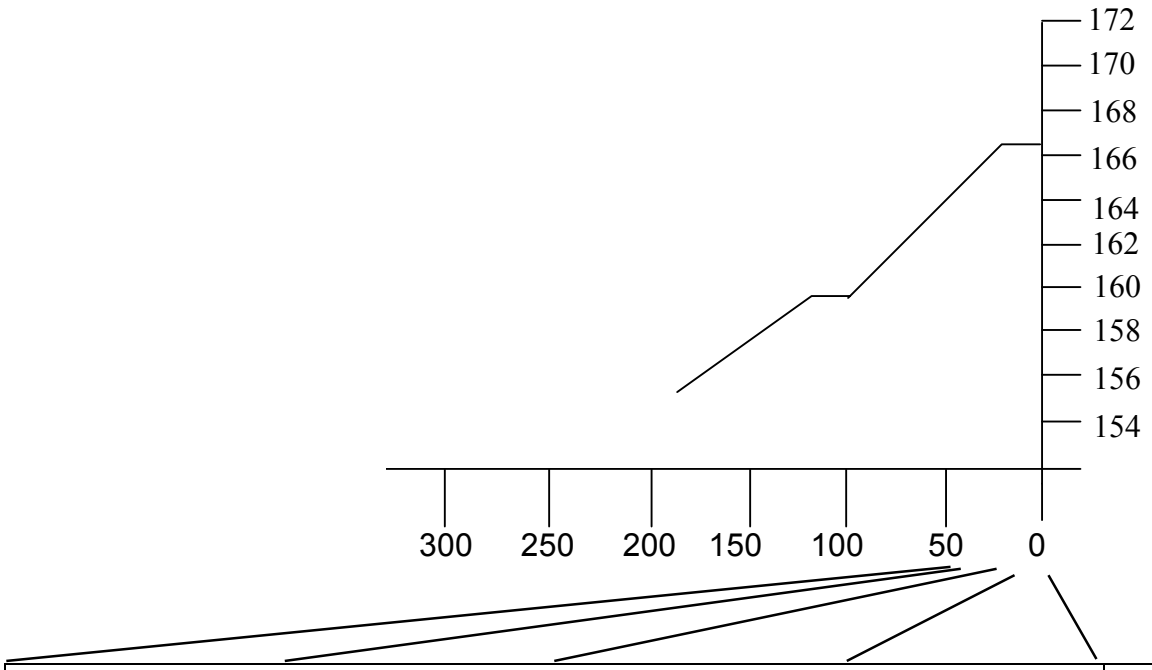


Figure 1.20 Vegetation Map in Dongphosi Site

Figure 1.21 Vegetation Map in Dongphosi Site

Date of Survey	1/06/04



Vertical distance				Remark
35.5m～49.5m	34m～35.5m	8 m～34m	0m～8m	
- Spp - Ipomaea chryseides - Saccharum arundinaceum - Saccharum Spp - Ricinus communish - Spp - Polyalthia corticosa	- Spp - Ipomaea chryseides - Saccharum arundinaceum - Saccharum Spp - Ricinus communish - Spp - Spp - Polyalthia corticosa	- Spp - Spp - Saccharumarundinaceum - Saccharum Spp - Ricinus communish - Enterolobium saman - Ipomaea chryseides - Crateva magna - Urena lobota - Achyranthes aspera - Spp - Spp - Indigofera subverticillata - Dolichos Spp - Spp - Sida supina - Amarantus spinosus - Spp - Crotalaria Spp - Spp - Cyperus rotundus - Spp - Cassia siamea - Spp - Celosia cristata - Mimosa pudica - Polyalthia corticosa	- Leersia hexandra - Saccharum Spp - Ipomaea chryseides - Urena lobota - Achyranthes aspera - Spp - Ricinus communish - Spp - Indigofera subverticillata - Cyperus rotundus - Spp - Cassia siamea - Packdanghae - Eupatorium odoratum - Haplophragma adenophyllum - Vitex pubescens - Enterolobium saman - Ficus hispida	

Figure 1.22 Cross Section of Vegetation in Dongphosi Site

1.3.5 Recommendations

Planting by seedling was the most successfully among three planting methods. However, this method was costly than other two due to the preparation of the seedling in the nursery at least three months before bringing to plan and the cost for seedling transport.

In general, the stump directly planting and seed sowing in the construction sites are not successfully. The reasons of failing are as follows:

- It is necessary for stump directly planting to keep moisture by watering every day. However, the site condition of the slope was with stones and it was difficult to keep moisture.
- The time of seed sowing was at the end of March. It was only two months before flood, too short for the seed to mature in order to make the young seedling grow against flood. If the seed was sown more deeply under the stones or soil, the seed and the young seedling could be alive.
- The monitoring period is short. There is possibility that the willow included in Shikisoda will germinate in two or three years after construction.

According to the monitoring result, it is better to plant willow by seedling on the cobble stone works. However, there is a fair possibility of success by another planting method. Based on the finding of the test planting and experience, recommendations for the further vegetation riverbank protection works are thereby made as below:

- Using vertical willow branch (TATE-SODA) to plant deeply instead of stump directory planting.
- Sowing seed under Siki-Soda and using germinated seed before sowing.
- Planting by seedling should be promoted for the construction site.
- It is necessary to continue monitoring for three to five years.

Situation of willow survived (Seedling)
Dec/2003

Situation of willow survived
(Stump directly planting) Dec/2003

Growth Situation of willow (Seedling, Kok khai)
Jan/2004

Growth Situation of Willow Root
(Seedling, Kok khai) Jan/2004

Growth Situation of Willow
(Stump directory planting, khai Nun) Jan/2004

Growth Situation of Willow Root
(Stump directory planting, khai Nun) Jan/2004

Figure 1.23 Growth Performance of Willow in Dongphosi Site

2 VEGETATION CONDITION AT RELATED SITES

2.1 Riverine Vegetation Survey

2.1.1 Objective

- To know the characteristic of the riverine vegetation along the Mekong River.

