Air Quality Technical Report

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TABLE OF CONTENTS

1.0 INTRODUCTION TO AIR QUALITY ANALYSIS 1
1.1 BACKGROUND 1
1.2 TRANSPORTATION CONFORMITY REQUIREMENTS 1
1.2.1 Applicability in the Denver Metropolitan Area 1
1.2.2 Conforming Transportation Plan 2

2.0 AFFECTED ENVIRONMENT 2
2.1 METEOROLOGY AND CLIMATE 3
2.2 RELATED PLANS AND POLICIES 3
2.3 EXISTING CONDITIONS AND KNOWN FUTURE CONDITIONS 3
2.3.1 Regional Emissions Budgets 4
2.3.2 DRCOG Plan Meets the Approved Emissions Budgets 4

3.0 ENVIRONMENTAL CONSEQUENCES 5
3.1 METHODOLOGY FOR IMPACT EVALUATION 5
3.2 ANALYSIS OF ALTERNATIVES 6
3.2.1 Carbon Monoxide Emissions Analysis 7
3.2.2 Carbon Monoxide Microscale Analysis 8
3.2.3 Ozone Emissions Analysis 9
3.2.4 PM_{10} Emissions Analysis 10
3.2.5 PM_{10} Microscale Analysis 11
3.2.6 Construction-Related Fugitive Emissions 12
3.2.7 Hazardous Air Pollutants 13
3.2.8 Impact on Transportation Control Measures 16
4.0 MITIGATION 16
5.0 SUMMARY 16
6.0 APPENDICES 17
APPENDIX A – Emission Rates Derived from DRCOG Conformity Analysis
APPENDIX B – Selection of Intersections for Carbon Monoxide Hotspot Analysis
APPENDIX C – CAL3QHC Model Inputs and Outputs for Nine Model Runs

LIST OF TABLES

Table 1 Projected Daily Vehicle Travel in the C-470 Corridor 7
Table 2 Impact of C-470 Corridor Alternatives on Carbon Monoxide Emissions.....8
Table 3 Number of C-470 Corridor Interchanges by Predicted Year 2025 Level of Service in Morning and Evening Peak Periods 8
Table 4 Modeled Worst-Case Microscale Concentrations of Carbon Monoxide 9
Table 5 Impact of C-470 Corridor Alternatives on Ozone-Related VOC Emissions.....10
Table 6 Impact of C-470 Corridor Alternatives on Ozone-Related NO_x Emissions.....10
Table 7 Impact of C-470 Corridor Alternatives on PM_{10} Emissions 11
Table 8 Impact of C-470 Corridor Alternatives on PM_{10}-Related NO_x Emissions 11
Table 9 Modeled Year 2015 PM_{10} Concentrations in the C-470 Corridor 12

1.0 INTRODUCTION TO AIR QUALITY ANALYSIS

The purpose of this air quality analysis is to identify the air quality impacts of the alternatives in the C-470 Environmental Assessment. Because project-level emissions are related to overall regional compliance with national air quality standards, the overall regulatory context for transportation/air quality issues is presented below.

1.1 BACKGROUND

Motor vehicle use is a major contributor to urban air pollution, and has been the focus of air quality improvement strategies since the 1970s. Thanks to the effectiveness of pollution control measures, the Denver Metropolitan Area has been transformed from a place that was in violation of air quality standards on most days in 1970 to a place with no violations n 1997, despite decades of dramatic growth in population and the number of vehicle-miles driven each day in the region. Since then, the Denver area remained free of air quality violations until the introduction of the new national eight-hour standard for ozone. This ozone standard was violated in 2002 and 2003.

The Denver area is under an EPA approved Early Action Compact (EAC) that voluntarily imposed control measures to lower eight-hour ozone precursors with the goal to clean the air sooner than required by law. If the EAC is successful in achieving its goals, the Denver area will attain the eight-hour ozone NAAQS in 2007.

1.2 TRANSPORTATION CONFORMITY REQUIREMENTS

Federal air quality conformity regulations were developed during the 1990s to ensure that transportation plans, programs and projects would not jeopardize attainment of National Ambient Air Quality Standards (NAAQS). These regulations comprise Section 176 of the Clean Air Act, and are also enforceable through Colorado's State Implementation Plan (SIP) for air quality. Colorado Air Quality Control Commission Regulation No. 10, "Criteria for Analysis of Conformity" enacts the federal conformity requirements as part of Colorado's SIP. As part of the Colorado SIP development process, emissions budgets for applicable pollutants are established for non-attainment and attainment-maintenance areas to maintain the national ambient air quality standards.

1.2.1 Applicability in the Denver Metropolitan Area

Conformity regulations apply to the Denver Metropolitan Area because the region was previously a nonattainment area for three pollutants: carbon monoxide; ozone; and particulate matter.

The Denver Metropolitan Area has never been a nonattainment area for three other pollutants for which the U.S. Environmental Protection Agency has established air

quality standards: sulfur oxides, nitrogen dioxide, and lead. Therefore conformity requirements do not apply in the region with respect to these pollutants.

1.2.2 Conforming Transportation Plan

Conformity requirements apply to transportation plans and programs that are developed by Metropolitan Planning Organizations (MPOs). The requirements also apply to Federal transportation projects. The designated MPO for the Denver Metropolitan Area is the Denver Regional Council of Governments (DRCOG). MPOs are required to assess future emissions of air pollutants from on-road vehicle use to ensure that projected future emissions are within limits that enable the region to meet national air quality standards. If a Federal project is not from a conforming long-range transportation plan and a short-range transportation improvement program (TIP), it must be analyzed to determine whether or not it could meet the conformity criteria. In accordance with Colorado Regulation Number 10, "hot-spot" carbon monoxide analysis also may be required.

Conformity has been demonstrated by DRCOG for the current, fiscally-constrained long-range transportation plan and TIP for the Denver Metropolitan Area are as follows:

- *Metro Vision 2030 Regional Transportation Plan*, adopted by DRCOG in January 2005.
- *2005-2010 Transportation Improvement Program*, adopted by DRCOG on March 17, 2004

The current, conforming and fiscally-constrained DRCOG long-range transportation plan and TIP do not reflect capacity improvements on C-470 because funding was not identified for the project at the time DRCOG completed the RTP and TIP. CDOT is currently working with DRCOG to amend these plans to include the C-470 project. Once the plans are amended, this project can be approved for implementation.

The analysis in this Air Quality Technical Report indicates that if the C-470 Proposed Action were included in the Regional Transportation Plan, all conformity requirements would be met.

2.0 AFFECTED ENVIRONMENT

The C-470 corridor is within the Denver Metropolitan Air Quality Control Region. This airshed includes the entire City and County of Denver; those portions of Adams and Arapahoe counties west of Kiowa Creek; all of Douglas and Jefferson counties; and all of Boulder County except Rocky Mountain National Park. As was noted earlier, C-470 traverses portions of Douglas County, southwestern Arapahoe County, and Jefferson County.

2.1 METEOROLOGY AND CLIMATE

The geographical and meteorological characteristics of the Denver Metropolitan Air Quality Control Region contribute to air quality conditions. The region is located along the foothills of the Front Range of the Rocky Mountains. Within this region, the C-470 corridor is at a slightly higher altitude than the "mile-high" City of Denver. Representative elevations along the C-470 corridor include the City of Centennial, at 5,650 feet above sea level, the City of Littleton at 5,362 feet, and the Chatfield Reservoir at 5,426 feet.

The climate is generally characterized by low relative humidity, light precipitation, and abundant sunshine. Denver receives 15.6 inches of precipitation annually. The Denver region is situated in the South Platte River Valley, and the prevailing wind direction is out of the south. Normal daily high temperatures range from an average of 43 degrees Fahrenheit in January to 88° in July, with a normal daily mean temperature of 50.3^{o}.

