CHAPTER 6

PRELIMINARY DESIGN

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6.1 ENGINEERING SURVEYS UNDERTAKEN

6.1.1 General

This section of the report highlights the engineering surveys undertaken for the proposed.

Following two (2) engineering survey was conducted;

(1) Topographical Suvey
(2) Soils and Geo-technical Investigation

6.1.2 Topographical Survey

Table 6.1.2-1 shows summary of survey work conducted.

TABLE 6.1.2-1 SUMMARY OF TOPOGRAPHICAL SURVEY

No	Item	Value	Remark
1	Coordinate. grid	PRS-92	
2	Methodology	Conformed to DAO* DENR regulation	
3	Reference for Horizontal	NAMRIA NEJ-44	1st Order
		NAMRIA NEJ-58	3rd Order
4	Reference for Vertical	NAMRIA TA-254	1st Order
		NAMRIA TA-262	3rd Order
5	Quantity of levering	30.480 km	For profile
6	Quantity of topographic survey	4,876,865.44 sqm	For Main alignment
7	Quantity of topographic survey	2,191,500 sqm	For IC
8	Quantity of topographic survey	160,000 sqm	For bridge, 200m both upper stream and down stream
9	Cross Sectional Survey	608 cross section	Every 50m interval 80m both sides from center line

*DAO-Department Administrative Order. DENR-Department of Environment and Natural Resources

6.1.3 Soils And Geo-Technical Investigation

The geological survey conducted in the previous feasibility study was referred for the study. The following Soils Investigation along road alignment has been conducted especially where alignment has been changed.

Including some important description of the past feasibility study, geotechnical feature is described as below;

(1) General Geology

1) Topography

Nueva Ecija The terrain of Nueva Ecija begins with the southwest marshes near the Pampanga border. It levels off and then gradually increases in the elevation to rolling hills as it approaches the mountains of Sierra Madre in the east, and the Caraballo and Cordillera ranges in the north.

It is dominated by a broad expanse of alluvial plain covering more than one-half of the whole provinces. The only areas of high relief are the northern and eastern boundaries where the Sierra Madre, Cordillera and the Caraballo Mountains occur. The Sierra Madre constitutes one continuous topographic unit that forms an almost north-south trending block bordering the eastern boundary of the provinces of Quezon. The alluvial plain is gently undulating towards the east and rises abruptly to the Sierra Madre Cordillera.

Tarlac The Tarlac province is situated in the Central Plain of Luzon and is bounded by Pangasinan Province on the north, Nueva Ecija Province on the east, Pampanga Province on the south, and the Zambales Province on the west. Its exact position is between 120^{0}10’ to 120^{0}47’ longitudes and 15^{0}10’ to 15^{0}55’ north latitude. The location of this province in Central Luzon is nearer to the Gulf of Lingayen than to Manila Bay. Tarlac, the provincial capital, is 131.3 kilometers from Manila.

There are two distinct geographical areas in the province. The northern and eastern parts consist of an extensive level plain of recent alluvial deposits of sand, silt and small amount of clay. The western and northwestern parts consist of hills and mountains comprising the eastern sides of the Zambales mountain range. There are three prominent mountains in this range, namely, Dome Park (1,389 meters high), Iba Mountain (1,605 meters high) and Sawtooth Mountain (1,806 meters high). These mountains and the areas surrounding them consist of volcanic rocks of basalts and andesites. The andesites are mostly porphyritic.

2) General Geology

Geologically, the plain of the provinces consists of recent alluvial deposits of various materials. The depths of these deposits vary in many places according to the elevation of the area. The absence of gravel, cobble-stones, and pebble in the substratum shows that these deposits were made by slow-moving streams. The mountains in the northern part consist of Tertiary undifferentiated rocks, while those on the eastern sides consist of Tertiary and later effusive rocks of rhyolites, dacites, and basalts. The foothills on the western flank of Sierra Madre Range consist of narrow strips of volcanic tuff material, sandstone, shales and limestones.

The rock formation in the province is represented by time units ranging in the age from Pre-Cretaceous to Quarternary. Below is the Geology of Nueva Ecija presented in tabulated form. This is adopted from the Geology and Mineral Resources of Nueva Ecija by Leonardo R. Antonio.

3) Regional Tectonic and Seismic Setting

The major structural element recognized in the area of Nueva Ecija is the Dingalan-Dingalan-Gabaldon Rift; a segment of Philippine Fault. The fault appears to be the major factor that influences the formation of Gabaldon Valley. It trends N 40^{0}W and branches out into numerous secondary faults of minor magnitude that the northeastern part, cutting the Cretaceous-Paleogene rock series. These secondary faults appear to have sliced the rocks into a series of parallel fault blocks. The orientation of these faults, together with the schistocity and fold axes appears to be closely related to the major northwest structure.

Gabaldon lies along the boundary between the northerly trending Southern Sierra Madre Mountains and the northeasterly trending Northern Sierra Madre Mountains. The Sierra Madre Mountain Ranges represent the uplifted magnetic arc form during the westward subduction of the Philippine Sea Plate beneath the Eurasian Plate. Offshore, to the east of Sierra Madre Mountains, the surface extension of the subduction zone is represented by the East Luzon Trough, a north-northeasterly trending ocean trench that extends from northeast of Luzon to east of Gabaldon. Offshore to the west of Luzon to Mindoro. Folding of Tertiary deposits, strike-slip and thrust faulting of the Sierra Madre Mountains, and uplift and unroofing of the East Luzon Trough and the Manila Trench (Ringenbach, 1992).

The Philippine Fault Zone is a major left-lateral strike-slip fault zone that has a mapped length of 1,200 km from the eastern part of Mindanao to Northern Luzon. Slip on the Philippine Fault Zone accommodates a significant portion of oblique convergence between the Philippine Sea and Eurasian Plates (Acharya, 1980; Acharya and Aggarwal, 1980). The Philippine Fault Zone trends northwest from Dingalan Bay just east of Gabaldon to the southern end of the Central Cordillera; this reach of the fault is referred to as the Philippine Fault. Northwest of Gabaldon the Philippine Fault splays into the Digdig Fault and the San Jose Fault are considered to be active, on those, are potential sources of future earthquakes.

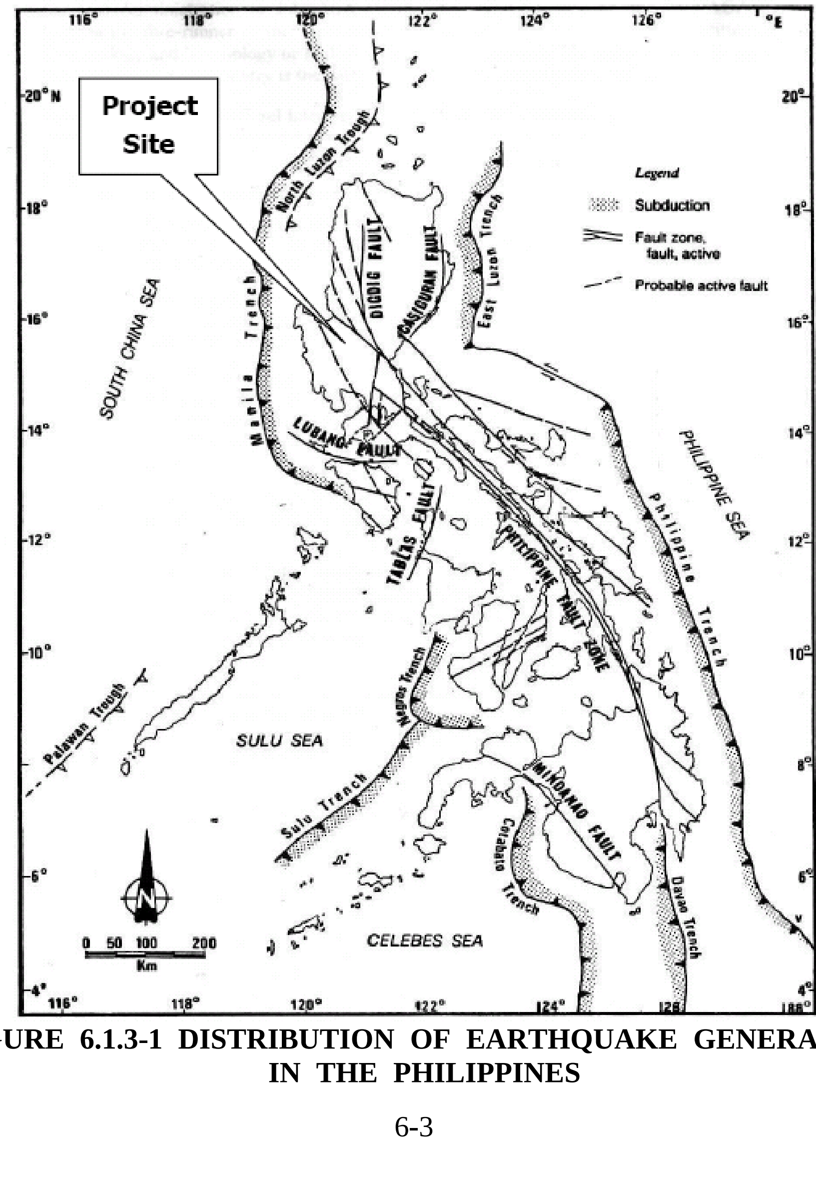


FIGURE 6.1.3-1 DISTRIBUTION OF EARTHQUAKE GENERATORS IN THE PHILIPPINES

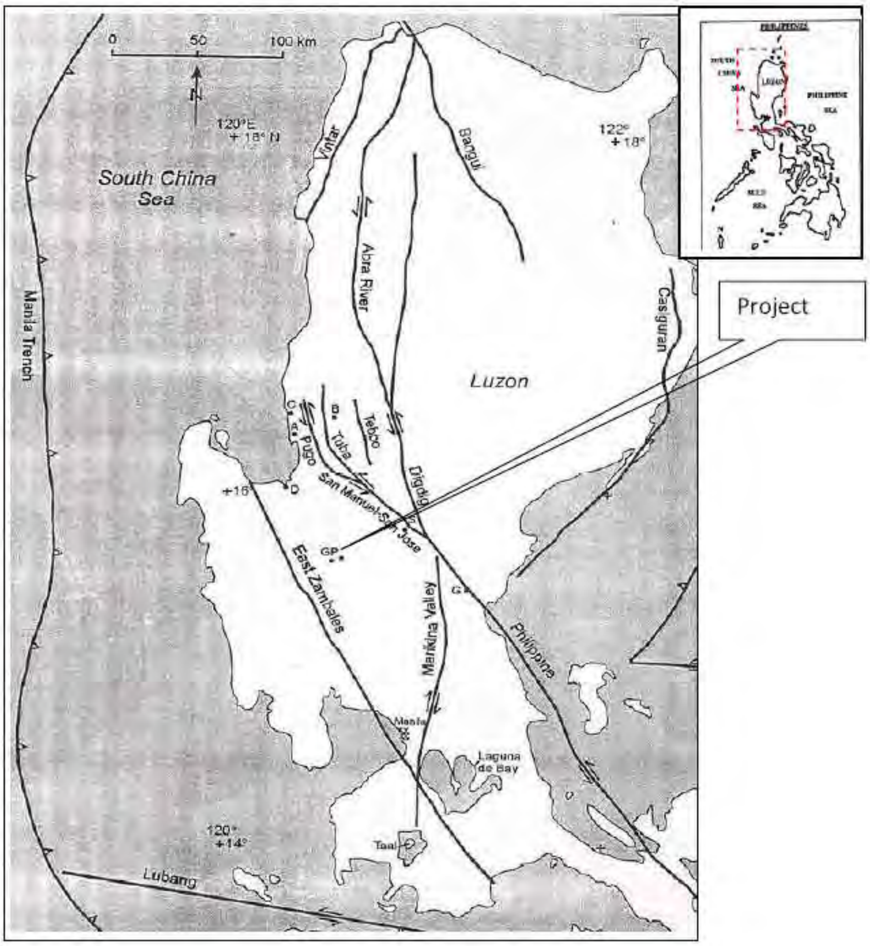


FIGURE 6.1.3-2 MAP SHOWING ACTIVE AND SUSPECTED ACTIVE FAULTS AND SEISMIC SOURCES IN CENTRAL LUZON

4) Seismicity

A compilation of historical seismicity for Luzon shows that many earthquakes occur in the vicinity of Nueva Ecija (Rapetti, 1946; SEASEE, 1985; Su, 1988; Thenhaus and others, 1995). The epicenters of huge magnitude earthquakes (Moment Magnitude M>6) are reported to have occurred in the vicinity of Gabaldon. However, the area has been repeatedly affected by large events on distant faults, and the possibility of large-magnitude local earthquakes cannot be ruled out. The 1990 fault rupture passed through the study area, and the earthquake recorded by PHIVOLCS occur primarily near the epicenter at Rizal and the north (Bautista and others, 1992; Besana and others, 1991).

Recent studies of seismic sources in the Luzon have been completed by Thenhaus and others (1995), Tungol and Daligdig (1993), Maleterre (1989) Ringenbach (1992), and Dr. R. Punongbayan. Several active seismogenic faults, including the Philippine Fault, have been identified in the Gabaldon area. Other active earthquakes sources identified in these studies that could cause strong ground shaking in Gabaldon include: the Digdig Fault, the San Jose-San Manuel Fault and the East Luzon Trough/subduction zone.

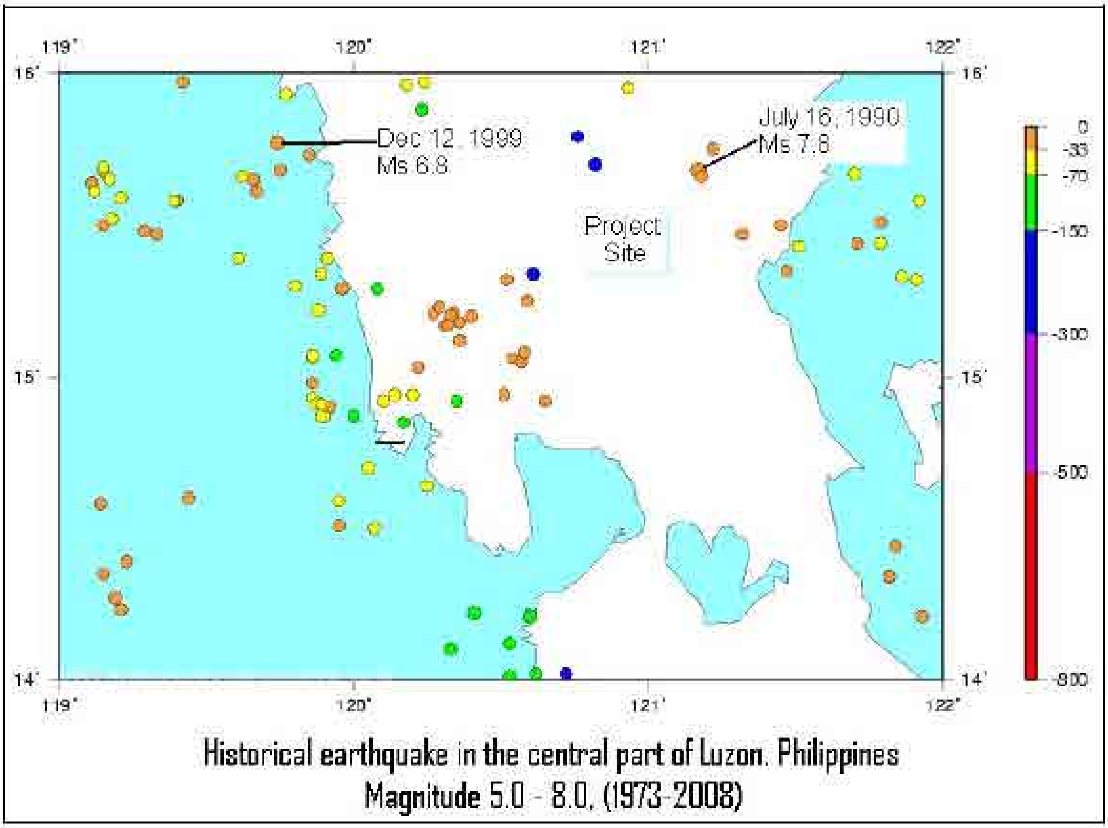


FIGURE 6.1.3-3 HISTORICAL EATHQUAKE IN THE CENTRAL LUZON, PHILIPPINES

5) Seismic Design Calculation

The nearest faults that can generate large-scale magnitude earthquake for this site are the East Zambales Fault in the western portion and the Philippines Fault-Gabaldon Segment. The East Zambales Fault is situated at an approximate distance of 20km west of Tarlac while the Gabaldon Fault is situated at an approximate distance of 10km east of the farthest station near Nueva Ecija area. Hence, considerations should be made in designng the structure to resist against earthquake. As a conservative approach, the deisgn ground accerelation can be based from these faults.

The National Structural Code of the Philippines (NSCP, 1997) Code prescribes a minimum value of 0.40g for bridges located in the seismic zone 4. This site falls in the Seismic Zone 4, having A=0.4.

6) Liquefaction Potential

Alluvial deposits are susceptible to liquefaction, since most soil consists of sandy to silty in nature. Majority of the recovered soil samples (in previous study and this study) are cohesive in nature, although loose to medium dense granular materials were encountered in few intervals. It is predicted that the risk of liquefaction for this particular site is low.

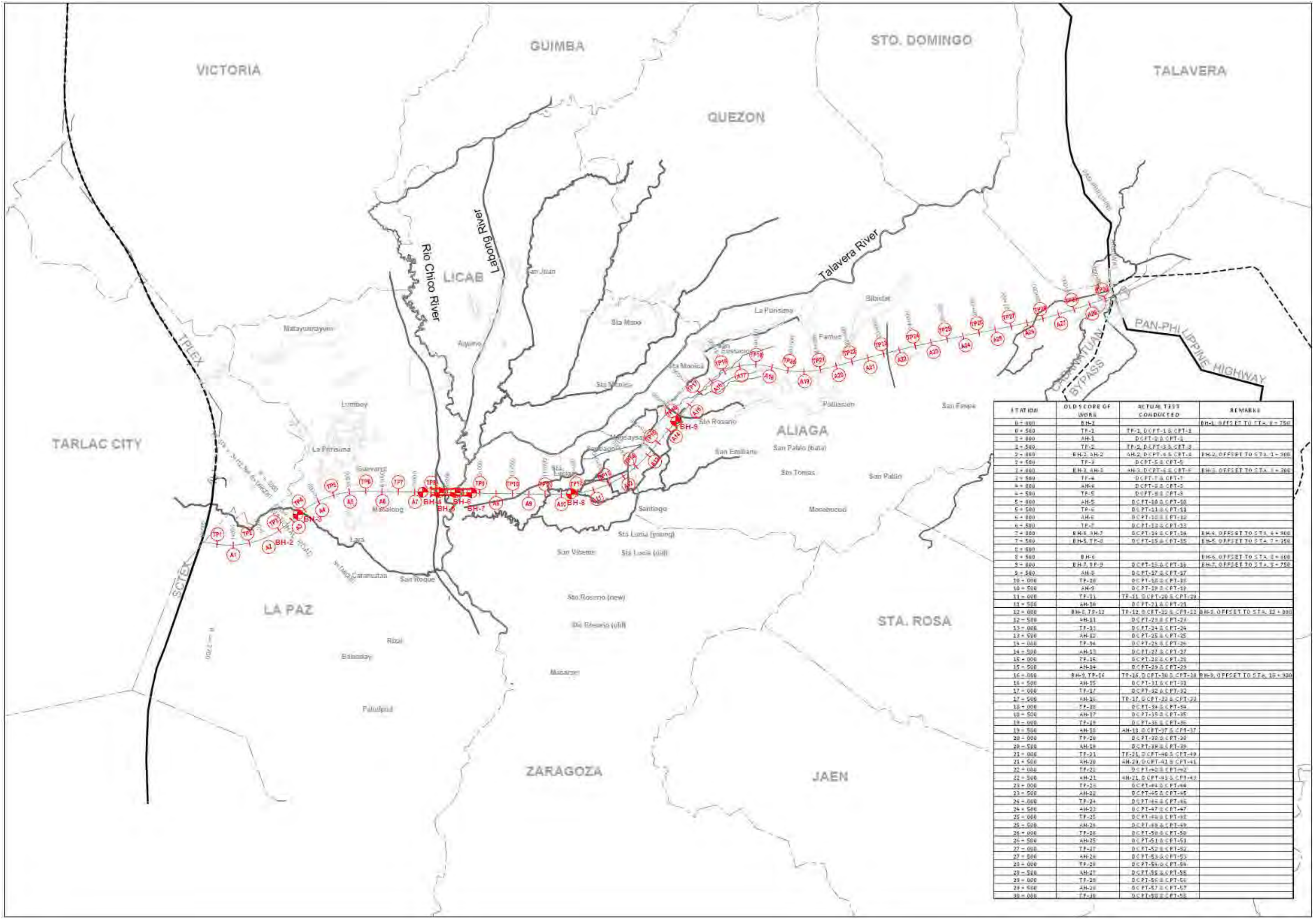
(2) Geotechnical Investigation and Analysis

1) List of the geotechnical test conducted

Table 6.1.3-1 shows number of geotechnical survey conducted.
Figure 6.1.3-1 shows location of geotechnical survey.

TABLE 6.1.3-1 LIST OF GEOTECHNICAL TEST

No.	Test	Number
1	Drilling of boreholes	9
2	Test Pit	7
3	Augrer Hole	5
4	Cone Penetration Test (CPT)	58
5	Dynamic Cone Penetration Test (DCPT)	58
6	Material Sources	2



STATION	OLD SCOPE OF WORK	ACTUAL TEST CONDUCTED	REMARKS
0 + 000	BH-1		BH-1, OFFSET TO STA. 0 + 750
0 + 500	TP-1	TP-1, DCPT-1 & CPT-1	
1 + 000	AH-1	DCPT-2 & CPT-2	
1 + 500	TP-2	TP-2, DCPT-3 & CPT-3	
2 + 000	BH-2, AH-2	AH-2, DCPT-4 & CPT-4	BH-2, OFFSET TO STA. 1 + 900
2 + 500	TP-3	DCPT-5 & CPT-5	
3 + 000	BH-3, AH-3	AH-3, DCPT-6 & CPT-6	BH-3, OFFSET TO STA. 3 + 300
3 + 500	TP-4	DCPT-7 & CPT-7	
4 + 000	AH-4	DCPT-8 & CPT-8	
4 + 500	TP-5	DCPT-9 & CPT-9	
5 + 000	AH-5	DCPT-10 & CPT-10	
5 + 500	TP-6	DCPT-11 & CPT-11	
6 + 000	AH-6	DCPT-12 & CPT-12	
6 + 500	TP-7	DCPT-13 & CPT-13	
7 + 000	BH-4, AH-7	DCPT-14 & CPT-14	BH-4, OFFSET TO STA. 6 + 900
7 + 500	BH-5, TP-8	DCPT-15 & CPT-15	BH-5, OFFSET TO STA. 7 + 250
8 + 000			
8 + 500	BH-6		BH-6, OFFSET TO STA. 8 + 600
9 + 000	BH-7, TP-9	DCPT-16 & CPT-16	BH-7, OFFSET TO STA. 9 + 750
9 + 500	AH-8	DCPT-17 & CPT-17	
10 + 000	TP-10	DCPT-18 & CPT-18	
10 + 500	AH-9	DCPT-19 & CPT-19	
11 + 000	TP-11	TP-11, DCPT-20 & CPT-20	
11 + 500	AH-10	DCPT-21 & CPT-21	
12 + 000	BH-8, TP-12	TP-12, DCPT-22 & CPT-22	BH-8, OFFSET TO STA. 12 + 000
12 + 500	AH-11	DCPT-23 & CPT-23	
13 + 000	TP-13	DCPT-24 & CPT-24	
13 + 500	AH-12	DCPT-25 & CPT-25	
14 + 000	TP-14	DCPT-26 & CPT-26	
14 + 500	AH-13	DCPT-27 & CPT-27	
15 + 000	TP-15	DCPT-28 & CPT-28	
15 + 500	AH-14	DCPT-29 & CPT-29	
16 + 000	BH-9, TP-16	TP-16, DCPT-30 & CPT-30	BH-9, OFFSET TO STA. 16 + 900
16 + 500	AH-15	DCPT-31 & CPT-31	
17 + 000	TP-17	DCPT-32 & CPT-32	
17 + 500	AH-16	TP-17, DCPT-33 & CPT-33	
18 + 000	TP-18	DCPT-34 & CPT-34	
18 + 500	AH-17	DCPT-35 & CPT-35	
19 + 000	TP-19	DCPT-36 & CPT-36	
19 + 500	AH-18	AH-18, DCPT-37 & CPT-37	
20 + 000	TP-20	DCPT-38 & CPT-38	
20 + 500	AH-19	DCPT-39 & CPT-39	
21 + 000	TP-21	TP-21, DCPT-40 & CPT-40	
21 + 500	AH-20	AH-20, DCPT-41 & CPT-41	
22 + 000	TP-22	DCPT-42 & CPT-42	
22 + 500	AH-21	AH-21, DCPT-43 & CPT-43	
23 + 000	TP-23	DCPT-44 & CPT-44	
23 + 500	AH-22	DCPT-45 & CPT-45	
24 + 000	TP-24	DCPT-46 & CPT-46	
24 + 500	AH-23	DCPT-47 & CPT-47	
25 + 000	TP-25	DCPT-48 & CPT-48	
25 + 500	AH-20	DCPT-49 & CPT-49	
26 + 000	TP-26	DCPT-50 & CPT-50	
26 + 500	AH-25	DCPT-51 & CPT-51	
27 + 000	TP-27	DCPT-52 & CPT-52	
27 + 500	AH-26	DCPT-53 & CPT-53	
28 + 000	TP-28	DCPT-54 & CPT-54	
28 + 500	AH-27	DCPT-55 & CPT-55	
29 + 000	TP-29	DCPT-56 & CPT-56	
29 + 500	AH-28	DCPT-57 & CPT-57	
30 + 000	TP-30	DCPT-58 & CPT-58	

FIGURE 6.1.3-1 GEOTECHNICAL TEST LOCATION MAP

(3) Summary of Result and Findings

1) Bridge site geotechnical investigation

The profile accomplished by borehole test result is shown in **Table 6.1.3-2** and **Figure 6.1.3-2**.

TABLE 6.1.3-2 BOREHOLE TEST LOCATION

BH I.D.	Coordinates		Elevation (m)	Final Depth (m)
	Northing	Easting		
BH-1	15.45984	120.68010	21.787	18.35
BH-2	15.45937	120.69176	21.165	15.05
BH-3	15.46706	120.70262	19.656	15.40
BH-4	15.47615	120.73277	14.640	18.20
BH-5	15.47521	120.73604	14.386	18.20
BH-6	15.47313	120.74921	14.756	26.30
BH-7	15.47252	120.7499	14.638	21.35
BH-8	15.47271	120.78129	14.710	24.35
BH-9	15.50129	120.81637	18.979	25.40

The result of nine (9) boreholes revealed that the project site is underlain by alternating layers of clays and sands. In general, the soft to medium stiff Clay forms the uppermost soil cover, and then followed by the dense to very dense fine Sand where most of the boreholes were terminated.

The cohesive material is described as grayish brown, slight to high plastic Clay (CL/CH), with appreciable amount of sand. Consistency of the layer is soft to very stiff towards the bottom of the layer, with SPT blow counts ranging from $4<N<30$.

Underneath the cohesive layer is the medium dense to very dense fine Sand (SM), with some content of non-plastic silt. Generally, the layer found at the bottom of the borehole where blow counts hits practical refusals.

All the nine (9) boreholes were terminated after hitting five (5) meters thick of competent stratum (very dense Sand or hard Clay).

2) Test Pits and Auger Holes

Field and laboratory test result of the seven (7) test pits and five (5) auger holes, the excavated soil taken at the uppermost 0.70m to 2.00 meter is shown in **Table 6.1.3-3**.

