Chapter 25 Master Plan of Navigation Channel for 2020

25.1 Dimensions of navigation channel

Future dimensions of navigation channel are proposed as shown in **Table 25.1.1** and **Figure 25.1.1**. The grounds of each proposed dimension are mentioned in the following part.

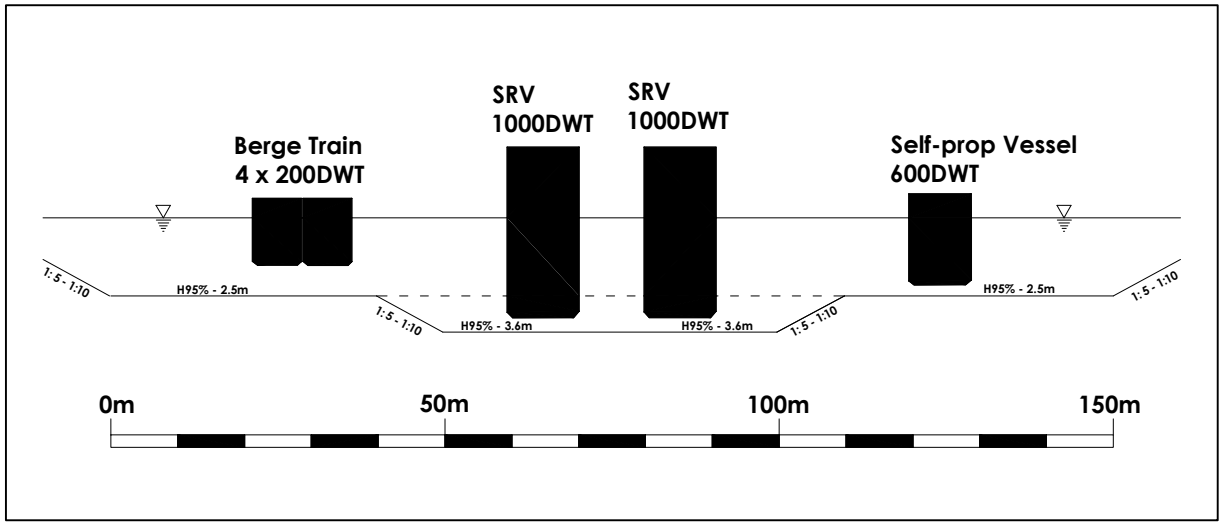
Table 25.1.1 Future Dimensions of Navigation Channel in Hanoi Segment

Section	Corridor	LAD	LAW	Bend Radius	Vertical Clearance of Bridge
Red River (Don Lai - Hanoi Port)	1 (Quang Ninh - Viet Tri)	2.5m	50m - 150m	500m-700m	H5% + 7m
Red River (Hanoi Port - Yen Mi)	4 (Sea - Hanoi)	3.6m	50m - 150m	> 700m	H5% + 10m
Duong River (Bifurcation - Phu Dong)	1 (Quang Ninh - Viet Tri)	2.5m	> 50m	500m-700m	H5% + 7m

Note) Navigation channel in the Red River Hanoi segment shall be 4-lane channel.

Note) As to vertical clearance of bridge for Corridor 1, JICA Study Team proposes the vertical clearance of 7m, which is the same clearance as Vinh Bridge spanning over Kinh Thay River, although Class II requires 9m.

Source) JICA Study Team



Note) SRVs will be deployed up to Hanoi Port.

Source) JICA Study Team

Figure 25.1.1 Typical Cross Section of Navigation Channel (Red River Hanoi Segment)

(1) Depth of navigation channel

Based on the Long-term Strategy for the IWT system in the Red River Delta, LAD (Least Available Depth) of navigation channel shall be 2.5m for class II (Corridor 1: Quang Ninh - Viet Tri) and 3.6m for class I (Corridor 4: sea - Hanoi).

(2) Width of navigation channel

Based on the Long-term Strategy for the IWT system in the Red River Delta, LAW (Least Available Width) of navigation channel shall be 50m in principle for double-way channel.

However, navigation channel in the Red River Hanoi segment shall be 4-lane channel with a LAW of 150m taking into account the future heavy vessel traffic, the existence of many ports/Berths in the segment and the future possible vessel congestion at Duong Bifurcation.