2.2 RELATED PLANS AND POLICIES

In addition to the DRCOG long-range transportation plan and TIP mentioned above, the following plans are directly relevant to this C-470 Corridor air quality technical report:

- *Carbon Monoxide Maintenance Plan for the Denver Metropolitan Area*, approved by the U.S. Environmental Protection Agency effective November 15, 2004.
- *PM-10 Redesignation Request and Maintenance Plan for the Denver Metropolitan Area*, approved by the U.S. Environmental Protection Agency on September 16, 2002.
- *Ozone Redesignation and Maintenance Plan for the Metropolitan Denver Area*, approved by the U.S. Environmental Protection Agency on September 11, 2001. This plan addressed the 1-hour standard for ozone.
- *Early Action Compact Ozone Action Plan: Proposed Revision to the State Implementation Plan*, approved by the Colorado Air Quality Control Commission on March 12, 2004, and submitted to the U.S. Environmental Protection Agency by Colorado's Governor in July 2004. This plan addresses the new 8-hour standard for ozone.

2.3 EXISTING CONDITIONS AND KNOWN FUTURE CONDITIONS

The Denver metropolitan area is designated as an attainment/maintenance area for carbon monoxide, PM_{10}, and the 1-hour ozone standard. No violations of these standards have been monitored in the region since 1995. Additionally, as there have

been no monitored violations of the new $PM_{2.5}$ standard, the Denver region has not been designated by EPA as a nonattainment area for fine particulates.

With respect to the new 8-hour ozone standard, however, monitoring data collected since 1996 indicates that the region consistently is very close to the standard. Because of monitored violations of this standard in 2002 and 2003, state and regional air quality agencies in the Denver metropolitan area have developed a plan for achieving this standard by December 31, 2007. This plan, called the Early Action Compact (EAC) for Ozone, includes specific milestones that must be met to achieve the standard by December 31, 2007. The EAC was submitted to EPA by the Governor in July 2004. EPA has deferred nonattainment designation for the region as long as the area meets the milestones in the Early Action Compact. In the region's favor, precursor emissions in the region are continuing to trend downward, offering hope that maximum monitored readings will soon decline below the standard once and for all.

2.3.1 Regional Emissions Budgets

The approved SIP elements listed above demonstrate that the Denver metro area will continue to meet the national ambient air quality standards as follows:

- Maintenance of the carbon monoxide standard through 2013, with an on-road motor-vehicle emissions budget of 1,520 tons per day
- Maintenance of the PM_{10} standard through 2015, with wintertime motor-vehicle emissions budgets of 51 tons per day of PM_{10} and 101 tons of NO_x per day
- Maintenance of the 1-hour ozone standard through 2013, with summertime motor-vehicle emissions budgets of 119 tons per day of volatile organic compounds (VOC), and 134 tons of NO_x per day

2.3.2 DRCOG Plan Meets the Approved Emissions Budgets

DRCOG's August 2003 conformity analysis of the *Amended Metro Vision 2025 Interim Regional Transportation Plan* demonstrated that emissions from on-road motor vehicles will remain within the applicable conformity budgets through the year 2025, even as the region's population grows by one million residents and daily vehicle-miles of travel increase by 50 percent, from 58 million in 2000 to 87 million in 2025.

Each of the emission budgets would be met in 2025 with at least ten tons of safety margin, except for the PM_{10} budget. The regional budget for PM_{10} is 51 tons per day, and weekday motor vehicle traffic in 2025 would generate 50.2 tons, according to DRCOG's conformity analysis.

During the course of the C-470 Environmental Assessment, DRCOG adopted a subsequent, newer long-range transportation plan, called Metro Vision 2030. DRCOG's

conformity findings indicate that the 2030 plan generally meets the standards by slightly increased margins of safety, compared to the 2025 Plan. For example, regional daily carbon monoxide emissions previously were projected to be 1,395 tons in 2025, some 125 tons below the allowable emissions budget (1,520 tons), and now are projected to be 1,207 tons in 2030, or 313 tons under the limit.

3.0 ENVIRONMENTAL CONSEQUENCES

Air quality quantitative and qualitative analyses were performed to determine whether there were differences in the air quality impacts of the three alternatives (no-action, general purpose lanes, and express lanes), to determine whether or not any alternative would likely cause a conformity emissions budget to be exceeded, and whether or not localized hotspot concentrations at worst-case intersections would be likely to cause or contribute to a violation of a standard.

3.1 METHODOLOGY FOR IMPACT EVALUATION

The type of analysis appropriate for each type of air pollutant was determined based on interagency consultation involving the Colorado Department of Transportation, Federal Highway Administration, DRCOG, Colorado Department of Public Health and Environment, and the U.S. Environmental Protection Agency. A formal consultation meeting was held on September 24, 2004.

For carbon monoxide, analysis of emissions from the C-470 corridor was conducted based on projected changes in the number of vehicle miles of travel (VMT). Also, in accordance with Federal and State requirements, microscale modeling was performed for worst-case intersections. This was done by determining the projected future level of service for 32 signalized intersections at C-470 interchanges and the next nearest signalized intersection north and south of C-470 on major cross-streets. Intersections with Level of Service D, E, or F were considered candidates for analysis, and from this list of congested intersections, modeling locations were selected largely based on highest traffic volumes.

An emissions analysis was prepared for ozone, based on projected changes in VMT. Ozone is a pollutant produced by complex chemical reactions, involving precursor emissions from many sources in addition to on-road motor vehicle use. Emissions of the precursor emissions, volatile organic compounds (VOC) and oxides of nitrogen (NO_x) were made. Hotspot intersection analysis is not feasible for ozone.

For particulate matter, the methodology involves a quantitative analysis regarding emissions of PM_{10} and PM_{10}-related oxides of nitrogen. In addition to an emissions analysis, conformity requirements now include a qualitative assessment of potential hotspot intersections. This was done based on modeling results from the Technical Support Document for the region's PM_{10} Maintenance Plan.

The air quality analysis for the C-470 Environmental Analysis was prepared prior to the adoption of DRCOG's 2030 regional transportation plan. At that time, the adopted transportation plan and conformity analysis extended only through the year 2025. The analysis was prepared based on these then-applicable planning assumptions, and the results of the analysis, detailed in this Technical Report, show that all C-470 alternatives would meet all air quality requirements for all years analyzed.

As noted earlier, the results of the regional emissions tests for the 2030 Plan relative to the adopted regional emissions budgets generally indicates that the region will be farther below the budgets in 2030 than had been projected for 2025 (The lone exception is the projected total for emissions of particulate matter, which would remain approximately the same). Similarly, estimated microscale concentrations of carbon monoxide and PM_{10} in the C-470 corridor were so far below the allowable maximums in 2025 that they would clearly not result in any violations of the standards in 2030 either.

Rather than repeat the analysis to incorporate a 2030 planning horizon, when that effort would clearly would not yield any different conclusion about project impacts, this EA presents the more conservative results for the 2025 planning horizon, as was required at the time of the analysis. An updated conformity analysis based on the 2030 Regional Transportation Plan will be performed by DRCOG as part of the plan amendment process that is needed to approve any C-470 capacity improvements.

3.2 ANALYSIS OF ALTERNATIVES

A key input to the air quality analysis was the projection of future traffic volumes on C-470 and on the major arterial streets that are affected by C-470 traffic. Traffic modeling results for the year 2025 were obtained from the Denver Regional Council of Governments (DRCOG), consistent with the latest planning assumptions used in the *Amended Metro Vision 2025 Interim Regional Transportation Plan*. These results served as a basis for the No-Action Alternative, because the 2025 Plan does not include additional capacity on C-470. Morning and evening peak period volumes were then developed for all three alternatives. The AIMSUN traffic model was used to project the traffic changes that would occur in response to adding capacity on the C-470 freeway.

The results of the traffic modeling for 13.75 miles of freeway and approximately 80 miles of surrounding arterial streets are presented in Table 1.

