Draft Final Report

Economic and Air Quality/Climate Impacts of Delays at the Border

Volume 3: Emission Impact of Border Delay

San Diego, CA
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In Coordination with T. Kear Transportation Planning and Management, Inc.

Border Glossary and Acronyms

Aduanas	Administración General de Aduanas: Mexican customs agency.
APCD	Air Pollution Control District, regional agencies responsible for regional air quality planning and regulation in California.
BMPs	Best Management Practice: (strategies, policies, or projects) to reduce POE delay and emissions.
CARB	California Air Resources Board: State of California air pollution planning and regulatory agency.
CBP	United States (U.S.) Customs and Border Protection: the U.S. customs agency.
CO	Carbon monoxide.
CO2	Carbon dioxide.
Commercial vehicle STP	Scaled tractive power is the power delivered to the axel of a commercial vehicle normalized by an average weight for vehicles in that class. This parameter is closely related to passenger vehicle VSP.
Design day	Used to represent either worst case or average environmental and congestions conditions, for which emissions are to be quantified.
Diurnal emissions	Evaporative emissions from parked vehicles that are driven by the diurnal (daily) increase in temperature. Related to resting losses.
DPM	Diesel particulate matter.
Eagle scanner	A non-intrusive cargo inspection based on x-ray and/or gamma-ray imaging, similar to the VACIS.
EMFAC	The California Air Resources Board’s emission factor model for on-road motor vehicles. EMFAC2014 is the latest version approved by U.S. Environmental Protection Agency.
Emission control	Emission control is any device intended to limit the amount of pollution emitted by a vehicle, and include both after treatment devices such as exhaust catalysts and the computer systems that manage the combustion process.

FAST	Fast and Secure Trade, a trusted traveler/trusted shipper program allows expedited processing for commercial vehicles. This program is managed by the U.S. Customs and Border Protection.
FHWA	U.S. Federal Highway Administration: part of the U.S. Federal Department of Transportation.
FMM	Forma Migratoria Múltiple: A document issued by Mexico’s Instituto Nacional de Migración which allows U.S. and Canadian residents to travel beyond the 35-km border zone in Mexico.
Gantry	A non-intrusive cargo inspection based on x-ray and/or gamma-ray imaging which is more sophisticated than the VACIS and Eagle inspections.
GSA	U.S. General Services Administration.
ICTC	Imperial County Transportation Commission, which serves as the regional transportation planning agency for Imperial County, California.
I/M	Inspection and Maintenance (Smog Check) program.
INDAABIN	Instituto de Administración y Avalúos de Bienes Nacionales: Mexico’s federal agency which is responsible for the administration of federal property, similar to the General Services Administration (GSA) in the U.S.
LPOE	Land Port-of-Entry.
MOVES	USEPA on-road emission factor model (MOtor Vehicle Emission Simulator), MOVES2014a is the latest version.
NOx	Oxides of nitrogen.
Passenger vehicle VSP	Vehicle specific power is the power that a vehicle delivers to the road/divided by vehicle mass and represents instantaneous vehicle engine power. This parameter is closely related to commercial vehicle STP.
PM2.5	Particulate matter with diameter less than or equal to 2.5 micrometers.
PM10	Particulate matter with diameter less than or equal to 10 micrometers.

POE	See LPOE.
POV	Privately-owned vehicles (generally passenger vehicles).
Resting losses	Evaporative emissions that occur when a vehicle is parked, largely as a result of permeation of fuels and lubricants through vehicle components and off-gassing of vehicle components. Resting loss emissions are defined as only occurring when temperatures are declining. Related to diurnal emissions.
Running emissions	Running Emissions include both exhaust and evaporative emissions that occur when a vehicle is in use.
ROG	Reactive Organic Gases.
SANDAG	San Diego Association of Governments, which serves as the regional planning agency for San Diego County, California.
SEMARNAT	Secretaría de Medio Ambiente y Recursos Naturales, Mexico's federal agency responsible for environmental regulation.
SIDUE	Secretaría de Infraestructura y Desarrollo Urbano del Estado, Baja California agency responsible for transportation.
Soak time	Soak time is the length of time that a vehicle sits once it has been turned off, before it is restarted. It is important in determining starting emissions, resting losses, and diurnal emissions.
SPA	Secretaría de Protección al Ambiente de Baja California, the Baja California agency responsible for environmental regulation.
Starting Emissions	Starting emissions are additional emissions resulting whenever a vehicle is started. They vary based on the temperature of the engine and operating state of the vehicle's emission control system, which in term can be characterized based on "soak time".
STP	See commercial vehicle STP.
USEPA	U.S. Environmental Protection Agency.
VACIS	Vehicle and Cargo Inspection System: A non-intrusive cargo inspection based on x-ray and/or gamma-ray imaging, similar to the Eagle scanner.

Vehicle Activity Data	Quantifies the amount that a vehicle spends in different modes of operation and the distance traveled in each mode. Typically quantified as vehicle miles of travel (VMT), vehicle hours of travel (VHT), or soak time.
VMT	Vehicle miles of travel.
VHT	Vehicle hours of travel.
VSP	See passenger vehicle VSP.

Contents

1 Executive Summary (volume 3)

This volume of the Economic and Air Quality/Climate Impacts of Delays at the Border study report quantifies emissions at the land ports-of-entry (LPOEs). Six pollutants are covered for privately owned vehicles (POVs) and commercial vehicles:

- Carbon dioxide (CO2);
- Reactive Organic Gases (ROG);
- Oxides of Nitrogen (NOx);
- Particulate matter smaller than 10 microns in aerodynamic diameter (PM10);
- Particulate matter smaller than 2.5 microns in aerodynamic diameter (PM2.5); and
- Carbon Monoxide (CO).

Results are presented separately for San Diego County and Imperial County, across five scenarios spanning several strategies and analysis years (Table ES-1).

Table ES-1. Overview of analysis scenarios

2016 Analyses	2025 Analysis	2035 Analysis
Baseline 2016	Baseline 2025	
	Baseline 2025 plus Capacity Enhancements	
	Baseline 2025 plus Capacity Enhancements, Transit, and Active Transportation	Baseline 2035 plus Capacity Enhancements, Transit, and Active Transportation

These scenarios are detailed in section three of this volume. Broadly, the 2025 baseline and 2035 baseline include projects that are either funded, or were anticipated to receive funding. The capacity enhancement scenario and capacity enhancement plus transit and active transportation scenarios looked at the effect of projects that are still being planned, such as Otay Mesa East (OME), an expanded bridge over the All American Canal at Calexico East, and proposed transit improvements.

The basic framework for land port-of-entry (LPOE) emissions analyses will leverage approaches developed for the U.S. Federal Highway Administration (FHWA) and the U.S. – Mexico Joint Working Committee on Transportation Planning in the United States-Mexico LPOE Emissions and Border Wait-Time Analysis Template (JWC template)[1]. That process (see Figure 1 under section 2 of this volume), utilizes queue models to study each process at the LPOE, along with estimated demand for each lane type, to estimate how much delay and queuing POVs and commercial vehicles experience as they cross the border. The resulting estimates of vehicle activity are coupled with emission rates from the California Air Resources Board (CARB) EMFAC model, the United States Environmental Protection Agency (USEPA) MOVES model. and its adaption to Mexico, known as MOVES-Mexico.

[1] FHWA, United States-Mexico Land Ports-of-Entry Emissions and Border Wait-Time White Paper and Analysis Template. 2012.

Results for a typical weekly average day during the summer for POVs and commercial vehicles are show in figures ES-1 through ES-4 below. These figures report the CO2, ROG, and NOX emissions, pollutants whose significance lies in their contribution to pollution concerns on a county-wide scale. LPOE specific results for the remaining pollutants, and winter season emissions, are in the body of this report volume. Emissions estimates are presented per 1000 vehicles crossing the border so that the trends are not overwhelmed by changes in the volume of border crossers.

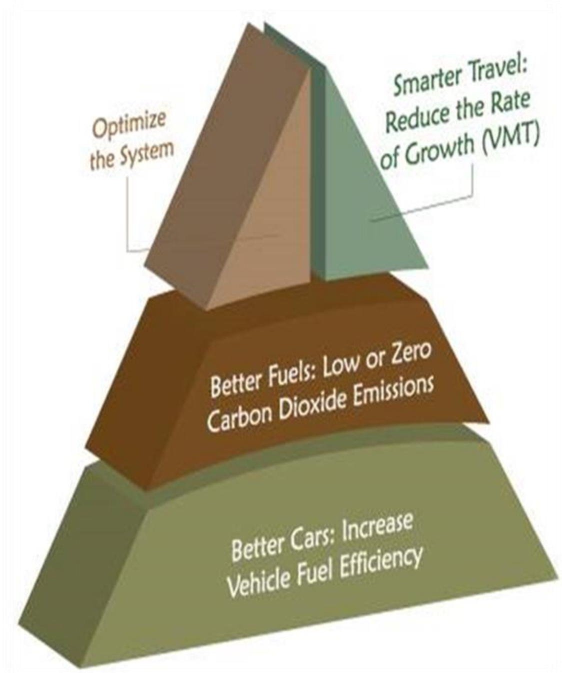


Figure ES-5. Emission Reduction Strategy Pyramid

Policy, strategy and project recommendations are considered within an overall hierarchy of emission reduction strategies (Figure ES-5)[2]. The base of the pyramid (cleaner, more efficient vehicles and better fuels) includes strategies that are already being implemented at regional, state and national scales

The analysis shows that the planned infrastructure improvements and policies to expand capacity are needed by 2025 and 2035 so that growing delay and queuing does not overwhelm emission reductions derived from the lower polluting, more efficient vehicles and fuels.

Specific recommendations that help reduce emissions by managing demand, minimizing delay, and promoting lower polluting, more efficient vehicles include (Table ES-2 through Table ES-6).

[2] CEC (2016) Reducing Air Pollution at Land Ports of Entry: Recommendations for Canada, Mexico and the United States, Montreal, Canada: Commission for Environmental Cooperation.

Figure ES-1. Summer Design Day CO2, ROG, NOx from POVs at San Diego County LPOEs

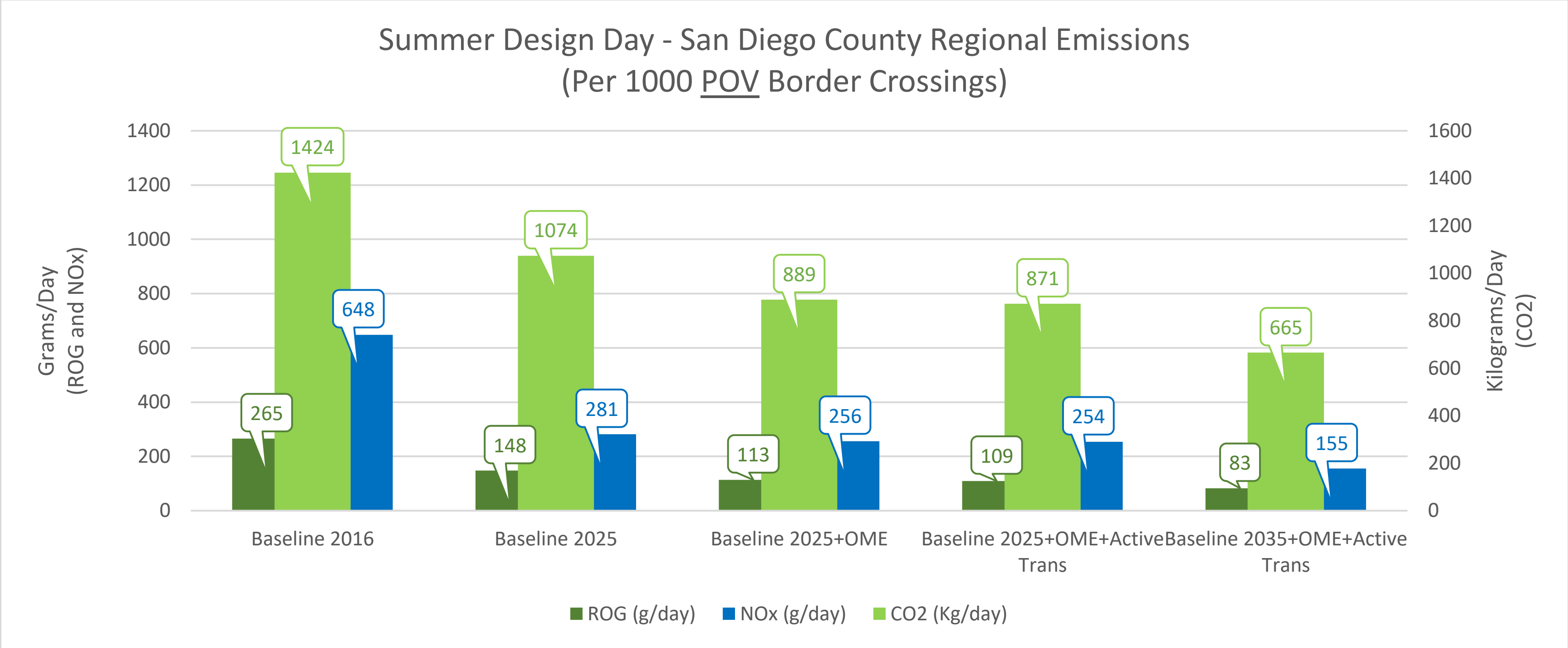


Figure ES-2. Summer Design Day CO2, ROG, NOx from POVs at Imperial County LPOEs

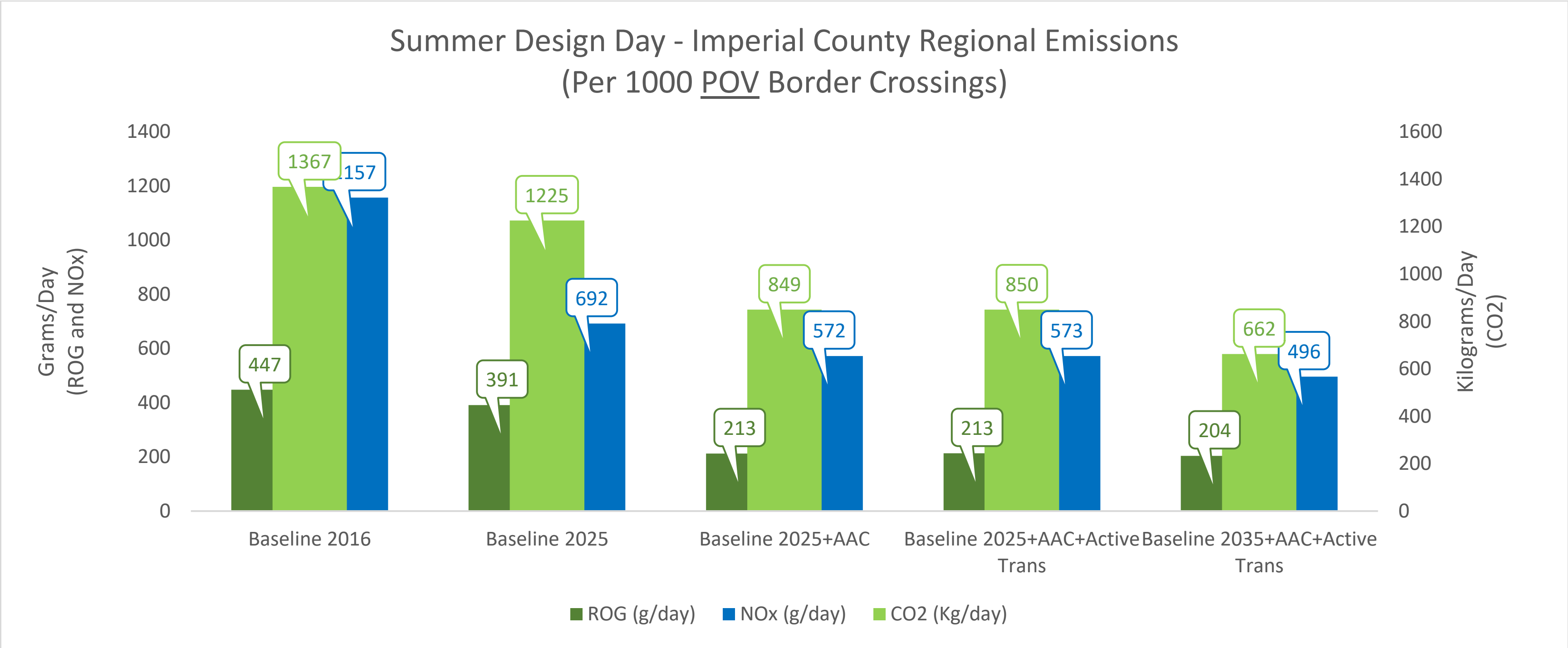


Figure ES-3. Summer Design Day CO2, ROG, NOx from Commercial Vehicle at San Diego County LPOEs

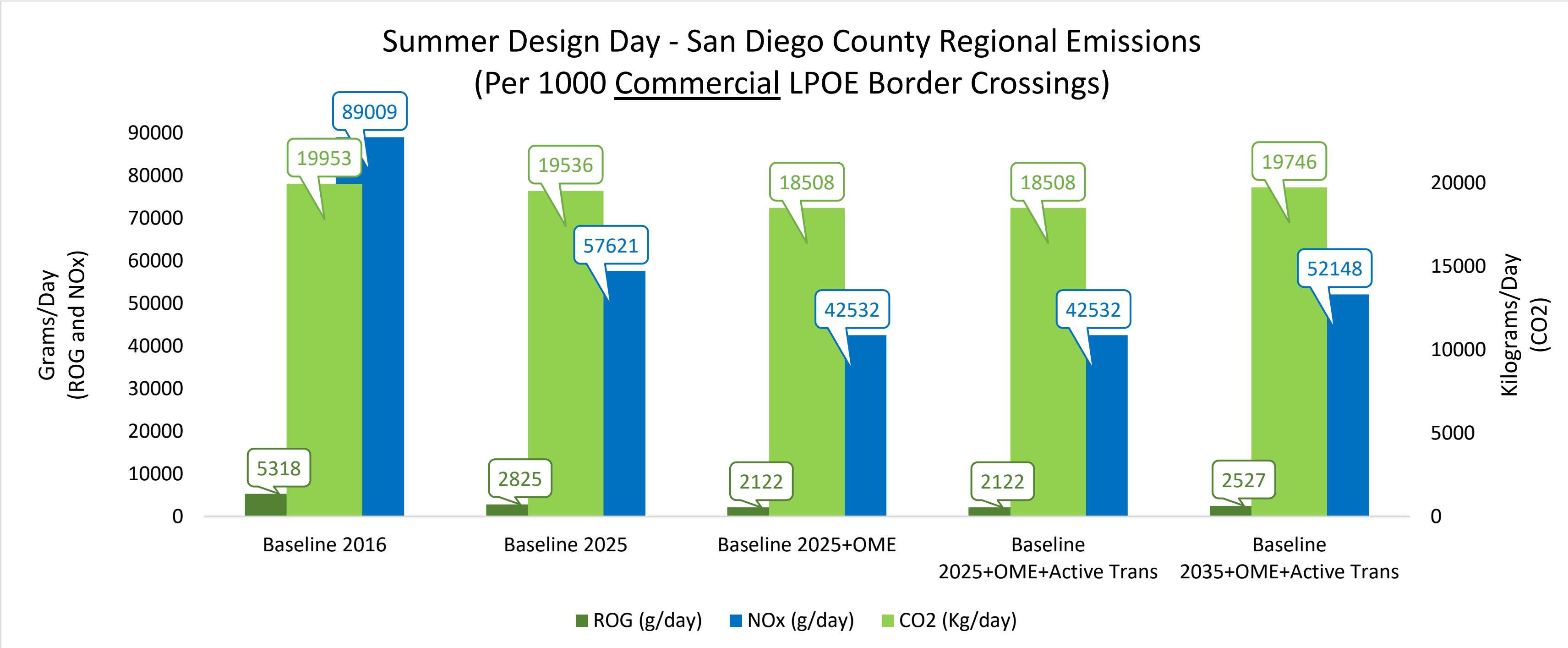


Figure ES-4. Summer Design Day CO2, ROG, NOx from Commercial Vehicle at Imperial County LPOEs

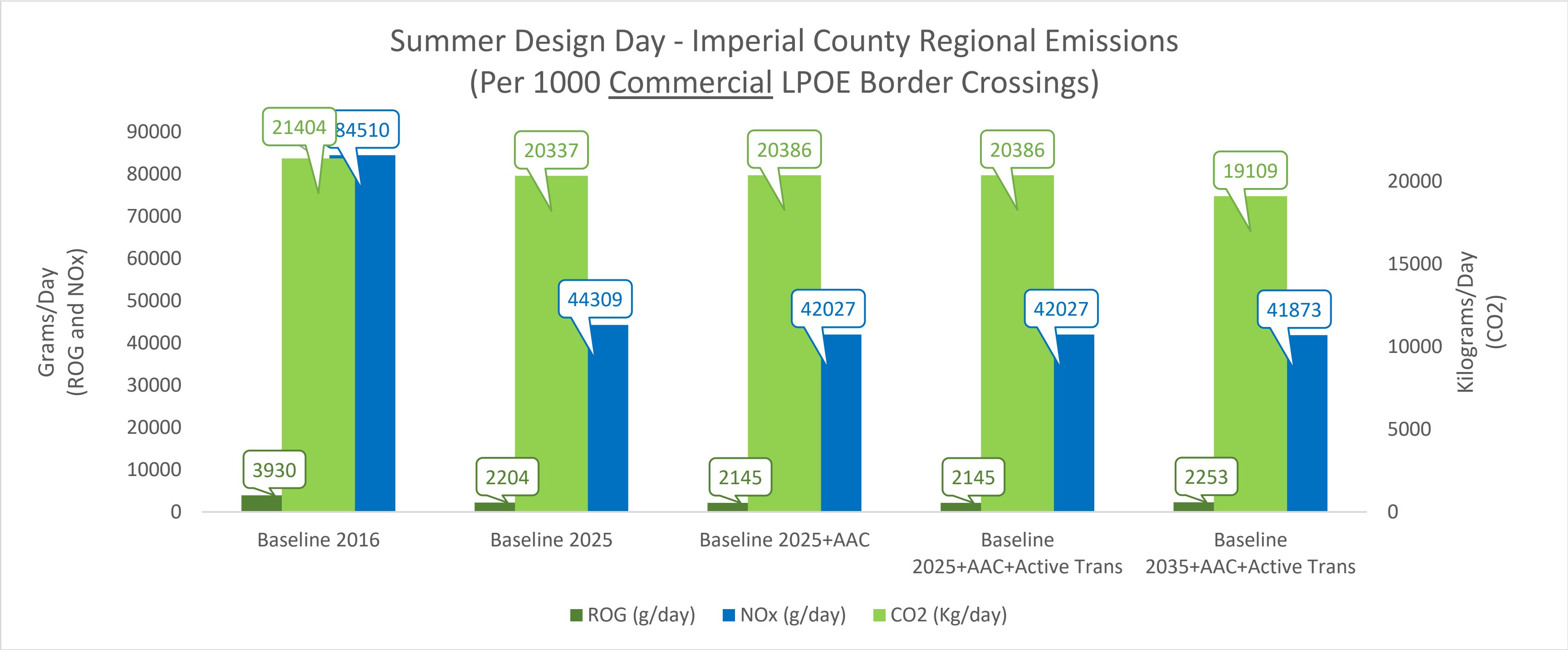


Table ES-2. Expansion of Physical Capacity at LPOEs:

Improvement	Impact on Wait Times	Impact on Modal Split
Additional lanes and booths for motorized vehicles • Phase 3 Improvements at San Ysidro, • Phase 1 and Phase 2 Improvements at Calexico West, Phase 1 Bridge Expansion over All-American Canal at Calexico East, and • Phase 2 Improvements at Calexico East	Reduces wait-times for motorized crossers in bi-national region	Minimal, but may increase share of motorized crossers
Additional lanes and booths for pedestrian crossers (Phase 2 Improvements at Calexico West)	Reduces wait-times for pedestrian crossers in bi-national region	Minimal, but may increase share of pedestrian users
New LPOE facilities (Otay Mesa East)	Reduces wait-times for motorized crossers across SD-Tijuana region	Minimal, but may increase share of motorized crossers

Table ES-3. Improved Operations at LPOEs

Improvement	Impact on Wait Times	Impact on Modal Split
Southbound electronic commercial clearance (Aduanas PITA program)	None. *But reduces total crossing and idling time for truck crossers at LPOE*	-
Unified Cargo Processing	None. *But potentially reduces total crossing and idling time for truck crossers at LPOE*	-
Joint Inspection Facility	None. *But reduces total crossing and idling time for truck crossers at LPOE*	-
Interchangeable Lanes	Reduces wait-times for crossers at LPOE	Minimal, but may increase share of motorized crossers
Reversible Lanes	Reduces wait-times for crossers at LPOE	Minimal, but may increase share of motorized crossers
Lane Management	Reduces wait-times for crossers at LPOE	Minimal, but may increase share of motorized crossers
Appointment Time for Truck Crossers	Potential to reduce wait-times for truck crossers at LPOE	-
Extended Hours of Operations	Potential to reduce wait-times for truck crossers at LPOE	-
Variable tools at OME	Potential to reduce wait-times for truck crossers at Otay Mesa	-

Table ES-4. Improved Access to LPOEs

Improvement	Impact on Wait Times	Impact on Modal Split
Bike/pedestrian access improvements (San Ysidro, Calexico West and Calexico East)	-	Potential shift to pedestrian mode from motorized mode
Enhanced transit services (including: Tijuana BRT and higher frequency of transit service at San Ysidro and Otay Mesa), completion of Calexico West Intermodal Transit Center, and completion of Transit Center/Cell Phone Lot at Calexico East.	-	Potential shift to pedestrian mode from motorized mode
RFID and Wi-Fi readers on Mexico's northbound lanes to capture commercial and POV vehicle wait-time data	Potential reduction in NB wait-times for trucks and POVs due to planning and routing to faster LPOE	-
Zero/Near-Zero Truck Prioritization at LPOEs	Potential to reduce wait-times for truck crossers at LPOE *(and reduce emissions from using zero/near-zero emission trucks)*	-

Table ES-5. Corridor-Wide Improvements for Corridors that Include a LPOE

Improvement	Impact on Wait Times	Impact on Modal Split
Regional Border Management System (RBMS) and Subcomponents - • Southbound Congestion Management and ITS Infrastructure Improvements • Freight Advanced Traveler Information System (FRATIS), including Information Dissemination Process • Integrated Corridor Management (ICM) and Active Traffic Management (ATM)	Potential reduction in SB wait-times due to re-routing to faster route (and LPOE) could be realized for commercial and passenger vehicles with advanced travel information	Minimal, but may increase share of motorized crossers

Table ES-6. Other Improvements and Long-Term Strategies

Improvement or Strategy	Impact on Wait Times	Impact on Modal Split
Support Bi-national Planning Process for LPOEs and Transportation Infrastructure	Potential reductions to NB and SB wait-times	Potential shift to pedestrian mode from motorized mode

2 Methodological Framework

Details of the air quality analysis methods, border crossing process, existing LPOE configurations, and the peer review process undertaken to focus this study, are discussed in section 2 below.

2.1 Air Quality Analysis Methodology

The basic framework for land port-of-entry (LPOE) emissions analysis will leverage approaches developed for the U.S. Federal Highway Administration (FHWA) and the U.S. – Mexico Joint Working Committee on Transportation Planning in the United States-Mexico LPOE Emissions and Border Wait-Time Analysis Template (JWC template)[3]. A flowchart of the approach is provided as Figure 1. The process involves developing representative emission rates and then combining those rates with vehicle activity data for all the scenarios being analyzed. Differences between scenarios can then be quantified by contrasting the results from the emissions analysis.

Development of Emission Factors

This section encapsulates three related steps needed for estimating emissions at a border crossing: defining the types of vehicle behavior or activity that occur at ports-of-entry; developing emission rates corresponding to those types of activity; and compositing those emission rates into a form that can be applied directly to the border activity.

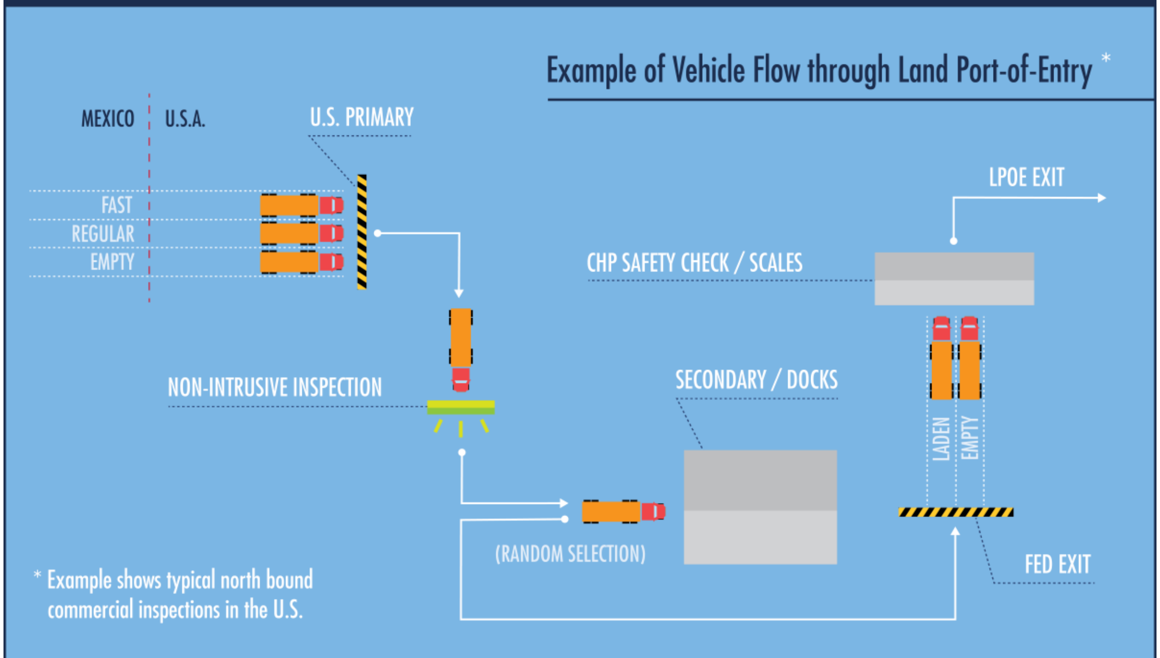
DEFINING VEHICLE BEHAVIOR AT PORTS-OF-ENTRY

The JWC template utilized detailed analysis of vehicle behavior through the use of a VISSIM[4] microsimulation model for both Bridge of the Americas and Ysleta-Zaragoza ports-of-entry in El Paso. Vehicle behavior was generated and aggregated in a manner intended to make it applicable to all U.S. – Mexico LPOEs. The analysis identified the difference between different types of approach lanes both in terms of the classes of vehicles that use the lane, and the customs and border protection programs serviced by the lanes. Differentiation also was made between northbound and southbound vehicle movements. The JWC template parameterization of vehicle behavior will be used in this study, no new VISSIM analysis is planned.

[3] FHWA, United States-Mexico Land Ports-of-Entry Emissions and Border Wait-Time White Paper and Analysis Template. 2012.
[4] VISSIM is a software package from PTV Group that enables the development and application of detailed traffic microsimulation models. Specific rules can be defined to mimic the distribution of time required for primary and secondary inspections of different types of vehicles and to mimic interactions between vehicles and vehicle-environment interactions.

Figure 1. Overview JWC Template Methodology

Emission Estimate Methodology Example for Land Port-of-Entry (LPOE)



EMISSIONS BY LANE TYPE = VEHICLE FLOW x EMISSION FACTORS x EMISSION WEIGHTING FACTORS

VEHICLE FLOW

SPECIFIC TO INSPECTION STOPS			BETWEEN INSPECTIONS
Identifying lane types specific to each LPOE, which may include: COMMERCIAL: • FAST • Regular • Empty POV: • Regular • Ready • Sentri	Identifying inspection stops specific to each LPOE, which may include: • Inspections within Aduanas • U.S. Primary • Non-intrusive inspection • Secondary inspection/docks • CHP safety check/scales • Toll collection	Identifying and quantifying vehicle behaviors associated with each individual inspection stop: • Stop and start queue • Creeping queue • Extended idle • Soak and restart • Free-flow driving	Identifying vehicle behaviors on roads between inspection stops, and identify queue spill-back with potential to block upcoming inspection stop(s).

EMISSION FACTORS

Obtain applicable emission factors specific to **vehicle class**, **vehicle age**, **fuel type**, **inspection and maintenance programs**, etc., from MOVES or EMFAC.

EMISSION WEIGHTING FACTORS

Additional emission weighting factors specific to each LPOE such as **time of day**, **vehicle class**, and **fuel type**, derived from surveys, observations, and secondary sources.

Three types of vehicle behavior were selected for detailed analysis. These were defined as:

- **Stop-and-go queuing**: Stop-and-go queues reflect the dense congested traffic in storage lanes similar to that found in the storage lanes providing immediate service to the primary inspection booths. Within the VISSIM model, this activity was identified as travel on the links located at, or immediately upstream of, the primary inspection booths where the average speed over a five-minute period was below 10 miles per hour on both ends of the link. In practice, simulated speeds on links tagged as having stop-and-go queuing average less than 1 mile per hour.
- **Creeping queues**: Creeping queues characterize vehicle behavior on congested road-way segments that feed the stop-and-go queue lanes. The queues have more of a creeping behavior than a stop-and-go behavior because each lane feeds multiple stop-and-go queue lanes. Within the VISSIM model, this activity was identified as travel on links where the average speed over a five-minute period was below 10 miles per hour on both ends of the link. In practice, simulated speeds on links that have creeping queues average about 5 miles per hour.
- **Uncongested operation**: Travel and roadway segments leading up to queue links is representative of the behavior considered to be uncongested vehicle operation. Within the VISSIM model this activity was identified as occurring on links where the average speed over a five-minute period was greater than 10 miles per hour on both ends of the link. The uncongested operations behavior identified in the VISSIM microsimulation had average speeds in the 25 to 35 miles-per-hour range (depending on vehicle class, type of link, etc.).

Table 1 through Table 3 summarize representative vehicle speeds for use with the California Air Resources Board (CARB) EMFAC model, the U.S. Environmental Protection Agency (USEPA) MOVES model, and its adaptation “MOVES Mexico”. Passenger vehicle-specific power (VSP) and commercial vehicle scaled tractive power (STP) profiles are detailed for use with the MOVES and MOVES Mexico models. The VSP profiles consist of the fraction of vehicle activity occurring in the various vehicle modes of operation, for stop-and-go queues, creeping queues, and uncongested movements for use with the U.S. EPA MOVES model (note that each column sums to 1.0). EMFAC2014 will be utilized for this study.

- The MOVES operating modes used in this analysis include vehicle deceleration, idling, and cruise/acceleration; with cruise/acceleration broken into low (less than 25 mph), medium (25-50 mph), and high (greater than 50 mph) speeds at varying VSP levels indicative of the engine load.
- Eight types of lanes are represented in the vehicle activity characterizations:
  1) Northbound FAST[5] trucks (laden),
  2) Northbound unladen trucks,

[5] Free and Secure Trade (FAST) program where drivers, vehicles, and cargo are pre-cleared for entry into the U.S.

