5.3 ALIGNMENTSTUDYOFLAGUNASECTIONOFCALAX

5.3.1 Characteristics of Laguna Section Area

(1) Land Area Acquired by Private Land Developers

Land area acquired by the private land developers is shown in **Figure 5.3.1-1**. Most of the lands of the project area have been purchased and owned by the large scale land developers (real estate companies).

There are many economic zones/industrial estates along SLEx and Governor's Drive. Residential subdivisions were and will be developed in the project area. Mixed uses area such as residential subdivision/commercial complexes/leisure facility (mostly golf courses) also widely occupy the project area. Areas along SLEx (4 to 5 km. areas from SLEx) has been and/or being developed.

Since land development by private companies are quite active in the project area, most of the project area will be fully urbanized in 15 to 20 years.

(2) Road Network in Project Area

Road network in the project area is shown in **Figure 5.3.1-2**. Major roads are as follows;

- South Luzon Expressway (8-lane, toll road)
- Aguinaldo Highway (4-lane, national road)
- Governor's Drive (4-lane, national road)
- Sta. Rosa-Tagaytay Road (2 to 4-lane, national road)

As shown above, national road network density is quite scarce. Private roads are providing access to the project area, however, there are following problems; ①Some of private roads are limited to vehicles with sticker sold by the private land developers, thus usage of private roads are limited and not for general public. ② Private roads are developed to provide access to each land developer's area, thus, continuity of road is not always good. Sometimes, it is not possible to go from one land developer's area to another.

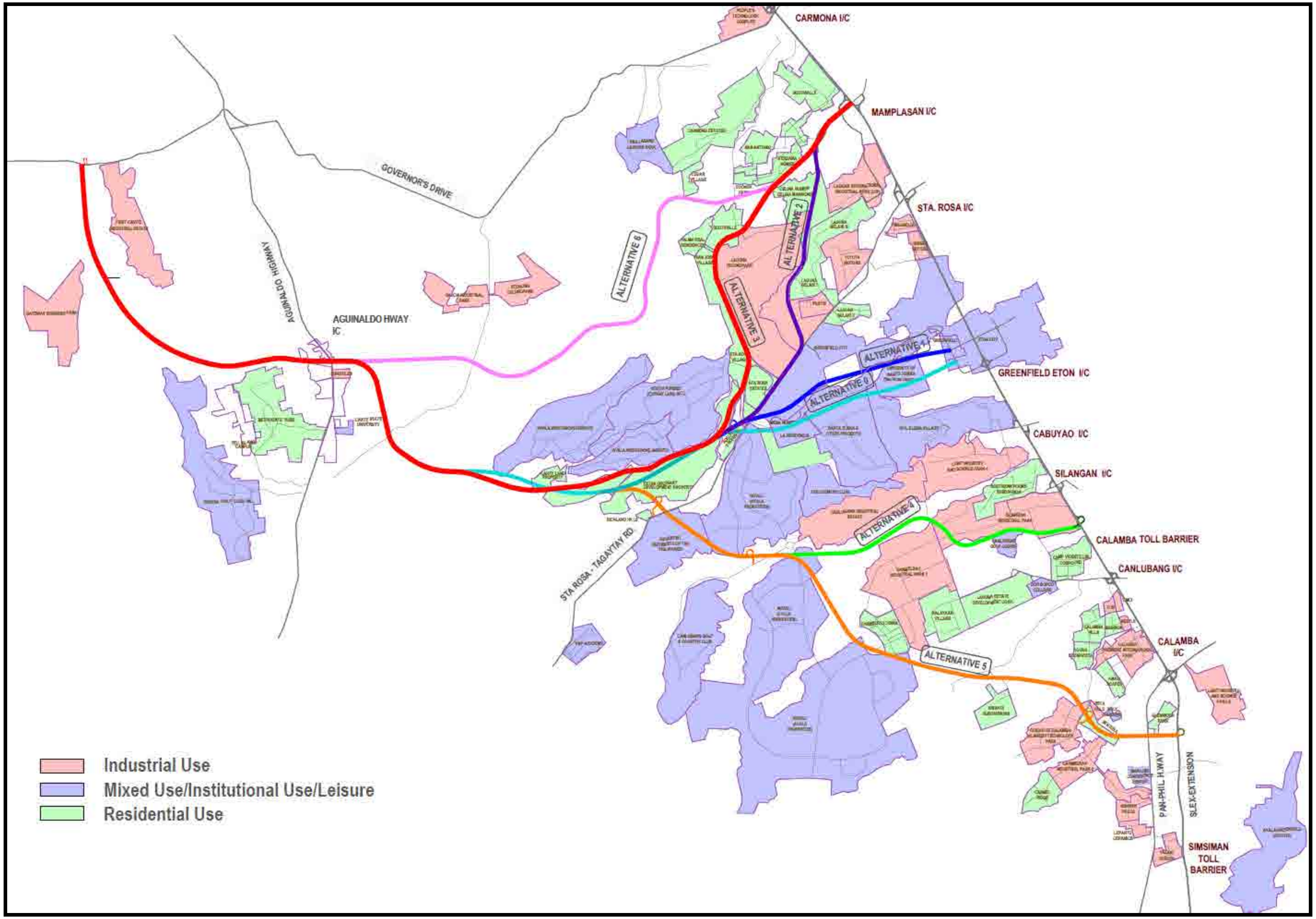


FIGURE 5.3.1-1 LAND AREA ACQUIRED BY PRIVATE LAND DEVELOPERS

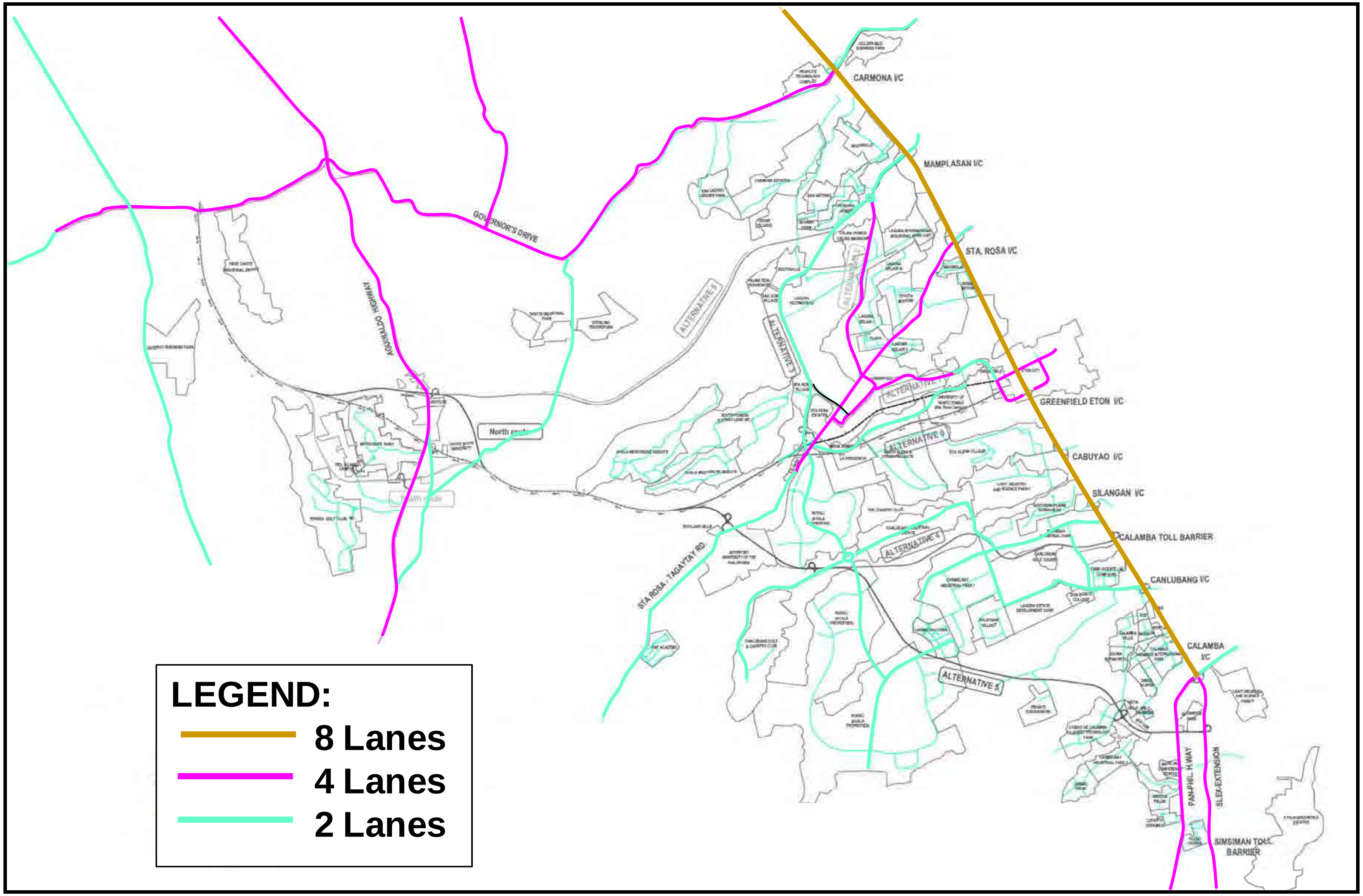


FIGURE 5.3.1-2 ROAD NETWORK IN PROJECT AREA

5.3.2 Procedure of Alignment Study

Alignment study was undertaken in accordance with the following steps;

Step-1	:	Selection of the beginning point of Laguna Section (connection point of Cavite and Laguna sections).
Step-2	:	Selection of the end point at SLEx.
Step-3	:	Selection of the alignment to connect the beginning point and end point. Various alternative alignments were studied.

5.3.3 Step-1 : Selection of the Beginning Point of Laguna Section (Connection Point of Cavite and Laguna Sections)

Three (3) alternative alignments were developed focusing on minimization of social impact (or dislocation of people) as shown in **Figure 5.3.3-1**.

Alternative-1	:	Alignment Recommended by the 2006 FS
Alternative-2	:	North Alignment to minimize social impact in the northern area of Silang Municipality town proper.
Alternative-3	:	South Alignment to minimize social impact in the southern area of Silang Municipality town proper.

Three alternative alignments were evaluated as shown in **Table 5.3.3-1** and Alternative-2 was recommended due to the following reasons;

- Alternative-2 achieves minimum social impact.
- Alternative-2 achieves minimum cost.

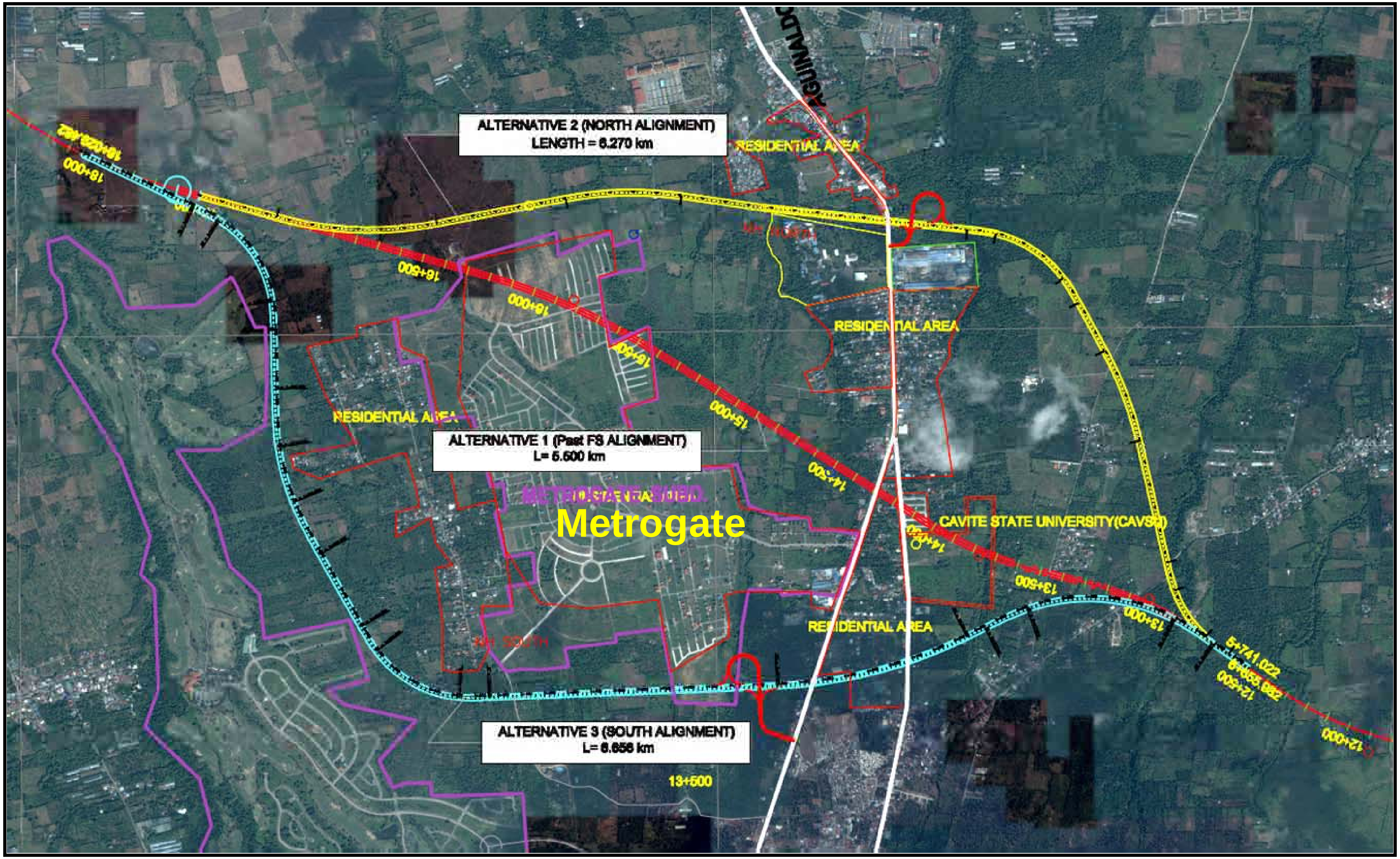


FIGURE 5.3.3-1 ALTERNATIVE ALIGNMENTS OF BEGINNING POINT OF LAGUNA SECTION

TABLE 5.3.3-1 EVALUATION OF ALTERNATIVE ALIGNMENTS AT BEGINNING POINT

(Confidential)

5.3.4 Step-2 : Selection of the End Point at SLEx.

(1) Existing Interchange Interval along SLEx

Many interchanges have been built along SLEx. **Table 5.3.4-1** and **Figure 5.3.4-1** show existing interchanges in the project area along SLEx from Carmona Interchange to Simsiman Toll Barrier.

TABLE 5.3.4-1 EXISTING INTERCHANGES IN PROJECT AREA ALONG SLEX

Name of Interchange	Interval of Interchanges (km)
Carmona I/C	
	2.53
Mamplasan I/C	
	2.33
Sta. Rosa I/C	
	4.00
Greenfield/Eton I/C	
	1.48
Cabyao I/C	
	1.46
Silang I/C	
	1.40
Calamba Toll Barrier (removed at present)	
	0.80
Canlubang I/C	
	2.40
Calamba I/C	
	4.00
Simsiman Toll Barrier	

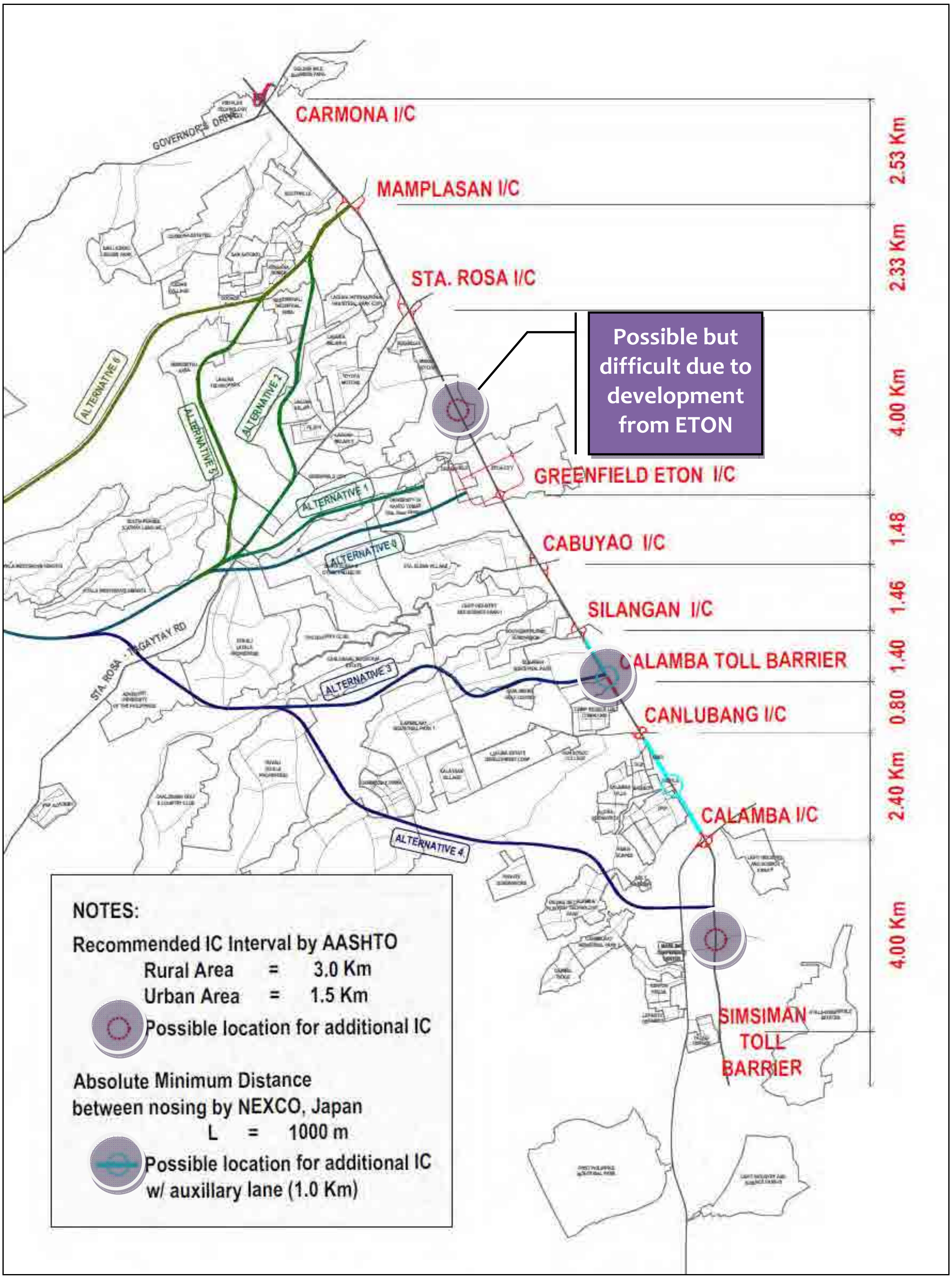


FIGURE 5.3.4-1 EXISTING INTERCHANGES IN PROJECT AREA ALONG SLEX

(2) Standard Minimum Interval Between Interchanges

Standard minimum interval between interchanges is recommended by AASHTO, as follows;

MINIMUM INTERVAL BETWEEN INTERCHANGES

- Rural Area = 3.0 km
- Urban Area = 1.5 km

In the Philippines, 2.0 km. is adopted for the minimum interval between interchanges.

When additional lane along the main line of expressway is added as an auxiliary lane, minimum nose to nose distance of 1 km. is accepted in Japan.

(3) Possible Location to Construct New Interchange

Possible locations to construct new interchange between existing interchanges are as follows;

POSSIBLE LOCATION FOR NEW INTERCHANGE

- Between Sta. Rosa I/C and Greenfield/Eton IC
- Between Calamba I/C and Simsiman Toll Barrier
- At Calamba Toll Barrier (now removed) with auxiliary lane

Among three (3) candidate locations, however, to construct new interchange between Sta. Rosa I/C and Greenfield/Eton I/C is quite difficult due to the following (see **Figure 5.3.4-2**);

- Eton Properties is now developing “South Lake Project”
- CALAX needs to be an elevated expressway over Sta. Rosa-Tagaytay Road, however, it has only 20 m road right-of-way and cannot accommodate an elevated expressway.
- Some other developments by Greenfield Development Corporation is on-going.

Remaining candidate locations for new interchange are as follows;

- Between Calamba I/C and Simsiman Toll Barrier
- At Calamba Toll Barrier which was removed at present

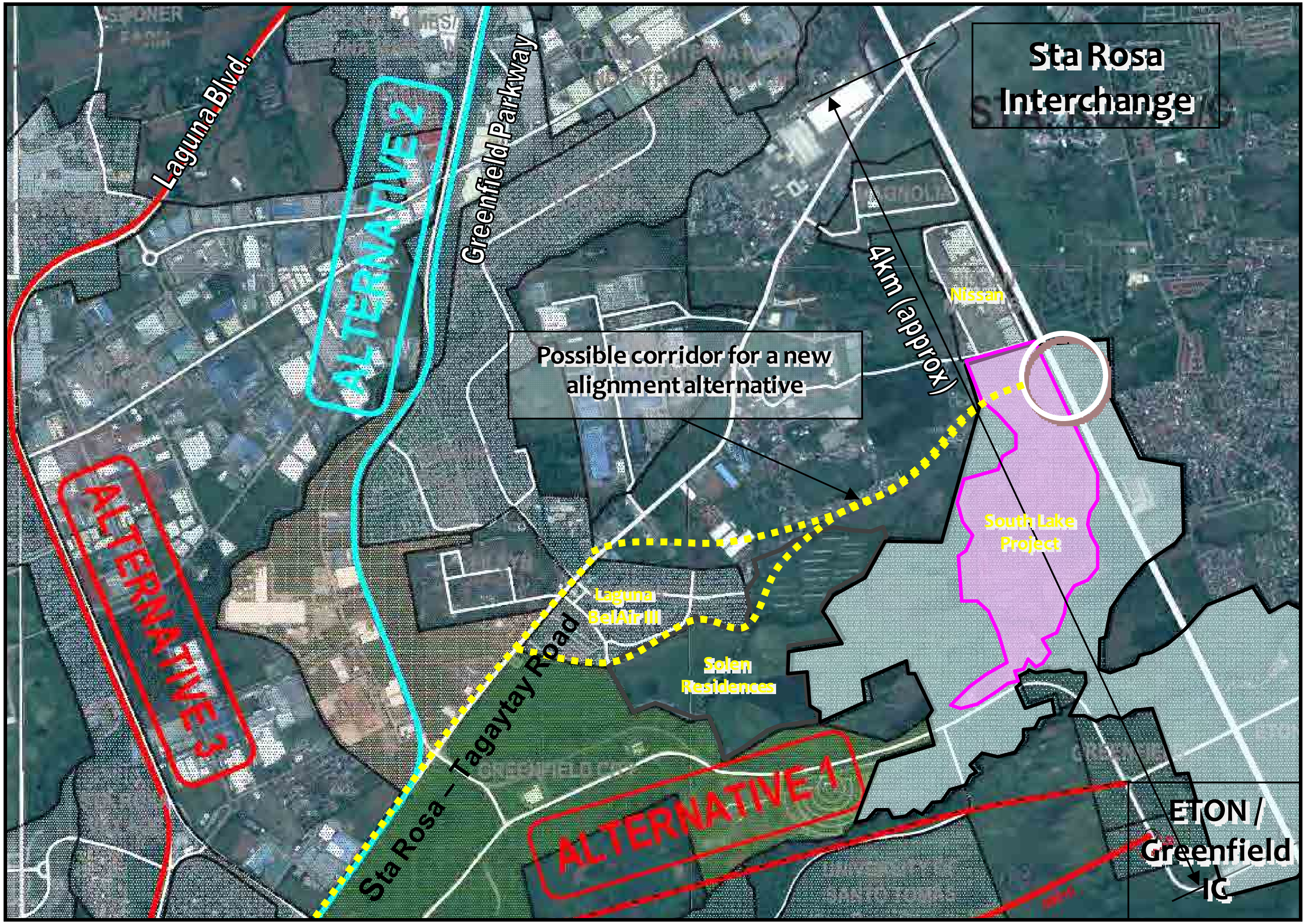


FIGURE 5.3.4-2 DEVELOPMENT CONDITION BETWEEN STA. ROSA I/C AND ETON/GREENFIELD I/C

(4) Connection with Existing SLEX Interchanges

There are two (2) methods to connect CALAx with the existing SLEx Interchanges.

a. CALAx is directly connected with SLEx at existing SLEx interchange. In this case, existing SLEx interchange must be converted to achieve direct connection between 2 expressways (this type is called as "Junction" in Japan). This requires drastic conversion of an existing interchange.

b. CALAx and SLEx are indirectly connected through a public road between CALAx and SLEx. Improvement of an existing interchange is required such as installation of additional toll booths, improvement of intersections, and widening of some portions of ramps.

Direct Connection by Converting Existing Interchange

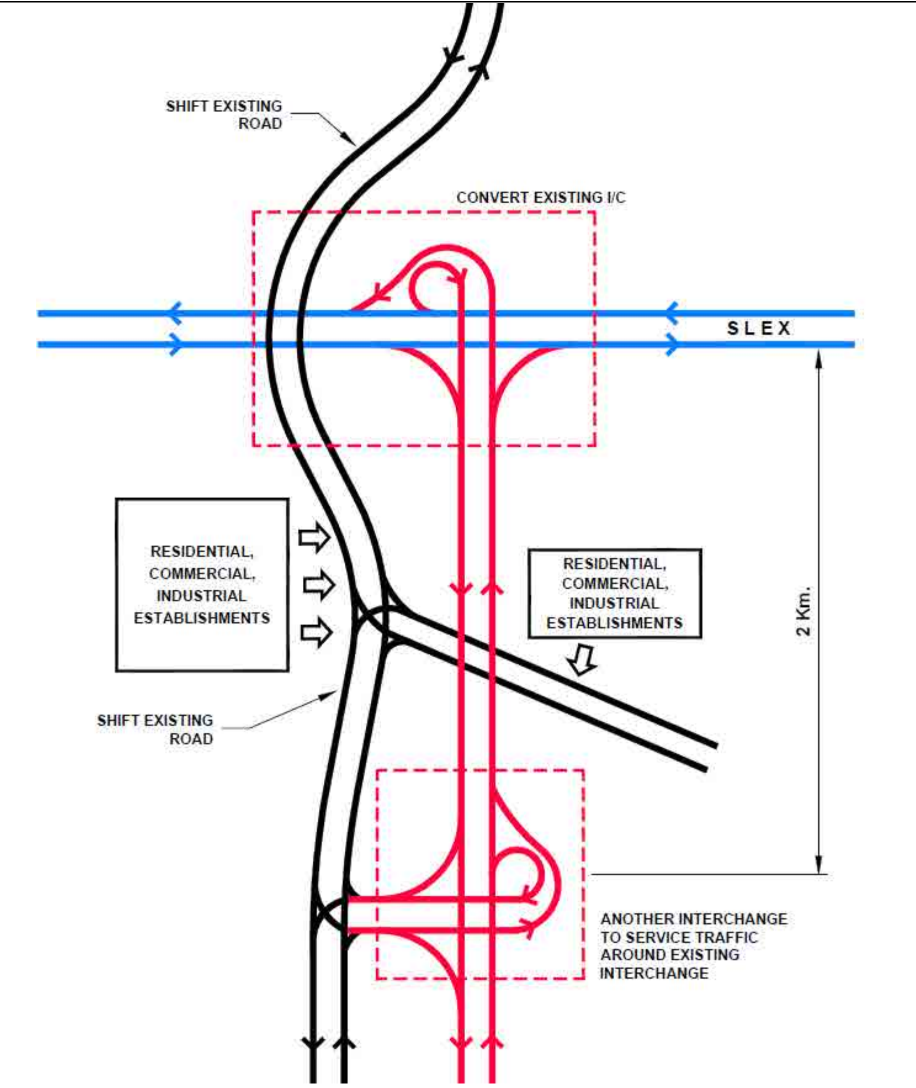
Two (2) examples are shown in **Figure 5.3.4-3**.

Example-1

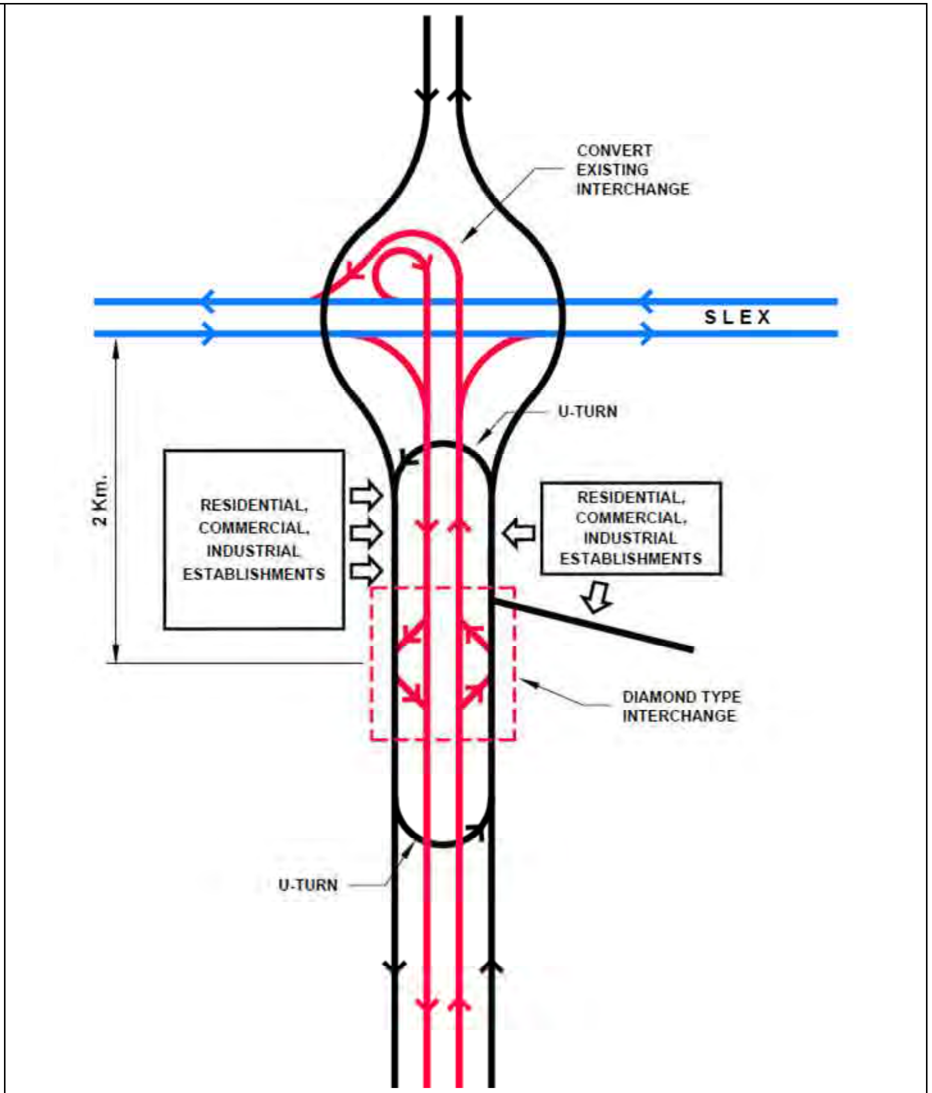
- Existing road is to be shifted (which is quite difficult due to ROW acquisition) to maintain accessibility to neighboring establishments of an existing interchange.
- Another interchange is needed at about 2 km away from SLEx to provide accessibility to existing establishments near the existing interchange.

Example-2

- Wide road right-of-way of about 60 m is required (which is also difficult due to ROW acquisition)
- Diamond type of interchange is to be constructed at about 2 km from SLEx and U-turn slots are also needed to provide accessibility to existing establishments near the existing interchange.



DIRECT CONNECTION WITH CONVERSION OF EXISTING INTERCHANGE: EXAMPLE - 1



DIRECT CONNECTION WITH CONVERSION OF EXISTING INTERCHANGE: EXAMPLE - 2

FIGURE 5.3.4-3 EXAMPLES OF DIRECT CONNECTION

In-Direct Connection by Improving Existing Interchange

In-direct connection means CALAx and SLEx is not directly connected, instead both expressways are connected via short section of public road. CALAx will end before reaching to SLEx and a gap between two expressways is connected by a public road as shown in **Figure 5.3.4-4**.

Demerit of this Scheme

- Continuity of travel on an expressway is interrupted.
- Travel speed at the public road section is reduced, thus transport efficiency is affected.