Table 1
Projected Daily Vehicle Travel in the C-470 Corridor

Year*	Facility Type	Daily Vehicle miles of travel (millions)		
		No-Action Alternative	General Purpose Lanes Alternative	Express Lanes Alternative
2003	C-470 Freeway	1.00	1.00	1.00
	Nearby Arterials	1.66	1.66	1.66
	Corridor Total	2.66	2.66	2.66
2013	C-470 Freeway	1.23	1.93	1.92
	Nearby Arterials	1.90	1.99	2.02
	Corridor Total	3.13	3.92	3.94
2020	C-470 Freeway	1.30	2.04	2.03
	Nearby Arterials	2.00	2.09	2.13
	Corridor Total	3.30	4.13	4.16
2025	C-470 Freeway	1.35	2.12	2.11
	Nearby Arterials	2.07	2.21	2.26
	Corridor Total	3.42	4.33	4.37
Increase, 2003 to 2025:		36.8%	73.2%	75.8%

3.2.1 Carbon Monoxide Emissions Analysis

Projected total daily vehicle miles of travels for each of the three alternatives are presented in Table 2. These projections and the average regional emission rates as derived in Appendix 1 were used to assess projected C-470 corridor emissions of carbon monoxide for each alternative in the years 2013, 2020 and 2025, corresponding to conformity test years for the DRCOG *Metro Vision 2025 Interim Regional Transportation Plan*. This is a conservative approach, since it does not take credit for emission reductions attributable to congestion relief.

Under this approach, the No-Action Alternative would generate the least CO emissions in the corridor by not accommodating additional traffic on C-470. Corridor-wide, daily carbon monoxide emissions for the General Purpose Lanes and Express Lanes alternatives would exceed the No-Action emissions by about 16 tons per day in 2013, 13 tons in 2020, and 15 tons in 2025. These projected emissions would not jeopardize the region's ability to meet its SIP-established conformity emissions budget. In all cases, emissions would be within the budget by a margin of no less than 124 tons per day.

Table 2
Impact of C-470 Corridor Alternatives on Carbon Monoxide Emissions

Year	Alternative	Corridor VMT (millions)	Corridor Emissions (tons/day)	Regional Total Emissions (tons/day)	Amount below Budget (1,520 tons/day)
2013	No Action (RTP)	3.13	45.5	1,169	351
	General Purpose Lanes	3.92	61.9	1,185	335
	Express Lanes	3.94	62.3	1,186	334
2020*	No Action (RTP)	3.30	52.1	1,296	224
	General Purpose Lanes	4.13	65.3	1,309	211
	Express Lanes	4.16	65.7	1,310	210
2025*	No Action (RTP)	3.42	54.0	1,381	139
	General Purpose Lanes	4.33	68.4	1,395	125
	Express Lanes	4.37	69.0	1,396	124

**As a conservative approach, 2013 emission rates were used for 2020 and 2025. Under this worst-case assumption, no alternative produces CO emissions that remotely approach the allowable emissions budget.*

3.2.2 Carbon Monoxide Microscale Analysis

Traffic levels of service were calculated for morning (AM) and evening (PM) peak hours for all three alternatives to identify signalized intersections that would operate at congested levels of service D, E, or F in the year 2025. Generally, signalized intersections in the C-470 corridor accommodate more traffic and experience greater levels of congestion during the evening (PM) peak period than during the morning (AM) peak period. The number of intersections by Level of Service (LOS) is presented below in Table 3.

Table 3

Number of C-470 Corridor Intersections by Predicted Year 2025 Level of Service in Morning and Evening Peak Periods

Peak Period	Alternative	Number of Intersections by LOS in Year 2025			
		F	E	D	A,B,C
AM	No-Action	5	2	7	17
	General Purpose	3	2	5	21
	Express Lanes	3	2	7	19
PM	No-Action	7	6	2	16
	General Purpose	8	2	6	15
	Express Lanes	5	3	6	17

Appendix B describes the process that was used to select intersections for hot-spot modeling. The intersections selected for modeling included the highest-volume and most-congested locations in the C-470 corridor. Worst-case conditions were considered by modeling these locations using current emission factors, rather than future, lower

emission factors. The analysis was conducted using MOBILE6.2 emission factors as inputs to the CAL3QHC microscale model. Model inputs and detailed results are documented in Appendix 3. The results are summarized below in Table 4.

Table 4
Modeled Worst-Case Microscale Concentrations of Carbon Monoxide

Predicted 8-hour average carbon monoxide concentration (parts per million)			
Intersection	Express Lanes	General Purpose	No-Action
Broadway/County Line Road	6.54	6.74	6.74
Quebec/County Line Road	6.80	6.28	6.03
Santa Fe/north (WB) C-470 ramps	4.55	4.74	4.74

All of the worst-case concentrations in the table are well below the national ambient air quality standard of 9.0 parts per million. The difference of up to 2 parts per million in the concentrations between the County Line Road intersections and the Santa Fe intersection is reflective of comparatively less traffic and less congestion on Santa Fe, in the western part of the C-470 corridor, compared to the eastern part of the corridor. It can be concluded from the analyses of these intersections that no violations of the carbon monoxide standard are expected along the corridor under any of the three alternatives. The project clearly meets the conformity requirement regarding carbon monoxide hotspot evaluation.

3.2.3 Ozone Emissions Analysis

Emissions analysis for ozone involves consideration of two classes of precursor emissions, volatile organic compounds (VOC) and oxides of nitrogen (NO_x). The analysis was performed based on C-470 corridor VMT and regional average emission rates from the approved Ozone SIP. For all years examined, the No-Action Alternative would generate the least VOC and NO_x emissions in the corridor by not accommodating additional traffic on C-470. As seen in Tables 5 and 6, ozone-related emissions within the corridor would be slightly higher under the General Purpose Lanes of Express Lanes alternatives. These differences would affect total regional emissions by amounts less than one ton per day, and would not jeopardize the region's ability to stay within its approved conformity emissions budgets for these pollutants.

Table 5
Impact of C-470 Corridor Alternatives on Ozone-Related VOC Emissions

Year	Alternative	Corridor VMT (millions)	Corridor Emissions (tons/day)	Regional Total Emissions (tons/day)	Amount below Budget (119 tons/day)
2013	No Action (RTP)	3.13	3.4	84	35
	General Purpose Lanes	3.92	4.3	85	34
	Express Lanes	3.94	4.3	85	34
2020	No Action (RTP)	3.30	3.3	80	39
	General Purpose Lanes	4.13	4.1	80	39
	Express Lanes	4.16	4.2	80	39
2025	No Action (RTP)	3.42	3.4	86	33
	General Purpose Lanes	4.33	4.3	86	33
	Express Lanes	4.37	4.4	86	33

Table 6
Impact of C-470 Corridor Alternatives on Ozone-Related NOx Emissions

Year	Alternative	Corridor VMT (millions)	Corridor Emissions (tons/day)	Regional Total Emissions (tons/day)	Amount below Budget (134 tons/day)
2013	No Action (RTP)	3.13	4.1	96	38
	General Purpose Lanes	3.92	5.1	97	37
	Express Lanes	3.94	5.1	97	37
2020	No Action (RTP)	3.30	3.6	88	46
	General Purpose Lanes	4.13	4.5	89	45
	Express Lanes	4.16	4.6	89	45
2025	No Action (RTP)	3.42	3.8	93	41
	General Purpose Lanes	4.33	4.8	94	40
	Express Lanes	4.37	4.8	94	40

3.2.4 PM_{10} Emissions Analysis

An assessment of emissions of PM_{10} and NO_x related to fine particulate matter was performed based on C-470 corridor VMT and regional average emission rates from the approved PM_{10} SIP. The results are presented in Tables 7 and 8. For both 2020 and 2025, the No-Action Alternative would generate the least PM_{10} and NO_x emissions in the corridor by not accommodating additional traffic on C-470. Compared to the No-Action Alternative, emissions within the corridor would be about 25 to 30 percent higher under the General Purpose Lanes or Express Lanes alternatives. These differences would affect total regional emissions by less than one ton per day, and the region would remain within its approved conformity emissions budgets for these pollutants.