2.1.2 Location

Four places were selected for riverine vegetation survey covering exiting riverbank protection site and natural slope:

- Existing Riverbank Protection Sites: Culture Park, Wattay and Sibounheuang (constructed by IDI) .
- Natural Slope: Watchan

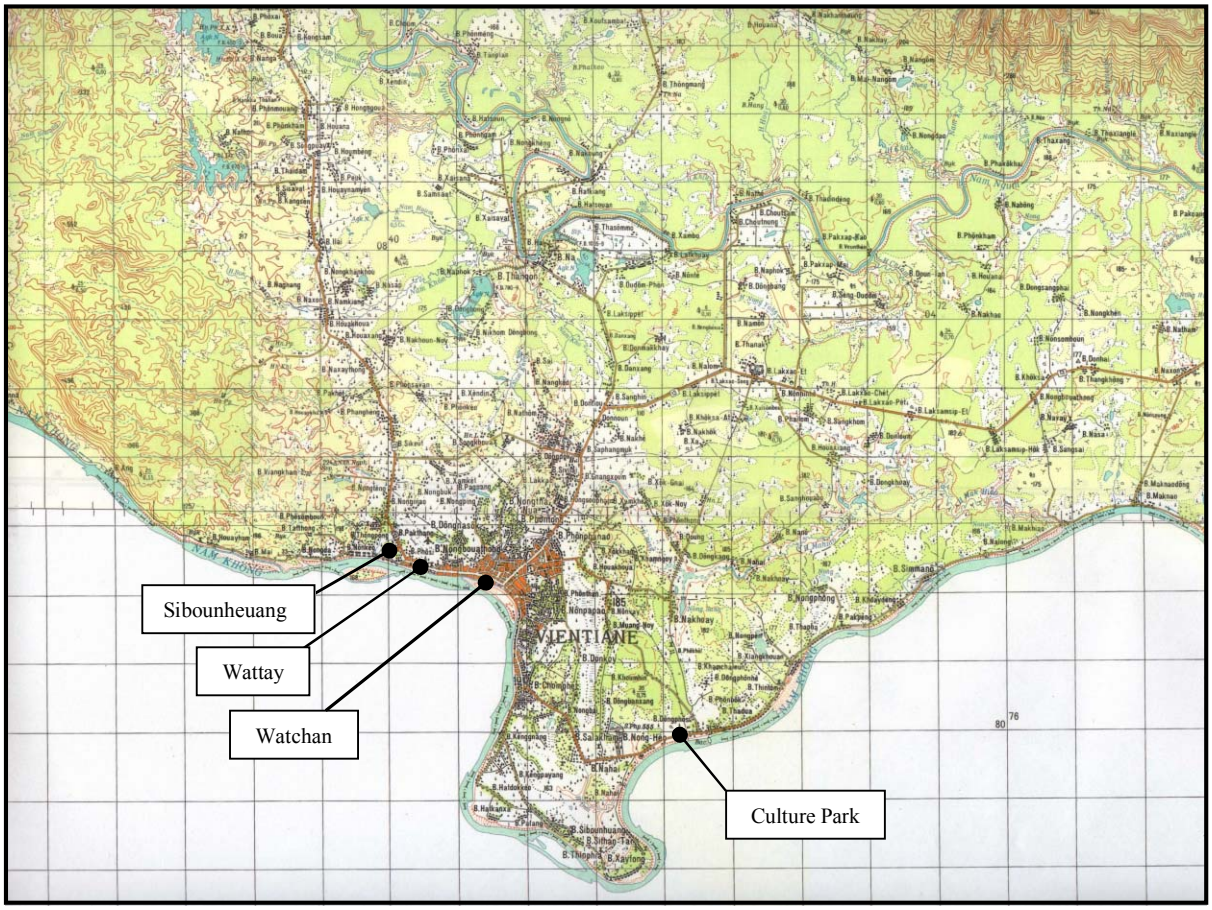


Figure 2.1 Location of the Riverine Vegetation Survey

2.1.3 Items and Schedule

Survey items of riverine vegetation are follows:

- Survey for drawing up riverine vegetation map.
- Flora survey by listing all existing plant growth along the survey place.
- Survey for drawing up cross section of riverine vegetation from the water edge to the top of slope including the typical stock in the survey place.

Survey items and schedule are as shown in Table 2.1.

Table 2.1 Items and Schedule of Riverine Vegetation Survey

Location	Monitoring Items	Unit	Q'ty	2003												2004											
				1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12
Culture Park	Distribution of vegetation and flora	Time	1																								
Watty	Distribution of vegetation and flora	Time	1																								
Sibounheuang (Constructed by IDI)	Distribution of vegetation and flora	Time	1																								
WatChan	Distribution of vegetation and flora	Time	1																								

2.1.4 Result

Figure 2.2-Figure 2.9 show the vegetation maps and each representative cross section. Table 2.2- Table 2.5 show the comparative results of the checked plants before rainy season and after rainy season.

(1) Existing riverbank protection sites:

1) Culture Park:

In comparison between two monitoring before and after rainy seasons, it was shown that 22 species were found for the first survey before raining season (February 2003) which showing one of 22 species could not identified. However, there were ten species increasing after raining season survey (December 2003) especially the *Herbaceous and grass* species such as Khua makbeop, Khua makpebnam, Khua houn, Nha dockbonghan which were short live period species. There were also 4 species could not identified. Table 2.2 shows the comparative results in Culture Park site.

February 2003

December 2003

Figure 2.2 Situation of Vegetation in Culture Park

2) Wattay:

The total of 33 species which were found during the first survey, however, five species were increasing after rainy season which were belong to *Herbaceous* species as shown in Table 2.3. During the second monitoring, the upper riverbank protection was clear and burned by local people for planting some species for consumption such as Munton and Wattay.

February 2003

December 2003

Figure 2.3 Situation of Vegetation in Watty

3) Sibounheuang (Constructed by IDI):

There were no change between the first and second surveys which the total of 14 species. Among them, it was five belong to the fast growing tree species namely: Kok samsa, somphor, kathin, kathan and takob, while two were belong to Shrub communities such as Lao and Or. The rest belong to Grass and Herbaceous communities. Table 2.4 shows the results of the two monitoring at Sibounheuang Site (constructed by IDI).

February 2003

December 2003

Figure 2.4 Situation of Vegetation in Sibounheuang (Constructed by IDI)

(2) Natural slope sites:

1) Watchan :

There were few species increased and reduced during between the first and second monitoring. Most of them were grasses and climbers which were short live period. The total of 23 were found during the first monitoring (Feb. 2003) while 22 were found during the second monitoring (Dec. 2003). Among these, two were found as a new species and three were missing from previous monitoring as shown in Table 2.5.

