26.8 Revision of arrangement of channel stabilization facilities

26.8.1 Subjects to be reviewed

Alternative 1 is selected in the former section as basically the most preferable channel stabilization plan. Here the plan is reviewed to deepen the discussions on appropriateness of its alignment and refine the plan, if necessary.

The main subjects are effectiveness of the groins in terms of their structure and permeability, and optimum width of main channels related to the location of the training walls and slope protections.

Reflecting the results of these analyses, numerical simulations will be carried out to confirm the effect of revisions.

26.8.2 Permeability of groins

The structures of the planned groins are discussed, and a pile structure with stone mound is selected as the most suitable for this Project. The reasons are as follows:

1) During the flood season, the groin shall not hinder the flow as much as possible so as to secure flood discharge, and not to increase the water level during the flood.
2) During the intermediate and dry seasons, the groin shall be effective enough to stop the current and deviate the main stream to offshore.
3) Construction materials and machinery must be available in Vietnam with reasonable cost.

Two-row pile structure is selected from the practical point of view. The pile is made of reinforced concrete with a square section of 40cm x 40cm. The interval of piles in a row is 2m taking account of construction and economy. The top level of group piles is taken as LSD +9m, which corresponds to the bankful-discharge water level. The crown level of the stone mound is decided to be 3m to 4m to secure the current blocking effect and pile sustaining function.

Then, the overall Permeability of the groins is discussed, and the diagram to show the permeability is presented in **Figure 26.8.1**. It is confirmed that the groin has an overall permeability of 0.5 to 0.7 under the flood condition with water levels between 10m to 13m, which corresponds to usual values for such type of constructions.

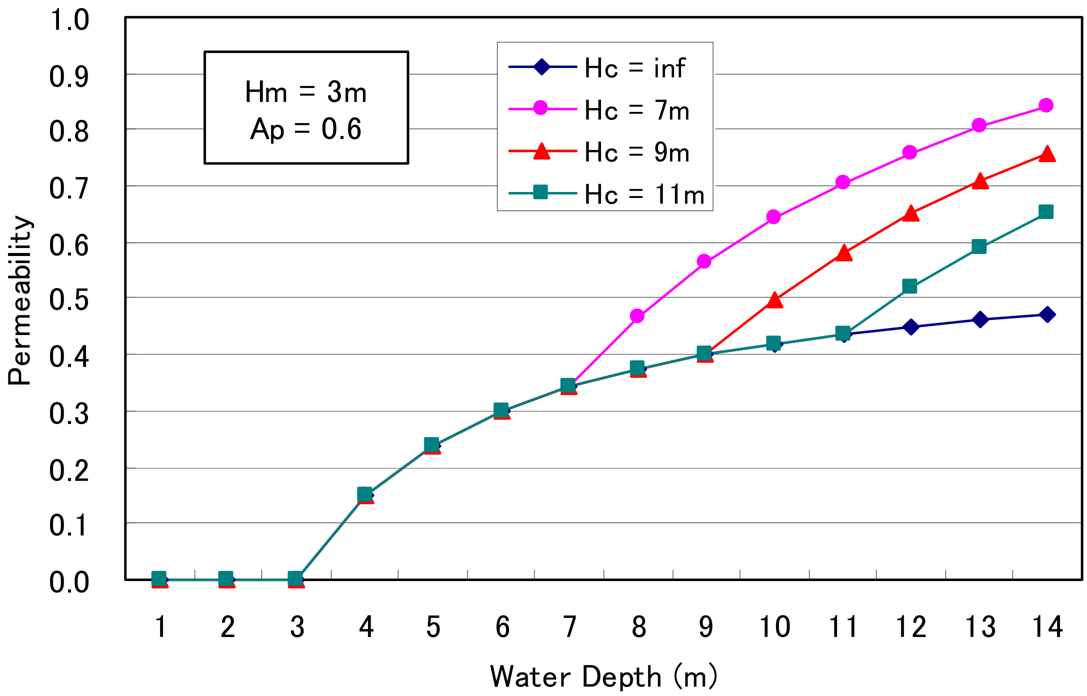

Figure 26.8.1 (1) Permeability of Groins
(Mound height: 3m, Permeability of Piles: 0.6)

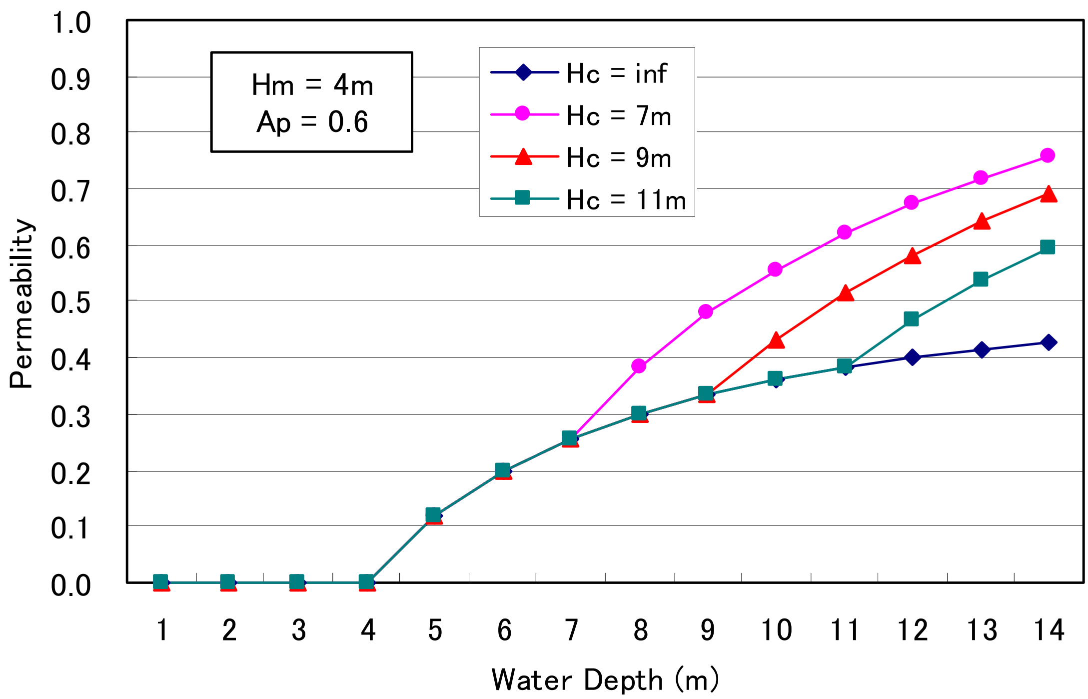

Figure 26.8.1 (2) Permeability of Groins
(Mound height: 4m, Permeability of Piles: 0.6)

26.8.3 Optimum channel width

(1) Statistical characteristics of channel width

In order to confirm the appropriate width of the channels at Nhat Tan and Trung Ha-Tu Lien, surveyed hydraulic parameters are examined statistically in terms of hydraulic section, *A*, water surface width, *B*, and average water depth, *H*. The result is shown in **Figure 26.8.2 (1)** , which is the case of the transitional season, in which water level is LSD +6.00 m at Hanoi H-M Station.

It is derived from this Figure that the existing channels have the following dimensional characteristics:

At Nhat Tan Sand Bar,

Main Channel:	*B* **600m** x *H* 6m = *A* 3,600 m^2	
Secondary Channel:	*B* 300m x *H* 5m = *A* 1,500 m^2	
Total:	*B* **900m**	*A* 5,100 m^2

At Tu Lien- Trung Ha Sand Bar,

Main Channel:	*B* **500m** x *H* 6m = *A* 3,000 m^2	
Secondary Channel:	*B* 200m x *H* 3m = *A* 600 m^2	
Total:	*B* **700m**	*A* 3,600 m^2

(2) Theoretical approach to derive optimum cannel width

Another examination is made theoretically based on an established relationship between width and depth of a rectangular channel under dynamic equilibrium state:

$$y = a\,x^{-b} \qquad (1)$$

where $y = B/B_0$ and $x = H/H_0$, *a* and *b* are parameters, and B_0 and H_0 are reference width and depth, respectively.

The actual data at the main channels of Nhat Tan and Tu Lien-Trun Ha Sand bars are applied to this equation by rms approximation. The result is shown in **Figure 26.8.2 (2)**, or a = 1.0624 and b = 0.8218.

Then, the optimum main channel widths are confirmed to be about **600m** for Nhat Than Sand Bar and about **500m** for Tu Lien- Trung Ha Sand Bar as shown in **Table 26.8.1**.

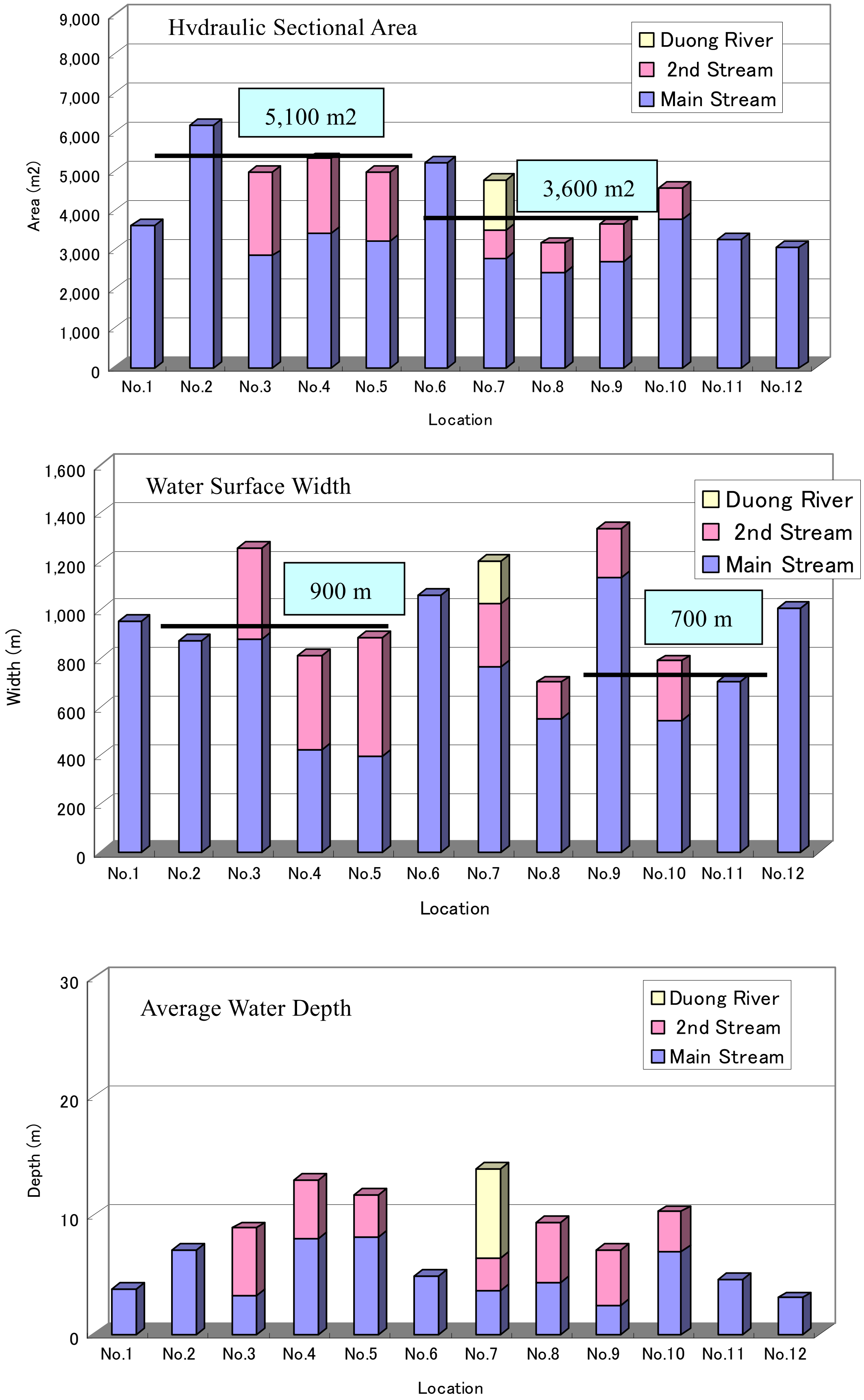

Figure 26.8.2 (1) Dimensional Characteristics of the Existing Channels in the Transitional Season (Water level: CDL +6.00m)

