A Quantification of Greenhouse Gas Emissions from Increased Travel to the Tahoe Reno Industrial Center

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INTRODUCTION

The purpose of this project is to 1) understand existing pollutant emissions and energy consumption in the Sparks metropolitan area (including Reno and Washoe County), and 2) evaluate the effect of increased growth and additional highways on emissions and energy consumption. The Interstate 80 (I80) corridor between Reno-Sparks and USA Parkway is experiencing increased congestion because of the recently-developed Tahoe Reno Industrial Center (TRIC). Among the proposed solutions to this congestion is construction of a new highway linking Spanish Springs to USA Parkway. In this study we evaluate the effect that increased traffic on the existing and proposed network has on greenhouse gas emissions and energy consumption. The greenhouse gases (GHG) and other pollutants we evaluated are: carbon dioxide (CO_2), carbon monoxide (CO), methane (CH_4), nitrous oxide (N_2O), oxides of nitrogen (NO_x), hydrocarbons (HC), particulate matter (PM_x), and energy consumption.

TRANSPORTATION NETWORK

The TRIC is an industrial park located south of I80 at the USA Parkway exit near Clark, NV (Figure 1). The urban transportation network that connects the City of Sparks, Reno, Sun Valley, and Spanish Springs with TRIC includes Interstate 80, US395, Interstate 580, and the major arterials Pyramid Way, Sparks Boulevard, and Vista Boulevard. The current road infrastructure from northern Sparks and Spanish Springs to TRIC is limited to state route 445 (Pyramid Way), Sparks Boulevard, and Vista Boulevard–all of which provide access to I80.

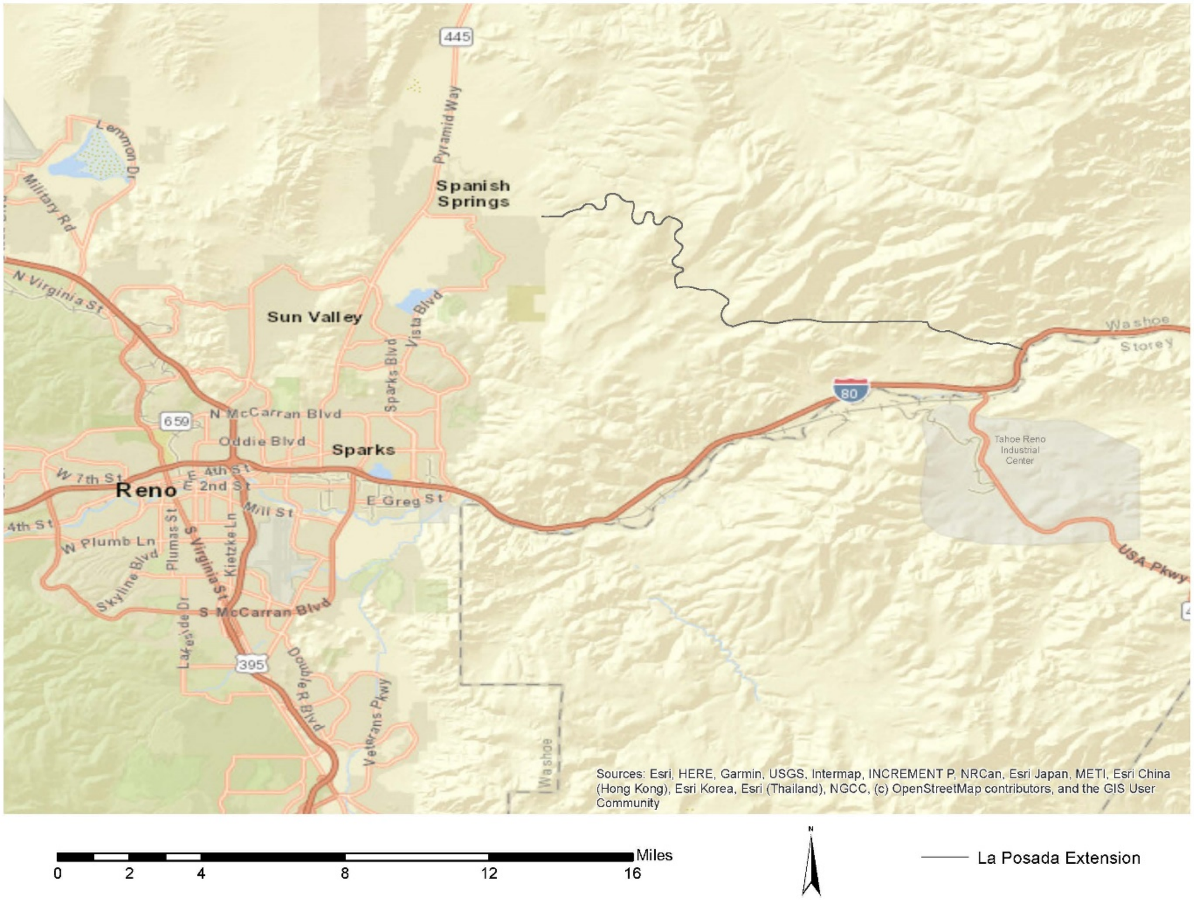


Figure 1 Map of the Reno/Sparks Metropolitan area and Tahoe Reno Industrial Center.

