ADDENDUM

Estimating atmospheric concentrations and the resulting risks posed by the chemicals of concern for the South Coast Air Basin is a very complex and dynamic process. As more information is obtained on atmospheric chemistry fate and health effects of these chemicals, there is the expectation that the modeled atmospheric concentrations and health risk values will change. Ultimately, the goal is to provide a more accurate analysis and lower the uncertainty involved in the process. Thus, CARB performed a supplementary "upper-bound model" simulation on the five fuel scenarios that formed the original basis of the health impacts assessment. The additional model inputs included the effects of emission uncertainty and chlorine chemistry, uses updated MTBE and ethanol rate constants, and corrects boundary conditions for several substances.

The resulting atmospheric concentration estimates are shown in Table A-1, and our conclusions are as follows:

- The "upper-bound model atmospheric concentrations" presented here are generally lower than the original atmospheric concentrations presented in Table 4. Thus, the cumulative hazard indices and cumulative cancer risks are predicted to be lower under this modified model simulation.
- The only increased atmospheric levels under the modified model simulation were for ethanol. In some cases these were nearly double the original predicted atmospheric concentrations. However, the increased ethanol concentrations are expected to have no impact on health due to ethanol's low anticipated health risk relative to other fuel-related chemicals.
- Comparing the atmospheric concentrations among the year 2003 fuel scenarios under the modified model, there are higher concentrations of acetaldehyde in the scenario with ethanol (3.5% oxygen) fuel. This difference was less marked in the predictions of the previous version of the model. However, the health impact of the higher acetaldehyde concentrations is negligible due to its relatively low health risk compared to other chemicals of concern.
- Under the modified model, the upper range estimates of PAN concentrations are higher in the scenario with ethanol (3.5% oxygen) fuel. This difference also was less marked with the previous version of the model. If the atmospheric concentrations of PAN were in fact to be substantially increased, this would be of concern since PAN has a relatively high health impact for acute eye irritation. However, given the total range of the predicted PAN concentrations and the uncertainty in the model prediction, it is unclear whether PAN results in a greater health risk under the ethanol (3.5% oxygen) fuel scenario.
- It appears that the modified model simulations are more sensitive to fuel composition in the predictions of ethanol, acetaldehyde, and PAN concentrations (and therefore of the associated health impacts) compared to the other chemicals of concern.

- There are no indications of substantial differences between the 2003 fuel types in cancer or noncancer health impacts of airborne exposures, whether the original or modified model is used. Therefore, there are no grounds to recommend one fuel over another based on health impacts of air pollution. Similarly, there is no indication that any of those fuel choices would result in worse health impacts than the current situation.

In addition to predicted values for PM_{10}, CARB also included in their latest report predicted values for $PM_{2.5}$. As with PM_{10}, CARB states that they expect no difference among 2003 scenarios, and therefore only provided a maximum daily average (81 $\mu g/m^3$) and a maximum annual average (25.9 $\mu g/m^3$) for the 1997 MTBE fuel scenario for $PM_{2.5}$. Currently, although U. S. EPA has proposed standards for $PM_{2.5}$, there are no state or federal standards in place for this material. However, it is commonly assumed that the ratio of $PM_{2.5}/PM_{10}$ is 0.5. Use of the California PM_{10} standards (30 $\mu g/m^3$ for the annual average; 50 $\mu g/m^3$ for the 24-hr average standard) results in values of 15 and 25 $\mu g/m^3$, respectively, as guidance for interpreting the significance of the predicted $PM_{2.5}$ concentrations. While it is known that these guidance values for particulates are frequently exceeded in California, according to CARB's report, there is no difference expected among the 2003 scenarios.

Further discussion and analysis of the atmospheric concentration estimates based on the modified model simulations can be found in section 4.2.2 of CARB’s “Air Quality Impacts of the Use of Ethanol in California Reformulated Gasoline. Final Report to the California Environmental Policy Council. December, 1999”.