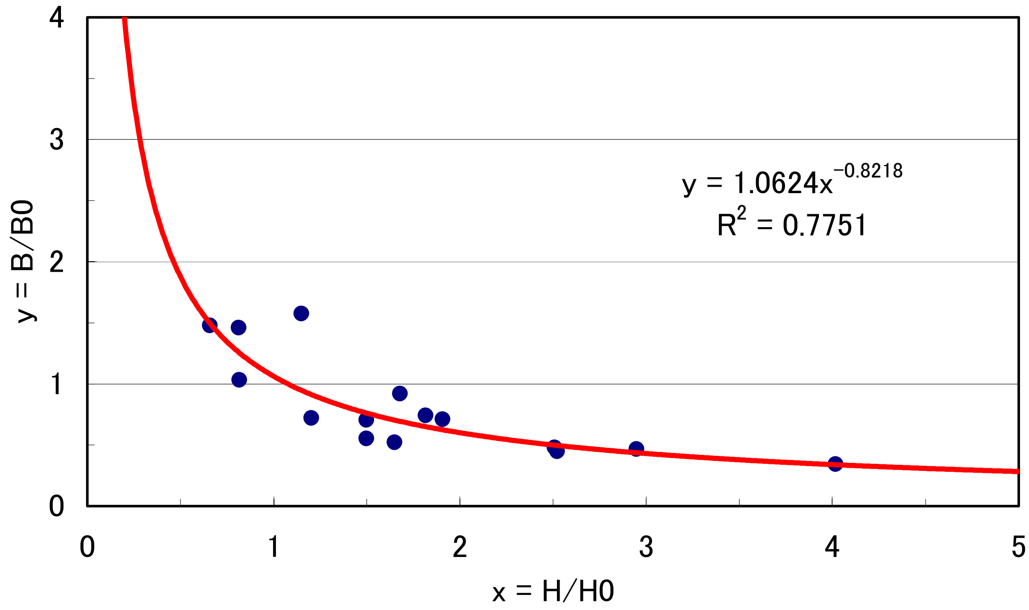

Figure 26.8.2 (2) Relationship between Channel Width and Depth

Table 26.8.1 Required Channel Width based on Theoretical Balance Equation

(Unit: m)

Location	Percentage Occurrence	Water Depth		Channel Width	
		H	*H₀*	*B₀*	*B*
Nhat Tan Sand Bar	7%	9	6.18	891	695
	27%	6	3.22	883	563
	95%	2.5	1.56	794	573
	Average				610
Tu Lien-Trung Ha Sand Bar	7%	9	6.46	794	642
	27%	6	3.63	766	539
	95%	2.5	1.74	362	286
	Average				490

26.8.4 Confirmation by computer simulations

(1) Cases of simulations

The following cases are examined by numerical simulations based on **Alternative 1** for the conditions of the dry season:

1) Alternative 1d (Original Location and Moved Location) : Groins are set to be impermeable. The location of the two groins at Dong Ngoc can be moved within a distance of about 100m upward from the originally planned location to examine the effect of the location to the flow into the secondary channel.

2) Alternative 4 : Width of the main channel at both Nhat Tan and Tu Lien-TrunHa are widened to about 600m. The Dong Ngoc Groins are kept at the same location as that of original Alternative 1.

3) Alternative 5 : Width of the main channel at Nhat Tan is widened to about 600m, while maintaining that of Tu Lien-Trun Ha same as **Alternative 1**, or about 500m. The Dong Ngoc Groins are moved about 100m upstream from the original location.

(2) Result of simulations

The current vector distributions are shown as follows:

Figure 26.8.3 Current Vector (Dry Season, **Alternative 1d** (Dong Ngoc Groin: Original Location))

Figure 26.8.4 Current Vector (Dry Season, **Alternative 4** (Dong Ngoc Groin: Original Location))

Figure 26.8.5 Current Vector (Dry Season, **Alternative 5** (Dong Ngoc Groin: Moved upstream))

The hydraulic characteristics of the flow for the above Alternatives are summarized in **Table 26.8.2.** The locations of the cross sections denoted by capital letters, A to Q, are shown in **Figure 26.8.6**. The longitudinal distribution of the velocity along Talweg is shown in **Figure 26.8.7**.

One of the significant results of the above simulations is that, in the case of **Alternative 1d** (Dong Ngoc Groin: Original location), the secondary channel at Nhat Tan Sand Bar is substantially closed by the lower groin. This means that the groin has an effect like the weir of **Alternatives 2** and **3**. In order to maintain the flow into the secondary channel, it is necessary to move it upstream as demonstrated in **Alternative 5** (Dong Ngoc Groin: Moved upstream)).

The overall flow pattern is smooth for all Alternatives except at the left slope of Trun Ha Sand Bar where the current converges to the Bar.

Thus, Judging from velocity distribution in **Figure 26.8.7**, **Alternative 5** can be considered as the most preferable case. In this case the discharge into the Duong River decreases by 4%.

(3) Consideration on Self-scouring Effect

Further on **Alternative 5**, an examination is made on the self-scouring effect owing to construction of the channel stabilization facilities. The effect of deepening is assumed as already shown in **Figure 26.7.9(1)**. This case is called **Alternative 5s** and simulation calculations are carried out for the flood season (Water level: H=9.09m at Hanoi Station and Water discharge: Q=10,445m^3 at the upper boundary).

The current vector distribution is shown in **Figure 26.8.9**. The flow pattern is smoothened very much. The ratio of current speeds between **Alternative 5s** and the present condition is shown in **Figure 26.8.10**. Hydraulic characteristics are summarized in **Table 26.8.3.** Most of the locations above Chuong Duong Bridge experience a certain decrease in water level during the flood compared with the dry season. The decrease ranges from 2cm to 8cm. Down from the Bridge, water level increases by about 2cm to 4cm. Change of water discharge is preferable throughout the segment, e.g. 15% increase at Nhat Tan main channel and decrease in the secondary channel, 3% decrease at the Duong River, 5% increase in the Trung Ha main channel, and 8% decrease in Lach Quit.

The resultant riverbed variation is assessed as shown in **Figure 26.8.11**. Change of water depth in the main and secondary channels are small in quantity.

The above characteristics can be understand that they might feature the general picture of the effect of channel stabilization after construction of the channel stabilization facilities.

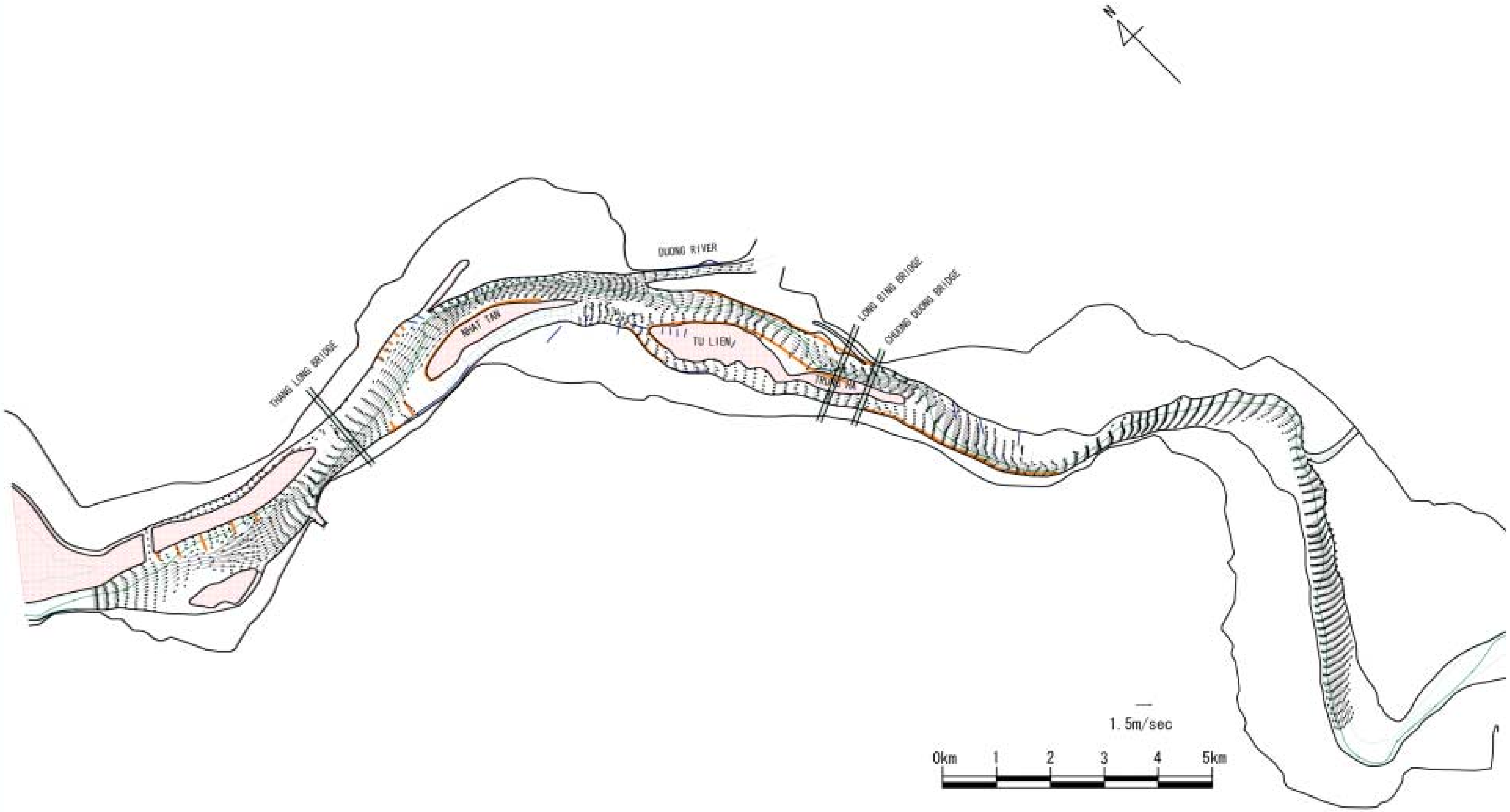

Figure 26.8.3 Current Vector (Dry Season, Alternative 1d
(Dong Ngoc Groin: Original Location)

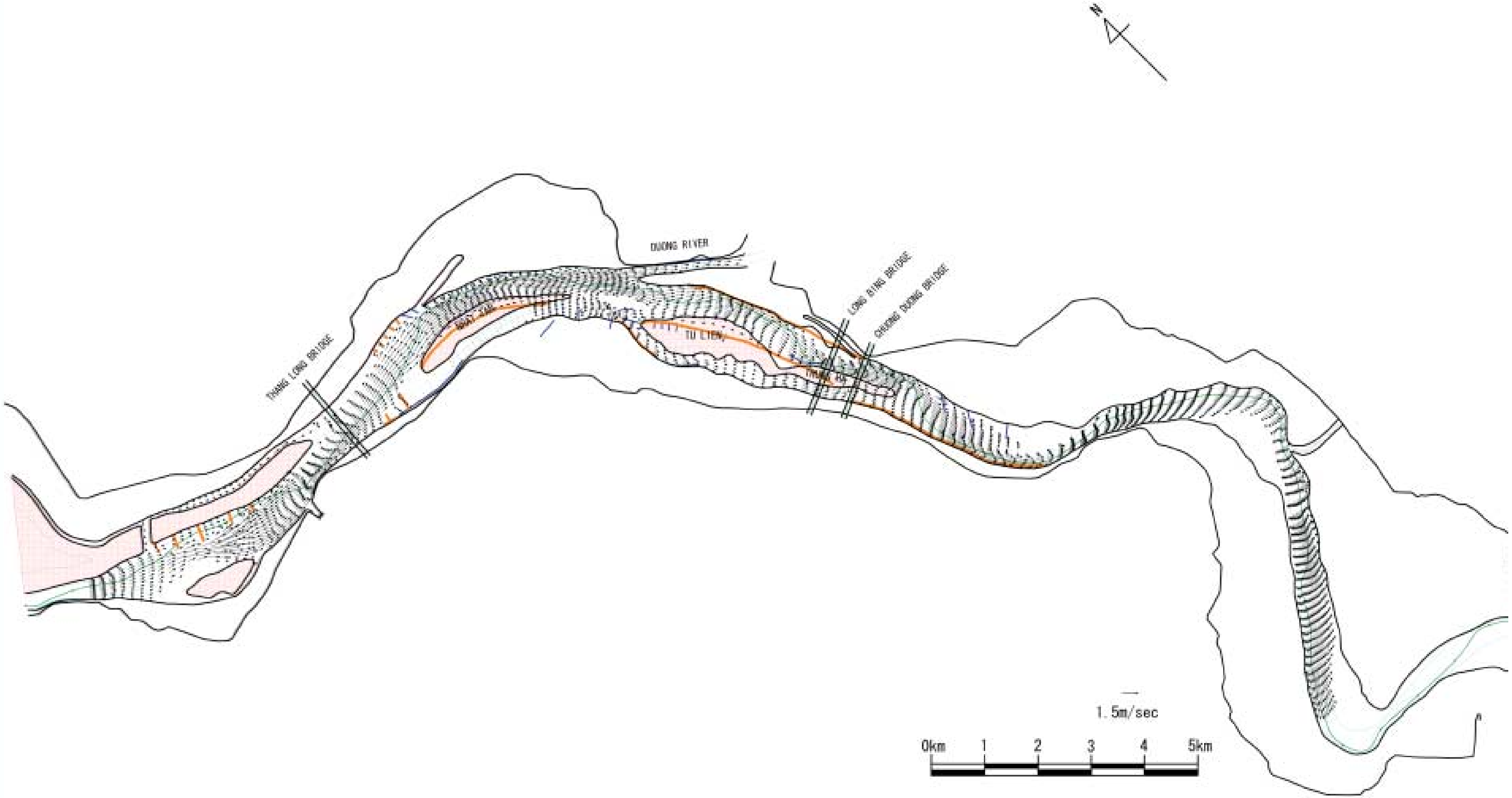

Figure 26.8.4 Current Vector (Dry Season, Alternative 4
(Dong Ngoc Groin: Original Location)