REGIONAL ENERGY AND POLLUTANT INVENTORY

A regional inventory of GHG emissions establishes a baseline estimate of transportation sector pollutants from which to perform transportation scenario testing. GHG emissions are estimated by approximating the amount of fuel consumed by a vehicle and the amount of pollution generated from burning that fuel (US EPA, 2019c). We estimated baseline GHG emissions for the region using the Environmental Protection Agency's software MOtor Vehicle Emissions Simulator (MOVES - US EPA, 2019c). MOVES is a commonly-used platform that implements the EPA's Office of Transportation and Air Quality emission and emission factor estimation tools for mobile sources. These tools were developed to facilitate characterization of emissions at the national, regional, and local scale.

Washoe County Air Quality Department (WCAQD) and the Regional Transportation Commission of Washoe County (RTC) provided regional transportation data, including: meteorological data, ramp fractions, road type distribution, age distribution, average speed distribution, vehicle source type distribution, and Vehicle Miles Traveled (VMT). The data cover the road network shown in Figure 2. Using these region-specific inputs in a MOVES simulation, we estimated emissions and energy consumption for the region. The 2015 and 2017 GHG and pollutant inventories are shown in Table 1:

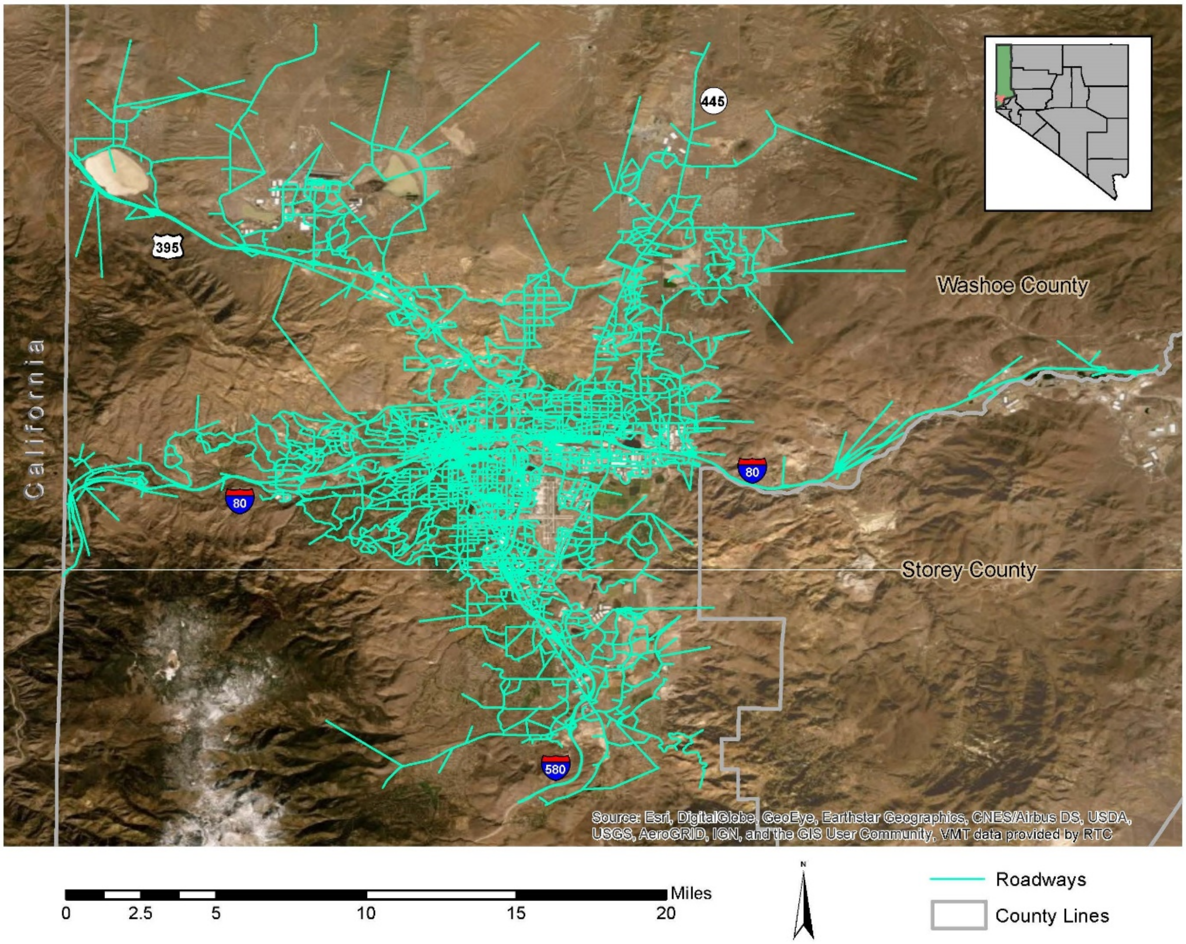


Figure 2 Map of roadways used for the greenhouse gas inventory simulations in MOVES.

Table 1 Greenhouse gas emissions inventory results for hydrocarbons (HC), carbon monoxide (CO), atmospheric carbon dioxide (CO2), carbon dioxide as methane equivalent (CO2 eq), particulate matter (PM2.5), methane (CH4), total energy consumption (TEC), and oxides of nitrogen (NOx).