Table A-1. Atmospheric Concentration Estimates: Range of Predicted 1997 and 2003 Air Quality for the South Coast Air Basin Using "Upper-Bound Model Simulations" [a]

		1997 MTBE	2003 MTBE	2003 Et2%	2003 Et3.5%	2003 Non-Oxy
Acetaldehyde (ppb)						
Population-Weighted Annual Exposure						
	Upper	1.8	1.5	1.5	1.8	1.5
	Lower	1.8	1.4	1.5	1.7	1.4
Maximum Daily Average						
	Upper	11.0	7.9	8.1	8.5	8.0
	Lower	5.1	3.7	3.8	4.0	3.7
Maximum 1 Hour Average						
	Upper	17.7	12.4	12.7	13.6	12.3
	Lower	13.8	9.7	9.9	10.6	9.6
Benzene (ppb)						
Population-Weighted Annual Average						
	Upper	1.19	0.68	0.67	0.69	0.63
	Lower	1.07	0.61	0.60	0.62	0.57
Maximum Daily Average						
	Upper	9.5	5.6	5.6	5.7	5.2
	Lower	7.4	4.4	4.3	4.4	4.1
Maximum 1 Hour Average						
	Upper	22.4	13.1	13.1	13.1	12.1
	Lower	11.6	6.8	6.8	6.8	6.3
Butadiene (ppb)						
Population-Weighted Annual Average						
	Upper	0.36	0.20	0.19	0.20	0.20
	Lower	0.34	0.19	0.18	0.19	0.18
Maximum Daily Average						
	Upper	2.9	1.5	1.5	1.5	1.5
	Lower	2.0	1.1	1.1	1.1	1.1
Maximum 1 Hour Average						
	Upper	6.7	4.0	4.0	4.0	4.0
	Lower	3.1	1.9	1.9	1.9	1.9
Ethanol (ppb)						
Population-Weighted Annual Average						
	Upper	5.4	5.1	10.9	14.2	5.1
Maximum Daily Average						
	Upper	51	48	98	125	48
	Lower	47	45	93	121	44
Maximum 1 Hour Average						
	Upper	108	101	213	268	101
	Lower	78	74	191	267	74

Table A-1 (continued). Atmospheric Concentration Estimates: Range of Predicted 1997 and 2003 Air Quality for the South Coast Air Basin Using "Upper-Bound Model Simulations"[a]

		1997 MTBE	2003 MTBE	2003 Et2%	2003 Et3.5%	2003 Non-Oxy
Formaldehyde (ppb)						
Population-Weighted Annual Average						
	Upper	4.7	3.7	3.4	3.5	3.4
	Lower	4.7	3.6	3.4	3.5	3.4
Maximum Daily Average						
	Best	14.0	9.8	9.2	9.6	9.1
Maximum 1 Hour Average						
	Upper	37.8	26.5	25.1	25.9	24.9
	Lower	20.3	14.2	13.5	13.9	13.4
MTBE (ppb)						
Population-Weighted Annual Average						
	Upper	3.9	2.4	0	0	0
	Lower	3.6	2.2	0	0	0
Maximum Daily Average						
	Upper	29	18	0	0	0
	Lower	13	8	0	0	0
Maximum 1 Hour Average						
	Upper	67	41	0	0	0
	Lower	19	12	0	0	0
PAN (ppb)[b]						
Maximum Daily Average						
	Upper	5.0	3.3	3.2	3.4	3.1
	Lower	2.5	1.7	1.6	1.7	1.6
Maximum 1 Hour Average						
	Upper	10.0	6.3	6.0	6.5	5.7
	Lower	5.0	3.1	3.0	3.2	2.9

Table A-1 (continued). Atmospheric Concentration Estimates: Range of Predicted 1997 and 2003 Air Quality for the South Coast Air Basin Using "Upper-Bound Model Simulations"[a]

	1997 MTBE	2003 MTBE	2003 Et2%	2003 Et3.5%	2003 Non-Oxy
Carbon Monoxide (ppm)					
Maximum 8 Hour Average					
Best	**17.5**	**12.7**	**12.7**	**12.1**	**13.1**[c]
Maximum 1 Hour Average					
Best	**22.5**	**16.1**	**16.1**	**15.3**	**16.6**[c]
Nitrogen Dioxide (ppm)					
Maximum Annual Average					
Best	**0.043**	CARB reported, "No difference expected among 2003 scenarios" [d]			
Maximum Daily Average					
Best	**0.117**	**0.095**	**0.095**	**0.095**	**0.095**
Maximum 1 Hour Average					
Best	**0.255**	**0.207**	**0.207**	**0.207**	**0.207**
Ozone (ppm)					
Maximum 8 Hour Average					
Best	**0.206**	**0.165**	**0.159**	**0.162**	**0.159**
Maximum 1 Hour Average					
Best	**0.244**	**0.190**	**0.182**	**0.186**	**0.182**
Particulate Matter (10 microns or less) (mg/m³)					
Maximum Annual Geometric Mean					
Best	**56**	CARB reported, "No difference expected among 2003 scenarios" [d]			
Maximum Daily Average					
Best	**227**	CARB reported, "No difference expected among 2003 scenarios" [d]			

