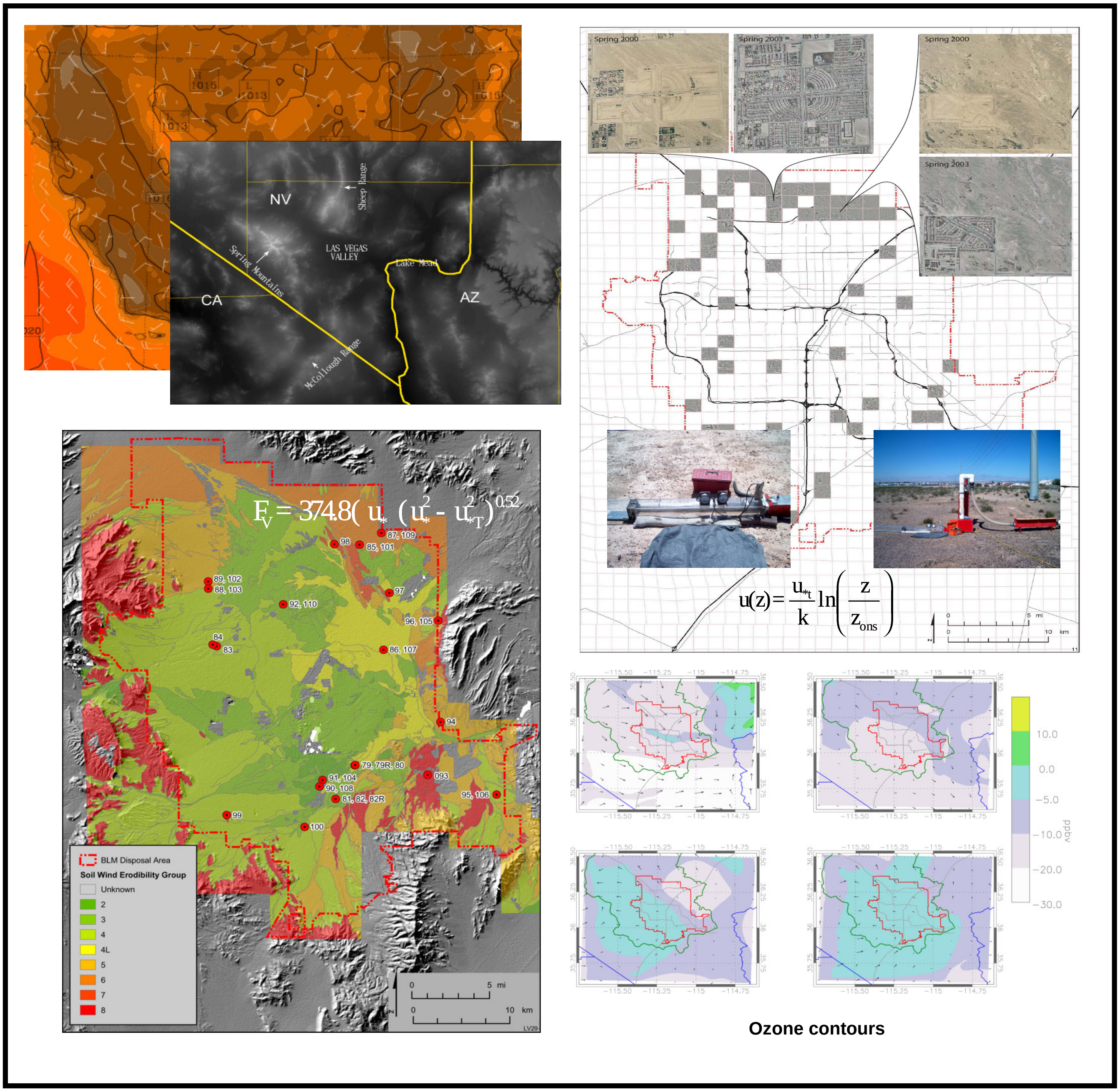
Cumulative Las Vegas Valley Air Quality Modeling Assessment

of Ongoing Bureau of Land Management (BLM) Federal Land Disposition Actions within the BLM Disposal Boundary



Work Conducted in Support of
Current and Proposed Land Disposition Actions
October 1998 through 2018

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Notation

Acronyms and Abbreviations

ADP	automatic data processing
AQD	Air Quality Division
ASOS	Automated Surface Observing System
BACM	best available control measure
BEIS	Biogenic Emissions Inventory System
BELD	Biogenic Emissions Land Cover Database
BLM	U.S. Bureau of Land Management
CAA	Clean Air Act
CARB	California Air Resources Board
CB-4	carbon bond 4
CBER	Center for Business and Economic Research
CCM	Community Climate Model
CFR	*Code of Federal Regulations*
CEM	continuous emissions monitoring
CG	conventional gasoline
CMA	McCarran Cooperative Management Area
CMAQ	Community Multiscale Air Quality (model)
CEM	continuous emissions monitoring
DAQEM	Department of Air Quality and Environmental Management
DDM-3D	decoupled direct method for three-dimensional model
DOE	U.S. Department of Energy
DRI	Desert Research Institute
EC	elutriation chamber
EIS	Environmental Impact Statement
EPA	U.S. Environmental Protection Agency
FAA	Federal Aviation Administration
FDDA	four-dimensional data assimilation
FLPMA	Federal Land Policy Management Act
FR	*Federal Register*
GCM	global circulation model
GIS	geographic information system
GMT	Greenwich mean time
GPS	global positioning system
LEV	low-emissions vehicle
LVFO	Las Vegas Field Office
LVRMP/FEIS	*Las Vegas Resource Management Plan and Final Environmental Impact Statement*
LVWBD	Las Vegas Windblown Dust (model)
MM5	Mesoscale Meteorological (model)
MSL	mean sea level

NAAQS	National Ambient Air Quality Standard(s)
NAD 83	North American Datum of 1983
NAQMS	Nevada Ambient Quality Monitoring Standards
NASA	National Aeronautics and Space Administration
NCAR	National Center for Atmospheric Research
NCEP	National Centers for Environmental Prediction
NDEP	Nevada Division of Environmental Protection
NEI	National Emissions Inventory
NLCD	National Land Cover Database
NOAA	National Oceanic and Atmospheric Administration
PBL	planetary boundary layer
PM	particulate matter
$PM_{2.5}$	particulate matter with a mean aerodynamic diameter of 2.5 μm or less
PM_{10}	particulate matter with a mean aerodynamic diameter of 10 μm or less
PSD	prevention of significant deterioration
R&PP	recreation and public purposes
REMI	Regional Economic Models, Inc.
RFG	reformulated gasoline
RMP	BLM's Resource Management Plan
ROW	right-of-way
RTC	Regional Transportation Commission of Southern Nevada
RVP	Reid vapor pressure
SAAQS	State Ambient Air Quality Standard(s)
SCAQMD	South Coast Air Quality Management District
SCC	source classification code
SCR	selective catalytic reduction
SECC	soil erodability condition class
SIP	State Implementation Plan
SMOKE	Sparse Matrix Operational Kernel Emissions (model)
SNPLMA	Southern Nevada Public Land Management Act
SUV	sport utility vehicle
SWG	Southwest Gas Corporation
TFV	threshold friction velocity
TFV_{eff}	effective threshold friction velocity
UAM-V	Urban Air Shed (model)
UNLV	University of Nevada at Las Vegas
USC	*United States Code*
USDA	U.S. Department of Agriculture
USGS	U.S. Geological Survey
VMT	vehicle mile(s) traveled
VOC	volatile organic compound
WEG	Wind Erodability Group
WRAP	Western Regional Air Partnership

Chemical Notation

CO	carbon monoxide
CO_2	carbon dioxide
H_2S	hydrogen sulfide
NH_3	ammonia
NO_2	nitrogen dioxide
NO_x	nitrogen oxides
O_3	ozone
Pb	lead
SO_2	sulfur dioxide
SO_x	sulfur oxides

Units of Measure

ACFM	actual cubic foot (feet) per minute
d	day(s)
°F	degree(s) Fahrenheit
ft	foot (feet)
g	gram(s)
h	hour(s)
in.	inch(es)
km	kilometer(s)
m	meter(s)
m^2	square meter(s)
m^3	cubic meter(s)
mb	millibar(s)
mi	mile(s)
mi^2	square mile(s)
min	minute(s)
mm	millimeter(s)
mph	mile(s) per hour
ppb	part(s) per billion
ppbv	part(s) per billion, volume
ppm	part(s) per million
ppmv	part(s) per million, volume
psi	pounds per square inch
s	second(s)
yr	year(s)
µg	microgram(s)

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Summary

Cumulative Las Vegas Valley Air Quality Modeling Assessment of Ongoing Bureau of Land Management (BLM) Federal Land Disposition Actions within the BLM Disposal Boundary

S.1 Introduction

A comprehensive air quality modeling study and supporting field measurements were conducted to assess current and future cumulative air quality impacts in the Las Vegas metropolitan urban valley. This study used a third-generation, state-of-the-art Eulerian dispersion model (Community Multiscale Air Quality [CMAQ]/Models-3), along with a fifth-generation prognostic mesoscale meteorological (MM5) model to simulate the influences of atmospheric physics and chemistry on pollutant transport and diffusion. The simulations included complex local terrain influences and addressed transport and diffusion of more than 70 air pollutants over multi-state regional to local scales.

The study revealed that, even employing a conservative assumption — a 50% land development rate[1] of between 1,100 and 1,300 acres per year of BLM-conveyed lands — the health and welfare standards for all criteria air pollutants can be attained and maintained by means of aggressive implementation of existing and planned air emission controls at the county, state, and federal levels. These controls include (1) air pollution emission regulations for new and existing sources (which are being implemented by Clark County in existing State Implementation Plans [SIPs] for attainment and maintenance of national and local air pollution health and welfare standards) and (2) the use of reformulated gasoline (RFG) to control photochemical oxidants within the newly designated nonattainment area within Clark County for the 8-hour ozone (O_3) National Ambient Air Quality Standard (NAAQS).

The principal objective of the study is to determine whether BLM's plan to accelerate the rate of federal land disposition (from approximately 1,300 acres per year to 4,000 acres per year) over a slightly expanded disposal boundary (approximately 22,000 acres) could be accomplished within the resource management objectives spelled out in BLM's Resource Management Plan (RMP). This plan and the supporting Environmental Impact Statement (EIS) addresses BLM's completed land disposal actions since 1998, along with future planned actions through 2018. The specific air resource management objectives spelled out in the plan are consistent with Clark County's mandate for attaining and maintaining all federal and state ambient air quality standards.

[1] At 50% land development or 50% conversion of BLM-conveyed land to private end use, approximately 35,000 acres of newly developed private, recreational, and public-purpose land would be added within the Las Vegas disposal boundary.

S.2 Background

Within the Clark County Las Vegas planning area, Hydrographic Basin 212 is currently designated as a serious nonattainment area for both carbon monoxide (CO) and particulate matter with a mean aerodynamic diameter of 10 μm or less (PM_{10}). Over the past five years (1999–2003), no CO measurements in Clark County have exceeded the NAAQS. However, over the same period, measurements of particulates at more than one location show violations of the 24-hour PM_{10} NAAQS, and measurements of O_3 at the Joe Neal site in North Las Vegas revealed a violation of the 8-hour ozone NAAQS[2]. On April 15, 2004, the U.S. Environmental Protection Agency (EPA) announced that large parts of California and two smaller areas in Nevada and Arizona had been included on its list of over 100 nonattainment areas in 31 states nationwide that failed to meet a new, more stringent 8-hour health standard for O_3. The EPA action included designation of Clark County, Nevada, as a basic nonattainment area (Clean Air Act [CAA] Part D, Subpart 1) for the new federal O_3 standard.

On June 15, 2004, EPA granted the State of Nevada a deferral of the effective date for establishing the boundary of the 8-hour nonattainment designation for Clark County to September 13, 2004. Support for a sub-county designation was provided by the State. The County has 3 years to develop an EPA-approvable SIP to achieve the 8-hour ozone standard as expeditiously as possible; the standard must be met by no later than June 2009 (Kelly 2004).

This cumulative air quality impact study describes the control measures that will be used to attain and maintain the CO and PM_{10} NAAQS spelled out in Clark County's CO and PM_{10} SIPs. The study assumes that the federally required use of lower-volatility RFG with a location-specific, ultra-low Reid vapor pressure (RVP) of 6.8 psi during the "high-ozone season," (from June 1 to September 15 of each year) will be implemented as a part of the federally approved O_3 SIP in 2009. In the study, we account for the required use of RFG (a fuel-based control measure), as well as the federally required technology-based cleaner engine standards that take effect beginning with 2004 model-year light-duty automobiles.[3] In addition to RFG, the approved O_3 SIP will likely adopt a set of transportation control measures, such as area-wide ride-sharing incentives and improved public transit, specific to designated nonattainment areas (as needed and required by Part D, Subpart 1 of the CAA for O_3 nonattainment areas); these transportation measures were not evaluated during this study. Brief descriptions of the study and the study results are provided on the following pages.

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[2] The 8-hour O_3 standard is not met if the 3-year average of the annual fourth-highest daily maximum 8-hour O_3 concentration is greater than 0.08 ppm (0.085 ppb rounded up). An O_3 measurement of 86 ppb averaged over the 2001–2003 period was obtained at the Joe Neal site in North Las Vegas.

[3] These standards are referred to as the Tier 2 federal vehicle emission standards, or the new tailpipe standards, which are set at an average of 0.07 g/mi for nitrogen oxides (NO_x) for all classes of passenger vehicles beginning in 2004. These include all light-duty trucks, as well as the largest sport utility vehicles (SUVs). Vehicles weighing less than 6,000 pounds will be phased into this standard between 2004 and 2007. For new passenger cars and light-duty trucks, these standards will phase in beginning in 2004 (fully phased in by 2007). For heavy light-duty trucks and medium-duty passenger vehicles, the Tier 2 standards will be phased in beginning in 2008, with full compliance in 2009.

S.3 Study Description

The modeling simulations completed for this study account for local volatile organic compound (VOC) and nitrogen dioxide (NO_2) emissions and the long-range O_3 transport from Los Angeles, along with the synoptic and local-scale weather measurements used in simulating the complex, terrain-influenced meteorological conditions for the Las Vegas Valley. The predicted PM_{10} exceedances are suspected to be primarily caused by windblown dust "natural events." In these cases, according to EPA natural events policy, exceedances of the PM_{10} NAAQS are not construed as causing violations of the federal PM_{10} standards. The policy gives the states sole discretion in determining standard violations caused by a natural event.

The modeling analysis included conservative assumptions concerning the rate of BLM land disposition and associated land development over the next 10 to 15 years. The cumulative assessment fully considered the growth in the Valley attributable to development of conveyed BLM land and private lands through use of projected population and economic growth for Clark County. The 2009 and 2018 projections account for emission changes caused by future land development and for changes in soil sheltering that result from this development.

Although the study included the assessment of a comprehensive set of air pollutants (over 70) from numerous sources (approximately 800 within Clark County), emphasis was placed on the cumulative impacts from current and future emissions of PM_{10} and CO and the formation of O_3 from its principal directly emitted precursors: NO_x and VOCs. The research team compiled and developed detailed spatial and temporally varying air pollutant emissions from both human activities (e.g., emissions from smoke stacks, vehicle exhausts, construction activities) and natural source origins (e.g., biogenesis, windblown dust). For non-BLM-related land disposition emissions, the emissions from existing permitted and non-permitted sources are based on actual measured stack data or are derived from source activity levels and source emission factors. Future emissions were adjusted on the basis of projected county-wide population growth forecasts.

S.4 Study Results — Cumulative and BLM-Associated Air Emissions

The cumulative air quality modeling analysis included the development and compilation of a comprehensive air emissions inventory for a 2000 base year (i.e., baseline analysis) and three future or projection years (2006, 2009 and 2018). The estimated CO, PM_{10}, NO_x, and VOC emissions attributable to BLM land disposition actions, i.e., associated with development on conveyed federal lands and end use of these lands, are summarized in Table S-1. The BLM-associated O_3 precursor emissions (VOCs and NO_x) for the base-year analysis represent less than 1.3% of the total Clark County emissions for these pollutants. In 2009, percentages of County totals increase to approximately 9%. By 2018, BLM's contribution to County VOC and NO_x totals represents approximately 14% and 11%, respectively. The reduction in electric generating capacity due to the anticipated retirement of the Mohave Generating Station is expected to be compensated for by several current and planned new combined-cycle power plants within the

TABLE S.1 Baseline (2000) and Future-Year (2009 and 2018) BLM Land Sale Emissions

Air Emission Source	Year[a]	Emissions (tons)[b]			
		CO	NO_X	VOC	PM_{10}
BLM land disposition	2000	4,005	791	371	1,187
Development-attributable emissions	2009	29,301	3,668	1,900	11,101
	2018	47,947	4,805	2,472	20,581
Cumulative Clark County emissions	2000	294,275	77,752	28,126	87,896
	2009	301,387	53,763	21,059	115,945
	2018	305,508	44,921	17,333	135,380
% of BLM contribution to Clark County totals	2000	1.4	1.0	1.3	1.4
	2009	9.7	6.8	9.0	9.6
	2018	15.7	10.7	14.3	15.2

[a] In the calculations, construction emissions denote those occurring during the year of interest, and operation emissions denote those occurring from BLM lands patented [e.g., conveyed from BLM ownership or title] through the year of interest since 1998.