TABLE 6.1.3-3 TEST RESULT OF TEST PITS AND AUGER HOLES

TP No.	Depth	Soil Description	AASHTO Class	Max. Dry Density (g/cc)	Optimum Moisture Content (%)	% CBR @ 95% MDD
1	0.10 – 2.0	sandy Clay	A-6 (7)	1.96	13.0	8.80
2	0.10 – 1.20	Sand and Clay mixture	A-6 (4)	1.96	14.2	8.00
11	0.10 – 2.00	Clay	A-7-6 (20)	1.62	24.0	2.4
12	0.10 – 2.00	Clay	A-7-6 (15)	1.64	20.8	1.9
16	0.20 – 1.00	Clay	A-7-5 (19)	1.66	21.2	3.4
17	0.10 – 2.00	Clay	A-7-6 (20)	1.645	21.2	2.3
21	0.20 – 1.00	sandy Clay	A-6 (9)	1.90	14.2	9.0

* Modified compaction: ASTM D1557/AASHTO T180, California Bearing Ratio: ASTM D1883/AASHTO T193

It is to note that uppermost 0.10 to 0.20 meters thick of soil cover is unsuitable materials, described as odorous, very soft organic Clay, with decayed roots and grasses.

3) Cone Penetration Test (CPT)

With respect to the Cone Penetometer Tests (CPT), the uppermost 0.20 to 0.40 meters were generally having zero reading (indicating very little resistance), and would suggest the thickness of the unsuitable materials.
The seven (7) test pits locations with CPT would confirm very well that the unsuitable materials (zero CPT readings) correspond to the odorous, spongy, and slight to highly plastic, very soft organic Clay, with decayed roots and grasses described in the boring logs.
Thereafter, the CPT reading would progressively increase with increasing depth going thru the subsequent soil layers. Final depth of CPT ranged from 1.0m to 2.5m.

4) Dynamic Cone Penetrometer Tests (DCPT)

Generally, the uppermost 0.2-0.9 meters depth has a very low in-situ CBR values, about 1.2%, with marked increase in the calculated in-situ CBR with increasing depth.

5) Material Source Investigation

The following two (2) potential souses are identified and surveyed;
Location of the material source is shown in **Figure 6.1.3-3**.

a. MS-1, Upper Pampanga River
   Location: Brgy. Mayapyap Sur, Cabanatuan City
   Type of materials: Sand and Gravel
   Approx. Quantity: 2,000,000 cu.m
b. BS-1, BRGY. Care Mountain Soil
   Location: Brgy. Care, Tarlac City
   Type of Materials Silty Clay
   Approx. Quantity: 1,000,000 cu.m

Laboratory test result is shown in **Table 6.1.3-4**.

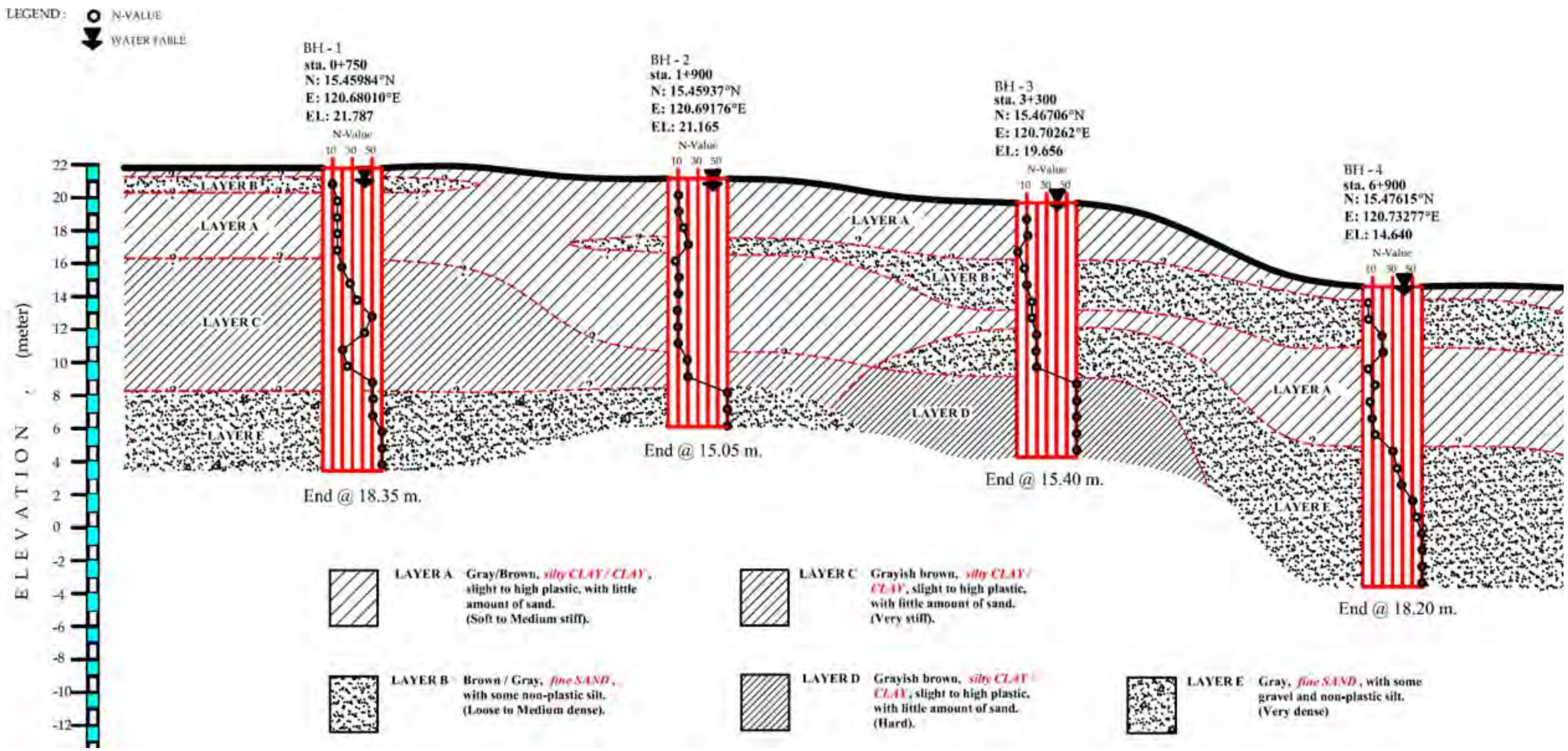


FIGURE 6.1.3-2 GEOGRAPHICAL PROFILE (1/2)

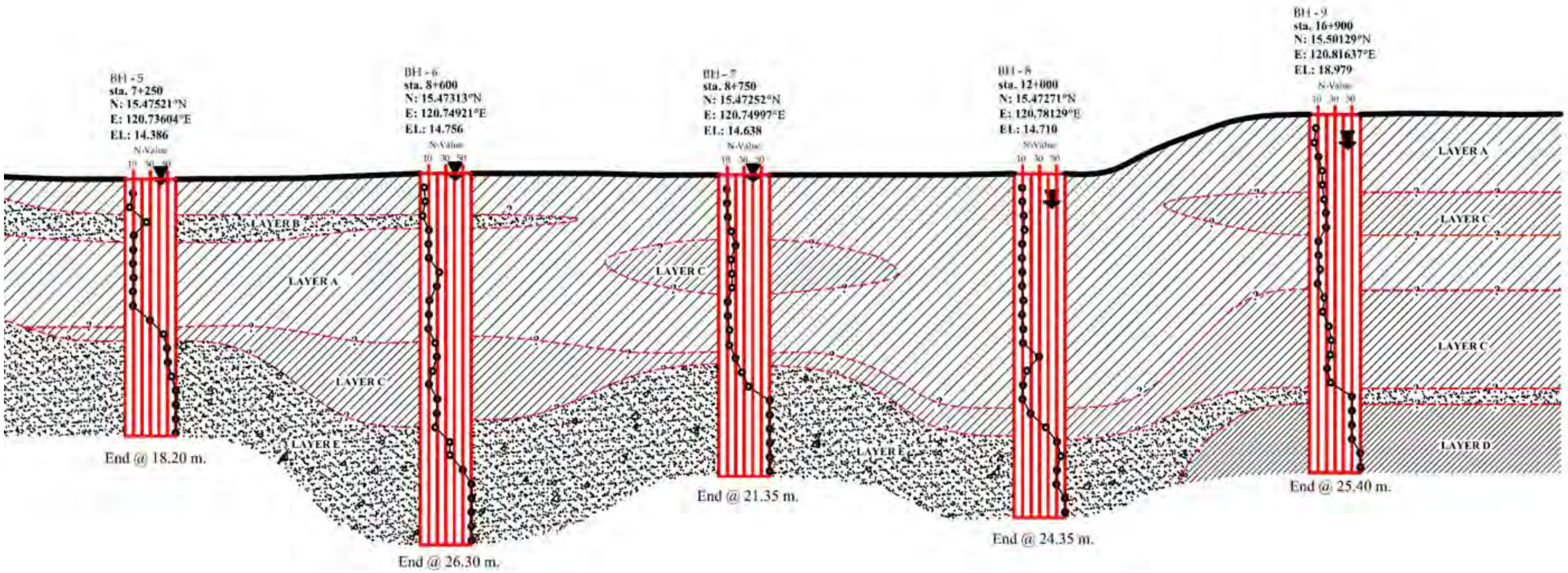
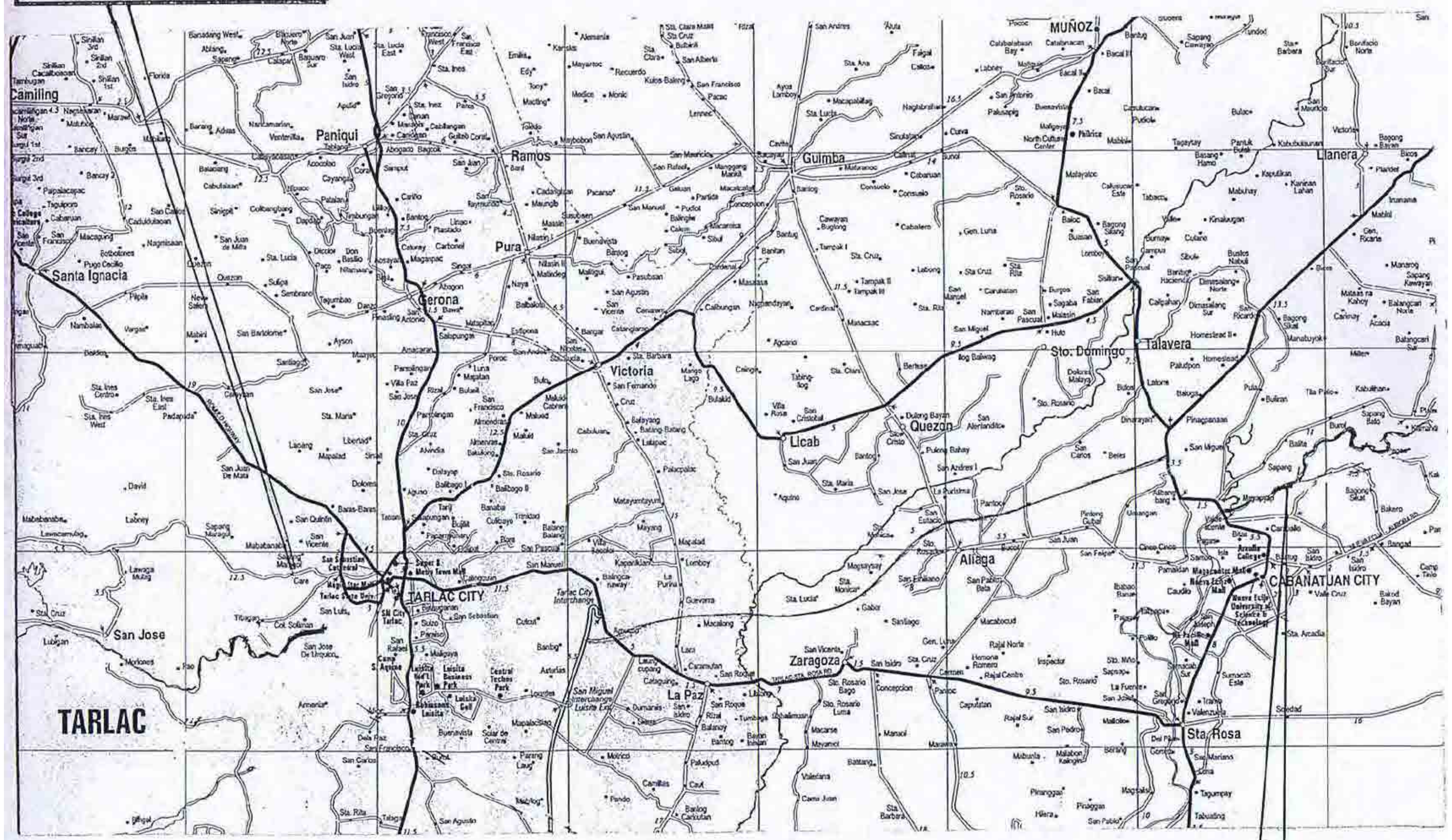


FIGURE 6.1.3-2 GEOGRAPHICAL PROFILE (2/2)

Source No	:	BS-1
Source	:	Brgy. Care Mountain Soil
Location	:	Brgy. Care, Tarlac City
Materials	:	Brown, silty CLAY
Estimated Quantity	:	1,000,000 cu. m.
Acces	:	Passable to any kind of vehicles
Coordinates	:	Northing 15.45913°N Easting 120.69173°E



Source No	:	MS-1
Source	:	Upper Pampanga River
Location	:	Brgy. Mayapyap Sur, Cabanatuan City
Materials	:	SAND and GRAVEL
Item	:	104, 200, 201, 300 Fines and coarse aggregates
Estimated Quantity	:	2,000,000 cu. m.
Acces	:	Passable to any kind of vehicles
Coordinates	:	Northing 15.51729°N Easting 120.96107°E

FIGURE 6.1.3-3 LOCATION MAP OF SAMPLE MATERIAL

TABLE 6.1.3-4 LABORATORY TEST RESULT OF MATERIAL SOURCE INVESTIGATION

Laboratory Tests Results		Upper Pampanga River	Brgy. Care Mountain Soil
Sieve Analysis (% Passing)	3"	-	-
	2"	91	-
	1.5"	83	-
	1"	67	-
	3/4"	55	-
	1/2"	42	-
	3/8"	35	-
	# 4	29	100
	# 8	24	99
	# 10	23	99
	# 16	21	97
	# 30	17	93
	# 40	15	91
	# 50	13	88
	# 100	10	80
	# 200	9	75
Atterberg Limit	Liquid Limit	NP	50
	Plastic Limit	NP	29
Classification		A-1-a (0)	A-7-6 (18)
Soundness (%)	Fine Aggregates	5.63	-
	Coarse Aggregates	0.16	-
Los Angeles Abrasion, %		17.82	-
Apparent Specific Gravity	Fine Aggregates	2.83	2.70
	Coarse Aggregates	2.81	-
Absorption (%)	Fine Aggregates	1.78	14.03
	Coarse Aggregates	1.2	-
Moisture Density Relation	MDD (g/cc)	2.21	1.68
	OMC (%)	8.5	21.8
California Bearing Ratio	@ 95% MDD	26.0	3.8
	@ 100% MDD	39.0	5.6
Flakiness		14.25	-
Organic Matter (%)		1.91	7.28

6.2 DESIGN STANDARD

6.2.1 Design Concept

The design concept is to provide a high speed toll road that allows safe and efficient movement of traffic as an expressway with fully controlled access, especially to improve the access from Tarlac (connection to Subic Clark Trlac Expressway) to Cabanatuan (Pan Philippines Highway) in the total length of **30.73**km.

The scope of work of the study is to review the past study and to consider stage construction in accordance with traffic demand forecast.

6.2.2 Design Standard

The following standard is mainly used as reference in Central Luzon Link Expressway (Phase I) design.

- A Policy on Geometric Design of Highways and Streets, AASHTO 2004
- Highway Safety Design Standards Part 1 Road Safety Design Manual, May 2004, DPWH
- Japan Road Association, Road Structure Ordinance,2004
- Highway design manual, Metropolitan Expressway Co., Ltd., Japan
- Highway design manual, NEXCO, Japan

6.2.3 Design Speed

(1) Main Alignment

Recommended design speed by the previous feasibility study was 100kmh. In accordance with Road Safety Design Manual (DPWH,2004) as well as considering to the moderate topographic condition and safety of the traffic of staging construction, the design speed is recommended **100kph** for the express highway.

(2) Interchange Ramps

The interchange ramp design speed was employed as **40kph** which is 40% of the highway design speed and described minimum design speed in AASHTO 2004.

6.2.4 Design Vehicle

A WB-15 is considered as design vehicle of the main alignment and ramp.

6.2.5 Summary of Express Highway Geometry

Geometry applied to the design of main alignment and ramp is summarized in **Table 6.2.5-1** and **Table 6.2.5-2**.

TABLE 6.2.5-1 GEOMETRY OF CLEX (MAIN ALIGNMENT) (100KM/HR)

Geometric Design Standards

Project: CLEX

Item	Unit	Standard	Absolute	Remark
Design Speed	kmh	100		
Design Vehicle	-	WB-15		
Stopping Sight Distance	m	185		page 56, Table 16.3, DPWH Rad Safety Design Manual
Passing Sight Distance	〃	670		Page 69, Table 16.4 DPWH Road Safety Design Manual

1. Cross Section Elements

Item	Unit	Standard	Substandard	Remark
Pavement Type				Asphalt Concrete
Lane Width	m	3.50		12ft(AASHTO2004)for high type highway, p311
Median Width(Center Separator	〃	3.00		Guard rail, drainage, tree planting included, refer to NEXCO
Inner Shoulder Wdth	〃	1.00		Considering to mergin for staging construction
Outer Shoulder width	〃	2.50		WB-15 trailer (2.44m)
Number of Lanes	nos	4		2 for 1st stage construction
Normal Crossfall	%	2.00		
Maximum super elevation	%	6.00		page 53, table 16.1 DPWH Road Safety Design Manual
Super elevation	%	exhibit 3-26		page 168, exhibit 3-26, ASSHTO 2004
Maximum relative gradients	%	0.43		page 62, super elevation DPWH, Road Safety Design Manual

2.Horizontal Alignment

Item	Unit	Standard	Absolute	Remark
Minimum Radius	m	437		Page 147, exhibit 3-15, ASSHTO 2004
Min. Transition Curve Length	〃	56		Page 61, Figure 16.3 DPWH Road Safety Design Manual
Min.Radius not requiring Transition Curve	〃	2560		page 168, exhibit 3-26, ASSHTO 2004 (2.0%)
Superelevation run off		0.43%		p62 for 100kmh DPWH, Road Safety Design Manual

3. Vertical Alignment

Item		Unit	Standard	Absolute	Remark
Max Vertical Gradient		%	3	4	Page 53,Table 16.1 DPWH Road Safety Deisgn Manual
Min.K value	Crest	〃	85.0		1500(1000) JPN Standard
	Sag	〃	52.0		2000(1400)JPN Standard
Min. Vertical Curve Length		〃	60		Page 636, DPWH Design Guidelines, Criteria and Standards Vol II
Max.Composition Grade		%			

4.Vertical Clearance

Object	Vertical Clearance (m)	Remark
Road	5.200	DPHW Requirement, 4.9m(16feets) Clearance +0.3m (Fugure AC Overlay)

TABLE 6.2.5-2 GEOMETRY OF CLEX (RAMP) (40KM/HR)

Geometric Design Standards

Project: CLEX Ramp

Item	Unit	Standard	Absolute	Remark
Design Speed	〃	40		
Design Vehicle	-	WB-15		Exhibit 2-4, p22 AASHTO 2004
Stopping Sight Distance	〃	50		page 56, Table 16.3, DPWH Rad Safety Design Manual
Passing Sight Distance	〃	270		Page 69, Table 16.4 DPWH Road Safety Design Manual

1. Cross Section Elements

Item	Unit	Standard	Substandard	Remark
Pavement Type				Asphalt Concrete
Lane Width	m	3.50		NEXCO A Type
Median Width	〃	1.00		NEXCO A Type
Inner Shoulder Strip	〃	1.00		NEXCO A Type, 1 direction 1lane ramp
Inner Shoulder Strip	〃	0.75		NEXCO A Type, 2 direction 3lane ramp
Outer Shoulder Strip	〃	2.50		NEXCO A Type
Number of Lanes	nos	1		
Normal Crossfall	%	2.00		
Maximum super elevation	%	6.00		page 53, table 16.1 DPWH Road Safety Design Manual
Super elevation	%	exhibit 3-26		page 168, exhibit 3-26, ASSHTO 2004
Maximum relative gradients	%	0.66		page 62, super elevation DPWH, Road Safety Design Manual

2.Horizontal Alignment

Item	Unit	Standard	Absolute	Remark
Minimum Radius	m	50	43	Page 825,Page 147, exhibit 3-15, ASSHTO 2004
Min. Transition Curve Length	〃	22		Page 61, Figure 16.3 DPWH Road Safety Design Manual
Min.Radius not requiring Transition Curve	〃	525		page 168, exhibit 3-26, ASSHTO 2004 (2.0%)
Superelevation run off		0.66%		p62 for 40kmh DPWH, Road Safety Design Manual

3. Vertical Alignment

Item		Unit	Standard	Absolute	Remark
Max Vertical Gradient		%	6	7	Page 53,Table 16.1 DPWH Road Safety Deisgn Manual
Min.K value	Crest	〃	6.0		( ) is recommended value
	Sag	〃	9.0		( ) is recommended value
Min. Vertical Curve Length		〃	60		Page 636, DPWH Design Guidelines, Criteria and Standards Vol II
Max.Composition Grade		%	11.5		

4.Vertical Clearance

Object	Vertical Clearance (m)	Remark
Road	5.200	DPHW Requirement, 4.9m(16feets) Clearance +0.3m (Fugure AC Overlay)

6.2.6 Vertical Clearance

The vertical clearance of the highway and crossing road shall be 4.0m to 5.2m (4.9m (16 feet) + 0.3m (overlay)).

6.2.7 Number of Lanes

Number of lane is set as below in accordance with traffic demand forecast;

1) Ultimate Stage: 4 lanes
2) Interim Stage: 2 lanes

6.2.8 Carriageway, Shoulder and Median Width

The cross sectional configuration is reviewed and recommended as below;

(1) Main alignment

The carriage way of the main alignment is **3.5m** in accordance with Road Safety Manual (DPWH 2004). Likewise the inner shoulder is designed as **1.0m**. This allows the construction of the 2^{nd} stage cross without conflict from the section for the 1^{st} stage construction. The outer shoulder is designed as **2.5m**. This permit semi trailer class (w=2.44m) emergent stops. The width of median is designed as **3.0m** with guard rail post and plantation of low height trees.

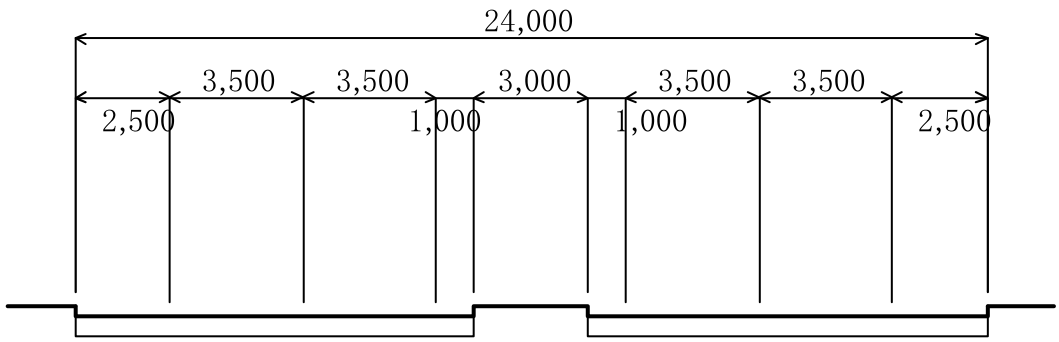


FIGURE 6.2.8-1 CROSS SECTIONAL CONFIGURATION (4 LANES)

(2) Ramp

The carriage way of the ramp is recommended same width as main alignment, namely **3.5m**. Widening of **1.0m** is added to this carriage way. The inner shoulder is designed as **1.0m** and outer shoulder **2.5m** with provision for passing a stalled vehicle of predominantly P vehicles but consideration for WB-15 trailers.

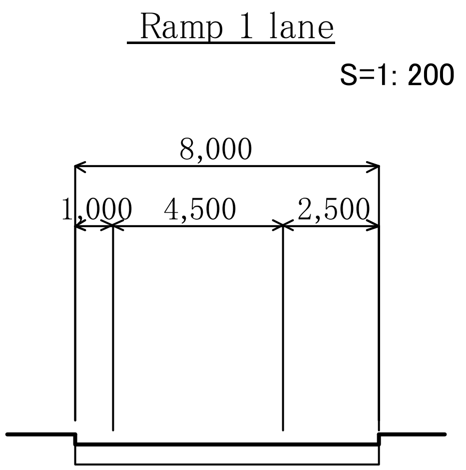


FIGURE 6.2.8-2 CROSS SECTIONAL CONFIGURATION (1 LANE RAMP)

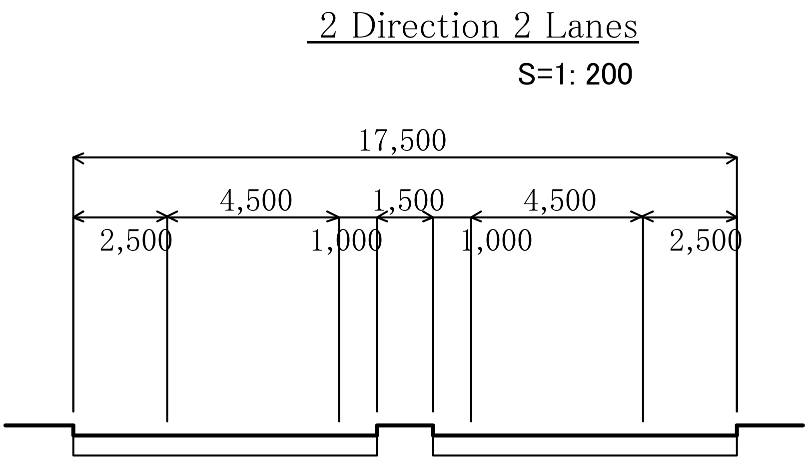


FIGURE 6.2.8-3 CROSS SECTIONAL CONFIGURATION
(2 DIRECTION 2 LANE RAMP)

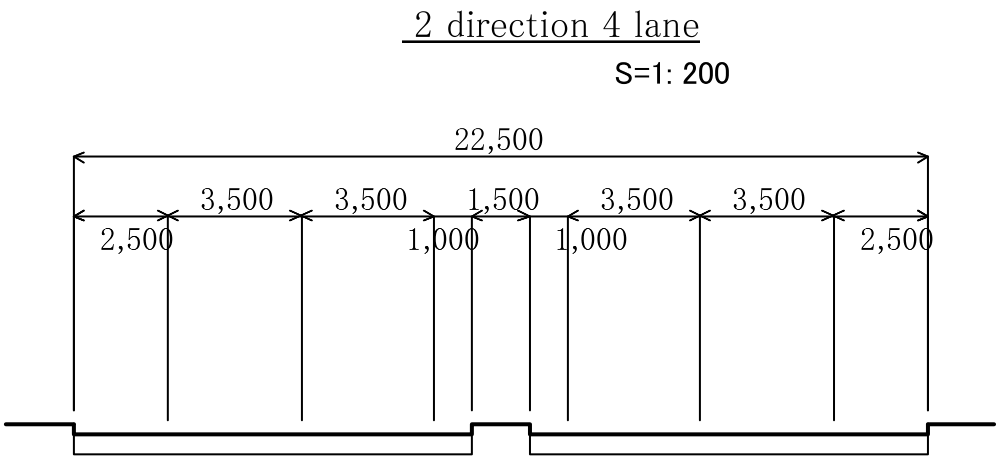


FIGURE 6.2.8-4 CROSS SECTIONAL CONFIGURATION
(2 DIRECTION 4 LANE)

(3) Medium/ Small size bridge (L=<100m)

For small and medium size bridge (L=<100m), cross sectional configuration shall be the same as embankment roadway section.

