BINATIONAL SAN LUIS TRANSPORTATION STUDY

Working Paper No. 2

Draft Transportation Plan

January 2013

Prepared For:

ADOT

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1.0 INTRODUCTION

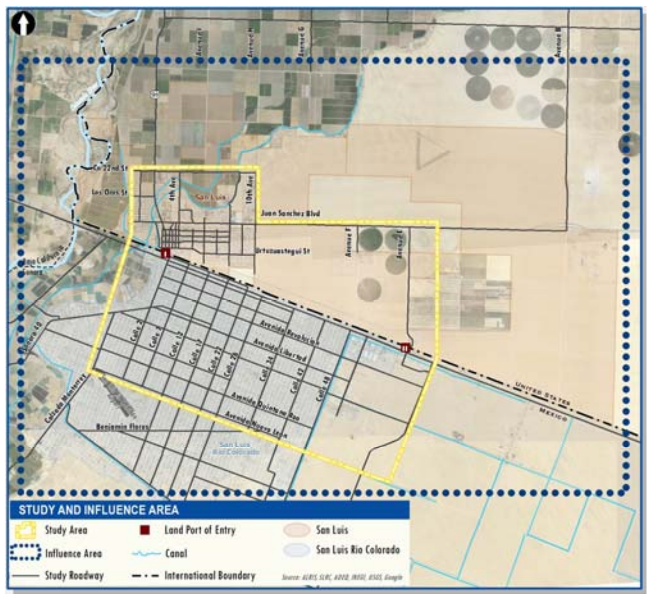
Purpose of the Study

The Binational San Luis Transportation Study is a joint effort by the City of San Luis, Municipal de San Luis Rio Colorado and the Arizona Department of Transportation (ADOT). The primary purpose of this study is to prepare a long-range multimodal transportation plan that will address the most critical current and future transportation issues for the cities of San Luis, Arizona and San Luis Rio Colorado, Sonora, Mexico. The study is being funded by the Federal Highway Administration's (FHWA) Coordinated Border Infrastructure (CBI) program and administered through ADOT's Office of International Affairs. Working Paper 2 consists of two reports - one for each of the two cities. The focus of this report is San Luis, Arizona.

Study Area Overview

Figure 1.1 displays the Binational study area boundary, which represents the limits of the transportation plan. Also, shown is the influence area which extends beyond the study area but has some impact on the study area transportation system by either daily use of the facilities or by proximity to the study area. Within the City of San Luis, regional access to the study area is provided by US 95 and SR 195. US 95, a major north-south thoroughfare, connects San Luis I LPOE and downtown San Luis with I-8 in the City of Yuma through the City of Somerton, while SR 195 provides a direct route from I-8 in the City of Yuma to San Luis II POE via Avenue E.

FIGURE 1.1 STUDY AND INFLUENCE AREA



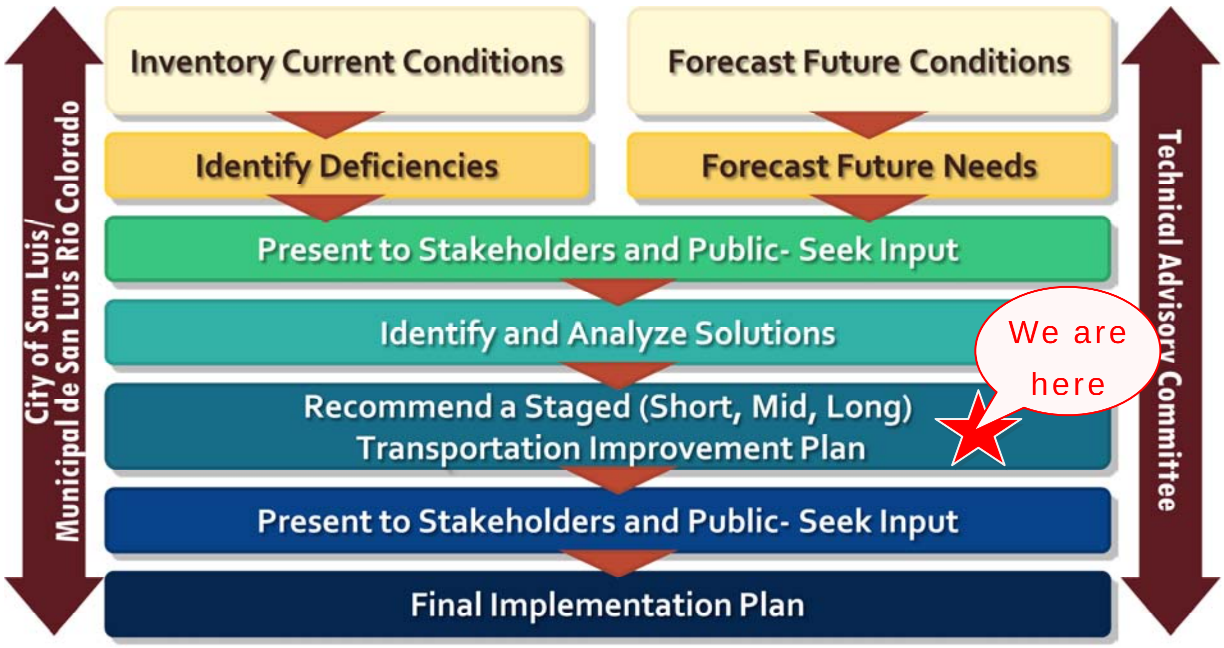
Study Process

Working Paper 1: Existing and Future Conditions inventoried and analyzed the existing and future conditions in the study area, including existing transportation system deficiencies, constraints, and needs. The first Public Open House was conducted in October 2012 to present existing and projected transportation conditions and issues.

This document, *Working Paper 2: Draft Transportation Plan*, will validate the recommended improvements included in the *San Luis Small Area Transportation Study* (*SATS*) and other regional studies, identify new improvements if necessary and prioritize accordingly in order to address the needs and deficiencies identified in Working Paper 1. The next step in the study is to present the transportation improvements to the public and seek input.

Figure 1.2 illustrates the process utilized to conduct this study

FIGURE 1.2: STUDY PROCESS



After presentation of the improvement plan to the public and resolution of their concerns, the study will prepare the final implementation plan.

2.0 EVALUATION OF ROADWAY IMPROVEMENTS

Population, Housing Unit, and Employment Forecasts

As outlined in *Working Paper 1: Existing and Future Conditions*, future population, housing units, and employment were forecasted for the horizon years 2018, 2030, and 2040. Future population estimates for the City of San Luis are based on the Arizona Department of Administration, Office of Employment and Population Statistics projections. However, the 2018 City population was adjusted to reflect a growth rate of 3.4 percent per year similar to the trend shown between 2010 and 2012. There is no forecasted data for housing units; it is assumed that the current population to occupied housing unit ratio will continue for future horizon years. Similar to the housing units, there is no known source for employment projections however through coordination with City Staff and utilizing the *City of San Luis 2020 General Plan* employment estimates were developed. In addition, it was assumed that the current employment to population ratio will remain relatively constant for all future horizon years. Table 2.1 shows a tabular summary of the projected socioeconomic data for each horizon year while Figures 2.1 and 2.2 display the study area population and employment densities for each of the horizon years respectively.

TABLE 2.1 PROJECTED POPULATION, HOUSING UNITS AND EMPLOYMENT

		2013	2018	2030	2040
Study Area	**Population**	**28,072**	**32,501**	**47,664**	**55,211**
	Occupied Housing Units	6,227	7,224	10,507	11,988
	Total Employment	5,385	6,268	8,403	9,022
City of San Luis	**Population**	**28,413**	**33,355**	**55,651**	**64,728**
	Occupied Housing Units	6,317	7,412	12,376	14,384
	Total Employment	6,141	7,142	10,038	12,574
YMPO Region	**Population**	**195,683**	**222,455**	**295,892**	**330,161**
	Occupied Housing Units	76,011	80,497	101,208	113,018
	Total Employment	71,208	86,739	111,353	124,271

Socioeconomic Data for Travel Demand Model

The YMPO travel demand model used to estimate the 2013 traffic volumes was utilized to forecast future traffic volumes for the horizon years (2018, 2030, and 2040) presented in this paper. Future socioeconomic data, as previously discussed, was disaggregated into the travel demand model's TAZs and allocated using the *City of San Luis 2020 General Plan*'s Land Use Plan as a guide. Furthermore, with help from the City Staff several locations were identified as potential employment and/or residential growth areas. Areas identified include corridors along Juan Sanchez Boulevard from US 95/Main Street to 10th Avenue; Avenue E from SR 195 to U.S.-Mexico Border; US 95/Main Street from County 22nd Street to south of County 19th Street and the area east of 10th Avenue from County 22nd Street to County 24th Street.

FIGURE 2.1: POPULATION DENSITY

Population per Square Mile

- No Population
- 1 - 3,000
- 3,001 - 6,000
- 6,001 - 9,000
- 9,001 - 13,000
- 13,001 - 18,000
- 18,001 and above

Source: U.S. Census 2010, ADOT, ALRIS, SLRC, ADEQ, INEGI, USGS, SL, Arizona Dept. of Administration Office of Employment and Population Statistics

FIGURE 2.2: EMPLOYMENT DENSITY

Employees per Square Mile

- No Employees
- 1 - 250
- 251 - 500
- 501 - 1,000
- 1,001 - 2,000
- 2,001 - 5,000
- 5,001 and above

Source: U.S. Census 2010, ADOT, ALRIS, SLRC, ADEQ, INEGI, USGS, SL, Arizona Dept. of Administration Office of Employment and Population Statistics

Status Update of Projects Identified in the Previous Plan

The *San Luis SATS* identified projects for the short-, mid-, and long-range time frames. Table 2.2 displays the status of the projects for each of the three timeframes. As discussed in *Working Paper 1* the downtown circulation improvements, Archibald Street and 1st Street one-way couplets, are anticipated to be completed by the 2013 base year. The *San Luis SATS* transportation plan was included as part of the *2010-2033 YMPO Regional Transportation Plan (RTP).* It should be noted that two construction projects, 9th Avenue and Avenue E from County 19th Street to SR 195, have since been modified per *YMPO RTP*. The construction of 10th Avenue has replaced 9th Avenue improvements while the ending terminus at County 19th Street for Avenue E improvements will now align to Avenue D.

TABLE 2.2: SAN LUIS SATS TRANSPORTATION PLAN PROJECT STATUS

Short-Term (Y2008 - Y2014)		Status
Roadway	County 22nd Street: construct 2-lanes from 9th Avenue to 10th Avenue	✔
	Conduct downtown circulation study	✔
	Conduct bi-national study for Southbound traffic on US 95	Study In-progress
	Conduct a parking structure location feasibility study	✘
Transit	Organize a transit advisory committee	✘
	Designate a city transportation coordinator	✘
	Implement transit oriented development policies	✘
Bicycle & Pedestrian	Improve side walks	✘
	Review and research bicycle users travel patterns	✘
Mid-Term (Y2015 - Y2019)		
Roadway	Juan Sanchez Boulevard: widen to 5-lanes from US 95 to 10th Avenue	Study In-progress
	New Roadway: construct 2-lanes from 8th Avenue to Avenue F	✘
	6th Avenue: construct 2 lanes from Union Street to County 22nd Street	✘
Transit	Develop a transportation demand management program	✘
	Review ridership on YCAT and request increase in service frequency	✘
Bicycle & Pedestrian	Study the feasibility to install bicycle lane on Main Street	✔
	Study feasibility of pedestrian signal crossing locations and devices	✘
	Study feasibility for bicycle and pedestrian amenities such as landscaping for shade	✘

✔ Completed ✘ Not Started

TABLE 2.2: SAN LUIS SATS TRANSPORTATION PLAN PROJECT STATUS (Continued)

Long-Term (2020-2030)		Status
Roadway	Juan Sanchez Boulevard: widen to 5-lanes from 10th Avenue to Avenue E	Study In-progress
	9th Avenue: construct 2-lanes from County 19th Street to SR 195	✘
	New Roadway: construct 2-lanes from 6th Avenue to Avenue E	✘
	Avenue E: widen to a 4-lanes parkway	✘
	Avenue E: construct 2-lanes from SR 195 to County 19th Street	✘
	County 22nd Street: construct 2-lanes from 10th Avenue to Avenue E½	✘
	Archibald Street & 1st Avenue: convert Archibald Street and 1st Avenue to one-way couplet from C Street to Urtuzuastegui Street	✔
Transit	Develop a transit center	✘
Bicycle & Pedestrian	Implement studies' findings	✘

✔ Completed ✘ Not Started

Potential Roadway Improvements for Short-Term Phase

Projected 2018 No-Build Traffic Conditions

Figure 2.3 displays the LOS for the year 2013 roadway network with projected 2018 socioeconomic conditions *if no roadway improvements are made (No-Build)*. This information was utilized to identify potential improvements needed to address the future travel demand for the short-term horizon. Major findings include:

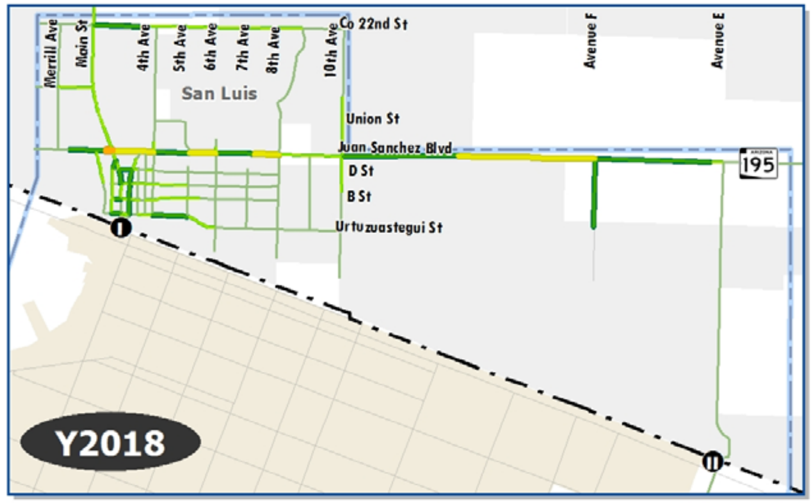


FIGURE 2.3: LEVEL OF SERVICE 2018 NO-BUILD

LOS A | LOS B | LOS C | LOS D | LOS E | LOS F

Source: ADOT, ALRIS, SLRC, ADEQ, INEGI, USGS, SL, YMPO

LOS E

- Juan Sanchez Boulevard: Mesa Street to US 95/Main Street

LOS D

- Juan Sanchez Boulevard: US 95/Main Street to 4th Avenue
- Juan Sanchez Boulevard: 5th Avenue to 6th Avenue
- Juan Sanchez Boulevard: 7th Avenue to 8th Avenue
- Juan Sanchez Boulevard: 0.9 mile east of 10th Avenue to Avenue F

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Potential Roadway Improvements

ADOT State Transportation Improvement Program (STIP) was reviewed to identify transportation projects scheduled for implementation. Using Table 2.2, potential improvement projects were identified to meet the traffic demand for the year 2018. Below is a list of potential capacity roadway improvements that were evaluated for the short-term phase while Figure 2.4 depicts the roadway number of lanes.

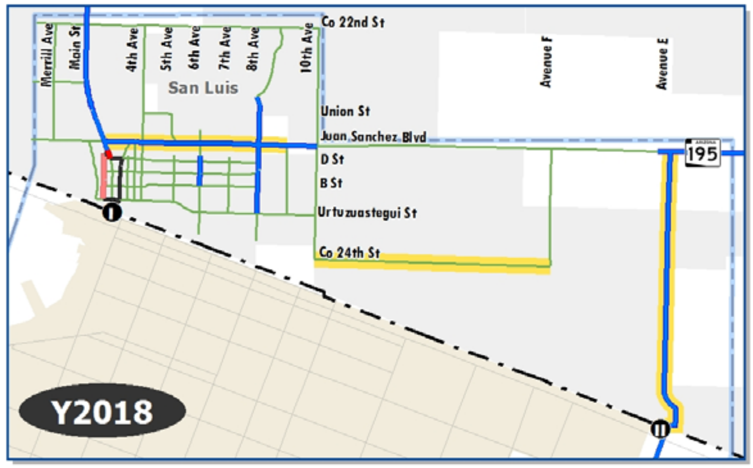

FIGURE 2.4: NUMBER OF LANES FOR SHORT-TERM PHASE

Capacity Related Roadway Improvements

New Roadways

- County 24th Street: 10th Avenue to Avenue F

Widening to four lanes

- Juan Sanchez Boulevard: US 95/Main Street to 9th Avenue
- Avenue E: SR 195 to U.S./Mexico Border

Roadway LOS

Figure 2.5 displays the projected 2018 traffic volumes with the roadway improvements and Figure 2.6 illustrates the corresponding LOS for the 2018 roadway network in the study area for the short-term phase. Traffic volumes and LOS results in this section represent average annual daily traffic conditions. All roads located within the study area operate at a LOS A and B, except for the following:

LOS E

- Juan Sanchez Boulevard: Merrill Avenue to US 95. This portion of roadway is the primary access to the San Luis Post Office. For all future horizon years, it was assumed that the postal service will not change from the current status.

LOS C

- Archibald Street: US 95/Main Street to north of D Street
- 1st Avenue: D Street to Urtuzuastegui Street
- Juan Sanchez Boulevard: east of Merrill Avenue
- Juan Sanchez Boulevard: US 95/Main Street to 6th Avenue
- Juan Sanchez Boulevard: 7th Avenue to 8th Avenue
- Juan Sanchez Boulevard: 10th Avenue to Avenue E
- D Street: US 95/Main Street to 1st Avenue
- Urtuzuastegui Street: Archibald Street to US 95/Main Street

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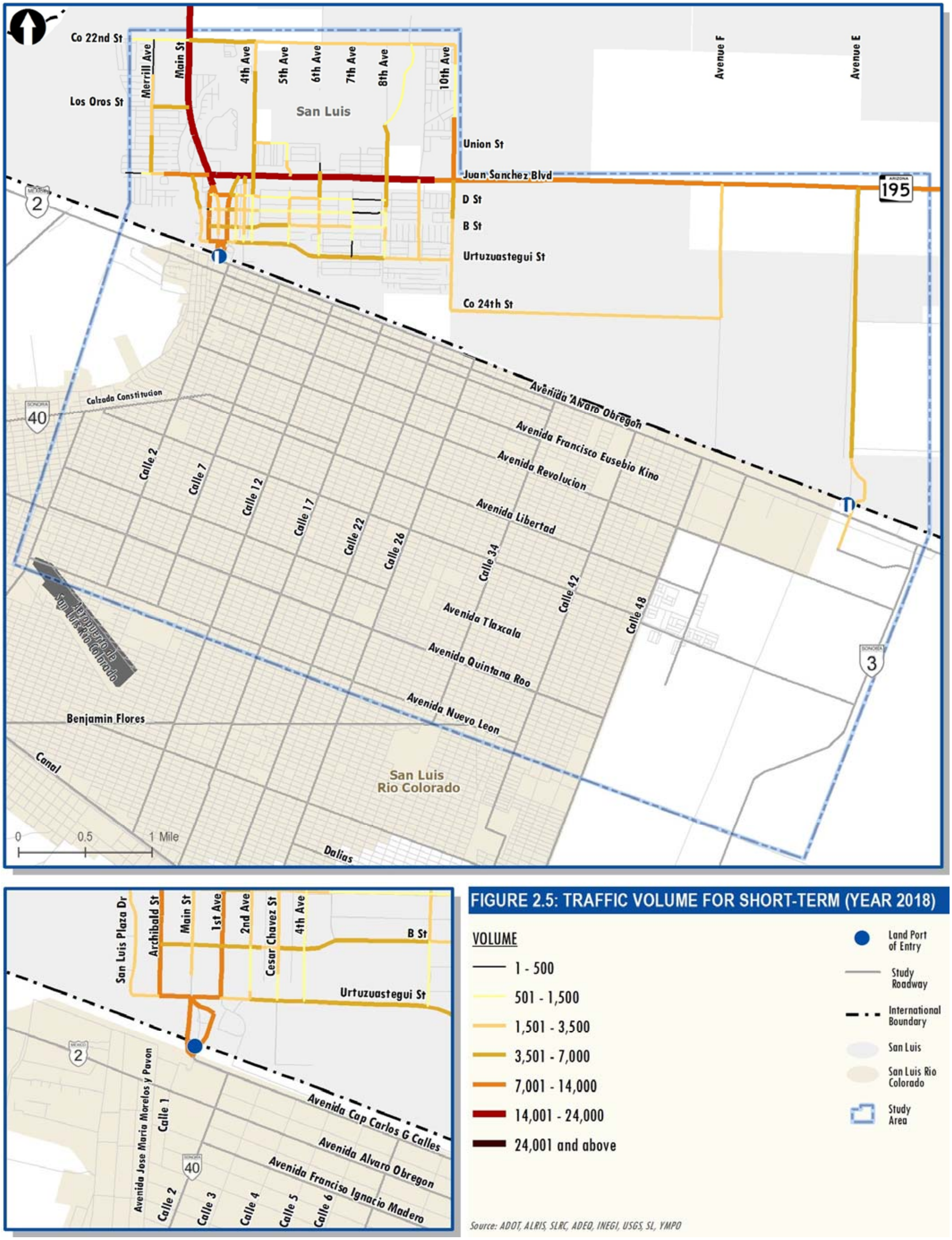

FIGURE 2.5: TRAFFIC VOLUME FOR SHORT-TERM (YEAR 2018)

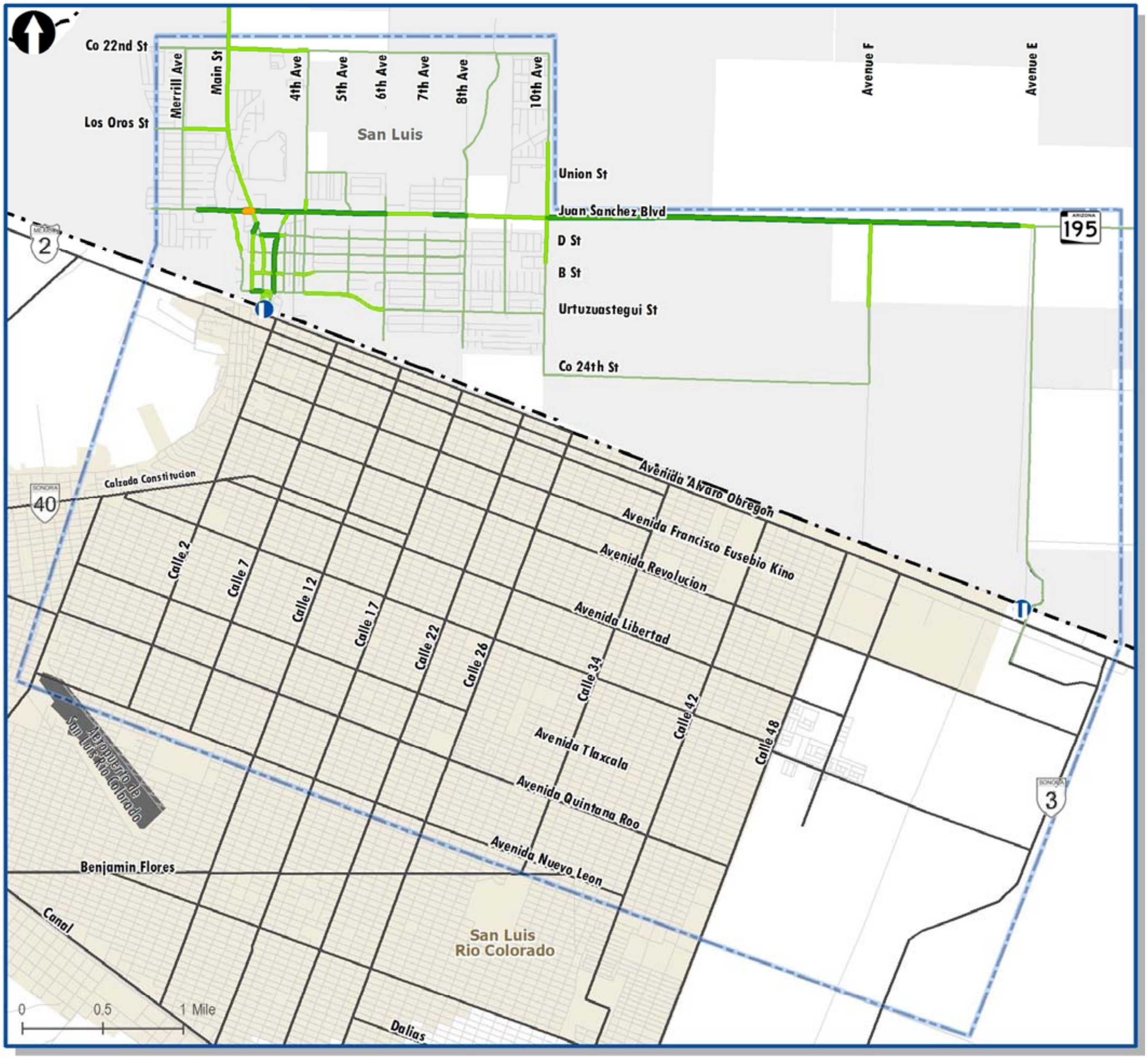

FIGURE 2.6: LEVEL OF SERVICE FOR SHORT-TERM (YEAR 2018)