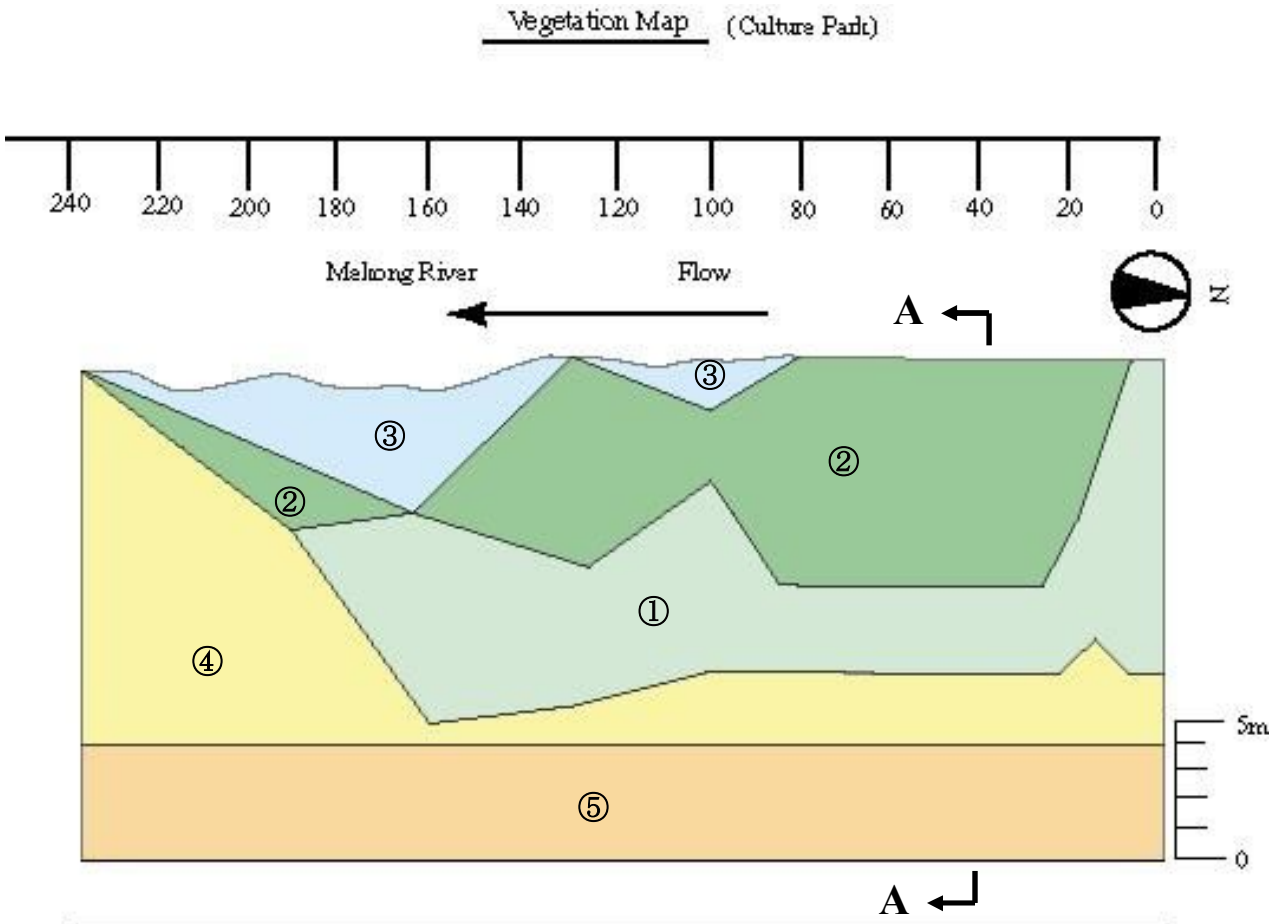
February 2003 December 2003

Figure 2.5 Situation of Vegetation in Watchan

2.1.5 Conclusions

In general, there were similar vegetation, annual community and gramineae community, at middle and upper layer in existing riverbank protection sites and natural slope. There were gramuneae community and willow community at the lower layer of riverbank.

It looks like easy for vegetation growing up on the Mekong riverbank, if soil could be kept there. So vegetation will be able to grow after construction of riverbank protection work. However, it is easy to flow away them with soil in flood season at natural riverbank. Therefore, it is effective for vegetation riverbank protection work to plant perennial plants, like willow, at lower layer and to keep soil there.



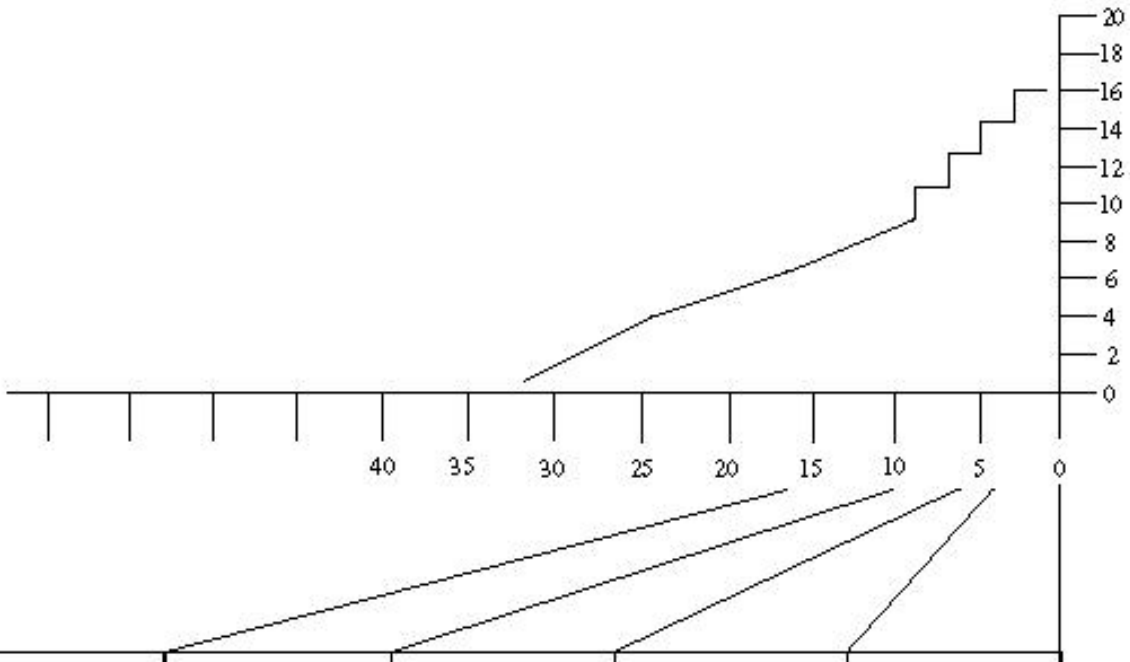
Location	Cultural Park	Date of survey	20/12/2003

Color	Community name etc.
①	Willow was cut
②	Willow community
③	Gramineae, Grass-covered
④	Annual communities
⑤	Annual + Perennail community
	Water