Table 1. Stop-and-Go Queue VSP Profiles

	VSP STP	Bin	NB FAST Trucks	NB Unladen Trucks	NB Laden Trucks	SB Trucks (All)	NB Autos	NB SENTRI Autos	SB Autos (All)
Deceleration		0	0.229	0.330	0.212	0.266	0.267	0.244	0.203
Idle		1	0.627	0.549	0.659	0.590	0.629	0.597	0.610
1 to 25 mph	< 0	11	0.044	0.044	0.042	0.047	0.038	0.055	0.001
	0-3	12	0.091	0.071	0.075	0.089	0.065	0.095	0.184
	3-6	13	0.004	0.002	0.003	0.003	0.001	0.002	0.001
	6-9	14	0.001	0.001	0.002	0.001	0.000	0.002	0.000
	9-12	15	0.001	0.000	0.001	0.001	0.000	0.001	0.000
	12+	16	0.003	0.003	0.005	0.002	0.001	0.003	0.000
25 to 50 mph	< 0	21	–	–	–	–	0.000	–	–
	0-3	22	–	–	–	–	0.000	–	0.000
	3-6	23	–	–	–	0.000	0.000	–	0.000
	6-9	24	–	–	–	–	0.000	–	0.000
	9-12	25	–	–	–	–	–	–	–
	12-18	27	–	–	–	0.000	–	–	–
	18-24	28	–	–	0.000	–	0.000	–	–
	24-30	29	–	–	–	–	0.000	0.000	0.000
	30+	30	–	–	0.000	0.000	0.000	0.000	0.000
50 + mph	< 6	33	–	–	–	–	–	–	–
	6-12	35	–	–	–	–	–	–	–
	12-18	37	–	–	–	–	–	–	–
	18-24	38	–	–	–	–	–	–	–
	24-30	39	–	–	–	–	–	–	–
	30+	40	–	–	–	–	–	–	–
Average Speed			1	1	1	1	1	1	1

Table 2. Creeping Queue VSP Profiles

	VSP STP	Bin	NB FAST Trucks	NB Unladen Trucks	NB Laden Trucks	SB Trucks (All)	NB Autos	NB SENTRI Autos	SB Autos (All)
Deceleration		0	0.295	0.364	0.294	0.286	0.276	0.259	0.259
Idle		1	0.504	0.439	0.495	0.521	0.525	0.505	0.507
1 to 25 mph	< 0	11	0.060	0.071	0.073	0.065	0.073	0.081	0.002
	0-3	12	0.132	0.118	0.128	0.119	0.119	0.140	0.232
	3-6	13	0.004	0.004	0.006	0.005	0.004	0.004	0.000
	6-9	14	0.002	0.002	0.001	0.001	0.002	0.001	0.000
	9-12	15	0.001	0.001	0.001	0.001	0.001	0.001	0.000
	12+	16	0.001	0.001	0.001	0.001	0.001	0.002	0.000
25 to 50 mph	< 0	21	0.000	0.000	0.000	0.000	0.000	0.000	–
	0-3	22	–	0.000	–	–	0.000	0.001	0.000
	3-6	23	0.000	0.000	0.000	0.000	0.000	0.001	0.000
	6-9	24	0.000	0.000	0.000	0.000	0.000	0.001	0.000
	9-12	25	0.000	0.000	0.000	0.000	0.000	0.000	–
	12-18	27	0.000	0.000	0.000	0.000	0.000	0.000	–
	18-24	28	–	0.000	0.000	0.000	0.000	0.000	–
	24-30	29	0.000	–	0.000	0.000	0.000	0.001	–
	30+	30	0.000	0.000	0.000	0.000	0.000	0.000	–
50 + mph	< 6	33	–	–	–	–	–	–	–
	6-12	35	–	–	–	–	–	–	–
	12-18	37	–	–	–	–	–	–	–
	18-24	38	–	–	–	–	–	–	–
	24-30	39	–	–	–	–	–	–	–
	30+	40	–	–	–	–	–	–	–
Average Speed			5	5	5	5	5	5	5

Table 3. Uncongested Movement VSP Profiles

	VSP STP	Bin	NB FAST Trucks	NB Unladen Trucks	NB Laden Trucks	SB Trucks (All)	NB Autos	NB SENTRI Autos	SB Autos (All)
Deceleration		0	0.248	0.187	0.206	0.195	0.265	0.153	0.215
Idle		1	0.123	0.111	0.174	0.268	0.297	0.118	0.362
1 to 25 mph	< 0	11	0.024	0.027	0.026	0.029	0.040	0.021	0.001
	0-3	12	0.034	0.028	0.036	0.041	0.053	0.025	0.118
	3-6	13	0.007	0.008	0.008	0.007	0.010	0.007	0.003
	6-9	14	0.004	0.006	0.004	0.004	0.005	0.004	0.000
	9-12	15	0.005	0.005	0.004	0.004	0.002	0.003	0.000
	12+	16	0.008	0.010	0.009	0.012	0.005	0.018	0.000
25 to 50 mph	< 0	21	0.014	0.016	0.016	0.014	0.012	0.027	0.000
	0-3	22	0.266	0.327	0.290	0.214	0.037	0.074	0.058
	3-6	23	0.222	0.226	0.189	0.180	0.213	0.393	0.239
	6-9	24	0.006	0.010	0.006	0.007	0.051	0.120	0.003
	9-12	25	0.017	0.016	0.013	0.008	0.005	0.013	0.000
	12-18	27	0.016	0.019	0.014	0.013	0.001	0.004	0.000
	18-24	28	0.002	0.002	0.002	0.002	0.001	0.005	0.000
	24-30	29	0.001	0.001	0.000	0.000	0.001	0.008	0.000
	30+	30	0.001	0.001	0.001	0.001	0.001	0.009	0.000
50 + mph	< 6	33	–	–	–	–	–	–	–
	6-12	35	–	–	–	–	–	–	–
	12-18	37	–	–	–	–	–	–	–
	18-24	38	–	–	–	–	–	–	–
	24-30	39	–	–	–	–	–	–	–
	30+	40	–	–	–	–	–	–	–
Average Speed			30	30	30	25	35	35	35

3) Northbound laden trucks,
4) Southbound trucks (all types),
5) Northbound Regular lane passenger vehicles,
6) Northbound SENTRI[6] passenger vehicles,
7) Northbound Ready Lane passenger vehicles (represented by SENTRI) and
8) Southbound autos (all types).

Note that data for VSP distributions and average speeds for SENTRI lanes are assumed to represent the Ready[7] lane VSP distributions and average speeds. This assumption has been used in multiple studies because both Ready lanes and SENTRI lanes cater to regular border crossers, and vehicle activity data has never been parameterized for Ready lane traffic.

Additional types of vehicle behavior that need to be quantified for the analysis consist of information about vehicles which are parked, idling, extended idling[8] or starting, when those activities do not occur on the roadway segments. In the case of most U.S. - Mexico border crossings, trucks stopping and restarting for inspections need to be accounted for outside of the queue and uncongested flow described above. As was the case for running emissions, off-network emissions estimates are developed as emission rates (start emissions in grams/start and extended idling in grams per hour) and are specific to soak times (i.e., specific start emission rates are developed for each specific soak). The soak times considered by EMFAC and MOVES include:

- Soak < 6 minutes;
- 6 minutes ≤ Soak < 30 minutes;
- 30 minutes ≤ Soak < 60 minutes;
- 60 minutes ≤ Soak < 90 minutes;
- 90 minutes ≤ Soak < 120 minutes;
- 120 minutes ≤ Soak < 360 minutes;
- 360 minutes ≤ Soak < 720 minutes; and
- 720 minutes ≤ Soak.

Within the context of border analysis, all soak periods are considered to be between six minutes and thirty minutes.

EMISSION FACTORS BY VEHICLE ACTIVITY

Emission rates for use with this analysis template are based on EMFAC2014, MOVES2014a, and MOVES Mexico. These models produce detailed emission rate information that will subsequently be combined into composite emission rates, through weighted averages. This

[6] Secured Electronic Network for Travelers Rapid Inspection (SENTRI) program is a transponder based program providing expedited inspection and clearance through primary inspection via dedicated commuter lanes.
[7] Ready lanes provide a dedicated lane for privately-owned vehicles entering the U.S. for vehicles whose occupants have WHTI-compliant, RFID-enabled cards approved by the Department of Homeland Security.
[8] Extended idle is used to power accessory loads such as air conditioning when a vehicle is parked.

section presents a discussion of background information and key underlying concepts for project-level emissions analysis. The concepts and approaches are also applicable to MOVES and MOVES Mexico unless noted otherwise. The parameters that have the greatest influence on vehicle emissions in queuing and congested operating situations are summarized below.

Vehicle Type

Vehicle classes based on the EMFAC2014, MOVES, and MOVES 2014a classification systems, which are subsets of six Highway Performance Monitoring System (HPMS) vehicle classes, are used in this analysis. Characterization of border crossing vehicle data according to FHWA's HPMS classes is a critical step. To best represent the specific vehicle emission rates occurring at these crossings, local information on vehicle volumes by source type or HPMS class is needed. These data come from the intercept surveys and visual observations performed by the consultant team at each LPOE. Data are be aggregated into six vehicle classes that can readily be classified visually in the field.

Vehicle Age and Country of Registration

Vehicle age distributions by vehicle type are important when modeling emissions as these age groups are used to define the emission standards the vehicle was initially certified to meet as well as to account for the effects of deterioration of the emission control components over time. In addition, since vehicles operating in the U.S. and Mexico are subject to different emission standards, the country of registration is important. More detail is provided below on vehicle age and registration data when representing a mix of U.S. and Mexican domiciled vehicles in EMFAC2014, MOVES 2014a, and MOVES Mexico

A specific age distribution will be developed for the following classes:

- Passenger cars;
- Light duty trucks[9];
- Light commercial trucks[10];
- Single unit short-haul trucks and combination short-haul trucks[11]; and
- Buses.

The EMFAC2014 model is designed for vehicles certified to California and U.S. emissions standards and uses vehicle age to determine which standard vehicles were certified to; it is important to distinguish between U.S. and Mexico certified vehicles and either map the Mexican vehicles to "technology groups" used by EMFAC, or to model the Mexican fleet with MOVES Mexico. Because California requires all commercial vehicles to comply with California standards for the same model year, this is only an issue for privately-owned vehicles.

The first Mexican emission standards for light-duty vehicles became effective in model year 1993 and were later strengthened, effective 2001. A mix of U.S. Tier 1/2 and Euro 3/4 standards

[9] Including the EMFAC2014 LDT1 and LDT2 vehicle classes.
[10] Including the following EMFAC2014 vehicle classes: MDV, LHDT1, LHDT2, and MHDT.
[11] EMFAC2014 HHDT vehicle class.

is required since 2004. Mexico has not revised its light-duty emission standards to reflect Tier 2 U.S. standards which require a significant reduction in NO_X and PM. Therefore, if EMFAC2014a were to be used, the age distribution of Mexican cars for those age groups (pre-1993 and post-2007) need to be shifted to make them "artificially older" and account for higher emissions. MOVES Mexico is used to model the Mexican fleet in order to avoid that complexity.

Operating Mode

The JWC template provides for speed bins to be used to characterize the operating modes of vehicles. Detailed modal data and corresponding average speeds were presented in Table 1 through Table 3 above.

Fuel Formulation and Supply

A fuel correction was previously estimated for the formulation of Mexican gasoline. The adjustment was derived in MOVES, using fuel data from the San Diego and Tijuana[12] regions that had been developed for a related study. For San Diego, the default EMFAC2014 fuel formulations were used; the Tijuana fuel formulation was determined using data from the Alliance of Automobile Manufacturer's North American Fuel Survey[13] . The fuel formulations and the share from each country varied by season. The percentages of fuel last purchased in each country were obtained from the at-border surveys.

Inspection and Maintenance (I/M) Program

An adjustment for the Mexicali and Tijuana I/M programs is being derived from MOVES Mexico. Baja California has phased in an I/M program that is as stringent or more stringent than the Enhanced California I/M program in San Diego, and much more stringent than the change of ownership I/M program for Imperial County. However, compliance rates are not yet known for the Baja California program.

COMPOSITE EMISSION RATES

Composite emission rates can be generated by taking weighted averages with respect to time of day, fuel type, and vehicle class. This analysis performs emission calculations by hour and lane type. The vehicle class distribution and age distribution data discussed above are used to generate hourly emission rates for each lane type and activity type, at each LPOE.

2.2 Port-of-Entry Crossing Process

This section provides a step by step overview of the process that commercial vehicles, privately-owned vehicles, and busses go through for northbound and southbound border crossings. The description helps identify the location and type of vehicle activity that must be analyzed to estimate emissions from the LPOE. These processes are adapted to fit the unique characteristics of each LPOE.

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[12] Tijuana and Mexicali fuel characteristics should be similar because both regions utilize fuel delivered through Ensenada; San Diego and Calexico both utilize California reformulated gasoline and are expected to have similar fuel characteristics,

[13] Alliance of Automobile Manufacturers, (07/2013, 01/2013, 01/2014, 07/2014) Alliance of Automobile Manufacturers North American Fuel Survey. 2014: http://www.autoalliance.org/index.cfm?objectid=6E64B9C0-40B5-11E3-8898000C296BA163.

Commercial Vehicle Processes

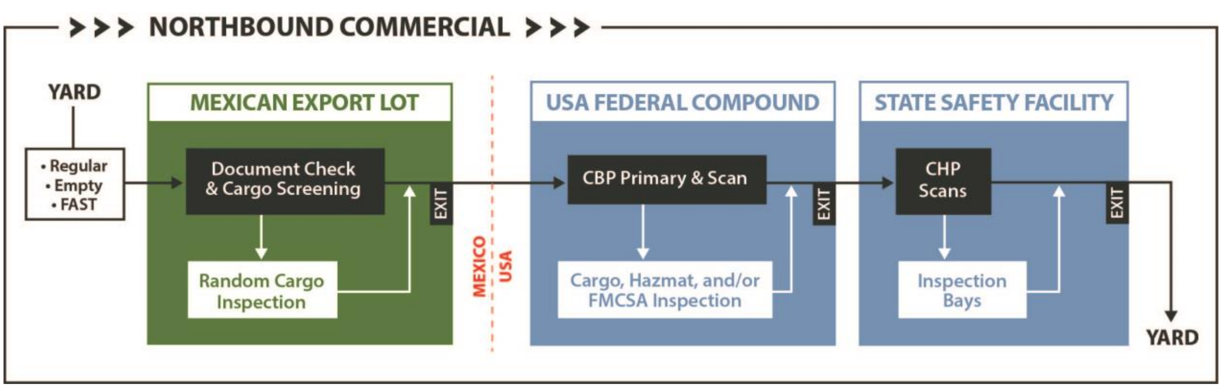
Because of the economic and regulatory setting for commercial traffic, cross border commercial trucking between California and Baja California is principally a drayage operation. Most Mexican domiciled tractors are restricted to circulation in the United States to a narrow commercial zone extending out to 20 miles from the border and are restricted from hauling anything but international cargo. Those constraints do not bind all trucks; for example, those with dual registration in both the U.S. and Mexico or U.S. owned and domiciled trucks. However, since commercial border crossings take several hours and require specialized experience to efficiently navigate Mexican Aduanas and U.S. Customs requirements, almost all of the commercial trucking is done as drayage. For example, during the three-year (October 2011-October 2014) FHWA/ Federal Motor Carrier Safety Administration (FMCSA) pilot program allowing certain Mexican carriers to operate farther into the United States, the busiest LPOE was Otay Mesa, where the pilot program amounted to less than 1% of border traffic[14]. Therefore, truck shipments between the United States and Mexico use drayage tractors that pick up a trailer from a yard on one side of the border and then haul it over the border to another yard for transfer to a domestic carrier.

NORTHBOUND COMMERCIAL CROSSING

The typical northbound border-crossing process requires a shipper in Mexico to file shipment data with both Mexican and U.S. Federal agencies, prepare both paper and electronic forms, and use a drayage or transfer tractor to move the goods from Mexico to the United States. Once the shipment is at the border with the drayage or transfer tractor and an authorized driver, the process flows through three main inspection areas (Figure 2)[15]:

- Mexican export lot,
- U.S. Federal compound, and,
- State of California inspection facility.

Figure 2. Northbound Commercial Crossing Process



[14] FMCSA (2015) United States-Mexico Cross-Border Long-Haul Trucking Pilot Program Report to Congress, https://www.fmcsa.dot.gov/sites/fmcsa.dot.gov/files/docs/US-Mexico%20Cross-Border%20Long-Haul%20Trucking%20Pilot%20Program%20Report%20FINAL%20January%202015.pdf

[15] Adapted from FHWA (2012) Border-Wide Assessment of Intelligent Transportation Systems (ITS)Technology – Current and Future Concepts, Report FHWA-HOP-12-015.

At the Mexican export lot, an inbound gate screens drivers for the required documentation and directs a portion of the truck traffic into the Mexican Customs (Aduanas) cargo inspection area. Aduanas does a random audit which can include nonintrusive inspection and/or physical inspection of the cargo. Trucks not selected for audit proceed to the exit gate and onto the border and the U.S. Federal compound. The inbound gate often differentiates between regular, empty, and “Free and Secure Trade” (FAST) vehicles and there may be approach lanes and/or booths dedicated to each.

Designating specific lanes to regular, empty, and FAST vehicles recognizes the differing levels of scrutiny and processing time required for each. The FAST program is a trusted traveler/trusted shipper program allowing expedited processing for commercial carriers who have completed background checks and fulfill certain eligibility requirements. Participation in FAST requires that every link in the supply chain, from manufacturer to carrier to driver to importer, is certified under the Customs-Trade Partnership Against Terrorism program. FAST lanes typically have a much higher through-put than the regular lanes. Similarly, empty trucks take less time to inspect and with nothing to declare can be processed through customs faster. For both northbound crossing and southbound crossings, empty trucks typically lock their rear doors open so that both CBP and Aduanas officers easily verify that there is no cargo onboard.

Several U.S. agencies operate within the U.S. Federal Compound. At the Customs and Border Protection (CBP) primary inspection booth, identification and shipment documentation is presented to the processing agent. The vehicle is also scanned by non-intrusive pylon mounted scanners as it passes through the primary inspection booth. The CBP inspector at the primary inspection booth uses a computer terminal to crosscheck the information about the driver, vehicle, and cargo with information sent previously by the carrier via the CBP’s Automated Cargo Environment (ACE) electronic manifest (e-Manifest). The CBP inspector then makes a decision to refer the truck, driver, or cargo for a more detailed secondary inspection of any or all of these elements, or alternatively releases the truck to the exit gate. Loaded, empty, and FAST vehicles are differentiated and there are typically approach lanes and/or booths dedicated to each. The average processing time through the primary inspection booth and the cargo inspection area differs between the FAST, regular, and empty lanes.

Cargo inspection includes any inspection that the driver, cargo, or conveyance undergoes between the primary inspection and the exit gate of the U.S. Federal compound. These may include one or more non-intrusive scanners, or physical inspection of cargo and checks with other agencies staffing the U.S. Federal compound, including the U.S. Department of Agriculture (USDA), Food and Drug Administration (FDA), and the Federal Motor Carrier Safety Administration (FMCSA). Non-intrusive inspections include Pylon (for FAST vehicles), VACIS, Gantry, or Eagle inspections, all of which utilize some form of x-ray, gamma-ray, or similar scanning technology. VACIS inspections and Eagle inspections operate similarly. Trucks line up in a queue, drivers exit the vehicle, and a mobile X-ray unit drives along the length of the vehicles, scanning them. The Gantry is a building that trucks drive into, the driver exits, and the truck is scanned. If something is detected or the CBP officer wants to take a closer look, they are sent to the dock for further inspection. After the cargo inspection, commercial traffic then passes through an exit gate before proceeding to the State of California inspection facility. Shipments that include hazardous materials (HAZMAT) also undergo a HAZMAT inspection within the U.S. Federal compound.

The state of California inspection facility is located adjacent to the federal compound and is primarily operated by the California Highway Patrol (CHP). Officers weigh and inspect commercial vehicles to determine whether they are in compliance with state standards and regulations. If their initial visual inspection finds any violation, they direct the truck to proceed to a more detailed inspection at a special facility. The CARB randomly inspects and tests a portion of the commercial traffic to ensure that the vehicles comply with California's emission control regulations. The engine of any truck operating in California must be certified to the same emissions criteria as a California registered truck and emissions controls must be maintained and functioning.

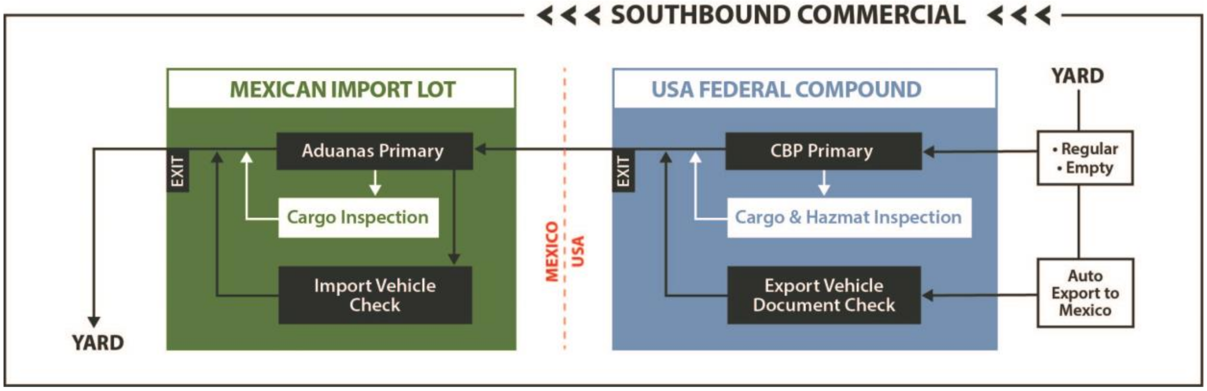
SOUTHBOUND COMMERCIAL CROSSING

No comprehensive description of the southbound commercial crossing process is publicly available. The best available data are the discussions of southbound commercial traffic from the technical appendices of the Joint Working Committee analysis template[16]. That discussion is not directly applicable to California. Additional input from Aduanas de Tijuana, gathered during a March 6, 2017 meeting at their facilities at their Mesa de Otay LPOE, augmented the prior literature to complete this description.

Southbound commercial crossing processes are similar to the northbound crossings, but do not involve state safety inspections. The Aduanas process, within the Mexican import lot, is more involved than the Aduanas export process for northbound crossings. The typical southbound border-crossing requires a shipper to file shipment data with both U.S. and Mexican Federal agencies, and use a drayage or transfer tractor to move the goods from the United State to Mexico. Once the shipment is at the border with the drayage or transfer tractor and an authorized driver, the process involves clearance through both the U.S. Federal compound and the Mexican import lot (Figure 3):

[16] FHWA (2012) United States – Mexico Land Ports-of-Entry Emissions and Border Wait-Time White Paper and Analysis Template: Task 3b Border Traffic characteristics.

Figure 3. Southbound Commercial Crossing Process



At the U.S. Federal compound, export shipments are routed into either the CBP cargo inspection area or to the exit gate and onto the Mexican import lot. The CBP export cargo inspection facilities have loading docks for the physical inspection of cargo, including HAZMAT. All trucks are subject to southbound inspections by CBP, though the majority of southbound shipments are cleared for export electronically before they arrive at the border and proceed directly to the exit gate from the U.S. federal compound. Empty and loaded trucks often have designated approach lanes and booths and can be subject to differing levels of scrutiny. Since 2009 CBP has had a more prevalent southbound inspection program in an effort to curb the flow of illegal weapons and money from the United States into Mexico. All shipments that include hazardous materials are subject to an additional inspection step to inventory the material and ensure that it's appropriately documented.

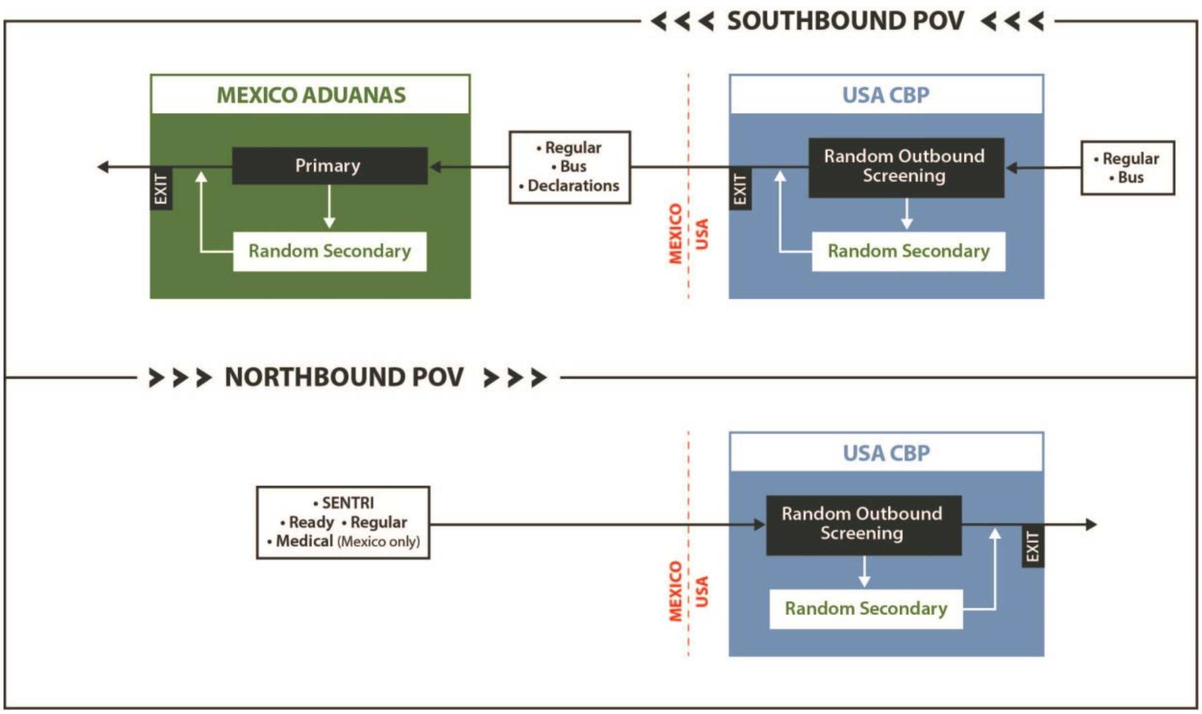
After exiting the U.S. facility, trucks enter the Mexican Secretariat of Communication and Transportation (SCT) and Aduanas facilities in the Mexican import lot. All trucks with HAZMAT and/or agricultural/biological cargo are subject to an initial inspection prior to the Aduanas entrance booth. At the entrance booth invoice papers are reviewed and stamped if the truck destination is beyond the border commercial zone. Trucks are then subject to cargo inspection which includes a review of paperwork where the Mexican Import Pedimentos are checked against the versions filed electronically by the Mexican customs broker. For trucks for which paperwork is in order, a large majority (> 90 percent) proceed directly to the exit gate, while the remaining trucks are randomly selected for a more thorough physical inspection.

Used passenger vehicles are exported from the United States and imported to Mexico through the Calexico East and Otay Mesa commercial ports-of-entry, and also must pass through the commercial facilities. The process typically involves the use of both Mexican and U.S. customs brokers. Each vehicle from the U.S. must be exported from the U.S. before it is imported to Mexico, which requires the services of a customs broker on the U.S. side. Before the passenger vehicle arrives at the U.S. export cargo inspection area it needs to already have had CBP confirm its title and approve the export, otherwise the passenger vehicle will be held in the cargo inspection area while CBP verifies the vehicle title and ensures it is eligible for export, a process that can take a week or longer. Once cleared by CBP, the U.S. title for the vehicle is stamped as "EXPORTED" by CBP and the passenger vehicle proceeds to the Mexican import lot, where the vehicle's eligibility for import is verified[17]. The Mexican customs broker will then pay import duties based on the type and age of the vehicle, as well as other taxes. It can take more than a day to complete this process, so there are areas to store passenger vehicles within the Aduanas cargo inspection area. In practice, vehicles being exported from the U.S. and imported to Mexico are batched together and processed on specific days. Both CBP and Aduanas designate specific lanes and booths through the Otay Mesa commercial port-of-entry for processing these passenger vehicles.

Privately Owned Vehicle Processes

The process for privately owned vehicles (Figure 4) is much more streamlined than what is required of commercial shipments.

Figure 4. Northbound and Southbound Privately-owned Vehicle Crossing Process



NORTHBOUND PRIVATELY OWNED VEHICLES

Northbound vehicles traveling from Mexico to the United States are not required to submit to inspection processes on the Mexican side. They queue to enter the CBP primary inspection booths. A secondary inspection area is located after the primary booths, only a fraction of vehicles is required to divert to the secondary area. As with commercial traffic, there are specific lane designations up to and in most cases through the primary booths:

[17] There are specific rules based on vehicle age and country of origin (manufacture) limiting the import of used vehicles to Mexico, in addition the vehicle must comply with all safety and emissions control regulations from both the U.S. and Mexico, as well as having a current smog check.

- The Secure Electronic Network for Travelers Rapid Inspection (SENTRI) is a CBP program that allows expedited clearance for pre-approved, low-risk travelers upon arrival in the United States. It requires pre-screening and certification of the driver, vehicle, and any passengers, and all occupants must be in possession of their SENTRI cards at the time of entry into the United States. Applicants for the program undergo a rigorous background check and in-person interview before enrollment. SENTRI lanes typically offer the shortest border crossing lines and fastest processing times.
- READY lane usage requires that all travelers have Western Hemisphere Travel Initiative (WHTI) compliant identification documents (such as a U.S. passport card; enhanced driver's license; enhanced tribal card; Trusted Traveler cards (NEXUS, SENTRI, Global Entry and FAST cards); the new enhanced permanent resident card, or new border crossing card). The WHTI-compliant identification allows for electronic identification of all passengers before the vehicle arrives at the CBP primary inspection booth, and thus faster processing. The type of lane that the medical lane merges with may limit eligibility (see description below).
- Regular lanes are applicable to all other vehicles. When the vehicle arrives at the CBP primary inspection booth an officer documents and screens all travelers.
- Medical lane "Fast Lane" program is a special lane for tourists and medical tourism for the exclusive use of visitors to Mexico that have patronized a participating business. This lane allows travelers to enter the border line at a designated entrance with a Fast Pass, cutting off a significant portion of the border line. A Mexican police officer will take the Fast Pass where the medical lane is entered. Because CBP does not recognize medical lanes, the lanes end just prior to crossing into the U.S. and vehicles are merged into other traffic lanes.

SOUTHBOUND PRIVATELY-OWNED VEHICLES.

As passenger vehicles head southbound into Mexico they are subject to outbound inspections by CBP at the entrance of the passenger vehicle portion of the POE. The enforcement times and percentage of vehicles inspected varies as the southbound inspections use a "pulse and surge[18] [19]" technique for outbound traffic. This procedure allows for immediate stand-down of outbound inspections to manage traffic flow departing the port-of-entry[20]. There are currently no designated "specialty" lanes in the U.S. approaching the border, and all lanes are considered regular lanes.

[18] "Pulse and surge" operations are short durations that involve periodic outbound inspections followed by periods without inspections.
[19] Testimony of Commissioner Alan Bersin, U.S. Customs and Border Protection, in Senate Caucus on International Narcotics Control, "Money Laundering and Bulk Cash Smuggling Along the Southwest Border". 2011, CBP: http://www.dhs.gov/news/2011/03/09/testimony-commissioner-alan-bersin-us-customs-and-border-protection-senate-caucus.
[20] CBP, National Southwest Border Counternarcotics Strategy Implementation Update. 2010: White House: available at http://www.whitehouse.gov/sites/default/files/ondcp/policy-and-research/swb_implementation10_0.pdf.

As vehicles enter Mexico, they are subject to inspected by Mexican Aduanas. Aduanas operates two separate lanes types:

- Declaration lanes for travelers that need to obtain a Forma Migratoria Múltiple (FMM) tourist card, declare items being imported to Mexico, or any other interaction with Aduanas. Travelers using the declaration lanes park and enter the administration building to conduct their business.
- Non-declaration lanes for POVs that do not require tourist cards and are importing personal goods valued below a de minimis threshold. Vehicles approach automated booths and are given either a green light allowing them to pass or a red light directing them to a secondary inspection area.

Depending on the primary inspection, vehicles are either directed to exit the facility, or are sent to secondary inspection. Vehicles that are selected for a secondary inspection are identified both randomly, and based on weight and vehicle characteristics collected at the automated inspection booth. The secondary inspections include more detailed reviews of both drivers and the vehicle. Upon completion of secondary inspection, these vehicles are then allowed to leave the facility.

2.3 Port-of-Entry Layout

One or more figures for each port-of-entry, which identify layout and document our current understanding of the number of lanes and booths available, and the cargo inspection areas, are provided below along with a summary of each port-of-entry's key attributes from the perspective of modeling emissions. The ports-of-entry are discussed in geographical order from San Ysidro in the west to Andrade in the east.

San Ysidro/Puerta México-Virginia Avenue/El Chaparral

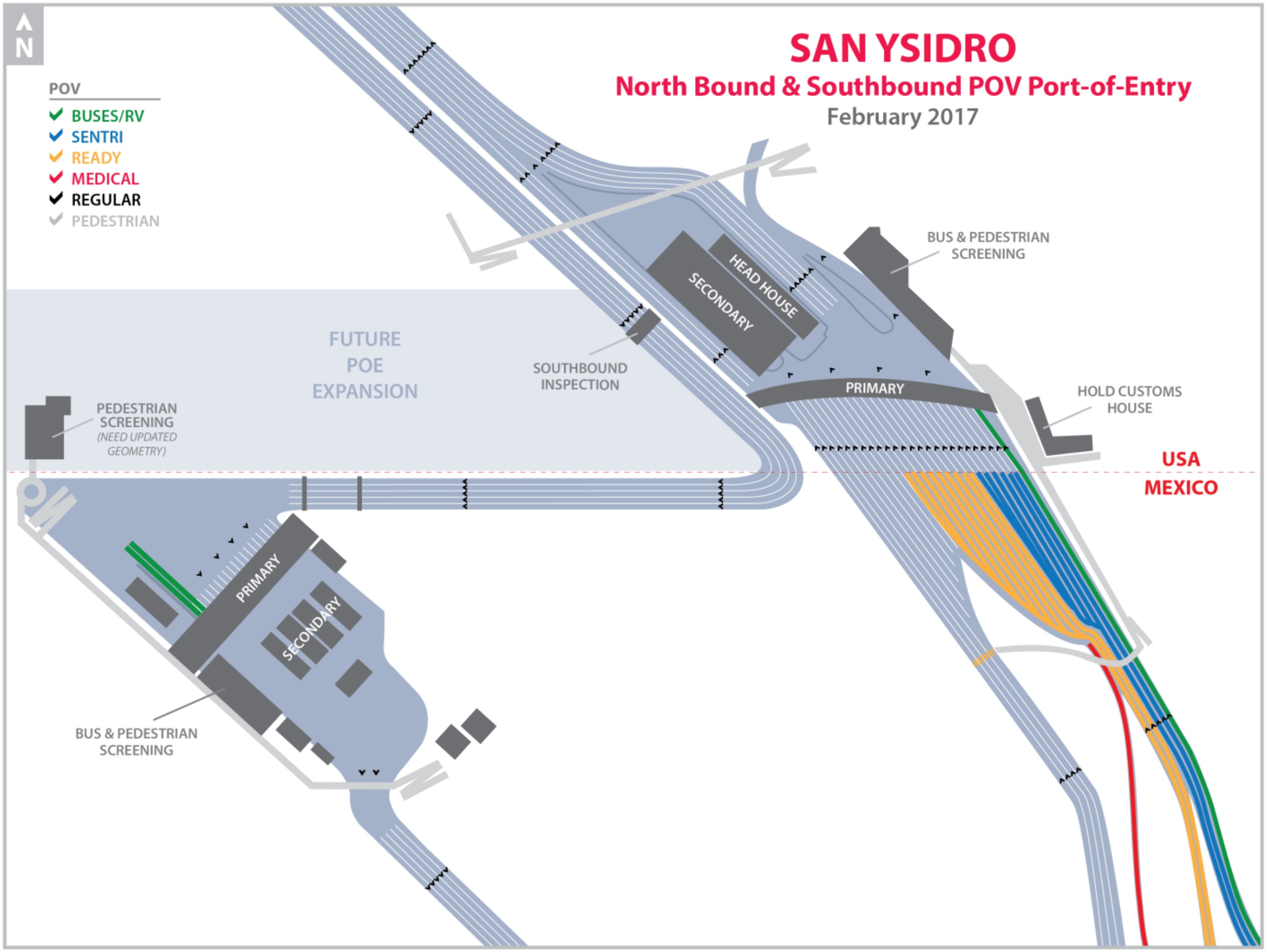
The San Ysidro/Puerta México POE forms the primary border crossing for privately-owned vehicles (POVs) and pedestrians traveling between San Diego, California and Tijuana, Baja California. San Ysidro/Virginia Avenue is the northbound border crossing located in the United States. Puerta México/El Chaparral is the southbound border crossing located in Mexico. Figure 5 provides a schematic representation of the two facilities, detailing the number and type of lanes approaching and crossing the border. The San Ysidro port-of-entry currently has:

- Up to 25 northbound privately-owned vehicle lanes, all but three of which have double stacked primary inspection booths;
- Up to 15 northbound pedestrian booths on the eastern edge of the port-of-entry and up to 14 northbound pedestrian booths on the west side of the port-of-entry;
- Up to 22 southbound inspection lanes, two of which are typically dedicated to declarations;
- NB buses utilize the right-most lane. Passengers must exit the bus at the border and be cleared for entry into the U.S. within the pedestrian facility, then re-board the bus in the United States. Vehicle scanners are available for buses entering the United States. The Aduanas secondary inspection area also includes vehicle scanners;

- Southbound pedestrian inspection booths in Mexico.

The specific number of vehicle lanes and booths that are open and dedicated SENTRI, Ready lane, or regular traffic, changes continuously to manage security and inspection needs. The U.S. General Services Administration (GSA) is overseeing an ongoing project to reconfigure and expand the San Ysidro POE which will add additional northbound lanes and reconfigure the southbound approach within the United States. This project is anticipated to be completed in summer 2019.

Figure 5. San Ysidro/Puerta México-Virginia Avenue/El Chaparral Port-of Entry Layout.



