

## 5. Technical Notes

**Technical Note**  
**The Preparatory Survey on Flood Disaster Rehabilitation and Mitigation**  
**in Kingdom of Cambodia**

The JICA Survey Team and MPWT of Royal Government of Cambodia held technical discussions and confirmed the following. However, it is noted that the confirmations and proposals might be revised in further discussions in Japan.

**1. Construction of Brides along National Road No. 11**

**1.1 Project Bridges**

The project bridges are 8 bridges along National Road No.11 as shown in Figure 1-1. Those bridges are dilapidated temporary bridges and having inadequate flood discharge capacity.

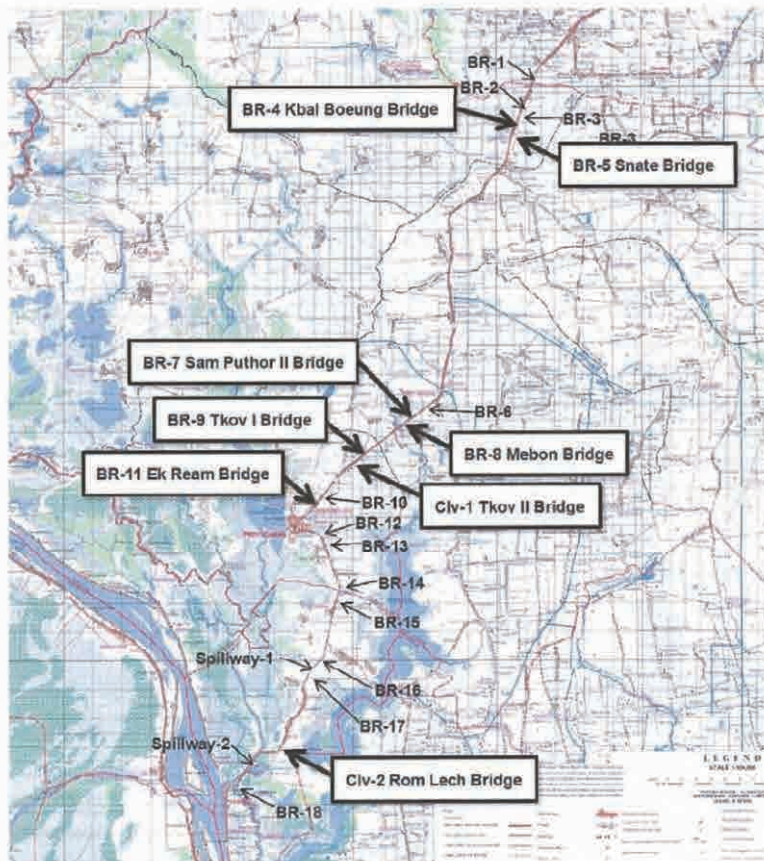


Figure 1-1 Location of Project Bridges

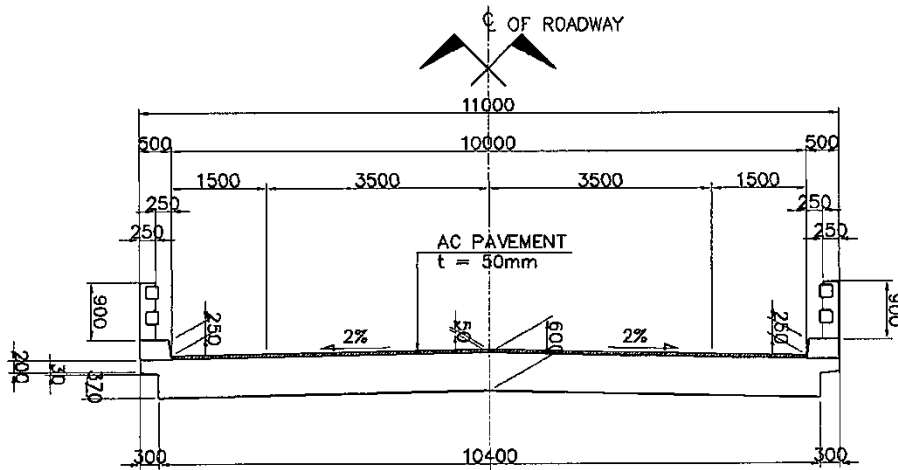
## 1.2 Bridge Design Criteria/Standards

### (1) Design Standard

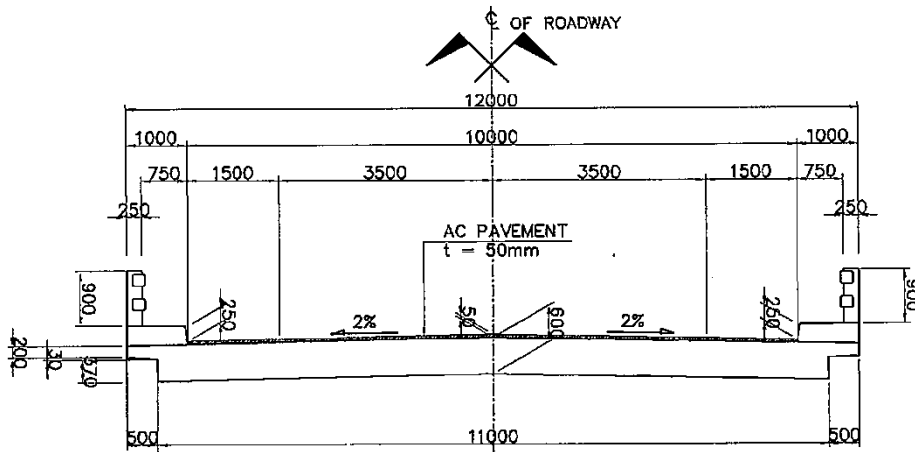
AASHTO Standard Specifications for Highway Bridges 2002 will be adopted as same as previous Japanese grant aid bridge projects. Japanese bridge design specifications are used supplementary.

### (2) Bridge width

The bridge width component is as shown in Figure 1-2. Sidewalks are provided for the bridges which are located near town or school.



Bridge without Sidewalk (BR-5, 7, 8, 9, Clv-1)



Bridge with Sidewalk (BR-4, 11, Clv-2)

Figure 1-2 Bridge Width Components

**(3) Design Criteria**

- Live load: HS20-44 x 1.25 (25% increase of AASHTO live loads)
- Temperature change :  $\pm 17^{\circ}\text{C}$  (8 - 42 $^{\circ}\text{C}$ )
- Earthquake load: Acceleration coefficient = 0.05
- Freeboard (clearance between HWL and bridge): 0.6 m

**(4) Concrete Specification (Design strength)**

- Superstructure: 32 Mpa
- Substructure 32 Mpa
- Under water concrete 24 Mpa
- Lean concrete 18 Mpa
- Precast Pile 32 Mpa

**(5) Steel Materials**

- Reinforcing steel bars: Grade 400 deformed bars (Min. yield point 400 Mpa)

**(6) Geometric Standards of Bridge Approach Road**

The geometric standard of the bridge approach road is shown in Table 1-1.

Table 1-1 Geometric Standard of Bridge Approach Road

Item	Standard
Carriageway Width (m)	3.5 x 2
Shoulder Width (m)	1.5 x 2
Design Speed (km/hr)	80
Horizontal Min. Curb Radius (m)	300
Maximum Grade (%)	4.0
Vertical Min. Curb Radius (m)	3000

**1.3 Proposed Bridge Length**

The proposed bridge length are shown in Table 1-2. The followings were considered in determining the proposed bridge length:

- The proposed bridge lengths should be longer than the existing bridges since the most of existing bridge protections have been eroded by high velocity flood flow.
- The proposed bridge lengths are determined based on level of the erosions at the bridges and the bridge site topographies (the bridge opening should be connected smoothly with the upstream and downstream opening).
- Mekong River Committee Flood Management and Mitigation Program, Road and Floods

Project Report 2009 mentioned that widening of opening of the existing bridges by 50% is recommended to reduce flood flow velocity.

- DPWT of Prey Veng requested to widen the opening of the bridges and agreed to the proposed bridge lengths as shown in Figure 1-2.

Table 1-2 Proposed Bridge Lengths

Bridge No.	Bridge Name	Location	Existing Bridge Type	Existing Bridge Length (m)	Proposed Bridge Length (m)
BR-4	Kbal Boeung	64+300	RC Girder	19.0	33.0
BR-5	Snate	63+650	2-lane bailey/Steel deck	27.0	40.0
BR-7	Sam Puthor II	40+950	2-lane bailey/Steel deck	42.0	44.0
BR-8	Mebon	40+350	RC Girder	29.5	50.0
BR-9	Tkov I	38+450	2-lane bailey/Steel deck	42.0	44.0
Clv-1	Tkov II	37+900	Pipe culvert	5.8	20.0
BR-11	Ek Ream	32+100	1-lane bailey/Steel deck	18.5	33.0
Clv-2	Rom Lech	14+745	Box culvert	10.0	44.0

#### 1.4 Proposal of Bridge Structures

##### (1) Bridge Structure and Span layout

RC flat slab type is proposed for all project bridges since it is superior to other types such as RC T-girder or PC hollow slab in the following points. The structure and span layout of the project bridges are as shown in Figure 1-3.

- Cost is minimal.
- Bridge approach road is smooth since the bridge height (60cm) is minimal.
- Construction is easy and fast.
- Heavy equipment for girder erection is not necessary.

##### (2) Bridge Foundation

Precast pile (40cm x 40cm) which is the most economical is used for all foundations.

##### (3) Railing Structure

- RC railing as shown in Figure 1-4 is proposed.

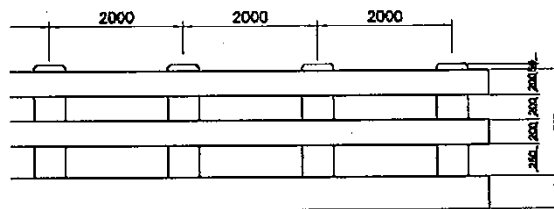


Figure 1-4 Railing Structure

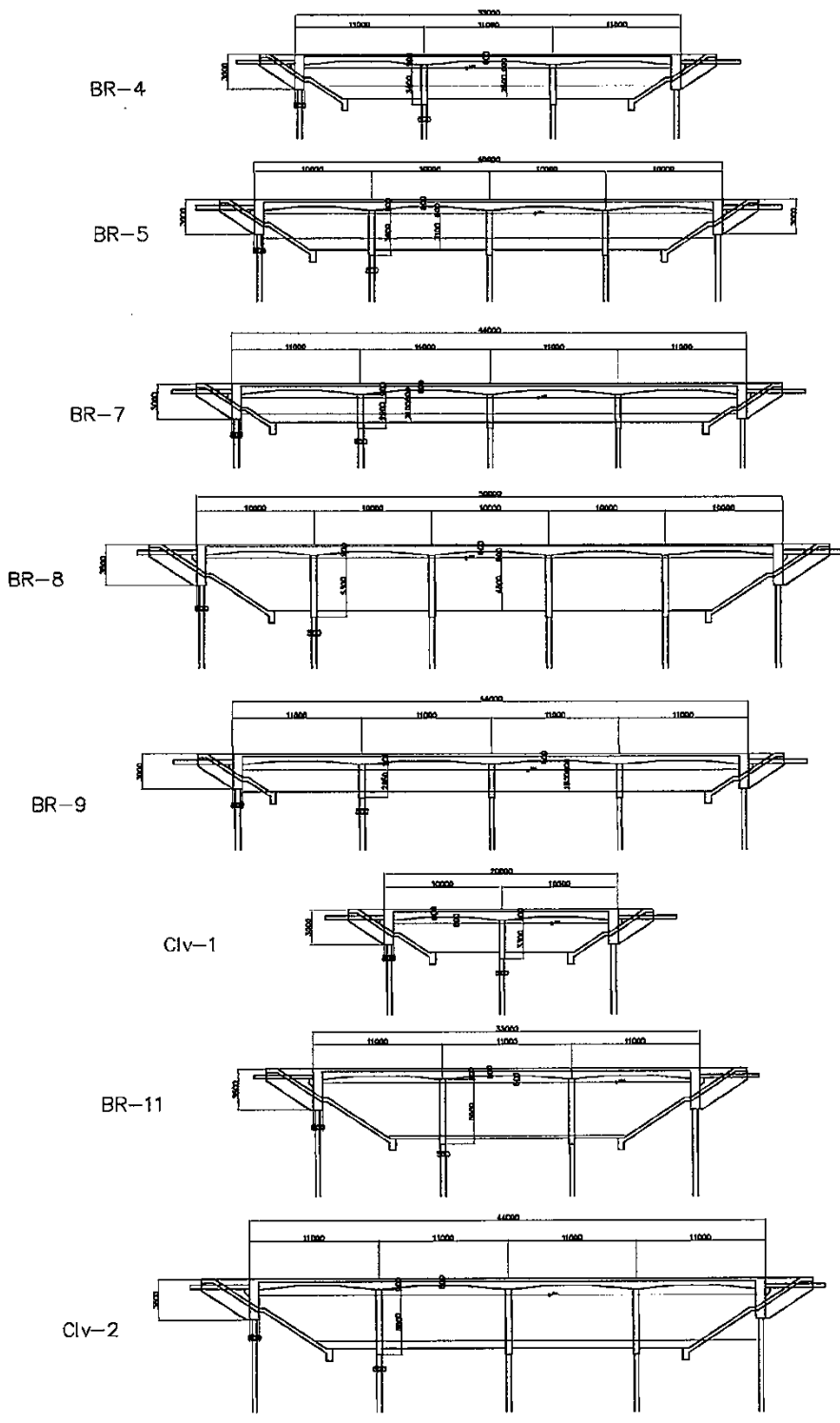


Figure -2 Bridge Structure and Span Layout of the Project Bridges

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**(4) Bridge Approach Road**

