Feasibility Study for Wilacollo-Desaguadero Road Expansion Project in Bolivia

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Kunhwa Engineering & Consulting
Saman Corporation

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< Project Team >

Feasibility Study for Wilacollo-Desaguadero Road Expansion Project in Bolivia

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I. Project Overview

Table 1. Project Summary

Item	Description
Project Title	Feasibility Study for the Bolivia Wilacollo -Desaguadero Road Widening Project
Host Country	Plurinational State of Bolivia (Estado Plurinacional de Bolivia)
Project Location	Ingavi Province (Provincia Ingavi), La Paz Department (Departamento de La Paz), Bolivia — from Wilacollo Village to Desaguadero City
Project Scope	National Highway No. 1 (Section 5): Widening from 2-lane to 4-lane (L = 16.6 km)
Pavement Type	Cement Concrete Pavement
Design Speed	80 km/h (mainline); 30-50 km/h (through-town segments)
Project Duration	2024 18 April ~ 2024 25 October
Base Year	2024
Opening Year	2029 (planned)
Target Year	2049 (20 years after opening)
Funding Agency	Export-Import Bank of Korea EDCF
Implementing Agency	Bolivian Road Administration (ABC — Administradora Boliviana de Carreteras)

1. Project Background

☐ Bolivia is a landlocked country in central South America where approximately 95% of trade is conducted by road. The country's road infrastructure remains underdeveloped, resulting in significant logistical challenges. The Bolivian government has been actively pursuing the development of efficient transport infrastructure to drive economic growth and improve the quality of life for its citizens.

☐ The Rio Seco - Desaguadero highway (98.1 km) is a national arterial road connecting the capital La Paz and the border city of Desaguadero, and serves as the principal trade corridor between Bolivia and Peru. The Bolivian Road Administration's Strategic Plan (2020-2025) includes the widening of this road to four lanes.

☐ In 2018, the Bolivian government conducted its own feasibility study for the four-lane widening of the Rio Seco - Desaguadero corridor (divided into five sections) and subsequently requested EDCF loan assistance for the priority implementation of Section 5: the Wilacollo - Desaguadero widening from a 2-lane to a 4-lane road.

2. Project Objectives

☐ Objectives are as below:

- Increase road capacity along the Bolivia-Peru border corridor to enhance freight transport efficiency.
- Improve mobility and accessibility along the La Paz - Desaguadero corridor.
- Improve road safety conditions through highway widening and raise the standard of living for local residents.
- Stimulate bilateral trade between Bolivia and Peru and alleviate traffic congestion in the border region.
- Strengthen the friendly relations and economic cooperation between Korea and Bolivia.

☐ This project aligns with the core infrastructure investment priorities of Bolivia's National Development Strategy (PDES 2021-2025) and is consistent with the Korean government's Official Development Assistance (ODA) policy direction for the transport infrastructure sector.

☐ In the medium-to-long term, the project is expected to contribute to the achievement of Sustainable Development Goal 9 (SDG 9: Industry, Innovation and Infrastructure), and in particular SDG 9.1, which calls for the development of quality, reliable, sustainable and resilient infrastructure to support economic development and human well-being.

3. Project Scope

☐ The project scope was finalized through joint field investigations and technical meetings between the study team and the implementing agency, the Bolivian Road Administration, on the basis of the Request for Proposal issued by the Export-Import Bank of Korea. Key elements of the feasibility study are summarized below.

Table 2. Project Scope Summary

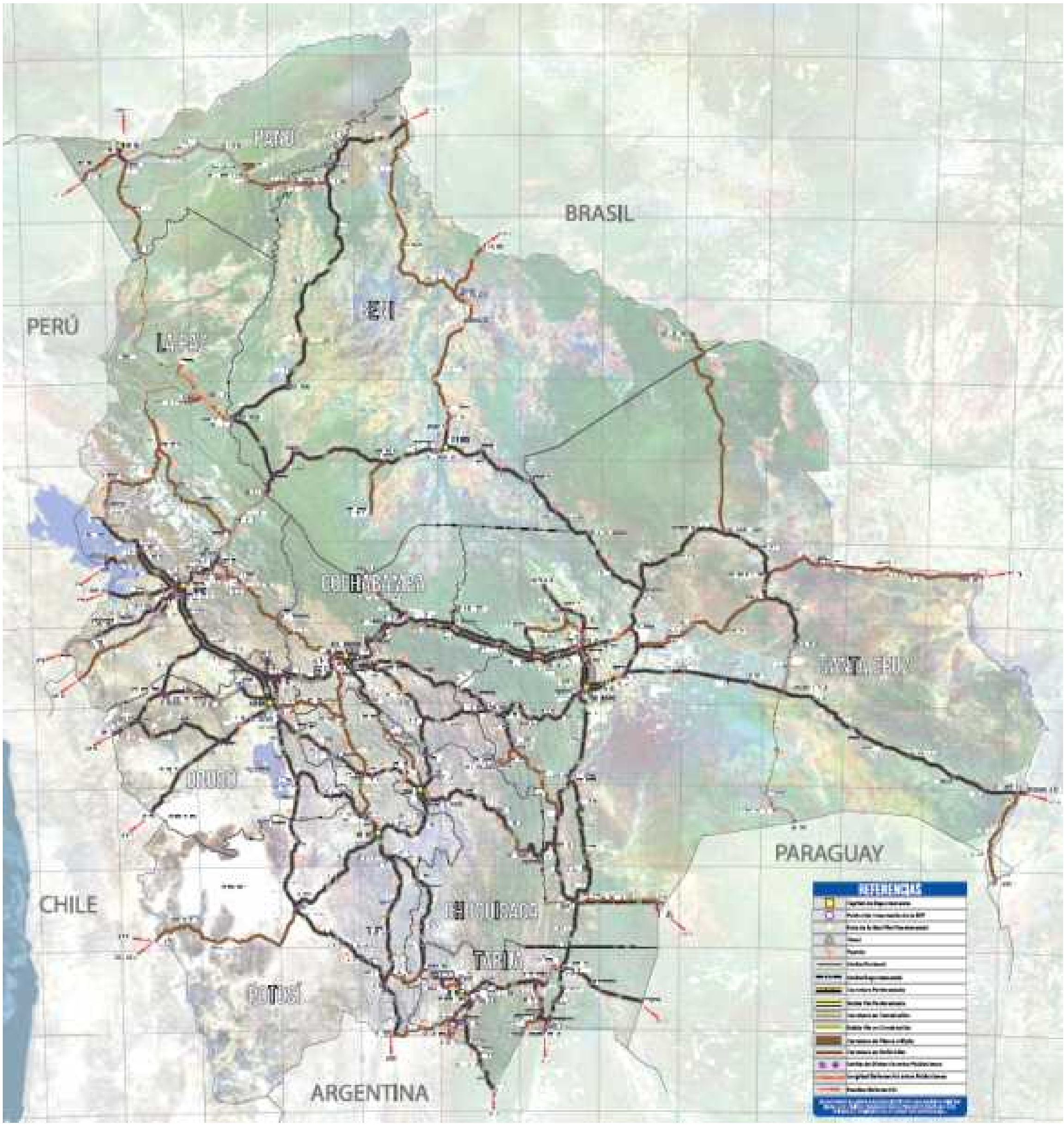
Category	Description
Location	La Paz Department (Departamento de La Paz), Ingavi Province (Provincia Ingavi) — from Wilacollo (Wilacollo) Village to Desaguadero (Desaguadero) City
Length	L = 16.6 km
Road Width	B = 24.0 m — 4-lane bidirectional
Design Speed	V = 80 km/h (mainline); V = 30-50 km/h (village approaches and urban zones)
Pavement Type	Cement Concrete Pavement
Structures	Retaining Walls: 1,656 m; Box Culverts: 35 locations; Drainage Pipes: 8 locations
time Scope	(Base Year) 2024 (Opening Year) 2029 (Target Year) 2049

II. Baseline Conditions Survey

1. General Conditions of the Road Sector

□ As of 2023, Bolivia's national highway network totals 16,539 km, the departmental road network 35,993 km, and the municipal road network 154,975 km. The paved ratio is 55.0% for national highways, 6.8% for departmental roads, and 13.0% for municipal roads. In the figure below, the black line represents a paved road, and the brown line represents an unpaved road.

Figure 1. Bolivian Road Network



☐ Rio Seco - Desaguadero road spans a total of 98.1 km and is divided into five sections. Section 1 (Rio Seco-Villa Litoral, 20.0 km) has been completed as a 4-lane road. Section 2 (Villa Litoral-Laja, 25.0 km) is currently under 4-lane widening construction. Section 3 (Laja-Tihuanacu, 24.0 km) is in the design phase. Section 4 (Tihuanacu-Wilacollo, 12.5 km) has completed its feasibility study. Section 5 (Wilacollo-Desaguadero, 16.6 km) constitutes the scope of this study.

2. Relevant Plans and Policies

☐ Bolivia enacted the Integrated State Planning System (SPIE — Sistema de Planificación Integral del Estado) by law in 2016. Under this framework, the government formulates a 25-year General Economic and Social Development Plan, 5-year Economic and Social Development Plans, and 5-year Institutional Strategic Plans by sector. The current five-year development plan, the "Economic and Social Development Plan 2021-2025 (PDES 2021-2025)," was adopted in 2021.

☐ The transport sector's 2021-2025 program was formulated by the Vice-Ministry of Transport, with the stated goal of improving surface, air, and waterway transport service provision as part of the economic reconstruction strategy.