[a] Source: Table 4.9 of "Air Quality Impacts of the Use of Ethanol in California Reformulated Gasoline. Final Report to the California Environmental Policy Council. December, 1999. California Air Resources Board, Cal/EPA"

[b] A population-weighted annual average for PAN was not determined because consistent long-term measurements of atmospheric PAN have not been performed. See CARB report for details.

[c] This apparent increase is a function of the emission assumptions. Due to the wintertime oxygenate requirement for the SoCAB, CO concentrations within the nonattainment area of Los Angeles County will not differ from the 2003 MTBE baseline.

[d] No significant change compared to 1997 MTBE-fuel scenario. See CARB report for details.

Tables A-2 and A-3 display the non-cancer Hazard Quotients (HQs) generated from the modeled atmospheric concentrations in Table A-1. The relatively marginal increase in the acute atmospheric acetaldehyde concentrations under the 3.5% ethanol fuel scenario relative to the other fuel scenarios did not translate into a proportionally higher HQ. This was primarily due to acetaldehyde's relatively low HQ. In contrast, the upper range atmospheric PAN concentrations under the 3.5% fuel scenario exhibited a proportionally increased HQ compared to the other fuel scenarios. Although the proportional increases in upper range PAN and acetaldehyde concentrations were similar under this fuel scenario, there is likely greater concern for PAN's acute effects because of its relatively high HQ. However, it is not clear how real this difference is because the lower range PAN HQ is proportionally similar to the lower range PAN HQs in the other fuel scenarios. Given the total range of the PAN HQs and the uncertainty in the model prediction, it is unclear whether PAN results in a greater health risk under the 3.5% ethanol fuel scenario.

Table A-2. Range of Estimated Maximum Noncancer Hazard Quotients (HQ) for Various Scenarios in the South Coast Air Basin Based on ARB's "Upper-Bound Model Simulations"

		1997 MTBE	2003 MTBE	2003 Et2%	2003 Et3.5%	2003 NonOxy
Acetaldehyde						
Chronic HQ	Upper	0.4	0.3	0.3	0.4	0.3
	Lower	0.4	0.3	0.3	0.3	0.3
Acute HQ	Upper	0.3	0.2	0.2	0.2	0.2
	Lower	0.2	0.1	0.2	0.2	0.1
Benzene						
Chronic HQ	Upper	0.06	0.03	0.03	0.03	0.03
	Lower	0.05	0.03	0.03	0.03	0.03
Acute HQ	Upper	0.06	0.03	0.03	0.03	0.03
	Lower	0.03	0.02	0.02	0.02	0.02
Butadiene						
Chronic HQ	Upper	0.09	0.05	0.05	0.05	0.05
	Lower	0.09	0.05	0.05	0.05	0.05
Acute HQ	Upper	0.05	0.03	0.03	0.03	0.03
	Lower	0.02	0.01	0.01	0.01	0.01
Ethanol						
Chronic HQ	Best	0.0001	0.0001	0.0002	0.0003	0.0001
Acute HQ	Upper	0.002	0.002	0.004	0.005	0.002
	Lower	0.001	0.001	0.004	0.005	0.001
Formaldehyde						
Chronic HQ	Upper	2.4	1.9	1.7	1.8	1.7
	Lower	2.4	1.8	1.7	1.8	1.7
Acute HQ	Upper	0.5	0.3	0.3	0.3	0.3
	Lower	0.3	0.2	0.2	0.2	0.2
MTBE						
Chronic HQ	Upper	0.005	0.003	0.0	0.0	0.0
	Lower	0.005	0.003	0.0	0.0	0.0
Acute HQ	Upper	0.01	0.006	0.0	0.0	0.0
	Lower	0.003	0.002	0.0	0.0	0.0
PAN*						
Acute HQ	Upper	5.5	3.5	3.3	3.6	3.2
	Lower	2.7	1.7	1.7	1.8	1.6

*** A population-weighted annual average for PAN was not determined because consistent long-term measurements of atmospheric PAN have not been performed. See CARB report for details.**