[b] Rounded to the nearest ton.

Las Vegas Valley, with capacities three times greater than that of Mohave. The NOx emissions from the new combined-cycle natural gas plants will be approximately 1/8th of the current emissions from the Mohave coal-fired plant. Current NO_X emissions (approximately 22,000 ton/yr) from the Mohave, which is the largest single pollution sources in Clark County, represent approximately 28% of the County totals. By contrast, the BLM-related NO_X emissions are only at approximately 800 ton/yr for the baseline land development and 3,700 ton/yr by 2009. The projected 2009 NO_X emission levels from BLM-related development in the Valley is expected to represent less than 7% of the County totals.

The emissions associated with development of BLM-conveyed land were estimated on the basis of a conservative set of assumptions that factor in land disposition, conveyance, and end-use development rates, and also construction initiation and end-use-dependant construction completion durations (3 to 12 months, depending on project size and end use). In general, two types of emissions are associated with BLM land disposal and development: temporary emissions generated during construction and permanent emissions associated with the land use, such as those from vehicle traffic (on-road vehicle exhaust and paved road dusts), electricity use, and space heating. Emissions resulting from electricity use would be lower than current emissions because one of the most polluting coal-burning power plants in the United States, the Mohave Generating Station, is expected to close in 2006. The shortfall in electricity that results from closure of the plant would be supplied by newly built clean-fuel facilities in the Las Vegas Valley or imported from the regional electricity grid.

In addition to the changes in emissions during development and end use, another change occurs between when the land is vacant (pre-construction) and when the land is fully developed and in use (post construction): a decrease in wind-generated dust from previously vacant lots. This particular change is significant, and the modeling shows a net *reduction* in PM_{10} concentrations over some areas within the BLM boundary. Although in estimating the emissions associated with the end use of the developed land, researchers used common vehicle commute distances and energy use emission factors, the emissions differences depend on the assumed unit size, commute distance, and energy consumption differences between each land-use category. The predominant baseline developed land use ranged from less than 1% (new hotels/casinos) to 80% (single-family housing) of the total developed acreage. By 2018, developed office, retail, and casino/hotel space are assumed to occupy a larger share of the developed land, as the growth in new single-family residential units slows. Nevertheless, the developed land space from single-family housing projects is assumed to continue its dominance of the total developed land acreage. The total BLM-related land development and use emissions for PM_{10}, CO, NO_x, and VOCs during the baseline period are estimated to be less than 2% of the total emissions for Clark County in 2000. By 2018, emissions of these pollutants from BLM land development are expected to represent between 14% (VOCs) and 11% (NO_x) of the total County emissions.

This study also included the development and use of a comprehensive natural source emissions inventory to complement the emissions inventory developed for man-made (or anthropogenic) sources. Particular attention was given to the proper characterization of the Las Vegas Valley windblown dust problem through the use of field measurements (taken with a portable wind tunnel) and development of a set of parametric native soil dust equations to estimate wind-suspended PM_{10} emissions and to model the cumulative air quality impacts from these emissions. Properly characterizing the relative magnitude of the windblown dust contribution to areas that experience high PM_{10} concentrations is important to determining the relative contribution from natural vs. man-made sources.

The cumulative air quality impacts for the criteria air pollutants are summarized in the following paragraphs.

Ozone (O_3) and Carbon Monoxide (CO) — On the basis of the study results, the baseline (2000) and future (2018) O_3 and CO cumulative air quality impacts are expected to be well within the respective 1-hour average health standards (NAAQS and State of Nevada standards), as well as the 8-hour CO standards. By 2018, CO levels (1-hour averages) are not expected to increase more than 2 ppmv. Although the modeled O_3 concentrations for the summer of 2000 were generally lower than the observed values, the differences were small; on average, they were within 15% of the measured values. However, the highest modeled 1-hour concentration (104 ppb) among the monitoring stations is only 3 ppb lower than observed concentrations, although they are predicted to occur at different times and locations. The highest predicted concentrations of 107 ppb in 2009 and 109 ppb in 2018 over the domain are well below the 120-ppb O_3 standard. Maximum O_3 decreases of 14 ppbv were calculated in regions corresponding to a calculated peak O_3 episode day (July 31) in the model baseline simulation. Small increases (on the order of 5–10 ppbv) in O_3 occur in the urban core. The urban core in general has peak O_3 values of 15 ppbv lower than peak values calculated for the entire Valley.

The cumulative 1-hour average O_3 impacts between 2000 and 2018 show the highest level of O_3 changes to be north of the city center.

The peak 8-hour average O_3 concentration of 90.1 ppbv in 2000 is predicted to occur in the north-northeast portion of the Las Vegas Valley during southwesterly flow and temperatures near 100°F. In 2009 and 2018, peak O_3 levels are estimated at 84.6 ppbv and 82.3 ppbv, respectively. With the assumed use of RFG by 2009, model projections of 8-hour O_3 concentrations are expected to decrease by 5 to 10 ppbv over most of the BLM boundary, with an average 5 ppbv increase for a small, isolated area in the city center. Maximum increases of up to 12 ppbv during off-peak hours (late evening/nighttime) were calculated. This level of improvement in air quality is estimated to cover the entire model domain, except for the urban core area. These improvements will be achieved with the use of ultra-low-RVP gasoline and phase-in of new, cleaner vehicle engines beginning in model year 2004. Further reductions will likely occur with implementation of specific transportation control measures developed for Clark County's O_3 SIP.

Ozone transport from the Los Angeles air basin was shown to contribute significantly to cumulative O_3 impacts within the Las Vegas Valley, with long-range contributions between 6% and 8% during high-O_3 episodes days (65 to 85 ppbv). Therefore continued efforts to address the long-standing ozone problem in Los Angeles will be important to the success of future control measures in Las Vegas to address the its current O_3 nonattainment status.

The assumptions used in projecting future BLM end-use-related emissions, including O_3 air quality impacts, are generally conservative. This is especially true as it relates to vehicle-generated O_3 precursor emissions. These emissions were based on an assumed future-year BLM conveyed land development rate that is over 30% greater than the actual historical rate of BLM-conveyed land development between 1998 and mid-2002. In addition, the assumed added vehicle miles traveled (VMT) per year (10,000 to 15,000 to commute to office, store, local activities) would also produce conservative (i.e., higher than actual) estimates in vehicle-related smog-producing emissions.

Particulate Matter (PM_{10} and $PM_{2.5}$) — Major PM_{10} sources consist of windblown dust from vacant lands, construction dust, and dust from paved and unpaved roads. In the Las Vegas Valley, windblown dusts from vacant lands account for more PM emissions than any other emission source whenever they occur. In the base year (2000), the 211 $\mu g/m^3$ maximum predicted PM_{10} concentration occurred over the extreme southern end of the designated BLM boundary. During this episode, on July 30, winds in the southern portion of the Las Vegas Valley exceeded 30 mph, which produced significant locally generated windblown dust emissions. It is estimated that windblown dust from native soil on vacant lots contributed up to 40% of the peak concentration during this episode. On May 10, 2000, a major windstorm swept over the Valley, and PM_{10} concentrations at more than half of the monitoring stations exceeded the standards. The windblown dust model developed for this study and incorporated in CMAQ is limited to locally generated dust from urban-valley native soils; it is not applicable to the large-scale dust storm conditions that occurred on May 10, 2000. These dust storms typically involve transport of Mohave Desert dust from California. On August 12 and 13, 2000, high PM_{10} concentrations were reported at several monitoring stations, albeit at relatively low wind speeds. This episode is probably linked to the California wildfires, some of the worst in U.S. history. Except for the two major episodes described, there was only one exceedance in 2000 (minor impacts would be predicted related to anthropogenic sources only).

In future years, PM_{10} emissions associated with BLM land sales and the population and economic growth of Clark County are projected to increase; but windblown dust from vacant lands will decrease because of land development. The baseline modeling assessment shows relatively high PM_{10} concentrations in a region of the Valley that straddles the southwest corner of the BLM boundary and in an area in the southeast portion of the boundary. The high concentrations in the southwest region appear to be primarily caused by model-simulated windblown dust, while modeled concentrations in the southeast portion are contributed by on-road vehicle resuspension from two nearby interstate highways, construction-related emissions, and native windblown dust.

Future-year projections show the maximum incremental increase (26 $\mu g/m^3$) in PM_{10} between 2000 and 2018; this increase is limited to a hot spot near the southern end of Las Vegas. The future-year projections also show a concentration increase of less than 5 $\mu g/m^3$ in the southern and southeastern ends of the Valley. For most of the Valley, the model shows no change or a reduction in concentrations compared to the baseline cumulative impacts assessment.

$PM_{2.5}$ emissions, or fine (with a mean diameter of 2.5 μm or less) particles, originate from fuel combustion from a variety of sources, such as motor vehicles, power-generating stations, other industrial facilities, and residential fireplaces and wood-burning stoves. Secondary fine particles also form from the interaction of chemicals, such as SO_2, NO_x, and VOCs, with other compounds in the air. Levels of $PM_{2.5}$ may be affected by smoke from large fuel sources, such as forest fires, or by dust storms. The attainment status for Las Vegas Valley is currently under review, and no exceedances have been monitored for 24-hour and annual averages in the Valley. Air quality modeling for the base and future years indicates that no exceedances are expected.

Nitrogen Dioxide (NO_2) — Primary emissions of NO_x are from motor vehicles; electric utilities; and other industrial, commercial, and residential sources that burn fuels. NO_2 is one of the ozone-forming precursors (along with VOCs) that is converted into nitrate via chemical reactions. The nitrite is a major contributor to acid deposition and visibility degradation. Monitoring data for the period 1999 through 2000 indicate that NO_2 concentrations are higher at monitoring stations along major Las Vegas highways; 110 ppbv and 27 ppbv for 1-hour and annual averages respectively. Concentrations at other monitoring stations are quite low. Projected future emissions would decrease and, thus, future concentrations of NO_2 would remain the same or be lower than those for the base year.

Sulfur Dioxide (SO_2) — Primary emission sources for SO_2 are electric utilities and industrial facilities that burn fossil fuels containing sulfur, such as coal and oil, predominantly from a coal-burning power plant in Clark County. Other sources are on-road and non-road mobile sources and aircraft sources (from landings and takeoffs), but their contribution is less than 2% in the Valley. Based on recent monitoring data in Clark County, ambient SO_2 concentrations are less than 7% of their respective standards. Considering a decrease in SO_2

emissions in the future, potential ambient air quality associated with future BLM and Clark County activities would improve.

Lead (Pb) — In the past, automobile sources were the primary contributor of Pb emissions into the atmosphere. As a direct result of the phase-out of leaded gasoline in automobiles, lead concentrations in urban areas have decreased dramatically. Although nonferrous smelters and battery plants are now the major sources for release of Pb emissions into the atmosphere, their emissions are limited to the vicinity of their facilities, which are mostly located in remote areas. Ambient lead concentrations are generally so low that Pb monitoring is no longer done in many parts of the country, including Nevada.

Although emissions associated with future land development resulting from BLM land sales and the concomitant population and economic growth in the Valley are expected to increase, future reductions in on-road vehicle emissions and non-road-related emissions are expected to contribute to offsetting any increase in Pb emissions that results from land development. Above all, many vacant lands, predominant PM sources in the Valley, would be developed as a result of BLM land sales, which would reduce erodible soil surface areas, as well as associated windblown dust emissions.

1 Introduction

Clark County, Nevada, is located at the southernmost tip of the state. It encompasses approximately 5.12 million acres of land having a wide variety of urban, rural, recreational, and environmental uses. Only about 10% of the land in the county is not under federal control (e.g., it may be under private ownership, under state or local government ownership, or on an Indian reservation). The population center of Clark County is the city of Las Vegas and the surrounding communities in the Las Vegas Valley, which is currently the fastest-growing metropolitan area in the United States. The most current (2003) population figures show that the population of the Las Vegas metropolitan area, including the municipalities of Las Vegas, North Las Vegas, Henderson, Boulder City, and 14 other communities in the Las Vegas Valley, is 1,620,748 (Source: State of Nevada Demographer's Office). In addition, the annual average tourist population is estimated at 582,000.

The Las Vegas Valley is essentially equivalent to Hydrographic Basin 212. The Clark County PM_{10} nonattainment area (Figure 1.1) mirrors Hydrographic Basin 212. (PM_{10} is particulate matter with a mean aerodynamic diameter of 10 μm or less. Major sources of PM_{10} include suspended or resuspended windblown dust and soot from fossil fuel combustion.) Outside the Las Vegas Valley, a number of growing rural communities are scattered across the county. All of these communities either contain or are surrounded by lands administered by federal agencies. The U.S. Bureau of Land Management (BLM) is responsible for administration of about 63% of the federally owned land in the county.

The *Proposed Las Vegas Resource Management Plan and Final Environmental Impact Statement* (LVRMP/FEIS) (BLM 1998) provides for 20 years of management direction for approximately 3.4 million acres of public lands and federal mineral estate within the Las Vegas District, which is administered by the BLM's Las Vegas Field Office (LVFO). The BLM-administered lands include approximately 2.6 million acres in Clark County, 700,000 acres in Nye County, and 111,100 acres of mineral estate (where the surface is not federal land). The LVRMP/FEIS also provides planning guidance for the BLM's management and protection of a broad spectrum of environmental resources associated with BLM land disposition authorizations.

The BLM LVFO land authorizations cover, but are not limited to, disposition actions by sale of land to the general public, whether through oral or Internet auction,[1] direct sale, or exchange. The legal authorization for land sales through auctions and exchanges is contained in the Southern Nevada Public Land Management Act (SNPLMA), which was enacted into law in October 1998. The purpose of the SNPLMA is to provide for the orderly disposal of certain federal lands in Clark County. The SNPLMA also provides for BLM's acquisition of environmentally sensitive lands in Nevada through direct purchase or exchange. The authorization provided by the SNPLMA allows BLM to sell public land within a specific boundary around Las Vegas. Sale or lease of public lands to state and local governments and to

[1] Both oral and Internet auctions are public auctions.

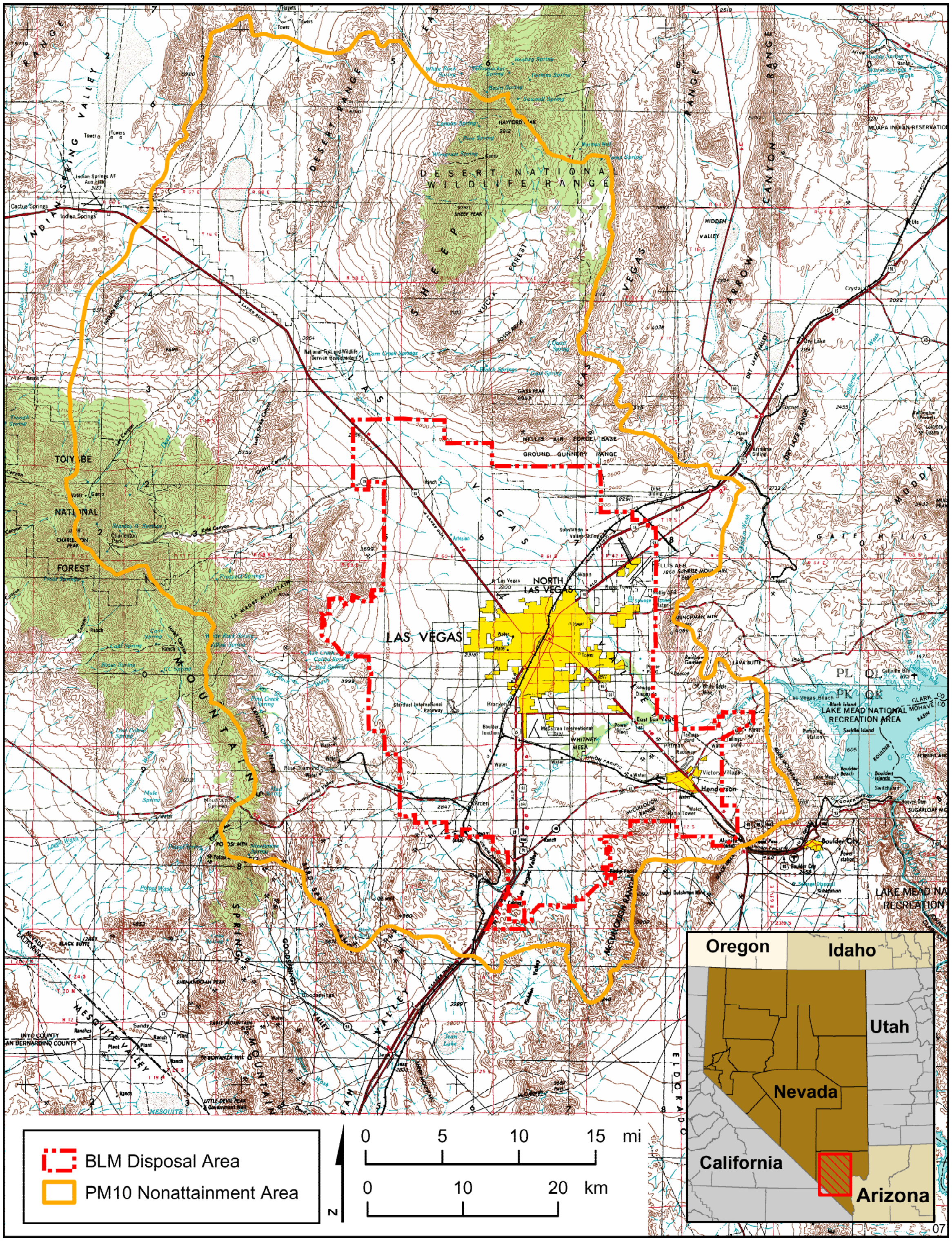

FIGURE 1.1 BLM Disposal Area Boundary

qualified nonprofit organizations is also allowed for specific recreational or public purposes. Such conveyances are authorized under the Recreation and Public Purposes (R&PP) Act (68 Statute 173; 43 *United States Code* [USC] 869 et seq.). Examples of some typical R&PP end uses are parks, fairgrounds, campgrounds, schools, fire houses, law-enforcement facilities, municipal facilities, landfills, churches, and hospitals. Other federal land conveyances are authorized by granting rights-of-way (ROWs), issuing recreation permits, and authorizing federal construction and gravel pits.