Otay Mesa/Mesa de Otay

The Otay Mesa/Mesa de Otay POE forms the primary border crossing for commercial traffic traveling between San Diego, California and Tijuana, Baja California, as well as additional capacity for privately-owned vehicles and pedestrians to cross the border. Figure 6 shows the northbound commercial port-of-entry facilities in Mexico and the U.S. Figure 7 provides the same information for the southbound commercial ports-of-entry and the privately-owned vehicle ports-of-entry. The lane geometry, location of primary, secondary, and cargo inspection facilities are all shown. Otay Mesa includes:

- Up to six northbound commercial lanes through the Mexican export lot feeding up to ten primary commercial inspection booths in the United States;
- Up to 13 northbound privately-owned vehicle lanes with one inspection booth per lane;
- Up to six northbound pedestrian booths on the eastern edge of the privately-owned vehicle port-of-entry;
- Up to four southbound commercial lanes exiting the United States, plus an additional lane (not shown) that is dedicated to the export of used vehicles from the United States to Mexico;
- Up to two southbound privately-owned vehicle lanes on the U.S. side of the border feeding approximately 15 primary inspection lanes in Mexico, one or two of which would be for declarations;
- Southbound pedestrians located on the western edge of the port-of-entry in Mexico and up to14 northbound pedestrian booths on the east side of the port-of-entry in the U.S.

The figure for each port-of-entry depicts typical lane configurations (e.g., FAST, SENTRI, Ready, regular, empty), but the actual configuration at any time will be set to best manage the security and inspection needs at those ports-of-entry.

Because of space limitations, the California inspection facility is located about a half mile to the east of the commercial portion of the U.S. Federal Compound. Both the commercial portion of the U.S. Federal compound and State of California inspection facility are designed with a “race track” layout, designed for trucks to circulate near the perimeter of the facilities, with key infrastructure (i.e. scales, inspection bays and scanners) located in the center of the track.

Figure 6. Otay Mesa-Mesa de Otay Port-of Entry Layout.

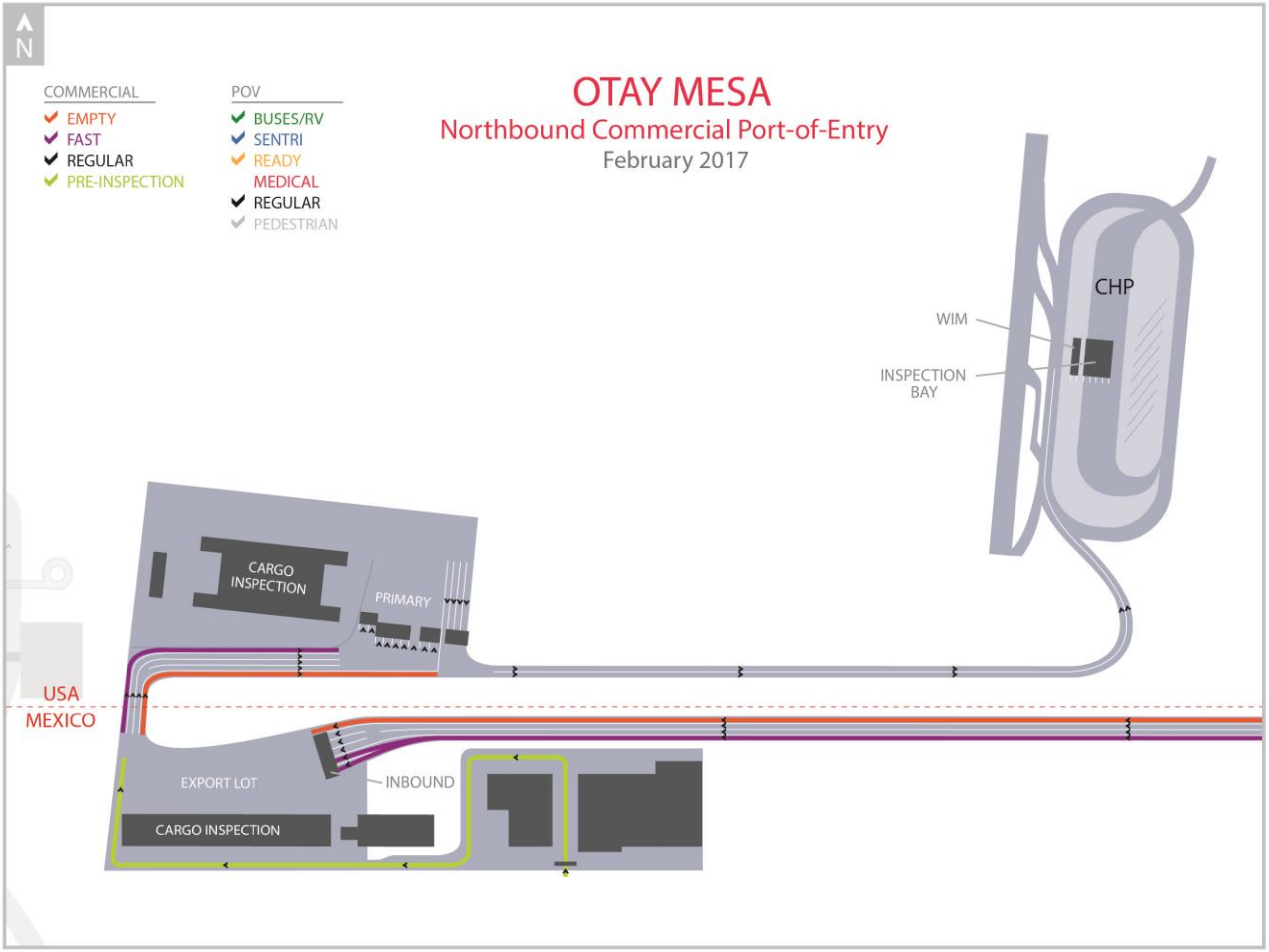
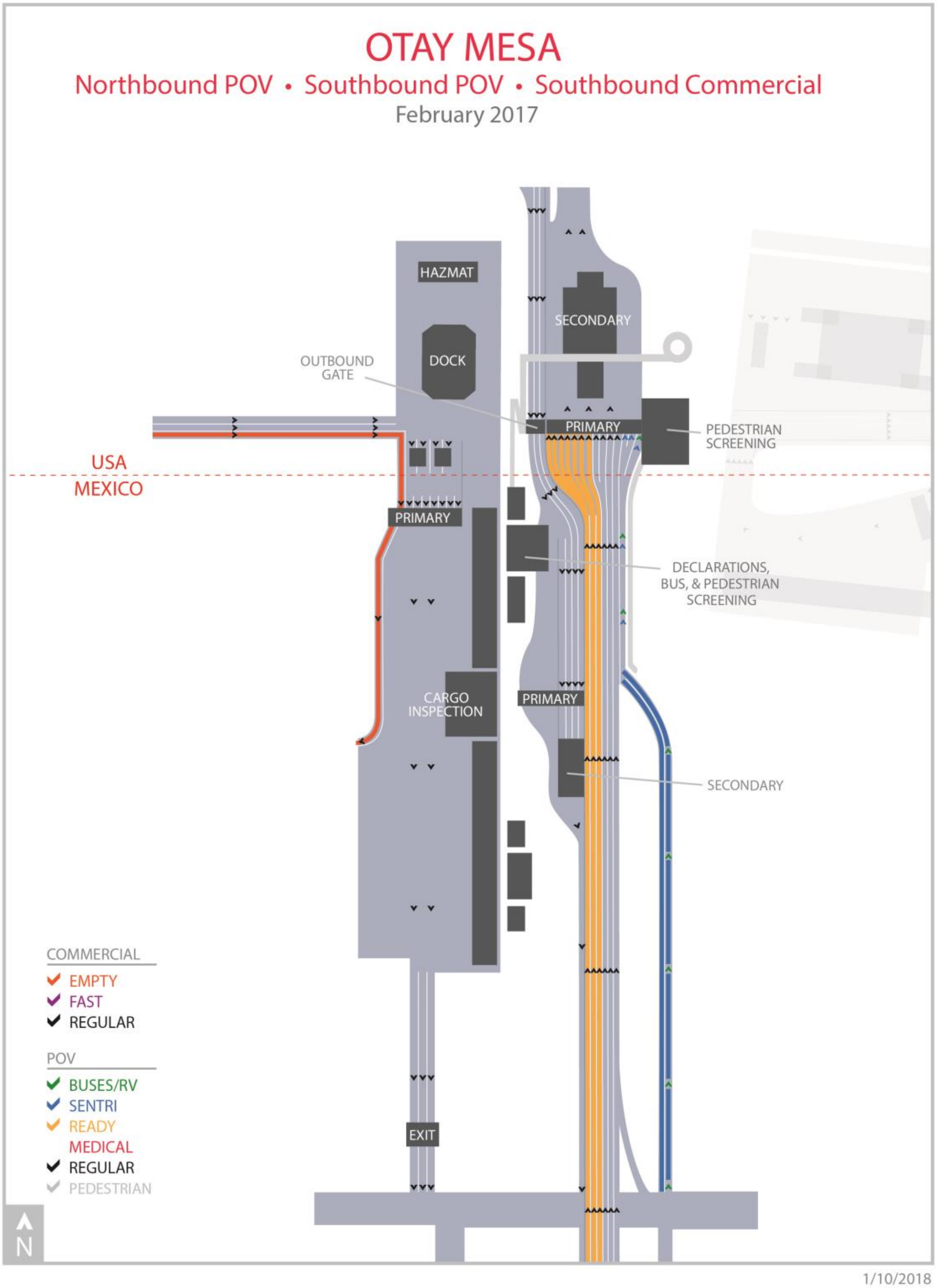


Figure 7. Otay Mesa/Mesa de Otay Port-of Entry Layout.



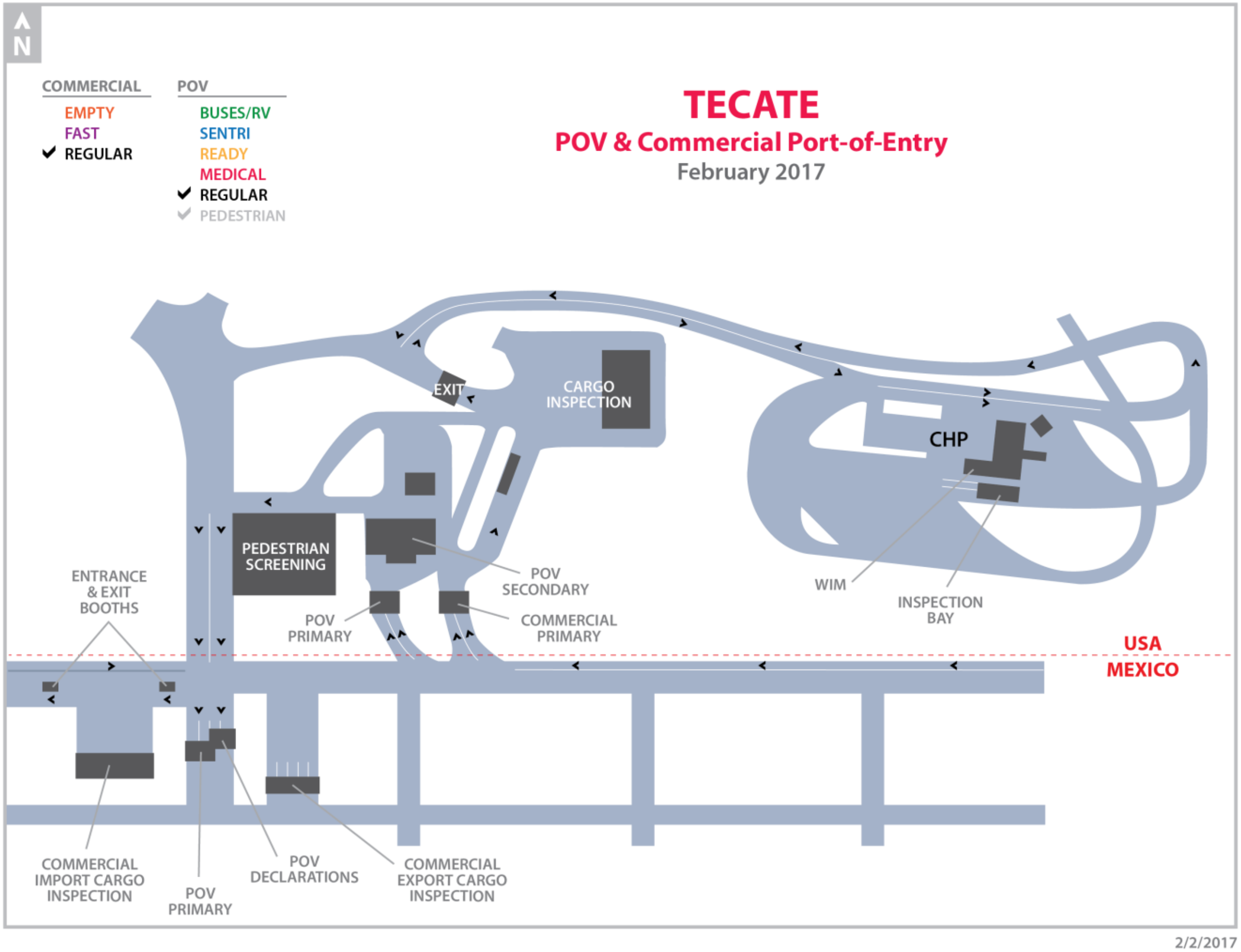
Tecate

The Tecate port-of-entry is located east of the San Diego/Tijuana urban core and is a relatively small port-of-entry that serves both commercial, privately-owned vehicles, and pedestrians. Figure 8 provides the general layout of both the commercial and privately-owned vehicle port-of-entry facilities in both Mexico and the United States. The configuration includes:

- One northbound commercial lane through the Mexican export lot and up to two northbound commercial lanes entering the United States;
- Up to two northbound privately-owned vehicle lanes with one inspection booth per lane;
- Up to two northbound pedestrian booths;
- One southbound commercial lane through the U.S. Federal compound and Mexican import lot;
- One southbound privately-owned vehicle lane on the U.S. side of the border feeding up to four primary inspection lanes in Mexico;
- Southbound pedestrians located on the western edge of the port-of-entry and up to 14 northbound pedestrian booths on the west side of the port-of-entry.

All of the commercial and privately-owned vehicle lanes at Tecate operate as regular lanes. Though not shown in the figure, when private vehicle traffic exceeds the capacity of the port-of-entry and commercial traffic is light, CBP can process privately-owned vehicles through the commercial portion of the port-of-entry. This capability is unique to Tecate.

Figure 8. Tecate Port-of Entry Layout.



Calexico West/Mexicali Centro

A schematic showing Calexico West, known as Mexicali Centro in Mexico, is provided in Figure 9. Calexico West serves privately-owned vehicles (POVs), including recreational vehicles and vehicles towing trailers, as well as pedestrians. Buses and commercial vehicles exclusively use the Calexico East POE. The Calexico East POE is described later.

Calexico West has ten northbound primary inspection booths and traffic through those booths is divided into three different streams, two of which are merged together just before the POE. The traffic streams are:

- Regular POV lanes;
- SENTRI lanes; and
- A medical lane which is managed by the City of Mexicali to facilitate medical tourism by allowing eligible travelers to bypass most of the regular lane queue.

There are also six northbound pedestrian booths. The vehicle inspection booths are typically configured so that up to three booths can service the SENTRI lane POVs, with the balance serving the regular lane POVs. Most traffic exits the Calexico West POE onto East 1st Street. POVs routed through secondary exit directly onto Imperial Avenue (SR 111). The secondary inspection area is located adjacent to the primary inspection booths.

Southbound traffic into Mexicali Centro has three lanes through the U.S. Federal compound feeding up to 11 primary inspection lanes in Mexico, an unknown number of which would be designated for declarations.

Calexico East/Mexicali II

Commercial vehicles and POVs have separate crossing facilities at Calexico East. Pedestrians also are processed at this POE. Figure 10 and Figure 11 provide a traffic flow schematic for both sets of crossings at the POE. The schematic is split across two figures. POV and commercial facilities are described separately.

CALEXICO EAST POV FACILITIES

The POV crossing consists of eight northbound inspection booths. Traffic through those booths is divided into three different vehicle streams:

- SENTRI lane POVs typically use the left most primary inspection booths, though additional lanes can be assigned to serve the SENTRI traffic as warranted.
- Regular POV traffic utilizes from one to three of the right most primary inspection booths. All busses utilize the right most lane so that passengers can debus and be individually cleared for entry into the United States. The bus and regular POV traffic is intermixed.
- Ready lane traffic is served by one to five of the available booths in between the SENTRI and regular POV booths.
- Calexico East also includes up to four northbound pedestrian inspection booths.
- The number of southbound pedestrian inspection booths in Mexico is unknown.

Figure 9. Calexico West/Mexicali Centro Port-of Entry Layout.

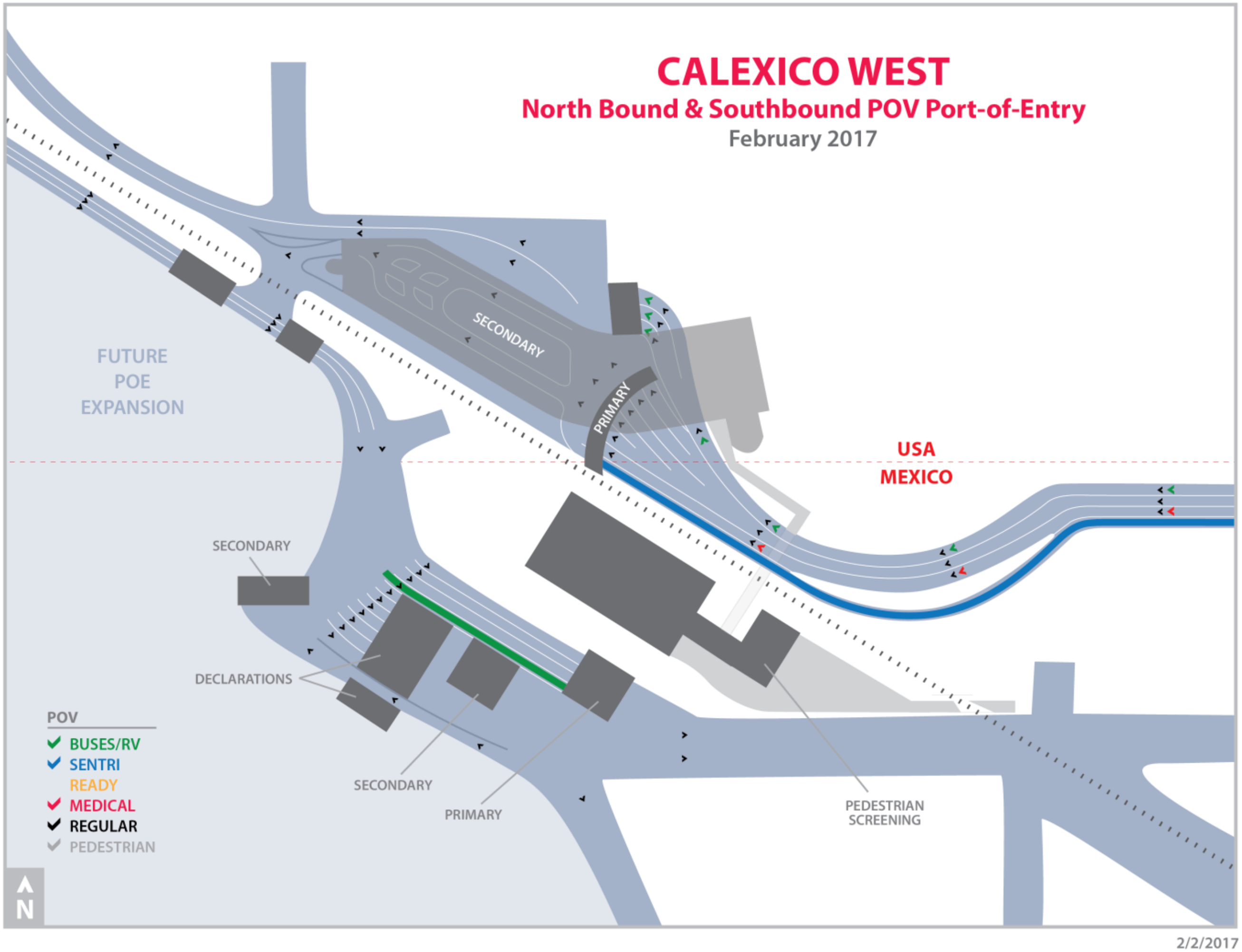


Figure 10. Calexico East Port-of Entry Layout.

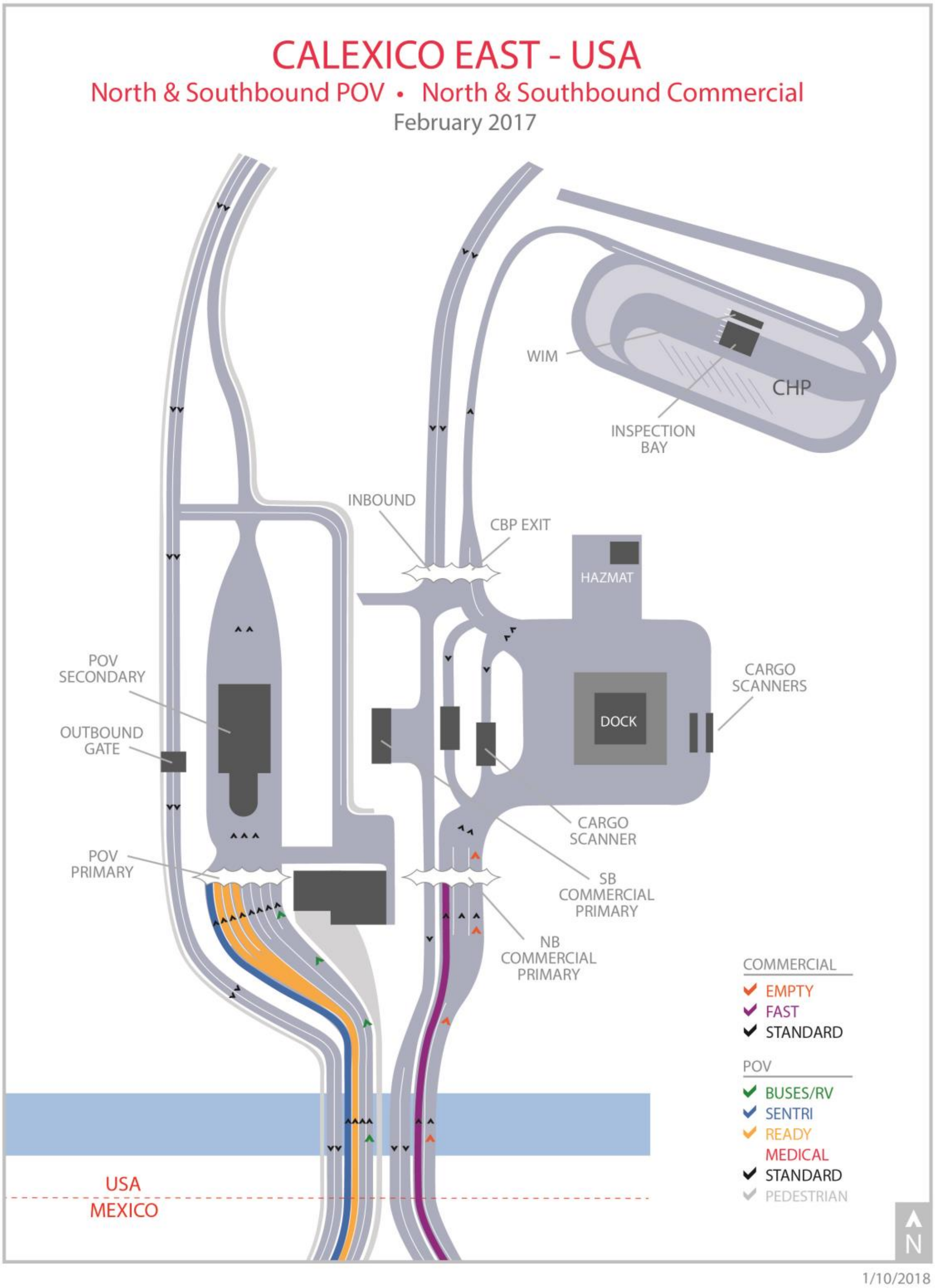
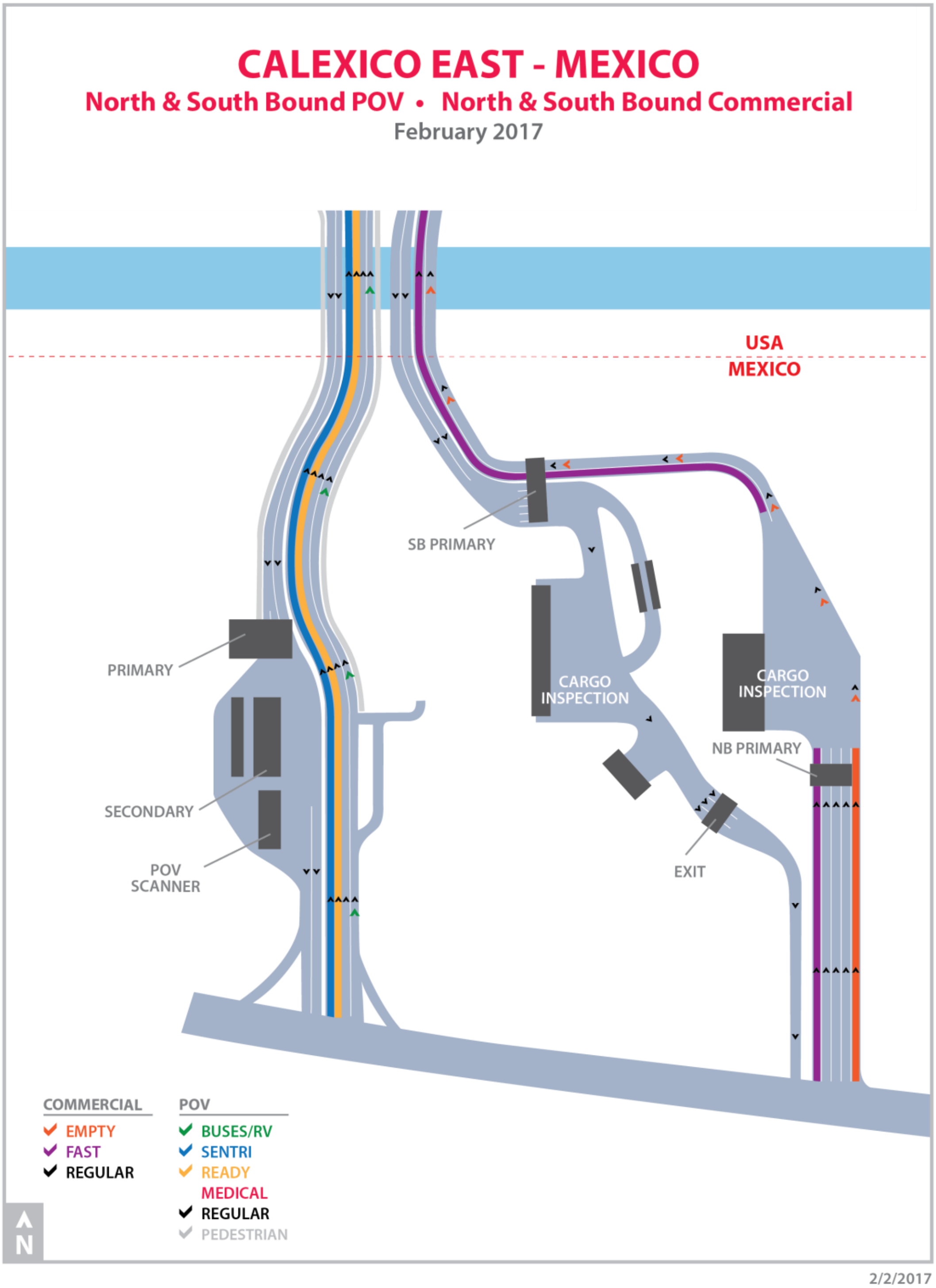


Figure 11. Mexicali II Port-of Entry Layout.



Ready Lane POV processing is only available at Calexico East, which makes it the most utilized border crossing program at the Calexico East POE. All of the POV traffic exits around the secondary inspection area onto SR-7. Traffic exits the Calexico East POE onto SR-7. The secondary inspection area is located adjacent to the primary inspection booths.

Southbound privately-owned vehicles utilize two lanes to traverse the U.S. Federal compound, which is large enough to accommodate periodic southbound inspections on outgoing vehicles. Within the Mexican Aduanas portion of the facility there are four primary inspection lanes and a large declarations area. The secondary inspection area in Mexico also includes vehicle scanners.

CALEXICO EAST COMMERCIAL FACILITIES

As shown (Figure 10 and Figure 11) northbound trucks go through six different key clearance processes as they cross the border:

- Aduanas entrance booth;
- Aduanas cargo inspection area;
- CBP primary inspection booth;
- CBP cargo inspection area;
- CBP exit booth; and
- CHP scales and safety inspections.

At each booth that the commercial vehicle passes through, and at the CHP scales, there is the potential for queuing and idling. The U.S. Federal compound cargo inspection areas include VACIS and gantry non-intrusive scanners. A portion of vehicles are also referred to loading docks for physical inspection of the vehicle and cargo, which may require several hours.

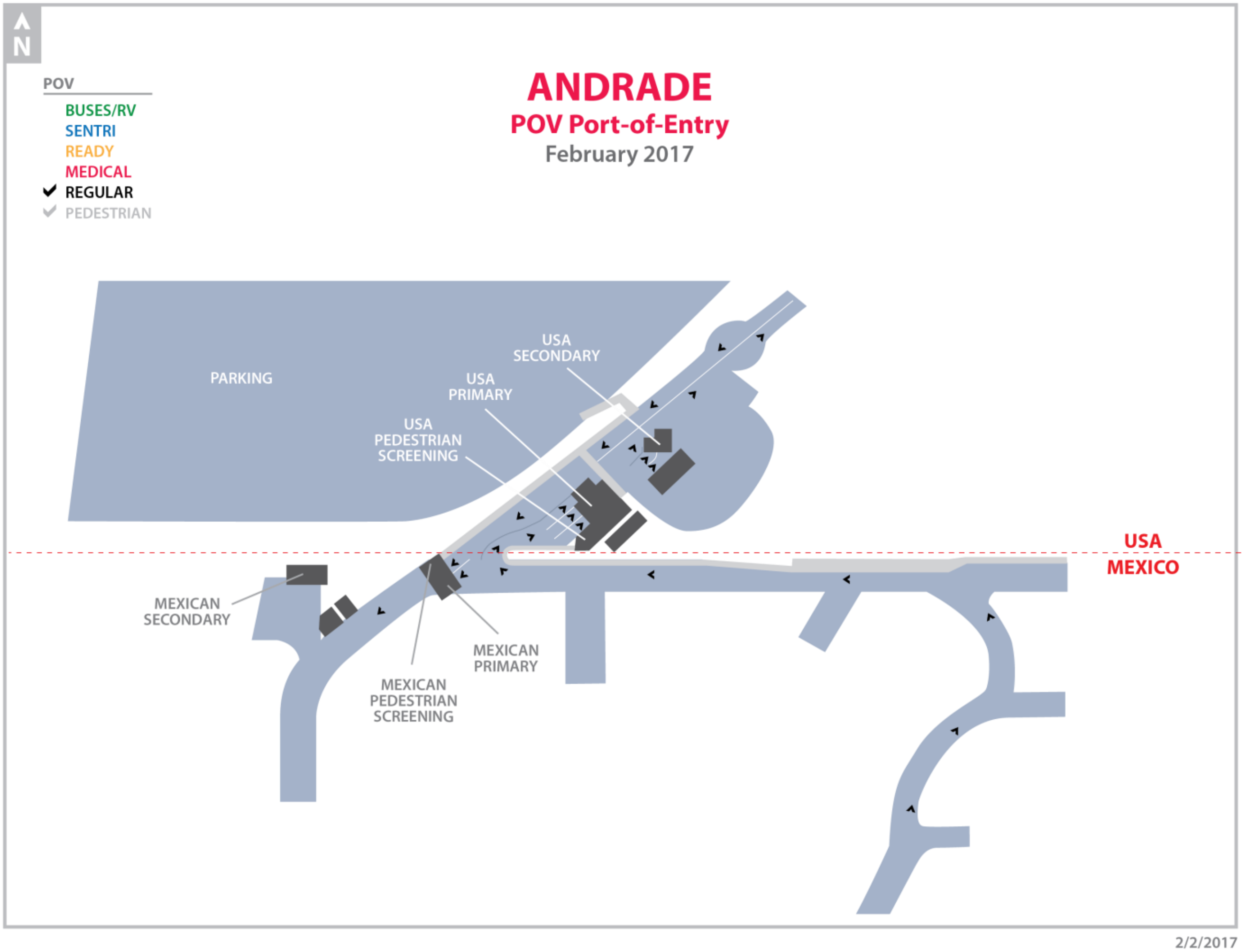
Southbound commercial traffic has up to two lanes entering the U.S. Federal compound and one lane exiting. There are up to six lanes entering the Mexican import lot, which would allow for separation of empty and regular trucks. The Aduanas cargo inspection area includes three non-intrusive vehicle scanners.

Andrade/Algodones

Andrade/Algodones (Figure 12) is a small port-of-entry complex on the eastern edge of California, adjacent to the Colorado River in the U.S. State of Arizona, and near the border between the Mexican Baja California and Sonora states. Northbound there is a single lane exiting Mexico which feeds into three POV lanes. Commercial vehicles are no longer processed at Andrade/Algodones. Southbound there is a single lane for privately-owned vehicles exiting the United States and through the Mexican Aduanas area.

There are four northbound pedestrian inspection booths at Andrade/Algodones. The number of southbound pedestrian inspection booths in Mexico is unknown.

Figure 12. Andrade/Algodones Port-of Entry Layout.



2.4 Air Quality Methodology Peer-Review

This section documents the framework and outcomes for the February 16, 2017 emissions peer review roundtable covering proposed methods and data for the emissions analysis.

Goal

The goal of the emissions peer review roundtable was to develop and vet, in collaboration with SANDAG, Caltrans, and ICTC, strategies to determine the necessary emission data and methodology to estimate particulate matter (PM), oxides of nitrogen (NO_x), reactive organic gases (ROG), carbon monoxide (CO), and greenhouse gas (GHG) emissions at the LPOEs due to cross-border passenger vehicle and truck northbound and southbound delays.

Topics

The roundtable focused on the methodologies and data discussed in sections 2.1 through 2.3 above.

1. Scope of the analysis (annual average PM, NOx, ROG, CO, and GHG emissions).
2. Overview of northbound and southbound border crossing process at each LPOE for both privately owned vehicles (POV) and commercial vehicles (trucks).
3. The seasonal and daily variability of volumes and delay at each LPOE, seasonal effects (including fuel and temperature effects) on emission rates, and the identification of "design day" characteristics to estimate annual average emissions.

- Overview of the JWC analysis template.
- Discussion of the types of strategies that might ultimately be considered in the study and data being collected to address them.
- Current understanding of Baja California and California fuel formulations and impact on emissions.
- Current Mexican and US inspection and maintenance programs and their effect on emissions.
- Comparison of Mexican mileage accrual to assumptions in EMFAC 2014.

Logistics

Roundtable discussion and webinar was hosted at SANDAG's offices on February 16, 2017, from 10 AM to 2 PM with lunch provided for participants. A briefing package was distributed on February 8th. A webcast was provided for remote participants. The topics and agenda emphasized reaching consensus over technical and data issues, rather than detailing the specific strategies for analysis. Spanish-English translation services were provided both in the room and on the phone for those participating through the webcast.

The agenda included:

- Welcome and introductions.
- Overview of the project purpose, participating agencies, and consultant team. The purpose and need for the peer review roundtable and the significance of this work and input from participants.
- Review of the overall approach as detailed in the JWC template.
- Discuss the specific configuration and operational details of each port-of-entry, along with the border crossing process for northbound and southbound travelers.
- Review of the EMFAC and MOVES emissions models, and the types of data required as input to ensure that appropriate emission rates are estimated.
- Brainstorm strategies, policies, and projects that the study might consider as recommendations to reduce emissions at the ports-of-entry. (Note that the specific strategies, policies, and projects to be tested were selected in coordination with the economic portion of the study by SANDAG, ICTC, and Caltrans.)

Email invitations were distributed in English and Spanish on January 24th, 2017. Along with copies of the preliminary methodology and links to the JWC Template online. Attendees at the emissions peer review roundtable are listed in **Table 4** below.