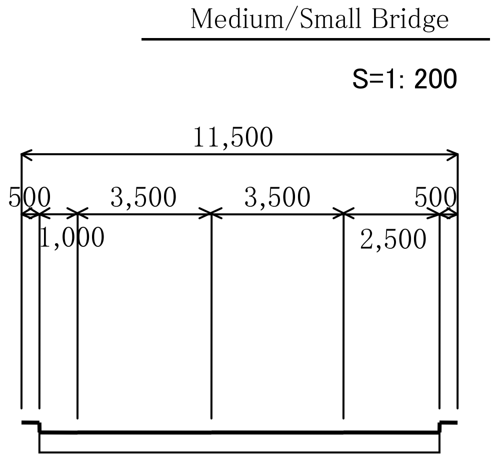


FIGURE 6.2.8-5 CROSS SECTIONAL CONFIGURATION (MEDIUM/ SMALL SIZE BRIDGE (L=<100M)

(4) Viaduct Bridge (L>100m)

For viaduct bridge, inner shoulder shall be reduced to **0.5m** and outer shoulder shall be reduced to **1.5m** for economical reason. (**Figure 6.2.8-6**)

However, the bridge which will be constructed for initial open stage (2 lanes, 2 directions) shall be accommodated with outer shoulder of **1.5m**. (**Figure 6.2.8-7**)

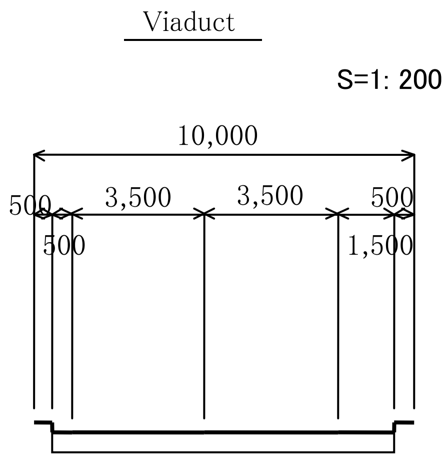


FIGURE 6.2.8-6 CROSS SECTIONAL CONFIGURATION FOR VIADUCT (STANDARD)

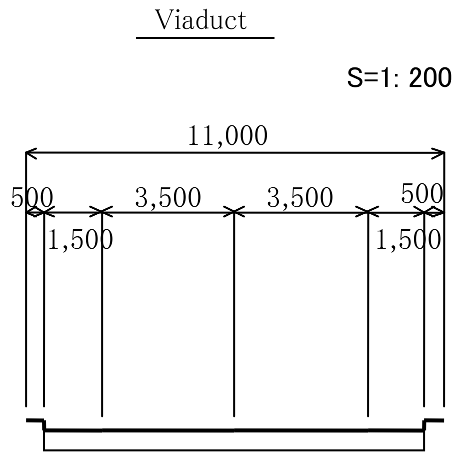
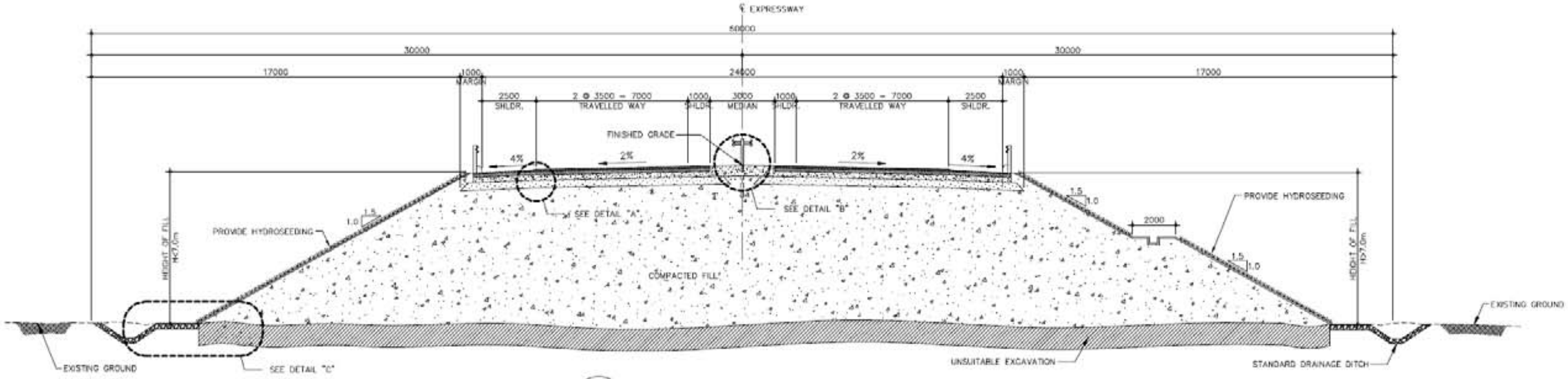


FIGURE 6.2.8-7 CROSS SECTIONAL CONFIGURATION FOR VIADUCT (INITIAL OPEN SIDE)

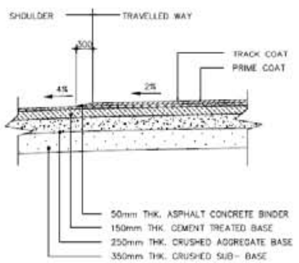
(5) Typical Cross Section

Typical Cross Sections are shown in the following pages.



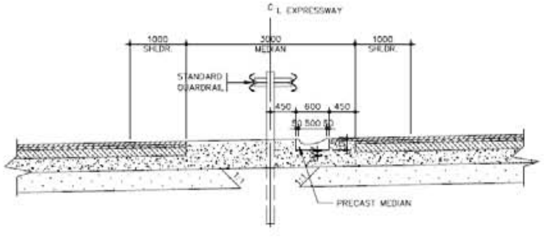
1 TYPICAL ROADWAY SECTION

a SCALE 1:100



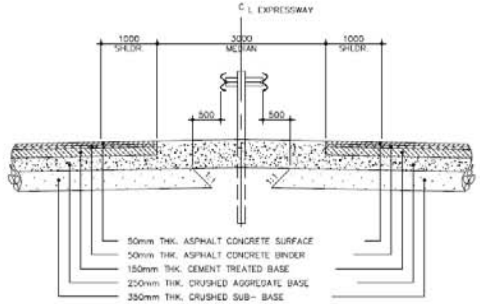
1 DETAIL – "A"

b SCALE 1:40



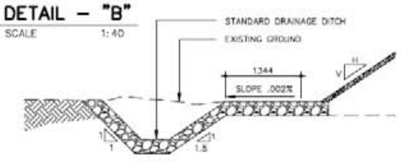
1 DETAIL – "B"

c SCALE 1:40



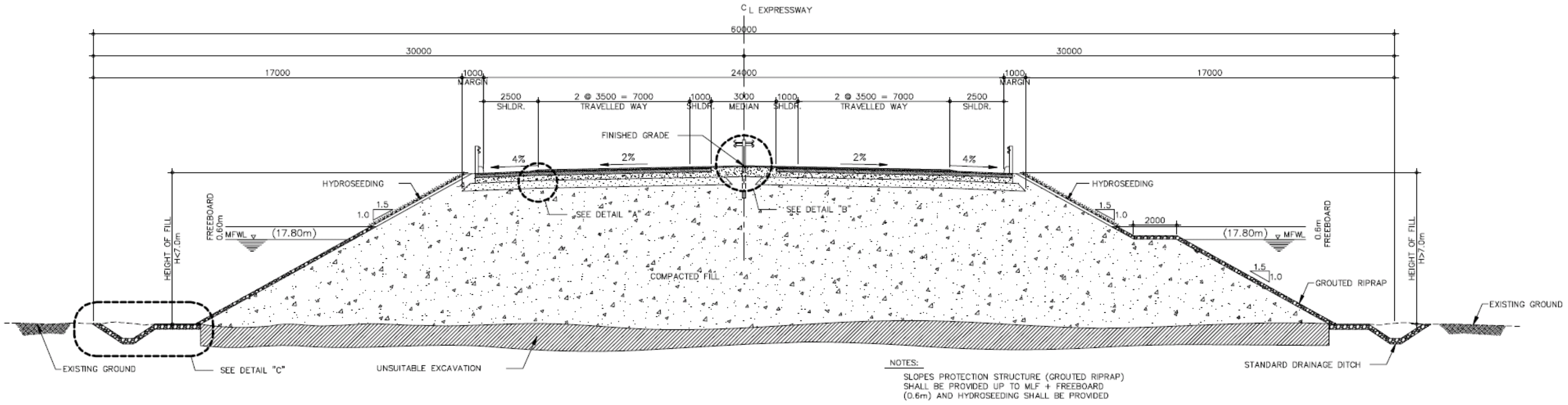
1 DETAIL – "B-2"

d SCALE 1:40

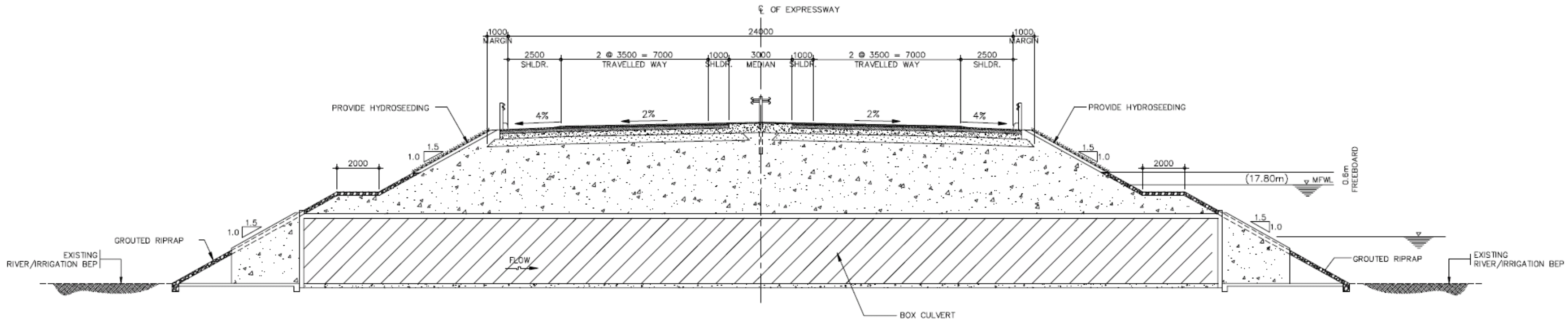


1 DETAIL – "C"

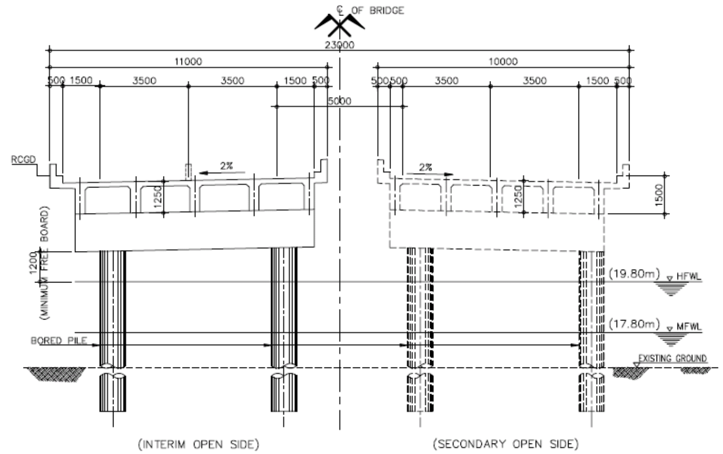
e SCALE 1:40



2A TYPICAL ROADWAY SECTION (EQUALIZING ZONE)
SCALE 1:100

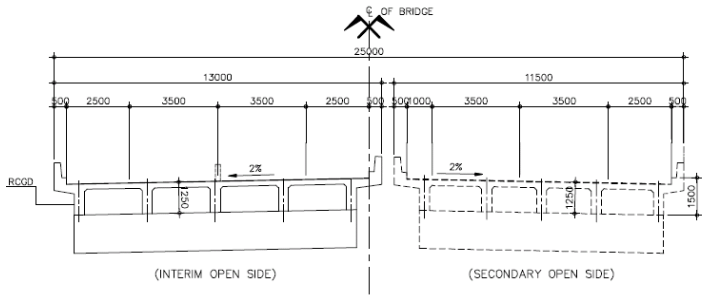


2B TYPICAL ROADWAY SECTION (EQUALIZING ZONE (BOX CULVERT))
SCALE 1:100



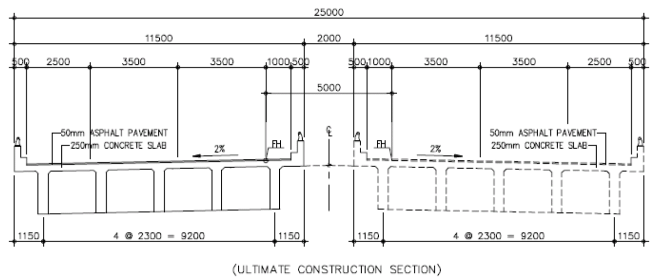
3A TYPICAL CROSS SECTION (VIADUCT)

– SCALE 1:100



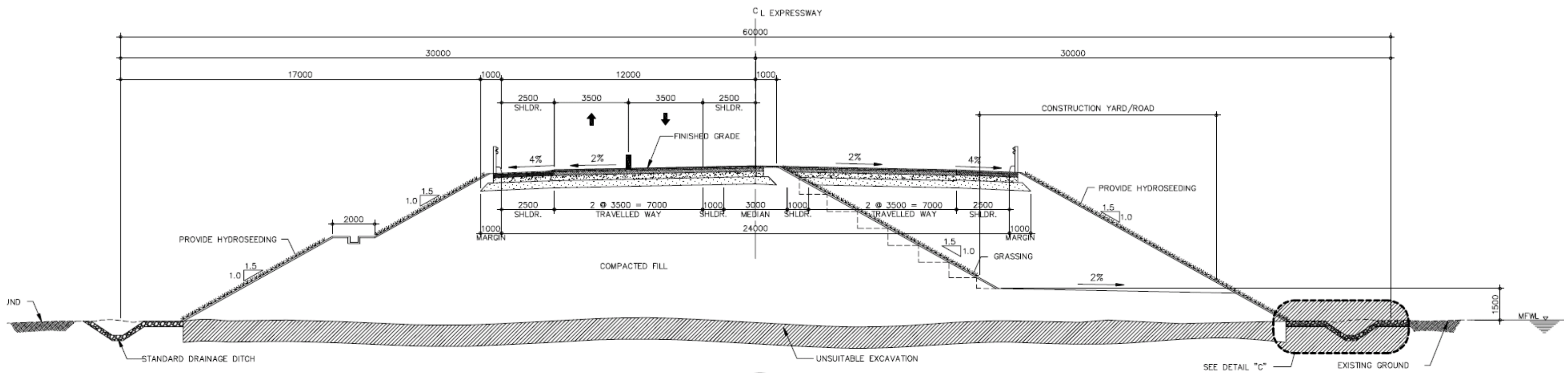
3B TYPICAL CROSS SECTION (SMALL/MIDIUM BRIDGE INTERIM SECTION)

– SCALE 1:100



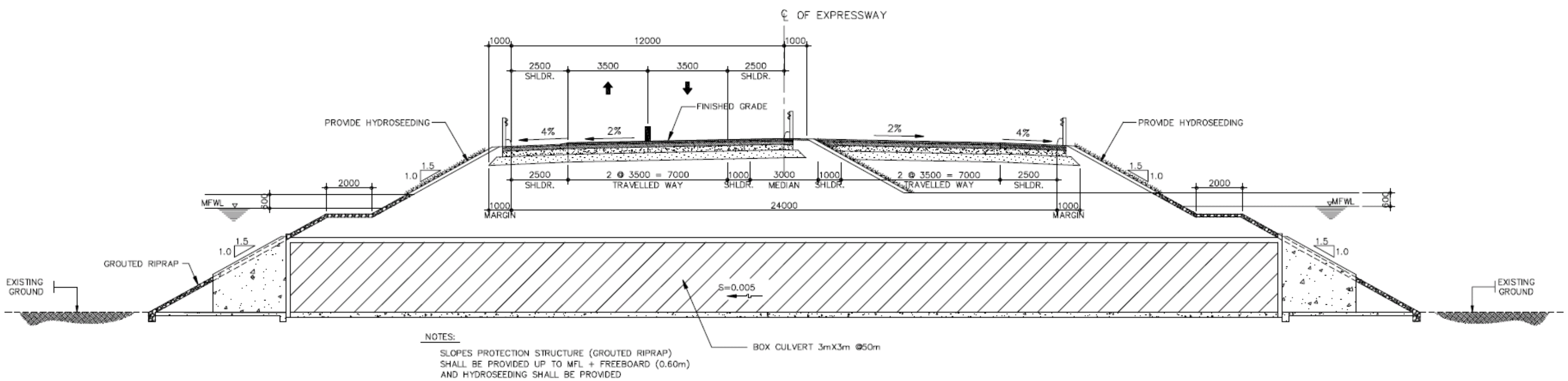
3C TYPICAL CROSS SECTION (SMALL/MIDIUM BRIDGE ULTIMATE SECTION)

– SCALE 1:100



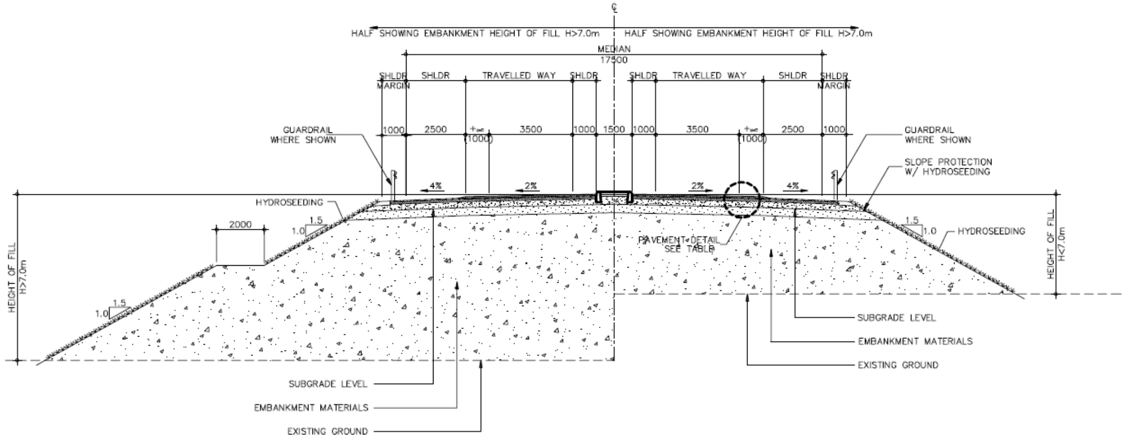
4A TYPICAL ROADWAY SECTION

SCALE 1:100



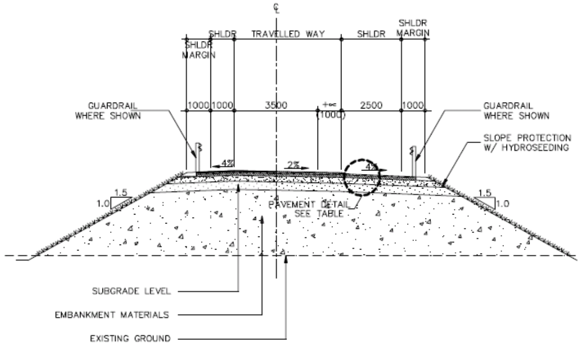
4B TYPICAL ROADWAY SECTION (EQUALIZING ZONE (BOX CULVERT))

SCALE 1:100



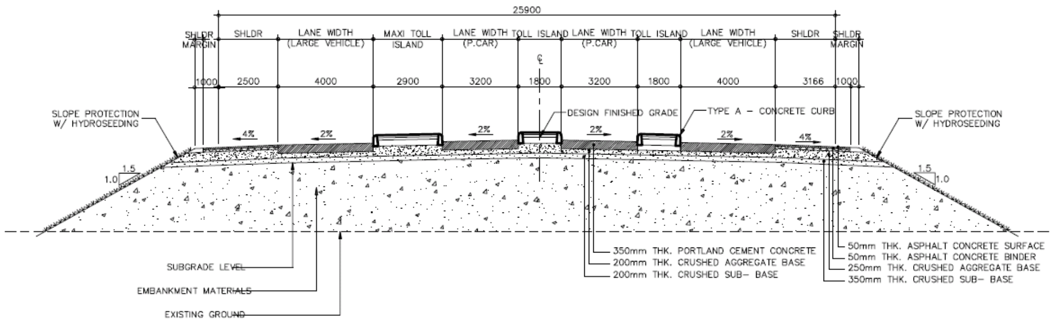
5A **SECTION @ LOOP RAMP**

SCALE 1:100



5B **SECTION @ LOOP RAMP**

SCALE 1:100



5C **SECTION @ TOLL PLAZA**

SCALE 1:100

PAVEMENT THICKNESS TABLE

LAYER	TRAVELLED WAY	SHOULDER
SURFACE COURSE	50mm THK. ASPHALT CONCRETE SURFACE COURSE	
BINDER COURSE	50mm THK. ASPHALT CONCRETE BINDER COURSE	50mm THK. ASPHALT CONCRETE BINDER COURSE
BASE COURSE	100mm THK. CEMENT TREATED BASE COURSE	100mm THK. CEMENT TREATED BASE COURSE
	250mm THK. CRUSH AGGREGATE BASE COURSE	250mm THK. CRUSH AGGREGATE BASE COURSE
SUBBASE COURSE	350mm THK. AGGREGATE SUBBASE COURSE	350mm THK. AGGREGATE SUBBASE COURSE

6.2.9 Stopping Distance

According to Road Safety Design Manual (2004, DPWH);
Stopping distance for design speed of 100kph is 185m.
Stopping distance for design speed of 40kph is 50m.

6.2.10 Crossfall Development

Superelevation of the carriageway shall be considered to accommodate recommendation of AASHTO 2004 as shown in **Table 6.2.10-1**. The maximum value of superelevation is 6.0% as guided in Road Safety Manual(2004) in page 53.

In principal, the superelevation is attained within spiral curve. The runoff rate of super elevation is considered 0.43% for 100kph and 0.65% for 50kph in accordance to the Road Safety Design Manual.

TABLE 6.2.10-1 MINIMUM RADII FOR DESIGN SUPERELEVATION RATES, emax = 6.0%

METRIC

e (%)	V_d = 20 km/h R (m)	V_d = 30 km/h R (m)	V_d = 40 km/h R (m)	V_d = 50 km/h R (m)	V_d = 60 km/h R (m)	V_d = 70 km/h R (m)	V_d = 80 km/h R (m)	V_d = 90 km/h R (m)	V_d = 100 km/h R (m)	V_d = 110 km/h R (m)	V_d = 120 km/h R (m)	V_d = 130 km/h R (m)
1.5	194	421	738	1050	1440	1910	2360	2880	3510	4060	4770	5240
2.0	138	299	525	750	1030	1360	1710	2090	2560	2970	3510	3880
2.2	122	265	465	668	919	1230	1530	1880	2300	2670	3160	3500
2.4	109	236	415	599	825	1110	1380	1700	2080	2420	2870	3190
2.6	97	212	372	540	746	1000	1260	1540	1890	2210	2630	2930
2.8	87	190	334	488	676	910	1150	1410	1730	2020	2420	2700
3.0	78	170	300	443	615	831	1050	1290	1590	1870	2240	2510
3.2	70	152	269	402	561	761	959	1190	1470	1730	2080	2330
3.4	61	133	239	364	511	697	882	1100	1360	1600	1940	2180
3.6	51	113	206	329	465	640	813	1020	1260	1490	1810	2050
3.8	42	96	177	294	422	586	749	939	1170	1390	1700	1930
4.0	36	82	155	261	380	535	690	870	1090	1300	1590	1820
4.2	31	72	136	234	343	488	635	806	1010	1220	1500	1720
4.4	27	63	121	210	311	446	584	746	938	1140	1410	1630
4.6	24	56	108	190	283	408	538	692	873	1070	1330	1540
4.8	21	50	97	172	258	374	496	641	812	997	1260	1470
5.0	19	45	88	156	235	343	457	594	755	933	1190	1400
5.2	17	40	79	142	214	315	421	549	701	871	1120	1330
5.4	15	36	71	128	195	287	386	506	648	810	1060	1260
5.6	13	32	63	115	176	260	351	463	594	747	980	1190
5.8	11	28	56	102	156	232	315	416	537	679	900	1110
6.0	8	21	43	79	123	184	252	336	437	560	756	951

Exhibit 3-26. Minimum Radii for Design Superelevation Rates, Design Speeds, and e_{max} = 6%

6.2.11 Minimum Radius Without Superelevation

When the curve radius is larger than R2560min, superelevation can be omitted in accordance with AASHTO 2004.

6.2.12 Minimum Curve Length

(1) Minimum Curve length

The length of the spiral curve is recommended to take for 2 seconds of the design speed by AASHTO 2004.
50km/h: Ld=13.9(m/s)x2(sec)=27.8m(28m)
100km/h: Ld=27.7(m/s)x2(sec)=55.5(56m)

(2) Minimum Spiral Curve Length

The spiral lengths listed in **Table 6.2.12-1** are recommended as desirable values for highway design by AASHTO 2004. Spiral curve length shall be as long as to adequate the desired superelevation runoff. Minimun spiral curve length for superelevation runoff is shown in **Table 6.2.12-2**.

TABLE 6.2.12-1 DESIRABLE LENGTH OF SPIRAL CURVE TRANSITION

Design Speed (km/h)	Spiral Length(m)
20	11
30	17
40	22
50	28
60	33
70	39
80	44
90	50
100	56
110	61
120	67
130	72
AASHTO 2004, p189	

TABLE 6.2.12-2 MINIMUM SPIRAL CURVE LENGTH FOR SUPERELEVATION RUNOFF (Ld)

4 lane Main alignment

Super elevation(%)	Radius	We(m)	e(m)	S(%)	Ld	Remark
6.00	437	9.5	0.570	0.430	133	100km/h
5.00	755	9.5	0.475	0.430	110	100km/h
4.00	1000	9.5	0.380	0.430	88	100km/h
3.00	1690	9.5	0.285	0.430	66	100km/h
2.00	2560	9.5	0.190	0.430	44	100km/h

2 direction 2lane Ramp

Super elevation(%)	Radius	We(m)	e(m)	S(%)	Ld	Remark
6.00	437	6.25	0.375	0.660	87	40km/h
5.00	755	6.25	0.313	0.660	73	40km/h
4.00	1000	6.25	0.250	0.660	58	40km/h
3.00	1690	6.25	0.188	0.660	44	40km/h
2.00	2560	6.25	0.125	0.660	29	40km/h

1 direction 1 lane Ramp

Super elevation(%)	Radius	We(m)	e(m)	S(%)	Ld	Remark
6.00	437	2.75	0.165	0.660	38	40km/h
5.00	755	2.75	0.138	0.660	32	40km/h
4.00	1000	2.75	0.110	0.660	26	40km/h
3.00	1690	2.75	0.083	0.660	19	40km/h
2.00	2560	2.75	0.055	0.660	13	40km/h

6.2.13 Speed Change Lanes

The deceleration and acceleration length requirements are calculated based of AASHTO (2004).