The area within Clark County covered by the above land disposal actions is referred to as the “BLM disposal boundary.” The original BLM disposal boundary established under the authorization of the SNPLMA covered 303,776 acres of federal, local/county, and private lands within the Las Vegas Valley. One estimate indicated that about 62% of this original area was primarily vacant land (PM_{10} State Implementation Plan [SIP], Clark County 2001). The BLM land lying within this boundary and authorized for disposal by sale or exchange under the SNPLMA consisted of approximately 50,000 acres, equivalent to about 30% of the existing vacant land. Recent amendments to the SNPLMA have slightly expanded the boundaries and added approximately 21,670 acres; the present total BLM disposal boundary is about 71,670 acres. In addition to the lands authorized for disposition through sale and exchange, another approximately 17,000 acres is available for lease, ROWs, or transfer. These land actions, such as granting of ROWs for power lines, are not expected to result in any significant change in end use and therefore would pose a relatively small change in the air quality of the Las Vegas Valley. The boundaries of the expanded BLM disposal area are shown in Figure 1.1, along with the boundary for the designated PM_{10} Clark County air quality nonattainment area.

The initial BLM land disposal authorization after the passage of the SNPLMA involved approximately 16 acres of land, sold under the conveyance authority of both the SNPLMA and R&PP in November 1998. As of December 31, 2003, approximately 20,330 acres of BLM land had been conveyed through auction, exchange, or transfer. These actions included 16 land sales offered through oral or Internet auction, resulting in the sale of 306 parcels covering 5,656 acres since the passage of the SNPLMA (BLM 2004). Most of the individual sales thus far were sales of fewer than 50 acres, with many sales around 2.5 acres (Fry 2003). The average rate of BLM land disposal over the last 5 years has been approximately 4,000 acres annually.

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2 Study Scope and Purpose

The primary purpose of this study is to provide a detailed technical supplement to the Affected Environment and Environmental Consequence chapters for air quality in the LVRMP/FEIS (BLM 1998). The scope of this study is limited to the assessment of impacts on air resources in the Las Vegas Valley. The air quality modeling analysis provides a comprehensive assessment, over four time periods, of the cumulative potential air quality impacts associated with the ongoing and proposed disposition of federal lands managed by BLM, as authorized under the 1998 SNPLMA. The first assessment — a baseline assessment — addresses the impacts of BLM disposition actions initiated in October 1998 and ending in December 2000. Future impacts are assessed from actual land disposal records through 2005 and actual land use records through June 2002, available from the Clark County Regional Transportation Commission (RTC). Land disposition is forecasted from anticipated land development on the basis of the historical record and information on planned land use provided by the RTC. Cumulative impacts from actual and forecasted BLM disposal actions are assessed for both 2009 and 2018. This study's analysis of air impact estimates, developed by application of models, provides a forecast of both the indirect and cumulative air quality impacts associated with BLM's ongoing and planned disposition actions, authorized primarily under the SNPLMA but also under other federal land management laws.

The planned increase in the rate of land disposition by BLM, along with prior public concern about the protection of air resources under the current plan, has added some uncertainty about air resource protection in the Las Vegas Valley over the next 14 years. This study was funded by BLM to specifically address these uncertainties and to provide the necessary technical support for BLM to ensure that air resources in Clark County are adequately protected during disposition actions.

2.1 Analysis Approach

Cumulative impacts are assessed by accounting for contributions under the existing PM_{10} SIP (Clark County 2001) and carbon monoxide (CO) SIP (Clark County 2000) and by accounting for the existing allowed local and regionally important emissions of ozone (O_3) precursors, which contribute to high-O_3 episodes in Las Vegas. The baseline years for the assessment are 1990 and 1998. These time points are considered reasonably consistent with the existing Department of Air Quality and Environmental Management's (DAQEM's) PM_{10} and CO SIPs, respectively, and with the LVRMP/FEIS[2]. The study accounts for future growth by quantifying

[2] On May 3, 2004, EPA finalized its approval of the Clark County PM_{10} SIP as meeting the Clean Air Act requirements for serious PM_{10} nonattainment areas. As part of this action, EPA approved a series of rules adopted by the Clark County DAQEM to control fugitive dust sources, including disturbed vacant lots, construction sites, unpaved roads, paved roads, and unpaved parking lots. These are the major control measures described in the PM_{10} SIP to demonstrate attainment of the health-based standard.

emissions directly related to BLM land authorizations and associated development on existing private lands. From October 1998 through December 2000, BLM land disposition actions (primarily through sales and exchanges) conveyed federal lands at a rate of approximately 3,500 acres/yr. The rate of land development for the conveyed parcels averaged around 800 acres/yr. These figures seem consistent with current population growth forecasts for Clark County, which predict a reduction from the peak growth level experienced in Las Vegas during 1999.

On April 15, 2004, the U.S. Environmental Protection Agency (EPA) designated Clark County as a nonattainment area for the 8-hour O_3 National Ambient Air Quality Standards (NAAQS). Clark County is classified as a Category 1 or “basic” (subpart 1 of the Clean Air Act [CAA]) nonattainment area, which means that the DAQEM will be required to meet the general provisions of the 1990 CAA Amendments. This designation is applicable to all areas that attain the 1-hour O_3 standard but not the 8-hour standard. The 8-hour O_3 NAAQS is 0.08 ppm. The air quality design value for the 8-hour O_3 NAAQS is the 3-year average of the annual 4th-highest daily maximum 8-hour average O_3 concentration. The 8-hour O_3 NAAQS is not considered to be met when the 8-hour ozone design value is greater than 0.08 ppm (85 ppb rounded up). Therefore, a county with a design value of 85 ppb does not meet the NAAQS. Clark County’s current design value is 86 ppb.

The initial cumulative air quality impact assessment showed an estimated peak increase of 9 ppb in the 8-hour average O_3 concentrations from 2000 to 2018. This increase is isolated in areas north and west of the city center. However, on average, the increase would likely be less than 2 to 6 ppbv over most areas around or adjacent to the BLM boundary. The projections for the central or south-central portions of the BLM boundary, including the city center, show 8-hour O_3 reductions of up to 4 ppb, primarily because of EPA’s national new clean engine standards. Ozone transport from the Los Angeles air basin was shown to contribute significantly to the cumulative O_3 impacts in the Las Vegas Valley.

For the O_3 assessment conducted as part of this study, researchers assumed that the federal requirement for the use of reformulated gasoline (RFG) in all designated nonattainment areas applies to the newly designated Clark County 8-hour O_3 nonattainment area. This requirement pertains to highly polluted areas of the country for which the CAA specifies that only a special type of gasoline (RFG) be sold and used. The RFG must meet specific emission performance standards to ensure that it is a cleaner-burning gasoline. In addition to these standards, RFG is also subject to the recently promulgated Tier 2/low-sulfur gasoline regulations. In other areas of the country, conventional gasoline (CG) is used; like RFG, CG is subject to the Tier 2/low-sulfur gasoline regulations. All gasoline, whether CG or RFG, must meet requirements that limit their Reid vapor pressure (RVP) to a maximum of 9.0 psi throughout the 48 contiguous states during the summer ozone season. The CAA also authorizes EPA to set more stringent RVP limits for nonattainment areas. EPA has published rules for such areas; these regulations limit the RVP of gasoline in these areas to a maximum of 7.8 psi during the “high ozone season,” from June 1 to September 15 of each year.

The analytical methods used in this study are based on the review and subsequent selection of an approach that provides a comprehensive, scientifically sound assessment of air dispersion in a complex urban valley. The approach is intended to account for the complex influences of the surrounding terrain on wind field patterns in the Las Vegas Valley. The air impacts assessed are associated with land use authorizations or management actions on BLM-administered lands in the past (beginning in 1998) and, to the extent practically foreseeable, in the planned future (through 2018). A wide variety of dispersion approaches was considered, including receptor-oriented analyses for PM_{10} and simple Gaussian dispersion models. A modeling approach that couples a mesoscale meteorological model with a multipollutant, multiscale model was chosen to address the micro- and mesoscale meteorological complexities of urban valleys, such as the Las Vegas Valley, and long-range O_3 transport from western sources (e.g., Los Angeles), as well as to account for potentially significant contributions from windblown native desert dust to PM_{10} concentrations.

To address episodic impacts of primarily local PM_{10} emissions, regional O_3 precursor emissions, and area-wide CO emissions, an Eulerian grid model was applied. The model, a third-generation code developed by EPA, is called the Community Multiscale Air Quality (CMAQ) model (Byun 1999) or "Models-3." The model has been applied in several air pollution studies, including an assessment by The University of Chicago of the relationship between urban air pollution and the high incidence of asthma among Chicago residents. The model has also been applied in assessments of urban regional haze, PM_{10}, and O_3 in New York, Atlanta, and Seattle, as well as in assessments of regional haze being conducted by the University of California at Riverside for the Western Regional Air Partnership. The CMAQ model has been successfully subjected to scientific peer review and has been shown to perform well in regional- and urban-scale assessments of O_3 and particulates.

2.2 Rationale for the Proposed Approach

The selection of the proposed modeling approach outlined above and described in more detail in Section 4 is supported by careful consideration of expected complex air flow patterns in the Las Vegas urban area. In addition, the proposed protocol takes into account the critical findings of recent air quality assessments and studies conducted for the Las Vegas region. These studies include the analyses conducted to support the Clark County DAQEM's PM_{10} and CO SIPs, as well as specific recent studies on fugitive dust in the Las Vegas region conducted by the Desert Research Institute (DRI) at Reno and the University of Nevada at Las Vegas (UNLV).

One fundamental finding from the DRI study is that more than 80% of the Las Vegas PM_{10} problem can be attributed to fugitive dust sources of primarily urban origin. Methods used to estimate emissions from these sources were cited as contributing to overly conservative estimates of air impacts obtained with dispersion model simulations. One of the key recommendations was the development of a more refined emissions model, based on a geographic information system (GIS), that would provide improved estimates of wind-driven fugitive dust emissions and their spatial distributions (Chow et al. 1999). A key contribution made by the subsequent UNLV study was the development of more accurate fugitive dust emission factors and a refined GIS-based system that greatly improve the spatial disaggregation or allocation of these emissions in and around the Las Vegas Valley (Pulugurtha and

James 2002). These findings and emissions inventory methodology refinements vastly improve the accuracy of results obtained through application of the proposed PM_{10} air dispersion protocol for Las Vegas.

The basic difference between the objectives of the PM_{10} and CO analyses conducted in support of the PM_{10} and CO SIPs and this study is that the focus here is the quantification of cumulative air quality impacts associated with BLM land disposition actions and the contributions from Las Vegas baseline sources. The requirement for spatial and temporal distributions of impacts necessitates the use of a dispersion modeling approach. The analysis for the existing SIPs focuses more on compliance-related regulatory control issues associated with measured air quality violations in the Las Vegas area. The use of proportional rollback or receptor-oriented models for PM_{10} relies primarily on microinventories for a limited set of source areas close to measurement sites. Areawide PM_{10} cumulative concentration contours (baseline emissions plus BLM actions and other reasonably foreseeable future emissions) cannot be generated by using a receptor-oriented modeling approach. On the other hand, the air modeling applied in support of the CO SIP used an Eulerian grid-based modeling approach that is consistent with EPA modeling guidance; this CO modeling approach was adopted for the present study. This approach employs the latest versions of the transportation and emissions models (MOBILE6) (EPA 2003b) and the state-of-the-science Eulerian dispersion model CMAQ. Recently published EPA modeling guidance (EPA 2003d) no longer recommends using the Urban Air Shed model (UAM-V) for O_3. However, the guidance (EPA 2003d) still recommends the use of a Eulerian grid model for an urban-area-wide analysis of CO.

The scientific basis for the specific model chosen is the unique geophysical influences in the Las Vegas Valley and the specialized nature of the air pollution problem posed by source emissions within and outside the valley. First, the spatial scales of importance in quantifying air impacts range from local to regional, with significant urban-scale influences. A comprehensive and scientifically sound analysis that adequately addresses the complex chemistry of multiple reactive pollutant species contributing to high-O_3 urban impacts is also required. Wind field and other meteorological influences from the rugged, sharp mountain ranges surrounding the valley and the urban heat island effects from the city itself are important for characterizing air quality impacts attributable to both nonreactive (e.g., PM_{10}) and reactive (O_3) pollutants in the Las Vegas Valley region.

Finally, because fugitive dust generated from both natural and anthropogenic sources in and around the Las Vegas area contributes significantly to the PM_{10} nonattainment problem in Las Vegas, special attention is required to properly characterize these emissions and their spatial distributions within and around the Las Vegas Valley. Although significant uncertainty still surrounds the quantification and spatial allocation of these emissions, the contributions of researchers at UNLV have significantly reduced this uncertainty for Las Vegas. In fact, recent discussions with the principal investigator (James 2003) at UNLV support the conclusion that the uncertainties in the quantification of windblown dust emissions obtained from experimentally derived UNLV emission factors are within the uncertainty bounds of most air dispersion models, including the models used in this study.

The supporting data and technical basis and rationale for the analysis methods and models used to conduct this study are addressed in Sections 3 and 4 of this report, which describe the approach in detail and explain why field data in support of the analysis were necessary and why state-of-the-science, newly developed modeling tools were employed. Section 5 covers in detail the results of the air quality impact assessment.

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3 Baseline Ambient Conditions

3.1 Climatology and Local and Regional Meteorology

The Las Vegas Valley, situated on the edge of the Mojave Desert, is characterized by an arid climate typical of the southern Mojave Desert. The Las Vegas Valley, measuring about 600 mi^2, is surrounded by mountains 2,000–10,000 ft higher than the floor of the valley. The valley extends and slopes in a northwest-southeast direction. The valley also slopes gradually upward on each side toward the surrounding mountains. The Sierra Nevada of California and the Spring Mountains immediately west of the Las Vegas Valley act as effective barriers to moisture moving eastward from the Pacific Ocean, in the so-called "rain shadow" effect.

The four seasons are well defined in the Las Vegas Valley (Wood 1996). Summers, typical of the Southwest desert environment, are characterized by daily maximum temperatures exceeding 100°F with lows in the 70s. However, the summer heat is moderated by extremely low relative humidity. On the other hand, winters are mild and pleasant, with daytime average temperatures of 60°F and clear skies. The spring and fall seasons are generally considered ideal, although rather sharp temperature changes can occur during these months.

The average annual temperature at the McCarran International Airport is 67.1°F. January is the coldest month, averaging 45.5°F, and July is the warmest month, averaging 91.1°F. Recorded extreme temperatures range from 8°F in January 1963 to 116°F in July 1985.

Average annual wind speed is about 9.3 miles per hour (mph). The wind is predominantly from the southwest, except that west-southwesterly and westerly winds dominate from October to January. In 2000, meteorological data were collected at the 18 DAQEM air monitoring stations operated by Clark County. Annual wind roses for selected locations are presented in Figure 3.1. The local wind direction from these stations is generally from the southwest; however, with the exception of the Apex site, the average annual wind speed is lower at these sites than the average wind speed at McCarran International Airport.

Average annual relative humidity at McCarran Airport ranges from 21% to 27% during the daytime and from 32% to 40% during the nighttime. The average annual precipitation and number of days with ≥0.01 in. of precipitation at McCarran Airport are about 4.13 in. and 26.5 days, respectively. During about 2 weeks almost every summer, warm, moist air predominates in the area and causes scattered thunderstorms, occasionally quite severe. Snow rarely falls in the Las Vegas Valley; when it occurs, it usually melts quickly.

Tornadoes are rare in the Las Vegas Valley but have occurred in every month of the year. All of the 13 tornadoes reported in Clark County since 1950 have been very weak, at most F1 of the Fujita tornado scale (National Oceanic and Atmospheric Administration [NOAA] 2004).