Merit of this Scheme

- Existing and future establishments near the existing SLEx interchange can enjoy the present level of accessibility even during construction/improvement.
- No extensive ROW acquisition is needed.
- In case of Direct Connection Case, temporary closure of the existing interchange is required, however, this scheme does not require temporary closure of existing interchange.
- Civil work cost is much cheaper than the direct connection scheme.

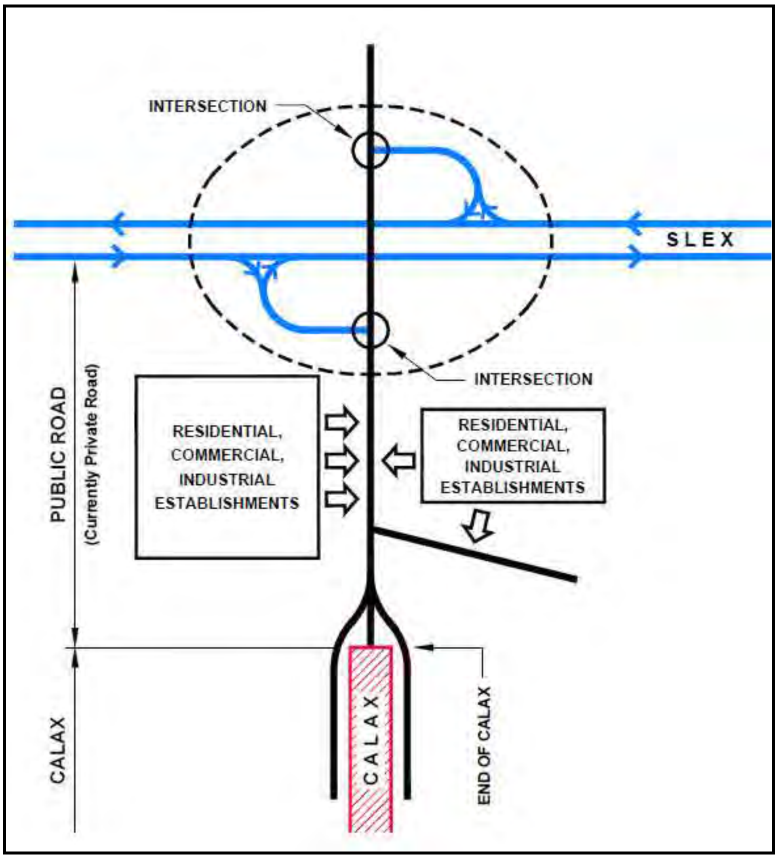


FIGURE 5.3.4-4 INDIRECT CONNECTION VIA PUBLIC ROAD TO EXISTING INTERCHANGE

5.3.5 Step-3 : Alternative Alignments and Evaluation

The beginning section was selected as discussed in Section 5.3.3. The end point has several alternatives as discussed in Section 5.3.4 and the following points were selected as an alternative end point;

Alternative End Points (Connection with SLEx)

- Existing Mamplasan Interchange
- Existing Eton/Greenfield Interchange
- Old Calamba Toll Barrier
- New Location between Calamba Interchange and Simsiman Toll Barrier

(1) Alternative Alignments

Six (6) alternatives were developed as shown in **Figure 5.3.5-1**.

Alternative-1

- This is the revised alignment of the 2006 FS and connected with the existing Eton/Greenfield Interchange.
- This route is the second shortest alignment among the alternatives.
- Intended to capture generated traffic from the on-going and future development areas.

Alternative-2

- End point is Mamplasan Interchange.
- Intended to utilize the existing private road of Greenfield Parkway (ROW width is 40 m.)
- Intended to capture generated traffic from the existing, on-going and future development areas.

Alternative-3

- Same concept as Alternative-2 above.
- Intended to utilize the existing private road of Laguna Blvd. (ROW width is 60 m.)

Alternative-4

- End point is Calamba Toll Barrier which was shifted to Simsiman Toll Barrier of SLEx Extension, and new interchange is constructed.
- Intended to capture generated traffic from the existing, on-going and future development areas.

Alternative-5

- End point is located at about the middle point between Calamba Interchange and Simsiman Toll Barrier and new interchange is constructed.
- This is the longest route among the alternatives.
- Intended to capture traffic from the existing, on-going and future development areas.
- Generated traffic from the developing areas can utilize both CALAx and SLEx.

Alternative-6

- This is the shortest route among the alternatives, however, it has to pass through steep slope areas.
- This route functions as a bypass route of Governor’s Drive.

Each alignment of alternatives is shown in **Figures 5.3.5-2 (1) to (6)**.

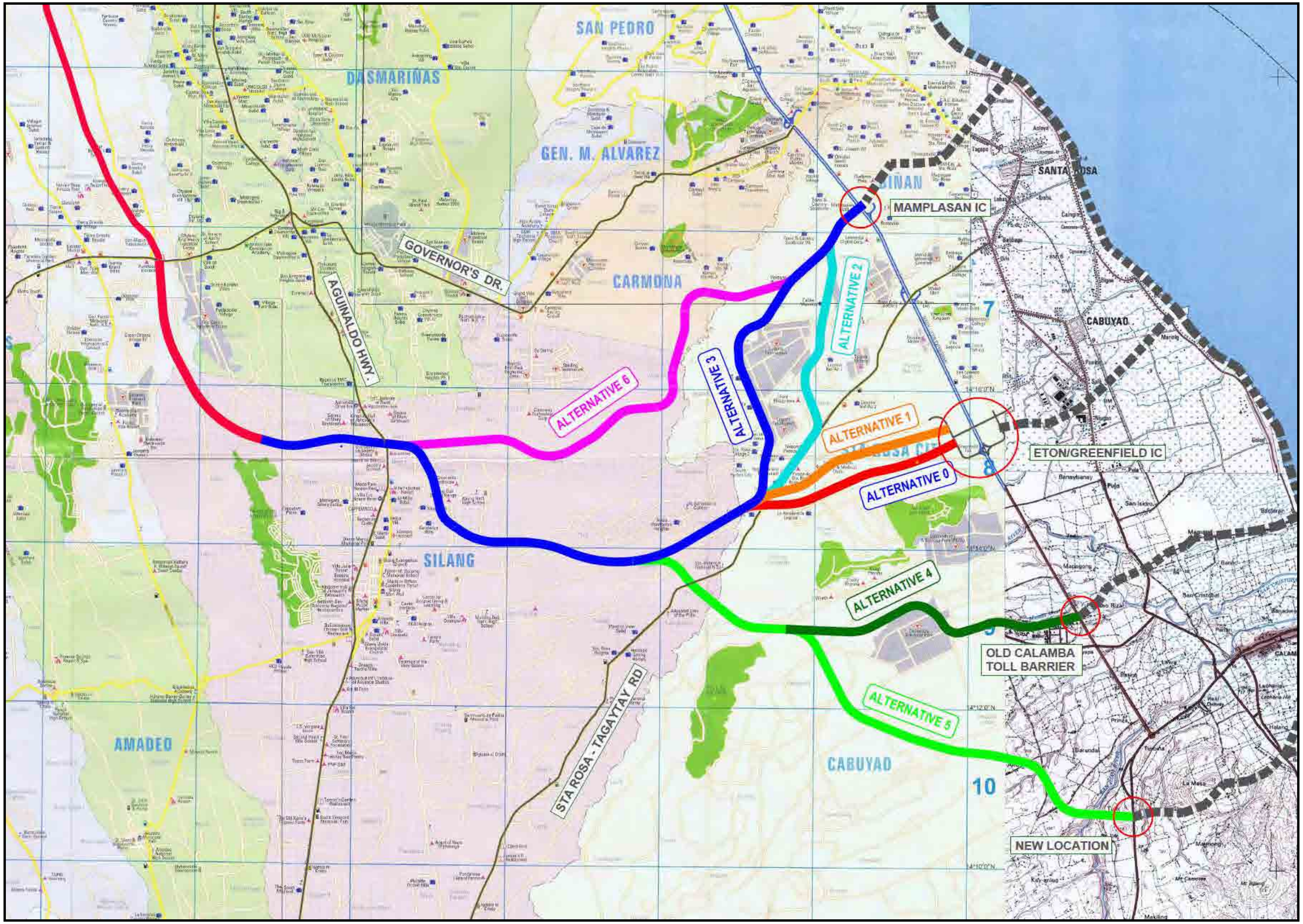


FIGURE 5.3.5-1 ALTERNATIVE ALIGNMENTS

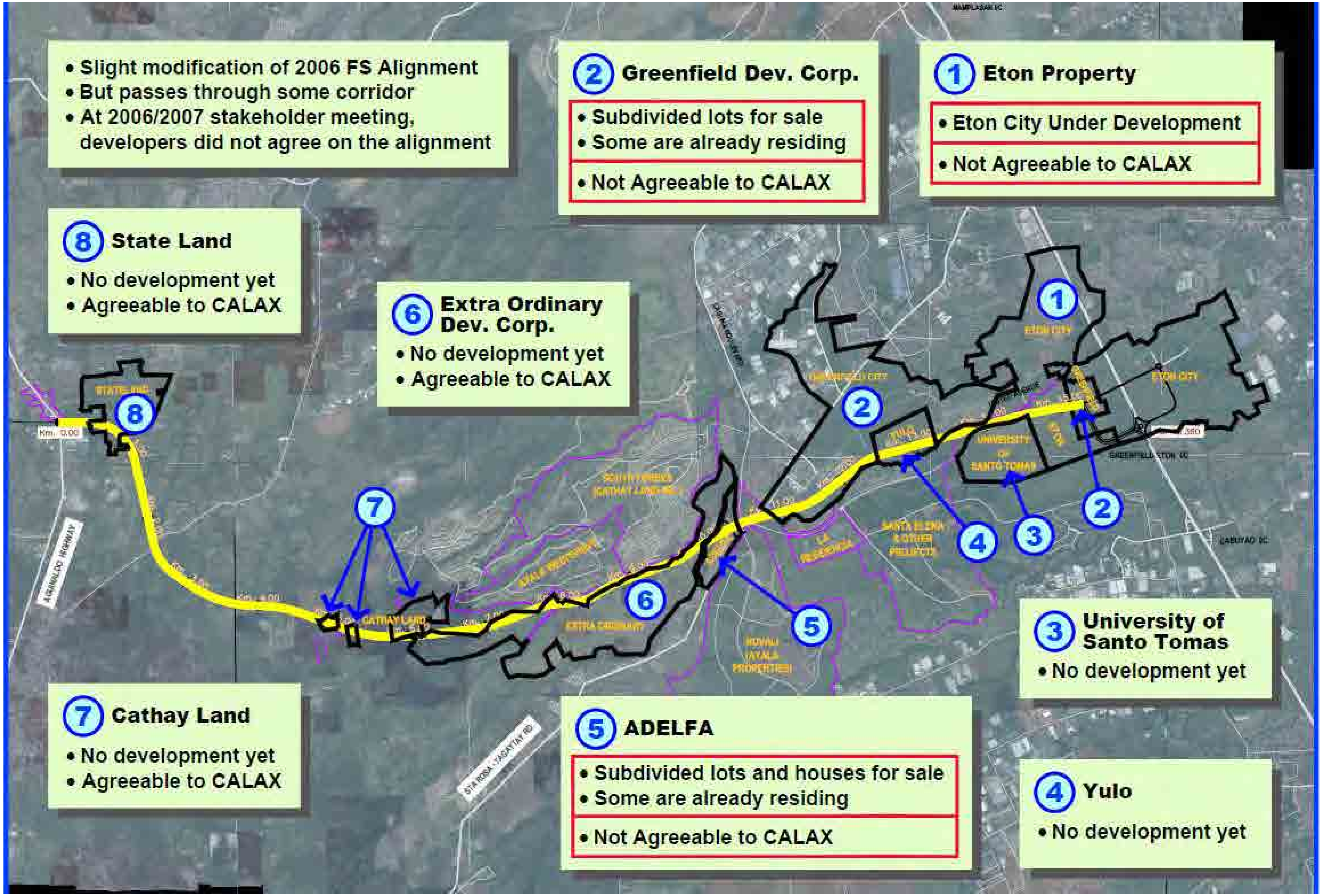


FIGURE 5.3.5-2 (1) ALTERNATIVE ALIGNMENT 1

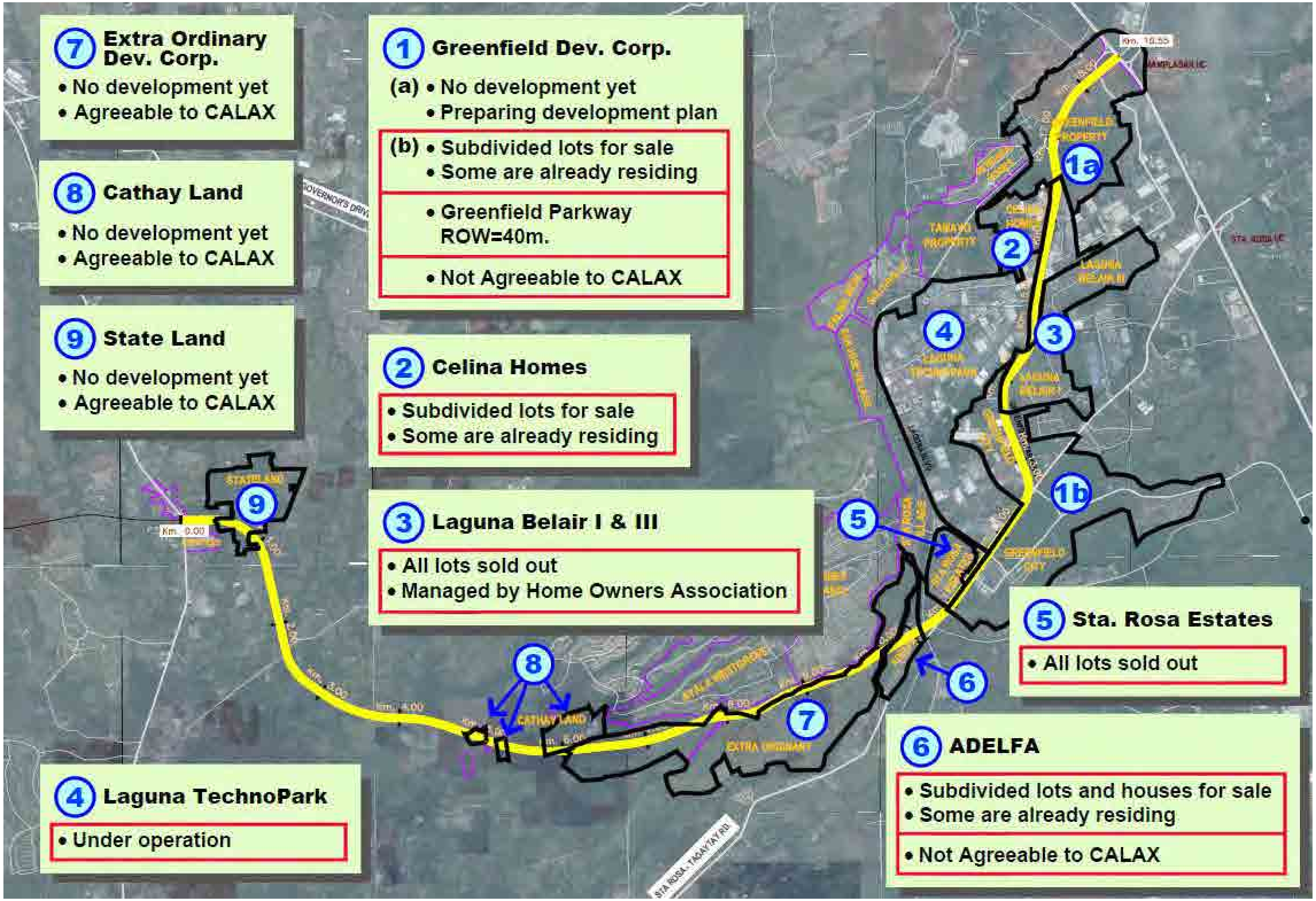


FIGURE 5.3.5-2 (2) ALTERNATIVE ALIGNMENT 2

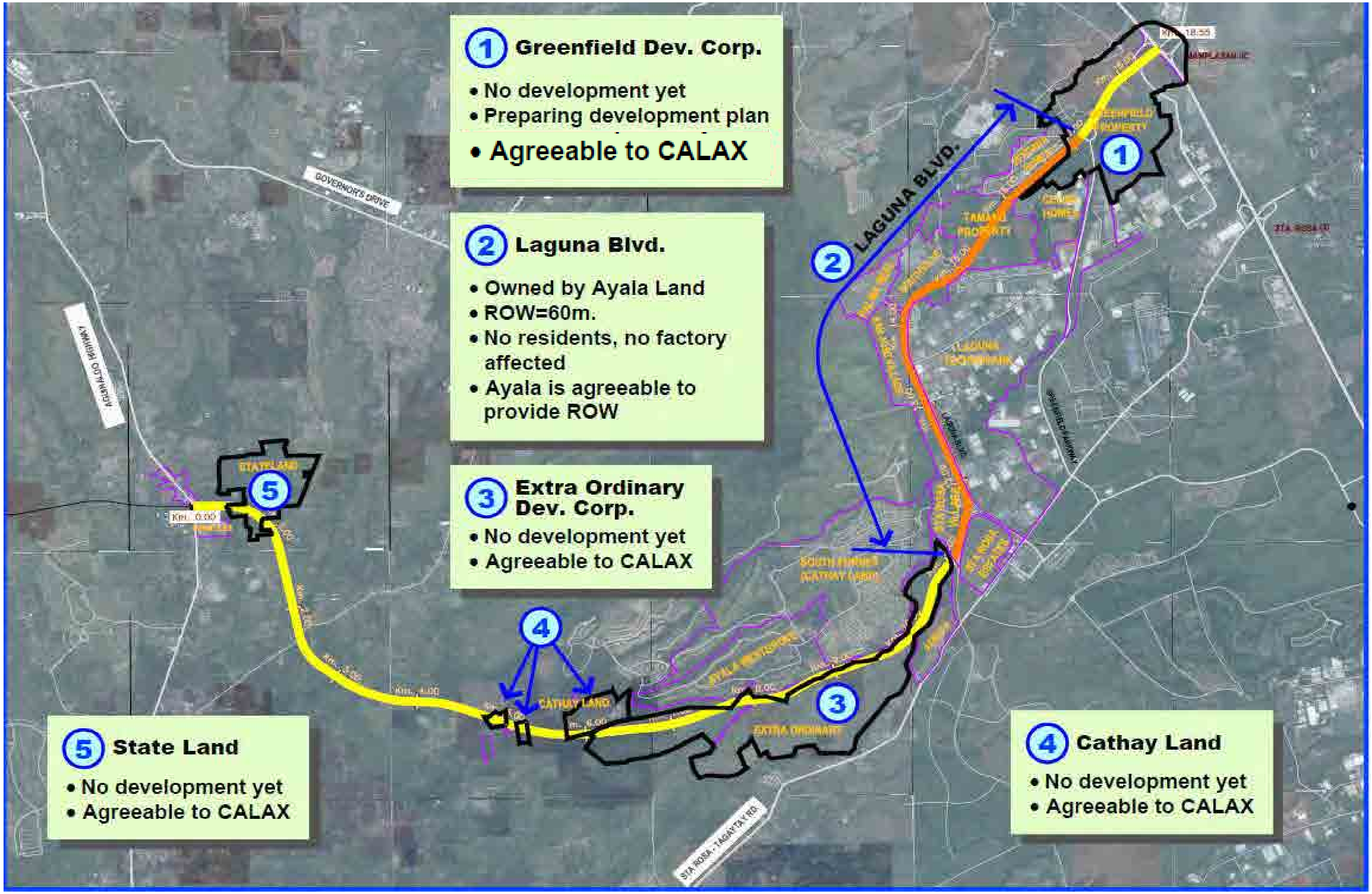


FIGURE 5.3.5-2 (3) ALTERNATIVE ALIGNMENT 3

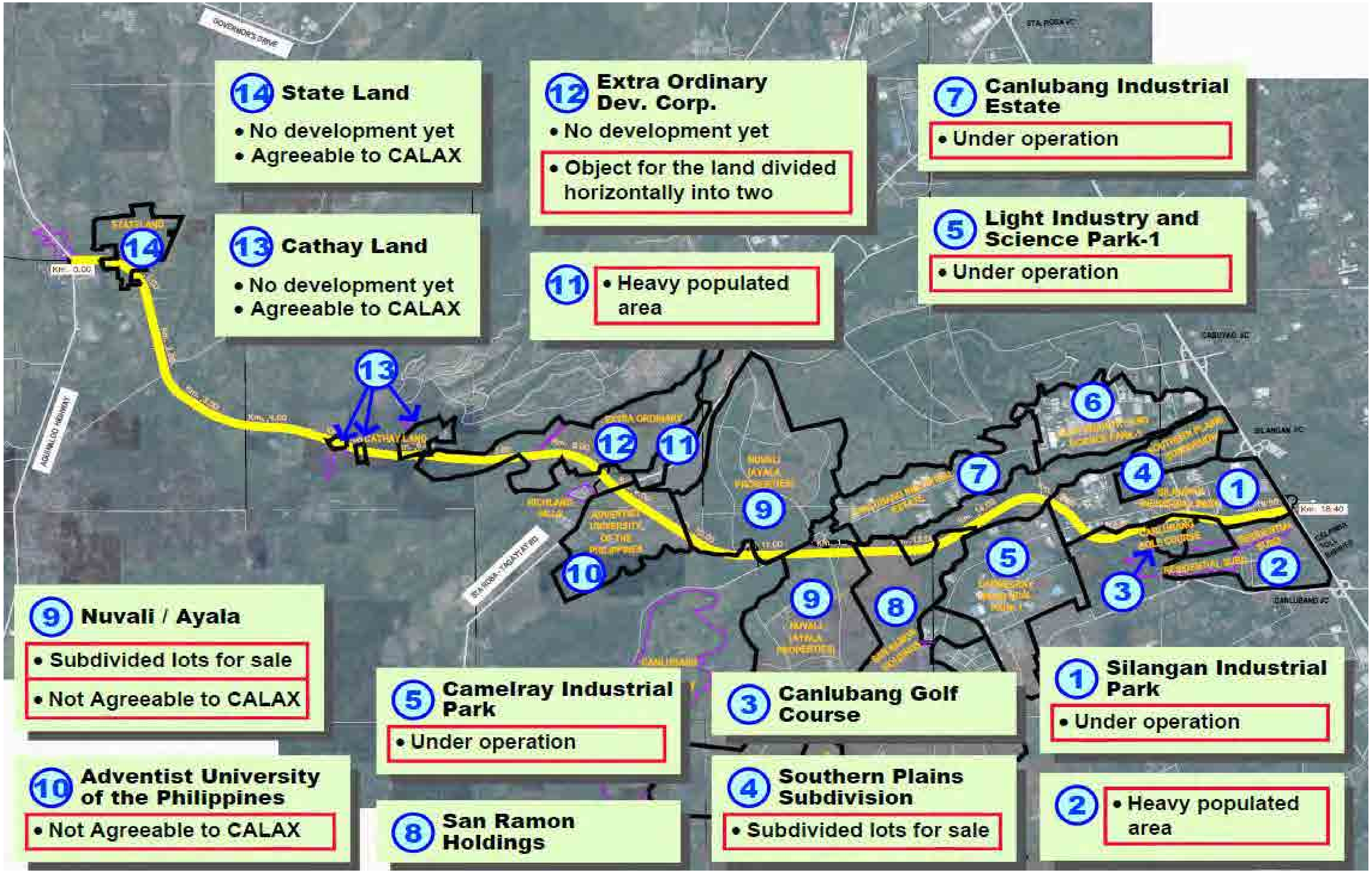


FIGURE 5.3.5-2 (4) ALTERNATIVE ALIGNMENT 4

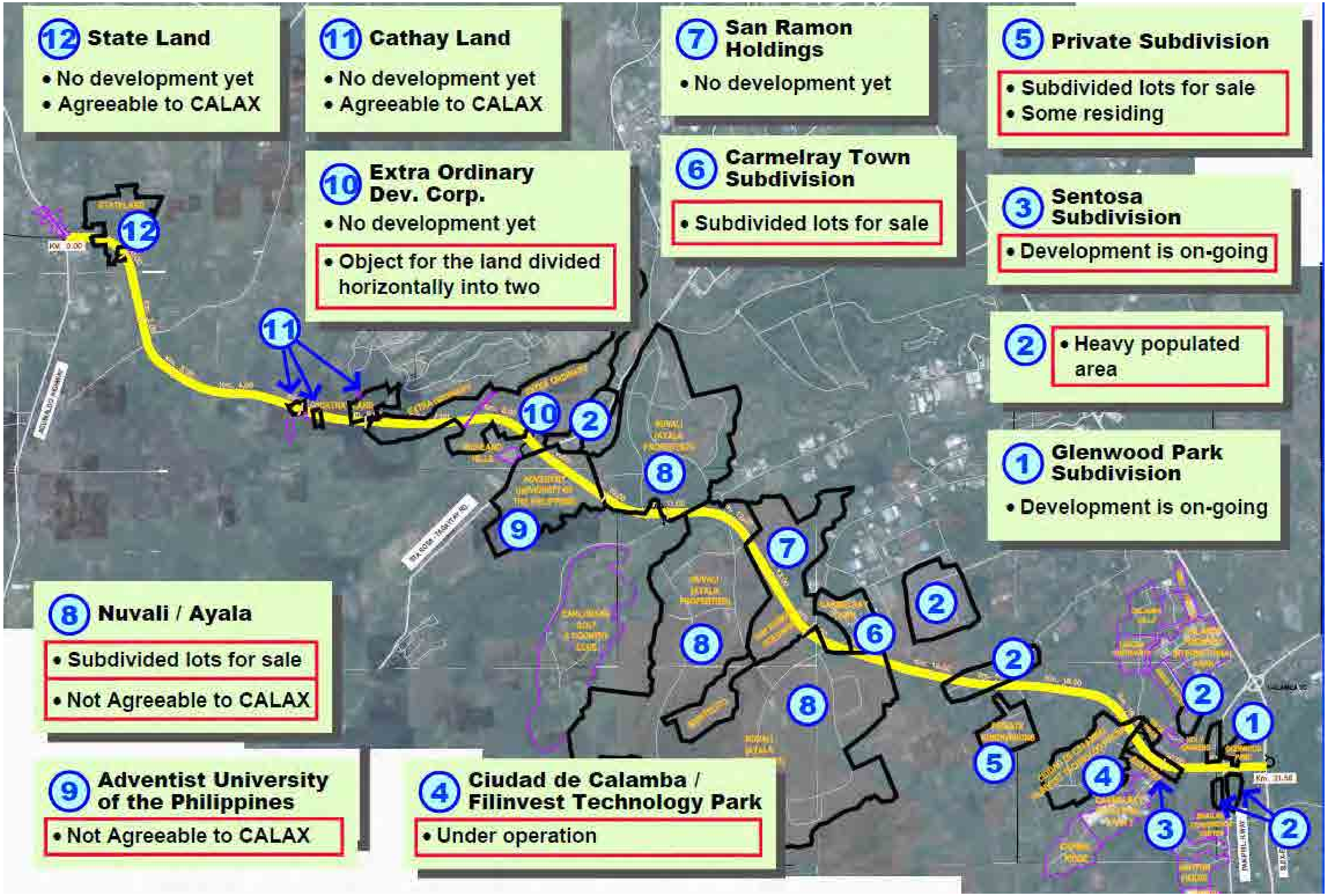


FIGURE 5.3.5-2 (5) ALTERNATIVE ALIGNMENT 5

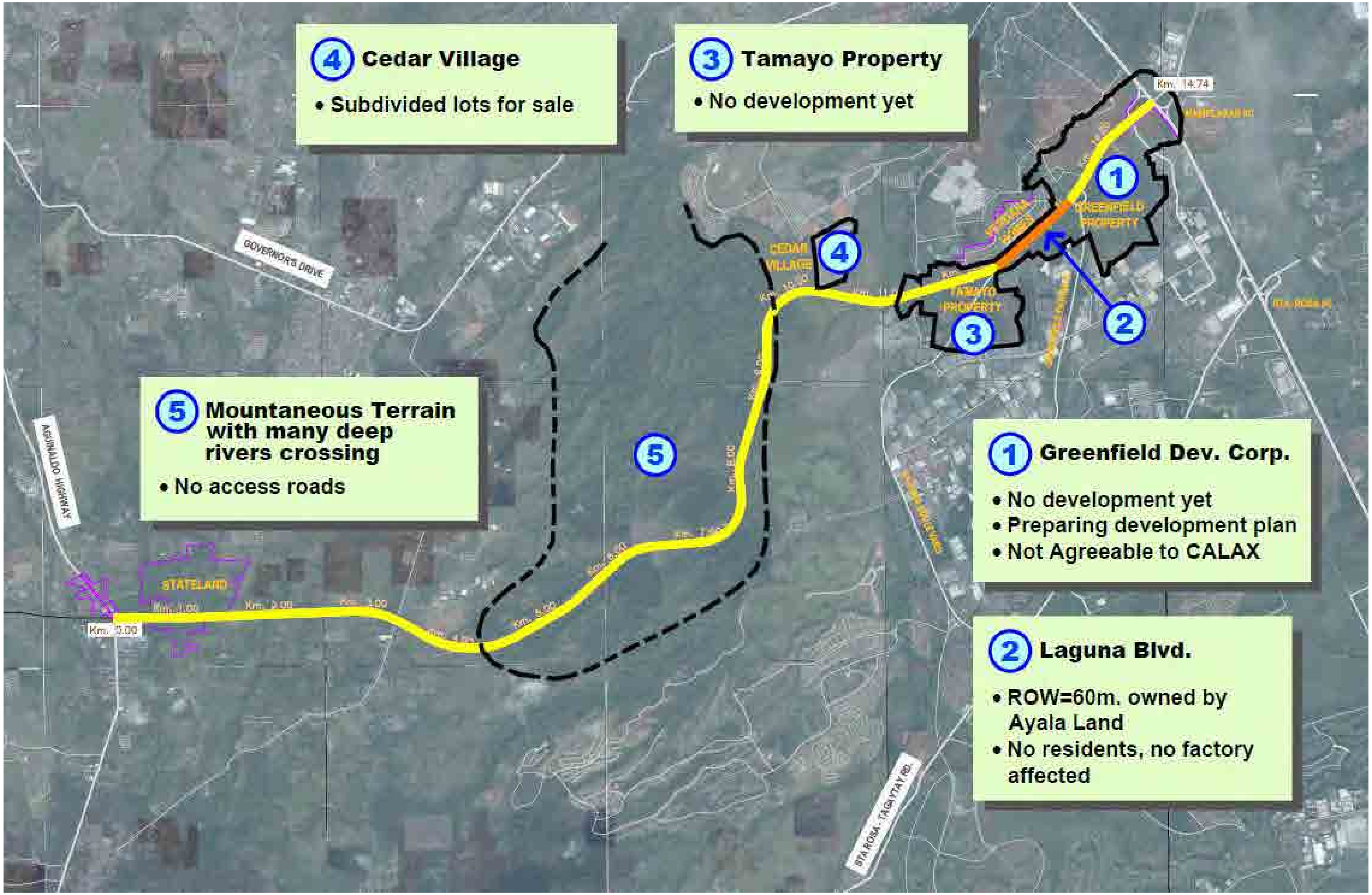


FIGURE 5.3.5-2 (6) ALTERNATIVE ALIGNMENT 6

(2) Civil Work Component and Cost Estimate

Civil work component of each alternative is shown in **Table 5.3.5-1**. Since all alternatives pass through urbanized/to be urbanized area, viaduct type was planned.

TABLE 5.3.5-1 CIVIL WORK COMPONENT OF ALTERNATIVES

Alternative	Length (km.)	Cost (Million Pesos)				No. of IC
		Roadway	Bridge	MSE Wall	Viaduct	
1	16.4 (100%)	10.20 (62%)	1.49 (9%)	2.90 (18%)	1.81 (11%)	3
2	18.6 (100%)	10.00 (54%)	1.09 (6%)	2.40 (13%)	5.11 (27%)	4
3	18.6 (100%)	10.50 (81%)	1.09 (6%)	2.20 (12%)	4.81 (26%)	4 + 1/2
4	18.4 (100%)	10.80 (59%)	1.69 (9%)	1.60 (9%)	4.31 (23%)	3
5	21.6 (100%)	13.40 (62%)	2.09 (10%)	3.00 (14%)	3.11 (14%)	3
6	14.8 (100%)	8.58 (58%)	3.29 (22%)	1.60 (11%)	1.33 (9%)	3

Civil work cost and right-of-way acquisition cost were roughly estimated and shown in **Table 5.3.5-2** and **Figure 5.3.5-3**.For cost estimate, the following unit prices per km was used;

- Cut/Embankment Section — 250 Million Php/km
- SME wall Section — 450 Million Php/km
- Bridge/Viaduct Section — 1,000 Million Php/km

ROW acquisition cost was based on BIR Zonal Value.