(1) Deceleration Lane Length and Acceleration Lane Length

TABLE 6.2.13-1 DECELERATION LENGTH

Highway Design Speed, V (KPH)	Speed Reached, Va (KPH)	Stop Condition	20	30	40	50	60	70	80
		For Average Running Speed on Exit Curve, V'a (KPH)							
		0	20	28	35	42	51	63	70
50	47	75	70	60	45	-			
60	55	95	90	80	65	55	-		
70	63	110	105	95	85	70	55	-	
80	70	130	125	115	100	90	80	55	-
90	77	145	140	135	120	110	100	75	60
100	85	170	165	155	145	135	120	100	85
110	91	180	180	170	160	150	140	120	105
120	98	200	195	185	175	170	155	140	120

Where:

V = Design Speed of Toll-way (KPH)

Va = Average Running Speed on Toll-way (KPH)

V' = Design Speed of Exit (KPH)

V'a = Average Running Speed on Exit Curve (KPH)

TABLE 6.2.13-2 ACCELERATION LENGTH

Highway Design Speed, V (KPH)	Speed Reached, Va (KPH)	L (meters) for Entrance Curve Design Speed, V' (KPH)							
		Stop Condition	20	30	40	50	60	70	80
		And Initial Speed, V'a (KPH)							
		0	20	28	35	42	51	63	70
50	37	60	50	30	-	-			
60	45	95	80	65	**45**	-	-		
70	53	150	130	110	90	65	-	-	
80	60	200	180	165	145	115	65	-	-
90	67	260	245	225	205	175	125	35	-
100	74	345	325	305	285	255	205	110	40
110	81	430	410	390	370	340	290	200	125
120	88	545	530	515	490	460	410	25	245

Where:

V = Design Speed of Toll-way (KPH)

Va = Average Running Speed on Toll-way (KPH)

V' = Design Speed of Entrance Curve (KPH)

V'a = Initial Speed on Entrance Curve (KPH)

TABLE 6.2.13-3 SPEED CHANGE LANE ADJUSTMENT FACTORS AS A FUNCTION OF GRADE

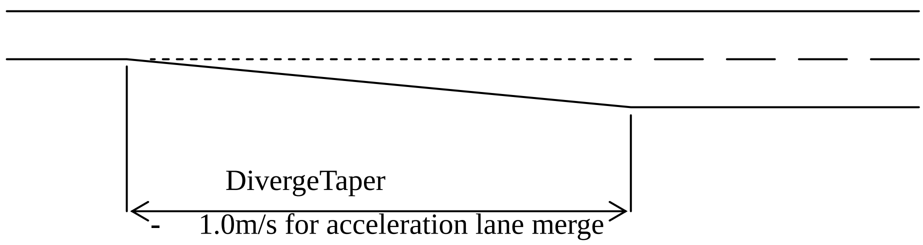
Highway Design Speed, V (KPH)	Ratio of Length on Grade to Length on Level for Design Speed of Turning Curve (Km/h)	
All Speeds	3 to 4% Upgrade 0.90	3 to 4% Downgrade 1.2
All Speeds	5 to 6% Upgrade 0.80	5 to 6 % Downgrade 1.35

TABLE 6.2.13-4 SPEED CHANGE LANE ADJUSTMENT FACTORS AS A FUNCTION OF GRADE

Highway Design Speed, V (KPH)	Ratio of Length on Grade to Length on Level for Design Speed of Turning Curve (Km/h)					
	40	50	60	70	80	All Speeds
3 to 4 % Upgrade						3 to 4 % Downgrade
60	1.3	1.4	1.4			0.70
70	1.3	1.4	1.4	1.5		0.65
80	1.4	1.5	1.5	1.5	1.6	0.65
90	1.4	1.5	1.5	1.5	1.6	0.6
100	1.5	1.6	1.7	1.7	1.8	0.6
110	1.5	1.6	1.7	1.7	1.8	0.6
120	1.5	1.6	1.7	1.7	1.8	0.6
5 to 6 % Upgrade						5 to 6 % Downgrade
60	1.5	1.5				0.6
70	1.5	1.6	1.7			0.6
80	1.5	1.7	1.9	1.8		0.55
90	1.6	1.8	2.0	2.1	2.2	0.55
100	1.7	1.9	2.2	2.4	2.5	0.5
110	2.0	2.2	2.6	2.8	3.0	0.5
120	2.3	2.5	3.0	3.2	3.5	0.5

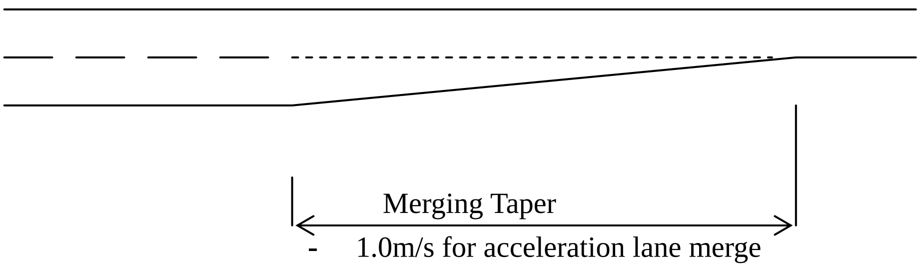
(2) Diverging Taper

*Vertical Gradient less than 3.0%



Design Speed	Lane width
	3.5m
100km/h (27.78m/s)	97m

(3) Merging Taper



Design Speed	Lane width
	3.5m
100km/h (27.78m/s)	97m

6.2.14 Maximum Gradient

For the main alignment with design speed of 100kph, the maximum vertical gradient could be applied is **4%** by referring to Road Safety Manual (2004 DPWH) while desirable max gradient is **3%**.

For interchange On and Off Ramp with design speed of 50kph, the maximum gradient recommended to apply is **6.0%** while absolute grade is **7.0%**.

6.3 EXPRESSWAY DESIGN

6.3.1 General

This section of the report highlights the engineering studies undertaken for the proposed project following the AASHTO and DPWH technical guidelines and procedures.

This section contains following technical studies;

(1) Hydrological analysis
(2) Crossing Road and River Design
(3) Vertical Control
(4) Rio Chico River Flood Prone Area Design
(5) Interchange Design
(6) Interim 2 Lanes Design

6.3.2 Hydrological Analysis

(1) Technical Approach

This study was carried out in the following steps;

1) Data collection
2) Hydrologic study
3) Hydraulic analysis
4) Drainage Design

(2) Data collection

Topographic maps from the National Mapping and Resource Information Authority (NAMRIA) were acquired. For the rainfall data, the same data from the existing Feasibility Study was obtained from the Philippine Atmospheric, Geophysical Astronomical Services Administration (PAGASA) was used.

1) Topographic Maps

NAMIRA is the government agency responsible for the preparation of topographic maps of the Philippines. For the project location, 1:50,000 maps were available.

2) Rainfall Data

For the purpose of this study, the same rainfall data used in the existing Feasibility Study is utilized. The available data are from the Cabanatuan City (based on 33 years of record), Munoz, Nueva Ecija (based on 21 years of record) and Pantabangan (based on 19 years of record.)

RAINFALL INTENSITY-DURATION FREQUENCY DATA

For

CABANATUAN CITY

Based on 33 years of record

COMPUTED EXTREME VALUES (in mm) OF PRECIPITATION

Return Period	5	10	15	20	30	45	60	80	100	120	150	3	6	12	24
Yrs.	min.	min.	min.	min.	min.	min.	min.	min.	min.	min.	min.	hrs.	hrs.	hrs.	hrs.
2	12.10	18.80	24.10	28.60	36.60	45.00	50.70	57.00	62.30	66.10	70.80	75.10	92.60	108.90	127.90
5	17.5	26.90	34.30	40.50	52.40	65.00	74.60	83.30	90.50	95.60	101.60	108.70	137.80	162.60	194.50
10	21.10	32.20	41.10	48.40	62.80	73.80	90.50	100.70	109.10	115.10	121.90	131.00	167.70	198.10	238.60
15	23.10	35.30	44.90	52.90	68.70	85.80	99.40	110.50	119.60	126.10	133.40	143.50	184.50	218.10	263.40
20	24.50	37.40	47.60	56.00	72.80	91.00	105.70	117.40	127.00	133.80	141.50	152.30	196.30	232.20	280.80
25	25.60	39.00	49.70	58.50	76.00	95.10	110.50	122.70	132.70	139.70	147.70	159.10	205.40	243.00	294.30
50	28.90	44.00	56.00	65.90	85.70	107.50	125.40	139.00	150.10	158.00	166.80	180.00	233.40	276.30	335.60
100	32.20	49.00	62.30	73.30	95.40	119.80	140.10	155.20	167.50	176.10	185.70	200.70	261.20	309.30	376.60

EQUIVALENT AVERAGE INTENSITY (in mm/hr.) OF COMPUTED EXTREME VALUES

Return Period Yrs.	5 min.	10 min.	15 min.	20 min.	30 min.	45 min.	60 min.	80 min.	100 min.	120 min.	150 min.	180 min.	360 min.	720 min.	1440 min.
2	145.20	112.80	96.40	85.80	73.20	60.00	50.70	42.80	37.40	33.00	28.30	25.00	15.40	9.10	5.30
5	210.00	161.40	137.20	121.50	104.80	86.70	74.60	62.50	54.30	47.80	40.60	36.20	23.00	13.60	8.10
10	253.20	193.20	164.40	145.20	125.60	104.40	90.50	75.50	65.50	57.50	48.80	43.70	28.00	16.50	9.90
15	277.20	211.80	179.60	158.70	137.40	114.40	99.40	82.90	71.80	63.00	53.40	47.80	30.80	18.20	11.00
20	294.00	224.40	190.40	168.00	145.60	121.30	105.70	88.00	76.20	66.90	56.60	50.80	32.70	19.30	11.70
25	307.20	234.00	198.80	175.50	152.00	126.80	110.50	92.00	79.60	69.80	59.10	53.00	34.20	20.30	12.30
50	346.80	264.00	224.00	197.70	171.40	143.30	125.40	104.30	90.10	79.00	66.70	60.00	38.90	23.00	14.00
100	386.40	294.00	249.20	219.90	190.80	159.70	140.10	116.40	100.50	88.10	74.30	66.90	43.50	25.80	15.70

Prepared by:

The HYDROMETEOROLOGICAL INVESTIGATIONS and SPECIAL STUDIES SECTION

Flood Forecasting Branch, PAGASA

RAINFALL INTENSITY-DURATION FREQUENCY DATA

for

MUNOZ, NUEVA ECIJA

Based on 21 years of record

COMPUTED EXTREME VALUES (in mm) of PRECIPITATION

Return Period	60	3	6	12	24
Yrs.	min.	hrs.	hrs.	hrs.	hrs.
2	58.80	66.30	78.70	89.00	105.40
5	67.10	82.60	98.80	125.60	144.70
10	75.30	93.30	112.10	149.90	170.70
20	83.10	103.70	124.80	173.20	195.70
25	85.60	107.00	128.80	180.50	203.60
50	93.20	117.10	141.30	203.30	228.00
100	100.80	127.10	153.60	225.90	252.30

EQUIVALENT AVERAGE INTENSITY (in mm/hr.) OF COMPUTED EXTREME VALUES

Return Period	60	180	360	720	1440
Yrs.	min.	min.	min.	min.	min.
2	54.80	22.10	13.10	7.40	4.40
5	67.10	27.50	16.50	10.50	6.00
10	75.30	31.10	18.70	12.50	7.10
20	83.10	34.60	20.80	14.40	8.20
25	85.60	35.70	21.50	15.00	8.50
50	93.20	39.00	23.50	16.90	9.50
100	100.80	42.40	25.60	18.80	10.50

Prepared by:

The HYDROMETEOROLOGICAL INVESTIGATIONS and SPECIAL STUDIES SECTION

Flood Forecasting Branch, PAGASA

RAINFALL INTENSITY-DURATION FREQUENCY DATA

for

PANTABANGAN

Based on 19 years of record

COMPUTED EXTREME VALUES (in mm) of PRECIPITATION

Return Period	60	3	6	12	24
Yrs.	min.	hrs.	hrs.	hrs.	hrs.
2	45.80	66.70	83.80	99.10	120.80
5	62.50	99.10	119.70	147.00	187.10
10	73.60	120.60	143.50	178.70	230.90
20	84.20	141.20	166.30	209.10	273.00
25	87.50	147.70	173.50	218.70	286.40
50	97.90	167.90	195.80	248.40	327.50
100	108.20	187.80	217.90	277.90	368.30

EQUIVALENT AVERAGE INTENSITY (in mm/hr.) OF COMPUTED EXTREME VALUES

Return Period	60	180	360	720	1440
Yrs.	min.	min.	min.	min.	min.
2	45.80	22.20	14.00	8.30	5.00
5	62.50	33.00	20.00	12.20	7.80
10	73.60	40.20	23.90	14.90	9.60
20	84.20	47.10	27.70	17.40	11.40
25	87.50	49.20	28.90	18.20	11.90
50	97.90	56.00	32.60	20.70	13.60
100	108.20	62.60	36.30	23.20	15.30

Prepared by:

The HYDROMETEOROLOGICAL INVESTIGATIONS and SPECIAL STUDIES SECTION

Flood Forecasting Branch, PAGASA

(3) Hydrologic Study

1) Design Criteria

The method used in computing the discharge was selected based on the size of the catchment area. The following criteria were used;

Catchment area	Method
0 – 20 km2	Rational Fomula
> 20 km2	JICA Study 1982 (Rio Chico River and Talavera River)

2) Rational Formula

The Rainfall Formula is the simplest method in estimation maximum discharge. This is widely applied when the catchment are is less than $20km^2$.

The formula is;

$$\mathbf{Q = 0.278\ CIA} \quad (\text{in } m^3/\text{sec})$$

Where

Q = discharge in cubic meters per second

C = coefficient of runoff which depends on the topographical character of the drainage area

I = Rainfall intensity in mm/hr for a duration equal to the time of concentration

A = Drainage are in Km^2

3) Catchment or Drainage Areas

The preferred alignment was plotted on the topographic maps. Eighteen (18) natural waterways were identified along the alignment. The catchment areas for each water way was delineated. A catchment area is defined as the limits of the topographic divide which is the line that separates water flow between basins. Other hydrologic parameters such as length of waterway and difference of elevation are identified. Figure ** shows the delineated catchment areas.

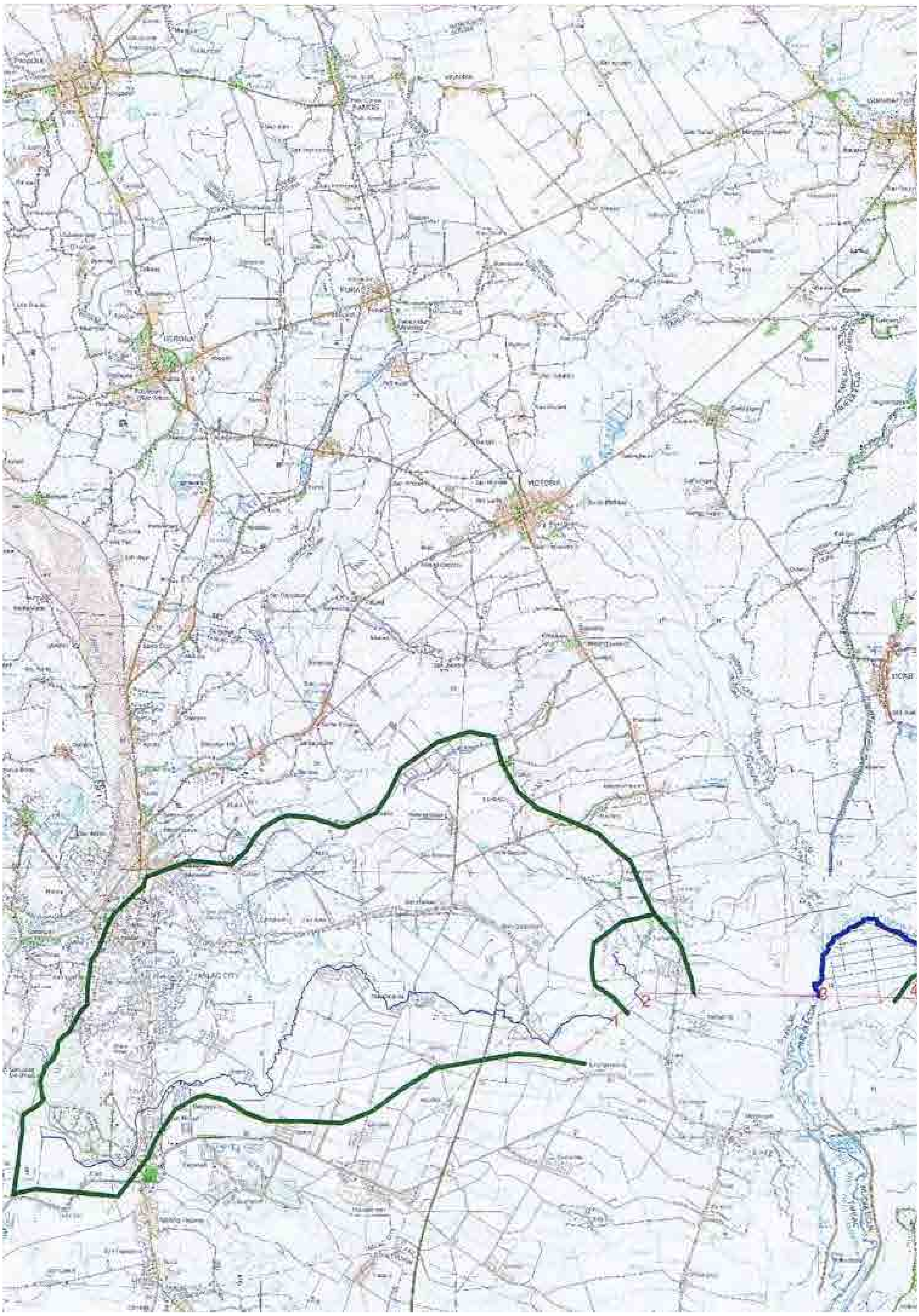


FIGURE 6.3.2-1 CATCHMENT AREA (1/2)

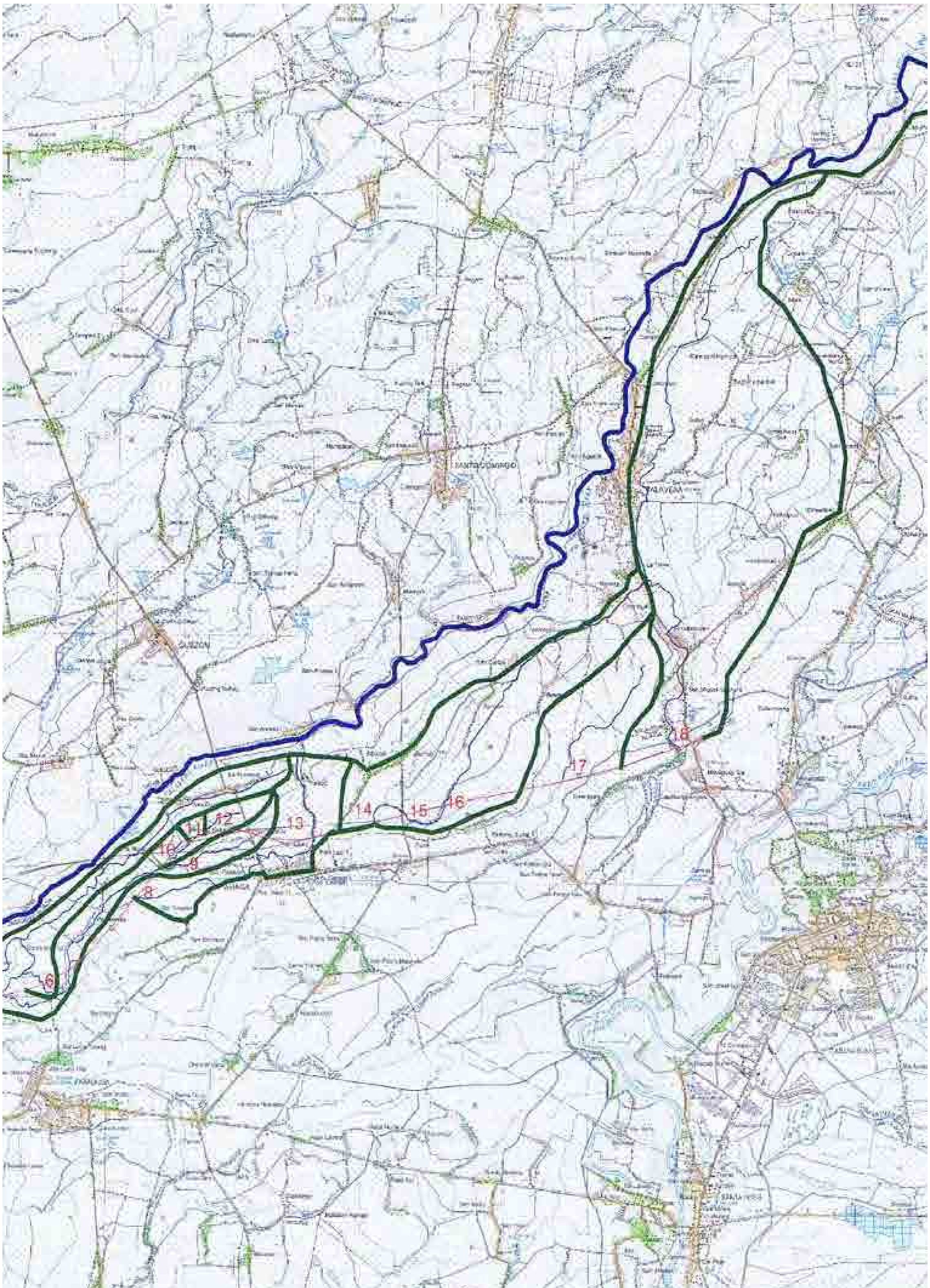


FIGURE 6.3.2-1 CATCHMENT AREA (2/2)

4) Rainfall Analysis

The rainfall data from PAGASA was converted into a simple equation in the form:

Where:

I = Rainfall Intensity, mm/hr
t = duration of rain in hours or minutes
A,B and c are constants determined from the curves

Converting the data into formula form makes it easier to compute the corresponding rainfall value for different values of the time of concentration. The result of the analysis are as follows;

Station	Return Period	A	b	c
Cabanatuan	2	977.38	0.7168	9.3
	5	1275.6	0.6951	8.4
	10	1477.9	0.6878	8.0
	15	1605.0	0.6847	8.0
	20	1868.5	0.6970	9.2
	25	1945.6	0.6957	9.2
	50	1963.7	0.6793	7.8
	100	2176.8	0.6777	7.8
Munoz, Nueva Ecija	2	1178.1	0.7691	-6.0
	5	1156.7	0.7241	-9.0
	10	1219.3	0.7082	-9.0
	20	1238.6	0.6906	-10.0
	25	1266.5	0.6887	-10.0
	50	1337.5	0.6809	-10.0
	100	1410.5	0.6745	-10.0
Pantabangan	2	1151.9	0.7469	15
	5	1475.7	0.7195	21
	10	1880.2	0.7238	28
	20	1986.6	0.7078	27
	25	2091.6	0.7089	28
	50	2353.9	0.7067	30
	100	2628.6	0.7055	32

5) Time of concentration

The time of concentration, Tc, is the required time for the stream under consideration to reach its peak discharge and could be computed using the formula developed by Kirpich as shown below;

$$T_c = \frac{L^{1.15}}{51H^{0.38}}$$

Where:

Tc = Time of concentration in minutes
L = Length of longest water course in the watershed in meter
H = Difference in elevation between the highest point of the watershed and the point under consideration in meters

Rainfall Intensity Curve is shown in **Figure 6.3.2-1**

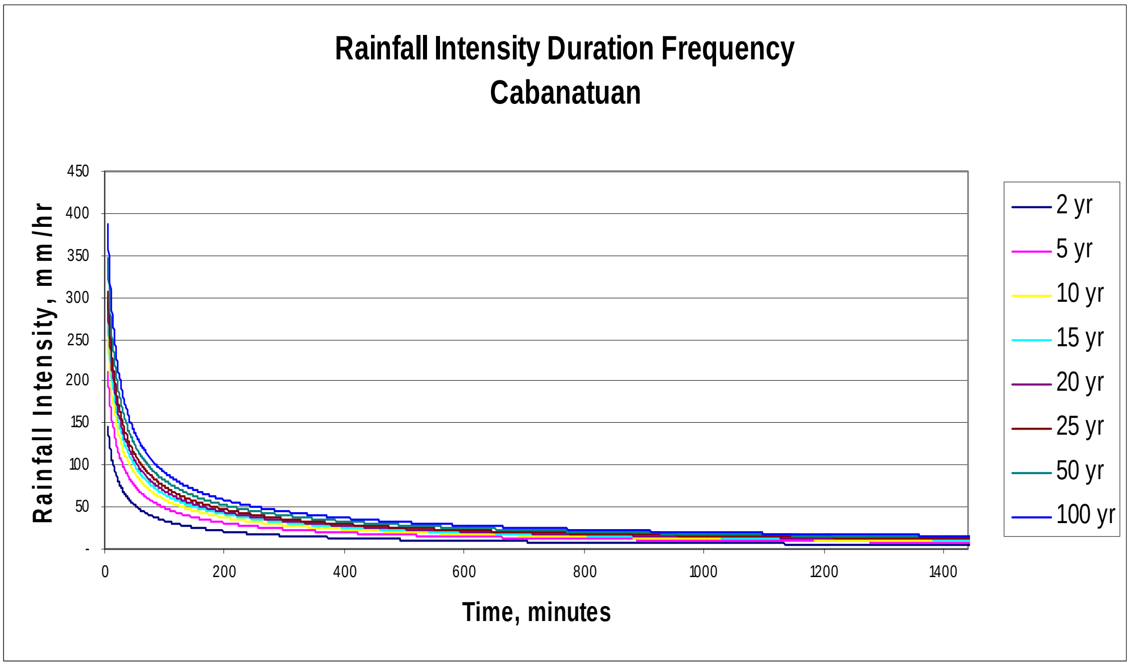


FIGURE 6.3.2-1 (1) RAINFALL INTENSITY FREQUENCY (CABANATUAN)

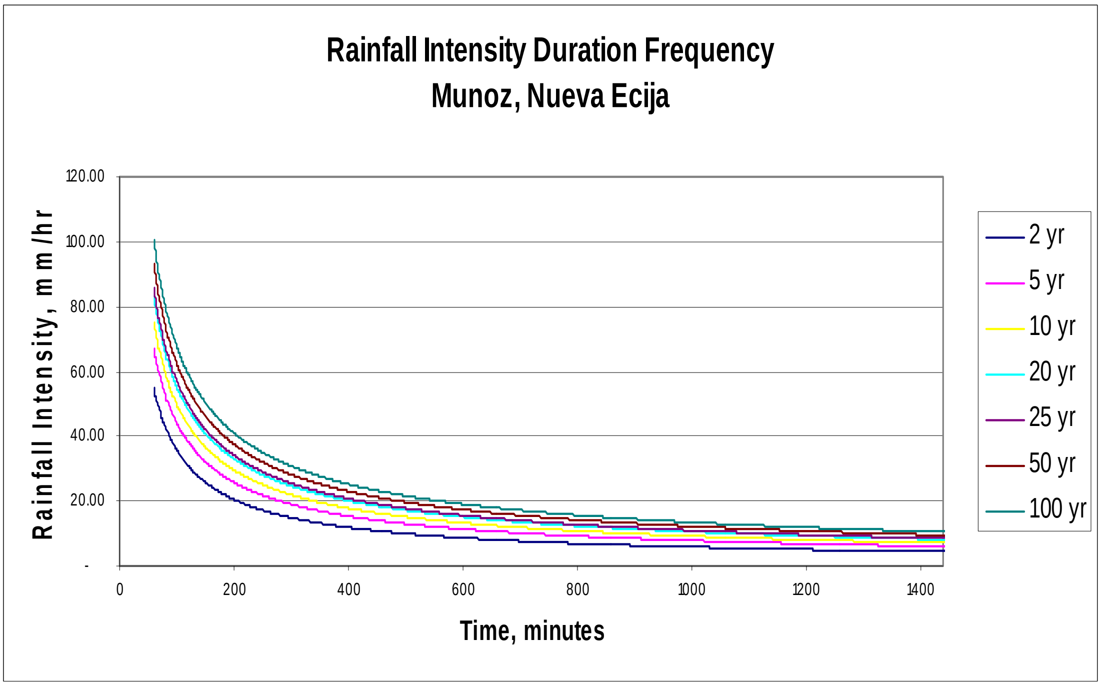


FIGURE 6.3.2-1 (2) RAINFALL INTENSITY FREQUENCY (MUNOZ, NUEVA ECIJA)

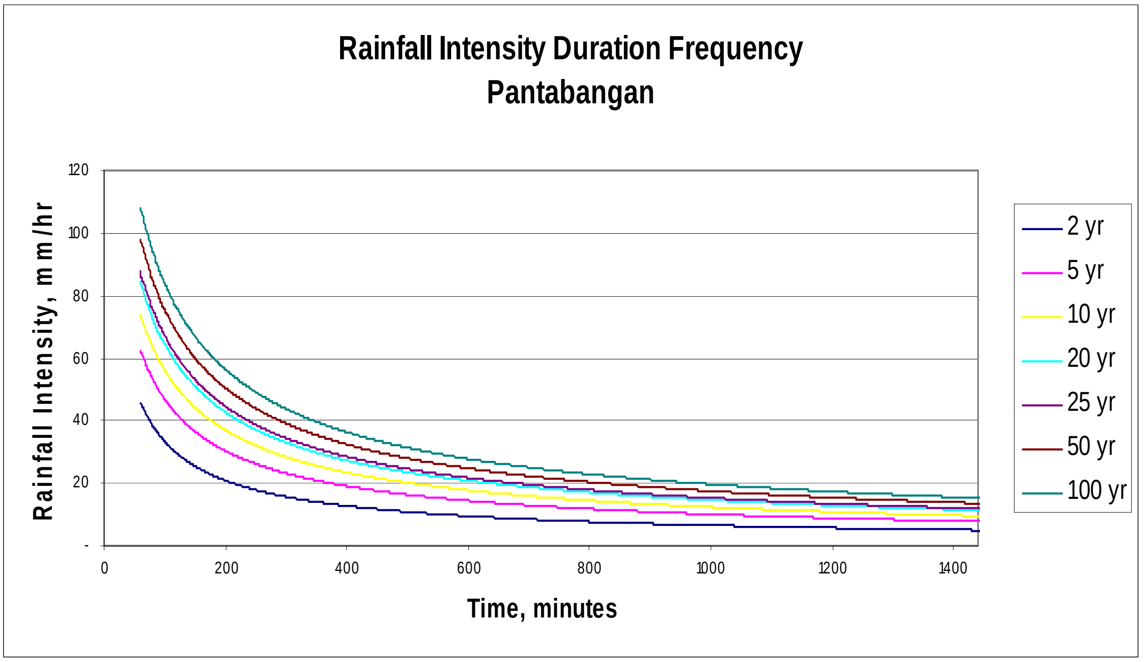


FIGURE 6.3.2-1 (3) RAINFALL INTENSITY FREQUENCY (PANTABANGAN)

6) Runoff Coefficient

The coefficient of runoff "C" is expressed as a percentage to which the peak runoff is reduced due to transitory storage. It varies according to the surface condition, slope, soil nature and rainfall duration in the drainage area. (**Table 6.3.2-1**)

TABLE 6.3.2-1 VALUES OF "C" FOR USE IN THE RATIONAL FORMULA

DPWH Vol. II

Surface	Value Proposed
Concrete or Asphalt Pavement *	0.9-1.0
Bituminous Macadam and Double Bituminous	
Surface Treatment (Sandy to Clay)	0.7-0.9
Gravel Surface Road and Shoulder	0.3-0.6
Residential Area - City	0.3-0.6
Residential Area – Town and Village	0.2-0.5
Rocky Surface	0.7-0.9
Bare Clay Surface (faces of slips, etc.)	0.7-0.9
Forested Land (Sandy to Clay)	0.3-0.5
Flattish Cultivated Area (not flooded)	0.3-0.5
Steep or Rolling Grassed Areas	0.5-0.7
Flooded or Wet Paddies	0.7-0.8

Adopted from BOD Guidelines, Table 4.11

7) Synthetic Unit Hydrograph

The Unit Hydrograph for each catchment area in the project was derived using the fifty (50) years rainfall intensity of Nueva Ecija as the design storm rainfall and the US Soil Conservation Service (USCS) Dimensionless Unit Hydrograph shown in Figure. A.2.

