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MEMORANDUM

Date: August 6, 2013 Project #: 12904

To: Rosemarie Gaglione, City of Goleta

From: Kittelson and Associates, Inc.

Project: Hollister Avenue Improvement

Subject: Emissions Analysis

This memorandum describes the analysis approach used for calculating future year greenhouse gas (GHG) emission changes of a lane reduction of Hollister Avenue within Old Town Goleta (between Fairview Avenue and Kellogg). This analysis is based on the assumptions and traffic operations results provided in the Two-Lane Hollister Avenue Traffic Operational Study dated March 14, 2011.

Project Overview

The Two-Lane Hollister Avenue Traffic Operational Study (Dowling Associates Inc., March 14, 2011) analyzed the operational implications of reducing Hollister Avenue from four lanes to two lanes (one lane each direction). This analysis supplements that study with a GHG emission analysis.

Traffic Volume

The 2030 AM and PM peak hour traffic volumes for 4-lane and 2-lane Hollister Avenue scenarios were developed using the City's Goleta Traffic Model. For a complete description of the modeling performed see Two-Lane Hollister Avenue Traffic Operational Study (Dowling Associates Inc., March 14, 2011).

For purposes of this analysis, the forecast AM and PM peak hour volumes were assumed to represent 8% and 10% of the daily traffic volume respectively. Each peak hour volume was expanded to 2-hour peak period based on traffic counts conducted within the area in April 2013. Based on these counts, the 2-hour AM and PM peak periods reflect 14.7% and 15.6% of the daily traffic volume respectively.

Study Roadway Segments

Table 1 provides a list of the selected roadway segments (total of 13 segments), their 2-hour volumes, and operational speeds for both AM and PM peaks. These segments were selected based on the traffic volume changes and the queue conditions identified in the traffic operational study. The operational speeds were assumed based on output from the operational software SYNCHRO and observing the SIM-TRAFFIC simulation runs developed for the Two-Lane Hollister Avenue Traffic Operational Study.

Table 1 Study Roadway Segments

Route	From	To	Centerline Mile	2-Hour Peak Volume						Operational Speed			
				4-Lane Hollister		2-Lane Hollister		Diff.		4-Lane Hollister		2-Lane Hollister	
				AM	PM	AM	PM	AM	PM	AM	PM	AM	PM
US101	Fairview	Patterson	1.2	18,454	15,591	18,855	15,803	401	212	45	45	45	45
SR217	US101	Hollister	0.5	4,095	2,424	4,014	2,437	-81	12	65	65	65	65
SR217	Hollister	University	1.3	4,462	3,733	4,734	3,758	272	25	65	65	65	65
Hollister	Lopez	Fairview	0.3	5,087	3,753	4,953	3,497	-134	-256	20	20	5	5
Hollister	Fairview	Kellogg	0.6	4,040	3,091	2,970	2,340	-1,070	-751	20	20	20	20
Hollister	Kellogg	Sumida Gardens	0.4	5,304	4,286	4,812	3,978	-493	-308	15	15	5	5
Fairview	Ekwill	Carson	0.25	3,628	2,740	3,994	2,890	366	150	20	20	5	5
Fairview	Carson	Hollister	0.15	3,628	2,740	3,994	2,890	366	150	20	20	5	5
Fairview	Hollister	Ramp	0.43	7,412	5,218	7,673	5,365	261	147	15	15	5	5
Fairview	Ramp	Calle Real	0.08	5,797	3,328	5,988	3,377	191	48	15	15	5	5
Carson	Fairview	Pine	0.2	309	226	781	372	472	145	15	15	15	15
Mandarin	Nectarine	Fairview	0.3	996	650	994	768	-2	119	15	15	15	15
Ekwill	Fairview	Kellogg	0.5	1,382	962	1,564	1,084	182	122	20	20	20	20

Peak Periods Emissions Calculation

The calculation for emissions used information provided by the California Air Resources Board (CARB). CARB maintains the Emission FACtors (EMFAC) model, which is used to develop on-road motor vehicle emission inventories and California. This analysis was performed using the recent version: EMFAC2011. The new EMFAC2011 consists of three modules, EMFAC-LDV for passenger vehicles emissions, EMFAC-HD for trucks and buses over 14,000 lbs., and EMFAC-SG for integration of the first two modules. In addition, the CARB also provides inventory database through EMFAC Web Database which provides emissions and emission rates at varying levels of detail. For this analysis purpose, the emission rates were generated using the web-based EMFAC2011 Emissions Database (www.arb.ca.gov/emfac/).