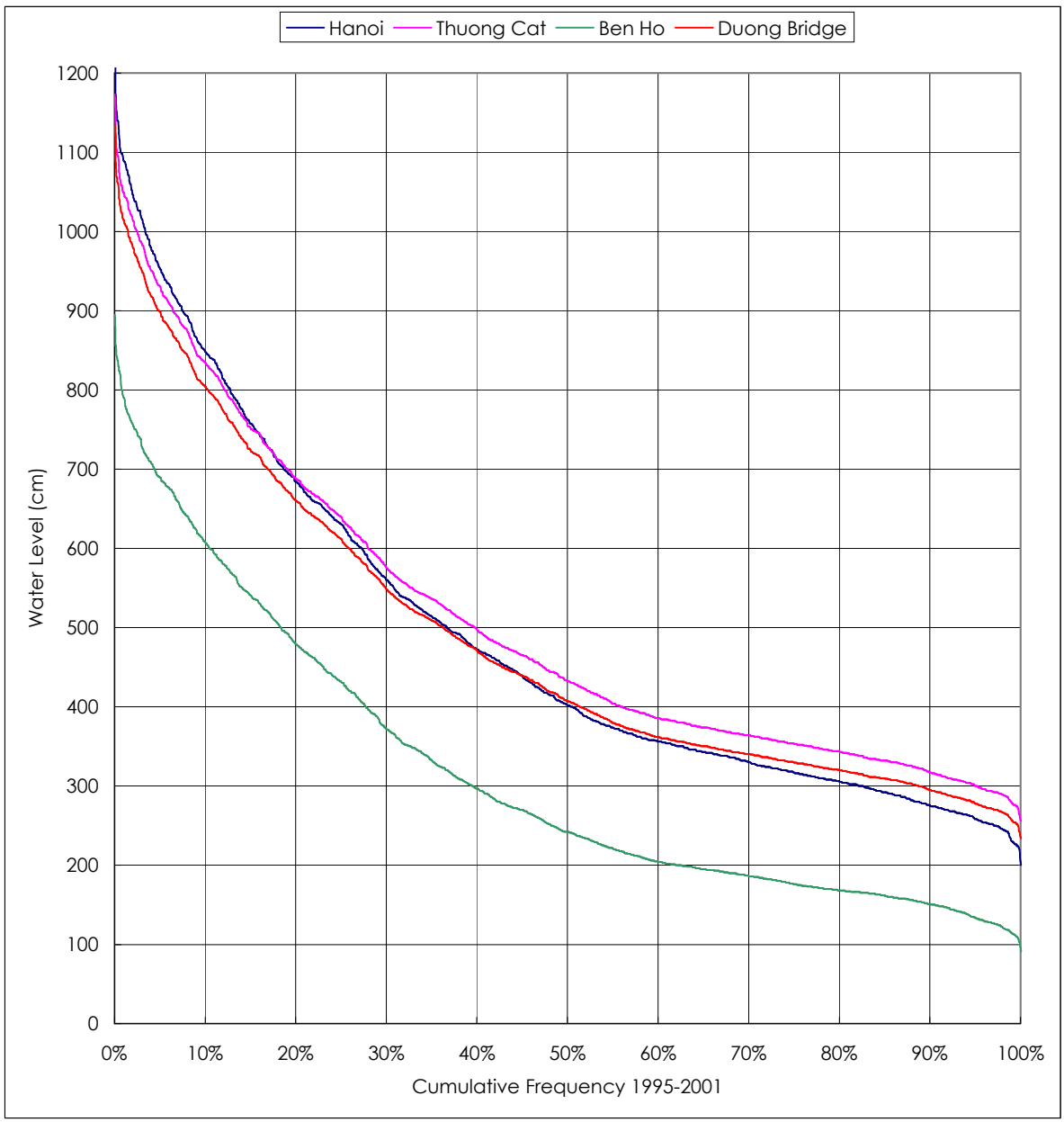
(3) Bend radius of navigation channel

Based on the Long-term Strategy for the IWT system in the Red River Delta, bend radius of navigation channel shall be 500m - 700m for class II (Corridor 1: Quang Ninh - Viet Tri) and more than 700m for class I (Corridor 4: sea - Hanoi).

(4) Vertical clearance of bridge

Based on the Long-term Strategy for the IWT system in the Red River Delta, vertical clearance of bridge shall be 10m for Class I (Corridor 4: Hanoi - sea).

As to vertical clearance of bridge for Corridor 1 (Quang Ninh - Viet Tri), JICA Study Team proposes the vertical clearance of 7m, which is the same clearance as Vinh Bridge spanning over Kinh Thay River, although Class II requires 9m. It should be noted, however, that Duong, Long Bien and Ho Bridges have lower vertical clearance than 7m (see **Figure 25.1.2**, **Table 25.1.2** and **Table 25.1.3**).



Note) Observation period: Hanoi Station (1995-2001), Thuong Cat Station (1995-2001), Ben Ho Station (1995-2001)
Note) Water levels at Duong Bridge are calculated by interpolating method using the data at Thuong Cat and Ben Ho Stations.
Source) Analyzed by JICA Study Team based on the data at Hanoi, Thuong Cat and Ben Ho Stations.

Figure 25.1.2 Cumulative Frequency of Water Level

Table 25.1.2 H5% Water Level at Bridges (cm)

	Station			Difference		Bridge		
	Hanoi	Thuong Cat	Ben Ho	Hanoi	Thuong Cat	Long Bien	Duong	Ho
	Red km+19	Duong km+4	Duong km+34	Thong Cat	Ben Ho	Red km+19	Duong km+8	Duong km+34
HHWL	1234	1173	895	61	278	1234	1136	895
H5%	952	931	689	21	242	952	899	689
H10%	849	835	608	14	227	849	805	608
H20%	684	689	480	-5	209	684	661	480
H30%	560	576	372	-16	204	560	549	372
H40%	473	499	297	-26	202	473	472	297
H50%	402	432	242	-30	190	402	407	242
H60%	356	386	205	-30	181	356	362	205
H70%	330	364	187	-34	177	330	340	187
H80%	306	344	168	-38	176	306	321	168
H90%	276	317	151	-41	166	276	295	151
H95%	258	301	134	-43	167	258	279	134
LLWL	200	256	91	-56	165	200	234	91

Note) Observation period: Hanoi Station (1995-2001), Thuong Cat Station (1995-2001), Ben Ho Station (1995-2001)
Note) Water levels at Duong Bridge are calculated by interpolating method using the data at Thuong Cat and Ben Ho Stations.
Source) Analyzed by JICA Study Team based on the data at Hanoi, Thuong Cat and Ben Ho Stations.

Table 25.1.3 Vertical Clearance of Bridges (m)

	Bridge				
	Long Bien	Duong	Ho	Thang Long	Chuong Duong
Girder Bottom	+15.13	+11.78	+12.895	+21.0	+18.24
H5%	+9.52	+8.99	+6.89	(-)	(-)
Clearance	5.6	2.8	6.0	10m <	8m <

Note) H5% water level: see Table 25.1.3

Source) JICA Study Team

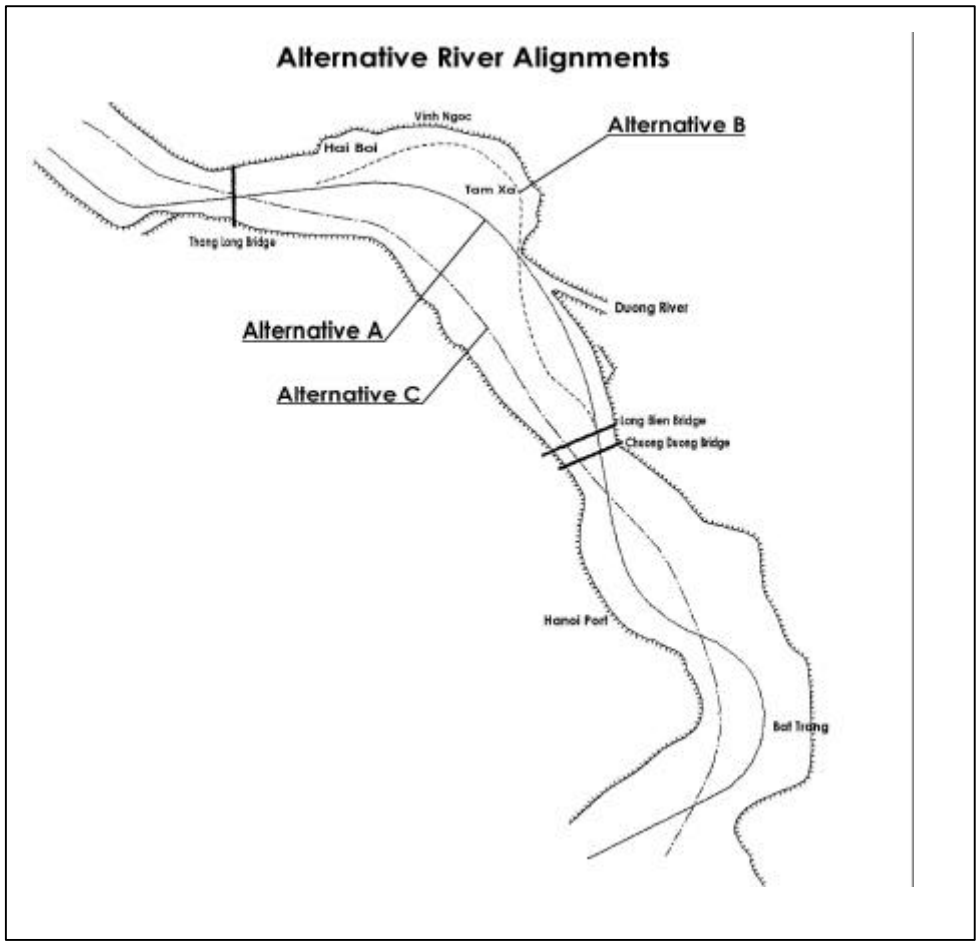
25.2 Alignment of navigation channel

According to the "Pre-F/S on Red River - Hanoi Section Rehabilitation Project", 3 main river forms have historically been observed (see **Figure 25.2.1** and **Table 25.2.1**).