Source: ADOT, ALRIS, SLRC, ADEQ, INEGI, USGS, SL, YMPO

Potential Roadway Improvements for Mid-Term Phase

Projected 2030 No-Build Traffic Conditions

Figure 2.7 displays the LOS for the year 2013 roadway network with projected 2030 socioeconomic conditions *if no roadway improvements are made (No-Build).* This information was utilized to identify potential improvements needed to address the future travel demand for the mid-term horizon. Major findings include:

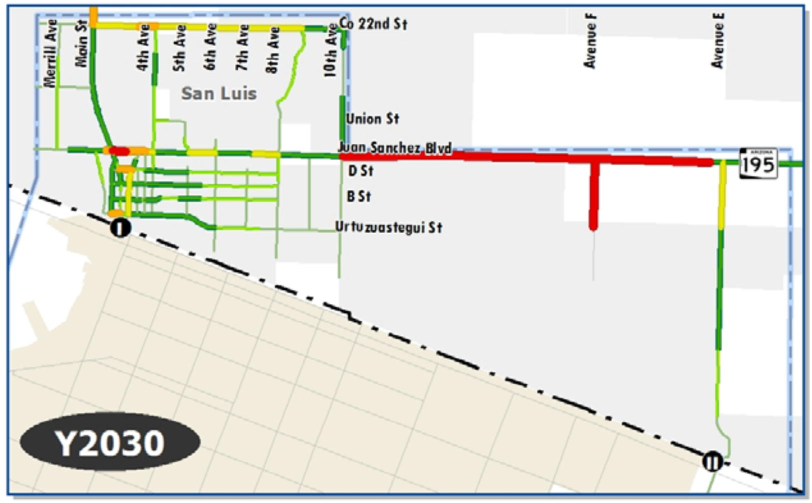

FIGURE 2.7: LEVEL OF SERVICE 2030 NO-BUILD

LOS A | LOS C | LOS E
LOS B | LOS D | LOS F

Source: ADOT, ALRIS, SLRC, ADEQ, INEGI, USGS, SL, YMPO

LOS F

- Juan Sanchez Boulevard: US 95/Main Street to Joe Orduno Memorial Park entrance
- Juan Sanchez Boulevard: 10th Avenue to SR 195 west of Avenue E
- Avenue F: south of Juan Sanchez Boulevard

LOS E

- County 22nd Street: Orgullo del Sol Apartment entrance to 4th Avenue
- Juan Sanchez Boulevard: Mesa Street to US 95/Main Street
- Juan Sanchez Boulevard: Joe Orduno Memorial Park entrance to Cesar Chavez Street
- US 95/Main Street north of County 22nd Street

LOS D

- County 22nd Street: Main Street to Orgullo del Sol Apartment entrance
- County 22nd Street : 4th Avenue to 8th Avenue
- Juan Sanchez Boulevard: Cesar Chavez Street to 4th Avenue
- Juan Sanchez Boulevard: 5th Avenue to 6th Avenue
- Juan Sanchez Boulevard: 7th Avenue to 8th Avenue
- Avenue E: Juan Sanchez Boulevard to 0.48 mile north of County 24th Street

Potential Roadway Improvements

As the study area reaches the mid-term phase, additional transportation improvements are required to meet the higher traffic demand resulting from the increase in population and employment. Below is a list of potential capacity roadway improvements that were evaluated for the mid-term phase. These transportation improvements are in addition to those identified in the short-term phase. Figure 2.8 depicts the roadway number of lanes for the mid-term phase.

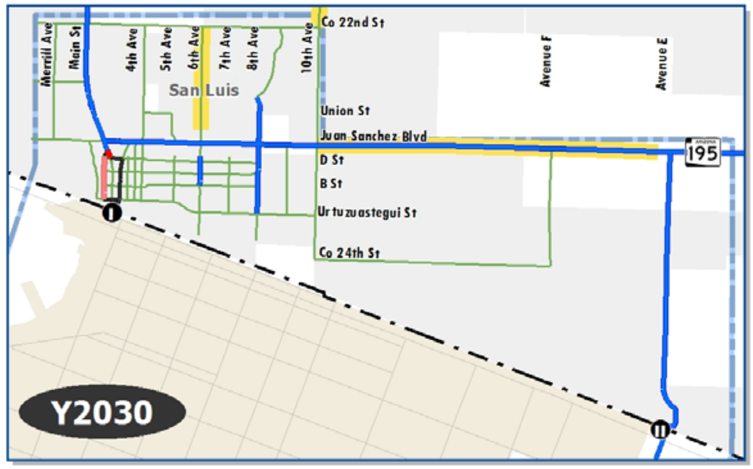

FIGURE 2.8: NUMBER OF LANES FOR MID-TERM PHASE

4-lanes · 3-lanes (one-way) · 2-lanes (one-way) · 3-lanes · 2-lanes · Improvements

Capacity Related Roadway Improvements

New Roadways

- 6th Avenue: County 22nd Street to California Street
- Avenue H: County 19th Street to County 22nd Street

Widening to four lanes

- Juan Sanchez Boulevard: 10th Avenue to SR 195 (just west of Avenue E)

Roadway LOS

Figure 2.9 displays the projected 2030 traffic volumes with the roadway improvements and Figure 2.10 illustrates the corresponding LOS for the 2030 roadway network in the study area for the mid-term phase. Traffic volumes and LOS results in this section represent average annual daily traffic conditions. All roads located within the study area operate at a LOS A and B, except for the following:

LOS F

- Juan Sanchez Boulevard: Merrill Avenue to US 95/Main Street. This portion of roadway is the primary access to the San Luis Post Office. For all future horizon years, it was assumed that the postal service will not change from the current status.

LOS E

- Urtuzuastegui Street: Archibald Street to US-95/Main Street

LOS D

- 1st Avenue: B Street to Urtuzuastegui Street
- 1st Avenue: C Street to north of B Street
- Avenue F: Juan Sanchez Boulevard to County 24th Street
- Juan Sanchez Boulevard: 7th Avenue to east of 9th Avenue
- Juan Sanchez Boulevard: 1.0 mile west of Avenue F to Avenue E

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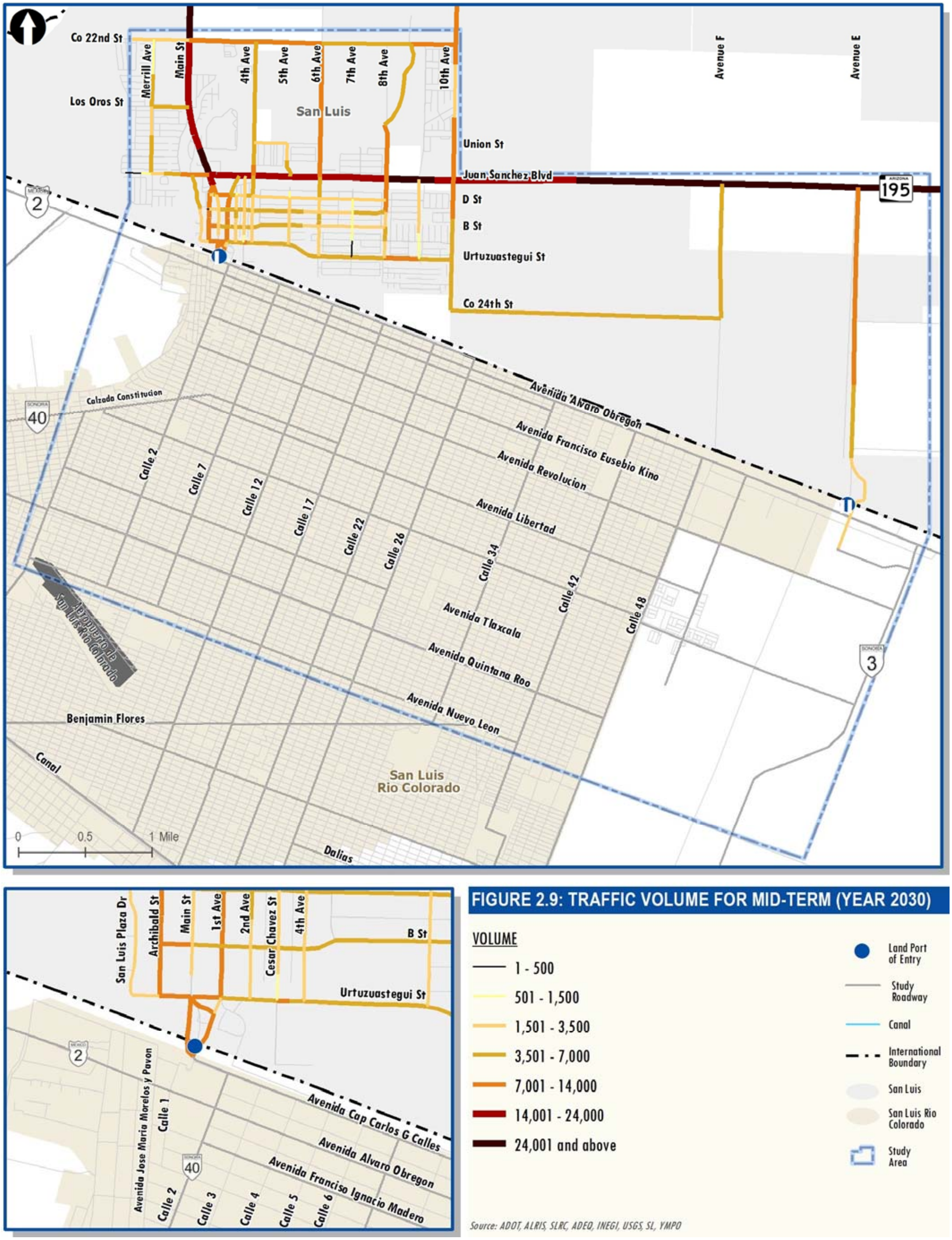

FIGURE 2.9: TRAFFIC VOLUME FOR MID-TERM (YEAR 2030)

Source: ADOT, ALRIS, SLRC, ADEQ, INEGI, USGS, SL, YMPO

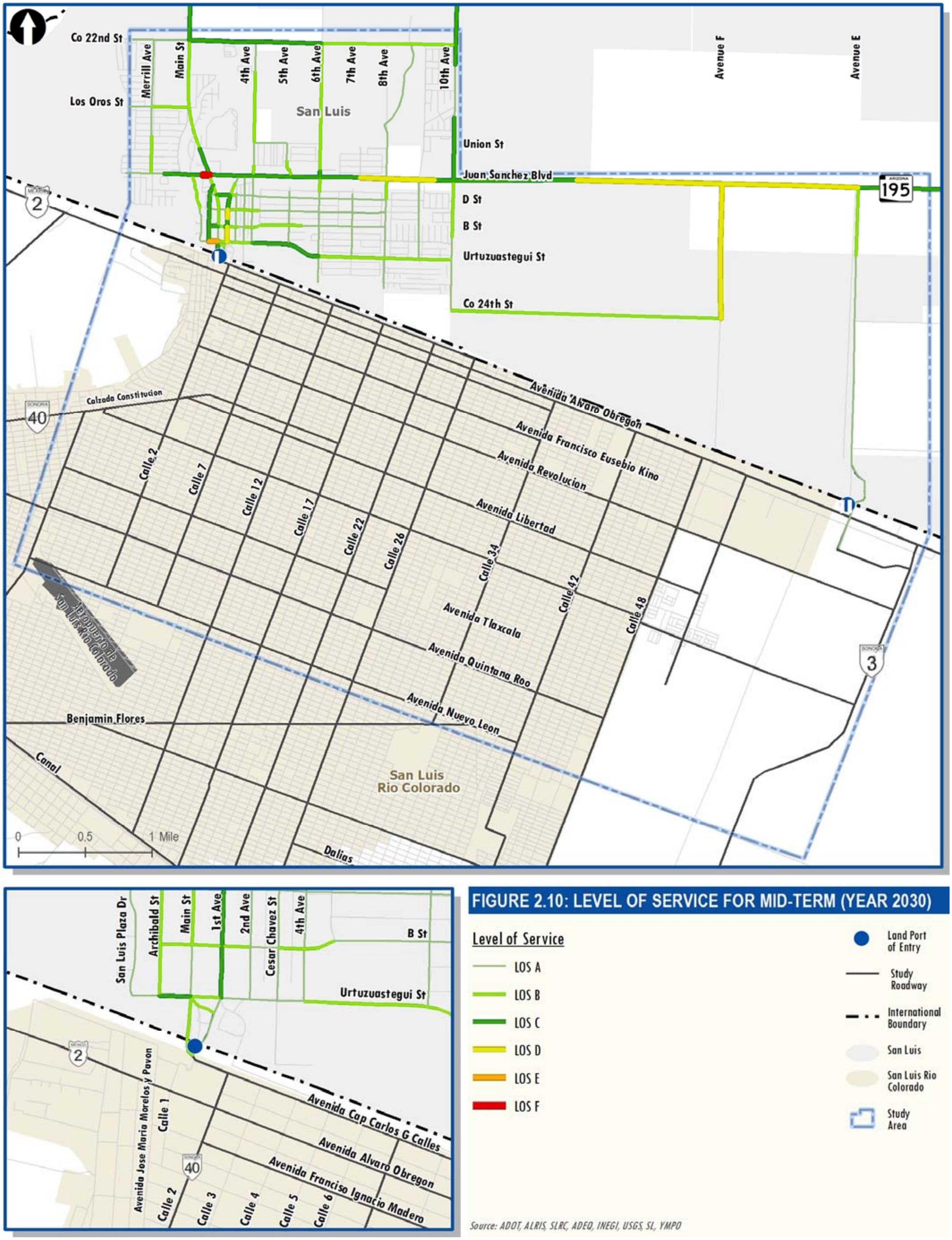

FIGURE 2.10: LEVEL OF SERVICE FOR MID-TERM (YEAR 2030)

Source: ADOT, ALRIS, SLRC, ADEQ, INEGI, USGS, SL, YMPO

LOS C

- Archibald Street: US 95/Main Street to north of D Street
- Archibald Street: D Street to Urtuzuastegui Street
- US 95/Main Street: northern study limits to County 22nd Street
- US 95/Main Street: south of Beach Street to Juan Sanchez Boulevard
- US 95/Main Street: Urtuzuastegui Street to LPOE I
- 1st Avenue: D Street to C Street
- 1st Avenue: south of C Street to B Street
- 6th Avenue: south of California Street to Juan Sanchez Boulevard
- 10th Avenue/Avenue H: northern study limits to south of County 22nd Street
- 10th Avenue: south of Black Street to Juan Sanchez Boulevard
- County 22nd Street: US 95/Main Street to 6th Avenue
- Juan Sanchez Boulevard: east of Merrill Avenue to Mesa Street
- Juan Sanchez Boulevard: US 95/Main Street to 7th Avenue
- Juan Sanchez Boulevard: west of 10th Avenue to 1.0 mile west of Avenue F
- SR 195: Avenue E to western study limits
- D Street: US 95/Main Street to 1st Avenue
- B Street: Archibald Street to US 95/Main Street
- B Street: east of US 95/Main Street to 1st Avenue
- Urtuzuastegui Street: 4th Avenue to 6th Avenue

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Potential Roadway Improvements for Long-Term Phase

Projected 2040 No-Build Traffic Conditions

Figure 2.11 displays the LOS for the year 2013 roadway network with projected 2040 socioeconomic conditions *if no roadway improvements are made (No-Build).* This information was utilized to identify potential improvements needed to address the future travel demand for the long-term horizon. Major findings include:

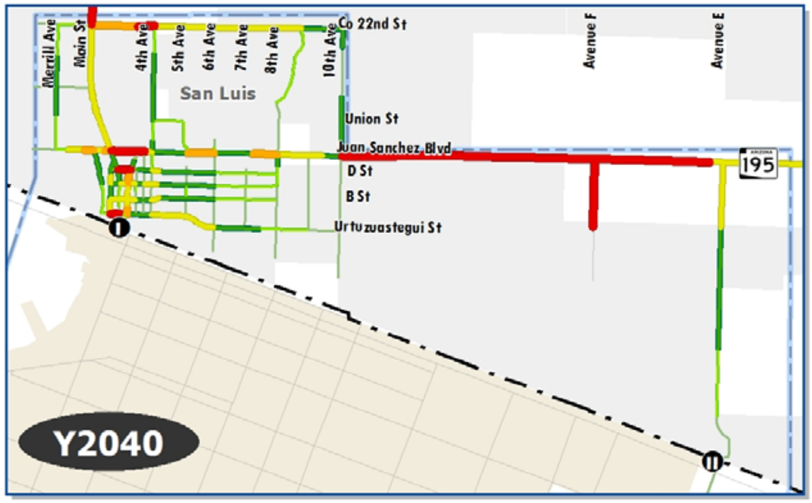

FIGURE 2.11: LEVEL OF SERVICE 2040 NO-BUILD

LOS A, LOS B, LOS C, LOS D, LOS E, LOS F

Source: ADOT, ALRIS, SLRC, ADEQ, INEGI, USGS, SL, YMPO

LOS F

- County 22nd Street: Orgullo del Sol Apartment entrance to 4th Avenue
- Juan Sanchez Boulevard: US 95/Main Street to Cesar Chavez Street
- Juan Sanchez Boulevard: 10th Avenue to SR 195 west of Avenue E
- Main Street north of County 22nd Street
- Avenue F: Juan Sanchez Boulevard to Los Olivos Drive

LOS E

- County 22nd Street:: US 95/Main Street to west of 4th Avenue
- Juan Sanchez Boulevard: Avenue J to San Luis Plaza Drive
- Juan Sanchez Boulevard: Mesa Street to US 95/Main Street
- Juan Sanchez Boulevard: 5th Avenue to 6th Avenue
- Juan Sanchez Boulevard: 7th Avenue to 8th Avenue

LOS D

- County 22nd Street: 4th Avenue to 8th Avenue
- Juan Sanchez Boulevard: Moctezuma Apartment entrance to Avenue J
- Juan Sanchez Boulevard: San Luis Plaza Drive to Mesa Street
- Juan Sanchez Boulevard: Cesar Chavez Street to 4th Avenue
- Juan Sanchez Boulevard: 8th Avenue to east of 9th Avenue
- SR 195 from east of Avenue E to study limits
- D Street: US95/Main Street to 1st Avenue
- D Street: 4th Avenue to 4th Drive
- C Street: US 95/Main Street to 2nd Avenue
- C Street: Cesar Chavez Street to 4th Drive
- B Street: Archibald Street to 2nd Avenue
- B Street: 4th Avenue to 4th Drive
- Urtuzuastegui Street: Archibald Street to I LPOE
- Urtuzuastegui Street: 4th Avenue to 6th Avenue
- US 95/Main Street from Juan Sanchez Boulevard to County 22nd Street
- Avenue E: Juan Sanchez Boulevard to 0.48 mile north of County 24th Street

Potential Roadway Improvements

As the study area reaches the long-term phase, further transportation improvements are required, in addition to those identified in the short- and mid-term phases, to meet the higher traffic demand resulting from the increase in population and employment. Below is a list of potential capacity roadway improvements that were evaluated for the long-term phase. Figure 2.12 depicts the roadway number of lanes for the long-phase.

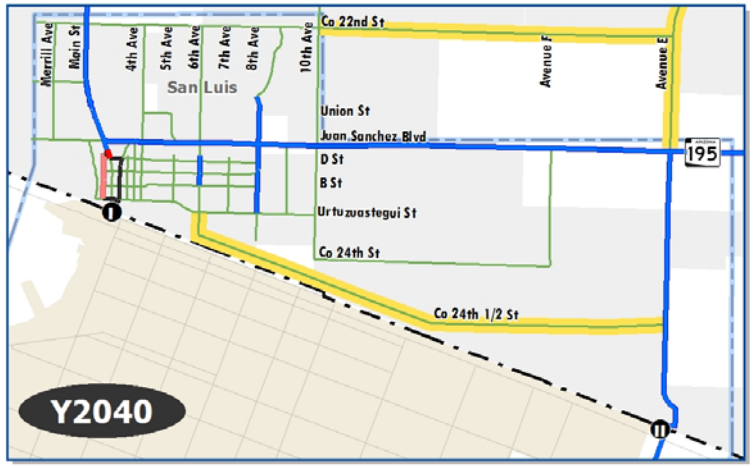

FIGURE 2.12: NUMBER OF LANES FOR LONG-TERM PHASE

4-lanes | 3-lanes (one-way) | 2-lanes (one-way)
3-lanes | 2-lanes | Improvements

Capacity Related Roadway Improvements

New Roadways

- County 22nd Street: 10th Avenue to Avenue E/Avenue D
- County 24th ½ Street: 6th Avenue to Avenue E
- Avenue E/Avenue D: County 19th Street to SR 195

Roadway LOS

Figure 2.13 displays the projected 2040 traffic volumes with the roadway improvements and Figure 2.14 illustrates the corresponding LOS for the 2040 roadway network in the study area for the long-term phase. Traffic volumes and LOS results in this section represent average annual daily traffic conditions. All roads located within the study area operate at a LOS A and B, except for the following:

LOS F

- Juan Sanchez Boulevard: Merrill Avenue to US 95/Main Street. This portion of roadway is the primary access to the San Luis Post Office. For all future horizon years, it was assumed that the postal service will not change from the current status.
- Urtuzuastegui Street: Archibald Street to US 95/Main Street

LOS D

- Archibald Street: B Street to Urtuzuastegui Street
- 1st Avenue: D Street to north of B Street
- 1st Avenue: B Street to Urtuzuastegui Street
- 10th Street: south of Black Street to north of Juan Sanchez Boulevard
- Avenue F: Juan Sanchez Boulevard to County 24th Street
- Avenue E: County 22nd Street to Juan Sanchez Boulevard
- County 22nd Street: 0.4 miles east of US 95/Main Street to 4th Avenue
- Juan Sanchez Boulevard: US 95/Main Street to west of 1st Avenue
- Juan Sanchez Boulevard: 7th Avenue to west of 10th Avenue