☐ The ABC(Bolivian Road Administration) Strategic Plan identified 95 road projects, among which the project segment in this study is ranked 7th in priority.

Table 3. ABC Priority Project List (Extract)

Priority	Project Name	length(km)
1	CONSTRUCCIÓN DEL TRAMO SEGUNDO CRUCE RIO SEQUE - LA CUMBRE; FASE II PUENTES RIO SEQUE - RIO SECO	0.64
2	CONSTRUCCIÓN DE OBRAS COMPLEMENTARIAS RÍO SEQUE – LA CUMBRE	28.00
3	INTERVENCIÓN DE SITIOS CRÍTICOS Y CONSTRUCCIÓN DE OBRAS COMPLEMENTARIAS CARRETERA SANTA BARBARA - CARANAVI (FASE II)	59.68
4	CONSTRUCCIÓN DOBLE VÍA COTOCA – PAILON – PARAISO	42.89
5	COSTRUCCIÓNDOBLEVÍALAGUARDIA–ELTORNO	13.00
6	CONSTRUCCIÓN CARRETERA BOTIJLACA - CHARAÑA,TRAMO I: BOTIJLACA- CAQUIAVIRI	33.11
7	CONSTRUCCIÓN CARRETERA DOBLE VIA RIO SECO – DESAGUADERO TRAMO V	16.59

3. Project Area

☐ The project corridor constitutes a portion (Section 5) of National Highway No. 1, which links La Paz and El Alto — the economic center of western Bolivia — to Desaguadero, a border city adjacent to Peru. It represents one of the primary bilateral trade routes between Bolivia and Peru.

☐ The project corridor falls within Ingavi Province, La Paz Department. The city of Desaguadero functions as a key trade hub between Bolivia and Peru.

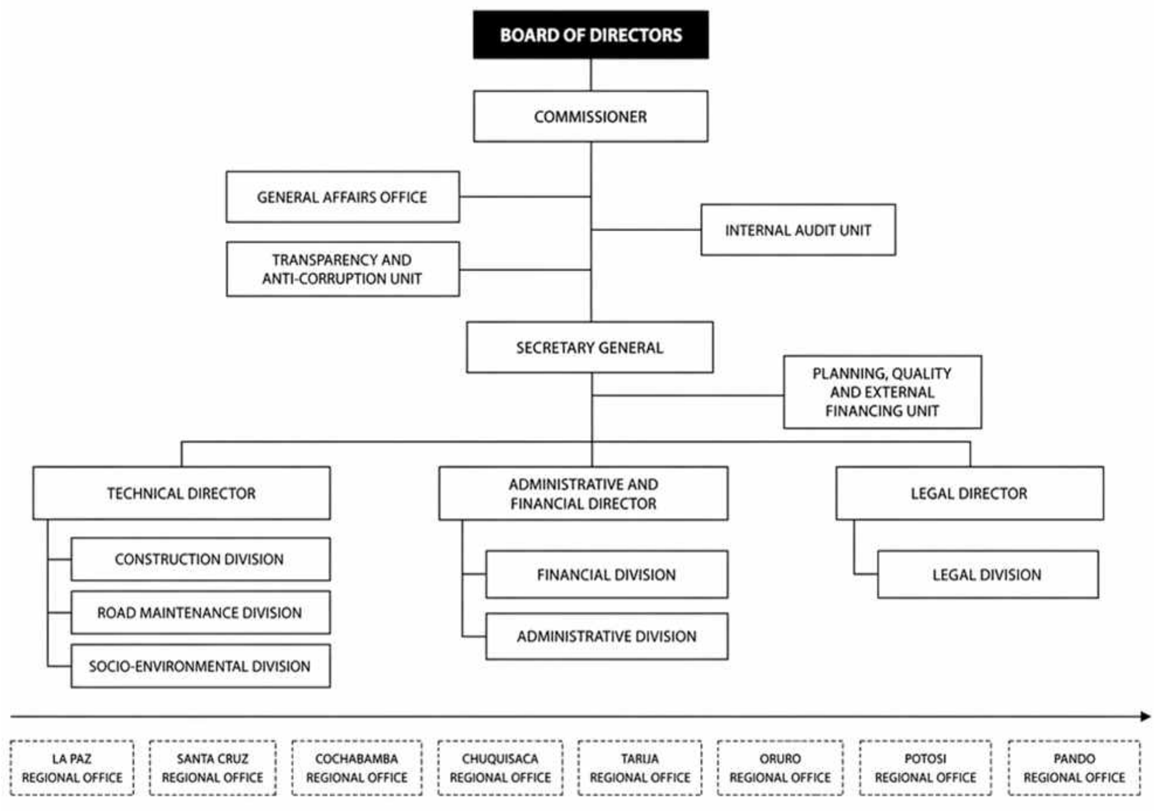
☐ The elevation along the project area ranges from approximately 3,800 m above sea level at the start point (Wilacollo) to approximately 3,808 m at the terminus (Desaguadero), indicating a relatively flat and uniform topography consisting of plains and gentle rolling terrain.

4. Implementing Agency and Project Execution Structure

☐ The implementing agency is the Bolivian Road Administration, which is vested with authority over the construction, management, and operation of Bolivia's national road infrastructure.

- ABC operates as a subordinate agency directly under the Ministry of Public Works, Services and Housing (MOPSV — Ministerio de Obras Públicas, Servicios y Vivienda). Its governance structure comprises a Board of Directors as the supreme decision-making body, a Director General, and a Secretary General. Three national directorates — the National Operations Directorate, the National Administrative and Financial Directorate, and the National Legal Directorate — are responsible for administrative, technical, and legal affairs respectively. Regional offices in nine departments handle on-site supervision, maintenance coordination, and liaison with local governments.

Figure 2. Organizational Chart of the ABC



□ For this project, the Vice-Ministry of Investment and External Financing (VIPFE — Viceministerio de Inversión Pública y Financiamiento Externo) oversees the overall loan administration, while ABC leads project implementation. ABC has a successful track record of cooperation with Korea, including the Venegas Bridge construction (EDCF-financed, completed 2018), and is considered well-positioned to execute this project effectively.

III. Field Investigation

1. Existing Road Condition Survey

□ Section 1 (Sta.0+000-Sta.10+500, Flat Terrain)

- The road alignment maintains a clearance of more than 100 m from Lake Titicaca on the right side, posing no conflict risk during widening. Adjacent land is used primarily as pastureland, with unpaved tracks accessing nearby villages.
- No drainage facilities exist at the paved shoulder edge. Significant pavement distress and asphalt heaving are observed, likely due to frequent heavy vehicle traffic.
- Lane markings are recently repainted and visibility is sufficient. However, pedestrian crossings, traffic signals, and streetlights are absent, posing collision risks to pedestrians, particularly at night.

Figure 3. Field Survey Photos of Section 1

□ Section 2 (Sta.10+500-Sta.13+300, Flat Terrain)

- An urban design speed of 30 km/h is applied in this section. The Janq'u jaqhi hill is located on the left, and Lake Titicaca is immediately adjacent on the right. The left hillside is predominantly composed of claystone and features steep, untreated slopes, presenting a significant rockfall hazard.

- The right side adjoins Lake Titicaca with a level difference, and guardrails have been installed at certain locations. An open−lined ditch is installed on the left hillside section, and cross−drainage pipes discharge stormwater to the right into Lake Titicaca. No side ditches are provided on the lake side, and pavement distress is observed at the road edge.
- Guardrails are installed on sharp curves but are poorly maintained, with damage observed at several locations. The absence of roadway lighting and safety facilities such as retro−reflective guide signs and delineators poses a high nighttime accident risk on sharp curve sections.

Figure 4. Field Survey Photos of Section 2

□ Section 3 (Sta. 13+300 - End, Bypass / Flat Terrain)

- A 2.45km−long bypass (Sta. 13+400 - Sta. 15+850) was planned to route traffic around the periphery of Desaguadero city, avoiding conflict with the city's main buildings.
- The bypass was designed to preserve the only cathedral in Desaguadero — a structure of significant cultural value — and to retain a gas station serving local residents. After traversing the hillside, the

alignment is planned to pass through the rear hills behind Desaguadero city.

○ The bypass section includes a cut into the Janq'u jaqhi hillside, and a careful assessment of slope stability will be required during detailed design and construction. An alignment optimization study was conducted during route review to minimize cut volumes in this section.

○ Unpaved village roads of poor quality exist on both sides of the planned new road, and significant fugitive dust generation has resulted in poor ambient air quality. Two residential structures are located near the terminal section of the new road but are understood not to fall within the land acquisition boundary.

○ The existing 2-lane bidirectional road experiences near-constant blockage by freight trucks queuing for customs clearance on both weekdays and weekends. Upon widening to four lanes, adequate shoulder width should be secured in the detour section to accommodate waiting vehicles.

○ Compared to sections 1 and 2, there are some lighting facilities, but there are no safety facilities for pedestrians such as crosswalks.

Figure 5. Field Survey Photos of Section 3

2. Topographic Survey

□ The survey covered the horizontal and vertical profiles of the existing road, cross-sections, centerline and shoulder lines, adjacent buildings and structures, bridge conditions, culvert and pipe conditions, ancillary road facilities, utility obstacles within the corridor, and land acquisition boundaries.

□ Surveys were performed by a local partner firm. Real-time kinematic (RTK) triangulation surveys were conducted with base stations installed at 2 km intervals and leveling points set at 500 m intervals, producing a digital terrain model (DTM) of the project corridor.