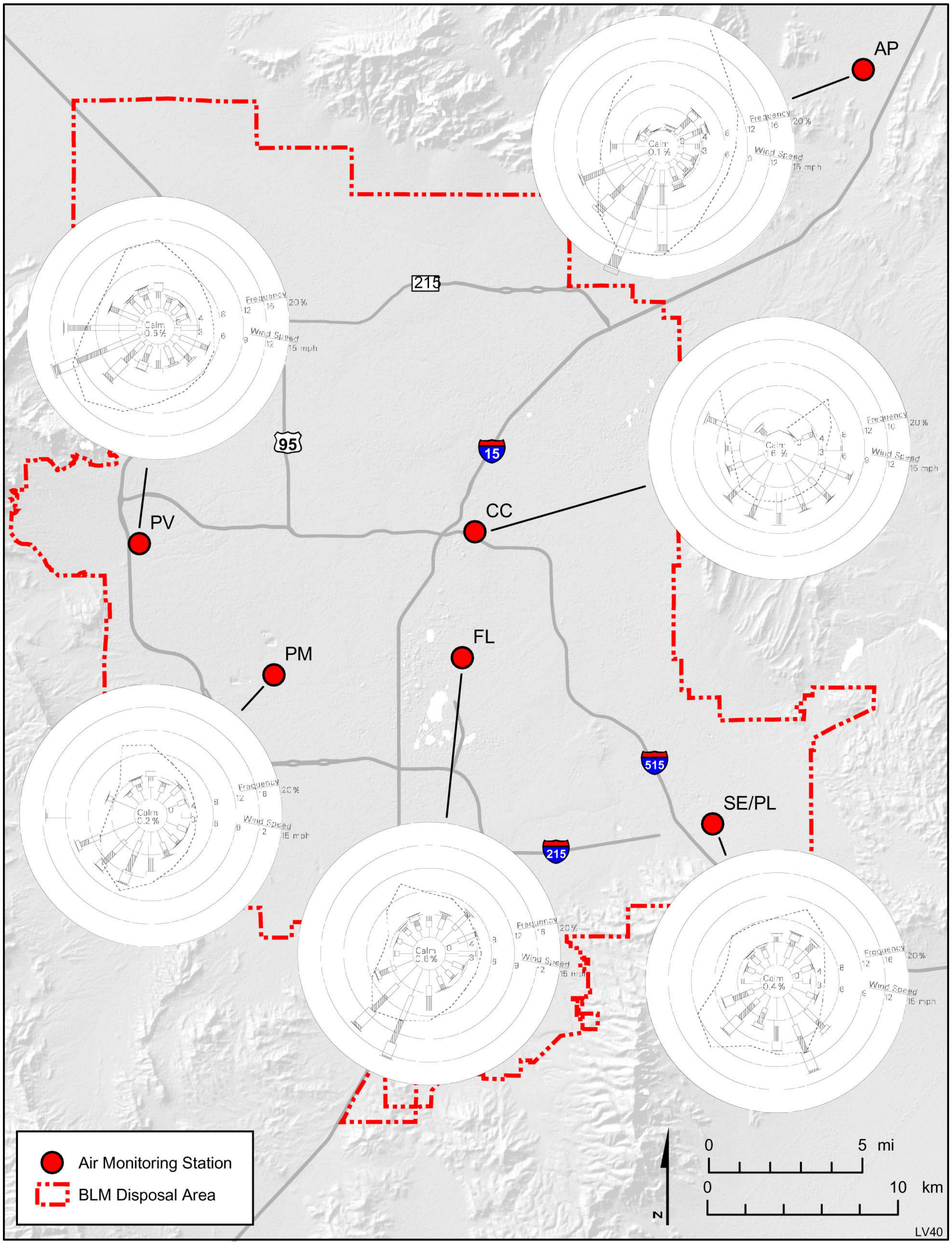

FIGURE 3.1 Annual Wind Roses from Selected DAQEM Monitoring Stations in Clark County, Nevada, in 2000

Strong winds associated with major storms usually reach the Las Vegas Valley from the southwest or though the pass from the northwest (Wood 1996). Winds over 50 mph are infrequent, but when they occur, the area experiences degraded visibility and health hazards caused by blowing dust. Winter and spring wind events blanket widespread areas with blowing dust and sand. Strong-wind episodes in summer are usually associated with thunderstorms that are more isolated and localized.

3.2 Las Vegas Air Quality Status

The Las Vegas Valley region is currently classified as a serious nonattainment area for 24-hour and annual average PM_{10}, as well as for 8-hour CO. Although the valley is currently classified as an attainment area for O_3, some of the more recent data from selected monitoring stations show concentration levels very close to the 8-hour NAAQS for O_3. Although the monitoring record for $PM_{2.5}$ (PM with a mean aerodynamic diameter of 2.5 μm or less) is relatively short, available measurements over the most recently reported 4-year period (1999–2002) show that 24-hour and annual average $PM_{2.5}$ concentrations are approaching the NAAQS (about 86% and 78% of their NAAQS, respectively). The Las Vegas Valley is currently unclassified for $PM_{2.5}$. The monitored concentration levels of sulfur dioxide (SO_2), nitrogen dioxide (NO_2), and lead (Pb) in Clark County are very low — well below the NAAQS. Figure 3.2 shows the locations of the DAQEM air quality monitoring sites in the county.

3.2.1 Particulates (PM_{10})

EPA has established an annual NAAQS of 50 $\mu g/m^3$ and a 24-hour NAAQS of 150 $\mu g/m^3$ for PM_{10}. The Las Vegas Valley has not attained these standards, and EPA has designated the region as a serious PM_{10} nonattainment area. Under authority granted by the state governor, the Clark County Board of Commissioners is responsible for the preparation of SIPs for nonattainment areas within Clark County to attain the NAAQS at the earliest practicable date. The PM_{10} SIP for Clark County has been prepared in response to the federal mandate and submitted to the EPA's Region IX Office for review and approval. The purpose of the PM_{10} SIP is to demonstrate that the adoption and implementation of the best available control measures (BACMs) and technologies for all significant sources of PM_{10} will result in attainment of the annual NAAQS by 2001 and the 24-hour NAAQS by 2006 (Clark County 2001). On the basis of 1990–2001 monitoring data in the Las Vegas Valley, PM_{10} violation days and the highest annual average PM_{10} concentrations have tended to decrease since peak values were recorded in 1995–1997 (Clark County 2001).

In 1997, EPA promulgated new NAAQS for $PM_{2.5,}$ establishing a 65 $\mu g/m^3$ 24-hour standard and a 15 $\mu g/m^3$ annual standard. Since the inception of monitoring for $PM_{2.5}$ in 1999–2003, monitoring data have indicated no violations of 24-hour and annual standards in Clark County, including the Las Vegas Valley. In the same period, the highest 24-hour $PM_{2.5}$ concentrations ranged from 38 to 85 $\mu g/m^3$, and the highest annual average $PM_{2.5}$ concentrations

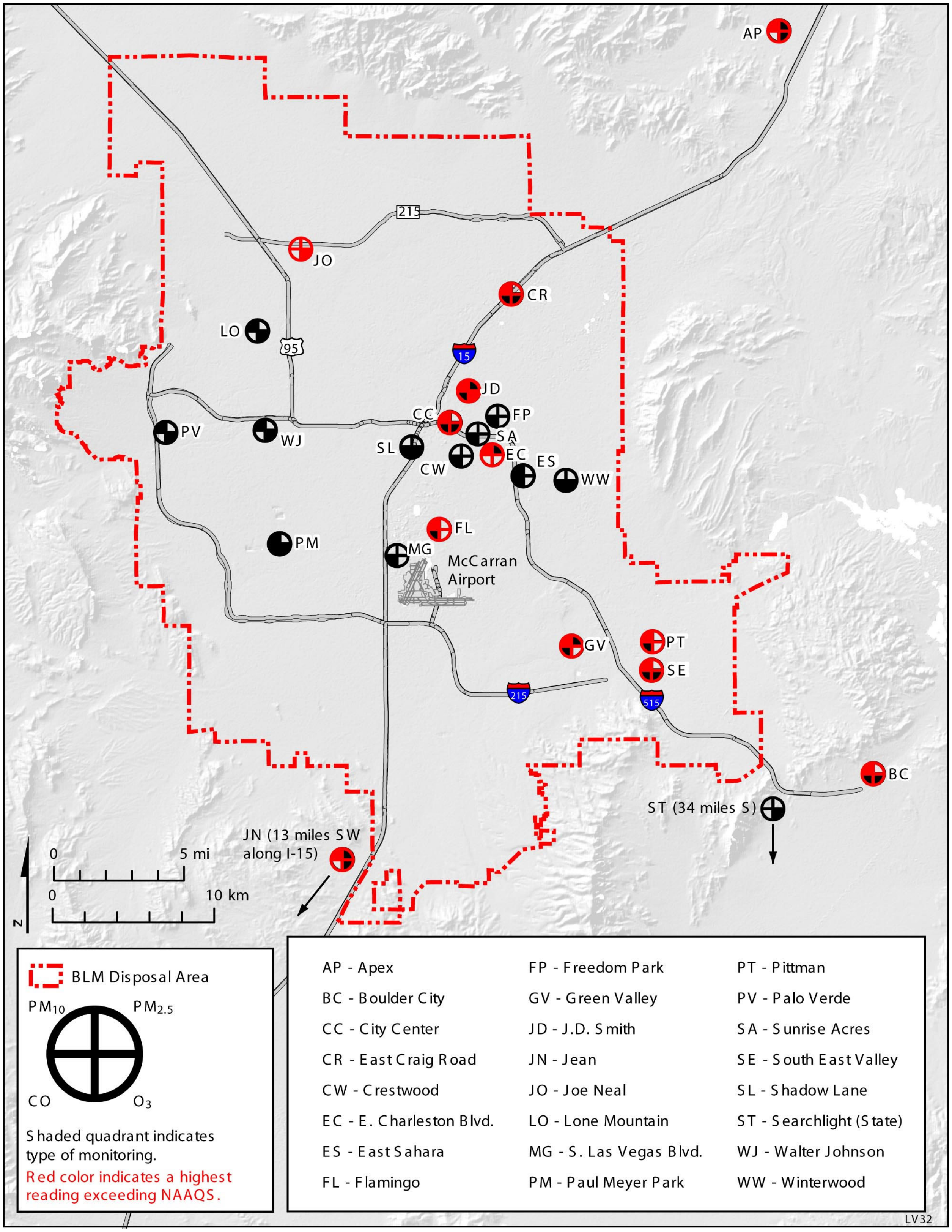

FIGURE 3.2 DAQEM Air Quality Monitoring Network for PM_{10}, $PM_{2.5}$, CO, and O_3 in Clark County, Nevada, in 2000

ranged from 10.8 to 11.7 μg/m^3. It is difficult to draw general trends from limited $PM_{2.5}$ monitoring data, but the highest 24-hour and annual average $PM_{2.5}$ concentrations in Clark County are exceeding or approaching approximately 55% and 78% of their respective NAAQS.

3.2.2 Carbon Monoxide

EPA has established a 1-hour NAAQS of 35 ppm and an 8-hour NAAQS of 9 ppm for CO. The Las Vegas Valley is designated a serious nonattainment area for CO on the basis of 8-hour exceedances. In August 2000, the Clark County Board of Commissioners prepared a CO SIP to demonstrate attainment of the NAAQS for CO by the end of 2000. The monitoring data generally show improvement in 8-hour average CO concentrations in the Las Vegas Valley. No violations were recorded in the valley in calendar years 1999–2001. No exceedance of the 1-hour CO national standard has ever been recorded in the Las Vegas Valley, and violations of the 8-hour CO NAAQS are limited to one station in an urbanized area east-southeast of downtown Las Vegas.

3.2.3 Ozone

The O_3 NAAQS is 0.12 ppm. In 1997, EPA promulgated a new NAAQS for O_3 by establishing an 8-hour standard. The Las Vegas Valley has been designated as being in attainment for the 1-hour O_3 NAAQS of 0.12 ppm since 1986. The last violation of the 1-hour O_3 NAAQS occurred in July 1990. On the basis of 1999–2001 monitoring data, all of Clark County is in attainment with the new 8-hour O_3 standards. However, monitored fourth-highest 8-hour concentration levels in the Las Vegas Valley are in the range of 0.07–0.08 ppm. New programs are being developed to ensure that Clark County remains in attainment with the 8-hour O_3 NAAQS as the population grows and industry expands. Although the state has submitted its 8-hour O_3 attainment designation requests, EPA has not yet issued classifications with regard to the new standard.

Typically, the formation of O_3 from precursor gases (nitrogen oxides [NO_x] and volatile organic compounds [VOCs]) is considered a regional and seasonal issue. Given the prevalence of southwesterly winds, a substantial portion of O_3 in the valley is likely transported from the Los Angeles, California, area or the area covered by the South Coast Air Quality Management District (SCAQMD) in California. Thus, a concerted effort is needed to address both the regional-scale and future local-scale emission sources connected with BLM land authorization contributions to valley-wide O_3 concentrations. Therefore, an air quality modeling assessment has been conducted to identify contributions from O_3 precursor sources in the Las Vegas Valley and from sources outside the Valley.

3.3 Las Vegas Background Air Quality

The Clark County DAQEM operates air quality monitoring stations to measure ambient concentrations of some criteria pollutants (SO_2, NO_x, CO, PM_{10}, and $PM_{2.5}$), hydrogen sulfide (H_2S), and ammonia (NH_3), as well as visibility and haze, which are closely related to particulate concentrations. In 2000, criteria pollutants were measured at 18 monitoring stations in Clark County. Figure 3.2 illustrates the locations of these monitoring stations within the nonattainment area and outlying areas in Clark County. Tables 3.1–3.4 present the statistics for observed concentrations of PM_{10}, CO, and O_3 (1-hour and 8-hour) in Clark County in 2000.

In 2000, many air quality monitoring stations experienced exceedances of the 24-hour PM_{10} NAAQS, predominantly on May 10 and August 12–13, 2000, as shown in Table 3.1. On May 10, high concentrations were recorded at more than half of the monitoring stations within the valley, caused by persistent high-wind events (over 20 mph). The highest 24-hour PM_{10} concentration of 508 $\mu g/m^3$ was recorded at the Apex station, which is located outside the nonattainment area but in the Las Vegas Valley. Many stations also recorded exceedances on August 12–13. In contrast to the high-wind episode on May 10, wind speeds at most monitoring stations in the Las Vegas Valley were relatively moderate, about 10 mph, thoughout the August episode. Most 24-hour violations are typically associated with high winds. Occasionally, under low-wind or stagnant conditions, nearby sources of PM_{10} (e.g., construction site dust and paved-road dust) with high activity levels may lead to emissions at levels high enough to cause a violation of the 24-hour health standard (Clark County 2001). Another potential contributor was a large forest fire in the western United States in the summer of 2000 (National Aeronautics and Space Administration [NASA] 2004). From EPA's regulatory standpoint, the 24-hour PM_{10} NAAQS is met when the 99th percentile 24-hour concentration is less than or equal to 150 $\mu g/m^3$. By this criterion, the fourth-highest 24-hour concentration (158 $\mu g/m^3$) is the only violation in Clark County in 2000. The annual PM_{10} NAAQS was not exceeded at any monitoring station in Clark County in 2000.

The Las Vegas Valley did not exceed the 1-hour and 8-hour NAAQS for CO in 2000. The highest 1-hour and 8-hour concentrations recorded were 9.98 and 7.36 ppm, respectively, corresponding to 29% and 82% of the standards. As shown in Table 3.2, most of the high CO concentrations occurred in winter. During the winter months, local inversions cause air masses to become stagnant and trap pollutants. The overnight buildup of pollutants caused exceedance of the CO 8-hour air quality standard in a limited area.

Typically, the Las Vegas Valley's O_3 season lasts from May 1 though October 1, a period that coincides with the hottest months of the year. In 2000, the highest 1-hour concentration recorded was 0.107 ppm, as shown in Table 3.3. Accordingly, no exceedances for 1-hour O_3 were recorded at any monitoring stations in Clark County. As shown in Table 3.4, three exceedances of the 8-hour standard occurred in 2000, but the fourth-highest concentrations, which are the EPA's regulatory criteria, were below the NAAQS. However, as discussed above, Clark County has frequently experienced O_3 excursions above the NAAQS since 1999.