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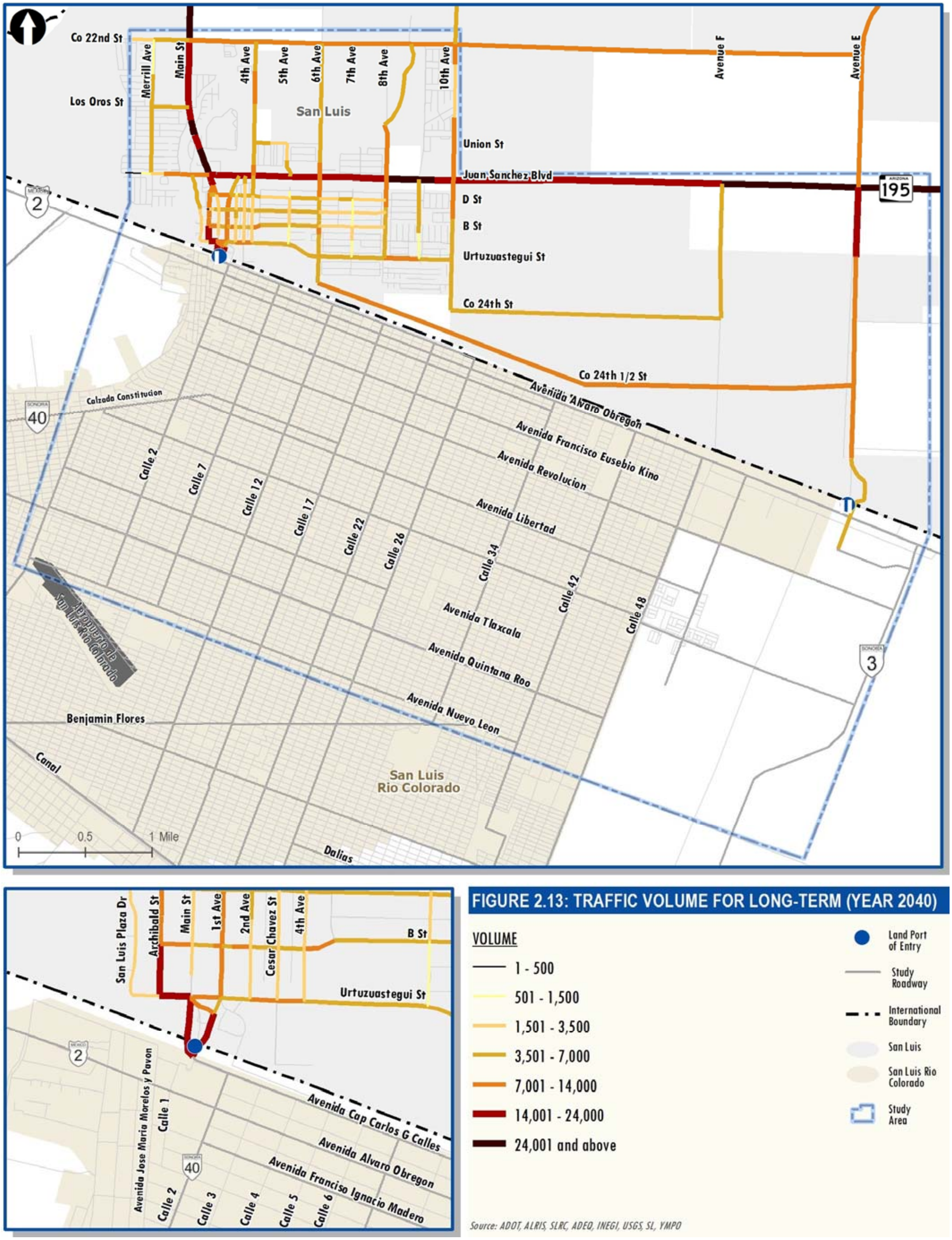

FIGURE 2.13: TRAFFIC VOLUME FOR LONG-TERM (YEAR 2040)

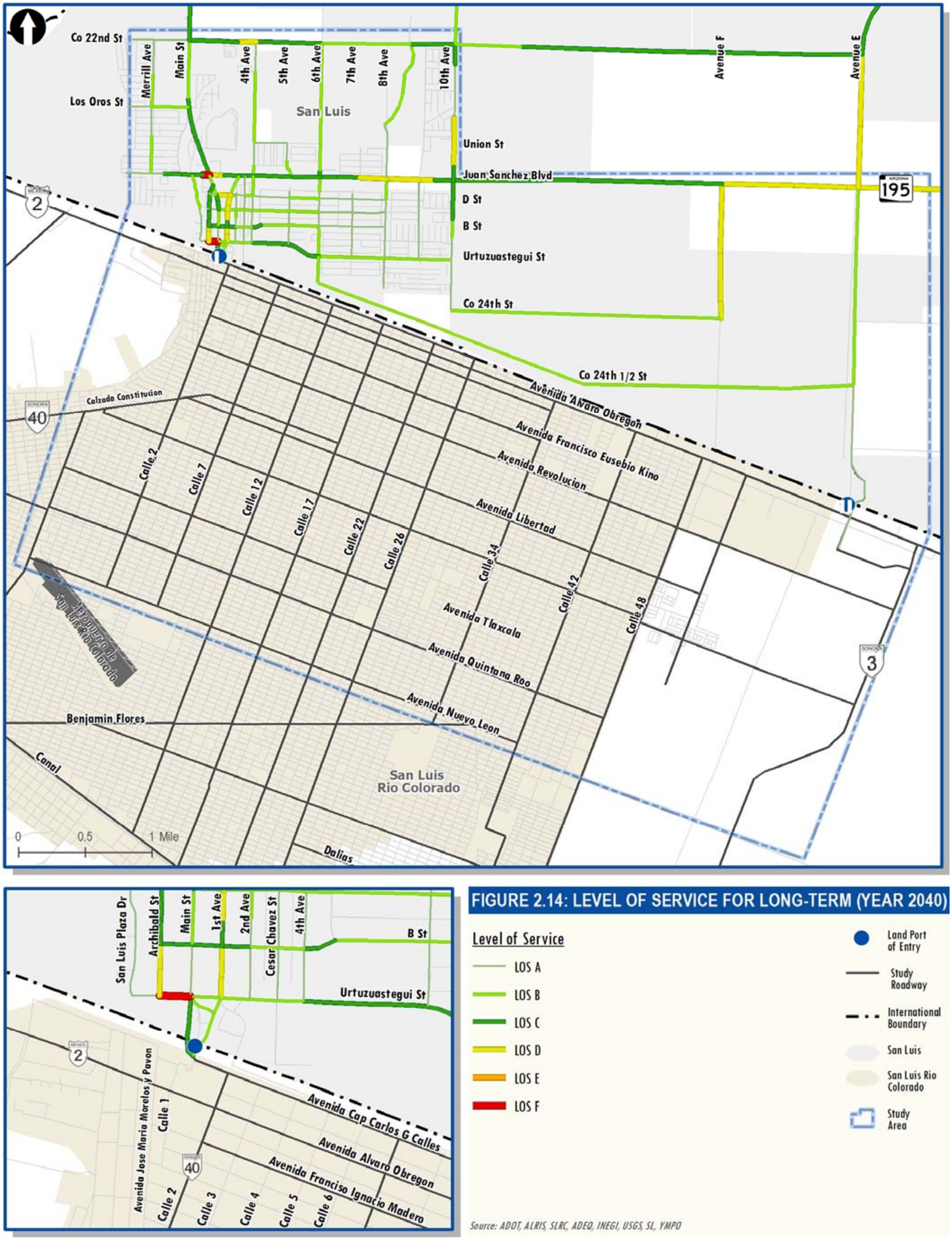

FIGURE 2.14: LEVEL OF SERVICE FOR LONG-TERM (YEAR 2040)

Source: ADOT, ALRIS, SLRC, ADEQ, INEGI, USGS, SL, YMPO

LOS D (continued)

- Juan Sanchez Boulevard: Avenue F to the eastern study limits
- D Street: US 95/Main Street to 1^{st} Avenue

LOS C

- Archibald Street: US 95/Main Street to north of D Street
- Archibald Street: D Street to B Street
- US 95/Main Street: D Street to C Street
- US 95/Main Street: Urtuzuastegui Street to LPOE I
- US 95/Main Street: north of Estibella Drive to Juan Sanchez Boulevard
- US 95/Main Street: northern study limits to County 22^{nd} Street
- 1^{st} Avenue: south of C Street to B Street
- 6^{th}Avenue: south of California Street to Juan Sanchez Boulevard
- 10^{th}Avenue: County 22^{nd} Street to south of Krystal Street
- 10^{th}Avenue: north of Juan Sanchez Boulevard to north of Fuentes
- Avenue E/Avenue D: north of County 22^{nd} Street
- County 22^{nd} Street: US 95/Main Street to west of 4^{th} Avenue
- County 22^{nd} Street: 4^{th} Avenue to 6^{th} Avenue
- County 22^{nd} Street: 8^{th}Avenue to 10^{th}Avenue
- County 22^{nd} Street: east of 10^{th} Avenue to Avenue E
- Juan Sanchez Boulevard: east of Merrill Avenue to Mesa Street
- Juan Sanchez Boulevard: west of 1^{st} Avenue to 7^{th} Avenue
- Juan Sanchez Boulevard: west of 10^{th} Avenue to Avenue F
- B Street from Archibald Street to 2^{nd}Avenue
- B Street: 4^{th} Avenue to 4^{th} Drive
- Urtuzuastegui Street: 4^{th} Avenue to 6^{th}Avenue

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3.0 EVALUATION OF TRANSIT AND NON-MOTORIZED MODES

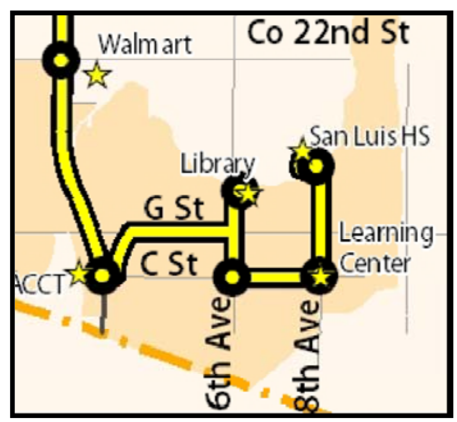
Transit

Formed in 2010, the Yuma County Intergovernmental Public Transit Authority (YCIPTA) administers, plans, operates, and maintains the public transit services, including YCAT, throughout Yuma County. The Yuma Regional Transit Study conducted in January 2012 identified specific transit needs in the region. An implementation plan for the YCIPTA was then developed for the regional transit system based on the three funding scenarios: the current funding sources and two proposed sales tax levies. Option 1 included a 1/10 cent county-wide sales tax, and Option 2 included a 1/5 cent county-wide sales tax.

Currently, the Yellow Route connects Yuma with Somerton and San Luis seven days a week from 6:30 AM to 7:22 PM at one-hour intervals. The current route follows US 95/Main Street and loops around 1st Avenue via C Street and Juan Sanchez Boulevard in the study area with stops including Wal-Mart, San Luis Community Center/Library, and the downtown area.

- At current funding sources the Yellow Route would remain the same as the existing route.
- With Option 1 the Yellow Route would expand to include local services in the City, with additional stops at the High School, Library, and AWC Learning Center. The route, as depicted in Figure 3.1, would initially follow the same streets as before, however at Juan Sanchez Boulevard the route would extend east to provide new service along 6th Avenue, C Street, and 8th Avenue. The Yellow Route would operate at 30-minute frequencies Monday through Sunday, starting at 6:00 AM to 10:17 PM during the weekdays with the last trip from San Luis at 9:04 PM. On the weekend, transit operations would start at 8:00 AM to 10:17 PM, with the last trip from San Luis at 9:04 PM.

FIGURE 3.1: YCAT YELLOW ROUTE IN SAN LUIS AT 1/10 CENT SALES TAX



- With Option 2 the Yellow Route would follow same route and operation times as in Option 1, however bus frequency would increase to 15-minutes headways.
- Option 2 also recommends a bus bay at US 95 and County 22nd Street in the vicinity of Wal-Mart.

As mentioned, two of the three scenarios are dependent on dedicated sales tax, which voters in the Yuma County will consider in November 2014 and potential implementation at the beginning of FY 2014/2015.

The *San Luis SATS* determined that the City should provide local transit services in order to meet the needs and demands of the ever growing transit dependent population within the study area. The transit projects listed in Table 2.2 of the preceding chapter were evaluated for their relevancy and prioritized accordingly. After further review, two additional recommendations were identified that would provide extended local service within the city. The first recommendation should evaluate

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potential circulator routes within the City to include current and future major activity centers east of the downtown area to 10th Avenue. The second recommendation would extend the route further east to include the city limits east of 10th Avenue where residential and employment growth are expected to occur per the *City of San Luis 2020 General Plan*.

Non-Motorized Modes of Transportation

Alternative modes of transportation such as sidewalks, bike paths/routes, and trails are an important aspect of the multimodal transportation network as they provide mobility for those not able to operate or without access to a vehicle and also for recreational purpose. Sidewalks currently exist in the downtown core providing access to certain activity centers such as the post office, and some stores located along Main Street. Beyond the downtown area, sidewalks are needed in the vicinity of schools and other activity centers. The City has very limited to no bike paths and bike lanes in both the downtown core and to major activity centers.

Needs Analysis

The City of San Luis existing sidewalks, bike lanes, and trails were reviewed in relation to:

- The location of activity centers such as schools, large retail establishments, libraries, hospitals, recreation activity centers, and;
- Existing and future roadway alignments.

Analyzing the study area's existing pedestrian and bicycle facilities helped to identify locations that would benefit from these amenities and that would be closely integrated with the area's roadway system. The pedestrian and bicycle improvements from Table 2.2 in the preceding chapter, are still needed to provide mobility, connectivity, and safety to the pedestrians and bicyclists in the study area. It is also recommended that pedestrian facilities be implemented along Juan Sanchez corridor to provide access to the major activity centers in the vicinity.

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4.0 DRAFT MULTIMODAL TRANSPORTATION PLAN

This section presents the draft Multimodal Transportation Plan for the short-, mid-, and long-term phases. This transportation plan is the result of the deficiency analysis from Working Paper 1, Public Open House Input, and Chapters 2- 3 of this report. It is a multimodal plan that includes roadway, transit, pedestrian, and bicycle improvements. Each project is assigned a unique project number that the City can use to track project progress. Unless otherwise noted, the recommended projects are not yet funded.

Roadway Recommendations

Estimated costs for each project are expressed in 2012 dollars and are general estimates. Actual costs for projects could vary at the time of implementation; therefore, a detailed analysis should be performed on a case-by-case basis to determine actual costs.

** The Project Identification Number (e.g.: ST -1) does NOT represent the priority of the project; rather it is an identification number to track project progress in the future.*

Short-Term Transportation Recommendations

Short-term phase projects are recommended to be completed as the study area reaches year 2018. Table 4.1 lists the transportation recommendations for this phase, as well as the project number*, location, description, and estimated costs for each project. Figure 4.1 displays the recommend roadway improvements for the three phases, the short-term improvements are displayed in green.

TABLE 4.1: SHORT-TERM ROADWAY RECOMMENDATIONS

ID*	Project Location and Project Description	Cost	Agency
ST-1	**Juan Sanchez Boulevard: US 95 to 9th Avenue** Widen to a four lane roadway (two lanes in each direction) with a center turn lane, and sidewalk on each side	$4,750,000	ADOT
ST-2	**County 24th Street: 10th Avenue to Avenue F** Construct a new two lane (one lane in each direction) collector road	$2,250,000	San Luis/ YMPO
ST-3	**Avenue E: SR 195 to San Luis LPOE II** Widen to a four lane roadway (two lanes in each direction)	$6,850,000	ADOT
ST-4	**Conduct a parking structure location feasibility study** Evaluate potential locations in the downtown area for a parking facility	$25,000	

Mid-Term Transportation Recommendations

Mid-term phase projects are recommended to be completed as the study area reaches year 2030. Table 4.2 lists the transportation recommendations for this phase, as well as the project number*, location, description, and estimated costs for each project. As illustrated in Figure 4.1, mid-term improvements are displayed in light brown.

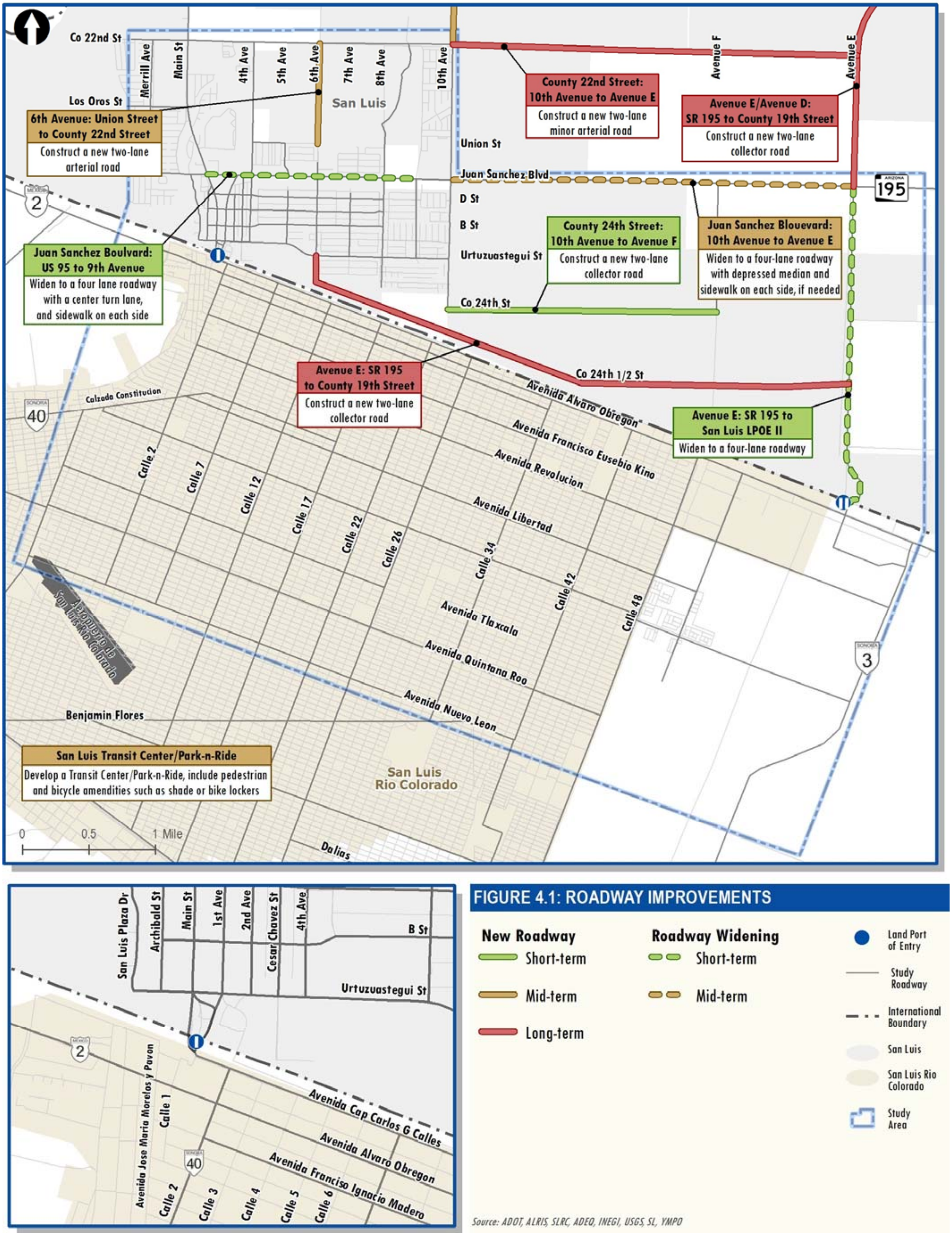

FIGURE 4.1: ROADWAY IMPROVEMENTS

TABLE 4.2 MID-TERM ROADWAY RECOMMENDATIONS

ID*	Project Location and Project Description	Cost	Agency
MT-1	**Juan Sanchez Boulevard: 10^{th} Avenue to Avenue E** Widen to a four lane roadway (two lanes in each direction), with depressed median and sidewalk on each side if needed	$8,100,000	ADOT
MT-2	**6^{th} Avenue: Union Street to County 22^{nd} Street** Construct a new two lane (one lane in each direction) arterial road	$1,100,000	San Luis/ YMPO
MT-3	**Avenue H: County 19^{th} Street to County 22^{nd} Street** Construct a new two lane (one lane in each direction) collector road	$3,650,000	YMPO

Long-Term Transportation Recommendations

Long-term phase projects are recommended to be completed as the study area reaches year 2040. Table 4.3 lists the transportation recommendations for this phase, as well as the project number*, location, description, and estimated costs for each project. As illustrated in Figure 4.1, long-term improvements are displayed in light red.

TABLE 4.3 LONG-TERM ROADWAY RECOMMENDATIONS

ID*	Project Location and Project Description	Cost	Agency
LT-1	**Avenue E/Avenue D: SR 195 to County 19^{th} Street** Construct a new two lane (one lane in each direction) collector road	$5,550,000	ADOT
LT-2	**County 22^{nd} Street: 10^{th} Avenue to Avenue E/Avenue D** Construct a new two lane (one lane in each direction) minor arterial road	$3,750,000	San Luis/ YMPO
LT-3	**County 24^{th} ½ Street: 6^{th} Avenue to Avenue E** Construct a new two lane (one lane in each direction) minor arterial road	$5,250,000	ADOT

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Transit Recommendations

Table 4.4 outlines the recommended short-, mid-, and long-term transit oriented improvements, as well as the project number*, location, description, and estimated costs for each project.

TABLE 4.4 RECOMMENDED TRANSIT IMPROVEMENTS

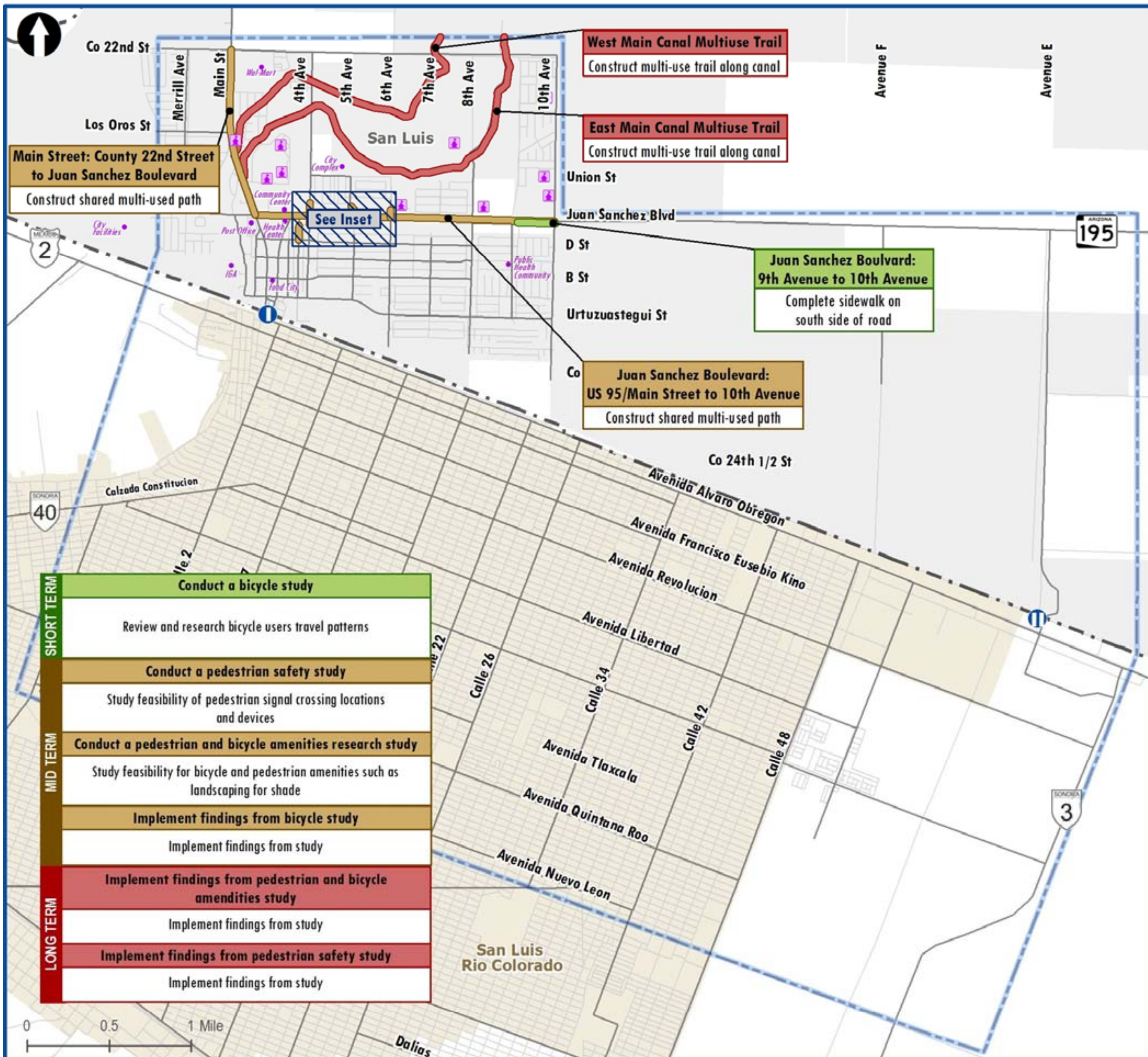
ID*	Item	Project Description	Cost
Short-Term (2013 - 2018)			
ST-5	**Organize a transit advisory committee**	Organize a transit advisory committee	N/A
ST-6	**Designate a city transportation coordinator**	Designate a city transportation coordinator	N/A
ST-7	**Develop transit oriented development policies**	Develop a transit oriented development policies	$25,000
ST-8	**Develop a transportation demand management program**	Develop a transportation demand management program	$45,000
ST-9	**Review ridership on YCAT**	Request increase in service frequency if needed	N/A
Mid-Term (2019 - 2030)			
MT-4	**Develop circulator routes**	Evaluate potential circulator routes, include major activity centers east of the downtown area	$25,000
MT-5	**Develop a San Luis Transit Center**	Develop a Transit Center that includes a park-n-ride facility as well as pedestrian and bicycle amenities such as shade or bike lockers	$2,750,000
Long-Term (2030 - 2040)			
LT-4	**Extend circulator service**	Extend circulator route to include area east of 10th Avenue	TBD

Pedestrians and Bicycles Facilities Recommendations

Table 4.5 lists the pedestrian, bicycle, and trail facility improvements recommended for the short-, mid-, and long-term phases, as well as the project number*, location, description, and estimated costs for each project. Figure 4.2 displays the recommended pedestrian, bicycle, and trail facility improvements for the three phases.