Layout of the bridges approach road is shown in Figure-3. The pavement on the bridge shoulders are tapered (ratio 1/30) along the approach roads. Guardrails (length 16 m) and guide posts (length 40 m with spacing 4 m) are installed along the approach roads as shown in the Figure-5. The typical cross sections of the bridge approach road are shown in Figure-6.

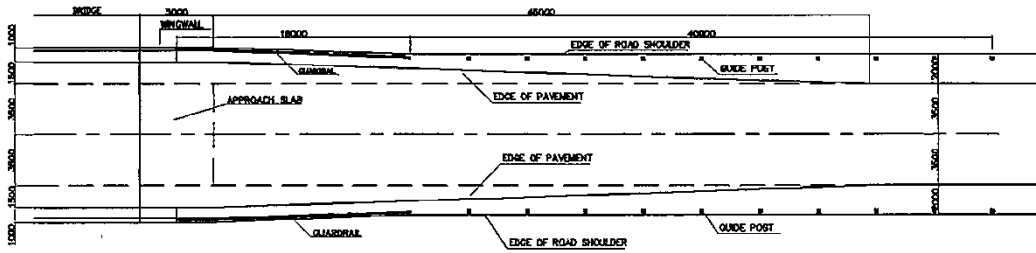


Figure-5 Layout of Bridge Approach Road

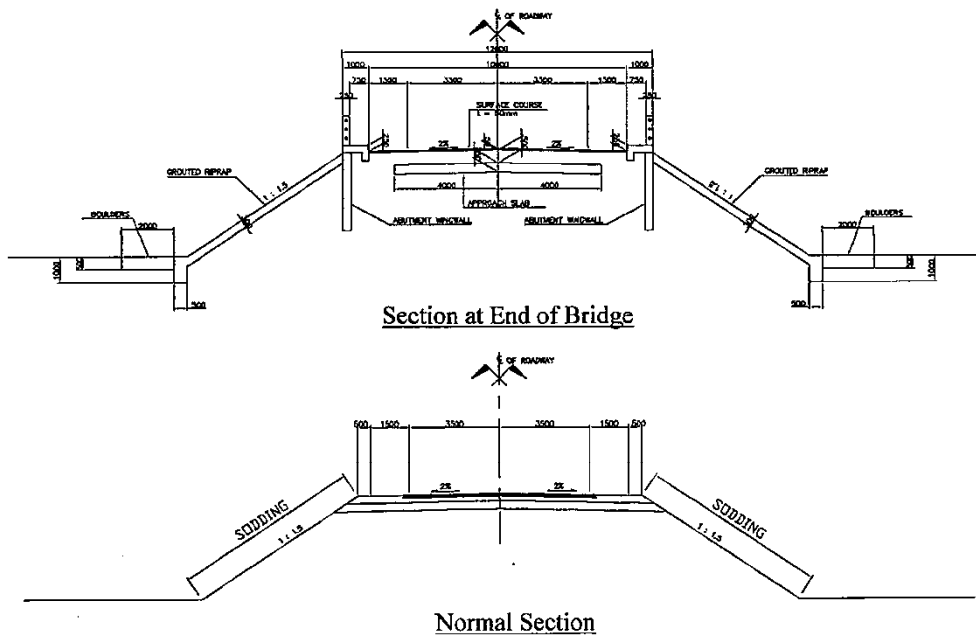


Figure-6 Typical Cross Section of Bridge Approach Road

**(5) Slope Protection**

Grouted riprap slope protection (30 cm thick) will be installed around the abutments (within 16 m from the edge of the wing walls). Sod will be installed on the approach road slopes.

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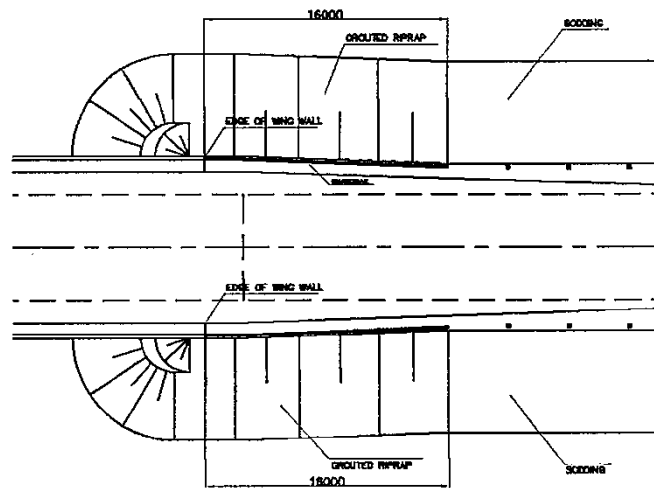


Figure-7 Slope Protection Area

**(6) Riverbed Protection**

Boulders (minimum size 20 cm) will be installed on the riverbed for protection from riverbed erosion. The area of riverbed protection to be installed is shown in Figure-8. The thickness of the boulder riverbed protection is 50 cm.

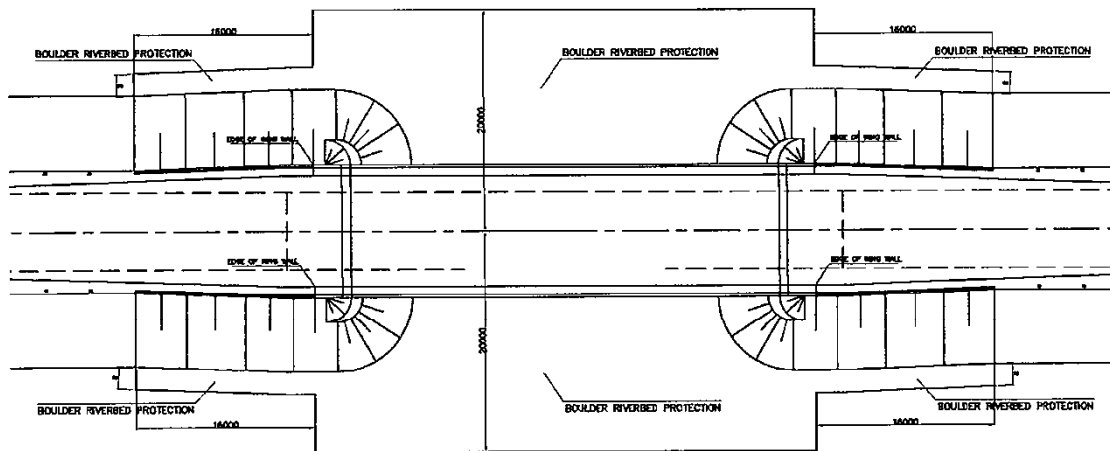


Figure-8 Area of Riverbed Protection

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## 2. Improvement of Road and Drainage Facilities in Kampong Chhnang City

### 2.1 Project Roads and Drainage Ways

The project roads and drainage ways are shown in Figure 2-1. Those roads are the major roads in the city and were damaged by flood in 2011. The roads have been temporary rehabilitated, however, improvement with permanent pavement and installation/repair of drainage facilities are necessary.

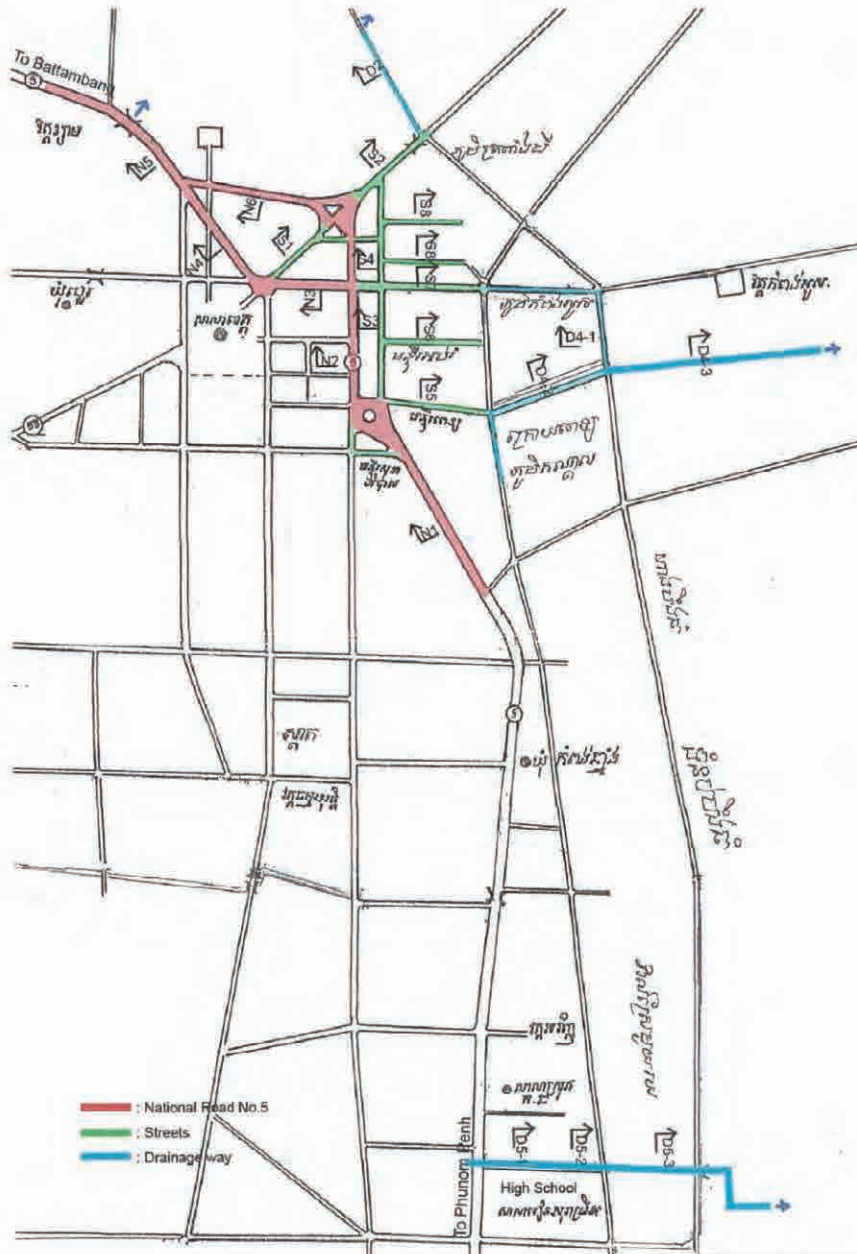


Figure 2-1 Project Roads and Drainage Ways in Kampong Chhnang City

## 2.2 Design Specifications

The Cambodia Road Design Standard – Part 1 (Geometry), Part 2 (Pavement), Part 3 (Drainage) issued by Ministry of Public Works and Transport will be basically adopted. Specifications of AASHTO (for pavement design) and Japan Road Association (for road design and drainage detail) are adopted supplementary.