River Alignment A: The flow goes from Lien Mac to Tam Xa bank, and along the left bank up to Chuong Duong Bridge, and then moves to the right bank. This river form is the present one.

River Alignment B: The flow goes along the left dyke (Hai Boi - Vinh Ngoc - Tam Xa). This river form has not existed for more than 60 years.

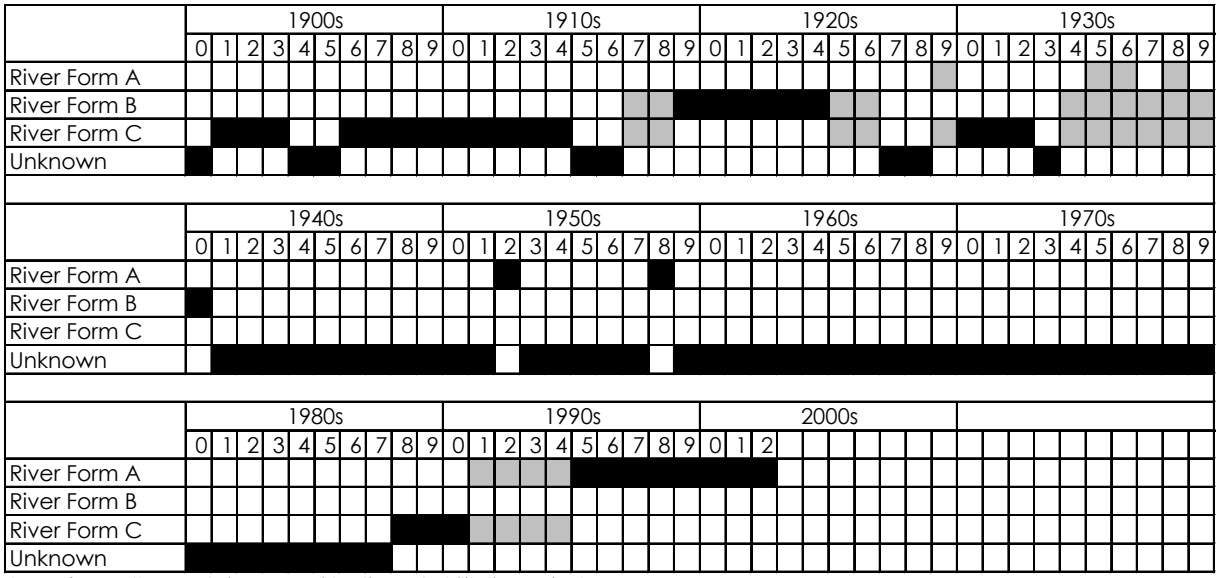
River Alignment C: The flow goes along the right bank between Thang Long and Chuong Duong Bridges, and then moves to the left bank. When this river form appeared in around 1990, Hanoi Port experienced serious sedimentation and could not operate accordingly.



Source) Pre-F/S on Red River - Hanoi Section Rehabilitation Project

Figure 25.2.1 Alternative River Alignment

Table 25.2.1 Histrical Change of River Form



Source) Pre-F/S on Red River - Hanoi Section Rehabilitation Project

Among the 3 Alternatives, Alternative A is proposed as a future desirable river alignment from the viewpoints of the sedimentation at ports, bifurcation and sluices, possible erosion at resident quarters, making good use of existing constructions of river training works and investment scale.

Table 25.2.2 Evaluation of River Alignment Alternatives

Evaluation Item	Alternative A	Alternative B	Alternative C
Sedimentation at Hanoi Port	No	No	Yes
Sedimentation at New North Port	No	No	Yes
Sedimentation at Duong Bifurcation	No	Moderate	Yes
Sedimentation at Lien Mac Sluice	No	No	Yes
Sedimentation at Xuan Quang Sluice	No	No	Yes
Possible erosion at resident quarters	Hai Ba Trung Dist.	Hai Ba Trung Dist.	Tay Ho Dist. Ba Dinh Dist. Hoan Kiem Dist.
Making good use of existing constructions of river training works	Yes	Moderate	No
Investment scale	Moderate	Large	Large
Overall Evaluation	Superior	Inferior	Inferior

Source) Pre-F/S on Red River - Hanoi Section Rehabilitation Project, JICA Study Team

Proposed alignments of navigation channel on condition that the talweg line will not change from that of January 2002 are as follows:

Case-1 (**Figure 25.2.2**)

Smooth alignment along the talweg line of January 2002.

Lateral clearance from ports is set at 150m.

Case-2 (**Figure 25.2.3**)

Modifying case-1 in order to minimize dredging volume makes case-2.

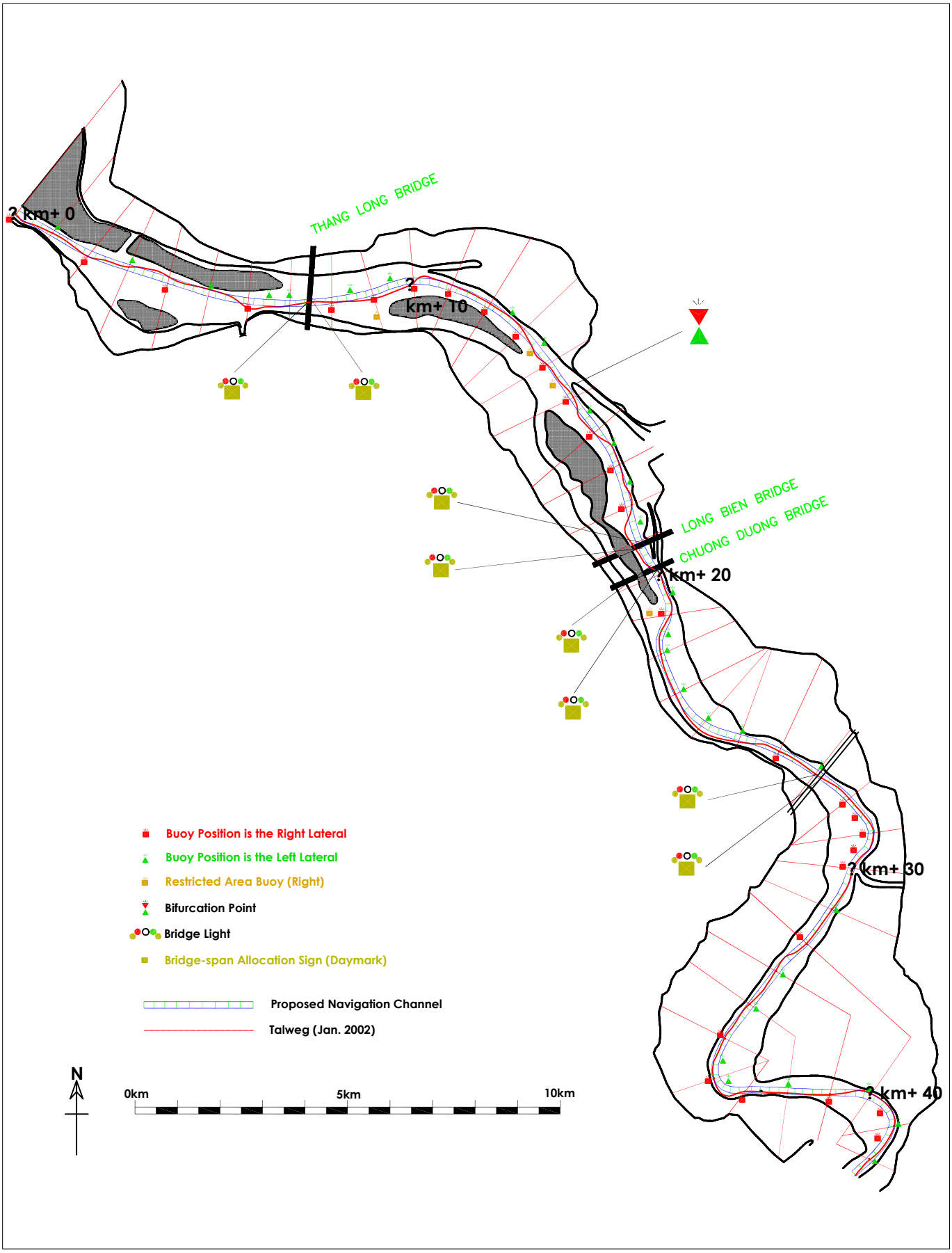
Minimum bend radius is set at 500m - 700m.