TABLE 4.5 RECOMMENDED PEDESTRIAN, BICYCLE, AND TRAILS FACILITIES IMPROVEMENTS

ID*	Project Location and Project Description	Cost	Agency
Short-Term (2013 - 2018)			
ST-10	**Juan Sanchez Boulevard: 9th Avenue to 10th Avenue** Complete sidewalk on south side of road	$50,000	ADOT
ST-11	**Conduct a bicycle study** Review and research bicycle users travel patterns	$35,000	
Mid-Term (2019 - 2030)			
MT-6	**Main Street: County 22nd Street to Juan Sanchez Boulevard** Construct shared multi-use path	$175,000	
MT-7	**Juan Sanchez Boulevard: US 95/Main Street to 10th Avenue** Construct shared multi-use path	$325,000	
MT-8	**Cesar Chavez Street: Juan Sanchez Boulevard to E Street** Complete sidewalk on both sides of road	$10,000	San Luis
MT-9	**4th Avenue: Arizona Street to E Street** Complete sidewalk on both sides of road	$52,000	San Luis
MT-10	**5th Avenue: south of Arizona Street to Juan Sanchez Boulevard** Complete sidewalk on both sides of road	$40,000	San Luis
MT-11	**6th Avenue: Arizona Street to Juan Sanchez Boulevard** Complete sidewalk on west side of road	$20,000	San Luis
MT-12	**Conduct a pedestrian and bicycle amenities research study** Study feasibility for bicycle and pedestrian amenities such as landscaping for shade	$45,000	
MT-13	**Conduct a pedestrian safety study** Study feasibility for pedestrian signal locations and devices	$30,000	
MT-14	**Implement findings from bicycle study**	TBD	
Long-Term (2030 - 2040)			
LT-5	**East Main Canal Multiuse Trail** Construct multi-use trail along canal	$475,000	
LT-6	**West Main Canal Multiuse Trail** Construct multi-use trail along canal	$360,000	
LT-7	**Implement findings from pedestrian and bicycle amenities study**	TBD	
LT-8	**Implement findings from pedestrian safety study**	TBD	



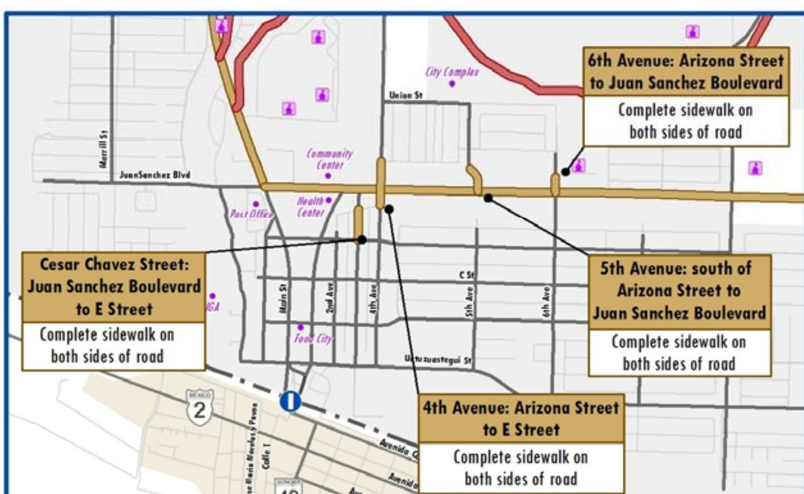
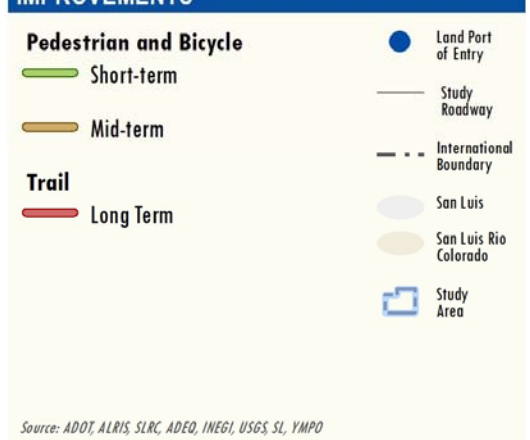


FIGURE 4.2: PEDESTRIAN, BICYCLE, AND TRAIL IMPROVEMENTS



APPENDIX A

SAN LUIS I LPOE, AZ SYSTEM CONDITIONS

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INTRODUCTION

This report documents the activities and analyses performed during the second phase of Arizona Department of Transportation's Binational San Luis Transportation Study. The main objective of the project is the creation of a transportation plan for San Luis, AZ and San Luis Rio Colorado, Mexico. The activities discussed in this document are specific to the analysis of the San Luis I Land Port of Entry (LPOE) as a system where users queue to be served by the inspection process. In the previous phase, the analysis evaluation was started for the current system conditions and it will be completed in this document. Additionally, this document discusses the expected traffic forecast by mode and the corresponding impacts at the LPOE.

The first step of this task was to complete the analyses of the current conditions, by examining the crossing volumes at the San Luis I LPOE, AZ. Fiscal Year 2010 (FY 2010) data provided by Customs and Border Protection (CBP) for the Privately Owned Vehicles (POV) and pedestrians was utilized to assess the high congestion rates at the port. Vehicular and pedestrian traffic volume information was dissected and analyzed on a monthly, weekly and hourly basis in order to identify their different behaviors throughout the various time periods.

Once the crossing volumes were analyzed and segmented following the different observed behaviors, analytical models were used to describe the queuing system as a function of different factors. These factors include arrival patterns, service patterns and system capacity. To simplify the analysis, the LPOE queuing system is assumed to be stable and to follow a single queue-multiple servers model protocol. This means that a single POV/pedestrian arrives at a certain rate to the queue waits a specific period of time and then it's set for inspection by one of the multiple servers available at the LPOE.

During the analysis some impacts are defined for the POV and pedestrian mode. These impacts are determined from the result of the queue length and waiting times observed by the customers and are defined in different schemas. From the POV queues, economic and environmental issues are identified from the idling vehicles in line to potential issues related to the region's traffic congestion. On the other hand, the effect of the queuing for the pedestrian mode was measured with a Level of Server (LOS) defined by the Transportation Research Board of the National Academies, along with other issues such as safety and changes in demand.

The current conditions analysis and the historical LPOE information were used to develop traffic volume forecast models by mode. These models are based on the external factors (potential drivers) identified in Working Paper 1 and additional statistical and probabilistic forecasting tools. The objective is to have a valid and defensible procedure to help determine the expected future traffic volumes through the LPOE in the short, mid and long term. In the last part of this study phase, the predicted volumes for these time frames are tested in the same queuing models. These tests will help establish the future conditions of the LPOE as a relationship of future demands and capacity.

1. CROSSING VOLUMES DETAILED ANALYSIS

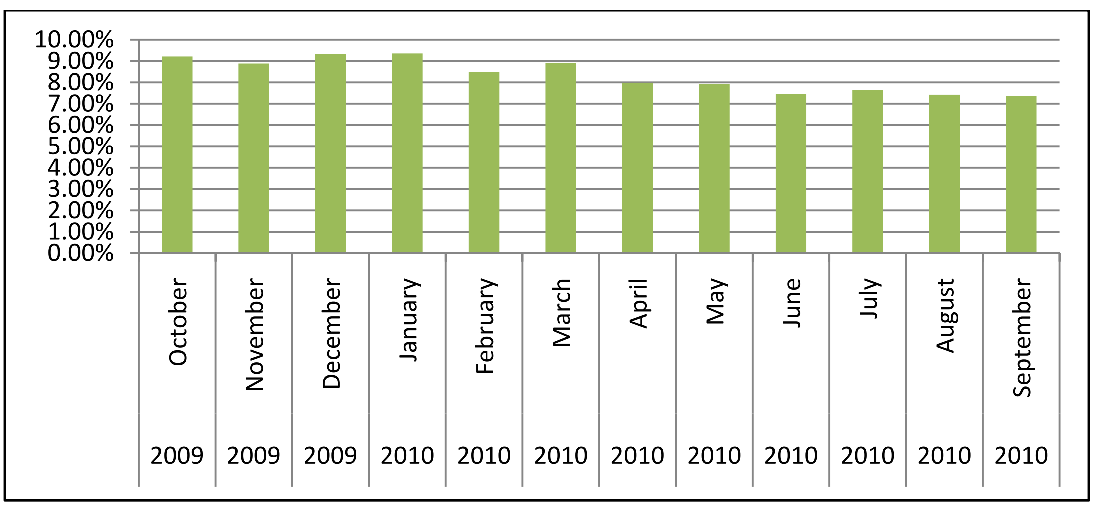
In Working Paper 1, monthly volumes of the different transportation modes using the San Luis I LPOE, AZ were analyzed in order to identify their behavior throughout the year. In order to complement the research and analyses already performed, a more extensive analysis was conducted for the San Luis I LPOE, AZ crossing volumes. The purpose of this section is to discuss additional analyses of the historical traffic volume data which will complete the analysis of the current conditions, and will be utilized in the development of the future conditions.

The objective of this task is to have a finite perspective of the different border crossing behaviors during a period of time on a monthly, daily and hourly basis. To achieve this, hourly volumes of northbound crossings obtained from U.S. Customs and Border Protection (CBP) were explored in more detail. The initial step was to aggregate and/or segregate the data in year, month, week and day time intervals. The decomposition of the time series data in such fashion allowed for the identification of potential seasonal components and traffic loads during the day. It is relevant to note that these analyses are focused on POV and Pedestrian border crossing modes only.

Privately Owned Vehicles Border Crossing Volumes

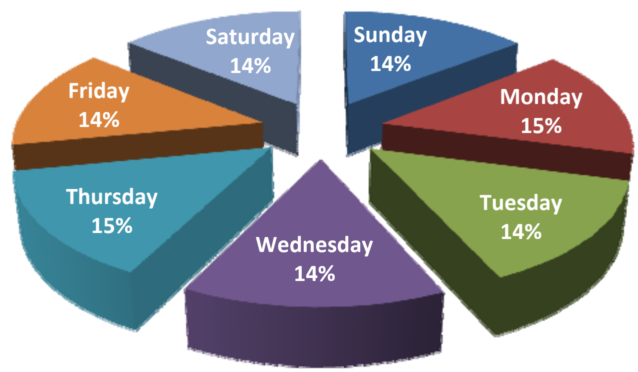
The POV mode, as the major motorized traffic crossing the border every hour, represents a major concern to the region environment and economy. The information provided by CBP for the POV volumes was analyzed more thoroughly and it was observed that the percentile changes of crossing volumes from month to month do not present significant variability; however, there is a significant difference between winter months and summer months. Figure 1.1 shows the monthly distribution of POV crossing volumes in FY 2010. A monthly average of 9% of the total yearly volume crosses the border from October to March. This percent is probably related to the agricultural season which generally starts in November and ends in April each year.

FIGURE 1.1: MONTHLY PERCENTAGE OF POV CROSSINGS (FY 2010)



Likewise, crossings volumes were analyzed on daily basis by comparing the number of vehicles crossing from one day to another. This comparison is presented on Figure 1.2. It can be observed that crossing volumes do not change significantly by day of the week; almost every day shows the same percentage with the exception of Monday and Thursday which present the higher volumes, though not a significant difference.

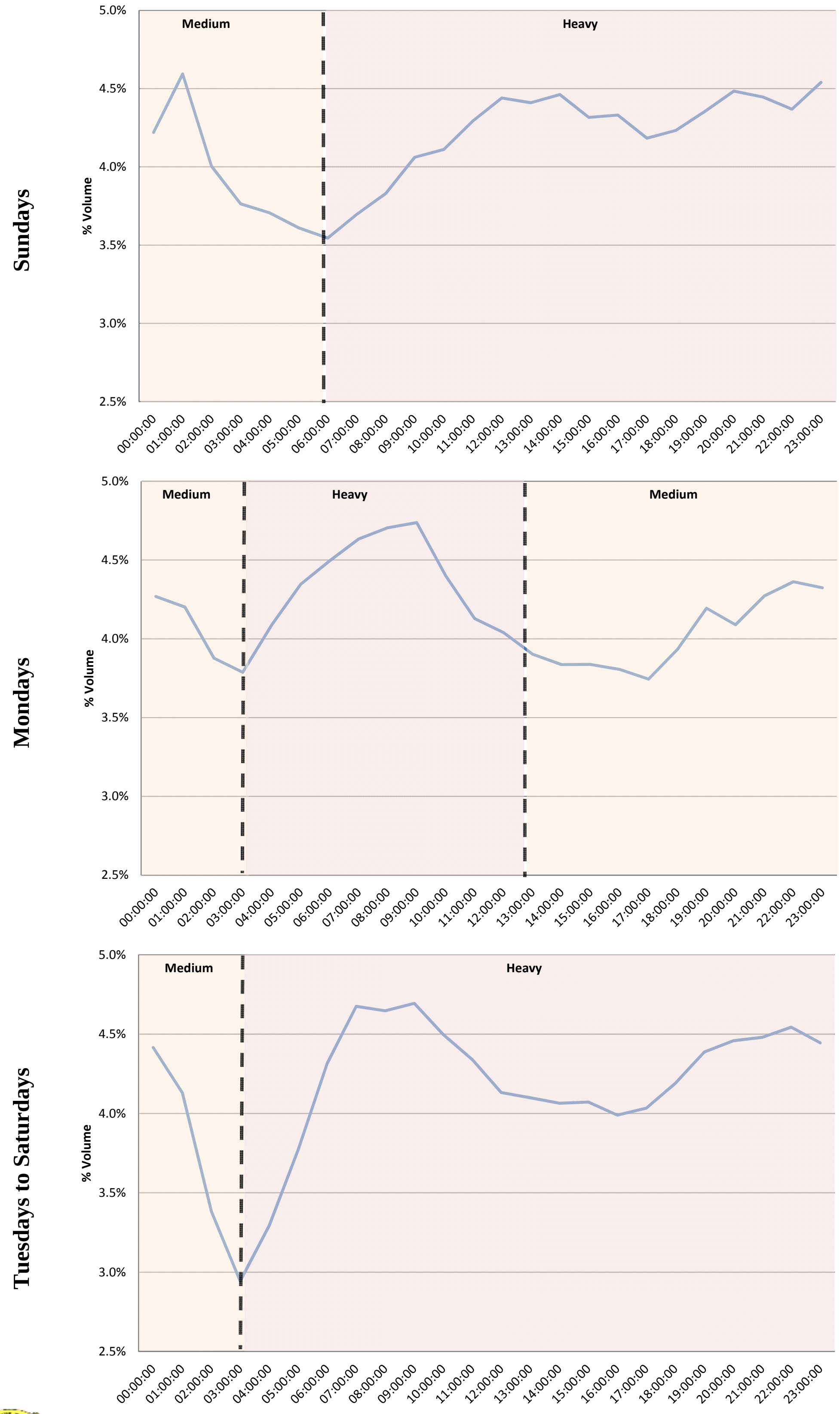
FIGURE 1.2: DAILY DISTRIBUTION OF POV CROSSINGS IN FY 2010



The next step consisted in creating a better resolution comparison. For this, the data was reduced to a crossing volumes distribution on hourly basis. The average of the processed POVs in the LPOE by hour demonstrates that different behaviors exist during the week. This is, the rush hours observed in the POV crossing border stations are a function of the time of the day and of the day of the week. From here, it was observed that crossing volumes have different distributions and behavior during the days of the week. Three behaviors were identified: (1) Sunday, (2) Monday, and (3) Tuesday to Saturday. This is related to the fact that people have different motives to cross the border on these different days and do so at different times during each day. Therefore it was decided to analyze these different days separately, as it was done previously for the waiting times (See Working Paper 1 – Section 3.6). Figure 1.3 shows the POV crossing volume distributions for the different identified day-segments.

Figure 1.3 displays the different behavior for each day time period. The Sunday segment for instance, has medium traffic volume from midnight to 6:00 am; then it starts increasing and remains heavy for the rest of the day. The Monday segment presents a different behavior; a heavy percentage of the crossings occur during the morning hours, while the rest of the day presents a medium volume. The rest of the week presents a totally different crossing volume distribution; while there is a significant decrease from midnight to 3:00 am, the volume increases almost 2% and remains within this range all day long.

FIGURE 1.3: POV CROSSING VOLUME DISTRIBUTION BY HOUR AND DAY SEGMENT (FY 2010)



After reviewing the POV crossing data,the general conclusion is that different **days of the week** present different daily POV traffic through the LPOE. This is, the daily POV traffic change patterns only in the following day-segments:

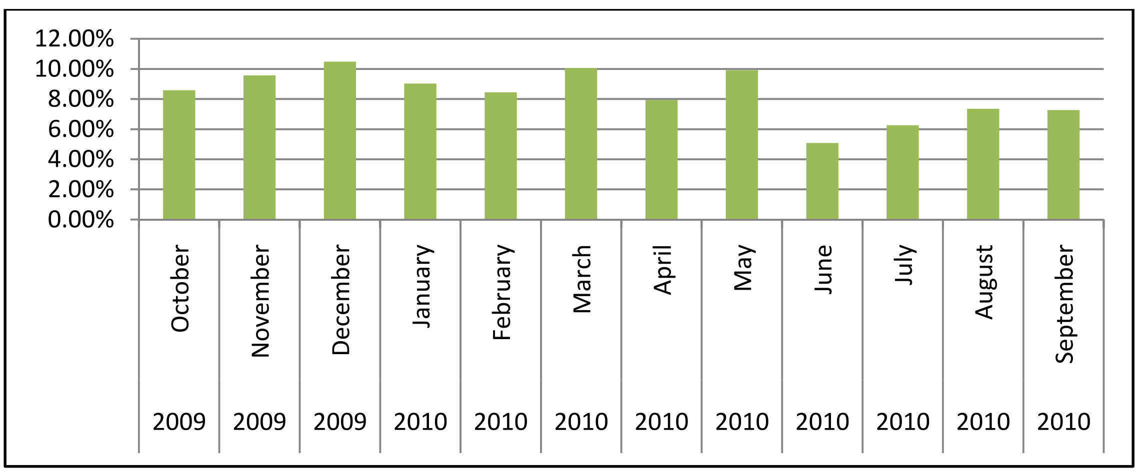
a) Sundays
b) Mondays
c) Tuesdays through Saturdays

Other explored time frames such as day of the month and month of the year have no noticeable effect on the traffic volumes. Therefore, only the segmentation frame by days of the week for motorized vehicles crossings was used during the queuing analysis presented in the following sections, as well as in the environmental and economic impact of the queues derived from this traffic.

Pedestrian Border Crossing Volumes

The pedestrian volumes were analyzed with a similar approach as the POV mode. CBP provided detailed information for the daily pedestrian crossings for FY 2010 which was examined in different timeframes as well; by months, weeks, days and hours through the year. Different conclusions surfaced from these analyses compared to the POV mode. It was found that pedestrians, crossing the border during the winter months, are almost 4% more than during the summer as shown in Figure 1.4. Previous studies suggest that this may be closely related to Yuma's County agriculture seasonality.

FIGURE 1.4: MONTHLY PERCENTAGE OF PEDESTRIAN CROSSINGS (FY 2010)



Using a more thorough method, the monthly separated data was analyzed to determine if this different behavior through the year was also observed on the weekly and daily basis. For this, the hourly crossings were laid out for every month and tested for differences. The crossing volume distributions through the day behave differently for each of the three parts of the year: (1) winter time, (2) summer, and (3) during the transition of these two seasons. Figure 1.5 shows the average pedestrian volume distribution of the day by hour within the three different time segments mentioned above.

FIGURE 1.5: DIFFERENT MONTHLY BEHAVIORS OF PEDESTRIAN VOLUME CROSSINGS (FY 2010)

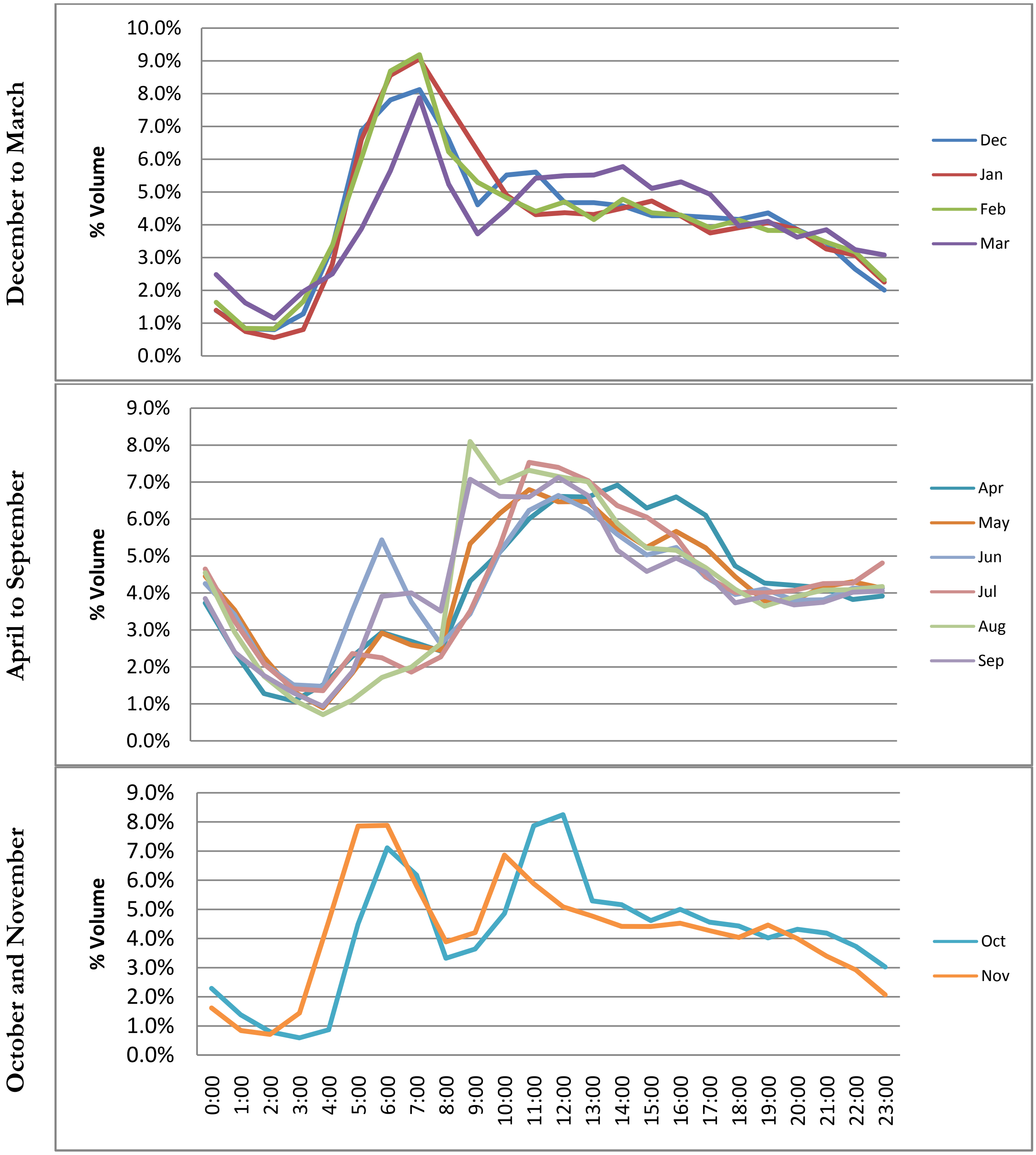
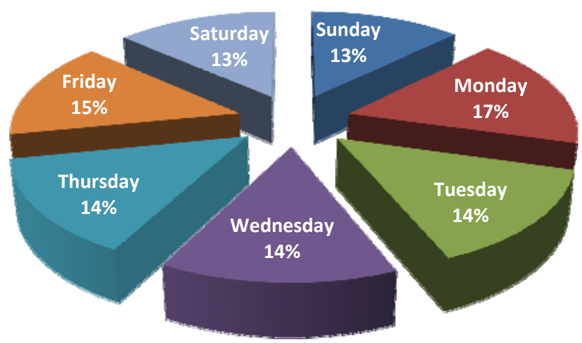


Figure 1.5 shows the proposed window comparisons for the pedestrian's crossings. From December to March the crossing peak hours are early in the morning, from 3:00 a.m. to 8:00 a.m. For the segment that considers the months of April to September the percentage of volume crossings increases towards mid-morning and ends in the afternoon. The last two months segment, October and November, shows a transition from summer to winter with peak hours at the morning and noon.