Table 4. Roundtable Participants

Group Category	Group/Organization	Participant Name	Location
U.S. Local Agencies	Imperial County Air Pollution Control District (ICAPCD)	Belen Lopez	Webcast
		Matt Dessert	Webcast
	San Diego County Air Pollution Control District (SDCAPCD)	David Shina	Webcast
		Laura Shield	Webcast
		Nick Cormier	Webcast
U.S. State Agencies	California Air Resources Board (CARB)	Vernon Hughes	Webcast
U.S. Federal Agencies	FHWA Office of Planning	Sylvia Grijalva	Webcast
	U.S. Customs and Border Protection (CBP)	Amy Archibald	SANDAG
		Carlos Rodriguez	SANDAG
		Sally Carrillo	SANDAG
	USEPA Border Liaison Office	Jeremy Bauer	SANDAG
U.S. Academics	San Diego State University (SDSU)	Jenny Quintana	SANDAG
		Paul Ganster	SANDAG
	University of California, Davis - Department of Civil and Environmental Engineering	Deb Niemeier	Webcast
Mexico State Agencies	Secretaría de Infraestructura y Desarrollo Urbano Del Estado (SIDUE)	Carlos López Rodríguez	SANDAG
		Karlo Limon	SANDAG
		Victor Rangel	SANDAG
	Secretaría de Protección al Ambiente de Baja California (SPA)	Margarito Quintero Nuñez	Webcast

Table 4. Roundtable Participants (Continued)

Group Category	Group/Organization	Participant Name	Location
Mexico Federal Agencies	Consulate of Mexico (San Diego)	Hon Rafael Laveaga Rendón (Represented)	SANDAG
	Secretaria De Medio Ambiente Y Recursos Naturales (SEMARNAT)	Daniel López Vicuña	Webcast
		Judith Trujillo Machado	Webcast
		Rodrigo Perrusquía Máximo	Webcast
Mexico Academics	El Colegio de la Frontera Norte (COLEF) - DEPARTAMENTO DE ESTUDIOS URBANOS Y DEL MEDIO AMBIENTE	Tito Alegría Olazábal	Webcast
	Universidad Autonoma de Baja California (UABC) - Instituto de Ingeniería	Marco Antonio Reyna Carranza	Webcast
Project Study Team	Caltrans	Ilene Gallo	SANDAG
		Maurice Eaton	SANDAG
		Sergio Pallares	SANDAG
	ICTC	Mark Baza	SANDAG
		Virginia Mendoza	SANDAG
	SANDAG	Elisa Arias	SANDAG
		Hector Vanegas	SANDAG
		Marcial Gutierrez	SANDAG
		Muggs Stoll	SANDAG
		Rachel Kennedy	SANDAG
		Sanchita Mukherjee	SANDAG
		Wu Sun	SANDAG
		Zach Hernandez	SANDAG
Consultant Team	HDR	Alejandro Solis	SANDAG
	T. Kear Transportation Planning and Management	Susan Kear	Webcast
		Tom Kear	SANDAG

Discussion and Outcomes

Questions and discussion occurred both during the peer review round table, and through follow-up discussions.

- Several questions related to the development of vehicle activity profiles for the JWC template came up during the peer review roundtable, including questions about the application of microsimulation, the representation of different lane types and process, differentiation by vehicle classes, and sources of data. TKTPM described and clarified that VISSIM micro-simulation models were used characterize process specific vehicle activity during development of the JWC template, and the resulting tool was then used to characterize how vehicle activity differed by lane type and vehicle class. The resulting data, regarding vehicle speed and instantaneous power demand, is applicable across all ports-of-entry. It was also clarified that the analysis is conducted for each type of lane and process. There was discussion of LPOE specific activity. Both TKTPM and HDR went into detail regarding onsite primary data collection, public secondary data sources, and how those data are combined and utilized to support both the emissions and the economic analysis for this study. These sources include data collected through at-border surveys conducted for this study and recent San Ysidro and Calexico studies. It was also explained that there are areas and processes within the LPOEs for which security measures do not allow any data to be made available, and that reasonable representations of those processes are incorporated into the analysis such that the predicted delay and queues matched observed average and peak delay and queues.

- The section of the roundtable focusing on LPOE configuration and operations was initiated with a description of what is required for privately-owned and commercial vehicles to cross the border, combined with preliminary diagrams documenting how each lane-type approaches, and passes through, the ports-of-entry along with the location of inspection processes. Questions came up regarding the location of traffic and exposure to LPOE emissions in adjacent neighborhoods. The consultant team noted that the queue lengths are accounted for in the emission estimates, but that the study considers emissions, not concertation and exposure to, those emissions.

- During discussion of the emission factor models (EMFAC and MOVES) questions and discussion focused on: how period level data will be disaggregated to hourly data, the correlation between black carbon emissions and PM2.5 emissions as modeled by this study, and how vehicle type distributions are developed for the LPOEs. The Project Steering Committee decided not to add black carbon to the list of pollutants being analyzed. TKTPM explained that traffic flows were derived from control totals, such as Bureau of Transportation Statistics (BTS) Border Crossing/Entry Data, and disaggregated based on primary data such as onsite traffic counts, and secondary data such as PeMS sensors and data provided by CBP and the California Highway Patrol. HDR explained that the direct observations were gathered for peak and off-peak travel seasons, 2-4 days per season, for each type of observation. TKTPM noted that a statistical target of a 90 percent confidence rate at the 10% level (i.e., having 90 percent confidence in identifying a 10 percent difference as statistically significant), is typically met for key variables.

- Potential strategies that this study analyses for reducing delays are selected by the Project Steering Committee. This portion of the discussion focused on some of the types of strategies that might be included. One question that came up was if the cause of delays would be identified. HDR and TKTPM clarified that while the study modeled the delay, specific causal effects would not necessarily be identified and that doing so was not part of this study. There was specific interest in consideration of increased LPOE staffing to ensure that infrastructure is fully utilized, along with better coordination between federal, state, and local agencies to implement high impact low coast actions, and remove bottlenecks.

Several additional comments and questions came in, and were addressed, via email:

- USEPA's Border Liaison office suggested that the study consider additional peer review as the model and reports were completed, as well as sensitivity checks. The potential for consideration of induced demand was also discussed in their comment. The SR-11 model developed for the Otay Mesa East LPOE is now being used by SANDAG to forecast typical daily volumes at San Ysidro and OTAY Mesa, with HDR extrapolating those data to other LPOEs. Analysis of induced demand is limited to what those tools consider. Additional peer review and sensitivity tests are not funded at this time.

- USEPA Office of Transportation Air Quality (OTAQ) commented on the limitations and potential challenges of using the MOVES model to estimate emission factors for vehicles certified, domiciled, and/or fueled in Mexico. This study will be using the MOVES Mexico model, developed for Mexico by Eastern Research Group for the United States Agency for International Development (USAID), to estimate emission factors for those vehicles.

- UABC noted that the historic center of border cities in Mexico are closely located to the older LPOE. Because there are numerous trips between the LPOE and the urban centers, a percentage of the LPOE emissions could be attributed to the urban centers. It was also noted that solutions need to address both politics and infrastructure. With specific recommendations for unified cargo processing (joint USCBP/Aduanas cargo inspections), and improved coordination between pedestrian facilities and transit. The Project Steering Committee did not choose to include unified cargo processing in this study, but may consider it in the future as additional data become available from the Nogales LPOE and the Otay Mesa pilot project. Transit improvements are being analyzed but it is outside the scope of this study to look at specific changes.

- There were also a handful of technical questions, and requests for supporting documentation and calculation detail, and comments suggesting additional data to consider.

Another outcome of the emissions roundtable were follow-up meetings with Aduanas and USCBP regarding operational details at the LPOEs. Meetings were held on March 6, 2017 (Aduanas), and March 15, 2017 (USCBP). The agencies clarified details regarding the processes of some types of commercial shipments, and how buses and bus passengers cross the border. Some approximate throughput and processing data was also shared to improve the modeling of emissions resulting from secondary inspections.

3 Analysis Scenarios

Volume 1 of this report describes the analysis scenarios and traffic forecasting methodologies in detail. Some if that information is repeated here.

Overview of Conceptual Scenarios

The future conceptual scenarios analyzed as part of this study are defined for each border sub-region (i.e., San Diego County-Tijuana/Tecate and Imperial County-Mexicali), POE, and year of analysis. The scenario for 2016 represents existing conditions. The conceptual scenarios for future years and both sub-regions can be summarized based on the following characteristics:

- **Baseline Scenario** includes limited improvement to border-crossing capacity. This scenario is estimated for all currently existing POEs.
- **Baseline Scenario Plus Capacity Enhancements** considers significant border crossing capacity improvements such as the additional POE at Otay Mesa East, improvements at existing POEs like Calexico East with the expansion of the All-American Canal bridge.
- **Transit and Active Transportation Scenario** considers transit and bicycle/pedestrian access improvements in the vicinity of the POEs. This scenario will be estimated for the POEs for which these improvements are being considered.
- **Sensitivity Scenario** models changes to future volumes or wait-times by assuming a change in the processing rate of the POE. This scenario is estimated for all POEs.

The conceptual scenarios match the mode types available for each land POE. Broadly, each POE has a baseline scenario that represents existing border-crossing volumes and circumstances. For all of the POEs (except Andrade) the baseline includes some planned improvements. San Ysidro and Otay Mesa POEs have additional baseline scenarios that include the existence of the Otay Mesa East (OME) POE. Similarly, Calexico West and East POEs have baseline scenarios that incorporate capacity improvements at the All-American Canal. For each of the four largest POEs (San Ysidro, Otay Mesa, Calexico West, and Calexico East) there is a scenario that includes enhanced transit service and bike and pedestrian access improvements, designated as Transit and Active Transportation scenarios.

For the economic and emissions analyses, the conceptual scenarios comprise the most likely growth in traffic volumes for 2025. The emissions analysis also considers 2035 as a year to be analyzed, and the economic analysis additionally considers a sensitivity scenario with a +/-10 percent change in crossing volumes and/or wait-times, to represent changes in policies, level of economic activity, or other factors. A tabular explanation of the scenarios and sensitivity analysis utilized in this project is presented in Table 5.

Table 5. Conceptual Scenarios for Economic and Emissions Analyses

	Scenario	Scenario 1: Most Likely Growth Traffic Volume		Scenario 2: Sensitivity Analysis
	Forecast Year	2025	2035	2025
POE	Type of Analysis	Economic and Emissions	Emissions	Economic
San Ysidro	Baseline	Existing + Phase 3 improvements[21] [without Otay Mesa East (OME)]		Baseline plus OME Scenario for all POEs: Sensitivity analysis of a plus or minus 10 percent change in crossing volumes and/or wait times (due to changes in policies, level of economic activity, or other factors).[22]
	Baseline plus OME	Existing + Phase 3 improvements		
	Transit and Active Transportation	Existing + Phase 3 improvements, Tijuana BRT[23], bike/pedestrian access improvements[24], with OME	Existing + Phase 3 improvements, Tijuana BRT, bike/pedestrian access improvements, with OME	
Otay Mesa	Baseline	Existing + southbound (SB) electronic commercial clearance[25], Otay Mesa Commercial Modernization[26] (without OME)		
	Baseline plus OME	Existing + SB electronic commercial clearance, Otay Mesa Commercial Modernization		
	Transit and Active Transportation	Existing + Otay Mesa Pedestrian Modernization[27], enhanced transit service[28], bike/pedestrian access improvements, with OME	Existing + Otay Mesa Pedestrian Modernization, enhanced transit service, bike/pedestrian access improvements, with OME	
Otay Mesa East	Baseline plus OME	Proposed OME facility + SB electronic commercial clearance	Proposed OME facility + SB electronic commercial clearance	
Tecate	Baseline	Existing + SB electronic commercial clearance (with OME)	Existing + SB electronic commercial clearance (with OME)	
Note: All scenarios for San Ysidro, Otay Mesa and Otay Mesa East assume current wait time information.				

[21] Phase 3 improvements at San Ysidro include the addition of 10 southbound POV lanes with additional southbound primary inspection booths and 8 northbound POV lanes with 15 additional northbound inspection booths. Completion of this project is scheduled for 2019. *Source: General Services Administration.*

[22] This refers to changes in CBP staff vehicle processing rates at the POEs and is represented by a change in the processing rates in the SR-11 Binational Travel Demand Model.

[23] Tijuana BRT is a public bus service in Tijuana operated by Sistema Integral de Transporte de Tijuana (SITT). One route serves communities between the southern terminus along Bulevar Simon Bolivar and the San Ysidro POE, and the second route connects the southern terminus along Bulevar Simon Bolivar with the Otay Mesa POE. *Source:* SITT.

[24] Bike/pedestrian access improvements include completion of planned bike and pedestrian facilities connecting to the POEs identified in the Imperial County Transportation Commission's Pedestrian and Bicycle Transportation Access Study (2015). In addition, in San Ysidro this includes the Border to Bayshore Bikeway which will construct a bike route connecting the San Ysidro POE to the City of Imperial Beach through the community of San Ysidro. Please see Volume 1 appendix.

[25] Southbound electronic commercial clearance refers to expedited processing for the Mexican import cargo (U.S. export shipments) as part of Aduanas' PITA program.

[26] Otay Mesa Commercial Modernization refers to a General Services Administration (GSA) led effort to renovate and expand commercial facilities at the Otay Mesa POE. The construction is expected to include 6 additional commercial processing booths and other related improvements. *Source: General Services Administration.*

[27] Otay Mesa Pedestrian Modernization refers to a General Services Administration (GSA) led effort to renovate and expand pedestrian facilities at the Otay Mesa POE. The construction is expected to include 6 additional pedestrian processing lanes and other related improvements. *Source: General Services Administration.*

[28] Enhanced transit service refers to increased frequencies in existing services or newly implemented services, e.g. South Bay Rapid bus service connecting Otay Mesa POE with Downtown San Diego via eastern Chula Vista. Please see appendix Volume 1 appendix.

Calexico West	Baseline	Existing + Phase 1 improvements[29]		Baseline Scenario for all POEs: Sensitivity analysis of a plus or minus 10 percent change in crossing volumes and/or wait times (due to changes in policies, level of economic activity, or other factors).
	With All American Canal	Phase 1 and 2 improvements[30], plus Calexico East with expanded bridge over the All American Canal[31]		
	Transit and Active Transportation	Phase 1 and 2 improvements, plus Calexico East with expanded bridge over the All American Canal, enhanced transit service[32], bike/pedestrian access improvements[33]	Phase 1 and 2 improvements, plus Calexico East with expanded bridge over the All American Canal, enhanced transit service, bike/pedestrian access improvements	
Calexico East	Baseline	Existing + Phase 1 improvements at Calexico West, and southbound (SB) electronic commercial clearance	Existing + Phase 1 improvements at Calexico West, and SB electronic commercial clearance	
	With All American Canal	Existing + expanded bridge over the All American Canal, additional 3 commercial primary booths, Phase 1 improvements at Calexico West, and SB electronic commercial clearance	Existing + expanded bridge over the All American Canal, additional 3 commercial primary booths, Phase 1 improvements at Calexico West, and SB electronic commercial clearance	
	Transit and Active Transportation	Existing + expanded bridge over the All American Canal, Phase 1 improvements at Calexico West, enhanced transit service, and bike/pedestrian access improvements	Existing + expanded bridge over the All American Canal, Phase 1 improvements at Calexico West, enhanced transit service, and bike/pedestrian access improvements	
Andrade	Baseline	Existing	Existing	

[29] Phase 1 improvements at Calexico West include the addition of 5 southbound POV lanes and a southbound bridge over the New River as well as 10 northbound POV lanes. Completion is scheduled for 2018. *Source:* General Services Administration.

[30] Phase 2 improvements at Calexico West include a new pedestrian processing facility, 5 additional southbound POV lanes and 6 additional northbound POV lanes. This phase is currently unfunded but expected to be constructed by the corresponding analysis year (2025).

[31] "Expanded bridge over the All American Canal" is part of proposed improvements to increase capacity at the Calexico East POE. Envisioned expansion comprises 6 additional northbound POV lanes and 3 additional commercial lanes. The bridge expansion component is proposed to address the current bottleneck observed over this section of the approach road to the POE. These improvements are currently unfunded but expected to be constructed by the corresponding analysis year (2025).

[32] Enhanced transit service refers to increased frequencies in existing services or newly implemented services connecting to Imperial County POEs. Please see Volume 1 appendix.

[33] Bike/pedestrian access improvements at Imperial County POEs include completion of planned bike and pedestrian facilities connecting to the POEs identified in the Pedestrian and Bicycle Transportation Access Study (Imperial County Transportation Commission, 2015). Please see Volume 1 appendix.

4 Summary Statistics for Key Air Quality Variables

In addition to the summary statistics prepared for the study as a whole, vehicle fleet and fuel source data were analyzed in more detail to generate inputs for EMFAC2014 and MOVES Mexico.

(Note that Section 4.1 is still in Draft)

Vehicle Class Analysis

Generalized linear models are used to identify statistically significant variations in the mix of vehicle classes across lane types and LPOEs. Passenger vehicles and commercial vehicles are analyzed separately.

For passenger vehicles, the generalized linear model considers first and second order terms, taking the form:

Model:	Class=(lane) (LPOE) (domicile) (lane*LPOE) (lane*domicile) (LPOE*domicile)
Where:	Class = LDA, LDT1, LDT2, MDV Lane = Regular, Ready, SENTRI, southbound LPOE= San Ysidro, Otay Mesa POV, Tecate POV, Calexico West, Calexico East POV, Andrade Domicile=united states, Mexico, other

Results indicate that …(current results suggesting that lane type and domicile are significant, and LPOE may not be a statistically significant term.)

Two models are developed for commercial vehicles:

Model:	Class=(lane) (LPOE) (fuel) (lane*LPOE) (lane*fuel) (LPOE*fuel)
Where:	Class = LHDT, MHDT, HHDT, Line Haul Lane = FAST, Regular, unladen, southbound LPOE= Otay Mesa commercial, Tecate commercial, Calexico East commercial fuel=gas, diesel

Model:	type= (class) (lane) (LPOE) (fuel) (class*lane) (class*LPOE) (class*fuel) (lane*LPOE) (lane*fuel) (LPOE*fuel)
Where:	type = Tractor, single unit, combination unit Class = LHDT, MHDT, HHDT, Line Haul Lane = FAST, Regular, unladen, southbound LPOE= Otay Mesa commercial, Tecate commercial, Calexico East commercial fuel=gas, diesel

Class is used as an input to EMFAC 2014 and MOVES Mexico, type is an input to MOVES Mexico which may be used to refine the effect of diesel fuel purchased in Mexico

Vehicle Age Distribution Analysis

Generalized linear model are used to identify statistically significant variations in vehicle age distribution across lane types and LPOEs. Passenger vehicles and commercial vehicles are analyzed separately.

For passenger vehicles, the generalized linear model considers first and second order terms, taking takes the form:

Model:	age= (class) (lane) (LPOE) (domicile) (class*lane) (class*LPOE) (class*domicile) (lane*LPOE) (lane*domicile) (LPOE*domicile)
Where:	age = expected age class=LDA, LDT1, LDT2, MDV lane = Regular, Ready, SENTRI, southbound LPOE= San Ysidro, Otay Mesa POV, Tecate POV, Calexico West, Calexico East POV, Andrade Domicile=united states, Mexico, other

Results indicate that …

For commercial vehicles, the model takes the form:

Model:	age=(class) (lane) (LPOE) (fuel) (class*lane) (class*LPOE) (class*fuel) (lane*LPOE) (lane*fuel) (LPOE*fuel)
Where:	age=expected age class = LHDT, MHDT, HHDT, Line Haul lane = FAST, Regular, unladen, southbound LPOE= Otay Mesa commercial, Tecate commercial, Calexico East commercial fuel=gas, diesel

Results indicate that …

Vehicle Odometer Analysis

Generalized linear model are used to identify statistically significant variations in vehicle odometer readings as a function of age across lane types and LPOEs. Passenger vehicles and commercial vehicles are analyzed separately.

For passenger vehicles, the generalized linear model considers first and second order terms, taking the form:

Model:	odom = (age) (class) (lane) (LPOE) (domicile) (age*class) (age*lane) (age*LPOE) (age*domicile) (class*lane) (class*LPOE) (class*domicile) (lane*LPOE) (lane*domicile) (LPOE*domicile)
Where:	odom = expected odometer age = age class=LDA, LDT1, LDT2, MDV lane = Regular, Ready, SENTRI, southbound LPOE= San Ysidro, Otay Mesa POV, Tecate POV, Calexico West, Calexico East POV, Andrade Domicile=united states, Mexico, other

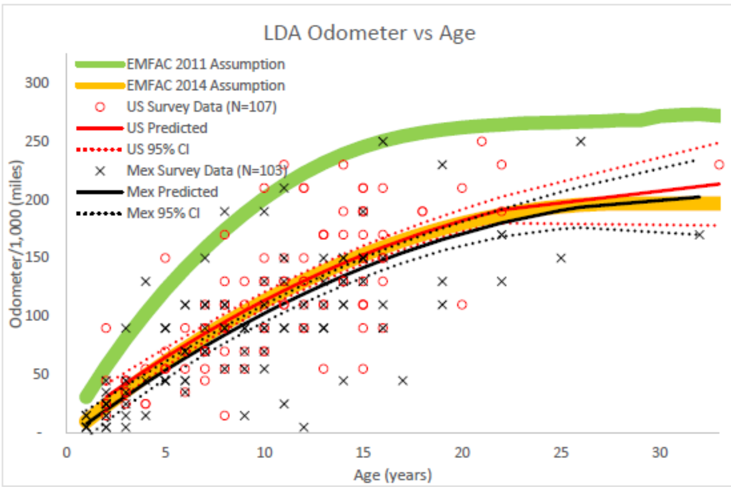
Results indicate that …

For commercial vehicles, the model takes the form:

Model:	odom=(age) (class) (lane) (LPOE) (fuel) (age*class) age(lane) (age*LPOE) (age*fuel) (class*lane) (class*LPOE) (class*fuel) (lane*LPOE) (lane*fuel) (LPOE*fuel)
Where:	odom = expected odometer Age=age class = LHDT, MHDT, HHDT, Line Haul lane = FAST, Regular, unladen, southbound LPOE= Otay Mesa commercial, Tecate commercial, Calexico East commercial fuel=gas, diesel

Results indicate that …

Note that odometer results will be graphically compared to EMFAC2014 assumptions as was done for the CEC and ICAPCD.



Analysis of Mexican Fuel Use

This will also be a series of generalized linear models

Anticipated results are that fuel use will be a function of domicile… in the past about 75% of US vehicles were running US fuel and about 75% of Mexican vehicles were running Mexican fuel.

5 Assessment of San Diego County LPOE Emissions

San Diego county results for POV and commercial LPOE's are presented in separate sections below. The spatial domain of interest, and reporting, varies by pollutant. Seasonal PM10, PM2.5, and CO are presented for each LPOE. Whereas for each season, a single ROG result, a single NOx result, and a single CO2 result are presented, which represents the combined emissions from all POV border crossings in the county, and separately for all commercial border crossings in the county. Excel spreadsheets that calculate emissions for each LPOE by lane type, process, and hour of the day are available as electronic appendices.

The five San Diego County scenarios described in section three are addressed for ROG, NOx, CO2, PM10, PM2.5, and CO:

- Baseline 2016 POV: This scenario reflects how each LPOE operates in 2016.
- Baseline 2025 POV: This scenario reflects how each LPOE is anticipated to operate in 2025. Key changes relative to 2016 include:
    - ✓ Phase 3 at San Ysidro improvements, including 10 purpose-built southbound inspection lanes, and an additional eight northbound inspection lanes.
    - ✓ Otay Mesa commercial LPOE modernization, including six additional northbound commercial primary inspection booths.
    - ✓ Electronic clearance for all Aduanas primary commercial inspections.
- Baseline 2025 plus OME: This scenario adds the Otay Mesa East LPOE as a tolled facility with average crossing times of about 20 minutes.
- Baseline 2025 plus OME and Active Transportation: this scenario reflects changes in POV and bus volumes associated with the planned active transportation and transit improvements discussed in Section 3.
- Baseline 2035 plus OME and Active Transportation: This scenario reflects an additional ten years of growth.

Annual volume estimates for each LPOE are presented before the emissions results. In general, the volumes grow over time, and are discussed in detail in Volume 1. The volumes include the effect of induced growth in person and commercial trips associated with the various capacity enhancements, and the mode shift from POVs to pedestrian and transit associated with active transportation and transit investments.

Emissions data are normalized based on the number of border crossings, and presented per one thousand border crossings. This emphasizes the combined effect of reduced delay and queuing plus cleaner, more efficient, vehicles. For POVs, the emissions are reduced by both capacity enhancement scenarios and the active transportation and transit improvement scenarios, despite a roughly 20% increase in the volume of POVs crossing the border. Commercial vehicle emissions per border crossing drop through 2025, capacity enhancements reduce delay, and improvements in vehicle technology combine, to produce this benefit. However, by 2025 the benefit of more stringent emission certification standards for commercial vehicle engines has permeated most of the commercial vehicle fleet, and delays increase between 2025 and 2035 without additional infrastructure investment. Commercial vehicle emissions tend to show little addition improvement between 2025 and 2035; with some pollutants increasing due to increased delay and queuing.

Sections 5.1 and 5.2 below present the POV border crossing volumes and emissions, respectively. Sections 5.3 and 5.4 present the corresponding commercial vehicle volumes and emissions.

5.1 San Diego County Annual Northbound and Southbound POV Border Crossings

Figure 13 through Figure 17 show San Diego County POV volumes for each scenario. Volumes for each of the four LPOEs that process POVs are presented, along with the county wide totals. Volume 1 details the sources of existing and forecast traffic volumes.

To understand how volumes and emissions change between scenarios for POVs, note that:

- POV border crossings are anticipated to increase by about 11% from 2016 to 2025 without OME. Induced demand with OME results in an additional 10% increase in border traffic relative to 2016, for overall volume growth of about 21%.
- The active transportation and transit improvements then reduce POV border crossings slightly (by about -0.9%) in 2025.
- Across all San Diego County LPOEs, Growth in POV volume from 2025 to 2035 is essentially flat because of the active transportation and transit mode shift. However, those benefits accrue primarily at Otay Mesa and OME, where POV crossings are anticipated to drop. In contrast, POV traffic grows slightly from 2025 to 2035 at San Ysidro and Tecate.

The annual northbound volume for each LPOE was scaled to represent seasonal weekdays and weekend-days, and split into Regular lane, Ready lane, and SENTRI lane volumes based on information from the Bureau of Transportation Statistics[34], a data set provided by CBP through SANDAG[35], and data collected for this study. Southbound flows were also adjusted for seasonality and day of the week. Weekdays represent Tuesday through Thursday, while weekends reflect Saturday and Sunday Conditions. Seasonal and weekday/weekend

[34] BTS xxx
[35] SANDAG xxx

adjustments are provided in Table 6. The breakout of traffic by Regular lane, Ready lane, and SENTRI lane for each LPOE is provided in Table 7.

Table 6. Northbound San Diego County POV seasonal weekday and weekend adjustments to annualized daily border crossing data.

LPOE	Winter Weekday	Winter Weekend	Summer Weekday	Summer Weekend
San Ysidro				
Regular lane	111%	106%	97%	103%
Ready lane	99%	96%	107%	86%
SENTRI lane	104%	106%	109%	101%
southbound	109%	106%	109%	101%
Otay Mesa				
Regular lane	93%	107%	101%	98%
Ready lane	98%	91%	107%	94%
SENTRI lane	102%	84%	104%	94%
southbound	104%	107%	111%	110%
Otay Mesa East (when open)				
Regular lane	93%	107%	101%	98%
Ready lane	98%	91%	107%	94%
SENTRI lane	102%	84%	104%	94%
southbound	104%	107%	111%	110%
Tecate				
Regular lane	93%	93%	106%	105%
southbound	89%	101%	101%	115%

Table 7. Northbound San Diego County POV lane utilization

LPOE	Regular Lane	Ready Lane	SENTRI Lane
San Ysidro	22%	39%	39%
Otay Mesa (when open)	20%	57%	23%
Otay Mesa East	20%	57%	23%
Tecate	100%		

Southbound POV travel, through San Ysidro, Otay Mesa, and OME LPOEs are assumed to operate as if the LPOEs share capacity across a single system, with about 72% of the southbound POVs using San Ysidro. The remaining 28% of southbound POV traffic was assumed to split evenly between Otay Mesa and OME.

Figure 13. Baseline 2016 San Diego County POV Border Crossing Volume by LPOE

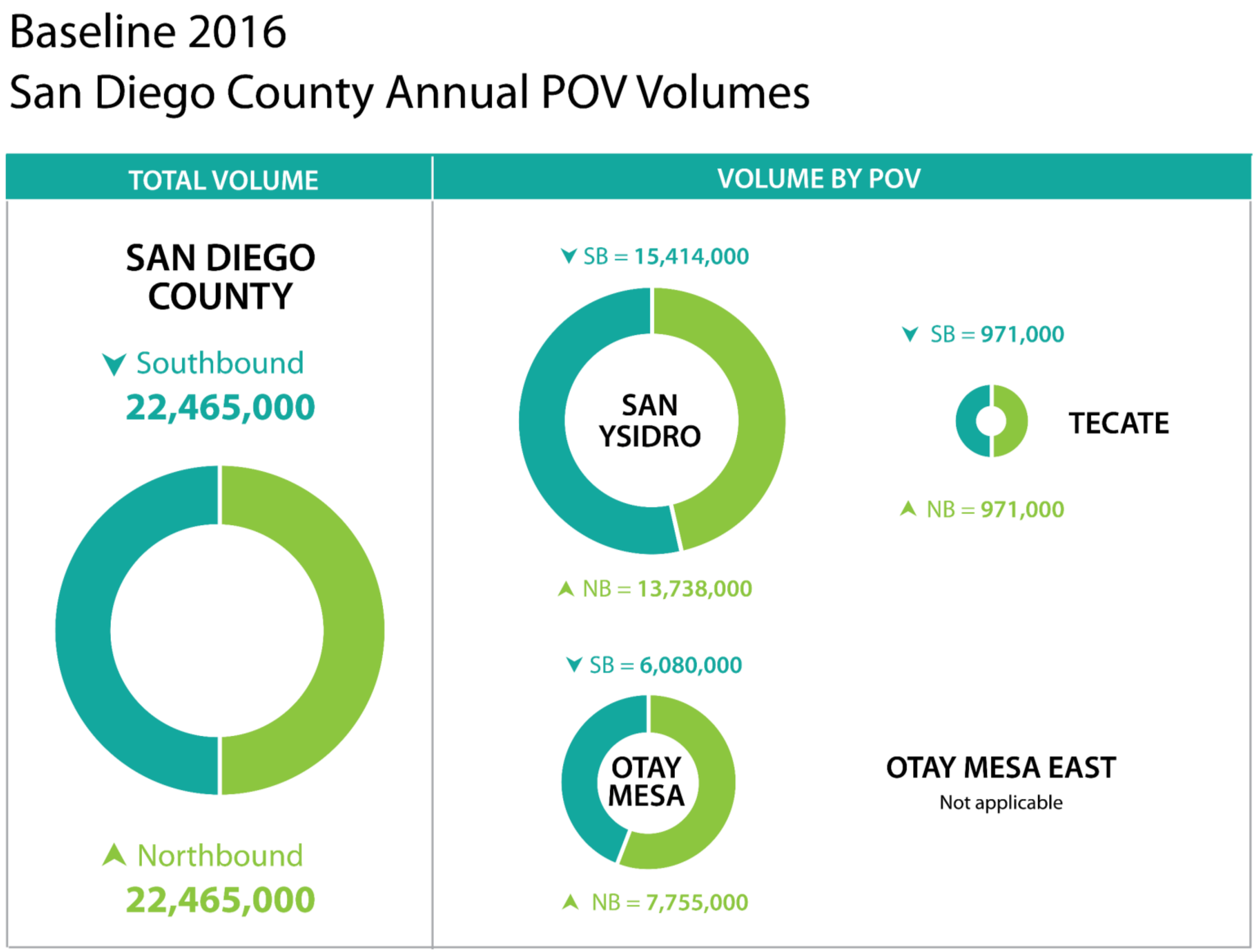


Figure 14. Baseline 2025 San Diego County POV Border Crossing Volume by LPOE

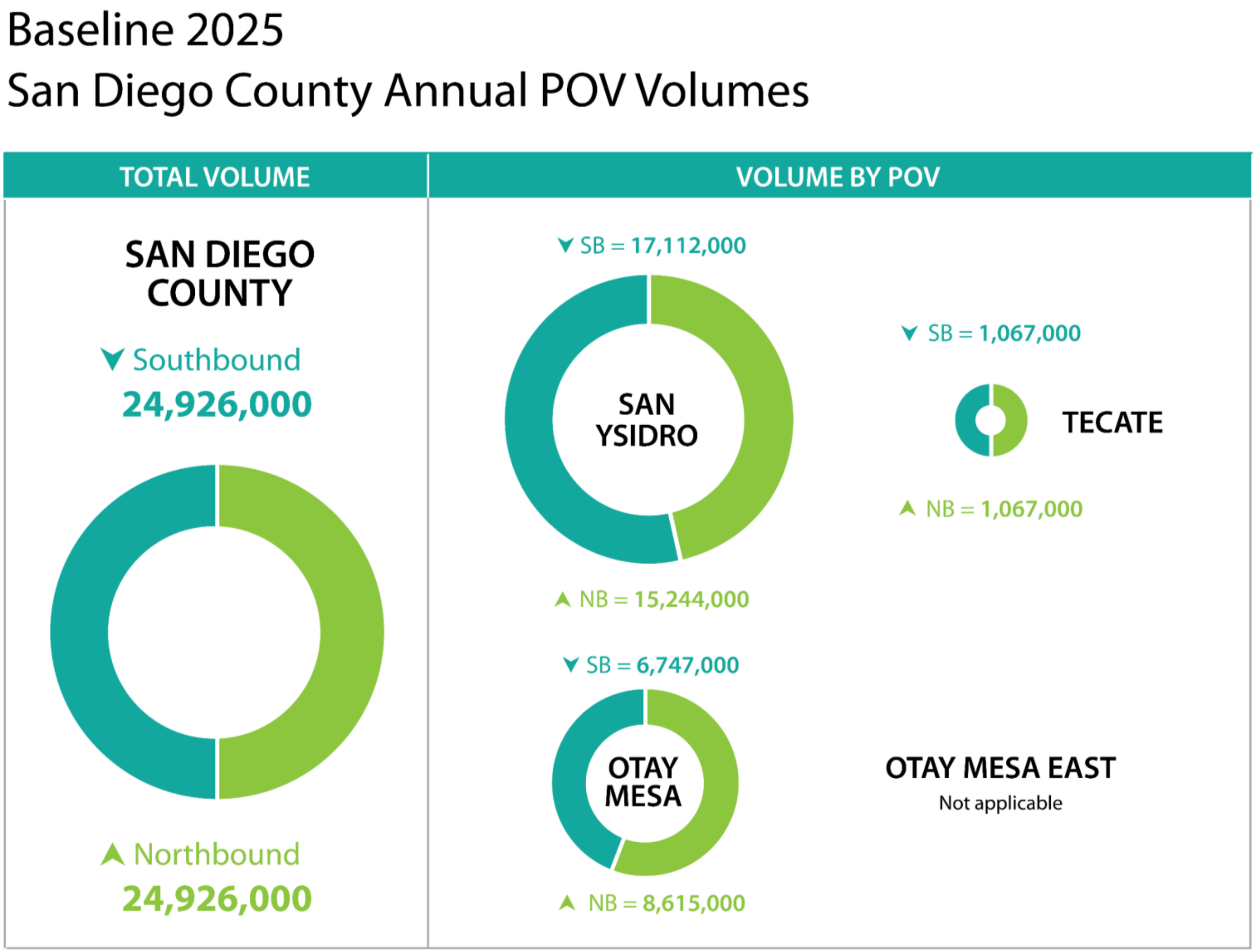


Figure 15. 2025 San Diego County POV Border Crossing Volume by LPOE with the Otay Mesa East LPOE