Each Unit Hydrograph was developed following the procedures below:

(a) Determine Elements of the unit Hydrograph by Snyder's Modified Lag Equation shown below:

1. The lag time (Lg), in hours based on Snyder's Modified Lag Equations are:

$$Lg = 0.6865\ (Ct) \left[\frac{L \times Lca}{\sqrt{S}} \right]^{0.38}$$

Where:

Lg	=	lag time, in hours
Ct	=	lag time coefficient
L	=	Length of watercourse from the drainage divide line to the point of interest, in km.
Lca	=	Length of watercourse perpendicular to the watershed centroid to the point of interest, in km.
S	=	Average basin slope.

2. Compute the rainfall duration (D or tr), in hours, which should be equal to one fourth (1/4) or less of lag time

$$D = tr = \frac{Lg}{5.5} \text{ in hours}$$

3. Time to peak in Hours, tp

$$tp = Lg + ½ (tr)$$

4. Unit Peak Discharge in m3/s, qp

$$qp = \frac{0.278\ Cp\ (D.A.)}{tp}$$

5. Derivation of Unit Hydrograph for subject rivers using US SCS Dimensionless Graph

6. Tabulate ratios of T/Tp and Q/Qp of the US SCS Dimensionless Unit Hydrograph as shown on Figure

7. With computed tp and qp, determine T and Q for the subject rivers

8. Construct unit hydrograph for subject basins

9. Read unit hydrograph ordinates at every time interval, tr.

(b) Derivation of Net Rainfall

1. At every tr (or D) interval, tabulate depth of rainfall from the 50-year rainfall of Nueva Ecija station.

2. Tabulate rainfall increment for each time tr determined as the rainfall difference in succeeding time tr.

3. Rearrange rainfall increment so that the peak or maximum value will be located approximately within the middle third or the two third of the base of the hydrograph reckoned from the origin and plot the hyetograph.

4. Determine rainfall losses at every time tr.

5. Tabulate rainfall excess (net rainfall) for every time tr.

(c) Flood Hydrograph Derivation

1. Compute the flood hydrograph ordinate.

The ordinates of the flood hydrograph are computed by Convolution Method, the equation of which is as follows:

$$Qj = \sum_{i=1}^{j} Pi\ (Uj - i + 1)$$

where:

Qj	=	Run-off at time I in m^3/s
Pi	=	Ordinate of Unit Hydrograph in m^3/s
U_j-1 + 1	=	Excess rainfall at time J-i+1
i	=	number of rainfall excess
j	=	number of unit hydrograph ordinates

The computed value for maximum discharge represents the discharge coming from rainfall during a storm event. To compute the total runoff on the river the baseflow of the river must be added. The baseflow is the flow in the river during ordinary time.

The results of the Rational Formula calculation is presented in **Table 6.3.2-2 to 3 and Figure 6.3.2-3 to 4.**

TABLE 6.3.2-2 RESULT OF THE RATIONAL FORMULA CALCULATION (BASIN NO.1)

D E S I G N   S H E E T

Project : CENTRAL LUZON EXPRESSWAY
Location: Basin No. 1
Item : DERIVATION OF FLOOD HYDROGRAPH
Date :

	tr	U.H.O.	Net Rainfall	Q_{50}
1	1.50	0.018	0.0	0.017
2	3.00	0.091	0.0	0.114
3	4.50	0.193	0.0	0.574
4	6.00	0.339	0.0	2.205
5	7.50	0.521	0.0	7.773
6	9.00	0.725	0.0	22.164
7	10.50	0.932	0.0	43.474
8	12.00	1.078	0.9	72.363
9	13.50	1.176	1.6	107.638
10	15.00	1.213	13.5	146.190
11	16.50	1.190	19.2	183.766
12	18.00	1.118	130.8	211.753
13	19.50	1.021	27.5	229.648
14	21.00	0.913	4.3	236.134
15	22.50	0.804	0.0	231.593
16	24.00	0.683	0.0	218.110
17	25.50	0.597	0.0	199.565
18	27.00	0.513	0.0	178.482
19	28.50	0.451	0.0	157.122
20	30.00	0.390	0.0	134.870
21	31.50	0.342	0.0	117.233
22	33.00	0.293	0.0	101.181
23	34.50	0.256	0.0	88.509
24	36.00	0.220	0.0	76.831
25	37.50	0.189	0.0	66.998
26	39.00	0.159	0.0	57.787
27	40.50	0.139	0.0	50.241
28	42.00	0.120	0.0	43.210
29	43.50	0.106	0.0	37.167
30	45.00	0.092	0.0	31.534

Baseflow: 23.61 m^3/s
Peak Discharge: 236.134
Maximum Q: **259.747** m^3/s

Table 6.3.2-3 Result of the Rational Formula Calculation (Basin No.18)

D E S I G N   S H E E T

Project : CENTRAL LUZON EXPRESSWAY
Location: Basin No. 18
Item : DERIVATION OF FLOOD HYDROGRAPH
Date :

PRELIMINARY CALCULATIONS

	tr	U.H.O.	Net Rainfall	Q_{50}
1	1.50	0.019	0.0	0.017
2	3.00	0.075	0.0	0.100
3	4.50	0.158	0.0	0.521
4	6.00	0.273	0.0	1.880
5	7.50	0.409	0.0	6.842
6	9.00	0.535	0.0	18.171
7	10.50	0.617	0.0	35.075
8	12.00	0.656	0.9	57.123
9	13.50	0.647	1.6	81.959
10	15.00	0.595	13.5	104.711
11	16.50	0.527	19.2	119.989
12	18.00	0.455	130.8	126.799
13	19.50	0.376	27.5	124.923
14	21.00	0.318	4.3	115.651
15	22.50	0.266	0.0	102.737
16	24.00	0.225	0.0	88.751
17	25.50	0.190	0.0	74.234
18	27.00	0.158	0.0	62.492
19	28.50	0.134	0.0	52.434
20	30.00	0.111	0.0	44.297
21	31.50	0.091	0.0	37.358
22	33.00	0.076	0.0	31.184
23	34.50	0.064	0.0	26.242
24	36.00	0.054	0.0	21.855
25	37.50	0.047	0.0	18.008
26	39.00	0.040	0.0	15.030
27	40.50	0.034	0.0	12.595
28	42.00	0.028	0.0	10.722
29	43.50	0.023	0.0	9.162
30	45.00	0.020	0.0	7.865

Baseflow: 12.68 m^3/s
Peak Discharge: 126.799
Maximum Q: **139.479** m^3/s

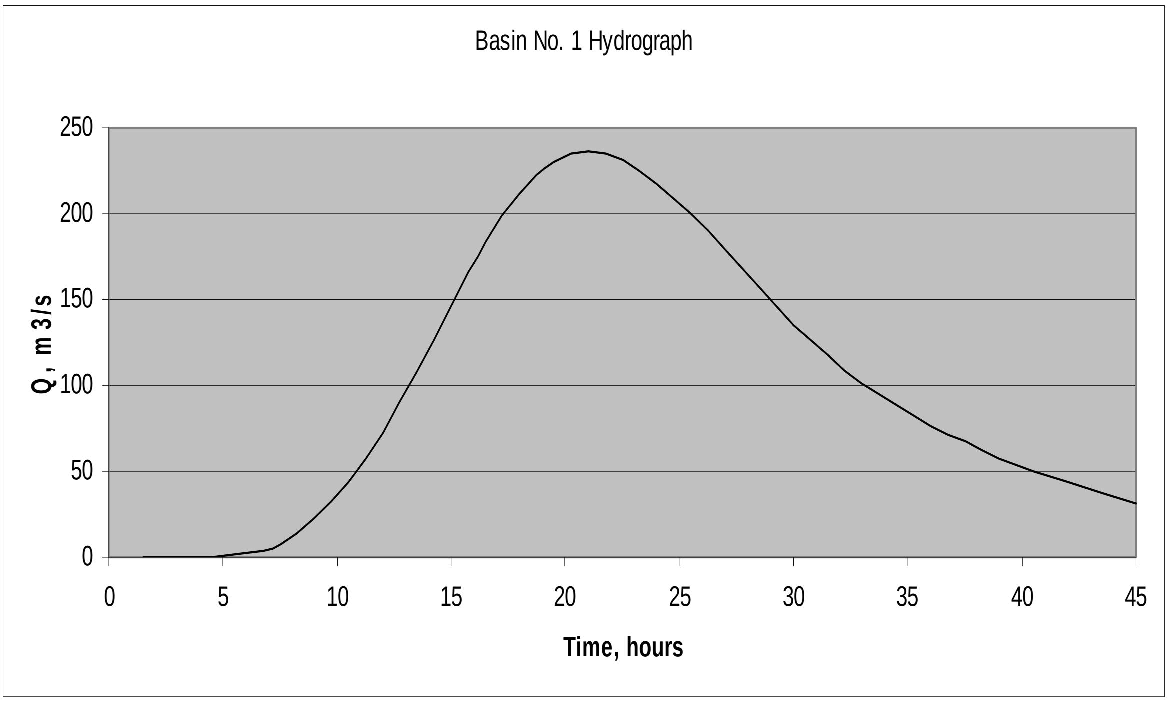


FIGURE 6.3.2-3 RESULT OF THE RATIONAL FORMULA CALCULATION (BASIN NO.1)

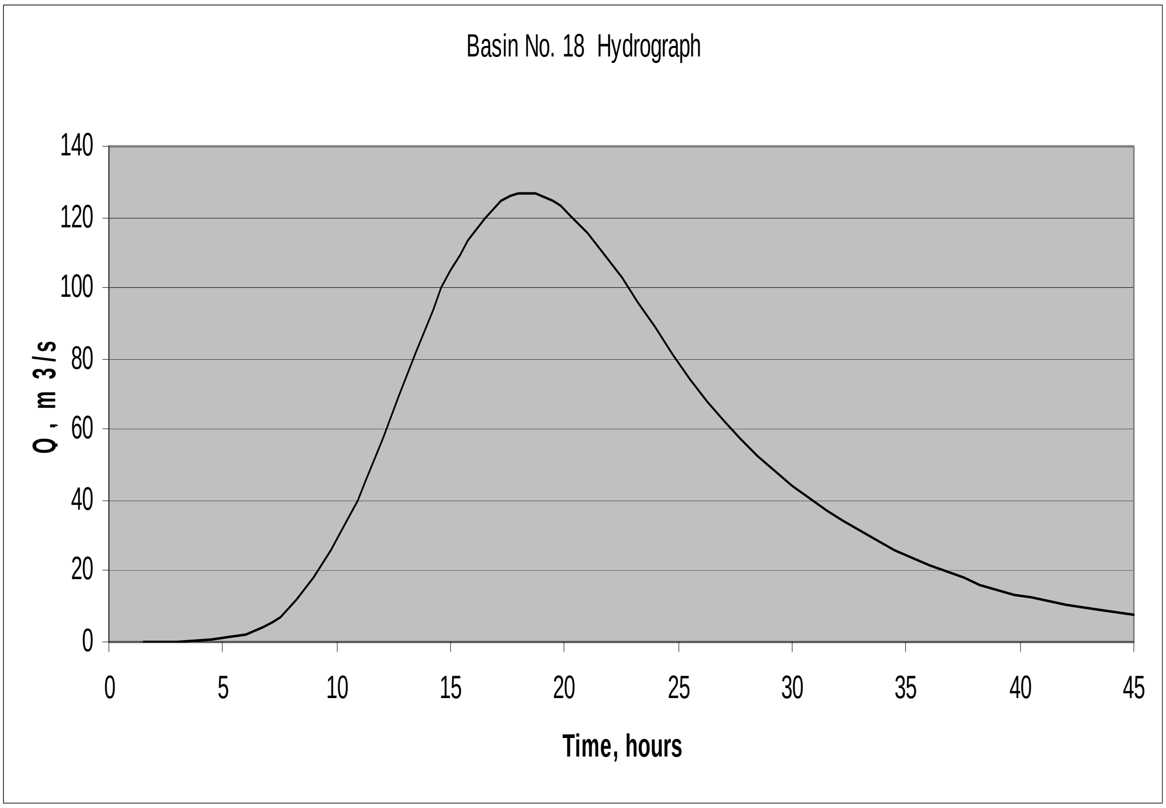


FIGURE 6.3.2-4 RESULT OF THE RATIONAL FORMULA CALCULATION (BASIN NO.18)

8) Rio Chico

Attached is an excerpt from the JICA Study indicating the Fifty (50) Year Maximum Discharge of Rio Chico and Talavera River calculated by storage function method. The sum of the discharges of the two rivers is the design discharge used. Below is the summary of the study:

TABLE 6.3.2-4 DISCHARGE OF RIO CHICO RIVER

Discharge Volume (m3/s)			
	Rio Chico	Talavera	Total
No.	45	41	
100	1,488	1,410	2,898
50	**1,269**	**1,203**	**2,472**
20	985	932	1,917
10	778	735	1,513

Fig. 3.5 RUNOFF CALCULATION MODEL DIAGRAM

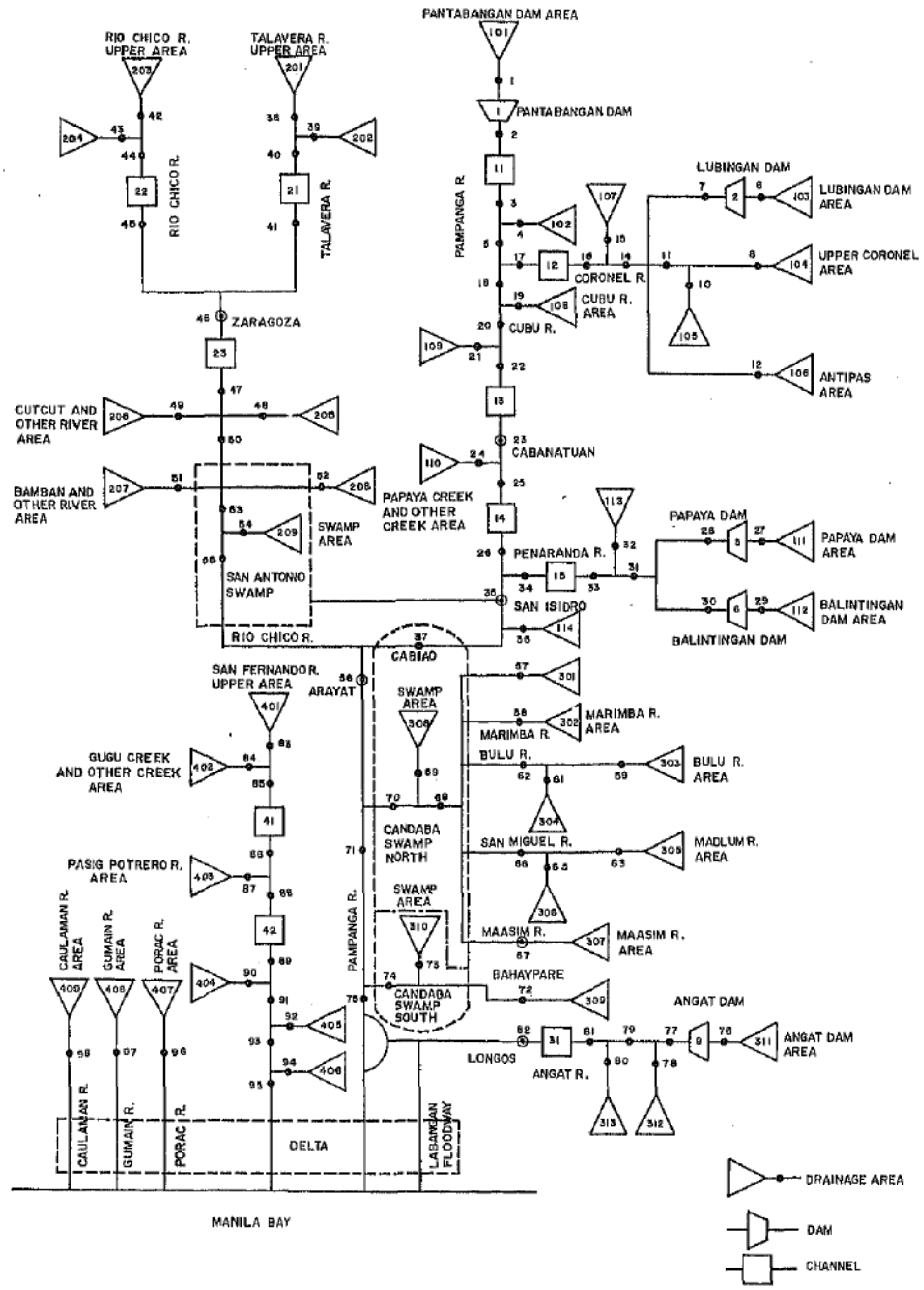


Table 3.10 (2) PEAK DISCHARGE OF PROBABLE FLOOD (continued)

(Unit: m^3/sec)

Calculation Point No.	Location	Return Period (year) 5	10	20	50	100
B. Rio Chico-Talavera Basin						
38		597	926	1,272	1,753	2,140
39		98	146	192	253	300
40		675	1,048	1,436	1,971	2,401
41		502	735	932	1,203	1,410
42		500	722	959	1,279	1,531
43		96	136	173	222	259
44		583	834	1,110	1,482	1,774
45		568	778	985	1,269	1,488
46	Zaragoza	1,061	1,497	1,883	2,422	2,840
47		1,022	1,469	1,863	2,398	2,812
48		86	116	147	186	217
49		241	332	418	528	612
50		1,247	1,816	2,341	3,069	3,605
51		193	285	386	521	627
52		96	133	167	211	243
53		1,485	2,180	2,812	3,667	4,307
54		56	76	97	122	140
55		1,508	2,212	2,853	3,721	4,368
C. Sierra Madre Mountain Basin						
57		26	36	44	55	65
58		88	138	184	239	280
59		24	35	50	74	95
60		24	35	50	74	95
61		87	121	159	211	250
62		106	152	209	282	336
63		41	60	88	127	163
64		41	60	88	127	163
65		154	216	294	423	530
66		190	264	380	546	681
67		59	94	130	172	201
68		466	655	869	1,233	1,520
69		89	117	142	187	228
70		551	764	970	1,393	1,728

9) Hydrological Characteristics of Watershed along CLLEX

The hydrological characteristics studied are shown in **Table 6.3.2-5**.

TABLE 6.3.2-5 HYDROLOGICAL CHARACTERISTICS OF WATERSHEDS

Basin No.	Station	Catchment Area (km2)	Difference in Elevation H (m)	Length of Stream L (m)	Time of Concentration Tc (min)					Runoff Coeff.	Discharge Q (Rational Formula)				JICA Study	Synthetic Unit Hydrograph	Design Q
						2.Yrs. mm/hr	10.Yrs. mm/hr	25 Yrs. mm/hr	50 Yrs. mm/hr		2 Yrs. m^3/s	10 Yrs. m^3/s	25 Yrs. m^3/s	50 Yrs. m^3/s			
1	3+380.00	93.70	37	21599	471.26											259.75	259.75
2	4+220.00	3.88	1	1686	100.78	33.62	58.73	73.95	81.32	0.75	27.22	47.56	59.88	65.84			65.84
3						RIO CHICO									2472		2472.00
4	1+140.00	16.01	5	10020	421.04	12.65	22.86	28.63	31.99	0.75	42.25	76.31	95.59	106.81			106.81
5	11+970.00	2.71	5	8876	366.24	13.95	25.11	31.48	35.10	0.75	7.90	14.21	17.82	19.87			19.87
6	13+000.00	2.36	4	7708	339.31	14.72	26.43	33.15	36.93	0.75	7.24	13.00	16.31	18.17			18.17
7	13+660.00	3.81	4	6344	271.26	17.20	30.71	38.56	42.83	0.75	13.67	24.42	30.66	34.06			34.06
8	16+050.00	6.46	5	7658	309.08	15.71	28.14	35.31	39.29	0.75	21.16	37.90	47.56	52.92			52.92
9	16+930.00	1.73	1	2160	133.95	27.84	48.91	61.56	67.85	0.75	10.04	17.63	22.19	24.46			24.46
10	17+050.00	0.20	5	2628	90.33	36.12	62.96	79.27	87.10	0.75	1.47	2.56	3.23	3.54			3.54
11	17+860.00	1.20	5	1570	49.95	52.42	90.57	113.85	124.83	0.75	13.10	22.63	28.44	31.19			31.19
12	18+020.00	0.90	5	1059	31.76	68.17	117.36	147.01	161.37	0.75	12.81	22.05	27.62	30.32			30.32

TABLE 6.3.2-5 HYDROLOGICAL CHARACTERISTICS OF WATERSHEDS

Basin No.	Station	Catchment Area (km2)	Difference in Elevation H (m)	Length of Stream L (m)	Time of Concentration Tc (min)					Runoff Coeff.	Discharge Q (Rational Formula)				JICA Study	Synthetic Unit Hydrograph	Design Q
						2.Yrs. mm/hr	10.Yrs. mm/hr	25 Yrs. mm/hr	50 Yrs. mm/hr		2 Yrs. m^3/s	10 Yrs. m^3/s	25 Yrs. m^3/s	50 Yrs. m^3/s			
13	20+920.00	3.31	2	2112	99.98	33.80	59.03	74.33	81.72	0.75	23.32	40.73	51.29	56.39			56.39
14	22+430.00	15.67	10	10324	333.69	14.89	26.73	33.53	37.34	0.60	38.93	69.88	87.65	97.63			97.63
15	23+210.00	14.00	9.5	9148	296.18	16.18	28.96	36.34	40.42	0.60	37.77	67.59	84.84	94.35			94.35
16	24+150.00	12.76	8	7820	264.20	17.51	31.25	39.25	43.58	0.60	37.29	66.54	83.56	92.80			92.80
17	27+040.00	6.44	3	4030	179.79	22.82	40.34	50.74	56.09	0.60	24.50	43.32	54.48	60.23			60.23
18	29+990.00	41.68	22	16280	415.91											139.48	139.48

(4) Hydraulic Analysis

1) Manning's Formula

For open channel, the calculation of Discharge, Q is based on the river properties such as cross-sectional area, perimeter and slope. Manning's Formula is of the form:

$$V = \frac{R^{2/3} S^{1/2}}{n}$$

$$Q = AV$$

Where:

V = velocity in m/s

Q = discharge in m^3/s

A = cross-sectional area of water in m^2

R = hydraulic radius in m.

= A 1

P

P = wetted perimeter in m.

S = slope

n = coefficient of roughness tabulated below

2) Values of Manning's Roughness Coefficient "n"

Surface / Description	Range	
	Minimum	Maximum
1. Natural stream channels (top flood width less than 30 m.	0.030	0.035
i. Fairly regular section:		
a. Some grass and weeds, little or no brush	0.035	0.050
b. Dense growth of weeds, depth of flow materially greater than weed height	0.035	0.050
c. Some weeds, light brush on banks	0.050	0.530
d. Some weeds, heavy brush on banks	0.050	0.070
e. Some weeds, dense trees	0.050	0.070
f. For trees within channel, with branches submerged at high flood increase all above values by	0.010	0.020
ii. Irregular sections, with pools, slight channel meander; increase values given above about	0.01	0.02
iii. Mountain streams, no vegetation in channel banks usually steep, trees and brush along banks submerged at high flood:		
a. Bottom of gravel, cobbles, and few boulders	0.040	0.050
b. Bottom of cobbles, with large boulders	0.050	0.070
2. Larger stream channels (top flood width greater than 30 m.)		
Reduce smaller coefficient by 0.010		
3. Flood plain (adjacent to stream beds)		
Pasture, short grass, no brush	0.030	0.035
Pasture, tall grass, no brush	0.035	0.050
Cultivated land – no crop	0.030	0.040
Cultivated land – nature field crops	0.045	0.055
Scrub and scattered bush	0.050	0.070
Wooded	0.120	0.160
4. Man-made channels and ditches		
Earth, straight and uniform	0.017	0.025
Grass covered	0.035	0.050
Dredged	0.025	0.033
Stone lined and rock cuts, smooth & uniform	0.025	0.033
Stone lined and rock cuts, rough and irregular	0.035	0.045
Lined – metal corrugated	0.021	0.024
Lined – smooth concrete	0.012	0.018
Lined – grouted riprap	0.017	0.030
5. Pipes		
Cast Iron	0.011	0.015
Wrought Iron	0.012	0.017
Corrugated Steel	0.021	0.035
Concrete	0.010	0.017

3) Results of the Hydraulic Analysis

Results of the hydraulic analysis are shown in **Table 6.3.2-6 to 8** and **Figure 6.3.2-5 to 7**.