Moreover, an analysis of the daily pedestrian crossing distribution was performed. In Figure 1.6 one can observe that there is a slight increase of crossings during Mondays and a slight decrease during Saturdays and Sundays while remaining fairly even during weekdays.

FIGURE 1.6: DAILY DISTRIBUTION OF POV CROSSINGS (FY 2010)



Pedestrian crossings were also analyzed at a higher resolution to determine if the day of the week also represents a difference on the crossing volumes distribution during the day. It was determined that two different behaviors exist during the week. Figure 1.7 presents the hourly percentage of volume crossings by the identified segments: (1) Sundays, and (2) the rest of the week. These two segments present different crossings behavior through the day.

In Figure 1.7 one can observe that Sunday presents a small percentage of the daily volumes during the morning; as crossings start increasing during the evening they remain high until the end of the day. The rest of the week has a significantly different behavior from that of Sundays. For this week segment, higher crossing volumes occur from 3:00 am to 1:00 pm. This may be related to the labor hours of agriculture activities in the region.

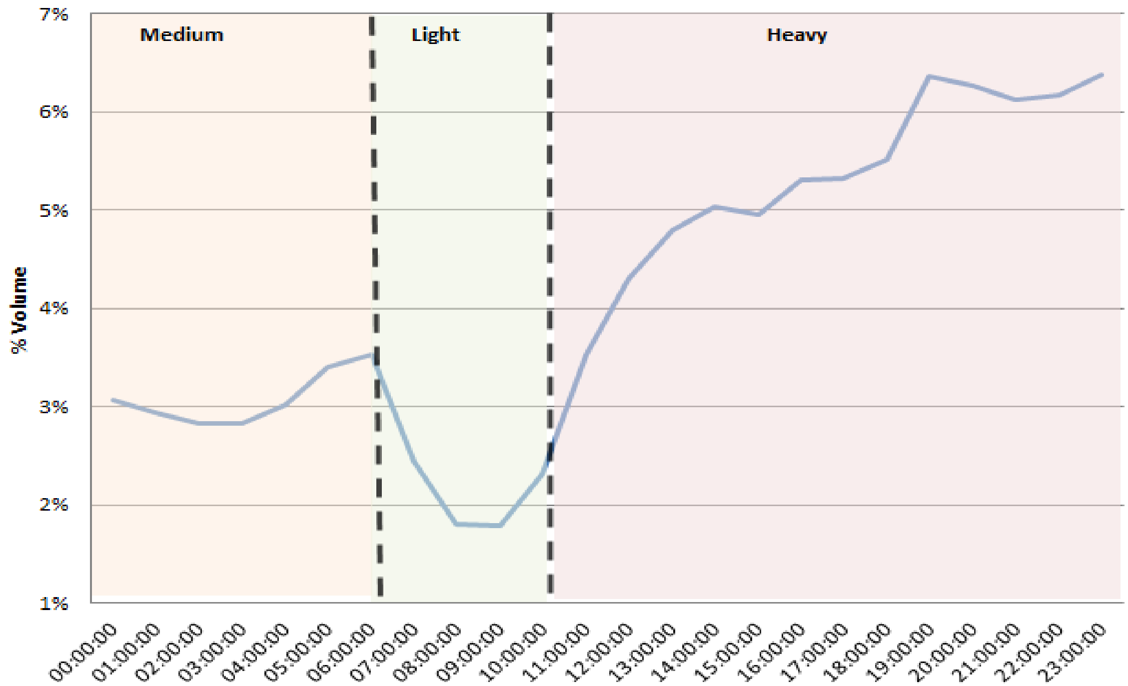
After reviewing the pedestrians crossing data from the perspectives above, the general conclusion is that different time factors have certain effect on the daily pedestrian traffic through the LPOE. These time-factors are:

1. **Month of the Year**. The daily pedestrian traffic change patterns in the following months:
   a) December to March
   b) April to September
   c) October and November
2. **Day of the Week**. The daily pedestrian traffic change patterns in the following day-segments:
   a) Sundays
   b) Mondays through Saturdays

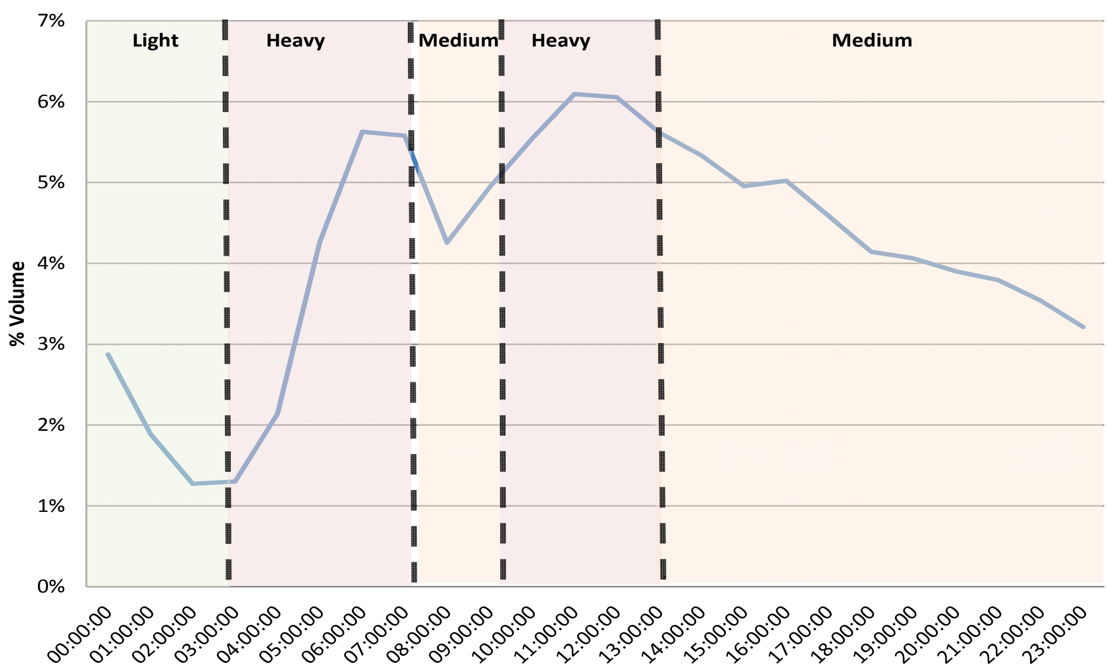
This aforementioned segmentation frame for crossing volumes was used during the queuing analysis presented in the forthcoming sections. The general impact of the queues derived from this traffic is also analyzed from this reference.

FIGURE 1.7: PEDESTRIAN CROSSING VOLUME DISTRIBUTION BY HOUR AND DAY SEGMENT (FY 2010)

Sundays



Mondays to Saturdays



2. ADDITIONAL ANALYSES ON SAN LUIS I LPOE, AZ CURRENT CONDITIONS

After the crossing volumes and their different behaviors during the day were identified, the next step was to examine the LPOE as an entity-flow system. The objective of these current conditions additional analyses is to create a model that can easily replicate these conditions (current demand vs. current capacity) and set a reference for future conditions analyses as well.

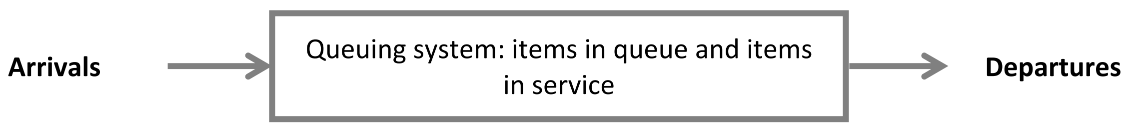
In order to discuss the main ideas related to the system analysis, the operational process followed by the entire LPOE system is shown first. This is followed by the POV queues analyses and a discussion of the observed situations during this process, such as the waiting times and how these queues affect the environment and the users' economy. Lastly, pedestrian queues analyses are also discussed along with a Pedestrian Level of Service (Ped-LOS) derived from the queues at the LPOE.

The systematic and mathematical processes performed to measure these impacts are presented in this section, followed by the results of these processes.

Analytical Queuing Models

Analytical models are mathematical models that can be used to interpret and predict a system behavior. There are different models that can be used in queuing theory and they can be classified based on how the system is structured using different elements. Figure 2.1 shows the basic flow of entities through queuing system.

FIGURE 2.1: FLOW OF ITEMS THROUGH A QUEUING SYSTEM

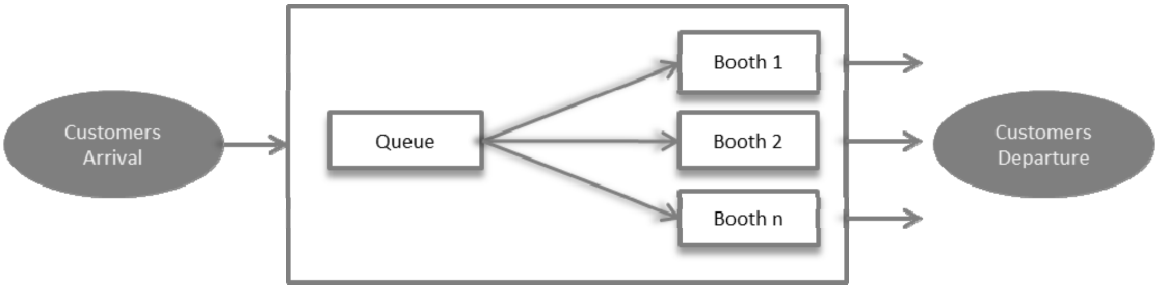


The queuing system considers different elements to study. The basic elements are:

- Arrival process
- Service process
- Number of servers
- Capacity of the servers
- Capacity of the queue
- Service methods and disciplines

The general system used to model the LPOE (for both POV and Pedestrians) functions as a single queue-multiple servers model. This is, customers will arrive to a queue, wait for a server (booth) to be idle, enter the booth for inspection procedures and then exit the system. Analyzing the LPOE as a single queue-multiple server system provides quick and acceptable results for the scope of study.

FIGURE 2.2: SINGLE QUEUE/MULTIPLE SERVERS MODEL



The model depicted in Figure 2.2 is considered for the LPOE analysis. In order to define important system characteristics, several assumptions and considerations are made. These are discussed next:

- Arrival process. - Includes the number of units arriving to the system and a certain behavior in the arrival times. Based on similar LPOE's studies the arrivals are considered to follow a Poisson process; this means the time between arrivals would be exponentially distributed.
- Service process. - It includes mainly the serving time; in this case it will be the time that takes to do the inspection process. Based on similar POE's studies, the serving rate of a booth at the POE follows an Erlang distribution Phase 4. For these queuing analyses different process times were considered. These times were based on information provided by San Luis, AZ LPOE direction and from the CBP Border Waiting Times report.
- Number of servers available. - It refers to the number of booths that could service customers at the same time. This information was retrieved from the CBP's public information and corroborated with San Luis, AZ LPOE Direction as well.
- Capacity of the servers. - The capacity considers how many entities can be inspected by each booth at the same time. For these analyses, and as part of the inspection process, only one entity can be assigned per booth.
- Capacity of the queue. - If there's a limit of space for queuing, this would be a resource that needs to be considered. In the LPOE analysis, the assumption for this parameter is that the space assigned for POV and pedestrian's queues is next to infinite.
- Service methods and disciplines. - The service methods are related to the requirements of each entity and/or the different service processes a single server provide. For this case, the assumption to follow is that all entities follow the same inspection process.

Moving into the mathematical schema used as part of the analytical models, for the general analysis of the queue Little Law's formula was used. The formulation of this law is presented as follows

$$L = \lambda W$$

Where:

L= average number of items in the queuing system,
W = average waiting time in the system for an item,
λ = average number of items arriving per unit time.

Following this nomenclature, *L* is the number of vehicles in the queue at a certain time which is an estimate to be determined from field studies; *W* is the expected waiting time of the queue (which is available online through the BWT (Border Wait Time) system and provided by CBP; and λ (lambda) is the arrival rate of the vehicles calculated with queries of crossings provided by CBP. As mentioned above, the system is considered a single queue and multiple servers model.

This mathematical approximation assumes the system is stable, which means that it will remain unchanged for a long period of time. It is important to note that this is not to be totally accurate, but provides approximate results in terms of average queue lengths. The following sub-sections will consider these analytical models to identify the main queues behaviors and impacts for both privately owned vehicles and pedestrians.

Privately Owned Vehicle's Border Crossing Conditions

In this subsection the results obtained from the analytical models for the (POVs) border crossing are discussed. The estimated behavior of the POV queues is discussed followed by the suggested method to measure its impact in the region.

POV's Queues Behavior

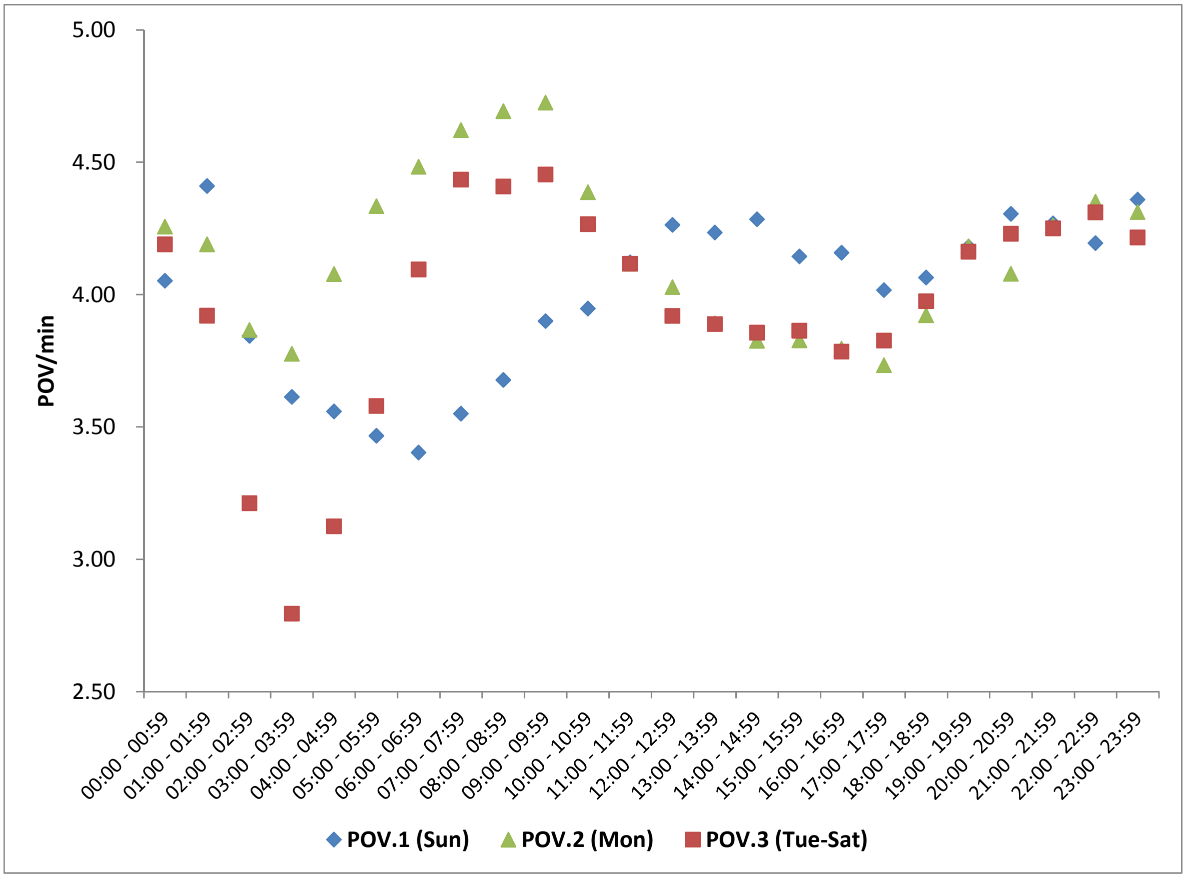
As mentioned before, a single queue/multiple servers model was used for the POV queuing analysis. According to the different behaviors of the crossings through the week observed in Section 1, queues were analyzed under the following segments:

TABLE 2.1: POV CROSSING MODE SEGMENTATION

Segment	Day
POV.1	Sundays
POV.2	Mondays
POV.3	Tuesdays through Saturdays

The analytical model was set to six open booths at all times, but different service cycle times are considered throughout the day. This cycle time includes the inspection time, the idle time of the booth, and the pull-up time; the second is fairly rare since the system is mostly at full capacity and the latter refers to the time from where one vehicle is released from inspection and the next moves forward. From the San Luis I LPOE, AZ data this cycle time is estimated toan average of 89.94 seconds, and the entire system has an average service rate of 4.04 vehicles per minute. Figure 2.3 shows the service rate per hour for the three different segments.

FIGURE 2.3: POV SERVICE RATE



It is important to note that a low rate does not equal a slow service. As this rate is estimated from the available cycle time's data, it reflects system utilization as well. Overall, the maximum observed rate serves 285 vehicles within an hour.

Table 2.2 presents the analyses' summary results for each segment. In the summary, each segment contains two attributes and three resulting figures. These are: (1) the open booths by hour, (2) the average waiting time in the queue by each vehicle, (3) the average cars in the queue, and (4) queue behavior –the latter is shown with a symbol (▲)for increasing queues and (▼) for decreasing or stable queues. Attributes (1) and (2) were retrieved from public databases during the early stages of the project (U.S. Bureau of Transportation Statistics 2012) and complemented by CBP (U.S. Customs and Border Protection 2012); result figures (3) and (4) were estimated by the analytical queuing models from the available data.

TABLE 2.2: POV QUEUING MODELS RESULTS SUMMARY

Hour	POV.1 (Sun) Open Booths: 6			POV.2 (Mon) Open Booths: 6			POV.3 (Tue-Sat) Open Booths: 6		
	WT (min)	Avg. Que. (POVs)	Status	WT (min)	Avg. Que. (POVs)	Status	WT (min)	Avg. Que. (POVs)	Status
0:00	59	238	▲	80	339	▲	26	108	▲
1:00	72	318	▼	75	315	▲	17	65	▲
2:00	73	279	▲	60	233	▲	11	34	▲
3:00	68	245	▲	52	195	▲	17	47	▲
4:00	63	224	▲	57	234	▼	29	92	▼
5:00	50	174	▲	66	286	▼	40	144	▼
6:00	35	119	▲	68	306	▼	45	183	▼
7:00	31	110	▼	69	320	▼	48	214	▼
8:00	36	131	▼	67	316	▼	49	216	▲
9:00	38	147	▼	67	319	▼	49	219	▼
10:00	41	160	▼	70	307	▲	48	207	▲
11:00	42	174	▼	70	287	▲	48	200	▲
12:00	45	193	▼	71	284	▲	50	196	▲
13:00	48	204	▲	73	283	▲	52	203	▲
14:00	54	231	▼	74	284	▲	54	209	▲
15:00	59	243	▲	78	299	▼	57	221	▼
16:00	63	262	▼	76	288	▲	55	209	▲
17:00	66	266	▲	72	270	▲	51	195	▼
18:00	66	270	▼	66	258	▼	44	173	▼
19:00	68	283	▼	59	245	▼	39	162	▼
20:00	72	311	▼	56	228	▲	38	161	▼
21:00	77	327	▲	56	240	▼	40	169	▼
22:00	80	338	▲	53	232	▼	40	174	▼
23:00	82	356	▼	45	193	▲	38	159	▲

For the POV border crossing, Mondays and late Sundays represent the longest queues and waiting times. During Monday's and Sunday's heavy hours an average of 300 vehicles are expected in the queue, as compared to the heavy periods for the other weekdays where the average expected vehicles in the queues is around 200 units.

It is important to note that these numbers represent the entire number of units in the system. If the two (2) uniform lanes configuration feed is assumed, then the average length of the queues is reduced.

The expected length of the two (2) queues that feed the system is shown in Figure 2.4. The assumed standard measurement for a vehicle, considering the spaces between entities is 25 feet. Table 2.3 presents the perceived length of both queues each hour.

FIGURE 2.4: EXPECTED QUEUE LENGTHS (2 QUEUES FEED SYSTEM)

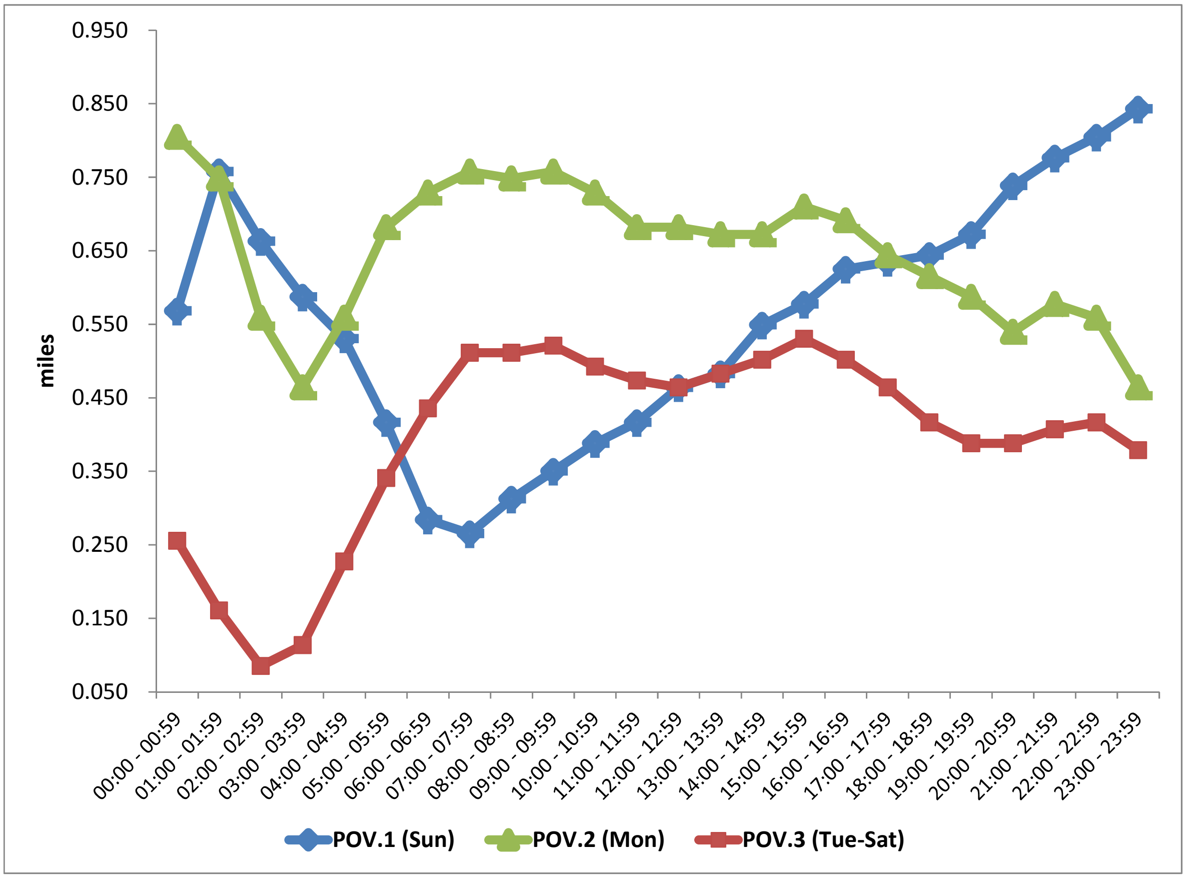


TABLE 2.3: LENGTH OF THE QUEUE (MILES)

Statistic	Sun (med)	Sun (hi)	Mon (med)	Mon (hi)	T-S (med)	T-S (hi)
Mean	0.54	0.56	0.62	0.70	0.15	0.44
Max	1.35	1.67	1.77	1.48	1.39	1.13

These overall results are to be considered in the next section to help identify the general impact of the queue in the region. In a similar fashion, they will be considered when analyzing the future system conditions.