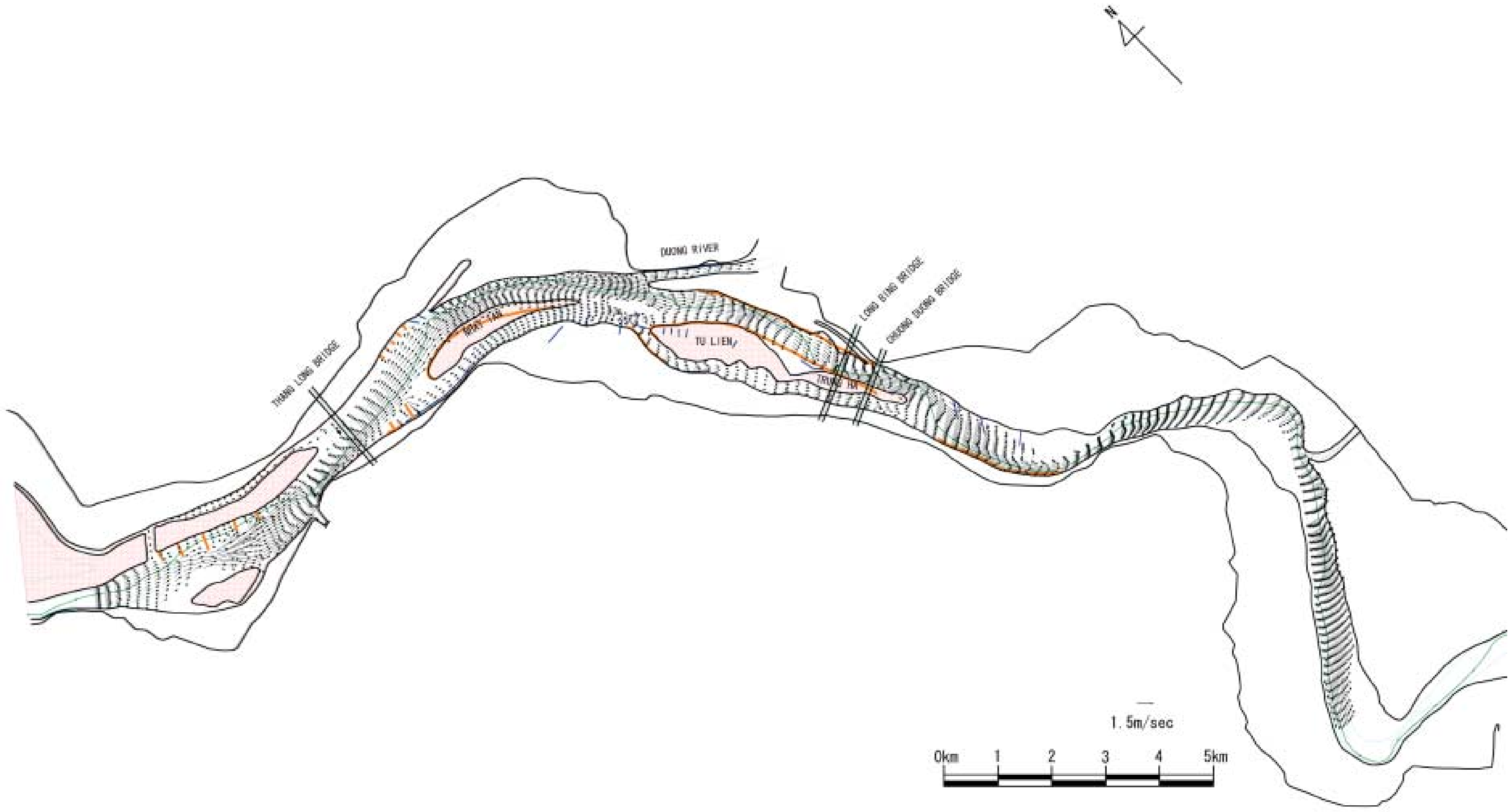

Figure 26.8.5 Current Vector (Dry Season, Alternative 5
(Dong Ngoc Groin: Moved upstream)

Table 26.8.2 Hydraulic Characteristics of the Flow (Dry Season)

Water Level (m)

Section	Present Condition	Alternative 1d	Alternative 4	Alternative 5	
A	4.263	4.448	4.289	4.211	Main
B	4.225	4.258	4.122	4.032	Main
C	3.782	4.000	3.879	3.843	NHAT TAN Main Channel
D	3.790	3.608	3.663	3.702	NHAT TAN 2nd Cannel
E	3.700	3.729	3.684	3.695	Main
F	3.751	3.608	3.663	3.688	2nd
G	3.553	3.585	3.542	3.539	Duong River
H	3.463	3.491	3.433	3.429	TU LIEN Main Channel
I	3.595	3.500	3.521	3.542	TU LIEN 2nd Cannel
J	3.312	3.361	3.316	3.285	Main
K	3.436	3.351	3.350	3.395	2nd
L	3.261	3.308	3.270	3.245	Main
M	3.397	3.316	3.323	3.372	2nd
N	3.041	3.004	3.058	3.069	TRUNG Ha Main Channel
O	3.265	3.193	3.154	3.242	TRUNG Ha 2nd Channel
P	2.841	2.794	2.849	2.852	Ha noi port
Q	2.497	2.482	2.502	2.504	Main

Velocity (m/sec)

Section	Present Condition	Alternative 1d	Alternative 4	Alternative 5	
A	1.480	1.284	1.337	1.373	Main
B	0.970	0.966	0.976	0.954	Main
C	1.020	1.368	1.297	1.153	NHAT TAN Main Channel
D	0.687			0.414	NHAT TAN 2nd Cannel
E	0.852	1.411	1.304	1.119	Main
F	0.444			0.267	2nd
G	0.798	0.979	0.772	0.767	Duong River
H	0.959	0.979	1.028	1.036	TU LIEN Main Channel
I	0.671	0.637	0.679	0.642	TU LIEN 2nd Cannel
J	0.957	0.906	0.813	0.914	Main
K	0.414	0.380	0.412	0.386	2nd
L	0.929	0.939	0.915	0.922	Main
M	0.605	0.472	0.616	0.568	2nd
N	1.023	0.961	0.904	1.014	TRUNG Ha Main Channel
O	0.631	0.585	0.655	0.587	TRUNG Ha 2nd Channel
P	0.526	0.499	0.535	0.537	Ha noi port
Q	0.670	0.639	0.681	0.683	Main

Discharge (m3/sec)

Section	Present Condition	Alternative 1d	Alternative 4	Alternative 5	
A	1750.0	1750.0	1750.0	1750.0	Main
B	1750.0	1750.0	1750.0	1750.0	Main
C	1287.0	1750.0	1750.0	1473.4	NHAT TAN Main Channel
D	463.0			276.6	NHAT TAN 2nd Cannel
E	1287.0	1750.0	1750.0	1473.4	Main
F	463.0			276.6	2nd
G	605.9	664.4	585.8	581.7	Duong River
H	975.5	938.5	1004.7	1014.6	TU LIEN Main Channel
I	168.7	147.1	159.5	153.6	TU LIEN 2nd Cannel
J	975.4	938.5	1004.7	1014.6	Main
K	168.6	147.1	159.5	153.6	2nd
L	975.4	938.5	1004.7	1014.6	Main
M	168.6	147.1	159.5	153.6	2nd
N	975.4	938.5	(1004.7)	(1014.6)	TRUNG Ha Main Channel
O	168.6	147.1	(159.5)	(153.6)	TRUNG Ha 2nd Channel
P	1144.1	1085.6	1164.2	1168.3	Ha noi port
Q	1144.1	1085.6	1164.2	1168.3	Main

Cross-sectional area of flow (m2)

Section	Present Condition	Alternative 1d	Alternative 4	Alternative 5	
A	2749.2	2785.4	2703.9	2649.4	Main
B	3356.1	3325.1	3219.8	3097.4	Main
C	2121.4	1890.4	2019.0	1883.6	NHAT TAN Main Channel
D	203.5			711.6	NHAT TAN 2nd Cannel
E	2169.3	2272.6	2661.8	2598.2	Main
F	281.6			952.9	2nd*
G	936.1	943.2	934.2	933.7	Duong River
H	1398.8	1431.9	1543.1	1538.7	TU LIEN Main Channel
I	302.7	276.3	281.9	287.9	TU LIEN 2nd Cannel
J	1229.6	1252.3	1601.6	1309.1	Main
K	596.0	561.7	561.5	580.0	2nd
L	1440.7	1476.0	1618.856	1578.000	Main
M	501.1	480.6	557.459	575.553	2nd
N	1335.5	1317.2	1520.9	1491.1	TRUNG Ha Main Channel
O	289.7	272.7	263.4	284.1	TRUNG Ha 2nd Channel
P	1270.1	1267.9	1311.8	1313.5	Ha noi port
Q	2668.8	2663.5	2668.4	2668.1	Main

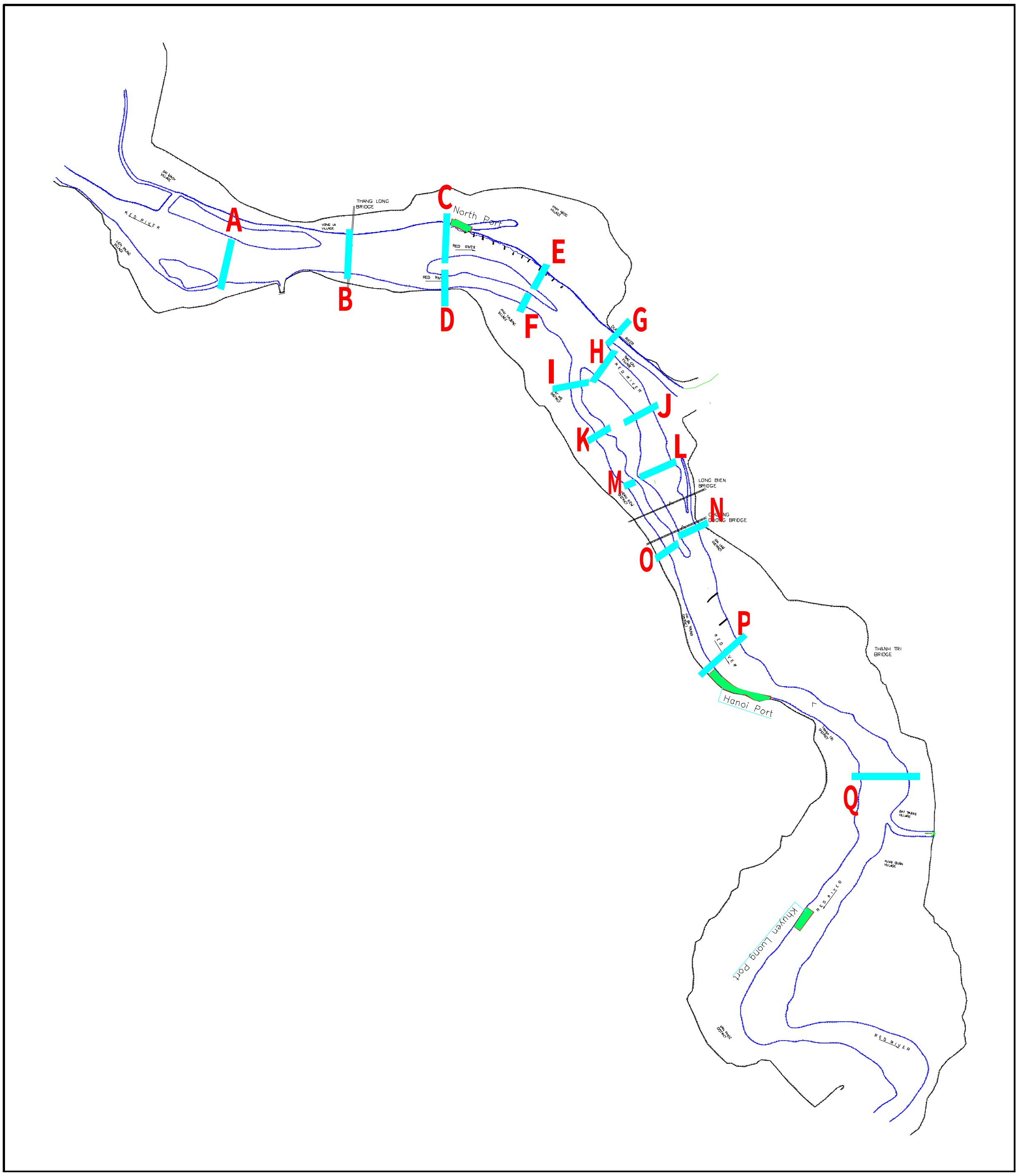

Figure 26.8.6 Locations of the Cross Sections to Compare Hydraulic Characteristics