Year	HC (tons/d)	CO (tons/d)	CO2 Atm. (tons/d)	CO2 Eq. (tons/d)	PM2.5 (tons/d)	CH4 (tons/d)	TEC (tons/d)	NOx (tons/d)
2015	1.18	29	3,771	3,773	0.29	0.06	4,4758	9.16
2017	1.17	36	4,664	4,666	0.15	0.08	5,5404	8.49

CORRIDOR-SPECIFIC ENERGY AND POLLUTANT INVENTORY

We developed an energy and pollutant inventory for individual travel corridors and travel demands within the study area by simulating emissions from average daily traffic under various travel demands for three corridors: 1) Pyramid Way between Spanish Springs and the I80 intersection, 2) I80 between Pyramid Way and Clark, and 3) a potential new highway connecting Spanish Springs in Sparks to I80 at USA Parkway, called La Posada Extension here (Figure 3).

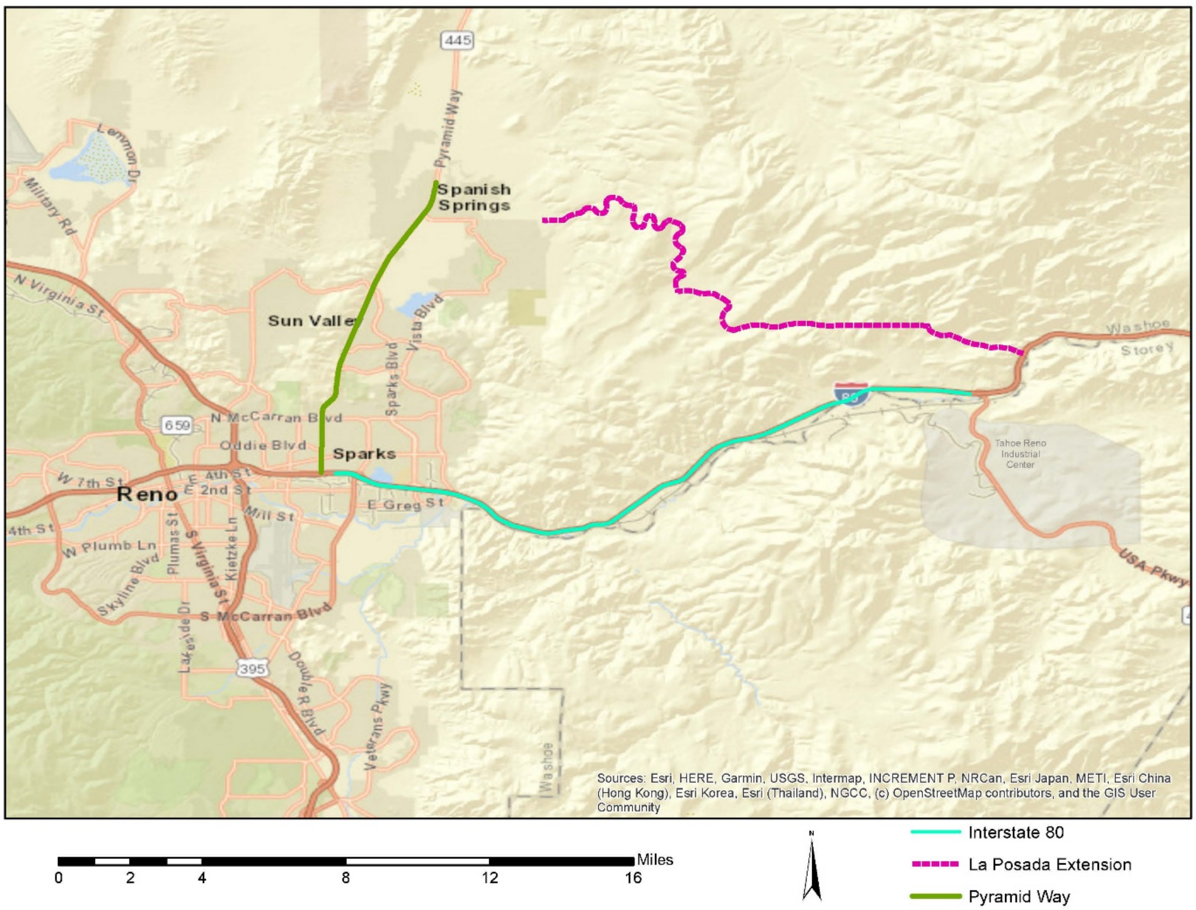


Figure 3 Location of travel corridors.

We developed the corridor-specific energy and pollutant inventory using the SUMO software (Simulation of Urban Mobility, Alvarez-Lopez, et al, 2019). SUMO is a microscopic traffic simulation tool capable of modeling individual vehicles and their interactions through a given road network. Microsimulation models simulate the movement of every vehicle individually and assume the behavior of the vehicles depend on the physical abilities of the vehicle to move and on the driver's controlling behavior. SUMO can accommodate multiple vehicle types (e.g., passenger cars, commercial trucks, motorhomes, motorcycles), multi-lane roads, traffic lights, as well as congested traffic and employs empirical emissions factors to estimate each vehicle's emissions. These emissions factors are a function of several elements, including: vehicle type, fuel type, acceleration/deceleration, speed, and idle time. Results of simulations in SUMO relevant to this study include each vehicle's emissions of CO_2, CO, hydrocarbons (HC), oxides of nitrogen (NO_x), particulate matter (PM_x), and fuel consumption.