Lateral clearance from ports is set at 50m.

Case-1 is considered to be ideal in terms of vessel traffic capacity and safety. On the other hand, Case-2 is considered to be acceptable if ship crews are richly experienced in navigating this segment and are provided with accurate information on the navigation channel.

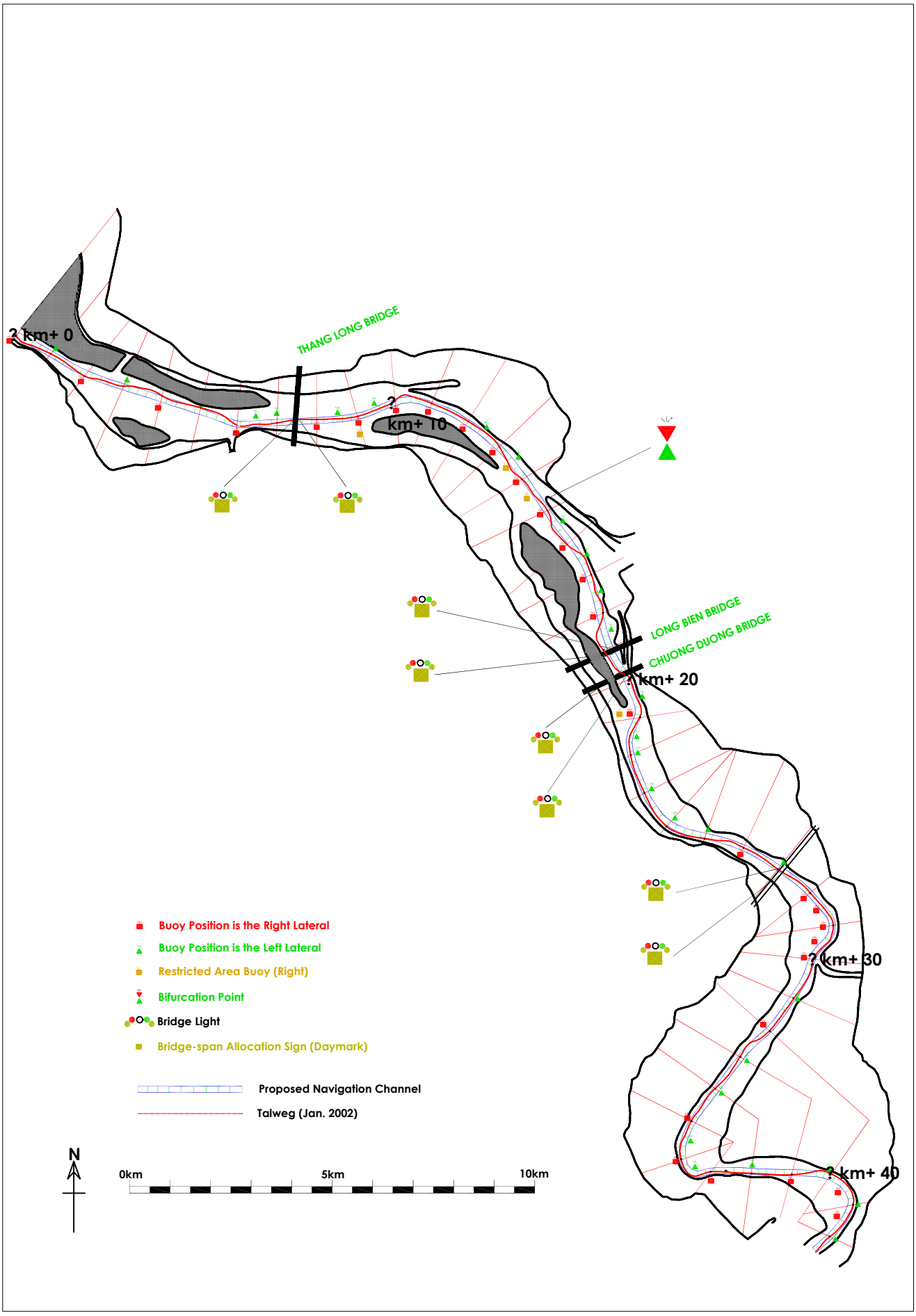
It should be noted that the talweg line changes year by year by natural forces, although change ratio will decrease by river training works. Therefore, perfect fixing of the navigation channel would be impracticable and costly.

Taking into account the above-mentioned factors, JICA Study Team proposes that Case-2 should be adopted in the beginning. In adopting Case-2, it is important above all that VIWA should properly manage and maintain the navigation channel, provide accurate information on the navigation channel as well as promote the skill-up of ship crews.



Note) Kilometerage goes downstream along the talweg of January 2002.
Source) JICA Study Team

Figure 25.2.2 Alignment of Navigation Channel in Hanoi Segment (case-1)



Note) Kilometerage goes downstream along the talweg of January 2002.
Source) JICA Study Team

Figure 25.2.3 Alignment of Navigation Channel in Hanoi Segment (case-2)

25.3 Vertical clearance improvement of Duong Bridge

Duong Bridge is located on Highway No.1 as well as a railway between Gia Lam and Yen Bien Stations crossing Duong River at km+8 in Hanoi. The bridge is a railway and highway combined bridge with the center lane for railway and two side lanes for road by cantilever structure. Highway No.1 and the railway are under the management of VRA (Vietnam Road Administration) and VR (Vietnam Railway) respectively.

