

Impact of Biodiesel Fuels on Air Quality and Human Health: Task 3 Report

The Impact of Biodiesel Fuels on Ambient Carbon Monoxide Levels in the Las Vegas Nonattainment Area

G. Mansell, R.E. Morris, and G. Wilson
ENVIRON International Corporation
Novato, California



NREL

National Renewable Energy Laboratory

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Golden, Colorado 80401-3393

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NREL Technical Monitor: K.S. Tyson and R. McCormick

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EXECUTIVE SUMMARY

INTRODUCTION

Carbon monoxide (CO) air pollution is generated by a variety of combustion processes ranging from industrial sources, to household heating, to motor vehicles. Due to the sheer number of automobiles, the vast majority (typically 90%) of area-wide CO emissions in congested urban areas comes from on-road motor vehicles. Numerous urban centers in the western U.S. have experienced elevated CO air pollution episodes due to climatic influences, particularly during cold, dry, stagnant winter evenings and mornings. During these periods, CO emissions are trapped near the ground where they build up in direct response to hourly variations in traffic volume during the commute hours. Two National Ambient Air Quality Standards (NAAQS) have been established for CO: a one-hour standard of 35 parts-per-million (ppm), and an eight-hour standard of 9 ppm. The 1990 Clean Air Act Amendments (CAAA) specify that regions violating the CO NAAQS more than three times in a three-year period are to be classified as nonattainment areas. The CAAA required CO nonattainment areas to develop State Implementation Plans (SIP) which list various control strategies that, by appropriate demonstration, are estimated to lead to attainment of the CO NAAQS by the date required in the CAA.

Purpose

This document is the Task 3 report for the NREL “Impacts of Biodiesel Fuels on Air Quality and Human Health” study. The objectives of Task 3 are to estimate the impacts of biodiesel fuels on elevated winter carbon monoxide concentrations for an urban area that is not currently in attainment of the CO standard.

OVERVIEW OF APPROACH

CO modeling databases for the Las Vegas Valley (LVV) developed by Clark County, Nevada (Emery et al., 1999) were selected for use in assessing the impacts of biodiesel fuel use on ambient CO concentrations since:

- Clark County was designated an 8-hour CO nonattainment area;
- The databases were used in recent (1999) SIP CO modeling;
- The database year (1996) was more recent than that used for CO SIP modeling in other area; and
- The databases and models used were publicly available.

Two LVV CO modeling databases were used in the SIP modeling, December 8-9, 1996 and December 19-20, 1996. Because biodiesel fuel use would occur in a future-year, the biodiesel CO assessment was performed for the year 2001, the only future -year for which emissions projection data were readily available.

The effects of the biodiesel on CO emissions were assessed in the NREL Biodiesel Study Task 1 report (Lindhjem and Pollack, 2000). Based on an analysis of engine dynamometer test data for a standard diesel, a 100% biodiesel, and a 20%/80% biodiesel/standard diesel blend (B20),

Lindhjem and Pollack (2000) estimated that the mean effect on fleet average Heavy Duty Diesel Vehicle (HDDV) emissions of a B20 fuel would be to reduce CO emissions by 13.1 percent. Three different emission scenarios were analyzed in 2001 using the two 1996 LVV CO episodes:

- 2001 Base Case diesel (CARB standard diesel);
- 100% penetration of a B20 fuel in the HDDV fleet; and
- 50% penetration of a B20 fuel in the HDDV fleet.

Table ES-1 summarizes the CO emissions in the LVV for the 1996 and 2001 base case simulations. Although on-road mobile sources contribute the most to CO emissions in the LVV area (> 90%), the HDDV fraction only contributes less than one percent (0.7%) to the total on-road mobile CO emissions. The percent reduction in CO emissions due to the 100% B20 and 50% B20 biodiesel emissions scenarios from the 2001 standard diesel base case for the HDDV, on-road mobile, and total emissions are shown in Table ES-2. Although the biodiesel fuel results in substantial reductions in CO emissions from the HDDV fleet (7-13%), because the HDDV contributes such a small fraction of the total CO emissions, the CO reductions from on-road mobile sources (0.08-0.19%) and total emissions in the LVV area (0.09-0.18%) are quite small.

Table ES-1. Base year 1996 and base year 2001 CO emissions by emission component for the Las Vegas Valley.

Emissions Component	Emissions (tons/day)			
	December 9		December 20	
	1996	2001	1996	2001
Area	12.7	14.3	12.7	14.3
Surface Points	22.6	22.6	22.6	22.6
Elevated Points	2.1	2.1	2.1	2.1
On-Road Mobile	415.2	366.6	511.8	451
Total	452.6	405.6	549.2	490

Table ES-2. Reductions from base year 2001 CO emissions by emission component for the Las Vegas Valley.

Emissions Component	Emissions Reductions (%)			
	December 9		December 20	
	50% B20	100% B20	50% B20	100% B20
HDDV	6.55	13.1	6.55	13.1
On-Road Mobile	0.095	0.190	0.084	0.168
Total	0.089	0.178	0.082	0.164

BIODIESEL CO IMPACT ASSESSMENT

Table ES-3 displays the peak estimated 1-hour and 8-hour CO concentrations in the LVV area for the standard diesel base case and the two biodiesel emission scenarios. The use of biodiesel fuel is estimated to reduce the peak CO concentrations as well as CO concentrations throughout the LVV area. However, these reductions are extremely small ranging from 0.01 to 0-.03 ppm (< 0.2%). Thus, the use of biodiesel fuel is estimated to have no significant impact on ambient CO concentrations.

Table ES-3. Peak estimated 1-hour and 8-hour CO concentrations in the Las Vegas Valley for the 2001 Base Case, 100% B20, and 50% B20 emission scenarios and the differences in CO concentrations between the biodiesel fuel scenarios and standard diesel base case.

Episode	Std.Diesel (ppm)	50% B20		100% B20	
		(ppm)	Difference	(ppm)	Difference
1-Hour CO Dec 8-9	17.90	17.89	-0.01	17.87	-0.02
8-Hour CO Dec 8-9	9.39	9.38	-0.01	9.37	-0.02
1-Hour CO Dec 19-20	18.38	18.36	-0.02	18.35	-0.03
8-Hour CO Dec 19-20	13.73	13.72	-0.01	13.71	-0.02

TABLE OF CONTENTS

	Page
EXECUTIVE SUMMARY	ES-1
Introduction.....	ES-1
Overview of Approach.....	ES-1
Biodiesel CO Impact Assessment	ES-3
1. INTRODUCTION.....	1-1
Background.....	1-1
Purpose	1-1
2. DATABASE AND MODEL SELECTION.....	2-1
Available Models	2-1
Modeling Databases.....	2-1
Overview of Las Vegas CO Air Quality.....	2-2
Assessment Year Selection	2-3
3. BIODIESEL CO EMISSIONS ASSESSMENT.....	3-1
Las Vegas CO Emissions Summaries.....	3-2
4. BIODIESEL CO ASSESSMENT	4-1
UAM Model Performance Issues.....	4-1
UAM Modeling Results.....	4-2
REFERENCES.....	R-1

TABLES

Table ES-1. Base year 1996 and base year 2001 CO emissions by emission component for the Las Vegas Valley.....	ES-2
Table ES-2. Reductions from base year 2001 CO emissions by emission component for the Las Vegas Valley.....	ES-2

Table ES-3.	Peak estimated 1-hour and 8-hour CO concentrations in the Las Vegas Valley for the 2001 Base Case, 100% B20, and 50% B20 emission scenarios and the differences in CO concentrations between the biodiesel fuel scenarios and standard diesel base case.	ES-3
Table 3-1.	Base year 1996 and base year 2001 CO emissions by emission component for the Las Vegas Valley.....	3-2
Table 3-2.	Reductions from base year 2001 CO emissions by emission component for the Las Vegas Valley.....	3-3
Table 4-1.	Peak CO concentrations for base year 2001 and biodiesel scenarios for the Las Vegas Valley.	4-2
Table 4-2.	Summary of CO exposure metrics for the Las Vegas Valley for the December 8-9 episode.....	4-3
Table 4-3.	Summary of CO exposure metrics for the Las Vegas Valley for the December 19-20 episode.....	4-3

FIGURES

Figure 3-1.	Location and relative emission strengths of point sources in the LVV CO UAM emission inventory.	3-4
Figure 3-2.	Daily total CO emissions (TPD) for December 9, 2001, in the LVV CO UAM modeling.	3-5
Figure 3-3.	Daily on-road mobile source CO emissions (TPD) for December 9, 2001, in the LVV CO UAM modeling domain.	3-6
Figure 3-4.	Daily total CO emissions (TPD) for December 20, 2001, in the LVV CO UAM modeling.	3-7
Figure 3-5.	Daily on-road mobile source CO emissions (TPD) for December 20, 2001, in the LVV CO UAM modeling domain.	3-8
Figure 3-6.	Reductions in daily total CO emissions (TPD) for December 9, 2001, in the LVV CO UAM modeling due to 50% penetration of B20 biodiesel fuel.....	3-9
Figure 3-7.	Reductions in daily total CO emissions (TPD) for December 9, 2001, in the LVV CO UAM modeling due to 100% penetration of B20 biodiesel fuel.....	3-10
Figure 3-8.	Reductions in daily total CO emissions (TPD) for December 20, 2001, in the LVV CO UAM modeling due to 50% penetration of B20 biodiesel fuel.....	3-11
Figure 3-9.	Reductions in daily total CO emissions (TPD) for December 20, 2001, in the LVV CO UAM modeling due to 100% penetration of B20 biodiesel fuel.....	3-12
Figure 4-1.	Spatial distribution of 1-hour maximum CO concentrations predicted for the December 8-9, 2001 base case. All UAM concentrations scaled by 1.14.	4-4

Figure 4-2.	Spatial distribution of 8-hour maximum CO concentrations predicted for the December 8-9, 2001 base case. All UAM concentrations scaled by 1.14.	4-5
Figure 4-3.	Impacts of 50% penetration of B20 biodiesel fuel on 1-hour maximum CO concentrations predicted for December 8-9, 2001.	4-6
Figure 4-4.	Impacts of 100% penetration of B20 biodiesel fuel on 1-hour maximum CO concentrations predicted for December 8-9, 2001.	4-7
Figure 4-5.	Impacts of 50% penetration of B20 biodiesel fuel on 8-hour maximum CO concentrations predicted for December 8-9, 2001.	4-8
Figure 4-6.	Impacts of 100% penetration of B20 biodiesel fuel on 8-hour maximum CO concentrations predicted for December 8-9, 2001.	4-9
Figure 4-7.	Spatial distribution of 1-hour maximum CO concentrations predicted for the December 19-20, 2001 Base Case. All UAM concentrations scaled by 1.14.	4-10
Figure 4-8.	Spatial distribution of 8-hour maximum CO concentrations predicted for the December 19-20, 2001 Base Case. All UAM concentrations scaled by 1.14.	4-11
Figure 4-9.	Impacts of 50% penetration of B20 biodiesel fuel on 1-hour maximum CO concentrations predicted for December 19-20, 2001.	4-12
Figure 4-10.	Impacts of 100% penetration of B20 biodiesel fuel on 1-hour maximum CO concentrations predicted for December 19-20, 2001.	4-13
Figure 4-11.	Impacts of 50% penetration of B20 biodiesel fuel on 8-hour maximum CO concentrations predicted for December 19-20, 2001.	4-14
Figure 4-12.	Impacts of 100% penetration of B20 biodiesel fuel on 8-hour maximum CO concentrations predicted for December 19-20, 2001.	4-15

1. INTRODUCTION

BACKGROUND

Carbon monoxide (CO) air pollution is generated by a variety of combustion processes ranging from industrial sources, to household heating, to motor vehicles. Due to the sheer number of automobiles, the vast majority (typically 90%) of area-wide CO emissions in congested urban areas comes from on-road motor vehicles. Numerous urban centers in the western U.S. have experienced elevated CO air pollution episodes due to climatic influences, particularly during cold, dry, stagnant winter evenings and mornings. During these periods, CO emissions are trapped near the ground where they build up in direct response to hourly variations in traffic volume during the commute hours. Exacerbating the limited ventilation during such periods is the fact that automobile CO emission rates increase dramatically in cold temperatures due to less efficient engine and catalyst operation, particularly for “cold starts” that are prevalent during the morning hours. In some areas, local topography induces nocturnal drainage flows that can cause CO to pool in depressions, which in turn can lead to persistently high concentrations during many hours of the night.

Two National Ambient Air Quality Standards (NAAQS) have been established for CO: a one-hour standard of 35 parts-per-million (ppm), and an eight-hour standard of 9 ppm. One-hour exceedances are practically nonexistent in the U.S. today, and eight-hour exceedances have continued to decline in number and severity over the past ten years due to more efficient automobile engines, improved emission controls, reformulated and oxygenated gasolines, and other area-specific emission mitigation measures. The 1990 Clean Air Act Amendments (CAAA) specify that regions violating the CO NAAQS more than three times in a three-year period are to be classified as nonattainment areas. The CAAA required CO nonattainment areas to develop State Implementation Plans (SIP) which list various control strategies that, by appropriate demonstration, are estimated to lead to attainment of the 8-hour CO NAAQS by the date required in the CAA. The SIP due dates and CO attainment dates depend on the classification of the CO nonattainment area (e.g., November 1992 and the end of 1995 for a moderate area).

PURPOSE

This document is the Task 3 report for the NREL “Impacts of Biodiesel Fuels on Air Quality and Human Health” study. The objectives of Task 3 are to estimate the impacts of biodiesel fuels on elevated winter carbon monoxide concentrations for an urban area that is not currently in attainment of the CO standard. This report presents a discussion of the database and modeling episode selection, and the technical approach and analysis of air quality modeling results used to estimate biodiesel impacts. A discussion and analysis of biodiesel test data, and recommendations for incorporating biodiesel effects on pollutant mass emission for use in air quality modeling can be found in the NREL Task 1 report (Lindhjem and Pollack, 2000).

2. DATABASE AND MODEL SELECTION

The selection of the model and database for use in evaluating the impacts of biodiesel fuels on carbon monoxide concentrations in an urban nonattainment area is based on the following criteria:

- Access to database and models
- Used recently to generate public policy (e.g. SIP)
- Current baseline (1995-1999) is preferable to future-year baseline

This section provides a brief discussion of available models and databases and presents the rationale for the selection of the database/models used in the present study.

AVAILABLE MODELS

There are generally two types of CO modeling approaches commonly used: microscale intersection modeling and urban-scale grid modeling. Microscale intersection modeling is typically used to simulate CO hot spots and to design mitigating measures for reducing these CO concentrations to below the NAAQS using a microscale model such as CAL3QHC. By contrast, urban-scale grid modeling is used to simulate CO concentrations throughout an entire urban area. Because CO SIP attainment modeling must demonstrate compliance with the CO NAAQS throughout the urban area, the EPA requires urban areas to always use urban-scale modeling as part of SIP attainment demonstration. As the impacts of biodiesel fuel use on ambient CO concentrations will be present in an urban area wherever Heavy Duty Diesel Vehicle (HDDV) Vehicle Miles Traveled (VMT) occurs, microscale modeling of the effects of biodiesel would provide only a very localized impact analysis. Thus, to provide a more comprehensive analysis of the benefits of biodiesel fuel use for reducing CO concentrations, urban-scale grid modeling is the preferred approach.