A SUMO simulation requires a description of the road network, a route for each vehicle, and the physical constraints for each vehicle. Physical constraints include each vehicle type's length, acceleration/deceleration potential, and maximum speed. For each simulation, the volume and distribution of vehicle types is prescribed by the user. For this study, we obtained the most-recent (2015) available vehicle volume data for each road segment from the Regional Transportation Commission of Washoe County (RTC). These vehicle volumes represent the baseline simulation.

To predict emissions and energy consumption under alternate traffic volume or new route scenarios, ten simulations were performed:

Category 1: Baseline.

We simulated both westbound and eastbound baseline vehicle volumes using data from 2015. Westbound traffic is westbound on I80 and northbound on Pyramid Way. Eastbound traffic is southbound on Pyramid Way and eastbound on I80. As westbound and eastbound I80 traffic are expected to be symmetric, we performed a single simulation of westbound traffic to confirm that data and models in both directions were accurate. Traffic in all other simulations is eastbound. In the figures and tables below, these scenarios are labeled (a) and (b).

Scenarios:

(a) Baseline traffic, westbound (SUMO simulation name: WB baseline)
(b) Baseline traffic, eastbound (EB baseline)

Results:

As westbound and eastbound traffic are expected to be symmetric, we performed a single simulation of westbound traffic to confirm that data and models in both directions were accurate. All other scenarios simulate eastbound traffic.

We estimate the baseline eastbound CO_2 emission rate is 104 tons/day.

Category 2: Diverting a fraction of existing traffic from Pyramid-I80 to the La Posada Extension.

Diverting a fraction of existing traffic is represented by scenarios (c) and (d). In these scenarios, 10 and 25 percent of the traffic was removed from Pyramid Way and I80 and applied to the La Posada Extension. These scenarios should be compared to the eastbound baseline scenario (b).

Scenarios:

(c) Divert 10% of vehicles to new roadway (divert 10pct)
(d) Divert 25% of vehicles to new roadway (divert 25pct)

Results:

Diverting ten percent of Pyramid-I80 traffic to the La Posada extension reduces CO2 emissions by approximately 4 tons/day, while diverting 25 percent of traffic reduces CO2 emissions by 9 tons/day.

Category 3: Adding traffic to the Pyramid-I80 corridor.

If development continues as expected at TRIC, there will be additional traffic along the Pyramid-I80 corridor. Scenarios (e), (f), and (g) represent an additional 1000, 2000, and 5000 vehicles per day.

Scenarios:

(e) Increase volume on Pyramid/I80 by 1000 vehicles per day (add 1000 veh Pyramid-I80)

(f) Increase volume on Pyramid/I80 by 2000 vehicles per day (add 2000 veh Pyramid-I80)

(g) Increase volume on Pyramid/I80 by 5000 vehicles per day (add 5000 veh Pyramid-I80)

Results:

Scenarios (e), (f), and (g) represent an additional 1000, 2000, and 5000 vehicles per day on the Pyramid-I80 corridor. Comparing the results of these scenarios to the baseline (b) shows a significant increase in CO2 emissions of 7, 15, and 40 tons/day, respectively.

Category 4: Adding traffic to the La Posada Extension.

Finally, scenarios (h), (i), and (j) represent an additional 1000, 2000, and 5000 vehicles per day on the proposed La Posada Extension.

Scenarios:

(h) Increase volume on the new road by 1000 vehicles per day (add 1000 veh La Posada)

(i) Increase volume on the new road by 2000 vehicles per day (add 2000 veh La Posada)

(j) Increase volume on the new road by 5000 vehicles per day (add 5000 veh La Posada)

Results:

Increasing La Posada Extension traffic by the same amounts simulated in Category 3 (increasing volumes on Pyramid-I80) increases emissions by approximately 40% less than adding the same traffic volumes to the existing corridors. Specifically, in these scenarios CO2 is increased over the baseline by 4, 9, and 24 tons/day, respectively.

Table 2 shows the results of the two baseline simulations and eight alternatives. Totals are presented for all corridors and for the pollutants CO2, CO, HC, NOx, and PMx, as well as fuel consumption.

Table 2 Predicted pollutant emissions and fuel consumption for all baseline and alternative scenarios.

Scenario	CO2 (tons/d)	CO (tons/d)	HC (tons/d)	NOx (tons/d)	PMx (tons/d)	fuel (gallons/d)
(a) WB baseline	102	1.60	0.0098	0.0412	0.0022	12731
(b) EB baseline	104	1.69	0.0103	0.0422	0.0023	13039
(c) divert 10pct	100	1.58	0.0097	0.0404	0.0022	12493
(d) divert 25pct	95	1.47	0.0090	0.0384	0.0020	11922
(e) add 1000 veh Pyramid-I80	111	1.80	0.0110	0.0451	0.0024	13911
(f) add 2000 veh Pyramid-I80	119	1.94	0.0118	0.0482	0.0026	14870
(g) add 5000 veh Pyramid-I80	144	2.54	0.0151	0.0588	0.0032	18059
(h) add 1000 veh La Posada	108	1.74	0.0106	0.0439	0.0023	13572
(i) add 2000 veh La Posada	113	1.79	0.0109	0.0457	0.0024	14147
(j) add 5000 veh La Posada	128	1.98	0.0121	0.0515	0.0027	15970

Figure 4 and Table 3 show the predicted carbon dioxide emissions for each scenario, separated by traffic corridor. The relative relationship among all scenarios is similar for each pollutant considered; therefore, to simplify discussion for this study, only carbon dioxide results are discussed below. Results for CO, HC NOx, PMx, and fuel are presented in Appendix A.