TABLE 6.3.2-6 RIO CHICO RIVER

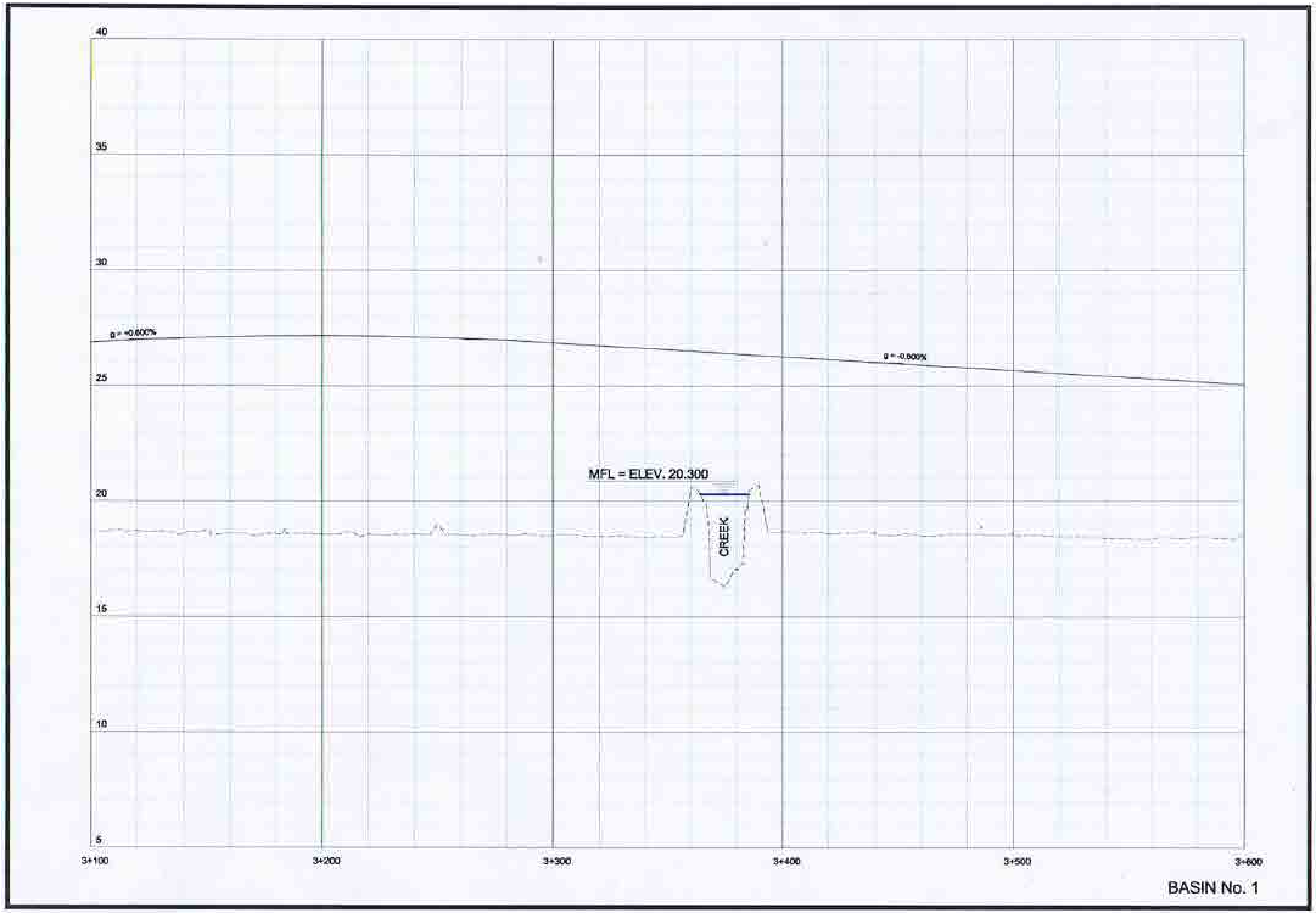
Elevation m	Area m2	Perimeter m	n	Slope	Velocity m/s	Capacity m3/s
17.00	7869.23	3483.98	0.12	0.0003	0.24	1908.19
17.30	8913.86	3485.78	0.12	0.0003	0.26	2347.98
17.40	**9262.19**	**3486.50**	**0.12**	**0.0003**	**0.27**	**2502.54**
17.50	9610.59	3487.37	0.12	0.003	0.28	2660.95

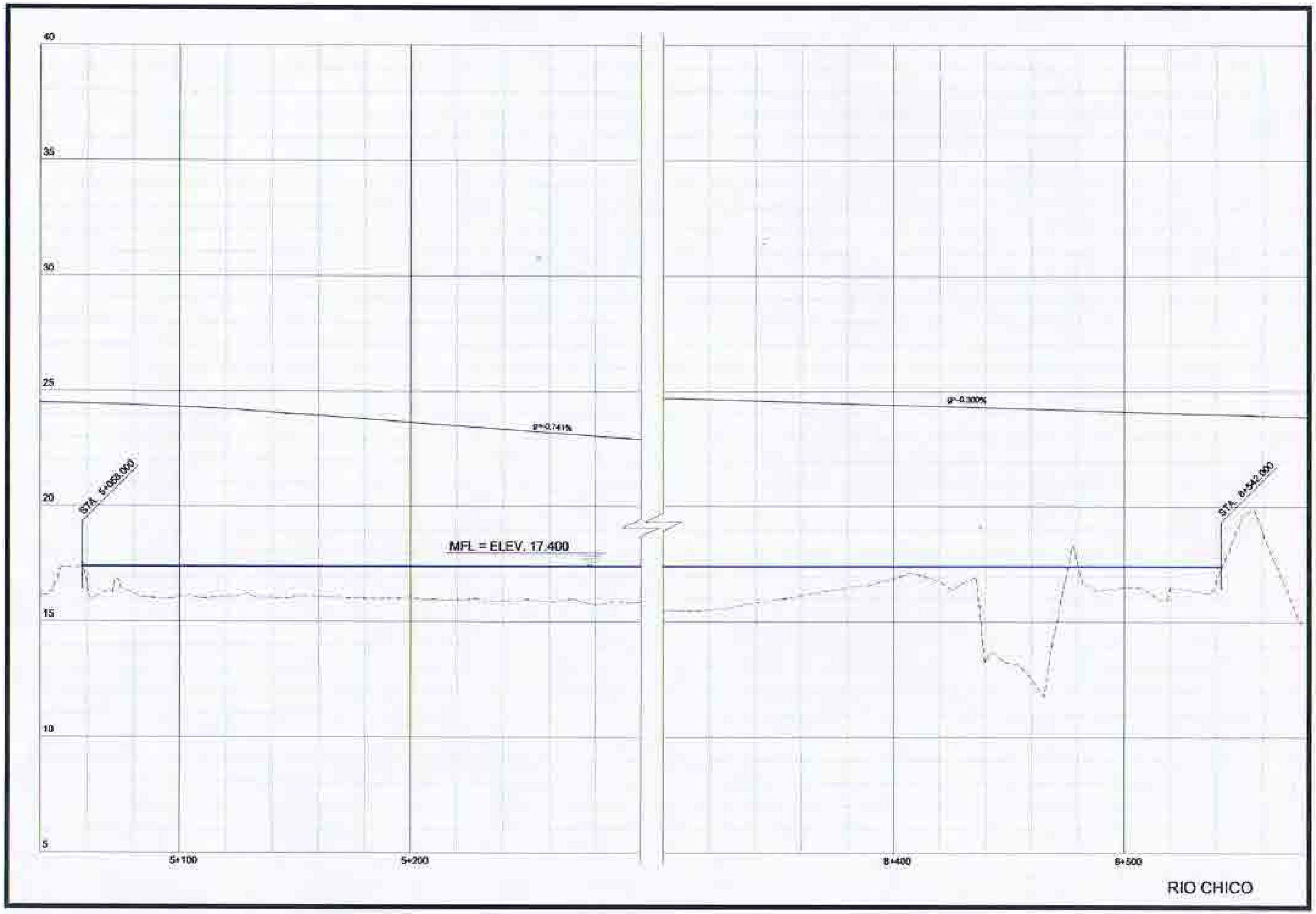
TABLE 6.3.2-7 BASIN NO. 1

Elevation m	Area m2	Perimeter m	n	Slope	Velocity m/s	Capacity m3/s
19.00	104.82	257.93	0.04	0.003	0.23	24.30
20.00	489.90	426.01	0.04	0.003	0.46	227.23
20.10	**532.41**	**426.53**	**0.04**	**0.003**	**0.49**	**260.83**
20.50	702.93	429.38	0.04	0.003	0.59	412.60

TABLE 6.3.2-8 BASIN NO. 18

Elevation m	Area m2	Perimeter m	n	Slope	Velocity m/s	Capacity m3/s
31.00	0.232	4.12	0.04	0.005	0.26	0.06
32.00	21.73	39.00	0.04	0.005	1.20	26.01
32.70	**151.07**	**322.60**	**0.04**	**0.005**	**1.07**	**161.20**
33.00	248.86	331.32	0.04	0.005	1.46	362.60


40
35
30
25
20
15
10
5
g = -0.600%
MFL = ELEV. 20.300
CREEK
3+100
3+200
3+300
3+400
3+500
3+600
BASIN No. 1



40
35
30
25
20
15
10
5
g=-0.741%
g=-0.300%
STA. 5+058.000
STA. 8+542.000
MFL = ELEV. 17.400
5+100
5+200
8+400
8+500
RIO CHICO

40
35
30
25
20
15
CANAL
CREEK
MFL = ELEV. 32.700
29+800
29+900
30+000
30+100
30+200
30+300
BASIN No. 18

(5) Drainage Design Frequency

The design storm frequency adopted for this project is shown in **Table 6.3.2-9** by recommendation in DPWH Design Guidelines Criteria and Standards Volume II (p697).

TABLE 6.3.2-9 DESIGN FREQUENCY BY ROAD STRUCTURE

Structure	Return Period (year)
Bridge	1/50
Box Culvert	1/25
Earth Embankment	1/10
Pipe Culvert	1/10
Road Structure Drainage	1/2
Road side drainage	1/2

Source: DPWH

(6) Design Flood Level

The area between SCTEX and Aliaga is known as flood prone area (more detail is described in Section 6.3.5). Water from Rio Chico River overflows and causes flood frequently.

In the profile design of this section, two (2) design flood level was considered to determine the finished grade, namely 1) Medium Flood Water Level (MFWL) and 2) HWL (High Water Level).

6.3.3 Crossing Road and Water Way Design

(1) Technical Approach

In order to maintain the present accessibility after the construction of the highway, crossing road (under the highway or overpass the highway) and service road are designed.

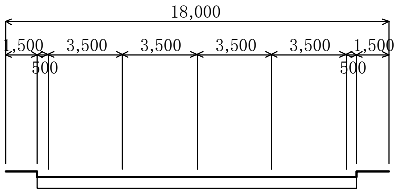
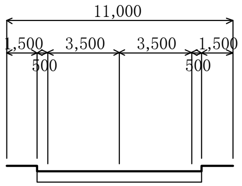
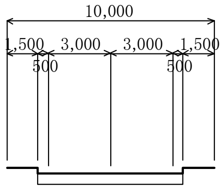
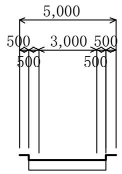
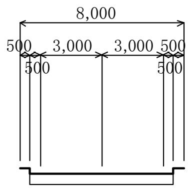
Technical approach of the design is described as below;

(1) To provide crossing road to maintain present accessibility after the construction
(2) To provide enough road width considering future widening if any.
(3) To provide enough vertical clearance in accordance with road category

(2) Typical Condition of Crossing Road

Cross sectional configuration of the crossing road and vertical clearance is designed According to present condition of the road, as shown in **Table 6.3.3-1.**

TABLE 6.3.3.-1 CROSS SECTIONAL CONFIGURATION OF CROSSING ROAD

No	Road Category	Road width (m)	Cross Sectional Configuration	Vertical Clearance (m)	Remark
1	National Road/ Municipality Road to be widened	18.0m		5.2m Vertical clearance (4.9m) + overlay(0.3m)=5.2m	Pan Philippine Highway Sta.Roas-Tarlac RD Cabanatuan BP
2	National Road / Provincial Road not to be widened	10.0m		5.2m Vertical clearance (4.9m) + overlay(0.3m)=5.2m	La Paz- Victoria RD Gumba-Aliaga RD
3	Municipality Road	10.0m		4.0 m Vertical clearance (3.8m) +Over ray(0.2m) =4.0m	
4	Farm road / BRGY Road (1lane)	5.0m		4.0 m Vertical clearance (3.8m) +Over ray(0.2m) =4.0m	
5	Farm road / BRGY Road (2 lane)	8.0m		4.0 m Vertical clearance (3.8m) +Over ray(0.2m) =4.0m	

(3) Typical Condition of Crossing Water Way

Table 6.3.3-2 shows Typical condition of crossing water way.

TABLE 6.3.3-2 TYPICAL CONDITION OF CROSSING WATER WAY

Category of water way	Crossing Condition	Structure
River	Discharge Volume (50years) <80m3/s	RCBC with free board
	Discharge Volume(50 years)>80m3/s	Bridge with free board
	Existing Water Way Width >10m	Bridge with free board
Irrigation Canal	Keep the same or more cross section of existing canal	Varies with free board

Table 6.3.3-3 shows Freeboard allowance of water way.

TABLE 6.3.3-3 FREEBOARD ALLOWANCE

No	Design Discharge Q (m3/s)	Free board (m)
1	Less than 200	0.6m
2	200 to less than 500	0.8m
3	500 to less than 2,000	1.0m
4	2000 to less than 5,000	1.2m
5	5000 to less than 10,000	1.5m
6	More than 10,000	2.0m

(4) List of crossing road and water way

List of crossing road and water way is shown in **Table 6.3.3-4 to Table 6.3.3-7**.

TABLE 6.3.3-4 LIST OF BRIDGE

Package	No.	Station	Length (m)	No. of Span(s)	Span Arrangement	Angle (degrees)	Bridge Type	Crossing Object		Remarks
Main Carriageway Bridge										
Package 1	1	-0 + 024.4 - 0 + 035.6	60.0	2	30+30	80.00	AASHTO Girder V	Road	SCTEX Junction (Ramp Bridge)	
	2	1 + 875.0 - 1 + 899.0	24.0	1	24	115.00	RCDG	Road	(National Road) Sta. Rosa - Tarlac Road	
	3	3 + 358.0 - 3 + 393.0	35.0	1	35	115.00	AASHTO Girder V	River	Tin Tin River	
	4	7 + 528.0 - 9 + 033.0	1,505.0	43	43@35	90.00	AASHTO Girder V	River	Rio Chico River	
	5	11 + 107.0 - 11 + 179.0	72.0	3	3@24	115.00	RCDG	River	Natural creek	
Package 2	6	29 + 971.0 - 30 + 006.0	35.0	1	35	105.00	AASHTO Girder V	River	Natural creek	
	7	30 + 255.0 - 30 + 325.0	70.0	2	35+35	90.00	AASHTO Girder V	Road	(Local Road) Cabanatuan Bypass (National Road) Pan-Philippines Highway	West Bound
		30 + 245.0 - 30 + 330.0	85.0	3	30+25+30	90.00	AASHTO Girder V			East Bound
Crossover Bridge for Main Carriageway										
Package 2	8	23 + 108.0	60.0	2	30+30	100.00	AASHTO Girder V	Road	CLLEX main expressway	
	9	25 + 840.0	60.0	2	30+30	90.00	AASHTO Girder V	Road	CLLEX main expressway (Cabanatuan Half IC Ramp Bridge)	

TABLE 6.3.3-5 LIST OF RCBC OF ROADWAY

Package	No.	Station	Crossing Object	Skew (degrees)	Dimensions			Remarks
					Barrel(s)	Inner Section (mm)		
						Width	Height	
Package 1	1	2 + 935	Farm road	138.00	1	5,000	4,600	
	2	3 + 830	Municipal road (paved)	135.00	1	8,000	4,600	
	3	4 + 554	Municipal road (paved) with irrigation canal	70.00	1	8,000	6,000	
	4	5 + 050	National Road: La Paz - Victoria Road (paved) with natural creek	78.00	1	16,000	8,000	
	5	6 + 788	Municipal road (earth)	90.00	1	5,000	4,600	
	6	9 + 100	Farm road	105.00	1	5,000	4,600	
	7	9 + 388	Farm road	100.00	1	5,000	4,600	
	8	10 + 102	Farm road	103.00	1	5,000	4,600	
	9	10 + 268	Municipal road (earth) with natural creek	40.00	1	12,000	6,000	
	10	10 + 448	Farm road with irrigation canal	92.00	1	8,000	6,000	
	11	10 + 858	Farm road with irrigation canal	65.00	1	8,000	6,000	
	12	11 + 002	Municipal road (earth)	85.00	1	8,000	4,600	
Package 2	13	11 + 888	Farm road with irrigation canal	145.00	1	8,000	6,000	
	14	12 + 248	Farm road	67.00	1	5,000	4,600	
	15	12 + 598	Farm road	82.00	1	5,000	4,600	
	16	12 + 988	Farm road with irrigation canal	80.00	1	8,000	6,000	
	17	13 + 682	Municipal road (earth) with natural creek	55.00	1	12,000	6,000	
	18	14 + 688	Farm road with irrigation canal	86.00	1	8,000	6,000	
	19	15 + 653	Farm road with irrigation canal	60.00	1	8,000	6,000	
	20	17 + 021	Farm road	87.00	1	5,000	4,600	
	21	19 + 388	Municipal road - Guimba - Aliaga Road (paved)	123.00	1	11,000	5,800	
	22	19 + 715	Aliaga Interchange	90.00	2	9,000	5,800	
	23	20 + 948	Municipal road (paved)	80.00	1	11,000	4,600	
	24	21 + 248	Municipal road (paved)	33.00	1	11,000	4,600	
	25	24 + 098	Farm road with irrigation canal	60.00	1	12,000	6,000	
	26	26 + 348	Municipal road (earth) with irrigation canal	75.00	1	12,000	6,000	
	27	26 + 528	Farm road with irrigation canal	65.00	1	8,000	6,000	
	28	27 + 748	Municipal road (paved) with irrigation canal	45.00	1	16,000	6,800	
	29	29 + 918	Municipal road (paved) with irrigation canal	100.00	1	16,000	8,000	

TABLE 6.3.3-6 LIST OF RCBC OF RIVER AND IRRIGATION

Package	No	Station	Crossing Object	Skew (degrees)	Dimensions			Remarks
					Nos. of Barrel(s)	Inner Section (mm)		
						Width (m)	Height (m)	
Package 1	1	0 + 566	Irrigation canal	90.00	1	3,000	2,400	
	2	1 + 220	Irrigation canal	85.00	1	3,000	2,400	
	3	4 + 220	Irrigation canal	95.00	1	3,000	2,400	
	4	9 + 665	Irrigation canal	100.00	2	3,000	2,400	
Package 2	5	11 + 988	River - Natural creek	145.0	1	3,000	2,400	
	6	15 + 858	Irrigation canal	120.00	1	2,400	2,100	
	7	16 + 050	River - Natural creek	75.00	3	3,000	2,750	
	8	16 + 928	River - Natural creek	120.00	2	2,400	2,400	
	9	17 + 060	River - Natural creek	135.00	1	2,400	1,800	
	10	17 + 860	River - Natural creek	75.00	2	3,000	2,100	
	11	18 + 510	Irrigation canal	120.00	1	2,400	2,100	
	12	20 + 920	River - Natural creek	75.00	3	3,000	2,400	
	13	22 + 428	Irrigation canal	90.00	2	2,400	2,100	
	14	23 + 210	Irrigation canal	120.00	2	2,400	2,100	
	15	24 + 148	Irrigation canal	90.00	1	3,000	2,400	
	16	24 + 428	Irrigation canal	35.00	1	3,000	2,400	
	17	25 + 588	Irrigation canal	110.00	1	2,400	2,100	
	18	25 + 768	Irrigation canal	47.00	1	3,000	2,400	
	19	0 + 205	Irrigation canal	85.00	1	3,000	2,400	Cabanatuan Half IC STA.
	20	0 + 380	Irrigation canal	80.00	1	3,000	2,400	Cabanatuan Half IC STA.
	21	0 + 400	Irrigation canal	75.00	1	3,000	2,400	Cabanatuan Half IC STA.
	22	27 + 038	River - Natural creek	40.00	3	3,000	2,750	
	23	28 + 148	Irrigation canal	35.00	2	2,400	2,100	

TABLE 6.3.3-7 LIST OF RCBC (EQUALIZATION ZONE)

RCBC Dimension: 1barrel - 3.0m x 3.0m

Package	No	Station	Crossing Object	Skew (degrees)	Dimensions			Remarks
					Barrel(s)	Width (m)	Height (m)	
Package 1		*6 + 788*	*Municipal Road (earth)*	*90.00*	*1*	*5.00*	*4.60*	
	1	6 + 888	River - RCBC for equalizing zone	90.00	1	3.00	3.00	
	2	6 + 988	River - RCBC for equalizing zone	90.00	1	3.00	3.00	
	3	7 + 088	River - RCBC for equalizing zone	90.00	1	3.00	3.00	
	4	7 + 188	River - RCBC for equalizing zone	90.00	1	3.00	3.00	
	5	7 + 288	River - RCBC for equalizing zone	90.00	1	3.00	3.00	
	6	7 + 388	River - RCBC for equalizing zone	90.00	1	3.00	3.00	
	7	7 + 488	River - RCBC for equalizing zone	90.00	1	3.00	3.00	
		7 + 528	*Rio Chico River*	*Rio Chico River Bridge A1 Abutment*				
		9 + 033		*Rio Chico River Bridge A2 Abutment*				
		9 + 100	*Farm road (earth)*	*105.00*	*1*	*5.00*	*4.60*	
	8	9 + 196	River - RCBC for equalizing zone	90.00	1	3.00	3.00	
	9	9 + 292	River - RCBC for equalizing zone	90.00	1	3.00	3.00	
		9 + 388	*Farm road (earth)*	*100.00*	*1*	*5.00*	*4.60*	
	10	9 + 480	River - RCBC for equalizing zone	90.00	1	3.00	3.00	
	11	9 + 572	River - RCBC for equalizing zone	90.00	1	3.00	3.00	
		9 + 665	*Irrigation canal*	*100.00*	*2*	*3.00*	*2.40*	
	12	9 + 774	River - RCBC for equalizing zone	90.00	1	3.00	3.00	
	13	9 + 884	River - RCBC for equalizing zone	90.00	1	3.00	3.00	
	14	9 + 993	River - RCBC for equalizing zone	90.00	1	3.00	3.00	
		10 + 102	*Farm road (earth)*	*103.00*	*1*	*5.00*	*4.60*	
	15	10 + 185	River - RCBC for equalizing zone	90.00	1	3.00	3.00	
		10 + 268	*Municipal Road (earth) with Natural Creek*	*40.00*	*1*	*12.00*	*6.00*	
	16	10 + 358	River - RCBC for equalizing zone	90.00	1	3.00	3.00	
		10 + 448	*Farm road (earth) with irrigation canal*	*95.00*	*1*	*8.00*	*6.00*	
	17	10 + 551	River - RCBC for equalizing zone	90.00	1	3.00	3.00	
	18	10 + 653	River - RCBC for equalizing zone	90.00	1	3.00	3.00	
	19	10 + 756	River - RCBC for equalizing zone	90.00	1	3.00	3.00	
		10 + 858	*Farm road (earth) with irrigation canal*	*65.00*	*1*	*8.00*	*6.00*	
	20	10 + 930	River - RCBC for equalizing zone	90.00	1	3.00	3.00	
		11 + 002	*Municipal road (earth)*	*85.00*	*1*	*8.00*	*5.80*	
		11 + 107	*River Bridge*	*A1 Abutment*				
		11 + 179		*A2 Abutment*				
Package 2	21	11 + 280	River - RCBC for equalizing zone	90.00	1	3.00	3.00	
	22	11 + 381	River - RCBC for equalizing zone	90.00	1	3.00	3.00	
	23	11 + 482	River - RCBC for equalizing zone	90.00	1	3.00	3.00	
	24	11 + 583	River - RCBC for equalizing zone	90.00	1	3.00	3.00	
	25	11 + 684	River - RCBC for equalizing zone	90.00	1	3.00	3.00	
	26	11 + 785	River - RCBC for equalizing zone	90.00	1	3.00	3.00	
		11 + 888	*Footpath (earth) with irrigation canal*	*145.00*	*1*	*8.00*	*6.00*	
		11 + 988	*River - Natural creek*	*145.00*	*1*	*3.0*	*2.4*	

6.3.4 Vertical Control

(1) Technical Approach

The Express highway is situated in the very flat plane land. The profile was studied in accordance with following orientations;

1) To Minimize Construction Cost: The embankment height shall be minimum while providing sufficient clearance at road and water way crossing points.

2) To Secure from Flood: The minimum finished grade shall be determined in accordance with present and past flood in order to be secured from flood.

3) To Secure smoothness of drive: The minimum distance between PI point of vertical profile shall be 500m in order to secure smoothness of drive.

4) To accommodate surface drainage: It is also important to accommodate surface drainage to secure drivers safety during rain. The minimum vertical gradient is set as 0.3% for this reason.

(2) Minimum Embankment Height

The most parts of the present surface of the land is paddy filed. The minimum embankment height is set as **1.5m**. This is to secure stability of embankment from water and to provide sufficient clearance for small size pipe culverts for drainage.

(3) Vertical Control and Clearance List

Vertical Control List is shown in **Table 6.3.4-1**.

TABLE 6.3.4-1 VERTICAL CONTROL POINT LIST (1/2)

Profile Control Point List (CLLEX 1)

No	Station	Control name	Crossing Type	No	Type of Crossing structure	Control Elevation (A): Existing GL	Vertical CL	Girder	Top Slab	Pave	Super elevation: %	width	Height	Others	Total
1	0 + 5.000	SCTEX	Under pass	1	Br W=25.00 L=35.00	25.600	5.200	2.0		0.080	2.0 %	9.500	0.190		33.070
2	1 + 887.000	Sta Rosa-Tarlac RD	Under pass	1	Br W=25.00 L=35.00	22.200	5.200	2.0		0.080	2.0 %	9.500	0.190		29.670
3	2 + 940.000	Farm Road	Under pass	2	RCBC W=4.00 H=4.60		4.000		0.500		2.0 %	9.500	0.190		4.690
4	3 + 375.000	Tin Tin River	Under pass	1	Br W=25.00 L=35.00	18.800	4.000	2.0		0.080	2.0 %	9.500	0.190		25.070
5	3 + 830.000	Municipal Road	Under pass	2	RCBC W=8.00 H=5.80	18.200	4.000		0.500	0.500	2.0 %	9.500	0.190		23.390
6	4 + 363.600	Natural Creek	Under pass	1	Br W=25.00 L=35.00	18.100	4.000	2.0		0.080	2.0 %	9.500	0.190		24.370
7	4 + 550.000	Municipal Road	Under pass	2	RCBC W=8.00 H=6.00	17.100	4.000		0.500	0.500	2.0 %	9.500	0.190		22.290
8	5 + 50.000	La Paz-Victoria Rd	Under pass	2	RCBC W=16.00 H=8.00	17.400	5.200		1.200	0.500	2.0 %	9.500	0.190		24.490
9	7 + 528.100	Rio Chico(W)	Under pass	1	Br W=25.00 L=35.00	HWL 19.200	3.200			0.080	2.0 %	9.500	0.190		22.670
10	9 + 33.000	Rio Chico(E)	Under pass	1	Br W=25.00 L=35.00	HWL 19.200	3.200			0.080	2.0 %	9.500	0.190		22.670
11	9 + 388.000	Farm Road	Under pass	2	RCBC W=5.00 L=4.60	14.400	4.000		0.400	0.500	2.0 %	9.500	0.190		19.490
12	10 + 108.000	Farm Road	Under pass	2	RCBC W=5.00 L=4.60	14.500	4.000		0.400	0.500	2.0 %	9.500	0.190		19.590
13	10 + 268.000	Municipal Road	Under pass	2	RCBC W=12.00 L=6.00	15.100	4.000		0.600	0.500	2.0 %	9.500	0.190		20.390
14	10 + 448.000	Farm Road	Under pass	2	RCBC W=8.00 L=6.00	14.600	4.000		0.500	0.500	2.0 %	9.500	0.190		19.790
15	10 + 858.000	Farm Road	Under pass	2	RCBC W=8.00 L=6.00	15.400	4.000		0.500	0.500	2.0 %	9.500	0.190		20.590
16	11 + 8.000	Municipal Road	Under pass	2	RCBC W=8.00 L=5.80	15.500	4.000		0.500	0.500	2.0 %	9.500	0.190		20.690
17	11 + 103.100	Natural Creek	Under pass	1	Br W=25.00 L=25.00	14.600	4.700	2.0		0.080	2.0 %	9.500	0.190		21.570
18	11 + 888.000	Farm Road	Under pass	2	RCBC W=8.00 H=6.00	14.800	4.000		0.500	0.500	2.0 %	9.500	0.190		19.990
19	12 + 248.000	Farm Road	Under pass	2	RCBC W=5.00 H=4.60	14.800	4.000		0.400	0.500	2.0 %	9.500	0.190		19.890
20	12 + 598.000	Farm Road	Under pass	2	RCBC W=5.00 H=4.60	15.500	4.000		0.400	0.500	2.0 %	9.500	0.190		20.590
21	12 + 988.000	Farm Road	Under pass	2	RCBC W=8.00 H=6.00	15.300	4.000		0.500	0.500	2.0 %	9.500	0.190		20.490
22	13 + 668.000	Municipal Road	Under pass	2	RCBC W=12.00 H=6.00	15.800	4.000		0.600	0.500	2.0 %	9.500	0.190		21.090
23	14 + 688.000	Farm Road	Under pass	2	RCBC W=12.00 L=6.00	15.800	4.000		0.500	0.500	2.0 %	9.500	0.190		20.990

TABLE 6.3.4-1 VERTICAL CONTROL POINT LIST (2/2)

Profile Control Point List (CLLEX 2)

No	Station	Control name	Crossing Type	No	Type of Crossing structure	Control Elevation (A) GL	Vertical CL	Girder	Top Slab	Pave	Super elevation %	width	Height	Others	Total
24	15 + 653.000	Farm Road	Under pass	2	RCBC W=8.00 L=6.00	17.000	4.000		0.500	0.500	2.0 %	9.500	0.190		22.190
25	16 + 28.000	Farm Road	Under pass	2	RCBC W=5.00 H=4.60	17.500	4.000		0.400	0.500	2.0 %	9.500	0.190		22.590
26	17 + 28.000	Farm Road	Under pass	2	RCBC W=5.00 H=4.60	17.700	4.000		0.400	0.500	2.0 %	9.500	0.190		22.790
27	19 + 388.000	Provincial RD Guimba-Aliaga	Under pass	2	RCBC W=11.00 L=5.80	21.100	5.200		0.600	0.500	2.0 %	9.500	0.190		27.590
28	19 + 715.000	Aliaga IC	Under pass	2	RCBC W=9.00 H=5.80	20.800	5.200		0.500	0.500	2.0 %	9.500	0.190	1.500	28.690
29	20 + 948.000	Municiparity RD	Under pass	2	RCBC W=11.00 L=5.80	22.600	4.000		0.600	0.500	2.0 %	9.500	0.190		27.890
30	21 + 248.000	Municiparity RD	Under pass	2	RCBC W=11.00 H=5.80	22.100	4.000		0.600	0.500	2.0 %	9.500	0.190		27.390
31	23 + 108.000	Municipality RD	**Over pass**	2	RCBC W=8.00 H=5.80	24.100	5.200		0.500	0.500	2.0 %	9.500	0.190		17.710
32	24 + 98.000	Farm Road	Under pass	2	RCBC W=12.00 L=6.00	25.300	4.000		0.600	0.500	2.0 %	9.500	0.190		30.590
33	25 + 838.000	Cabanatuan H IC	Under pass	2	RCBC W=9.00 H=5.80	25.200	5.200		0.500	0.500	2.0 %	9.500	0.190	1.500	33.090
34	26 + 348.000	Municipality RD	Under pass	2	RCBC W=12.00 H=6.00	28.200	4.000		0.600	0.500	2.0 %	9.500	0.190		33.490
35	26 + 528.000	Farm Road	Under pass	2	RCBC W=8.00 H=6.00	26.800	4.000		0.500	0.500	2.0 %	9.500	0.190		31.990
36	27 + 748.000	NH Cabanatuan- Carmen	Under pass	2	RCBC W=18.00 H=8.00	30.500	4.000		1.800	0.500	2.0 %	9.500	0.190		36.990
37	29 + 918.000	Municipality RD	Under pass	2	RCBC W=16.00 H=8.00	33.000	4.000		1.200	0.500	2.0 %	9.500	0.190		38.890
38	29 + 988.600	Natural Creek	Under pass	1	Br W=25.00 L=35.00	32.500	4.000	2.0		0.080	2.0 %	9.500	0.190		38.770
39	30 + 290.000	Cabanatuan BP	Under pass	1	Br W=25.00 L=35.00	32.800	5.200	2.0		0.080	2.0 %	9.500	0.190		40.270
40	17 + 88.000	Irrigation	Under pass	2	RCBC										

6.3.5 Rio Chico River Flood Prone Area Design

(1) Technical Approach

The express highway across flood prone area of Rio Chico River. This Section summarize following points regarding to road structure design in such area.