Table 7
Impact of C-470 Corridor Alternatives on PM_{10} Emissions

Year	Alternative	Corridor VMT (millions)	Corridor Emissions (tons/day)	Regional Total Emissions (tons/day)	Amount below Budget (51 tons/day)
2020	No Action (RTP)	3.30	2.0	47.3	3.7
	General Purpose Lanes	4.13	2.5	47.8	3.6
	Express Lanes	4.16	2.5	47.4	3.6
2025	No Action (RTP)	3.42	2.0	50.2	0.8
	General Purpose Lanes	4.33	2.6	50.8	0.2
	Express Lanes	4.37	2.6	50.8	0.2

Table 8
Impact of C-470 Corridor Alternatives on PM_{10}-Related NO_x Emissions

Year	Alternative	Corridor VMT (millions)	Corridor Emissions (tons/day)	Regional Total Emissions (tons/day)	Amount below Budget (101 tons/day)
2020	No Action (RTP)	3.30	3.3	86	15
	General Purpose Lanes	4.13	4.1	87	14
	Express Lanes	4.16	4.2	87	14
2025	No Action (RTP)	3.42	3.4	89	12
	General Purpose Lanes	4.33	4.3	90	11
	Express Lanes	4.37	4.4	90	11

3.2.5 PM_{10} Microscale Analysis

Federal transportation conformity regulations were modified in July 2004 to include requirements for PM_{10} hot-spots analysis for federal projects not in a conforming TIP and Regional Transportation Plan. According to 40 CFR 51.123(b)(1), quantitative analysis is required in some cases (verified violation sites, sites similar to a verified violation site, and new or expanded bus or transit facilities that cause a congregation of diesel vehicles). The proposed C-470 improvements would not meet these conditions, however, and therefore are subject to 40 CFR 51.123(b)(1): "the demonstration… may be based on a qualitative consideration of local factors."

Concentrations of PM_{10} throughout the Denver metropolitan area were predicted for several future years as part of the region's Maintenance Plan approved by EPA in 2002. The attainment demonstration was based on the predicted sixth highest PM_{10} average daily concentration over a five-year period. Ten of the modeled receptor locations surround the C-470 corridor. From west to east, receptors 3 through 7 are located south of C-470, and receptors 18 through 22 are north of C-470. Receptors #18 and #3 are west of I-25. Receptors #22 and #7 are located just west of I-25 (#7 corresponds roughly to the vicinity of the Quebec/Lincoln Avenue intersection). Source: PM_{10} Plan Technical

Support Document (TSD), page 98. According to the TSD, predicted future concentrations at these locations are presented in Table 9.

Table 9
Modeled Year 2015 PM_{10} –Concentrations in the C-470 Corridor

Modeled Future PM_{10} Concentrations by Receptor/Location (24-hour average concentration in micrograms per cubic meter)				
Receptor #18 (n. of C-470)	Receptor #19 (n. of C-470)	Receptor #20 (n. of C-470)	Receptor #21 (n. of C-470)	Receptor #22 (n. of C-470)
95	105	109	113	116
	C-470		**C-470**	
Receptor #3 (s. of C-470)	Receptor #4 (s. of C-470)	Receptor #5 (s. of C-470)	Receptor #6 (s. of C-470)	Receptor #7 (s. of C-470)
101	101	107	105	115

It can be seen from the table that for 2015, every modeled concentration is well below the national ambient air quality standard of 150 micrograms per cubic meter (ug/m^3), for a 24-hour average.

From examination of the modeling results for 2015 and 2005, it was determined that the average change in modeled concentrations for the prior ten-year period was slightly over 2 ug/m^3, or an increase of two percent. This corresponds roughly to the decade of 2003 to 2013, when weekday VMT in the C-470 corridor is projected to increase by nearly a half million miles under the No-Action Alternative.

For the No-Action Alternative, applying this same relationship between corridor VMT change and modeled concentrations yields concentrations of 117 ug/m^3 in 2020 and 2025. Compared to No-Action, projected corridor traffic is about 800,000 VMT higher in 2015 for the General Purpose Lanes and Express Lanes alternatives, suggesting a concentration of about 119 ug/m^3 in 2015. Projected forward based on VMT, the results would be approximately 120 ug/m^3 in 2020 and 121 ug/m^3 in 2025 for both of these alternatives. All of these results remain well below the standard of 150 ug/m^3.

In summary, qualitative analysis indicates no reason to expect a hot-spot violation of the PM_{10} standard in the C-470 corridor by 2025 under any of the three alternatives being examined in this Environmental Assessment.

3.2.6 Construction-Related Fugitive Emissions

Any alternative involving construction will be required to implement dust control practices in accordance with Colorado Air Quality Control Commission Regulation No. 1 regarding fugitive emissions.

3.2.7 Hazardous Air Pollutants

In addition to the NAAQS, the EPA also regulates air toxics. The Clean Air Act identifies 188 compounds that mostly originate from human-made sources, including on-road mobile sources, non-road mobile sources (e.g., airplanes), area sources (e.g., dry cleaners) and stationary sources (e.g., factories or refineries). Of these compounds, the USEPA has identified 21 that are emitted from motor vehicle and are known or suspected to cause cancer or other serious health effects. These compounds, known as Mobile Source Air Toxics (MSATs) include various volatile organic compounds, such as acetaldehyde, benzene, formaldehyde, acrolein, and 1,3-butadiene, as well as metals, diesel particulate matter, and diesel exhaust organic gases. Some of these toxic compounds are present in fuel and are emitted to the air when the fuel evaporates or passes through the engine unburned. Other toxics are emitted from the incomplete combustion of fuels or as secondary combustion products. Metal air toxics result from engine wear or from impurities in oil or gasoline.

The EPA has existing and newly promulgated mobile source control programs that include the reformulated gasoline program, national low emission vehicle standards, Tier 2 motor vehicle emissions standards and gasoline sulfur control requirements, and the proposed heavy duty engine and vehicle standards, and on-highway diesel fuel sulfur control requirements. Between 1990 and 2020, the USEPA expects that these programs will reduce on-highway emissions of benzene, formaldehyde, 1,3-butadiene, and acetaldehyde by 67 to 76 percent, and will reduce on-highway diesel particulate matter emissions by 90 percent (16 FR 17229, March 29, 2001).

3.2.7.1 Analytical Limitations

The analysis of air toxics is an emerging field, however. To date, the EPA – the lead Federal agency responsible for the scientific study of air pollutants and for the development of national air quality standards -- has not developed NAAQS for MSATs or national project level guidelines or guidance for studying MSATs under various climatic and geographic situations. The EPA has also not established toxicity factors for diesel particulate matter. Without standards and guidance for MSATs, accurate and reliable estimates of actual human health or environmental impacts from MSATs that may result from transportation projects are not scientifically possible at this time.

However, the U.S. DOT and FHWA are currently working with the EPA to develop and evaluate the technical tools necessary to perform air toxics analysis, including improvements to emissions models and air quality dispersion models. The FHWA's ongoing work in air toxics includes a research program to determine and quantify the contribution of mobile sources to air toxic emissions, the establishment of policies for addressing air toxics in environmental reports, and the assessment of scientific literature on health impacts associated with motor vehicle toxic emissions.

3.2.7.2 Qualitative Assessment

Although there are quantitative methods that can be used, FHWA does not consider them appropriate and accurate for estimation of the health impacts of MSATs. However, it is possible to qualitatively assess future MSAT emissions. Since the amount of MSATs emitted are proportional to the amount of vehicle miles traveled, or VMT and congestion, it is possible to

compare the difference in VMT and congestion between the GPL and EL Alternatives to the No-Action Alternative and determine which alternative is likely to produce greater MSAT emissions in the future, assuming that other variables, such as the mix of vehicle types and age, are the same. For the DRCOG regional air quality planning area, although it is estimated that VMT in 2030 for the No-Action Alternative will be lower than the GPL or EL Alternatives, congestion in the GPL or EL Alternatives would be lower than the No-Action Alternative. Therefore, total MSAT emissions are likely to be lower in the future for the GPL or EL Alternatives than the No-Action Alternative. Furthermore, regardless of the alternative selected for C-470, regional MSAT emissions will likely be lower in 2030 than they are today. This is due to the implementation of EPA's national control programs that are projected to reduce MSAT emission by 67 to 90 percent. Although local conditions, such as the age and type of vehicles in the fleet, VMT growth rates, and local control measures, may differ from those used to derive these national projections, the magnitude of the projected reductions by EPA are so great that MSAT emissions in the region and along the C-470 Corridor are likely to be much lower in the future as well.