Table A-3. Range of Estimated Maximum Noncancer Hazard Quotients (HQ) for Various Scenarios in the South Coast Air Basin Based on ARB's "Upper-Bound Model Simulations" – Criteria Air Pollutants

	1997 MTBE	2003 MTBE	2003 Et2%	2003 Et3.5%	2003 NonOxy
Carbon Monoxide					
Acute 8 hour HQ	1.9	1.4	1.4	1.3	1.5
Acute 1 hour HQ	1.1	0.8	0.8	0.8	0.8
Nitrogen Dioxide					
Chronic HQ	0.8	concentrations not estimated by CARB since no significant change in Maximum 1-Hour*			
Acute 1 hour HQ	1.0	0.8	0.8	0.8	0.8
Ozone					
Acute 8 hour HQ	2.6	2.1	2.0	2.0	2.0
Acute 1 hour HQ	2.7	2.1	2.0	2.1	2.0
Particulate Matter (PM10)					
Chronic HQ	1.9	CARB reported, "No significant change expected among			
Acute 24 hour HQ	4.5	2003 scenarios" for both annual and daily concentrations*			

* compared to exposure estimates for the 1997 MTBE-fuel scenario (see CARB report for details)

With regard to the chemicals that are predicted to pose a cancer risk (Table A-4), the modified model simulation does not change the existing conclusions that, (1) we have more confidence in the relative risks estimates than the absolute values of concentrations and risk, and (2) there are no substantial differences between the 2003 fuel types with regard to the cumulative lifetime cancer risk estimates. As expected, the marginal increase in atmospheric acetaldehyde concentrations under the 3.5% ethanol fuel scenario relative to the other fuel scenarios did not result in a significant increase in cumulative cancer risk. This is primarily due to acetaldehyde's considerably lower cancer risk relative to other carcinogens such as benzene.

Table A-4. Lifetime Cancer Risk from Individual Chemicals and Cumulative Lifetime Cancer Risk for Each of the Five Fuel Scenarios Based on ARB's "Upper-Bound Model Simulations"

Chemical		1997 MTBE	2003 MTBE	2003 Et2%	2003 Et3.5%	2003 NonOxy
Acetaldehyde	Upper	8.6 E-6	7.2 E-6	7.2 E-6	8.6 E-6	7.2 E-6
	Lower	8.6 E-6	6.7 E-6	7.2 E-6	8.1 E-6	6.7 E-6
Benzene	Upper	1.1 E-4	6.3 E-5	6.2 E-5	6.4 E-5	5.9 E-5
	Lower	1.0 E-4	5.7 E-5	5.6 E-5	5.8 E-5	5.3 E-5
Butadiene	Upper	1.3 E-4	7.4 E-5	7.0 E-5	7.4 E-5	7.4 E-5
	Lower	1.3 E-4	7.0 E-5	6.7 E-5	7.0 E-5	6.7 E-5
Formaldehyde	Upper	3.3 E-5	2.6 E-5	2.4 E-5	2.5 E-5	2.4 E-5
	Lower	3.3 E-5	2.5 E-5	2.4 E-5	2.5 E-5	2.4 E-5
MTBE	Upper	3.6 E-6	2.2 E-6	0	0	0
	Lower	3.3 E-6	2.0 E-6	0	0	0
Cumulative Lifetime Risk	Upper	2.9 E-4	1.7 E-4	1.6 E-4	1.7 E-4	1.6 E-4
	Lower	2.7 E-4	1.6 E-4	1.5 E-4	1.6 E-4	1.5 E-4
Excess Cancer Cases Per Million Individuals	Upper	290	170	160	170	160
	Lower	270	160	150	160	150

For non-cancer cumulative impacts, the toxicological endpoints of concern, acute eye irritation (Table A-5), acute respiratory irritation (Table A-6), and chronic respiratory irritation (Table A-7), remained the same under the modified model simulations. The only noticeable difference among the fuel scenarios was that for acute eye irritation, the 2003 MTBE and 3.5% ethanol fuels had slightly higher upper range acute HIs relative to the other year 2003 fuels. The secondary pollutant PAN was primarily responsible for the increased disparity, due to the higher upper range estimate of its HQ under these two fuel scenarios. However, the lower range of the cumulative HIs does not show as great a disparity among the fuel scenarios. There is considerable uncertainty involved in the model predictions, including both the range of estimates with this "upper bound model" and the differences between this model and the earlier one. It cannot therefore be definitely concluded that the 3.5% ethanol fuel will result in greater eye irritation relative to the other fuels. Improvement in atmospheric modeling and measurement may eventually resolve this uncertainty.