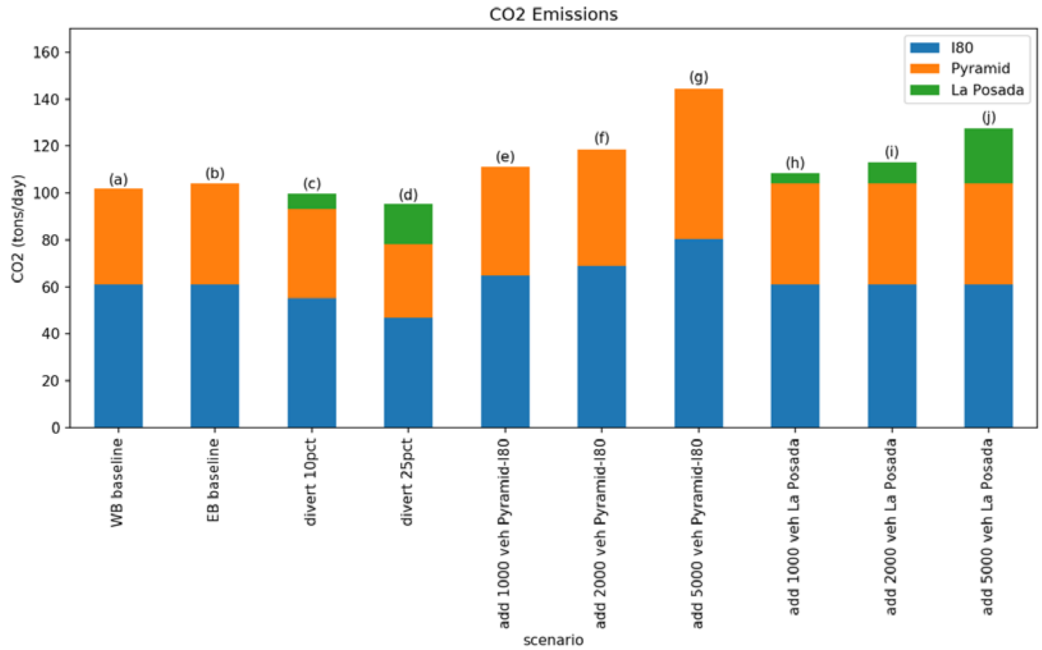


Figure 4 Estimated carbon dioxide emissions for baseline and alternative scenarios.

Table 3 Estimated carbon dioxide emissions for baseline and alternative scenarios.

	(a) WB baseline	(b) EB baseline	(c) divert 10pct	(d) divert 25pct	(e) add 1000 veh Pyramid-I80	(f) add 2000 veh Pyramid-I80	(g) add 5000 veh Pyramid-I80	(h) add 1000 veh La Posada	(i) add 2000 veh La Posada	(j) add 5000 veh La Posada
I80	61	61	55	47	65	69	80	61	61	61
Pyramid	41	43	38	31	46	50	64	43	43	43
La Posada	0	0	6	17	0	0	0	4	9	23

DISCUSSION

Regional Greenhouse Gas and Pollutant Inventory

The GHG and pollutant emissions inventory for urban transportation within the Reno-Sparks region establishes a baseline inventory from which to evaluate the changes in emissions from 2015 to 2017. From 2015 to 2017, we estimate higher rates of CO, CO2, CH4, and TEC and lower rates of HC, PM, and NOx. Varying increases and decreases among different pollutants have several contributing factors. Increases in CO, CO2, CH4, and TEC were likely correlated with the increase in vehicles in the network between 2015 and 2017. The decrease in PM2.5, HC, and NOx may be directly or indirectly related to several factors, including: an increase in the number of hybrid vehicles, replacement of older and lessefficient vehicles with newer models, more-stringent federal emissions standards for new vehicles, and an increase in Inspection/Maintenance (I/M) programs (NDEP 2016).

Corridor-specific Greenhouse Gas and Pollutant Inventory

We also developed the GHG and pollutant emissions inventory for specific transportation corridors. These corridors were chosen to highlight the relative changes in emissions under increased travel demand and alternate routes to and from TRIC. We evaluated four categories of scenarios for this study: 1) baseline traffic, 2) diverting a fraction of existing traffic from the Pyramid-I80 corridor to a proposed new route, 3) adding traffic to the existing Pyramid-I80 corridor, and 4) adding traffic to a proposed new route. The relative results and conclusions are similar for each pollutant. For the purposes of this discussion, only carbon dioxide results are presented here.

The baseline simulations show that emissions from the Pyramid Way corridor are comparable to those from I80, even though the I80 corridor is longer (15 miles compared to 8.5 for Pyramid Way) and carries more traffic. The relatively large emission from Pyramid Way may be attributed to more stop-and-go traffic and idling. Diverting a fraction of traffic from Pyramid-I80 to the La Posada Extension, as in the Category 2 scenarios, results in a significant reduction in CO2. For every 1000 vehicles diverted from Pyramid-I80 to the La Posada Extension, we observe a reduction in CO2 emissions of approximately 2.5 tons/day. This reduction is a result of moving vehicles from an inefficient, often-congested roadway to one with higher speeds and more free-flowing traffic.