POV's Queue and Idling Impact

Once the expected behavior of the POVs queuing to use the LPOE is identified, the next step is to measure its impact to the surrounding area in San Luis, AZ/San Luis Río Colorado, MX. In order to determine the general effect of the vehicles at the LPOE region two basic metrics were used: (1) the amount of gas spent due to idling, and (2) the CO2 emissions from the queuing vehicles. These provide a quick, yet quantifiable way to size the impact from the economic and environmental perspectives respectively.

Both of these metrics are function of the waiting times (or idle times), and the quantity of vehicles in the queue. The POV crossing mode's waiting times explored in Working Paper 1 and Section 2.2.1 are summarized in Table 2.4.

TABLE 2.4: OBSERVED WAITING TIMES (MINUTES BY POV)

Statistic	Sun (med)	Sun (hi)	Mon (med)	Mon (hi)	T-S (med)	T-S (hi)
Mean	60	57	65	67	17	46
Max	160	161	234	160	175	141

Besides providing an overview of the implications of long waiting times at the LPOE,such as negative trends on users crossing for retail purposes that may impact the economy of both cities, this data is used to estimate the aforementioned metric values. Overall, the long waiting times imply hundreds of idle vehicles during the day. Studies show that idle medium size automobiles (i.e. with a three liters engine) burn approximately 8.45 U.S. fluid ounces of a gasoline in ten minutes, resulting in a huge economic impact due to the fuel consumption. This fuel consumption can be interpreted as another important issue: air pollution. An idle car burning one gallon of fuel will emit 20 pounds of CO_2 (carbon dioxide) into the atmosphere (Government of Canada 2009).

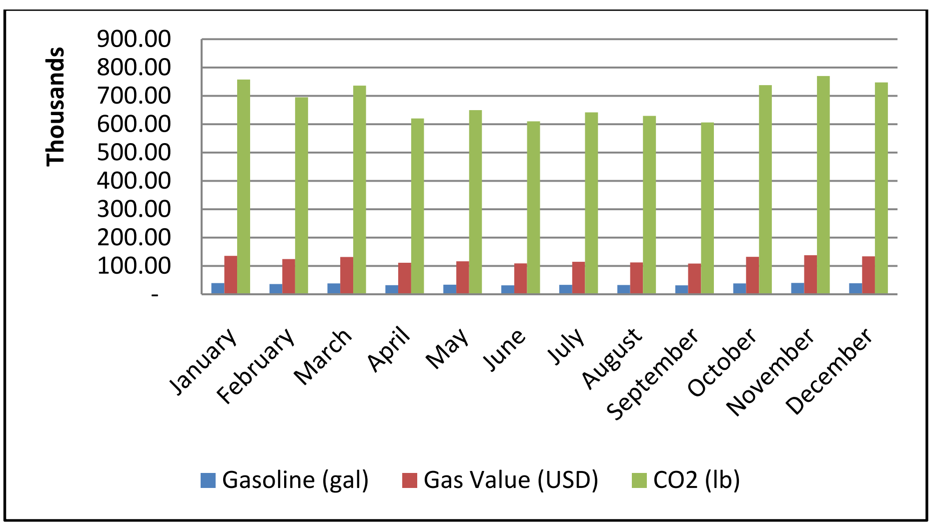
Considering these consumption and emission rates along the POV's waiting times and transit volumes an impact was determined with the proposed metrics. Table 2.5 presents an annual report of these estimations for the FY 2010 data (gas price: 3.44 USD/gal; source: U.S. Energy Information Administration 2010).

TABLE 2.5: ECONOMIC AND ENVIRONMENTAL EFFECTS OF POV QUEUING (FY 2010)

Month	Gasoline (Gal)	Gas Value (USD)	CO2 (lb)
January	39,468.76	$ 135,570.55	757,580.31
February	36,207.26	$ 124,367.68	694,977.66
March	38,340.58	$ 131,695.39	735,925.54
April	32,320.86	$ 111,018.35	620,380.42
May	33,850.12	$ 116,271.17	649,733.67
June	31,790.20	$ 109,195.61	610,194.79
July	33,428.46	$ 114,822.85	641,640.31
August	32,802.51	$ 112,672.77	629,625.45
September	31,587.71	$ 108,500.09	606,308.15
October	38,431.78	$ 132,008.67	737,676.18
November	40,116.61	$ 137,795.84	770,015.40
December	38,955.27	$ 133,806.79	747,724.27
Year	**427,300.11**	**$ 1,467,725.74**	**8,201,782.15**

An estimate of 430 thousand fuel gallons with a $1.5 million USD value is consumed by the idling vehicles at the San Luis I LPOE, AZ. This means an estimated 8.2 million CO_2 pounds emitted into the atmosphere as a consequence of idle mid-sized vehicle engines.

FIGURE 2.5: IMPACT OF POV QUEUING (FY 2010)



As shown in Figure 2.5, the impact is not only affecting the economic growth of the region; one must also consider the monetary impact to the LPOE users because of idle vehicles, the consumption of a non-renewable resource such as gasoline or diesel, and the environmental impact of CO_2 emissions.

As a reference, the New York City metropolitan area is a heavily congested traffic zone. It produces an average of 396 million CO_2 pounds a year by idling vehicles (Burgess, Peffers, and Silverman 2009). As shown in Table 2.6, the POV queues at the San Luis I LPOE, AZ produce 2.07% of the CO_2 produced by idle cars in New York; but if the CO_2 produced per vehicle at San Luis I LPOE is compared to the one produced per vehicle in the NYM area it is 186% higher, which is rather significant.

TABLE 2.6: ENVIRONMENTAL EFFECTS COMPARISON BETWEEN NEW YORK METRO AND SAN LUIS I LPOE, AZ

Region	Idle CO2 (lb/year)	Approx. Pop. in Region	Approx. Cars per Region	Idle CO2 (lb/car)
New York Metro	396 M	18.9 M	10.78 M	36.74
San Luis AZ/SLRC MX	8.2 M	297,000	120,000	68.35
NYM vs. San Luis AZ/SLRC MX	**2.07%**	**1.57%**	**1.12%**	**186%**

Pedestrian's Border Crossing Conditions

As in the previous subsection, the results of the analytical model implementation for the pedestrian's border crossing mode are now discussed. First, the behavior of the queue is presented followed by a suggested method to measure the level of service observed by the users.

Pedestrian Queues

Pedestrian crossings were analyzed with the same single queue/multiple servers-model method. The analysis results are presented by the time segmentation shown in Section 1.2. Table 2.7 shows a summary of the segmentation's dimensions used.

TABLE 2.7: PEDESTRIAN CROSSINGS ANALYSES SEGMENTATION

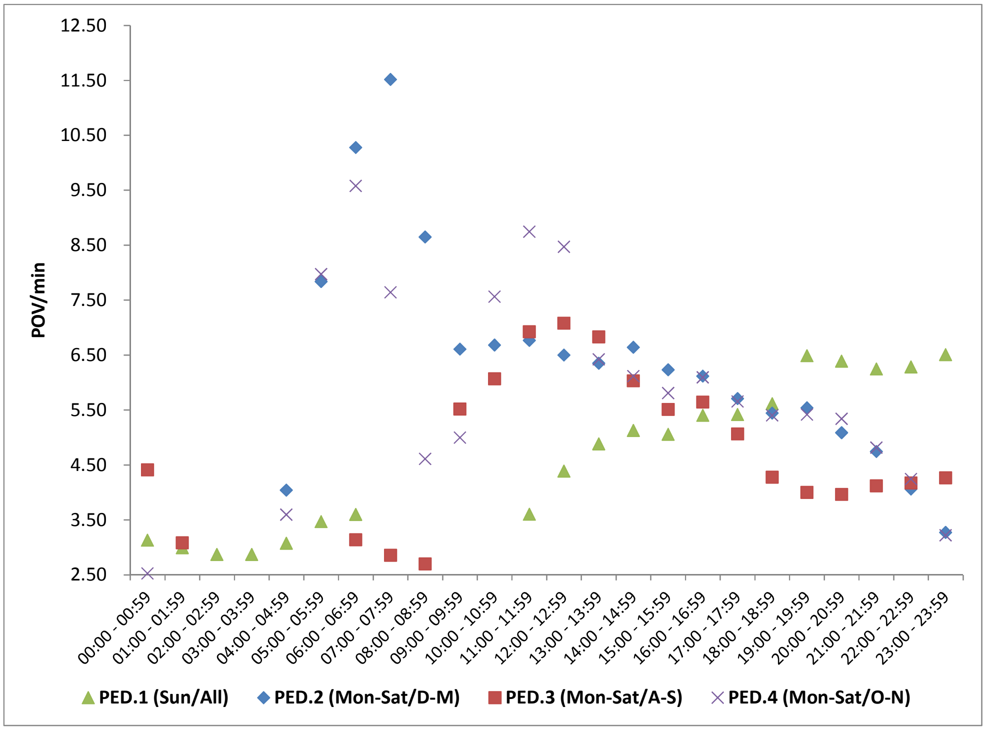
Segment	Day	Month
Ped.1	Sunday	All
Ped.2	Monday through Saturday	December to March
Ped.3	Monday through Saturday	April to September
Ped.4	Monday through Saturday	October and November

For this crossing mode, the analytical model was set to different open booths at the different times, and different service cycle times are considered throughout the day. This cycle time includes the inspection time, the idle time of the booth, and the pull-up time –the second is fairly rare since the system is mostly at full capacity and the latter refers to the time from where one pedestrian is released from inspection and the next moves forward inspection. From the San Luis I LPOE, AZ data, the cycle time and average service rate is estimated for the different segments and shown in Table 2.8. An important factor to consider is that when the line is getting long, additional officers open a couple of additional lanes to cover this demand, which is also added to the available servers (Schroeder 2012). In a similar way, Figure 2.6 shows the service rate per hour for the four different segments.

TABLE 2.8: PEDESTRIAN CAPABILITY BY SEGMENT

Open Booths per Segment				
Time	**Ped.1**	**Ped.2**	**Ped.3**	**Ped.4**
00:00 - 00:59	2	2	2	2
01:00 - 01:59	2	2	2	2
02:00 - 02:59	2	2	2	2
03:00 - 03:59	2	3	3	3
04:00 - 04:59	2	5	5	5
05:00 - 05:59	2	5	5	5
06:00 - 06:59	4	6	6	6
07:00 - 07:59	4	4	4	4
08:00 - 08:59	4	4	4	4
09:00 - 09:59	4	4	4	4
10:00 - 10:59	4	4	4	4
11:00 - 11:59	4	4	4	4
12:00 - 12:59	4	4	4	4
13:00 - 13:59	4	4	4	4
14:00 - 14:59	4	4	4	4
15:00 - 15:59	4	4	4	4
16:00 - 16:59	5	4	4	4
17:00 - 17:59	6	4	4	4
18:00 - 18:59	6	4	4	4
19:00 - 19:59	5	4	4	4
20:00 - 20:59	6	4	2	4
21:00 - 21:59	6	4	2	4
22:00 - 22:59	6	4	2	4
23:00 - 23:59	2	2	2	2
Average Cycle Time (sec)	60.47	47.93	64.56	51.80
Average System Service Rate (PED/min)	4.67	5.45	4.68	5.18

FIGURE 2.6: PEDESTRIAN SERVICE RATE



It is important to note that a low rate does not equal a slow service. As this rate is estimated from the available cycle time's data, it reflects system utilization as well. Overall, the maximum observed rate serves 11.50 pedestrians per minute. The highest rates are observed during the winter months.

Moving onto the analyses' results, the summary for each segment is presented in Table 2.2 in a similar way as in the POV section. In this summary, each segment contains one attribute and three result figures. These are: (1) the average waiting time in the queue by each user, (2) the average number of people in the queue, and (3) the queue behavior; the latter is shown with a symbol (▲)for increasing queues and (▼) for decreasing or stable queues. As mentioned in the POV section, attribute (1) is retrieved from BTS and complemented by CBP; result figures (2) and (3) were estimated by the analytical queuing models from available data.

Table 2.9 displays the busiest times for each segment. As mentioned before, the weekdays have different patterns throughout the months:

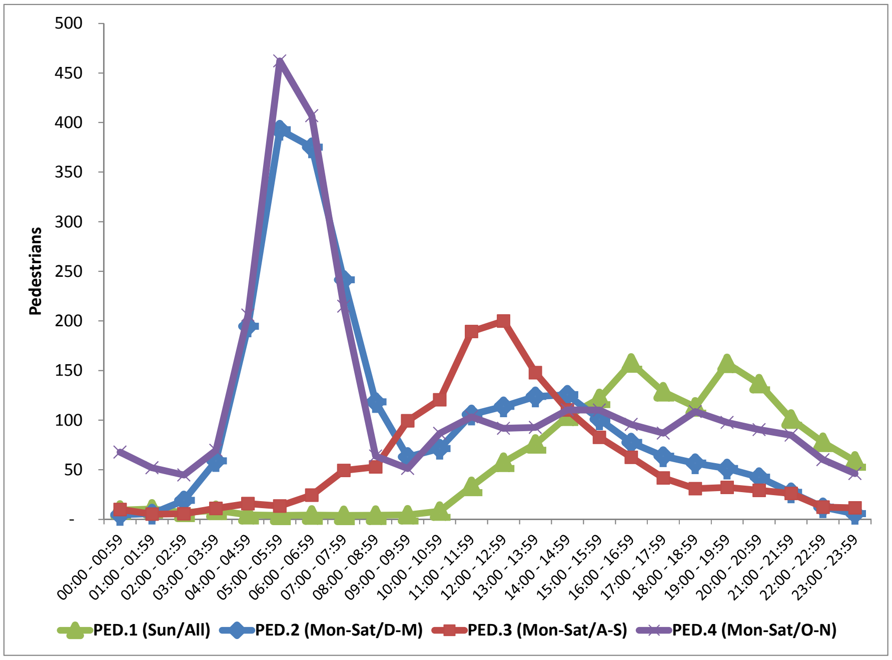
- Sunday's heavy traffic for all months occurs in the afternoons with an average of 115 people in queue.
- December to March shows the heaviest traffic is early in the morning (4 to 8 am) with an average of 270 users in queue.
- April through September shows the heavy traffic later in the morning and early afternoon (from 9 am to 2 pm) with an average of 150 people waiting for inspection.
- October to November show a relatively high pedestrian traffic throughout the whole day, with averages of 300+ people in queue in the busiest hours.

TABLE 2.9: PEDESTRIAN QUEUING MODELS RESULTS SUMMARY

Hour	PED.1 (Sun/All)			PED.2 (Mon-Sat/D-M)			PED.3 (Mon-Sat/A-S)			PED.4 (Mon-Sat/O-N)		
	WT (min)	Avg. Que. (Ped)	St	WT (min)	Avg. Que. (Ped)	St	WT (min)	Avg. Que. (Ped)	St	WT (min)	Avg. Que. (Ped)	St
0:00	3	9	▼	2	4	▼	2	10	▼	27	68	▼
1:00	3	10	▼	4	6	▼	2	5	▼	36	52	▼
2:00	2	7	▼	17	19	▲	3	6	▼	46	45	▲
3:00	3	9	▲	30	59	▲	8	11	▼	52	69	▲
4:00	1	4	▲	48	194	▲	14	16	▲	57	206	▲
5:00	1	4	▲	50	393	▲	6	13	▲	58	462	▲
6:00	1	4	▼	36	375	▲	8	24	▼	42	407	▼
7:00	2	4	▼	21	241	▼	17	49	▼	28	215	▼
8:00	2	4	▼	14	118	▼	20	53	▲	14	64	▲
9:00	2	4	▲	10	63	▲	18	99	▲	10	51	▲
10:00	3	8	▲	11	71	▲	20	121	▲	11	87	▲
11:00	9	33	▲	16	106	▼	27	189	▲	12	103	▼
12:00	13	57	▲	18	114	▼	28	200	▼	11	92	▼
13:00	16	76	▲	20	124	▲	22	148	▼	14	93	▼
14:00	20	104	▼	19	126	▼	18	110	▼	18	110	▼
15:00	24	122	▲	16	101	▼	15	83	▲	19	110	▲
16:00	29	158	▲	13	77	▼	11	62	▼	16	96	▼
17:00	24	128	▲	11	64	▼	8	42	▼	15	87	▼
18:00	20	113	▲	10	56	▲	7	31	▼	20	109	▲
19:00	24	157	▼	9	51	▼	8	32	▼	18	98	▼
20:00	21	137	▼	8	42	▼	7	29	▲	17	90	▼
21:00	16	101	▲	6	27	▼	6	26	▲	18	85	▼
22:00	12	78	▲	3	12	▼	3	12	▲	14	60	▼
23:00	9	59	▼	2	6	▼	3	12	▲	14	46	▼

As presented previously, days from Monday to Saturday have three different behaviors through the year, winter and summer time, and the transition of the agricultural seasons. The number of open booths changes from winter to summer. This is related to the fact that during the winter months the SENTRI and bicycle lanes are open from 6:00 a.m. to 10:00 p.m., while during summer these lanes are open until 7:00 p.m. Figure 2.7 shows a graphical representation of the average queues for each pedestrian border crossing segments.

FIGURE 2.7: EXPECTED PEDESTRIANS IN QUEUE



The behavior of the queue has an impact to the level of service observed by the LPOE users. The expected level of people in line is used to evaluate the congestion in the pedestrian area.

Level of Service for Pedestrian Border Crossing

Pedestrian traffic service levels at the LPOE were estimated using the expected queue lengths, pedestrian flows and speed of the queue. Ped-LOS is a measurement used to evaluate the capacity and comfort for an active pedestrian space. According to the proposed metric, for a queue ranked with a LOS "A" pedestrians can move freely and no conflict occurs with other pedestrians. On the other hand, a level "F" queue presents unavoidable contact with others and severely restricted speeds. This can be easily determined by the volume-to-capacity ratio, which is the existing relationship between the demands (in terms of pedestrian's arrivals per minute to the queue, ***v***) and the service rate of the system (pedestrians that can be inspected by the system per minute, ***c***). Table 2.10 contains the different ranges of volume to capacity ratio and corresponding LOS used in the evaluation of the queues behavior. (Kittelson & Associates, Inc 1999).

TABLE 2.10: PEDESTRIAN LEVEL OF SERVICE REFERENCE

Ped-LOS	Expected Flows and Speeds (volume/capacity ratio)
A	0.0-0.3
B	0.3-0.4
C	0.4-0.6
D	0.6-0.8
E	0.8-1.0
F	>1.0

This ratio interprets the system's ability to work through the required demand. The closer to 1 the ratio is (or above) means that the arrivals are faster than the service rates; on the other hand, lower ratios represent those times where the system flows faster than the arrivals. Table 2.11 shows the estimated LOS for the San Luis I LPOE, AZ pedestrian's crossings for FY 2010 by the different time segments. Overall, most parts of the segments are highly congested with Ped-LOS of "E" and "F". The best Ped-LOS identified is "C", which occurred only in very few time intervals.

TABLE 2.11: PEDESTRIAN LOS

Hour	PED.1 (Sun/All)		PED.2 (Mon-Sat/D-M)		PED.3 (Mon-Sat/A-S)		PED.4 (Mon-Sat/O-N)	
	v/c ratio (ρ)	LOS	v/c ratio (ρ)	LOS	v/c ratio (ρ)	LOS	v/c ratio (ρ)	LOS
0:00	0.96	E	0.59	C	0.70	D	0.56	C
1:00	0.96	E	0.82	E	0.62	D	0.69	D
2:00	1.00	E	1.72	F	0.68	D	1.37	F
3:00	1.07	F	2.07	F	0.88	E	2.67	F
4:00	1.13	F	1.94	F	1.85	F	2.22	F
5:00	1.04	F	1.31	F	1.48	F	1.20	F
6:00	0.69	D	1.12	F	0.91	E	0.80	D
7:00	0.74	D	0.75	D	0.95	E	0.60	D
8:00	0.99	E	0.76	D	2.04	F	1.08	F
9:00	1.30	F	1.01	F	1.10	F	1.51	F
10:00	1.53	F	1.01	F	1.14	F	1.16	F
11:00	1.22	F	0.96	E	1.02	F	0.97	E
12:00	1.11	F	0.98	E	0.96	E	0.76	D
13:00	1.05	F	1.05	F	0.88	E	0.95	E
14:00	0.99	E	0.94	E	0.91	E	0.95	E
15:00	1.07	F	0.98	E	1.02	F	1.05	F
16:00	1.00	F	0.93	E	0.90	E	0.93	E
17:00	1.04	F	0.95	E	0.84	E	0.96	E
18:00	1.16	F	1.02	F	0.94	E	1.00	F
19:00	0.98	E	0.92	E	0.99	E	0.99	E
20:00	0.98	E	0.93	E	1.04	F	0.90	E
21:00	1.01	F	0.86	E	1.01	F	0.88	E
22:00	1.04	F	0.81	E	1.02	F	0.76	D
23:00	0.48	C	0.72	D	1.03	F	0.78	D

3. SYSTEM ANALYSES ON SAN LUIS I LPOE, AZ FUTURE CONDITIONS

One of the main focuses of *Working Paper 2* is to complement the analyses of the LPOE future conditions, which will be address in this section. The best approach to present the analysis and its results is to divide this section into two main topics: forecast and analytical modeling. The forecasts in this study are based on statistical models that seek to predict the behavior of the crossing volumes at the LPOE. This is achieved by establishing a mathematical relationship between the relative change of certain economic variables and the crossing volumes. The analytical modeling of the future conditions will consider the results of both the proposed LPOE queuing models and the traffic forecast models. In a similar way as for the current conditions, the predicted demands are to be tested over the current capacities to determine its impact. At the same time, this would help determine the required capacity (i.e. operations and/or infrastructure wise) for the LPOE to align with future demand. The analytical modeling of the LPOE system can assist in the evaluation of any changes in either volume or capacity without incurring large investments such as prototypes or construction. Nevertheless, the first step is to identify the future border crossing volumes.

The LPOE Future Volume Forecasts

One of the main objectives of this study is to provide recommendations for future infrastructure and capacity needs at the San Luis I LPOE, AZ. These recommendations are mostly based on projected usage of the border infrastructure in 5, 10 and 20 years into the future for different modes of transportation primarily POV and pedestrian. For this purpose, analytical and statistical tools are used to analyze historical data of the external factors in order to identify pattern and behaviors in the dataset that interact with border crossings and that can explain their variability. Once the factors' interactions are identified, one can use this information to forecast future changes in the patterns of border crossings.

Forecast Methodology

The following outlines the general steps in this methodology:

1. Based on expertise knowledge, gather important factors that can potentially cause variability in the number of border crossings
2. Pre-process the data for consistency in resolution, time frame, trend, seasonality, etc.
3. Use statistical methods (regression analysis) to analyze candidate external factors
4. Form a statistical model that can explain the variability in the number of border crossings per mode of transportation
5. Test and select an adequate forecasting procedure that can use the results provided by the regression analysis to develop future projections of infrastructure usage for different modes of transportation

Once this methodology has been completed, the next step is to develop future projections of border crossings.