The science and modeling of project specific MSAT impacts has not developed to the point where there is certainty or acceptance by the scientific community. Accordingly, information is not available on MSAT impacts for the No-Action or the action alternatives evaluated in this EA, and the means to obtain this information have not been fully developed. When this is the case, Federal regulations require FHWA to include the following information: "1) A statement that such information is incomplete or unavailable; 2) a statement of the relevance of the incomplete or unavailable information to evaluating reasonably foreseeable significant adverse impacts on the human environment; 3) a summary of existing credible scientific evidence which is relevant to evaluating reasonably foreseeable significant adverse impacts on the human environment, and 4) the agency's evaluation of such impacts based on theoretical approaches or research methods generally accepted in the scientific community" (40 CFR 1502.22(b)). These provisions are addressed as follows:

1. Project specific MSAT analysis is an emerging field and the science has not been fully developed and is therefore unavailable. FHWA is aware that MSAT releases to the environment may cause some level of pollution. What is not scientifically definable is an accurate level of human health or environmental effects that will result from the construction of new transportation facilities or modification of existing facilities. Project-level MSAT risk assessment involves four major steps: emissions modeling, dispersion modeling in order to estimate ambient concentrations resulting from the estimated emissions, exposure modeling in order to estimate human exposure to the estimated concentrations, and then final determination of health effects based on the estimated exposure. Each of these steps is currently encumbered by technical shortcomings that prevent a formal determination of the MSAT effects of this project. The air quality emissions model (MOBILE 6.2) is based on limited data raising concerns over the accuracy of the final estimates. Further the particulate emissions rates from MOBILE 6.2 are not sensitive to vehicle speed, which is an important determinant of emissions rates (this is a shortcoming for diesel particulate matter, but not the remaining priority MSATs) or acceleration. Given uncertainties in the emissions estimation process, subsequent calculated concentrations would be equally uncertain. But beyond this, the available dispersion models have not been successfully validated for estimating ambient concentrations of particulate matter or

reactive organic MSATs. Available exposure models are not well designed to simulate roadside environments. Finally, the toxicity value of at least one of the priority MSATs, that of diesel particulate matter, has not been nationally established, which would prevent the determination of health impacts of this pollutant even if the other necessary tools were available. Thus, current scientific techniques, tools, and data make it impossible to accurately estimate actual human health or environmental impacts from MSATs that would result from a transportation project.

2. Without this project specific MSATs analysis, it is impossible to quantitatively evaluate the air toxic impacts at the project level. Therefore, this unavailable or incomplete information is very relevant to understanding the "significant adverse impacts on the human environment," since the significance of the likely MSAT levels cannot be assessed.

3. Research into the health impacts of MSATs is ongoing. For different emission types, there are a variety of studies that show that some either are statistically associated with negative health outcomes through epidemiological studies (frequently based on emissions levels found in occupational settings) or that animals demonstrate negative health outcomes when exposed to large doses. There have been other studies and papers that suggest MSATs have health impacts. However, noting that unresolved issues still remain, the Health Effects Institute, a non-profit organization jointly funded by EPA and industry, has undertaken a major series of studies to determine whether MSAT hot spots exist and what the health implications are if they do. The final summary of these studies is not expected to be completed for several more years.

   Recent studies have been reported to show that close proximity to roadways is related to negative health outcomes -- particularly respiratory problems. Yet these studies are often not specific to MSATs. Instead they have encompassed the full spectrum of both criteria pollutants and other pollutants. Thus it is impossible to determine whether MSATs are responsible for the health outcomes or the criteria pollutants.

   There is also considerable literature on the uncertainties associated with the emissions modeling process. The most significant of these is an assessment conducted by the National Research Council of the National Academy of Sciences, entitled "Modeling Mobile-Source Emissions" (2000). This review noted numerous problems associated with then current models, including the predecessor to the current MOBILE 6.2 model. The review found that, "significant resources will be needed to improve mobile source emissions modeling." The improvements cited include model evaluation and validation, and uncertainty analysis to raise confidence in the model's output. While the release of MOBILE 6.2 represents an improvement over its predecessor, the MSAT emission factors have not been fully validated due to limits on dispersion modeling and monitoring data. The MOBILE 6.2 model is currently being updated and its results will not be evaluated and validated for several years.

4. Even though there is no accepted model or accepted science for determining the impacts of project specific MSATs, as noted above, EPA predicts that its national control programs will result in meaningful future reductions in MSAT emissions, as measured on both a per vehicle mile and total fleet basis. FHWA believes that these projections are credible, because the control programs are required by statute and regulation. Also, since the congestion for both the action alternatives will be lower than the No-Action Alternative, FHWA is confident that MSAT emissions will also be lower in the project area in the design year (2030). There could be slightly elevated but unquantifiable increases in MSATs to residents

and others in a few localized areas where VMT increase, which may be important particularly to any members of sensitive populations. Because MSAT emissions on a per VMT basis are expected to decline due to EPA's control program, FHWA does not believe that there will be significant adverse impacts on the human environment.

3.2.8 Impact on Transportation Control Measures

One of the Federal transportation conformity regulations (40 CFR 93.113(d)) states that FHWA/FTA projects which are not from a conforming transportation plan and TIP must not "interfere with the implementation of any TCM in the applicable implementation plan."

The region's applicable implementation plans contain various strategies that affect vehicle-related emissions, including compliance with federal tailpipe emissions standards, various motor vehicle fuel specifications, and reductions in use of sand for street de-icing. The applicable current air quality plans do not include, as is specifically stated in the Carbon Monoxide Maintenance Plan, "any 'transportation control measures', as that term is defined at 40 CFR 93.101." The Ozone Maintenance Plan notes at page 3-2 that TCMs that had been included in the 1982 ozone SIP "have all been implemented."

As there are no TCMs in the region's applicable air quality implementation plans, clearly all three of the C-470 corridor alternatives are in compliance with the requirements of 40 CFR 93.113(d).

4.0 MITIGATION

In the analysis above, no air quality impacts were identified for which mitigation would be required. Planned additional Park-n-ride lots and a planned extension of the regional light rail system into the C-470 corridor are independent actions that are not included as part of a C-470 alternative. Those other facilities, if they are Federal actions, will themselves undergo analysis in accordance with NEPA requirements to assure that their air quality impacts are acceptable under Federal and State regulations.

5.0 SUMMARY

It has been shown in the above analysis that regardless of the alternative selected, traffic in the C-470 corridor will increase between now and 2025. Increasing VMT will be largely offset by declining vehicle emission rates for approximately the next decade, after which VMT increases will lead to increasing total emissions. The General Purpose Lanes and Express Lanes Alternatives would enable C-470 to carry more traffic, thus accommodating increased through-trips as well as increased local trips on the adjacent arterial street network.

Compared to the congested No-Action Alternative, the General Purpose Lanes Alternative and the Express Lanes Alternative would provide better levels of service on the freeway mainline and on Santa Fe Drive, as well as on other nearby arterials in general. Also, there are locations in the corridor (e.g., portions of County Line Road) that are and will continue to be congested under any alternative. The purpose and need for C-470 improvements does not include solving congestion problems on other roadways.

Under the General Purpose Lanes Alternative or the Express Lanes Alternative, improved traffic flow and higher travel speeds will result in improved emission rates per mile traveled. Even without specifically taking this benefit into account, it has been shown qualitatively that all three C-470 alternatives would meet applicable air quality requirements, including transportation conformity regulations. Further, the analysis has shown that under all alternatives, no localized "hotspot" violation is foreseen for carbon monoxide or particulate matter.

No air quality mitigation measures are required or proposed, other than compliance with State regulations for fugitive dust control during project construction.

6.0 APPENDICES

Three Appendices are attached to this report:

- Appendix A – Emission Rates Derived from DRCOG Conformity Analysis
- Appendix B – Selection of Intersections for Carbon Monoxide Hotspot Analysis
- Appendix C – CAL3QHC Model Inputs and Outputs for Nine Model Runs

APPENDIX A

APPENDIX A

EMISSION RATES DERIVED FROM DRCOG CONFORMITY ANALYSIS

Conformity modeling results by the Denver Regional Council of Governments were used as the basis for deriving emission rates used in the air quality analysis for the C-470 Corridor Environmental Assessment. It is important to note that the emissions data for carbon monoxide in Table 1 has been superseded due to establishment of a new carbon monoxide emissions budget calculated using MOBILE 6.2 emission factors.