1) Hydrological characteristics of Rio Chico River
2) Flood condition and mechanism
3) Structural design for the flood prone area

(2) Hydrological characteristics of Rio Chico River

Tarlac province is boundendby two (2) principal rivers; Tarlac River and Rio Chico River which are both heavily silted. Tarlac River aggradation problem is attributed to the heavy transport of lahar due to Mt.Pinatubo eruption while Rio Chico has narrow/limited river cross section with meandering flow and serves as the catch basin of waterways from Talavera-Aliaga, Zaragoza, Cabanatuan, Guimba, LIcab and Sto.Domingo and the eastern towns of Tarlac, outfall to Sacobia-Bamban-Paura River and Quitangil River.

Rio Chico River is one of the tribunal of Pampanga River which is located upper part of Pampanga Rive Basin. The Rio Chico River and Talavera River confluent in La Paz and flow to San Antonio Swamp before meet to Pampanga River.

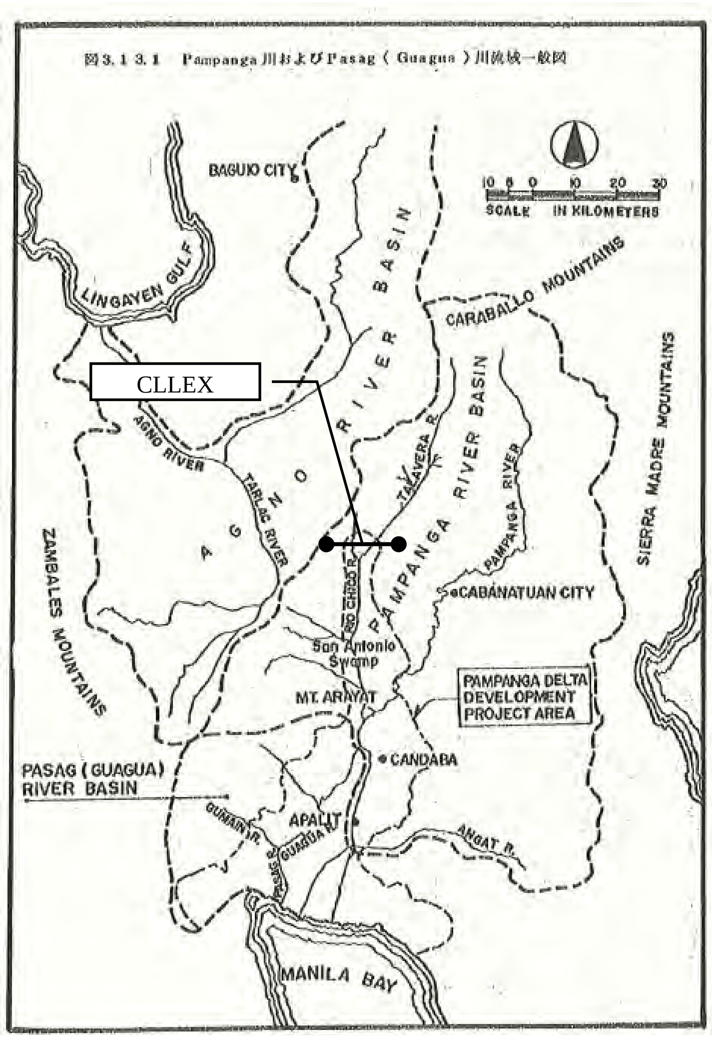


FIGURE 6.3.5-1 PAMPANGA RIVER BASIN

Major characteristics of Rio Chico River is shown in **Table 6.3.5-1**.

TABLE 6.3.5-1 CHARACTERISTICS OF RIO CHICO AND PAMPANGA RIVER

	Rio Chico River	Pampanga River
Catchment Area	1700km2	7700km2
River Slope	1/3,500	1/10,000 – 1/8,000
Discharge (50years)	2,400 (at Zaragoza) 3,700(at San Antonio)	4,350 (at Cabiao)
Discharge (100 years)	2,800(at Zaragoza) 4,400(at San Antonio)	4,900 (at Cabiao)

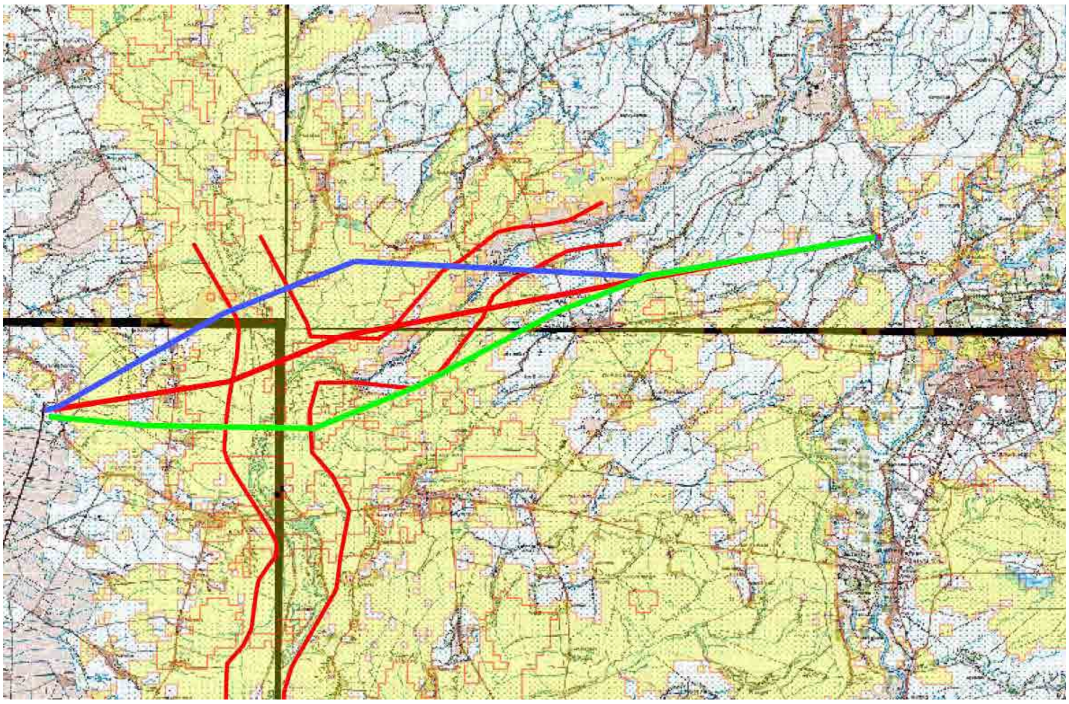
Source: JICA 1982

(3) Flood Condition

1) Flood Prone Area

The maximum inundated area by 2004 is shown in **Figure 6.3.5-2**. The inundated area by Typhoon Pepeng in 2009, which caused the most flood disaster in this region, is assumed almost the same according to interview survey by the study team. This figure illustrates that major parts of the road stretch is within inundated area.

Table 6.3.5-2 shows average inundated depth and days of related municipalities. La Paz has the most serious flood condition among all.



Source: JICA 2010

FIGURE 6.3.5-2 INUNDATED AREA ALONG STUDY ROUTE (MAXIMUM FLOOD BY 2004)

TABLE 6.3.5-2 FLOOD CONDITION BY MUNICIPALITY ALONG RIO CHICO RIVER

Municipality	Inundated depth (ave)	Inundated days (ave)
Victoria	0.8m	3-5 days
Licab	0.5m	1-3 days
Quezon	0.5m	1-3 days
La Paz	1.8m	8-12 days
Zaragoza	0.5m	2-3 days

Frequent flood area and historical flood area were identified by interview survey to the Local Government Office.

2) Close of Tarlac- Sta. Rosa National Highway

Table 6.3.5-3 shows closure days of national highway due to flood.

TABLE 6.3.5-3 RECORD OF ROAD CLOSURE TARLAC-STA ROSA ROAD

Year	Month/ Date	Cause
2006	July 24	Not specified
2007	Record not found	n/a
2008	August 10	Typhoon "Julian"
2009	October 09-11	Typhoon "Pepeng"
2010	October 21-22	Typhoon "Juan"
2011	June 26-27, 2011	Typhoon "Falcon")
Source: DPWH Tarlac 2nd District Eng'g. Office		

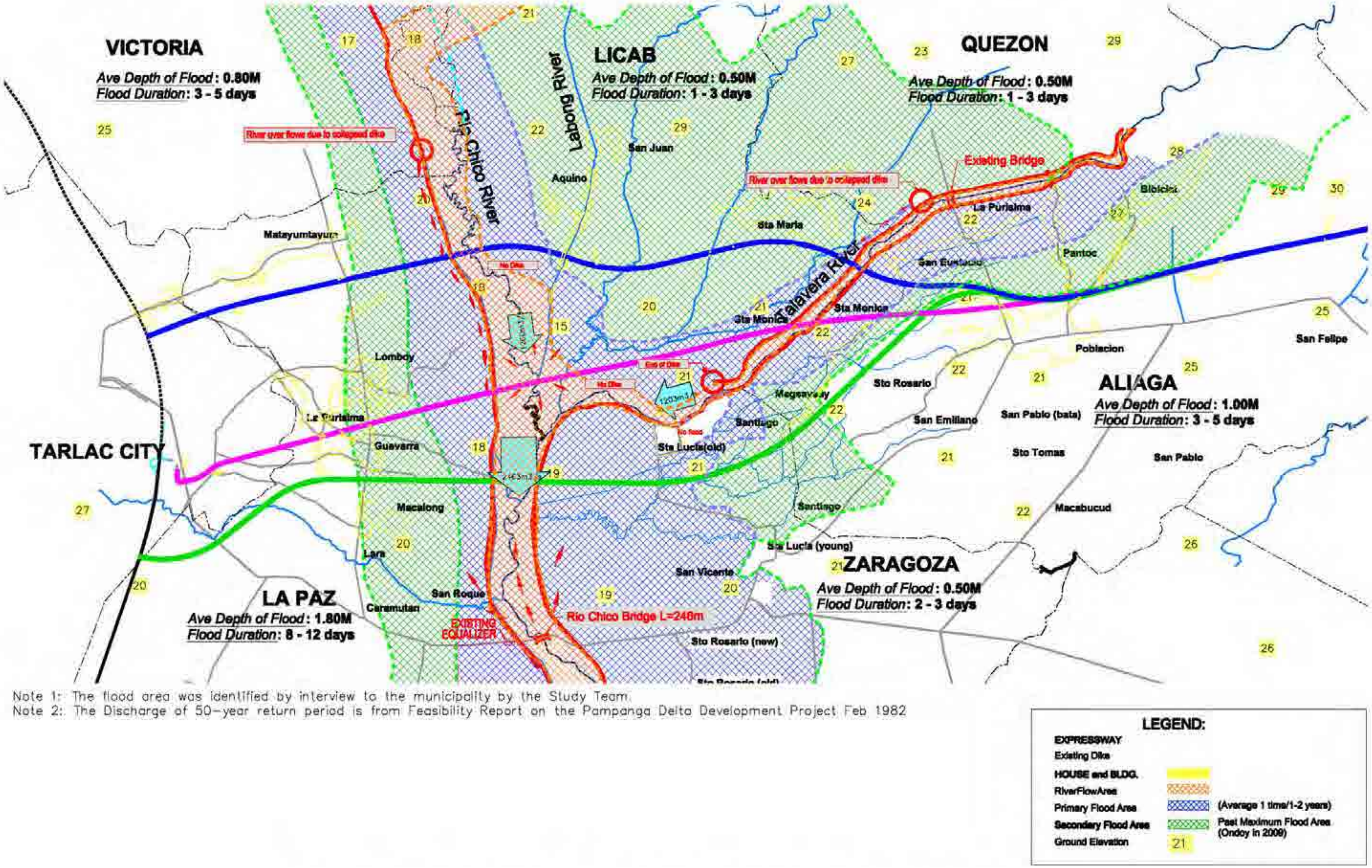
Year	Month/ Date	Cause
Average for the last 5 years	Three (3) incidents of road closures each year. Each road closure incident is about 2 to 3 days long. Thus, about 6-10 days (with 10 as maximum).	Heavy Rains / Typhoons (June to November)

(4) Flood Mechanism

Flood mechanism in this area is summarized as **Table 6.3.5-4** and **Figure 6.3.5-3**.

TABLE 6.3.5-4 SUMMARY OF FLOOD MECHANISM AT RIO CHICO RIVER

No	Location	Reason	Flood
1	Confluence of Rio Chico River and Labong River	Low land	Ground elevation is 16 to 18m while other is approx.20m River water gathers at low land.
2	Confluence of Rio Chico Rive and Talavera River	Confluence of two major river	Both rive has approx 1,200m3/s (50years). There is only low earth dike at the confluence point which is easily flow over.
3	National Road Crossing Point at Rio Chico River	Narrow river channel	There is equalizer constructed in 2009 and a bridge of 250m passes over Rio Chico River. Flood frequently occurs at this point due to insufficient capacity of present river corridor. This causes back flow to the upper stream.
4	Rio Chico River and Talavera River	Collaption of existing dike	Existing dike is mostly earth bank which is already collapsed due to lack of maintenance. River water easily over flow from such portion.



Note 1: The flood area was identified by interview to the municipality by the Study Team.
Note 2: The Discharge of 50-year return period is from Feasibility Report on the Pampanga Delta Development Project Feb 1982

FIGURE 6.3.5-3 FLOOD CONDITION AT RIO-CHICO RIVER

(5) Rehabilitation Plan Of Rio Chico River

The JICA study conducted in 2007, THE STUDY ON THE NATIONWIDE FLOOD RISK ASSESSMENT AND THE FLOOD MITIGATION PLAN FOR THE SELECTED AREAS IN THE REPUBLIC OF THE PHILIPPINES, is proposing the rehabilitation of Rio Chico River as **20th priority** among all river in the Philippines.

(6) Design High Water Level of Rio Chico River Flood Prone Area

Historical flood level is shown in **Table 6.3.5-5** and comparison from analyzed value is shown in **Table 6.3.5-6**.

Design flood level is determined as shown in **Table 6.3.5-7** by following reasons;

a. The actual high water level at crossing point is calculated as 19.2m from past record which can be assumed corresponding to 50 years return period.

b. Analyzed water level is 17.4m for 50 years discharge. It is -1.8m of record level.

c. The existing equalizer elevation at Tarlac-Sta Rosa NH is approximately 17.8m verified by topographic survey.

d. It is observed that flood water is blocked at equalizer and causing backflow to the upper stream. This explains recorded water level is higher than calculated level.

e. For such reason the Design Water Level is set as **19.2m** for Bridge Design (50years) and **17.8m** for Embankment Design.

TABLE 6.3.5-5 HISTORICAL FLOOD LEVEL

Location	Water level	Remark	Source
1.Along C route (FS2010)	19.75m	Ondoy 2009, 5.1km from recommended alignment	FS2010 DPWH
2.Tarlac-Sta.Rosa NH	18.4m	Ondoy 2009, 3.2km from recommended alignment	FS2010 DPWH
3. Tarlac-Sta Rosa NH	17.8m	Average flood area	DPWH Tarlac
Tarlac –Sta Rosa NH	+1.0m from road surface at Equalizer	According to interview to LGU, Ondoy 2009	
Tarlac – Sta.Rosa NH		Surface elevation 17.5m – 18.0m	Topo survey conducted July 2011
Assumed water level at CLLEX crossing	**19.2m**	Calculated from 1 and 2	

TABLE 6.3.5-6 COMPARISON OF RECORD AND ANALYZED VALUE

	Water level	Remark
(1) Recorded water level (historical)	19.2m	Table 6.3.5-5
(2) Calculated water level (50years)	17.4m	Table 6.3.2-6

TABLE 6.3.5-7 DESIGN FLOOD LEVEL

Design Water Level	Corresponding Return Period (assumed)	Water Level	Design Control		Structure
MFWL (Medium Flood Water Level)	10 years	17.8m*	19.2m	Minimum elevation = MFWL +0.6m(Freeboard) +0.8 (Pavement) =17.8+0.6+0.8=19.2m	Embankment
HWL (High Water Level)	50 years	19.2m**	22.4m	Minimum elevation = HWL+1.2m(Freeboard)+2.0 m(Bridge girder and slab) = 19.2+1.2+2.0=22.4m	Rio Chico Bridge

** Assumed from flood at Tarlac – Sta.Rosa National Road*
*** Assumed from past maximum flood level*

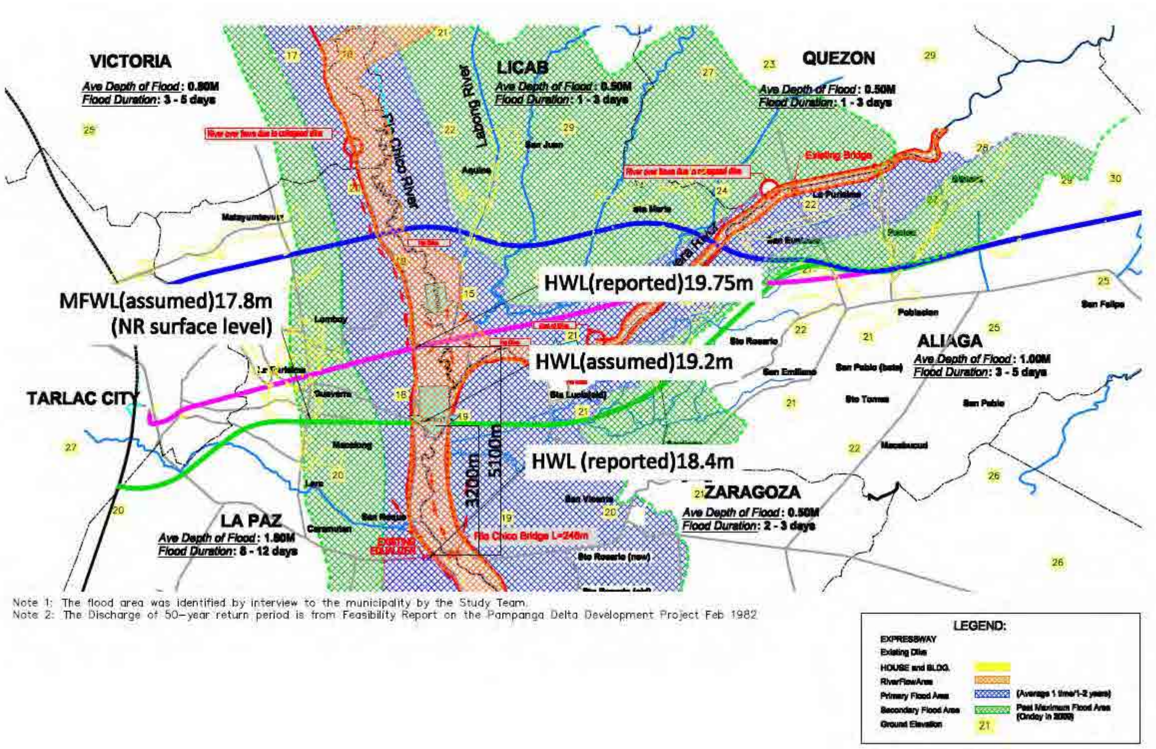


FIGURE 6.3.5-4 ASSUMPTION OF MFWL AND HWL

(7) Vertical Control at Rio Chico River Bridge

Considering the flood condition, vertical control of Rio Chico River bridge is set as below; (**Figure 6.3.5-5**)

Minimum Vertical Clearance is 19.2m(HWL) + Freeboard 1.2m (corresponding to 2,500m3/s for 50 years return period.)

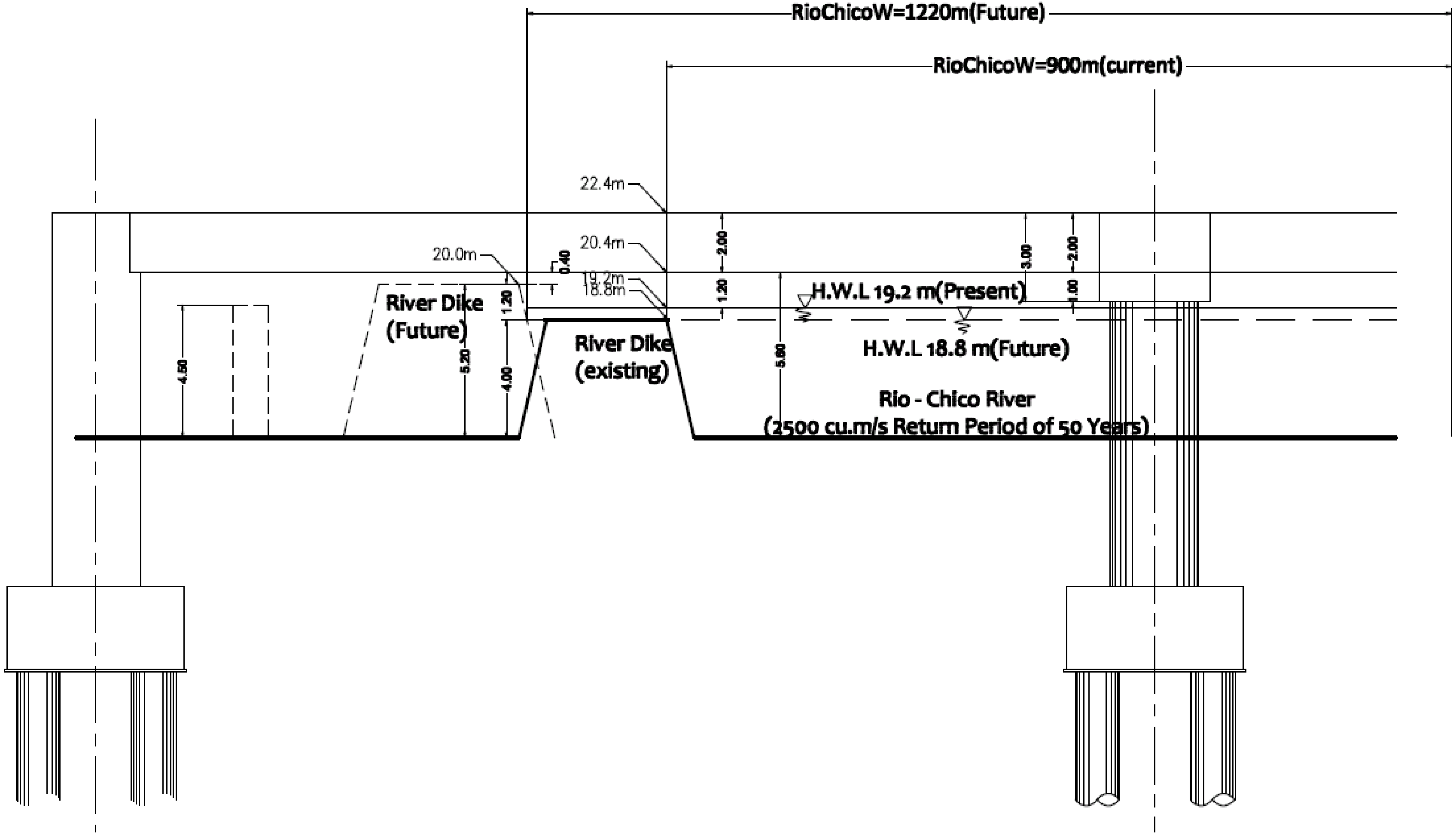


FIGURE 6.3.5-5 SCHEMATIC IMAGE OF VERTICAL CONTROL POINT OF RIO CHICO RIVER

(8) Structural design in the flood prone area

1) Bridge and Equalizer

Technical approach of the structural design in flood prone area is shown as follows;

1) Existing Rio Chico River corridor and future river corridor (for 50 years return period) shall be crossed by bridge structure.