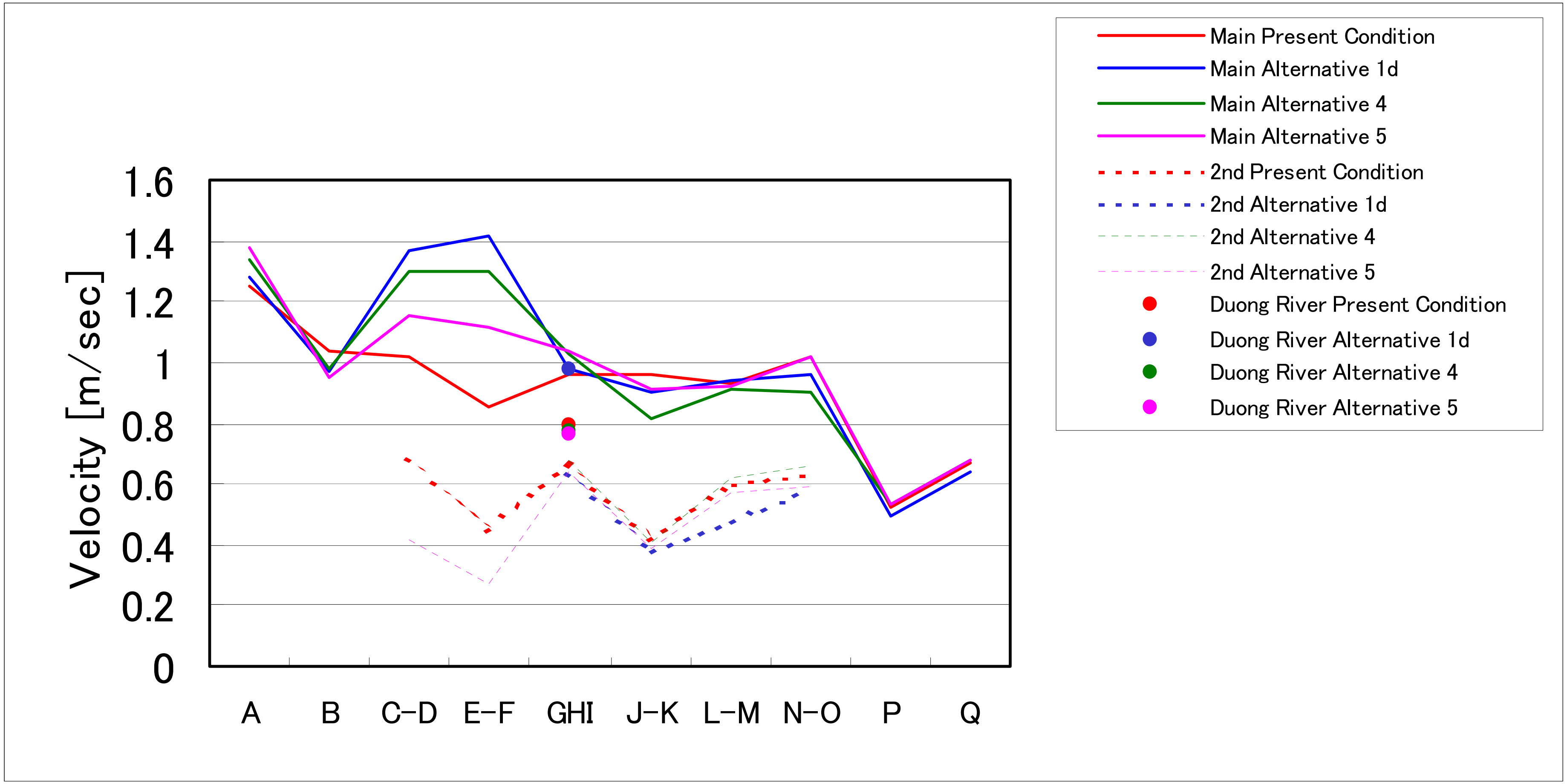

Figure 26.8.7 Longitudinal Distribution of Velocity along Talweg (Dry Season)

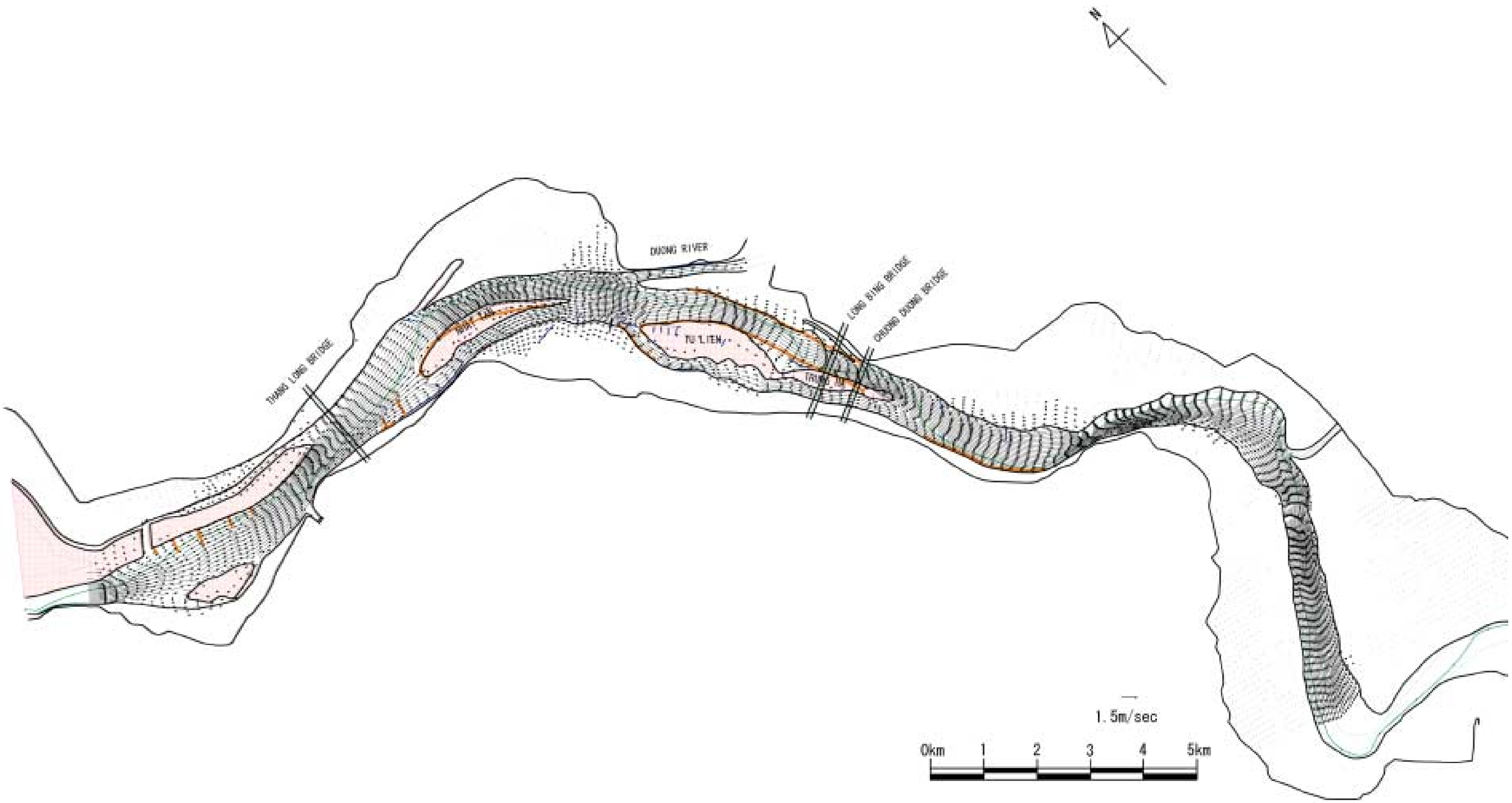

Figure 26.8.9 Current Vector (Flood Season: H=9.09m, Alternative 5s)

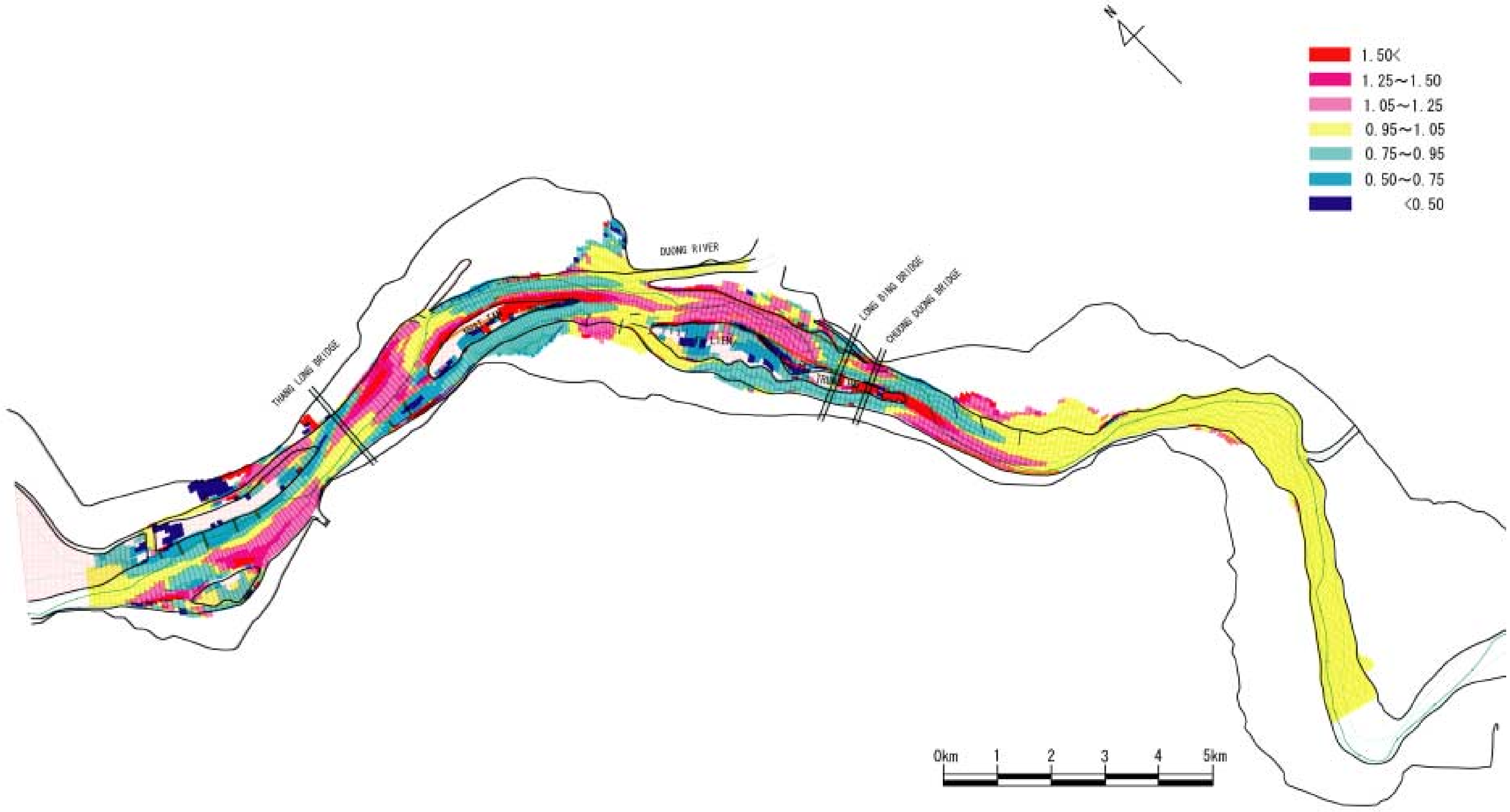

Figure 26.8.10 Ratio of Current Speed (Flood Season: H=9.09m, Alternative 5s)