The bridge was reconstructed in 1980 and the specifications of the bridge are as follows:

Location:	Duong River km+8.0 (from Duong Bifurcation)
Width of bridge:	5.5m (road) + 5.0m (railway) + 5.5m (road)
Span arrangement:	45.14m + 64.64m + 69.78m + 44.50m = 224.06m
Design load:	Railway = T16, Road = H13, X60
Superstructure:	All spans of the bridge are simple supported Warren Truss girders with the width between two main trusses of 5.75m and the length of cantilevers used for motorized and non-motorized vehicles of 5.5m.
Substructure:	Reinforced concrete abutments and piers with caisson foundation by reusing the structure of old bridge and strengthening and expanding.
Elevation of top rail:	+13.71m
Elevation of girder bottom:	+11.78m
Water level	
H5%:	+8.92m
H95%:	+2.74m
Vertical clearance:	11.78 - 8.92 = 2.86m
Horizontal clearance:	57.0m

Small vertical clearance of Duong Bridge causes a major bottleneck to IWT on corridor 1 during flood season. The traffic regulation is conducted by IWMS No.6 when water level becomes more than +6.8m for about 75 days a year. Once the traffic regulation starts, vessels, in due order from higher height of mast/cabin to lower height, are obliged to make a detour of 60km (equivalent to 9 hours at a speed of 7km/h) through Luoc and Red Rivers.

Therefore a project of vertical clearance improvement of Duong Bridge is

proposed as far as the economic analysis justifies it. Vertical clearance improvement of Duong Bridge will bring about a significant decrease of vessel traffic regulated period, although its effect may be set off to some extent by the existence of small vertical clearance bridges, namely Ho and Long Bien Bridges (see **Table 25.3.1**).

Table 25.3.1 Decrease of Regulated Period by Improving Duong Bridge

		Mast/Cabin Height of Vessel (m)			
		3.0	3.5	4.0	4.5
	Required Vertical Clearance (m)	3.5	4.0	4.5	5.0
	Current Regulated Water Level (m)	8.3	7.8	7.3	6.8
	Current Regulated Period (day)	30	42	52	66
Case-1	Future Regulated Water Level (m)	12.4	11.9	11.4	10.9
	Future Regulated Period (day)	0	0	0	1
	Decrease of Regurated Period (day)	30	42	52	65
Case-2	Future Regulated Water Level (m)	11.4	10.9	10.4	9.9
	Future Regulated Period (day)	0	1	2	5
	Decrease of Regurated Period (day)	30	41	50	61
Case-3	Future Regulated Water Level (m)	11.0	10.5	10.0	9.5
	Future Regulated Period (day)	0	2	4	10
	Decrease of Regurated Period (day)	30	40	48	56

Note) Current elevation of girder bottom of Duong Bridge: + 11.78 m

Note) Future effective elevation of girder bottom of Duong Bridge:

Case-1: for vessel passing only Duong Bridge + 15.92 m
= 8.92 (H5% at Duong Bridge) + 7

Case-2: for vessel passing Duong and Ho Bridges + 14.93 m
= 8.92 (H5% at Duong Bridge) + 6.01 (Clearance of Ho Bridge)

Case-3: for vessel passing Duong and Long Bien Bridges + 14.53 m
= 8.92 (H5% at Duong Bridge) + 5.61 (Clearance of Long Bien Bridge)

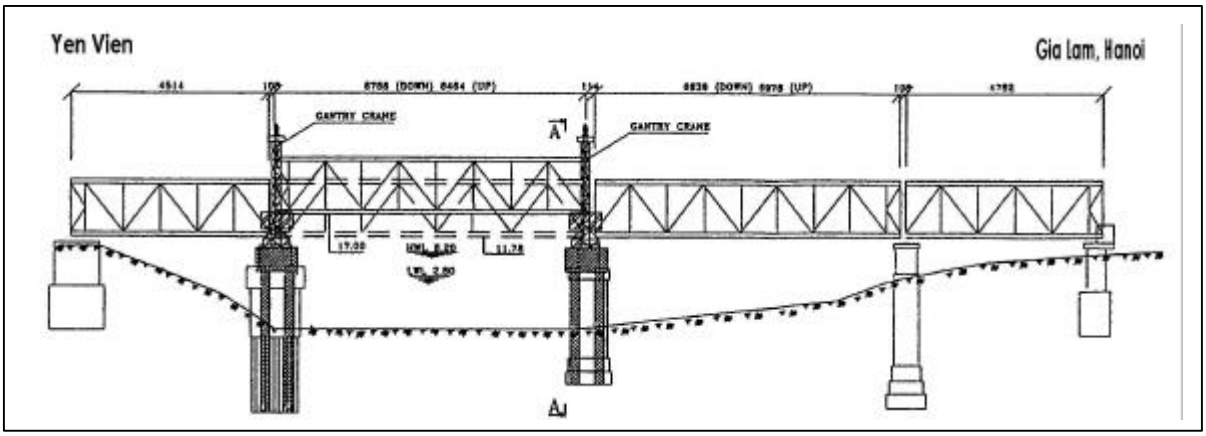
Note) Shortening Distance 60 km

Source) JICA Study Team

The following structural alternatives are conceived in order to improve vertical clearance of Duong Bridge:

Alternative-1: This alternative is to improve vertical clearance of all spans of the bridge.

Alternative-2: This alternative is to improve vertical clearance of only the center span of the bridge with movable span technique (see **Figure 25.3.1**).



Source) TEDI, within the Red River Waterways Project, Jan 1998 (TA No.2615-VIE)

Figure 25.3.1 Conceptual Design of Duong Bridge (Alternative-2)

As mentioned above, Duong Bridge is a railway and highway combined bridge. It is located in the middle of two railway stations named Gia Lam and Yen Bien.

As to road transport, Phu Dong Bridge (5km downstream of Duong Bridge) was completed as a part of Highway No.1 (new route) in 2000 and construction of a new bridge (3km upstream of Duong Bridge) will be started in 2003 as an extension of Highway No.5. In addition, another 2 bridges upstream of Duong Bridge are planned by HNPC.

The Study Team conducted the rough cost estimation of both alternatives. The results are as follows (see **Appendix 25**):

Alternative-1: US$ 17.7 million
Alternative-2: US$ 9.6 million

On the other hand, the maximum cost, which vertical clearance improvement project of Duong Bridge is justified from the benefit of IWT sector, is estimated at some US$ 4 million. Hence, the project is not feasible as an IWT project alone. Therefore, the Study Team recommends that vertical clearance improvement project of Duong Bridge should be prepared as a comprehensive transport project through close consultation with VR and VRA.

25.4 Navigation safety measures for Duong Bifurcation

(1) Distribution of roles and functions among ports/berths

The vessel traffic at three points in Hanoi Segment in 2020 is forecast as follows:

Dong Lai: approx. 480 vessels/day
Phu Dong: approx. 240 vessels/day
Yen My: approx. 130 vessels/day

Note) Vessels carrying containers are excluded.

Special attention should be paid to Duong Bifurcation in terms of vessel traffic capacity and traffic safety, since many of the above vessels will pass through Duong Bifurcation.

Therefore, distribution of roles and functions among ports/berths is carried out taking into account easing vessel traffic concentration at Duong Bifurcation. As a result, vessel traffic in 2020 at Duong Bifurcation will be decreased by some percents compared with present distribution pattern of roles and functions among ports/berths (see **Table 25.4.1** through **Table 25.4.6**).

However, a large number of vessels will still pass through Duong Bifurcation and thus prudent navigation safety measures should be implemented.