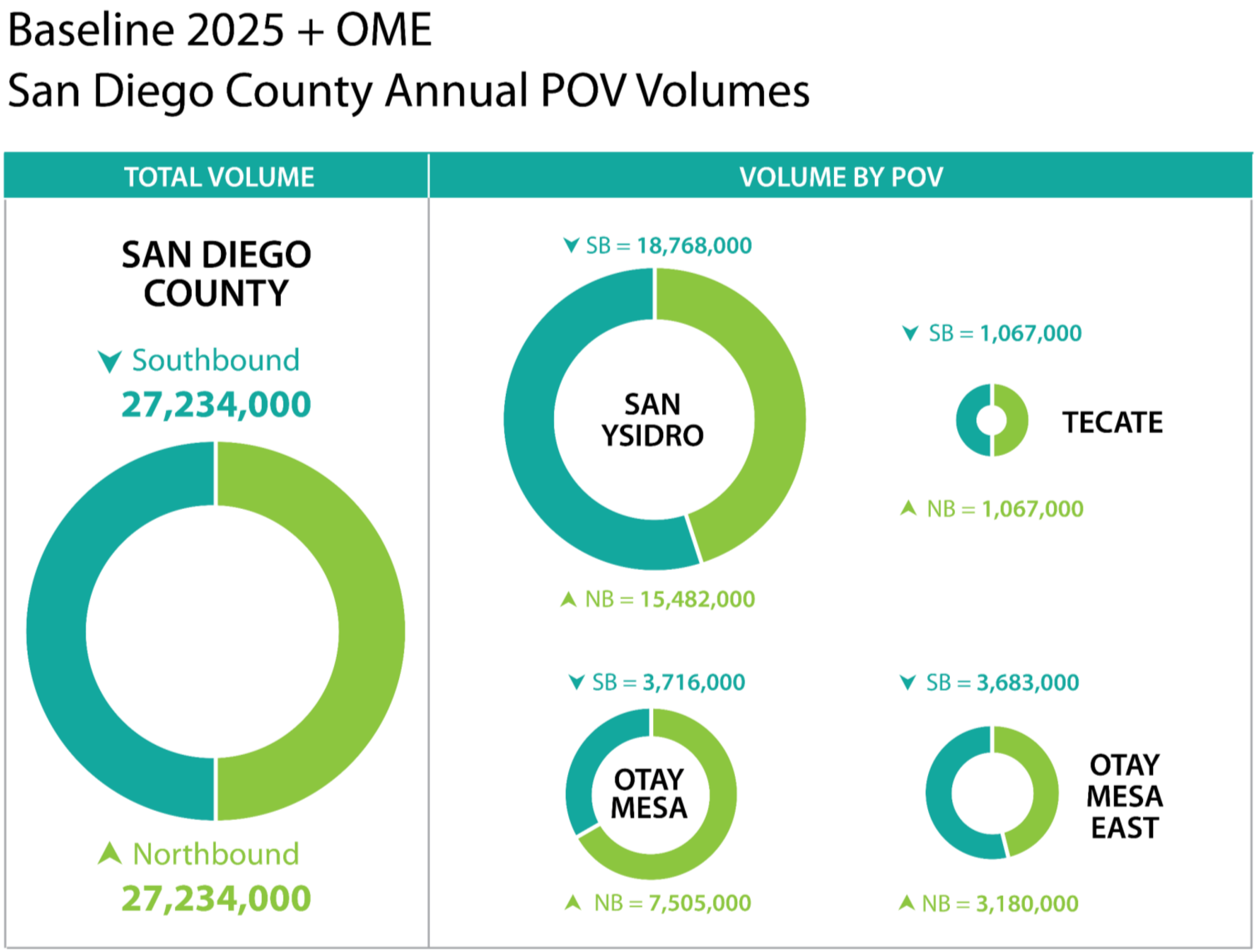


Figure 16. 2025 San Diego County POV Border Crossing Volume by LPOE with the Otay Mesa East LPOE and Active Transportation Improvements

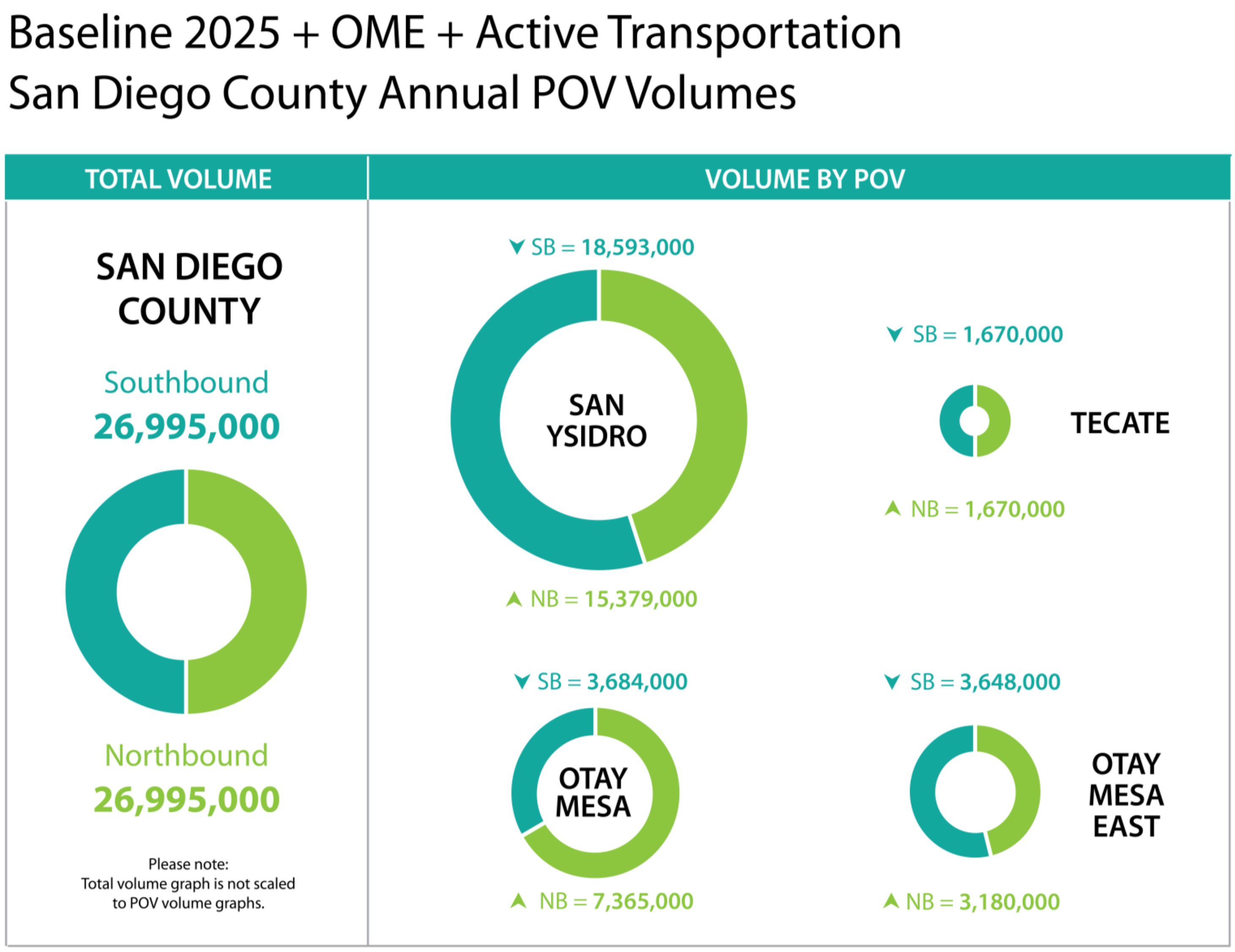
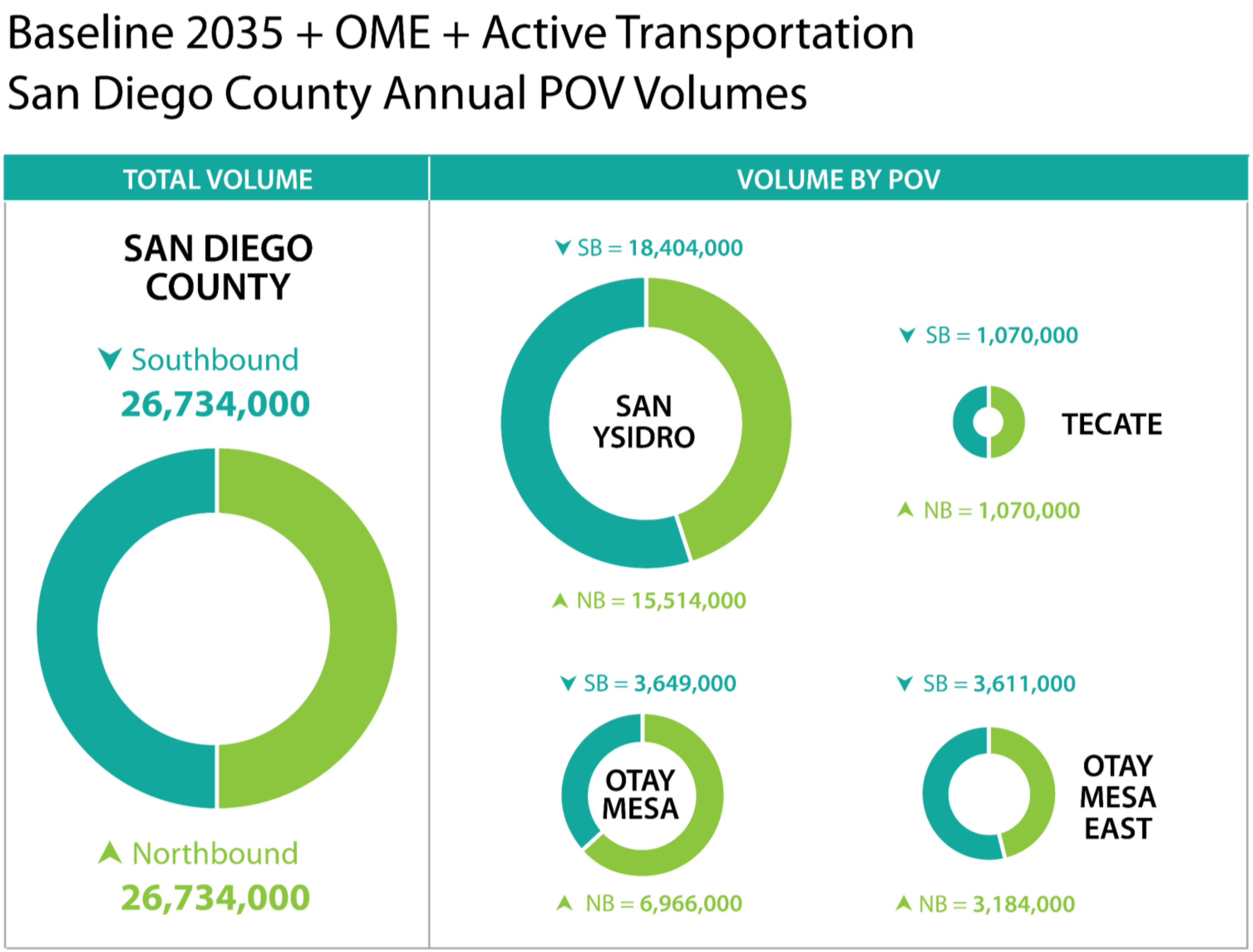


Figure 17. 2035 San Diego County POV Border Crossing Volume by LPOE with the Otay Mesa East LPOE and Active Transportation Improvements



5.2 San Diego County Annual Northbound and Southbound POV Emissions

Average seasonal day emissions are reported for winter and summer “design days”. The averages weigh together both weekday and weekend results to report values that represent a typical day (i.e. that if multiplied by 90 would reflect all LPOE emissions for that season). Emissions are reported in units of grams per day, except for CO2 which is reported in units of kilograms per day. More detailed results and calculations are available as Excel spreadsheets in the electronic appendices.

Figure 18 and Figure 19 report emissions for ROG, NOx, and CO2 per 1000 POVs crossing the through the LPOEs between San Diego County, and the state of Baja California. The results show emission reductions from the 2016 to 2025 baseline scenarios. This result reflects reduced crossing times at San Ysidro associated with the Phase 3 improvements, and a less polluting vehicle fleet in 2025 as older vehicles age out of the fleet. Implementation of OME and the active transportation and transit enhancements further reduce emissions through reduced border crossing delay. POV emission are anticipated to continue dropping between the 2025 and 2035 OME with activate transportation and transit enhancement scenarios due to a cleaner overall vehicle fleet in 2035 and the predicted increase in alternative modes of travel.

PM10, PM2.5, and NOx emission results are reported separately for each San Diego County LPOE in Figure 20 through Figure 27. There are two figures for each LPOE providing winter design day and summer design day results for all five analysis scenarios. Trends for each LPOE differ from the one another depending on where capacity improvements are built and mode shift is anticipated to occur due to the active transportation and transit enhancements.

- At San Ysidro, apart from the summer 2035 with OME and active transportation scenario, emissions of PM10, PM2.5 and NOx per border crossing are expected to decline over time due to capacity enhancements, investments in non-POV modes, and cleaner-more efficient vehicle technologies. During the more congested summer season, emissions of PM10 and CO are anticipated to be higher in 2035 than 2025. This increase reflects growing congestions as volumes increase without additional capacity investments to offset the growth in POV traffic.

- At Otay Mesa and OME emissions of PM2.5 per border crossing are anticipated to increase slightly from 2016 to 2025 as growing congestion increases emissions more than vehicle technology can mitigate. With the OME, emissions of PM10, PM2.5 and NOx per border crossing are expected to decline over time.

- The Tecate LPOE is not affected by capacity enhancements or active transportation and transit improvements that occur at San Ysidro, Otay Mesa, and OME. Therefore, emissions from the three 2025 scenarios are identical at Tecate. Emissions per border crossing are anticipated to drop from 2016 through 2035 as cleaner, more efficient, vehicles offset the effects of increasing delay and queuing.

The trends for both the winter and summer design days are similar, with minor variations in emissions resulting from the seasonal traffic differences, and temperature effects on emissions.

Figure 18. Winter Design Day CO2, ROG, NOx from POVs at San Diego County LPOEs

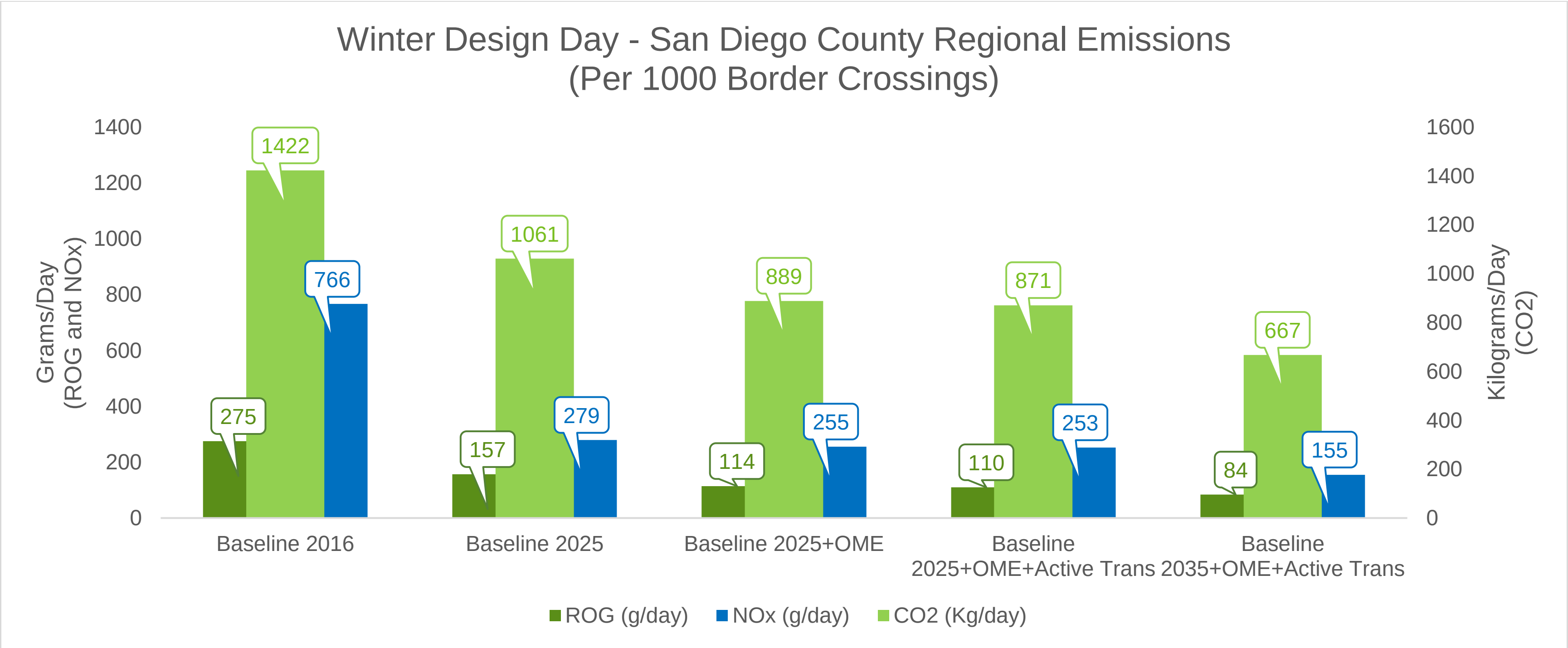


Figure 19. Sumer Design Day CO2, ROG, NOx from POVs at San Diego County LPOEs

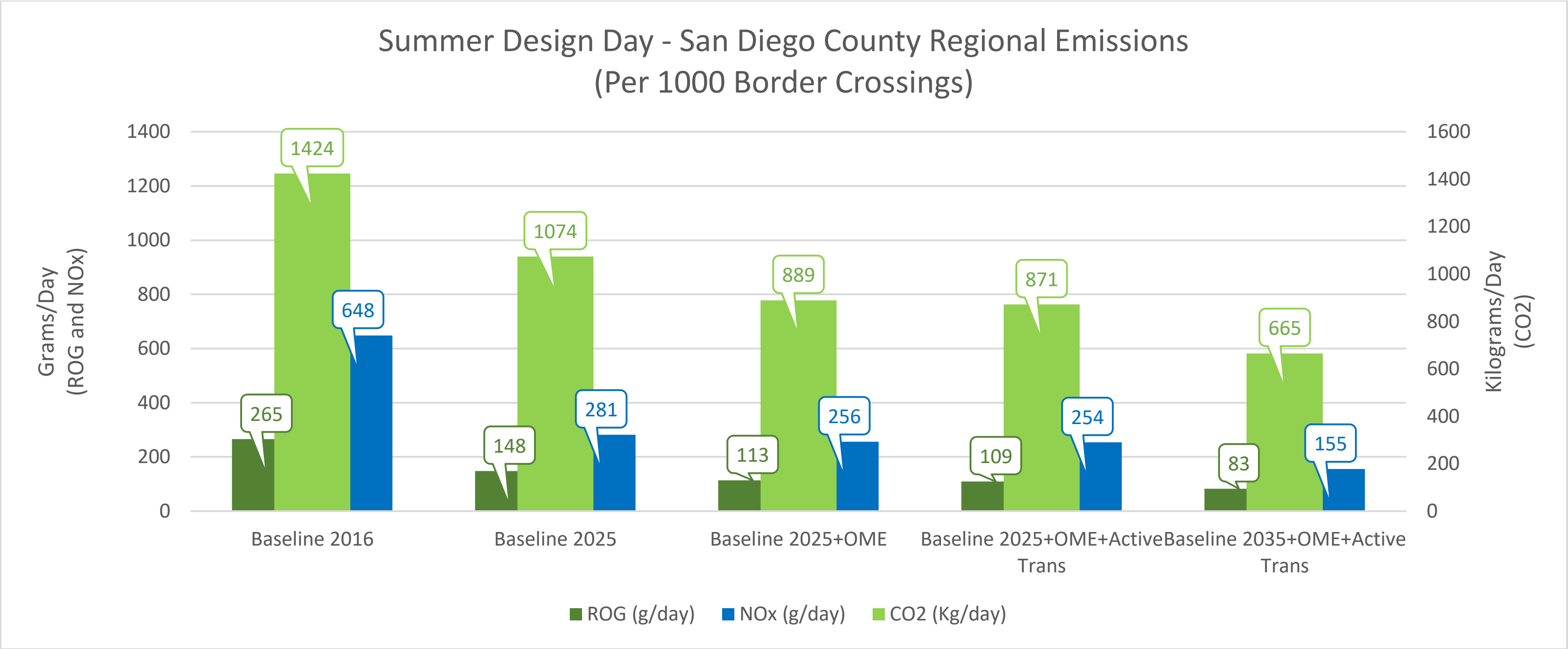


Figure 20. Winter Design Day CPM10, PM2.5, and CO from POVs at the San Ysidro LPOE

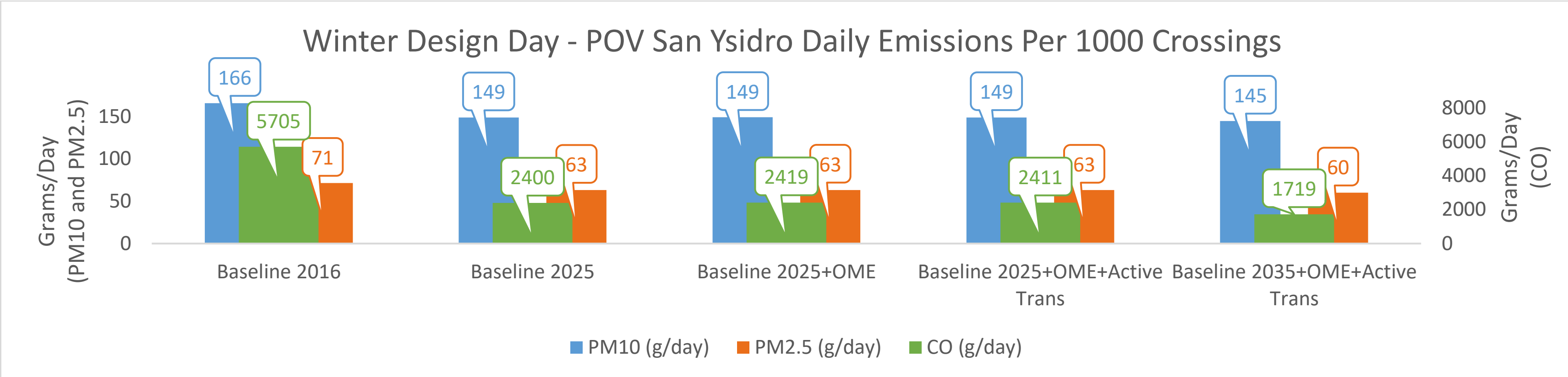


Figure 21. Summer Design Day CPM10, PM2.5, and CO from POVs at the San Ysidro LPOE

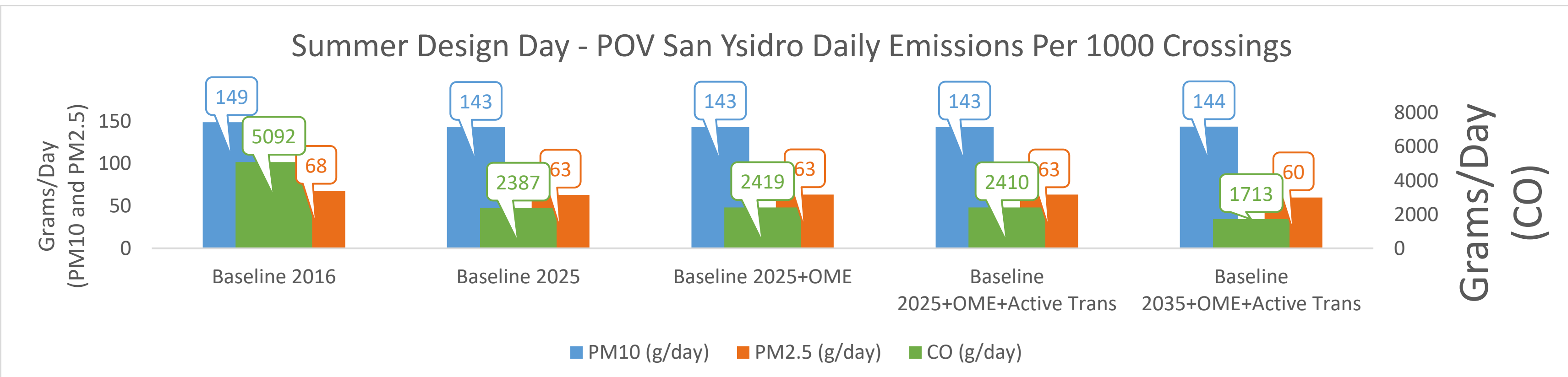


Figure 22. Winter Design Day CPM10, PM2.5, and CO from POVs at the Otay Mesa LPOE

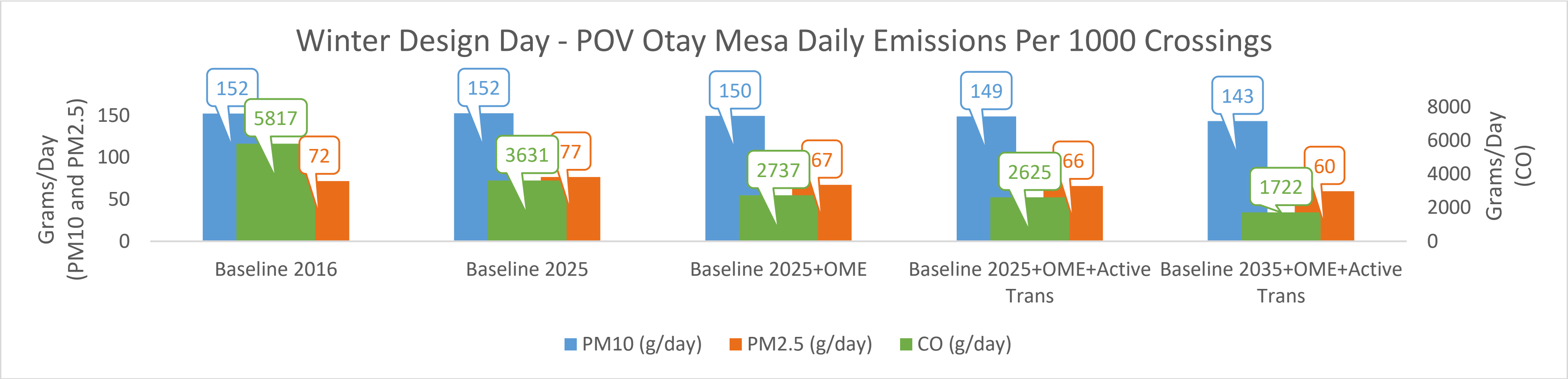


Figure 23. Summer Design Day CPM10, PM2.5, and CO from POVs at the Otay Mesa LPOE

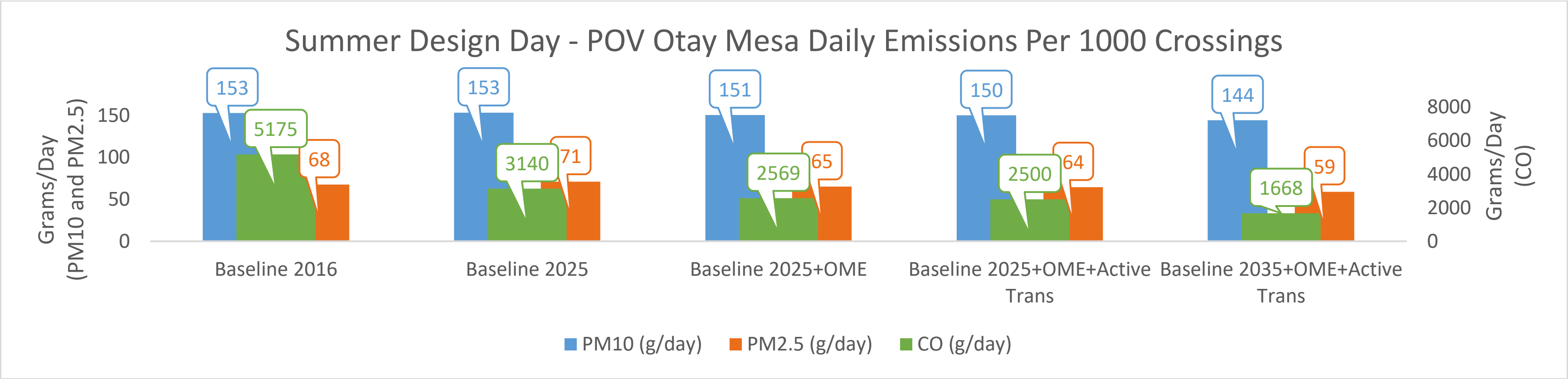


Figure 24. Winter Design Day CPM10, PM2.5, and CO from POVs at the Otay Mesa East LPOE

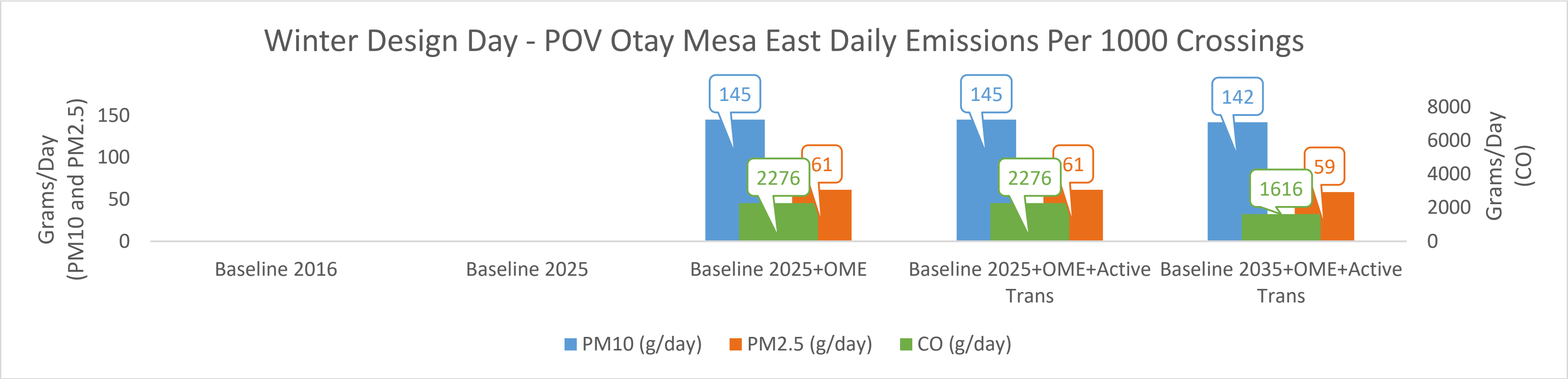


Figure 25. Summer Design Day CPM10, PM2.5, and CO from POVs at the Otay Mesa East LPOE

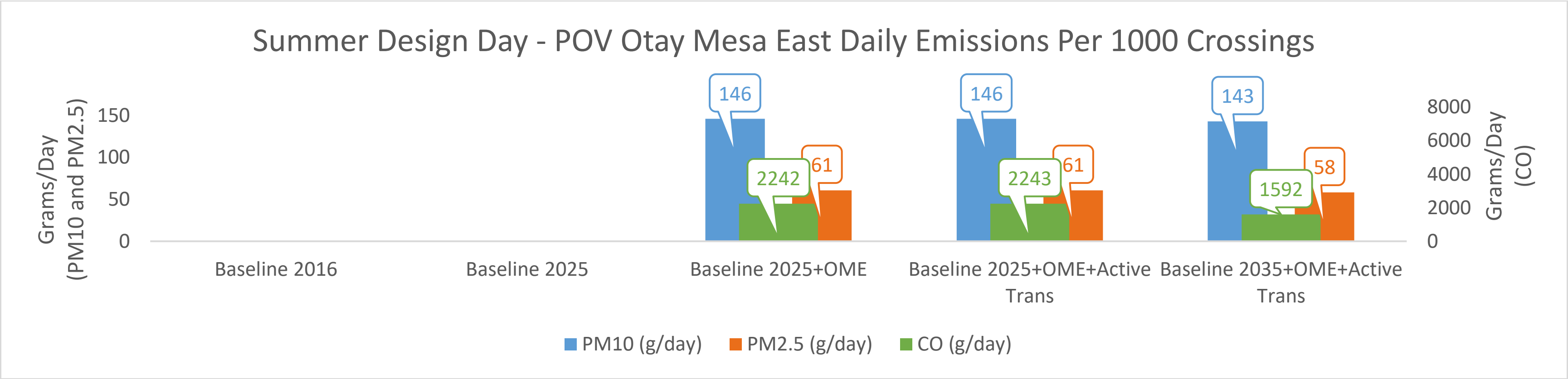


Figure 26. Winter Design Day CPM10, PM2.5, and CO from POVs at the Tecate LPOE

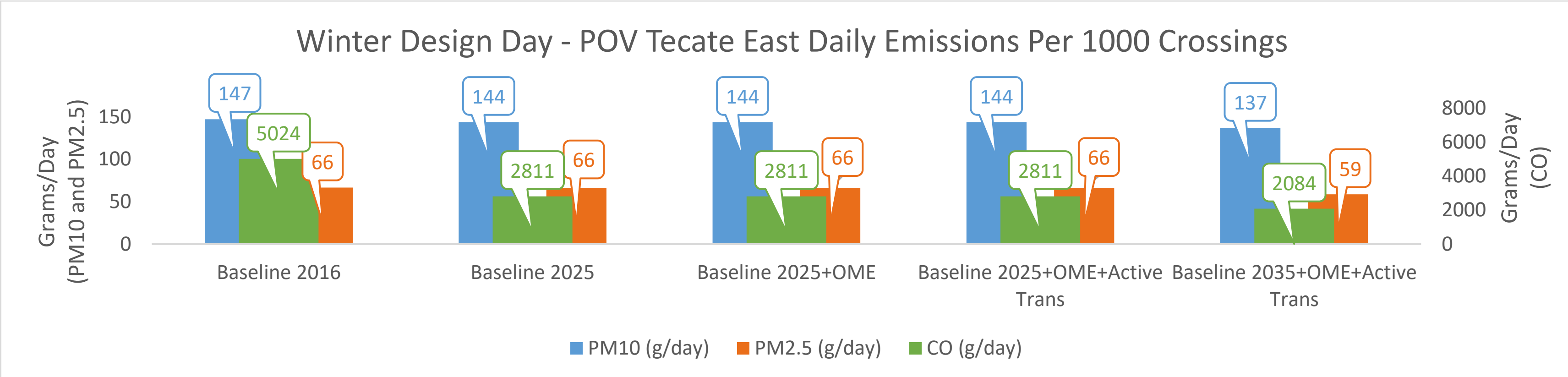
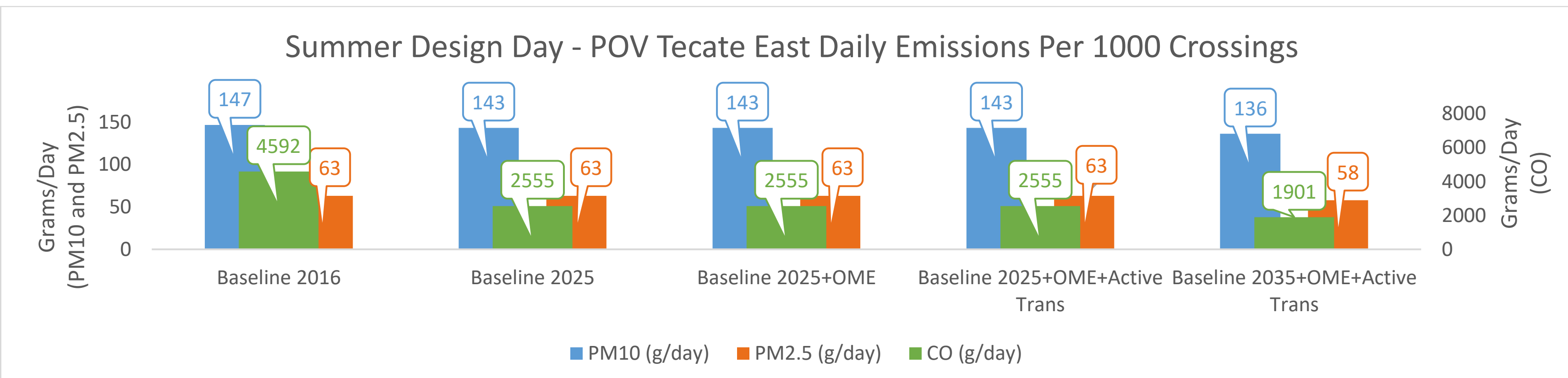


Figure 27. Summer Design Day CPM10, PM2.5, and CO from POVs at the Tecate LPOE



5.3 San Diego County Annual Northbound and Southbound Commercial Vehicle Border Crossings

San Diego county Commercial vehicle traffic is shown in Figure 28 through Figure 31, for the five San Diego County analysis scenarios. There are four figures covering the five scenarios because Figure 30 represents 2025 with the Otay mesa East LPOE, both with and without the active transportation and transit improvements.

From 2016 to 2025, commercial border crossings in San Diego County are anticipated to increase by 22%. With the addition of Otay Mesa East, demand is expected to increase by an additional ten percentage points of growth (for a total of 32%). Anticipated growth through 2035 results in an 80% increase in commercial vehicle border crossings relative to 2016. Most of that growth occurs at the Otay Mesa, and Otay Mesa East LPOEs, Growth at Tecate through 2035 is anticipated to be limited to 18%.