Explanatory Models

As discussed earlier, during the first phase of the project an explanatory model was developed to help identify the most relevant factors with respect to variations in the number of border crossings. For the purposes of this study, a regression analysis is performed on the candidate factors in order to identify their relevance. Nonetheless, since border crossing are time dependent, one of the major problems with the data is its inherent trend, and in some cases seasonality. Additionally, for some variables, their measurement intervals can be different and thus have to be adjusted. For example, crossings could be measured per day, week, or month, but industrial production is only available by month. Therefore, one of the first steps in the development of the explanatory models is to prepare the data by making sure time periods are comparable, major outliers are identified, and other efforts are pursued to ensure consistency between explanatory variables and forecast variables.

Collection and Pre-Process of Data

The first step in the process is to gather historical data of external factors that could potentially have an impact on the volume of border crossings per type of mode at the LPOE, truck, POV, and pedestrian. This data collection process is performed primarily in two ways; first through the gathering of publicly available data, and second through direct requests and/or *freedom of information* mechanisms (the latter of which was used mainly in Mexico). Most of the data collected at this stage of the study is related to the macroeconomic, social and demographic conditions in the San Luis, AZ/San Luis Río Colorado, MX region.

Table 3.1 presents the measurement intervals, or resolution of the data that is available from the different sources for all of the variables considered. As one can observe, most of the data was collected with at the monthly level, while some economic indicators such as GDP are only published on a quarterly basis. Additionally, the monetary exchange rate between the Mexican Peso and the U.S. Dollar is available on a daily basis. All of the variables were ultimately converted to a monthly basis using a linear fit for those months without data. In the case of the exchange rate, the rate published for the first day of the month was used.

TABLE 3.1: RESOLUTION AND PRE-PROCESS OF DATA

Variable (abbreviation)	Data Resolution	Conversion to Monthly
Commercial Trucks (trk)	Monthly	None
Privately-Owned Vehicles (pov)	Monthly	None
Pedestrians (ped)	Monthly	None
IMSS*-Farm (ssf)	Monthly	None
IMSS-Commerce (ssc)	Monthly	None
IMSS-Transformation (sst)	Monthly	None
IMSS-Services (sss)	Monthly	None
IMSS-Other Sectors (sso)	Monthly	None
IMSS-All Sectors (sum of all in SLRC) (ss)	Monthly	None
IMSS-All Sectors (sum of all in P. Peñasco) (sspp)	Monthly	None
IMSS-All Sectors (sum of all in Plutarco E.C.) (sspec)	Monthly	None
Gold Production (SLCR) (gold)	Monthly	None
Gold Production (Plutarco E.C.) (goldp)	Monthly	None
Silver Production (silv)	Monthly	None
Crime in state of Sonora (crim)	Monthly	None
Homicides in state of Sonora (hom)	Monthly	None
Personal Income in AZ (piaz)	Quarterly	Linear Fit
Compensation in AZ (caz)	Quarterly	Linear Fit
Wage in AZ (waz)	Quarterly	Linear Fit
Index of Industrial Production in MX (iipm)	Monthly	None
Index of Industrial Production in U.S. (iipu)	Monthly	None
Consumer Price Index in MX (cpim)	Monthly	None
Consumer Price Index in U.S. (cpiu)	Monthly	None
Gross Domestic Product in MX (gdpm)	Quarterly	Linear Fit
Gross Domestic Product in U.S. (gdpu)	Quarterly	Linear Fit
Diesel price (dslp)	Monthly	None
Gasoline price (gasp)	Monthly	None
Personal Income in U.S. (piu)	Monthly	None
Monetary Exchange Rate (exch)	Daily	First month day
Main Agricultural Production in Yuma County, AZ** (agri)	Monthly	None

*Beneficiaries of the Mexican Institute of Social Security program (active registered employees) for different sectors.
**The produce considered for this variable is broccoli, cauliflower, and lettuce (iceberg and romaine).

Once the resolutions (time frames) for the variables are consistent, the next step is to determine the length of history for the analysis. One should use the data that can provide a satisfactory representation of future behavior. Therefore, a historical plot of each of the variables was used in order to isolate any one time or unusual changes in the data that could affect the behavior and the reliability of the models being developed. One can observe that the events of September 11, 2001, have a drastic effect on the behavior of most of these variables, as discussed in Working Paper 1.

Therefore, in order to better represent future interactions between these variables, it is best to omit time frames that may be affected by extraordinary events. The selected window of time to use for this project's analyses starts from March, 2002 to May, 2011.

Data collected over time often reflects both long term trends and seasonality. In this case, the interest of this study lies in determining the effect of the variables on the number of border crossings by transportation mode. Thus, the analysis focused mainly on the effect of the variable changes by only using the first-order differentials (or month-to-month changes). This "differencing" filters out much of the dependency of the variables on characteristics like trend and seasonality. Ultimately, the regression analysis for selecting the external factors is performed based on the relationship between the changes of the independent variables and the changes of the dependent variable (Truck, POV, and Pedestrian crossings).

Sub-Selection of External Factors per Mode of Transportation

The initial selection of the external factors was performed primarily based on general and empirical knowledge of the area. However, this knowledge does not mean that there *is* in fact a strong relationship between the external factors and the number of border of crossings. For this purpose, the data pre-process should also be used to identify those factors whose time series have the highest correlation with historical border crossings data. This correlation must also consider any lag that may exist, since one cannot assume that changes in one factor immediately affect the other.

Table 3.2 shows the correlation of the external factors with the number of border crossings by mode of transportation. Since the analysis is performed on the first-order differentials of the data, these values represent the correlations between the monthly changes of each external factor to the monthly changes in the number of border crossings. Additionally, as mentioned previously, the lag that exists in the correlation between these variables must be accounted for. In Table 3.2 each factor is represented by its acronym shown in Table 3.1; its highest correlation with the response variable; and the months of lag at which this correlation occurs. Finally, one must note that if a negative lag was chosen; this means that a change in the value of the external factor precedes a variation in the number of border crossings.

TABLE 3.2: HIGHEST LAGGED CORRELATION PER EXTERNAL FACTOR

Mode	Variable/Correlation Level/Lag				
PED	ss/0.231/-5	sspp/0.164/-2	sspec/0.272/-5	ssf/0.167/0	ssc/0.231/-4
	sst/0.197/-5	sss/0.219/-8	sso/0.263/-4	gold/0.195/0	goldp/0.127/-4
	silv/0.256/-6	crim/0.211/-6	murd/0.214/-5	drug/0.241/-7	piaz/0.224/0
	caz/0.227/0	waz/0.227/0	iipm/0.071/-6	cpim/0.506/-11	gdpm/0.288/-3
	iipu/0.477/-9	cpiu/0.287/-6	gdpu/0.223/0	dslp/0.141/-6	gasp/0.244/-7
	piu/0.180/-12	exch/0.188/0	agri/0.595/0		
POV	ss/0.143/-6	sspp/0.228/-6	sspec/0.241/-3	ssf/0.182/-3	ssc/0.109/-1
	sst/0.127/-6	sss/0.179/-10	sso/0.227/-2	gold/0.166/-7	goldp/0.193/-1
	silv/0.195/-6	crim/0.191/-1	murd/0.208/-5	drug/0.101/-10	piaz/0.048/0
	caz/0.050/0	waz/0.050/0	iipm/0.078/-3	cpim/0.200/-1	gdpm/0.146/-5
	iipu/0.424/-7	cpiu/0.134/-7	gdpu/0.048/0	dslp/0.146/-7	gasp/0.147/-8
	piu/0.162/-10	exch/0.088/-9	agri/0.369/0		
TRK	ss/0.269/-5	sspp/0.386/-4	sspec/0.219/-8	ssf/0.242/-1	ssc/0.297/-3
	sst/0.233/-5	sss/0.186/-11	sso/0.156/-7	gold/0.254/-10	goldp/0.120/-6
	silv/0.248/-9	crim/0.258/-4	murd/0.120/-3	drug/0.114/-8	piaz/0.304/0
	caz/0.305/0	waz/0.305/0	iipm/0.085/-8	cpim/0.510/-11	gdpm/0.354/-3
	iipu/0.337/-9	cpiu/0.262/-6	gdpu/0.302/0	dslp/0.177/-7	gasp/0.277/-7
	piu/0.116/-10	exch/0.284/-12	agri/0.595/-0		

From the Table 3.2, one can observe that there are variables that have higher lagged correlation levels for the different modes of transportation. For the purpose of this study, those variables with correlations higher than **0.20** are used as the candidate factors (in **bold**) for explaining the variability in the number of border crossings. These external factors are selected for further analysis.

Regression Analysis of Candidate External Factors

In order to determine the factors that most affect the number of border crossings, regression analysis is performed on the lagged time-series for the candidate variables. As explained earlier, these variables are represented as the first-order differentials. Thus, the regression analysis helps identify those factors whose changes in value are most strongly associated with the changes observed in the number of border crossings by transportation mode. Once the primary factors are identified, the data values are transformed back to their original values to develop the forecast models.

Regression models are constructed based on the basic rules of regression analysis, which include constraining to the basic assumptions of linearity such as the normality and constant variance in fitted versus actual plots, as well as independence of time. The objective of this analysis is to identify the combination of factors that ultimately can explain the variability in the number of border crossings. The null hypothesis for each variable in the model states that if rejected, the probability of having done so in error should be less than 5%. Additional considerations in the model construction process include identifying outlier value points and reducing the *multicollinearity* between the selected variables.

Table 3.3 summarizes the final regression model developed by transportation mode. As mentioned earlier, since the data is transformed to its first-order differentials, this model represents the changes in the number of border crossings as a response to the changes in each factor in the model. In the right-most column is the adjusted R^2, which represents the variability in the response explained by the model. In other words, 35.7% of the variability in the changes of truck border crossings is represented by the factors in the model. The models for POV and Pedestrian crossings show that 27.0% and 39.5% variability observed in the border crossings' month-to-month fluctuations respectively.

TABLE 3.3: FINAL REGRESSION MODEL (FIRST-ORDER) BY TRANSPORTATION MODE

Border Crossing Mode	Regression Model Coefficients*LAG	R^2 adj
ΔPED	4997 * ΔIIPU-9 + 0.2519 *ΔAGRI0	39.5%
ΔPOV	3090 * ΔIIPU-7 + 0.08763 *ΔAGRI0	27.0%
ΔTRK	361 * ΔEXCH-12 + 0.00563 *ΔAGRI0	35.7%

These R^2 values are considered satisfactory considering they represent the users' decisions through economic and demographic factors. They are deemed acceptable for potential consideration in the development of the predictive models. These variables are used as external factors for making future border crossing forecasts. The factors are summarized again in Table 3.4.

TABLE 3.4: MAIN IDENTIFIED DRIVERS OF TRANSPORTATION CROSSINGS BY MODE

Border Crossing Mode	External Factors with High Correlation To Border Crossings
Pedestrian	Index of Industrial Production in the United States (nine-month lag) Main Agricultural Production in Yuma County, AZ (no lag)
Privately-Owned Vehicle	Index of Industrial Production in the United States (seven-month lag) Main Agricultural Production in Yuma County, AZ (no lag)
Truck	MXN/USD Exchange Rate (twelve-month lag) Main Agricultural Production in Yuma County, AZ (no lag)

Forecasting Models

Once the main factors were identified by the correlation/regression analyses, the next step is to build the forecasting models for the main transportation modes using the San Luis I LPOE, AZ. Following the methodology presented in the previous section, the forecasting modeling of the port traffic volumes focuses on the following main activities:

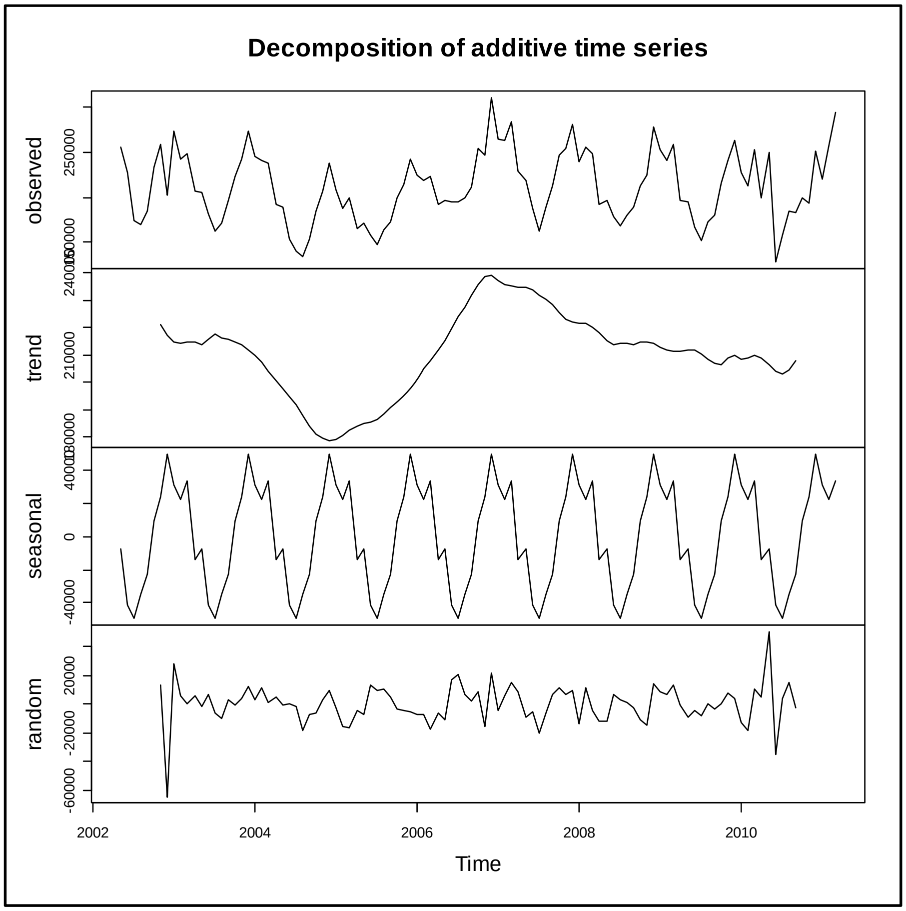
1. **Testing and determination of the best forecast method for the external drivers.** This activity searches for different ways to forecast the macro and micro economic factors identified as main drivers of the transportation mode behavior. The methods tested rely on a variety of statistics and probabilistic tools and are all based on the available historical data.
2. **Testing and determination of the best forecast method for each transportation mode**. This step is required to consider the different factors that can be used for the forecast (i.e. seasonal behavior, external drivers, historical data, breakpoints, or the combination of these). In the same fashion as for the drivers' forecasts, several statistical and probabilistic tools are explored for the best results. This test considers model stability and ease of approach. A method that is both easy to apply, easy to interpret and with acceptable results is preferred.
3. **Design and validation of different forecast scenarios.** The last part of the forecast activities consists of combining the results of the previous steps. This exercise focuses on having specific volumes for each of the time windows and growth scenarios. This provides a quantitative projection that can work as a reference for comparisons and as an input for future simulation models.

These activities are essential to estimate the future traffic volumes at the San Luis I LPOE, AZ. The volumes are to be confined to the time frames considered for this project, which are 5, 10 and 20 years. As in any statistical analysis, the forecasted data is based on confidence intervals and must be used with caution and with an understanding of the underlying assumptions. The next subsections discuss the aforementioned steps taken for each transportation mode at the LPOE. The algorithms and work related to these activities were developed by the consulting team and coded in the open source software "The R Project for Statistical Computing" (R Development Core Team 2008).

Pedestrian

The pedestrian traffic at the San Luis I LPOE, AZ is considered one of the crossing modes with the highest demand. The pedestrian crossing volumes at this LPOE represent nearly 30% of the total Arizona's pedestrian border crossing volume. In 2010 San Luis pedestrian volumes were ranked #2 among Arizona's LPOEs and #11 among the entire Mexican-U.S. ports of entry. In the past few years, it has been following a relatively steady trend with a significant seasonal behavior. This periodic behavior constitutes an approximate +/- **25%** of the average monthly volume. Figure 3.1 shows a decomposition of the pedestrian crossings from the available time series data.

FIGURE 3.1: PEDESTRIAN CROSSING VOLUMES DECOMPOSITION



In Figure 3.1 one can observe the trend, seasonal and random components of the pedestrian traffic considered in the forecast. The relevance of this decomposition is discussed in the following sections.

External Drivers related to Pedestrian Traffic

The factors highly related to the Pedestrian traffic were shown in the Table 3.3. These factors could be interpreted as how pedestrian traffic at San Luis I LPOE, AZ reacts mostly to changes in the main agricultural production levels in Yuma County, AZ and to the U.S. Index of Industrial Production. Therefore, the first step in the forecast method is to define forecast scenarios for each of these drivers.

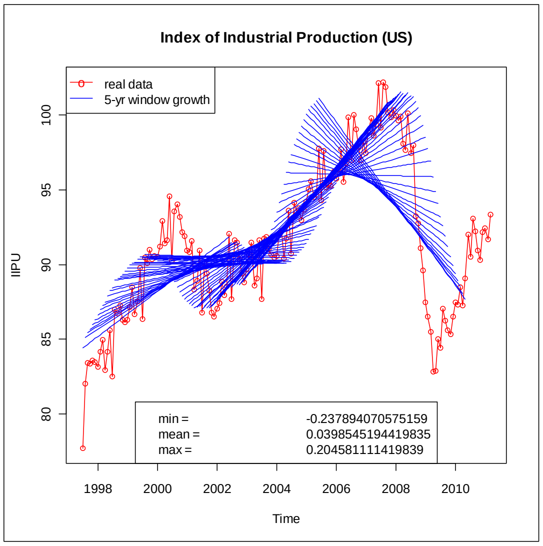
Several forecast techniques were tested for the different drivers depending mostly on their stationary behavior. For those drivers that presented high uncertainty associated with long forecast time windows, the best technique was based on the analyses of the gains (or losses) of magnitude of each driver known as *binomial lattice analysis*. In this technique, the driver's data (external factor) is tested for a 5-year window, and the observed gains are extrapolated to a monthly gain.

In turn, these gains were fitted into a binomial behavior to identify the probability of a positive or negative gain. For drivers showing highly seasonal behavior, such as the agricultural production in Yuma

County, a different forecasting technique was used. Auto-regressive models (ARIMA) that consider simple moving averages and specific periodic components showed better results.

Figure 3.2 shows the 5 years decomposition of the U.S. Index of Industrial Production on the left while the right plot shows its binomial lattice forecast. On the other hand, Figure 3.3 shows the ARIMA predictions for the agricultural production in Yuma AZ. These are the identified main drivers of the pedestrian crossings at the San Luis I LPOE, AZ.

FIGURE 3.2: GAIN ANALYSES AND LONG TERM FORECAST FOR THE IIPU



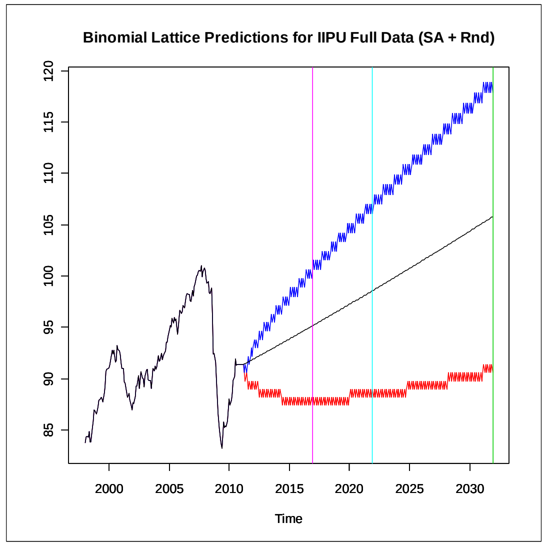
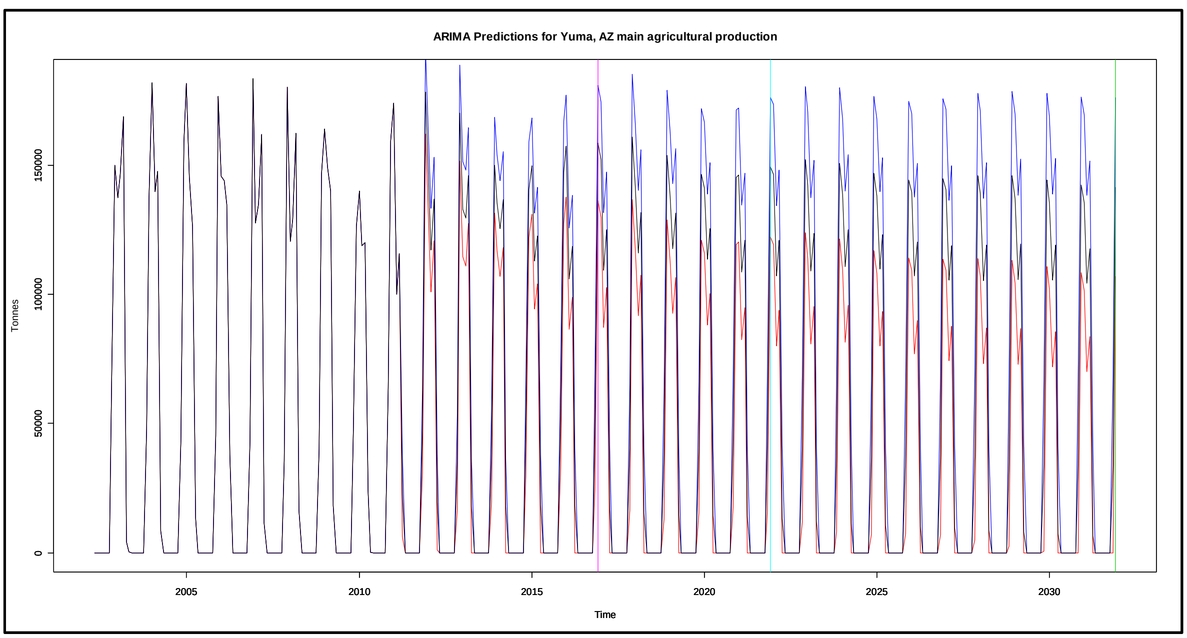


FIGURE 3.3: LONG TERM FORECAST FOR YUMA COUNTY, AZ AGRICULTURAL PRODUCTION



The different factors shown in the figures present three levels of prediction. Since it's a very challenging task to have a certain value for each prediction, the aforementioned levels refer to three different behaviors: the optimistic shown in a blue line (represent the high 85% confidence interval of the predictions), the expected shown in a black line (represent the mean of the predictions) and the pessimistic shown in red (which represents the lower 85% confidence interval of the predictions). These form the different scenarios that will define the upper and lower bounds of the transportation crossing modes. The forecast numbers for these drivers by each prediction level are shown in Table 3.5.

TABLE 3.5: FORECAST FIGURES FOR DRIVERS OF PEDESTRIAN AND POV CROSSINGS

United States Index of Industrial Production (IIPU)						
Level	+5 years		+10 years		+20 years	
	Jan 2017	% Increment	Jan 2022	% Increment	Jan 2032	% Increment
Hi 85	101.53	12%	107.02	18%	117.88	30%
Expected	95.22	5%	98.64	8%	105.80	16%
Lo 85	87.45	-4%	88.22	-3%	90.57	0%

Main Agricultural Production Levels in Yuma County (AGRI)						
Level	+5 years		+10 years		+20 years	
	2016-17	% Increment	2021-22	% Increment	2030-31	% Increment
Hi 85	721,241	25%	735,552	28%	745,047	29%
Expected	600,310	4%	578,649	0%	540,114	-6%
Lo 85	483,429	-16%	434,698	-25%	363,483	-37%

The Pedestrian Traffic Forecast

The next step considered several forecast methods to obtain the best fit. As mentioned before, several tools were explored. Some included binomial trees, auto-regressive models, exponential smoothing and dynamic regression models. Having the pedestrian crossing mode a highly seasonal behavior, the auto-regressive models with external drivers (called ARIMA models w/exogenous factors) presented the most stable model for long-term predictions. The ARIMA models consider the response of pedestrian traffic crossing the border to its own seasonal and average behavior plus the external drivers mentioned in the previous sub-section. These models test the lagged response as well, which means that this response may not be immediate and may take some time to respond. Once the forecasts of the external drivers were defined, they are then fed into the ARIMA model. The response of the model is presented in the Figure 3.4.