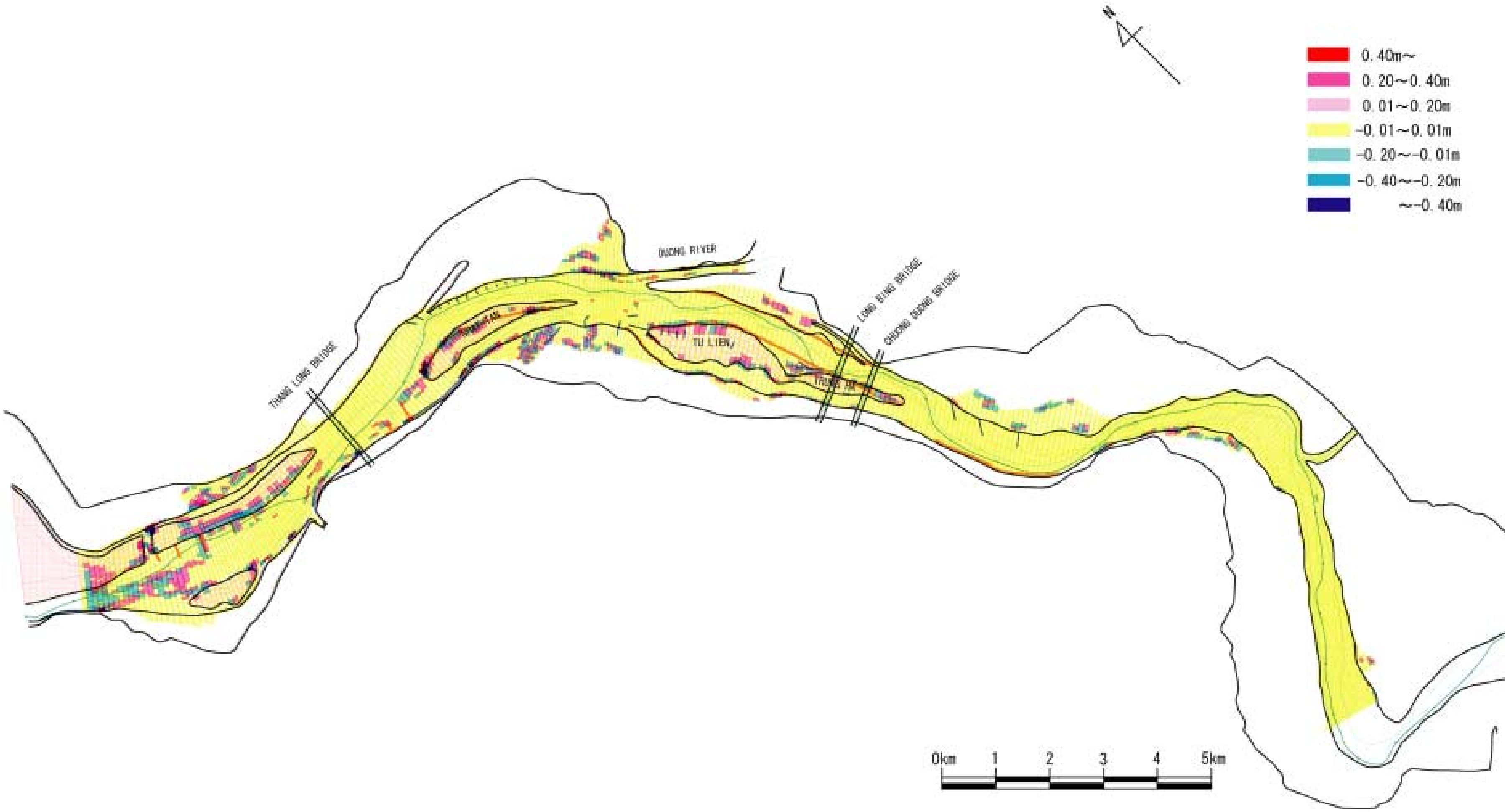

Figure 26.8.11 Riverbed Variation (Flood Season: H=9.09m, Alternative 5s)

Table 26.8.3 Hydraulic Characteristics of the Flow (Flood Season)

Water Level (m)

Section	Present Condition	Alternative 1	Alternative 2	Alternative 3	Alternative 5	Alternative 5s	
A	10.274	10.343	10.526	10.420	10.251	10.201	Main
B	10.017	10.066	10.271	10.152	9.965	9.949	Main
C	9.944	9.979	10.125	10.004	9.869	9.864	NHAT TAN Main Channel
D	9.816	9.793	9.703	9.679	9.764	9.754	NHAT TAN 2nd Cannel
E	9.715	9.722	9.715	9.718	9.719	9.710	Main
F	9.737	9.732	9.226	9.202	9.716	9.706	2nd
G	9.609	9.619	9.639	9.600	9.602	9.593	Duong River
H	9.522	9.535	9.545	9.475	9.510	9.497	TU LIEN Main Channel
I	9.490	9.498	9.321	9.323	9.480	9.470	TU LIEN 2nd Cannel
J	9.435	9.441	9.449	9.391	9.394	9.376	Main
K	9.333	9.336	9.199	9.238	9.348	9.345	2nd
L	9.406	9.392	9.396	9.331	9.350	9.329	Main
M	9.215	9.204	9.114	9.178	9.236	9.237	2nd
N	9.201	9.192	9.174	9.160	9.171	9.176	TRUNG Ha Main Channel
O	9.123	9.119	9.058	9.139	9.164	9.169	TRUNG Ha 2nd Channel
P	8.972	8.966	8.936	8.974	8.984	8.994	Ha noi port
Q	8.515	8.512	8.498	8.515	8.520	8.524	Main

Velocity (m/sec)

Section	Present Condition	Alternative 1	Alternative 2	Alternative 3	Alternative 5	Alternative 5s	
A	1.517	1.588	1.548	1.57	1.609	1.452	Main
B	2.205	2.219	2.123	2.161	2.236	2.080	Main
C	1.228	1.404	1.662	1.715	1.565	1.344	NHAT TAN Main Channel
D	1.783	1.624	0.694	0.619	1.403	1.376	NHAT TAN 2nd Cannel
E	1.792	1.904	2.433	2.049	1.459	1.469	Main
F	1.591	1.427	0.675	0.637	1.239	1.228	2nd
G	1.590	1.619	1.673	1.565	1.568	1.541	Duong River
H	1.507	1.532	1.732	1.791	1.500	1.522	TU LIEN Main Channel
I	1.155	1.169	0.814	0.719	1.165	1.164	TU LIEN 2nd Cannel
J	1.484	1.504	1.615	1.624	1.546	1.573	Main
K	1.403	1.427	1.149	0.976	1.309	1.277	2nd
L	1.271	1.318	1.381	1.386	1.371	1.402	Main
M	1.463	1.490	1.193	1.003	1.370	1.340	2nd
N	1.651	1.696	1.787	1.552	1.693	1.538	TRUNG Ha Main Channel
O	1.373	1.397	1.120	0.934	1.327	1.293	TRUNG Ha 2nd Channel
P	1.219	1.214	1.194	1.216	1.220	1.227	Ha noi port
Q	1.514	1.507	1.476	1.515	1.526	1.536	Main

Discharge (m3/sec)

Section	Present Condition	Alternative 1	Alternative 2	Alternative 3	Alternative 5	Alternative 5s	
A	10445.0	10445.0	10445.0	10445.0	10445.000	10445.000	Main
B	10445.0	10445.0	10445.0	10445.0	10445.000	10445.000	Main
C	6380.9	6791.4	8712.9	8901.3	7313.479	7346.722	NHAT TAN Main Channel
D	4064.1	3653.6	1732.1	1543.7	3131.521	3098.278	NHAT TAN 2nd Cannel
E	6392.8	6800.6	8715.4	8848.2	7300.718	7335.377	Main
F	4052.2	3644.4	1729.6	1596.8	3144.282	3109.623	2nd
G	2595.6	2639.3	2748.8	2566.5	2553.378	2506.936	Duong River
H	6019.2	5939.7	6537.8	6852.1	6043.848	6104.366	TU LIEN Main Channel
I	1830.2	1866.0	1158.4	1026.4	1847.774	1833.698	TU LIEN 2nd Cannel
J	5718.1	5637.8	5966.7	6414.9	5889.937	5981.436	Main
K	2131.3	2168.0	1729.3	1463.6	2001.424	1956.251	2nd
L	5717.9	5637.6	5966.6	6414.9	5889.758	5981.353	Main
M	2131.5	2168.2	1729.5	1463.5	2001.603	1956.333	2nd
N	5681.8	5603.1	5934.9	(6394.7)	5855.697	5951.610	TRUNG Ha Main Channel
O	2167.6	2202.7	1761.1	(1483.7)	2035.664	1986.077	TRUNG Ha 2nd Channel
P	7849.4	7805.8	7696.0	7878.4	7891.361	7937.687	Ha noi port
Q	7849.4	7805.8	7696.0	7878.4	7891.361	7937.687	Main

Cross-sectional area of flow (m2)

Section	Present Condition	Alternative 1	Alternative 2	Alternative 3	Alternative 5	Alternative 5s	
A	10326.3	10370.4	10611.3	10474.7	10205.881	10627.630	Main
B	8814.0	8866.0	9157.9	9008.9	8764.322	9308.774	Main
C	7391.1	7402.6	7600.9	7826.1	7451.679	7724.984	NHAT TAN Main Channel
D	3208.9	3092.0	3008.9	2984.8	3061.901	3089.287	NHAT TAN 2nd Cannel
E	5591.0	5433.7	5472.0	6362.2	6631.199	6618.203	Main
F	3892.9	3886.7	3885.9	3849.5	3868.892	3857.352	2nd
G	2340.0	2341.3	2367.0	2347.4	2332.369	2327.048	Duong River
H	5809.4	5804.4	5881.2	5801.7	5792.292	5775.405	TU LIEN Main Channel
I	2117.1	2118.4	2089.8	2080.9	2116.076	2102.810	TU LIEN 2nd Cannel
J	5518.6	5476.7	5525.3	6381.3	5262.210	5242.782	Main
K	2677.4	2675.8	2625.5	2637.3	2678.501	2674.862	2nd
L	7368.2	7264.5	7322.1	7379.137	6800.735	6765.049	Main
M	1729.3	1727.1	1714.0	1730.417	1734.852	1734.247	2nd
N	4381.5	4378.0	4408.4	5729.3	4590.349	4964.429	TRUNG Ha Main Channel
O	1745.0	1741.7	1736.4	1700.0	1697.683	1697.428	TRUNG Ha 2nd Channel
P	6412.9	6399.5	6400.4	6445.9	6436.715	6438.374	Ha noi port
Q	8494.4	8484.3	8528.5	8521.8	8479.084	8475.055	Main

26.9 Additional analyses and comments

26.9.1 Hydraulic phenomena

(1) Impact of construction of Son La and Na Hang dams

As described in **14.3.4**, there are many reservoirs and weirs in the tributaries of the Red River. The important existing ones are **Hoa Binh Dam** (live storage of 5.6 billion m^3) constructed from 1979 to 1988, and **Thac Ba Dam** (live storage volume of 1.2 billion m^3) constructed from 1962 to 1972. They have been playing a role of peek-shaving, stoppage of sediments, and prolonging the high water level.

Son La Dam (planned storage capacity of 4.5 billion m^3) is expected to complete in around 2015, and **Na Hang Dam** (total storage capacity of 2.2 billion m^3) is planned to complete in 2006. The effect of construction of Na Hang and Son La dams in the near future can be considered rather favorable for channel stabilization to reduce peak flood discharge and sediment discharge, and, as a result, to develop somewhat stable floodplains and possible bed degradation.

(2) Local erosion in the channel

There are following particular places where significant erosion of riverbed occurs in the channel:

a. Corner of large meandering, e.g. in front of Tam Xa Bank and Hanoi Port.
b. Corner of small meandering, e.g. in the main channel at Tu Lien-Trung Ha Sand Bar.
b. In front of groins.