Figure 6. Digital topographic map created from the results of a survey

3. Geological and Geotechnical Investigation

☐ Subsurface investigations were carried out to identify the soil profile and geotechnical characteristics within the project corridor, and to obtain baseline data for earthwork and pavement design.

- Structural zones (retaining wall sections and the terminal bridge zone): borehole drilling and standard penetration tests (SPT).
- Earthwork zones: test pits, dynamic cone penetration tests (DCPT), and laboratory California bearing ratio (CBR) tests to evaluate suitability of fill materials.
- Borrow source investigation: verification of existing borrow sources adjacent to the project corridor.
- A total of 16 test pits (10 along the alignment, 4 at borrow sites, 2 at material sources), 4 surface geological surveys, and 2 boreholes (to a depth of 15 m) were conducted.

☐ Analysis results indicate a stable silty-sandy subgrade with CBR values exceeding 13.3, providing adequate bearing capacity. Surface geological surveys at all four sections yielded favorable assessments.

Table 4.Laboratory Test Results from Test Pit Investigation

ID	Depth (G.L(−)m)	MC	LL	PL	PI	Soil Classification		Compaction Test		CBR	
						AASHTO	USCS	Dmax	OMC	95%	Swell
S－01	0.3−1.1	20.7	34.8	27.5	7.3	A−4	ML	1745	18.1	27.2	0.41
S－01	1.1−1.7	24.7	30.2	19.4	10.8	A−6	CL	1853	16.4	22.1	1.04
S－02	0.3−2.0	−0.8	−	NP	NP	A−4	ML	1799	8.8	27.6	0.20
S－03	0.3−1.0	10.9	−	NP	NP	A−1b	GM	1976	5.6	92.6	0.00
S－03	1.0−1.5	20.0	25.2	15.8	9.4	A−4	CL	1808	14.8	13.3	0.34
S－04	0.3−1.3	7.5	−	NP	NP	A−2−4	SM	2076	7.8	53.6	0.00
S－04	1.3−1.8	23.6	21.9	20.8	1.1	A−4	ML	1939	14.1	27.0	0.20
S－05	1.1−1.8	19.2	21.5	17.6	3.9	A−4	ML	1964	11.7	28.0	0.14
S－06	0.3−1.0	9.5	−	NP	NP	A−4	ML	1928	10.4	28.5	0.00
S－07	0.3−1.5	12.7	21.6	17.8	3.8	A−4	CL−ML	1942	12.7	19.3	0.13
S－08	0.3−1.5	19.2	21.5	17.6	3.9	A−4	ML	1778	16.3	19.7	0.39
S－10	0.3−2.0	12.7	−	NP	NP	A−4	SM	1882	10.8	37.3	0.06

Table 5. Surface Geological Survey Results

Station	No. of Measurements	Rock Mass Classification Score	Condition
12+020	25	50 – 74	Good
13+850	11	54 – 66	Good
14+010	9	56 – 65	Good
14+290	7	51 – 61	Good

□ The retaining wall fill zone demonstrates excellent bearing capacity at a relatively shallow depth of approximately 4.5 m. The terminal fill zone is located near a waterway, and weak subgrade conditions persist to a depth of 13.5 m.

Table 6. Borehole Investigation Results

Boring	G.L (−)m	Depth	Soil Layer		MC	N	Friction Angle (deg.)	Cohesion (kN/m²)	E (MN/cm²)	Poisson's Ratio
			AASHTO	USCS						
P−1 (Retaining Wall Fill)	1.45	1.5~3.0	A−4	ML	1.1	5	29	3.0	3.66	0.3
		4.5~6.0	A−4	ML	0.9	34	40	6.9	12.96	0.3
		7.5~9.0	A−4	ML	0.8					
		12.3~13.5	A−4	SM	3.5					
		13.5~15.0	A−1b	SM	3.4					
P−2 (Endpoint Fill)	0.00	0.0~1.5	A−4	ML	7.4	3	27	3.0	2.20	0.3
		1.5~3.0	A−4	SC−SM	15.5	3	27	5.6	1.61	0.3
		3.0~4.5	A−4	CL	17.7	3	28	8.2	1.76	0.3
		4.5~6.0	A−2−4	SC−SM	19.2	1	26	11.2	0.76	0.3
		6.0~9.0	A−2−4	SM	20.0	13	36	14.2	5.71	0.3
		9.0~10.5	A−2−4	SM	36.7	13	36	17.2	5.17	0.3
		10.5~12.0	A−2−4	SM	16.2	17	39	20.1	6.44	0.3
		12.0~13.5	A−3	SP	9.0	9	34	23.1	3.17	0.3
		13.5~15.0	A−4	CL−ML	3.0	50	52	26.1	16.62	0.3

4. Borrow Source Investigation

□ Test pit investigations were conducted at two borrow source sites in the vicinity of the project area. The river aggregate material, which exhibits high CBR values, is well−suited for use as subbase and base course material.

Table 7. Borrow Source Investigation Summary

Item	S−20(Sta. 66+900)	S−21(Sta. 68+000)
Condition		
Description	▫ Sand, gravel, and cobbles distributed across the full riverbed width. ▫ Estimated extractable volume: approx. 241,010 m³	▫ Irregular distribution of clay, silt, sand, and gravel. ▫ Estimated extractable volume: 441,200 m³

Table 8. Laboratory Test Results

ID	MC	LL	PL	PI	Soil Classification		Compaction Test		CBR	
					AASHTO	USCS	Dmax	OMC	95%	Swell
S−20	2.1	−	NP	NP	A−1a	GP	2347	5.3	131.7	0.00
S−21	12.7	−	NP	NP	A−1a	GW−GM	2261	5.3	96.6	0.00

IV. Traffic Demand Forecast

1. Traffic Volume and Travel Speed Survey Results

☐ Corridor traffic counts recorded 1,268 vehicles/day on the Peru Border (Freight Checkpoint)-Health Center Junction segment and 3,904 vehicles/day on the Health Center Junction-Wilacollo segment. The Health Center Junction-Peru Border (Passenger Checkpoint) branch recorded 2,123 vehicles/day. Near the freight checkpoint, semi-trailers dominate with 613 vehicles/day (48%); near Wilacollo, minibuses are the predominant vehicle type with 1,467 vehicles/day (38%).

Table 9. Corridor Traffic Volume (vehicles/day)

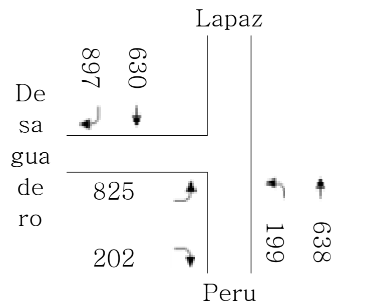
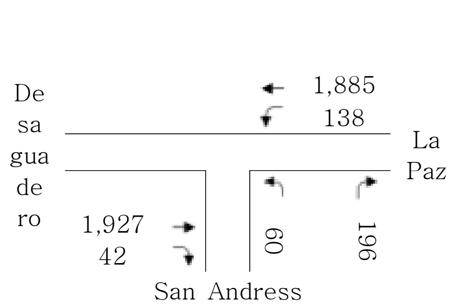
Direction	Peru Border (Freight) - Health Center Jct.	Health Center Jct. - Peru Border (Passenger)	Health Center Jct. - Wilacollo
Desaguadero → La Paz	638	1,027	1,902
La Paz → Desaguadero	630	1,096	2,002
Total	1,268	2,123	3,904

Table 10. Corridor Traffic Volume by Vehicle Class (both directions, vehicles/day)

Vehicle Class	Peru Border (Freight) - Health Center Jct.	Health Center Jct. - Peru Border (Passenger)	Health Center Jct. - Wilacollo
Passenger Car / Van	249	490	1,293
Pickup Truck (≤2 t)	37	52	220
Minibus (15-seat)	254	1,359	1,467
Microbus (21-seat)	0	1	5
Medium Bus (35-seat)	3	6	54
Large Bus (>35-seat)	7	2	15
Medium Truck	31	50	67
Heavy Truck (≥10 t, 2-axle)	10	10	31
Heavy Truck (≥10 t, 3-axle)	10	2	18
Semi-trailer	613	5	681
Full Trailer	10	0	14
Motorcycle	43	146	38
Other	1	0	1
Total	1,268	2,123	3,904

☐ Junction traffic volume was surveyed at the Santa Rosa junction in Wilacollo at the starting point and the Health Center junction in downtown Desaguadero. It was found that the traffic volume at the starting point junction was higher than that in downtown Desaguadero, and the main direction is Desaguadero to La Paz.

Table 11. Junction Traffic Volume (vehicles/day)

Health Center Jct. (Desaguadero downtown)	Santa Rosa (Wilacollo)
	

☐ Travel speeds were measured between 25.1 km/h and 49.1 km/h during the morning peak period, lower than those of afternoon peak. The in-city segments (Peru Border-Health Center Junction-Archaeological Site) exhibited notably lower speeds than the out-of-town segments.