(2) Giving clear priority to vessel navigation

There are six patterns of vessel navigation at Duong Bifurcation:

(a) From upstream in the Red River to the Duong River
(b) From upstream to downstream in the Red River
(c) From the Duong river to upstream in the Red River
(d) From the Duong River to downstream in the Red River
(e) From downstream to upstream in the Red River
(f) From downstream in the Red River to the Duong River

The top priority shall be given to the vessel that goes from upstream in the Red River to Duong River (a) and to downstream in the Red River (b). Vessel that goes from upstream in the Red River to Duong River (a), in particular, is the most difficult case among these six patterns, where a vessel heading for downstream has to steer to the left in a water flow, cross the opposite water lane and enter the waterway in

the Duong River.

The second priority shall be given to the vessel from Duong River to downstream in the Red River (d). In other cases, ships shall navigate paying special attention to other vessels near Duong Bifurcation.

(3) Alternatives on additional navigation safety measures

There are four alternatives on additional navigation safety measures for Duong Bifurcation as follows:

Alternative-1

Every vessel that passes through Duong Bifurcation in the day time shall put up the international signal flag showing its destination and shall navigate according to the above mentioned priority rule. During the night, every vessel shall navigate with whistles according to the priority rule. In general a vessel going straight blows one short whistle continuously and a vessel turning to the left blows two short whistles continuously.

Alternative-2

Vessel navigation is limited to particular times. Vessels going in the Red River can navigate during a certain time and vessels in the Duong River during the other time. This method may be difficult if many vessels concentrate on Duong Bifurcation.

Alternative-3

"Traffic Control Center" will be set up at Duong Bifurcation. Vessels shall communicate with the Center through VHF and shall navigate according to the direction from the Center.

Alternative-4

Turning left point for vessels from the Duong River to downstream in the Red River is moved to upstream in the Red River by installing land signs of "No Left Turn". This method may be effective for the improvement of vessel traffic capacity and safety at the Duong Bifurcation, although the navigation length of the vessel becomes longer.

JICA Study Team proposes that Alternative-1 should be adopted in the beginning. In adopting Alternative-1, it is important that every vessel strictly observes the rule. It is also advisable to study the details of Alternative-3 and Alternative-4 as vessel traffic will increase. In addition to the above measures, navigation aids such as buoys should be installed at closer intervals near Duong Bifurcation, since a lot of vessels concentrate on Duong Bifurcation and vessel operators are forced to maneuver very carefully.

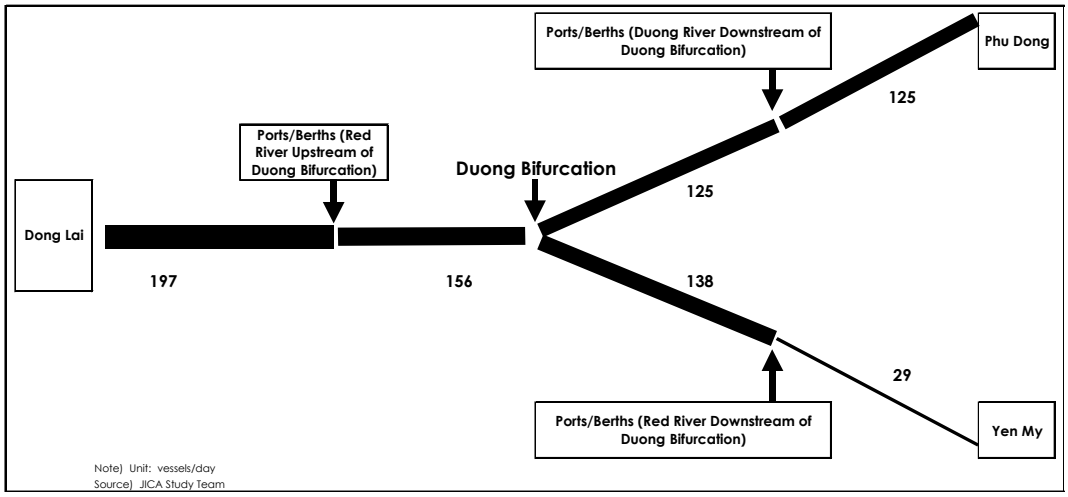


Figure 25.4.1 Daily Vessel Traffic in Hanoi Segment (2001)

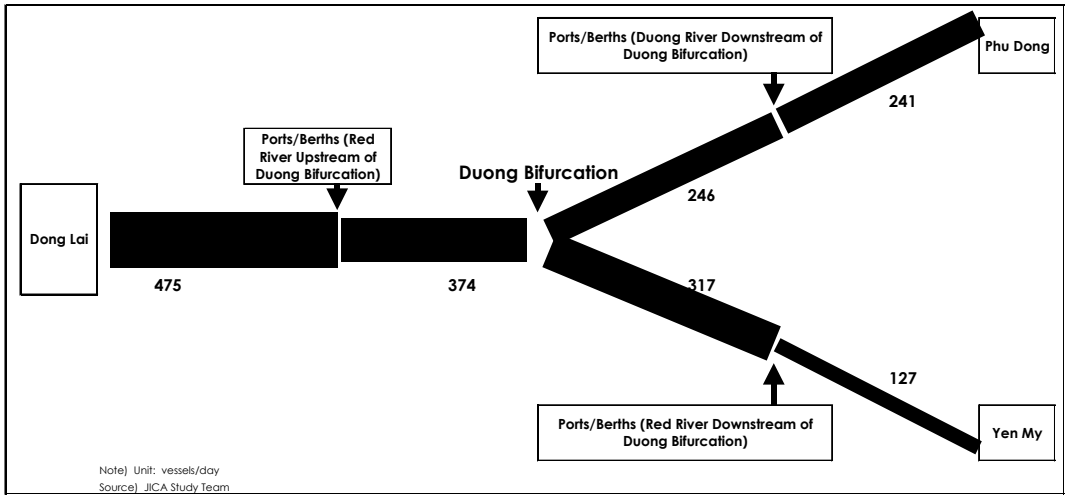


Figure 25.4.2 Daily Vessel Traffic in Hanoi Segment (2020, Present Pattern)

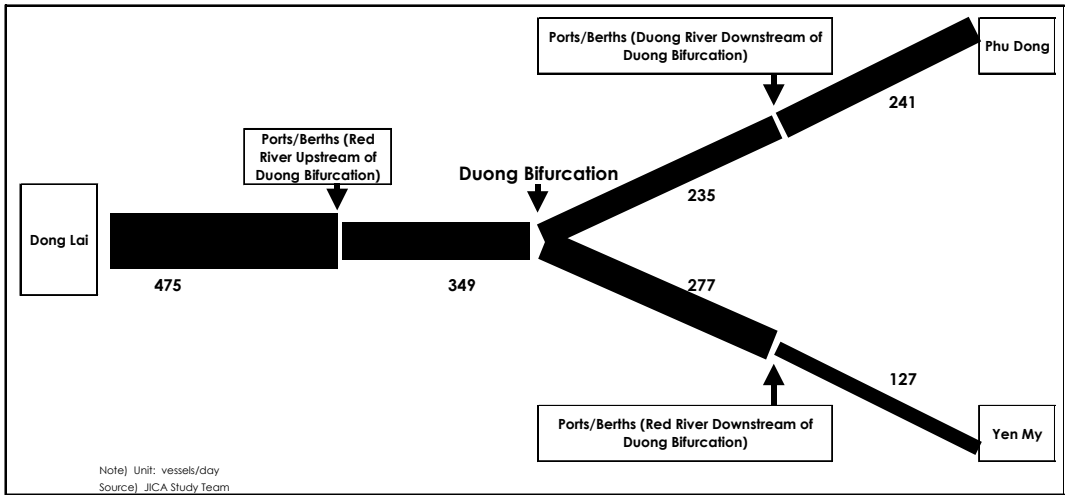


Figure 25.4.3 Daily Vessel Traffic in Hanoi Segment (2020, MP)