We also simulated an increase in vehicles on both the Pyramid-I80 and La Posada Extension corridors. These simulations result in an increase in all emissions, as expected; however, increasing traffic on the La Posada Extension (scenarios from Category 4) results in a smaller increase than that found on Pyramid-I80 (scenarios from Category 3). This is likely due to the shorter travel distance (La Posada is 13 miles and Pyramid-I80 is 23.5 miles) as well as avoiding the congested conditions on Pyramid Way.

CONCLUSION

In this study we evaluated the effect that increased traffic on the Pyramid-I80 corridor and proposed La Posada Extension has on greenhouse gas emissions and energy consumption. We established baseline emissions estimates for the Reno-Sparks-TRIC region, baseline emissions estimates for specific travel corridors from Sparks to TRIC, and evaluated the effect of several alternative travel scenarios on greenhouse gas emissions in the region.

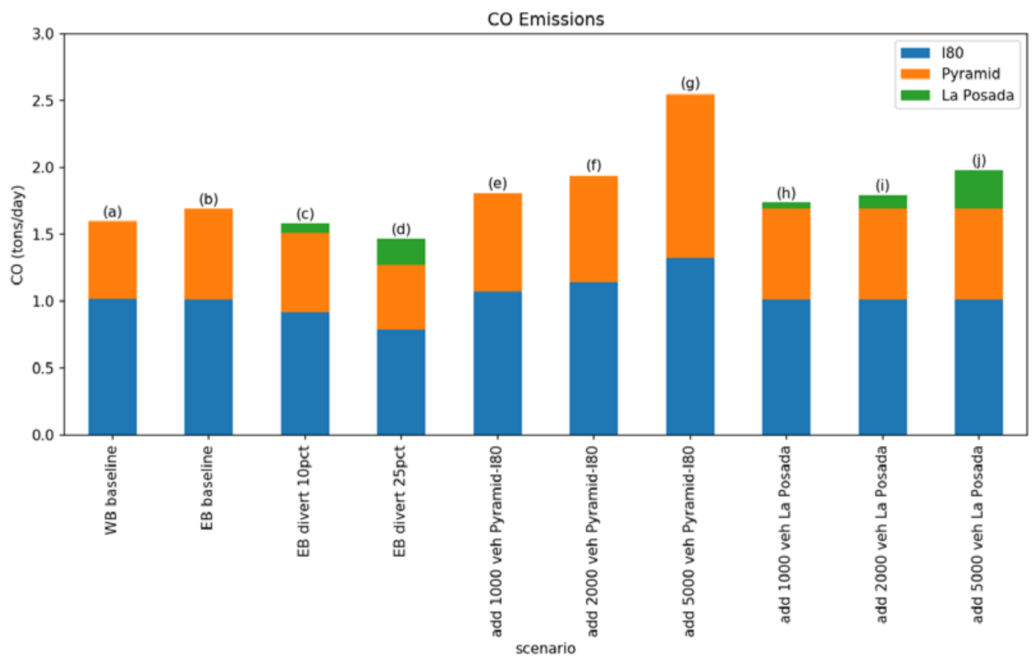
REFERENCES

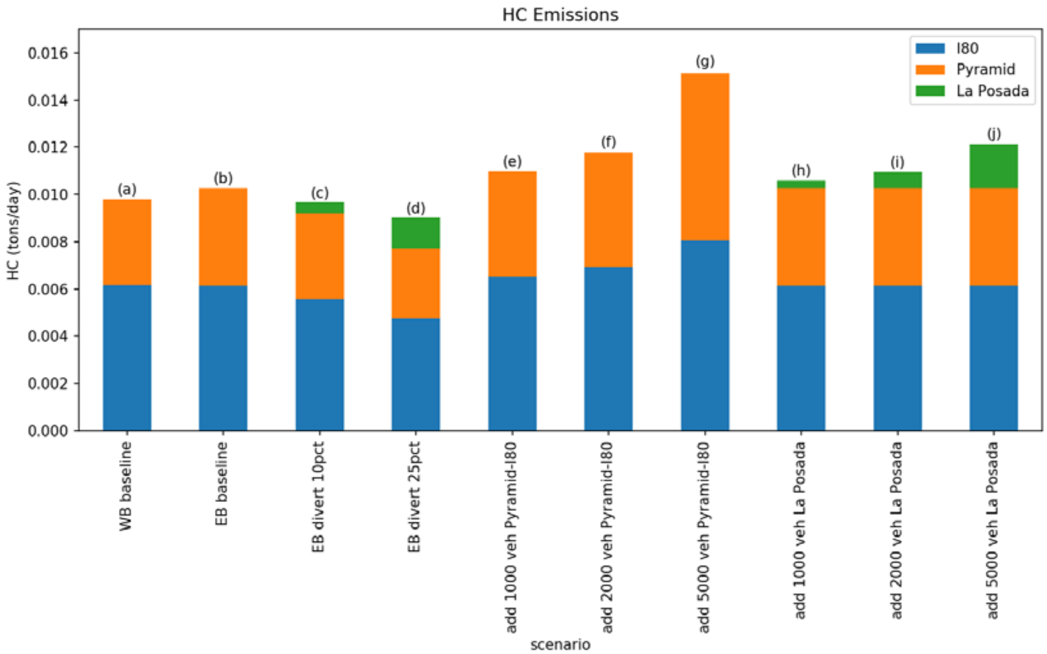
Alvarez-Lopez, Pablo and Behrisch, Michael and Bieker-Walz, Laura and Erdmann, Jakob and Flötteröd, Yun-Pang and Hilbrich, Robert and Lücken, Leonhard and Rummel, Johannes and Wagner, Peter and Wießner, Evamarie (2018) Microscopic Traffic Simulation using SUMO. In: 2019 IEEE Intelligent Transportation Systems Conference (ITSC), pp. 2575-2582. IEEE. The 21st IEEE International Conference on Intelligent Transportation Systems, 4-7 Nov 2018, Maui, USA.