Table 12. Average Travel Speeds by Direction

Segment	Distance (km)	Survey Period	Average Travel Speed (km/h)		Average Travel Speed (km/h)
			Desaguadero → La Paz	La Paz → Desaguadero	
Peru Border - Health Center Jct	2.06	07-10	30.1	25.1	27.6
		16-18	53.8	54.1	53.9
Health Center Jct. - Arch. Site	1.78	07-10	33.9	42.8	38.4
		16-18	58.4	58.4	58.4
Arch. Site - Yanari Village	10.67	07-10	49.1	48.3	48.7
		16-18	84.3	84.2	84.3
Yanari Village - Santa Rosa	4.31	07-10	42.0	32.6	37.3
		16-18	77.1	83.4	80.2

2. Traffic Demand Forecast Results

☐ The segment with the highest projected demand is the Health Center Junction-Santa Rosa (Santa Rosa) segment, with the forecasted Average Annual Daily Traffic (AADT) increasing from 11,655 vehicles/day in 2029 to 41,954 vehicles/day by 2049.

Table 13. Traffic Demand(vehicle/day)

Year	Peru Border - Health Center Jct.	Health Center Jct. - Santa Rosa
2024	3,325	8,139
2029	4,696	11,655
2034	6,511	16,383
2039	8,775	22,400
2044	11,841	30,649
2049	15,992	41,954

3. The Number of Required Lanes

☐ The number of required lanes was determined based on a design speed of 80 km/h and level of service D as the design threshold. Analysis indicates that a volume−to−capacity ratio of 1.03 is reached in 2042, which will necessitate a 4−lane (bidirectional) configuration.

Table 14. Lane Requirement Calculation

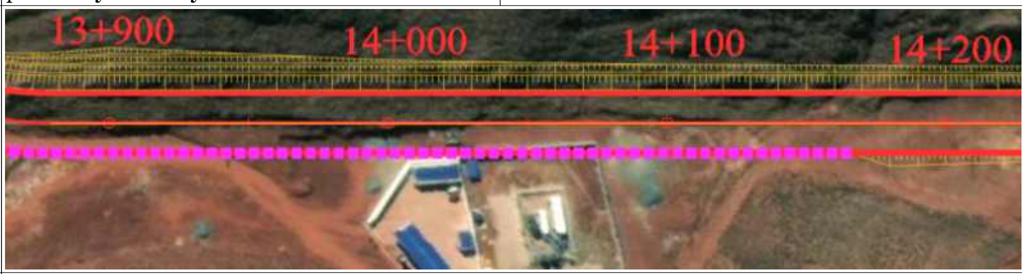
Year	Design Speed (km/h)	AADT	PDDHV	Service Capacity (SFd)	Lanes Required (one direction)	Total Lanes
2025	80	8,745	398	1,195	0.33	2
2030	80	12,523	570	1,195	0.48	2
2035	80	17,439	794	1,195	0.66	2
2040	80	23,847	1,085	1,195	0.91	2
2041	80	25,391	1,156	1,195	0.97	2
2042	80	27,036	1,231	1,195	1.03	4
2043	80	28,784	1,310	1,195	1.10	4
2044	80	30,649	1,395	1,195	1.17	4
2045	80	32,636	1,485	1,195	1.24	4
2049	80	41,954	1,910	1,195	1.60	4

V. Technical Feasibility Review

1. Alternative Alignment Assessment and Route Selection

☐ The bypass section was examined by comparing the baseline alignment (original Bolivian feasibility study) with an alternative alignment. Following comparative analysis and consultation with the Bolivian Road Administration, the baseline alignment was retained.

Table 15. Alternative Alignment Comparison

Item	Baseline (Original FS)	Alternative Alignment
Description	•Original Bolivian FS alignment •Routes around the gas station, a primary utility conflict.	•Shifts the original axis by 20 m while still bypassing the gas station.
Original FS Drawing		
Alternative Alignment Drawing		
Earthwork Quantities	•Retaining wall: 1,656 m	•Retaining wall: 1,300 m •Bridge: 100 m
Key Features	•Excessive cut volume due to bypass alignment around gas station. •Requires updated archaeological, resettlement, and environmental impact reviews (est. 5 months).	•Bridge option allowing installation over the gas station office. •Minimizes cut volume but requires new bridge structure. •Multi-span crossing unfeasible; pier installation required. •New archaeological, resettlement, and environmental surveys necessary.

☐ Following consultation with the ABC, the alternative alignment was dismissed due to the need for additional stakeholder negotiations with the gas station operator and the requirement for new structural elements. The baseline alignment was accordingly retained.

2. Road Design Standards

□ Both the Bolivian and Korean design standards are based on AASHTO criteria, resulting in negligible differences in applied design coefficients. The study reviewed the Manual de Diseño Geométrico (Bolivia), the Korean Road Structure and Facility Standards, and the AASHTO Policy on Geometric Design of Highways and Streets, and adopted the Bolivian design standards as most appropriate for local conditions.

Table 16. Geometric Design Standards Comparison

Criteria	Unit	Bolivia Manual for design	Korea STD.	AASHTO
Design Speed	km/h	80	80	80
Minimum Horizontal Curve Radius	m	250	250	280
Maximum Grade	%	6	4	4
Standard Cross Slope	%	2.0~2.5	2.0	2.0

□ The project corridor is an operational road classified as National Highway Class I (Autoruta), and this classification is retained for the widening project.

Table 17. Road Classification (ABC)

Classification	Design Speed (km/h)	Min. Number of Lanes
Expressway (AUTOPISTA)	120−100−80	4 lanes
National Road (Ⅰ. A) (AUTORUTA)	100−90−80	4 lanes
National Road (Ⅰ. B) (PRIMARIO)	100−90−80	2~4 lanes 2 lanes in one direction
Provincial Road (II) (COLECTOR)	80−70−60	2~4 lanes 2 lanes in one direction
Municipal Road (Ⅲ) (LOCAL)	70−60−50−40	2 lanes in one direction
Collector Road (DESARROLLO)	50−40−30	2 lanes in one direction

☐ The project section corresponds to Section 5 of the Rio Secco - Desaguadero road, and a speed of 80 km/h was applied considering connectivity with Sections 1 to 4. However, a design speed of 30 to 50 km/h was applied to village entrances and urban areas.

3. Cross-Section Configuration

☐ Standard cross-sections were established for rural and urban zones, in consultation with and as approved by the ABC, with the aim of minimizing conflicts with existing infrastructure and ensuring compatibility with the adjoining road network.

Figure 7. Standard cross-section: Rural mainline (Sta. 0+000-9+846)

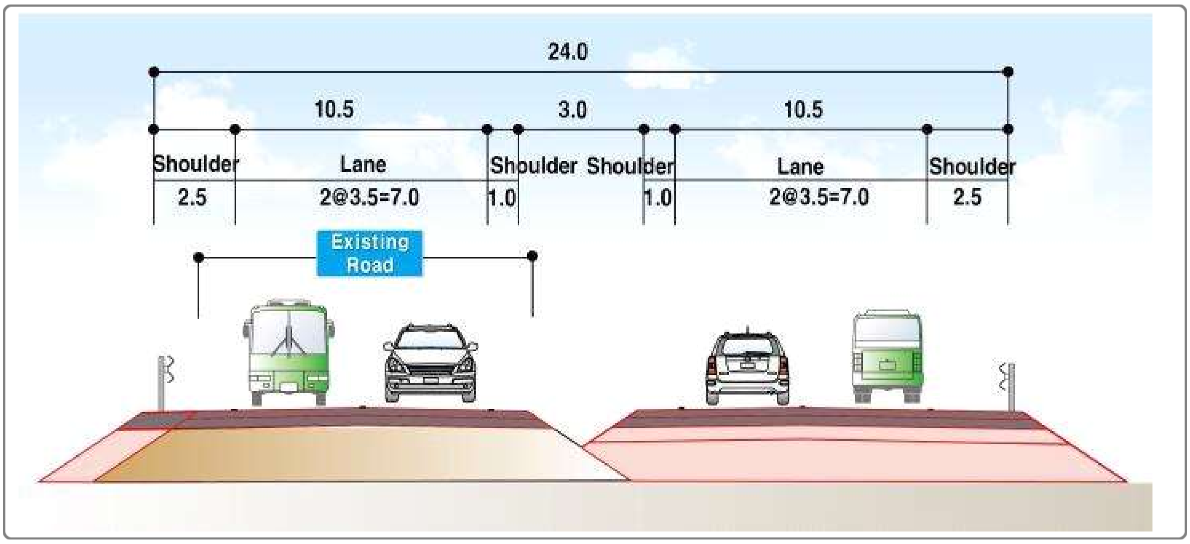


Figure 8. Standard cross−section: Urban (Sta. 9+846 -13+606, 14+256−16+600)