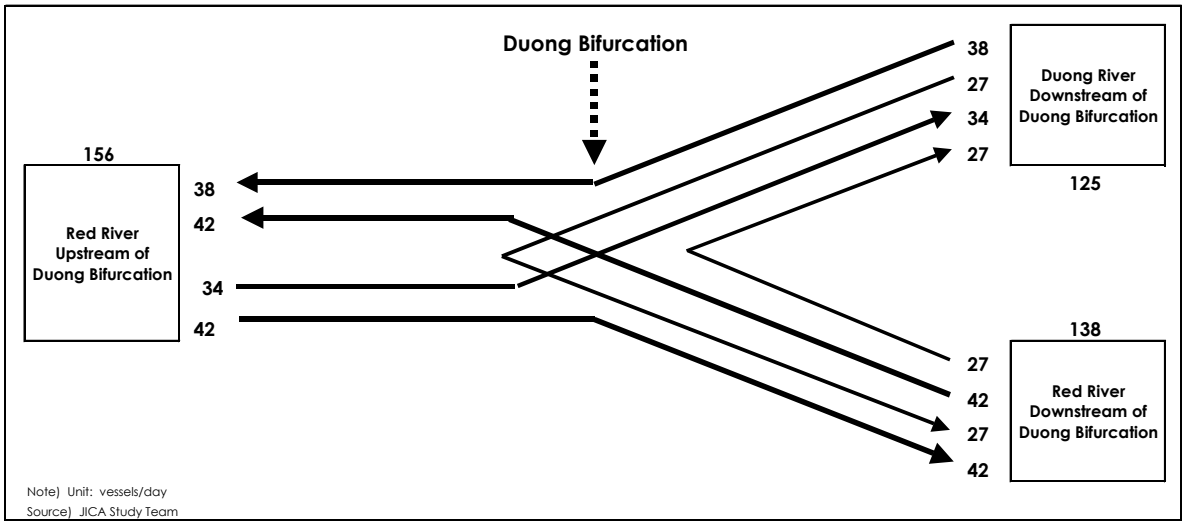


Figure 25.4.4 Daily Vessel Traffic at Duong Bifurcation (2001)

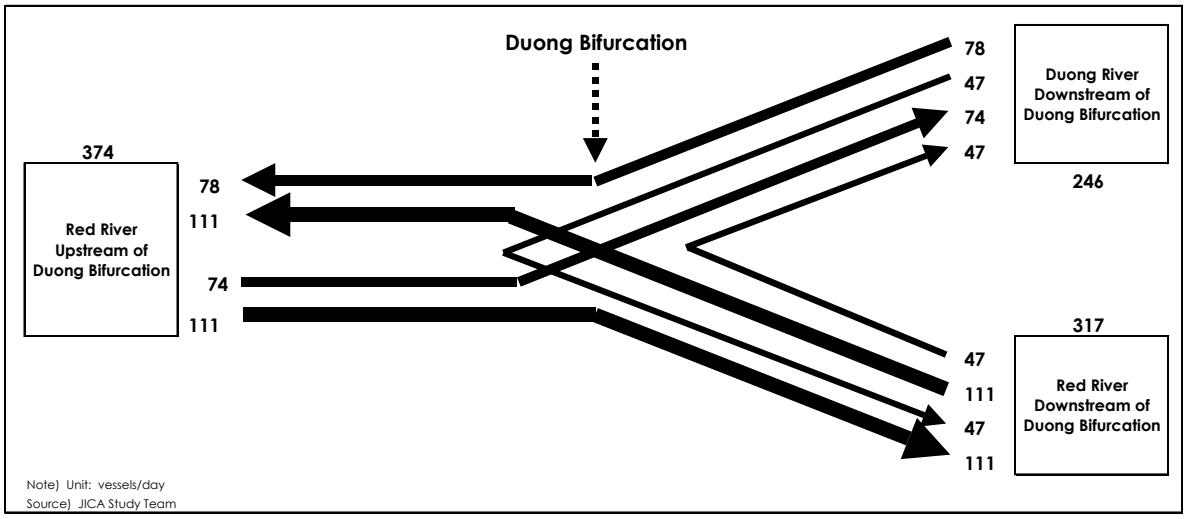


Figure 25.4.5 Daily Vessel Traffic at Duong Bifurcation (2020, Present Pattern)

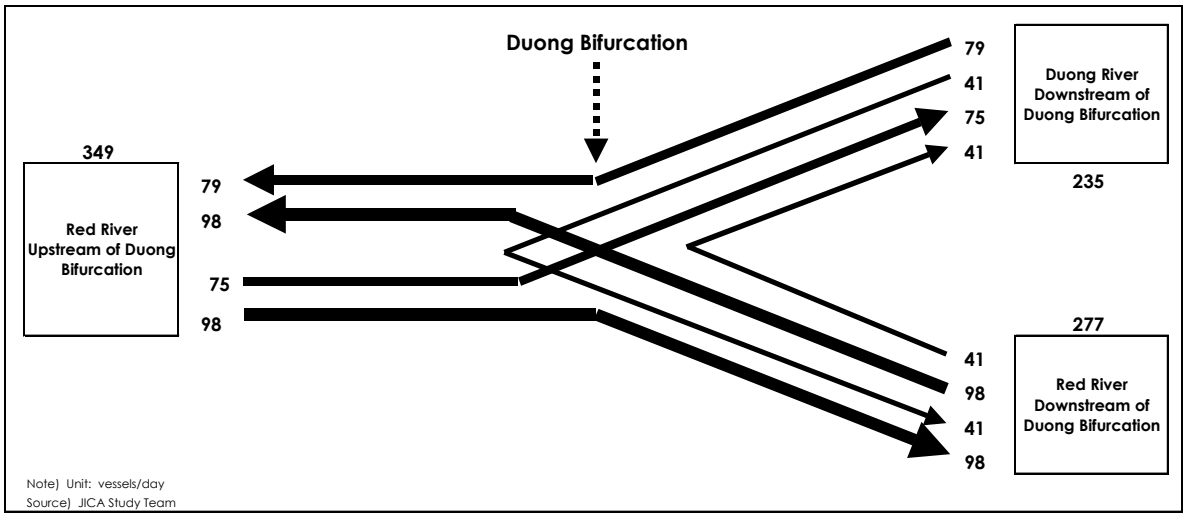


Figure 25.4.6 Daily Vessel Traffic at Duong Bifurcation (2020, MP)