Table A-5. Maximum Acute Hazard Quotients (HQ) and Cumulative Acute Hazard Indices (HI) for Eye Irritation for Each of the Five Fuel Scenarios Based on ARB's "Upper-Bound Model Simulations"

Chemical		1997 MTBE	2003 MTBE	2003 Et2%	2003 Et3.5%	2003 NonOxy
Acetaldehyde	Upper	0.3	0.2	0.2	0.2	0.2
	Lower	0.2	0.1	0.2	0.2	0.1
Ethanol	Upper	0.002	0.002	0.004	0.005	0.002
	Lower	0.001	0.001	0.004	0.005	0.001
Formaldehyde	Upper	0.5	0.3	0.3	0.3	0.3
	Lower	0.3	0.2	0.2	0.2	0.2
MTBE	Upper	0.01	0.006	0	0	0
	Lower	0.003	0.002	0	0	0
PAN	Upper	5.5	3.5	3.3	3.6	3.2
	Lower	2.7	1.7	1.7	1.8	1.6
Nitrogen dioxide	Best	1.0	0.8	0.8	0.8	0.8
Ozone	Best	2.7	2.1	2.0	2.1	2.0
Cumulative HI	Upper	10.0	6.9	6.6	7.0	6.5
	Lower	6.9	4.9	4.9	5.1	4.7

Table A-6. Maximum Acute Hazard Quotients (HQ) and Cumulative Acute Hazard Indices (HI) for Respiratory Irritation For Each of the Five Fuel Scenarios Based on ARB's "Upper-Bound Model Simulations"

Chemical		1997 MTBE	2003 MTBE	2003 Et2%	2003 Et3.5%	2003 NonOxy
Acetaldehyde	Upper	0.3	0.2	0.2	0.2	0.2
	Lower	0.2	0.1	0.2	0.2	0.1
Ethanol	Upper	0.002	0.002	0.004	0.005	0.002
	Lower	0.001	0.001	0.004	0.005	0.001
MTBE	Upper	0.01	0.006	0	0	0
	Lower	0.003	0.002	0	0	0
Nitrogen dioxide	Best	1.0	0.8	0.8	0.8	0.8
Ozone	Best	2.7	2.1	2.0	2.1	2.0
Cumulative HI	Upper	4.0	3.1	3.0	3.1	3.0
	Lower	3.9	3.0	3.0	3.1	2.9

Table A-7. Maximum Chronic Hazard Quotients (HQ) and Cumulative Chronic Hazard Indices (HI) for Respiratory Irritation for Each of the Five Fuel Scenarios Based on ARB's "Upper-Bound Model Simulations"

Chemical		1997 MTBE	2003 MTBE	2003 Et2%	2003 Et3.5%	2003 NonOxy
Acetaldehyde	Upper	0.4	0.3	0.3	0.4	0.3
	Lower	0.4	0.3	0.3	0.3	0.3
Ethanol	Best	0.0001	0.0001	0.0002	0.0003	0.0001
Formaldehyde	Upper	2.4	1.9	1.7	1.8	1.7
	Lower	2.4	1.8	1.7	1.8	1.7
Nitrogen dioxide	Best	0.8	0.8	0.8	0.8	0.8
PM_{10}	Best	1.9	1.9	1.9	1.9	1.9
Cumulative HI	Upper	5.5	4.9	4.7	4.9	4.7
	Lower	5.5	4.8	4.7	4.8	4.7

In conclusion, the modified model simulation did not change the original finding that the different fuel types are substantially the same with regard to airborne cancer and noncancer health risks. However, given that we have more confidence in the relative risk estimates than the absolute values of the risks, the slight increase in atmospheric PAN concentration resulting with the new model input should be further explored.

While the modified model simulation resulted in lower cancer risks and noncancer health effects under all 2003 fuel scenarios relative to the original model simulation, it should be emphasized that these changes are modest and do not diminish the need for the existing regulatory action on automobiles. With the complexities involved in predicting atmospheric concentrations, it is uncertain whether further refinements of the atmospheric modeling will increase or decrease the overall health risks. Ultimately, the differences for cancer and noncancer health risks are not substantial enough between the 2003 fuel types to recommend one fuel over another based on airborne exposure, nor is there any indication that any of those fuel choices would result in worse health impacts than the current situation.