2) Equalizer shall be provided whole stretch of "frequent flood area"

3) Equalizer shall be series of box culvert **(3.0mx3.0m) @100m**

4) Slope protection by stone rip rap shall be provided under MFWL within frequent flood area

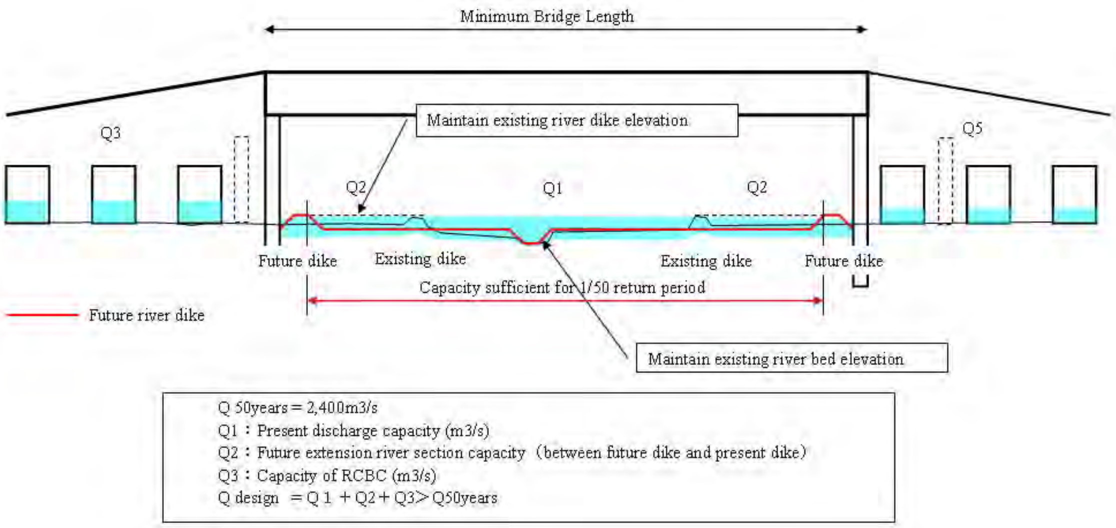


FIGURE 6.3.5-6 MINIMUM BRIDGE LENGTH AND DISCHARGE CAPACITY

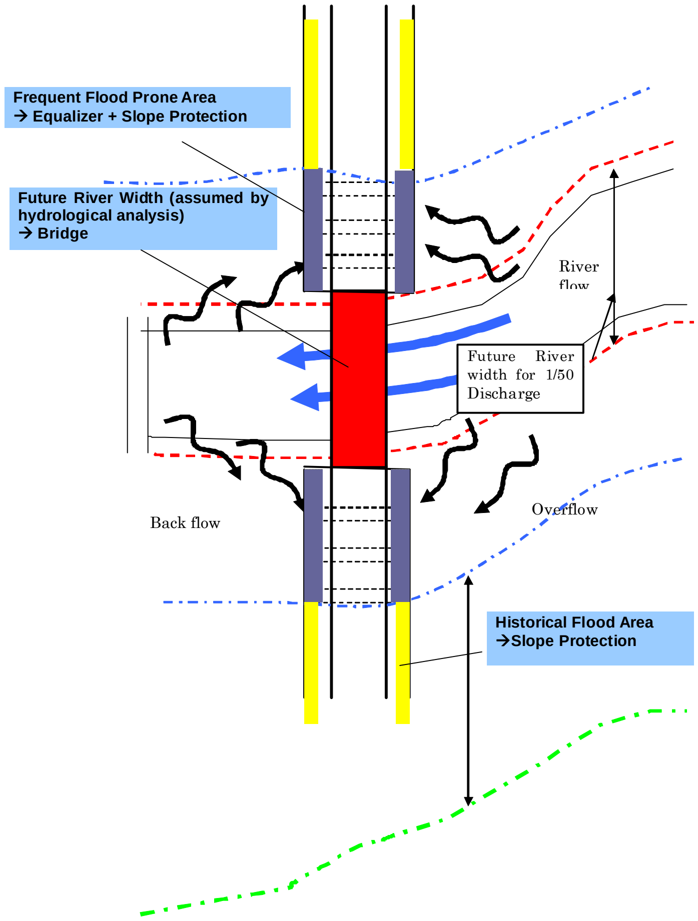


FIGURE 6.3.5-7 STRUCTURAL DESIGN AT FLOOD PRONE AREA

2) Minimum required bridge length of Rio Chico Bridge

Table 6.3.5-8 shows summary of hydrological calculation of Rio Chico River.

TABLE 6.3.5-8 REQUIRED BRIDGE LENGTH OF RIO CHICO RIVER

Case	Check	Width	Discharge	Calculation Condition			Remark
		m	m3/s	Roughness coefficient	Capacity (m3/s)	Evaluation for 50 years	
Rio Chico River	Necessary Section	1222m	2472	0.1	2479	OK	

3) Slope Protection

The water flow speed can be 1.5m/s to 2.0m/s during flood time. Riprup Stone shall be provided for slope protection. **Figure 6.3.5-8** illustrate existing equalizer along national highway and flooded situation (June 27, 2011, Typhoon Falcon).

FIGURE 6.3.5-8 FLOOD ON 27 JUNE, 2011 BY TYPHOON FALCON (RIO CHICO RIVER EQUALIZING ZONE)

FIGURE 6.3.5-9 EQUALIZER AT SAME PLACE ABOVE

6.3.6 Interchange Design

(1) Technical Approach

Followings are basic technical approach to design interchange of CLLEX.

1) To provide number of toll booth lane in accordance with traffic demand forecast.
2) To provide weigh station and U turn space for overloaded vehicle
3) To provide necessary widening of the existing road at future intersection

(2) Interchange location and booth lane number

Figure 6.3.6-1 illustrates IC location and booth lane number.

(3) Typical Toll booth layout

Basic layout and dimension of toll booth is referred to TPLEX which is under construction, as shown in **Figure 6.3.6-2.**

(4) Selection of Interchange Type

1) Junction from SCTEX

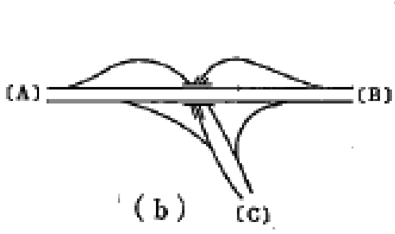
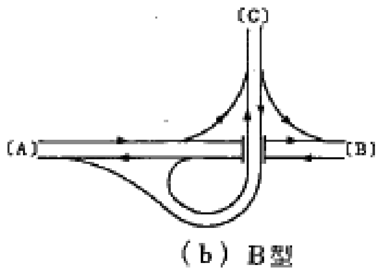
“Junction” is commonly applied to the road crossing structure between “expressway“ and “expressway”. It is widely applied “Y Type” because of good geometrical alignment of ramps for the Junction. (**Table 6.3.6-1**)

For CLLEX, Trumpet type is recommended by following reasons;

a. There is the main toll barrier at 1.9km from the Junction. All the traffic will be forced to stop at this point. Trumpet Type naturally guide drivers to slow down which encourage traffic safety and smoothness.

b. Trumpet type requires less land acquisition and less construction cost.

TABLE 6.3.6-1 TYPICAL JUNCTION TYPE

Plan		
Type	Y Type	Trumpet Type
Structure	3F	2F
Ramp Alignment	Good	Fair
Cost	High	Low
CLLEX		Recommended

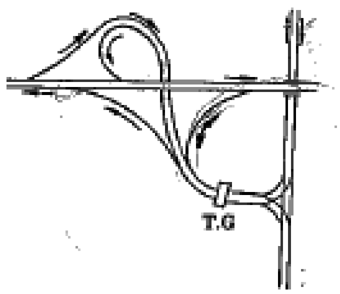
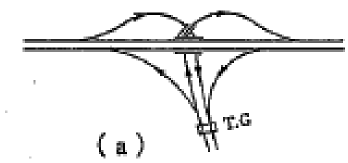
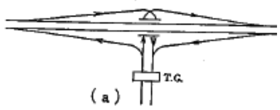
2) Interchange

Table 6.3.6-2 shows typical interchange type.
Trumpet type is most popular structure for interchange. Y type is often used where Trumpet type is difficult such as in terms of land acquisition. Flat Y type is the smallest structure and most economical in cost with least land acquisition. This type is adequate when In and Out traffic volume is small because two ramps are crossing by plat intersection.

For CLLEX, Trumpet type is recommended by following reasons;

a. Land acquisition is not critical and land price is not critical
b. It is recommendable to select commonly used type in Philippines.

TABLE 6.3.6-2 TYPICAL INTERCHANGE TYPE

Plan			
Type	Trumpet Type	Y Type	Flat Y Type
Structure	2F	3F	2F
Traffic	large	large	small
Cost	middle	high	Low
CLLEX	Recommended		

(5) Design Traffic Volume and required lane number

In accordance with traffic forecast (Chapter 4), the required lane number is studied as below. The recommendation is shown in **Table 6.3.6-3**.

a. The number of lane shall be sufficiently provided for 30^{th} peak hour traffic for Average Daily Traffic (ADT)
b. Capacity of traffic per lane for the design speed of 40km/h is 1200 /day.

The lane number is studied in year of **2030 (4 lane).**

DHV = ADT x K x D

Where;

ADT (Average Daily Traffic): Traffic projection
K: 30^{th} traffic (0.14 – 0.16) : **0.15**
D: Directional ratio (0.6 – 0.7):**0.65**

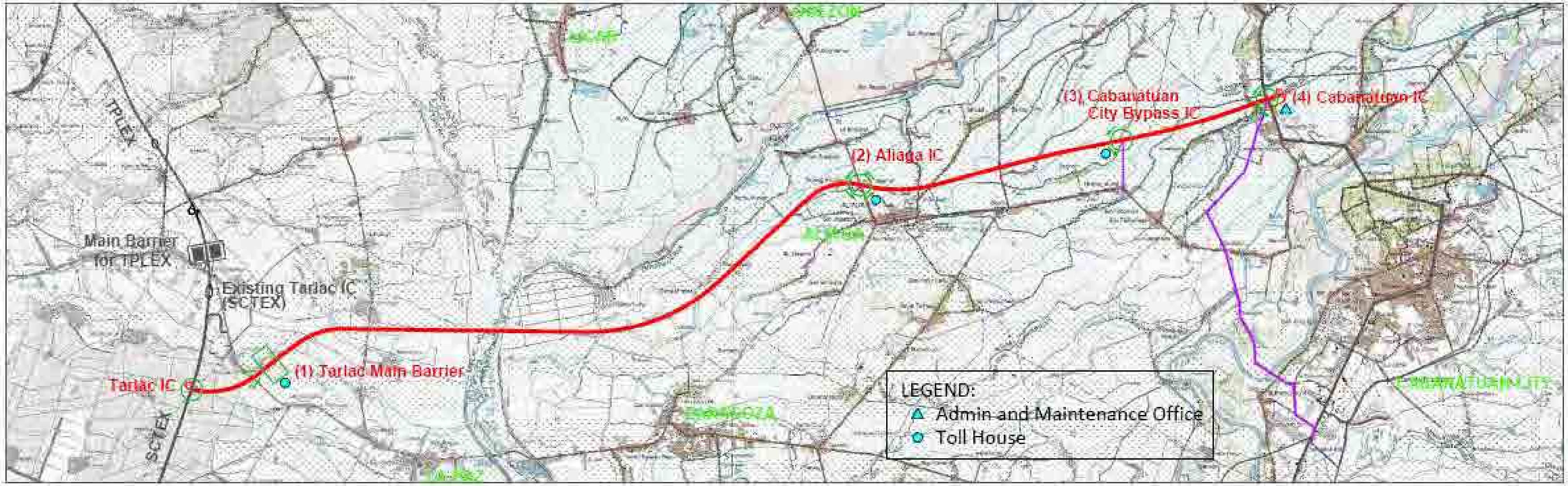
TABLE 6.3.6-3 REQUIRED LANE NUMBER OF INTERCHANGE RAMP

Interchange	Ramp		Estimated traffic(ADT) 2030	K	D	Design Traffic	Capacity of 1 lane (car/h)	Required lane number
Tarlac IC	A	CLLEX to SCTEX	6,154	0.15	0.65	600	1,200	1
	B	TPLEX to CLLEX	2,010	0.15	0.65	196	1,200	1
	C	CLLEX to TPLEX	1,933	0.15	0.65	188	1,200	1
	D	SCTEX to CLLEX	6,400	0.15	0.65	624	1,200	1
Tarlac IC	E	CLLEX to NH	2,473	0.15	0.65	241	1,200	1
	F	NH to CLLEX	2,529	0.15	0.65	247	1,200	1
Aliaga IC	A	Aliaga to SCTEX	241	0.15	0.65	23	1,200	1
	B	Cabanatuan to Aliaga	17	0.15	0.65	2	1,200	1
	C	Aliaga to Cabanatuan	15	0.15	0.65	1	1,200	1
	D	SCTEX to Aliaga	287	0.15	0.65	28	1,200	1
Cabanatuan Bypass IC	A	Bypass to SCTEX	3,152	0.15	0.65	307	1,200	1
	B	SCTEX to Bypass	2,706	0.15	0.65	264	1,200	1
Cabantuan IC	A	Cabantuan to SCTEX	7,183	0.15	0.65	700	1,200	1
	B	San Jose to Cabanatuan	6,566	0.15	0.65	640	1,200	1
	C	Cabantuan to San Jose	6,599	0.15	0.65	643	1,200	1
	D	SCTEX to Cabantuan	7,961	0.15	0.65	776	1,200	1

(6) Interchange Ramp Layout

Interchange Ramp layout are shown in **Figure 6.3.6.-3** to **Figure 6.3.6-8 .**

LOCATION FOR TRAFFIC AND MAINTENANCE OFFICE



INTERCHANGE	DESCRIPTION	NO. OF TOLL BOOTH *	WEIGHT IN MOTION	ADMIN/MAINT. OFFICE	TOLL HOUSE
(1) Tarlac Main Barrier	From SCTEX : Pay SCTEX Toll And Get Ticket For CLLEX	3	-	-	1
	From Tarlac IC : Get Ticket For CLLEX	2	1		
	To SCTEX : Pay CLLEX Toll And Get Ticket For SCTEX	3	-	-	-
	To Tarlac IC : Pay CLLEX Toll	2	-		
(2) Aliaga IC	Entrance : Get Ticket	2	1	-	1
	Exit : Pay CLLEX Toll	2	-		
(3) Cabanatuan City Bypass IC	Entrance : Get Ticket	2	1	-	1
	Exit : Pay CLLEX Toll	2	-		
(4) Cabanatuan IC	Entrance : Get Ticket	2	1	1	-
	Exit : Pay CLLEX Toll	3	-		
	TOTAL	**23**	**4**	**1**	**3**

Note: * Number of Toll Booth is estimated by future traffic volume and service time (entrance - 6 sec/veh., exit 14 sec/veh.)

FIGURE 6.3.6-1 LOCATION OF IC AND NUMBER OF FACILITIES

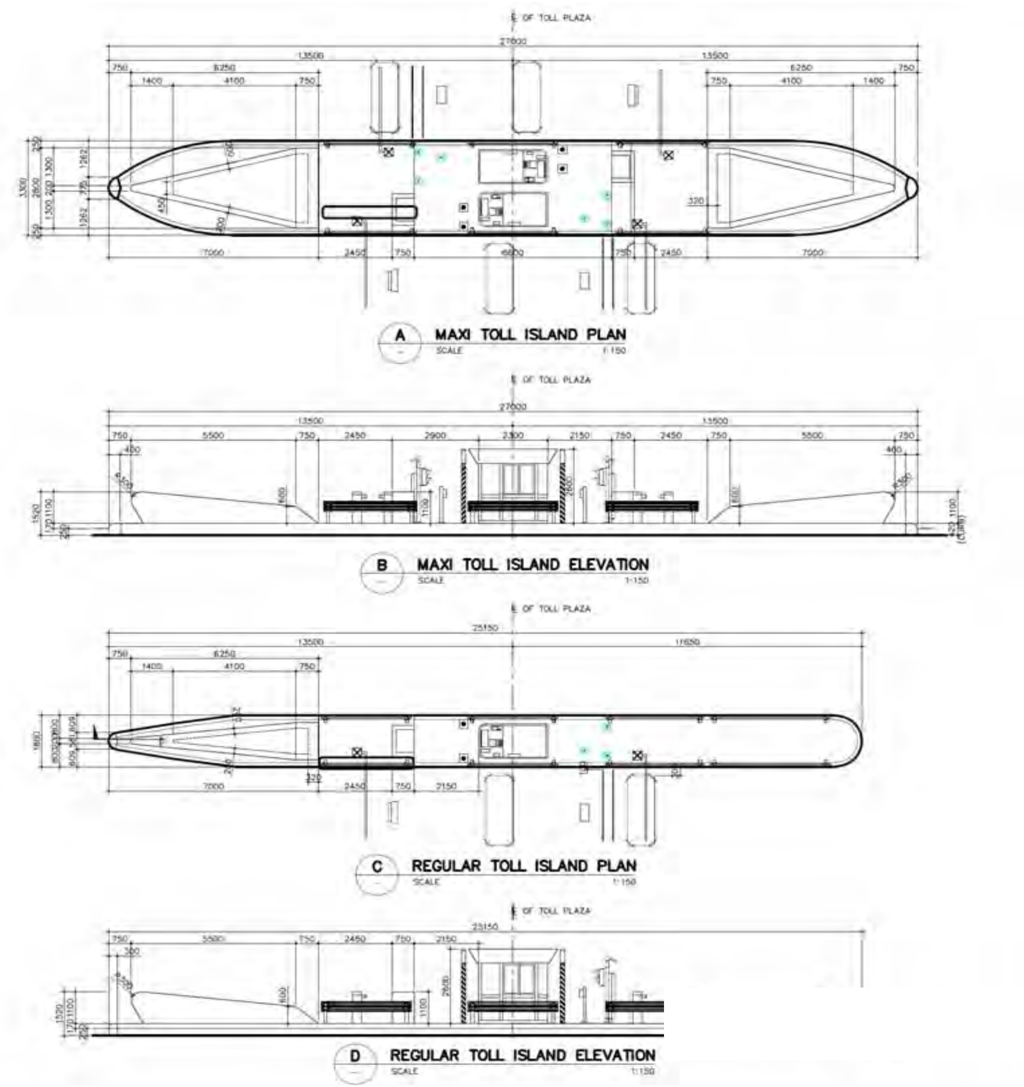


FIGURE 6.3.6-2(1) TYPICAL DRAWING OF TOLL BOOTH

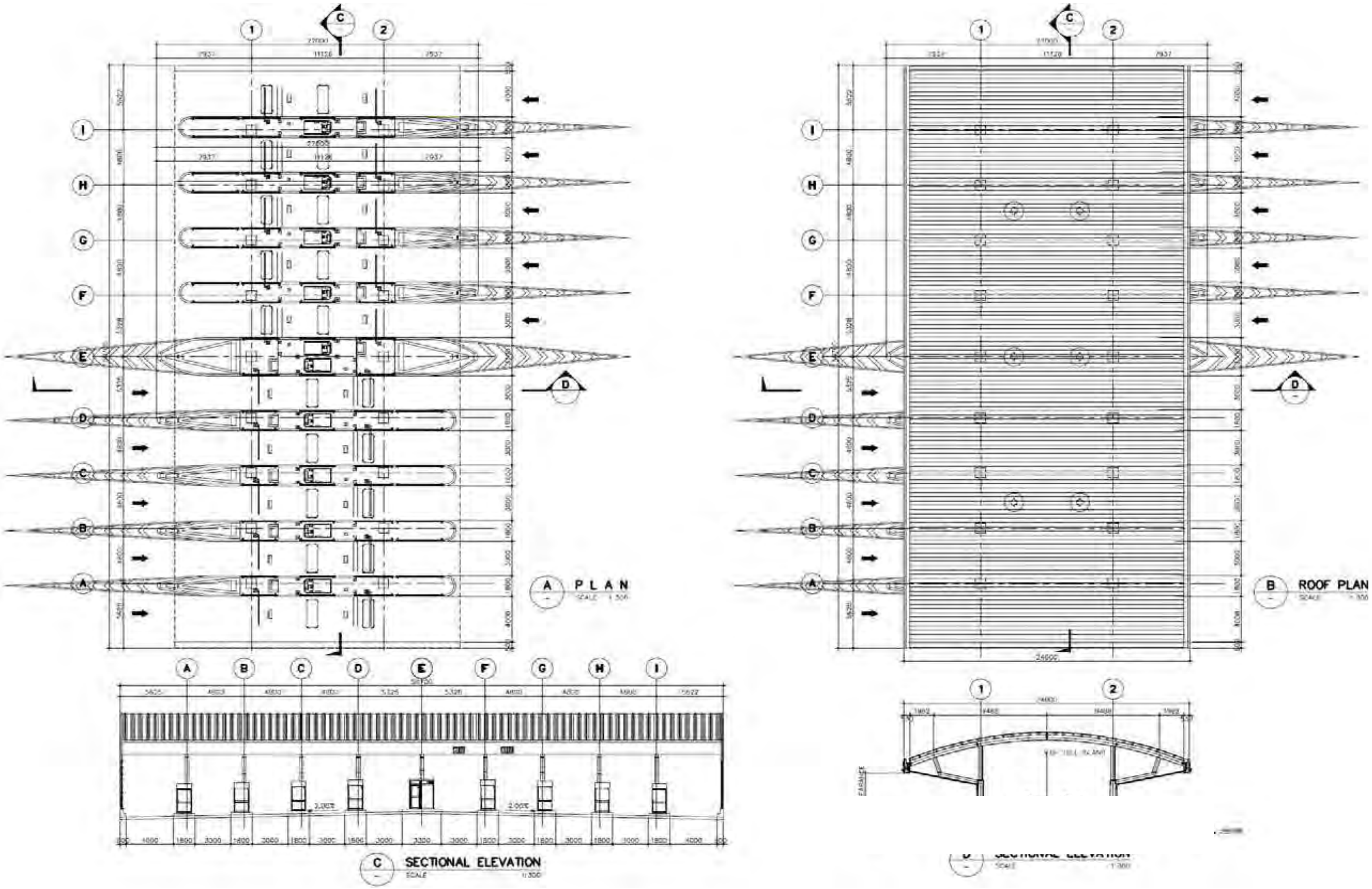


FIGURE 6.3.6-2(2) TYPICAL DRAWING OF TOLL BOOTH LAYOUT (9BOOTHS)

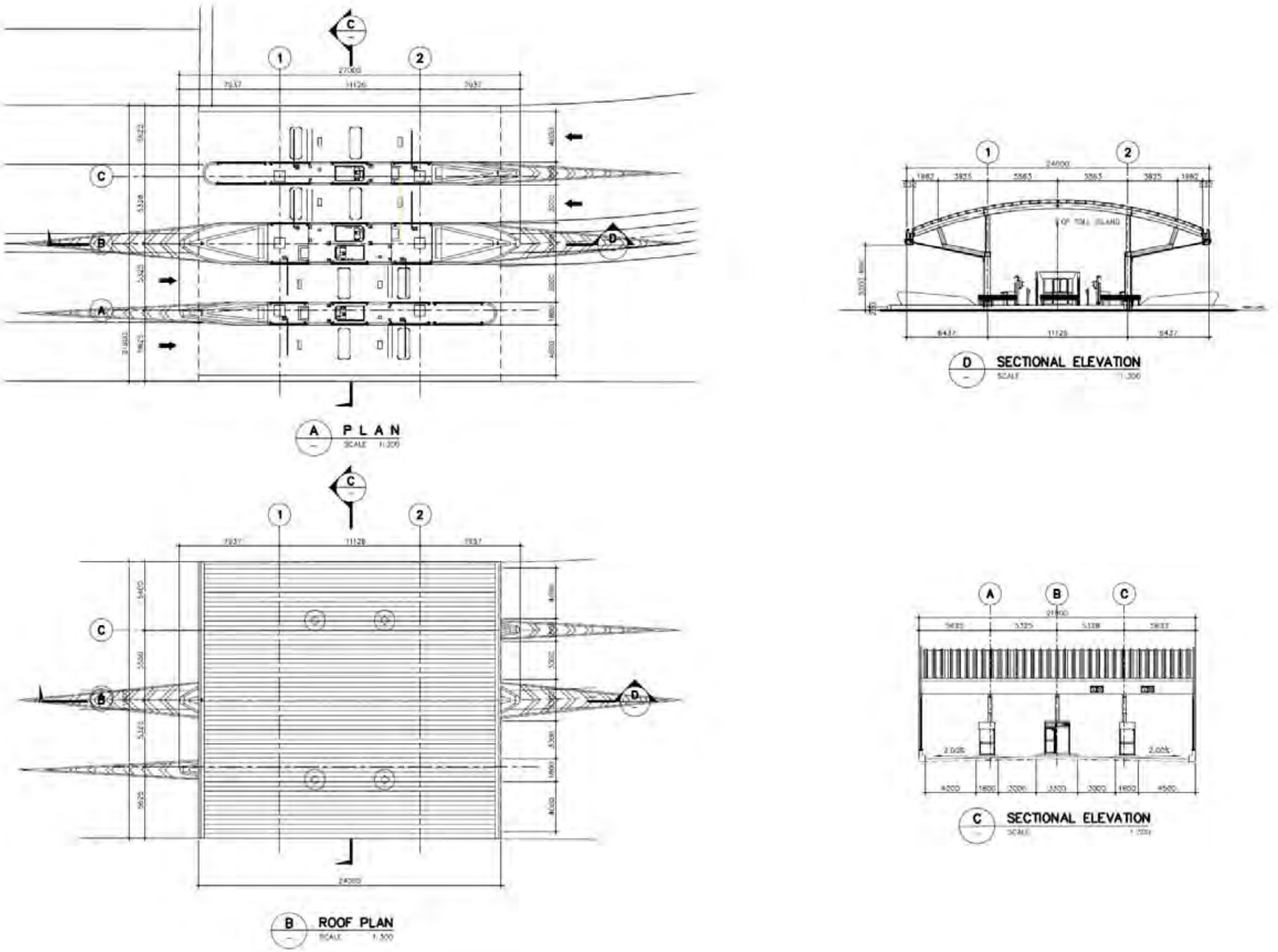


FIGURE 6.3.6-2(3) TYPICAL DRAWING OF TOLL BOOTH LAYOUT (3BOOTHS)

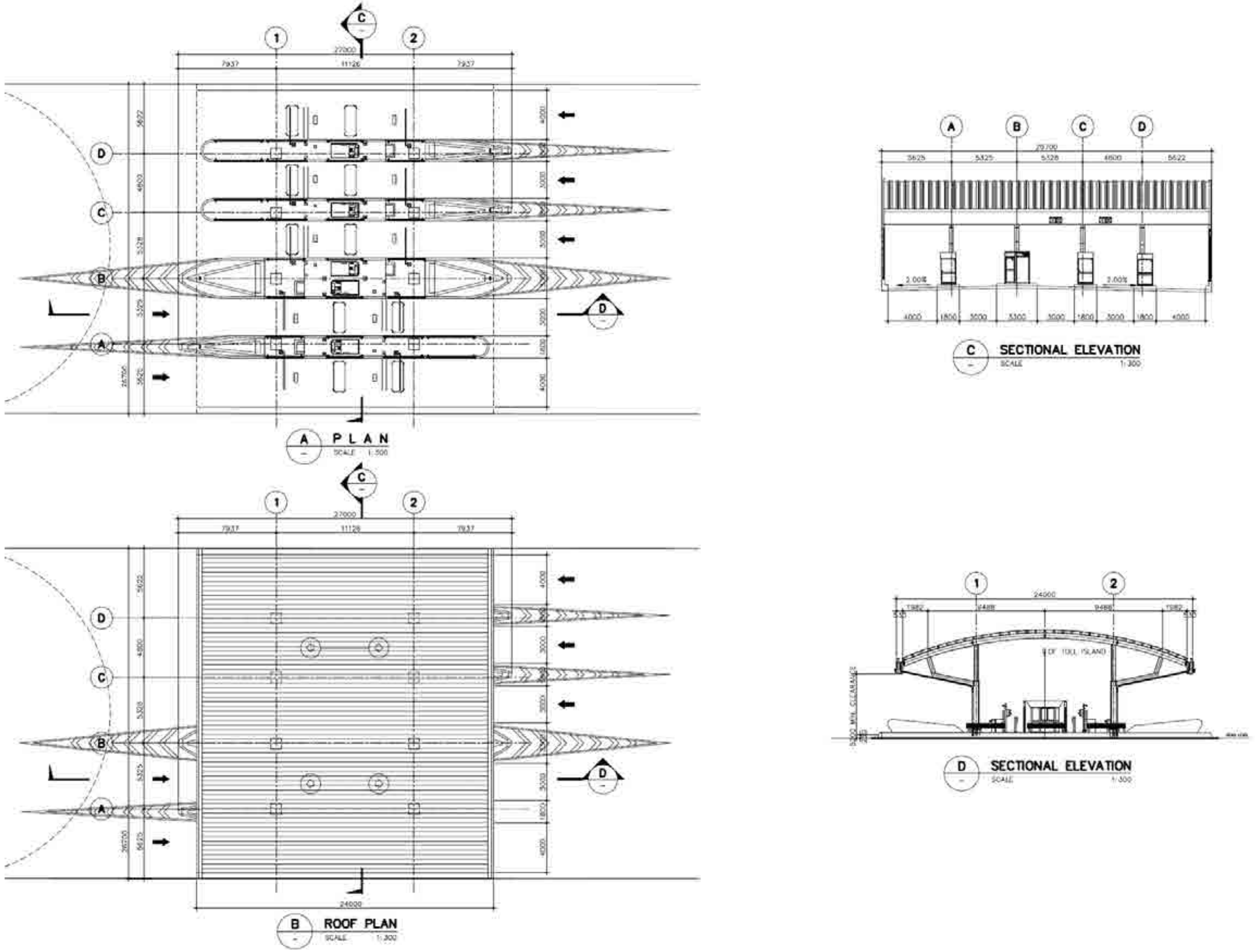


FIGURE 6.3.6-2(4) TYPICAL DRAWING OF TOLL BOOTH LAYOUT (4BOOTHS)

FIGURE 6.3.6-3 TARLAC JUNCTION

FIGURE 6.3.6-4 TARLAC INTERCHANGE AND TOLL BARRIER

FIGURE 6.3.6-5 ALIAGA INTERCHANGE