FIGURE 3.4: SHORT-, MID- AND LONG-TERM FORECAST FOR PEDESTRIAN TRAFFIC

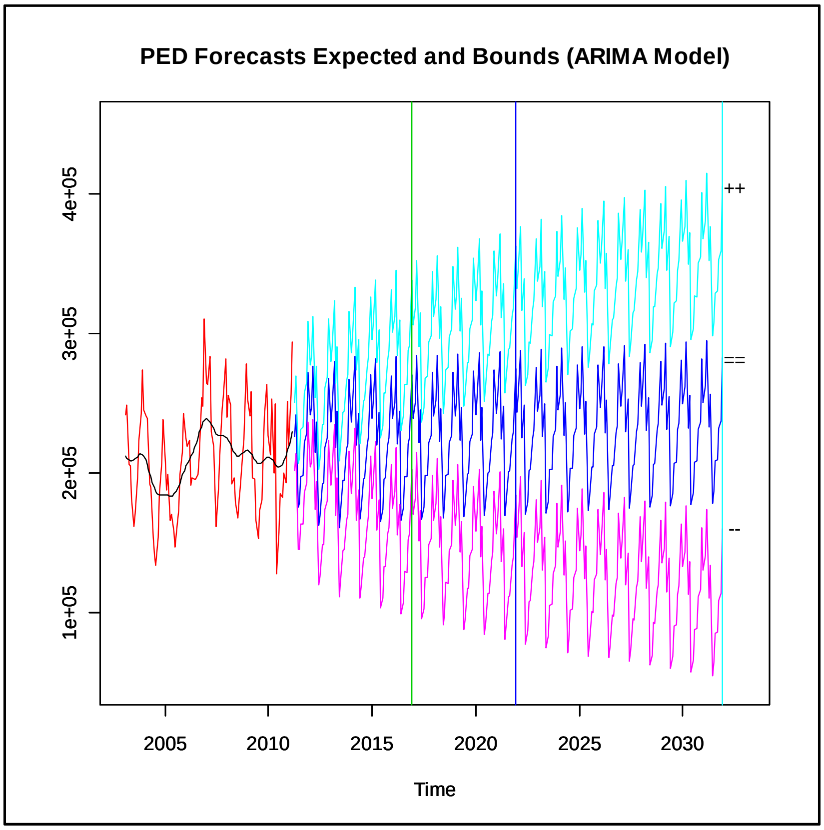


Figure 3.4 shows the upper and lower bounds, as well as the expected values of the prediction. These bounds are defined from the combination of the three factors scenarios: pure **optimistic** scenario (shown with "**+**" signs); pure **expected** scenarios (shown with "**=**" signs); and the more **pessimistic** scenarios (shown in "**–**"signs). Table 3.6 shows the yearly average pedestrian crossing for each time frame.

TABLE 3.6: FORECAST FIGURES FOR PEDESTRIAN CROSSINGS

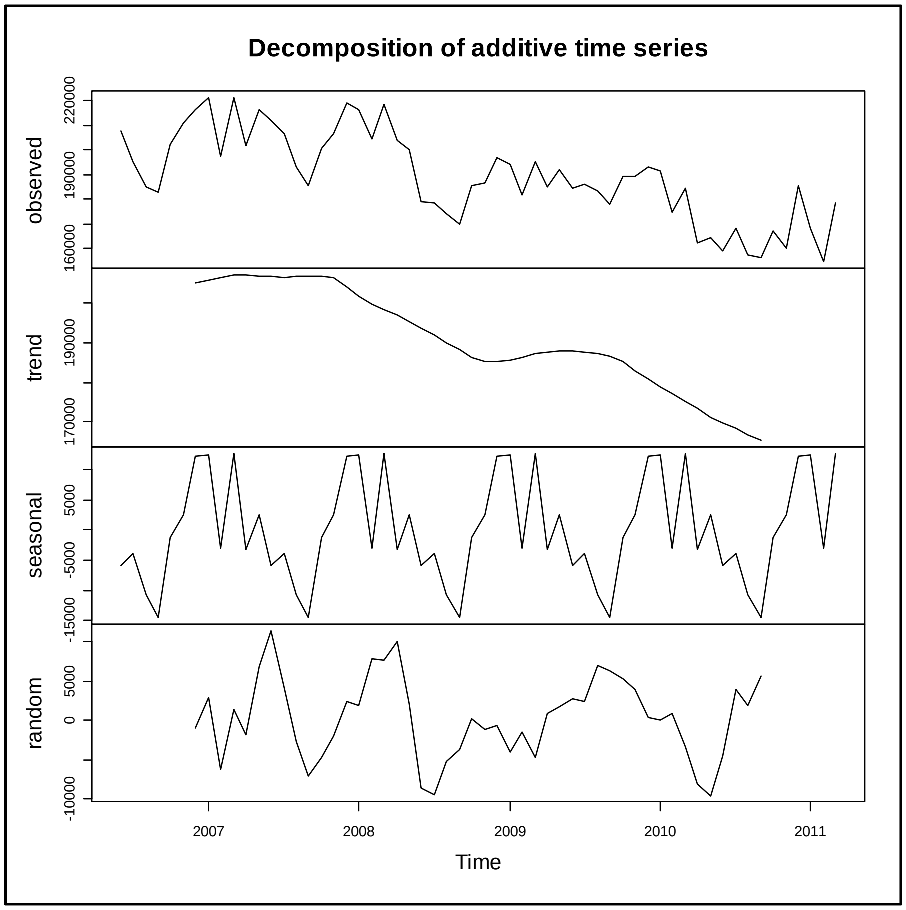
Pedestrian Border Crossing (PED) - Monthly						
Level	+5 years		+10 years		+20 years	
	2017	% Increment	2022	% Increment	2032	% Increment
Hi 85	294,944	38%	319,711	50%	356,321	67%
Expected	224,981	6%	228,724	7%	235,969	11%
Lo 85	153,078	-28%	136,117	-36%	113,409	-47%

It is important to mention that a similar methodology was used for the POV and commercial traffic. Certainly the external drivers are somewhat different, but some are shared and tested in the same fashion. The next part of this section presents the external drivers forecast and predictions for both POV and commercial traffic.

Privately owned vehicles (POV)

The POV traffic presents the highest volumes as expected. Nevertheless, the last few years show a reduction in the monthly volumes. This negative trend is rather noticeable as compared to the pedestrian traffic reduction. The decomposition of the POV volumes is shown in Figure 3.5. One can observe that the seasonal component is not as obvious as expected, and the negative trend is more noticeable as well.

FIGURE 3.5: POV CROSSING VOLUMES DECOMPOSITION



External Drivers related to POV Traffic

In the same fashion as the Pedestrian traffic explored in the previous sections, POV traffic at the San Luis I LPOE, AZ reacts to changes in the main agricultural production levels in Yuma County, AZ and to the U.S. Index of Industrial Production. The main difference is that the lag used for the IIPU in the POV forecast is set to -7 months, while the IIPU lag for the pedestrian model is -9 months. The same forecast method is used with these factors and the results are shown in Figure 3.2 and Figure 3.3.

The POV Traffic Forecast

Privately owned vehicles show mostly a trend behavior and not much of a noticeable seasonality. Due to this specific behavior, dynamic regression models are used to create the predictions for the POV traffic for the short-, mid- and long-range time frame. These dynamics models are similar to those shown in Section 2. These models do not consider specific seasonal nor trend components, but are based merely on the external components discussed in the previous subsection.

The model is fed with the predicted data from the forecasts of the agricultural and industrial production models. Figure 3.6 shows the upper and lower bounds as well as the expected crossings behavior once the external drivers' optimistic, pessimistic and expected scenarios are reflected in the prediction model.

FIGURE 3.6: SHORT-, MID- AND LONG-TERM FORECAST FOR POV TRAFFIC

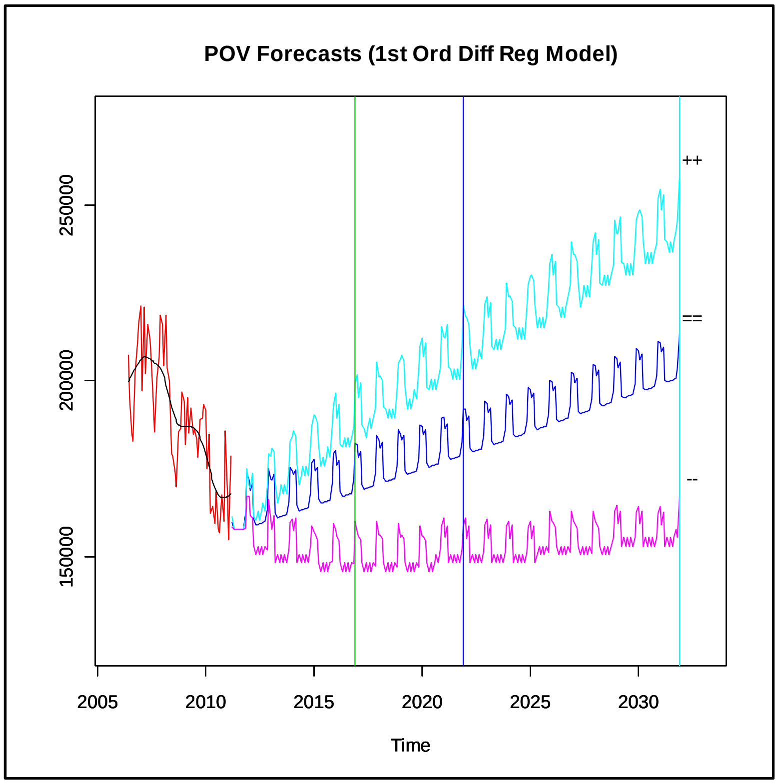


Figure 3.6 shows the upper and lower bounds, as well as the expected values of the prediction. As for the Pedestrian mode predictions, these bounds are defined from the combination of the three factors scenarios: pure **optimistic** scenario (shown with "**+**" signs); pure **expected** scenarios (shown with "**=**" signs); and the more **pessimistic** scenarios (shown with a "**–**"sign).

Table 3.7 shows the forecasted POV yearly average crossing volumes by time frame and level.

TABLE 3.7: FORECAST FIGURES FOR POV BORDER CROSSINGS

Privately Owned Vehicle Border Crossing (POV) - Monthly						
Level	+5 years		+10 years		+20 years	
	2017	% Increment	2022	% Increment	2032	% Increment
Hi 85	191,909	15%	211,153	27%	244,639	47%
Expected	173,862	4%	184,248	10%	203,936	22%
Lo 85	150,340	-10%	152,417	-9%	157,598	-6%

Commercial Crossing

Since San Luis II LPOE, AZ has only been operational for two years, not enough data is available to perform meaningful analyses of the commercial crossings at this location. Hence additional data from San Luis I LPOE, AZ prior to 2011 was also utilized for these analyses.

The commercial traffic at San Luis I LPOE, AZ is rather high once compared to the other Arizona's ports of entry. In 2010, it was ranked #2 among Arizona's LPOEs with 12% of the traffic entering the State and #13 among the entire Mexican-U.S. commercial ports of entry. Since the San Luis II commercial port of entry started operations, the commercial transit does not currently congest the immediate areas. Overall, CBP does not report heavy waiting times or outstanding transit-related issues for this border crossing mode. Nevertheless, as part of the study, a traffic forecast was also developed to have an overview of the expected volumes for the short-, mid- and long-term.

The data available for commercial trucks was decomposed in the similar way as the pedestrian and POV data. Showing a different behavior, the commercial traffic is extremely seasonal and does not show a specific trend as the other border crossing modes. These behaviors can be observed in Figure 3.7 where the data time components of the crossing trucks are shown. The trend factor is rather small in magnitude, while the seasonal component shows approximate deviations of **-20%** to **+30%** of the observed average.

External Drivers related to Commercial Truck Traffic

As mentioned in the previous sections, the commercial traffic in the San Luis I LPOE, AZ reacts mostly to changes in Mexican Peso/U.S. Dollar exchange rate and to the main agricultural production levels in Yuma County, AZ. These drivers were explored and forecasted in similar way using binomial lattice method for the exchange rate and ARIMA models for the agricultural data. Figure 3.8 shows the 5 year gain analyses for the MXN/USD exchange and the binomial lattice forecast outcome, while Table 3.8 shows the forecast for this driver.

The agricultural forecast is the same as shown in Figure 3.3 and Table 3.5.

FIGURE 3.7: COMMERCIAL CROSSING VOLUMES DECOMPOSITION

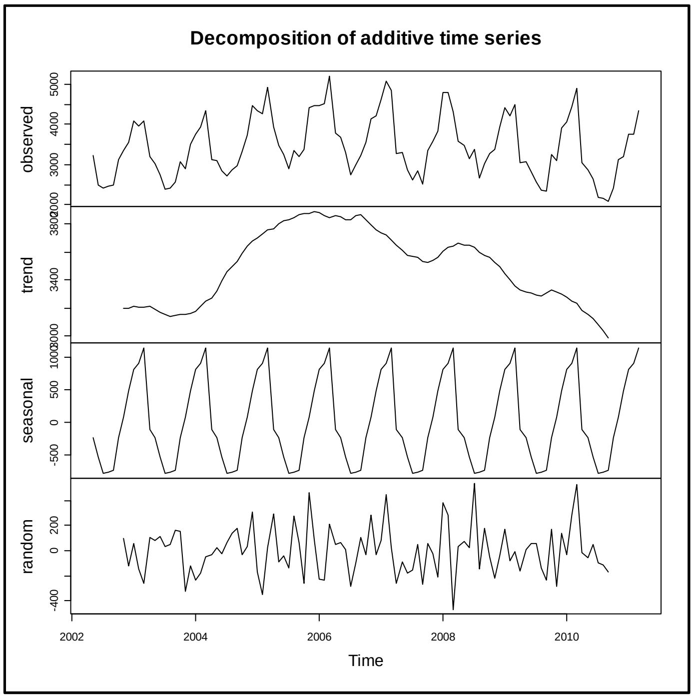


FIGURE 3.8: GAIN ANALYSES AND LONG-TERM FORECASTS FOR THE MXN/USD EXCHANGE RATE

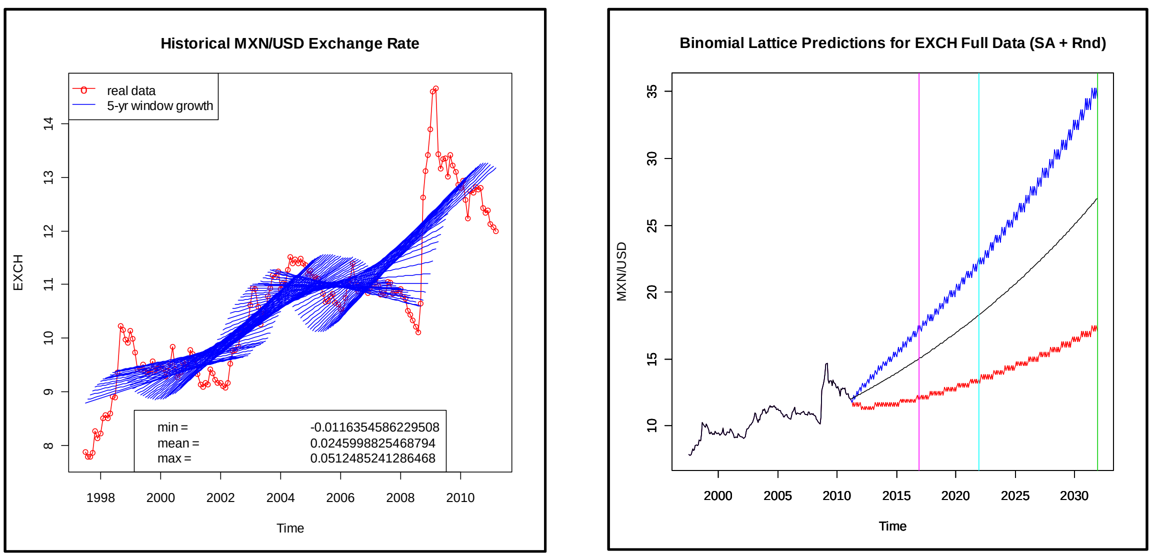


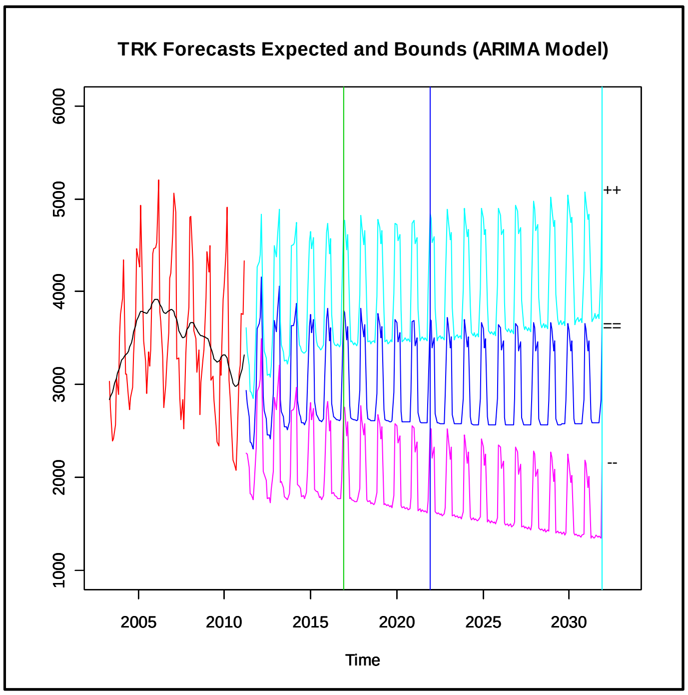
TABLE 3.8: FORECAST FOR DRIVERS OF COMMERCIAL CROSSINGS

MXN/USD Exchange Rate (EXCH)						
Level	+5 years		+10 years		+20 years	
	Jan 2017	% Increment	Jan 2022	% Increment	Jan 2032	% Increment
Hi 85	17.46	46%	22.08	84%	34.47	187%
Expected	15.07	26%	18.33	53%	27.02	125%
Lo 85	12.00	0%	13.18	10%	17.06	42%

The Commercial Traffic Forecast

As the pedestrian mode, the commercial mode is highly seasonal. For this reason, the forecast for commercial trucks using the San Luis II LPOE, AZ was modeled with the auto-regressive tools with external drivers (ARIMA models with exogenous factors). Using the data input from the previous step where the external drivers were forecasted, these optimistic, pessimistic and expected truck crossing volume predictions are developed. Once the forecasts of the external drivers were defined, they are fed into the ARIMA model. Figure 3.9 shows the predicted behavior for the commercial traffic in the San Luis II LPOE, AZ.

FIGURE 3.9: SHORT-, MID- AND LONG-TERM FORECAST FOR COMMERCIAL TRAFFIC



The figure above shows the upper and lower bounds, as well as the expected values of the prediction. As in the same way as the previous predictions, these bounds are defined from the combination of the three factors scenarios: pure optimistic scenario (shown with "+" signs); pure expected scenarios (shown with "=" signs); and the more pessimistic scenarios (shown in "–" signs). Table 3.9 shows the expected crossing quantities for each prediction time frame and scenario.

TABLE 3.9: FORECAST FIGURES FOR TRUCKS BORDER CROSSINGS AT SAN LUIS II LPOE, AZ

Commercial Trucks Border Crossing (TRK) - Monthly						
Level	+5 years		+10 years		+20 years	
	2017	% Increment	2022	% Increment	2032	% Increment
Hi 85	3,919	26%	3,969	27%	4,196	35%
Expected	3,013	-3%	2,948	-5%	2,925	-6%
Lo 85	2,067	-34%	1,880	-40%	1,594	-49%

4. CONCLUSION

The activities reported and discussed throughout this document consider the analytical aspect of the project. This analytical aspect focuses mostly on San Luis I LPOE, AZ as an entity-flow system, where several engineering tools were used to provide interesting and useful results. A critical milestone of this task was the update of the border crossing volumes data provided by U.S. Customs and Border Patrol Field Office and was instrumental in conducting a more in depth analysis. The update consisted of detailed volume and waiting time information for the main border crossings modes at the San Luis I LPOE, AZ containing hourly data for a full year worth of border activity.

After updating the information and revisiting certain tasks performed in the previous phases, the team was able to present additional analyses. This review focused on identifying different traffic patterns for the pedestrian and privately owned vehicles; the results show that crossings behaviors are function of different seasonal factors. For instance, the traffic volumes for privately owned vehicles change throughout the day differently for Sundays than for the rest of the week; on the other hand, the pedestrian traffic changes throughout the day and also by the month of the year. Not only pedestrians cross the border at different times during Sundays, Mondays, and the rest of the week; but also cross at different times from December to March, then from April to September, and from October to November. Other factors, such as business hours and lunch time are more consistent throughout the observations. This seasonal traffic behavior is highly related with the agricultural and industrial activities of the region, which means these segments had to be studied separately since different segments have different users' behaviors at the same hour of the day. Therefore, this segmentation was used for the analytical queuing models activities.

The results obtained from the queuing system analytic activities provide an overview of the current conditions (how the current capacities meet the current demands) and how these conditions are measured from the users' waiting times and queue lengths perspectives. For the POV border crossing mode, the results show that the LPOE is constantly at full capacity. At the time of the analyses, the six (6) available booths for POV inspection provided an average service rate of 4.04 vehicles per minute during a 24 hours period. The estimated length of the queues in the POV area reaches an average above the 0.60 miles in the busiest times; however in 2010 the longest estimated queue was approximately 1.80 miles long. As a complement to these analyses, the average queues were measured in terms of their impact on the economy and environment in the region. After certain assumptions were considered, which were discussed in their specific section, estimations such as gas consumption and CO_2 emitted from the queuing vehicles were compared with other congested areas. Overall, the estimations show that the idle vehicles in the San Luis I LPOE, AZ produced 8.2 million pounds of CO_2 in 2010, which equals approximately 68 pounds per car in the region.

For the pedestrian traffic, similar analyses were conducted using available data. As the pedestrian border crossing behavior is more seasonal than the POV, the port capacity changes as a function of the demand. The average system service rate for the pedestrians at the LPOE ranged from 2.5 to upmost 11.5 people per minute depending on the timeframe. Pedestrian queues were evaluated using a specific Level of Service schema and it was found that an "E" and "F" level is observed mostly during the day.

These levels are determined from the relationship between the pedestrian's arrivals per minute to the queue and the service rate of the system. Overall, pedestrian throughput is really restricted and there is an unavoidable congestion between users.

Having determined the current conditions of the San Luis I LPOE, AZ border crossings, the next step was to establish the future demand and evaluate the port capacity. Creating these scenarios is basic for the underlying objective of the study, since it will allow testing the current port capacity under predicted future traffic demands. Even though the focus of the study sets on the congested POV and pedestrian crossing modes, the commercial truck was also considered and the future volume forecasted. The results show that the truck crossing volumes at San Luis II LPOE, AZ have a certain relationship with the United States industrial production levels, the Mexican Peso/U.S. Dollar exchange rate, and the agricultural production levels in the immediate Arizona region. Working with these factors as external drivers of the traffic and following certain assumptions, the estimations for future volumes were predicted. The predictions done over the three different time periods included the expected behavior, as well as an optimist and pessimist trend scenarios.

The resulting forecasts from the Pedestrian and Commercial border crossing modes are rather seasonal and stationary, while the POV mode follows the drivers' trends more closely. In general terms, the pedestrian traffic through the port follows closely the agricultural seasons and the expected volumes are rather stationary in the short-, mid- and long-term. Commercial traffic behaves similarly to the pedestrian volumes in terms of seasonality, but does not show a noticeable increment in the predicted terms. The POV mode, on the other hand, is more sensitive to the trends of the industrial production levels; therefore the POV volume's predictions show an expected increasing trend rather than a stationary behavior.

Overall, the volumes' predictions were discussed in detail throughout the document. In conclusion, the analytical stage of the study helps support the results that pedestrian and POV traffic through the San Luis I LPOE, AZ are expected to increase. A very preliminary review of the current port operation is not sufficient to determine if the port infrastructures will be sufficient to address the future POV and pedestrian demand. The implementation of SENTRY and REDI lanes at the LPOE has improved service and wait times for the current conditions, but no evaluation was conducted for the future conditions.

On the other hand, the commercial traffic is expected to have more than sufficient installed capacity at San Luis II to satisfy future demand.

Although not part of the scope of this study, to complete the analysis, the forecasted volumes should be tested over the current San Luis I LPOE, AZ capacity, deficiencies should be identified (infrastructure or operations) and recommendations should be prepared to maximize the future LPOE utilization.

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