While several urban-scale grid models are available (UAM-IV, CALGRID, CAMx, etc.) which would likely be acceptable to the EPA for CO modeling, the UAM-IV (Morris and Myers, 1990) has been the preferred model in EPA's current Guidelines for Air Quality Modeling. As none of these other models has yet been used in CO SIP modeling, the impacts of biodiesel fuels on urban CO concentrations is evaluated using the UAM-IV for this study.

MODELING DATABASES

There are three recent SIP-quality CO modeling analyses that have been carried out that used or are using urban-scale CO grid modeling. For the Phoenix area, EPA Region IX and the Maricopa Association of Governments (MAG) applied UAM-IV for an episode from 1992 in the preparation of the CO SIP attainment plan (Emery and Ligoeki, 1992). Clark County Nevada performed UAM-IV CO modeling of the Las Vegas area for a 1996 episode for the Las Vegas area which was included in their very latest SIP (Emery et al., 1999). Finally, during the summer of 1999, urban-scale CO modeling for the Spokane Washington area was performed for the Spokane County Air Pollution Control Authority (SCAPCA) and episodes from 1998 and

1992-1996 to be included in a SIP to be submitted to the EPA. All three cities are current CO nonattainment areas.

The Phoenix and Las Vegas CO SIP modeling databases are currently available, whereas the Spokane databases are still undergoing review. Further, the Spokane CO modeling used a proprietary model (UAM-V) thus eliminating it from consideration. The Phoenix database is for an older episode (1992 episode) and less current. The Las Vegas database is for a more recent episode (1996) and is very current (part of the Las Vegas 1999 CO SIP). Thus, based on discussions with NREL, it was determined that the Las Vegas 1996 CO modeling database is more appropriate for evaluating biodiesel fuel impacts on CO nonattainment and is therefore used in this study.

OVERVIEW OF LAS VEGAS CO AIR QUALITY

The Las Vegas Valley (LVV) is classified as a nonattainment area for the eight-hour CO NAAQS. Although CO concentrations in the Las Vegas Valley have never exceeded the one-hour NAAQS of 35 ppm, they have historically exceeded the eight-hour NAAQS of 9 ppm during the late fall/winter season. There has been a declining trend over the past years in the number of LVV CO exceedances events as well as the intensity of CO concentrations. The number of exceedances per year has improved from a high of 41 in 1985 to only two in 1998. Between December 1988 and December 1991, numerous exceedances were recorded at a single monitoring site (East Charleston) where the highest 8-hour CO concentration was 14.4 ppm in December 1988. This same site also recorded ten exceedances during the 1991/92 winter season alone, three exceedances during the 1994/95 winter season and four exceedances during the 1995/96 winter season. Currently, out of fourteen monitoring stations, only the Sunrise Acre site (a nearby replacement for the East Charleston station) registers infrequent exceedances of the standard.

Almost all ambient CO emanates from near-ground sources, the majority of which results from motor vehicle emissions. During fall and winter months, development of strong surface-based stability at night leads to stagnation conditions that trap pollutants in the valley and concentrates them near the ground. The buildup of CO causes exceedances of the 8-hour NAAQS, historically in a limited area surrounding the East Charleston monitoring station. This site is located near several major transportation corridors, and lies within a topographic depression where valley air often converges during stagnation events.

Various studies have shown that the ambient CO levels can be rather high within about a mile of this site, while routine CO monitoring at numerous other locations always measure lower CO concentrations. As in other western urban areas, CO concentrations at most monitoring stations reach two maxima each day: one between 7-9 AM coincident with the morning rush hour, and the other between 8 PM and 1 AM. The delayed evening CO peak suggests that a combination of meteorological, topographical, and emission factors influence the CO distribution, combining in such a way as to result in the highest CO concentrations in the vicinity of the East Charleston site.

ASSESSMENT YEAR SELECTION

As listed in the database selection criteria above, the selection of an appropriate assessment year should consider a current baseline (1995-1999) as preferable over a projected future-year baseline. As there are many uncertainties associated with projecting emissions to a future year, the use of such a projected inventory potentially adds an additional unnecessary level of uncertainty to the modeling analysis. The Las Vegas modeling database contains episode days in 1996, within the range of the selection criteria, so no projection would be required. However, the impact of biodiesel fuel use would occur in future years not current years. Therefore, based on discussions with NREL, the biodiesel CO evaluation is performed for a 2001 assessment year.

3. BIODIESEL CO EMISSIONS ASSESSMENT

Under Task 1 of the study, a review and analysis of engine dynamometer test data for a variety of engine types and model years was conducted for both a 20%/80% biodiesel/diesel fuel blend (B20) and a 100% biodiesel fuel (B100). Based on the results of the test data analysis, the effects of biodiesel fuels on carbon monoxide (CO) emissions is found to result in an overall average reduction of 13.1% for the B20 biodiesel fuels (Lindhjem and Pollack, 2000). As it is probably unrealistic to expect a significant penetration of B100 biodiesel fuels in the heavy-duty diesel vehicle (HDDV) fleet by the year 2001, the impacts of biodiesel fuels on ambient CO concentrations will be assessed for the B20 fuel only. Since a linear relationship exists between CO emission reductions and ambient CO concentrations, the effects due to B100 fuels may be easily estimated. A detailed discussion of the emission effects due to biodiesel fuels can be found in the NREL Task 1 report (Lindhjem and Pollack, 2000).

The effects of biodiesel fuel use on ambient CO concentrations are assessed for the following scenarios and the 2001 assessment year:

- Future-year baseline diesel fuel (CARB standard diesel)
- 100% penetration of B20 fuel
- 50% penetration of B20 fuel

The effects of B20 fuels are only accounted for in the HDDV fleet.

The gridded model-ready CO emission inventories were prepared for the three biodiesel scenarios using the same procedures as for the UAM-IV CO modeling performed as part of the Clark County, Nevada SIP for the Las Vegas area. Emissions from area and point sources were processed using the Emissions Preprocessing System, version 2.0 (EPS2) as distributed for use with UAM by the EPA. Area source emissions were projected to the future year 2001 taking into account estimated growth, as well as the mitigating effects of any local and national control regulations that are currently mandated to take effect by the year 2001. It was assumed that point sources were operating at full load in the base 1996 inventory, and therefore the future year point source emission estimates were held constant at the 1996 levels. No additional specific point source were added to the future year inventory. Figure 3-1 shows the location of all the point sources within the modeling domain. The size of the marker at the source location indicates the relative magnitude of the daily emission rate. Also shown for reference is the base year transportation network used in developing the mobile source component of the inventory.

The on-road motor vehicle component of the emissions inventory was prepared using the Direct Travel Impact Model, version 2.0 (DTIM2), distributed by the California Department of Transportation (CALTRANS). DTIM2 is a system of programs used to calculate hourly gridded emissions by combining roadway link-specific traffic volumes (in terms of vehicle miles traveled, or VMT) from a transportation model with vehicle fleet emission factors taken from an emission factor model. For this study, VMT distributions were developed from the Clark County transportation demand model TRANPLAN. The on-road mobile emission factors used in the development of the future year inventories were derived from EPA's MOBILE5b model with modifications incorporated to reflect the effects of "off-cycle" emissions as planned for the EPA's latest emission factor model, MOBILE6. The TRANPLAN model was exercised to produce a dataset containing link locations in the planned traffic network as well as the estimated

traffic volume on each for a typical day in the future year 2001. The resulting data were extracted and reformatted for use in the DTIM2 system. As the TRANPLAN estimates did not take into account any VMT from vehicles engaged in public transportation, a correction was made in the form of an across-the-board adjustment to the emission estimates generated from the DTIM2 system to account for the estimated increase in VMT. A detailed description of the emission inventory preparation may be found in the Las Vegas Valley Carbon Monoxide Phase II Modeling report (Emery et al., 1999).

The effects of biodiesel fuels on CO emissions were accounted for in the HDDV fleet only. Adjustments were made to the DTIM2 inputs to reflect the 13.1% emission reduction corresponding to the 100% penetration level of B20 biodiesel fuel. Similar adjustments were made for the 50% penetration level (an assumed 6.55% reduction in HDDV CO emissions). The DTIM2 system was then exercised to provide estimates of gridded CO emissions from on-road mobile sources. Gridded time-resolved emission files for area, point and mobile sources were combined into a single file for input into the UAM-IV modeling system.

LAS VEGAS CO EMISSION SUMMARIES

Table 3-1 summarizes the CO emissions in the Las Vegas Valley (LVV) for the December 8-9 and December 19-20, 1996 CO episodes. While on-road mobile source emissions contribute by far the most (>90%), the contribution from all diesel vehicles to the total CO on-road mobile source emissions in the LVV is approximately 1.35%, with HDDV making up about 51% of the total diesel vehicle fleet (i.e., approximately 0.7% of the LVV CO emissions are due to the HDDV fleet).

Table 3-1. Base year 1996 and base year 2001 CO emissions by emission component for the Las Vegas Valley.

Emissions Component	Emissions (tons/day)			
	December 9		December 20	
	1996	2001	1996	2001
Area	12.7	14.3	12.7	14.3
Surface Points	22.6	22.6	22.6	22.6
Elevated Points	2.1	2.1	2.1	2.1
On-Road Mobile	415.2	366.6	511.8	451
Total	452.6	405.6	549.2	490

The CO emission reductions realized in the LVV for each biodiesel scenario are summarized in Table 3-2. Figure 3-2 displays the spatial distribution of the daily total CO emission in the modeling domain while Figure 3-3 displays the distribution of mobile source CO emissions for the 2001 future year base case. Corresponding displays for the December 20 episode day are presented in Figure 3-4 and Figure 3-5. The CO emissions from on-road mobile source are distributed throughout the traffic network while the highest emission levels are seen to be concentrated along the major highways and the central urban core of Las Vegas.

Figure 3-6 and Figure 3-7 display the spatial distribution of the reductions in daily total CO emission for the 50% penetration and 100% penetration of B20 fuel on December 9, 2001, respectively. Spatial distribution of CO emission reductions for December 20 are displayed in

Figure 3-8 and Figure 3-9 for the 50% and 100% penetration of B20 fuels, respectively. As expected, the reductions in CO emissions are distributed throughout the traffic network, with the largest reductions occurring within the central Las Vegas area and along the major highways; however, all of the reductions are very small.

Table 3-2. Reductions from base year 2001 CO emissions by emission component for the Las Vegas Valley.

Emissions Component	Emissions Reductions (%)			
	December 9		December 20	
	50% B20	100% B20	50% B20	100% B20
HDDV	6.55	13.1	6.55	13.1
On-Road Mobile	0.095	0.190	0.084	0.168
Total	0.089	0.178	0.082	0.164

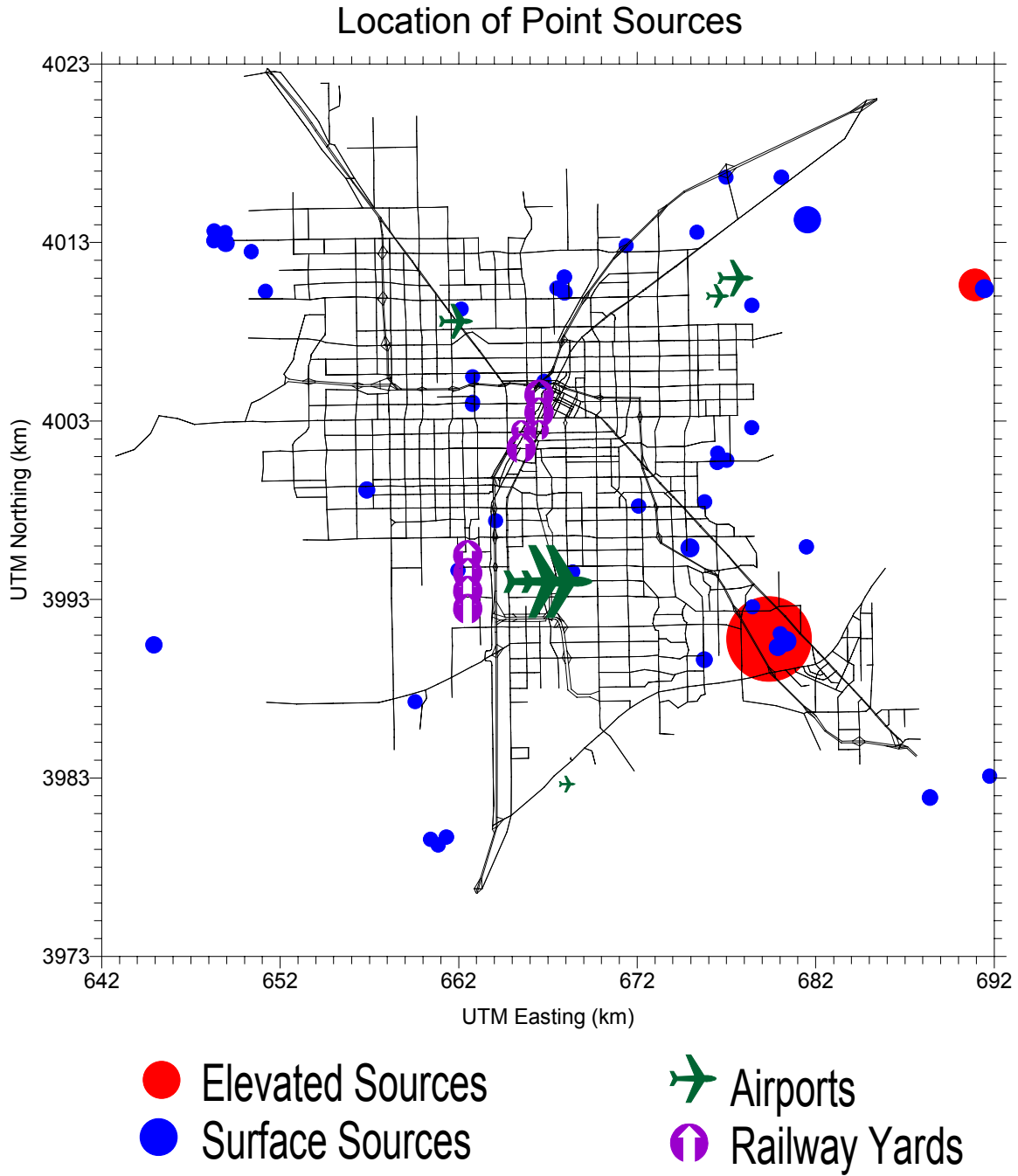


Figure 3-1. Location and relative emission strengths of point sources in the LVV CO UAM emission inventory.