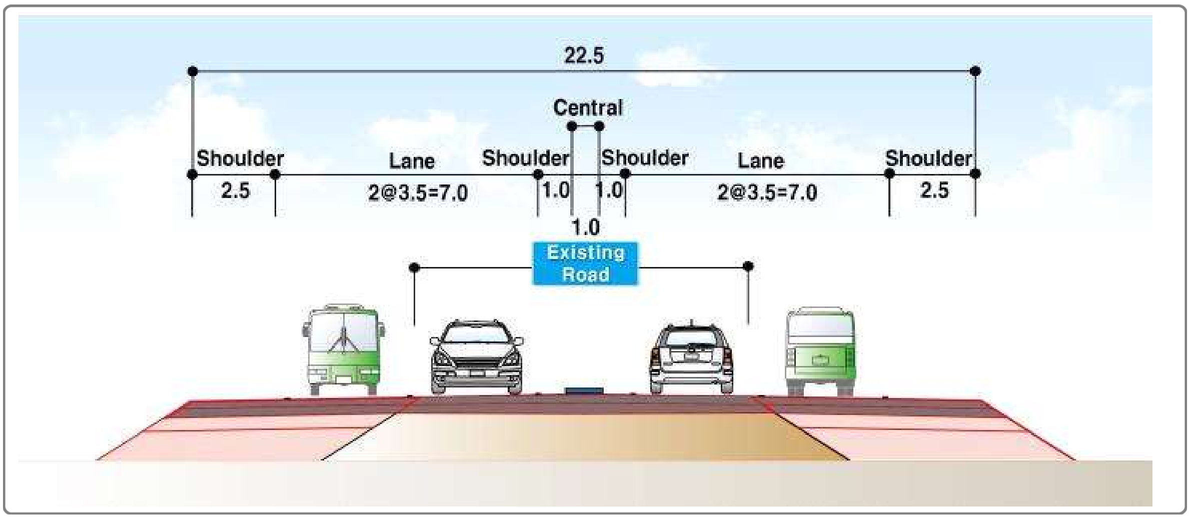


Figure 9. Standard cross−section: Urban Retaining Wall(Sta. 13+606−14+256)

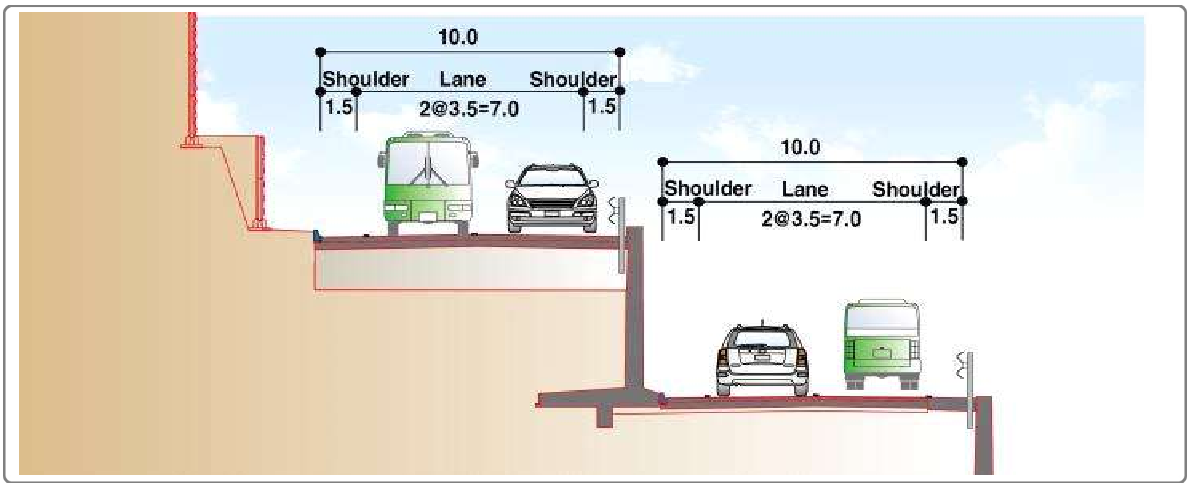
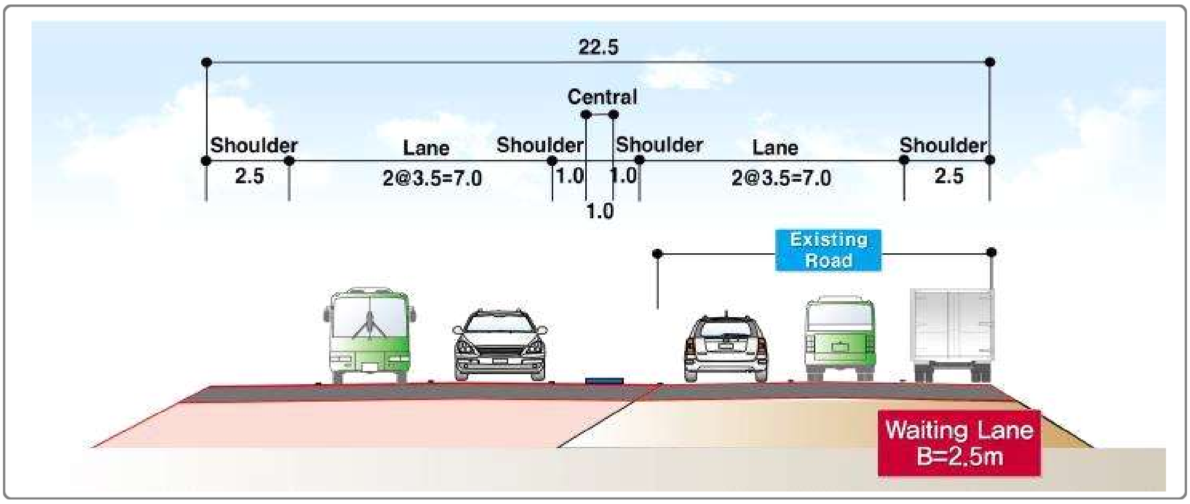


Figure 10. Endpoint section with truck waiting lane



4. Horizontal and Vertical Alignment

☐ Horizontal alignment was designed in compliance with geometric design standards while avoiding conflicts with existing structures. The total length with horizontal curve radius below R = 1,000 m is 1,614 m (9.7% of total length), occurring at village approaches and within urban zones where design speeds of 30-50 km/h apply.

Table 18. Horizontal Alignment Summary

Horizontal Alignment		Count	Length (m)	Ratio (%)
Radious	R＜1000	7	1,614	9.7
	1,000≤R＜3,000	6	1,299	7.8
	R≥3,000	3	1,338	8.1
	Subtotal	16	4,251	25.6
Straight		17	12,349	74.4
Total		33	16,600	100.0

☐ For the bypass section through Desaguadero city, an urban design speed of 30 km/h applies, permitting a maximum grade of 8%. A maximum grade of 7% was applied in selected segments to avoid conflict with the only church and the gas station in Desaguadero.

Table 19. Vertical Alignment Summary

Grade	Count	Length (m)	Ratio (%)
0.3%＜S	6	4,670	28.2
0.3%≤S＜1.0%	12	9,000	54.3
1.0%≤S＜2.0%	4	1,700	10.2
2.0%≤S＜3.0%	2	700	4.2
S≥3.0%	4	520	3.1
Total	28	16,600	100.0

5. Earthwork Design

☐ Surface geological surveys and laboratory testing were carried out for both the existing rock slope (SEC−1) and the newly created rock cut section (SEC−2) along the planned alignment.

☐ SEC−1 has the potential for wedge failure; additional protective measures must be evaluated during detailed design.

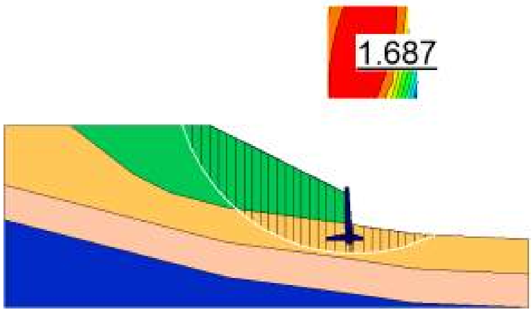
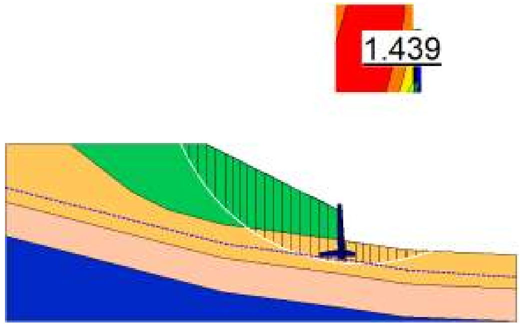
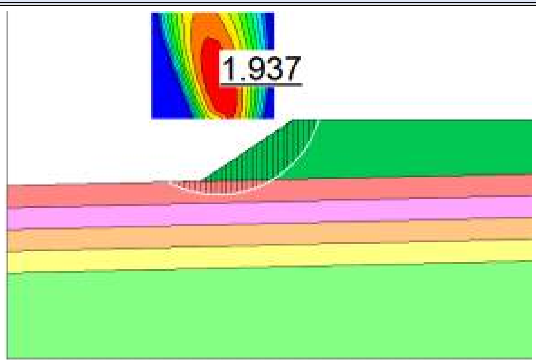
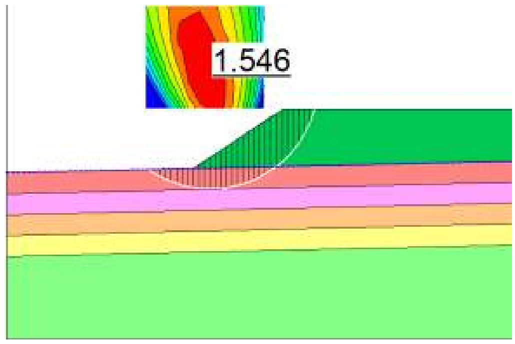
☐ SEC−2 was assessed to have no risk of planar, wedge, or toppling failure. However, given the cut slopes planned steeper than the maximum critical angle of 50°–60°, the large−scale cut extent, and the inherent limitations of surface geological surveys, additional slope stability assessments are required. It is recommended that supplementary investigations (boreholes, joint shear tests, borehole camera surveys, and laboratory testing) be carried out during detailed design to select reinforcement zones based on rigorous rock slope stability analysis, and to apply appropriate slope protection and reinforcement methods suited to local conditions.