Figure 28. Baseline 2016 San Diego County Commercial Vehicle Border Crossing Volume by LPOE

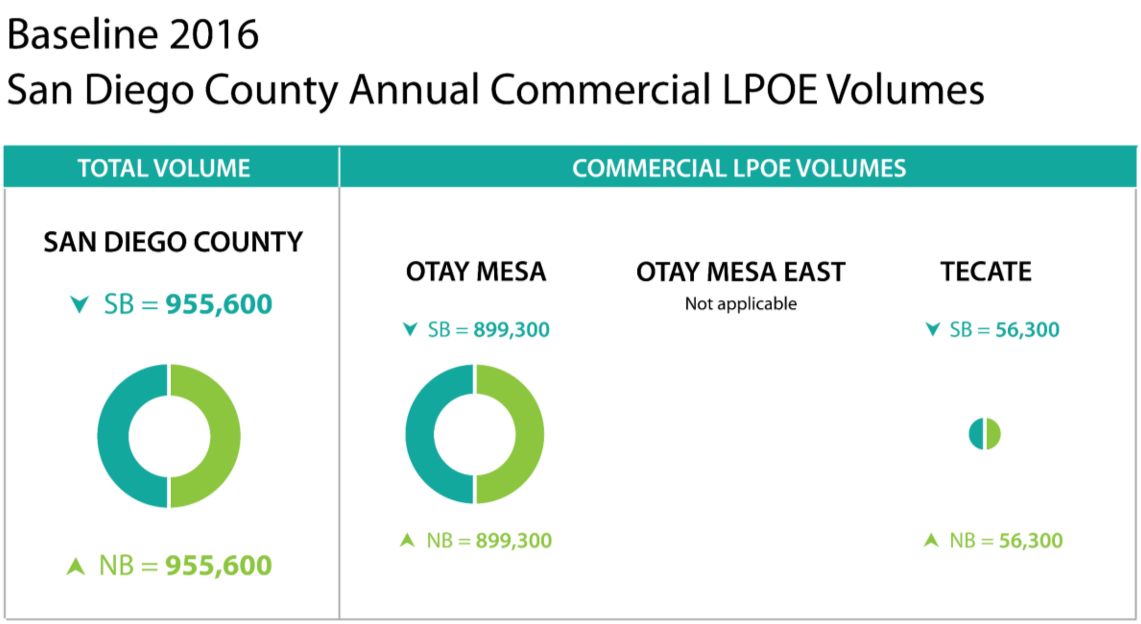


Figure 29. Baseline 2025 San Diego County Commercial Vehicle Border Crossing Volume by LPOE

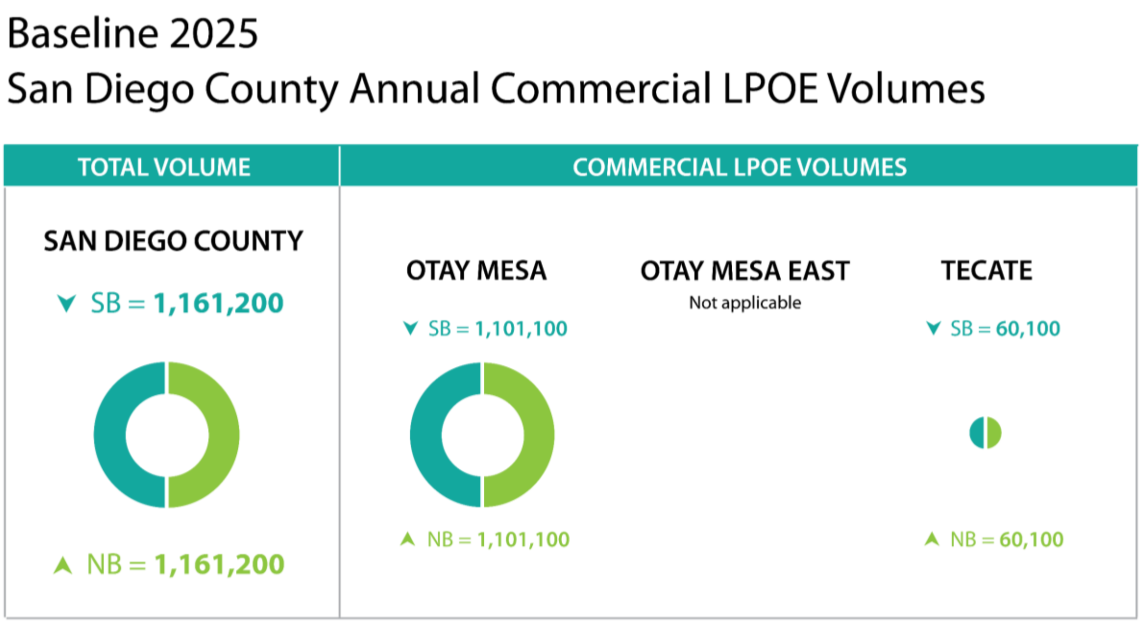


Figure 30. 2025 San Diego County Commercial Vehicle Border Crossing Volume by LPOE with the Otay Mesa East LPOE and Otay Mesa East plus Active Transportation and Transit enhancements

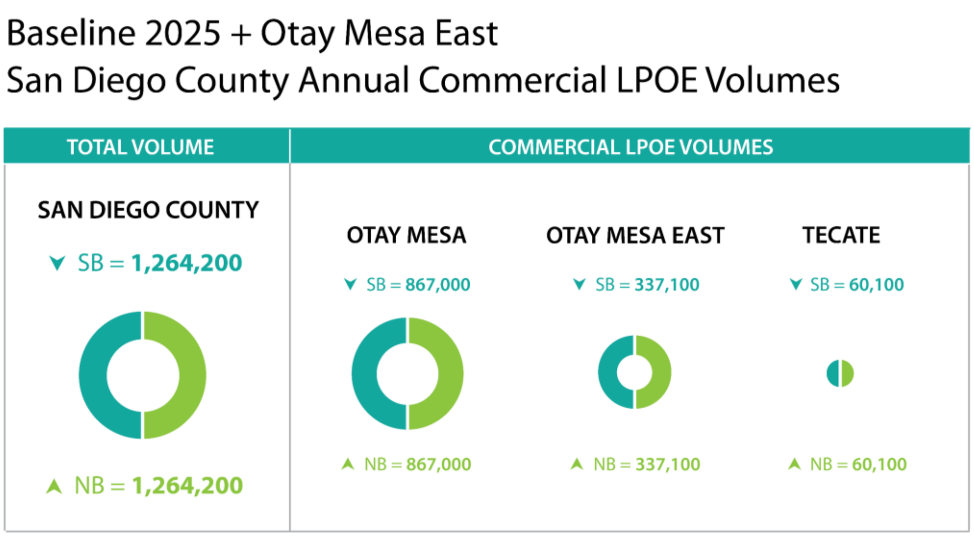
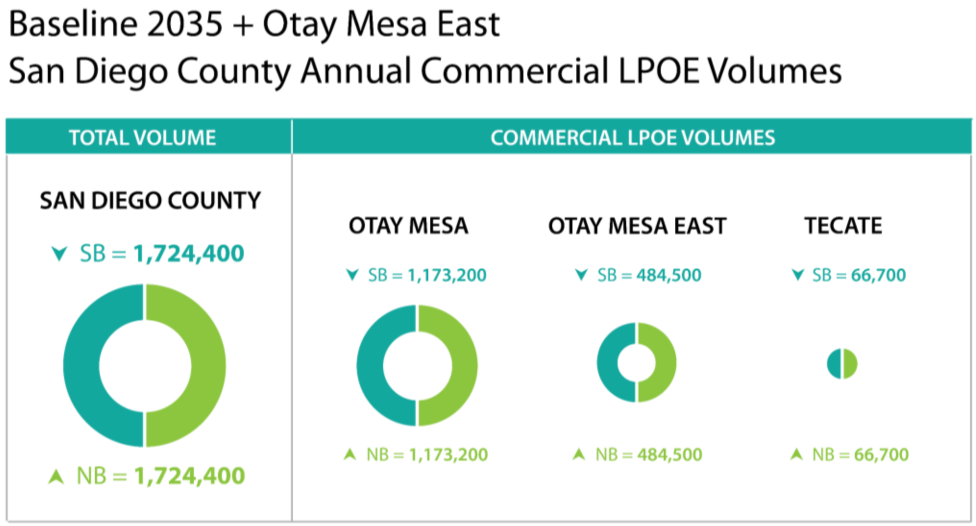


Figure 31. 2035 San Diego County Commercial Vehicle Border Crossing Volume by LPOE with the Otay Mesa East LPOE



5.4 San Diego County Annual Northbound and Southbound Commercial Vehicle Emissions

Average seasonal day emissions are reported for winter and summer "design days". The averages weigh together both weekday and weekend results to report values that represent a typical day (i.e. that if multiplied by 90 would reflect all LPOE emissions for that season). Emissions are reported in units of grams per day, except for CO2 which is reported in units of kilograms per day. More detailed results and calculations are available as Excel spreadsheets in the electronic appendices.

Figure 32 and Figure 33 report emissions for ROG, NOx, and CO2 per 1000 commercial vehicles crossing the through the LPOEs between San Diego County, and the state of Baja California. The results show emission reductions from the 2016 to 2025 baseline scenarios. This result reflects both the capacity enhancements from the Otay Mesa Cargo Modernization program, and the benefit of a less polluting and more efficient 2025 truck fleet relative to 2016. The capacity increase in 2025 through the addition of Otay Mesa East further reduces delay and emissions per commercial vehicle crossing, while volumes increase slightly as noted in the previous section. By 2035, particularly during the busier summer season, emissions of ROG, NOx, and CO2 from each border crossing increase slightly. These increases result from increases in delay at the Otay Mesa commercial port-of-entry. By 2025, more stringent vehicle certification standards have nearly permeated the commercial vehicle fleet. Thus the are not emission reduction benefits from fleet turn-over between 2025 and 2035 are not as substantial as those that occur between 2016 and 2025.

PM10, PM2.5, and NOx emission results are reported separately for each San Diego County LPOEs in Figure 34 through Figure 39. There are two figures for each LPOE providing winter design day and summer design day results for all five analysis scenarios. Trends for each LPOE differ from the one another depending on where capacity improvements are built and mode shift is anticipated to occur due to the active transportation and transit enhancements.

Figure 32. Winter Design Day CO2, ROG, NOx from Commercial Vehicle at San Diego County LPOEs

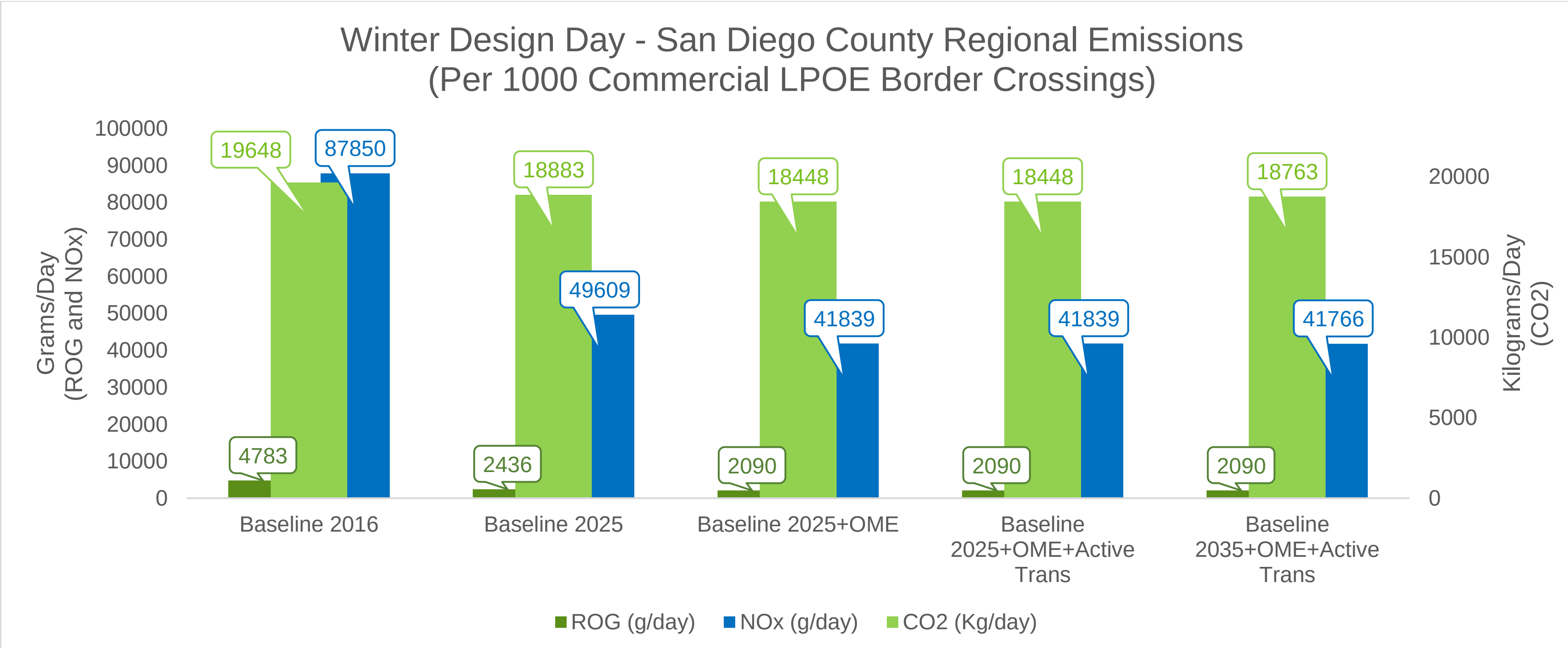


Figure 33. Summer Design Day CO2, ROG, NOx from Commercial Vehicle at San Diego County LPOEs

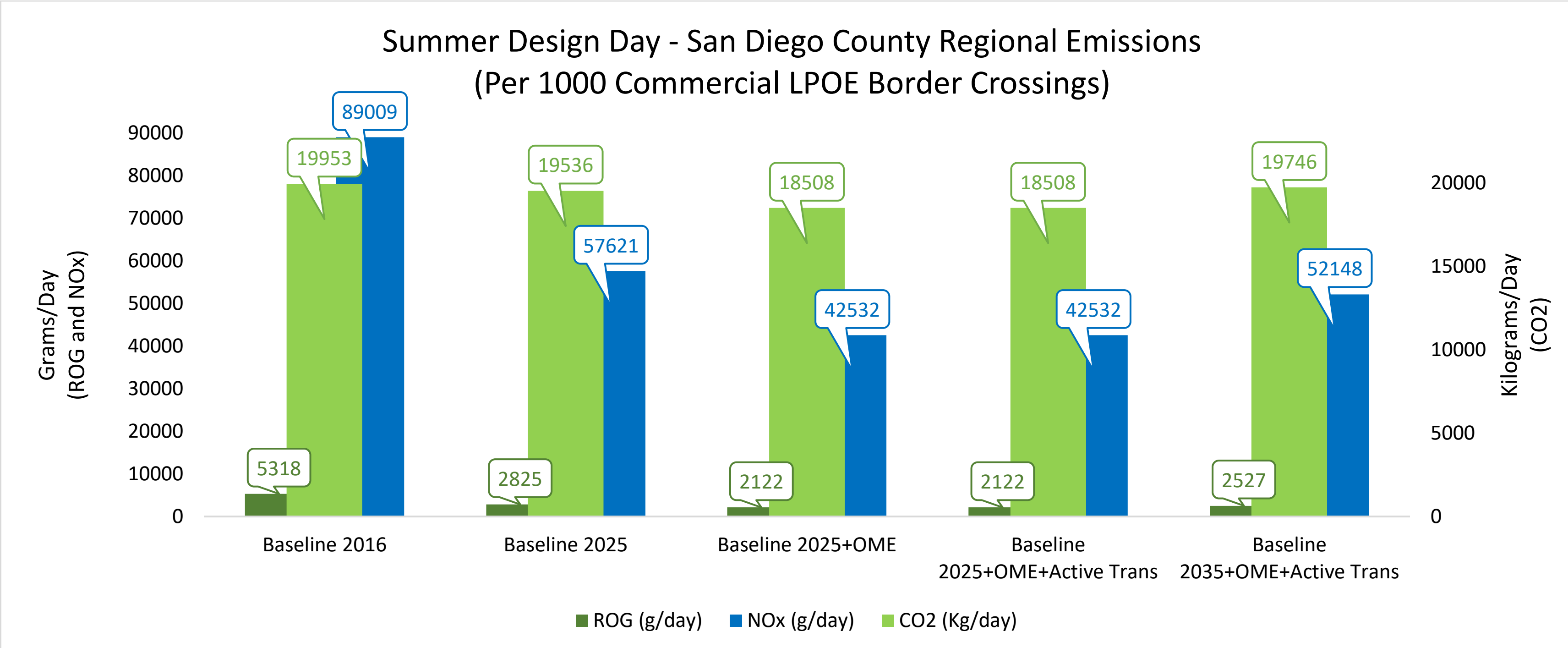


Figure 34. Winter Design Day CPM10, PM2.5, and CO from Commercial Vehicles at the Otay Mesa LPOE

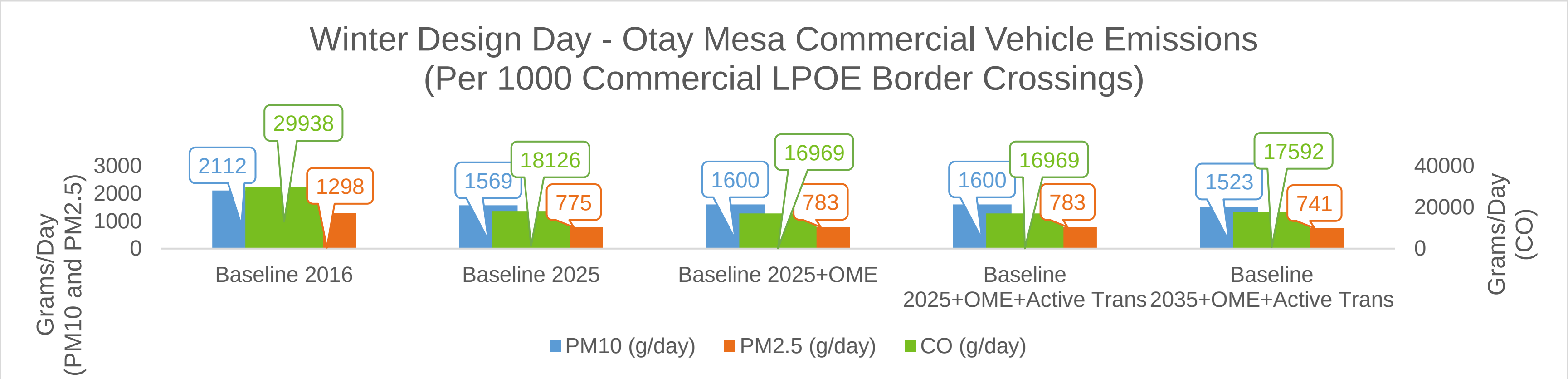


Figure 35. Summer Design Day CPM10, PM2.5, and CO from Commercial Vehicles at the Otay Mesa LPOE

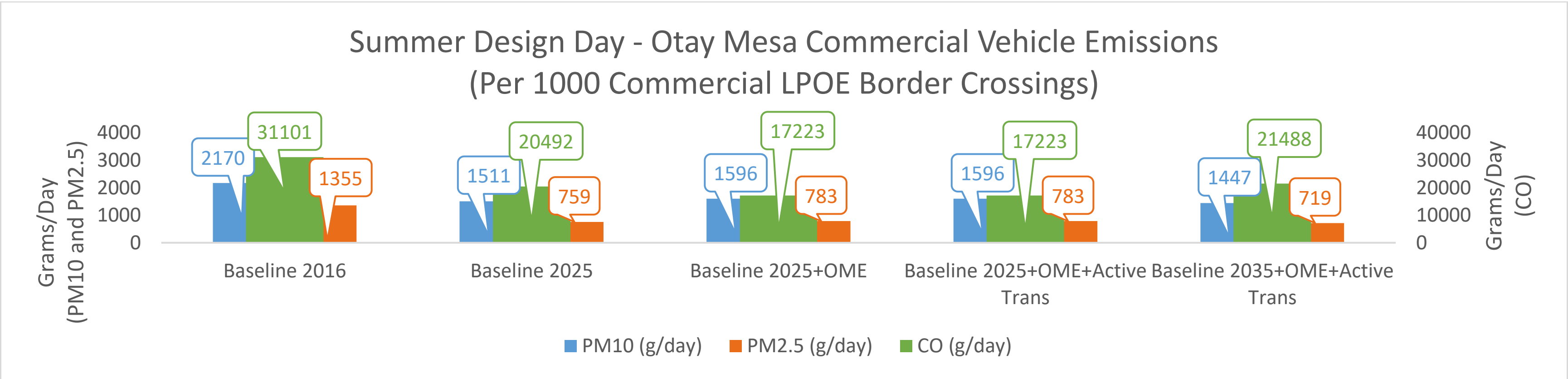


Figure 36. Winter Design Day CPM10, PM2.5, and CO from Commercial Vehicles at the Otay Mesa East LPOE

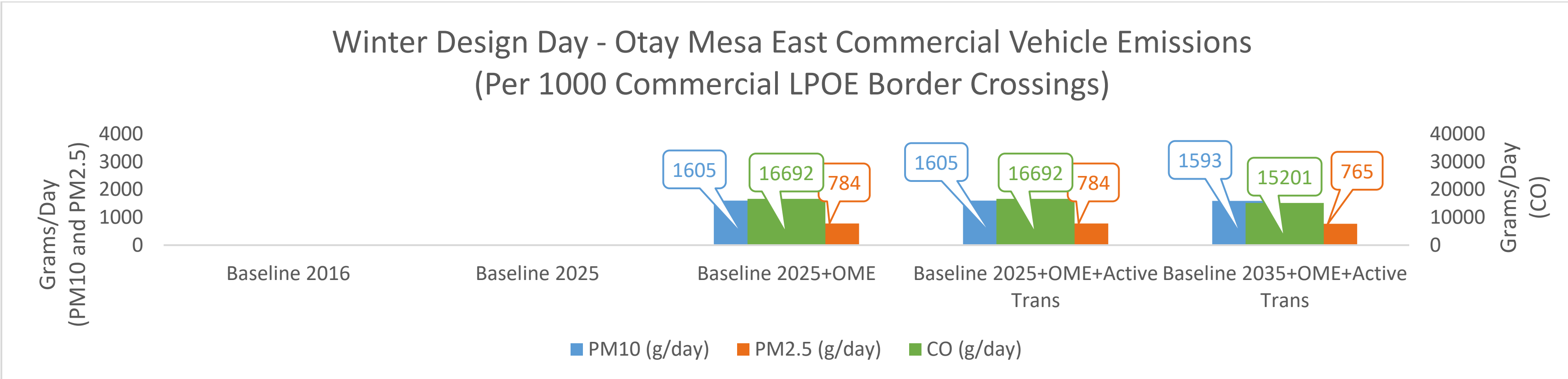


Figure 37. Summer Design Day CPM10, PM2.5, and CO from Commercial Vehicles at the Otay Mesa East LPOE

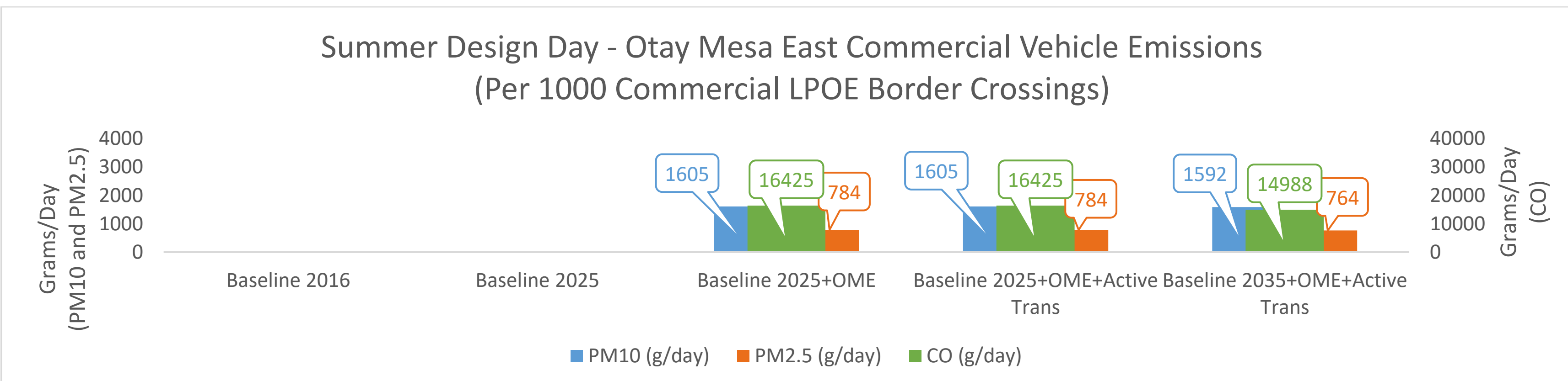


Figure 38. Winter Design Day CPM10, PM2.5, and CO from Commercial Vehicles at the Tecate LPOE

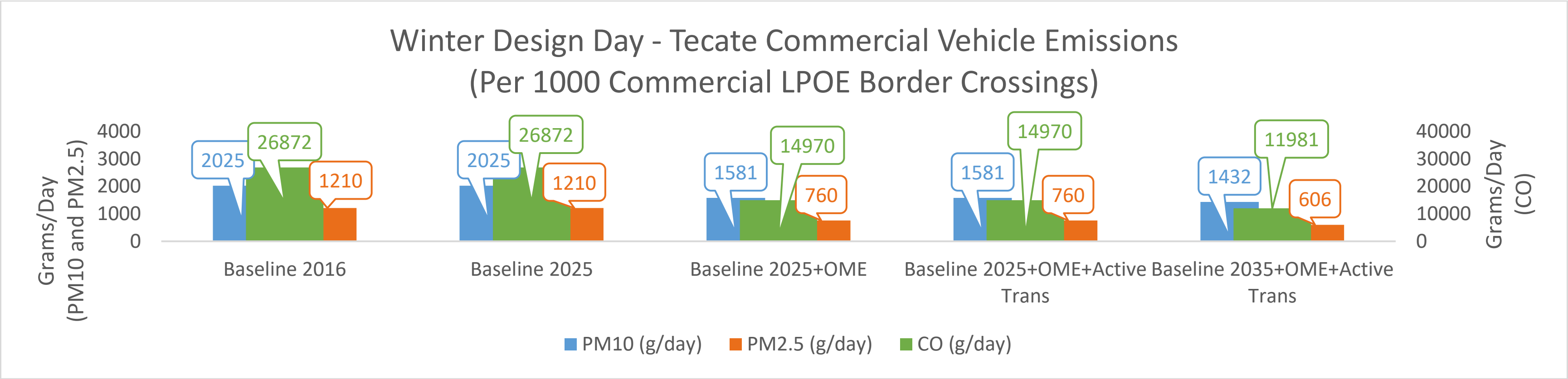
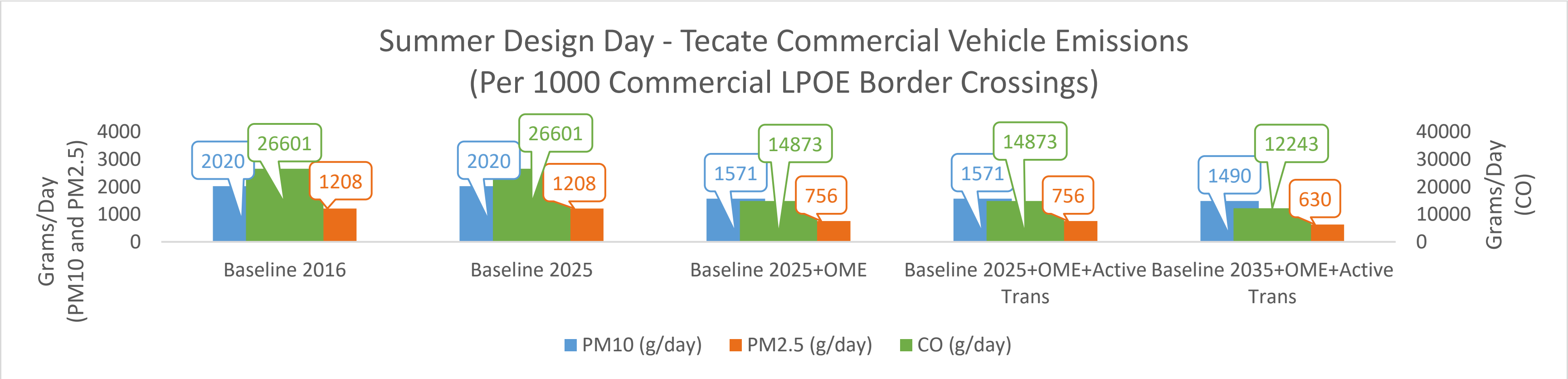


Figure 39. Summer Design Day CPM10, PM2.5, and CO from Commercial Vehicles at the Tecate LPOE



6 Assessment of Imperial County LPOE Emissions

Imperial county results for POV and commercial LPOE's are presented in separate sections below, mirroring how results were presented for San Diego County.

Seasonal PM10, PM2.5, and CO are presented for each LPOE. Whereas for each season, a single ROG result, a single NOx result, and A single CO2 result are presented, which represents the combined emissions from all POV border crossings in the county, and separately for all commercial border crossings in the county. Excel spreadsheets that calculate emissions for each LPOE by lane type, process, and hour of the day are available as electronic appendices.

The five Imperial County scenarios described in section three for all LPOEs are addressed for ROG, NOx, CO2, PM10, PM2.5, and CO:

- Baseline 2016 POV: This scenario reflects how each LPOE operates in 2016.
- Baseline 2025 POV: This scenario reflects how each LPOE is anticipated to operate in 2025. Key changes relative to 2016 include the Phase 1 improvements at Calexico West, including a new LPOE for POVs with ten northbound lanes and five southbound lanes. Note that the planned removal of the 10 existing northbound lanes does not occur until the Phase 2 improvements. Therefore, there are twenty northbound lanes at Calexico West under this scenario.
- Baseline 2025 plus the All American Canal (AAC): This scenario adds six additional northbound POV booths at Calexico East, and widens the bridge over the All American Canal. This scenario assumes construction of Calexico West Phase 2 improvements, which add six new northbound lanes and remove the ten older northbound lanes at the existing facility. Thus there are a total of sixteen northbound lanes at Calexico West, and 14 northbound lanes at Calexico East.
- Baseline 2025 plus AAC and Active Transportation: this scenario reflects changes in POV and bus volumes associated with the planned active transportation and transit improvements discussed in Section 3.
- Baseline 2035 plus AAC and Active Transportation: This scenario reflects an additional ten years of growth.

Two Additional scenarios are included for PM10, PM2.5, and CO at Calexico East: these include:

- Baseline 2035 POV: A scenario reflecting traffic through Calexico East in 2035, with just the Phase 1 improvements at Calexico West.

- Baseline 2035 plus the All American Canal (AAC): This scenario is identical to the corresponding 2025 scenario with ten additional years of growth.

The spreadsheet models in the electronic appendices include ROG, NOx and CO2 emissions for these scenarios as well.

Annual volume estimates for each LPOE are presented before the emissions results. In general, the volumes grow from 2016 to 2025, and are then relatively flat through 2035 as demand is offset by growth in non-POV mode share through Calexico West. Details of the traffic forecasting are discussed in Volume 1. Forecaster border crossing volume includes the effect of induced growth in person and commercial trips associated with the various capacity enhancements.

Emissions data are normalized based on the number of border crossings, and presented per one thousand border crossings. This emphasizes the combined effect of reduced delay and queuing plus cleaner, more efficient, vehicles.

For POVs, the emissions per border crossing are reduced by capacity enhancement scenarios. The active transportation and transit improvement scenarios effect reduce overall emissions, but do not alter congestion levels enough to have a noticeable impact on the emissions per POV border crossing. Commercial vehicle emissions per border crossing drop through 2025, capacity enhancements reduce delay, and improvements in vehicle technology combine to produce this benefit. However, by 2025 the benefit of more stringent emission certification standards for commercial vehicle engines has permeated most of the commercial vehicle fleet, and delays increase between 2025 and 2035 without additional infrastructure investment. Commercial vehicle emissions tend to show little addition improvement between 2025 and 2035; with some pollutants increasing due to increased delay and queuing.

Sections 6.1 and 6.2 below present the POV border crossing volumes and emissions, respectively. Sections 6.3 and 6.4 present the corresponding commercial vehicle volumes and emissions.

6.1 Imperial County Annual Northbound and Southbound POV Border Crossings

Figure 40 through Figure 44 show Imperial County POV volumes for each of the five county-wide scenarios. Volumes for each LPOEs that process POVs are presented, along with the county wide totals. Volume 1 details about the sources of existing and forecast traffic volumes.

To understand how volumes and emissions change between scenarios for POVs, note that:

- POV border crossings are anticipated to increase by about 13% from 2016 to 2025 without the All American Canal improvements at Calexico East. Induced demand with those improvements and Calexico West improvements results in an additional 16% increase in border traffic relative to 2016, for overall volume growth of about 29%.

- The active transportation and transit improvements then reduce POV border crossings slightly (by about -0.6%) in 2025.
- Across all Imperial County LPOEs, Growth in POV volume from 2025 to 2035 is essentially flat because of the active transportation and transit mode shift.

The annual northbound volume for each LPOE was scaled to represent seasonal weekdays and weekend-days, and split into Regular lane, Ready lane, and SENTRI lane volumes based on information from the Bureau of Transportation Statistics[36], data from prior studies[37], and data collected for this study. Southbound flows were also adjusted for seasonality and day of the week. Weekdays represent Tuesday through Thursday, while weekends reflect Saturday and Sunday Conditions. Seasonal and weekday/weekend adjustments are provided in Table 8. The breakout of traffic by Regular lane, Ready lane, and SENTRI lane for each LPOE is provided in Table 9.

Table 8. Northbound Imperial County POV seasonal weekday and weekend adjustments to annualized daily border crossing data.

LPOE	Winter Weekday	Winter Weekend	Summer Weekday	Summer Weekend
Calexico West				
Regular lane	99%	98%	99%	98%
Ready lane (2025 & 2035 only)	99%	98%	99%	98%
SENTRI lane	99%	98%	99%	98%
southbound	94%	107%	94%	107%
Calexico East				
Regular lane	106%	94%	102%	91%
Ready lane	106%	94%	102%	91%
SENTRI lane	106%	94%	102%	91%
southbound	102%	104%	98%	101%
Andrade				
Regular lane	103%	102%	95%	95%
southbound				

[36] BTS (2018) Bureau of Transportation Statistics, www.bts.gov/content/border-crossingentry-data.
[37] Imperial County APCD (2015) Vehicle Idling Emissions Study at Calexico East and Calexico West Ports-of-Entry, www.co.imperial.ca.us/airpollution/Forms%20&%20Documents/BORDER/Calexico%20POEs%20Final%20November%202,%202015.pdf.

Table 9. Northbound Imperial County POV lane utilization

LPOE	Regular Lane	Ready Lane	SENTRI Lane
Calexico West (2016)	55%		44%
Calexico West (2025 and 20135)	22%	39%	39%
Calexico East	27%	56%	17%
Andrade	100%		

Southbound POV travel, through Calexico West, and Calexico East LPOEs are assumed to operate as if the LPOEs share capacity across a single system, with about 72% of the southbound POVs using Calexico West and the 28% using Calexico East.