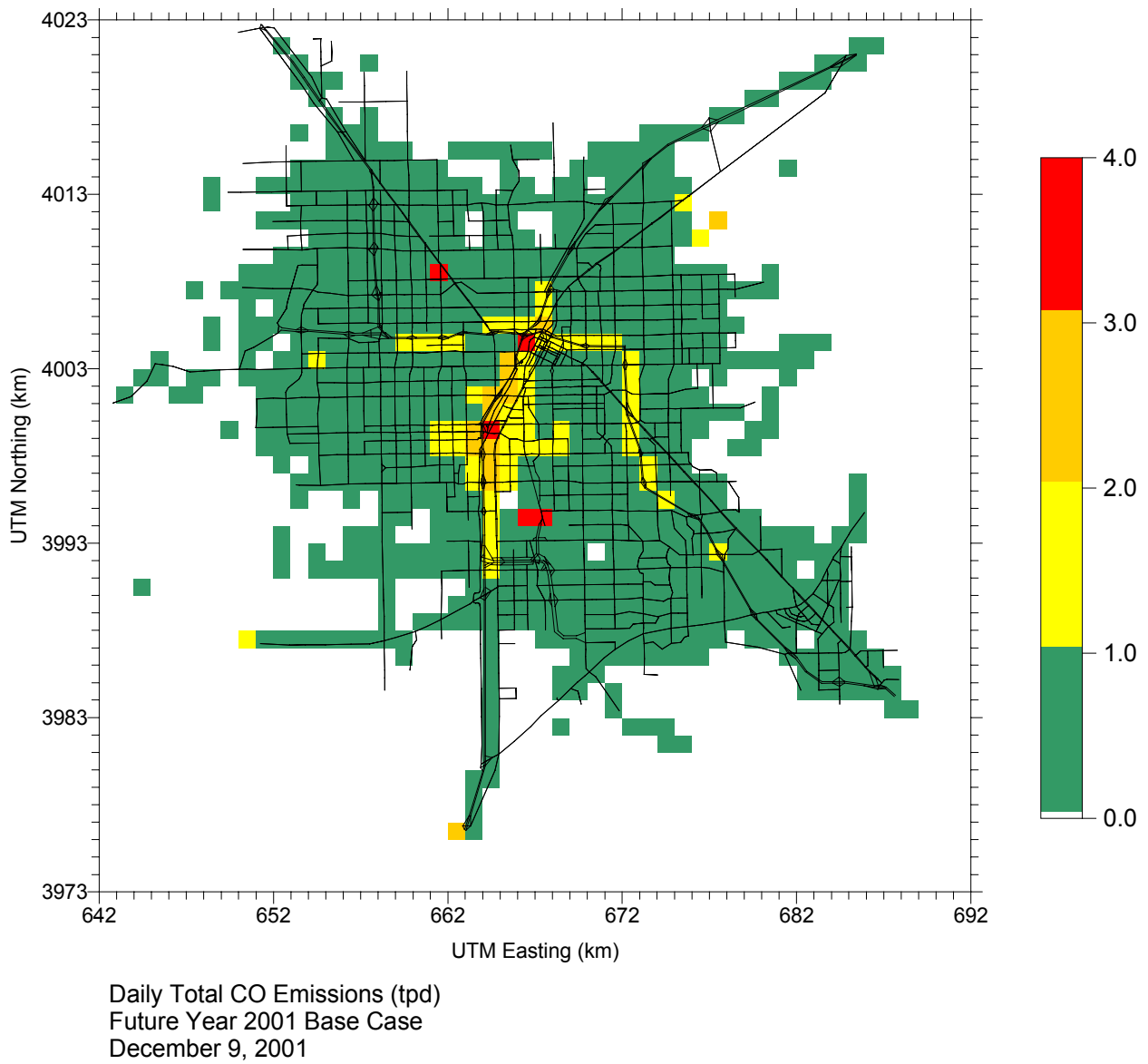
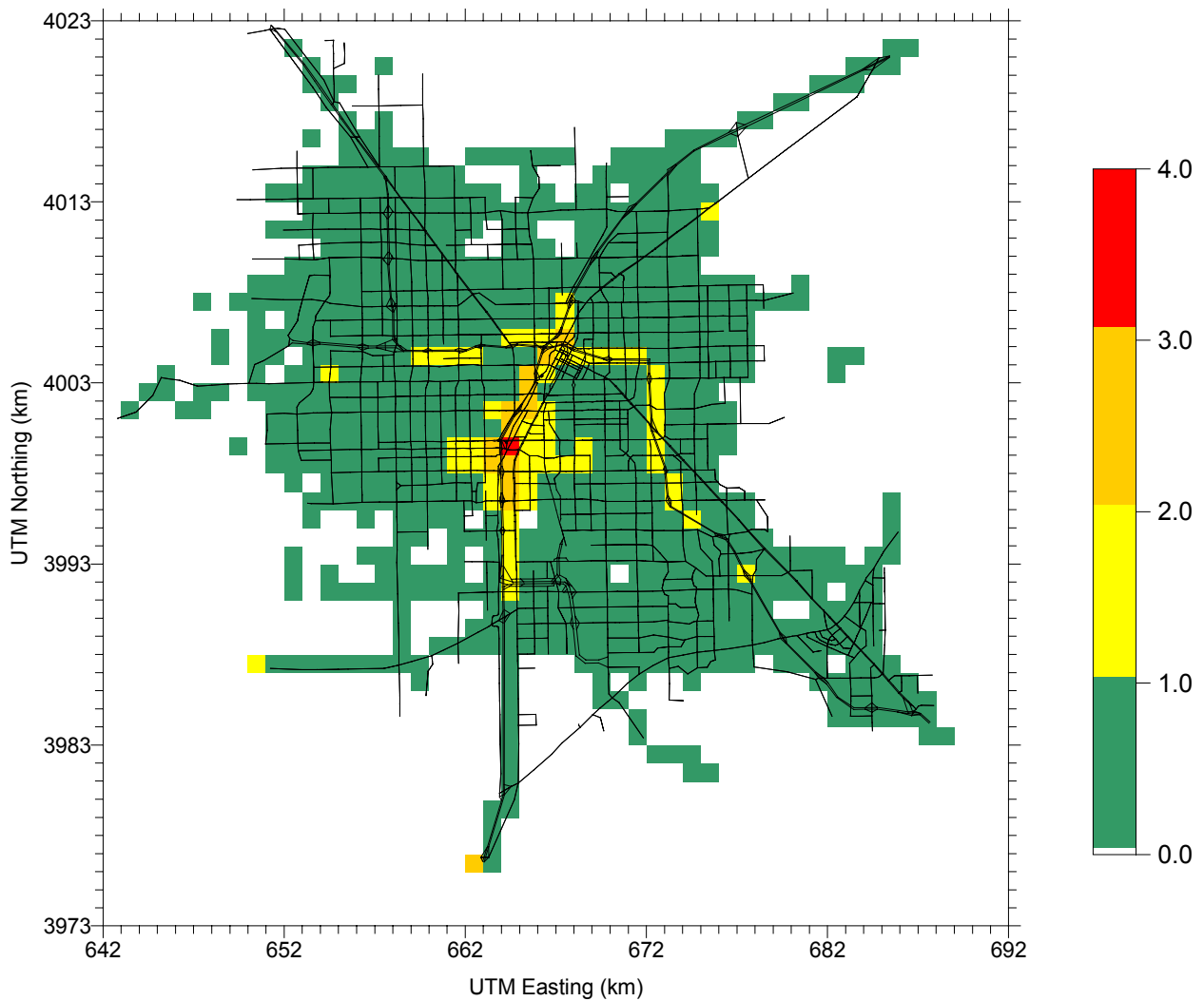
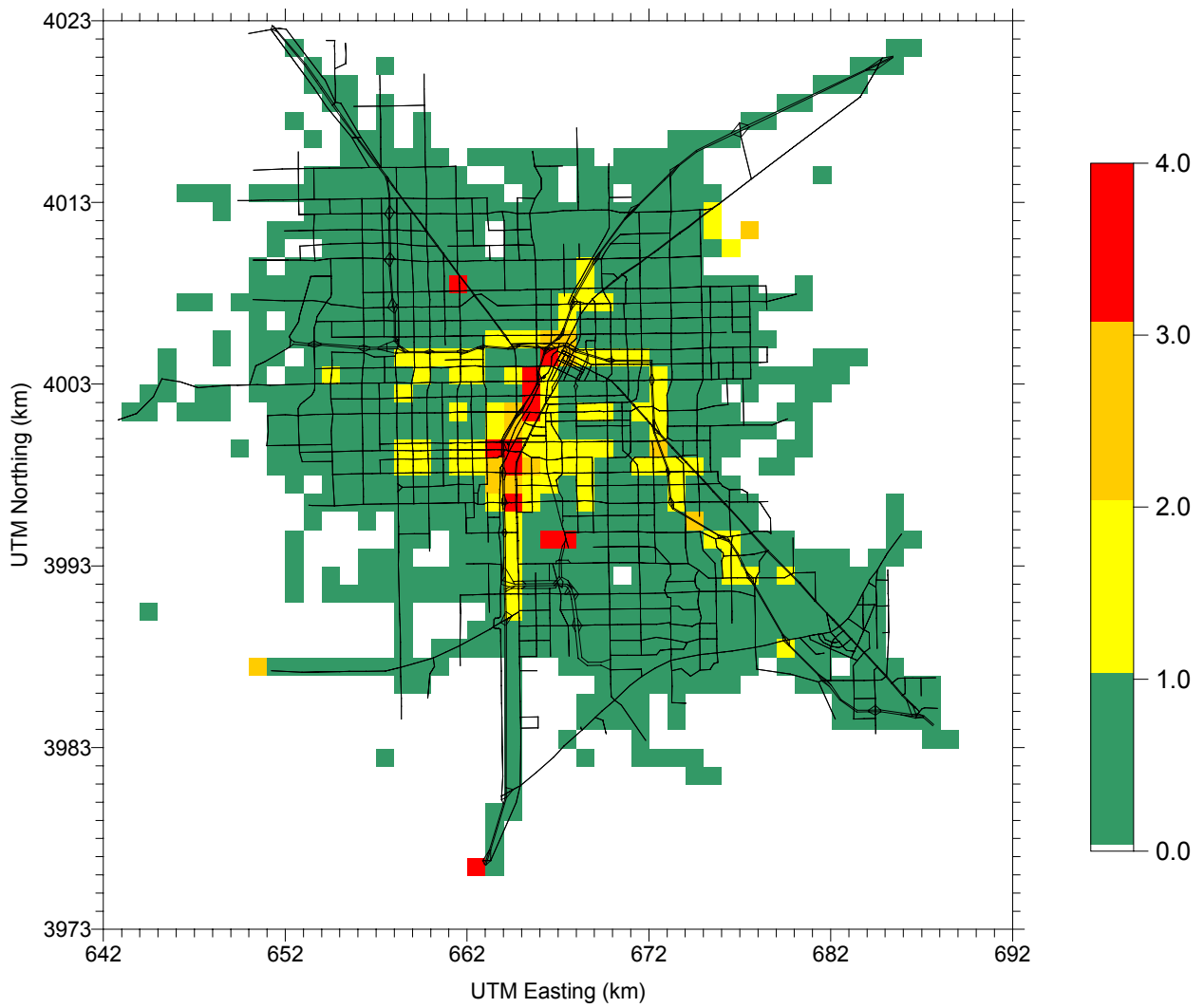


Figure 3-2. Daily total CO emissions (TPD) for December 9, 2001, in the LVV CO UAM modeling.



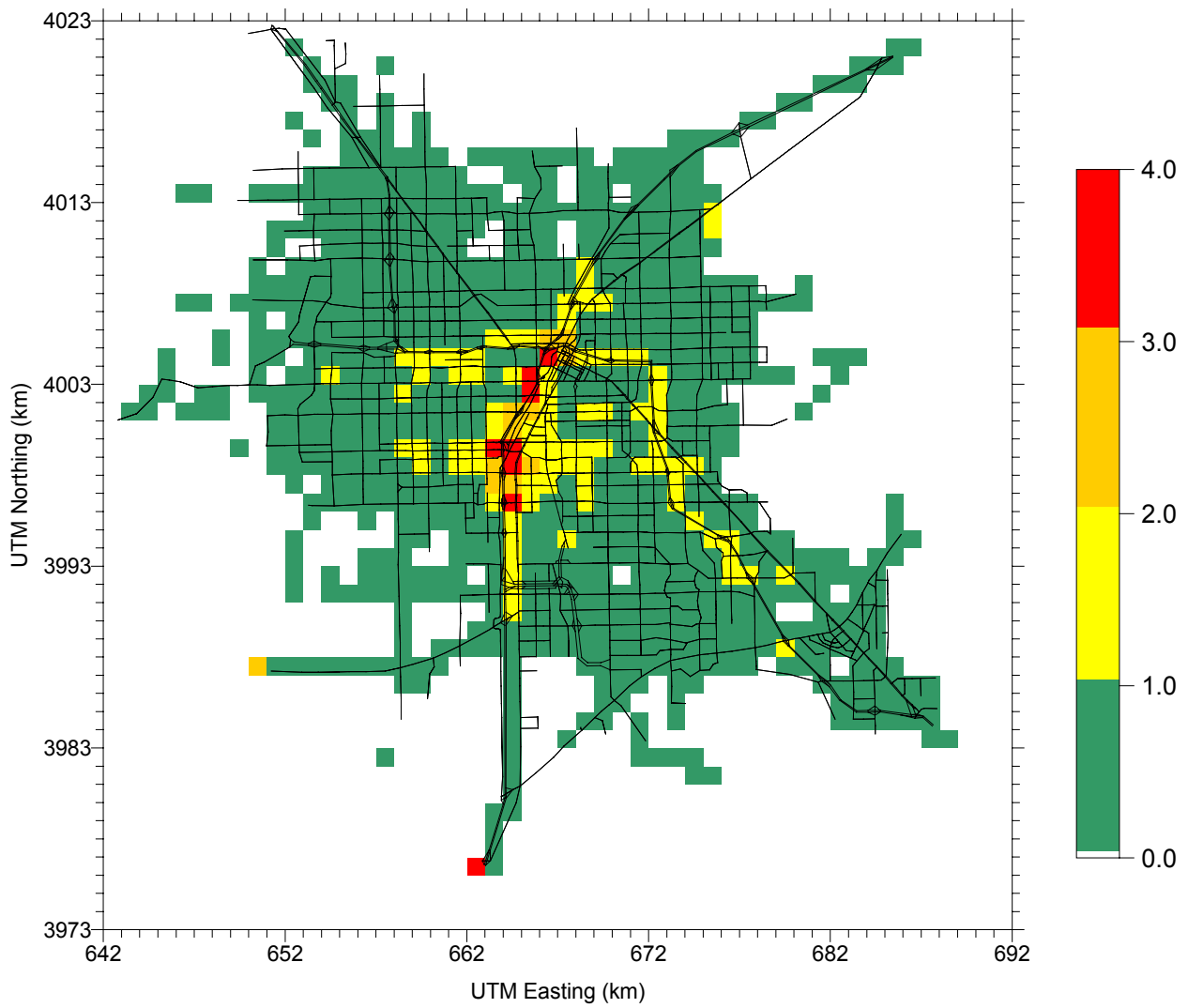
Daily Mobile Source CO Emissions (tpd)
 Future Year 2001 Base Case
 December 9, 2001

Figure 3-3. Daily on-road mobile source CO emissions (TPD) for December 9, 2001, in the LVV CO UAM modeling domain.