Table 20. Large−Scale Cut Slope Characteristics

Zone	Location	Height(m)	Bench Width (m)	Inclination
SEC−1	11+806 ~ 12+506	Existing natural slope	−	1:1(45°)
SEC−2	13+686 ~ 13+776	10.0m ~ 42.0m	1.5(H=10.0m)	1:2(63°)

☐ Fill slope stability analysis was performed using the limit equilibrium method, with minimum safety factors per AASHTO: FS = 1.2 (static) and FS = 1.1 (seismic). Results confirm adequate stability.

Table 21. Stability Analysis Results

Retaining Wall Fill (Sta. 12+106)	
Static	Seismic
	
F.S = 1.687 > 1.2 ∴O.K	F.S = 1.439 > 1.1 ∴O.K
Terminal Fill (Sta. 14+296)	
Static	Seismic
	
F.S = 1.937 > 1.2 ∴O.K	F.S = 1.546 > 1.1 ∴O.K

☐ Based on geotechnical investigation results, cut material from the excavation zones is considered unsuitable as fill material; embankment fill must therefore be sourced from designated borrow areas.

Table 22. Earthwork Volume Summary

Category		Unit	Quantity
Earthwork Volume	Embankment (Fill)	m3	445,787
	Excavation (Cut)	m3	391,170
	Net Fill Required	m3	119,812

6. Drainage Design

☐ Rainfall intensity analysis was conducted using data from the San Juan Huancollo meteorological station, which provides the most climatically representative data for the project area in proximity to Lake Titicaca. The project area experiences a dry season from April through October and a wet season from November through March, during which the majority of precipitation is concentrated. Mean annual rainfall is 690 mm.

☐ The project alignment does not cross any major watercourses; accordingly, transverse drainage structures consist of drainage pipes and box culverts. A 50-year return period was applied for drainage pipes and a 100-year return period for box culverts.

Table 23. Drainage Structure Summary

Type		Count	Remarks
Drainage Pipe (D=1.2m)		8	Return period: 50 years
Box Culvert	1.5m × 1.5m	15	Return period: 100 years
	2.0m × 1.5m	2	
	4.0m × 2.0m	18	
계		43	

Table 24. Drainage Pipe Installation Plan

Location	Dimension	Length	Return Period (years)	Discharge (m3/s)	Outlet Velocity(m/s)
2+701	D=1.2m	33.0m	50	0.76	2.63
			100	1.3	2.99
4+805	D=1.2m	52.0m	50	0.68	2.25
			100	0.97	2.56
6+307	D=1.2m	29.0m	50	0.14	1.64
			100	0.26	1.96
6+676	D=1.2m	27.0m	50	0.45	2.27
			100	0.8	2.62
7+311	D=1.2m	27.0m	50	0.47	2.30
			100	0.82	2.64
7+435	D=1.2m	29.0m	50	1.72	3.18
			100	2.99	3.67
9+382	D=1.2m	29.0m	50	1.13	2.86
			100	1.97	3.28
10+059	D=1.2m	27.0m	50	0.28	2.00
			100	0.47	2.30

Table 25. Box Culvert Installation Plan

Location	Dimension	Length	Return Period (years)	Discharge (m3/s)	Outlet Velocity(m/s)
0+015	4.0m × 2.0m	48.0m	100	0.6	1.73
			150	0.85	1.94
0+493	4.0m × 2.0m	27.0m	100	0.7	1.81
			150	1.06	2.02
0+863	4.0m × 2.0m	29.0m	100	0.31	1.34
			150	0.47	1.59
1+269	4.0m × 2.0m	45.0m	100	1.96	2.56
			150	2.85	2.87
1+592	4.0m × 2.0m	31.0m	100	0.97	1.97
			150	1.37	2.23
2+179	4.0m × 2.0m	27.0m	100	0.16	1.16
			150	0.24	1.17
2+876	4.0m × 2.0m	28.0m	100	0.98	1.97
			150	1.39	2.23
3+226	1.5m × 1.5m	28.0m	100	0.33	1.89
			150	0.45	2.04
3+818	1.5m × 1.5m	28.0m	100	0.52	2.13
			150	0.75	2.41
4+087	4.0m × 2.0m	28.0m	100	0.19	1.18
			150	0.28	1.27
4+339	4.0m × 2.0m	29.0m	100	1.63	2.36
			150	2.36	2.66
5+078	4.0m × 2.0m	31.0m	100	0.89	1.98
			150	1.24	2.15
5+509	4.0m × 2.0m	29.0m	100	2.33	2.65
			150	3.31	2.94
5+832	1.5m × 1.5m	28.0m	100	0.12	1.33
			150	0.17	1.47
6+111	4.0m × 2.0m	30.0m	100	0.77	1.86
			150	1.09	2.05
7+967	1.5m × 1.5m	29.0m	100	1.1	2.70
			150	1.59	2.99
8+299	4.0m × 2.0m	45.0m	100	0.12	1.18
			150	0.17	1.18
8+489	1.5m × 1.5m	33.0m	100	0.05	0.96
			150	0.07	1.08
8+711	4.0m × 2.0m	29.0m	100	1.83	2.45
			150	2.56	2.73
9+844	4.0m × 2.0m	28.0m	100	0.08	1.18
			150	0.11	1.18
10+314	4.0m × 2.0m	42.0m	100	0.41	2.05
			150	0.56	2.36

Location	Dimension	Length	Return Period (years)	Discharge (m3/s)	Outlet Velocity(m/s)
10+854	1.5m × 1.5m	33.0m	100	0.29	2.69
			150	0.41	2.77
11+039	1.5m × 1.5m	27.0m	100	0.1	1.25
			150	0.14	1.40
11+358	1.5m × 1.5m	27.0m	100	0.13	1.37
			150	0.19	1.55
11+666	1.5m × 1.5m	26.0m	100	0.08	1.07
			150	0.11	1.22
12+292	1.5m × 1.5m	34.0m	100	0.01	0.96
			150	0.01	0.96
12+602	1.5m × 1.5m	34.0m	100	0.16	1.85
			150	0.21	2.01
12+988	2.0m × 1.5m	44.0m	100	0.18	1.40
			150	0.26	1.58
13+275	1.5m × 1.5m	33.0m	100	0.11	1.29
			150	0.16	1.45
14+278	1.5m × 1.5m	38.0m	100	0.08	1.16
			150	0.13	1.39
14+572	1.5m × 1.5m	37.0m	100	0.03	1.66
			150	0.06	1.66
14+639	4.0m × 2.0m	37.0m	100	0.03	1.67
			150	0.06	1.67
15+155	4.0m × 2.0m	34.0m	100	5.88	3.53
			150	8.14	3.85
16+028	1.5m × 1.5m	31.0m	100	0.05	0.96
			150	0.08	1.07
16+315	2.0m × 1.5m	49.0m	100	0.05	1.68
			150	0.07	1.68

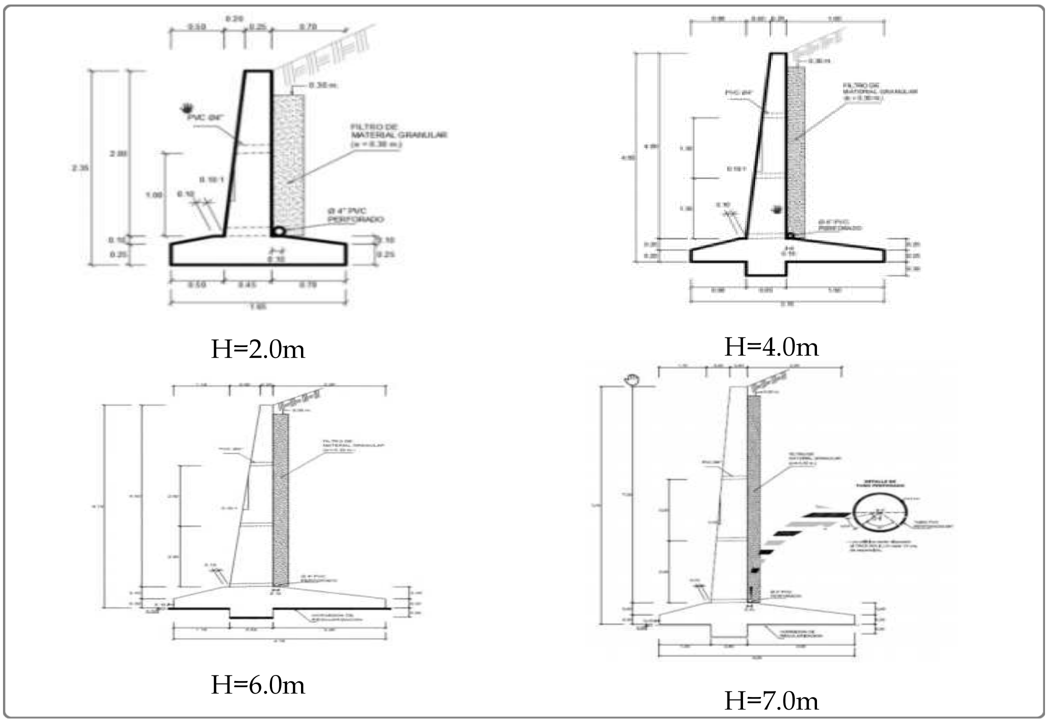
7. Retaining Wall Design

□ Reinforced concrete retaining wall types and representative cross-sections were established using the AASHTO Load and Resistance Factor Design (LRFD) methodology.