1) Local erosion at bends

The maximum water depth at a bend, connecting upstream and downstream straight channels, is determined by current speed, bottom material, curvature, width of the channel, etc. Two major causes are increase in current speed at a corner due to inertia force and creation of lateral secondary near-bed currents due to hydraulic gradient formed by centrifugal force at the corner. The theoretical formula to analyze this phenomenon is yet to be developed. There is an empirical formula based on model tests and site observations, which is applicable for a channel where alternate bars are formed at the straight portion and angle of the bend to be between 11.5 to 135 degrees:

If r/B = 2.5, H_{max} / H = 2.3 to 2.8,
If r/B = 4, H_{max} / H = 1.5 to 2.3,
If r/B = 8, H_{max} / H = 1.2 to 1.5,
If r/B = 12, H_{max} / H = 1.1 to 1.2, and
If r/B = 15, H_{max} / H = 1.0 to 1.1,

where r is the radius of a bend, B is the width of the channel, H_{max} is the maximum water depth at the corner, and H is the depth in a pool in the straight channel. Applying this formula for the flood condition (H=9m),

At Tam Xa Bank: r/B = 2,700m/500m = 5.4, then H_{max} = 1.7 x 9m = 15.3m,
Or the riverbed level = 15.3 – 9 = **SDL –6.3m**
At Hanoi Port: r/B = 1,600m/500m = 3.2, then H_{max} = 2.3 x 9m = 20.7m,
Or the riverbed level = 20.7 – 9 = **SDL –11.7m**

The above figure at Tam Xa Bank is shallower than the actual depth of SDL –10m in August 2002 as shown in **Figure A14.3.3 (6)**. This difference could be attributed to the effect of the existing groins. The above figure at Hanoi Port coincides pretty well with the actual depth of SDL – 10m measured in the same month.

It can be understood that, in the Hanoi segment, the maximum depth at a bend can reach a depth deeper than SDL -10m because of meandering.

2) Local erosion by groins

An artificial facility such as a groin causes erosion and accumulation of the riverbed around it and at the bank behind it. It is still difficult to assess the degree of erosion/accumulation quantitatively, especially if the groin is permeable.

An attempt is made to forecast the phenomena by means of numerical simulations employed in this Study. **Tables 26.9.1 (1)** to **(3)** show the distribution of current speed and riverbed variation around Groins 1 and 2 for the dry season (H=3.1m), flood season (H=9.3m) and very high flood (H=12.5m), respectively. The case of **(1)** is a typical case of impermeable groins consisting of stone mound because of low water level. The cases of **(2)** and **(3)** constitute permeable groins made of the mound and piles.

The results imply that significant erosion occurs at the tip of the Groin1 during the dry season. In the flood season and very high flood conditions, erosion occurs both at the tip and the root of Groin 1.

The above local erosions are induced by the local turbulences near the infrastructures (groins, training walls, and slope protection). These local erosions could be significant for the overall structural stability. Therefore, it is to be scrutinized these issues in the next project phase of Detailed Design, in which it is suggested to make use of detailed mathematical and physical models as a support to the engineering.

Tables 26.9.1 (1) Erosion/Accumulation around Groins (Dry Season: H=3.1m)

Groin 1

Velocity (m/sec)

	1.08	1.24	1.32	1.31	1.24	1.10	0.97	0.83	0.55	0.05	0.02	0.04	0.05	0.06	0.05
	1.38	1.50	1.57	1.59	1.38	1.06	0.81	0.61	0.38	0.06	0.03	0.06	0.06	0.08	0.06
	1.79	2.04	2.13	2.26	2.05	1.03	0.57	0.29	0.14	0.09	0.09	0.08	0.05	0.04	0.03
	2.24	2.51	2.66	2.53	1.93				Groin 1						
	2.47	2.67	2.93	2.56	1.78	0.17	0.07	0.06	0.04	0.03	0.02	0.02	0.01	0.01	0.01
	2.49	2.66	2.91	2.54	1.79	0.55	0.07	0.05	0.05	0.05	0.04	0.03	0.03	0.03	0.02
Current	2.43	2.55	2.74	2.52	1.89	0.91	0.31	0.06	0.04	0.05	0.06	0.06	0.09	0.08	0.04
	2.28	2.37	2.53	2.46	1.95	1.17	0.59	0.23	0.06	0.02	0.07	0.09	0.10	0.09	0.06
	2.09	2.19	2.31	2.31	1.90	1.31	0.77	0.42	0.21	0.08	0.05	0.09	0.11	0.11	0.09
	1.92	2.05	2.10	2.03	1.76	1.37	0.87	0.53	0.31	0.16	0.09	0.10	0.14	0.12	0.08
	1.77	1.88	1.89	1.77	1.62	1.40	0.98	0.63	0.38	0.21	0.11	0.05	0.03	0.02	0.02
	1.63	1.69	1.68	1.60	1.53	1.41	1.13	0.78	0.42	0.23	0.12	0.06	0.03	0.02	0.02
	1.51	1.55	1.57	1.56	1.58	1.63	1.50	1.24	0.54	0.26	0.12	0.06	0.03	0.02	0.01
	1.29	1.38	1.47	1.54	1.61	1.73	1.63	1.34				Groin 1			
	1.23	1.33	1.44	1.52	1.57	1.54	1.47	1.30	0.35	0.15	0.05	0.04	0.04	0.04	0.05
	1.19	1.26	1.33	1.37	1.37	1.29	1.24	1.13	0.67	0.44	0.26	0.15	0.09	0.07	0.05
	1.07	1.10	1.12	1.17	1.12	1.06	0.98	0.94	0.69	0.52	0.37	0.25	0.16	0.12	0.07

Riverbed Variation (m/day)

	0.001	0.003	-0.016	0.023	0.001	-0.004	-0.001	0.001	-0.004	-0.001	-0.011	0.000	0.000	0.000	0.000
	0.001	-0.004	-0.011	-0.005	-0.003	-0.019	-0.004	0.004	0.005	0.000	0.000	0.000	0.000	0.000	0.000
	-0.004	-0.034	0.029	0.003	-0.052	-0.022	-0.008	0.000	0.002	0.000	0.000	0.000	0.000	0.000	0.000
	-0.022	0.007	-0.092	-0.039	-0.100				Groin 1						
	-0.030	-0.109	-0.187	-0.252	-0.180	-0.013	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	-0.015	-0.074	-0.176	-0.275	-0.150	0.055	0.032	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Current	0.000	-0.016	-0.107	-0.229	-0.106	0.073	0.056	0.004	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	0.008	0.024	-0.011	-0.114	-0.066	0.043	0.056	0.016	0.001	0.000	0.000	0.000	0.002	0.001	0.000
	0.010	0.034	0.058	0.057	0.030	0.028	0.072	0.030	0.005	0.000	0.000	0.000	0.000	-0.002	0.000
	0.011	0.029	0.070	0.167	0.144	0.094	0.072	0.035	0.008	0.001	0.000	0.000	0.000	0.000	0.000
	0.010	0.022	0.051	0.129	0.158	0.121	0.030	0.047	0.008	0.001	0.000	0.000	-0.005	-0.002	0.005
	0.009	0.016	0.031	0.061	0.088	0.077	0.039	0.008	0.008	0.001	0.000	0.000	0.000	0.001	0.000
	0.008	0.011	0.018	0.027	0.036	0.033	0.019	-0.029	-0.007	-0.002	0.000	0.000	0.000	0.000	0.000
	0.002	0.004	0.006	0.006	0.003	-0.006	-0.039	-0.146				Groin 1			
	-0.002	-0.001	-0.001	-0.004	-0.012	-0.030	-0.066	-0.064	0.052	0.000	0.000	0.000	0.000	0.000	0.000
	0.007	0.007	0.006	0.004	0.000	-0.011	-0.013	0.143	0.050	0.027	0.000	0.000	0.000	0.000	0.000
	0.006	0.006	0.006	0.005	0.006	0.001	0.046	0.062	0.039	0.018	0.002	0.000	0.000	-0.007	0.000

Groin 2

Velocity (m/sec)

0.08	0.15	0.18	0.21	0.25	0.28	0.30	0.33	0.36	0.36	0.37	0.35	
0.06	0.11	0.13	0.17	0.22	0.27	0.31	0.35	0.38	0.39	0.39	0.36	
0.03	0.05	0.07	0.11	0.16	0.31	0.37	0.40	0.41	0.43	0.42	0.39	
		Groin 2			0.30	0.39	0.42	0.42	0.44	0.44	0.41	
0.01	0.01	0.02	0.05	0.10	0.30	0.38	0.42	0.42	0.44	0.43	0.42	
0.02	0.05	0.09	0.14	0.21	0.30	0.37	0.42	0.43	0.44	0.43	0.43	
0.10	0.14	0.19	0.23	0.26	0.33	0.39	0.43	0.45	0.45	0.43	0.43	Current
0.13	0.20	0.25	0.29	0.25	0.38	0.43	0.46	0.49	0.48	0.46	0.46	
0.09	0.18	0.23	0.26	0.20	0.41	0.45	0.48	0.51	0.52	0.51	0.51	
0.05	0.12	0.17	0.19	0.16	0.34	0.41	0.47	0.52	0.56	0.58	0.57	
0.01	0.05	0.07	0.08	0.09	0.17	0.27	0.54	0.63	0.68	0.68	0.64	
			Groin 2				0.69	0.79	0.82	0.79	0.69	
	0.03	0.03	0.02	0.05	0.14	0.30	0.83	0.82	0.87	0.85	0.73	
	0.01	0.05	0.11	0.22	0.37	0.58	0.77	0.71	0.77	0.72	0.51	
	0.12	0.18	0.24	0.34	0.47	0.62	0.68	0.59	0.65	0.58	0.38	
	0.17	0.28	0.33	0.41	0.49	0.59	0.61	0.52	0.54	0.52	0.39	
	0.16	0.28	0.35	0.41	0.46	0.53	0.58	0.52	0.25	0.49	0.48	
	0.14	0.25	0.32	0.39	0.43	0.48	0.56	0.54	0.00	0.24	0.53	
0.05	0.16	0.24	0.30	0.42	0.43	0.47	0.53	0.49	0.00	0.00	0.25	
0.10	0.18	0.25	0.28	0.44	0.47	0.47	0.47	0.30	0.05	0.00	0.00	
0.17	0.26	0.32	0.31	0.42	0.48	0.50	0.44	0.18	0.07	0.00	0.00	
0.25	0.32	0.34	0.34	0.35	0.40	0.43	0.36	0.14	0.00	0.00	0.00	

Riverbed Variation (m/day)

0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	-0.002	
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	-0.001	-0.001	0.000	
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	-0.001	-0.001	0.000	
		Groin 2			-0.001	0.000	-0.001	-0.001	0.000	0.000	0.000	
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	-0.001	0.000	0.000	0.000	
0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.001	0.001	-0.001	0.000	0.000	Current
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	-0.001	-0.001	0.000	
0.000	0.000	0.000	0.000	-0.004	-0.076	0.007	-0.001	-0.001	-0.001	-0.001	-0.001	
0.000	0.000	0.000	0.000	0.002	0.076	-0.002	-0.002	-0.002	-0.003	-0.003	-0.003	
0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.000	-0.001	0.001	-0.001	-0.002	
			Groin 2				-0.009	-0.007	-0.008	-0.008	-0.006	
	0.000	0.000	0.000	0.000	0.000	0.000	0.000	-0.002	-0.009	-0.014	-0.012	
	0.000	0.000	0.000	0.000	0.000	0.000	0.022	-0.002	0.006	0.001	-0.013	
	0.000	0.000	0.000	0.000	0.001	0.005	-0.002	0.003	0.012	0.010	0.005	
	0.000	0.000	0.000	0.000	0.000	0.000	-0.004	0.007	0.011	0.007	0.011	
	0.000	0.000	0.000	0.000	-0.001	-0.001	0.001	0.002	0.002	0.008	0.003	
	0.000	0.000	0.000	0.000	0.000	0.001	0.003	0.002	-0.003	0.002	-0.005	
0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.002	0.001	-0.001	0.000	0.003	
0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.001	0.001	0.000	0.002	0.000	
0.000	0.000	0.000	0.000	0.002	-0.002	-0.002	0.000	0.001	0.002	0.000	0.000	
0.000	0.000	0.000	0.000	0.000	0.004	0.001	-0.001	-0.001	-0.001	0.000	0.000	

Tables 26.9.1 (2) Erosion/Accumulation around Groins (Flood Season: H=9.3m)

Groin 1

Velocity (m/sec)