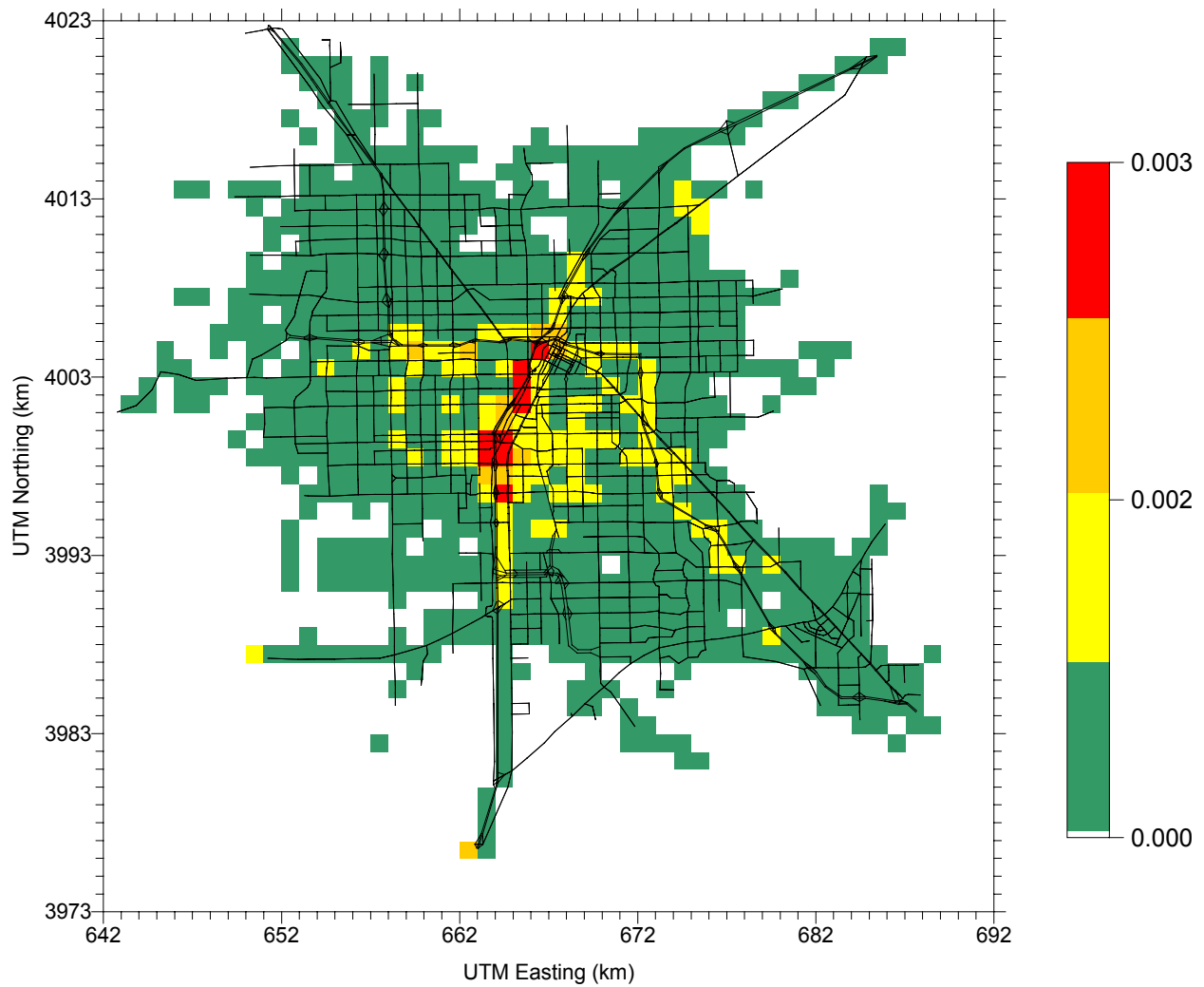
Daily Total CO Emissions (tpd)
 Future Year 2001 Base Case
 December 20, 2001

Figure 3-4. Daily total CO emissions (TPD) for December 20, 2001, in the LVV CO UAM modeling.



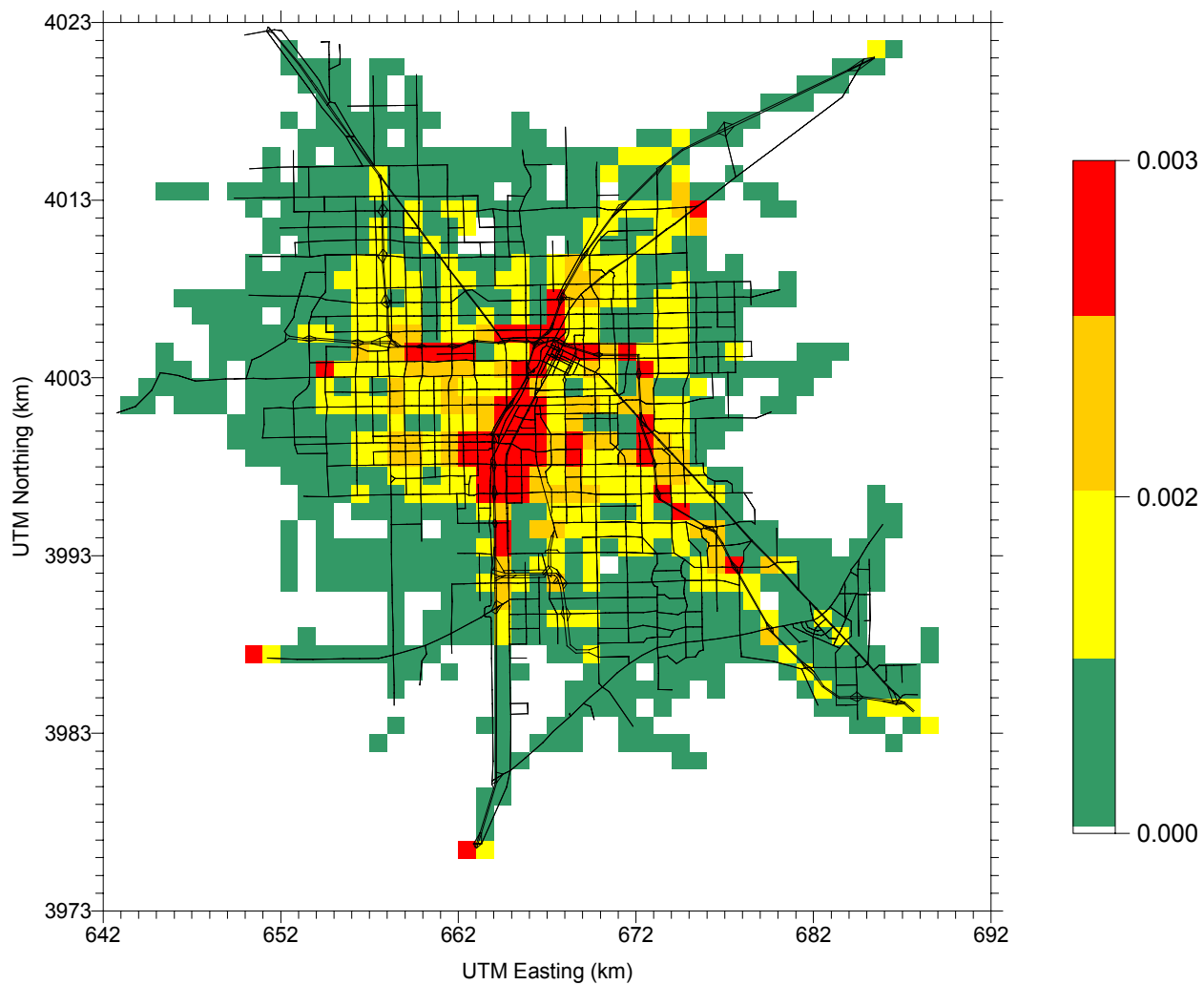
Daily Mobile Source CO Emissions (tpd)
 Future Year 2001 Base Case
 December 20, 2001

Figure 3-5. Daily on-road mobile source CO emissions (TPD) for December 20, 2001, in the LVV CO UAM modeling domain.



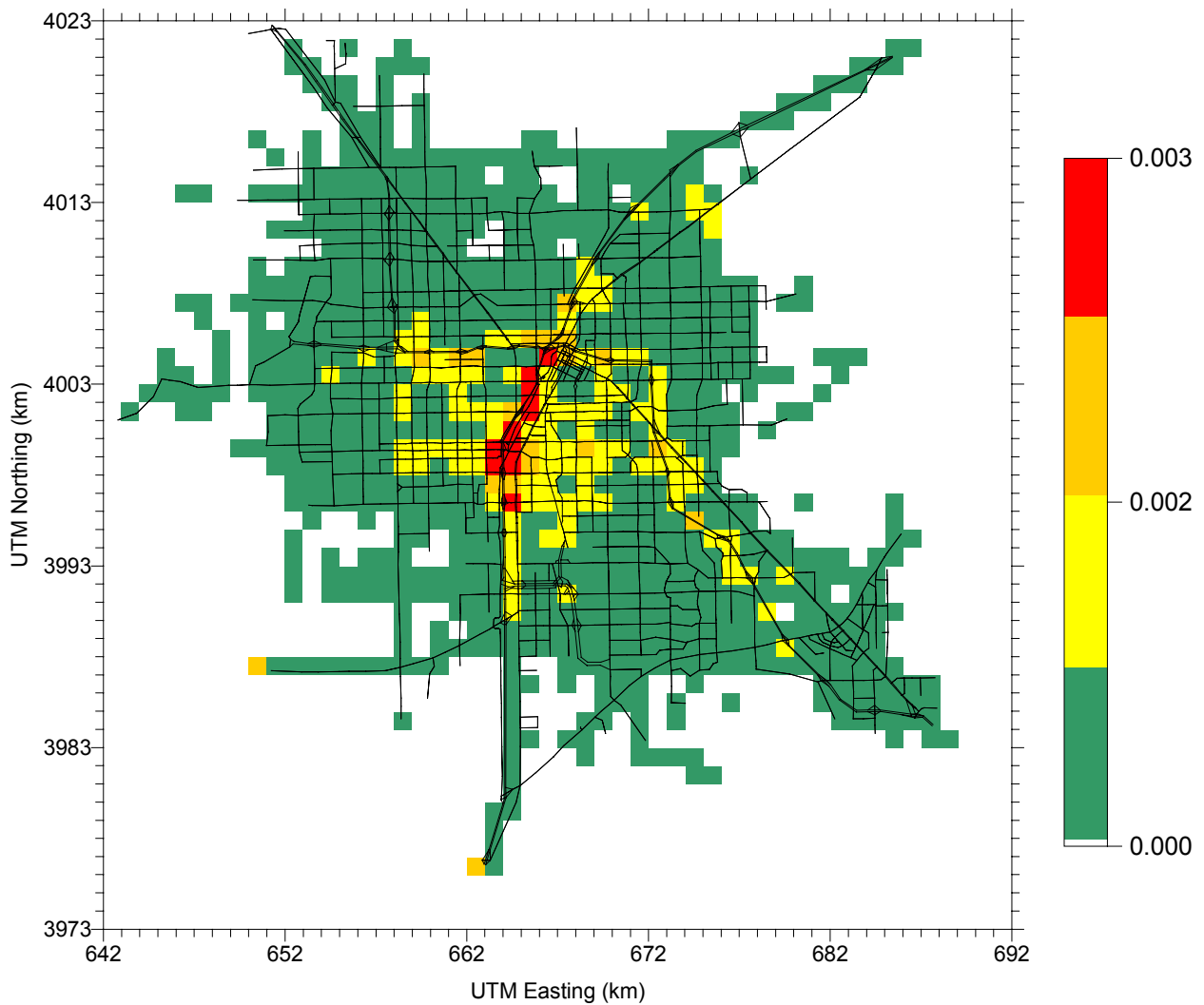
Reductions in Daily Total CO Emissions (tpd)
 50% Biodiesel
 December 9, 2001

Figure 3-6. Reductions in daily total CO emissions (TPD) for December 9, 2001, in the LVV CO UAM modeling due to 50% penetration of B20 biodiesel fuel.



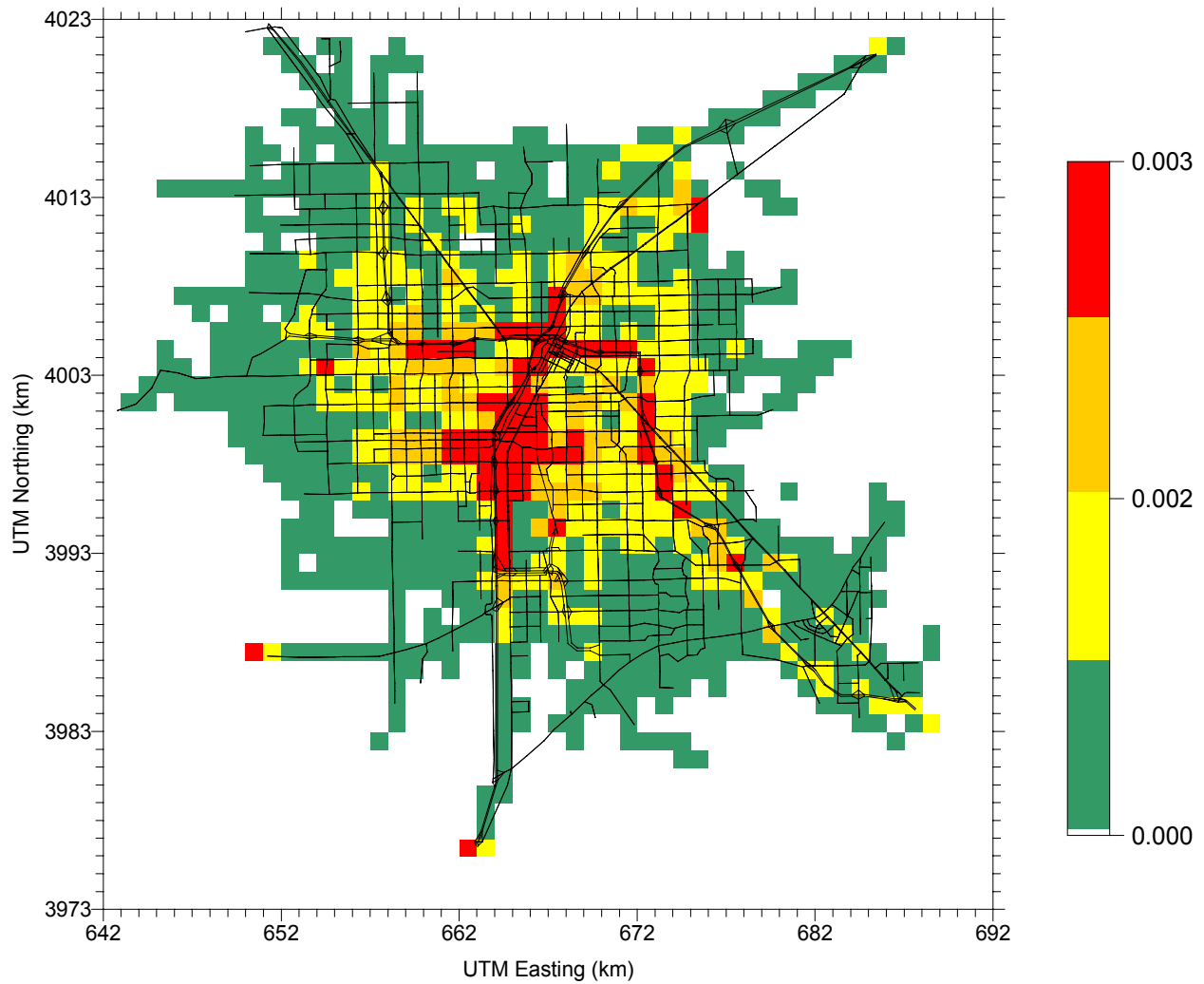
Reductions in Daily Total CO Emissions (tpd)
 100% Biodiesel
 December 9, 2001

Figure 3-7. Reductions in daily total CO emissions (TPD) for December 9, 2001, in the LVV CO UAM modeling due to 100% penetration of B20 biodiesel fuel.