Table 26. Retaining Wall Plan by Location

Location	Height (m)	Length (m)	Type
10+473 ~ 10+559	3.0 ~ 6.0	86.0	Platform edge wall
10+791 ~ 10+871	3.5 ~ 6.0	80.0	Platform edge wall
11+579 ~ 11+788	4.5 ~ 5.5	209.0	Platform edge wall
12+000 ~ 12+200	4.0 ~ 6.0	200.0	Platform edge wall
12+200 ~ 12+270	2.5 ~ 6.0	70.0	Platform edge wall
12+438 ~ 12+689	2.0 ~ 6.0	251.0	Platform edge wall
13+790 ~ 14+170	2.5 ~ 7.0	380.0	Platform edge wall
13+790 ~ 14+170	2.5 ~ 7.0	380.0	Platform edge wall

Figure 11. Typical Cross-Section of Retaining Wall



8. Pavement Design

□ Presidential Decree No. 3845, promulgated on March 27, 2019, mandates that all road pavement constructed after the decree be executed using concrete pavement with domestically produced Bolivian cement.

□ Pavement thickness was determined in accordance with the AASHTO 93 Pavement Design Guide, employing a concrete pavement design method using subbase material with CBR > 80% and zero swell. Applying the design traffic loading and field CBR values, the following pavement cross-section was derived:

Table 27. Pavement Cross-Section

Layer	Unit	Thickness (cm)
Concrete Slab	cm	27.0
Subbase Course	cm	20.0
Subgrade Layer	cm	40.0

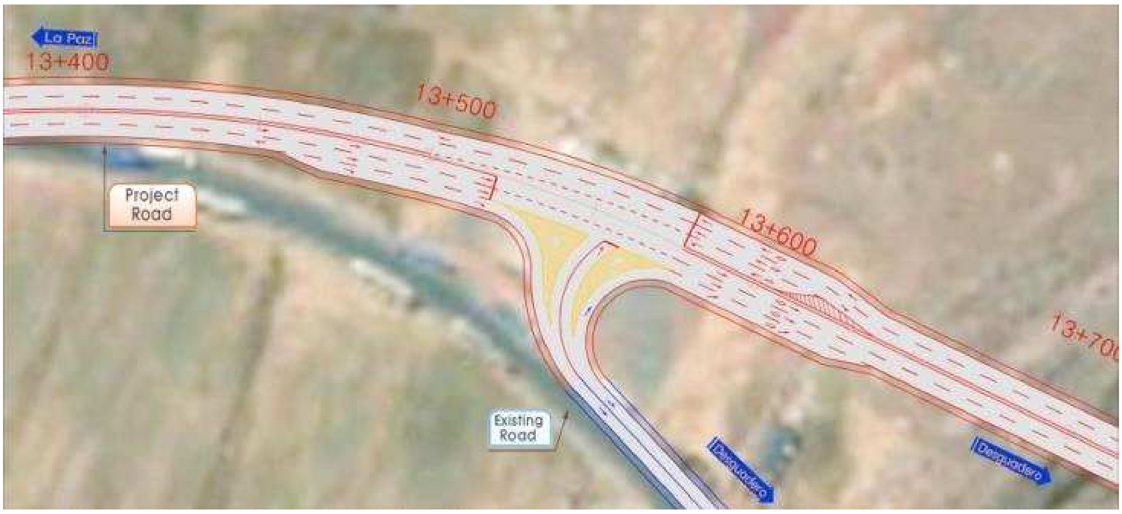
□ As Bolivia also applies finite element analysis (FEA) for pavement thickness determination in some cases, it is recommended that detailed design compare both the AASHTO 93 method and FEA to arrive at the optimal pavement thickness.

9. Intersection Design

□ Three-leg intersections are planned at the merge and diverge points of the bypass road.

□ New Intersection 1: Given frequent turning movements between the existing urban area and La Paz direction, a signalized intersection is recommended to reduce congestion and collision risks.

Figure 12. Intersection 1 Design



□ New Intersection 2: Traffic volumes entering and exiting the existing road are expected to be minimal; unsignalized intersection operation is therefore considered appropriate.

Figure 13. Intersection 2 Design

10. Ancillary Facilities Design

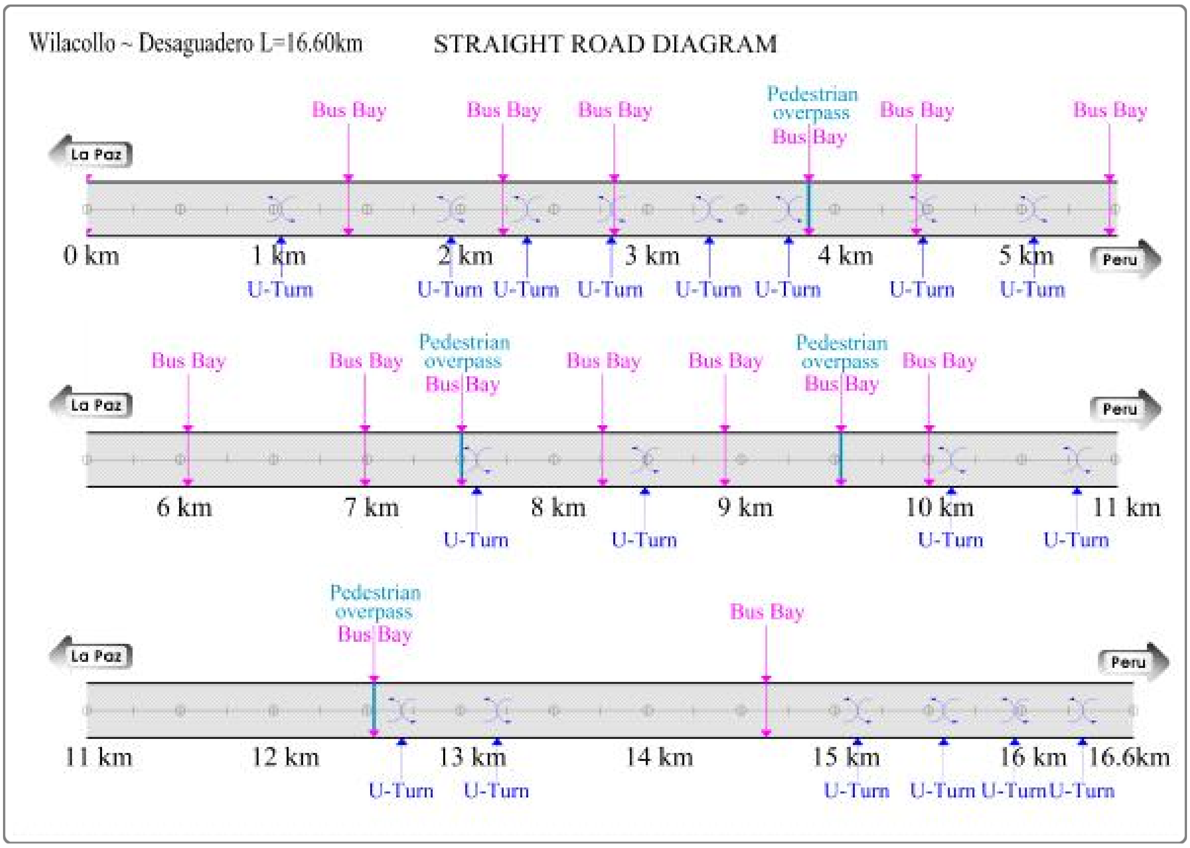
☐ The design of ancillary facilities references the Bolivian traffic control device standard (Manual de Dispositivo de Control de Transito, ABC 2007), design data from analogous neighboring projects, and Korean installation standards.

☐ U-turn Facilities: In accordance with the ABC design manual, U-turns are generally installed 400-600 m from intersections. Nine U-turn facilities are planned.

☐ Bus Stops: Thirty bus stop locations were planned, incorporating the Bolivian Road Administration's (ABC) stakeholder-consulted proposal.

☐ Pedestrian Overpasses: Four pedestrian overpass locations were planned, reflecting the ABC's stakeholder-consulted proposal.

Figure 14. U-turns, Bus-stops, Pedestrian Overpasses Plan



11. Weight−in−Motion (WIM) Review

☐ Vias Bolivia currently operates a weigh−in−motion (WIM) station on a dedicated WIM lane in Guaqui, approximately 10 km ahead of the project start point.

Figure 15. Axle Load Lane Operation Point and Current Status

☐ Based on freight traffic projections, a two−lane WIM station will be required after 2034.

Table 28. WIM Lane Requirements

WIM Lanes Required	1 lane	2 Lanes
Freight AADT Threshold (vehicles/day)	4,000	11,300

Source: Korea Expressway Corporation Guidelines

☐ Expanding the WIM facility to two lanes would increase installation and operating costs, add complexity to approach and departure vehicle movements, and raise the risk of traffic congestion and accidents at the WIM approach. It is therefore proposed to ABC that, concurrent with the future widening of Section 4 where the WIM station is located, a High−Speed WIM (HS−WIM) system be installed upstream of the existing WIM station.

VI. Economic and Financial Feasibility Analysis

1. Economic Feasibility Analysis

☐ Key assumptions: A social discount rate of 9% was applied in accordance with the EDCF Feasibility Study Preparation Guidelines (6th Revised Edition, March 2024). The base year is 2024, the opening year is 2029, the final target year is 2058, and the operating period is 30 years.