Current

1.56	1.53	1.47	1.40	1.34	1.25	1.15	1.07	0.95	0.72	0.58	0.47	0.40	0.43	0.36
1.56	1.49	1.44	1.44	1.37	1.28	1.16	1.07	0.97	0.80	0.67	0.56	0.48	0.53	0.43
1.51	1.48	1.44	1.46	1.42	1.25	1.14	1.05	0.96	0.85	0.75	0.66	0.61	0.62	0.55
1.50	1.52	1.52	1.51	1.51	1.18	1.07	1.00	0.93	0.85	0.77	0.71	0.71	0.71	0.67
1.50	1.54	1.59	1.56	1.55	1.16	1.04	0.97	0.91	0.86	0.78	0.74	0.74	0.70	0.73
1.48	1.54	1.59	1.59	1.56	1.18	1.07	0.97	0.90	0.86	0.79	0.77	0.84	0.78	0.76
1.47	1.52	1.57	1.61	1.59	1.20	1.09	0.98	0.90	0.85	0.82	0.81	0.98	0.89	0.76
1.46	1.51	1.56	1.60	1.61	1.24	1.09	0.99	0.92	0.85	0.84	0.87	0.91	0.85	0.74
1.45	1.49	1.53	1.58	1.60	1.30	1.11	1.00	0.93	0.87	0.87	0.95	0.93	0.86	0.75
1.42	1.46	1.50	1.54	1.57	1.37	1.16	1.03	0.96	0.89	0.89	1.00	1.03	0.93	0.78
1.37	1.41	1.46	1.50	1.53	1.40	1.24	1.09	1.00	0.93	0.92	0.96	0.92	0.88	0.83
1.33	1.37	1.42	1.47	1.50	1.41	1.31	1.15	1.05	0.98	0.94	0.92	0.82	0.90	0.86
1.30	1.35	1.40	1.44	1.47	1.41	1.33	1.19	1.04	0.99	0.94	0.91	0.82	0.97	0.84
1.21	1.27	1.32	1.37	1.39	1.36	1.28	1.14	0.93	0.94	0.91	0.89	0.83	0.88	0.78
1.23	1.29	1.34	1.38	1.40	1.38	1.27	1.15	0.92	0.95	0.93	0.92	0.87	0.88	0.75
1.33	1.37	1.41	1.44	1.45	1.43	1.32	1.20	1.00	1.00	0.98	0.98	0.95	1.01	0.79
1.37	1.41	1.44	1.47	1.47	1.45	1.34	1.25	1.08	1.06	1.06	1.05	1.04	0.99	0.87

Riverbed Variation (m/day)

Current

0.009	0.017	0.017	0.008	−0.004	0.003	0.003	0.002	0.002	0.001	0.000	0.000	0.000	0.000	−0.010
0.004	0.032	0.008	−0.007	0.007	0.002	0.003	0.002	0.002	0.001	0.000	0.000	0.000	−0.001	−0.017
0.018	−0.008	0.006	−0.001	−0.018	−0.004	0.000	0.003	0.003	0.001	0.000	0.000	0.000	0.001	−0.025
−0.010	−0.010	−0.020	−0.005	−0.011	**Groin 1**									
0.004	−0.006	−0.020	−0.010	−0.004	0.072	0.047	0.036	0.026	0.018	0.013	0.008	0.011	0.021	−0.005
0.003	0.003	0.002	−0.008	0.002	0.000	−0.003	0.000	0.002	0.000	0.000	0.000	−0.001	−0.003	−0.032
0.002	0.002	0.003	−0.010	−0.007	−0.001	0.001	0.000	0.001	0.001	0.000	0.001	−0.035	−0.012	−0.012
0.002	0.003	0.003	0.004	−0.008	0.000	0.002	0.000	0.000	0.001	0.000	−0.002	0.028	0.011	−0.013
0.002	0.002	0.003	0.004	0.008	−0.001	0.001	0.000	0.000	0.000	0.000	0.000	−0.001	−0.001	−0.015
0.001	0.001	0.001	0.002	0.005	−0.004	0.004	0.001	0.001	0.000	−0.001	−0.010	−0.033	−0.010	−0.020
0.001	0.001	0.001	0.001	0.004	0.001	−0.004	0.000	0.000	0.000	0.000	0.008	0.032	0.012	−0.027
0.002	0.001	0.001	0.002	0.003	0.001	−0.005	−0.001	−0.003	−0.002	0.000	0.001	0.001	0.000	−0.037
0.006	0.007	0.007	0.007	0.007	0.003	−0.003	−0.005	−0.002	−0.001	0.000	0.000	0.002	−0.020	−0.040
0.000	0.000	0.000	0.000	0.001	−0.004	−0.002	0.005	**Groin 1**						
0.004	0.004	0.004	0.003	0.003	−0.002	0.006	0.000	0.022	0.021	0.018	0.016	0.013	0.020	−0.094
0.001	0.001	0.001	0.000	0.000	0.000	−0.004	−0.001	−0.001	−0.001	0.000	−0.001	0.000	−0.040	−0.092
−0.003	−0.004	−0.004	−0.003	−0.003	−0.002	0.008	0.004	0.001	−0.003	−0.004	−0.002	−0.002	0.035	−0.125

Groin 2

Velocity (m/sec)

Current

0.25	0.46	0.66	0.80	0.92	1.00	1.03	1.06	1.09	1.07	1.04	0.97
0.24	0.43	0.60	0.75	0.90	1.00	1.04	1.08	1.11	1.11	1.07	1.00
0.32	0.42	0.52	0.62	0.93	1.03	1.09	1.12	1.13	1.14	1.11	1.04
0.30	0.36	0.42	0.52	0.99	1.07	1.12	1.15	1.14	1.15	1.11	1.05
0.33	0.39	0.48	0.64	1.04	1.09	1.14	1.17	1.15	1.16	1.12	1.07
0.42	0.50	0.63	0.82	1.07	1.09	1.15	1.18	1.17	1.17	1.13	1.09
0.54	0.63	0.76	0.95	1.17	1.10	1.16	1.20	1.21	1.19	1.15	1.13
0.63	0.72	0.84	1.02	1.23	1.12	1.18	1.22	1.24	1.23	1.19	1.19
0.63	0.73	0.84	0.97	1.13	1.11	1.17	1.21	1.24	1.24	1.22	1.24
0.58	0.68	0.77	0.86	0.94	1.03	1.10	1.16	1.19	1.22	1.23	1.26
0.53	0.62	0.67	0.72	0.75	0.85	0.91	1.10	1.17	1.23	1.25	1.28
0.53	0.58	0.61	0.63	0.64	0.68	0.69	1.04	1.17	1.26	1.30	1.31
0.54	0.58	0.60	0.61	0.63	0.63	0.65	1.04	1.18	1.31	1.36	1.36
0.59	0.64	0.64	0.65	0.67	0.69	0.79	1.11	1.21	1.36	1.41	1.36
0.68	0.72	0.72	0.72	0.75	0.80	0.94	1.16	1.21	1.35	1.37	1.26
0.72	0.77	0.78	0.78	0.81	0.86	1.00	1.15	1.16	1.25	1.28	1.18
0.60	0.71	0.76	0.78	0.83	0.87	0.99	1.14	1.15	0.79	1.06	1.06
0.41	0.59	0.69	0.76	0.84	0.88	1.01	1.17	1.15	0.31	0.58	0.84
0.31	0.54	0.71	0.83	0.97	1.04	1.14	1.21	1.00	0.24	0.24	0.71
0.27	0.55	0.75	0.88	1.09	1.19	1.26	1.20	0.84	0.48	0.30	0.43
0.38	0.67	0.87	0.97	1.16	1.28	1.30	1.12	0.62	0.26	0.00	0.00
0.47	0.69	0.83	0.92	1.01	1.11	1.13	0.92	0.42	0.00	0.00	0.00

Riverbed Variation (m/day)

Current

0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.001
0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.001
0.000	−0.001	0.002	−0.003	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Groin 2					0.000	0.000	0.000	0.000	−0.001	0.001	0.000
0.000	−0.001	0.003	0.003	0.000	0.000	0.000	−0.001	0.000	0.004	−0.004	0.000
0.000	−0.003	0.000	0.005	0.000	0.000	−0.001	0.002	0.001	−0.001	0.000	0.000
0.000	0.000	0.005	0.000	0.000	0.000	0.004	−0.001	−0.004	0.002	0.000	0.000
0.000	−0.001	−0.002	0.001	−0.005	0.001	−0.004	0.003	0.003	0.001	0.000	−0.001
0.000	−0.002	−0.001	−0.002	0.005	0.002	−0.001	0.004	−0.001	0.000	−0.001	−0.001
0.000	0.005	0.001	−0.003	0.000	0.002	0.003	0.004	0.000	0.000	0.000	−0.001
0.000	0.000	0.003	0.001	0.001	0.002	−0.004	0.000	0.000	0.000	−0.001	−0.001
Groin 2							0.001	0.000	0.000	−0.001	0.000
	0.001	−0.002	0.002	0.004	0.001	0.003	0.001	0.001	0.002	−0.002	−0.004
	0.003	0.003	0.000	0.001	0.002	0.000	0.000	0.001	−0.004	0.002	0.002
	0.000	0.001	0.000	−0.001	−0.001	0.000	0.000	0.000	0.000	−0.004	−0.004
	−0.004	0.003	0.000	−0.004	−0.004	0.000	0.000	0.000	0.000	0.005	0.005
	0.000	0.005	0.000	0.000	0.000	0.000	0.001	−0.002	0.001	0.001	−0.001
	−0.001	−0.003	0.000	0.000	0.000	0.000	0.000	−0.002	0.001	0.001	0.001
0.000	−0.002	0.004	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.000
0.000	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.000	0.000	0.000	0.000	0.000	0.000	−0.001	0.000	−0.001	0.000	0.000	0.000
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.016	−0.264	0.000	0.000

Tables 26.9.1 (3) Erosion/Accumulation around Groins (very High Flood: H=12.5m)

Groin 1

Velocity (m/sec)

Current

2.23	2.17	2.05	1.92	1.78	1.62	1.44	1.30	1.13	0.81	0.62	0.49	0.40	0.44	0.46
2.22	2.12	2.02	1.95	1.81	1.64	1.46	1.31	1.15	0.92	0.74	0.60	0.49	0.53	0.52
2.14	2.09	2.00	1.96	1.85	1.59	1.41	1.28	1.15	0.99	0.86	0.73	0.63	0.64	0.65
2.10	2.11	2.06	2.00	1.93	1.51	1.31	1.18	1.06	0.95	0.83	0.73	0.70	0.72	0.72
2.08	2.11	2.12	2.05	1.98	1.52	1.29	1.14	1.03	0.93	0.82	0.75	0.72	0.72	0.78
2.06	2.09	2.12	2.07	1.99	1.59	1.33	1.14	1.01	0.93	0.82	0.76	0.80	0.79	0.83
2.04	2.07	2.09	2.08	2.02	1.66	1.38	1.16	1.00	0.91	0.83	0.79	0.92	0.90	0.87
2.02	2.06	2.07	2.08	2.04	1.74	1.44	1.20	1.03	0.91	0.84	0.83	0.89	0.90	0.91
2.00	2.03	2.05	2.06	2.04	1.82	1.52	1.26	1.07	0.93	0.87	0.90	0.92	0.94	0.96
1.96	1.99	2.02	2.02	2.01	1.88	1.61	1.34	1.14	0.98	0.92	0.96	1.02	1.02	1.01
1.89	1.93	1.96	1.98	1.98	1.90	1.71	1.44	1.22	1.05	0.96	0.95	0.94	0.98	1.05
1.82	1.87	1.91	1.94	1.95	1.91	1.79	1.54	1.31	1.13	1.00	0.94	0.88	1.02	1.09
1.73	1.78	1.83	1.86	1.88	1.86	1.78	1.54	1.25	1.11	1.00	0.95	0.89	1.10	1.09
1.64	1.70	1.76	1.81	1.84	1.83	1.73	1.52	1.12	1.07	1.00	0.96	0.93	1.06	1.05
1.68	1.74	1.80	1.84	1.88	1.88	1.74	1.57	1.15	1.09	1.02	1.00	0.97	1.07	1.01
1.81	1.86	1.90	1.93	1.95	1.94	1.80	1.64	1.31	1.19	1.10	1.07	1.04	1.19	1.01
1.85	1.89	1.93	1.95	1.97	1.96	1.82	1.69	1.44	1.30	1.21	1.16	1.14	1.19	1.09

Riverbed Variation (m/day)