TABLE 5.3.5-2 ROUGHLY ESTIMATED COST OF ALTERNATIVES

Alternative	Length (km.)	Cost (Million Pesos)			Cost per Km (Million Pesos)		
		Civil Work	ROW	Total	Civil Work	ROW	Total
1	16.4	10,056 (65.5%)	5,303 (34.5%)	15,359 (100%)	613	323	937
2	18.6	13,196 (76.2%)	3,975 (23.8%)	17,171 (100%)	709	214	923
3	18.6	12,700 (80.5%)	2,962 (19.5%)	15,662 (100%)	683	159	842
4	18.4	12,484 (74.2%)	4,419 (25.8%)	16,903 (100%)	678	240	919
5	21.6	13,152 (74.2%)	4,581 (25.8%)	17,733 (100%)	609	212	821
6	14.8	11,869 (83.2%)	2,391 (16.8%)	14,260 (100%)	802	162	964

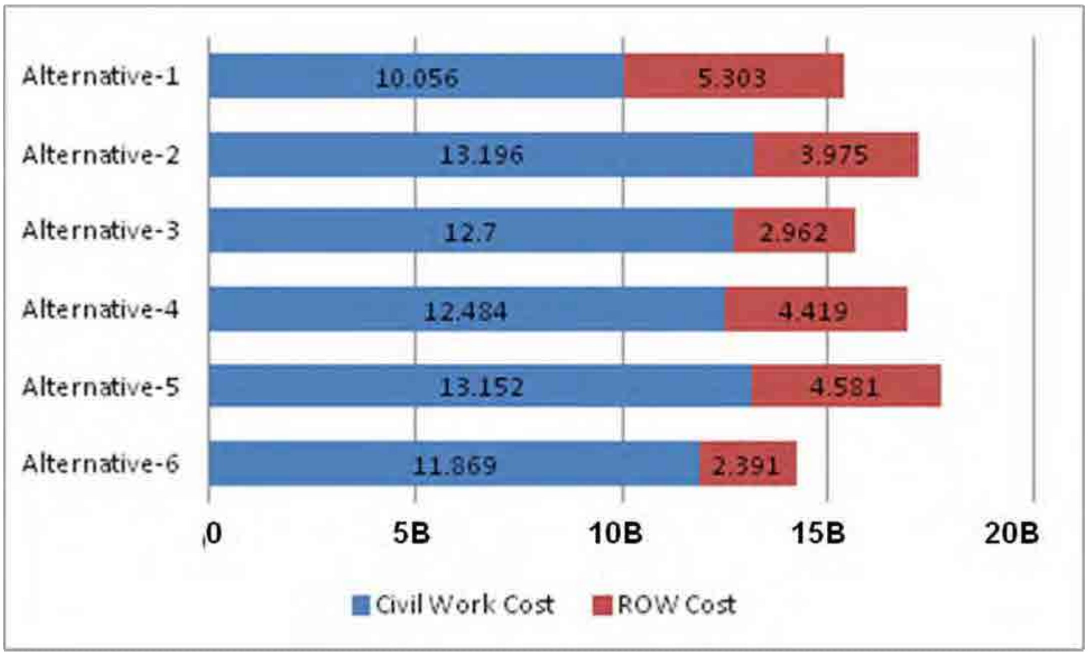


FIGURE 5.3.5-3 ROUGHLY ESTIMATE COST OF ALTERNATIVES

(3) Traffic Volume Attracted to Expressway

Traffic volume in 2020 was estimated as shown in **Table 5.3.5-3**.

TABLE 5.3.5-3 TRAFFIC VOLUME ATTRACTED TO CALAX (YEAR 2020)

Alternative	Length (km)	Traffic Volume which Enter CALAX per Day	Average Section Traffic Volume per Day	Vehicle-km per Day	Average Trip Distance (km)
1	16.4	48,500	36,800	609,100	12.6
2	18.6	53,900	31,400	548,100	10.2
3	18.6	57,600	34,300	576,800	10.0
4	18.4	58,500	30,600	591,300	10.1
5	21.6	52,200	28,500	643,200	12.3
6	14.8	37,100	27,100	434,200	11.7

(4) Characteristics of Alternatives

Characteristics of alternatives are summarized in **Table 5.3.5-4**.

TABLE 5.3.5-4 CHARACTERISTICS OF ALTERNATIVES

(Confidential)

(Confidential)

(5) Evaluation of Alternatives

Method : Relative superiority of an alternative.
All evaluation items were equally evaluated.
Relative superiority among alternatives.

Good : ○
Medium : △
Bad : X

Superiority of an alternative was evaluated by number of "Good, O"

a) Contribution to improvement of accessibility to the Project Area and Area Development

- Whether CALAX passes through an existing, on-going or proposed development area;
  - More than 70% of section ………………..… ○
  - 50% to 70% ……………………………..….. △
  - Less than 50% ……………………………... X

b) Connection with SLEX

- Direct Connection ………………………..………. ○
- Direct Connection is possible, but quite expensive … △

c) Traffic Volume Attracted

When higher traffic is attracted, it contributes more to reduce traffic congestion of public roads and the project is economically and financially feasible, thus an alternative which attract higher traffic is evaluated better than other alternatives.

- More than 50,000 veh./day ………………………….. ○
- 40,000 to 50,000 veh/day ……………………………. △
- Less than 40,000 veh/day ……………………………. X

d) Cost (Civil Work Cost + ROW Acquisition Cost)

Smaller cost is better for the project. When the smallest cost is set as 1.00, increase rate of other Alternative was evaluated as follows;

<u>Cost Ratio</u>

1.0 to 1.10 ……………………………………………. ○
1.10 to 1.20 …………………………………………... △
Over 1.20 …………………………………………….. X

e) Impact on Natural Environment

Major natural environmental impact of this project will be soil erosion and loss of greenery.

e-1) Soil Erosion

The project area is prone from slight to moderate soil erosion, depending on the gradient of land slope. Since slope cutting will affect soil erosion, thus evaluation indicator used is the volume of slope cutting.

Large scale of slope cut (over 500,000 m^3) required ………….….. X

Medium scale of slope cut (200,000 to 500,000 m^3) required ……... △
Small scale of slope cut (less than 200,000 m^3) required ……….… ○

e-2) Loss of Greenery

Loss of greenery is evaluated as the quantity of cut trees.

A large number of trees are cut …………………………………… X
Medium number of trees are cut ………………………………….. △
Small number of trees are cut ………….……………………….. ○

f) Social Impact

Evaluated by the number of houses to be affected.

10 or less houses ……………………………………………..... ○
10 to 30 houses ………………………………………………... △
Over 30 houses ……………………………………..………. X

g) Cost Performance

Cost performance = veh.km/cost in Million Php

High Efficiency over 35 ……………………..…………... ○
Medium Efficiency 30 to 35 ….………..………………………. △
Low Efficiency less than 30 ……………………………….. X

h) Easiness of Implementation (ROW Acquisition)

Development status of properties of land development companies is different and can be classified as follows;

(a) Lots were sold out and some people are already residing.
(b) Lots are being sold.
(c) No development is made yet.

Those who bought a lot sold by the land development companies were not informed that an expressway will be built and their properties may be affected by the project. Therefore, it will take a longer time to negotiate with these people, and DPWH will have a hard time to acquire the road right-of-way. Evaluation was made as follows;

- Lots are not affected or land development has not started yet ….. ○
- Some lots are being sold ……………………………………… △
- Many lots have been sold out or are being sold and some people are already residing …………………………… X

i) Easiness of Construction

This was evaluated as follows;

- Wide construction space is available, existing traffic is not disturbed, access road for construction needed, but its construction is easy. ………………… ○
- Above conditions become rather severe ………………………….. △
- Construction of access road itself is difficult due to terrain, and construction can start only at the beginning side and end side …………………………... X

TABLE 5.3.5-5 EVALUATION OF ALTERNATIVES: METHOD-1

(Confidential)

(6) Evaluation and Recommendation

Results of evaluation shows that Alternative-3 is the most preferable alternative. Advantages of Alternative-3 are as follows;

Alternative – 1: Not recommended

- Many land development companies are objecting to this alignment. ROW acquisition is extremely difficult and takes a long time for negotiating with them as well as those households who recently purchased lots.

Alternative -2: Not recommended

- Many land development companies are objecting to this alignment. ROW acquisition is extremely difficult and takes a long time for negotiating with them as well as those households who are residing along the alignment.

Alignment – 3: Recommended

- Cost is within 10% increase compared to the minimum cost alternative (Alternative-6).
- High traffic volume is affected. Although the alternative which attracts the highest traffic is Alternative – 4, however, difference between Alternative – 4 and this alternative is only 1.6% (or 900 vehicles per day).
- Number of people dislocated by this alternative is the smallest among alternatives, since this alternative utilize the existing private road right-of way for about 1/3 of the alignment.
- ROW acquisition is the easiest among alternatives, utilizes the existing 60m ROW of Laguna Blvd. for about 1/3 of the alignment.

Alignment – 4: Not recommended

- Although this alignment attracts the highest traffic volume, lands of four (4) existing industrial estates are taken by this alignment and industrial activities will be affected. Also, lands of a university and many of residential subdivisions are affected.
- Due to above, ROW acquisition will be extremely difficult and takes a long time.

Alignment – 5: Not recommended

- The alignment is the longest in length and the most expensive alternative.
- Land of one (1) industrial estates, many residential subdivisions and one (1) university are taken by this alignment, thus ROW acquisition is extremely difficult and takes a long time for negotiation with those affected.

Alternative – 6: Not recommended

- Although this alignment is the shortest and the cost is the smallest among alternatives, but this alternative attract the least traffic.
- This alignment passes through mountainous area, thus impact of this alignment on the urbanization and economic development is the smallest.

In view of the above, **Alternative-3** was **recommended**.

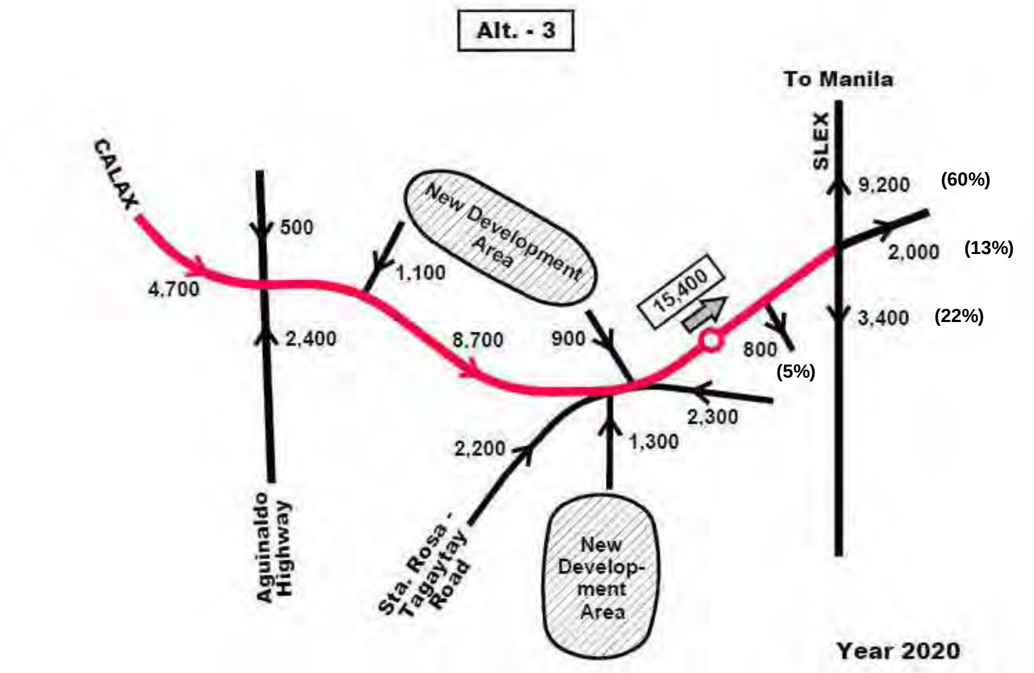
5.3.6 How CALAX will be Used?

Directionof traffic flow at the section over Laguna Blvd. is shown in **Figure 5.3.6-1** and summarized in **Table 5.3.6-1**.

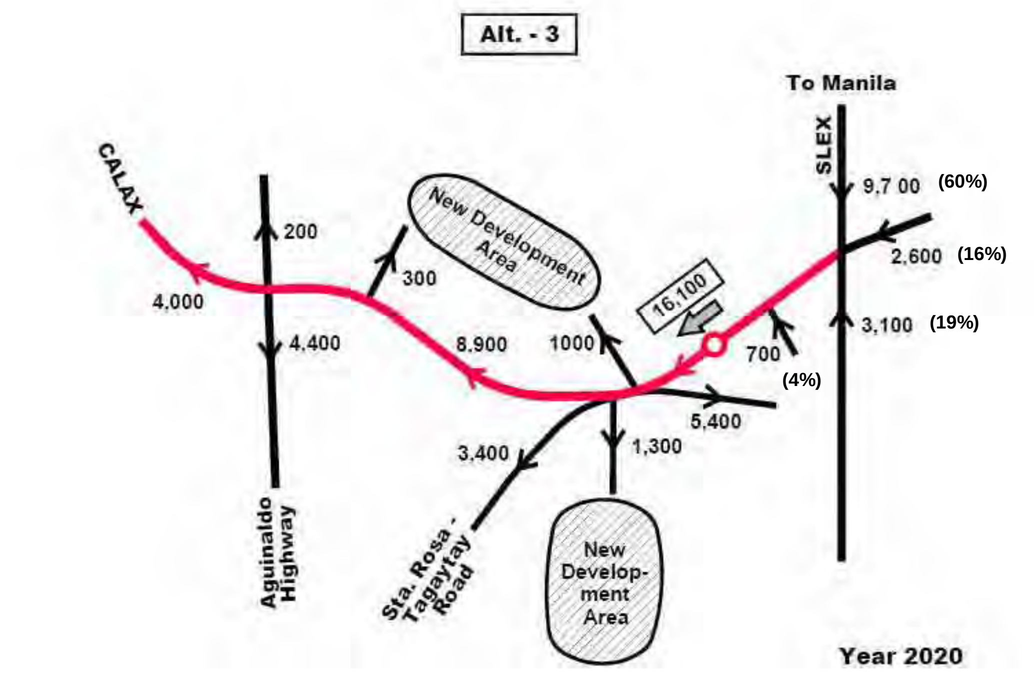
TABLE 5.3.6-1 DIRECTION OF TRAFFIC ON CALAX OVER LAGUNA BLVD.

Direction		**Traffic Volume**	**% Share**
Metro Manila related	To Metro Manila	9,200	60%
	From Metro Manila	9,700	60%
	Total	18,900	60%
Calamba (South of IC) or toward South related	To South	3,400	22%
	From South	3,100	19%
	Total	6,500	21%
Laguna Bay (East) side related	To East	2,000	13%
	From East	2,600	16%
	Total	4,600	15%
Industrial Estate Related	To Estate	800	5%
	From Estate	700	5%
	Total	1,500	5%

As shown in the table, 60% of CALAX traffic is to/from Metro Manila (towards the north), Calamba (or south of Mamplasan Interchange) is 21%, Laguna Bay-related (towards the east) is 15%, and Industrial Estate-related is 5%.



Traffic Direction to Mamplasan Interchange



Traffic Direction from Mamplasan Interchange

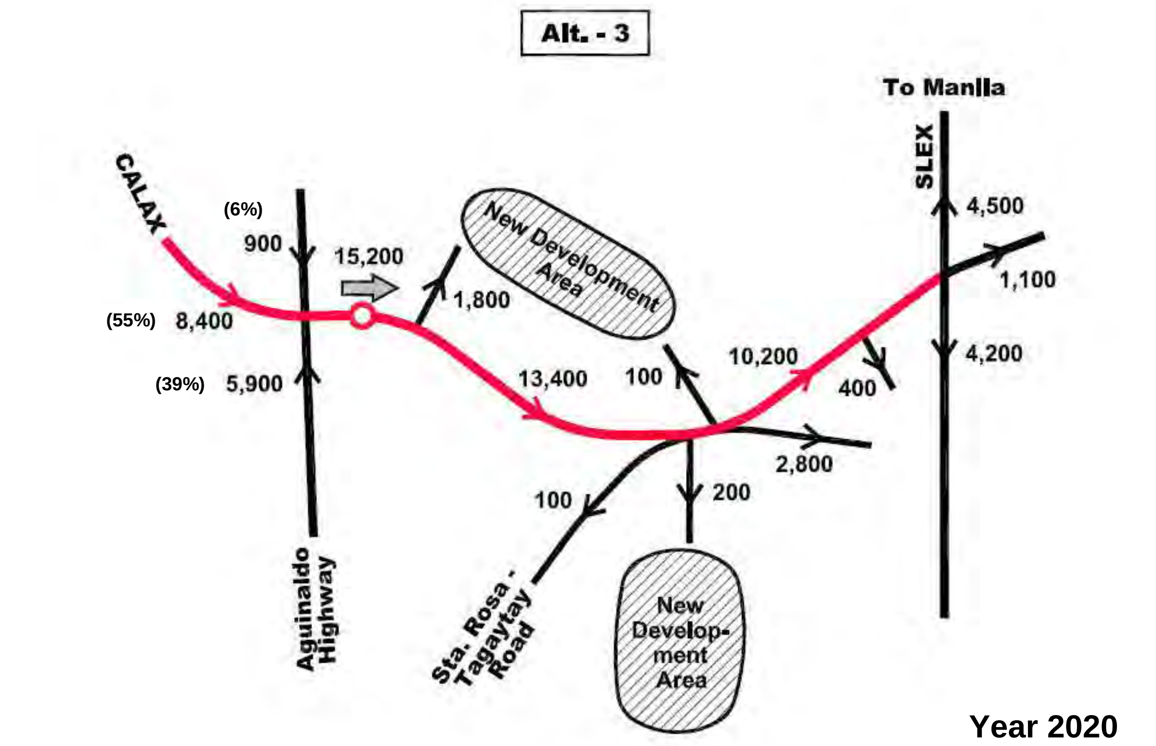
FIGURE 5.3.6-1 DIRECTION OF TRAFFIC NEAR MAMPLASAN INTERCHANGE

Direction of traffic flow at the section near Aguinaldo Highway is shown in **Figure 5.3.6-2** and summarized in **Table 5.3.6-2.**

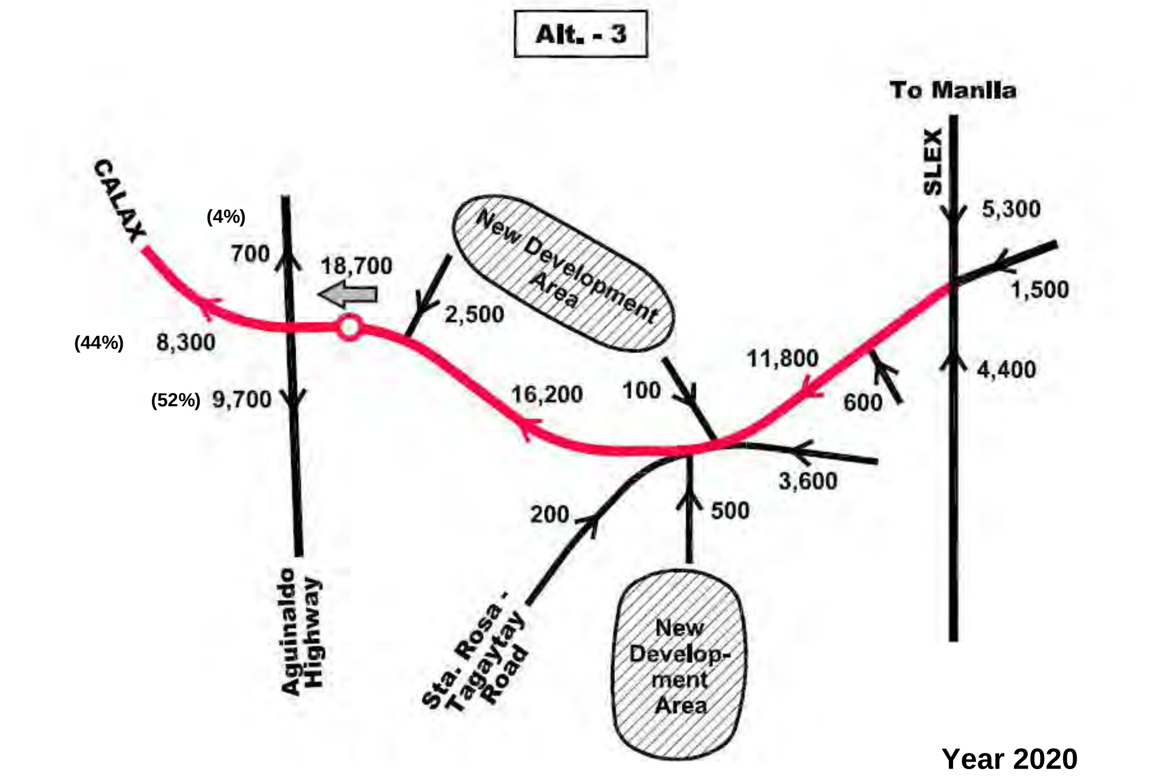
- 49% is to/from Cavite Section.
- 46% is to/from Tagaytay (or South) side via Aguinaldo Highway.
- 5% is to/from Dasmariñas (or North) side via Aguinaldo Highway.

TABLE 5.3.6-2 DIRECTION OF TRAFFIC ON CALAX SECTION NEAR AGUINALDO HIGHWAY

Direction		**Traffic Volume**	**% Share**
Cavite Section related	To Cavite Section	8,300	44%
	From Cavite Section	8,400	55%
	Total	16,700	49%
Aguinaldo Highway: Tagaytay (south) related	To Tagaytay	9,700	52%
	From Tagaytay	5,900	39%
	Total	15,600	46%
Aguinaldo Highway Dasmariñas (north) related	To Dasmariñas	700	4%
	From Dasmariñas	900	6%
	Total	1,600	5%



Traffic Direction From Cavite Section / Aguinaldo Highway



Traffic Direction to Cavite Section / Aguinaldo Highway

FIGURE 5.3.6-2 DIRECTION OF TRAFFIC NEAR AGUINALDO HIGHWAY

5.3.7 Viaduct along Laguna Blvd.

The proposed alignment utilized the existing Laguna Blvd. which was developed by Ayala Corporation and is operated as a private road, therefore, all vehicles cannot pass the road but only those with sticker.

The east side of the road is the Laguna Techno Park (industrial estate) and the west side of the road is mostly residential subdivisions.

The road has a right-of-way width of 60m. About 1/3 of the section is 4-lane divided road and the rest is a 2-lane road. Due to roadside development, there are many intersections as shown in **Figure 5.3.7-1.**

CALAX was planned to fly over all existing intersections and the profile of the section between intersections was planned to lower as much as possible to reduce the construction cost, thus, the section along Laguna Blvd. comprises of Viaduct Section and the mechanically stabilized earth wall (MSE Wall) as shown in **Figure 5.3.7-1.** Typical cross section of viaduct section and MSE Wall Section is shown in **Figure 5.3.7-2** and **Figure 5.3.7-3**, respectively.

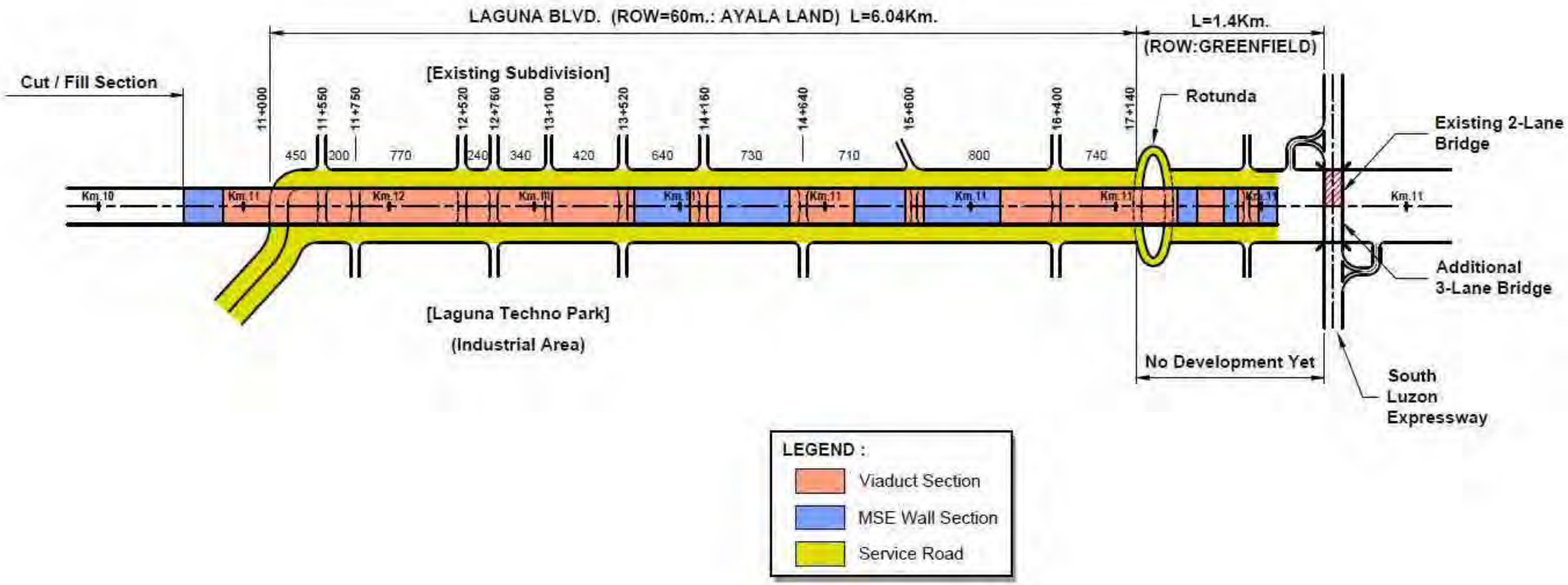


FIGURE 5.3.7-1 VIADUCT ALONG LAGUNA BLVD.

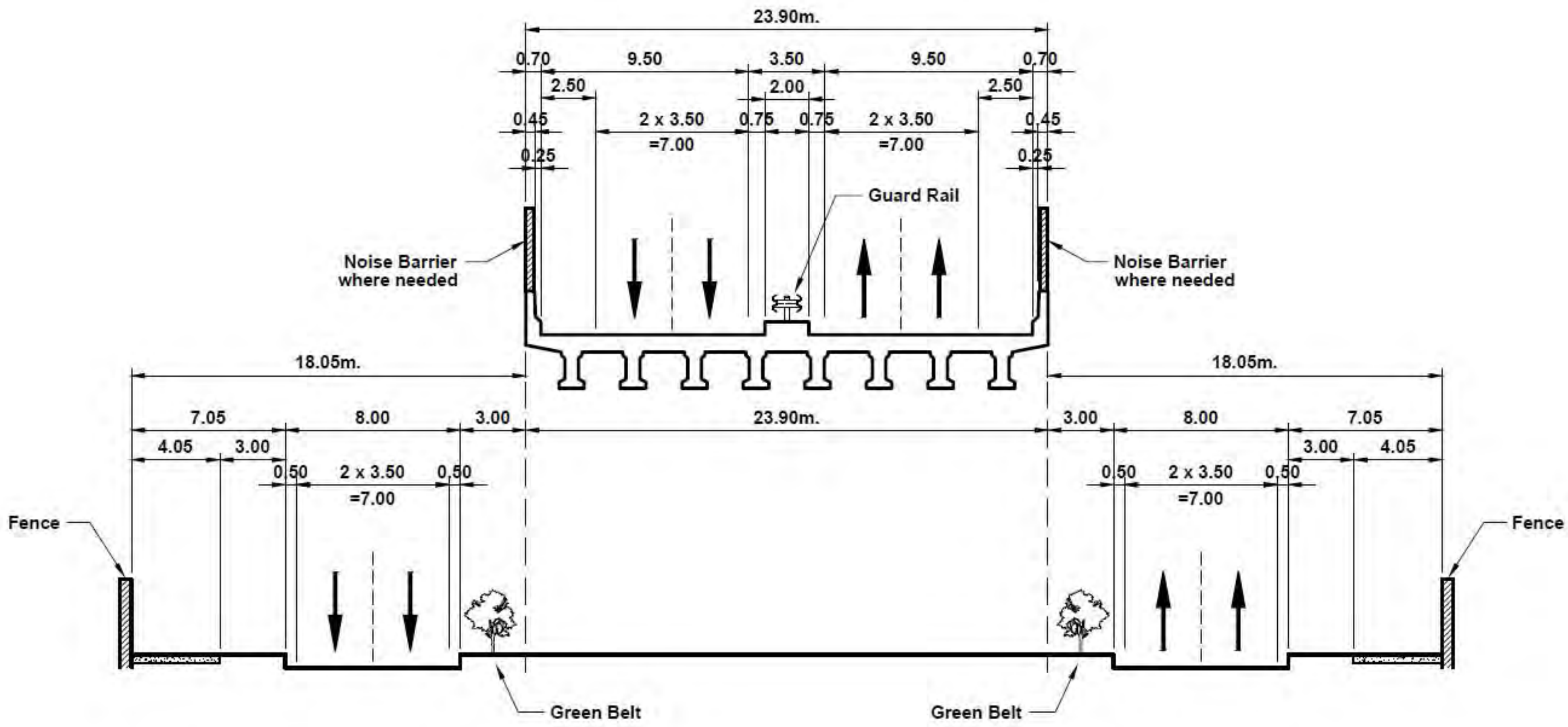


FIGURE 5.3.7-2 TYPICAL CROSS SECTION: FLYOVER SECTION

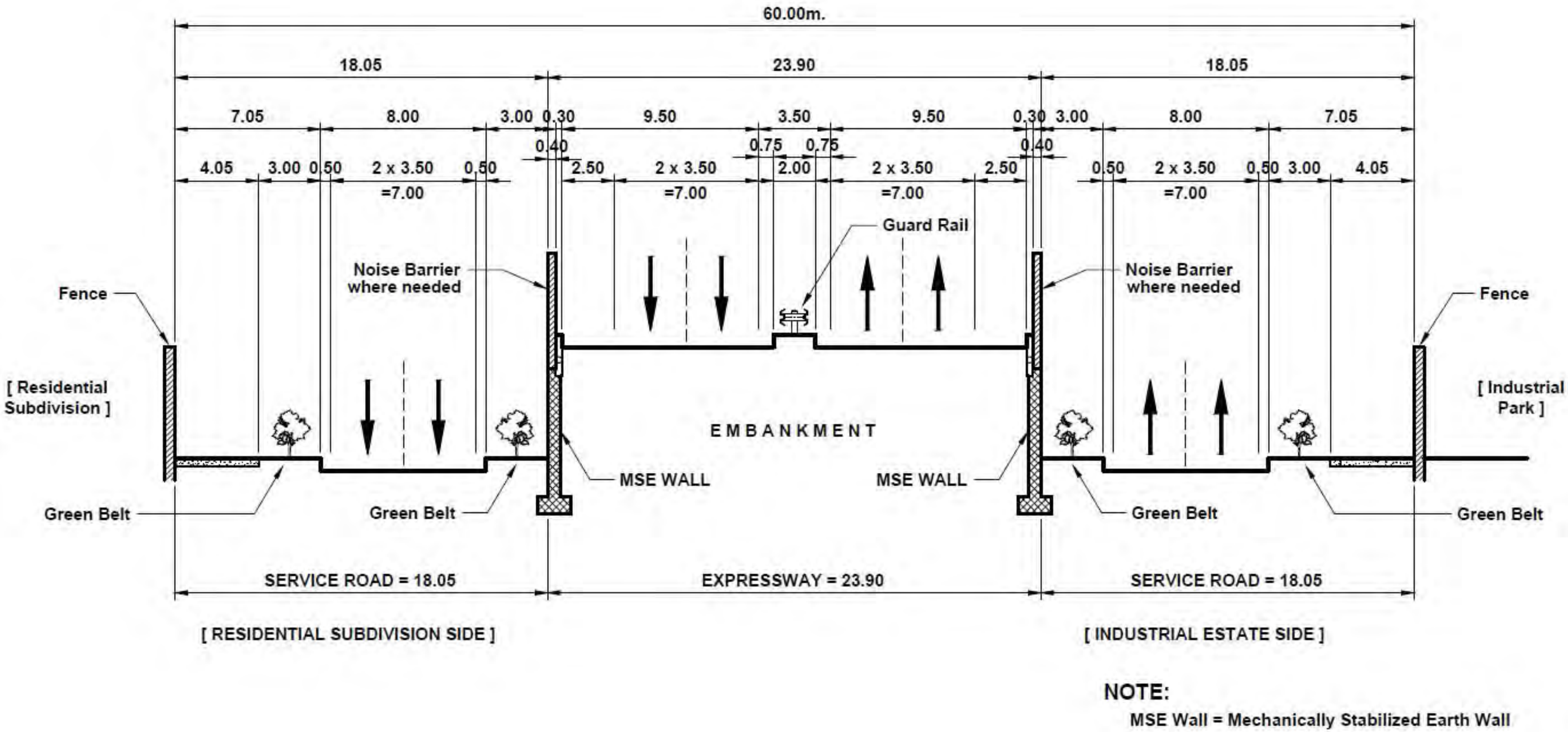


FIGURE 5.3.7-3 TYPICAL CROSS SECTION: MSE WALL SECTION

5.3.8 Mamplasan Interchange Connection

(1) Connection Method between CALAX and SLEX

Two types of connection methods were studied as follows;

Case-1: Direct connection between CALAX and SLEX (**Figure 5.3.8-1**)
Case-2: Indirect connection between CALAX and SLEX (**Figure 5.3.8-2**)

Both schemes were evaluated and Case-2: Indirect Connection was recommended due to the following reasons;

- Although the direct connection is ideal for the smooth traffic flow from/to CALAX to/from SLEX, however,
  - This scheme is quite expensive compared to Indirect Connection Method. (Higher by 1.67 times, or an additional Php 1,467 Million required.)
  - Accessibility to establishment/residents near the existing Mamplasan Interchange becomes worse than at present.
- Traffic flow of Indirect Connection Method can be improved by adopting flyovers at major intersections.