Figure 40. Baseline 2016 Imperial County POV Border Crossing Volume by LPOE

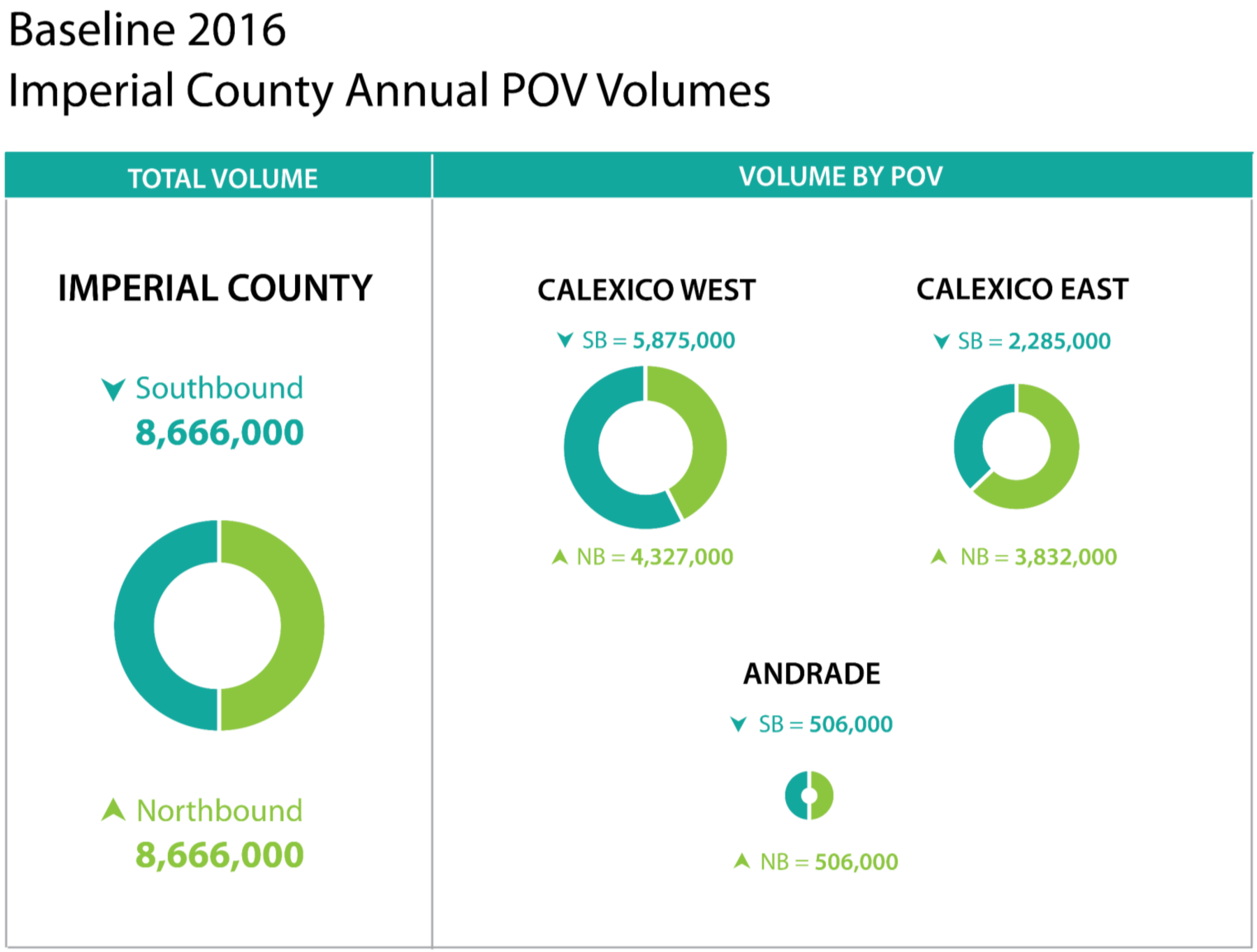


Figure 41. Baseline 2025 Imperial County POV Border Crossing Volume by LPOE

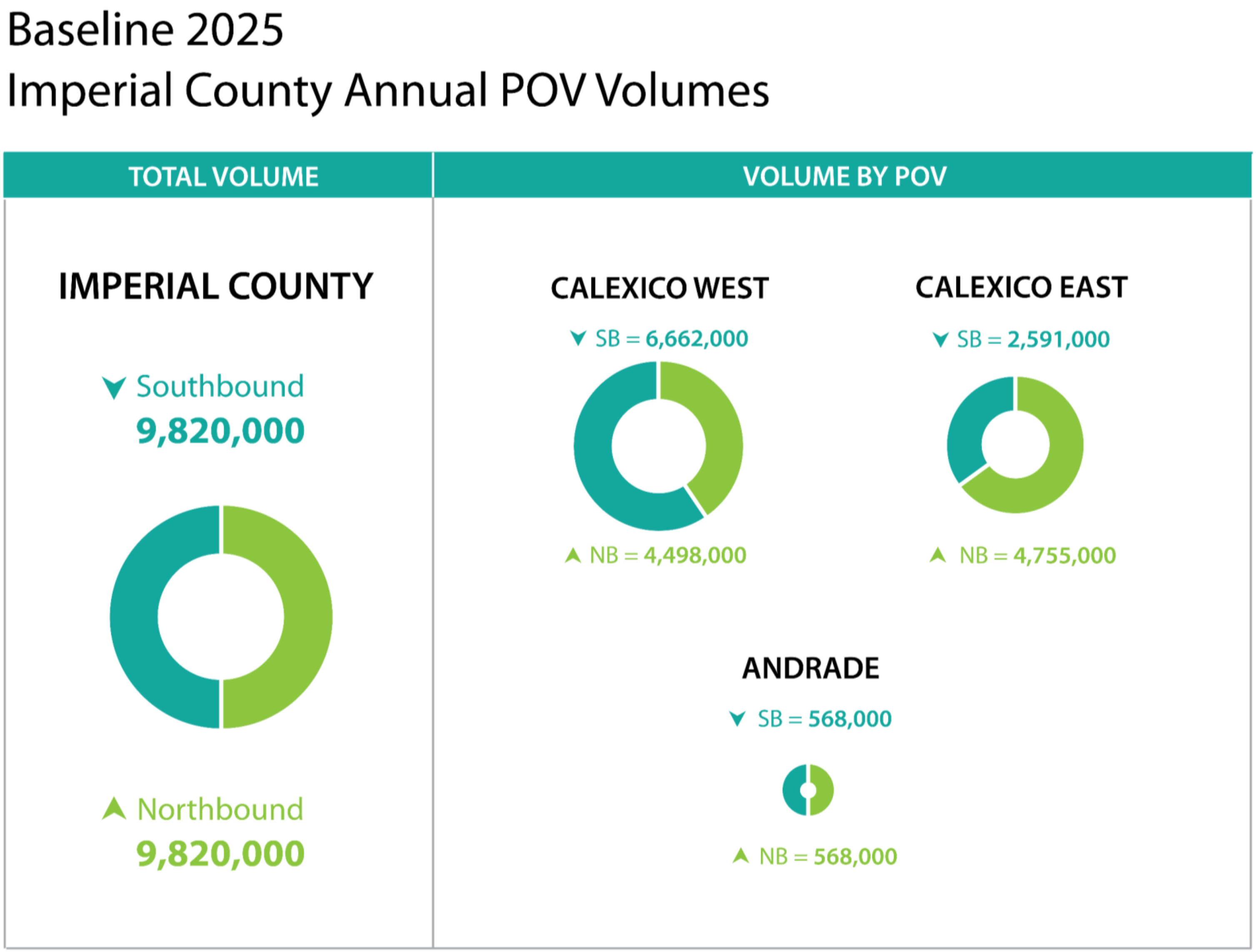


Figure 42. 2025 Imperial County POV Border Crossing Volume by LPOE with the All American Canal Improvements

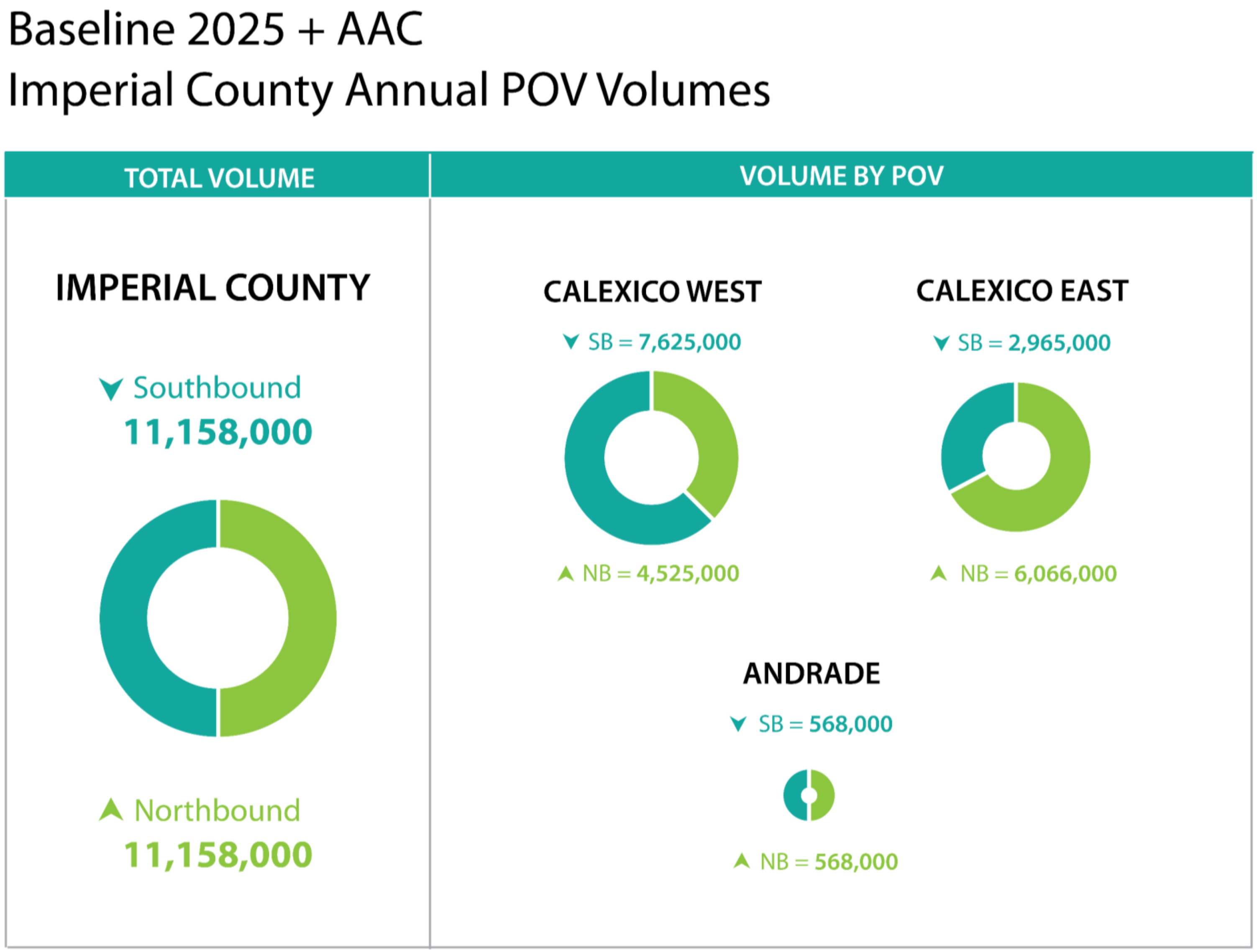


Figure 43. 2025 Imperial County POV Border Crossing Volume by LPOE with the All American Canal and Active Transportation Improvements

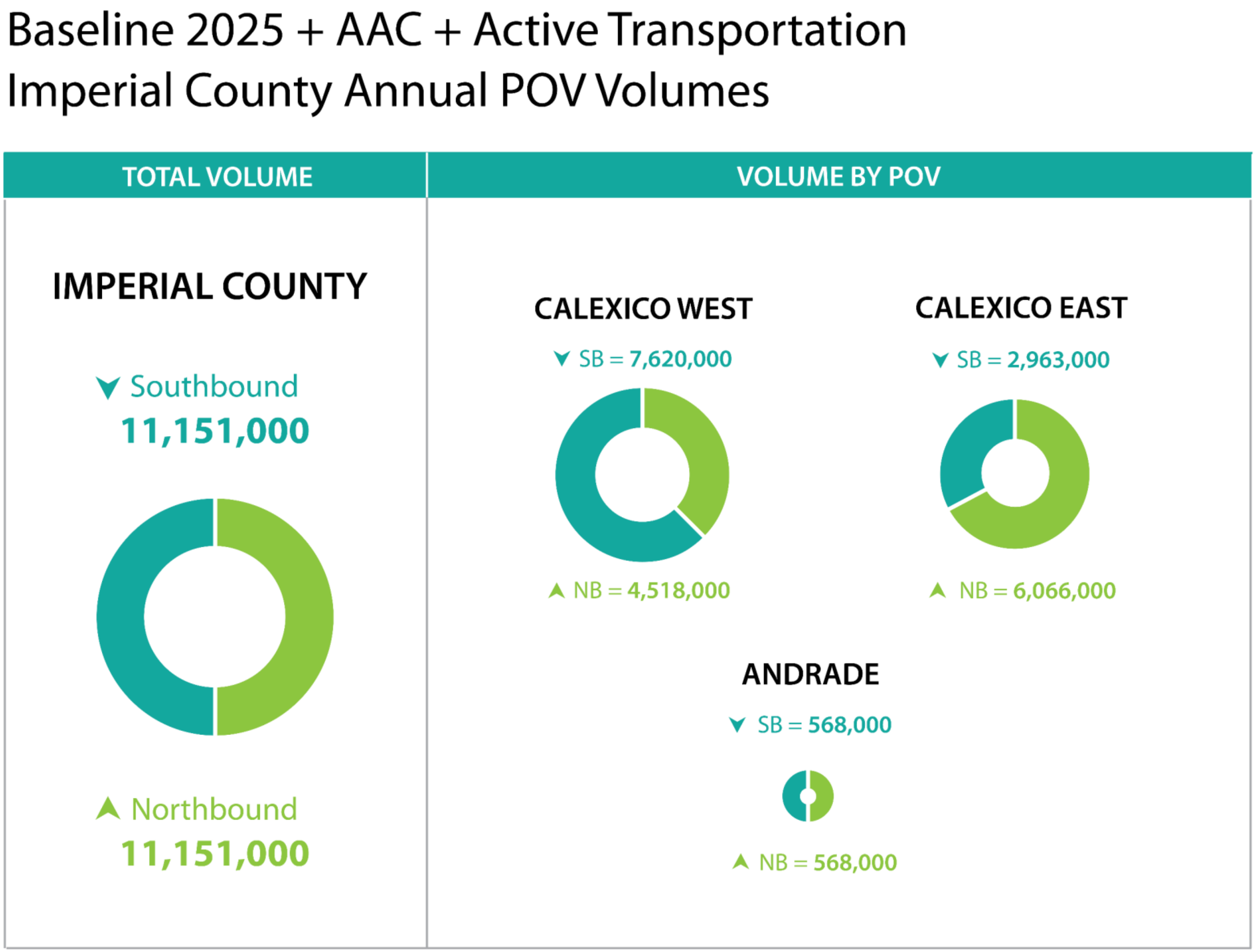
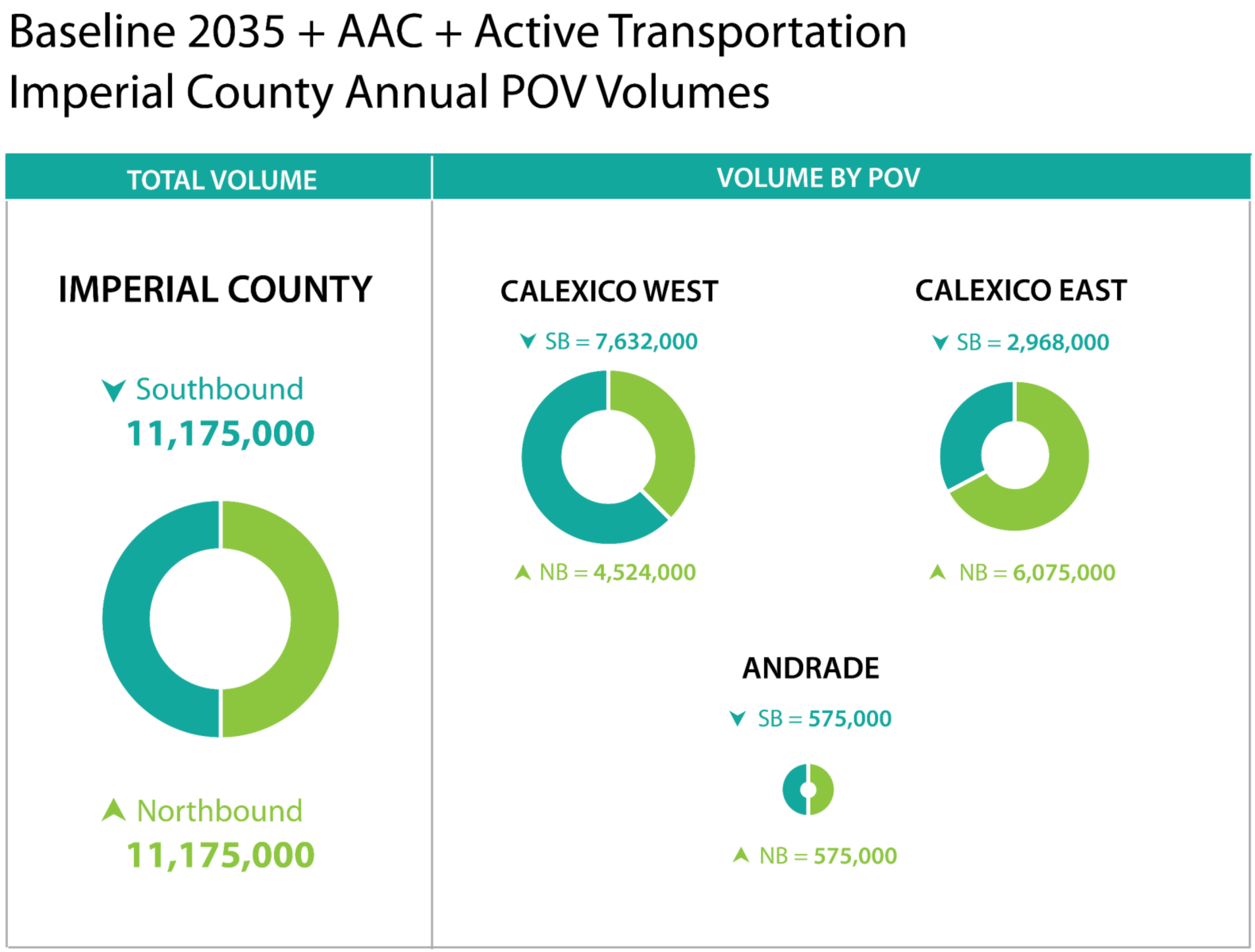


Figure 44. 2035 Imperial County POV Border Crossing Volume by LPOE with the All American Canal and Active Transportation Improvements



6.2 Imperial County Annual Northbound and Southbound POV Emissions

Similar to the presentation of results for San Diego County, Average seasonal day emissions for Imperial County are reported for winter and summer “design days”. The averages weigh together both weekday and weekend results to report values that represent a typical day (i.e. that if multiplied by 90 would reflect all LPOE emissions for that season). Emissions are reported in units of grams per day, except for CO2 which is reported in units of kilograms per day. More detailed results and calculations are available as Excel spreadsheets in the electronic appendices.

Figure 45 and Figure 46 report emissions for ROG, NOx, and CO2 per 1000 POVs crossing the through the LPOEs between San Diego County, and the state of Baja California. The results show emission reductions from the 2016 to 2025 baseline scenarios. This result reflects reduced crossing times at San Ysidro associated with the Phase 3 improvements, and a less polluting vehicle fleet in 2025 as older vehicles age out of the fleet. Implementation of OME and the active transportation and transit enhancements further reduce emissions through reduced border crossing delay. POV emissions are anticipated to continue dropping between the 2025 and 2035 OME with activate transportation and transit enhancement scenarios due to a cleaner overall vehicle fleet in 2035 and the predicted increase in alternative modes of travel.

PM10, PM2.5, and NOx emission results are reported separately for each San Diego County LPOE in Figure 47 through Figure 52. There are two figures for each LPOE providing winter design day and summer design day results for all five analysis scenarios. Trends for each LPOE differ from the one another depending on where capacity improvements are built and mode shift is anticipated to occur due to the active transportation and transit enhancements.

- At Calexico West emissions per POV crossing the border for all three pollutants drop from 2016 to 2025. The capacity added by the new northbound and southbound lanes in the Phase 1 improvements offsets growth in the number of POV’s crossing the border. Induced growth from the All American Canal improvements at Calexico East are then expected to result in slight emission increases at Calexico West.

- At Calexico East emissions of PM2.5 and CO per border crossing are anticipated to increase slightly from 2016 to 2025 as growing congestion increases emissions more than vehicle technology can mitigate. With the All American Canal improvements adding capacity at Calexico East, emissions per border crossing are anticipated to drop for all three pollutants.

- The Andrade LPOE is not affected by capacity enhancements or active transportation and transit improvements that occur at Calexico West and Calexico East. Therefore, emissions from the three 2025 scenarios are identical at Andrade. Per POV border crossing, emissions of PM10 and PM2.5 are flat to declining over time, and CO emissions drop continuously.

The trends for both the winter and summer design days are similar, with minor variations in emissions resulting from the seasonal traffic differences, and temperature effects on emissions.

Figure 45. Winter Design Day CO2, ROG, NOx from POVs at Imperial County LPOEs

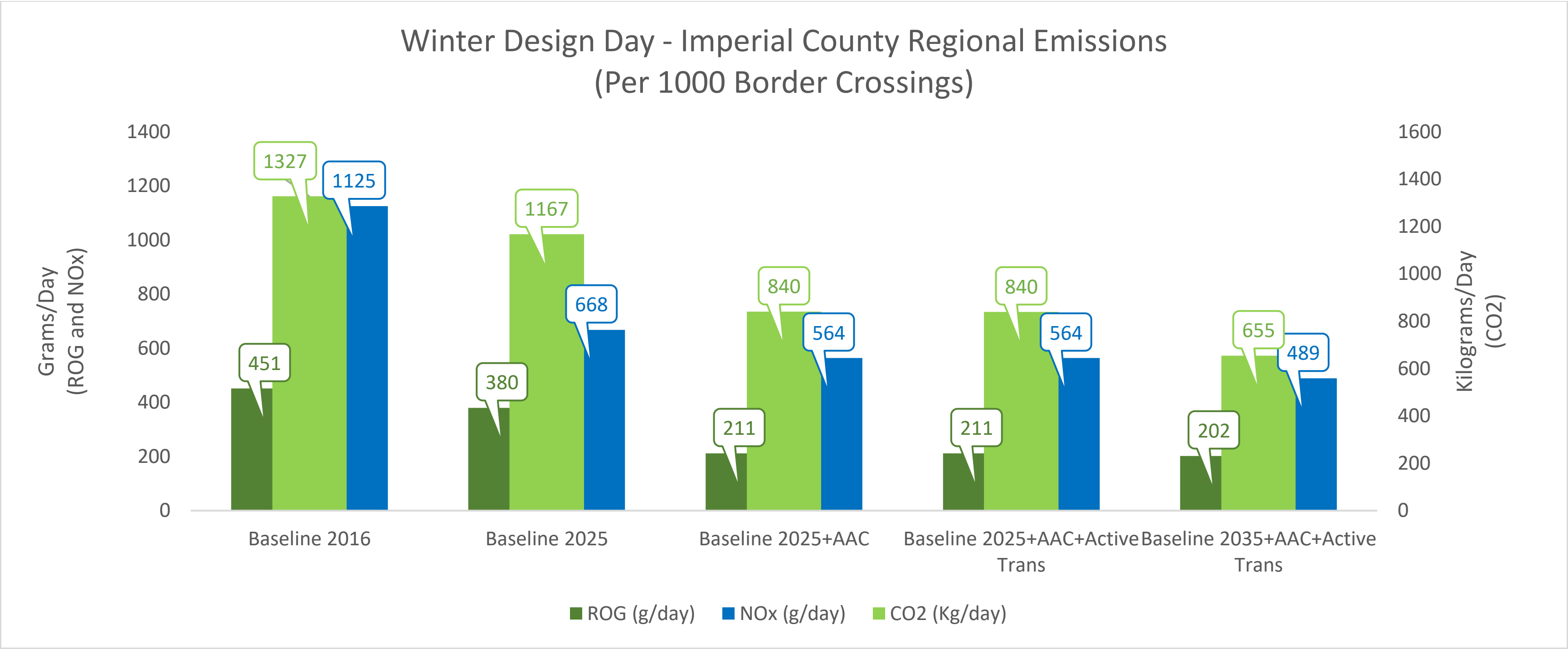


Figure 46. Sumer Design Day CO2, ROG, NOx from POVs at Imperial County LPOEs

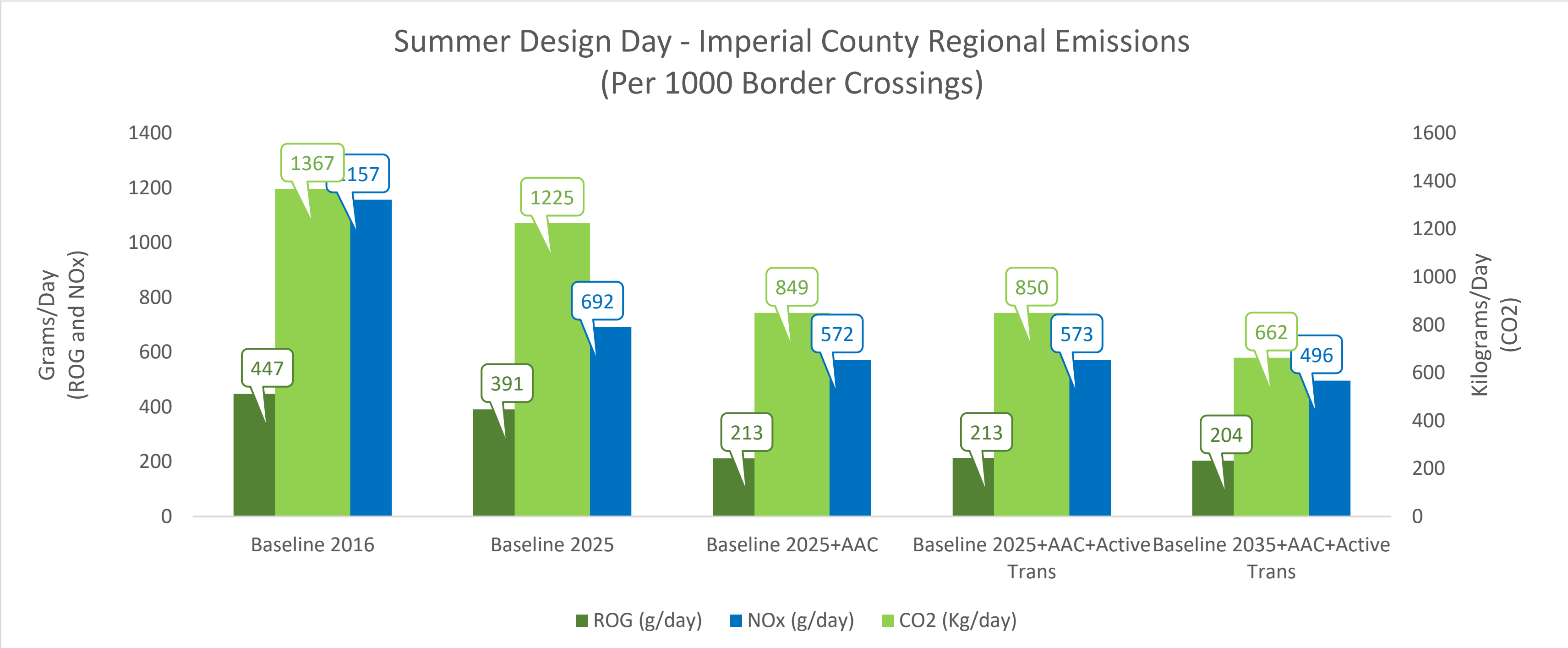


Figure 47. Winter Design Day CPM10, PM2.5, and CO from POVs at the Calexico West LPOE

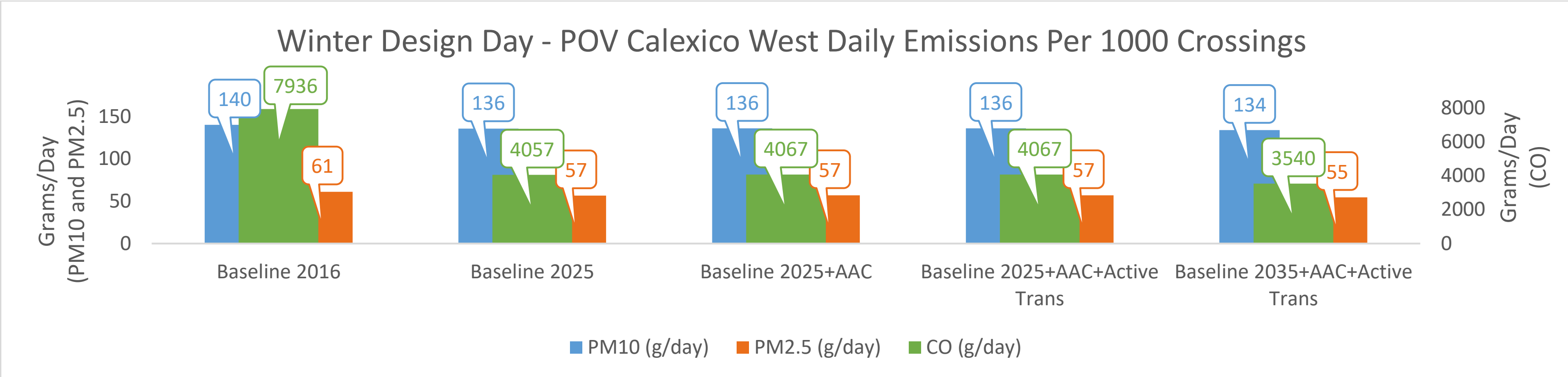


Figure 48. Summer Design Day CPM10, PM2.5, and CO from POVs at the Calexico West LPOE

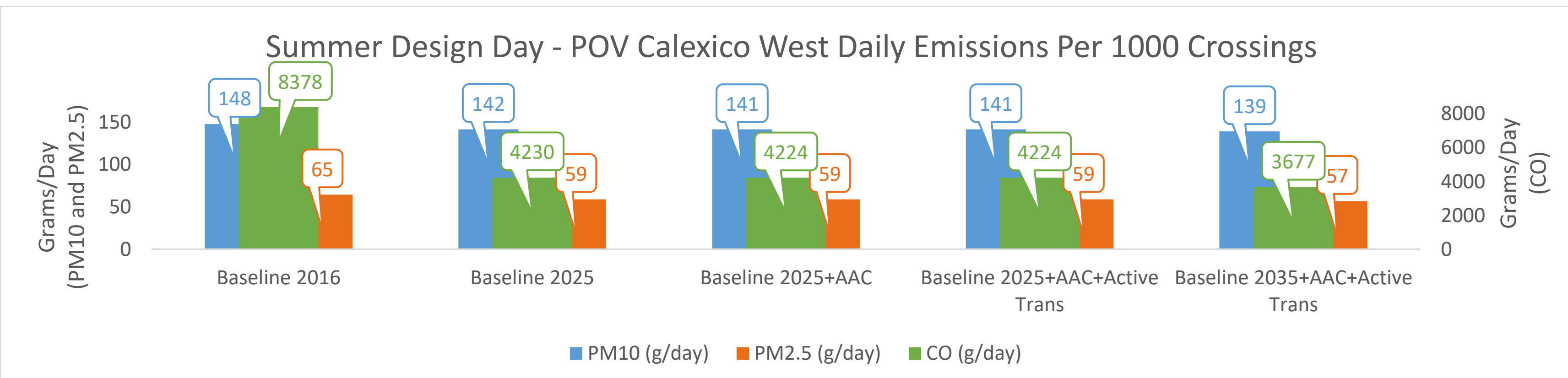


Figure 49. Winter Design Day CPM10, PM2.5, and CO from POVs at the Calexico East LPOE

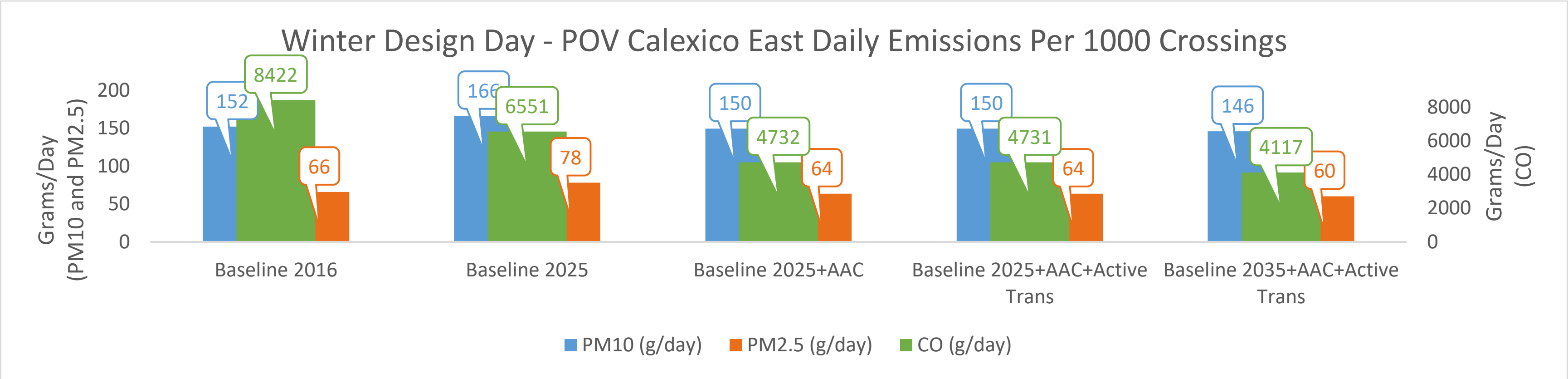


Figure 50. Summer Design Day CPM10, PM2.5, and CO from POVs at the Calexico East LPOE

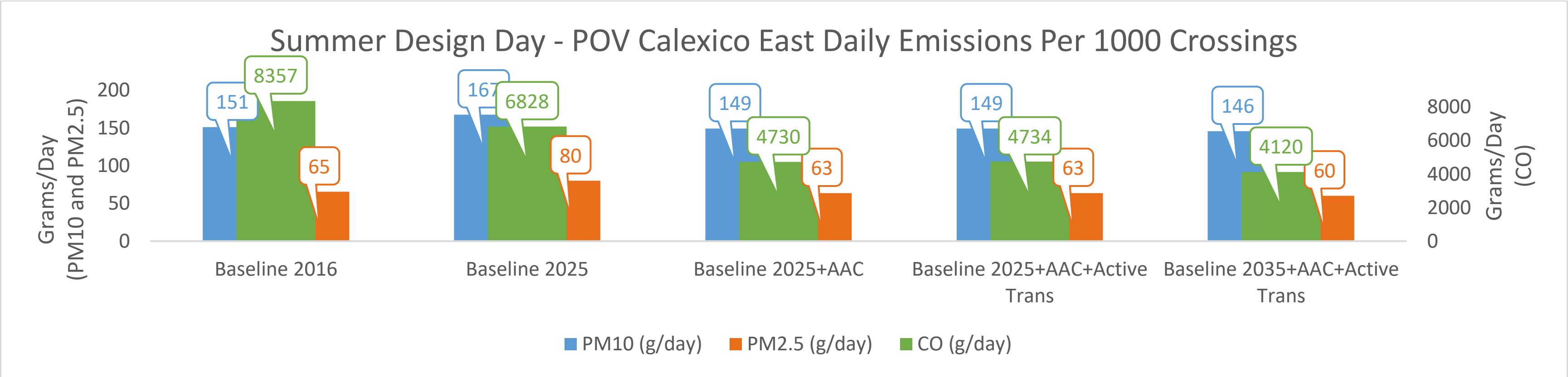


Figure 51. Winter Design Day CPM10, PM2.5, and CO from POVs at the Andrade LPOE

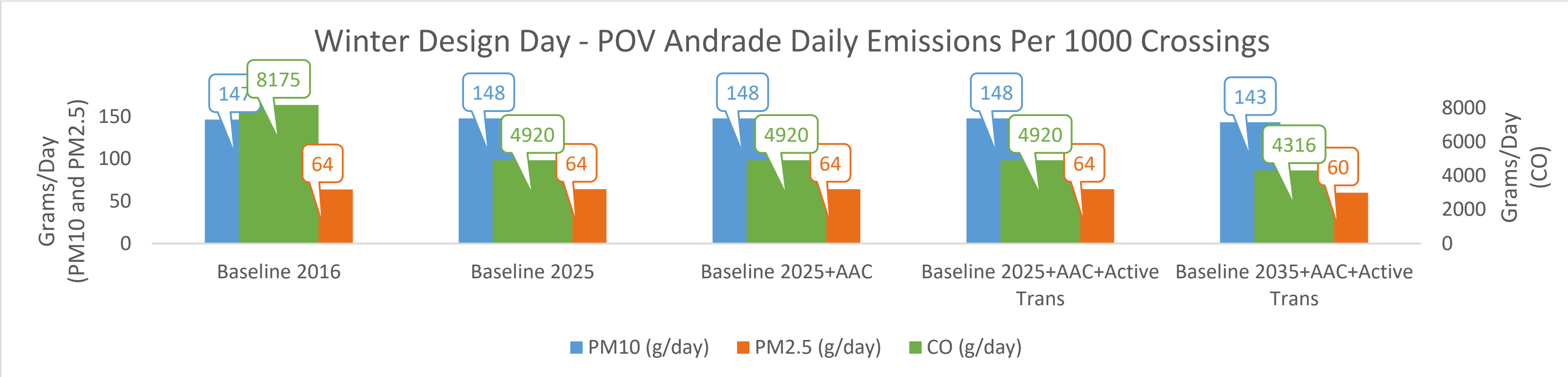
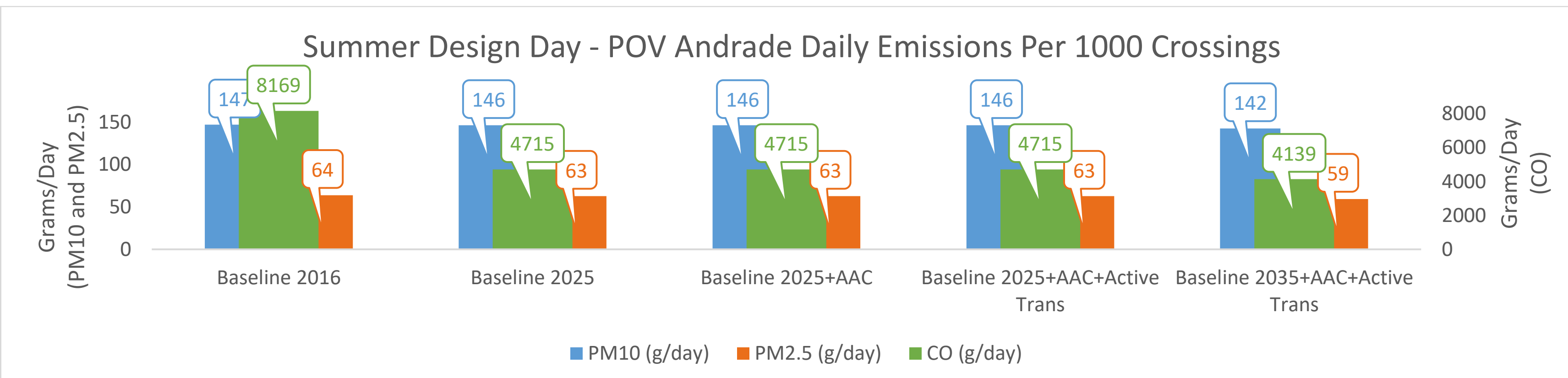


Figure 52. Summer Design Day CPM10, PM2.5, and CO from POVs at the Andrade LPOE



As noted in Section 6 above, two additional 2035 scenarios are addressed at Calexico East: Baseline 2035, and Baseline 2035 plus the All American Canal Improvements. Emissions, per 1000 border crossings, of PM10, PM2.5, and CO for those scenarios are shown in Figure 53 and Figure 54 below.