Table 1
Conformity Analysis Emission Projections
for the Amended Metro Vision 2025 Interim Transportation Plan

Pollutant*	Test*	Budget* (Tons/ day)	Plan Emissions *	Amount Under Budget	Daily VMT (millions)	Average Emissions (tons) per million VMT
Carbon Monoxide in the Denver Attainment Maintenance Area, calculated using MOBILE 5.2	2013 Staging	800*	675*	125 (15.6%)	74	9.1
	2020 Staging	800*	656*	144 (18%)	82	8.0
	2025 RTP	800*	710*	90 (11.2%)	87	8.2
PM_{10}	2020 Staging	51	47.3	3.7 (7.2%)	82	0.6
	2025 RTP	51	50.2	0.8 (1.6%)	87	0.6
NOx associated with PM_{10}	2020 Staging	101	86	15 (14.9%)	82	1.0
	2025 RTP	101	89	12 (11.9%)	87	1.0
Ozone VOC in Ozone Attainment Maintenance Area	2013 Staging	119	84	35 (29.4%)	74	1.1
	2020 Staging	119	80	39 (32.8%)	82	1.0
	2025 RTP	119	86	33 (27.7%)	87	1.0
NO_x in Ozone Attainment Maintenance Area	2013 Staging	134	96	38 28.3%)	74	1.3
	2020 Staging	134	88	46 (34.3%)	82	1.1
	2025 RTP	134	93	41 (30.6%)	87	1.1

**Source: Conformity of the Amended Metro Vision 2025 Interim Regional Transportation Plan, the Fiscally Constrained Element, and the 2003-2008 Transportation Improvement Program with the State Implementation Plan for Air Quality. Adopted by the Denver Regional Council of Governments, August 20, 2003, page 25.*

Note: The three right-most columns in the Table 1 were derived from the DRCOG data.

The carbon monoxide figures in Table 1 above were prepared using MOBILE 5.2 emission factors. The revised CO plan approved by EPA in November 2004 used MOBILE6.2 emission factors, and established a new emissions budget for carbon monoxide. The revised CO Plan projected CO on-road emissions of 1,125 tons from 71 million VMT, or 15.8 tons per million VMT. The new emissions budget for CO was set at 1,520 tons. Therefore the 2013 projection was below this budget by 395 tons, or 26%.

Table 2
Emission Projections from the Revised Carbon Monoxide Plan for the Denver Region

Description	Year	Daily VMT (millions)	Average Emission Rate (grams/mile)	On-road CO emissions (tons/day)	Amount under Budget (1,520 tons)	Average Emissions (tons) per million VMT
CO in the Denver Attainment Maintenance Plan, calculated using MOBILE 6.2	2010	67.9	26.00	1,197.6	322.4 (21%)	17.6
	2013	71.0	14.37 overall 14.44 suburban	1,125.0	395 (26%)	15.8

Source: Technical Support Document, Carbon Monoxide Maintenance Plan Revision for the Denver-Boulder Attainment Area, June 2003, page 12.

The CO Plan Revision did not make projections of future carbon monoxide emissions beyond the year 2013, and DRCOG has not yet published a conformity analysis that utilizes MOBILE 6.2 emission rates. For purposes of assessing conformity for the C-470 improvement project, projected emissions for 2013 and beyond were calculated using 2013 emission rates as derived above in Table 2. The resulting future emissions are presented below in Table 3. Based on future emission rates reflected in Table 1, utilizing MOBILE 5.2, future reductions in emission rates may be expected after 2013. The results in Table 3 therefore are highly conservative.

Table 3
Potential Future Regional Emissions of Carbon Monoxide in the Denver Region, Based on 2013 Average Emission Rates

Description	Year	Daily VMT (millions)	Average Emission Rate (grams/mile)	On-road CO emissions (tons/day)	Amount under Budget (1,520 tons)	Average Emissions (tons) per million VMT
CO emissions based on Metro Vision 2025 VMT, assuming 2013 emission rates from the SIP	2013	74	14.44	1,169	351 (23%)	15.8
	2020	82	14.44	1,296*	224 (15%)	15.8
	2025	87.4	14.44	1,381*	139 (9%)	15.8

APPENDIX B

APPENDIX B

SELECTION OF INTERSECTIONS FOR CARBON MONOXIDE HOTSPOT ANALYSIS

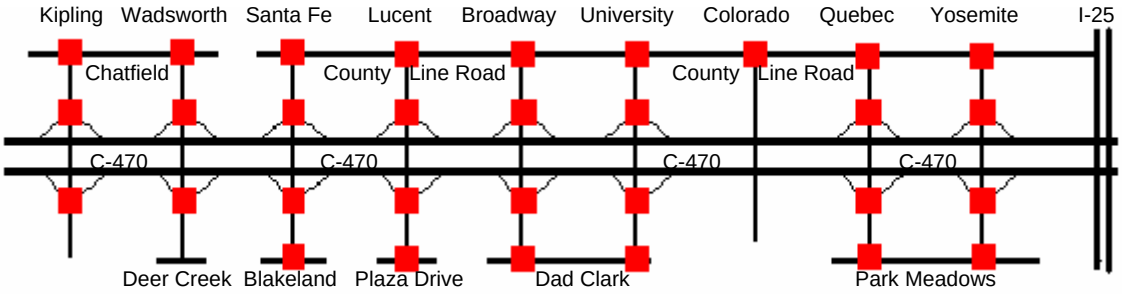
Modeling of microscale or "hotspot" concentrations for carbon monoxide is conducted for the purpose of determining whether or not a proposed transportation action is likely to cause or contribute to a violation of the national ambient air quality standards for carbon monoxide (CO). This analysis is conducted for signalized intersections with the latest EPA-approved microscale model, which is currently CAL3QHC, and with appropriate local inputs for fleet emission factors and meteorological conditions. The determination of which intersections to model is discussed below.

The C-470 Corridor Environmental Assessment includes environmental analysis of three alternatives:

- No-Action Alternative, in which improvements to C-470 would not be made.
- General Purpose Lanes Alternative, in which general-purpose lanes would be added to the existing C-470 freeway between Interstate 25 and Kipling Parkway; this alternative includes reconstruction of the C-470/Santa Fe interchange to a new configuration.
- Express Lanes Alternative, in which Express Lanes would be added to the existing C-470 freeway between Interstate 25 and Kipling Parkway; this alternative also includes reconstruction of the C-470/Santa Fe interchange to a new configuration.

For hotspot modeling purposes, the study area for this analysis included the intersections immediately north and south of the freeway (where the freeway ramps intersect with north-south cross streets), as well as the next signalized intersection to the north and south of these ramp intersections. Figure 1 indicates the general geographical relationship of these intersections.

Figure 1
Location of Signalized Intersections Considered for CO Hotspot Analysis



CORRIDOR OVERVIEW

Before examining locations that could be candidates for hotspot modeling, it is important to understand the context for the alternatives presented in the Environmental Assessment. The purpose of the project is to address congestion, reduce traveler delay, and improve reliability for drivers on the C-470 freeway itself. It has been determined that the Express Lanes Alternative and the General Purpose Lanes Alternative would meet this objective, while the No-Action Alternative would not. The purpose for a C-470 improvement project does not include alleviation of congestion on the nearby arterial street system, which experiences congestion today that will worsen in the future due to continued regional growth.

Tables 1, 2 and 3 indicate the projected future traffic operations for the signalized intersections that were identified in Figure 1, under the scenarios that were described earlier. Traffic levels of service are expressed as letters ranging from A to F, where A denotes minimal congestion and F denotes extreme congestion. The grade for each signalized intersection was determined based on projected traffic volumes and turning movements, utilizing the standard, accepted methodology from the Highway Capacity Manual. The tables present the projected levels of service for evening peak-hour conditions in the year 2025, assuming population and employment growth consistent with the latest regional plans adopted by the Denver Regional Council of Governments (DRCOG) in the *Amended Metro Vision 2025 Interim Regional Transportation Plan*.