TABLE 3.1 Statistics for Observed PM_{10} Concentrations at Monitoring Stations in Clark County, Nevada, in 2000

Site	Loc. Code	Location	AIRS Code	No. of Obs.	1st Highest 24-Hour		2nd Highest 24-Hour		3rd Highest 24-Hour		4th Highest 24-Hour		Annual Mean ($\mu g/m^3$)	Exceeded	
					Conc. ($\mu g/m^3$)	Month/ Day	Conc. ($\mu g/m^3$)	Month/ Day	Conc. ($\mu g/m^3$)	Month/ Day	Conc. ($\mu g/m^3$)	Month/ Day		24-Hour	Annual
Apex	AP	12101 US Hwy. 93	320030022	351	508	05/10	177	08/12	132	08/13	116	04/28	21	2	0
Boulder City	BC	1005 Industrial Rd.	320030601	351	188	08/12	161	08/13	138	05/10	84	05/08	17	2	0
Craig Road	BS	4701 Mitchell St.	320030020	338	380	05/10	164	06/29	160	08/12	158	08/13	45	4	0
City Center	CC	559 N. 7th St.	320030016	348	157	05/10	149	08/13	132	08/12	112	10/4	42	1	0
E. Flamingo	FL	210 E. Flamingo Rd.	320031022	331	247	05/10	109	04/28	96	05/24	94	08/12	36	1	0
Green Valley	GV	248 Arroyo Grande Blvd.	320030298	334	178	05/10	145	10/31	124	08/13	86	08/27	28	1	0
JD Smith	JD	1301B E. Tonopah Ave.	320032001	343	189	08/13	188	05/10	149	08/12	126	07/31	48	2	0
E. Sahara	MC	4001 E. Sahara Ave.	320030539	357	137	08/13	131	05/10	124	08/16	87	03/20	33	0	0
E. Charleston	EC	2801 E. Charleston Blvd.	320030558	350	157	08/13	124	05/10	119	08/12	96	12/04	41	1	0
S.E. Valley	PL	545 W. Lake Mead Dr.	320030007	337	206	05/10	170	08/12	97	03/20	91	05/8	34	2	0
Pittman	PT	1137 N. Boulder Hwy.	320030107	328	334	05/10	184	08/13	136	08/12	132	04/7	34	2	0
Paul Meyer Park	PM	4525 New Forest Dr.	320030043	351	127	10/04	125	05/10	121	05/24	111	09/12	36	0	0
Walter Johnson	WJ	7701 Ducharme Ave.	320030071	340	105	08/12	91	05/10	72	07/31	71	08/13	23	0	0
Jean	JN	1965 State Hwy. 161	320031019	343	162	05/10	103	05/08	49	05/07	43	03/19	13	1	0
Lone Mountain	LO	3525 N. Valadez St.	320030072	340	102	08/12	81	05/10	75	08/13	71	01/27	25	0	0
Palo Verde	PV	333 Pavillion Center Dr.	320030073	322	114	05/10	87	08/12	70	07/31	64	09/21	21	0	0

TABLE 3.2 Statistics for Observed CO Concentrations at Monitoring Stations in Clark County, Nevada, in 2000

					1st Highest 1-Hour		2nd Highest 1-Hour		1st Highest 8-Hour		2nd Highest 8-Hour			Exceeded	
Site	Loc. Code	Location	AIRS Code	No. of Obs.	Conc. (ppm)	Month/Day: Hour	Conc. (ppm)	Month/Day: Hour	Conc. (ppm)	Month/Day: Hour	Conc. (ppm)	Month/Day: Hour	Mean (ppm)	1-Hour	8-Hour
Boulder City	BC	1005 Industrial Rd.	320030601	8662	1.45	01/15:17	1.30	01/16:17	1.17	01/16:01	0.96	01/15:05	0.02	0	0
City Center	CC	559 N. 7th St.	320030016	8600	7.93	02/07:08	7.23	01/13:08	5.10	01/15:08	4.29	12/22:07	0.91	0	0
Craig Road	BS	4701 Mitchell St.	320030020	8719	4.63	04/19:11	3.30	05/15:19	2.64	05/15:05	1.46	12/24:07	0.10	0	0
Crestwood	CW	1300 Pauline Way	320030562	8591	7.18	01/15:23	6.93	12/19:09	5.19	01/15:08	4.67	01/07:08	0.74	0	0
E. Flamingo	FL	201 E. Flamingo Rd.	320031022	8620	6.41	01/13:08	6.16	11/28:08	5.12	12/20:08	4.19	11/27:15	0.87	0	0
E. Sahara	MC	4001 E. Sahara Ave.	320030539	8738	7.28	01/10:08	7.23	12/22:08	5.79	12/21:09	5.73	12/22:08	0.83	0	0
Green Valley	GV	248 Arroyo Grande	320030298	8712	2.94	12/05:09	2.74	11/21:09	1.66	12/04:17	1.59	01/12:17	0.26	0	0
JD Smith	JD	1301B E. Tonopah Ave.	320032002	8534	9.98	03/06:12	8.01	12/06:19	4.70	11/21:07	4.68	01/15:07	0.60	0	0
Paul Meyer Park	PM	4525 New Forest Dr.	320030043	8592	3.94	08/21:04	2.98	10/06:03	1.81	01/09:01	1.62	01/11:03	0.37	0	0
Pittman	PT	1137 N. Boulder Hwy.	320030107	8635	4.72	11/28:07	4.16	01/10:08	2.27	12/22:08	2.06	12/20:09	0.28	0	0
S. Las Vegas Blvd.	MG	3799 S. Las Vegas Blvd.	320031023	8709	6.98	07/11:07	5.62	02/03:08	3.91	12/20:07	3.67	01/15:09	1.05	0	0
S.E. Valley	PL	545 W. Lake Mead Dr.	320030007	8551	3.26	04/08:11	2.76	02/02:09	1.49	02/01:17	1.39	01/10:17	0.14	0	0
Shadow Lane	SL	625 Shadow Lane	320030021	8706	5.29	12/06:20	4.93	12/04:19	4.07	12/06:07	4.04	12/04:07	0.52	0	0
Sunrise Acres	SA	2501 S. Sunrise Ave.	320030561	8721	8.64	12/31:23	8.43	12/21:08	7.36	12/31:08	7.26	12/23:08	1.02	0	0
Winterwood	WW	5483 Club House Dr.	320030538	8732	6.99	12/22:08	5.98	01/11:23	4.13	01/11:08	4.06	12/21:15	0.51	0	0
Freedom Park	FP	650 N. Mojave Rd.	320030563	2190	8.51	12/28:20	7.21	11/28:20	5.75	12/31:08	5.46	11/28:08	1.17	0	0

TABLE 3.3 Statistics for Observed 1-Hour O_3 Concentrations at Monitoring Stations in Clark County, Nevada, in 2000

					1st Highest 1-Hour		2nd Highest 1-Hour		3rd Highest 1-Hour		4th Highest 1-Hour			
Site	Loc. Code	Location	AIRS Code	No. of Obs.	Conc. (ppm)	Month/Day: Hour	Conc. (ppm)	Month/Day: Hour	Conc. (ppm)	Month/Day: Hour	Conc. (ppm)	Month/Day: Hour	Annual Mean (ppm)	Exceeded 1-Hour
Apex	AP	12101 US Hwy. 93	320030022	8726	0.097	05/23:16	0.093	05/26:16	0.091	05/12:11	0.091	06/01:01	0.037	0
Boulder City	BC	1005 Industrial Rd.	320030601	8720	0.088	08/02:15	0.085	05/31:13	0.079	04/27:15	0.079	05/03:02	0.040	0
Craig Road	BS	4701 Mitchell St.	320030020	8733	0.089	05/23:15	0.086	08/02:17	0.085	08/26:16	0.083	06/04:01	0.023	0
City Center	CC	559 N. 7th St.	320030016	8699	0.096	08/02:17	0.081	06/04:14	0.081	08/05:13	0.078	05/02:01	0.019	0
JD Smith	JD	1301B E. Tonopah Ave.	320032002	8330	0.101	08/02:17	0.095	05/23:14	0.092	08/01:15	0.087	06/04:01	0.023	0
Jean	JN	1965 State Hwy. 161	320031019	8670	0.091	05/30:20	0.085	04/27:18	0.084	08/12:16	0.083	06/04:01	0.043	0
Lone Mountain	LO	3525 N. Valadez St.	320030072	8694	0.107	08/01:14	0.094	07/29:13	0.094	08/03:13	0.093	08/02:01	0.030	0
S.E. Valley	PL	545 W. Lake Mead Dr.	320030007	8470	0.094	08/02:17	0.085	05/30:22	0.085	05/31:01	0.084	06/01:03	0.029	0
Paul Meyer Park	PM	4525 New Forest Dr.	320030043	8709	0.097	08/02:16	0.090	06/20:17	0.089	06/04:12	0.085	08/01:01	0.031	0
Palo Verde	PV	333 Pavillion Center	320030073	8682	0.097	06/04:13	0.094	08/01:14	0.094	08/06:12	0.093	08/02:01	0.041	0
Shadow Lane	SL	625 Shadow Lane	320030021	8649	0.097	08/02:17	0.085	05/23:14	0.083	08/01:15	0.079	06/04:01	0.022	0
Walter Johnson	WJ	7701 Ducharme Ave.	320030071	8697	0.097	08/02:17	0.094	08/06:12	0.092	06/04:13	0.092	08/01:01	0.034	0
Winterwood	WW	5483 Club House Dr.	320030538	8688	0.093	08/02:16	0.092	05/23:14	0.085	08/03:12	0.083	05/01:01	0.026	0
Joe Neal	JO	6651 W. Azure Ave.	320030075	4392	0.102	08/01:14	0.097	07/29:14	0.094	08/03:13	0.089	08/04:01	0.035	0
Searchlight (State)	ST	103 Highway 95 Road	320030078	4201	0.082	07/25:24	0.082	08/03:11	0.081	07/26:24	0.079	07/02:03	0.043	0

TABLE 3.4 Statistics for Observed 8-Hour O_3 Concentrations at Monitoring Stations in Clark County, Nevada, in 2000

					1st Highest 8-Hour		2nd Highest 8-Hour		3rd Highest 8-Hour		4th Highest 8-Hour			
Site	Loc. Code	Location	AIRS Code	No. of Obs.	Conc. (ppm)	Month/Day: Hour	Conc. (ppm)	Month/Day: Hour	Conc. (ppm)	Month/Day: Hour	Conc. (ppm)	Month/Day: Hour	Annual Mean (ppm)	Exceeded 8-Hour
Apex	AP	12101 US Hwy. 93	320030022	8726	0.084	06/12:10	0.084	05/26:12	0.083	05/23:13	0.080	08/02:12	0.037	0
Boulder City	BC	1005 Industrial Rd.	320030601	8720	0.079	08/02:12	0.078	05/31:08	0.073	05/23:12	0.072	05/02:11	0.040	0
Craig Road	BS	4701 Mitchell St.	320030020	8733	0.076	06/04:11	0.074	08/26:11	0.074	08/02:13	0.074	06/01:10	0.023	0
City Center	CC	559 N. 7th St.	320030016	8699	0.076	08/02:12	0.074	06/04:10	0.071	06/11:10	0.070	06/01:11	0.019	0
JD Smith	JD	1301B E. Tonopah Ave.	320032002	8330	0.085	08/02:12	0.079	06/04:11	0.077	06/12:11	0.077	06/01:10	0.023	1
Jean	JN	1965 State Hwy. 161	320031019	8670	0.082	05/30:17	0.081	08/12:12	0.080	06/11:14	0.078	06/04:10	0.043	0
Lone Mountain	LO	3525 N. Valadez St.	320030072	8694	0.083	07/29:11	0.083	08/01:11	0.082	08/02:12	0.082	08/06:10	0.030	0
S.E. Valley	PL	545 W. Lake Mead Dr.	320030007	8470	0.080	08/02:13	0.077	06/11:10	0.074	05/30:17	0.073	05/02:13	0.029	0
Paul Meyer Park	PM	4525 New Forest Dr.	320030043	8709	0.083	06/04:11	0.080	08/02:12	0.079	06/20:12	0.077	06/01:11	0.031	0
Palo Verde	PV	333 Pavillion Center	320030073	8682	0.084	06/04:11	0.082	08/06:11	0.081	08/02:12	0.080	06/01:11	0.041	0
Shadow Lane	SL	625 Shadow Lane	320030021	8649	0.076	08/02:12	0.073	06/04:11	0.071	08/06:10	0.069	05/02:11	0.022	0
Walter Johnson	WJ	7701 Ducharme Ave.	320030071	8697	0.083	06/04:12	0.082	08/06:10	0.082	08/02:12	0.080	06/01:11	0.034	0
Winterwood	WW	5483 Club House Dr.	320030538	8688	0.081	05/23:10	0.081	08/02:12	0.079	05/19:11	0.077	08/06:10	0.026	0
Joe Neal	JO	6651 W. Azure Ave.	320030075	4392	0.086	07/29:11	0.085	08/01:11	0.081	08/26:11	0.080	08/06:10	0.035	2
Searchlight (State)	ST	103 Highway 95 Road	320030078	4201	0.078	07/25:12	0.073	08/06:09	0.072	08/17:11	0.072	08/02:01	0.043	0

4 Air Pollutant Emissions in Las Vegas Valley in the Current or Baseline Year (2000) and Future or Projection Years (2009 and 2018)

This study required the development of three types of air pollution emissions inventory data: non-BLM-related emissions, current and future BLM-related or associated emissions, and natural source emissions. The first type of emissions data represents all reasonably foreseeable non-BLM-disposal-related activities in the Las Vegas Valley. This cumulative impacts inventory was compiled from information provided in the current PM_{10} SIP (Clark County 2001) and CO SIP (Clark County 2000) and from data contained in the Clark County operating permit files and fugitive dust permit files. The second type of emissions data represents construction and operation emissions associated with historical (since 1998) and projected land development and use after BLM land disposal (e.g., sales, transfers, exchanges), authorizations, and conveyance. Land disposal emissions and resulting air emissions from projected land development and use are provided at 9-year increments from the baseline year (2000) through 2018. At an assumed disposal rate of 4,000 acres/yr beginning in 2005, disposal of all of the authorized BLM land within the disposal boundary (~72,000 acres) would be completed by 2016. However, at an assumed average annual development rate of around 1,200 acres/yr, it is expected that continued development of undeveloped acreage disposed in prior years would add to the cumulative total of BLM disposal-related emissions through 2018. The third type of emissions data represent emissions from natural sources, such as windblown dust.

The methodology that was used to compile the non-BLM-related emissions inventory is described in Section 4.1. The methods and assumptions used to develop emission projections for current and future BLM land use authorizations are described in Section 4.2. The windblown dust model that was developed is described in Section 4.3. Emission source disaggregation and spatial and temporal emission growth projections are discussed in Sections 4.4 and 4.5.

Note that the first type of emissions (non-BLM-related) and the second type of emissions (BLM-related) are similar; the emissions estimation method for each type is briefly described here. Emissions in many source categories are directly or indirectly related to population growth. The projections of population growth (Center for Business and Economic Research [CBER] 2000; 2003) and associated increases in vehicle miles traveled (Hoeft 2003) for Clark County (provided in tables later in this section) implicitly include the population growth associated with BLM land disposals. Considering the steady development of BLM land, BLM-related population was estimated on the basis of single- and multi-family housing acreages to be developed and the assumed average number of person per household (Archer 2002). On the basis of this estimate, cumulative BLM-related population would account for approximately 1.39% for 2000, 10.06% for 2009, and 16.21% for 2018, of the population in the nonattainment area.

For non-BLM-related emissions, population-related emissions (e.g., residential gas use) were estimated on the basis of a baseline and future emissions inventory developed from the PM_{10} and CO SIPs (Clark County 2000; 2001) and population growth in the nonattainment area minus BLM-related population growth. However, emissions independent of population growth (e.g., those from Nellis Air Force Base operations) were assigned to non-BLM-related emissions. Increases in “direct” emissions associated with BLM land sales primarily include those from energy use (natural gas and electricity), vehicle use (on-road mobile exhaust and paved road dust), and wind erosion at developed lands. These emissions were estimated using the methodology developed by the BLM (Archer 2002). “Indirect” emissions increases associated with BLM land sales (e.g., nonroad engine exhaust) were estimated on the basis of a baseline and future emissions inventory developed from the PM_{10} and CO SIPs (Clark County 2000; 2001) and BLM-related population growth.

4.1 Non-BLM Anthropogenic Baseline Emission Sources

Development of the emissions inventories consisted of four basic steps:

1. Identify potential emission sources in the study area,
2. Determine the activity level for each source,
3. Develop emission factors for each source, and
4. Estimate total emissions by multiplying the emission factor by the activity level and the control efficiency, as appropriate.

Each step is discussed briefly in this section. Detailed procedures and data are presented in Appendix A.

Comprehensive emissions inventory data for the baseline year (2000) were based primarily on data available from the Clark County DAQEM operating permit files and on data reported in the Clark County PM_{10} SIP (Clark County 2001) and CO SIP (Clark County 2000). The PM_{10} SIP contains Clark County emissions data for a base year of 1998 and a future SIP compliance year of 2006. The SIP baseline inventory was adjusted to reflect growth-related change (e.g., vehicle miles traveled [VMT]) from 1998 through 2000. The CO SIP contains Clark County emissions data for a base year of 1996 and compliance year of 2000. The CO SIP compliance year emissions were used to represent baseline conditions in this study. Both SIPs group emission sources into four broad categories:

1. Stationary point sources,
2. Stationary area sources,
3. Nonroad mobile sources, and
4. On-road mobile sources.

Stationary point sources include major point sources, such as electric utilities and sand and gravel operations. Stationary area sources include permitted small point sources, residential fuel combustion, fires, windblown native soil dust, and mechanically generated dust from construction and demolition activities. Nonroad mobile sources include nonroad engines and vehicles, such as airport equipment, construction equipment, and equipment and vehicles used for recreational activities, as well as aircraft landings and takeoffs. On-road mobile sources include dust from paved and unpaved roads, on-road vehicular engine exhaust, and tire or brake wear.

One additional emission source category covered in this study is stationary power plant sources regulated by the State of Nevada. These sources consist of four power-generating stations that are not included in the Clark County permit system because of a jurisdictional split between the state and the county.[3] The primarily natural-gas-burning Clark and Sunrise Stations are located within the BLM disposal boundary. Although the coal-burning Reid Gardner and Mohave Generating Stations are located within Clark County, but outside the nonattainment area, they are included in the emissions inventory as major tall-stack sources with relatively large emissions that could have some impacts in the nonattainment area.