(2) Development Plan of Greenfield Development Corp. (GDC)

The area of about 1.2 km section adjacent to the Mamplasan Interchange is owned by Greenfield Development Corporation (GDC). GDC has a development plan of this area as shown in **Figure 5.3.8-3.** GDC strongly requested CALAX not to follow the existing road, since GDC will totally change the road network in line with their development plan. It is also requested a rotary type of intersection (rotunda) be built near the Mamplasan Interchange. GDC committed to provide a 50m road right-of-way for the alignment of CALAX.

Many meetings were held and GDC agreed to follow the scheme shown in **Figure 5.3.8-4.**

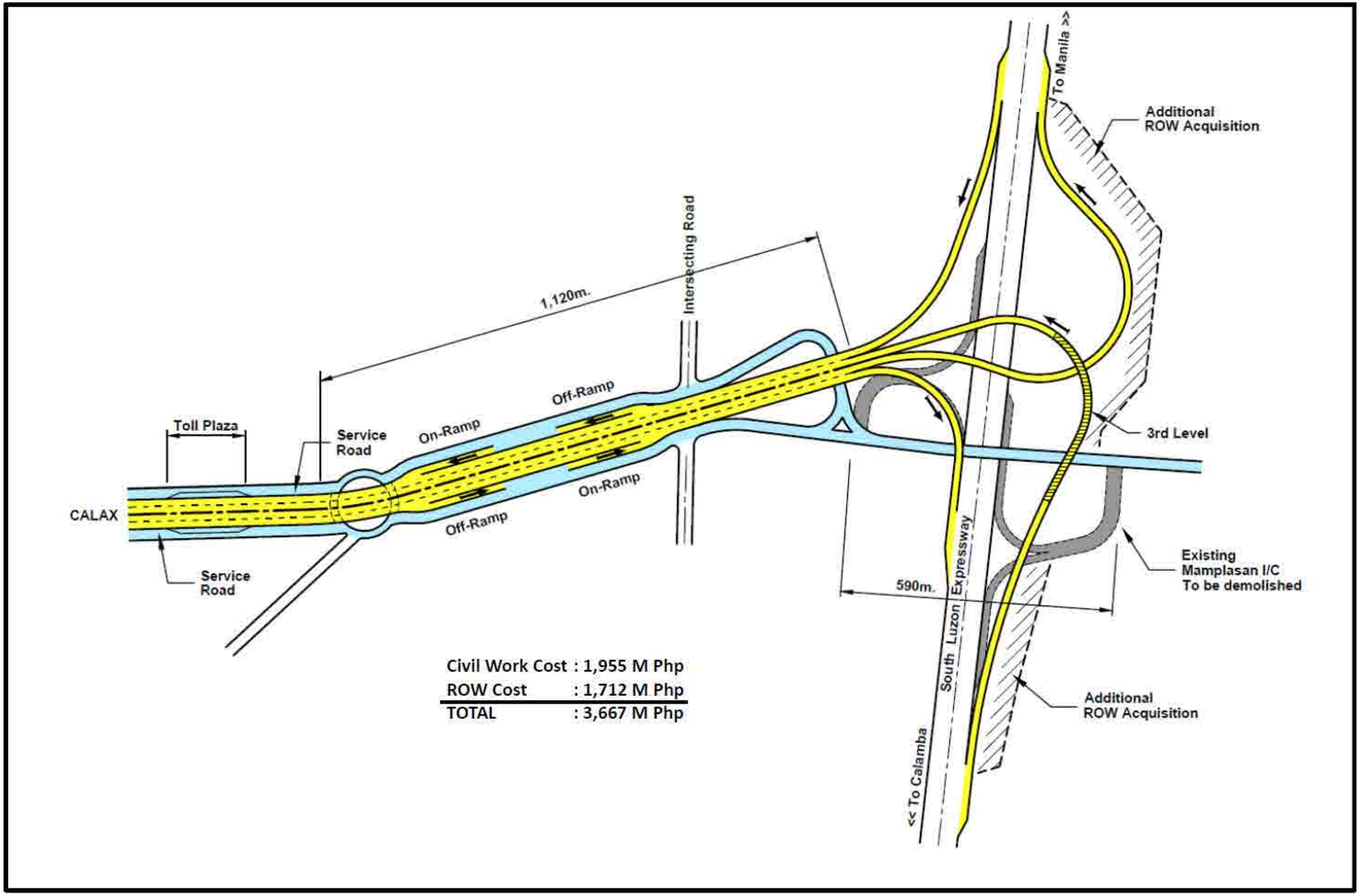


FIGURE 5.3.8-1 CASE-1: DIRECT CONNECTION BETWEEN SLEX AND CALAX

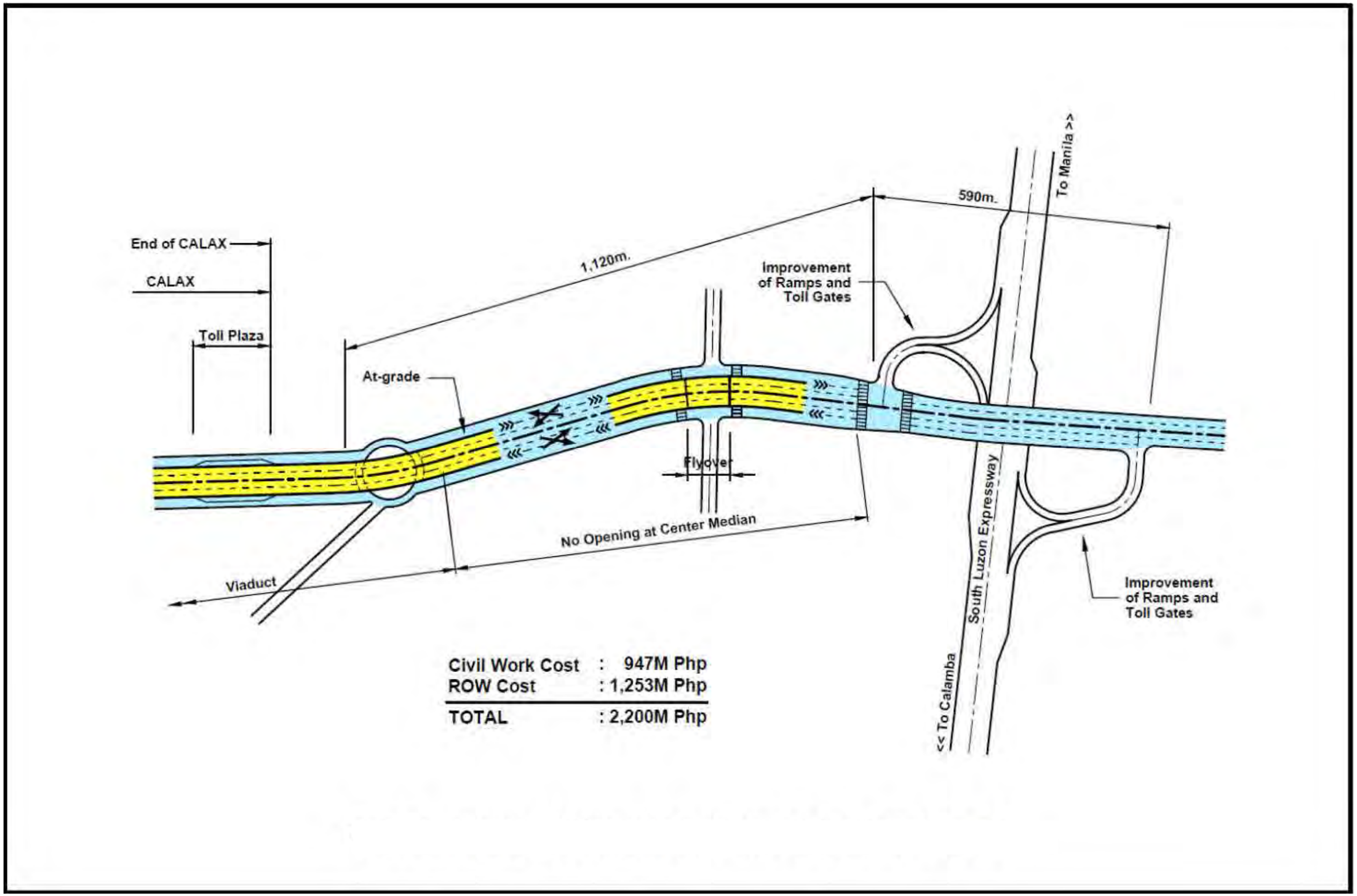


FIGURE 5.3.8-2 CASE-2: INDIRECT CONNECTION BETWEEN SLEX AND CALAX

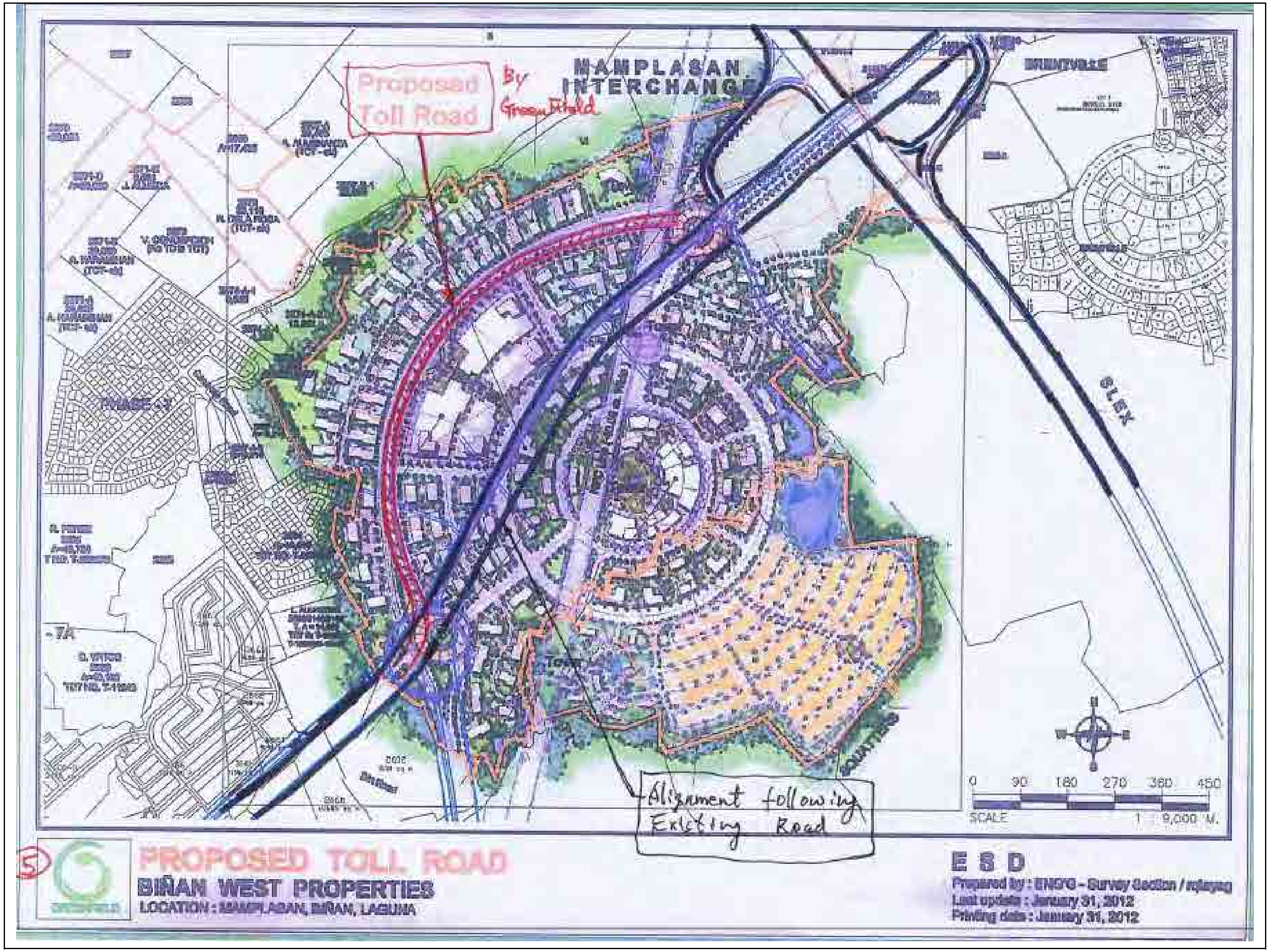


FIGURE 5.3.8-3 DEVELOPMENT PLAN OF GDC

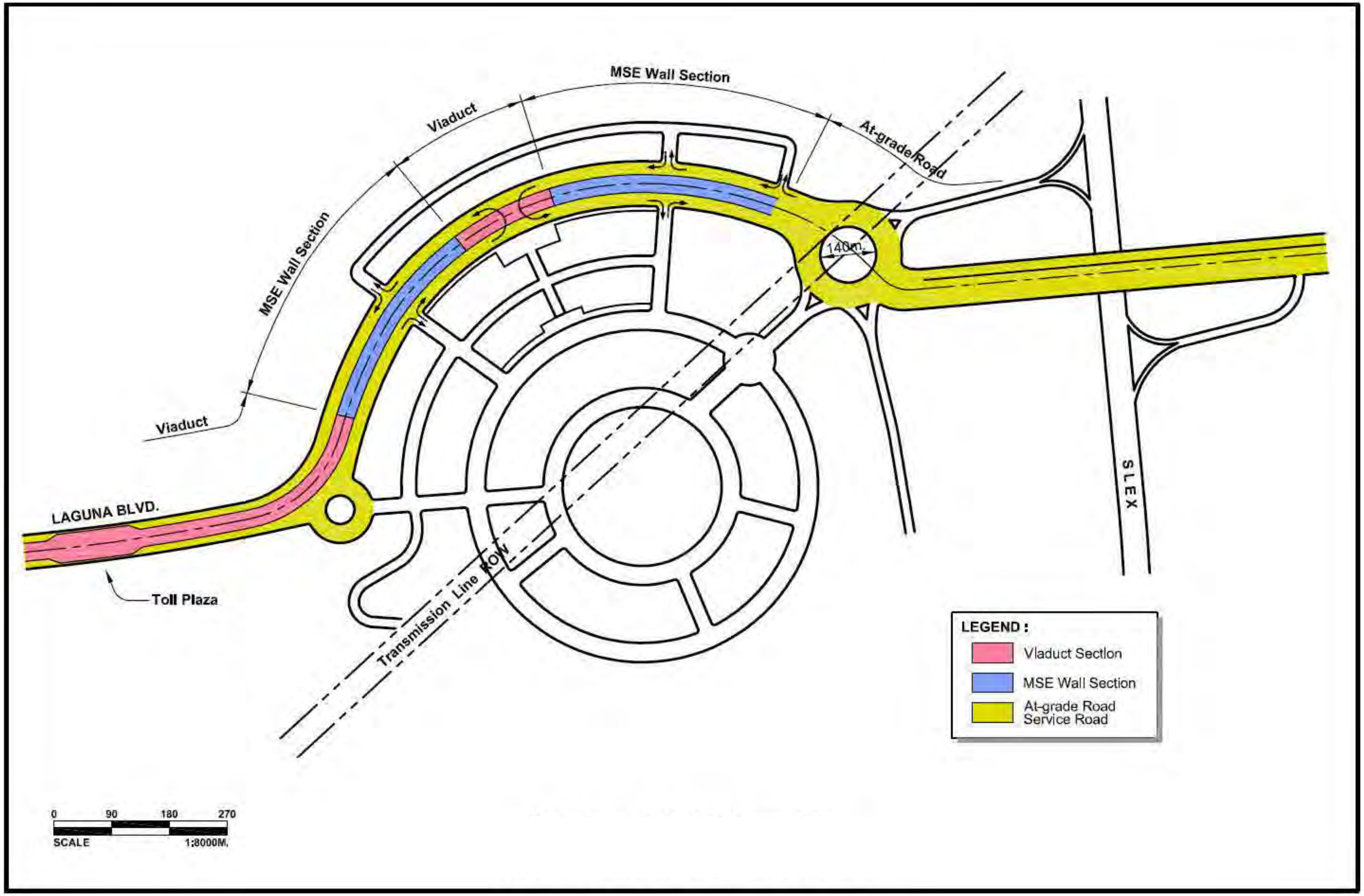


FIGURE 5.3.8-4 AGREED SCHEME FOR ROAD SECTION NEAR MAMPLASAN I/C

CHAPTER 6

PRELIMINARY DESIGN

CHAPTER 6
PRELIMINARY DESIGN

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 Survey
(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 CVT-3057	1st Order
4	Reference for Horizontal	NAMRIA CV-09	3rd Order
5	Road Centerline Survey	17.128 km	50 m interval
6	Road Centerline Profile Survey	17.128 km	50 m interval
7	Bridge Site Topographical Survey	14 Bridges	
8	Interchange Site Survey	3 IC	600 m x 600 m topo
9	Intersecting Road Survey	6 sites	
10	Cross Sectional Survey	343 cross section	Every 50m interval 60m 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 geotechnical survey was conducted along the proposed road alignment. **Table 6.1.3-1** shows the number of geo-technical survey. **Figure 6.1.3-1** shows the location of the geotechnical map.

TABLE 6.1.3-1 LIST OF GEOTECHNICAL TEST

No.	Test	Number
1	Drilling of bore hole	7
2	Test Pit	15
3	Auger Boring	14
4	Material Source	2

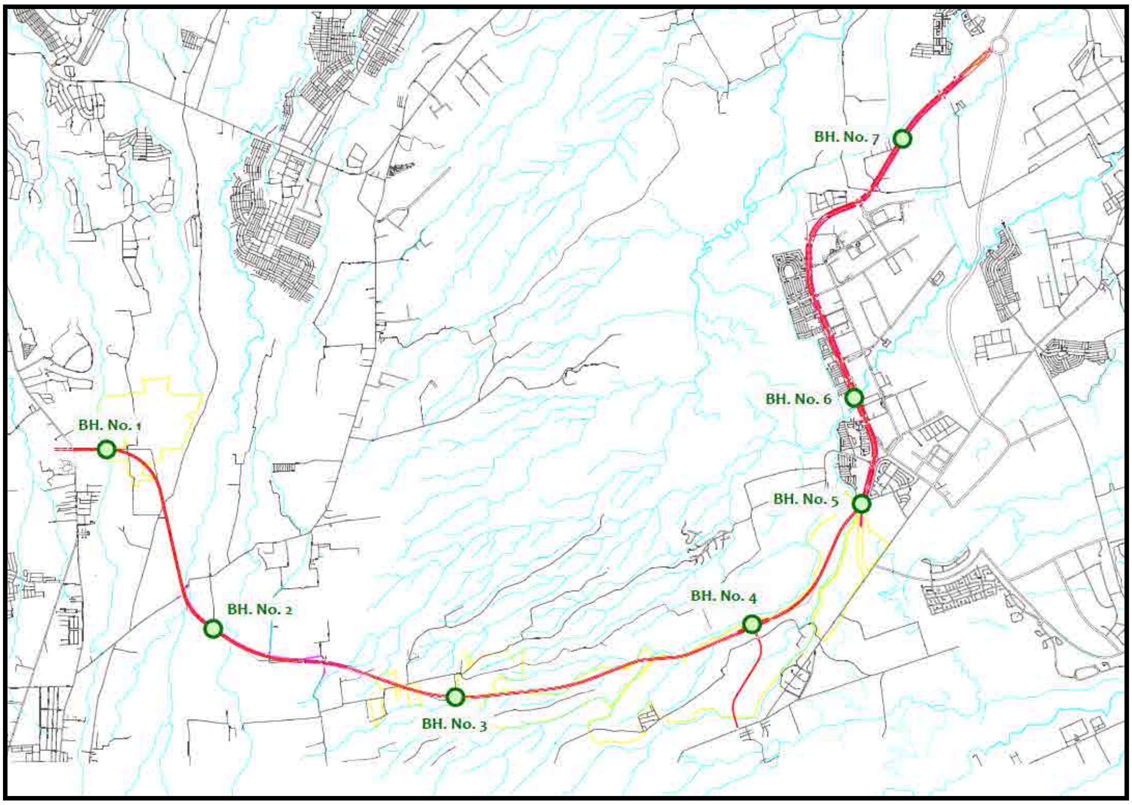


FIGURE 6.1.3-1 GEO-TECHNICAL TEST LOCATION MAP

(1) Summary of Geo-technical Survey Results

1) Bridge Site Investigation

The profile accomplished by the 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	1576401.3908	497426.7004	249.0	16.20
BH-2	1574373.3516	498764.1303	289.0	15.30
BH-3	1573605.8446	501112.6767	276.0	11.26
BH-4	1574340.7997	504623.8536	141.0	13.37
BH-5	1576004.0942	506065.6296	83.0	28.09
BH-6	1576962.0647	505920.3461	68.0	9.26
BH-7	1579848.9562	506447.5465	38.0	34.41

Source: JICA Study Team

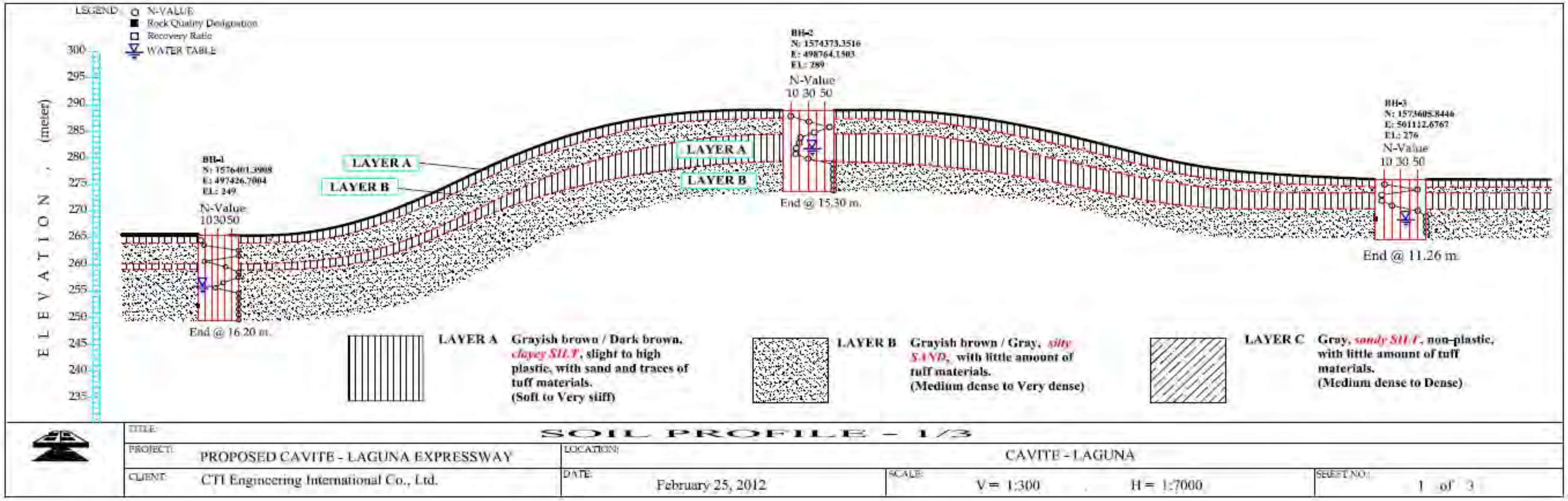


FIGURE 6.1.3-2 GEOGRAPHICAL PROFILE (1/3)

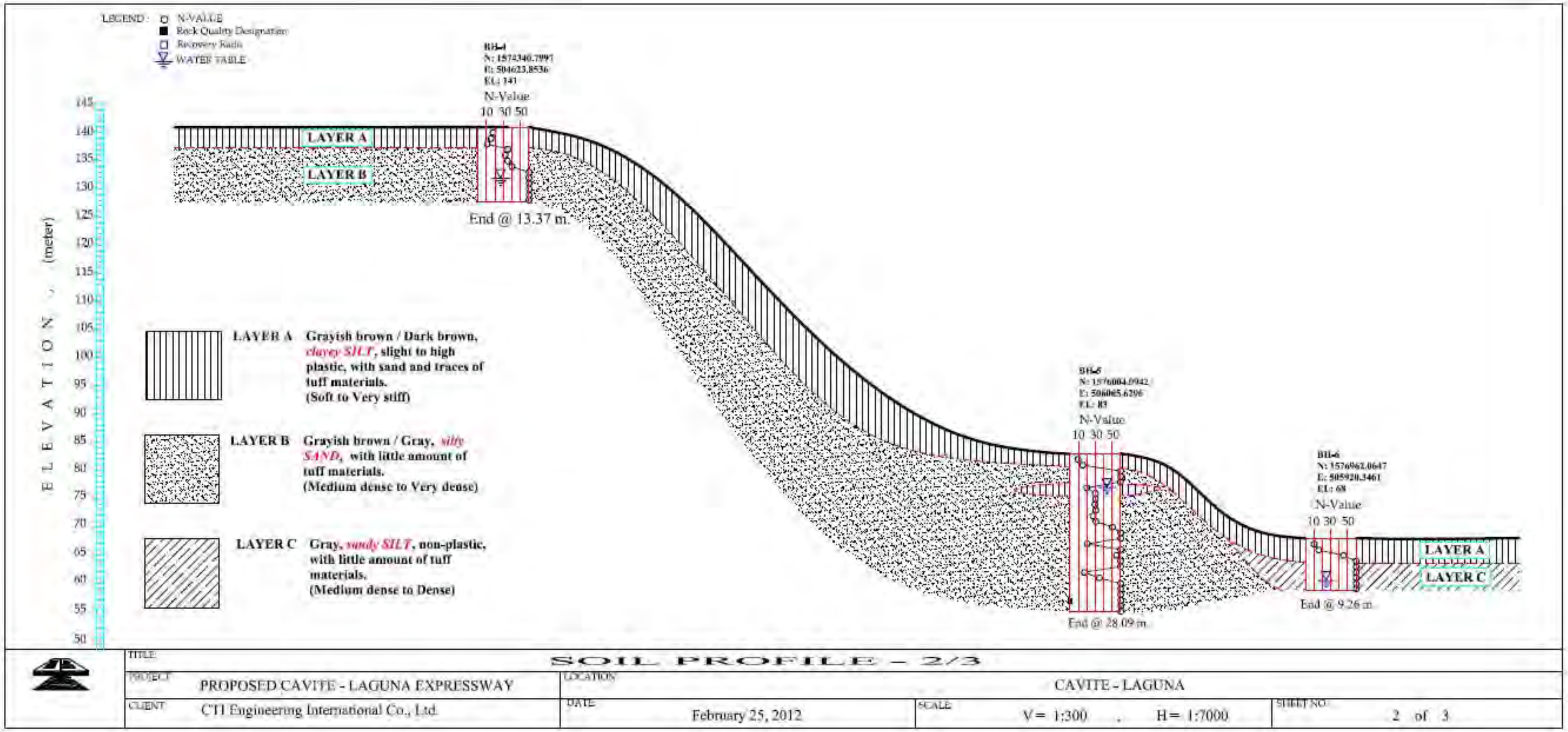


FIGURE 6.1.3-2 GEOGRAPHICAL PROFILE (2/3)

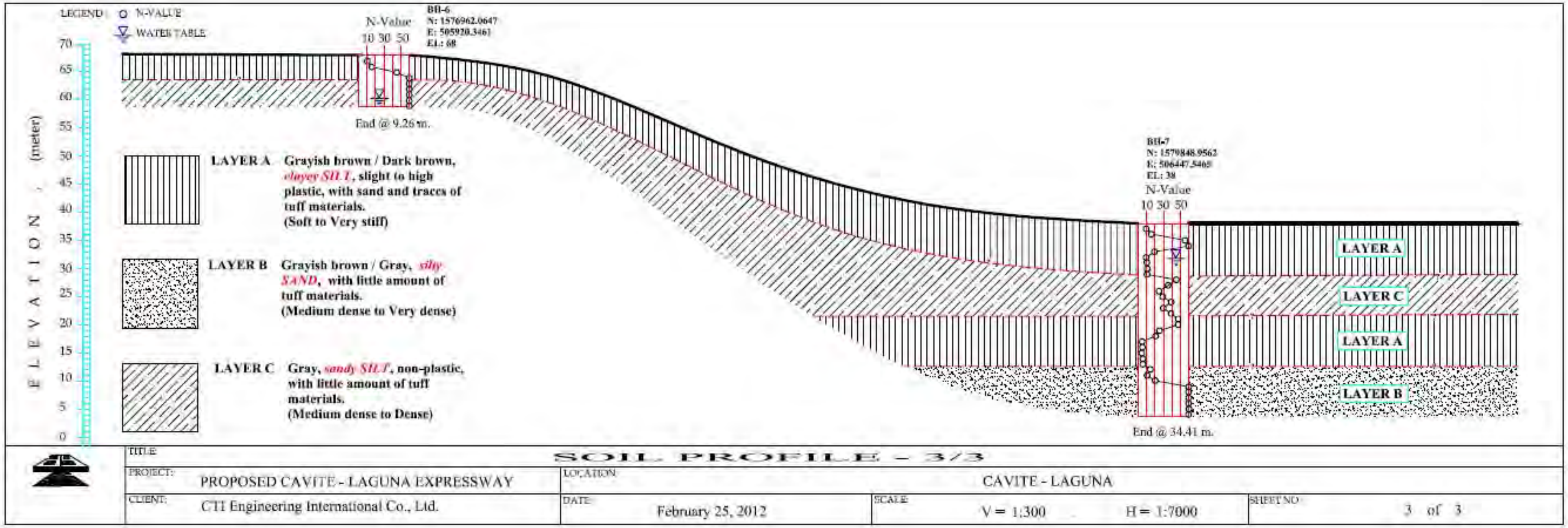


FIGURE 6.1.3-2 GEOGRAPHICAL PROFILE (3/3)

In general and based on the results of the seven (7) boreholes, the project site is underlain by alternating layers of silt and sands. The soft to very stiff Silt forms the uppermost cover, followed by the dense to very dense fine Sand where most of the boreholes were terminated.

The uppermost layer is described as grayish brown, slight to high plastic clayey Silt (ML/MH), with appreciable amount of sand and traces of tuff materials. Consistency of the layer is soft and becoming very stiff towards the bottom of the layer, with recorded SPT blow counts ranging from a low of 4 in the upper stretches to as high as 30. It has to be noted that this layer is thickest in BH-7, which was about 29.0 meters and thinnest in other boreholes (only about 2-4 meters).

Underneath the uppermost cohesive layer is the very dense silty Sand (SM), with some content of tuff materials. Generally, this layer forms the bottom of the boreholes where blow counts usually hit practical refusals (N>50).