Reductions in Daily Total CO Emissions (tpd)
 50% Biodiesel
 December 20,2001

Figure 3-8. Reductions in daily total CO emissions (TPD) for December 20, 2001, in the LVV CO UAM modeling due to 50% penetration of B20 biodiesel fuel.



Reductions in Daily Total CO Emissions (tpd)
 100% Biodiesel
 December 20,2001

Figure 3-9. Reductions in daily total CO emissions (TPD) for December 20, 2001, in the LVV CO UAM modeling due to 100% penetration of B20 biodiesel fuel.

4. BIODIESEL CO ASSESSMENT

In this section, the impacts of biodiesel fuels on ambient CO concentrations are presented. The results of the UAM-IV modeling for the Las Vegas Valley area are presented and discussed for each of the three emission scenarios investigated. The impacts of biodiesel fuel use on air quality and human health are related through the evaluation of various air quality exposure metrics.

The Urban Airshed Model (UAM) was exercised for each of the future year 2001 biodiesel emission scenarios. All meteorological and air quality inputs developed for use in the Phase II Las Vegas Valley CO Modeling project (Emery et al., 1999) were left unchanged for use in the present study. The resulting ambient CO concentrations under each scenario are presented for both daily maximum 1-hour and 8-hour CO concentrations. The impacts resulting from biodiesel fuel use are evaluated through comparison with the standard diesel scenario (2001 Base Case). Impacts on air quality metrics, including the changes in daily maximum 1-hour and 8-hour CO concentrations, spatial coverage (exposure) of hourly 1-hour and 8-hour CO concentrations above an appropriate threshold (5 ppm), and changes in the integrated concentrations of 1-hour and 8-hour CO concentrations (dosage) above the threshold, are presented.

UAM MODEL PERFORMANCE ISSUES

As part of the development of the Las Vegas Valley CO SIP, the model performance of the UAM for the December 8-9 and December 19-20, 1996 base case episodes were evaluated. Model performance statistics for the 1-hour and 8-hour CO concentrations were calculated and evaluated with respect to the EPA's model performance criteria. These criteria provide an assessment of the UAM model's ability to replicate the magnitude and time of peak concentrations, as well as an overall measure of the bias and error associated with the modeling system and database. In addition, the degree to which the modeling results conform to the conceptual model of CO buildup in the Las Vegas Valley were evaluated.

The result of the model performance evaluation revealed that the paired peak accuracy, the bias in paired (time and space) peaks over all observation sites, and the overall model bias all range from -10% to -12%. This suggests that some consistent error in the modeling is driving the UAM under predictions. Subsequently, a single scaling factor of 1.14 was found to lead to an elimination of these biases and an overall improvement in model performance. Therefore, all UAM predicted CO concentrations were scaled by a factor of 1.14. This same approach is used in the current study. A detailed discussion of the model performance and the rationale for scaling of the LVV CO modeling results can be found Las Vegas Valley CO SIP modeling report (Emery et al., 1999). The reason for the CO underprediction tendency is likely partly due to the underestimation of emission in MOBILE5b model. The new MOBILE6 model that was released after this portion of the study estimates higher CO emissions in 2001 than MOBILE5b.

UAM MODELING RESULTS

Spatial distributions of the daily maximum 1-hour and 8-hour predicted CO concentrations for the 2001 Base Case UAM simulation and the December 8-9, 1996 episode are presented in Figures 4-1 and 4-2, respectively. The predicted 1-hour daily peak is seen in the Las Vegas Boulevard area and an extensive plume of elevated CO concentrations is seen to follow northeast along I-15, continuing east and south along U.S. 95. Additionally, a secondary CO peak occurs in the vicinity of McCarran Airport. The daily maximum 8-hour CO concentrations displayed in Figure 4-2 shows a broad region of high CO concentrations generally following the main transportation corridors. The predicted peak 8-hour CO concentration (9.39 ppm) occurs slightly east of the urban core just north of the southward bend in U.S. 95. The results predicted by the UAM are seen to be consistent with the spatial distribution of CO emissions.

Figures 4-3 and 4-4 display the impacts on the daily 1-hour maximum CO concentrations due to the use of B20 biodiesel fuel for the 50% and 100% penetration levels, respectively. As can be seen, the impacts due to 50% penetration of B20 fuel are generally within 0.01-0.015 ppm with the maximum impact of 0.02 ppm occurring at the location of the 1-hour peak. The spatial distribution of CO concentration reductions reflect the reductions in CO emissions, as expected. Similar results are seen for the 100% penetration of B20 scenario where the impacts range from 0.015-0.02 ppm with a maximum impact of 0.03 ppm, again occurring at the location of the daily peak.

The impacts due to B20 fuel use on the daily 8-hour maximum CO concentrations are displayed in Figures 4-5 and 4-6 for the 50% and 100% penetration of B20 biodiesel, respectively. In both scenarios, minor impacts (0.01 – 0.02 ppm) are present along the major highways while the maximum impact on the peak 8-hour concentrations occurs at the location of the 1-hour peak. For the 50% B20 scenario the maximum reduction in 8-hour CO concentrations is 0.01 ppm, while for the 100% B20 scenario a maximum reduction of 0.02 ppm is achieved. However, at the location of the 8-hour peak, the reductions are significantly lower, implying that the effects of biodiesel fuels are, at best, minimal with respect to achievement of the 8-hour NAAQS for CO in the Las Vegas Valley nonattainment region. Given the relatively small fraction HDDV sources within the total mobile source inventory, these results are not surprising.

The corresponding results for the December 19-20 episodes are displayed in Figures 4-7 through 4-12. Qualitatively the results are similar to the December 8-9 episode although the overall ambient CO concentrations are somewhat higher during this period. Likewise, the impacts due to biodiesel fuels use are minimal ranging from approximately 0.01 ppm to 0.03 ppm, although they are seen to affect a somewhat larger spatial extent than for the December 8-9 episode.

The UAM modeling results are summarized in Table 4-1 with respect to the predicted daily maximum 1-hour and 8-hour CO concentrations for each scenario.

Table 4-1. Peak CO concentrations for base year 2001 and biodiesel scenarios for the Las Vegas Valley.

Scenario	Predicted CO Concentrations (ppm)			
	December 8-9		December 19-20	
	1-Hr Peak	8-Hr Peak	1-Hr Peak	8-Hr Peak
2001 Base Case	17.90	9.39	18.38	13.73
50% Penetration B20	17.89	9.38	18.36	13.72
100% Penetration B20	17.87	9.37	18.35	13.71

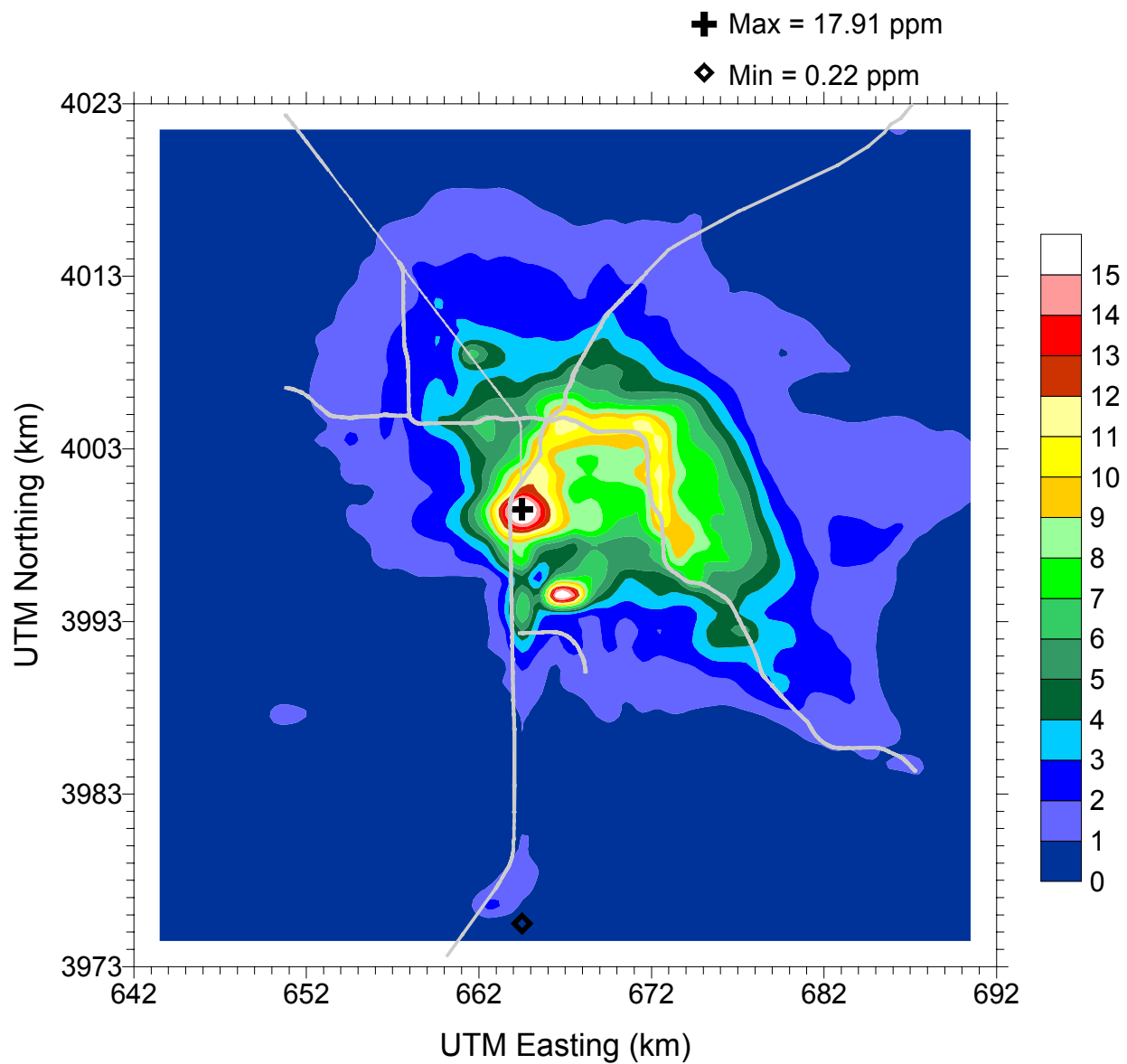
As another measure of the impacts of biodiesel fuels on air quality and human health, various exposure metrics are evaluated for each of the scenarios considered. Spatial coverage (exposure) of the hourly 1-hour and 8-hour CO concentrations above a threshold of 5 ppm are calculated for each scenario considered. As to be expected, the changes due to the use of the B20 biodiesel fuels are small. Also considered are changes in the integrated concentrations of 1-hour and 8-hour CO concentrations (dosage) above the threshold of 5 ppm. Again the impacts are seen to be minimal. These exposure metrics are summarized in Tables 4-2 and 4-3 for each scenario considered.

Table 4-2. Summary of CO exposure metrics for the Las Vegas Valley for the December 8-9 episode.