☐ Benefit items: Directly quantifiable benefits were identified as travel time savings, vehicle operating cost (VOC) savings, and traffic accident cost savings.

☐ Cost items: Construction costs, compensation costs, project overhead, and contingencies were included. Taxes, price contingencies, and loan handling fees were excluded from the economic analysis cost items.

☐ Analysis results: B/C ratio of 1.41, NPV > 0, and IRR of 11.4% — confirming economic viability.

☐ Sensitivity analysis: Economic viability was maintained under the following stress scenarios: 10% cost increase and 20% benefit decrease; 20% cost increase and 10% benefit decrease; and 30% cost increase only.

2. Financial Feasibility Analysis

☐ This project is a government-financed public infrastructure investment with no revenue-generating mechanism (e.g., tolls) on the project segment. A financial feasibility analysis is therefore not applicable and has been omitted.

VII. Environmental and Social Impact

1. Bolivian Environmental Impact Assessment Framework

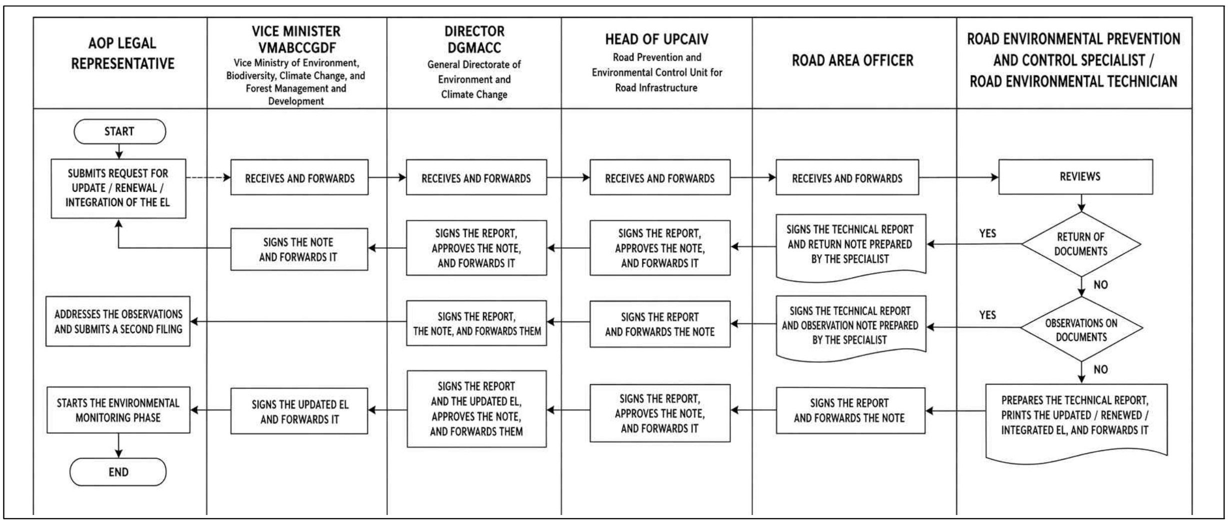
☐ The Environmental and Social Impact Assessment (ESIA) in Bolivia is governed by the Environmental Law (Ley de Medio Ambiente No. 1333, enacted April 1992) and the Environmental Control and Prevention Regulations (Reglamento de Control y Prevención Ambiental).

○ Category I and II projects require a full Environmental Impact Assessment (EIA). Category III projects require mitigation measures and monitoring plans. Category IV projects are exempt from EIA.

☐ The entire Rio Seco – Desaguadero corridor, which encompasses the project section, was classified as Category II in 2018, and an EIA was duly conducted. An environmental license (DIA No. 8471/2018) was issued and remains valid for 10 years.

☐ Since construction did not commence within two years of license issuance, the environmental license must be renewed during detailed design, in accordance with Article 90 of the Bolivian Environmental Law.

Figure 16. Environmental License Renewal Procedure



2. EDCF Environmental Assessment Classification

☐ The project — involving the widening of a 16.6 km road in the Wilacollo - Desaguadero corridor to four lanes — is classified as EDCF Category B+. An Environmental and Social Impact Assessment (ESIA) must be conducted prior to execution of the construction contract. The project is assessed to meet the conditions required for renewal of the environmental license under Bolivian regulations.

3. Mitigation Measures

☐ Mitigation measures for the construction phase include

Table 29. Mitigation Measures for the Construction Phase

Steps	Impact	Preventive or mitigating actions
Roads Construction	1. land cover and land use change	Restore sediment deposits
		Minimize the inclusion area
	2. reduced availability of public or private infrastructure	Run a loss prevention program
		Run social management programs
	3. inconvenience by social class and member	Run social management programs
	4. disruption of daily life for residents in the affected area	Execute and evaluate social management programs
	5. impact on areas of archaeological and cultural value	Run archaeology monitoring
		Suggestions for protecting archaeological heritage
	6. damage to vegetation cover	Re-record the inclusion area
		Minimize construction activity zones
	7. soil modification	Restore sediment deposits
		Re-record the inclusion area
	8. change soil composition	Re-record the inclusion area

Steps	Impact	Preventive or mitigating actions
Roads Construction	9. changes in surface water quality	Compliance with operational regulations, including construction sites and plant sites
		Establish a waste treatment system for construction sites
		Prohibit illegal dumping of waste
		Avoid construction equipment washing near streams
		Hazardous materials and waste storage away from streams
	10. Change the stream flow rate	Follow guidelines such as installing drainage, restoring damaged stream channels, etc.
	11. changes in vegetation	Restore damaged sections
		Re-record the inclusion area
	12. disturbance of specific species	Train workers on ecosystem conservation
	13. wild life and livestock incidents	Install road and environmental signage
	14. impairment of human health and public safety	Run social management programs
		Implement an occupational safety program
		Install construction signs
	15. community impact	Run social management programs
		Comply with construction codes and guidelines
	16. socio-cultural and tourism impacts	Implement tourism enhancement programs
	17. tree damage	Re-record the inclusion area
	18. wildlife Disturbance	Train workers on ecosystem conservation
		Prohibit hunting and fishing activities
		Restrict access to non-affiliated construction sites
	19. changes to aquatic, waterfront, and wetland ecosystems	Restrict construction activities in environmentally sensitive areas and unauthorized areas
		Adhere to guidelines

Steps	Impact	Preventive or mitigating actions
Roads Constr uction	20. soil contamination	Separate storage, fuel exchange, and refueling areas for construction equipment
		Oil spill prevention, cleanup, and disposal
		Set up and operate hazmat storage
		Implement a solid waste management program
	21. dusting	Designate aggregate transportation routes that exclude state rights of way
		Speed limits for transportation vehicles
		Vehicle and machine spraying, periodic cleaning
		Perform self-monitoring of dust emissions
	22. increased noise level	Periodic inspection of construction equipment and machinery
		Use noise protection (such as hearing protection)
		Schedule noise-generating processes
		Restrict the movement of construction equipment and machinery outside the construction area.
	23. combustion gas emissions	Perform self-monitoring of combustion gas emissions
	24. ground water impacts	Training for construction crews as needed
	25. violation of traditional life styles	Establish construction department work instructions
	26. transmission of pathogens, diseases	Establish and implement construction plans by construction type and stage
		Encourage local hiring
	27. job creation	Run social management programs
	28. stimulate the economy	Run social management programs
		Encourage local hiring

☐ Mitigation measures for operation phase are as follows.

Table 30. Mitigation Measures for the Operation Phase

Steps	Impact	Preventive or mitigating actions
Roads Operations	1. wildlife and livestock incidents 2. disturbance of animal habitat 3. disconnect animal paths	Setup animal trails
		Install environmental signage
	4. air pollution spread	Plant street trees
	5. increased noise level	Comply with municipal noise emission control regulations
		Plant street trees
	6.changesinsurfacewaterquality	Install environmental signage
	7. road safety 8. infrastructure damage	Implement road safety programs
		Install traffic control devices(speed control)
		Prevent drunk driving

☐ Mitigation measures for the long term are as follows.

Table 31. Mitigation Measures for the long term

Steps	Impact	Preventive or mitigating actions
long term	1. loss of vegetative cover 2. reducing wildlife habitat 3. habitat disturbance 4. habitat changes 5. aquatic ecosystems, wetland changes 6. land cover and land use change	Develop and implement a species diversity restoration and enhancement plan
	7. surface water quality degradation	Designing waste treatment and water restoration facilities
	8. increased noise level 9. increased combustion gas production	Implementation of air quality management and recording programs by local governments, etc.
	10. population change	Urban planning, including municipalities
	11. increased use of natural resources in the region	Comply with use control plans such as local governments

VIII. Other Considerations : Applicable Tax Regulations

☐ A key feature of the Bolivian tax system is that all tax rates are expressed as a percentage of the total invoiced price (i.e., taxes are included within the price).

☐ For Value Added Tax (VAT), the statutory rate is 13%, which corresponds to an effective tax rate of approximately 14.94% when applied on an exclusive basis.

Table 32. Applicable Tax Rates

Tax	Statutory Rate	Effective Rate
Value Added Tax (VAT — Impuesto al Valor Agregado, IVA)	13.0%	approx. 14.94%
Transaction Tax (IT — Impuesto a las Transacciones)	3.0%	approx. 3.09%
Corporate Income Tax (IUE — Impuesto sobre las Utilidades de las Empresas)	25.0%	approx. 33.33%