All the seven (7) boreholes were terminated after hitting five (5) meters thick of competent bearing stratum (N>50).

2) Pits and Auger Holes

Based on the field and laboratory test results of the fifteen (15) test pits and fourteen (14) auger holes, the excavated soils taken at the uppermost 1.2 to 2.0 meters depth mainly consisted of cohesive materials described as medium plastic Clay, with some content of sand and tuff materials.

The results of the Modified Compaction (ASTM D1557 / AASHTO T180) and California Bearing Ratio (ASTM D1883 / AASHTO T193) is shown in **Table 6.1.3-3**.

TABLE 6.1.3-3 TEST RESULT OF TEST PIT

TP No.	Depth (meters)	Soil Description	AASHTO Class	Max. Dry Density (g/cc)	Optimum Moisture Content (%)	% CBR @ 95% MDD
1	0.6 – 1.2	Clay	A-7-5 (9)	1.41	24.5	3.5
2	0.77 – 1.5	Clay	A-7-5 (20)	1.42	26.5	3.2
3	0 – 2.0	Clay	A-7-5 (7)	1.52	21.25	5.2
4	0 – 2.0	Clay	A-7-5 (14)	1.50	23.5	6.6
5	0.7 – 1.8	Clay	A-7-5 (11)	1.40	25.25	4.8
6	0.9 – 2.0	Clay	A-7-5 (20)	1.47	23.0	6.4
7	0 – 2.0	Clay	A-7-5 (11)	1.46	22.5	3.0
8	0 – 1.44	Clay	A-7-5 (10)	1.40	28.0	4.8
9	0 – 1.44	Clay	A-7-5 (19)	1.47	25.5	3.4
10	0 – 2.0	Clay	A-7-5 (10)	1.41	26.5	3.2
11	1.5 – 2.0	Clay	A-7-5 (10)	1.40	27.0	3.1
12	0 – 1.1	Tuff	A-2-4 (0)	1.59	18.75	9.0
	1.1 – 2.0	sandy Clay	A-7-5 (4)	1.58	17.75	8.0
13	1.0 – 2.0	Clay	A-7-6 (8)	1.39	26.25	3.2
14	0 – 0.8	Clay	A-6 (4)	1.54	22.2	6.2
	0.8 – 1.2	Tuff	A-2-7 (0)	1.50	22.5	5.4
15	0.5 – 2.0	Tuff	A-2-4 (0)	1.59	18.25	11.5

3) Material Source Investigation

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

a) BALANAC RIVER

Location	:	Brgy. Balanac, Magdalena, Laguna
Type of Materials	:	Gravel with sand
Approx. Quantity	:	Unlimited

b) MARAGONDON QUARRY

Location	:	3.5 km. Left of Maragondon – Ternate Road, Pinagsanghan, Maragondon, Cavite
Type of Materials	:	Clay
Approx. Quantity	:	Unlimited

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

TABLE 6.1.3-4 LABORATORY TEST RESULT OF MATERIAL SOURCE INVESTIGATION

Laboratory Tests Results		Balanac River	Maragondon Quarry
Sieve Analysis (% Passing)	3"		
	2"	100	
	1.5"	93	
	1"	80	
	3/4"	73	
	1/2"	62	
	3/8"	56	
	# 4	44	
	# 8	35	
	# 10	32	
	# 16	26	100
	# 30	17	99
	# 40	13	98
	# 50	9	97
	# 100	5	96
	# 200	4	95
Atterberg Limit	Liquid Limit	NP	60
	Plastic Limit	NP	34
Classification		A-1-a (0)	A-7-5 (18)
Soundness (%)	Fine Aggregates	3.35	-
	Coarse Aggregates	0.3	-
Los Angeles Abrasion, %		36.38	-
Apparent Specific Gravity	Fine Aggregates	2.78	2.70
	Coarse Aggregates	2.76	-
Absorption (%)	Fine Aggregates	2.84	5.66
	Coarse Aggregates	1.8	-
Moisture Density Relation	MDD (g/cc)	2.19	1.51
	OMC (%)	9.75	22.5
California Bearing Ratio	@ 95% MDD	30.0	4.80
	@ 100% MDD	48	7.6
Flakiness		3.16	-
Organic Matter (%)		0.9	4.2

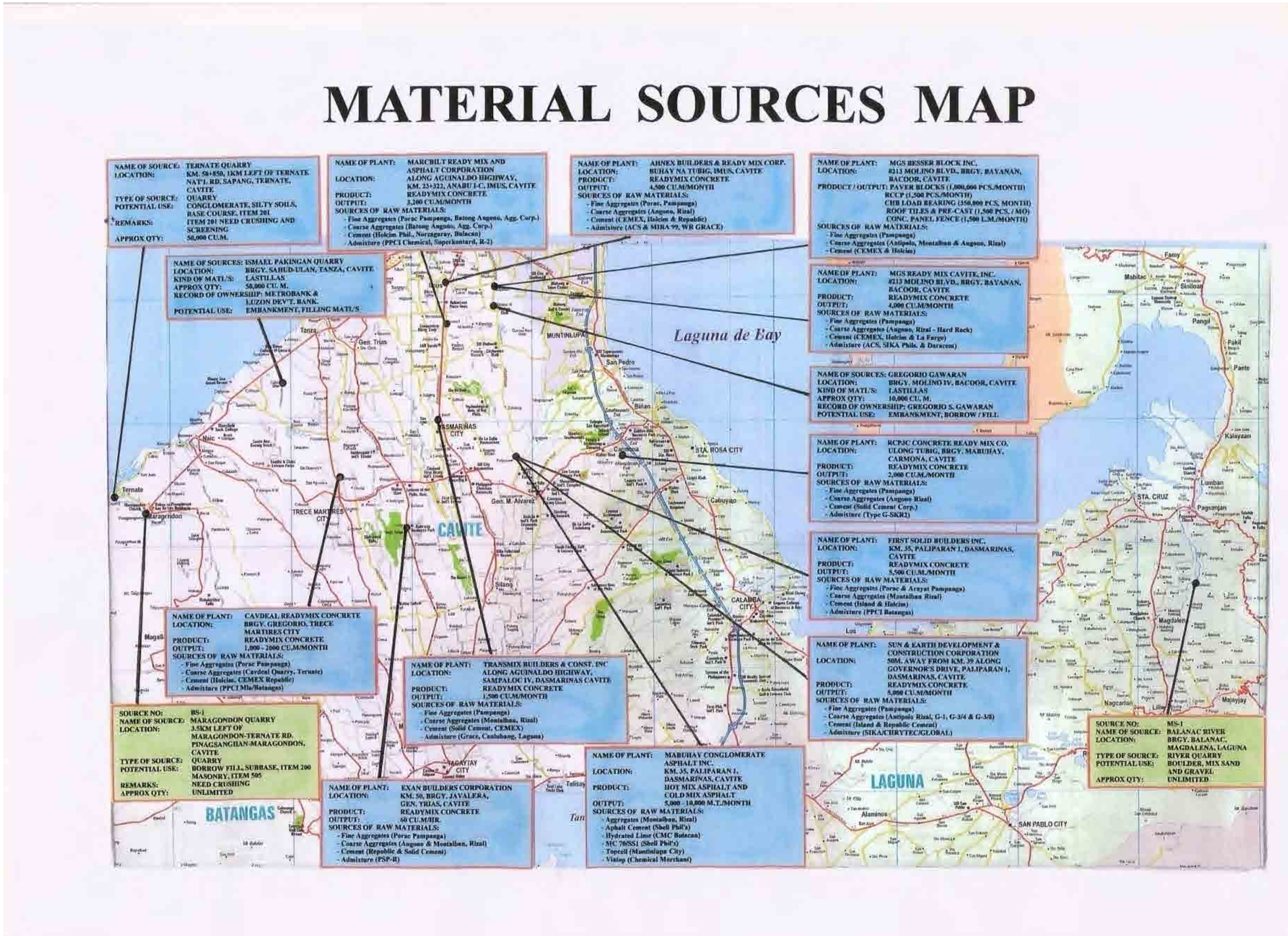


FIGURE 6.1.3-3 LOCATION MAP OF SAMPLE MATERIAL

6.1.4 Other Geo-technical Information

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

(1) Topography

A greater part of the land structure in CALA is underlain by volcanic tuff. **Figure 6.1.4-1** shows the topographic map in the study area. The Marikina Fault borders the Laguna Province on the west and gradually curves further to the west as it approaches the Batangas-Cavite boundary at the Tagaytay Ridge. The Lipa Fault is characterized by a prominent fault scarp along the southeastern coast of Laguna de Bay. It extends beyond Lumban on the north and cuts across the northern foothills of Mt. Nagcarlan and Mt. Lagula along the southeastern direction.
CALA is made up of four characteristic landscapes, namely:

- coastal landscapes
- alluvial plains
- piedmont plains and foothills (plateau)
- hills and mountains

(a) Coastal Landscapes

These are basically the transitional areas between land and sea or lake that are formed by the interplay of marine and terrestrial processes. These include the beaches and ridges and active and former tidal flats in Cavite and the freshwater marshes and the lake terraces in Laguna.

In Cavite, the strip of coastal landscapes extends from Bacoor and Cavite City in the north to Ternate in the south. In Laguna, coastal landscapes are common features in the towns bordering Laguna de Bay from San Pedro in the west to Mabitac in the east. Coastal landscapes are nearly level with slopes ranging from 0% to 2%.

(b) Alluvial Lowlands

The alluvial lowlands are those nearly flat to gently sloping alluvial plains formed from lateral erosion or soil deposition of running streams or rivers.

In Cavite, broad and minor alluvial plains form the transition area between the strip of coastal landscapes and the piedmont plains and foothills. These have slopes ranging from 0% to 5% and extend from Bacoor and Imus in the north through General Trias, Tanza and Naic to Maragondon. Approximately 75% are flat, 20% are gently sloping and 5% are levee.

In Laguna, the alluvial lowland is basically an extension of the minor alluvial plain in Taguig and Muntinlupa. It covers the low depressed areas of the towns bordering the western and southern shores of Laguna de Bay (i.e., from San Pedro to Santa Cruz). Slope ranges from 0% to 3%.

(c) Piedmont Plains and Foothills (Plateau)

This landscape extends from the Guadalupe Plateau in Metro Manila and culminates in the foothills of the Tagaytay Ridge. It comprises the undulating tuffaceous plains and the rolling tuffaceous plateau, including steep hills, ridges and elevated inland valley that are below higher hills or mountain foot slopes.

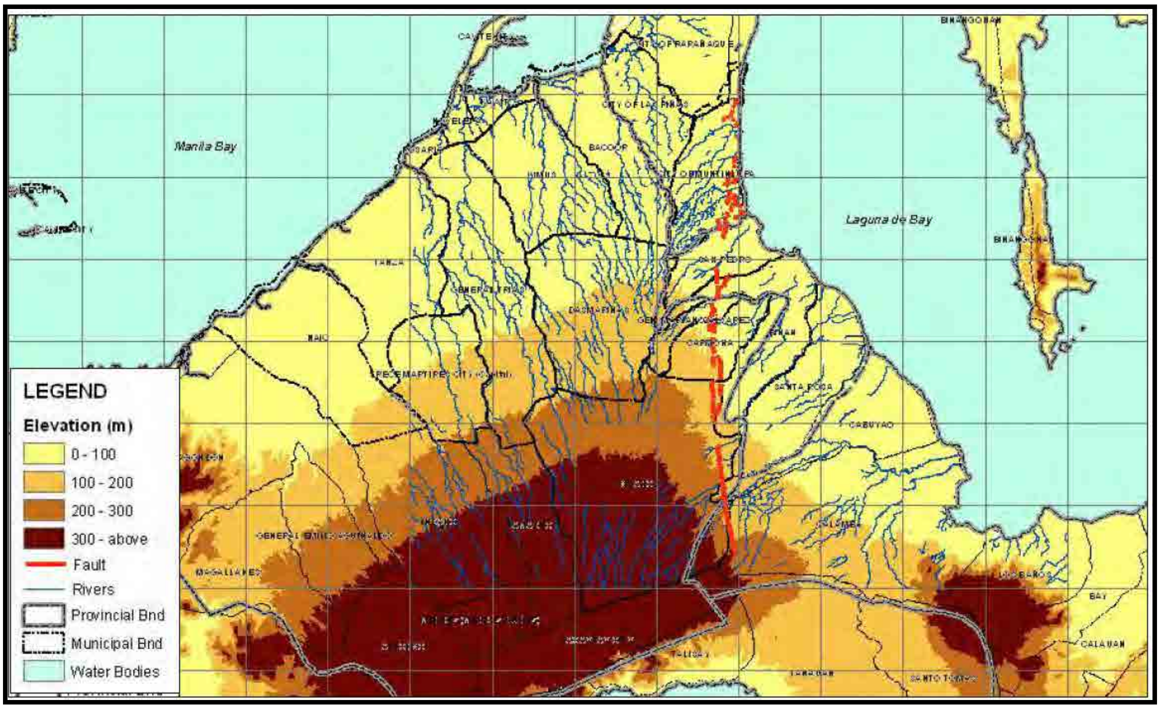
Parent soil material is volcanic tuff; clayey and/or loamy in texture; poorly drained and is plastic. Effective soil depth varies from very shallow to moderately deep.

Groundwater availability may be through deep wells and could be difficult in higher areas.
In Cavite, piedmont plains are characterized with elevation relief ranging from a low 20 meters above sea level to a high of nearly 550 meters above sea level. Slope ranges from 2% to 8%, although side slopes from 8% to 15% can be found in Carmona and Silang areas where the fault lines traverse.

In Laguna, the piedmont plains commence at a low elevation in the areas immediately adjoining Metro Manila. These extend up to Calamba, and join the higher elevations in Carmona and Silang, as these narrowly pass between the heights of Mt. Makiling and the Tagaytay ridge to the direction of Sto. Tomas in Batangas and San Pablo City. Slope generally ranges from 3% to 8%, although foothills possess 8% to 18%.

(d) Hills and Mountains

These are the areas at very high elevations with slopes over 18% and include higher hills and mountains. In Cavite, these include the mountains in Maragondon and the Tagaytay Ridge, forming the boundary of Cavite with Batangas Province in the south. In Laguna, these include Mt. Makiling, portions of Mt. Banahaw and the mountains bordering Laguna and Quezon Provinces.



Source: The feasibility Study and Implementation Support on the CALA East-West National Road Project

FIGURE 6.1.4-1 TOPOGRAPHY OF THE STUDY AREA

(2) Soil Characteristics

Table 6.1.4-1 summarizes the soil characteristics in the study area.

TABLE 6.1.4-1 SOIL CHARACTERISTICS IN THE STUDY AREA

Feature	Coastal Landscape	Alluvial Plains	Piedmont Plains and Foothills	Hills and Mountains
Effective Soil Depth	Shallow to moderately deep	Shallow to moderately deep	Shallow to deep	Shallow to deep
Composition	Organic	Organic	Non-organic	Non-organic
Soil Plasticity	High	Very high	Low	Low
Soil Drainage	Poor	Moderate	Good	Good

Source: The feasibility Study and Implementation Support on the CALA East-West National Road Project

(a) Coastal Landscapes

Parent soil material is fluvio-marine/alluvium. Soil is sandy and sometimes clayey and loamy in texture and is highly plastic.

(b) Alluvial Lowlands

In Cavite, parent soil material is largely fine clay that is poorly drained in flat to nearly flat areas and moderately drained in gently sloping areas. Fine loam is found in the levee areas. As such, the levee areas in the Cavite lowlands are moderately or well drained. In Laguna, soil varies from sandy to silty clay loam to clay and is somewhat poorly drained. The area possesses potentials for high yielding wells.

(c) Piedmont Plains and Foothills (Plateau)

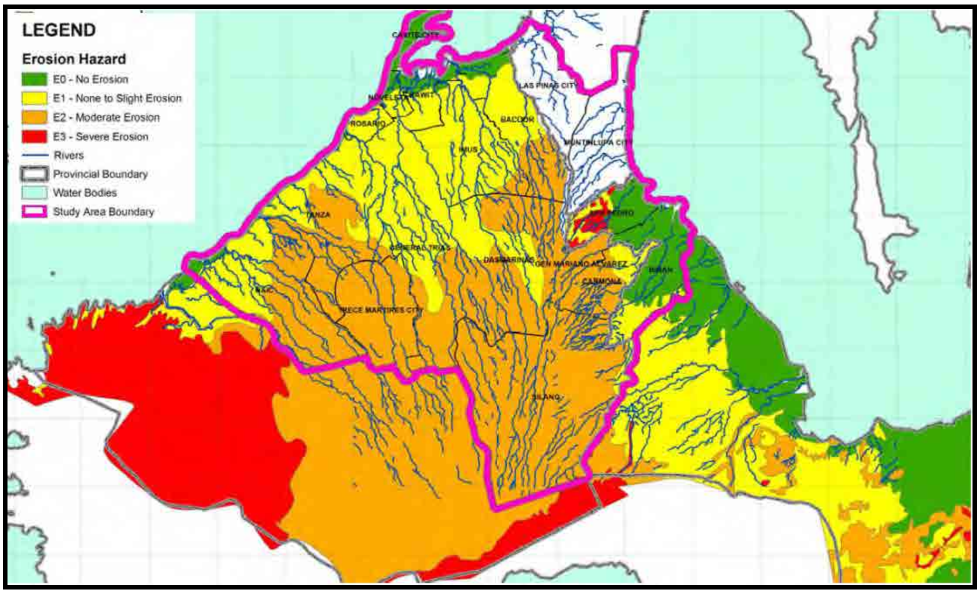
Parent soil material is volcanic tuff; clayey and/or loamy in texture; poorly drained and is plastic. Effective soil depth varies from very shallow to moderately deep.

(d) Hills and Mountains

Parent soil material is sandy loam or loam that is drained well. Effective soil depth varies from very shallow to deep.

(3) Soil Erosion

The study area includes moderately eroded area or severely eroded area as shown in the soil erosion map (**Figure 6.1.4-2**). Small parts of San Pedro are especially designated as severely eroded areas.



Source: The feasibility Study and Implementation Support on the CALA East-West National Road Project

FIGURE 6.1.4-2 SOIL EROSION MAP

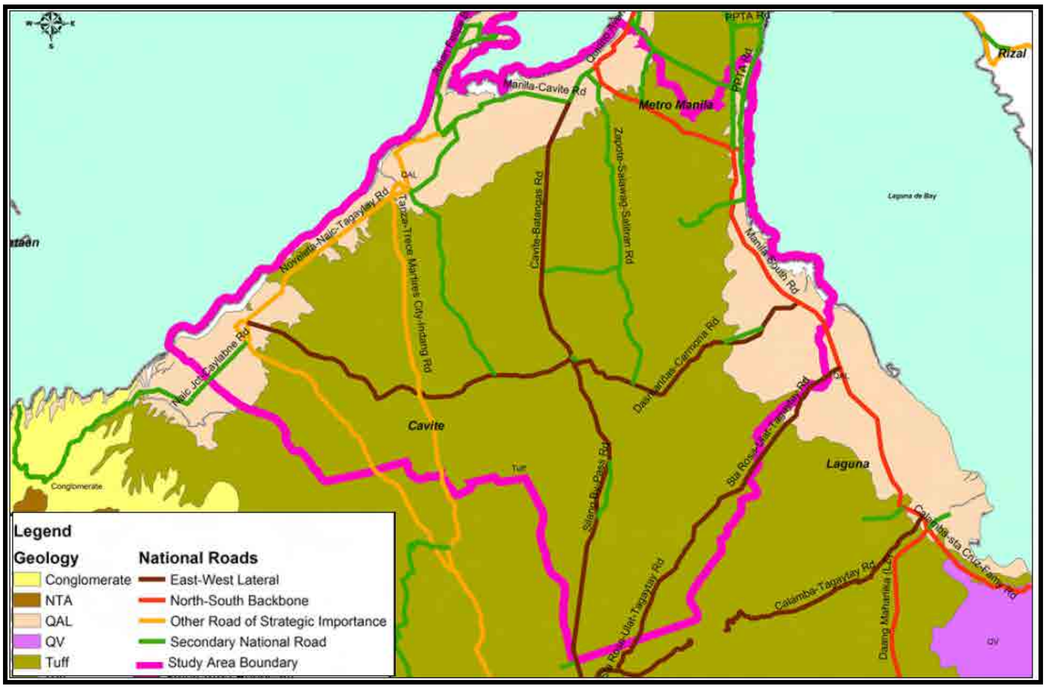
(4) Geological Condition

The study area is underlain by rocks of various origins and characteristics consisting primarily of QAL and Tuff as described in **Table 6.1.4-2**. These occur in association with other properties.

TABLE 6.1.4-2 GEOLOGIC DESCRIPTION OF THE STUDY AREA

Symbols	Description
QAL	Quatemary Alluvium: Unconsolidated deposits of silt, sand and gravel along valleys and coastal plains
Tuff	Tall Tull: Thin to medium-bedded, fine grained vitric tuffs, welded volcanic breccia with conglomerate, tuffaceous sandstone and shale

Source: The feasibility Study and Implementation Support on the CALA East-West National Road Project



Source: The feasibility Study and Implementation Support on the CALA East-West National Road Project

FIGURE 6.1.4-3 GEOLOGICAL MAP OF THE STUDY AREA

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

Aguinaldo Highway to South Luzon Expressway (SLEX).

6.2.2 Design Standard

The following standard is mainly used as reference in Cavite Laguna Expressway (CALAX) design.

- A Policy on Geometric Design of Highways and Streets, AASHTO 2004.
- Highway Safety Design Standards Part I 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 100 km. 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 recommended design speed is **100 kph** fro the expressway.

(2) Interchange Ramps

The interchange ramp design speed was employed as **40 kph** 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 Expressway 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 CALAX (MAIN ALIGNMENT) (100KM/HR)

Geometric Design Standards

Project: **CALAx** **Main**

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
R.O.W	m	50-60		50m: km 17+200 to End Other Section: 60m
Terrain Condition		Rolling		

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,Highway Design Safety Manual 2004,p53
Median Width(Center Separator)	〃	2.00		Guard rail, drainage, tree planting included, refer to NEXCO
Inner Shoulder Wdth	〃	0.75		
Outer Shoulder width	〃	2.50		Accommodate WB-15(w=2.44m)
Number of Lanes	nos	4		
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		%	10.0		

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 CALAX (RAMP) (40KM/HR)

Geometric Design Standards

Project: CALAx 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 2lane 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 at least 5.2 m (4.9 m (16 feet) + 0.3 m (overlay)).

6.2.7 Number of Lanes

Number of lane is set as 4 lanes in accordance with the traffic demand forecast.

6.2.8 Carriageway, Shoulder and Median Width

The cross sectional configuration is reviewed and recommended as below;

(3) Main Alignment

The carriageway of the main alignment is **3.5 m** in accordance with Road Safety Manual (DPWH 2004). The inner shoulder is designated as **0.75 m**. The outer shoulder is designed as **2.50 m.** This allows emergent stops at the shoulder without serious conflict to the traffic on the main lanes. The width of median is designed as **2.0m** with guard rail post.

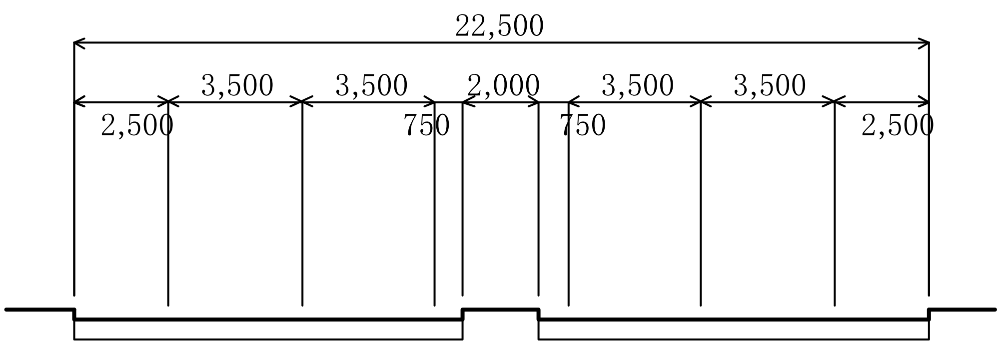


FIGURE 6.2.8-1 CROSS SECTIONAL CONFIGURATION (4 LANES)

(4) Ramp

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

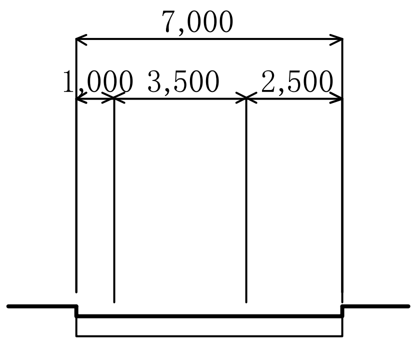


FIGURE 6.2.8-2 CROSS-SECTIONAL CONFIGURATION (1 LANE RAMP)

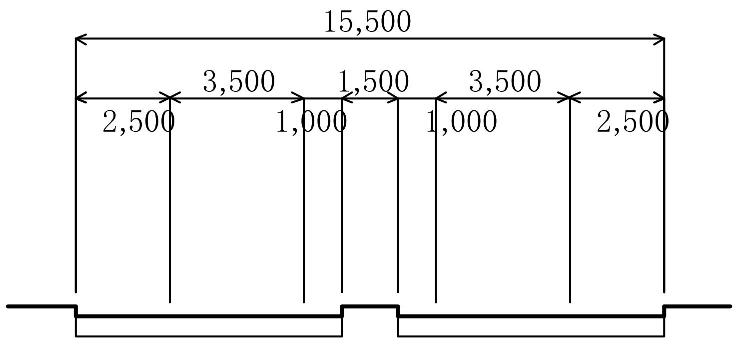


FIGURE 6.2.8-3 CROSS-SECTIONAL CONFIGURATION (2 DIRECTION 2 LANE RAMP)

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

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

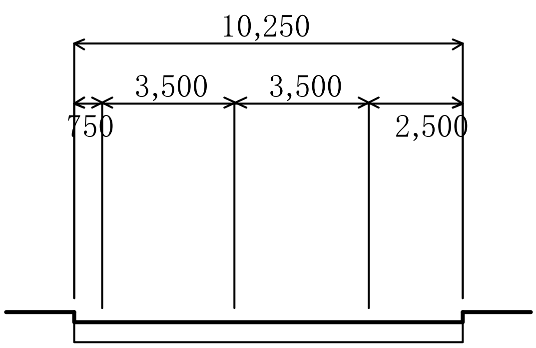


FIGURE 6.2.8-4 CROSS SECTIONAL CONFIGURATION (MEDIUM/SMALL SIZE BRIDGE (L=< 100 m)

(6) Viaduct Bridge (L>100 m)

For viaduct bridge, inner shoulder shall be reduced to **0.5m** and outer shoulder shall be reduced to **1.5m** for economical reason. (see **Figure 6.2.8-5**)

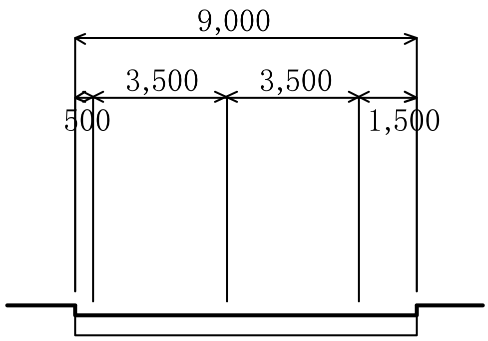


FIGURE 6.2.8-5 CROSS SECTIONAL CONFIGURATION FOR VIADUCT (STANDARD)

(7) Typical Cross Section

Typical cross sections are shown in **Figure 6.2.8-6 (1) to (6).**

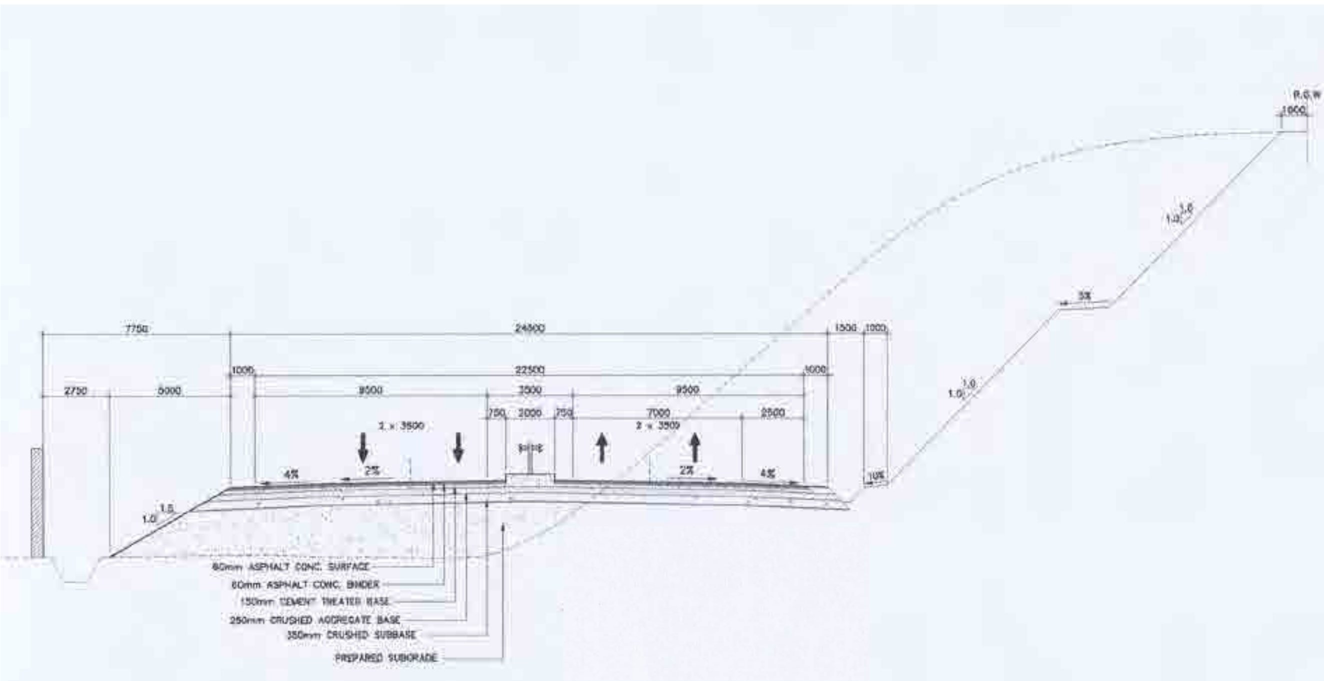


FIGURE 6.2.8-6 (1) TYPICAL CROSS SECTION EMBANKMENT AND CUT

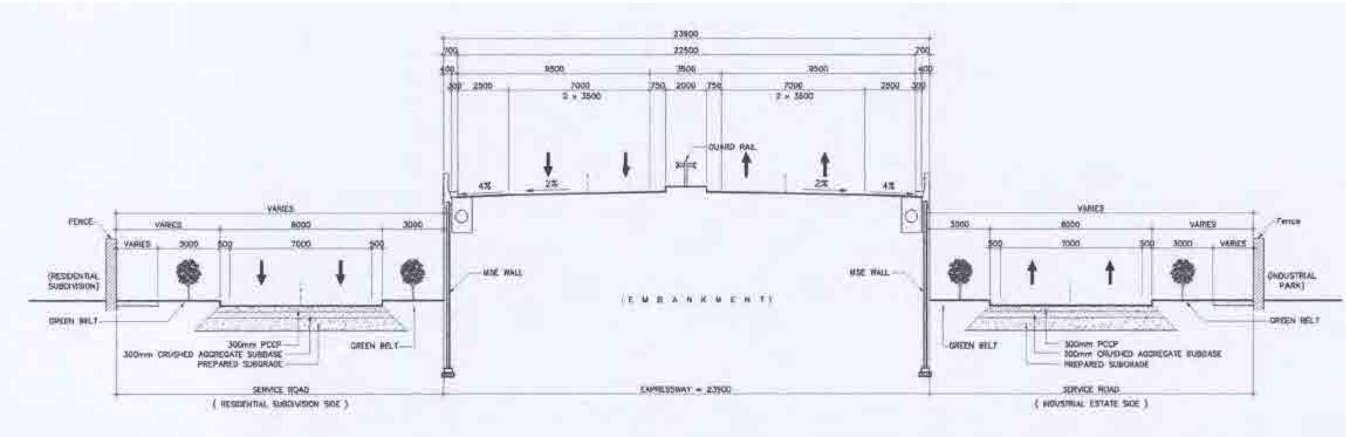


FIGURE 6.2.8-6(2) TYPICAL CROSS SECTION (MSE WALL SECTION)