The EMFAC2011 Emissions Database generates emission rates useful for a GHG analysis. For this analysis purpose, the three on-road vehicle GHG components were considered including Carbon dioxide (CO_2), Methane (CH_4), and Nitrous oxide (N_2O). By default, the CH_4 and N_2O are not directly calculated by EMFAC2011 model. However, CARB provides procedures to convert the EMFAC2011 results to CH_4 and N_2O[1]. Using the Global Warming Potentials (GWP), the CO_2, CH_4, and N_2O were further converted to CO_2 equivalent (CO_2–EQ). The GWP factors used for CO_2–EQ emissions are 1 for CO_2, 21 for CH_4, and 310 for N_2O[2]. The CO_2–EQ emission rates and emissions were used to compare between the two Hollister Avenue scenarios.

In addition, the emission rates from EMFAC2011 include CO_2 and CO_2 with Pavley I and Low Carbon Fuel Standard (LCFS) in grams per mile per vehicle unit. The Pavely I and LCFS strategies take into account for clean-car standards and low carbon intensity of vehicle fuel. For the 2030 calendar year, EMFAC2011 generates emission rates by vehicle class, fuel type, and speed bin. The EMFAC2011 vehicle category includes 41 classes of vehicles, 2 types of fuel (gas and diesel), and 13 bins of speed from 5 mph to 65 mph in 5 mph increment. The emission rates for all the vehicle classes and fuel types combined are shown in the Figure 1 below.

EMFAC2011 Emission Rates
Region Type: GAI
Region: Santa Barbara (SCC)
Calendar Year: 2030
Season: Annual
Vehicle Classification: EMFAC2011 Categories

Region	CalYr	Season	Veh_Class	Fuel	MdlYr	Speed (miles/hr)	VMT (miles/day)	ROG_RUNEX (gms/mile)	TOG_RUNEX (gms/mile)	CO_RUNEX (gms/mile)	NOX_RUNEX (gms/mile)	CO2_RUNEX (gms/mile)	CO2_RUNEX(Pavley I+LCFS) (gms/mile)	PM10_RUNEX (gms/mile)	PM2_5_RUNEX (gms/mile)
Santa Barbara (SCC)	2030	Annual	All	All	Aggregated	5	34886.856	64.48033061	73.85192992	317.1663736	205.2305068	126650.7051	112228.962	2.685716777	2.471403824
Santa Barbara (SCC)	2030	Annual	All	All	Aggregated	10	96561.71913	40.93581292	46.8924404	242.523272	159.959829	104795.2213	92935.11205	2.362699656	2.174045506
Santa Barbara (SCC)	2030	Annual	All	All	Aggregated	15	196081.8911	23.09689941	26.47685117	164.9803406	123.1312698	84250.41468	74732.89207	1.994581732	1.835253949
Santa Barbara (SCC)	2030	Annual	All	All	Aggregated	20	240909.9934	12.75771267	14.63617601	117.8844343	99.46045325	68801.6966	61022.9164	1.739384626	1.600399119
Santa Barbara (SCC)	2030	Annual	All	All	Aggregated	25	332794.8418	10.43598325	11.94875903	96.4885848	88.61394958	60715.71489	53875.86174	1.544837937	1.42137081
Santa Barbara (SCC)	2030	Annual	All	All	Aggregated	30	1339279.477	8.94272002	10.21820678	83.67288873	81.89463457	56220.01285	49914.87959	1.473561831	1.355768043
Santa Barbara (SCC)	2030	Annual	All	All	Aggregated	35	761586.8301	7.833097967	8.93657631	75.93810932	76.8530972	52828.20945	46913.89547	1.469973334	1.352448098
Santa Barbara (SCC)	2030	Annual	All	All	Aggregated	40	1289544.772	7.040535458	8.019929982	72.12431976	73.41627487	50366.86973	44723.32876	1.529262514	1.406982085
Santa Barbara (SCC)	2030	Annual	All	All	Aggregated	45	2357150.224	6.530525285	7.423993719	71.65826682	71.59215418	48746.93042	43265.84604	1.648481563	1.516655934
Santa Barbara (SCC)	2030	Annual	All	All	Aggregated	50	2157715.684	6.282553431	7.129125579	74.48182341	71.41720492	47936.12393	42512.46024	1.825934938	1.67990848
Santa Barbara (SCC)	2030	Annual	All	All	Aggregated	55	2220987.793	6.325844467	7.161533433	81.25115509	73.15793159	47949.88174	42474.28743	2.060864065	1.896041193
Santa Barbara (SCC)	2030	Annual	All	All	Aggregated	60	1533856.058	6.577700314	7.424618613	91.47444972	73.29431405	46734.2954	41296.43849	2.322936002	2.137144433
Santa Barbara (SCC)	2030	Annual	All	All	Aggregated	65	2353399.407	6.853892064	7.708356917	100.653592	52.46458856	43738.39617	38471.79776	2.471129616	2.273478999

Figure 1 EMFAC2011 Emission Rates

To calculate GHG emissions, VMT was calculated for each segment by multiplying the 2-hour peak volumes to the centerline miles of each segment. The segment VMT was then multiplied by the appropriate emission rates based on the operational speed of each segment. All other related inputs including vehicle fleet mix, age and technology mix, and meteorological inputs (e.g., temperature, humidity etc.) was based on CARB defaults for Santa Barbara County.