## 2.3 Road Class

National Road No.5 is classified as International Highway (urban section) and other streets are classified as Provincial Road and District Road.

## 2.4 Geometric Standards

The geometric standards by road class are proposed as shown in Table 2-1.

Table 2-1. Geometric Standards

Item	Specification by Road Class	
	International Highway (inside city area)	Provincial Road and District Road
Road Section		
Design Speed (km/h)	60	40
Maximum Grade (%)	6.0	8.0
Minimum Horizontal Curve Radius (m)	150	55
Stopping Sight Distance (m)	70	45
Crest Vertical Curve (K Values)	15	10
Sag Vertical Curve (K Values)	15	10
Maximum Super-elevation (%)	4.0	4.0
Crossfall for Bituminous Concrete (%)	2.5	2.5
Carriageway Width (m)	3.5	3.5

## 2.5 Proposed Road and Drainage Improvement Plan

### (1) Typical Cross Sections of Roads and Drainage Ways

The proposed typical cross sections of the project roads and drainage ways are shown Figure 2-2. The locations of the typical cross sections are shown in Figure 2-1.

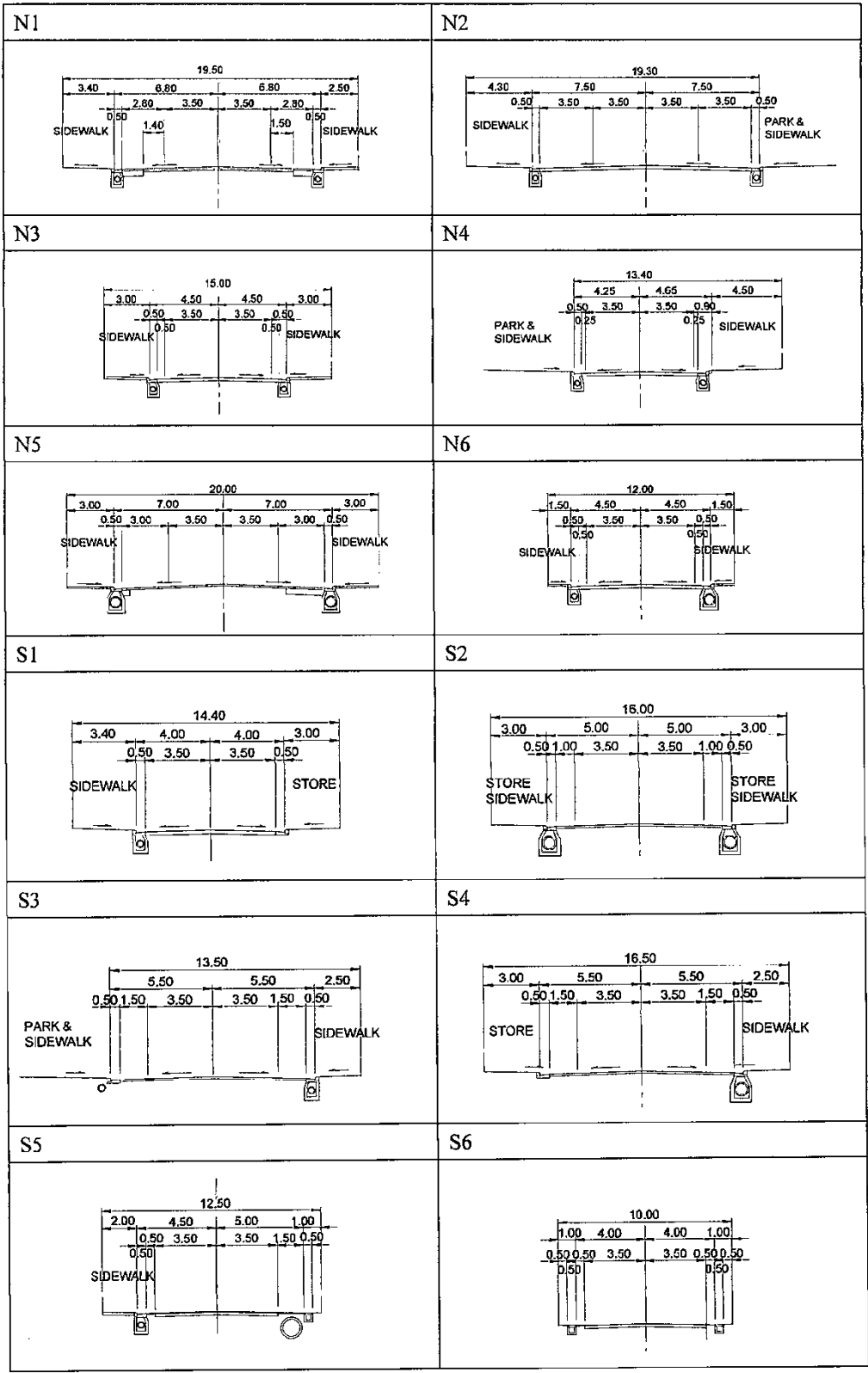
### (2) Pavement Structure

The pavement structure is proposed with the following materials. The thickness of the pavement will be studied based on the survey data of traffic and subgrade CBR.

- Surface course: Hot-mixed asphalt concrete
- Base course: Granular material (CBR>80)
- Subbase course: Granular material (CBR>30)

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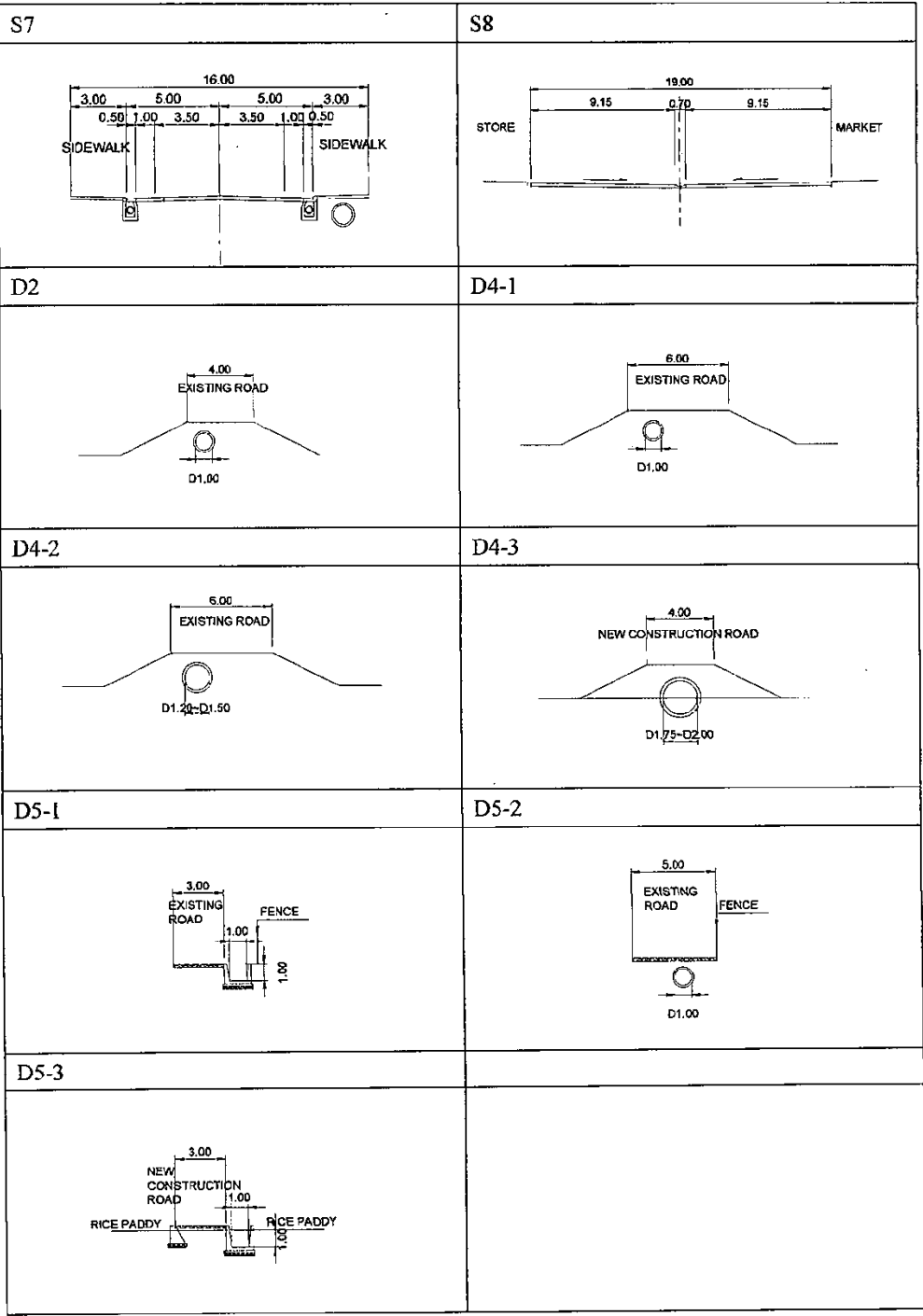


Figure 2-2 Typical Cross Sections of Project Roads and Drainage Ways

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**(3) Sidewalk Pavement**

The color block sidewalk pavement as shown in Figure 2-2 is proposed.



Figure 2-2 Propose Sidewalk Pavement

**(4) Road Marking**

Centerline, sideline (edge line) will be provided for all roads and crosswalk and arrow and zebra mark will be provided for intersections.

**(5) Typical Drainage Structures**

The proposed typical drainage structures are shown in Figure 2-4.

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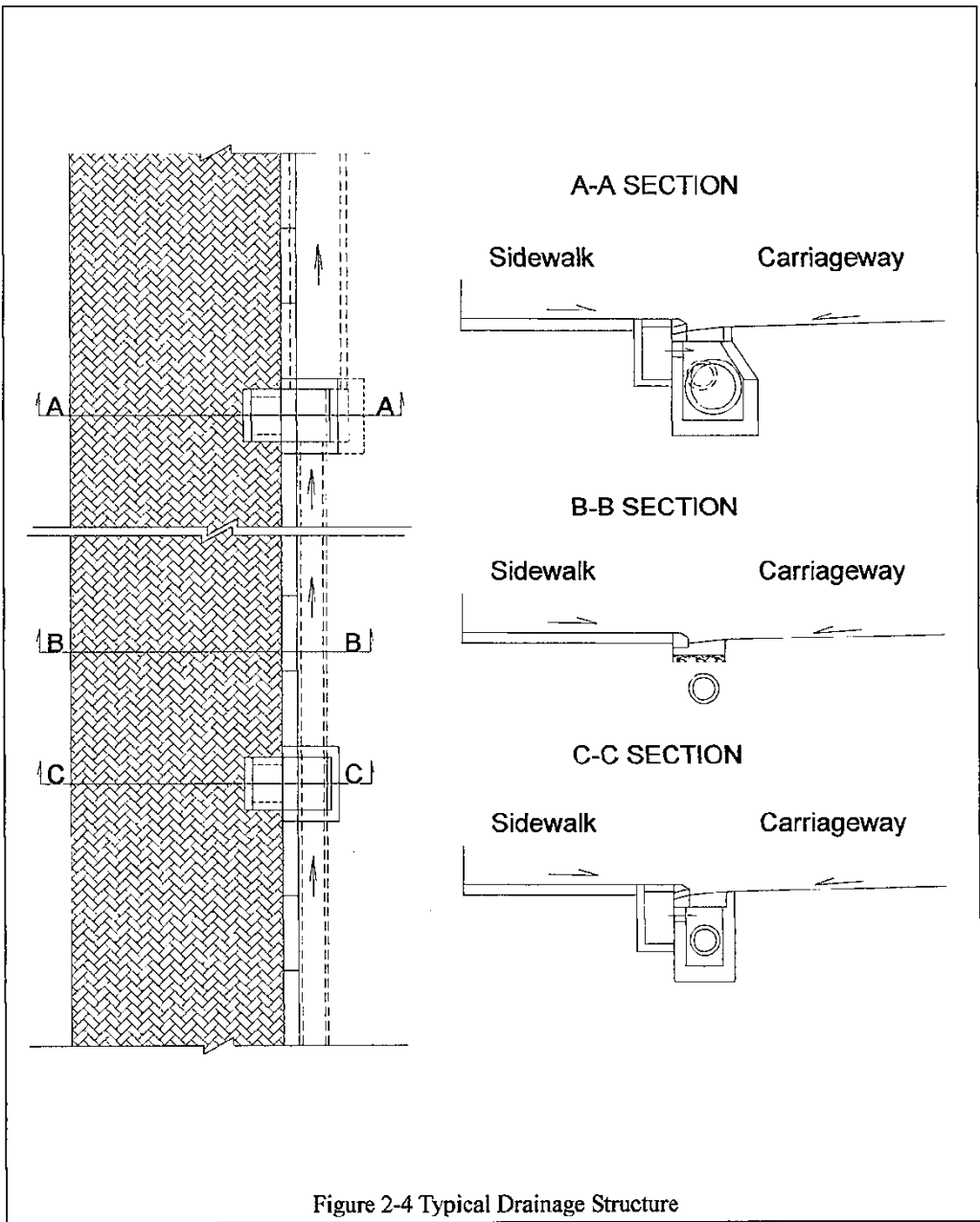