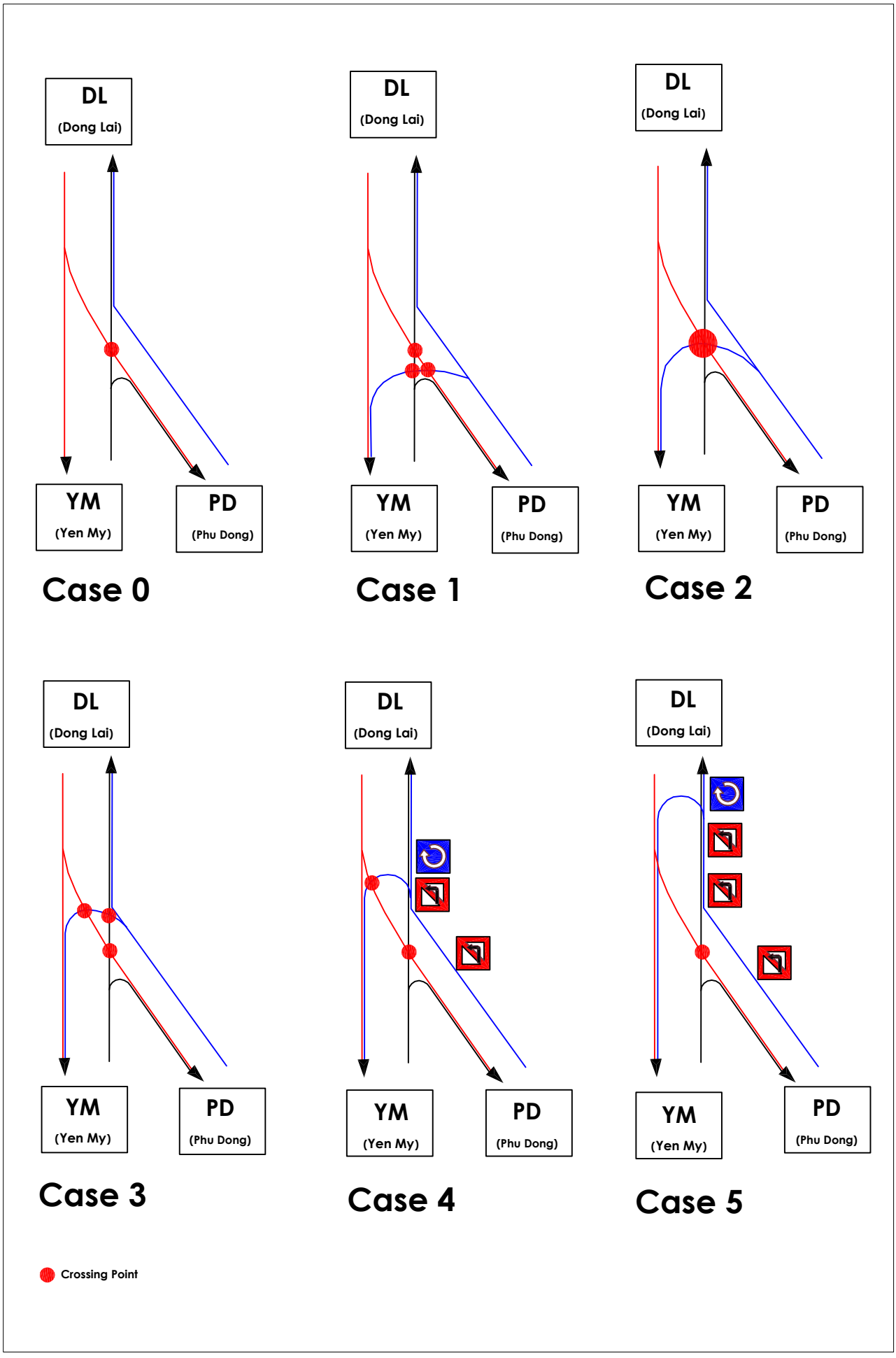


Figure 25.4.7 Crossing Point Alternatives at Duong Bifurcation

Table 25.4.1 Evaluation of Crossing Point Alternatives at Duong Bifurcation

Alternative	Description	Advantage	Disadvantage	Evaluation
Case 0	Base case without vessels PD-YM. There is one crossing point.			
Case 1	Vessels of PD-YM turn left before reaching the crossing point of Case 0.	Navigation length of PD-YM becomes the shortest.	There are two additional (total: three) crossing points. Visibility between vessels of PD-YM and YM-DL is the poorest.	Bad
Case 2	Vessels of PD-YM turn left at the crossing point of Case 0.	Navigation length of PD-YM becomes shorter.	There is no additional crossing point, but vessels from three directions may reach the unique crossing point at the same time. Visibility between vessels of PD-YM and YM-DL is poor.	Worst
Case 3	Vessels of PD-YM turn left beyond the crossing point of Case 0.		There are two additional (total: three) crossing points.	Bad
Case 4	Vessels of PD-YM turn left after merging with YM-DL.	There is only one additional (total: two) crossing point.	Navigation length of PD-YM becomes longer than those of case 1, 2 and 3. Land signs of "No Left Turn" shall be installed. Widening the navigation channel (required width = 300m) at turning zone is needed.	Acceptable
Case 5	Vessels of PD-YM turn left after merging with YM-DL and after passing the diverging point of DL-PD.	There is no additional crossing point.	Navigation length of PD-YM becomes the longest. Land signs of "No Left Turn" shall be installed. Widening the navigation channel (required width = 300m) at turning zone is needed.	Superior

Note) Case 0 to 5: see Figure 25.4.7

Source) JICA Study Team

25.5 Navigation aids

Planning fundamentals for providing navigation aids in the Red River Hanoi segment are proposed as follows:

- To install lateral/cardinal lighted marks conforming to the buoyage system for Vietnamese inland waterway (22 TCN 269-2000) as well as that of the International Association of Lighthouse Authority (IALA) zone A.
  + Each lateral mark (lighted buoy) should be placed 1000 meters apart (500 meters apart at sharp bends and near Duong Bifurcation) in a zigzag pattern as a general rule.
  + A lighted beacon should be placed at Duong Bifurcation as at present.
  + Cardinal marks should be placed at obstacles and restricted areas.
- To install bridge light sets and daymarks at bridges.
- To install jetty markers at ports. Each jetty marker should be placed 40m apart as a general rule.
- The source of light should be solar battery system with LED (light emitting diode) as a general rule.

Proposed number of navigation aids is listed in **Table 25.5.1** and layout plan of main navigation aids is depicted in **Figure 25.2.2** and **Figure 25.2.3**.

Table 25.5.1 Proposed number of main navigation aids

Type	Location	Interval	Required Number	Note
Lateral Mark(Lighted Buoy)	40km Red River Hanoi Segment	1000 m (500m) apart in a zigzag pattern	60	
Lateral Mark(Lighted Beacon)	Duong Bifurcation	(-)	1	Existing
Cardinal Mark(Lighted Buoy)	at obstacles and restricted areas	(-)	20	
Bridge Light set	Thang Long, Long Bien, Chuong Duong, Thanh Tri	(-)	8	
Bridge Daymark	Thang Long, Long Bien, Chuong Duong, Thanh Tri	(-)	8	Existing
Jetty Marker	Hanoi, Khuyen Luong, New North, New East	40 meters apart	80	

Note) Bridge Light set consists of a center light, a port edge light, a starboard edge light and two pier lights for both side of a bridge.
Source) JICA Study Team