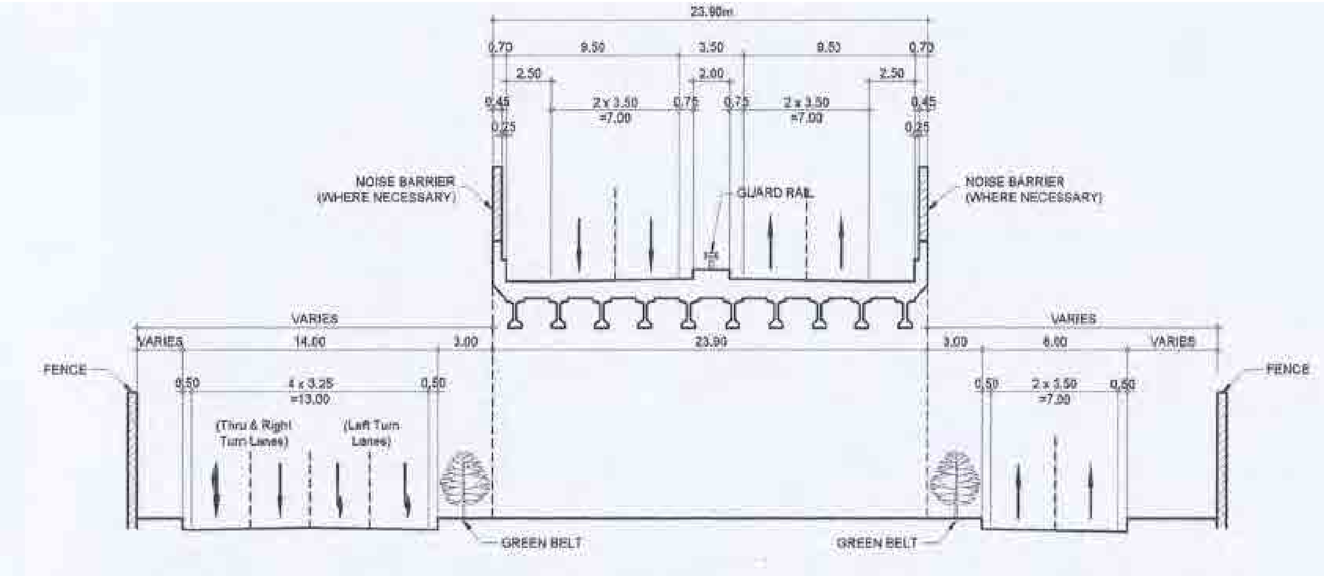


FIGURE 6.2.8-6(3) TYPICAL CROSS SECTION (VIADUCT SECTION): ROW = 60.0m

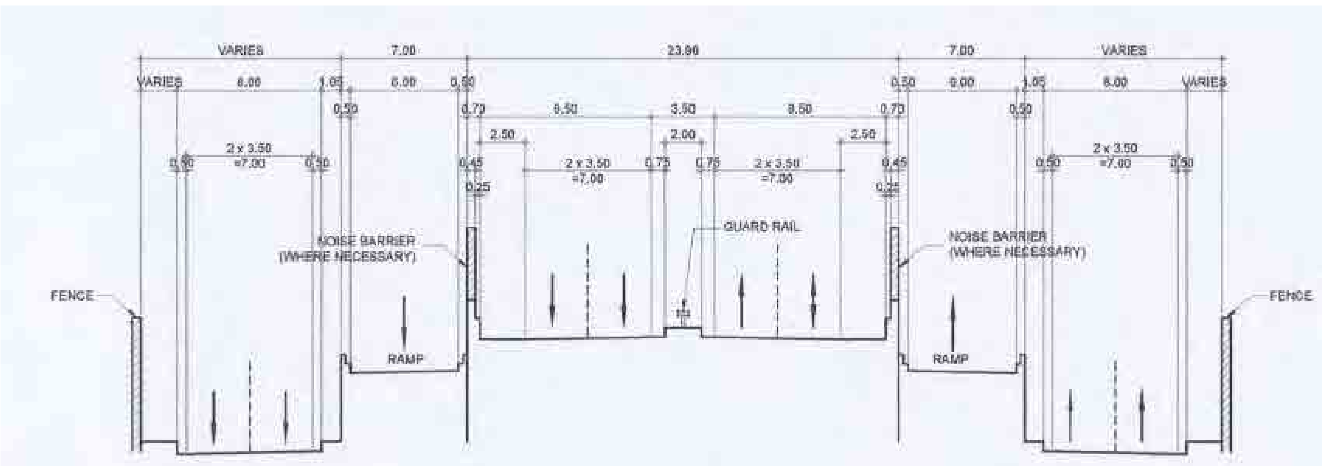


FIGURE 6.2.8-6(4) TYPICAL CROSS SECTION AT INTERCHANGE: ROW = 60.0 m

6.2.9 Stopping Distance

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

6.2.10 Cross fall Development

Super elevation of the carriageway shall be considered to accommodate recommendation of AASHTO 2004 as shown in **Table 6.2.10-1**. The maximum value of super elevation is 6.0% as guided in Road Safety Manual (2004) in page 53. The super elevation rate for the applied design speed is shown in **Table 6.2.10-1**.

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

TABLE 6.2.10-1 MINIMUM RADDI 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	1380	1710	2090	2560	2970	3510	3880
2.2	122	265	465	668	919	1230	1530	1680	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

6.2.11 Minimum Radius without Super elevation

When the curve radius is larger than R = 2560 m, super elevation 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.

50 kph : Ld = 13.9 (m/s) x 2 (sec) = 27.8 m (28 m)

100 kph : Ld = 27.7 (m/s) x 2 (sec) = 55.5 m (56 m)

(2) Minimum Spiral Curve

The spiral lengths listed 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 super elevation runoff. Minimum spiral curve length for super elevation 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 on 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

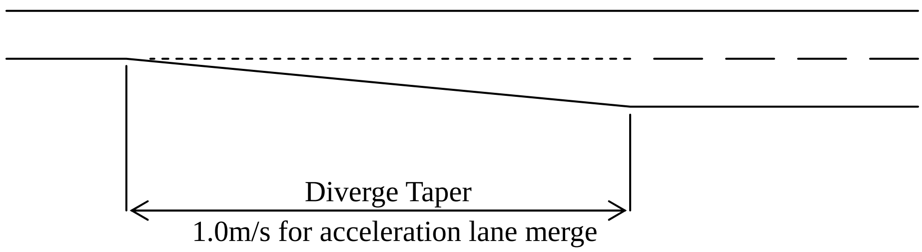
Highway Design Speed, V (kph)	**Radius of Length on Grade to Length on Level for Design Speed of Turning Curve (kph)**	
All Speeds	3 to 4% Upgrade 0.90	3 to 4% Downgrade 1.2
All Speeds	5 to 6% Upgrade 0.80	5 to 6% Downgrade 1.35

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

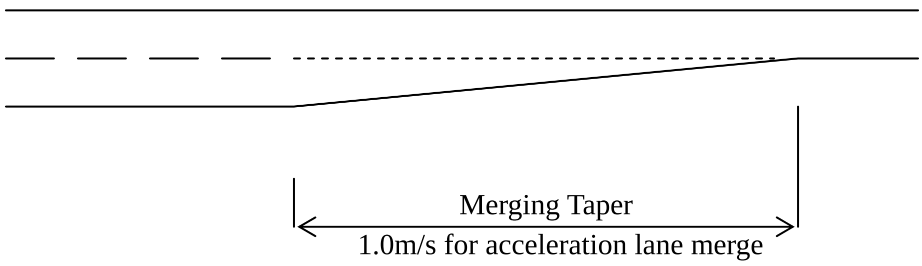
(2) Diverging Taper

*Vertical Gradient less than 3.0%



Diverging Taper = Design Speed (100 km/hr) x Lane Width
= 27.78 (m/s) x 3.5 m
= 97 m

(3) Merging Taper



Merging Taper = Design Speed (100 km/hr) x Lane Width

= 27.78 (m/s) x 3.5 m

= 97 m

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) Crossing Road Design
(2) Vertical Control
(3) Interchange Design

6.3.2 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 traffic demand.
(3) To provide enough vertical clearance in accordance with road category

(2) Typical Condition of Crossing Road

Figure 6.3.2-1 shows the typical crossing road of expressway (underpass or overpass).
Cross sectional configuration of the crossing road and vertical clearance is designed According to present condition of the road, as shown in **Table 6.3.2-1.**

(3) List of Crossing Road and Water Way

List of crossing road and water way is shown in **Table 6.3.2-1.**

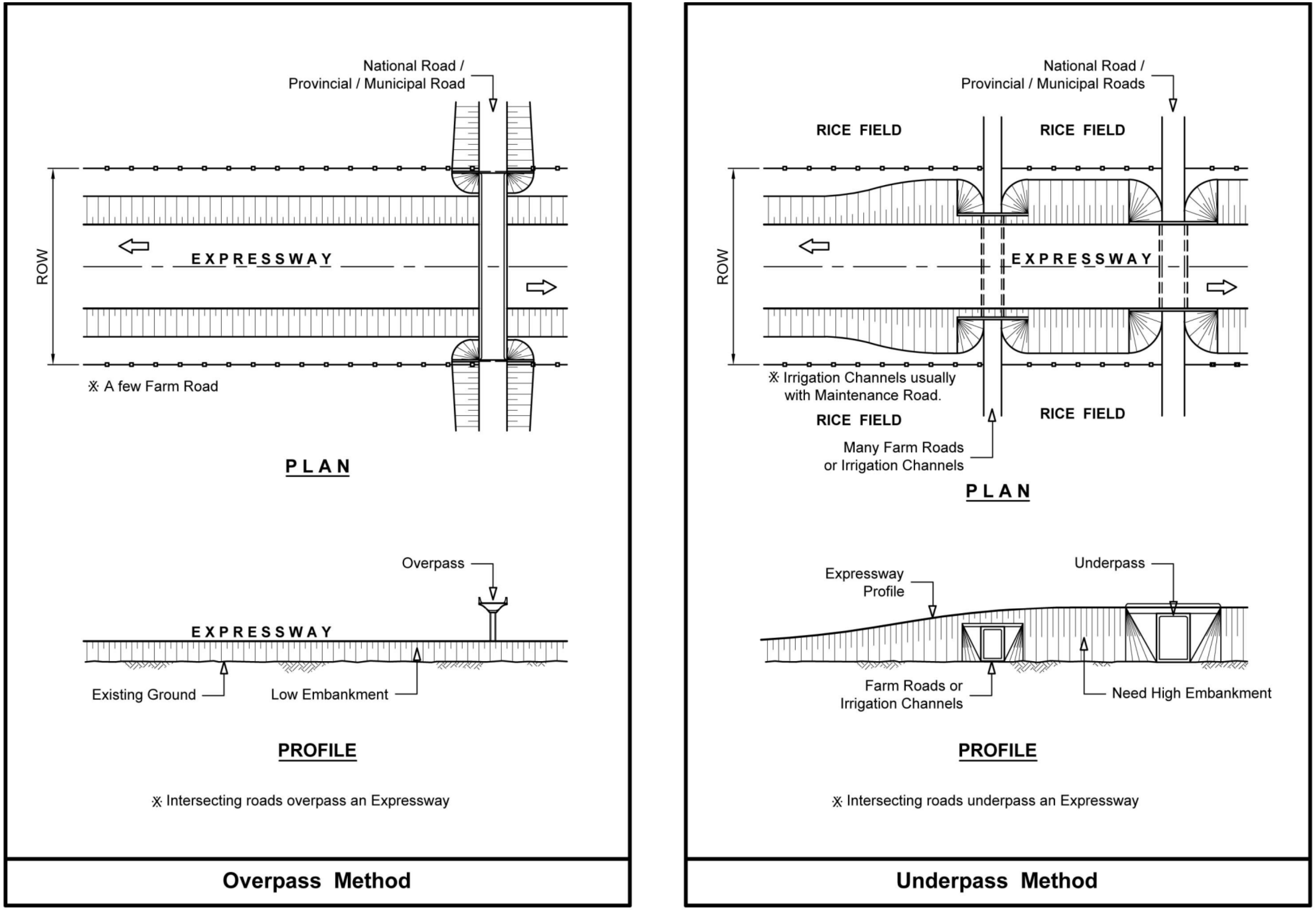
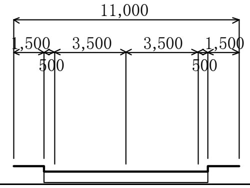
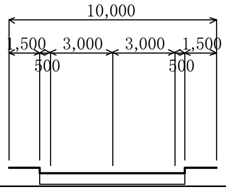
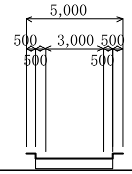


FIGURE 6.3.2-1 TYPICAL CROSSING ROAD OF EXPRESSWAY

TABLE 6.3.2-1 CROSS SECTIONAL CONFIGURATION OF CROSSING ROAD

No	Road Category	Road width (m)	Cross Sectional Configuration	Vertical Clearance (m)	Remark
1	Extra Ordinary Access Road			Vertical clearance (4.9 m) + overlay (0.3m) = 5.2 m 5.2 m	
2	Municipality Road	10.0m		Vertical clearance (4.9 m) + overlay (0.3 m) = 5.2 m 5.2 m	
3	BRGY Road (2 lane)	5.0 m		Vertical clearance (4.9 m) + overlay (0.3 m) = 5.2 m	

6.3.3 Vertical Control

(1) Technical Approach

The Expressway is situated in the very hills and plain land. The profile was studied in accordance with following orientations;

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

2) To Secure smoothness of drive: The minimum distance between PI point of vertical profile shall be 600m in order to secure smoothness of drive.

3) 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) Vertical Control and Clearance List

Vertical Control List is shown in **Table 6.3.3-1**.

TABLE 6.3.3-1 VERTICAL CONTROL LIST

No	Station	Control Name	Crossing Type	Type of Crossing Structure	Existing GL	Minimum Vertical Clearance	Finished Elevation
1	1 + 323	Municipal Road	Overpass	Bridge	258.997	5.20	267.260
2	2 + 293	Municipal Road	Underpass	Bridge	270.188	5.20	271.747
3	2 + 860	Farm Road	Overpass	Bridge	288.359	5.20	283.500
4	4 + 050	Interchange	Underpass	Bridge	289.673	5.20	298.186
5	4 + 740	Farm Road	Underpass	RCBC	278.575	4.00	281.551
6	5 + 107	Municipal Road	Overpass	Bridge	278.926	5.20	274.878
7	5 + 360	Farm Road	Overpass	Bridge	273.190	5.20	266.430
8	9 + 300	Interchange	Underpass	Bridge	124.661	5.20	131.058
9	9 + 980	Access Road	Underpass	Bridge	106.379	5.20	114.081
10	11 + 106	Service Road	Underpass	Bridge	87.031	5.20	94.914
11	11+ 546	Road Crossing	Underpass	Bridge	79.460	5.20	88.008
12	11 + 746	Road Crossing	Underpass	Bridge	78.099	5.20	86.242
13	12 + 519	Road Crossing	Underpass	Bridge	75.000	5.20	78.077
14	12 + 760	Road Crossing	Underpass	Bridge	69.998	5.20	78.823
15	13 + 100	Road Crossing	Underpass	Bridge	69.012	5.20	77.717
16	13 + 520	Road Crossing	Underpass	Bridge	64.000	5.20	71.442
17	14 + 160	Road Crossing	Underpass	Bridge	55.966	5.20	63.439
18	14 + 880	Road Crossing	Underpass	Bridge	49.001	5.20	56.831
19	15 + 600	Road Crossing	Underpass	Bridge	39.794	5.20	46.409
20	16 + 400	Road Crossing	Underpass	Bridge	32.997	5.20	40.611
21	17 + 267	Road Crossing	Underpass	Bridge	28.627	5.20	36.611
22	17 + 850	Road Crossing	Underpass	Bridge	25.543	5.20	33.611
23	18 + 750	SLEX	Overpass	Bridge	21.595	5.20	27.020

6.3.4 Interchange Design

(1) Technical Approach

Followings are basic technical approach to design interchange of CALAX (Laguna Section).

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) Selection of Interchange location

Figure 6.3.4-1 shows selected interchange locations.

Aguinaldo Highway Interchange

- This interchange is located at the end portion of Cavite section and provide access to Aguinaldo Highway which is one of the major national roads in Cavite Province.

Silan East Interchange

- This interchange is intended to provide access to A-**1** area where the urbanization is rapidly progressing and to B-2 area where the development is expected. Both A-1 and B-2 areas currently have no good land transportation access, therefore, this interchange will drastically improve the accessibility to both areas.

Sta. Rosa Interchange

- This interchange is intended to provide access to B-1 area where the residential/commercial development is planned and to Sta. Rosa-Tagaytay Road.
- Sta. Rosa-Tagaytay Road is already congested, thus traffic on Sta. Rosa-Tagaytay Road is expected to divert to CALAX.

Laguna Blvd. Interchange

- This interchange is intended to provide access c: Laguna Technopark Industrial Estate and to Areas A-2 and A-3 where rapid urbanization is progressing.
- This interchange provides access to Sta. Rosa-Tagaytay Road of which some traffic will be diverted to CALAX, and relieve traffic congestion of Sta. Rosa-Tagaytay Road.

Techno Park Interchange

- This interchange is intended to provide access to Laguna Technopark Industrial Estate.

Mamplasan Interchange of SLEX

- CALAX is connected to Mamplasan Interchange of SLEX.

- Necessary improvement such as toll booths, widening of bridge over SLEX, etc. are planned to be implemented by this project.

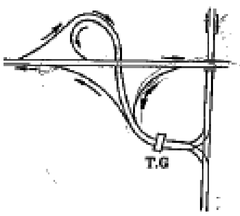
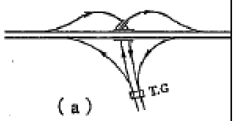
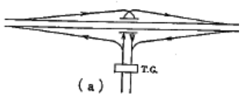
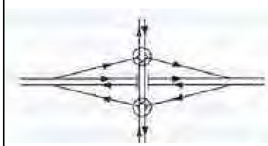
(3) Typical Toll booth layout

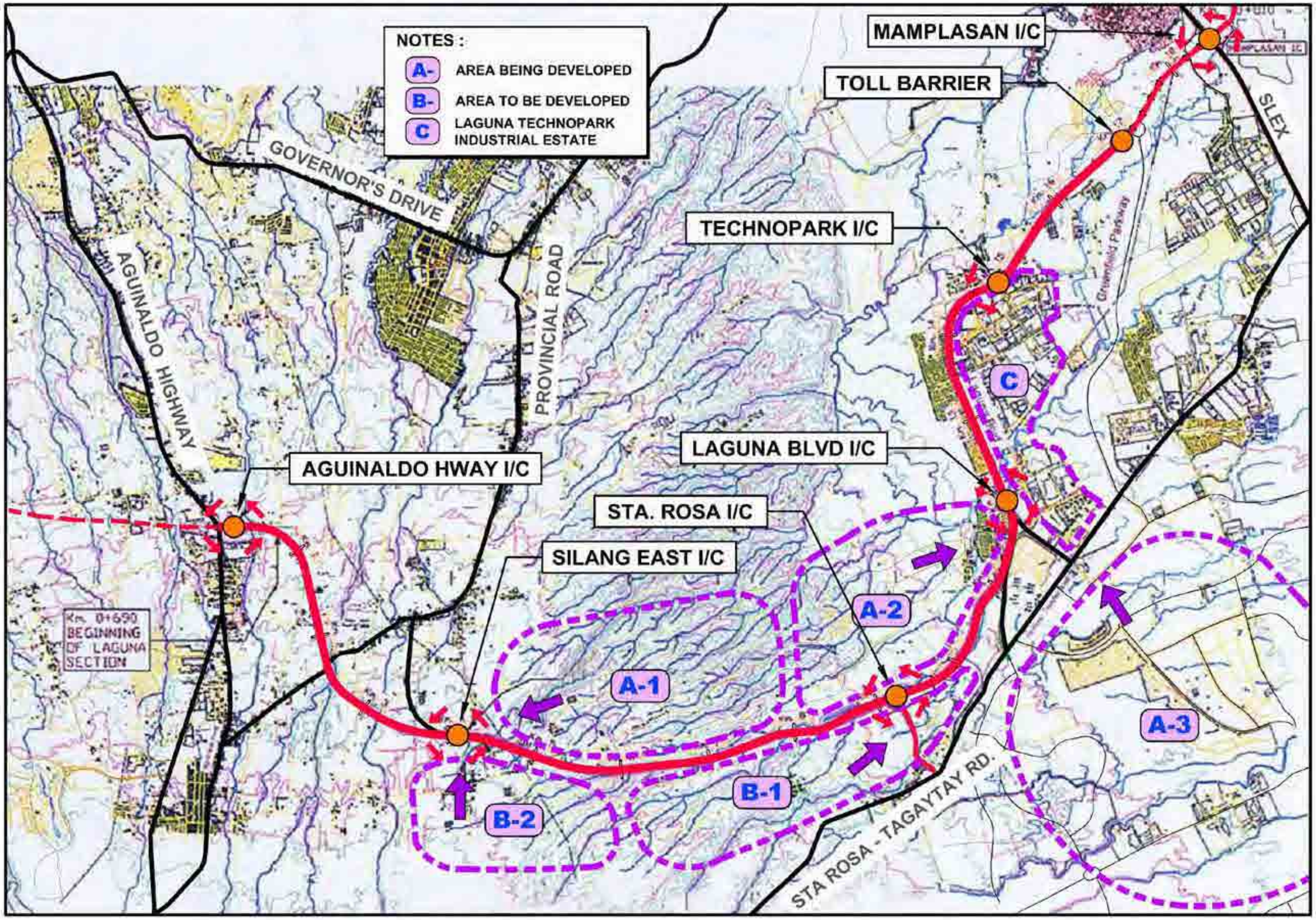
Basic layout and dimension of toll booth is referred to TPLEX which is under construction, as shown in **Figure 6.3.4-2.**

(4) Selection of Interchange Type

Table 6.3.4-1 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 and Diamond 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 intersection.

TABLE 6.3.4-1 TYPICAL INTERCHANGE TYPE

Plan				
Type	Trumpet Type	Y Type	Flat Y Type	Diamond Type
Structure	2F	3F	2F	2F
Traffic	Large	Large	Small	Small
Land Acquisition	Large	Medium	Small	Small
Cost	Middle	High	Low	Low
CALAX	Aguinaldo highway IC due to high traffic. (Cavite Section)	-	• Sta. Rosa – Tagaytay Rd. IC	• Silang East IC • Laguna Blvd. IC • Techno Park IC



SELECTION OF INTERCHANGE LOCATION

FIGURE 6.3.4-1 LOCATION OF IC

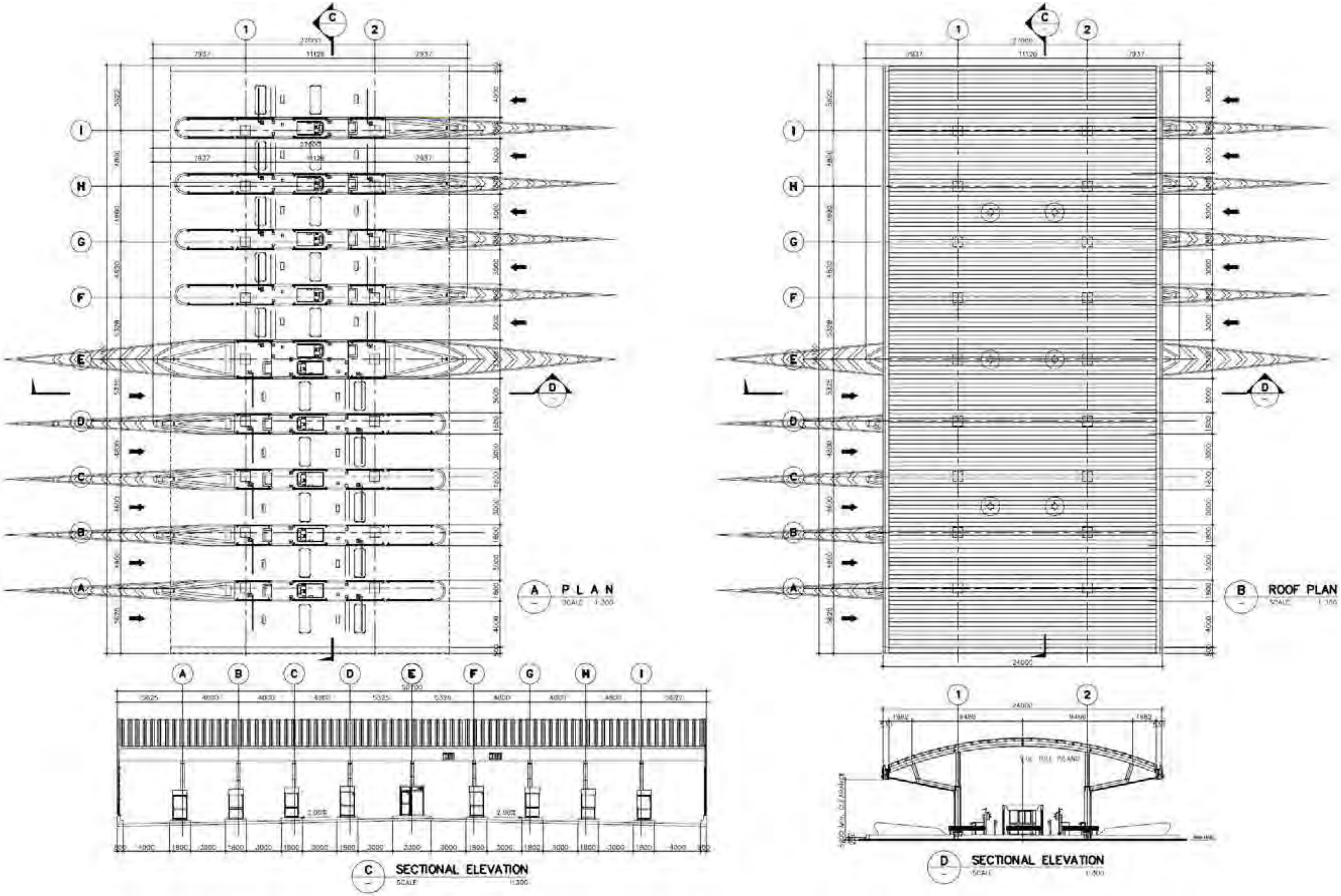


FIGURE 6.3.4-2 (1) TYPICAL DRAWING OF TOLL BOOTH LAYOUT (9 BOOTHS)

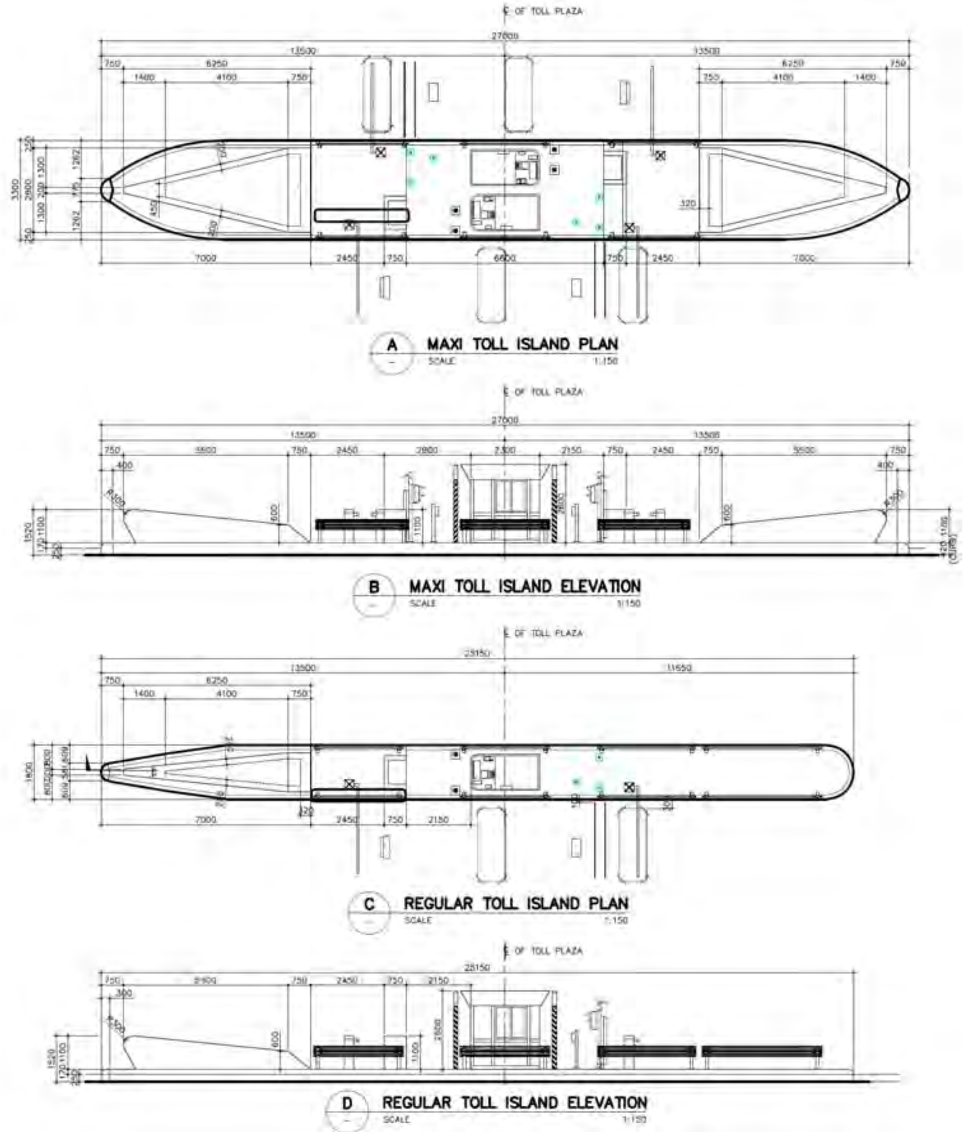


FIGURE 6.3.4-2 (2) TYPICAL DRAWING OF TOLL BOOTH

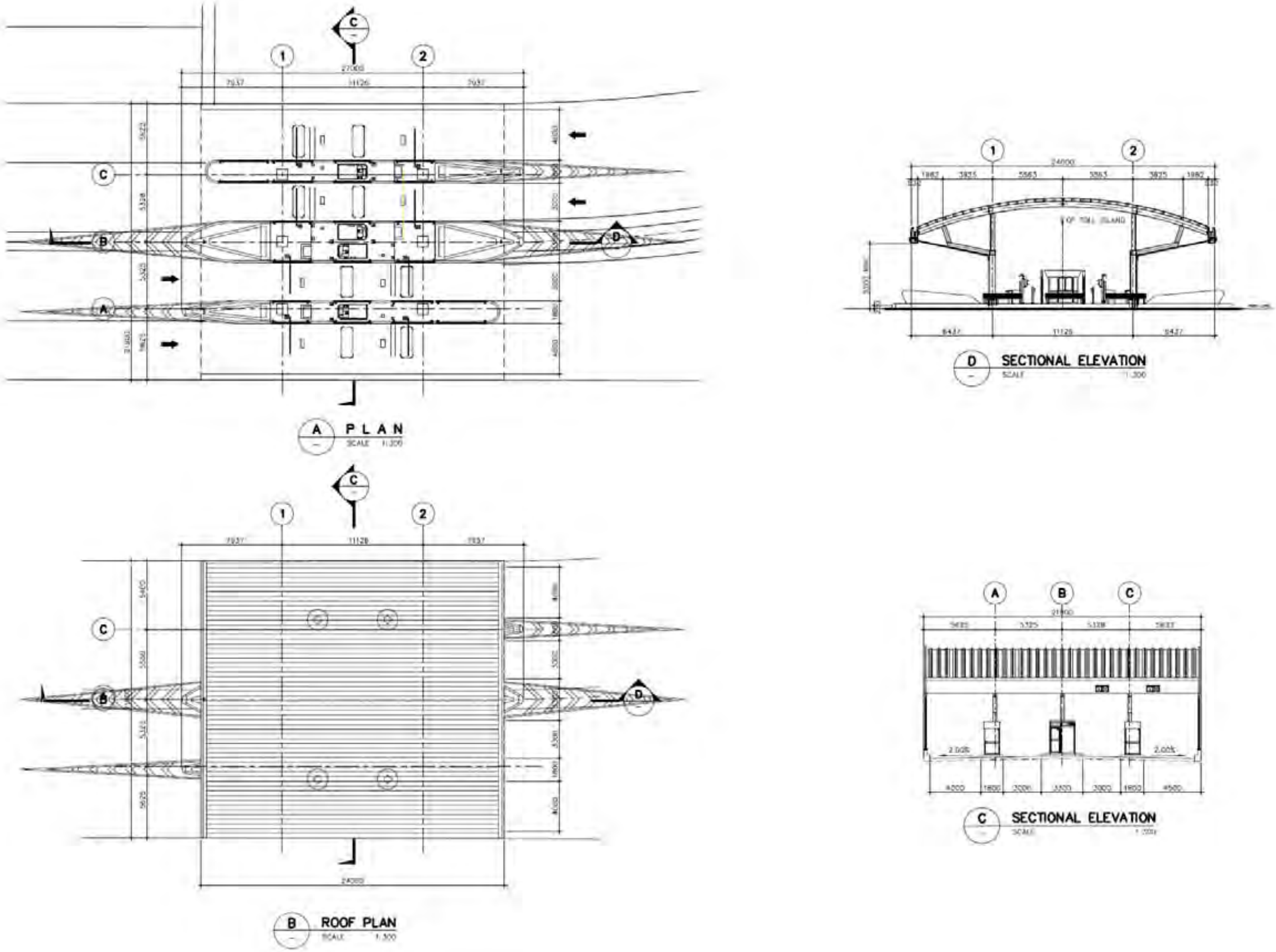


FIGURE 6.3.4-2 (3) TYPICAL DRAWING OF TOLL BOOTH LAYOUT (3 BOOTHS)