Figure 2-4 Typical Drainage Structure

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### 3. Undertaking of Both Countries

#### 3.1 Construction of Bridges along National Road No. 11

##### (1) Undertaking of Japan Side

- Demolition of existing bridges (Bailey material will be transported to DPWT storage)
- Construction of detour roads during the construction
- Construction of new bridges
- Construction of bridge approach roads
- Other necessary works (protection, guardrail, guide post, marking, traffic signs)

##### (2) Undertaking of Cambodian Side

- Removal of obstructions (temporary houses/shops) within the construction area
- Relocation of utilities within the construction area (water pipe of BR-11 and optic cable at Clv-2)
- Removal of mines within the construction area

#### 3.2 Improvement of Road and Drainage Facility in Kampong Chhnang City

##### (1) Undertaking of Japan Side

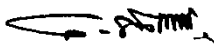
- Construction of Drainage Facility, Pavement, sidewalk and other miscellaneous facility of the project road.

##### (2) Undertaking of Cambodian Side

- Relocation of utilities which will conflict with the project road and drainage facility.
- Acquisition of lands which are necessary to construct the road and drainage facility.
- Removal of obstructions (temporary houses/shops) within the construction area
- Removal of mines within the construction area

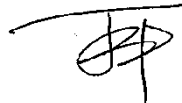
March 9, 2012

Noted by:



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Tauch Chankosal  
Secretary of State  
MPWT



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## 6. Abbreviated RAP





**KINGDOM OF CAMBODIA**

**JAPAN INTERNATIONAL COOPERATION AGENCY  
Preparatory Survey for  
THE PROJECT for FLOOD DISASTER  
REHABILITATION and MITIGATION**

**Draft Abbreviated Resettlement Planning**

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**JULY 2012**

**KATAHIRA & Engineers International (KEI)**



## ABBREVIATIONS

AH	:	Affected Household
AP	:	Affected Person
DPWT	:	Department of Public Works and Transport
DMS	:	Detailed measurement survey
EA	:	Executing Agency
EMO	:	External Monitoring Organization
IOL	:	Inventory of Losses
IRC	:	Inter-ministerial Resettlement Committee
JICA	:	Japan International Cooperation Agency
MEF	:	Ministry of Economy and Finance
MPWT	:	Ministry of Public Works and Transport
NR	:	National Road
PMU	:	Project Management Unit
PRSC	:	Provincial Resettlement Sub-Committee
RCS	:	Replacement Cost Study
RD	:	Resettlement Department
RGC	:	Royal Government of Cambodia
ROW	:	Right-of-Way
RP	:	Resettlement Plan
SES	:	Socio-economic Survey
WB	:	World Bank
WG	:	Working Group

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APPENDIX: Inventory of Affected Assets

## I. PROJECT DESCRIPTION

### 1.1 Background

During the rainy season in 2011, the water level of Mekong River reached almost same level as it of the serious flood occurred in 2000 due to unseal rainfall at the upstream of Mekong River.

Although there was no serious flood disaster in Phnom Penh, there was widespread damage from the flooding outside Phnom Penh, and it was reported that over 250 persons were sacrificed, 1.5 million people suffered some damage and 17 percent of paddy field in Cambodia was spoiled by the flooding.

Based on the above, the government of Cambodia urgently requested grant aid for the rehabilitation on the below flood disasters to the government of Japan.

#### **Kampong Chhnang flood disaster**

Kampong Chhnang city is located at west bank of Tonle Sap River, and when the water level of Tonle Sap River is raised during rainy season, low land area of the city is normally flooded, but center area of the city and the roads on embankment have seldom been flooded.

During the flood in 2011, most of the city, including National Road No.5 inside the city, has been flooded for over a month. Since the pavement type was DBST (Double Bituminous Surface Treatment), the pavement in most the city was seriously damaged. Although the repairing work has been carried out by using DBST, it is necessary to rehabilitate with Asphalt Concrete Pavement in order to avoid damage repeatedly occurred by flooding.

Furthermore, since the road was flooded for a long due to lack of drainage facilities in the city, it is also necessary to set up sufficient road drainage facilities.

#### **National Road No.11 flood disaster**

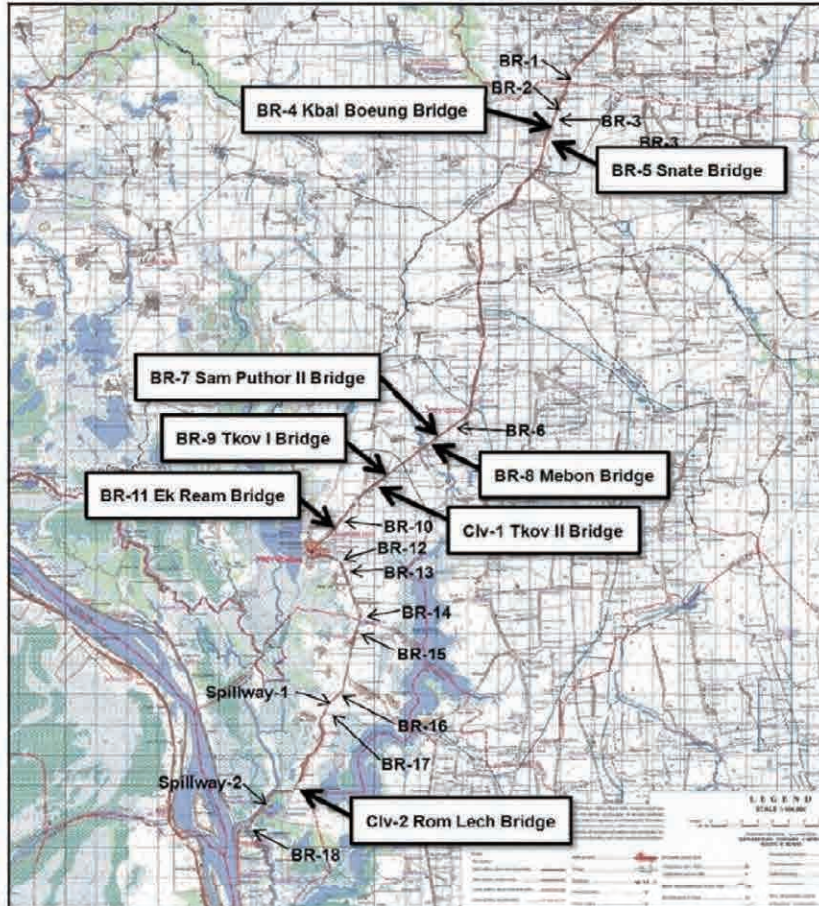
National Road No.11 is located at east bank of Mekong River in the flood plain of Cambodia, and it connects three National Roads, namely No.1, No.7 and No.8. It is also a part of the way to connect Vietnam and Thailand without passing through Phnom Penh, and it is very important route for the logistics from the section of NR 1 (Svay Reang Province), Preyveng Province to Kampong Cham and the north east Provinces.

On National Road No.11, there are very old 14 bridges which have only one lane with load restriction, and usual traffic as National Road cannot be achieved. Accordingly it is necessary to upgrade or enlarge the bridges to accommodate the traffic when cars or trucks passing through them.

Furthermore, damage of road bed occurred at two culverts location due to lack of the area of water through at rainy season and it is necessary to change from culverts to bridges in order to enlarge the above area.

## 1.2 Project Outline

### (1) Construction of Brides along National Road No. 11



**Figure 1.2-1 : NR11 Project Location Map**

Location of Project Bridges is as shown in Figure-1.2-1

Main components will be as stated below;-

- ✓ Reconstruction of 2 lanes Bridges namely, No.4, No.5, No.7, No.8, No.9, and No.11, river bank protection and access road with ancillary facilities construction.
- ✓ Change from existing Culverts No.1 & No.2 to Bridge namely Clv.1 and Clv2 respectively, river bank protection and access road with ancillary facilities construction

## (2) Improvement of Road and Drainage Facilities in Kampong Chhnang City



**Figure 1.2-2: Kampong Chhnang Location Map**

Location of Project Roads and Drainage Ways is as shown in Figure-1.2-2

Main components will be as stated below:-

- ✓ Rehabilitation of drainage facilities, pavement and side walk of National Road No.5 (approximately 2.2km).
- ✓ Rehabilitation of drainage facilities, pavement and side walk of main streets in the City (approximately 2.4km).
- ✓ Rehabilitation of drainage outlet of the above (approximately 2.6km).

### **1.3 Project Impact**

Table 1.3-1 provides a rough estimate of Affected Assets by the project. More detailed information include the position of Affected Assets is shown in Appendix. These are different types of affected assets include (a) loss of structure established in ROW, (b) loss of agricultural assets such as trees, crops and so on, (c) loss of residential and small shops, (d) loss of private lands.

#### **Land**

Land acquisition will be approximately 7,100 m<sup>2</sup> of the private land for the construction of new drainage facilities in Kampong Chhnang. Almost is the meadow but some is used for rice field.

#### **Structure**

A total of 4 houses in NR11 are adversely affected by the construction activities for the bridge. And also 19 independent shops in Kampong Chhnang city are affected by the construction of new drainage facilities

#### **Fruit Tree**

A approximately 33 fruit trees will be affected for the construction of new drainage facilities in Kampong Chhnang. These trees are not commercially grown but sporadically planted inside the ROW.

The final inventory of Affected Assets such as houses, other structures, fruit trees, wells, etc will be determined through Detailed Measurement Survey (DMS) of which vulnerable affected households (e.g. female-headed household, household earning below \$20 per month, etc.) will be identified.



**Table 1.3-1: Rough Estimate of Affected Assets by the Project.**

Description	Location	Affected Asset	AH	m2	unit	ROW			
House	NR-11	House	<b>CONFIDENTIAL due to personal data</b>			Inside ROW			
		House				Inside ROW			
		House				Inside ROW			
	Kampong Chhnang	Shop				Inside ROW			
		Shop				Inside ROW			
		Shop				Inside ROW			
Trees	Kampong Chhnang	Banana							Inside ROW
		Coconut Sugar palm							Inside ROW
Land	Kampong Chhnang	Meadow Rice field							
		Meadow	Outside ROW						

## **II. PROJECT RESETTLEMENT POLICY**

### **2.1 Objectives**

Although this project have little impact on society with about 4 houses, JICA required to prepare a Abbreviated Resettlement Planning (ARP) during the preparatory survey and updated it after the DMS for smooth implementation of the project.

The overall objective of the project resettlement policy is to ensure that all people affected by the Project are able to maintain and, preferably, improve their pre-project living standards and income-earning capacity by providing compensation for the loss of physical and non-physical assets and, as required, other assistance and rehabilitation measures to reestablish affected livelihood.