To provide a conservative estimate of GHG emissions, it was assumed that for the remaining off-peak hours – traffic operations would be not be affected by the lane reduction resulting in no VMT (i.e., diversion) or speed (i.e., congestion) differences between the two-lane and four-lane scenarios.

The results of CO_2–EQ emission with and without Pavley I + LCFS are shown in Table 2 in tons/day for the 4 hours. It shows that the 2-lane Hollister Avenue alternative would result in an increase of 14.21

[1] http://www.arb.ca.gov/msei/emfac2011-faq.htm#emfac2011_web_db_qstn07

[2] Table 2.14, 2007 IPCC Report, http://www.ipcc.ch/pdf/assessment-report/ar4/wg1/ar4-wg1-chapter2.pdf

tons/day of CO_2–EQ for the 4-hour peak periods due to longer delays and queues at the key intersections. When considering the Pavley I and LCFS standards, the amount of CO_2–EQ generated by the 2-lane alternative would increase by 12.17 tons/day for the 4-hour peak periods.

Table 2 CO_2–EQ Emissions for 4-Lane and 2-Lane Hollister Avenue (AM and PM Peak Periods)

CO2-EQ (tons)			CO2-EQ with Pavley I+LCFS (tons)		
4-Lane	**2-Lane**	**Diff.**	**4-Lane**	**2-Lane**	**Diff.**
48.51	62.72	14.21	37.91	50.08	12.17

Daily Emissions Calculation

The same calculation approach above was used to estimate daily emissions within the study area. The CO_2-EQ was calculated for the off-peak period (total of 20 hours) using the VMT fraction derived from the default VMT distribution provided by EMFAC2011 as shown in Figure 2. These VMT fractions broken down by vehicle class and fuel type were applied to the off-peak traffic volume for each segment.

Region	CalYr	Season	Veh_Class	Fuel	MdlYr	Speed (miles/hr)	VMT (miles/day)	VMT Fraction
Santa Barbara (SCC)	2030	Annual	All	All	Aggregated	5	34886.856	0.0023
Santa Barbara (SCC)	2030	Annual	All	All	Aggregated	10	96561.71913	0.0065
Santa Barbara (SCC)	2030	Annual	All	All	Aggregated	15	196081.8911	0.0131
Santa Barbara (SCC)	2030	Annual	All	All	Aggregated	20	240909.9934	0.0162
Santa Barbara (SCC)	2030	Annual	All	All	Aggregated	25	332794.8418	0.0223
Santa Barbara (SCC)	2030	Annual	All	All	Aggregated	30	1339279.477	0.0898
Santa Barbara (SCC)	2030	Annual	All	All	Aggregated	35	761586.8301	0.0511
Santa Barbara (SCC)	2030	Annual	All	All	Aggregated	40	1289544.772	0.0865
Santa Barbara (SCC)	2030	Annual	All	All	Aggregated	45	2357150.224	0.1580
Santa Barbara (SCC)	2030	Annual	All	All	Aggregated	50	2157715.684	0.1447
Santa Barbara (SCC)	2030	Annual	All	All	Aggregated	55	2220987.793	0.1489
Santa Barbara (SCC)	2030	Annual	All	All	Aggregated	60	1533856.058	0.1028
Santa Barbara (SCC)	2030	Annual	All	All	Aggregated	65	2353399.407	0.1578

Figure 2 EMFAC2011 VMT Distribution by Speed Bin

The off-peak traffic volume was calculated by applying the 2-hour-peak-to-daily traffic ratio (15.6% for PM peak) to the PM peak 2-hour volume. The VMT for each segment was then calculated as described previously.

Due to the travel speed reductions (i.e., overall increase in delay) associated with the 2-lane Hollister scenario, the CO_2-EQ during off-peak operations is estimated to increase (23 tons/day and 20 tons/day with and without Pavley I+LCFS, respectively). Both scenarios were assumed to have the same default VMT-by-speed profile from EMFAC2011.

Combining the off-peak results to the 4-hour peak results yields daily CO_2–EQ emissions with and without Pavley I + LCFS. These results are shown in Table 3 in tons/day. It shows that the 2-lane Hollister Avenue alternative would result in an increase of 37 tons/day of CO_2–EQ due to longer delays and queues at the key intersections during peak periods. When considering the Pavley I and LCFS standards, the amount of CO_2–EQ generated by the 2-lane alternative would increase by 32 tons/day.

Table 3 CO_2–EQ Emissions for 4-Lane and 2-Lane Hollister Avenue (Daily)

CO2-EQ (tons)			CO2-EQ with Pavley I+LCFS (tons)		
4-Lane	**2-Lane**	**Diff.**	**4-Lane**	**2-Lane**	**Diff.**
136	173	37	106	138	32