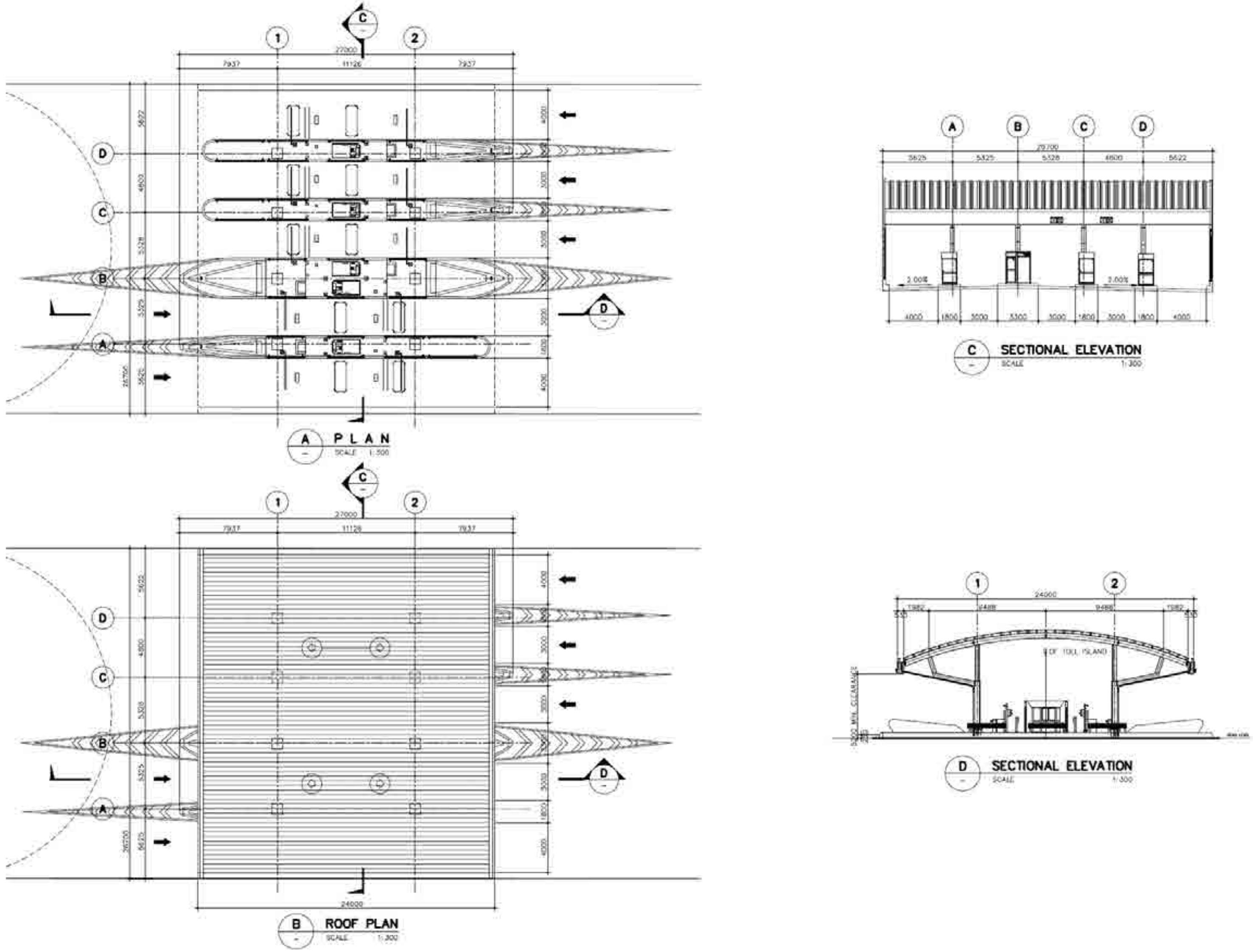


FIGURE 6.3.4-2 (4) TYPICAL DRAWING OF TOLL BOOTH LAYOUT (4 BOOTHS)

FIGURE 6.3.4-3 SILANG EAST INTERCHANGE

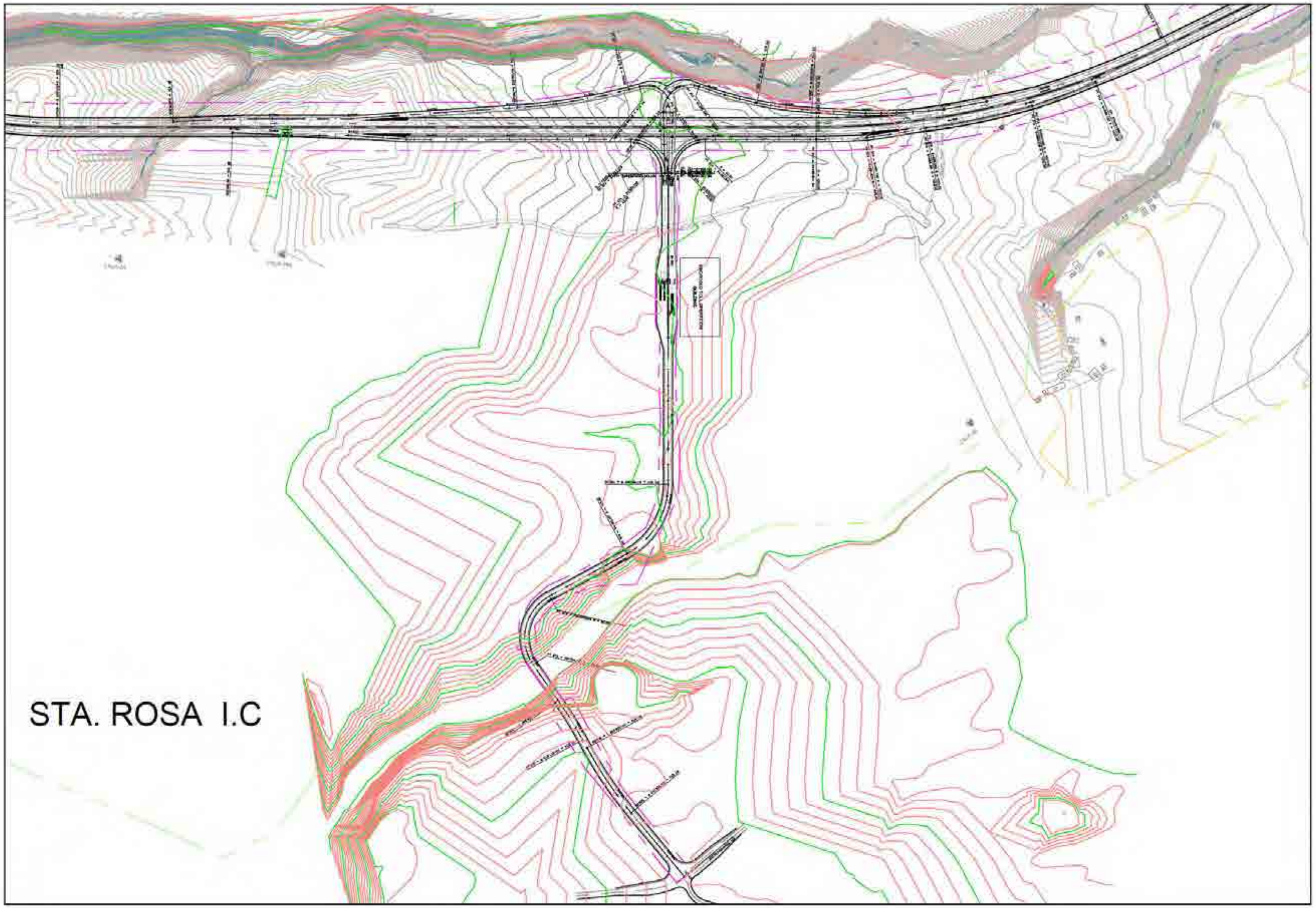


FIGURE 6.3.4-4 STA. ROSA INTERCHANGE

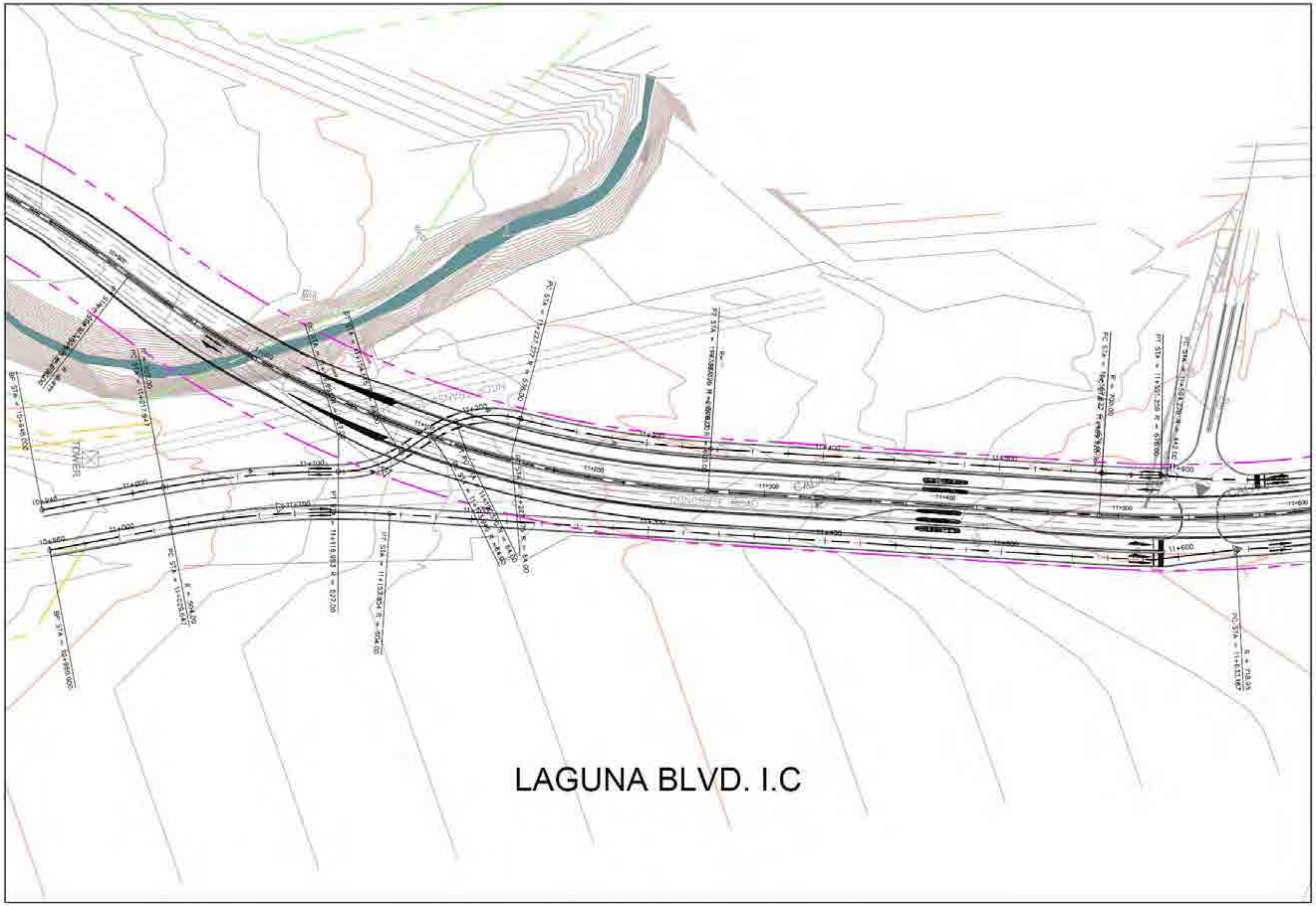


FIGURE 6.3.4-5 LAGUNA BLVD. INTERCHANGE (1/2)

FIGURE 6.3.4-6 LAGUNA BLVD. INTERCHANGE (2/2)

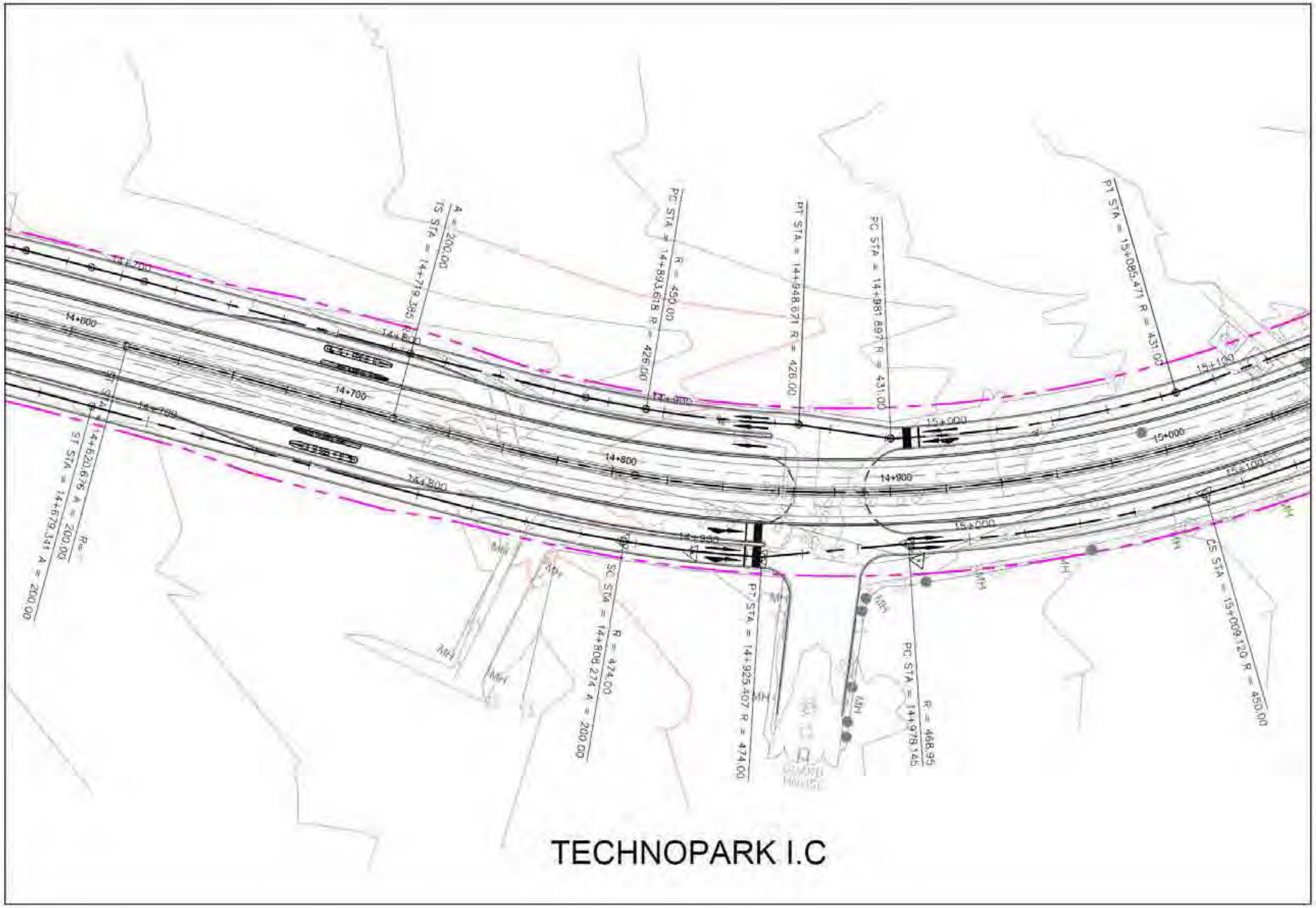


FIGURE 6.3.4-7 TECHNOPARK INTERCHANGE

(5) Design Traffic Volume and Required Lane Number

In accordance with traffic forecast (Chapter 4), the required lane number is studied below. The recommendation is shown in **Table 6.3.4-2**.

a. The number of lane shall be sufficiently the peak hour traffic for Average Annual Daily Traffic (AADT)
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**.

TABLE 6.3.4-2 REQUIRED LANE NUMBER OF INTERCHANGE RAMP

Year 2030

No.	Interchange	Direction	ON/OFF	AADT (2030)	Peak (%)	Peak Hr. Traffic	Capacity 1-lane (Veh/h)	Required lane number
				(a)	(b)	(c=a*b*)	(d)	
1	Aguinaldo IC		ON	8,936	8%	715	1,200	1
2			OFF	13,245	8%	1,060	1,200	1
3	Silang East IC	West	ON	4,931	8%	394	1,200	1
4		West	OFF	4,495	8%	360	1,200	1
5		East	ON	4,101	8%	328	1,200	1
6		East	OFF	2,278	8%	182	1,200	1
7	Sta. Rosa-Tagytay IC		ON	10,251	8%	820	1,200	1
8			OFF	9,996	8%	800	1,200	1
9	Laguna Blvd. IC	West	ON	8,520	8%	682	1,200	1
10		West	OFF	6,562	8%	525	1,200	1
11		East	ON	10,951	8%	876	1,200	1
12		East	OFF	10,898	8%	872	1,200	1
13	TechnoPark IC	West	ON	1,935	8%	155	1,200	1
14		West	OFF	2,124	8%	170	1,200	1

(6) Required Toll Booth Number

In accordance with traffic demand forecast, the required toll booth is estimated below.

The booth number estimated in year 2020 and 2030. It is assumed that the ETC user in year 2020 is 10% and that in the year 2030 is 40%. The capacity for entry booth is 600 vehicle/hour and that for exit booth is 255 vehicle /hour.

Based on this calculation, the required toll booth is shown in **Figure 6.3.4-8**.

TABLE 6.3.4-3 REQUIRED TOLL BOOTH OF INTERCHANGE

Year 2020 | ETC User 10%

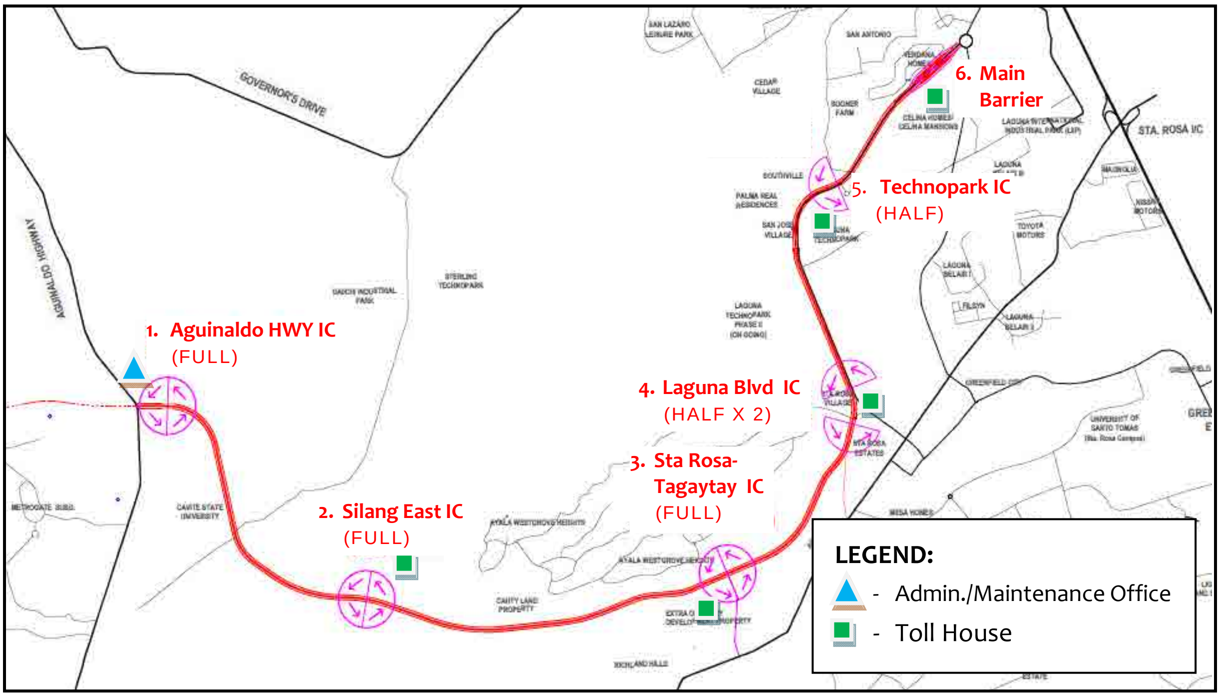
No.	Interchange	Type	Direction	ON/OFF	AADT (2020)	Peak (%)	Peak Hr. Traffic Manual	Peak Hr. Traffic ETC	Toll Collection Type	Toll Capacity (Manual)	Toll Capacity (ETC)	Required Toll Booth (Manual)	Required Toll Booth (ETC)	Required Toll Booth (Total)
					(a)	(b)	(c=a*b*(No_ETC)	(d=a*b*(ETC)		(e)	(f)	(g=roundup(c/e))	(h=roundup(d/f))	(i=g+h)
1	Aguinaldo IC	Trumpet		ON	6,180	8%	445	49	Ticket	600	900	1	1	**2**
2				OFF	10,275	8%	740	82	Pay	255	900	3	1	**4**
3	Silang East IC	Diamond	Western	ON	3,625	8%	261	29	Ticket	600	900	1	1	**2**
4			Western	OFF	2,972	8%	214	24	Pay	255	900	1	1	**2**
5			Eastern	ON	2,433	8%	175	19	Ticket	600	900	1	1	**2**
6			Eastern	OFF	842	8%	61	7	Pay	255	900	1	1	**2**
7	Sta. Rosa-Tagytay IC	Flat Y		ON	5,245	8%	378	42	Ticket	600	900	1	1	**2**
8				OFF	4,709	8%	339	38	Pay	255	900	2	1	**3**
9	Laguna Blvd.IC	Diamond	Western	ON	7,117	8%	512	57	Ticket	600	900	1	1	**2**
10			Western	OFF	6,550	8%	472	52	Pay	255	900	2	1	**3**
11			Eastern	ON	2,750	8%	198	22	Ticket	600	900	1	1	**2**
12			Eastern	OFF	3,967	8%	286	32	Pay	255	900	2	1	**3**
13	TechnoPark IC	Diamond (Half)	Western	ON	900	8%	65	7	Ticket	600	900	1	1	**2**
14			Western	OFF	920	8%	66	7	Pay	255	900	1	1	**2**
15	Toll Barrier			ON	12,483	8%	899	100	Ticket	600	900	2	1	**3**
16				OFF	11,335	8%	816	91	Pay	255	900	4	1	**5**
												Total		**41**

Exit	255
Entry	600

Year 2030 | ETC User 40%

No.	Interchange	Type	Direction	ON/OFF	AADT (2020)	Peak (%)	Peak Hr. Traffic Manual	Peak Hr. Traffic ETC	Toll Collection Type	Toll Capacity (Manual)	Toll Capacity (ETC)	Necessary Toll Booth (Manual)	Necessary Toll Booth (ETC)	Necessary Toll Booth (Total)
					(a)	(b)	(c=a*b*(No_ETC)	(d=a*b*(ETC)		(e)	(f)	(g=roundup(c/e))	(h=roundup(d/f))	(i=g+h)
1	Aguinaldo IC	Trumpet		ON	8,936	8%	429	286	Ticket	600	900	1	1	**2**
2				OFF	13,245	8%	636	424	Pay	255	900	3	1	**4**
3	Silang East IC	Diamond	Western	ON	4,931	8%	237	158	Ticket	600	900	1	1	**2**
4			Western	OFF	4,495	8%	216	144	Pay	255	900	1	1	**2**
5			Eastern	ON	4,101	8%	197	131	Ticket	600	900	1	1	**2**
6			Eastern	OFF	2,278	8%	109	73	Pay	255	900	1	1	**2**
7	Sta. Rosa-Tagytay IC	Flat Y		ON	10,251	8%	492	328	Ticket	600	900	1	1	**2**
8				OFF	9,996	8%	480	320	Pay	255	900	2	1	**3**
9	Laguna Blvd.IC	Diamond	Western	ON	8,520	8%	409	273	Ticket	600	900	1	1	**2**
10			Western	OFF	6,562	8%	315	210	Pay	255	900	2	1	**3**
11			Eastern	ON	10,951	8%	526	350	Ticket	600	900	1	1	**2**
12			Eastern	OFF	10,898	8%	523	349	Pay	255	900	3	1	**4**
13	TechnoPark IC	Diamond (Half)	Western	ON	1,935	8%	93	62	Ticket	600	900	1	1	**2**
14			Western	OFF	2,124	8%	102	68	Pay	255	900	1	1	**2**
15	Toll Barrier			ON	26,688	8%	1,281	854	Ticket	600	900	3	1	**4**
16				OFF	26,485	8%	1,271	848	Pay	255	900	5	1	**6**
												Total		**44**

LOCATION FOR TRAFFIC AND MAINTENANCE OFFICE



INTERCHANGE	DESCRIPTION		IC TYPE	NO. OF TOLL BOOTH	WEIGH IN MOTION	ADMIN / MAINT. OFFICE
1. Silang East IC	From Cavite From SLEX	Entry Exit Entry Exit	Diamond	2 2 2 2	-	-
2. Sta Rosa– Tagaytay Rd IC	ENTRY EXIT		Flat "Y"	2 3	-	1
3. Laguna Blvd. IC	From Cavite From SLEX	Entry Exit Entry Exit	Diamond	2 3 2 4	-	-
4. Techpark IC	From SLEX	Entry Exit	Diamond (Half)	2 2	-	-
5. Main Barrier	ENTRY EXIT		-	4 6	2	-
TOTAL				**38**	**2**	**1**

FIGURE 6.3.4-8 LOCATION OF IC AND FACILITIES

6.4 STRUCTURE DESIGN

In reference to the previous study, review of structure design and design standard and conceptual design for structures (bridge and box culvert) are proposed for this section.

6.4.1 Structure Design Standard

(1) General

The Structure Design Standard shall be in accordance with the following codes and guidelines:

- AASHTO Standard Specifications for Highway Bridges 17th edition 2002,
- DESIGN Guidelines Criteria and Standard for Department of Public Works And Highways,
- Basic Specifications – DPWH Standard Specifications 2004, Highways, Bridges and Airports
- Alternatively, Japanese Standards also will be adopted as the structure design standards.

(2) Loading Specifications

Structure shall be designed to carry the following loads and forces:

1) **Dead Load**

2) **Live Load**
Live Load shall be MS18 (HS-20-44)

3) Impact Load
I = 15.24/(L+38)

4) Sidewalk Live Load
4.07 KPa of sidewalk area

5) Earthquake Load
A = 0.4g, SPC D

6) Earth Pressure
Coulomb's Formula

7) **Wind Load**

For the Superstructure design, 2,394Pa of wind load shall be applied horizontally at right angle to the longitudinal axis of girders and beams.

8) **Thermal Forces**

The range of temperature shall be as follows:
17.8 °C to 48.9 °C
16.7 °C temperature rise
22.2 °C temperature fall

(3) Seismic Design

Seismic Design shall be in accordance with AASHTO Standard Specifications Division I-A. Acceleration coefficient of 0.4g shall be adopted to consider importance classification and past/recent experience in the Philippines.

(4) Superstructure

1) Bridge Type

The following bridge types shall be adopted depending on the span length, economy, and sight conditions:

a) Simple span prestressed concrete AASHTO I-Girders with continuous concrete deck slab every three or four spans.

b) Simple/multi span reinforced concrete deck girder.
Deck discontinuity such as expansion joints shall be kept to minimum in accordance to the DPWH Design Advisory.

2) Expansion Joint

The following types of expansion joints shall be adopted depending on the bridge type and movement.

a) Hot poured joint sealer with angles type,
b) Closed cell elastomeric sealer made of Neoprene type.

3) *Bridge Drainage*

Catch basins shall be made of cast iron and PVC drainpipes shall be used for bridge surface drainage system.

4) *Bearings Shoe*

Elastomeric bearing pad shall be used for prestressed concrete girder supports.

5) *Bridge Pavement*

Asphalt concrete pavement with 5 cm thickness shall be laid on concrete deck slab.

6) *Construction Force and Effect*

Forces and Effects developed during construction shall be considered in design.

(5) Substructure and Foundation

1) *The following type of pier shall be adopted in accordance to the site conditions and restrictions:*

a) Reinforced concrete column with pier-head type pier,
b) Reinforced concrete hammerhead type pier.
Pile bent-type shall be allowed for ramps and multi column type pier.

2) *Depth of Footing*

Footings in the ordinary condition shall be embedded into the ground at least 1.0 meter from the top of footing, and at least 2.0 meters shall be taken in the river area. Where necessary, effect of buoyancy on the structure shall be verified.

3) *Foundation Type*

Depending on the result of the sub-surface investigation of the site, construction constraints and other factors, the following types of foundation shall be used:

a) Spread footing type,

b) Cast in place concrete pile (1.2m to 2.0m diameter of piles will be adopted).

(6) Materials

All materials to be used in the project shall conform to DPWH Standard Specifications (2004), and AASHTO Code.

1) Concrete

DESCRIPTION	**fc' (Min.) MPa**	**MAXIMUM SIZE OF CONCRETE AGGREGATES (mm)**	**MINIMUM CONCRETE COVER (mm)**
a. Superstructure			
- Deck slabs, Diaphragms	28	20	Deck slab with BWS Top: 50 Bottom: 50 Others: 35
- Sidewalk, railings, parapets, medians	21	20	
- PSC I-Girders	38	20	PSC I-Girders: 35
b. Substructure			
- PC Pier copings, columns, footings	28	20	Pier Copings, RC & PSC: 50 PSC Hammerheads: 40 RC columns: 50 Footing and Bored Piles: 75 Abutment Walls: 50
- PSC Pier copings, rotating pier head	38	20	
- RC Abutment walls, footings	28	20	
- Bored piles	28	20	
c. Earth covered RC Box structures	28	20	Earth covered Box structures: 50
d. Other concrete (normal use)	21	20	
e. Lean concrete (for leveling)	17	25	
f. Non shrink grout	41	40	

2) Reinforcement Steel

All reinforcing steel shall be Grade 60, fy = 414 MPa.

All reinforcing steel shall be free from rust, paints, oil and any deleterious material that will tend weaken its strength or its bonding properties with concrete.

3) *Prestressing*

All prestressing steel shall be high strength stress relieved wires or strands with an ultimate stress, fs'=1860 MPa.

Prestressing steel shall be free from kinks, notches and other imperfections that will tend to weaken its strength or its bonding properties with concrete.

4) *Structural Steel*

All structural steel shall conform to the requirements of AASHTO or ASTM Designations as follows:

a) Structural Steel Shapes - AASHTO M 270 (ASTM A 36) Gr 36 and (ASTM A572) Gr 50.

b) Steel Sheet Pile - AASHTO M 202 (ASTM A 328)

c) Bridge Bearing - AASHTO M 270 (ASTM A 36) AASHTO M 106 (ASTM B 100) AASHTO M 103 (ASTM A 27) (Copper Alloy Bearing Expansion Plates Grade 70 – 36 of Steel and Sheets)

d) Deck Drain - AASHTO M 105 (ASTM A 46) Class No. 30 (Gray Iron Casting)

e) Bridge Railing - Sch. 40 Galvanized Steel Pipe

5) *Elastomeric Bearing Pads*

Elastomeric bearing pads shall be 100% virgin chloroprene (neoprene) pads with durometer hardness 60. Unless otherwise specified in the plans, bearing pads shall be laminated type bearing pads consisting of layer of elastomer, restrained at their interfaces by bonded laminations are required on the plans, laminated plate shall be non-corrosive mild steel sheet.