Table 10
Intersection Level of Service (LOS) for No-Action Alternative,
Year 2025 Evening (PM) Peak Period

Location	Kip-ling	Wads-worth	Santa Fe	Lu-cent	Broad-way	Uni-versity	Colo-rado	Que-bec	Yose-mite
Nearest arterial north of C-470		D	F		F	E	F-	F	F
C-470 north (WB) ramp			E				N/a		E
C-470 south (EB) Ramp	D/E		F				N/a		
Nearest arterial south of C-470	N/a		E		D		N/a	F	E

Table cells with no notation indicate level of service C or better.
N/a = Not applicable; no signalized intersection corresponding to this location.

From Santa Fe to Yosemite, the nearest arterial north of C-470 is County Line Road. In Table 1, the abundance of intersections with Level of Service F on County Line Road indicate that County Line Road would be a seriously congested route in 2025 under the No-Action Alternative. Santa Fe also would be congested. In general heavier congestion is seen in the eastern (Yosemite) end of the corridor than in the western end.

Table 2
Intersection Level of Service (LOS) for General Purpose Lanes Alternative, Year 2025 Evening (PM) Peak Period

Location	Kip-ling	Wads-worth	Santa Fe	Lu-cent	Broad-way	Uni-versity	Colo-rado	Que-bec	Yose-mite
Nearest arterial north of C-470		D	D		F	F	F	F	F
C-470 north (WB) ramp					E		N/a		E
C-470 south (EB) Ramp	D	F			E		N/a		
Nearest arterial south of C-470	N/a		D		D		N/a	F	E

Table cells with no notation indicate level of service C or better.
N/a = Not applicable; no signalized intersection corresponding to this location.

Table 2 shows future levels of service for the General Purpose Lanes Alternative. Compared to the No-Action Alternative, the General Purpose Lanes Alternative would result in notable reduction of congestion on Santa Fe, where the existing, outdated interchange would be replaced by a new configuration. However, increased congested is expected on Broadway, compared to the No-Action Alternative. County Line Road would remain congested under either alternative. Other isolated changes are seen in the western half of the corridor, with little change in the eastern half.

Table 3
Intersection Level of Service (LOS) for Express Lanes Alternative, Year 2025 Evening (PM) Peak Period

Location	Kip-ling	Wads-worth	Santa Fe	Lu-cent	Broad-way	Uni-versity	Colo-rado	Que-bec	Yose-mite
Nearest arterial north of C-470		D			F	F	E	F	F
C-470 north (WB) ramp			D				D		E
C-470 south (EB) Ramp	D	D							
Nearest arterial south of C-470	N/a				D		N/a	F	E

Table cells with no notation indicate level of service C or better.
N/a = Not applicable; no signalized intersection corresponding to this location.

Future levels of service under the Express Lanes Alternative are shown in Table 3. Compared to General Purpose Lanes (Table 2), the Express Lanes Alternative would reduce congestion on Broadway, as well as on Wadsworth and Santa Fe. However, County Line Road would remain congested between Broadway and Yosemite.

INTERSECTION SCREENING PROCESS

A screening process was utilized to determine which intersections in the corridor were logical candidate for CO hotspot analysis. The approach is to identify and analyze intersections where localized emissions are greatest. If projected microscale CO concentrations are found to be within national ambient air quality standards (NAAQS) at the "worst case" intersection(s), it can reasonably be deduced that there would not be violations at other intersections where fewer emissions are produced.

Tables 4 and 5 display the corridor's signalized intersections ranked in order of traffic volumes, in descending order (from most traffic to least traffic) based on the total number of vehicles that enter the intersection from all directions during the evening peak hour. The corresponding traffic level of service is also shown for each intersection. There is not a direct correlation between traffic volumes and level of service because the geometric configuration and capacity of the intersections vary. Thus a given intersection can provide a better level of service than another intersection that sees less traffic volume.

Tables 4 and 5 display evening peak period data. Morning peak hour volumes and level of service were also examined, although in general the morning peak has lower volumes and comparable or better levels of service.

Table 4
Intersections Listed by Order of PM Traffic Volume
For General Purpose Lanes Alternative

Location	PM Peak Traffic Volume	Level of Service			
		F	E	D	A,B,C
Quebec/County Line	7164	F			
University/County Line	6957	F			
Quebec/Park Meadows	6927	F			
Santa Fe/County Line	6789			D	
Broadway/County Line	6757	F			
Quebec/C-470 north ramps	6546				C
Santa Fe/north ramps	6438				C
Santa Fe/Blakeland	6369				D
Lucent/Plaza	6276				C
Santa Fe/south ramps	6256				C
Broadway/south ramps	6109		E		C
Quebec/C-470 south ramps	6098				C
Yosemite/c-470 north ramps	5961	F			
Lucent/south ramps	5917				B
Broadway/Dad Clark	5893			D	
Broadway/north ramps	5753		E		
University/north ramps	5669				B
University/south ramps	5511				B
Yosemite/ County Line	5041	F			
Wadsworth/north ramps	4993				C
Wadsworth/Chatfield	4889			D	
Wadsworth/south ramps	4877	F			
Colorado/County Line	4694	F			
Yosemite/south ramps	4422				C
Yosemite/Park Meadows	4692		E		
University/Dad Clark	4619				C
Lucent/north ramps	4585				C
Kipling/Chatfield	4518			D	
Kipling/north ramps	3313				
Lucent/County Line	3191				B
Kipling/south ramps	2112			D	
Colorado/new east ramps	N/A				

Table 5
Intersections Listed by Order of PM Traffic Volume
For Express Lanes Alternative

Location	PM Peak Traffic Volume	Level of Service			
		F	E	D	A,B,C
Quebec/County Line	7887	F			
Broadway/County Line	7776	F			
University/County Line	7333	F			
Santa Fe/County Line	7244				C
Quebec/C-470 north ramps	7037				C
Quebec/C-470 south ramps	6922				C
Quebec/Park Meadows	6446		E		
Yosemite/ County Line	6249	F			
Santa Fe/Blakeland	6249				C
Colorado/County Line	6203		E		
Lucent/Plaza	6187				C
Broadway/Dad Clark	6051			D	
Santa Fe/north ramps	5882			D	
Broadway/north ramps	5873				C
Santa Fe/south ramps	5837				C
Broadway/south ramps	5763				C
Lucent/south ramps	5613				B
Yosemite/south ramps	5355				C
Yosemite/Park Meadows	4999		E		
Wadsworth/Chatfield	4940			D	
University/north ramps	4806				B
University/south ramps	4760				B
Kipling/Chatfield	4721			D	
Yosemite/north ramps	4621		E		
University/Dad Clark	4577				C
Wadsworth/north ramps	4481				C
Colorado/new east ramps	4425			D	
Wadsworth/south ramps	4036			D	
Lucent/north ramps	3963				C
Lucent/County Line	3602				B
Kipling/north ramps	2693				B
Kipling/south ramps	1794			D	

Out of the 31 intersections listed in Table 4 and the 32 intersections listed in Table 5, just under half would operate at levels of service D, E, or F, indicative of congested conditions. In accordance with longstanding, standard practice utilized in Colorado based on consultation among Federal and state agencies, intersections with Level of Service A, B, or C are not normally considered candidates for hotspot CO analysis because they do not result in excess idling emissions. Instead, intersections with LOS D, E, or F are considered as candidate locations, being more representative of worst-case conditions.

Tables 6 and 7 list only the locations with Level of Service D, E, or F, and add a column to indicate how each location compares to the busiest location for the respective alternative.