### **2.2 Key Principles**

The key principles for resettlement and compensation under this Project are as follows:

- a) Acquisition of land and other assets, and resettlement of people will be minimized or avoided as much as possible by identifying possible alternative project designs and appropriate social, economic, operational and engineering solutions that have the least impact on the population.
- b) No site clearing will be done inside the ROW until and after the RP has been updated with approval of Royal Government of Cambodia (RGC) and confirmation of JICA, and until and after all entitlements to be provided for AHs in this resettlement policy have been delivered.
- c) All AHs residing, working, doing business, cultivating land, or having rights over resources within the Project area as of the cut-off date are entitled to compensation for their lost assets at replacement cost. Those displaced by the Project will be provided with additional allowances. They will also be provided with appropriate development assistance in order to improve or at least restore their incomes and living standards to pre-project levels.
- d) AHs affected by partial impact on their assets, i.e. partial loss of land or structures and the remaining assets remain viable for continued use, where livelihood is not land-based, the compensation for affected assets will be paid in cash.
- e) The compensation and rehabilitation measures to be provided are the following: (i) compensation at replacement cost for houses and other structures and all fixed assets without depreciation or deductions for salvaged material; (ii) compensation at the replacement cost of the affected land or the provision of replacement land of equal agricultural productivity, residential quality and business potential, as the case may be, at a location acceptable to the AHs; (iii) one-time cash assistance for loss of business income; (iv) rent allowance and assistance in finding alternate rental accommodation to tenant AHs; (v) transport allowance; (vi) special assistance or allowances for AHs belonging to vulnerable groups.
- f) Replacement agricultural lands or business lots will be as close as possible to such land that was lost and/or acceptable to the AHs. All replacement lands for agriculture, residential and businesses will be provided with secure tenure status and without any additional cost, tax, and surcharge to the AHs at the time of transfer.
- g) Where cultural minorities or indigenous peoples are affected, the social and economic benefits they receive would be in harmony with their cultural preferences and would be decided in consultation with affected communities.
- h) Particular attention shall be paid to the needs of the poorest affected people and vulnerable groups. This may include households headed by females with dependents,

AHs living under poverty line, the elderly and disabled without support. Appropriate assistance must be provided to help them improve their socio-economic status.

- i) Any acquisition of, or restriction on access to resources owned or managed by AHs as a common property will be mitigated by arrangements ensuring access of those AHs to equivalent resources on a continuing basis.
- j) The previous level of community services and access to resources will be maintained or improved after resettlement.
- k) Financial and physical resources for resettlement and rehabilitation will be made available as and when required.
- l) Project authorities will ensure effective coordination with relevant agencies for implementation of resettlement.
- m) The schedule of the start of civil works in any section or segment of the Project road will be coordinated and planned with the IRC and the PRSC in consultation with representatives of the AHs.

### **2.3 The Cut-off Date**

The Cut-off Date will be the date of public consultation with AHs before the DMS. This would mean that any land occupation or transfer, or structures to be built on affected land after the cut-off date will not be entitled to any compensation including the land use right.

### **2.4 Eligibility**

Persons not covered in the DMS and residing on the land after the Cut-off Date are not eligible for compensation and other entitlements, unless they can show proof that: (i) they have been inadvertently missed out during the DMS and certified by the local authority; or (ii) they have lawfully acquired the affected assets following completion of the DMS

AHs include anyone who, at the cut-off date of the Project, was located within the Project area or any of its component or subproject or part thereof, and would have their:

- a) Standard of living adversely affected;
- b) Right, title or interest in any house, land (including residential, commercial, agricultural and for grazing), water resources, or any other movable or fixed assets acquired or possessed, in full or in part, temporarily or permanently by public sector acquisition; or
- c) Business, occupation, place of work or residence or habitat adversely affected by public sector intervention.

An AH refers to households and consists of all members residing under one roof and operating as a single economic unit, who are adversely affected by the Project. For resettlement purposes, Project APs will be considered as members of the Project AHs including single person households.

### **2.5 Entitlements**

Consistent with Project-specific resettlement principles, policies on compensation and other entitlements are summarized in Table 2.5-1. Furthermore, compensation to be paid for affected assets will be based on the principle of replacement cost and which is operationally defined as follows:

- i. Productive land such as agricultural land, based on replacement cost that reflect recent land sales, and in the absence of such recent sales, based on productive value;
- ii. Residential land based on replacement cost that reflect recent land sales, and in the absence of such recent land sales, based on similar location attributes;
- iii. Houses and other related structures based on replacement cost reflecting current market prices of materials and labor without depreciation nor deductions for salvaged building materials;
- iv. Annual crops equivalent to current market value of crops ;
- v. For perennial crops and trees, cash compensation at replacement cost is equivalent to current market value given the type, age, and productive value (future production).

**Table 2.5-1 The Entitlement Matrix**

TYPE OF LOSS	ELIGIBLE PERSONS	ENTITLEMENTS	IMPLEMENTATION ISSUES
<b>A. LOSS OF LAND</b>			
<b>OUTSIDE ROW (PRIVATE LAND)</b>			
I. Loss of land (all kinds) – <b>either partial or entire land is lost</b>	All AHs with recognized proof of ownership whose land will be acquired for the Project.	<ul style="list-style-type: none"> <li>▪ For the affected land: <b>cash compensation at replacement cost.</b></li> <li>▪ To a possible extent, AHs will be <b>allowed to harvest</b> their annual and perennial crops and timber products prior to construction.</li> <li>▪</li> </ul>	<ul style="list-style-type: none"> <li>▪ AHs to be notified at least three months in advance before the start of civil works in the locality.</li> <li>▪ <b>Replacement land to be free from taxes, registration and transfer costs.</b></li> </ul>
<b>INSIDE ROW (PUBLIC STATE LAND)</b>			
I. Loss of use of productive land – <b>either partial or entire land is lost</b>	All AHs occupying land/or using land in the PRW.	<ul style="list-style-type: none"> <li>▪ No cash compensation is available for affected land in ROW.</li> <li>▪ If an AH belongs to any of the <b>vulnerable groups</b>, see entitlements for vulnerable AHs below in item D.</li> <li>▪ AHs will be <b>allowed to harvest</b> their crops prior to construction. If crops cannot be harvested due to construction schedule, AHs will be entitled for cash compensation for the affected crops as described in item C.</li> </ul>	<ul style="list-style-type: none"> <li>▪ AHs to be notified at least three months in advance before the start of civil works in the locality.</li> <li>▪ AHs will not be evicted from the ROW without justifiable cause, i.e., unless or until the land is required by the government for the project.</li> <li>▪ AHs will be <b>allowed to continue to cultivate</b> the residual area of the ROW for <b>agricultural purpose only.</b></li> </ul>
II. Partial loss of residential and/or commercial land – remaining land is <b>STILL VIABLE</b> for continued use	AHs with <u>main house and/or small shop (independent/ family-owned business)</u>	<ul style="list-style-type: none"> <li>▪ no cash compensation for affected land in the ROW.</li> <li>▪ AHs will be permitted to shift their houses and/or shop to the remaining land in ROW, or shift to another site in the ROW as close as possible to the original place, but no new permanent structures are permitted to construct in the ROW.</li> <li>▪</li> </ul>	<ul style="list-style-type: none"> <li>▪ AHs to be notified at least three months in advance before the start of civil works in the locality.</li> <li>▪ The EA will ensure payment of all compensation and allowances to which AHs are entitled at least one month prior to the scheduled beginning of civil works.</li> </ul>
III. Entire loss of residential and/or commercial land, or the remaining land is <b>NOT VIABLE</b> <sup>1</sup> for continued use (Landless AHs)	AHs with <u>main house and/or small shop (independent/ family-owned business) and no more remaining land in ROW to shift back</u>	<ul style="list-style-type: none"> <li>▪ In principle, no cash compensation will be provided for affected land in ROW. However, AHs have two options:                             <ol style="list-style-type: none"> <li>1. Land plot at the relocation site provided by the government.</li> <li>2. Land plot in the nearby village provided in the government.</li> </ol> </li> </ul>	<ul style="list-style-type: none"> <li>▪ AHs to be notified at least three months in advance before the start of civil works in the locality.</li> <li>▪ The EA will ensure payment of all compensation and allowances to which AHs are entitled at least one month prior to the scheduled beginning of civil works.</li> <li>▪ The EA will ensure allocation of replacement land with sufficient time for AHs to rebuild and relocate completely before the scheduled beginning of civil works.</li> </ul>
<b>B. LOSS OF STRUCTURES</b>			
I. Loss of house, <b>house-cum-shop</b> , shop/store – <b>either partial or entire structure is lost</b>	▪ Owners of the structures, with or without acceptable proof of ownership over the land.	<ul style="list-style-type: none"> <li>▪ <b>Cash compensation at replacement cost without deduction for depreciation or salvageable materials</b> (i.e., present cost of construction materials in the locality, plus cost of labor).</li> <li>▪</li> </ul>	<ul style="list-style-type: none"> <li>▪ AHs to get cash compensation at least three months ahead of civil works in the locality to allow the AH sufficient time to gradually reorganize the house and/or shop, thereby avoiding any disruption in the livelihood.</li> <li>▪ AHs must completely cut, move</li> </ul>

<sup>1</sup> The size of viable land will be discussed between Inter-ministerial Resettlement Committee (IRC) Working Group (WG) and the affected households during the DMS.

TYPE OF LOSS	ELIGIBLE PERSONS	ENTITLEMENTS	IMPLEMENTATION ISSUES
			<p>out or relocate their houses/structures to a new site within 30 days after receiving compensation.</p> <ul style="list-style-type: none"> <li>▪ If the structure is found no longer viable for living, compensation will be paid for the entire structure and the AH will also be entitled for other allowances.</li> </ul>
	Renters	<p>Renters are entitled to get allowances as follows:</p> <ul style="list-style-type: none"> <li>▪ <b>Transportation (moving) allowance</b></li> <li>▪ <b>Disruption allowance</b></li> <li>▪ <b>Rental allowance</b></li> <li>▪ If AH belongs to any of the <b>vulnerable group</b>, see item D. below.</li> </ul>	<ul style="list-style-type: none"> <li>▪ AHs to be notified at least three months in advance before the start of civil works in the locality.</li> <li>▪ AHs that rent house and/or shop are entitled to a one time transport allowance only.</li> </ul>
II. Other structures (porch, extended eaves, spirit house, fence, etc.)	Owners of the structures with or without acceptable proof of ownership over the land.	<ul style="list-style-type: none"> <li>▪ <b>Cash compensation at replacement cost without deduction for depreciation or salvageable materials</b> (i.e., present cost of construction materials and labor in the locality).</li> </ul>	<ul style="list-style-type: none"> <li>▪ AHs to be notified at least three months in advance before the start of civil works in the locality.</li> </ul>
<b>C. LOSS OF CROPS AND TREES</b>			
I. Loss of crops	Owners of crops regardless of land tenure status	<ul style="list-style-type: none"> <li>▪ To the extent possible, AHs will be <b>allowed to harvest</b> their annual and perennial crops prior to construction.</li> <li>▪ In case of emergency during civil works construction and when crops cannot be harvested, affected crops will be compensated in cash at replacement cost.</li> </ul>	<ul style="list-style-type: none"> <li>▪ Annual crops – AHs will be given six months prior notice stating that the land on which their crops are planted will be used by the Project and that they must harvest them before the civil works commence.</li> </ul>
II. Loss of fruit or shade trees	Owners of trees regardless of land tenure status	<ul style="list-style-type: none"> <li>▪ Cash compensation for Fruit trees</li> </ul>	<ul style="list-style-type: none"> <li>▪ AHs to be notified at least three months in advance before the start of civil works in the locality.</li> </ul>
<b>D. ALLOWANCE AND ASSISTANCE</b>			
I. Transport allowance	AHs which are to relocate their house or house/shop.	<ul style="list-style-type: none"> <li>▪ Shops and stalls made of light and temporary materials: <b>USD 5 to USD10</b></li> <li>▪ Regular shops and houses moving into the residual area of the ROW: <b>USD 40</b></li> <li>▪ Regular shops and houses relocating within the same village outside the ROW: <b>USD 60</b></li> <li>▪ Houses relocating in another village outside the ROW: <b>USD 70</b></li> </ul>	<ul style="list-style-type: none"> <li>▪ Owners of houses or houses/shops are entitled to a one time transport allowance only.</li> </ul>
II. Vulnerable allowance	<ul style="list-style-type: none"> <li>▪ Vulnerable AHs including female-headed households with dependence, the elderly without support, the disabled, and poor households with income of less than USD 20 per capita per month</li> </ul>	<ul style="list-style-type: none"> <li>▪ One time cash assistance equivalent to <b>USD 100</b> per household.</li> </ul>	<ul style="list-style-type: none"> <li>▪ Allowance shall be paid at the same time with compensation.</li> </ul>
III. Disruption allowance	AHs whose main structure will be relocated to a new site.	<ul style="list-style-type: none"> <li>▪ One-time cash assistance equivalent to <b>USD 200</b>.</li> </ul>	<ul style="list-style-type: none"> <li>▪ Allowance shall be paid at the same time with compensation.</li> </ul>