Figure 53. Winter Design Day CPM10, PM2.5, and CO from POVs at Calexico East in 2035 under the Baseline 2035 and Baseline 2035 plus All American Canal scenarios

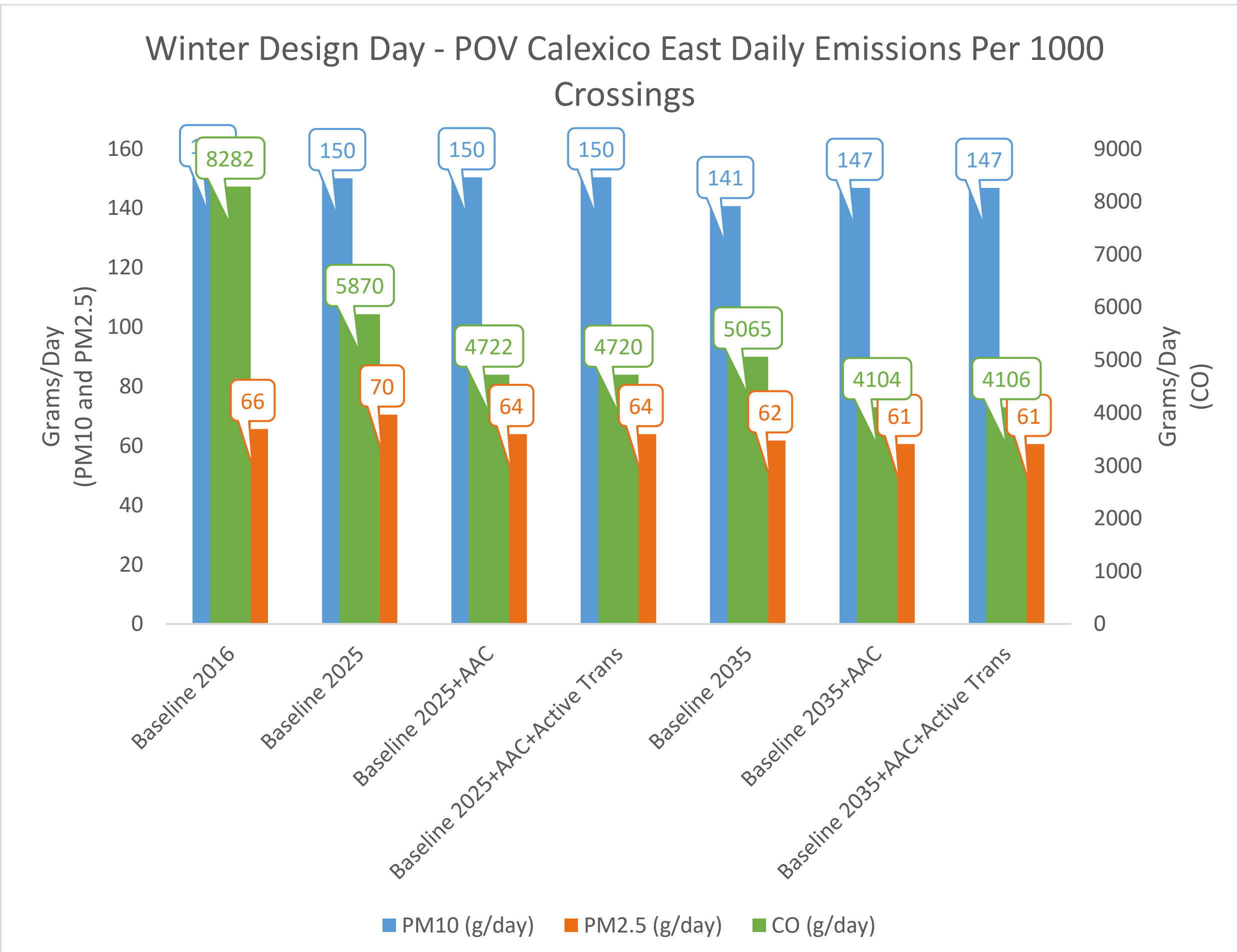
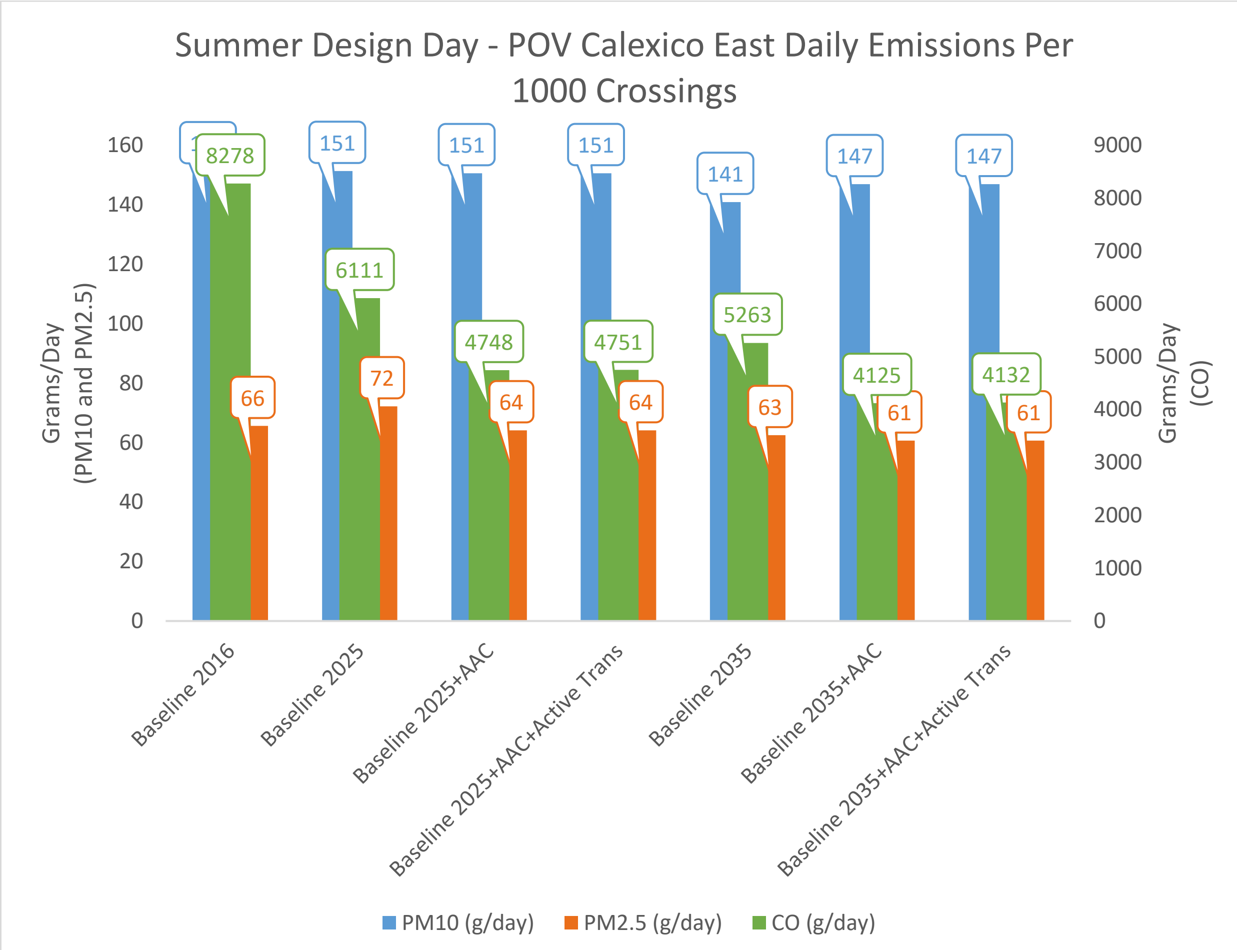


Figure 54. Summer Design Day CPM10, PM2.5, and CO from POVs at Calexico East in 2035 under the Baseline 2035 and Baseline 2035 plus All American Canal scenarios

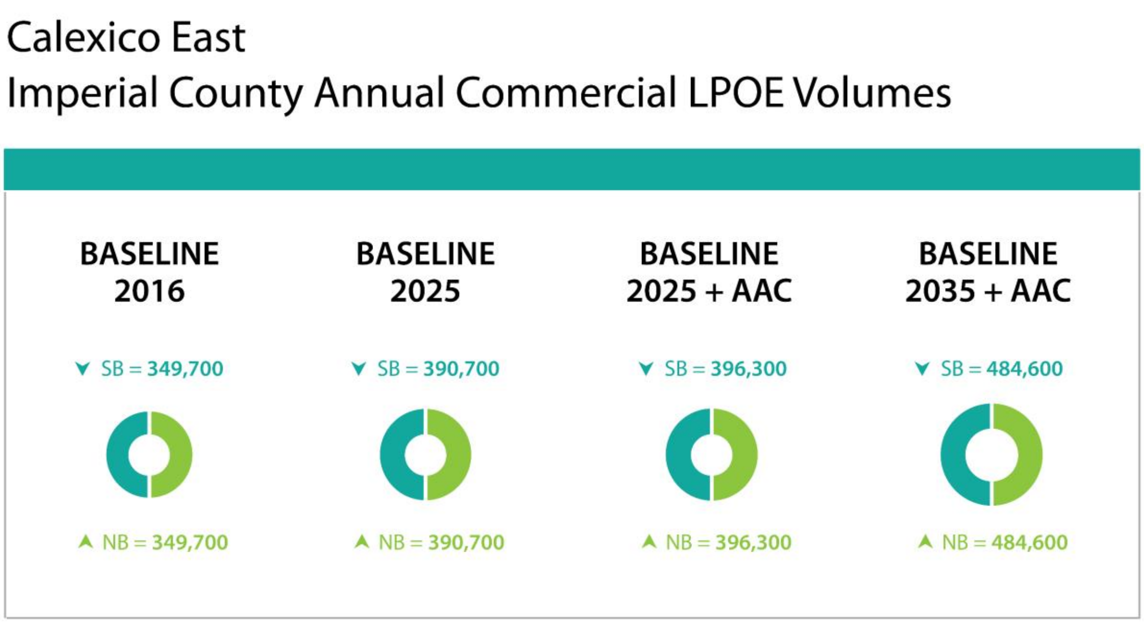


6.3 Imperial County Annual Northbound and Southbound Commercial Vehicle Border Crossings

Imperial County commercial vehicle traffic is shown in Figure 55. Calexico East is the only Imperial County LPOE that serves commercial vehicles. As with the San Diego County commercial vehicle scenarios only four of the five scenarios are shown because Baseline 2025 plus the All American Canal has identical volumes with or without the active transportation and transit improvements.

From 2016 to 2025, commercial border crossings in Imperial County are anticipated to increase by 12%. The three additional northbound primary booths under the 2025 scenario with the All American Canal improvements, is anticipated to increase traffic by another percentage point, to 13% above 2016 commercial vehicle border crossings. Through 2035, commercial border crossings are anticipated to increase by 39% relative to 2016.

Figure 55. Imperial County Commercial Vehicle Border Crossing Volume by LPOE for all Scenarios



6.4 Imperial County Annual Northbound and Southbound Commercial Vehicle Emissions

Following the same pattern as commercial vehicle results for San Diego County, average seasonal day emissions are reported for winter and summer “design days”. The averages weight together both weekday and weekend results to report values that represent a typical day (i.e. that if multiplied by 90 would reflect all LPOE emissions for that season). Emissions are reported in units of grams per day, except for CO2 which is reported in units of kilograms per day. More detailed results and calculations are available as Excel spreadsheets in the electronic appendices.

Figure 56 and Figure 57 report emissions for ROG, NOx, and CO2 per 1000 commercial vehicles crossing the through the LPOEs between Imperial County, and the state of Baja California.

The results show emission reductions from the 2016 to 2025 baseline scenarios, reflecting the less polluting, more efficient, commercial vehicle fleet in 2025. These emission reductions occur even though delays are growing with the increasing commercial vehicle volumes and the lack of additional capacity. The addition of three additional northbound primary inspection booths with the All American Canal improvements reduces delay, but induces additional commercial vehicle border crossings. This results in reduced ROG and NOx emissions, while CO2 emissions remain relatively unchanged per commercial vehicle processed through the LPOE. Between 2025 and 2035, CO2 emissions per crossing are anticipated to decline slightly, ROG emissions are anticipated to increase somewhat as congestion grows, and NOx emissions are anticipated to decrease slightly during the summer and increase slightly during the winter.

PM10, PM2.5, and NOx emission results are reported separately for each San Diego County LPOEs in Figure 58 and Figure 59. There are two figures for each LPOE providing winter design day and summer design day results for all five analysis scenarios. Trends for each LPOE differ from the one another depending on where capacity improvements are built and mode shift is anticipated to occur due to the active transportation and transit enhancements.

Figure 56. Winter Design Day CO2, ROG, NOx from Commercial Vehicle at Imperial County LPOEs

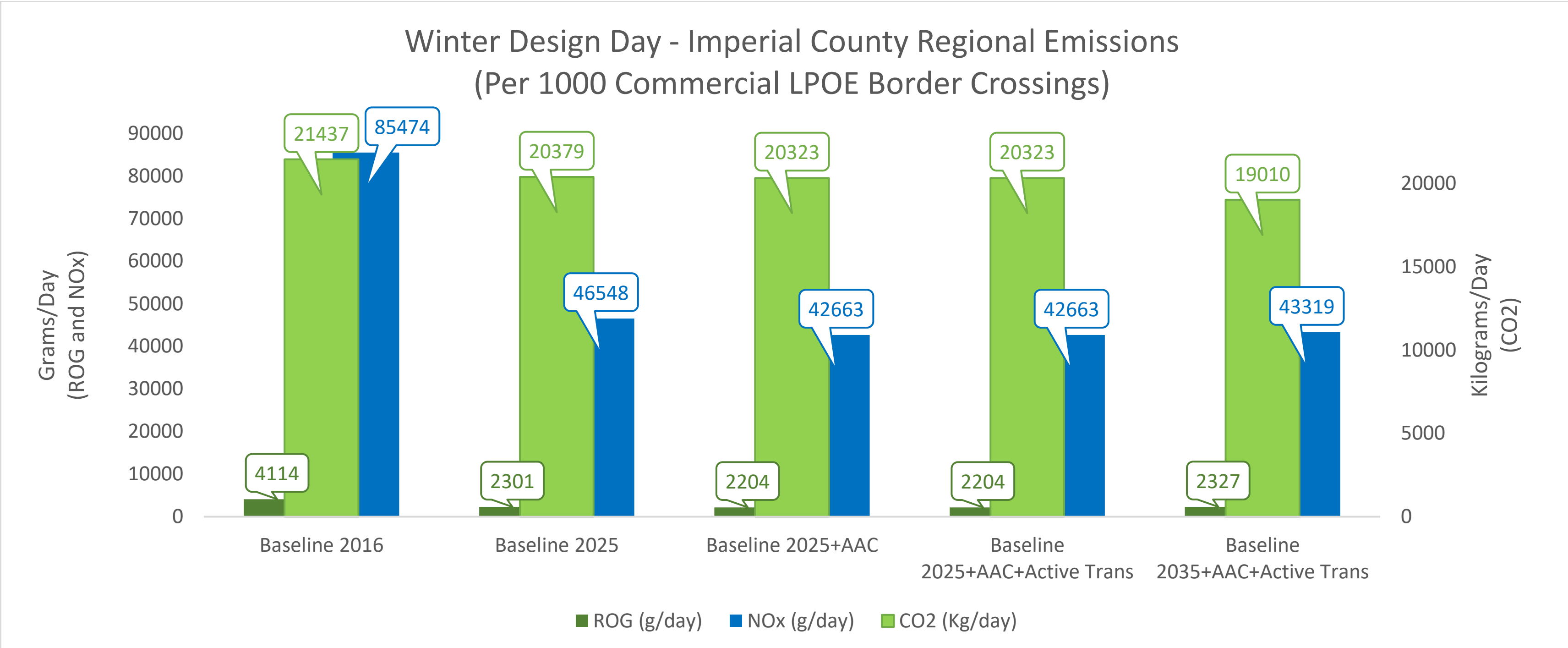


Figure 57. Summer Design Day CO2, ROG, NOx from Commercial Vehicle at Imperial County LPOEs

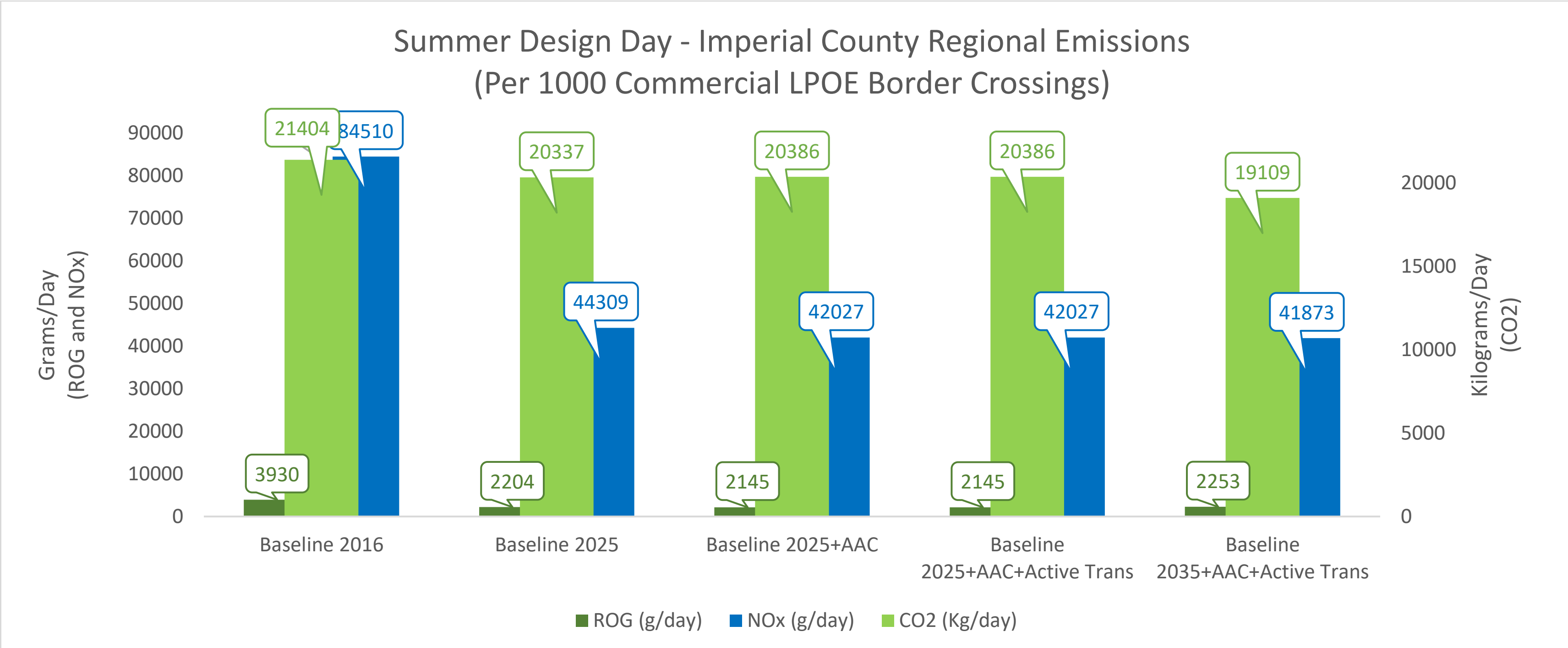


Figure 58. Winter Design Day CPM10, PM2.5, and CO from Commercial Vehicles at the Otay Mesa LPOE

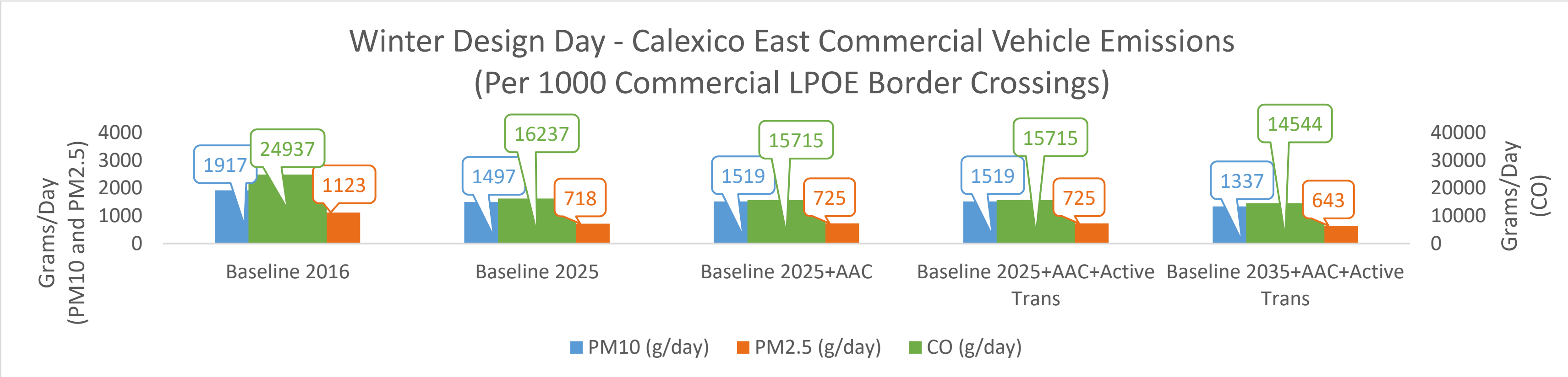
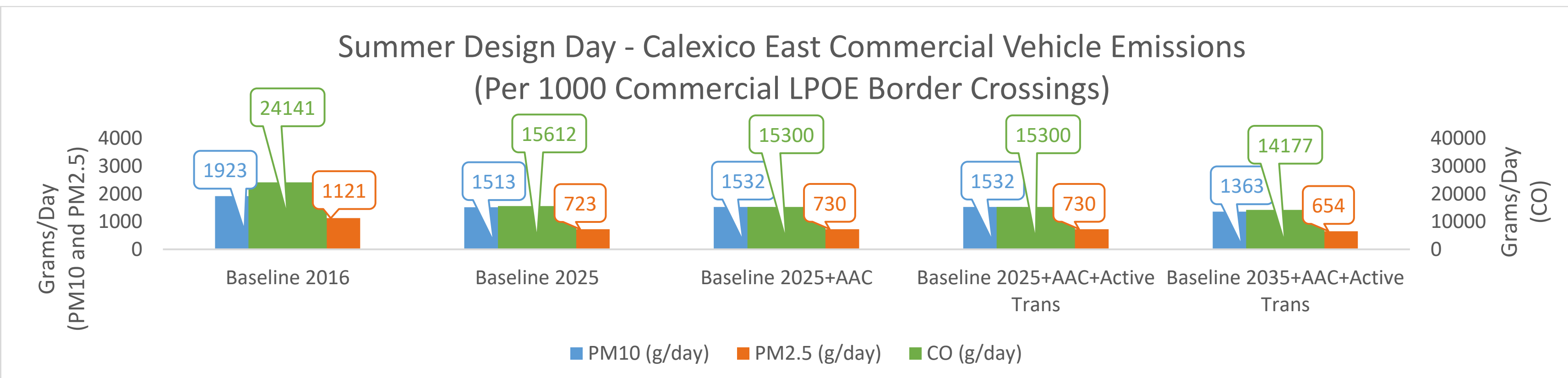


Figure 59. Summer Design Day CPM10, PM2.5, and CO from Commercial Vehicles at the Otay Mesa LPOE



7 Discussion

Results in this report emphasize that LPOE emissions are anticipated to drop from 2016 to 2025 due to:

- Reduced delay resulting capacity enhancements, active transportation, and transit enhancements; and
- Lower polluting, more efficient, vehicles.

Between 2025 and 2035, delay is anticipated to increase because there are not additional LPOE capacity improvements planned. It is anticipated that those increased delays will lead to increased vehicle emissions during the more congested times of the year. Components of LPOEs are anticipated to be operating near to or at the point where small volume increases result in expediential increases in delay. There are noteworthy capacity constraints identified through the LPOE queue models:

- Under 2016 conditions at Otay Mesa, northbound CBP primary booths and the CBP Cargo inspection area (specifically the VIACS non-intrusive inspections), appear to be bottlenecks. After implementation of the Otay Mesa cargo modernization project, the cargo inspection area is anticipated to constrain the throughput in 2025. Queues are anticipated to back up from the cargo inspection area into Mexico. Diversion of traffic to Otay Mesa East helps to mitigate this bottleneck.

- By 2035 at the Otay Mesa commercial LPOE, the existing CHP scales are anticipated to be over capacity.

- At the Calexico East Commercial LPOE, the northbound CBP primary inspection is the current bottleneck, however the VACIS non-intrusive inspections in the Cargo Area are near capacity during peak periods. After the addition of three more northbound primary commercial inspection booths, the VACIS scanners act as the bottleneck in 2025 and 2035.

- For POVs, planned capacity expansions at San Ysidro, Otay Mesa, Otay Mesa East, Calexico West, and Calexico East can accommodate the expected northbound traffic through those LPOEs. The planned improvements are anticipated to accommodate the southbound POV flows. However, CBP southbound inspection capacity is lower than Aduanas, and if CBP implemented more stringent southbound inspections, the southbound delay and queues at San Ysidro, Otay Mesa, and Calexico West could warrant additional study.

- Delay and queuing at Tecate and Andrade are anticipated to roughly double by 2035 due to growth in border crossing traffic and an absence of additional LPOE capacity

Results reported in this volume are in units of grams (or kilograms) of pollutant per 1000 vehicle crossings. Table 10 shows total emissions of CO2, broken out by county. As with the results shown earlier, there are emission reductions from 2016 to 2025, then increases in emissions between 2025 and 2035. When viewed as total emissions, the increase is more pronounced because of the combined effect of increasing volumes and the slight increase in pollution per vehicle crossing. Commercial vehicle crossings, which are anticipated to grow faster than POV crossings, are anticipated to become the largest source of emissions by 2035.

Table 10. Estimated Annual Average Day CO2 Emissions across all California/Baja California LPOEs

Scenario	San Diego County POV (kg/day)	San Diego County Commercial (kg/day)	Imperial County POV (kg/day)	Imperial County Commercial (kg/day)	California/Baja California Total (kg/day)
Baseline 2016	182,873	107,443	62,037	47,113	399,466
Baseline 2025	151,968	125,872	61,170	50,160	389,170
2025 with Capacity Enhancements	138,600	133,063	51,206	50,869	373,738
2025 with Capacity Enhancements Transit and Active Transportation	134,622	133,063	51,183	50,869	369,737
2035 with Capacity Enhancements Transit and Active Transportation	102,395	187,423	39,986	58,239	388,043

8 Emission Reduction Policies, Strategies, and Project Recommendations

Policy, strategy and project recommendations need to be considered within the overall hierarchy of emission reduction strategies (Figure 60)[38]. The base of the pyramid (cleaner, more efficient vehicles and better fuels) includes strategies that are implemented at regional, state and national scales. These emission reductions result from ever more stringent vehicle and engine emission certification standards and fuel economy standards. Benefits can take decades to be fully realized as newer, "cleaner" vehicles need to fully penetrate the fleet, replacing older vehicles as their useful life ends.

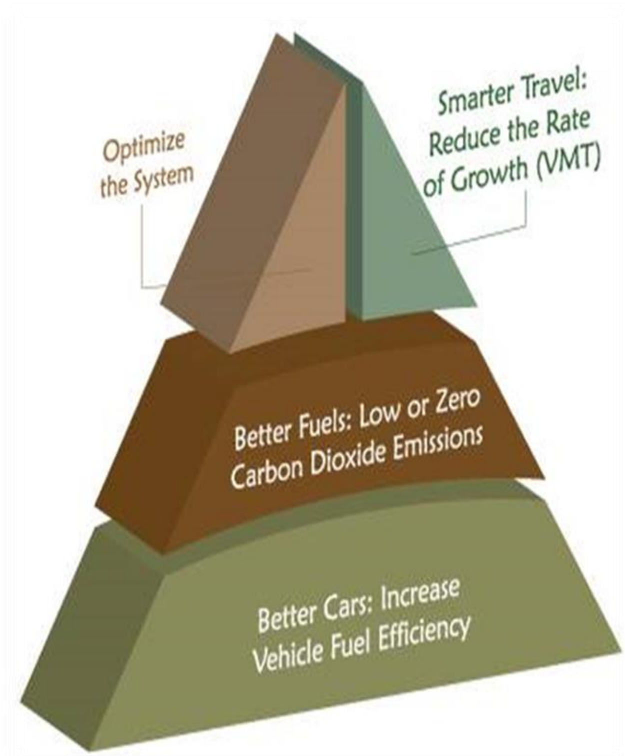


Figure 60. Emission Reduction Strategy Pyramid

Higher fuel economy standards, hybrid vehicles, and low carbon fuels result in more than a 40% drop in POV greenhouse gas emissions per mile of queuing between 2016 and 2035. Even greater emission reductions are anticipated for NOx, ROG, and CO from POVs. However, PM10 and PM2.5 emissions reductions are limited because of the effect of break and tire wear.

For commercial vehicles, California's in-use truck rules will require 2010 or newer engines on all heavy-duty trucks by 2025, including those entering through the LPOEs. Relative to 2016, recently implemented standards, coupled with the requirement to retire older engines, significantly reduce exhaust PM10, exhaust PM2.5, ROG and CO emissions by 2025; followed by only minor emission reduction benefits from 2025 to 2035. However, NOx emission rates from commercial vehicles operating in queues do not change significantly between 2016 and 2035, nor do greenhouse gas emissions from commercial vehicles. The best way to manage NOx emissions in particular are through measures at the top of the emission reduction strategy

[38] CEC (2016) Reducing Air Pollution at Land Ports of Entry: Recommendations for Canada, Mexico and the United States, Montreal, Canada: Commission for Environmental Cooperation.

pyramid, specifically through infrastructure investments (and staffing) that minimize commercial vehicle delay.

These improvements include construction of the planned commercial LPOE improvements identified in Section 3:

- Otay Mesa Commercial Modernization,
- Otay Mesa East, and
- Calexico East All American Canal.

POV LPOE improvements, including San Ysidro phase 3, Calexico West phases 1 and 2, and the Calexico East All American Canal allow the LPOEs to keep pace, or at least mitigate, the effect of growing traffic on delays. Those delays contribute to emissions, but as shown in Sections 5 and 6, it will likely be 2035 before increases in demand begin to overwhelm the lower polluting, more efficient, vehicle fleet. By that time additional infrastructure and vehicle technology measures will be needed. SANDAG, ICTC, and Caltrans should consider how to minimize border delay beyond 2035.

For commercial vehicles, the queue models used to estimate emissions indicate that the planned investments in northbound primary booth capacity would likely move bottlenecks to the CBP cargo inspection area in 2025; and at Otay Mesa to the CHP scales by 2035. CBP should further study operations in the commercial vehicle cargo inspection area, assuming significant growth in demand by 2035. California should study the addition of additional truck scales to the CHP facility at Otay Mesa before 2035.

Specific recommendations that help reduce emissions by managing demand, minimizing delay, and promoting lower polluting, more efficient vehicles, include (Table 11 through Table 15):

Table 11. Expansion of Physical Capacity at LPOEs:

Improvement	Impact on Wait-Times	Impact on Modal Split
Additional lanes and booths for motorized vehicles • Phase 3 Improvements at San Ysidro, • Phase 1 and Phase 2 Improvements at Calexico West, Phase 1 Bridge Expansion over All-American Canal at Calexico East, and • Phase 2 Improvements at Calexico East	Reduces wait-times for motorized crossers in bi-national region	Minimal, but may increase share of motorized crossers
Additional lanes and booths for pedestrian crossers (Phase 2 Improvements at Calexico West)	Reduces wait-times for pedestrian crossers in bi-national region	Minimal, but may increase share of pedestrian users
New LPOE facilities (Otay Mesa East)	Reduces wait-times for motorized crossers across SD-Tijuana region	Minimal, but may increase share of motorized crossers

Table 12. Improved Operations at LPOEs

Improvement	Impact on Wait Times	Impact on Modal Split
Southbound Electronic Commercial Clearance (Aduanas PITA program)	None. *But reduces total crossing and idling time for truck crossers at LPOE*	-
Unified Cargo Processing	None. *But potentially reduces total crossing and idling time for truck crossers at LPOE*	-
Joint Inspection Facility	None. *But reduces total crossing and idling time for truck crossers at LPOE*	-
Interchangeable Lanes	Reduces wait-times for crossers at LPOE	Minimal, but may increase share of motorized crossers
Reversible Lanes	Reduces wait-times for crossers at LPOE	Minimal, but may increase share of motorized crossers
Lane Management	Reduces wait-times for crossers at LPOE	Minimal, but may increase share of motorized crossers
Appointment Time for Truck Crossers	Potential to reduce wait-times for truck crossers at LPOE	-
Extended Hours of Operations	Potential to reduce wait-times for truck crossers at LPOE	-
Variable tools at OME	Potential to reduce wait-times for truck crossers at Otay Mesa	-

Table 13. Improved Access to LPOEs

Improvement	Impact on Wait Times	Impact on Modal Split
Bike/pedestrian access improvements (San Ysidro, Calexico West and Calexico East)	-	Potential shift to pedestrian mode from motorized mode
Enhanced transit services (including: Tijuana BRT and higher frequency of transit service at San Ysidro and Otay Mesa), completion of Calexico West Intermodal Transit Center, and completion of Transit Center/Cell Phone Lot at Calexico East.	-	Potential shift to pedestrian mode from motorized mode
RFID and Wi-Fi readers on Mexico's northbound lanes to capture commercial and POV vehicle wait-time data	Potential reduction in NB wait times for trucks and POVs due to planning and routing to faster LPOE	-
Zero/Near-Zero Truck Prioritization at LPOEs	Potential to reduce wait times for truck crossers at LPOE *(and reduce emissions from using zero/near-zero emission trucks)*	-

Table 14. Corridor-Wide Improvements for Corridors that Include a LPOE

Improvement	Impact on Wait Times	Impact on Modal Split
Regional Border Management System (RBMS) and Subcomponents - • Southbound Congestion Management and ITS Infrastructure Improvements • Freight Advanced Traveler Information System (FRATIS), including Information Dissemination Process • Integrated Corridor Management (ICM) and Active Traffic Management (ATM)	Potential reduction in SB wait-times due to re-routing to faster route (and LPOE) could be realized for commercial and passenger vehicles with advanced travel information	Minimal, but may increase share of motorized crossers

Table 15. Other Improvements and Long-Term Strategies

Improvement or Strategy	Impact on Wait Times	Impact on Modal Split
Support Bi-national Planning Process for LPOEs and Transportation Infrastructure	Potential reductions to NB and SB wait-times	Potential shift to pedestrian mode from motorized mode