Scenario	Exposure Metrics for Dec. 8-9			
	Exposure (grid cell-hours)		Dosage (ppm-grid cell-hours)	
	1-Hour	8-Hour	1-Hour	8-Hour
2001 Base Case	1163	740	2146.02	917.34
50% Penetration B20	1160	736	2139.37	913.45
100% Penetration B20	1159	734	2132.76	909.60

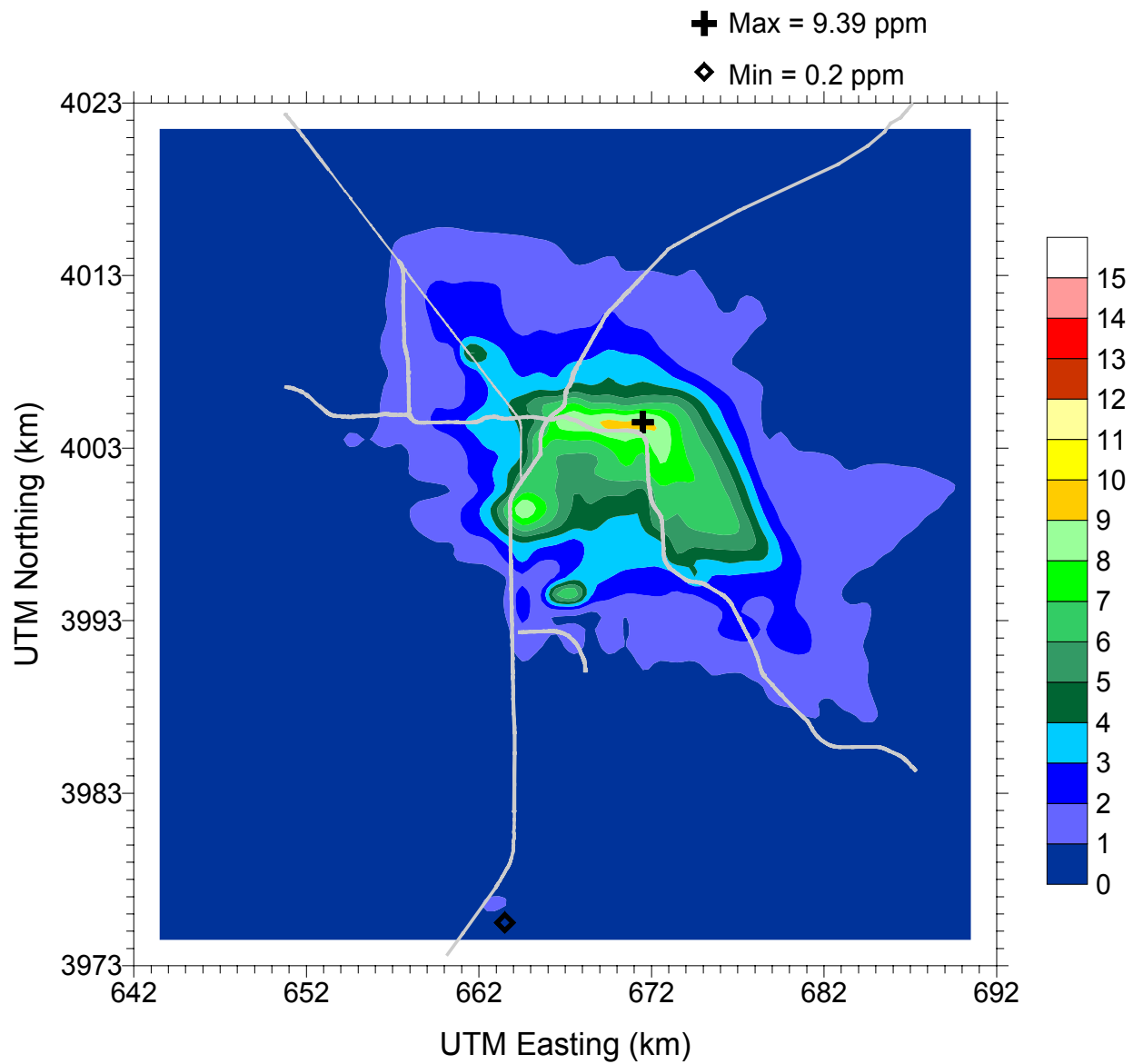
Table 4-3. Summary of CO exposure metrics for the Las Vegas Valley for the December 19-20 episode.

Scenario	Exposure Metrics for Dec. 19-20			
	Exposure (grid cell-hours)		Dosage (ppm-grid cell-hours)	
	1-Hour	8-Hour	1-Hour	8-Hour
2001 Base Case	1432	1002	3997.85	2179.05
50% Penetration B20	1432	1001	3989.47	2173.65
100% Penetration B20	1431	1001	3981.04	2168.22



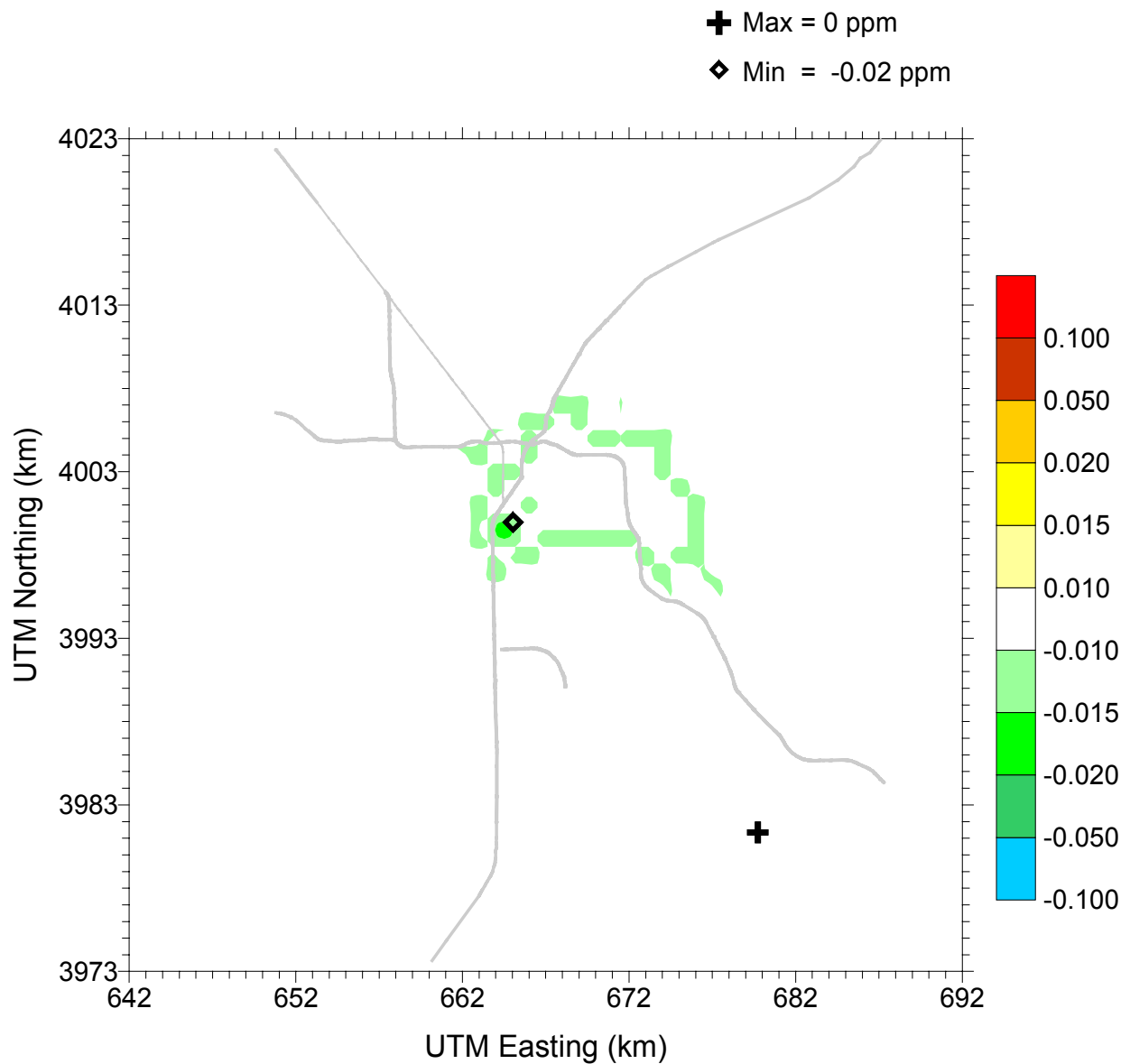
Daily Max 1-Hour CO (ppm) (Scaled by 1.14)
 NREL Biodiesel -- Las Vegas CO 2001 Base Case
 December 8-9, 1996

Figure 4-1. Spatial distribution of 1-hour maximum CO concentrations predicted for the December 8-9, 2001 base case. All UAM concentrations scaled by 1.14.



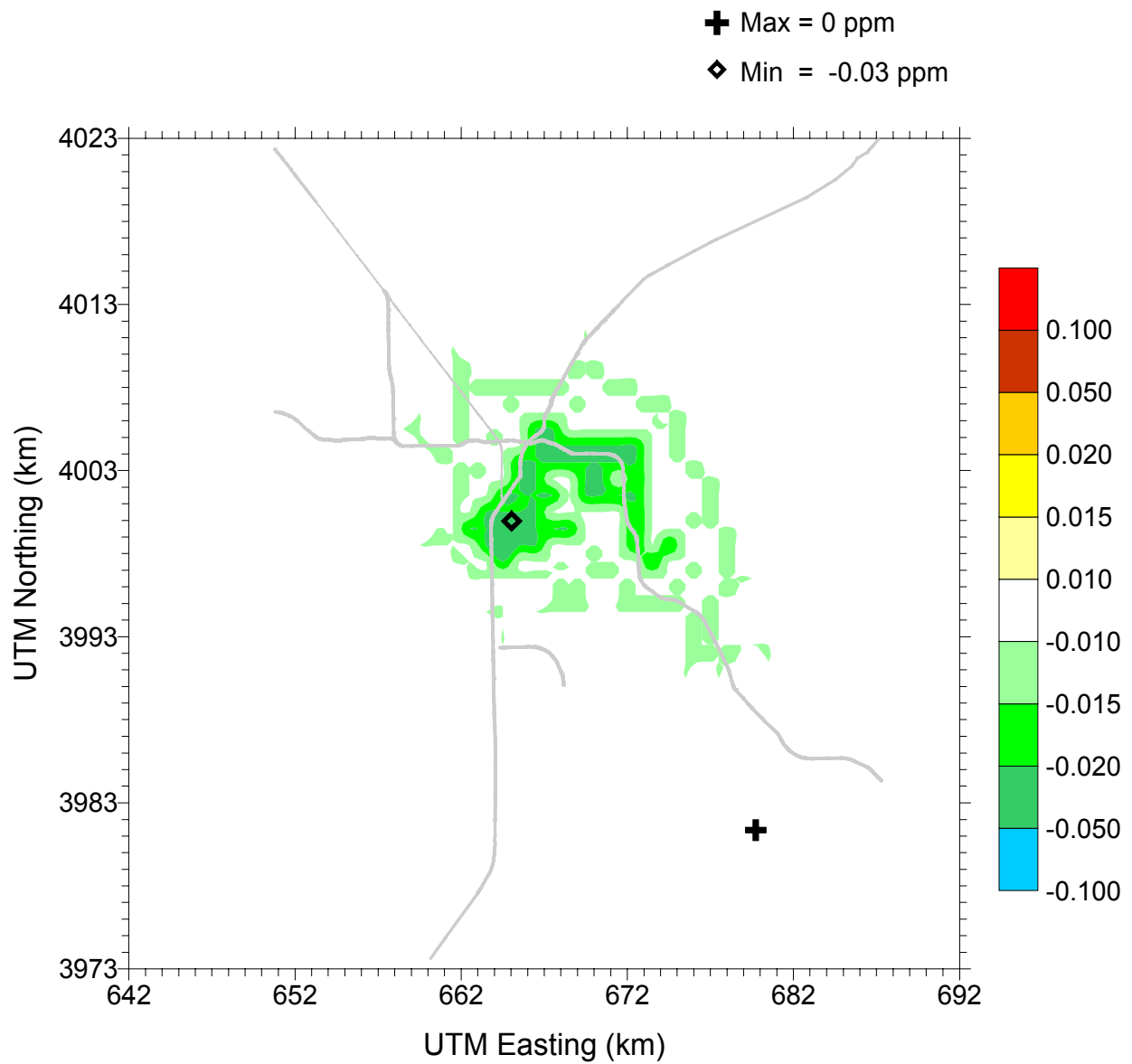
Daily Max 8-Hour CO (ppm) (Scaled by 1.14)
 NREL Biodiesel -- Las Vegas CO 2001 Base Case
 December 8-9, 1996

Figure 4-2. Spatial distribution of 8-hour maximum CO concentrations predicted for the December 8-9, 2001 base case. All UAM concentrations scaled by 1.14.



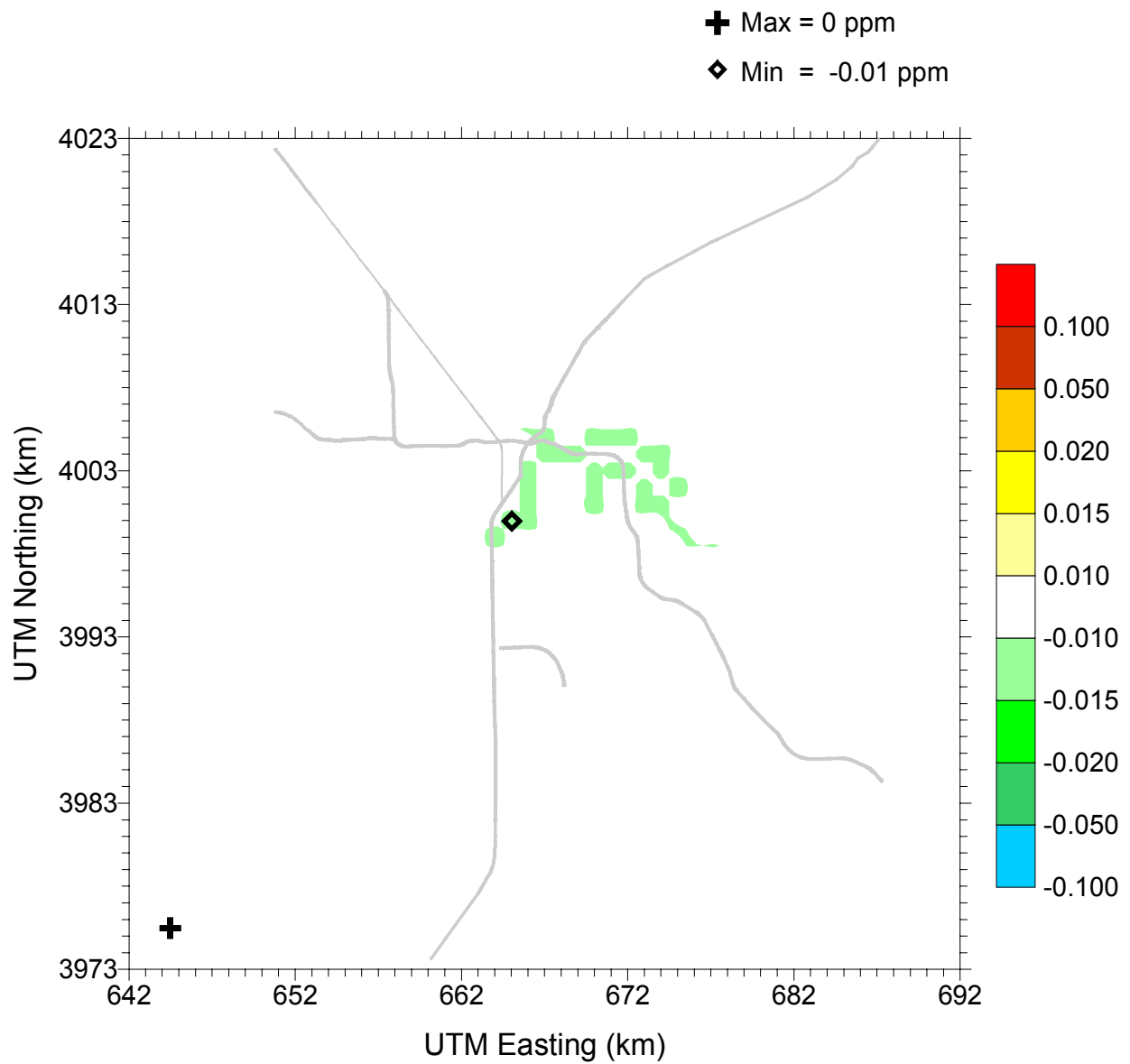
Difference in Daily Max 1-Hour CO (ppm)
 NREL Biodiesel -- Las Vegas CO 2001 50% Penetration B20 Biodiesel minus Base
 December 8-9, 1996

Figure 4-3. Impacts of 50% penetration of B20 biodiesel fuel on 1-hour maximum CO concentrations predicted for December 8-9, 2001.