TYPE OF LOSS	ELIGIBLE PERSONS	ENTITLEMENTS	IMPLEMENTATION ISSUES
	AHs that shift back and remain in the ROW (house, <b>house-cum-shop</b> , store/shop)	<ul style="list-style-type: none"> <li>▪ One-time cash assistance equivalent to <b>USD 100</b> for house and <b>house-cum-shop</b>.</li> <li>▪ One-time cash assistance equivalent to <b>USD33</b> for store/shop.</li> </ul>	<ul style="list-style-type: none"> <li>▪ Ambulant vendors (push carts): no payment for loss of land use, structures or allowances due to mobility.</li> <li>▪ Owners of secondary structures only (no main house and/or shops affected) are not entitled to any allowances because there is no disruption to their place of residence or business (minor impacts only).</li> </ul>
IV. Tenants' allowance	AHs that relocate due to loss of house and/or shop that they rent	<ul style="list-style-type: none"> <li>▪ AHs that rent house and/or shop are entitled to a one-time transport allowance only.</li> <li>▪ <u>Rental allowance</u>: equivalent to two months' rental fee;</li> <li>▪ <u>Transport allowance</u>: as indicated above;</li> <li>▪ <u>One-time cash assistance allowance</u>: USD33.00; and</li> <li>▪ If tenant has a shop, he/she is entitled to lump sum allowance for lost income.</li> </ul>	<ul style="list-style-type: none"> <li>▪ Tenant is entitled to a one time transport allowance only.</li> </ul>

Note : Every Unit Rate in the Table 2.5-1 will be reviewed at the time of implementation of DMS.

### **III. ORGANIZATIONAL FRAMEWORK**

#### **3.1 Inter-ministerial Resettlement Committee (IRC)**

The Inter-Ministerial Resettlement Committee (IRC) was established in 1999 by the Government led by the Ministry of Economy and Finance (MEF). At the national level, an Inter-Ministerial Resettlement Committee (IRC) has been convened to deal with all resettlement issues arising from all projects requiring land acquisition and resettlement. The IRC is composed of representatives from line Ministries such as the Ministry of Public Works and Transport, Ministry of Environment and Ministry of Land Management.

#### **3.2 Resettlement Department (RD) of the MEF**

The RD, former a Resettlement Unit (RU), a standing body in charge of resettlement, is secretariat of IRC. It will work in cooperation with the Project Management Unit (PMU) of the MPWT to ensure the effective implementation of the project. RD, for this project, will take a lead in:

- a) Conducting Detailed Measurement Survey
- b) Undertaking overall planning and management of resettlement
- c) Ensuring that all eligible AHs have been identified and are aware of their entitlements.
- d) Ensuring that staff at all levels understand the project and train resettlement staff at Provincial, District and Commune level in the planning and implementation of the resettlement activities.
- e) Being responsible for supervising the disbursement of compensation to AHs.
- f) Creating and update a database of resettlement related information on a regular basis.
- g) Ensuring that an effective monitoring system is developed and that local staff is able to access the relevant data.

#### **3.3 PMU**

PMU will be established within the MPWT to implement the project. It will work closely with the IRC and the RD. Its tasks include the following:

- a) Construction Supervision
- b) Contract Administration and Management
- c) Quality Control Procedures
- d) Detailed Design
- e) Financial Management
- f) Training and Human Resource Development

#### **3.4 Provincial Resettlement Subcommittee (PRSC) and its Working Group (PRSC-WG)**

The PRSC is a collegial body at the provincial level. Head by the Provincial Governor or Provincial Vice-Governor, its members are Directors from relevant Provincial Department of line Ministries represented in the IRC members, and also the chiefs of the districts and communes within the Project area. The technical arm of the PRSC is PRSC-WG. The PRSC-WG is a standing body in charge of resettlement within the province level.



#### IV Implementation Schedule of the RP

The schedule of implementation of resettlement activities are summarized in table 3.4-1 below.

The draft resettlement plans will be updated after the completion of the detailed design for the project. After this project is officially approved, the IRC and RD will conduct the detailed measurement survey (DMS) as part of updating the resettlement plan. The DMS will include **100% of affected households and will collect data required to verify the details of affected** people for finalizing the resettlement plan, including details of land ownership, plot sizes, types of land use, number and types of trees and crops, types and conditions of affected structural buildings, land prices, affected livelihoods and the required restoration activities as well as associated costs for land for resettlement of displaced people and development costs.

A replacement cost survey (RCS) will be undertaken by a professional appraiser engaged by IRC. The RCS will determine current market prices for (i) agricultural, and residential land; (ii) different types of structures; and, (iii) crops and trees. The RCS results will be the basis for estimating resettlement costs.

**Table 3.4-1 The schedule of implementation of resettlement activities**

Activities	2012							2013
	June	July	Aug	Sep	Oct	Nov	Dec	Jan
ARP Preparation	■	■						
Grant Agreement			■					
Set up Grievance Committee				■				
Detailed Design & Tendering			■	■	■	■		
Public Consultation			■		■			
Detailed Measurement Survey & Replacement Cost Study				■	■			
ARP Updating following Detailed Design					■	■		
JICA Approval of Updated ARP						■		
Implementation of the Approved Updated ARP							■	
Commencement of Construction								■

## V GRIEVANCE REDRESS

Grievances of AHs in connection with the implementation of the RP will be handled through negotiation with the aim of achieving consensus. Complaints will go through three stages before they may be elevated to the court procedure as a last resort. MPWT will shoulder all administrative and legal fees that will be incurred in the resolution of grievances and complaints if the complainants win the case.

- **First Stage.** Affected Household (AH) will submit a letter of complaints/requests to the Village or Commune Resettlement Sub-committee or IRC working group and, if he or she wishes, to the nominated NGO working on the GRC. The NGO will record the complaint/request in writing and accompany the AH to the Village or Commune Resettlement Sub-Committee. The Sub-Committee will be obliged to provide immediate written confirmation of receiving the complaint. If after 15 days the aggrieved AH does not hear from Village or Commune Resettlement Sub-Committee, or if the AH is not satisfied with the decision taken by in the first stage, the complaint may be brought to the District Office.
- **Second Stage.** The District office has 15 days within which to resolve the complaint to the satisfaction of all concerned. If the complaints cannot be solved in this stage, the district office will bring the case to the Provincial Grievance Committee.
- **Third Stage.** The Provincial Grievance Redress Committee meets with the aggrieved party and tries to resolve the complaint. The Committee may ask for a review of the DMS by the MPWT. Within 30 days of the submission of the grievance the Committee must make a written decision and submit a copy of the same to MPWT, the EMO, the IRC and the AH.
- **Final stage, the Court Procedures.** If the aggrieved AH is not satisfied with the solution made by the Provincial Grievance Redress Committee based on the agreed policy in the RP, the committee shall file administrative procedures against the AHs with the participation of provincial prosecutors. The case will be brought to the Provincial Court and the same will be litigated under the rules of the court. During the litigation of the case, Royal Government of Cambodia will request from the court that the project proceed without disruption while the case is being heard. If any party is unsatisfied with the ruling of the provincial court, that party can bring the case to a higher court. The Royal Government of Cambodia shall implement the decision of the court.

**APPENDIX**  
**Inventory of Affected Assets**

**CONFIDENTIAL**  
**due to personal data**

## 7. Design Data

## ANNEX 7-A DESIGN OF DRAINAGE FACILITIES

### (1) DRAIN AREA

It is assumed that the rainwater in the roads and roadside areas (residences and parks) flows into the project drainage facilities.

### (2) DESIGN OF DRAINAGE FACILITIES

#### (A) CALCULATION OF DISCHARGE

The discharges are calculated using Rational Formula.

Rational Formula:

$$Q = \frac{1}{3.6 \times 10^6} \cdot c \cdot I \cdot a$$

Where :

Q : design discharges (m<sup>3</sup>/sec)  
 c : run-off coefficient  
 I : rainfall intensity (mm/hr)  
 a : catchment area (m<sup>2</sup>)

#### ① Run-Off Coefficient: c

The value of run-off coefficients “c” are given by type of surfaces as follows:

Surface Type	Values of run-off coefficient, c
Road/Pavement	0.90
Residential Area / Park	0.75

#### ② Rainfall Intensity: I

Since there is no rainfall record in Kampong Chhnang, 10-minutes consecutive rainfall intensity of 2-year return period which was proposed by “F/S on Flood Prevention and Drainage Improvement Project in Phnom Penh” is applied.

$$I = 2555.07 / (10 + 25.48) - 0.93 = 71.1 \text{ (mm/hr.)}$$

#### ③ Catchment Area: a (m<sup>2</sup>)

The catchment areas are determined using topographic survey map and clarified with the field survey.

#### ④ Discharge Estimation

As the result of the above, discharge of each catchment are calculated as follows:

Surface Type	Constants	Discharge (m <sup>3</sup> /sec)
Road area	c = 0.90 I = 71.1 mm/hr a (m <sup>2</sup> )	Q = 0.000018 · a
Residence area	c = 0.75 I = 71.1 mm/hr a (m <sup>2</sup> )	Q = 0.000015 · a

#### (B) CALCULATION OF CAPACITY OF DRAINAGE STRUCTURES

Calculation of the capacity of drainage structures are calculated by Manning Formula.

Manning Formula:

$$Q_c = \frac{1}{n} \cdot R^{2/3} \cdot i^{1/2} \cdot A$$

Where :

Q<sub>c</sub>: flow rate in the channel (m<sup>3</sup>/sec)  
 n: Manning' s roughness coefficient  
 R: hydraulic radius (m)  
 (=A/P ; A: area of flow, P: wetted perimeter)  
 i: slope of energy grade line (m/m)  
 A: area of flow (m<sup>2</sup>)

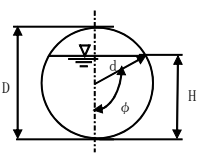
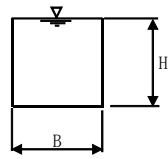
① **Manning's Roughness Coefficient : n**

Manning's roughness coefficient is as follows:

Drainage Surface Type	Roughness Coefficient: n
Drainage Pipe	0.013
Cast-in-place Concrete	0.015

② **Hydraulic radius 'R' and Area of flow 'A'**

Hydraulic radius R and area of flow A in different shape are as follows;

Drainage Section	Hydraulic Radius R	Area of Flow A
Drainage Pipe 	$\frac{d}{2} \left( 1 - \frac{\sin 2\phi}{2\phi} \right)$ ( φ : radians)	$d^2 \left( \phi - \frac{1}{2} \sin 2\phi \right)$ ( φ radians)
Line Ditch 	$\frac{B \cdot H}{B + 2H}$	B · H

③ **Gradient of Drainage Structure, i**

The minimum gradient of drainage structure is proposed to be 0.3%.