Because the PM_{10} SIP used a receptor-oriented modeling approach along with proportional rollback for compliance demonstration, it did not have the detailed source parameters required for the source-receptor-oriented dispersion modeling used in this study. The emissions inventory database for stationary point sources required for our study needed to include detailed information on items such as permit history; source locations; permitted, actual, peak, and average emission rates; operating schedules; and control measures. Additional data needed for stationary point sources included stack parameters (e.g., heights and diameters), dynamic operating conditions (e.g., effluent exit velocities, temperatures), and the dimensions of source buildings and nearby buildings. Emissions inventory data for existing and new sources and for reasonably foreseeable future sources were obtained by searching the Clark County DAQEM construction permit files and operating permit files and by consulting with the State of Nevada and electric utilities about plans for power plant retirements and the construction of new units and new plants. Argonne National Laboratory staff reviewed these data sets and compiled them into the necessary format for input to the emissions processing system (SMOKE) (EPA 2001). In addition, the emissions inventory data were revised on the basis of information available in the permits issued. Any revisions or updates to data in the existing emissions inventory databases that became necessary because of design or operational changes (including facility shutdowns) or because more appropriate emission factors became available were done according to guidance provided by the BLM and Clark County.

Area source inventories covered emissions generated from human activities (e.g., construction) and windblown fugitive dust. The inventory of data on anthropogenic area source emissions, such as those from construction and demolition activities, required parameters

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[3] As a point of interest, the Nevada statute that is the basis for the jurisdictional split (NRS 445B.500) essentially says that no county may regulate plants that generate electricity by using steam produced from the burning of fossil fuel. Hence, combustion turbines are regulated by the county, while boilers are regulated by the state.

(e.g., descriptions of the spatial extent of the source and any required temporal adjustments) to account for discernable daily variations in operations and diurnal changes. The availability of reliable data to account for time-varying area source emissions was discussed with Clark County staff. The most reliable, recently published emission factors were used to quantify emissions inventories for these sources. Sources of natural or background windblown fugitive dust emissions included dust generated from vacant land, primarily of native desert origin. Sufficient data did not exist to identify, quantity, and map stablized soils within the Clark County nonattainment area. Windblown dust functions were developed from portable wind tunnel measurements that accounted for soil characteristics (e.g., silt content, stability), which included the nine wind erodibility groups identified in the 1981 Soil Conservation Service soil survey for the Las Vegas Valley (Speck and McKay 1985). The parametrically fitted windblown dust functions that were developed were incorporated within the dispersion model used in estimating air quality impacts. Detailed methodologies and algorithms for these windblown dust emissions are presented in Section 4.3. The models used to simulate windblown dust and other emission source impacts are described in Section 5.

Nonroad and on-road mobile sources account for most of the total CO and VOC emissions. Stationary point and area sources contribute only a small fraction of the total CO and VOC emissions in Clark County. In addition, NO_X emissions from state-regulated power plants and from combined nonroad and on-road mobile vehicle exhaust are comparable, each accounting for about 40% of total emissions. As a consequence, NO_X and VOC emissions from nonroad engines and on-road vehicular exhaust account for substantial portions of O_3 precursor emissions. Accordingly, the use of the most updated emission factor for nonroad and on-road mobile sources is crucial for constructing an emissions inventory for air quality modeling. In the PM_{10} and CO SIPs, EPA's MOBILE5 model was used. Because the MOBILE6 model (EPA 2003a) was recently released, and vehicle emission modeling software has become available, the MOBILE6 software was used to develop emission factors for SO_2, NO_X, CO, VOCs, and PM (PM_{10} and $PM_{2.5}$) from cars, trucks, and motorcycles under various conditions. Projections of future vehicle counts and of the growth rate in VMT were obtained from the Clark County RTC baseline estimates (year 2000) and from the projection-year runs (2005, 2010, 2015, and 2020) (Hoeft 2003) by using the TransCAD model (Caliper Corporation 2003). EPA's Draft NONROAD2004 model (EPA 2002), developed for estimating emissions from nonroad engines and vehicles (e.g., graders and backhoes used in construction, forklifts used in industry, and all-terrain vehicles and off-road motorcycles used in recreation), was used in consultation with EPA (Janssen 2003). EPA considers nonroad vehicle emissions of VOC, NO_X, and PM to be significant. Because activities associated with recreational vehicles within the Las Vegas Valley are an issue of concern to the public and to local regulatory authorities, the model, even though it is still in draft form, reflects what EPA considers to be the most current and up-to-date method for estimating nonroad emissions.

In the current study, general methodologies and assumptions were adopted from available databases to the maximum extent possible, in order to be consistent with previous efforts for the Clark County nonattainment area. The updates and enhancements to these databases are discussed below. Non-BLM anthropogenic emissions for the baseline and future years were estimated primarily on the basis of methodologies and emission factors in the Clark County PM_{10} SIP (uses 1998 as the base year) and CO SIP (uses 1996 as the base year) (Clark County

2000; 2001), unless new emission factors and methodologies were available. Most emission sources were limited to the nonattainment area, but some sources were extended to the Clark County boundary because of regional impacts (e.g., power plants) or a lack of spatial distribution data (e.g., nonroad mobile emissions). The emission estimation methodology for each source category is discussed briefly here. Further details on the methods and data can be found in the PM_{10} and CO SIPs and in Appendix A of this report. For this study, detailed emission inventories were compiled for criteria pollutants (SO_2, NO_x, CO, and PM_{10}) and for VOCs for the baseline and future years. When practical, emissions data were also compiled for $PM_{2.5}$. A detailed list of potential sources by category and projection method from the PM_{10} and CO SIPs, along with the source type used in CMAQ modeling, is provided in Table 4.1. Emissions resulting from windblown dust (i.e., natural emissions) were estimated directly with a modified CMAQ model using surface-level wind data.

Emission inventories for the baseline year and future years were developed by using four basic methods:

1. For sources for which actual emissions data were available, these emissions data were used.

2. For sources for which there were actual (or estimated) activity data, the estimate was based on the emission factor and the actual or estimated activity data.

3. For sources for which emission changes were based on population, the estimate was based on the PM_{10} SIP or CO SIP and the population growth ratio.

4. For sources for which there were no emission changes, the same emission rates were used, and it was assumed that no emission changes would occur in the baseline year and future years.

For many source categories, emissions for the baseline year and future years were estimated on the basis of emissions in the PM_{10} SIP (Clark County 2001), the CO SIP (Clark County 2000), or both, plus the population growth between the two years. Projected populations in the PM_{10} SIP, CO SIP, and many other sources are different because their baseline years are different. For our analysis, two projections from the same source but with different starting years were joined to construct population data between 1997 and 2035, as presented in Table 4.2 (CBER 2000; 2003).

TABLE 4.1 Emission Estimation Basis for the Baseline Year and Future Years by Source Category and Type

Emission Source Category	Base Year (2000)		Future Years (2009, 2018)		Source Type in CMAQ Modeling[a]
	Projection Method	Reference	Projection Method	Reference	
Stationary Major Point Sources[b]	NA[c]	Actual emission data (2000)	No change projected	Actual emission data (2000)	Point
Stationary Area Sources					
Small point sources[b]	NA	Actual emission data (2000)	No change projected	Actual emission data (2000)	Area by SCC
Natural gas combustion					
Residential use	Change based on population	PM_{10} SIP	Change based on population	PM_{10} SIP	Area by SCC
Commercial use					
Industrial use	No change projected		No change projected		
Purchased at the source (carried by Southwest Gas Corporation [SWG])					
Residential firewood combustion	Change based on population	PM_{10} SIP	Change based on population	PM_{10} SIP	Area by SCC
Structure fires/vehicle fires/wildfires	Change based on population	PM_{10} SIP	Change based on population	PM_{10} SIP	Area by SCC
Charbroiling/meat cooking	Change based on population	PM_{10} SIP	Change based on population	PM_{10} SIP	Area by SCC
Windblown dust — vacant lots[d]					
Disturbed vacant lands/unpaved parking lots	NA	Land use data (2000)	NA	Change based on historic patterns and projected land developments	Area by actual location
Native desert					
Stabilized vacant land					
Construction fugitive dust					
Construction activities	NA	Actual dust permit data (2000)	NA	Change based on historic patterns and projected land developments[e]	Area by actual location
Windblown dust[d]	NA	Land use data (2000)	NA		Area by actual location

TABLE 4.1 (Cont.)

Emission Source Category	Base Year (2000) Projection Method	Base Year (2000) Reference	Future Years (2009, 2018) Projection Method	Future Years (2009, 2018) Reference	Source Type in CMAQ Modeling[a]
Nonroad Mobile Sources					
Nonroad engines and vehicles					
Agricultural equipment	NA	Emissions from NONROAD2004 model (2000)	NA	Emissions from NONROAD2004 model (future years)	Area by SCC
Airport equipment					
Commercial equipment					
Construction and mining equipment					
Industrial equipment					
Lawn and garden equipment (commercial)					
Lawn and garden equipment (residential)					
Logging equipment					
Pleasure craft					
Railroad equipment (maintenance)					
Recreational equipment					
Railroad equipment (line-haul and switching)	Change based on population	PM_{10} SIP	Change based on population	PM_{10} SIP	Area by SCC
Airport operations (landings and takeoffs)					
McCarran International Airport	Change based on population	PM_{10} SIP for SO_2, NO_x, and PM_{10}; CO SIP for CO and VOC	Change based on population	PM_{10} SIP for SO_2, NO_x, and PM_{10}; CO SIP for CO and VOC	Area-to-point
Henderson Executive Airport					
North Las Vegas Municipal Airport					
Nellis Air Force Base	No change		No change		
On-Road Mobile Sources					
Paved-road dust (includes construction trackout)	NA	Estimated VMT data (2000)	NA	Estimated VMT data (future years)	Area by actual location
Unpaved-road dust	Estimated VMT change	PM_{10} SIP	Estimated VMT change	PM_{10} SIP	Area by SCC

TABLE 4.1 (Cont.)

	Base Year (2000)		Future Years (2009, 2018)		
Emission Source Category	**Projection Method**	**Reference**	**Projection Method**	**Reference**	**Source Type in CMAQ Modeling[a]**
Highway construction fugitive dust					
Highway construction activities	NA	Actual dust permit data (2000)	NA	Change based on historic patterns and projected land developments[e]	Area by actual location
Windblown dust[d]	NA	Land use data (2000)	NA		Area by actual location
On-road vehicles					
Vehicular sulfate PM	NA	Estimated VMT data and emission factors from MOBILE6 model (2000)	NA	Estimated VMT data and emission factors from MOBILE6 model (future years)	Area by actual location
Vehicular tire wear					
Vehicular brake wear					
Vehicular exhaust					
Stationary Power Plant Sources Regulated by the State[f]					
Clark Station	NA	Continuous Emissions Monitoring (CEM) data (2000)	No change projected	Continuous Emissions Monitoring (CEM) data (2000)	Point
Mohave Generating Station					
Reid Gardner Station					
Sunrise Station					

a "Point" denotes emission sources at exact locations with stack parameters. "Area by SCC" denotes area emission sources that are disaggregated on the basis of surrogate ratios associated with the source classification code (SCC). "Area by actual location" denotes area emission sources that are disaggregated on the basis of grid cells, which are, in turn, based on the actual locations. "Area-to-point" denotes area sources with known locations that are modeled as point sources without stack parameters.

b "Stationary major point sources" denotes permitted major sources to be modeled as point sources. "Small point sources" denote permitted nonmajor sources to be modeled as area sources.

c NA indicates not applicable.

d Windblown dust emissions were calculated internally during the CMAQ modeling by using the surface wind data at each grid cell.

e For construction activities, locations and acreages of construction areas for future years are not available at this time, so the same areas to be disturbed in 2000 are assumed to be disturbed in future years.

f SO_2 and NO_x emission data were taken from the CEM database. CO, VOC, and PM_{10} emission data were estimated on the basis of the 1999 National Emissions Inventory (NEI) database and heat inputs for 1999 and 2000.

TABLE 4.2 Historic and Future Population Projections for 1997–2035 for Clark County, Nevada (REMI forecasts)

Year	Population in Clark County	Population Growth Rate (%)	Population in Nonattainment Area[a]	Ratio to 1998 Population	Note
1997	1,170,113	4.50	1,125,503	0.9390	Historical
1998	1,246,193	6.50	1,198,683	1.0000	Historical
1999	1,321,319	6.03	1,270,945	1.0603	Historical
2000	1,428,690	6.05[b]	1,374,222	1.1464	Annual estimate
2001	1,498,279	4.87	1,441,158	1.2023	Annual estimate
2002	1,583,998	5.72[c]	1,523,609	1.2711	Annual estimate
2003	1,637,600	3.38	1,575,168	1.3141	Start year
2004	1,686,062	2.96	1,621,782	1.3530	
2005	1,730,698	2.65	1,664,717	1.3888	
2006	1,772,274	2.40	1,704,707	1.4222	
2007	1,811,123	2.19	1,742,075	1.4533	
2008	1,847,089	1.99	1,776,670	1.4822	
2009	1,880,861	1.83	1,809,155	1.5093	
2010	1,912,777	1.70	1,839,854	1.5349	
2011	1,944,978	1.68	1,870,827	1.5607	
2012	1,977,466	1.67	1,902,077	1.5868	
2013	2,009,592	1.62	1,932,978	1.6126	
2014	2,041,279	1.58	1,963,457	1.6380	
2015	2,072,398	1.52	1,993,389	1.6630	
2016	2,102,905	1.47	2,022,733	1.6875	
2017	2,132,871	1.42	2,051,557	1.7115	
2018	2,162,262	1.38	2,079,828	1.7351	
2019	2,191,156	1.34	2,107,620	1.7583	
2020	2,219,714	1.30	2,135,089	1.7812	
2021	2,248,445	1.29	2,162,725	1.8043	
2022	2,277,696	1.30	2,190,861	1.8277	
2023	2,307,460	1.31	2,219,490	1.8516	
2024	2,337,706	1.31	2,248,583	1.8759	
2025	2,368,412	1.31	2,278,118	1.9005	
2026	2,399,738	1.32	2,308,250	1.9257	
2027	2,432,007	1.34	2,339,289	1.9515	
2028	2,465,170	1.36	2,371,187	1.9782	
2029	2,499,037	1.37	2,403,763	2.0053	
2030	2,533,477	1.38	2,436,890	2.0330	
2031	2,568,371	1.38	2,470,454	2.0610	
2032	2,604,019	1.39	2,504,743	2.0896	
2033	2,677,274	1.40	2,575,205	2.1484	
2034	2,714,396	1.40	2,610,912	2.1782	

[a] It was assumed, on the basis of U.S. Bureau of the Census 2000 TIGER statistics, that 96.16% of the population in Clark County lives in the nonattainment area. It was also assumed that population growth in Clark County is the same as that in the nonattainment area for past, current, and future years.

[b] The 2000 estimate is 8.13% higher that the 1999 estimate, but part of the increase is a result of the change in the estimation method. Estimated population growth is 6.05%.

[c] The growth rate is inflated as the result of a change in group quarter estimates.

Sources: CBER (2000; 2003).

The Clark County populations for 1997 (the base year for the airport emissions inventory in the CO SIP)[4] and 1998 (the base year in the PM_{10} SIP) were 1,125,503 and 1,198,683, respectively (CBER 2000). Regional Economic Models, Inc. (REMI) modeling results were used to estimate the Clark County population of 1,374,222 in 2000, the base year for the current study. Accordingly, the population growth rate from 1997 to 2000 is 1.2210% and that from 1998 to 2000 is 1.1464%. Population growth was assumed to be the same in the nonattainment area as it was in Clark County.

Estimates of emissions from source categories such as vehicular exhaust and paved-road dust were based on the VMT data developed by the Clark County RTC (Hoeft 2003). For the PM_{10} and CO SIPs, the TRANPLAN model was used to estimate VMT in the baseline and future years. However, the TransCAD model (Caliper Corporation 2003) was run by RTC for all approved and projected projects within Clark County. Table 4.3 summarizes the daily VMT values and average vehicle speeds for 2000, 2005, 2010, 2015, and 2020 by functional class. Annual total emissions inventories for baseline (2000) and future years (2009 and 2018) for criteria pollutants and VOCs by source category are provided in Tables 4.4 through 4.6.

4.1.1 Sources in California and Other Non-Local Emissions

In general, O_3 is a regional issue, because O_3 and its reactive precursor gases can be transported with the wind over long distances while undergoing further chemical reactions. Thus, regional emissions inventories are required for O_3 air quality modeling. In particular, the most recent O_3 precursor data from the SCAQMD in California were reviewed in light of the prevalence of southwesterly winds into the Las Vegas Valley. The SCAQMD emissions data (e.g., point, area, on-road, off-road) are available for their base year (1997) and future-year projections. These data were used in the initial set of simulations referenced in Section 5. However, because of difficulties encountered when processing these data using the SMOKE model and because of the recent availability of already-processed and more up-to-date data for 2002 California emissions being used by the Western Regional Air Partnership (WRAP) in support of a regional haze study (Holland and Adelman 2004), the WRAP data were used for the 2009 and 2018 simulations, also reported in Section 5. These emissions data, which cover most of California, Arizona, and Nevada, were processed in SMOKE to be input into CMAQ over the coarse grids, which in turn feed into the fine grids over Clark County.