Figure 2.6 Vegetation Map in Culture Park

CROSS-SECTION OF VEGETATION

Location	Cultural Park	Date of survey	20/12/2003

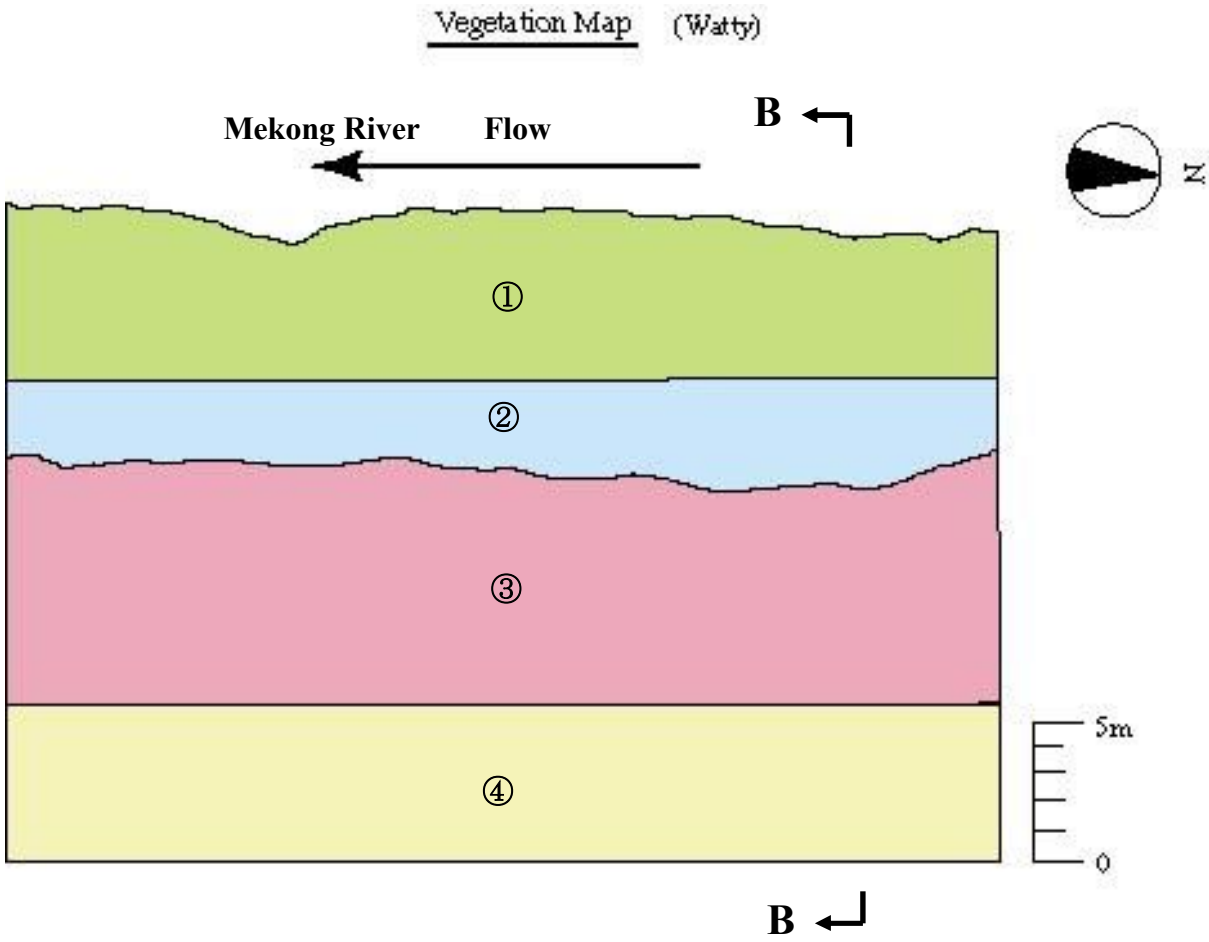


Horizontality	10～16m	6～10m	4～6m	0～4m
Plant Name (Lao)	Kolt Ithai	Nha Ithua Khua Ithiltadouay Kolt Ithai	Or Khua dou Khuanotnam	Khua Ithiltadouay Kolt hungsa Lao
Community Name	Willow Community	Gramineae, Grass-covered Community	Annual Community	Annual+Perennial Community

Remark

(E Kolt hungsa was young fruiting o-?Kolt Ithai is flowering

Figure 2.7 Cross Section A-A in Culture Park



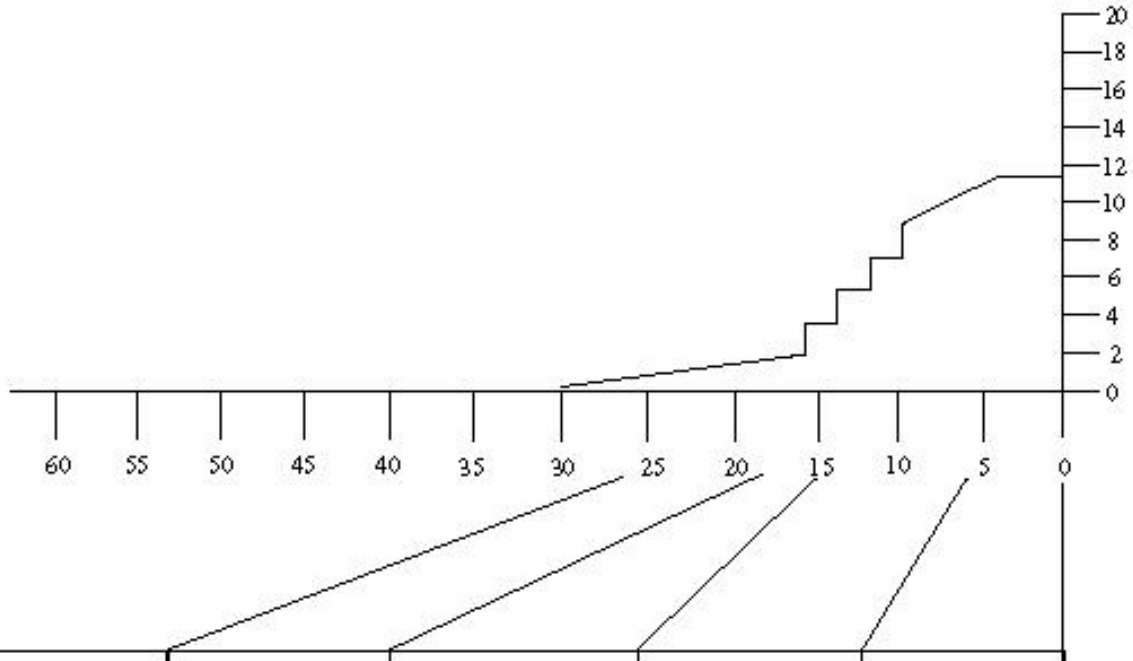
Location	Watty	Date of survey	20/12/2003