Table 6
Initial Candidate Intersections Listed by Order of PM Traffic Volume
For General Purpose Lanes Alternative

Location	PM Peak Traffic Volume	Level of Service			Traffic as a % of the busiest intersection
		F	E	D	
Quebec/County Line (busiest)	7164	F			100%
University/County Line	6957	F			97%
Quebec/Park Meadows	6927	F			97%
Santa Fe/County Line	6789			D	95%
Broadway/County Line	6757	F			94%
Santa Fe/Blakeland	6369			D	89%
Broadway/south ramps	6109		E		85%
Quebec/south ramps	6098			C/D	85%
Yosemite/C-470 north ramps	5961		E		83%
Broadway/Dad Clark	5893			D	82%
Broadway/north ramps	5753		E		80%
Yosemite/ County Line	5041	F			70%
Wadsworth/south ramps	4877	F			68%
Colorado/County Line	4694		E		66%
Yosemite/Park Meadows	4692		E		65%
Kipling/Chatfield	4518			D	63%
Kipling/south ramps	2112			D	29%

Table 7
Initial Candidate Intersections Listed by Order of PM Traffic Volume
For Express Lanes Alternative

Location	PM Peak Traffic Volume	Level of Service			Traffic as a % of the busiest intersection
		F	E	D	
Quebec/County Line (busiest)	7887	F			100%
Broadway/County Line	7776	F			99%
University/County Line	7333	F			93%
Quebec/Park Meadows	6446		E		82%
Yosemite/ County Line	6249	F			79%
Colorado/County Line	6203		E		79%
Broadway/Dad Clark	6051			D	77%
Santa Fe/C-470 north ramps	5882			D	75%
Yosemite/Park Meadows	4999		E		63%
Wadsworth/Chatfield	4940			D	63%
Kipling/Chatfield	4721			D	60%
Yosemite/C-470 north ramps	4621		E		59%
Colorado/C-470 new east ramps	4425			D	56%
Wadsworth/south ramps	4036		E		51%
Kipling/south ramps	1794				23%

It is clear from Tables 6 and 7 that there are dramatic differences in traffic volumes among the intersections with traffic level of service D, E, and F. For each alternative, for example, the least busy interchange among the initial candidates would carry less than one-third the amount of traffic volume as the busiest intersection. As a next step in the screening process, for purposes of examining worst-case conditions, each list was pared again by eliminating those locations that would not carry at least 90% of the traffic at the busiest intersection. The results are shown in Tables 8 and 9.

Table 8
Final Candidate Intersections Listed by Order of PM Traffic Volume
For General Purpose Lanes Alternative

Location	PM Peak Traffic Volume	Level of Service			Traffic as a % of the busiest intersection
		F	E	D	
Quebec/County Line (busiest)	7164	F			100%
University/County Line	6957	F			97%
Quebec/Park Meadows	6927	F			97%
Santa Fe/County Line	6789			D	95%
Broadway/County Line	6757	F			94%

Table 9
Final Candidate Intersections Listed by Order of PM Traffic Volume
For Express Lanes Alternative

Location	PM Peak Traffic Volume	Level of Service			Traffic as a % of the busiest intersection
		F	E	D	
Quebec/County Line (busiest)	7887	F			100%
Broadway/County Line	7776	F			99%
University/County Line	7333	F			93%

In comparing Tables 8 and 9, it is seen that all three locations in Table 9 also are listed in Table 8, although not in the same order. It is also seen that the traffic volumes for these intersections is higher for all three locations in the Express Lanes Alternative (Table 9) than for the General Purpose Lanes Alternative. Also it is noted that although the Santa Fe/County/Line location has a higher volume than Broadway/County Line in Table 8, it has a much better level of service (suggesting that Broadway/County Line would have greater excess emissions).

To distinguish between conditions on County Line Road at Broadway, as compared to University, intersection geometrics at both locations were examined and compared. Of the two, University has a larger number of total approach lanes, because it has a double left-turn configuration for westbound traffic, while at Broadway there is only one corresponding left-turn lane. This gives the intersection at University the ability to hold more queued traffic (and thus produce more idling emissions) in a geographically more concentrated manner.

Another input into the screening process was the fact that there was interest in two locations based on sensitive land uses in the surrounding area. The first sensitive area, the Wolhurst Community, is located in the northwest sector of the Santa Fe/C-470 interchange. It has been determined that this community meets CDOT's criteria for a low-income area, and it therefore subject to a higher level of scrutiny under environmental justice. The Santa Fe interchange would be completely reconfigured, and all of the impacts for the nearby community are being studied. Secondly, Chatfield State Park is located south of C-470 between Santa Fe and Wadsworth. As a State Recreation Area where outdoor recreation is a primary function of this resource, air quality impacts for this area have been questioned.

The signalized intersection that is closest to the Wolhurst Community is the intersection of Santa Fe at the C-470 north ramps. In Table 7, this intersection is listed with a future Level of Service D under the Express Lanes Alternative, making it eligible for consideration as a hotspot modeling site. The proximity of this intersection to Chatfield State Park makes it a useful modeling site for assessing potential impacts to the park, especially because Santa Fe (east side of the park) carries about 20% more traffic than

Wadsworth (west side of the park). Examination of morning peak traffic for the Santa Fe north ramps found that morning volumes were higher than evening peak volumes, so the higher peak period (AM) was used for modeling purposes.

CONCLUSION

On the basis of all of the above information, the following three intersections were selected for carbon monoxide hotspot modeling:

- Quebec/County Line: this is the busiest intersection in the study area, under both the General Purpose Lanes Alternative and the Express Lanes Alternative, experiencing Level of Service F under both build alternatives as well as the No Action Alternative.
- University/County Line Road: this is the second busiest intersection under the General Purpose Lanes Alternative (third busiest under Express Lanes, after Broadway/County Line), and has more approach lanes at the intersection than exist at Broadway/County Line. This intersection also will see Level of Service F traffic operations under all alternatives.
- Santa Fe/C-470 north ramps: this intersection will be reconstructed in a new configuration. Although it will serve only about 75% of the traffic of the busiest intersection in the study area, nevertheless this is a substantial volume (more than 6,000 vehicles in the peak hour) and the Level of Service D qualifies the location as a candidate for modeling. It would experience LOS E under the No Action Alternative. This intersection is very close to a sensitive land use (Wolhurst Community), and is also close enough and similar enough to represent a worst-case intersection for the nearby Chatfield State Park. This intersection experiences higher traffic volumes during the morning peak period than in the evening, and should be modeled with the higher AM volumes.

APPENDIX C

APPENDIX C

CAL3QHC MODEL INPUTS AND OUTPUTS FOR NINE MODEL RUNS

For the C-470 improvement project air quality analysis, the CAL3QHC microscale concentrations model was run for nine future scenarios, as listed below in Table 1:

Table 1
Modeled Worst-Case Microscale Concentrations of Carbon Monoxide

Predicted 8-hour average carbon monoxide concentration (parts per million)			
Intersection	Express Lanes	General Purpose	No-Action
Broadway/County Line Road	6.54	6.74	6.74
Quebec/County Line Road	6.80	6.28	6.03
Santa Fe/north (WB) C-470 ramps	4.55	4.74	4.74

These intersections were modeled using the combination of worst-case traffic (year 2025) and worst-case emission rates. The 2005 emission factors, based on Denver region fleet characteristics and wintertime temperatures, are 11.4 grams per mile for running emissions and 121.3 grams per hour for idle emissions.

The CAL3QHC model yields a one-hour average CO concentration, which is not the end of the evaluation. Two post-processing steps were also applied. In each case, the one-hour model result was factored upward by 1.13 for altitude adjustment and further multiplied by a persistence factor of 0.57 to yield an 8-hour average concentration. These calculations are shown in Table 2.

Table 2

Conversion of CAL3QHC Results to 8-hour Average Concentrations

Predicted 8-hour average carbon monoxide concentration (parts per million)					
Intersection	**CAL3QHC 1-hour concen-tration (ppm)**	**Altitude Adjust-ment**	**Persist ence Factor**	**Back-ground (ppm)**	**Resulting 8-hour concen-tration (ppm)**
Broadway/County Line Road					
Express Lanes	5.50	1.13	0.57	3.0	6.54
General Purpose Lanes	5.80				6.74
No-Action Alternative	5.80				6.74
Quebec/County Line Road					
Express Lanes	5.90	1.13	0.57	3.0	6.80
General Purpose Lanes	5.10				6.28
No-Action Alternative	4.70				6.03
Santa Fe/north (WB) C-470 ramps					
Express Lanes	6.40	1.13	0.57	3.0	4.55
General Purpose Lanes	4.50				4.74
No-Action Alternative	4.80				4.74