④ **Drain Capacity of Drainage Structure**

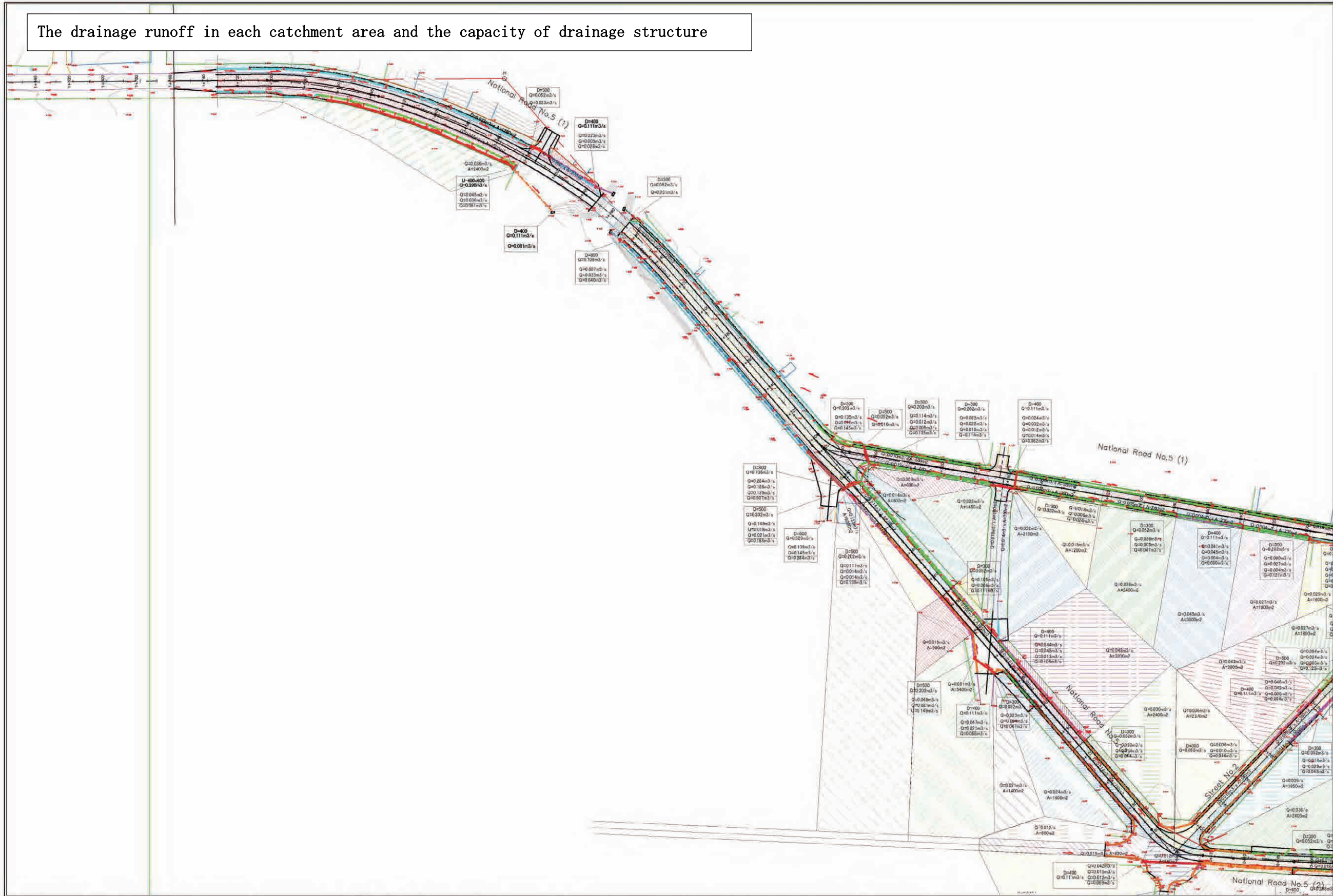
Assuming the drain capacity is 80% of the size in terms of water depth, the drain capacities by drainage type and size are calculated as follows:

Drainage Type and Size		Constants by Drainage	Capacity (m3/sec)
Pipe	D300	n=0.013, R=0.091m, i=0.30%, A=0.061m <sup>2</sup>	0.052
	D400	n=0.013, R=0.122m, i=0.30%, A=0.108m <sup>2</sup>	0.111
	D500	n=0.013, R=0.152m, i=0.30%, A=0.168m <sup>2</sup>	0.202
	D600	n=0.013, R=0.183m, i=0.30%, A=0.242m <sup>2</sup>	0.329
	D800	n=0.013, R=0.243m, i=0.30%, A=0.431m <sup>2</sup>	0.708
	D1000	n=0.013, R=0.304m, i=0.30%, A=0.674m <sup>2</sup>	1.284
	D1200	n=0.013, R=0.365m, i=0.30%, A=0.970m <sup>2</sup>	2.087
	D1500	n=0.013, R=0.456m, i=0.30%, A=1.516m <sup>2</sup>	3.785
	D1750	n=0.013, R=0.532m, i=0.30%, A=2.063m <sup>2</sup>	5.709
Ditch	400x600	n=0.015, R=0.141m, i=0.30%, A=0.192m <sup>2</sup>	0.152
	1000x1000	n=0.015, R=0.308m, i=0.30%, A=0.800m <sup>2</sup>	1.331

**(3) THE DISCHARGE OF EACH CATCHMENT AREA AND CAPACITY OF DRAINAGE STRUCTURE**

The discharge of each catchment area and the capacity of each drainage structure are calculated as shown in the drawings attached. The proposed sizes of the drainage structures are determined based on this.

The drainage runoff in each catchment area and the capacity of drainage structure



<p>MINISTRY OF PUBLIC WORKS AND TRANSPORT (MPWT)</p>	<p>THE PROJECT FOR FLOOD DISASTER REHABILITATION AND MITIGATION IN THE KINGDOM OF CAMBODIA</p>	<p>JAPAN INTERNATIONAL COOPERATION AGENCY KATAHIRA &amp; ENGINEERS INTERNATIONAL</p>	<p>集水域別流出量及び 排水構造物サイズ別可能通水量 (1/5)</p>	<p>Drawing No. _____ Sheet No. _____</p>
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Drawing No.	
Sheet No.	

MINISTRY OF  
PUBLIC WORKS AND TRANSPORT  
(MPWT)

THE PROJECT FOR FLOOD  
DISASTER REHABILITATION AND  
MITIGATION  
IN THE KINGDOM OF CAMBODIA

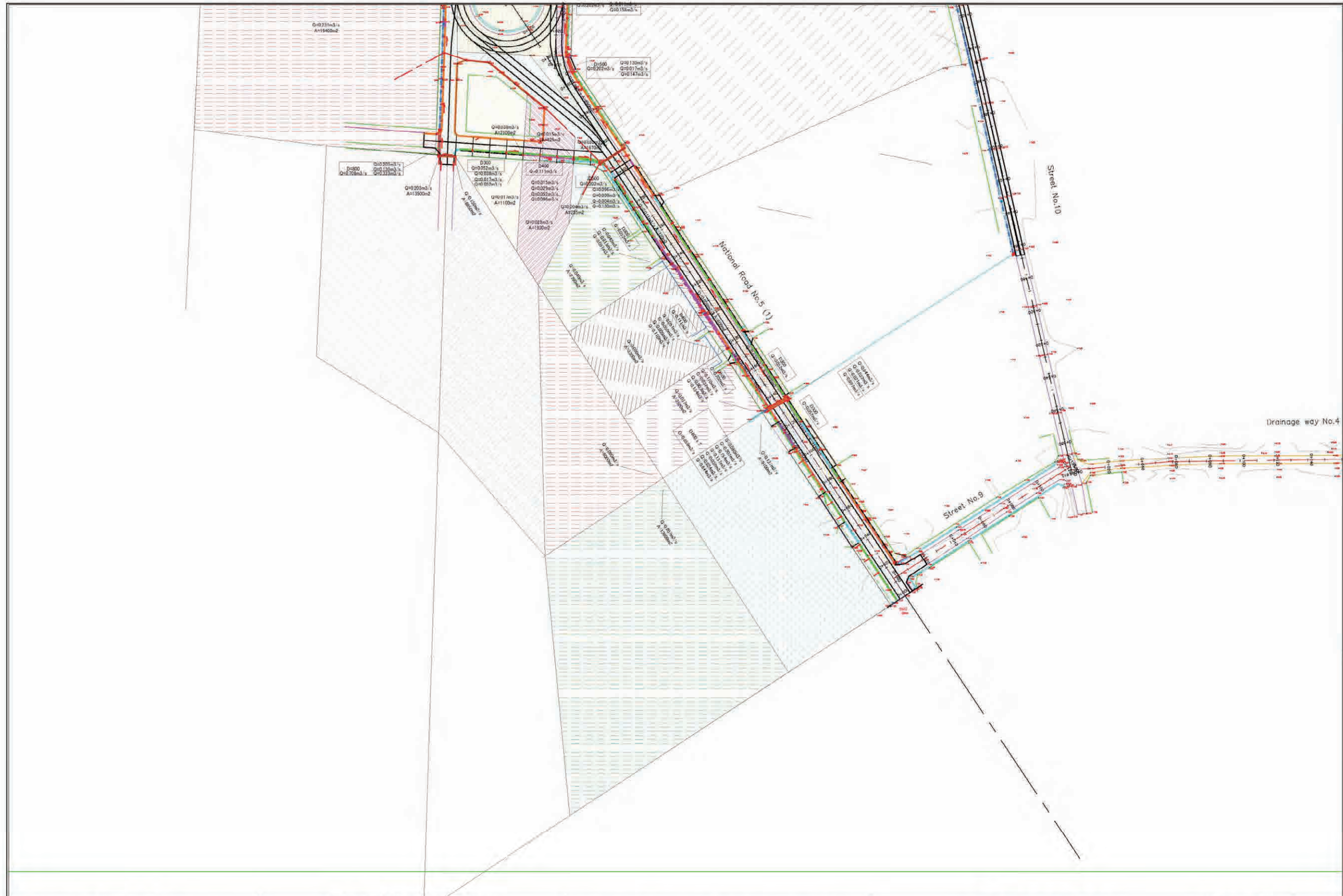
JAPAN INTERNATIONAL COOPERATION AGENCY  
KATAHIRA & ENGINEERS INTERNATIONAL

集水域別流出量及び  
排水構造物サイズ別可能通水量 (2/5)