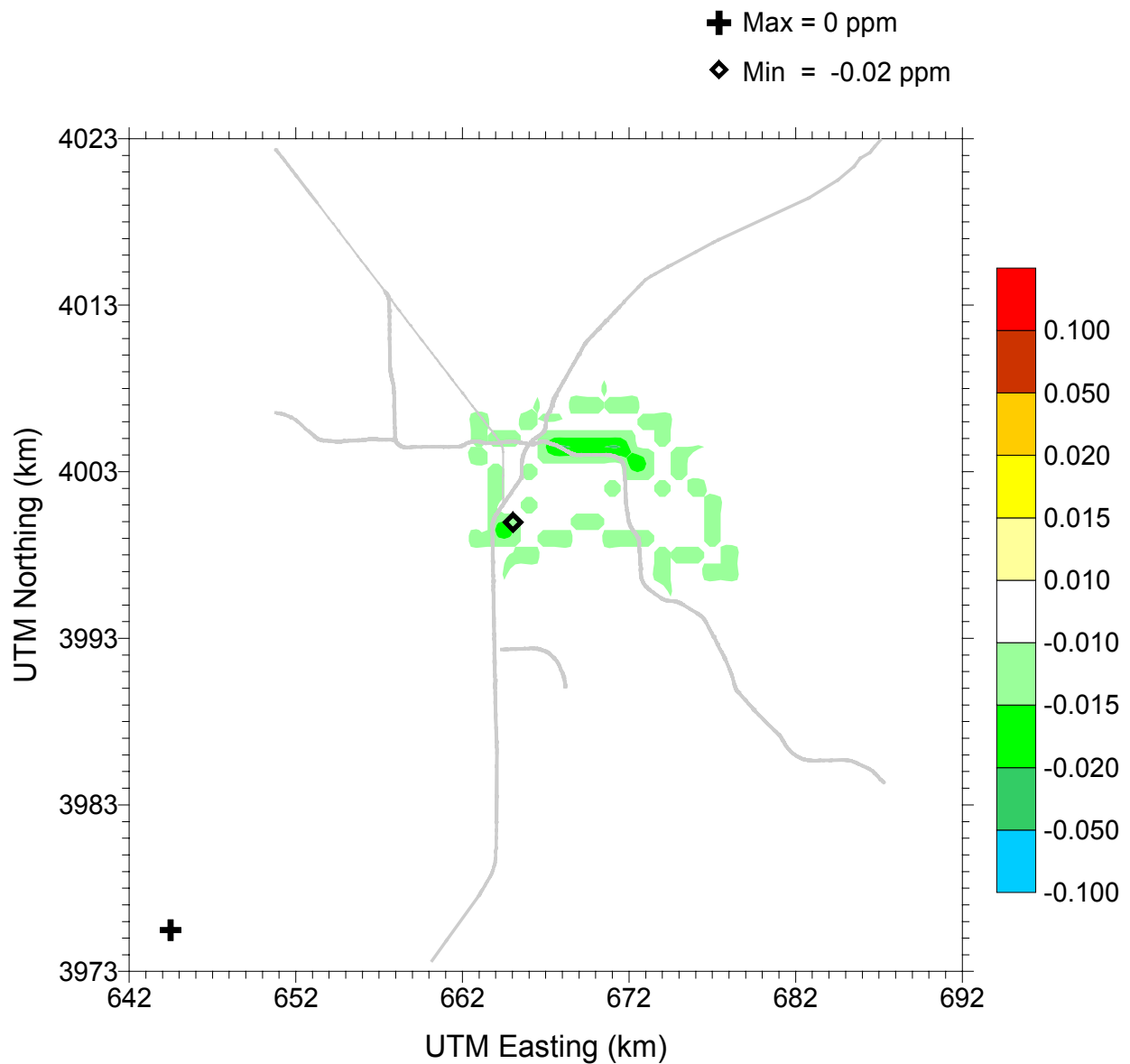
Difference in Daily Max 1-Hour CO (ppm)
 NREL Biodiesel -- Las Vegas CO 2001 100% Penetration B20 Biodiesel minus Base
 December 8-9, 1996

Figure 4-4. Impacts of 100% penetration of B20 biodiesel fuel on 1-hour maximum CO concentrations predicted for December 8-9, 2001.



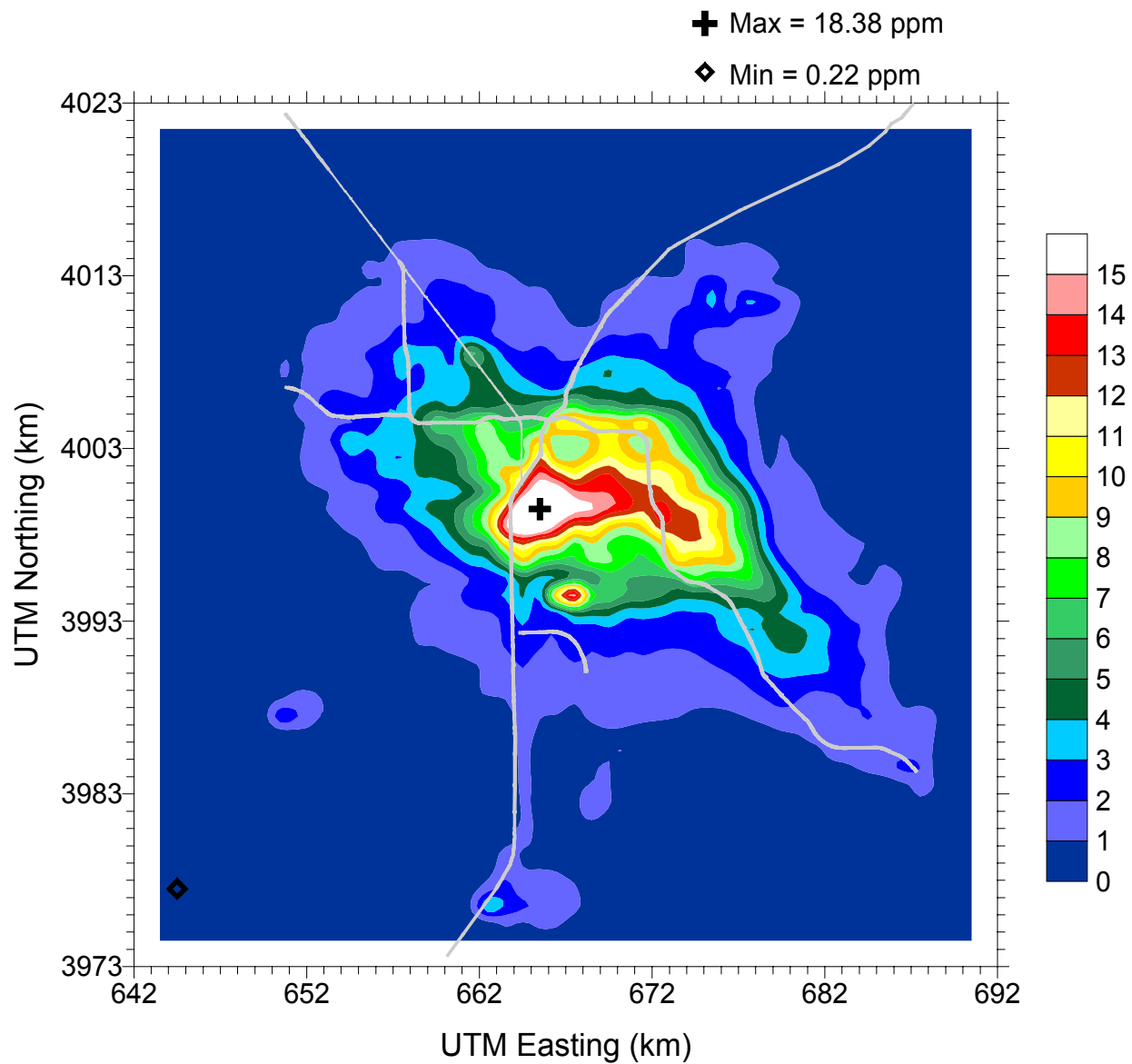
Difference in Daily Max 8-Hour CO (ppm)
 NREL Biodiesel -- Las Vegas CO 2001 50% Penetration B20 Biodiesel minus Base
 December 8-9, 1996

Figure 4-5. Impacts of 50% penetration of B20 biodiesel fuel on 8-hour maximum CO concentrations predicted for December 8-9, 2001.



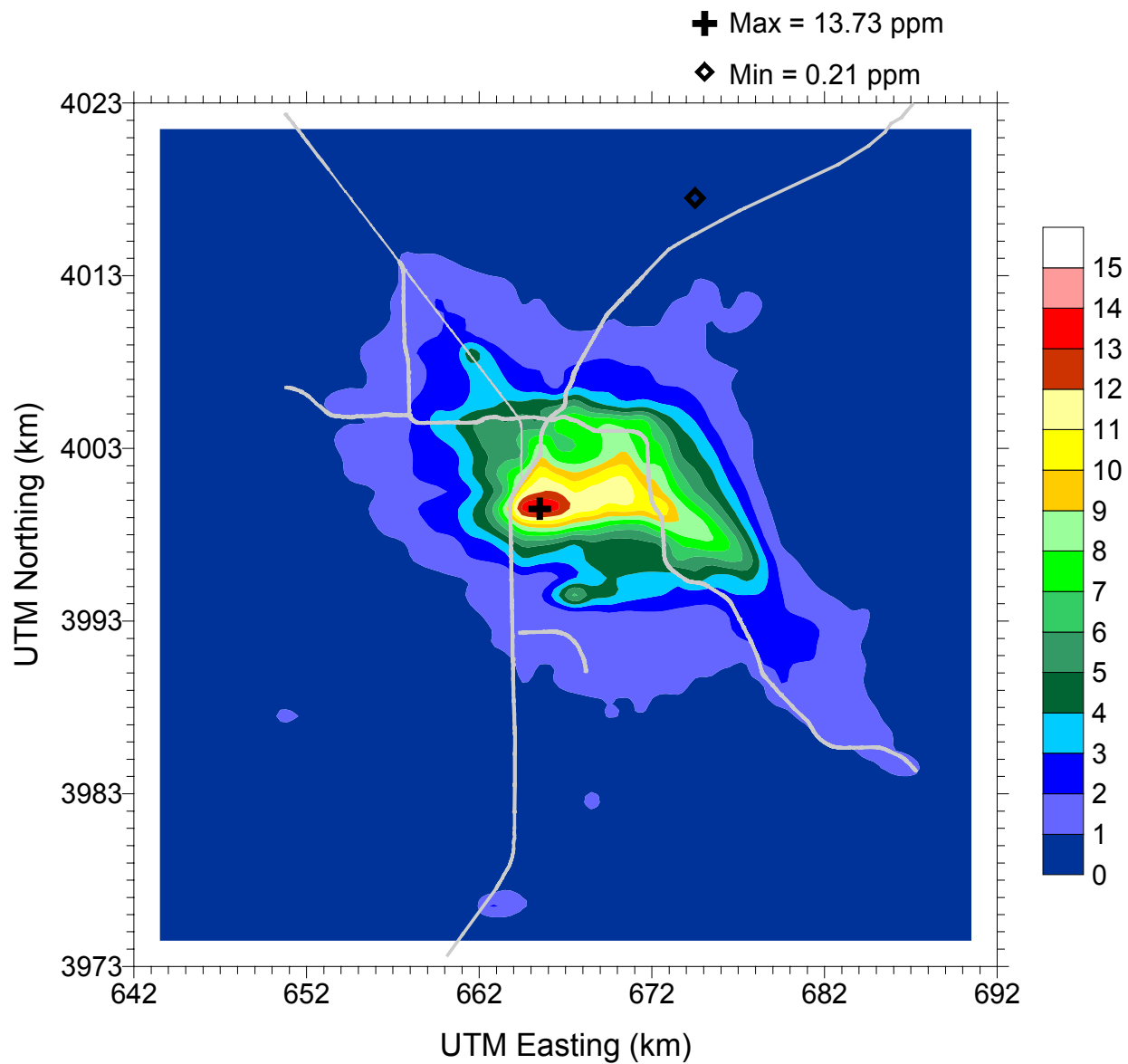
Difference in Daily Max 8-Hour CO (ppm)
 NREL Biodiesel -- Las Vegas CO 2001 100% Penetration B20 Biodiesel minus Base
 December 8-9, 1996

Figure 4-6. Impacts of 100% penetration of B20 biodiesel fuel on 8-hour maximum CO concentrations predicted for December 8-9, 2001.



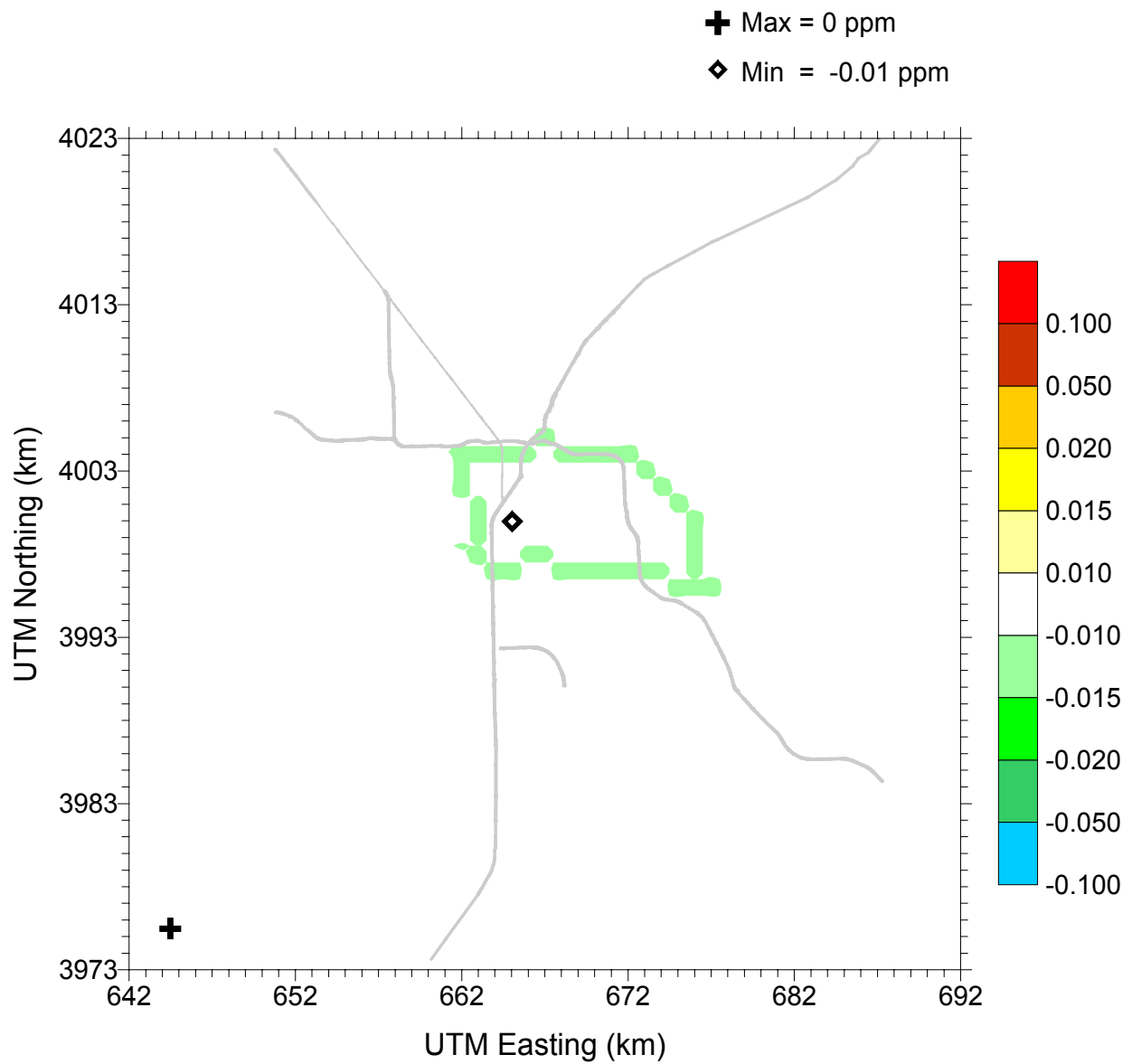
Daily Max 1-Hour CO (ppm) (Scaled by 1.14)
 NREL Biodiesel -- Las Vegas CO 2001 Base Case
 December 19-20, 1996

Figure 4-7. Spatial distribution of 1-hour maximum CO concentrations predicted for the December 19-20, 2001 base case. All UAM concentrations scaled by 1.14.