Color	Community name etc.
①	Gramineae Grass-Covered
②	Other Gramineae Community
③	Perennial Community
④	Annual Community
	Water

Figure 2.8 Vegetation Map in Wattay

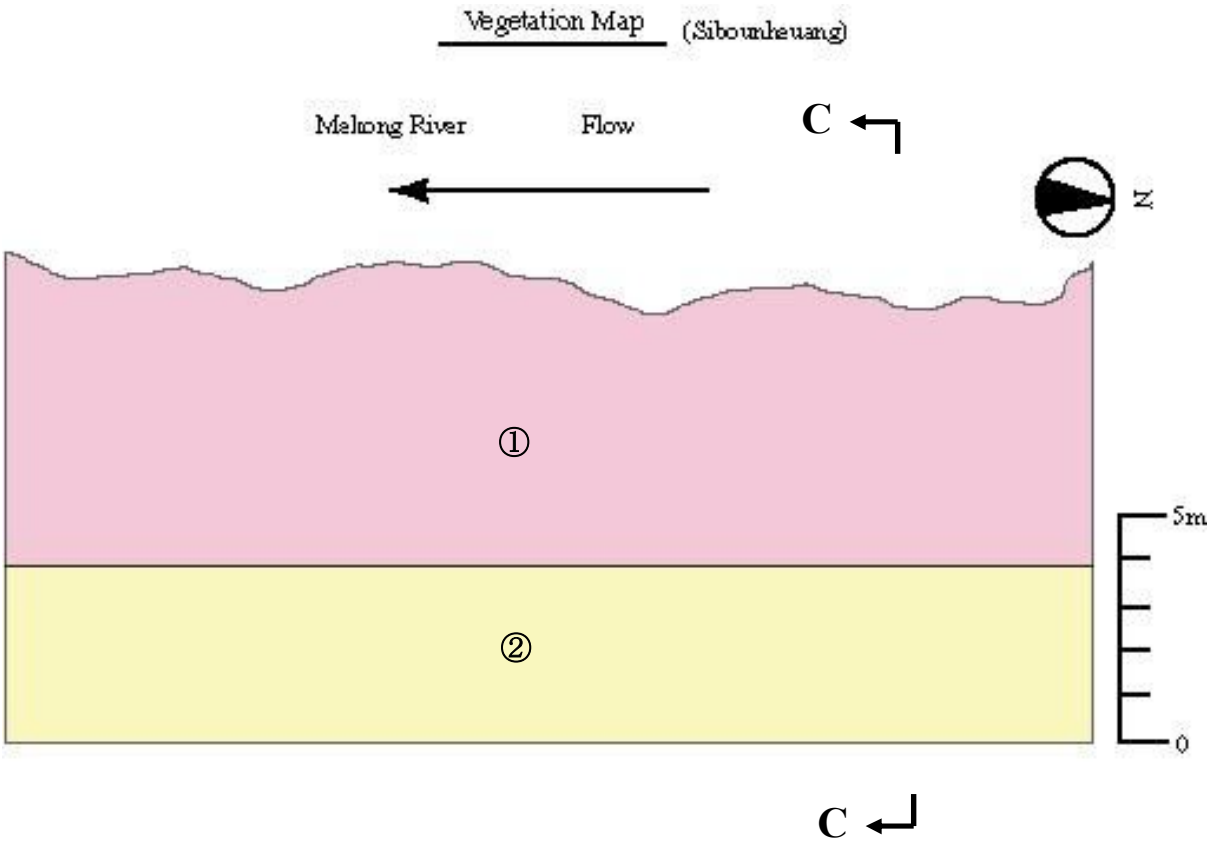
CROSS-SECTION OF VEGETATION

Location	Watty	Date of survey	20/12/2003



Horizontality	16~26m	15~16m	6~15m	0~6m
Plant Name (Lao)	Phalt pheonam Nha lthua Laolthipoun Khua lthiltaduan Or Khua hinghoy	Laolthipoun Khua lthiltaduan Khua nhanhang Or	Khua dou Laonoy Nha lthua Kolt lxathan Kolt dua Kolt lthan Kolt lxanthin Kolt lamnhai Kolt lthamthet Khua hinghoy Khua nhanhang Kolt lthao Khua lthiltaduan Kolt lthampome Nha lthoynhou Phalt bienh	Kolt lthamthet Nha lthew Kolt lxathan Nha nhoup Khua totma Khua nhanhang Kolt lxanthin Kolt moult Nha lthua Kolt lthan Kolt lthelao Kolt lthefalan Malt lthualthun Nha lthoynhou Kolt Linmai Kolt touahae
Community name	Gramineae Grass-covered	Other Gramineae Community	Perennial Community	Annual Community