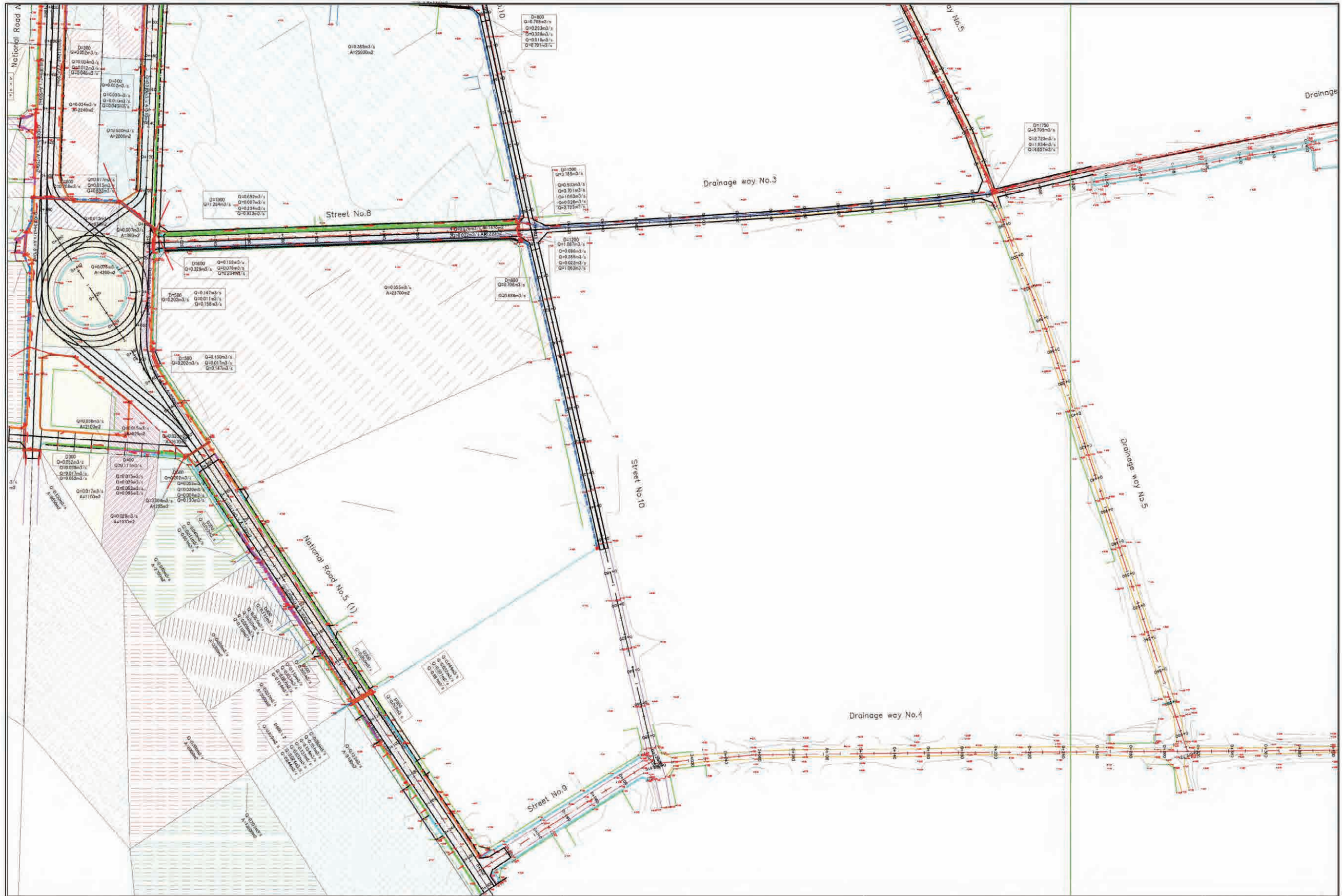
Drainage way No.2



<p>MINISTRY OF PUBLIC WORKS AND TRANSPORT (MPWT)</p>	<p>THE PROJECT FOR FLOOD DISASTER REHABILITATION AND MITIGATION IN THE KINGDOM OF CAMBODIA</p>	<p>JAPAN INTERNATIONAL COOPERATION AGENCY KATAHIRA &amp; ENGINEERS INTERNATIONAL</p>	<p>集水域別流出量及び 排水構造物サイズ別可能通水量 (3/5)</p>	<table border="1"> <tr> <td>Drawing No.</td> <td></td> </tr> <tr> <td>Sheet No.</td> <td></td> </tr> </table>	Drawing No.		Sheet No.	
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MINISTRY OF PUBLIC WORKS AND TRANSPORT (MPWT)	THE PROJECT FOR FLOOD DISASTER REHABILITATION AND MITIGATION IN THE KINGDOM OF CAMBODIA	<b>JAPAN INTERNATIONAL COOPERATION AGENCY</b> KATAHIRA & ENGINEERS INTERNATIONAL	集水域別流出量及び 排水構造物サイズ別可能通水量 (4/5)	Drawing No.	
				Sheet No.	



<p>MINISTRY OF PUBLIC WORKS AND TRANSPORT (MPWT)</p>	<p>THE PROJECT FOR FLOOD DISASTER REHABILITATION AND MITIGATION IN THE KINGDOM OF CAMBODIA</p>	<p>JAPAN INTERNATIONAL COOPERATION AGENCY KATAHIRA &amp; ENGINEERS INTERNATIONAL</p>	<p>集水域別流出量及び 排水構造物サイズ別可能通水量 (5/5)</p>	<table border="1"> <tr> <td>Drawing No.</td> <td></td> </tr> <tr> <td>Sheet No.</td> <td></td> </tr> </table>	Drawing No.		Sheet No.	
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## ANNEX 7-B PAVEMENT STRUCTURE DESIGN

### (1) Design Traffic Volume

The design traffic volume as of 2012 (surveyed present traffic volume), 2015 (opening year) and 2025 (10 years after opening) are shown in Table 4-6-1. The future traffic volumes are estimated with 6% growth rate which is GDP growth rate of Cambodia in 2010.

**Table 4-6-1 Future Traffic Volume by Section (veh./day)**

Location	Year	Car, Pick-up	Midium Truck/ Large Bus	Heavy Truck	Trailer
Kampong Chhunang NR-5	2012	3,284	228	457	51
	2015	3,911	272	544	61
	2025	7,004	487	974	109
Kampong Chhunang Streets	2012	1,221	92	19	0
	2015	1,454	110	23	0
	2025	2,604	196	41	0
Prey Veng NR11	2012	598	108	150	29
	2015	712	129	179	35
	2025	1,275	230	320	62

### (2) Commulative Traffic Volume during the Desing Period

The commulative traffic volume during the design period (10 years: 2015-2-25) are as shown in Table 4-6-2.

**Table 4-6-2 Commulative Traffic Volume durnig the Design Period ('1000,000 veh. )**

Location	Design Period	Car, Pick-up	Midium Truck/ Large Bus	Heavy Truck	Trailer
Kampong Chhunang NR-5	2015-2-2025	9.96	0.69	1.39	0.15
	90%	8.96	0.62	1.25	0.14
Kampong Chhunang Streets	2015-2-2025	3.70	0.28	0.06	0.00
Prey Veng NR11	2015-2-2025	1.81	0.33	0.45	0.09

Note: Above commulative traffic volumes are for one direction. 90% of a direction traffic volume is considered for a lane for 4-lane NR 5.

### (3) ESAL (18-kip Equivalent Single Axle Load) per Vehile

The ESAL per vehicle by vehicle type is shown in Table 4-6-3.

**Table 4-6-3 ESAL per Vehicle by Vehicle Type**

	Car/Pickup	Medium Truck/ Large Bus	Heavy Truck	Trailer
ESAL	0.01	1.0	3.0	5.0

### (4) Pavement Design Load (Commulative ESAL)

The pavement design load (Total ESAL) was obtained from the traffic volume during the design period by vehicle type multiplied by ESAL per vehicle by vehicle type as shown in Table 4-6-4.

**Table 4-6-4 Pavement Design Load (Commulative ESAL) (\*1000,000)**

Location	Design Period	Commulative ESAL
Kampong Chhunang NR-5	2015-2-2025	5.15
Kampong Chhunang Streets	2015-2-2025	0.49
Prey Veng NR11	2015-2-2025	2.15

**(5) Design CBR of Subgrade**

Design CBR are delivered based on the CBR tests result as shown in Table 4-6-5.

**Table 4-6-5 CBR Test Result and Design CBR**

Design Section	Road Name	Pit No.	CBR	CBR ave.	CBR dev.	Design CBR
1	Kampong Chhunang City	1	7	10.4	4.2	6
		2	7			
		3	12			
		4	8.5			
		5	5.3			
		6	(1.5)			
		7	10			
		8	17			
		9	9.5			
		10	17			
2	National Road No.11	BR-4-1	1	3.1	2.5	0.5
		BR-4-2	1.2			
		BR-5-1	7.5			
		BR-5-2	2.6			
		BR-7-1	2.1			
		BR-7-2	6.6			
		BR-8-1	2.1			
		BR-8-2	2.9			
		BR-9-1	1.7			
		BR-9-2	2.1			
		BR-11-1	0.9			
		BR-11-2	2			
		Clv-1-1	2.2			
		Clv-1-2	1.1			
		Clv-2-1	3.6			
Clv-2-2	9.5					

Note: CBR in ( ) was not considered since it deemed wrong value.

Subgrade of NR11 will be improved by cement stabilization since its CBR is too small. The design CBR becomes to be “3” by adding 40cm thick cement stabilized layer in the subgrade.

**(6) Calculation of Required Pavement Thickness**

The equation and constants given in AASHTO are referred as follows:

$$\log_{10}(W_{18}) = Z_R \times S_0 + 9.36 \times \log_{10}(SN+1) - 0.20 + \{ \log_{10}[\Delta PSI / (4.2 - 1.5)] / [0.40 + 1094 / (SN+1)^{5.19}] \} + 2.32 \times \log_{10}(M_R) - 8.07$$

Where,

W18: Total ESAL

ZR: Standard Deviation (= -1.282 in case reliability = 90%, -1.037 in case reliability 85%)

S0: Combined standard error (= 0.45 in case flexible pavement)

SN: Structural number = a1 x D1 + a2 x m2 x D2 + a3 x m3 x D3 + a4 x m4 x D4

(a: Layer coefficient, m: Drainage coefficient, D: Layer thickness in inch)

ΔPSI: Po - Pt

P0: Initial serviceability index (= 4.2 in case flexible pavement)

Pt: Terminal serviceability index (= 2.5 in case arterial road, 2.0 in case streets)

MR: Resilient modulus (= 1500 x CBR)

Layer coefficient:

a=0.44: asphalt concrete surface course

- a=0.35: bituminous stabilized base course
- a=0.14: mechanically stabilized base course
- a=0.11: crusher run subbase course

Drainage coefficient :

- m=1.0: in case fair condition (water removed within one week)
- m=0.6: very poor drainage condition (water will not drain within 1 month)

**Table 4-6-6 Calculation of Required Pavement Thickness (Kampong Chhnang City)**

Calculation of Required SN		1	2
Design Section		NR5	Streets in Kampon Chhnang
18kip Equivalent Single Axle Load	W18	5,150,000	490,000
Reliability	R (%)	90	85
Standard deviation	ZR	-1.282	-1.037
Combind standard erro	S0	0.45	0.45
Initial serviceability index	P0	4.2	4.2
Terminal serviceability index	P1	2.5	2.0
P0-P1	ΔPSI	1.7	2.2
Subgrade CBR	CBR	6	6
Resilient modulus	MR	9,000	9,000
Required SN	SN	<b>4.219</b>	<b>2.689</b>

Where,  $\text{Log}_{10}(W_{18}) = Z_R \times S_0 + 9.36 \times \text{Log}_{10}(\text{SN}+1) - 0.20 + [\text{Log}_{10}[\Delta\text{PSI}/(4.2-1.5)]] / [0.40 + 1094 / (\text{SN}+1)^{5.19}] + 2.32 \times \text{Log}_{10}(M_0) - 8.07$

Left value (log10(W18)=	6.712	5.690
Right value=	6.712	5.690

Proposed Pavement Thickness (cm) and SN			1	2
Design Section			NR5	Streets in Kampon Chhnang
Pavement Structure (new pavement)	Drainage coefficient	Layer coefficient		
Asphalt Concrete Surface	-	0.440	10.0	5.0
Asphalt Stabilized Base Course	1.0	0.350	8.0	5.0
Granular Base course	0.6	0.140	20.0	
Subbase course	0.6	0.110	30.0	20.0
Proposed pavement SN			<b>4.28</b>	<b>2.74</b>

**Table 4-6-7 Calculation of Required Pavement Thickness (NR 11)**

Calculation of Required SN		3
Design Section		NR11
18kip Equivalent Single Axle Load	W18	2,150,000
Reliability	R (%)	90
Standard deviation	ZR	-1.282
Combind standard erro	S0	0.45
Initial serviceability index	P0	4.2
Terminal serviceability index	P1	2.5
P0-P1	ΔPSI	1.7
Subgrade CBR	CBR	3
Resilient modulus	MR	4,500
Required SN	SN	<b>4.712</b>

Where,  $\text{Log}_{10}(W_{18}) = Z_R \times S_0 + 9.36 \times \text{Log}_{10}(\text{SN}+1) - 0.20 + [\text{Log}_{10}[\Delta\text{PSI}/(4.2-1.5)]] / [0.40 + 1094 / (\text{SN}+1)^{5.19}] + 2.32 \times \text{Log}_{10}(M_0) - 8.07$

Left value (log10(W18)=	6.332
Right value=	6.332

Proposed Pavement Thickness (cm) and SN			3
Design Section			NR11
Pavement Structure (new pavement)	Drainage coefficient	Layer coefficient	
Asphalt Concrete Surface	-	0.440	10.0
Asphalt Stabilized Base Course	1.0	0.350	8.0
Granular Base course	1.0	0.140	15.0
Subbase course	1.0	0.110	25.0
Proposed pavement SN			<b>5.02</b>