Current

0.067	0.064	0.082	0.080	0.044	0.001	0.018	0.016	0.012	0.009	0.005	0.001	0.001	0.000	−0.001
0.028	0.037	0.124	0.047	−0.007	0.030	0.016	0.016	0.011	0.010	0.007	0.003	0.001	0.000	−0.002
0.017	0.069	−0.010	0.030	0.005	−0.043	−0.197	−0.095	−0.079	−0.053	−0.036	−0.022	−0.018	−0.030	−0.040
0.024	−0.019	−0.020	−0.048	−0.004				**Groin 1**						
0.024	0.019	−0.010	−0.048	−0.020	0.001	0.273	0.168	0.117	0.079	0.053	0.035	0.020	0.022	0.036
0.012	0.013	0.011	0.010	−0.012	0.024	0.013	0.001	0.009	0.007	0.003	0.002	0.001	−0.001	−0.005
0.006	0.008	0.010	0.011	−0.020	0.003	0.008	0.009	0.006	0.005	0.004	0.001	−0.003	−0.037	−0.010
0.003	0.005	0.007	0.009	0.009	−0.005	0.013	0.016	0.007	0.004	0.004	0.000	−0.002	0.025	0.009
0.000	0.001	0.003	0.005	0.007	0.024	0.009	0.015	0.011	0.006	0.003	0.000	−0.001	−0.003	−0.004
−0.006	−0.005	−0.003	−0.001	0.001	0.014	−0.006	0.032	0.016	0.008	0.004	−0.003	−0.025	−0.050	−0.015
−0.006	−0.005	−0.004	−0.003	0.000	0.010	0.008	−0.005	0.017	0.012	0.007	0.001	0.014	0.042	0.013
0.001	0.001	0.002	0.003	0.005	0.011	0.008	−0.013	0.012	0.006	0.002	0.005	0.003	0.002	−0.005
0.058	0.062	0.065	0.065	0.063	0.059	0.047	0.025	0.019	−0.057	−0.071	−0.055	−0.050	−0.043	−0.040
−0.001	0.000	0.001	0.002	0.002	0.003	−0.005	0.011				**Groin 1**			
0.011	0.010	0.008	0.006	0.004	0.001	−0.005	0.031	0.013	0.101	0.075	0.056	0.047	0.041	0.073
−0.002	−0.003	−0.005	−0.008	−0.010	−0.011	−0.006	−0.013	0.008	0.005	0.002	0.001	−0.003	−0.014	−0.092
−0.022	−0.023	−0.023	−0.023	−0.022	−0.020	−0.006	0.038	0.029	0.008	−0.010	−0.009	−0.004	0.001	0.076

Groin 2

Velocity (m/sec)

Current

0.54	0.69	0.86	1.01	1.14	1.24	1.29	1.32	1.35	1.34	1.32	1.27
0.51	0.64	0.79	0.94	1.11	1.24	1.30	1.35	1.38	1.38	1.36	1.30
0.52	0.59	0.68	0.78	1.15	1.29	1.37	1.41	1.43	1.43	1.41	1.35
0.46	0.51	0.56	0.67	1.25	1.35	1.42	1.45	1.44	1.45	1.42	1.37
0.47	0.53	0.63	0.82	1.32	1.39	1.45	1.48	1.46	1.47	1.44	1.39
0.56	0.66	0.81	1.05	1.35	1.39	1.45	1.48	1.48	1.47	1.44	1.41
0.68	0.80	0.98	1.21	1.44	1.39	1.46	1.49	1.50	1.49	1.45	1.44
0.77	0.90	1.07	1.28	1.51	1.40	1.47	1.51	1.52	1.51	1.48	1.49
0.80	0.91	1.06	1.23	1.41	1.39	1.45	1.49	1.51	1.52	1.50	1.52
0.77	0.86	0.97	1.10	1.21	1.29	1.36	1.41	1.45	1.49	1.50	1.53
0.74	0.78	0.85	0.92	0.96	1.05	1.11	1.33	1.42	1.49	1.52	1.55
0.68	0.71	0.74	0.77	0.79	0.81	0.82	1.24	1.41	1.52	1.56	1.58
0.65	0.67	0.69	0.71	0.73	0.73	0.71	1.18	1.40	1.56	1.63	1.65
0.66	0.69	0.70	0.71	0.74	0.74	0.78	1.21	1.43	1.63	1.72	1.71
0.71	0.73	0.75	0.76	0.78	0.79	0.86	1.24	1.43	1.64	1.72	1.69
0.70	0.75	0.77	0.79	0.82	0.83	0.87	1.18	1.35	1.53	1.63	1.64
0.60	0.66	0.71	0.75	0.80	0.82	0.85	1.04	1.21	1.00	1.31	1.43
0.43	0.51	0.58	0.65	0.74	0.78	0.84	0.99	1.16	0.48	0.68	0.96
0.32	0.40	0.49	0.58	0.71	0.78	0.85	0.97	1.11	0.54	0.25	0.54
0.27	0.34	0.43	0.52	0.67	0.76	0.86	1.00	0.92	0.72	0.28	0.39
0.26	0.36	0.47	0.58	0.74	0.88	1.03	1.20	0.79	1.00	1.38	0.82
0.28	0.41	0.51	0.62	0.75	0.89	1.04	1.20	0.79	1.59	1.76	1.00

Riverbed Variation (m/day)

Current

0.005	0.001	0.001	0.002	−0.002	0.000	0.002	0.002	0.001	−0.001	−0.002	0.002
0.001	0.000	0.001	0.002	0.003	0.002	0.001	0.003	0.003	0.002	0.001	0.002
−0.002	0.000	0.000	0.003	−0.002	−0.002	0.001	−0.002	−0.002	0.002	0.001	0.001
		Groin 2			−0.003	−0.002	−0.002	−0.001	0.000	−0.001	0.001
0.003	0.002	0.003	0.008	0.018	0.003	−0.004	−0.004	−0.005	−0.001	0.002	−0.005
−0.002	0.000	−0.002	0.002	0.006	0.001	0.001	−0.001	0.001	−0.003	−0.004	−0.002
−0.004	0.000	0.001	0.006	−0.001	0.000	0.003	0.006	0.000	−0.005	0.000	−0.001
−0.003	0.000	−0.001	−0.002	0.003	−0.027	0.003	−0.002	0.004	0.002	0.000	−0.001
−0.004	0.000	−0.002	0.000	0.001	0.026	0.000	−0.002	0.003	−0.002	−0.003	−0.003
−0.003	0.000	0.006	0.003	0.000	0.003	0.003	0.004	0.005	0.003	0.000	−0.001
−0.013	−0.008	−0.008	−0.007	−0.012	−0.018	−0.017	−0.003	0.002	0.000	−0.002	−0.003
			Groin 2				−0.011	0.010	−0.001	−0.005	−0.005
	0.010	0.011	0.010	0.017	0.022	0.021	0.028	0.010	0.009	0.004	−0.002
	0.001	0.003	0.003	0.000	0.001	0.003	0.003	0.004	0.008	−0.003	−0.002
	0.000	0.000	0.001	0.000	−0.001	−0.001	−0.001	−0.001	0.004	−0.005	−0.007
	0.001	−0.004	0.002	0.000	−0.005	−0.005	−0.001	0.000	0.000	0.000	0.005
	0.005	0.000	0.005	−0.001	−0.001	−0.001	0.001	0.006	−0.014	0.006	0.005
	0.007	0.000	−0.003	0.000	−0.001	−0.001	0.000	0.003	−0.022	0.010	0.016
0.007	0.006	−0.001	0.004	0.000	−0.001	−0.001	−0.002	−0.003	0.005	0.007	0.002
0.007	0.005	0.000	0.001	0.000	−0.001	0.000	0.001	−0.002	0.007	−0.004	0.004
0.005	0.004	0.000	0.000	0.000	0.001	−0.001	−0.003	−0.002	−0.006	0.019	−0.207
0.004	0.004	0.000	0.000	−0.001	0.000	−0.001	−0.003	−0.002	0.084	−0.760	0.037

(3) Influence of groin field G1 on the facilities on the right bank

Groins G1 are to deviate the Talweg to the right hand side of the river, which might affect Thuy Phuong Slope Protection and Lien Mac Sluice. The present riverbed at the area in between the two facilities is very shallow. Therefore, it had better to watch and confirm the effect of the Groins 1 whether scouring could reach these facilities or not. In this context, the bank protection work along Thuong Cat Bank is planned in the Long-term Plan.

(4) Roles of existing groins at Tam Xa

The role of the existing Tam Xa Groins can be judged very important to protect the bank from erosion, and maintain the present route of the main channel. Their effectiveness is also apparent. Although some of the groins have been damaged, they could work for the coming a few years. It is to be noted that erosion of the bank in between the upper two groins is considerable.

Based on the above understanding, the slope protection work at the new North Port will be extended down to the root of the second groin in the Short-term Plan. The rehabilitation work of the existing groins will be taken account of in the Long-term Plan.

(5) Maximum Riverbed Slope formed by Erosion

In designing the toe structures of the planned groins, training walls, and bank slope protection work, the maximum bottom slope is examined based on the cross-sectional analyses of the surveyed profiles. The result is that the maximum slope is less than 1/2 as shown in **Figure 26.9.1** at the deepest point in the Tu Lien-Trung Ha channel.

This result is applied specifically on the design of lateral length of the foot-protection stone mound and depth of sheet piles. This subject is, however, to be reconfirmed in the detailed surveys during the detailed design stage.

In this study, priority is laid on the fixing of the entrance on the right bank and the sand bar, and control of inflow volume of water. Slope protection works at the middle portion of the channel, if necessary, can be discussed with the HN-PC how and which project shall take care of the works.

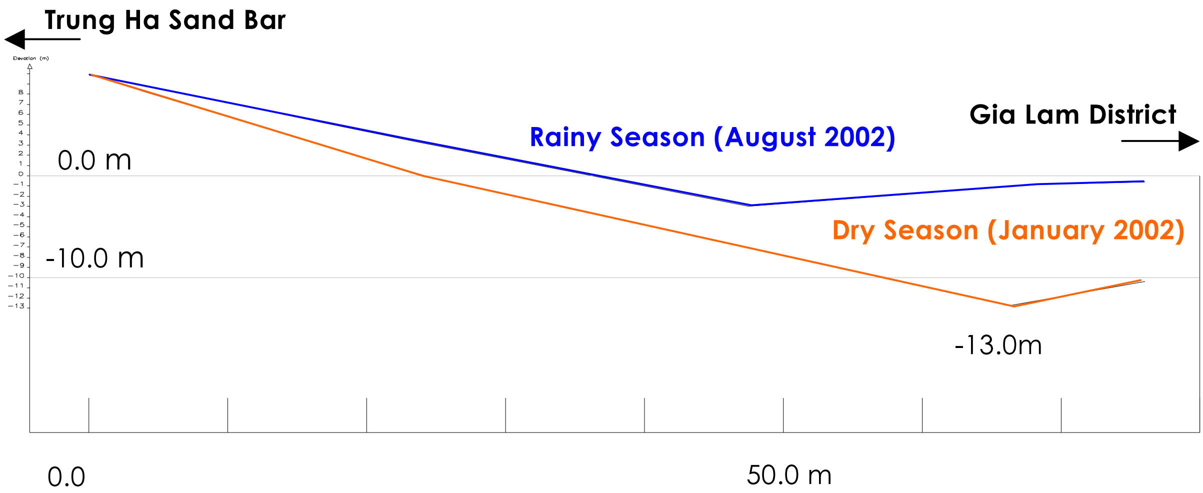

Figure 26.9.1 Profile at the Deepest Point in the Tu Lien – Trung Ha Channel

(6) Stability of the secondary channel, Lach Quyt

The secondary channel of Tu Lien-Trung Ha Sand Bar, i.e. Lach Quyt, suffered considerable erosion in 2002. Its entrance and exit are rather stable as shown in **Figure A14.3.3 (8)** to **(11).** This channel is left untouched without artificial slope protection works except a part of the right bank at the entrance.

(7) Effects on bridges

The effect of construction of the channel stabilization facilities on the existing and planned bridges, i.e. Thang Long, Long Bien, Chuon Duong and Thanh Tri Bridges, can be considered minimal, because of insignificant change in current velocities at the locations of these bridges.

26.9.2 Maintenance dredging

Assessment of riverbed variation for a long period of time is still difficult due to its irregular unsteady nature of the phenomena, and time-consuming calculation. In addition, meteorological and hydraulic conditions vary year by year. Hence, it is difficult to predict exact necessary volume of maintenance dredging after construction of the channel stabilization facilities.

A simplified method is to superimpose typical seasonal sedimentation volumes with some assumptions. Rate of sedimentation derived by numerical simulations is shown in **Table 26.9.2**, which is counted within the planned channel width of 150m along the basic sinusoid. The original riverbed is set at SDL 0.

Table 26.9.2 Rate of Sedimentation in Planned Channel assessed by Numerical Simulation

Season	Location (km)	Accumulation (m^3/day)	Erosion (m^3/day)	Remarks (Water level)
Dry Season	2.6 – 22.5	13,000	-13,000	H = 3.1m
Flood Season		3,000	-2,000	H = 9.3m
Very high Flood		15,000	-11,000	H =12.5m
Total		31,000	-26,000	

Source) JICA Study Team

The maintenance dredging volume depends on time necessary to reach the dynamic equilibrium state and duration of these seasonal conditions. Assuming the time required to reach the equilibrium state to be a few days, the accumulated volume could be an order of 300,000 to 1,500,000 m^3/year.

It should be noted that the above estimate is preliminary and approximate, which should be re-examined in the detailed design stage. The important is to reduce the maintenance dredging volume by modifying the plan of the stabilization facilities aiming at improvement of self-scouring effect.

26.9.3 Scope of surveys and monitoring works

Surveys, analyses and monitors of the effect of the channel stabilization facilities are indispensable as the basis and for the success of the Project. Recommended scope of necessary surveys and monitoring works during construction works is summarized and presented in **Table 38.3.1**.