Figure 2.9 Cross Section B-B in Wattay



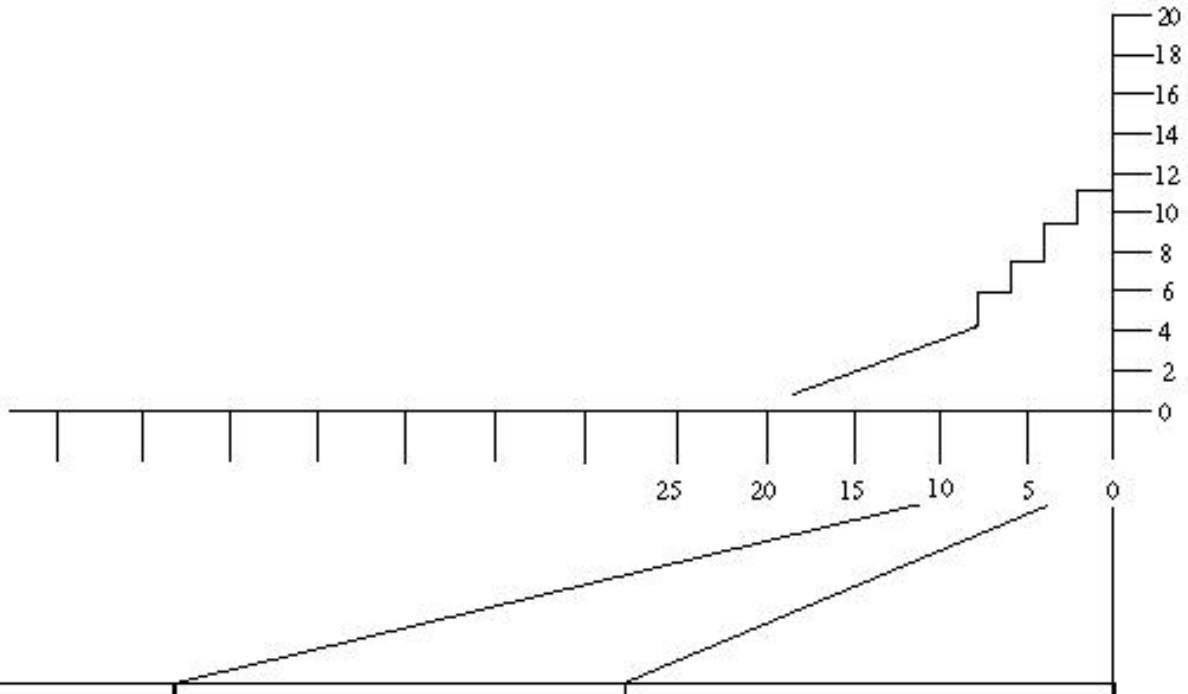
Location	Sibounheuang	Date	20/12/2003

Color	Community name
①	Gramineae (grass) community
②	Annual community
	Water

Figure 2.10 Vegetation Map in Sibounheuang (Constructed by IDI)

CROSS-SECTION OF VEGETATION

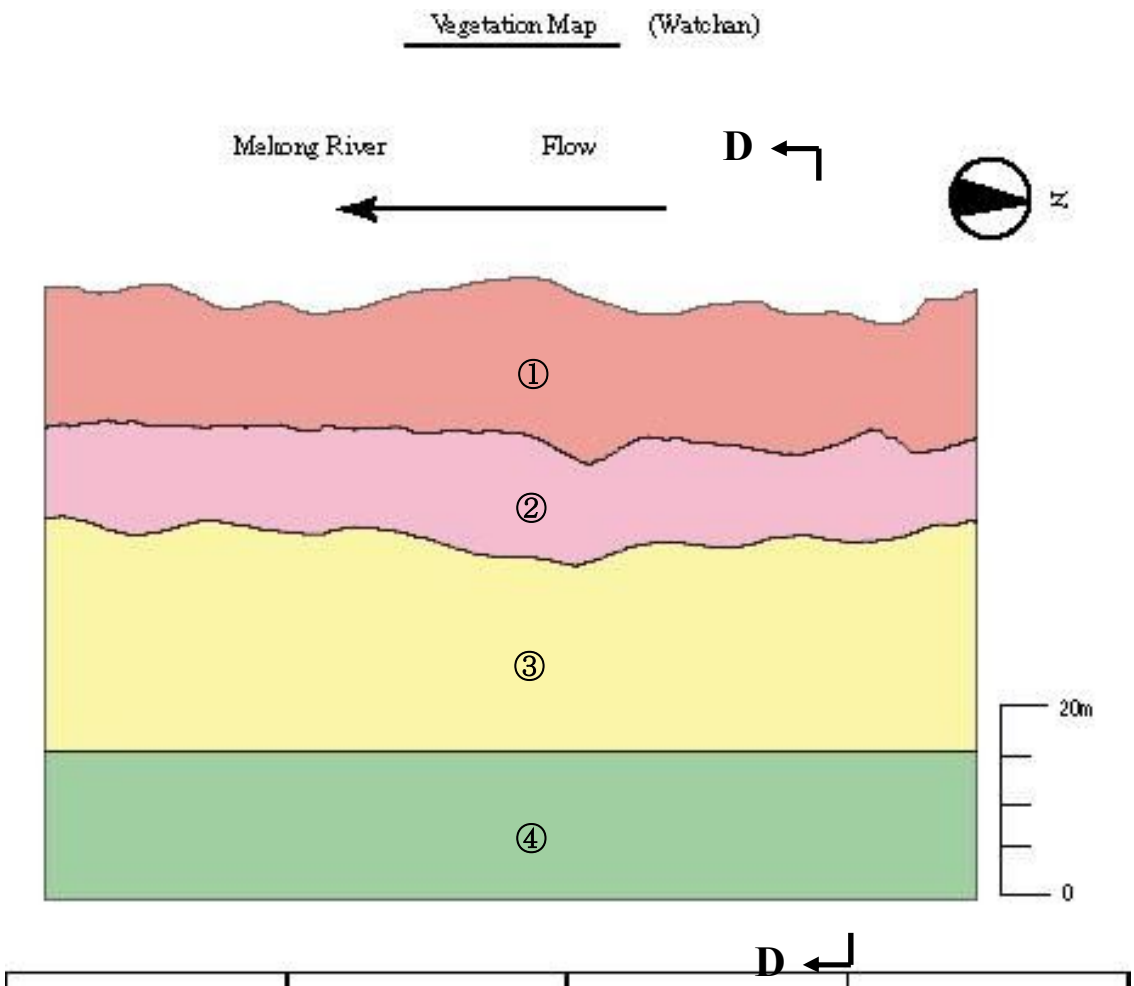
Location	Sibounheuang	Date of survey	20/12/2003



Horizontality	4~11m	0~4m
Plant Name (Lao)	Lao Khua khilladuan Or Nhahoualuoy	Kolk talop Khua khilladuan
Community Name	Gramineae(grass) Community	Annual Community

Remark
(E Partly distributed

Figure 2.11 Cross Section C-C in Sibounheuang (Constructed by IDI)