6) Joint Filler

Joint filler, hot poured elastic type, used for expansion joint shall conform to AASHTO M 213.

7) Bituminous Wearing Course

Bituminous wearing course to be used as surface overlay shall conform to the requirements of DPWH Standard Item 307 with minimum dry compressive strength of 1.4 MPa (200 pal). The wearing course may be used to adjust elevations on the vertical grade by varying the thickness from 50mm (min.) to 75mm (max).

6.4.3 Structure Type Study

A total of thirty four (34) bridges and one (1) reinforced concrete box culverts (RCBC) were proposed for the proposed expressway. Twenty nine (29) along the expressway, two (2) along a municipal roads crossing over the expressway, two (2) along a farm roads crossing over the expressway, One along the proposed Tagaytay access road and one RCBC road crossing. Refer to Plan and Profile.

(1) General

Marketability and constructability shall be mainly considered for CALAX project. And review of the previous study (feasibility study in Year 2006), bridge types were determined. The general features of bridges are described as follows:

1) AASHTO Girder

As the standard bridge type, AASHTO Girder – prestressed concrete I-section girder was adopted, because it is the most economical and widely used (many suppliers and local productions are existed in the Philippines). And the erection is not affecting to the underneath traffic and consideration of handling in the construction.

To apply the span ranged over 25 up to 35 m length (pier center to center length) was determined.

2) DPWH Standard Bridge – RCDG

DPWH standardized Reinforced Concrete Deck Girder, RCDG is adopted the bridge span raged up to 24m length.

3) Steel Panel I-Beam with Composite Slab Deck type Viaduct

Steel I-Beam girder with Composite Slab Deck type superstructure is adopted for simplified and quick/Easy construction to make shorter construction period.

4) Single/Multi Column type Pier

Single or multi column with pier-head type pier was adopted. The column section is adopted cylindrical or circular shape, especially in the river area to minimize the streaming inhibition. And the shape could be given mild impact to the road user and vicinity viewers.

5) Reversed T-shape Abutment

Based on the vertical alignment, abutment height is ranged from 10 to 12m. Most popular type of abutment in the range – reversed T shape was adopted, and the type for the height could be stable and minimized the cost.

6) Bored Pile Foundation

Bored pile foundation was considered because the hard stratum (assumed bearing strata) exists deeper than 8m (deepest is more than 24m) in the Project area based on the soil survey data of both previous and this study. The pile diameter is adopted ranged from 1.2m to 2.0m.

7) RCBC

DPWH Standard RCBC is adopted for the most of the crossing structure and partially medium section sized RCBC is referred to Japanese Standard on this study.

(2) Structure Features

Each bridge and RCBC structures are described in **Tables 6.4.3-1** through **6.4.3-2**. General views of the bridges are shown in ATTACHMENT – GENERAL VIEW OF BRIDGES.

TABLE 6.3.4-1 BRIDGE FEATURES - MAIN ALIGNMENT

PACKAGE I

Bridge No.	Location	Features
1	2+186.00 - 2+221.00 Waterway (L= 35.0 m)	Single 35 meter span PSC I-Girder (AASHTO TYPE-V) bridge with inverted tee abutments founded on 10 - 1.20m. diameter bored piles.
2	2+275.00 - 2+310.00 Road Crossing (L= 35.0 m)	Single 35 meter span PSC I-Girder (AASHTO TYPE-V) bridge with inverted tee abutments founded on 10 - 1.20m. diameter bored piles.
3	2+440.00 - 2+525.00 Waterway (L=85.0 m)	Multi-span (25-35-25m.) PSC I-Girder (AASHTO TYPE-V) bridge with single column piers founded on 4 – 1.80m. diameter bored piles. Abutments founded on 10 - 1.20 m diameter bored piles.
4	3+105.50 - 3+140.50 Waterway (L=35.0m)	Single 35 meter span PSC I-Girder (AASHTO TYPE-V) bridge with inverted tee abutments founded on 10 - 1.20 m diameter bored piles.
5	3+965.50 - 4+605.00 Waterway (L=639.5m)	Multi-span PSC I-Girder (AASHTO TYPE-V) Elevated roadway (flyover) of about 0.64km. in length, with variable pier to pier span lengths (25, 30 and 35 meters). Substructures are single column piers at the main viaduct and two column piers at sections where ramps are connected. Pier columns are founded on 4-1.80m. diameter bored piles. Abutments are inverted tee type founded on 10 – 1.20m. diameter bored piles. The proposed viaduct crosses the area that will be developed as interchange .
6	4+798.00 - 4+848.00 Waterway (L=50.0m)	Single 50.00 meter span steel box Girder bridge with inverted tee abutments founded on 10 - 1.20m. diameter bored piles.
7	5+660.00 - 6+115.00 Waterway (L=455.0m)	Multi-span PSC I-Girder (AASHTO TYPE-V) bridge with a uniform pier to pier span length of 35 meters. Substructures are either single or two column piers founded on bored piles, 4-1.80m. diameter for single column piers and 4-1.50m. diameter for two column piers. Abutments are inverted tee type founded on 10 – 1.20m. diameter bored piles.
8	6+602.50 - 6+777.50 Waterway (L=175.0m)	Multi-span PSC I-Girder (AASHTO TYPE-V) bridge with variable pier to pier span lengths (28 and 35 meters). Except for the abutments, the superstructures and piers at the east and west directions were designed to be independent from each other taken into considerations to the topography and skewed river flow at the bridge site. Intermediate piers are single cylindrical column (2.20m. diameter) piers founded on a single 2.80m. diameter bored piles. Abutments are beam type on 2 – 2.20m. diameter bored piles.

Bridge No.	Location	Features
9	6+953.50 - 7+048.50 Waterway (L=95.0m)	Multi-span (35m.-35m.-25m.) PSC I-Girder (AASHTO TYPE-V) bridge. Intermediate piers are single column piers founded on 4 – 1.80m. diameter bored piles. Abutments are inverted tee type founded on 10 – 1.20m. diameter bored piles.
10	7+822.00 - 7+958.00 Waterway (L=136.0m)	Multi-span PSC I-Girder (AASHTO TYPE-V) bridge with variable pier to pier span lengths (23 and 35 meters). Except for the abutments, the superstructures and piers at the east and west directions were designed to be independent from each other taken into considerations the topography and skewed river flow at the bridge site. Intermediate piers are single cylindrical column (2.00m. diameter) piers founded on a single 2.50m. diameter bored piles. Abutments are inverted tee type founded on 10 – 1.20m. diameter bored piles.
11	8+167.00 - 8+377.00 Waterway (L=210.0m)	Multi-span PSC I-Girder (AASHTO TYPE-V) bridge with a uniform pier to pier span length of 35 meters. Intermediate piers are single column pier founded on 4 – 1.80m. diameter bored piles. Abutments are inverted tee type founded on 10 – 1.20m. diameter bored piles.
12	8+644.00 - 8+719.00 (East Bound) 8+647.00 – 8+722.00 (West Bound) Waterway (L=75.0m)	Multi-span (15m.-25m.-35m.) PSC I-Girder bridge. AASHTO Type IV I girders for 15 and 25m. span and Type V for 35m. span. East and west bound were designed as separate independent bridge structures, taken into considerations the topography and the skew river flow at the bridge site. Intermediate piers are single cylindrical column (2.20m. diameter) piers founded on a single 2.80m. diameter bored piles. Abutments are beam type on a 2.20m. diameter bored piles.
13	9+282.50 - 9+317.50 Interchange (L=35.0m)	Single 35m. span PSC I-Girder (AASHTO TYPE-V) bridge over a proposed roadway. Abutments are inverted tee type founded on 10 – 1.20m. diameter bored piles.
14	9+860.00 - 10+070.00 Waterway (L=210.0m)	Multi-span (6-35m span) PSC I-Girder (AASHTO TYPE-V) bridge crossing an area intended to be developed for accessibility between the areas adjacent to the proposed expressway. Intermediate piers are single column piers founded on 4-1.80m diameter bored piles. Abutments are inverted tee type founded on 10 – 1.20m. diameter bored piles.

PACKAGE II

Bridge No.	Location	Features
15	10+860.00 - 13+606.50 Viaduct (L=2,746.5m)	Elevated roadway (viaduct) of about 2.75km. over existing waterways, developed areas and other areas be developed to provide access between the proposed service roads which are adjacent to the proposed expressway. The proposed viaduct is a combined PSC I-Girder (AASHTO Type V) and Steel I-Girder type with variable pier to pier span lengths of 25~35 meters. Intermediate piers are either single or two column piers. Columns are founded on 4- 1.80m. diameter bored piles. Abutments are inverted tee type founded on 10 – 1.20m. diameter bored piles.
16	14+074.00 - 14+354.00 Road Crossing (L=280.0m)	Multi-span (8-35m span) combined PSC I-Girder (AASHTO Type-V) and Steel I-Girder type bridge over an area to be developed to provide access between the proposed service roads which are adjacent to the proposed expressway. Intermediate piers are either single or two column piers founded on bored piles, 4-1.80m. diameter for single column piers and 4-1.50m. diameter for two column piers. Abutments are inverted tee type founded on 10 – 1.20m. diameter bored piles.
17	14+790.50 - 15+175.50 Road Crossing (L=385.0m)	Multi-span (11-35m.span) combined PSC I-Girder (AASHTO TYPE-V) and Steel I-Girder type bridge over an area to be developed to provide access between the proposed service roads which are adjacent to the proposed expressway. Intermediate piers are single column piers founded on 4 – 1.80m. diameter bored piles. Abutments are inverted tee type founded on 10 – 1.20m. diameter bored piles.
18	15+510.50 - 15+685.50 Viaduct (L=175.0m)	Multi-span (5-35m.span) PSC I-Girder (AASHTO TYPE-V) type bridge over an area to be developed to provide access between the proposed service roads which are adjacent to the proposed expressway. Intermediate piers are single column piers founded on 4 – 1.80m. diameter bored piles. Abutments are inverted tee type founded on 10 – 1.20m. diameter bored piles.
19	16+080.50 - 17+359.45 Viaduct (L=1,278.95m)	Elevated roadway (viaduct) of about 1.28km. over an existing developed areas and other areas be developed to provide access between the proposed service roads which are adjacent to the proposed expressway. Intermediate piers are single column piers at the main viaduct and two or three column piers at the toll plaza section. Single column piers are founded on 4-1.80m. diameter bored piles. For the two and three column piers, the exterior columns are founded on 2-1.80m. diameter bored piles and 4-1.80m. diameter bored piles for the middle columns. Abutments are inverted tee type founded on 10 – 1.20m. diameter bored piles.

Bridge No.	Location	Features
20	17+797.40 - 17+902.40 Roadway (L=105.0m)	Multi-span (3-35m.span) PSC I-Girder (AASHTO TYPE-V) type bridge over an area to be developed to provide access between the proposed service roads which are adjacent to the proposed expressway. Intermediate piers are single column piers founded on 4 – 1.80m. diameter bored piles. Abutments are inverted tee type founded on 10 – 1.20m. diameter bored piles.
21	18+724.00 - 18+784.00 Mamplasan Interchange SLEX (L=60.0m)	One directional three lane, two span (2-30m.) Steel I-Girder Bridge over the existing South Luzon Expressway (SLEX) just beside the existing Mamplasan Interchange bridge. The intermediate pier is a single column pier founded on 4-1.20m. diameter bored piles. Abutments are inverted tee type founded on 6 – 1.20m. diameter bored piles.

RAMPS

Ramp No.	Location	Features
IC-1 Ramp A	4+425.23 - 4+520.23 Interchange 1 (L=95.0m)	Single lane, 3-span (35m.-35m.-25m.), PSC I-Girder (AASHTO TYPE-V) interchange ramp bridge crossing an existing waterway. Intermediate piers are single cylindrical column (1.80m. diameter) piers founded on a 2.20m. diameter bored piles. Abutments are inverted tee type founded on a 2.20m. diameter bored pile.
IC-1 Ramp B	4+425.109 - 4+520.109 Interchange 1 (L=95.0m)	Single lane, 3-span (35m.-35m.-25m.), PSC I-Girder (AASHTO TYPE-V) interchange ramp bridge crossing an existing waterway. Intermediate piers are single cylindrical column (1.80m. diameter) piers founded on a 2.20m. diameter bored piles. Abutments are inverted tee type founded on a 2.20m. diameter bored pile.
Main Ramp A	11+080.00 - 11+174.00 Road Crossing (L=94.0m)	Single lane, 3-span (25m.-35m.-35m.), PSC I-Girder (AASHTO TYPE-V) interchange ramp bridge crossing a proposed road. Intermediate piers are single cylindrical column (1.80m. diameter) piers founded on a 2.20m. diameter bored pile. Abutments are inverted tee type founded on a 2.20m. diameter bored pile.
Main Ramp B	11+082.50 - 11+177.50 Road Crossing (L=95.0m)	Single lane, 3-span (25m.-35m.-35m.), PSC I-Girder (AASHTO TYPE-V) interchange ramp bridge crossing a proposed road. Intermediate piers are single cylindrical column (1.80m. diameter) piers founded on a 2.20m. diameter

Ramp No.	Location	Features
		bored pile. Abutments are inverted tee type founded on a 2.20m. diameter bored pile.
Ramp C	12+209.00 - 12+339.00 Waterway (L=130.0m)	Single lane, 4-span (35m.-35m.-35m.-25m.), PSC I-Girder (AASHTO TYPE-V) ramp bridge crossing a waterway and connected to Bridge no. 15. Intermediate piers are single cylindrical column (1.80m. diameter) piers founded on a 2.20m. diameter bored pile. Abutments are inverted tee type founded on a 2.20m. diameter bored pile.
Ramp D	12+163.00 - 12+258.00 Waterway (L=95.0m)	Single lane, 3-span (35m.-35m.-25m.), PSC I-Girder (AASHTO TYPE-V) ramp bridge crossing a waterway and connected to Bridge no. 15. Intermediate piers are single cylindrical column (1.80m. diameter) piers founded on a 2.20m. diameter bored pile. Abutments are inverted tee type founded on a 2.20m. diameter bored pile.

AT-GRADE BRIDGES

At-grade-A	12+262.50 - 12+337.50 Waterway (L=75.0m)	Two lane, 3-25m. span, PSC I-Girder (AASHTO TYPE-V) bridge crossing a waterway. Intermediate piers are single cylindrical column (2.00m. diameter) piers founded on a 2.50m. diameter bored pile. Abutments are inverted tee type founded on a 2.20m. diameter bored pile.
At-grade-C	12+262.50 - 12+337.50 Waterway (L=75.0m)	Two lane, 3-25m. span, PSC I-Girder (AASHTO TYPE-V) bridge crossing a waterway. Intermediate piers are single cylindrical column (2.00m. diameter) piers founded on a 2.50m. diameter bored pile. Abutments are inverted tee type founded on a 2.20m. diameter bored pile.

MUNICIPAL ROAD CROSSING

Station	Features
1+322.850 Municipal Road	Two lane, 2-35m. span, PSC I-Girder bridge along a municipal road crossing the proposed expressway. Intermediate pier is a single cylindrical column (2.00m. diameter) pier founded on a 2.50m. diameter bored pile. Abutments are beam type founded on a 2.20m. diameter bored pile.
5+107.106	Two lane, 2-35m. span, PSC I-Girder bridge along a municipal road

Station	Features
Municipal Road	crossing the proposed expressway. Intermediate pier is a single cylindrical column (2.00m. diameter) pier founded on a 2.50m. diameter bored pile. Abutments are beam type founded on a 2.20m. diameter bored pile.

FARM ROAD CROSSING

Station	Features
2+870.00 Farm Road	Single lane, 2-20m. span, PSC I-Girder bridge along a farm road crossing the proposed expressway. Intermediate pier is a single cylindrical column (1.80m. diameter) pier founded on a 2.20m. diameter bored pile. Abutments are beam type founded on a 2.20m. diameter bored pile.
5+360.00 Farm Road	Single lane, 2-20m. span, PSC I-Girder bridge along a farm road crossing the proposed expressway. Intermediate pier is a single cylindrical column (1.80m. diameter) pier founded on a 2.20m. diameter bored pile. Abutments are beam type founded on a 2.20m. diameter bored pile.

TAGAYTAY ACCESS

Station	Features
10+082.50	Two lane, Three span (25m.-35m.-20m.) span, PSC I-Girder bridge along the proposed Tagaytay Access Road. Intermediate piers are single cylindrical column (2.20m. diameter) piers founded on a 2.80m. diameter bored pile. Abutments are founded on a 2.20m. diameter bored pile.

TABLE 6.4.3-2 RCBC FEATURES

Station	Features
4+740.00 Farm Road	Single Barrel, 4.00m. x 4.00m. reinforced concrete box culvert (RCBC) type, along a farm road crossing the proposed expressway.

6.5 PAVEMENT DESIGN

6.5.1 General

This section describes pavement design for the project expressway. The pavement design are based on the following;

1) The results and findings of the subgrade characteristics over which the road is to built;
2) The traffic load anticipated to traverse the proposed road alignments over the selected design life; and
3) The type of pavement to be adopted based on the technical and economical advantages.

6.5.2 Pavement Design Standards

The pavement design are in accordance with the "Guide for Design of Pavement Structures, 1993" by the American Association of State Highway and Transportation Officials and in reference also to "Design Guidelines, Criteria and Standards for Public Works and Highways" by the Department of Public Works and Highway.

6.5.3 Technical Approach

The design parameters used in the pavement design includes time constrains, traffic, design serviceability loss, reliability, subgrade strength and material properties for pavement structure design.

Followings are major design conditions;

1) Design period

10 years

It is assumed that the design life of pavement consummates the 20-year design period before rehabilitation is performed.

2) Traffic

The structural design of the pavement is based on fatigue loads. Fatigue loading is taken as the cumulative number of passes of an Equivalent Standard Axle Load (ESAL) of 8,300kgs (18kips) per axle, to which the pavement structure will be subjected throughout its design life.

6.5.4 Recommended Pavement Structures

(1) Pavement Structure for Main Expressway

1) Main Carriage Way

The recommended pavement structures for both directions of the expressway main carriageway is as below;

No.	Thickness	Pavement Structure
1	60 mm	Asphalt Concrete Surface Course
2	60 mm	Asphalt Concrete Binder Course
3	150 mm	Cement Treated Base Course
4	250 mm	Crushed Aggregate Base Course
5	350 mm	Crushed Sub-Base Course

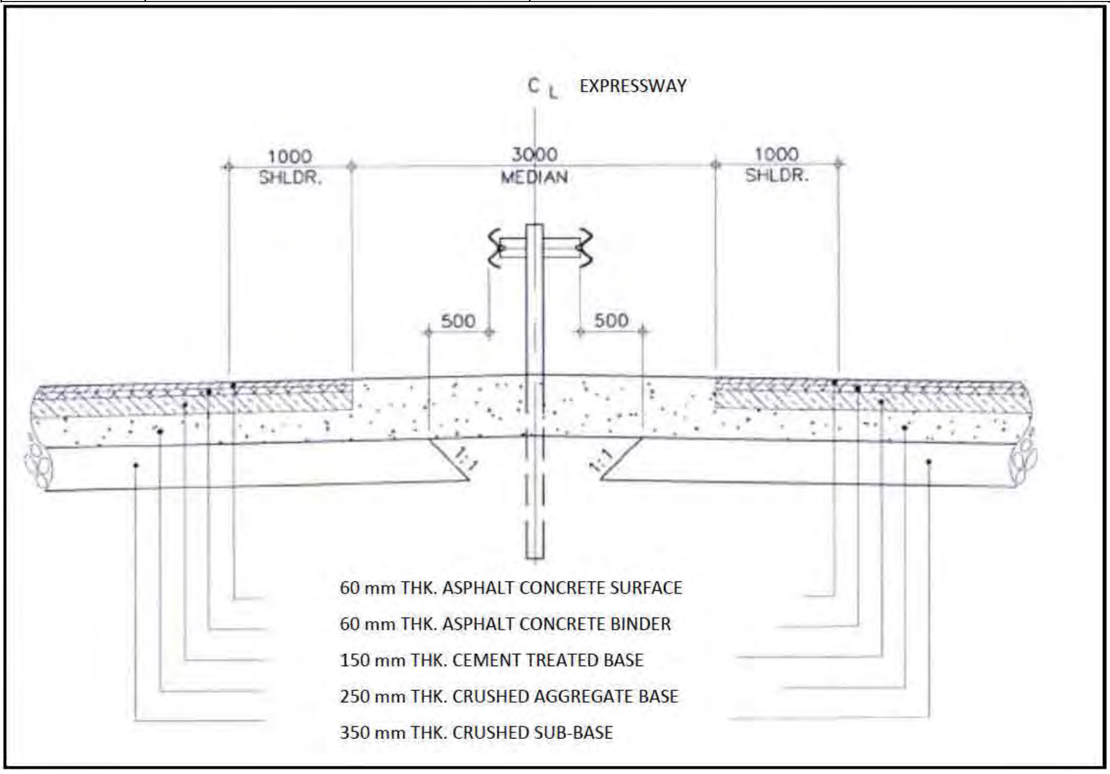


FIGURE 6.5.4-1 PAVEMENT STRUCTURE OF MAIN CARRIAGEWAY

2) Shoulder of Main Expressway

The pavement structure for shoulder followed the designed for the main carriageway. However, the surface course is not applied because shoulders is not subjected to carry full traffic on the expressway but only to accommodate vehicle emergency parking and temporary use of maintenance activities.

No.	Thickness	Pavement Structure
1	60mm	Asphalt Concrete Binder Course
2	150mm	Cement Treated Base Course
3	250mm	Crushed Aggregate Base Course
4	350mm	Crushed Sub-Base Course

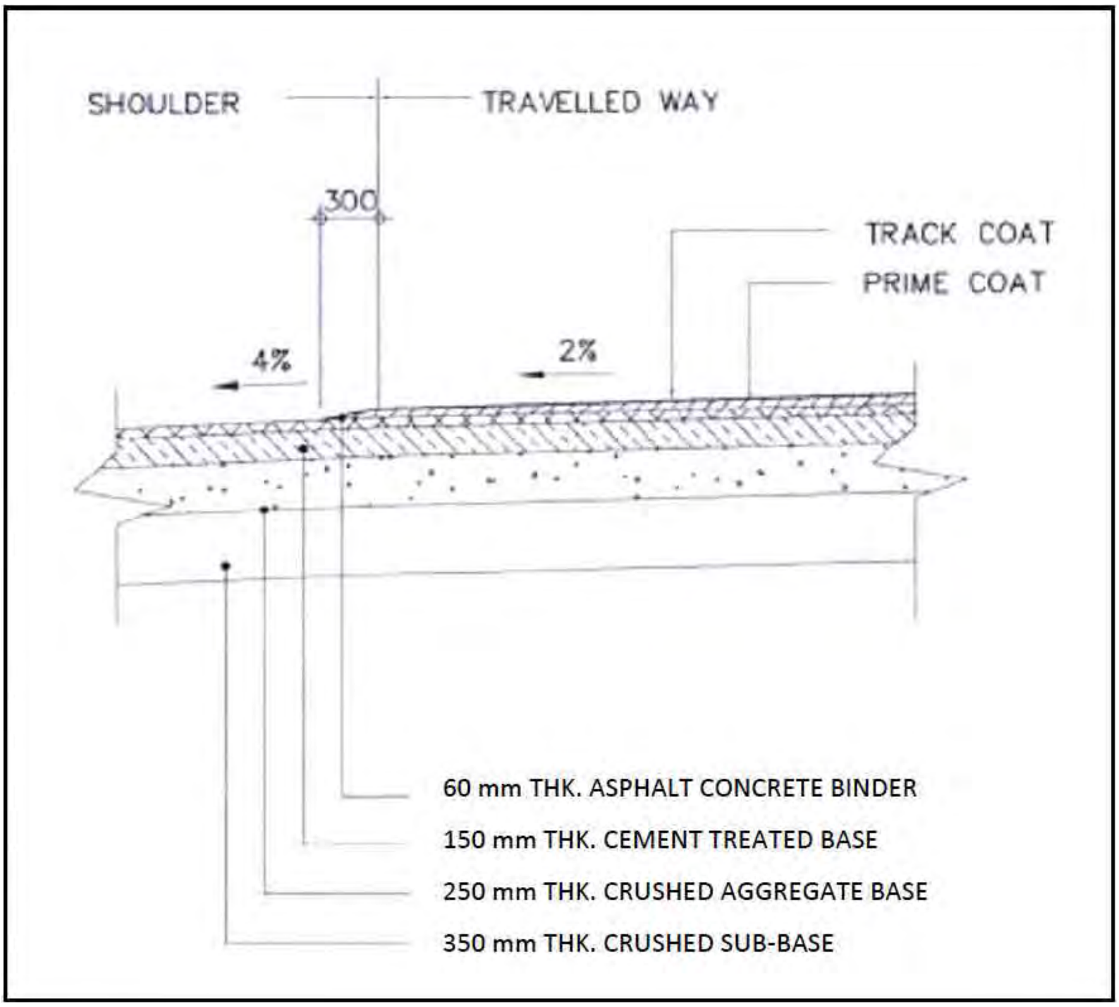


FIGURE 6.5.4-2 PAVEMENT STRUCTURE OF SHOULDER

(2) Pavement for Interchange Ramps

1) Carriage way of Ramp

The pavement structure of carriage way of ramp follows the same as the expressway.

2) Shoulder of Ramp

The pavement structure of carriage way of ramp follows the same as the expressway.

3) Toll plaza

Portland Cement Concrete Pavement (PCCP) will be used at least 50m both side from the center of toll gate.

No.	Thickness	Pavement Structure
1	350mm	Portland Cement Concrete Pavement
2	200mm	Crushed Aggregate Base Course
3	200mm	Crushed Aggregate Sub-Base Course

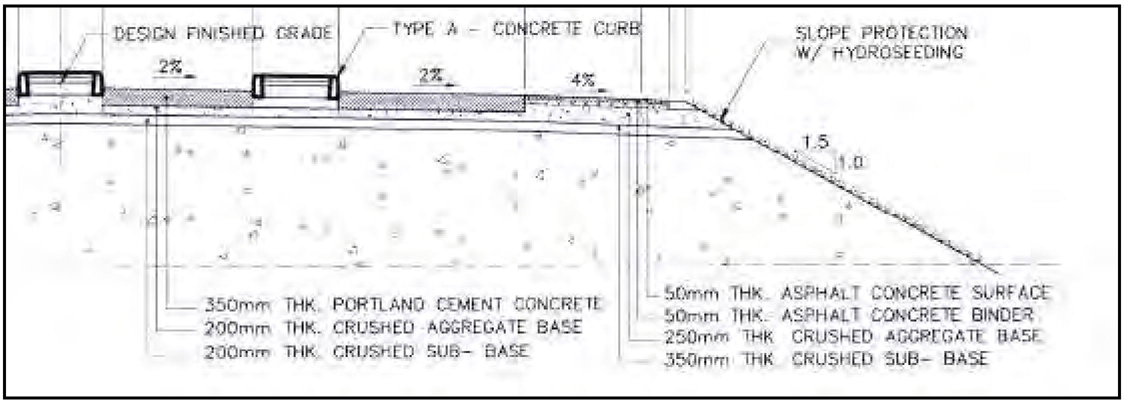


FIGURE 6.5.4-3 PAVEMENT STRUCTURE OF TOLL PLAZA

6.5.5 Pavement Design Calculation

Pavement calculation is shown as follows;

Traffic Volume and Cumulative Equivalent Standard Axle Load (ESAL)(W18kips)

［Design Period : 10 years］

Project Title : CALAX(Laguna Section)

Year				Total	Large V/Tota	Large V	Class 1	Class 2			Class 3		Total
			Vehicle Type				Cars	Bus/Trucks			Trailer		
			Traffic Volume in 2017	19,924	8%	1,503	14,381	4,040			1,503		
			Load Equivalence Factor (LEF)**			-	0.0001	5.7000			15.4000		
			Grouth Rate*	5.00%			5.00%	5.00%			5.00%		
	2017	1	Open				1.44	23,030.17			23,139.41		46,171.02
1	2018	2					1.51	24,181.68			24,296.38		48,479.57
2	2019	3					1.59	25,390.76			25,511.20		50,903.55
3	2020	4					1.66	26,660.30			26,786.76		53,448.73
4	2021	5					1.75	27,993.32			28,126.10		56,121.16
5	2022	6					1.84	29,392.98			29,532.40		58,927.22
6	2023	7					1.93	30,862.63			31,009.02		61,873.58
7	2024	8					2.02	32,405.77			32,559.47		64,967.26
8	2025	9					2.12	34,026.05			34,187.44		68,215.62
9	2026	10	in 10 years				2.23	35,727.36			35,896.82		71,626.40
Cummulative ESAL													580,734.11

one lane　　lane adjustment coefficient

580,734.11 × 365days × 0.5 × 0.8 = 84,787,180 (Design ESAL)

* Based on Traffic Demand Forecast

** Source:CY2008, Summary of Traffic Data by Project Evaluation Division, Planning Service, Report as of January 31,2009

SV03243LZ_AL, S00935LZ, Daang Maharika Highway (LZ), Nueva Ecija 2nd District Engineering Office

Flexible Pavement Design

Design Standard: Guide for Design of Pavement Structures, 1993, American Association of State Highway and Transportation Offcials

Design Case: 2016 to 2035 (20 years)

Project Title: CALAX(Laguna Section)

1. Calcuation of Structural Number

(1) Basic Fomula

The fomula shown below is applied for flexible pavement design in accordance with AASHTO design guideline.
Structural Number is computed to accommodate the basic fomula.

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

(2) Design Condition

Design Condition		Index	Value	Grounds	Remarks
	Design Period		10	2017 ～2026 (10 Years)	Design life of pavement of initial pavement structure
1. Traffic	Design ESAL	W18	84,787,180		
2. Level of Reliability	Reliability	R(%)	85	Interstate and other Freeways (AASHTO)	The possibility to satisfy road user during design period. Stronger pavement structure is required in accordance with
	Standard Normal Deviate	ZR	-1.037	Value corresponding to R=85%	Corresponding to R
	Overall Standard Deviation	S0	0.45	Average of Flexible Pavement	Variation of reliabiity according to regoinal traffic difference
3. Serviceabiity	Initial Serviceability Index	P0	4.2	Standard of AASHTO	5: Perfect 0: Inperfect
	Terminal Serviceability Index	P1	2.5	Standard of AASHTO	Serviceability expected at the end of design period
	Present Serviceability Index	ΔPSI	1.7	PSI = P0- Pt	
4. Pavement Support Layer	CBR(%)	CBR	6		
	Resilient Modulus	MR	9,000	MR=1,500×CBR	Soil Subgrade Strength

(3) Computation of SN

1. Left side of Basic Fomula	log10(W18)	7.928
2. Value of Righ side of Basi Fomula		7.928
3. SN Value required	SN	**6.059**

2. Pavement Structure

Pavement Structure		Layer Coefficient (a)	Thickness D (cm)	Thickness d (inch)	Drainage Coeffient (m)	Structural Number SN=a×m×D1	Remarks
Asphalt Concrete Surface	new	0.390	6.00	2.362	-	0.921	
Asphalt Concrete Binder	new	0.390	6.00	2.362	-	0.921	
Cement Treated Base	new	0.230	15.00	5.906	1.0	1.358	Cement treated base course
Crushed Aggregate Base	new	0.140	25.00	9.843	1.0	1.378	Crushed aggregate,CBR>20
Crushed sub-base	new	0.110	35.00	13.780	1.0	1.516	Crushed aggregate
Evaluation	Required SN			6.059	<	6.094	OK

W18 : Predicted number of 18-kip equivalent single axle load applications
ZR : Standard normal deviate
S0 : Combined standard error of the traffic prediction and performance prediction)
MR : Resilient modulus (psi)
D : Layer thickness(inches)
m : Layer drainage coeficient
SN is equal to the structural number indicative of the total pavement thickness required:

$$SN = a_1D_1 + a_2D_2m_2 + a_3D_3m_3$$

CHAPTER 7

PROJECT COST ESTIMATE

CHAPTER 7
PROJECT COST ESTIMATE

(Confidential)

CHAPTER 8

ECONOMIC AND FINANCIAL EVALUATION

CHAPTER 8
ECONOMIC AND FINANCIAL EVALUATION

(Confidential)