No projected WRAP emission data for future years are available. Therefore, for on-road mobile sources, emissions for future years were adjusted on the basis of projected on-road emissions from the EMFAC2002 model (California Air Resources Board [CARB] 2004).

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[4] The base year in the CO SIP is 1996, but 1997 emissions inventory data that were associated only with landing and takeoff cycles at airports were used.

TABLE 4.3 Estimated Daily VMT and Average Vehicle Speeds by Functional Class for Clark County, Nevada, for 2000, 2005, 2010, 2015, and 2020

		2000		2005		2010		2015		2020	
Group Code	Functional Class	Daily VMT	Average Speed (mph)	Daily VMT	Average Speed (mph)	Daily VMT	Average Speed (mph)	Daily VMT	Average Speed (mph)	Daily VMT	Average Speed (mph)
0	External links	358,326	21.74	865,054	21.74	982,139	21.74	1,034,399	21.74	1,281,541	21.74
1	System-to-system ramp	186,211	46.96	261,971	42.61	361,400	46.20	391,650	46.44	452,507	45.88
2	Minor arterial	8,824,212	34.94	10,627,830	34.01	12,219,189	33.59	11,790,511	34.35	14,458,734	31.84
3	Major arterial	2,391,363	36.15	2,931,242	36.47	3,351,581	35.64	3,301,290	36.71	3,739,806	34.09
4	Ramp	698,226	28.23	934,722	27.19	1,093,835	27.27	1,099,362	27.52	1,302,588	26.45
5	Interstate	5,170,295	53.61	7,377,741	53.53	10,157,203	51.21	10,182,867	53.72	12,334,524	49.73
6	Freeway	1,816,941	48.92	2,418,013	50.21	3,561,547	50.80	3,990,574	49.37	4,881,636	48.16
7	Expressway/beltway	171,140	48.13	314,453	42.00	29,628	50.00	0	NA[a]	0	NA
8	Collector	2,697,822	34.96	4,119,905	34.69	5,730,217	34.33	5,817,698	34.66	8,229,407	32.97
9	Centroid connector	1,809,440	25.00	2,299,762	25.00	2,897,409	25.00	2,867,244	25.00	3,551,669	25.00
10	Local road	7,230	23.92	13,547	24.70	15,287	23.94	16,149	23.49	20,041	21.84
11	High-occupancy vehicle lanes[b]	0	13.50	862,867	49.42	867,202	50.96	879,832	53.86	885,407	48.42
	Total VMT	24,131,206		33,027,108		41,266,638		41,371,576		51,137,862	

[a] NA = not applicable.

[b] Fixed route transit for year 2000.

Source: Hoeft (2003).

TABLE 4.4 Non-BLM Annual Total Anthropogenic Emissions Inventory by Source Category in the Nonattainment Area for Base Year 2000

Emission Source Category	Emissions (tons/yr)					
	SO_2	NO_x	CO	VOCs	PM_{10}	$PM_{2.5}$
Stationary Major Point Sources[a]	**248.8**	**6,812.0**	**1,973.5**	**419.8**	**916.0**	**NA**[b]
Stationary Area Sources						
Small point sources[c]	121.6	1,247.3	887.7	761.1	1,227.7	NA
Natural gas combustion						
Residential use	6.1	954.9	406.3	55.9	77.2	77.2
Commercial use	3.0	615.2	421.2	27.6	38.1	38.1
Industrial use	1.1	182.2	151.8	9.9	13.7	13.7
Purchased at the source (carried by SWG)	16.6	2,767.3	2,324.5	152.2	210.3	210.3
Residential firewood combustion	1.0	6.5	628.5	569.8	86.1	NA
Structure fires/vehicle fires/wildfires	NA	2.5	109.1	20.0	19.6	17.8
Charbroiling/meat cooking	NA	NA	NA	82.1	856.3	NA
Windblown dust — vacant lots[d]						
Disturbed vacant lands/unpaved parking lots	NA	NA	NA	NA	NA	NA
Native desert	NA	NA	NA	NA	NA	NA
Stabilized vacant land	NA	NA	NA	NA	NA	NA
Construction fugitive dust						
Construction activities	NA	NA	NA	NA	20,513.1	NA
Windblown dust[d]	NA	NA	NA	NA	NA	NA
Subtotal	**149.4**	**5,775.9**	**4,929.1**	**1,678.6**	**23,042.1**	**357.2**
Nonroad Mobile Sources						
Nonroad engines and vehicles						
Agricultural equipment	0.1	9.0	10.9	1.4	1.2	1.1
Airport equipment	0.5	51.5	57.7	6.0	3.9	3.8
Commercial equipment	3.2	351.0	10,636.4	499.9	31.4	30.1
Construction and mining equipment	122.1	10,377.5	15,453.5	1,985.9	955.0	924.9
Industrial equipment	3.6	477.6	1,416.6	107.2	26.0	25.2
Lawn and garden equipment (commercial)	9.2	698.4	63,913.4	4,584.8	169.9	157.7
Lawn and garden equipment (residential)	1.2	63.9	11,594.5	822.5	13.3	12.2
Logging equipment	0.0	0.0	0.0	0.0	0.0	0.0
Pleasure craft	1.3	88.2	2,470.8	1,211.9	48.1	44.3
Railroad equipment (maintenance)	0.1	13.0	36.3	3.4	2.0	1.9
Recreational equipment	0.5	24.0	3,304.9	606.4	19.8	18.2
Railroad equipment (line-haul and switching)	8.8	748.7	74.3	29.5	18.6	NA
Airport operations (landings and takeoffs)						
McCarran International Airport	105.4	2,351.4	5,088.4	649.6	282.8	NA
Henderson Executive Airport	0.6	6.4	688.6	34.9	6.2	NA
North Las Vegas Municipal Airport	1.7	21.6	3,404.8	104.4	25.8	NA
Nellis Air Force Base	396.5	268.6	1,043.1	128.4	31.9	NA
Subtotal	**654.9**	**15,550.8**	**119,194.0**	**10,776.1**	**1,635.8**	**1,219.5**

TABLE 4.4 (Cont.)

Emission Source Category	Emissions (tons/yr)					
	SO_2	NO_x	CO	VOCs	PM_{10}	$PM_{2.5}$
On-Road Mobile Sources						
Paved-road dust (includes construction trackout)	NA	NA	NA	NA	38,408.7	NA
Unpaved-road dust	NA	NA	NA	NA	17,536.3	NA
Highway construction fugitive dust						
Highway construction activities	NA	NA	NA	NA	2,310.3	NA
Windblown dust[d]	NA	NA	NA	NA	NA	NA
On-road vehicles						
Vehicular sulfate PM	NA	NA	NA	NA	13.8	13.8
Vehicular tire wear	NA	NA	NA	NA	80.7	20.2
Vehicular brake wear	NA	NA	NA	NA	119.7	50.7
Vehicular exhaust	225.9	15,552.8	162,106.8	14,639.3	174.0	156.9
Subtotal	**225.9**	**15,552.8**	**162,106.8**	**14,639.3**	**58,643.5**	**241.6**
Stationary Power Plant Sources Regulated by the State						
Clark Station	2.4	1,127.7	215.4	24.6	3.1	3.1
Mohave Generating Station	42,749.6	21,736.6	1,203.3	145.6	1,395.9	689.7
Reid Gardner Station	2,976.0	9,585.0	505.0	60.6	1,194.5	736.2
Sunrise Station	22.4	1,175.1	177.5	14.2	0.8	0.8
Subtotal	**45,750.4**	**33,624.5**	**2,101.2**	**244.9**	**2,594.3**	**1,429.8**
Total	**47,029.4**	**77,316.0**	**290,304.5**	**27,758.8**	**86,831.8**	**3,248.2**
BLM Contribution (gas & electricity)[e]	**-384.1**	**-354.9**	**-35.1**	**-4.5**	**-123.2**	**-55.2**
Grand Total	**46,645.3**	**76,961.1**	**290,269.4**	**27,754.3**	**86,708.6**	**3,193.0**

[a] "Stationary major point sources" are permitted major sources modeled as point sources.

[b] NA = not applicable, not available, or not estimated because of a lack of data.

[c] "Small point sources" are permitted nonmajor sources modeled as area sources.

[d] Windblown dust emissions were calculated internally during the CMAQ modeling by using the surface wind data at each grid cell.

[e] BLM emissions from gas and electricity uses were subtracted because these emissions are implicitly included in non-BLM emissions from natural gas combustion and power plants (see page 4-1 for explanation).

TABLE 4.5 Non-BLM Annual Total Anthropogenic Emissions Inventory by Source Category in the Nonattainment Area for Future Year 2009

Emission Source Category	Emissions (tons/yr)					
	SO_2	NO_x	CO	VOCs	PM_{10}	$PM_{2.5}$
Stationary Major Point Sources[a]	**768.9**	**9,478.1**	**7,014.8**	**1,448.5**	**2,778.0**	**NA[b]**
Stationary Area Sources						
Small point sources[c]	121.6	1,247.3	887.7	761.1	1,227.7	NA
Natural gas combustion						
Residential use	8.0	1,257.1	534.9	73.6	101.6	101.6
Commercial use	4.0	810.0	554.5	36.3	50.2	50.2
Industrial use	1.1	182.2	151.8	9.9	13.7	13.7
Purchased at the source (carried by SWG)	16.6	2,767.3	2,324.5	152.2	210.3	210.3
Residential firewood combustion	1.2	7.8	754.7	684.2	103.4	NA
Structure fires/vehicle fires/wildfires	NA	3.1	131.0	24.0	23.6	21.4
Charbroiling/meat cooking	NA	NA	NA	98.6	1,028.2	NA
Windblown dust — vacant lots[d]						
Disturbed vacant lands/unpaved parking lots	NA	NA	NA	NA	NA	NA
Native desert	NA	NA	NA	NA	NA	NA
Stabilized vacant land	NA	NA	NA	NA	NA	NA
Construction fugitive dust						
Construction activities	NA	NA	NA	NA	19,476.1	NA
Windblown dust[d]	NA	NA	NA	NA	NA	NA
Subtotal	**152.4**	**6,274.6**	**5,339.1**	**1,839.9**	**22,234.8**	**397.2**
Nonroad Mobile Sources						
Nonroad engines and vehicles						
Agricultural equipment	0.0	7.1	8.1	0.8	0.7	0.7
Airport equipment	0.0	41.1	42.0	3.6	2.7	2.6
Commercial equipment	0.7	316.7	11,954.1	274.3	27.3	26.2
Construction and mining equipment	8.7	7,673.2	11,927.7	1,074.1	655.0	634.1
Industrial equipment	0.5	297.2	887.2	46.6	16.0	15.6
Lawn and garden equipment (commercial)	2.4	592.8	60,981.5	2,030.4	160.0	148.3
Lawn and garden equipment (residential)	0.4	63.0	11,241.3	404.8	11.8	10.8
Logging equipment	0.0	0.0	0.0	0.0	0.0	0.0
Pleasure craft	0.3	119.3	1,966.8	635.9	33.8	31.1
Railroad equipment (maintenance)	0.0	11.8	33.5	2.5	1.5	1.4
Recreational equipment	0.3	32.6	4,233.4	972.2	34.7	31.9
Railroad equipment (line-haul and switching)	10.6	346.7	89.2	19.0	11.8	NA
Airport operations (landings and takeoffs)						
McCarran International Airport	126.5	2,823.5	6,110.0	780.0	339.6	NA
Henderson Executive Airport	0.7	7.7	826.9	41.9	7.5	NA
North Las Vegas Municipal Airport	2.0	25.9	4,088.3	125.3	30.9	NA
Nellis Air Force Base	396.5	268.6	1,043.1	128.4	31.9	NA
Subtotal	**549.5**	**12,627.3**	**115,433.0**	**6,539.7**	**1,365.2**	**902.8**

TABLE 4.5 (Cont.)

Emission Source Category	Emissions (tons/yr)					
	SO_2	NO_x	CO	VOCs	PM_{10}	$PM_{2.5}$
On-Road Mobile Sources						
Paved-road dust (includes construction trackout)	NA	NA	NA	NA	56,649.0	NA
Unpaved-road dust	NA	NA	NA	NA	18,920.0	NA
Highway construction fugitive dust						
Highway construction activities	NA	NA	NA	NA	2,107.2	NA
Windblown dust[d]	NA	NA	NA	NA	NA	NA
On-road vehicles						
Vehicular sulfate PM	NA	NA	NA	NA	5.4	5.4
Vehicular tire wear	NA	NA	NA	NA	125.8	31.5
Vehicular brake wear	NA	NA	NA	NA	186.7	79.1
Vehicular exhaust	123.4	10,892.8	143,727.4	9,285.3	121.3	110.8
Subtotal	**123.4**	**10,892.8**	**143,727.4**	**9,285.3**	**78,115.3**	**226.9**
Stationary Power Plant Sources Regulated by the State						
Clark Station	2.4	1,127.7	215.4	24.6	3.1	3.1
Mohave Generating Station[e]	0.0	0.0	0.0	0.0	0.0	0.0
Reid Gardner Station	2,976.0	9,585.0	505.0	60.6	1,194.5	736.2
Sunrise Station	22.4	1,175.1	177.5	14.2	0.8	0.8
Subtotal	**3,000.8**	**11,887.9**	**897.9**	**99.3**	**1,198.4**	**740.1**
Total	**4,594.9**	**51,160.7**	**272,412.3**	**19,212.8**	**105,691.7**	**2,267.0**
BLM Contribution (gas & electricity)[f]	**-146.7**	**-1,065.8**	**-326.4**	**-53.9**	**-848.2**	**-408.0**
Grand Total	**4,448.2**	**50,094.8**	**272,085.9**	**19,158.9**	**104,843.6**	**1,859.0**

[a] "Stationary major point sources" are permitted major sources modeled as point sources.

[b] NA = not applicable, not available, or not estimated because of a lack of data.

[c] "Small point sources" are permitted nonmajor sources modeled as area sources.

[d] Windblown dust emissions were calculated internally during the CMAQ modeling by using the surface wind data at each grid cell.

[e] Based in part on the large degree of uncertainty associated with a number of factors that would need to fall in place to allow continued operation of the Mohave Generating Station beyond 2005 and on earlier discussions (summer 2003) with Clark County permitting officials, this study assumed that the plant would be closed in the 2009 and 2018 assessments. Compliance with a Consent Decree would require the installation of a baghouse to control particulate emissions and a scrubber to control SO_2 emissions by January 2006 for one unit and April 2006 for both units. In addition to the Consent Decree, Mohave would also need to secure continued future water and coal slurry supplies. Considering the location of the plant (~75 miles south of Las Vegas) and the meteorology occurring for the 18 episode days assessed in this study, the Mohave plant would play a minor role as a contributor to Las Vegas's current O_3 nonattainment problem. The basis for this is that during typical O_3 episode days (afternoon hours from ~ 1 pm to 5 pm), including the days assessed in this study, winds usually flow from the northwest and southwest, with distinct valley drainage flow during the night. Although predominant southerly flow does occur, this flow appears to be restricted to nonozone episode days when observed O_3 levels are relatively low.

[f] BLM emissions from gas and electricity uses were subtracted because these emissions are implicitly included in non-BLM emissions from natural gas combustion and power plants (see page 4-1 for explanation).

TABLE 4.6 Non-BLM Annual Total Anthropogenic Emissions Inventory by Source Category in the Nonattainment Area for Future Year 2018

Emission Source Category	Emissions (tons/yr)					
	SO_2	NO_x	CO	VOCs	PM_{10}	$PM_{2.5}$
Stationary Major Point Sources[a]	**768.9**	**9,478.1**	**7,014.8**	**1,448.5**	**2,778.0**	**NA[b]**
Stationary Area Sources						
Small point sources[c]	121.6	1,247.3	887.7	761.1	1,227.7	NA
Natural gas combustion						
Residential use	9.2	1,445.2	615.0	84.6	116.8	116.8
Commercial use	4.6	931.1	637.4	41.7	57.7	57.7
Industrial use	1.1	182.2	151.8	9.9	13.7	13.7
Purchased at the source (carried by SWG)	16.6	2,767.3	2,324.5	152.2	210.3	210.3
Residential firewood combustion	1.3	8.3	808.3	732.8	110.7	NA
Structure fires/vehicle fires/wildfires	NA	3.3	140.3	25.7	25.3	22.9
Charbroiling/meat cooking	NA	NA	NA	105.6	1,101.3	NA
Windblown dust — vacant lots[d]						
Disturbed vacant lands/unpaved parking lots	NA	NA	NA	NA	NA	NA
Native desert	NA	NA	NA	NA	NA	NA
Stabilized vacant land	NA	NA	NA	NA	NA	NA
Construction fugitive dust						
Construction activities	NA	NA	NA	NA	19,476.1	NA
Windblown dust[d]	NA	NA	NA	NA	NA	NA
Subtotal	**154.3**	**6,584.7**	**5,565.0**	**1,913.7**	**22,339.6**	**421.5**
Nonroad Mobile Sources						
Nonroad engines and vehicles						
Agricultural equipment	0.0	4.4	6.3	0.5	0.4	0.4
Airport equipment	0.0	18.4	25.1	2.2	1.3	1.2
Commercial equipment	0.7	260.6	13,626.3	283.5	20.4	19.5
Construction and mining equipment	7.8	3,559.0	9,098.7	714.6	308.0	297.5
Industrial equipment	0.5	153.5	203.7	13.5	5.8	5.7
Lawn and garden equipment (commercial)	2.6	551.6	65,936.6	2,083.6	163.5	151.2
Lawn and garden equipment (residential)	0.4	62.1	12,238.0	366.0	12.3	11.3
Logging equipment	0.0	0.0	0.0	0.0	0.0	0.0
Pleasure craft	0.3	126.8	1,812.8	485.1	30.6	28.2
Railroad equipment (maintenance)	0.0	8.1	30.0	1.7	0.9	0.9
Recreational equipment	0.3	32.5	4,299.0	470.5	16.0	14.8
Railroad equipment (line-haul and switching)	0.3	371.4	95.6	20.4	12.7	NA
Airport operations (landings and takeoffs)						
McCarran International Airport	135.5	3,024.1	6,544.2	835.4	363.8	NA
Henderson Executive Airport	0.7	8.3	885.7	44.8	8.0	NA
North Las Vegas Municipal Airport	2.2	27.8	4,378.9	134.2	33.1	NA
Nellis Air Force Base	396.5	268.6	1,043.1	128.4	31.9	NA
Subtotal	**548.0**	**8,477.2**	**120,223.8**	**5,584.3**	**1,008.7**	**530.6**

TABLE 4.6 (Cont.)