Location	Watchan	Dete of survey	20/1 2/2003

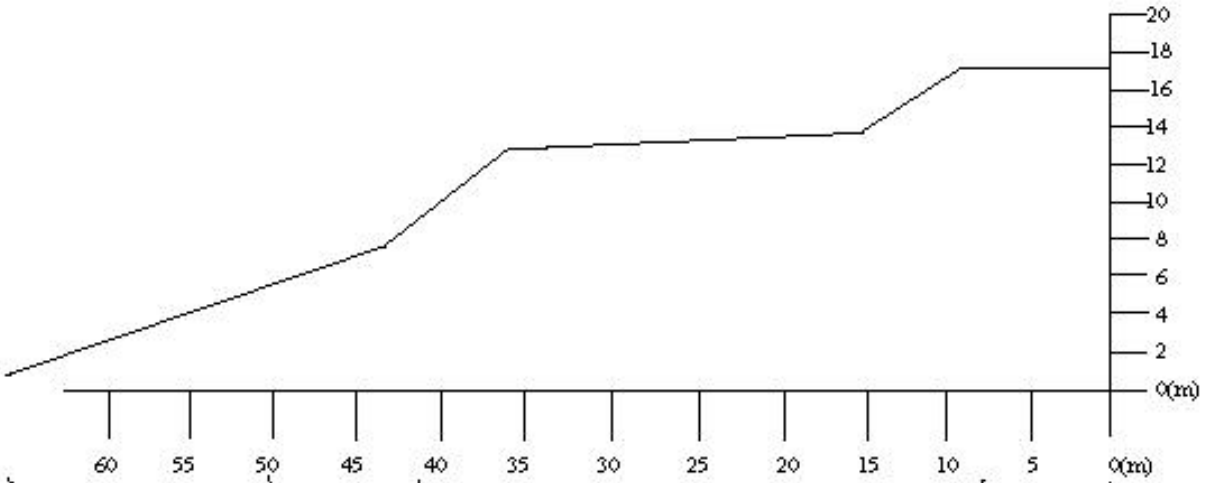
Color	Community Name
①	Herbaceous communities
②	Lao communities (highly distributed)
③	Lao and Herbaceous (medium distributed)
④	Fertile soil and Herbaceous communities (low distributed)
	Water

Gravel soil

Figure 2.12 Vegetation Map in Sibounheuang (Constructed by IDI)

CROSS-SECTION OF VEGETATION

Location	Watchan	Date of survey	20/12/2003



Horizontality	50~66m	41~50m	16~41m	8~16m	0~8m
Plant Name (Lao)	No	Lao Nha lthua Laolthipoun Phalt bong Or Phalt pheonam Malt lthualthun	Malt phet Phu Malt oc Nha houalthouay Kolt talop Laolthipoun Lao Malt lthualthun Doolt sampy Nha lthua Khua malteng Phalt lthat Phalt bongg Khua lthiltachuan Nhalt hewpha	Nha houalthouay Lao	Nha lthua Nha houalthouay
Community Name	No Vegetation	Herbaceous Community	Lao community	Lao and Herbaceous Community	

Figure 2.13 Cross Section D-D in Watchan

Table 2.2 Comparative Results in Culture Park Site

No.	Feb. 2003	Dec. 2003	Dec. 2003		Scientific Name
			Increased	Reduced	
1	Kok hungsa	Kok hungsa			*Ricinus communish*
2	Khua khikaduan	Khua khikaduan			*Ipomaea chryseides*
3	Lao	Lao			*Saccharum arundinaceum*
4	Or	Or			*Spp*
5	Nhakhew	Nhakhew			*Spp*
6	Khua dou	Khua dou			*Spp*
7	Tamngaenam	Tamngaenam			*Spp*
8	Khua notnam	Khua notnam			*Spp*
9	Kok kanluang	Kok kanluang			*Gonocaryum subrostratum*
10	Spp.	Spp.			*Spp.*
11		**Spp.**	**Spp.**		***Spp.***
12		**Dock honkai**	**Dock honkai**		***Spp***
13	Touaseong	Touaseong			*Phaseolus calca*
14		**Nha dockbonghan**	**Nha dockbonghan**		***Spp***
15	Khua nhanhang	Khua nhanhang			*Spp*
16	Kok khaonam	Kok khaonam			*Spp*
17		**Khua makbeop**	**Khua makbeop**		***Spp.***
18	Kok kanthin	Kok kanthin			*Leucaena glauca*
19		**Kok hai**	**Kok hai**		***Ficus superba***
20	Kok kum	Kok kum			*Crateva magna*
21		**Spp.**	**Spp.**		***Spp.***
22		**Spp.**	**Spp.**		***Spp.***
23		**Khua houn**	**Khua houn**		***Spp***
24		**Spp.**	**Spp.**		***Spp.***
25	Khua hinghoy	Khua hinghoy			*Crotalaria Spp*
26		**Khua makpebnam**	**Khua makpebnam**		***Dolichos Spp***
27	Nha khua	Nha khua			*Spp*
28	Phak pheonam	Phak pheonam			*Polygonum odoratum*
29	Mak khuaba	Mak khuaba			*Datura metel*
30	Kok khai	Kok khai			*Polyalthia corticosa*
31	Kok dua	Kok dua			*Ficus auriculata*
32	Khua makphet	Khua makphet			*Dolichos lablab*
Total	**22**	**32**	**10**		

Table 2.3 Comparative Results in Wattay Site

No.	Jan. 2003	Dec. 2003	Dec. 2003		Scientific Name
			Increased	Reduced	
1	Munton	Munton			*Manihot utilissima*
2	Sikai	Sikai			*Andropogon citratus*
3	Khua dou	Khua dou			*Spp*
4	Khua totma	Khua totma			*Paederia tomentosa*
5	-	**Nha dockbonghan**	**Nha dockbonghan**		***Spp.***
6	-	**Spp.**	**Spp.**		***Spp.***
7	Kok kanthin	Kok kanthin			*Leucaena glauca*
8	Kok lamnhai	Kok lamnhai			*Spp*
9	Kok khamthet	Kok khamthet			*Pithecolobium dulce*
10	Kok kathan	Kok kathan			*Zixyphus jujuba*
11	Kok puay	Kok puay			*Lagerstroemia balansae*
12	Kok khao	Kok khao			*Eupatorium odoratum*
13	Kok dua	Kok dua			*Ficus auriculata*
14	Kok ngiouban	Kok ngiouban			*Bombax malabaricum*
15	Kok linmai	Kok linmai			*Oroxylum indicum*
16	-	**Kok touahae**	**Kok touahae**		***Cajanus indicus***
17	Nha heomou	Nha heomou			*Spp*
18	Khua nhanhang	Khua nhanhang			*Spp*
19	Laonoy	Laonoy			*Saccharum Spp*
20	Phak pheonam	Phak pheonam			*Polygonum barbatum*
21	Khua notnam	Khua notnam			*Ficus heterophylia*
22	Laokhipoun	Laokhipoun			*Saccharum Spp*
23	Nha khoynhou	Nha khoynhou			*Achyranthes aspera*
24	Nha kha	Nha kha			*Imperata cylindrica*
25	-	**Phak bieang**	**Phak bieang**		***Spp***
26	Kok khelao	Kok khelao			*Haplophragma adenophyllum*
27	-	**Dock honkai**	**Dock honkai**		***Spp***
28	Nha khew	Nha khew			*Spp*
29	Nha nhoup	Nha nhoup			*Cassia tora*
30	Kok mouk	Kok mouk			*Wrightia tomentosa*
31	Nha khua	Nha khua			*Panicum sarmentosum*
32	Kok kham	Kok kham			*Tamarindus indica*
33	Mak khuakhun	Mak khuakhun			*Solanum sanitwongsei*
34	Khua khikaduan	Khua khikaduan			*Ipomaea chryseides*
35	Kok kanluang	Kok kanluang			*Gonocaryum sobrostratum*
36	Kok khampome	Kok khampome			*Phyllaqnthus emblica*
37	Khua hinghoy	Khua hinghoy			*Crotaloria Spp*
38	Or	Or			*Spp*
Total:	**33**	**38**	**5**	**0**	