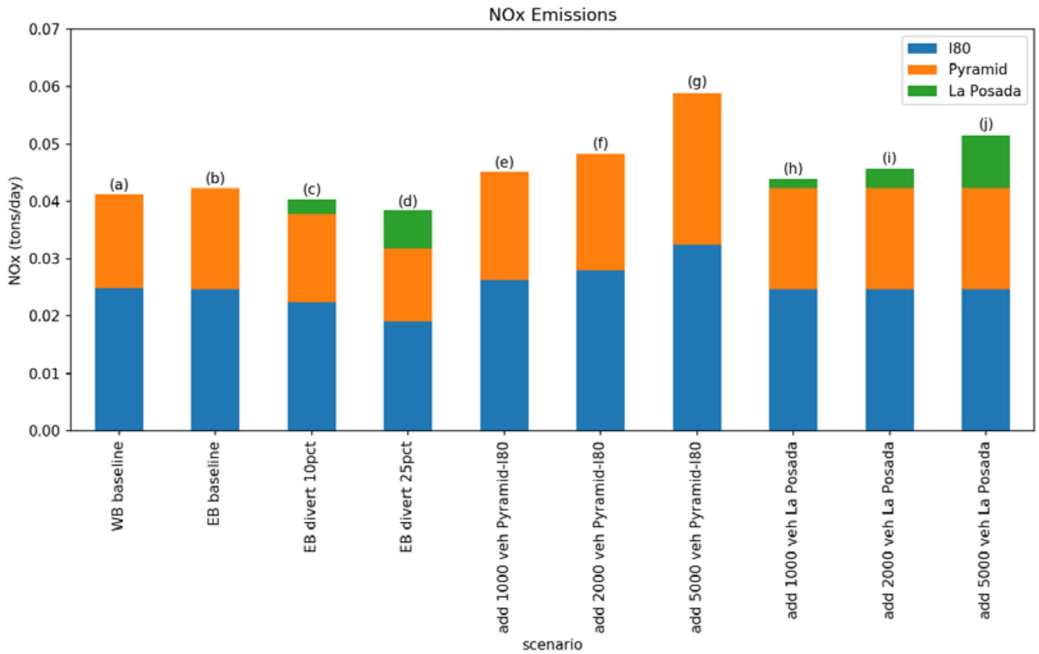
Nevada Division of Environmental Protection (NDEP), 2016. Report on Assembly Bill 146 Study Concerning the Inspection and Testing of Motor Vehicles and Systems for the Control of Emissions from Motor Vehicles in Nevada.