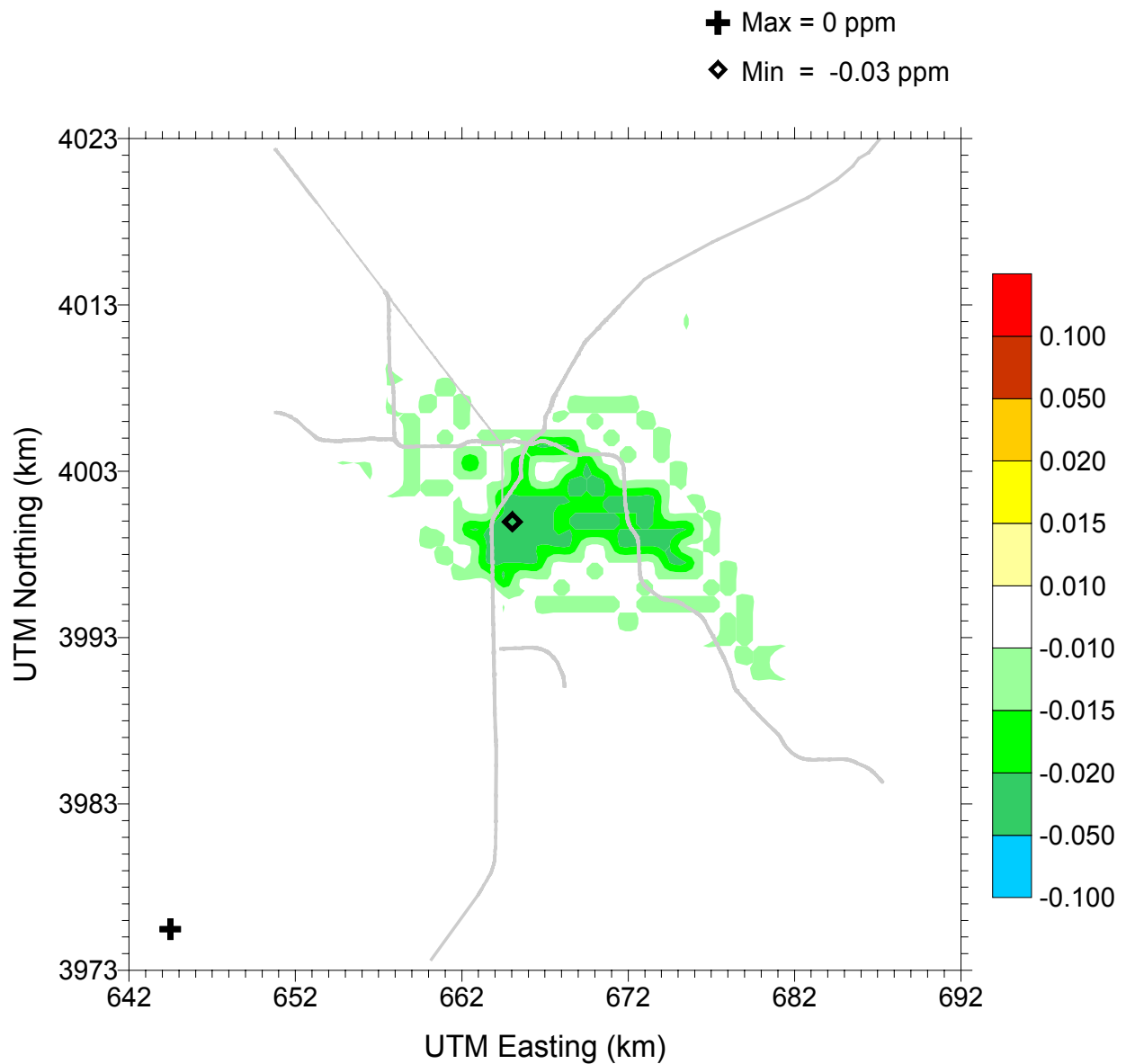
Daily Max 8-Hour CO (ppm) (Scaled by 1.14)
 NREL Biodiesel -- Las Vegas CO 2001 Base Case
 December 19-20, 1996

Figure 4-8. Spatial distribution of 8-hour maximum CO concentrations predicted for the December 19-20, 2001 base case. All UAM concentrations scaled by 1.14.



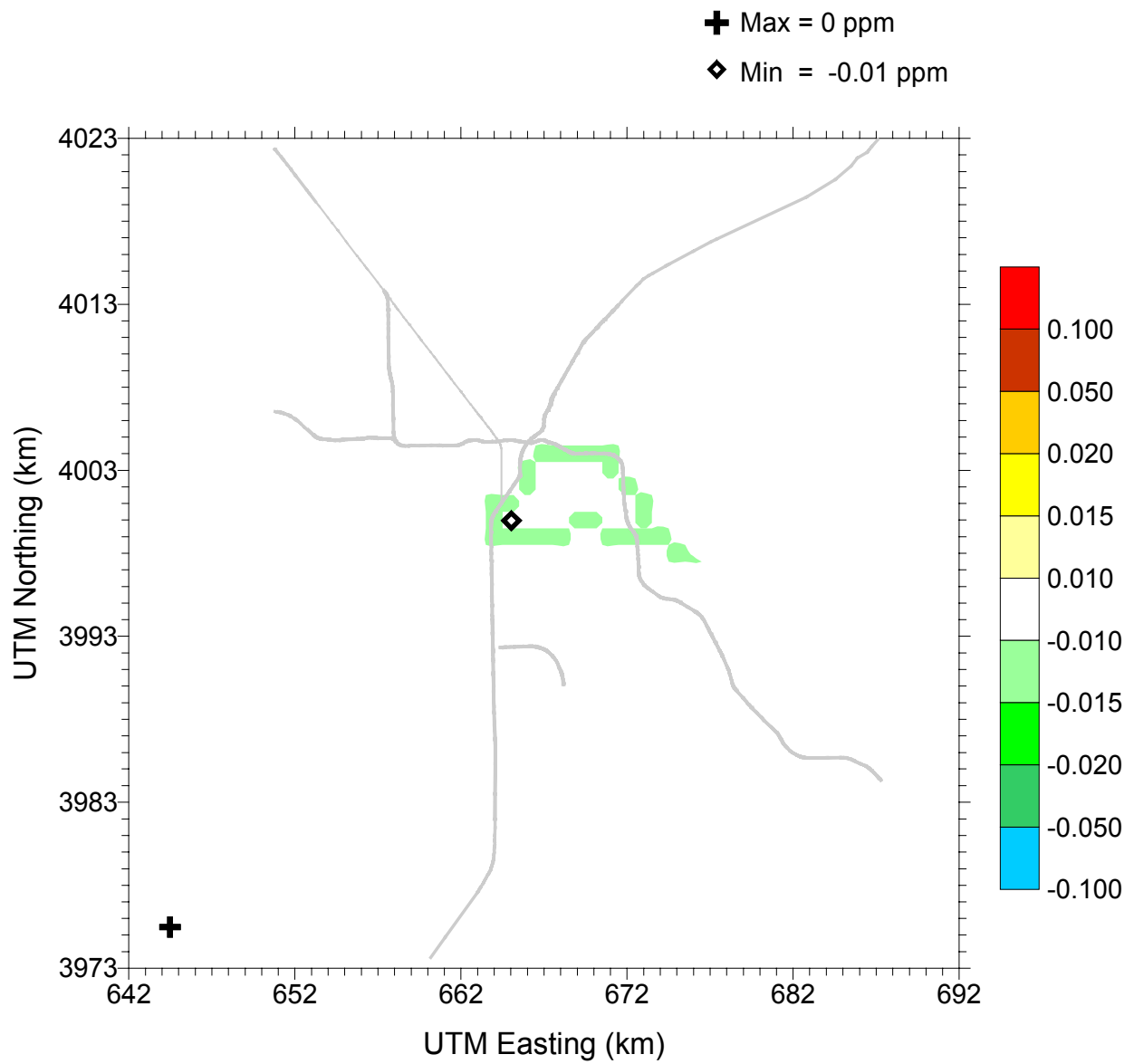
Difference in Daily Max 1-Hour CO (ppm)
 NREL Biodiesel -- Las Vegas CO 2001 50% B20 Biodiesel minus Base
 December 19-20, 1996

Figure 4-9. Impacts of 50% penetration of B20 biodiesel fuel on 1-hour maximum CO concentrations predicted for December 19-20, 2001.



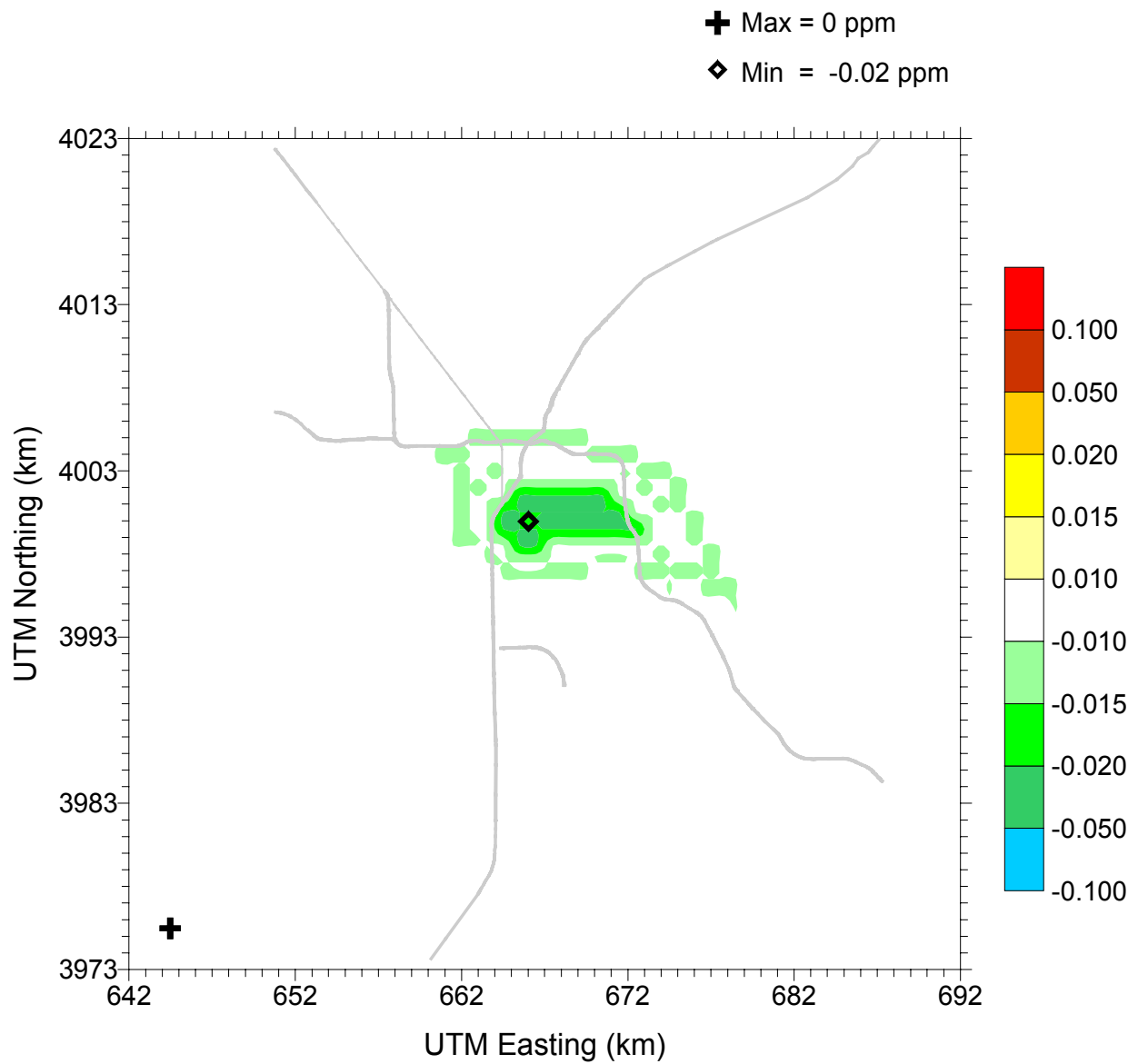
Difference in Daily Max 1-Hour CO (ppm)
 NREL Biodiesel -- Las Vegas CO 2001 100% B20 Biodiesel minus Base
 December 19-20, 1996

Figure 4-10. Impacts of 100% penetration of B20 biodiesel fuel on 1-hour maximum CO concentrations predicted for December 19-20, 2001.



Difference in Daily Max 8-Hour CO (ppm)
 NREL Biodiesel -- Las Vegas CO 2001 50% Penetration B20 Biodiesel minus Base
 December 19-20, 1996

Figure 4-11. Impacts of 50% penetration of B20 biodiesel fuel on 8-hour maximum CO concentrations predicted for December 19-20, 2001.



Difference in Daily Max 8-Hour CO (ppm)
 NREL Biodiesel -- Las Vegas CO 2001 100% Penetration B20 Biodiesel minus Base
 December 19-20, 1996

Figure 4-12. Impacts of 100% penetration of B20 biodiesel fuel on 8-hour maximum CO concentrations predicted for December 19-20, 2001.

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