Table 2.4 Comparative Results in Sibounheuang Site

No.	Jan. 2003	Dec. 2003	Dec. 2003		Scientific Name
			Increased	Reduced	
1	Khua khikaduan	Khua khikaduan			*Ipomaea chryseides*
2	Lao	Lao			*Saccharum arundinaceum*
3	Kok samsa	Kok samsa			*Enterolobium saman*
4	Kok somphor	Kok somphor			*Streblus asper*
5	Kok kanthin	Kok kanthin			*Leucaena glauca*
6	Kok kathan	Kok kathan			*Zixyphus jujuba*
7	Nha khewpha	Nha khewpha			*Spp*
8	Khua todma	Khua todma			*Spp*
9	Or	Or			*Spp*
10	Nha khua	Nha khua			*Panicum sarmemtosum*
11	Kok takob	Kok takob			*Muntingia calabura*
12	Phac bon	Phac bong			*Ipomoea aquatica*
13	Khua makkhika	Khua makkhika			*Spp*
14	Nha houakeow	Nha houakeow			*Spp*
Total:	**14**	**14**	**0**	**0**	

Table 2.5 Comparative Results in Watchan Site

No.	Jan. 2003	Dec. 2003	Dec. 2003		Scientific Name
			Increased	Reduced	
1	Lao	Lao			*Saccharum arundinaceum*
2	Khua khikaduan	Khua khikaduan			*Ipomaea chryseides*
3	Kok takob	Kok takob			*Muntingia calabura*
4	Phuk bong	Phuk bong			*Ipomoea aquatica*
5	Nha sai	Nha sai			*Spp*
6	Phak pheonam	Phak pheonam			*Polygonum odoratum*
7	Nha khua	Nha khua			*Panicum sarmemtosum*
8	**-**	**Nha khionh**	**Nha khionh**		***Spp***
9	**-**	**Nha khewpha**	**Nha khewpha**		***Spp***
10	Kok kathan	Kok kathan			*Zixyphus jujuba*
11	Nha houakhouay	Nha houakhouay			
12	Kok khamthet	Kok khamthet			*Pithecolobium dulce*
13	Or	Or			*Spp*
14	Mak khuakhun	Mak khuakheun			*Solanum sanitwongsei*
15	Mak khua	Mak khua			*Solanum Spp*
16	Mak phet	Mak phet			*Capsicum frutescens*
17	Phu	Phu			*Spp*
18	Mak oc	Mak oc			*Spp*
19	Laokhipoun	Laokhipoun			*Saccharum Spp*
20	Dock sampy	Dock sampy			*Spp*
21	Phak khat	Phak khat			*Spp*
22	**Nha nhoup**	**-**		**Nha nhoup**	***Cassia tora***
23	Nha pong	Nha pong			*Spp*
24	**Phak danghae**	**-**		**Phak danghae**	***Spp***
25	**Nha khew**	**-**		**Nha khew**	***Spp***
Total	**23**	**22**	**2**	**3**	

2.2 Wooden Materials Collection Site

2.2.1 Soda Materials

Sosa materials were collected at several sites such as Danxi, Nongpen and Laxanship, etc. The survey of Vegetation condition of the forest was executed at Nongpen site on February 2004. It is judged that the vegetation condition is almost the same before Soda materials collection and after, because many trees have been growing.

Figure 2.14 Vegetation Condition at Nongpen Site

SECTOR G

MONITORING SURVEY FOR PILOT WORKS

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SECTOR G

MONITORING SURVEY FOR PILOT WORKS

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SECTOR G

MONITORING SURVEY FOR PILOT WORKS

This sector describes detailed specification and general result of the field survey and investigations conducted by local contractors for the monitoring of the three (3) pilot work sites. This includes 1) Cross-sectional survey and 2) Velocity measurement.

1 CROSS-SECTIONAL SURVEY

1.1 General

Cross-sectional survey were carried out to obtain the topographical condition in/around three pilot work sites for the monitoring under the condition in the dry (low water) season during 2002 – 2004, including once on February 2002 before the construction of the Pilot Works and two times, on June 2003 and January 2004 after the completion of the Pilot Works. The survey works were conducted by a local contractor under the supervision of the Study Team.

1.2 Method

Cross-sectional survey were carried out by applying the same method described in Section 1 of Sector C and by using the facilities established in the field survey work done in the period from January to February 2002. Cross-sectional survey was carried out at existing course of traverse established in the field survey work.

1.3 Quantity of Works

Quantity of each monitoring work is as shown in Table 1.1.

Table 1.1 Quantity of Cross-sectional Survey

Location of Cross-sectional survey	Unit	Quantity	Remark
1) Ban Dongphosi Site	Line	43	pitch=20m, line length=50m
2) Wat Chom Cheng Site		21	
3) Sibounheuang Site		16	

1.4 Result

The drawings of cross sections are prepared with the vertical scale of 1:100 and horizontal scale of 1:100. The final results are 3 sets of the drawings.

2 VELOCITY MEASUREMENT

2.1 General

Velocity measurements were carried out to obtain the current speed and direction in/around three pilot work sites for the monitoring under the condition in the rainy (high water) season and in the dry (low water) season, including twice on January and on October 2002, before the construction of the Pilot Works and four times, on June 2003, September 2003, January 2004 and August 2004 after the completion of the Pilot Works.

2.2 Method

The survey works were conducted by a local contractor under the supervision of the Study Team. The measurement was carried out by applying the same method as described in Section 3 of Sector C and by using the facilities established in the filed survey work in the period form January to February 2002.

2.3 Quantity of Works

Quantity of each monitoring work is as shown in Table 2.1.

Table 2.1 Quantity of Velocity Measurement Works

Work Item	Quantity
a) Ban Dongphosi Site	9 lines x 20 points/line = 180 points
b) Wat Chom Cheng Site	3 lines x 20 points/line = 60 points
c) Sibounheuang Site	3 lines x 20 points/line = 60 points

2.4 Result

Final results are as follows:

Results of measurement in tabulated form and figures on:

- Location of each measurement
- Vertical distribution of current speed
- Plan distribution of current speed and direction