US EPA, 2019c. MOVES2014a Software Design Reference Manual

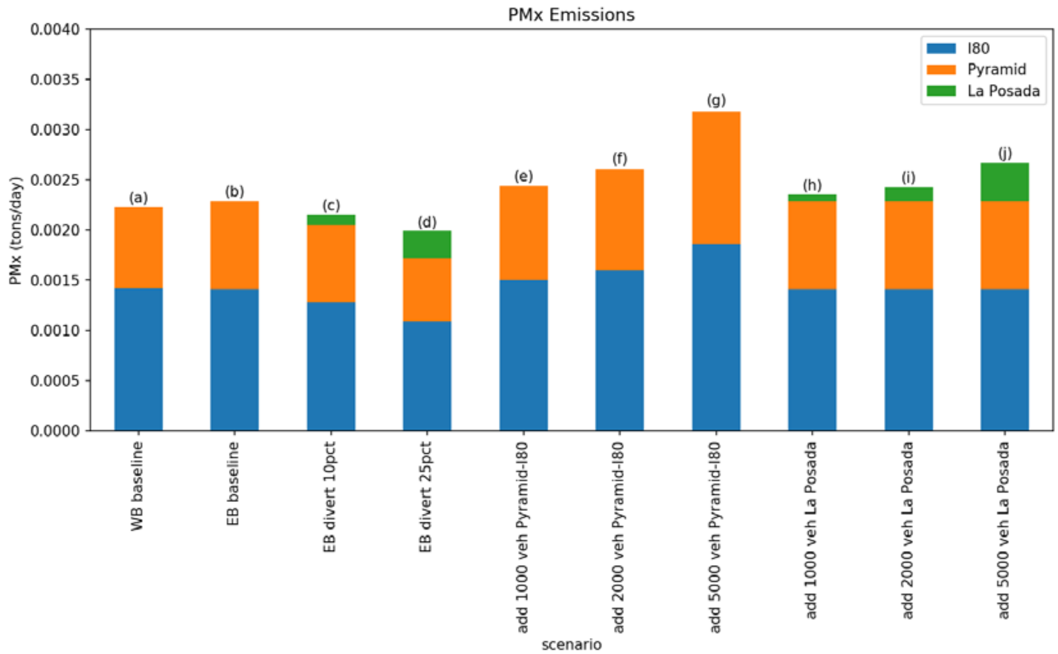
APPENDIX A: EMISSIONS ESTIMATES FOR CORRIDOR-SPECIFIC SCENARIOS

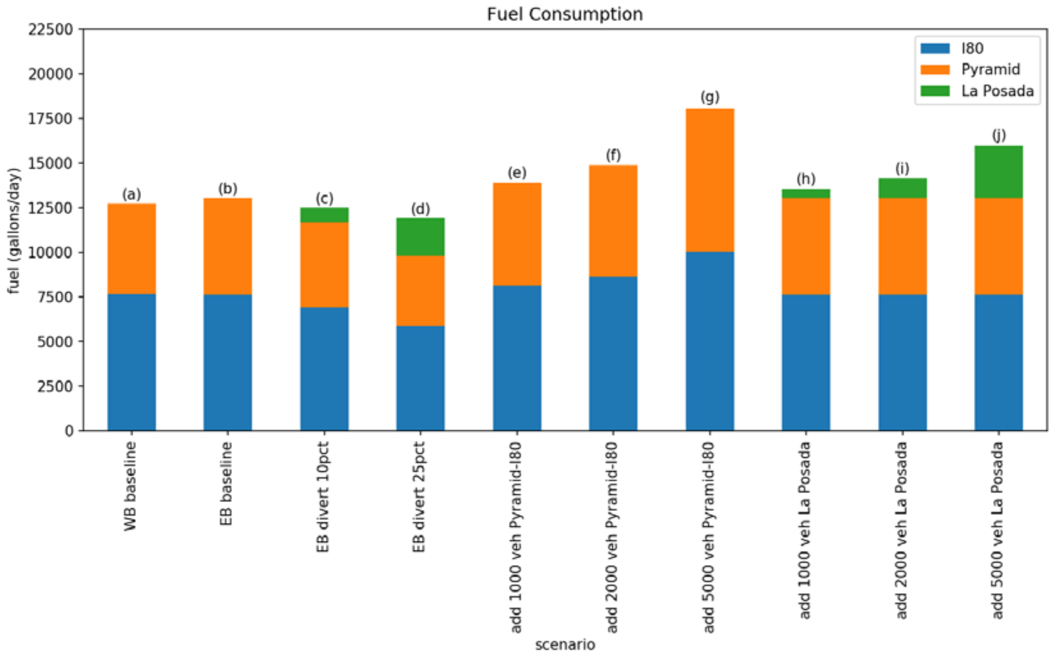



HC Emissions
I80
Pyramid
La Posada
0.016
0.014
0.012
0.010
0.008
0.006
0.004
0.002
0.000
HC (tons/day)
(a)
(b)
(c)
(d)
(e)
(f)
(g)
(h)
(i)
(j)
WB baseline
EB baseline
EB divert 10pct
EB divert 25pct
add 1000 veh Pyramid-I80
add 2000 veh Pyramid-I80
add 5000 veh Pyramid-I80
add 1000 veh La Posada
add 2000 veh La Posada
add 5000 veh La Posada
scenario



NOx Emissions
I80
Pyramid
La Posada
NOx (tons/day)
0.00
0.01
0.02
0.03
0.04
0.05
0.06
0.07
(a)
(b)
(c)
(d)
(e)
(f)
(g)
(h)
(i)
(j)
WB baseline
EB baseline
EB divert 10pct
EB divert 25pct
add 1000 veh Pyramid-I80
add 2000 veh Pyramid-I80
add 5000 veh Pyramid-I80
add 1000 veh La Posada
add 2000 veh La Posada
add 5000 veh La Posada
scenario


PMx Emissions
PMx (tons/day)
0.0040
0.0035
0.0030
0.0025
0.0020
0.0015
0.0010
0.0005
0.0000
I80
Pyramid
La Posada
(a)
(b)
(c)
(d)
(e)
(f)
(g)
(h)
(i)
(j)
WB baseline
EB baseline
EB divert 10pct
EB divert 25pct
add 1000 veh Pyramid-I80
add 2000 veh Pyramid-I80
add 5000 veh Pyramid-I80
add 1000 veh La Posada
add 2000 veh La Posada
add 5000 veh La Posada
scenario


Fuel Consumption
I80
Pyramid
La Posada
fuel (gallons/day)
22500
20000
17500
15000
12500
10000
7500
5000
2500
0
(a)
(b)
(c)
(d)
(e)
(f)
(g)
(h)
(i)
(j)
WB baseline
EB baseline
EB divert 10pct
EB divert 25pct
add 1000 veh Pyramid-I80
add 2000 veh Pyramid-I80
add 5000 veh Pyramid-I80
add 1000 veh La Posada
add 2000 veh La Posada
add 5000 veh La Posada
scenario