Emission Source Category	Emissions (tons/yr)					
	SO_2	NO_x	CO	VOCs	PM_{10}	$PM_{2.5}$
On-Road Mobile Sources						
Paved-road dust (includes construction trackout)	NA	NA	NA	NA	67,274.1	NA
Unpaved-road dust	NA	NA	NA	NA	19,456.0	NA
Highway construction fugitive dust						
Highway construction activities	NA	NA	NA	NA	1,963.2	NA
Windblown dust[d]	NA	NA	NA	NA	NA	NA
On-road vehicles						
Vehicular sulfate PM	NA	NA	NA	NA	6.4	6.4
Vehicular tire wear	NA	NA	NA	NA	146.8	36.7
Vehicular brake wear	NA	NA	NA	NA	217.7	92.3
Vehicular exhaust	143.8	5,784.9	124,494.6	5,919.6	85.2	77.9
Subtotal	143.8	5,784.9	124,494.6	5,919.6	89,149.4	213.3
Stationary Power Plant Sources Regulated by the State						
Clark Station	2.4	1,127.7	215.4	24.6	3.1	3.1
Mohave Generating Station[e]	0.0	0.0	0.0	0.0	0.0	0.0
Reid Gardner Station	2,976.0	9,585.0	505.0	60.6	1,194.5	736.2
Sunrise Station	22.4	1,175.1	177.5	14.2	0.8	0.8
Subtotal	3,000.8	11,887.9	897.9	99.3	1,198.4	740.1
Total	**4,615.8**	**42,212.8**	**258,196.2**	**14,965.5**	**116,474.1**	**1,905.5**
BLM Contribution (gas & electricity)[f]	**-295.0**	**-2,096.5**	**-634.6**	**-104.4**	**-1,674.9**	**-805.0**
Grand Total	**4,320.8**	**40,116.3**	**257,561.6**	**14,861.1**	**114,799.2**	**1,100.5**

[a] "Stationary major point sources" are permitted major sources modeled as point sources.

[b] NA = not applicable, not available, or not estimated because of a lack of data.

[c] "Small point sources" are permitted nonmajor sources modeled as area sources.

[d] Windblown dust emissions were calculated internally during the CMAQ modeling by using the surface wind data at each grid cell.

[e] Based in part on the large degree of uncertainty associated with a number of factors that would need to fall in place to allow continued operation of the Mohave Generating Station beyond 2005 and on earlier discussions (summer 2003) with Clark County permitting officials, this study assumed that the plant would be closed in the 2009 and 2018 assessments. Compliance with a Consent Decree would require the installation of a baghouse to control particulate emissions and a scrubber to control SO_2 emissions by January 2006 for one unit and April 2006 for both units. In addition to the Consent Decree, Mohave would also need to secure continued future water and coal slurry supplies. Considering the location of the plant (~75 miles south of Las Vegas) and the meteorology occurring for the 18 episode days assessed in this study, the Mohave plant would play a minor role as a contributor to Las Vegas's current O_3 nonattainment problem. The basis for this is that during typical O_3 episode days (afternoon hours from ~ 1 pm to 5 pm), including the days assessed in this study, winds usually flow from the northwest and southwest, with distinct valley drainage flow during the night. Although predominant southerly flow does occur, this flow appears to be restricted to nonozone episode days when observed O_3 levels are relatively low.

[f] BLM emissions from gas and electricity uses were subtracted because these emissions are implicitly included in non-BLM emissions from natural gas combustion and power plants (see page 4-1 for explanation).

4.1.2 Sources with Actual Emissions Data

4.1.2.1 For the Base Year

Actual emissions data or continuous emissions monitoring (CEM) data for base year 2000 were available and inventoried for the following emissions source categories: stationary major point sources, small point sources, and stationary power plant sources regulated by the State of Nevada.

- ***Stationary Major Point Sources.*** Permitted stationary sources report their actual emission levels each year to the Clark County Health District, Air Quality Division (AQD) (Hoch 2003). These self-reported levels, which are reviewed and approved by AQD, were used in the emissions inventory for the base year (2000). However, actual data were available for only a small portion of emission sources for that year. Accordingly, actual emissions data for 2000 were preferentially compiled into the emissions inventory for the base year. If no actual emissions data for 2000 were available, then actual emissions data for 2001 or 2002 were used.

  Only 26 permitted sources in Clark County are considered major sources (with the potential to emit more than 70 tons/yr of PM_{10} and CO for the serious nonattainment area and 100 tons/yr of SO_2, NO_x, and VOCs for the PSD area). These sources were modeled as point sources in the CMAQ runs; that is, they were placed at their exact locations with stack data (obtained from the Clark County staff) and permit application files.

- ***Small Point Sources.*** Nonmajor permitted sources were labeled “small point sources” and grouped with other area sources. The emissions from these sources were inventoried using the same methods used for those from major point sources. More than 700 permitted emission sources were included in this category. These sources, along with other anthropogenic sources in the “stationary area sources” category, were modeled in the CMAQ runs as area sources by using the Source Classification Codes (SCC) associated with the spatial surrogate data, which allows disaggregation of areawide emissions into grid cells.

- ***Stationary Power Plant Sources Regulated by the State of Nevada.*** Four power-generating facilities regulated by the State of Nevada were in operation in Clark County in 2000. These included the primarily natural-gas-burning Clark and Sunrise Stations and the primarily coal-burning Reid Gardner and Mohave Generating Stations. In 2000, hourly CEM data for SO_2, NO_x, and CO_2, along with heat input data, were reported to EPA (EPA 2003b). However, the hourly CEM data did not include emissions of CO, VOCs, and PM, so these emissions were estimated by using the 1999 National Emissions Inventory (NEI) database (EPA 2003c) and heat input data. These sources were also modeled in the CMAQ runs as point sources. Their actual hourly emission data were input to the model, distinct from data for "stationary point sources," by using a temporal allocation factor (if any). Stack information for these power plant sources was provided by the State of Nevada (Remer 2003).

4.1.2.2 For Future Years

In general, emissions from individual point sources may vary from year to year, but they are not expected to change significantly unless major modifications are made. Accordingly, these source emissions were assumed to remain the same for future years. The highest emissions data for 2000–2002 for point sources permitted by Clark County were used for the future years, as a conservative measure. In addition, several new and expanded gas-fired combined-cycle power plants to be built in and around Clark County were also included for future years.

4.1.3 Sources with Actual or Estimated Activity Data

4.1.3.1 For the Base Year

For this source category, actual (or estimated) activity data for 2000 were available, so their emissions were estimated. The following emission sources fall under this category: construction activities, nonroad engines and vehicles, paved-road dust (including construction trackout), unpaved road dust, highway construction activities, and on-road vehicles. The emissions estimation method for each source is described below.

- ***Construction (including Highway Construction) Activities.*** Construction-related emissions (including highway construction-related emissions) were estimated on the basis of dust control permits issued by the AQD for individual projects. In 2000, 19,041 acres were permitted for construction. However, projects that received permits near the end of 2000 would not generate construction-related fugitive dusts in 2000. On the other hand, projects that received permits in 1999 would generate fugitive dust emissions in 2000. Accordingly, monthly emission rates were estimated by construction type by considering construction startup or groundbreaking times and average construction durations, ranging from 1 month (e.g., underground utilities) to 1 year (e.g., highway construction); the monthly rates were then summed to arrive at annual total emissions. Construction startup or groundbreaking was assumed to begin a month after the issuance of the dust control permit. For the CMAQ model runs, individual construction emissions were disaggregated onto fine grid cells on the basis of their central locations.

- ***Nonroad Engines and Vehicles.*** The emissions inventory for nonroad mobile sources in the PM_{10} and CO SIPs were based on an outdated EPA database (EPA 1992). The Draft NONROAD2004 model (EPA 2002) — developed to calculate past, present, and future emissions inventories for nonroad engines and vehicles — was used in accordance with EPA's recommendation, although the model was still a draft and did not reflect all of EPA's final nonroad engine emission standards to date (EPA 2002). The sulfur content in gasoline was assumed to be 100 ppm in summer and 30 ppm in winter, while the sulfur content in diesel fuel was assumed to be 250 ppm throughout the year (Li 2003). The model generates emission rates (not emission factors) by SCC, horsepower, equipment type, engine type, and source type.

On the basis of the built-in activity level and emission factor, the nonroad engine emissions were estimated by year for the following subcategories: (1) agricultural equipment, (2) airport equipment, (3) commercial equipment, (4) construction and mining equipment, (5) industrial equipment, (6) lawn and garden equipment (commercial), (7) lawn and garden equipment (residential), (8) logging equipment, (9) pleasure craft, (10) railroad equipment (maintenance), and (11) recreational equipment.

All emissions for nonroad mobile sources were conservatively assumed to represent the nonattainment area for air quality modeling, because spatial distribution data were not available. These emissions were distributed over the modeling domain by using the SCC associated with the surrogate ratios.

- ***Paved-Road Dust.*** PM_{10} emissions from paved road dust were estimated on the basis of daily VMT provided by RTC (Hoeft 2003) and emission factors developed for paved roads (with and without improved shoulders) in the PM_{10} SIP. Increased emissions across the paved roads with trackout at construction sites were also estimated based on the methodology developed in the PM_{10} SIP, including the assumed number of access points by construction type, average number of vehicles and trackout distance, and emission factors derived from silt loading field measurements. These emissions were distributed into fine grid cells on the basis of the given location of each road segment.

- ***Unpaved-Road Dust.*** In accordance with the PM_{10} SIP, changes in average daily trips on unpaved roads were based on the predicted change in VMT for local roads. The local road traffic was estimated to change by a factor of 1.26 from 1998 to 2001 and by a factor of 1.34 from 1998 to 2006. With a linear interpolation, traffic on unpaved roads was estimated to change by a factor of 1.18 from 1998 to 2000 for the emissions inventory. The emissions were distributed over the modeling domain by using the SCC associated with the surrogate ratios.

- ***On-Road Vehicles.*** Emissions factors for vehicular sulfate PM emissions, tire and brake wear emissions, and vehicle exhaust emissions were developed by using the MOBILE6 model (EPA 2003a), which assumes that federal programs for vehicles are implemented. The sulfur contents used were the same as those used for nonroad engines. Emissions from vehicle exhaust and from tire and brake wear were estimated by using emission factors from the MOBILE6 model and daily VMT data by functional class, provided by the RTC. These emissions were distributed into fine grid cells on the basis of the location of each road segment.

4.1.3.2 For Future Years

- ***Construction (including Highway Construction) Activities.*** For construction fugitive dust, no information was available about the areas to be developed. In consultation with the BLM and Clark County staff, construction areas were projected on the basis of historic construction patterns and information about vacant lands within the BLM disposal boundary. However, no general trends were projected, so the research team assumed that construction (including highway construction) activities and their associated construction trackout would occur at the same modeling grid cells and the same levels.

- ***Nonroad Engines and Vehicles.*** For nonroad mobile sources, future emissions were estimated by using the Draft NONROAD2004 model (EPA 2002).

  Because of its designation as a nonattainment area for 8-hour O_3 (on April 15, 2004), Clark County should adopt federal requirements in its O_3 SIP. In highly polluted areas of the country, the CAA requires that only RFG be sold and used. The RFG must meet specific emission performance standards to ensure that it is a cleaner-burning gasoline. In addition to these standards, RFG is also subject to the recently promulgated Tier 2/low-sulfur gasoline regulations. For our analysis, an RVP of 6.8 psi for gasoline was assumed in summer but an RVP of 9 psi is used in winter. Sulfur contents of 30 ppm for gasoline and 15 ppm for diesel were used for future years.

- ***Paved-Road Dust.*** Future emissions were estimated by using the same emission factors as those used for the baseline and projected daily VMT data developed by RTC (Hoeft 2003).

- ***Unpaved-Road Dust.*** Future average daily trips were estimated by linear extrapolation on the basis of the ratios of unpaved road traffic change from 1998 to 2001 and 2006 in the PM_{10} SIP. Unpaved road emissions were estimated to change by a factor of 1.39 for 2009 and 1.53 for 2018 compared to the 1998 emissions in the inventory.

- ***On-Road Vehicles.*** For on-road mobile sources, future emission rates were estimated by using the emission factors from the MOBILE6 model and projected daily VMT values developed by RTC (Hoeft 2003). The sulfur contents and RVP values used were the same as those used for nonroad engines.

4.1.4 Sources with Emission Changes Based on Population

4.1.4.1 For the Base Year

Emission rates for 2000 were estimated on the basis of population data changes from the population data used in the PM_{10} and CO SIPs. The emission data from the 1997 CO SIP or the 1998 PM_{10} emission inventories were multiplied by population growth factors of 1.2210[5] and 1.1464, respectively, to estimate the 2000 emission levels for the following emission categories:

- Natural gas combustion (residential and commercial use)[6];
- Residential firewood burning;
- Structure fires, vehicle fires, wildfires;
- Charbroiling and meat cooking;
- Railroad equipment (line-haul and switching); and
- Airport operations (landings and takeoffs) at
  - McCarran International Airport,
  - Henderson Executive Airport, and
  - North Las Vegas Municipal Airport.

All emissions except those from airport operations were modeled as area sources, with emissions disaggregated into grid cells on the basis of the SCC associated with the surrogate ratios. In general, emission sources for airport operations were based on actual airport activity data. However, neither detailed flight data nor aircraft emission inventories for 2000 were available, so aircraft traffic and resultant emissions were assumed to increase by the ratio of the population increase. Emissions from airport operations were assigned to the area-to-point algorithm for area sources, the exact locations of which were input into the CMAQ model.

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[5] This factor includes BLM-related and non-BLM-related population growth.

[6] In the PM_{10} SIP, the commercial use of natural gas was assumed to have no projected change. Considering that commercial activities would increase with population growth, it was assumed for this analysis that emissions would increase with population growth.

4.1.4.2 For Future Years

Emissions for these sources (with emission changes based on population) were projected for future years by using the population growth data listed in Table 4.2. Future emissions will change with changes in population; growth factors over the 2000 baseline levels are 1.5093 for 2009 and 1.7351 for 2018.

4.1.5 Sources without Emission Changes

4.1.5.1 For the Base Year

In 2000, the following sources were projected to remain at levels that were similar to those in 1997 and 1998: (1) natural gas combustion (both industrial use and purchased at the source, carried by SWG) and (2) airport operations (landings and takeoffs) at Nellis Air Force Base.

- ***Natural Gas Combustion.*** Combustion of natural gas, including that for industrial use and that purchased at the source by SWG, was assumed to be relatively constant. Emissions from natural gas combustion were modeled as area sources by using the SCC associated with surrogate ratios.

- ***Airport Operations (Landings and Takeoffs).*** Aircraft emissions from Nellis Air Force Base were also assumed to remain relatively constant. No new aircraft are proposed for the base unless Congress approves funding for the new F-22 fighters. Even if the new fighters are deployed, no net emission changes are anticipated. The Nellis Air Force Base emissions were modeled by using the area-to-point algorithm, as were emissions for the other commercial airports.

4.1.5.2 For Future Years

Projections were the same as those for the base year.

4.2 Air Emission Estimates Associated with Land Use Changes Due to BLM Land Disposition Actions

The analysis of baseline and future BLM land disposal actions covered a 20-year period, from 1998 to 2018, consistent with the current LVRMP/FEIS. Baseline air emissions were defined as emissions generated from new construction and new development operations during calendar year 2000, accounting for BLM disposition actions beginning in October 1998 and ending in December 2000. Estimates of land disposition emissions were also made for 2009 and

2018. The BLM emissions inventory covers new source construction activities and emissions generated during source operation (e.g., automobile and residential energy use). For the analysis, issue of a patent and groundbreaking were assumed to occur 1 month after the purchase, exchange, or transfer date for both the baseline-year and the future-year analyses.

GIS data used to support the analysis required two main data sources: (1) a land conveyance layer spanning the period from October 1998 through December 2018 (see Appendix B for details) and (2) existing and planned land use (see Appendix C for details). Land use data were added to a land use GIS layer matched to the Clark County Assessor's Office records, as adapted by the RTC (RTC 2002). The actual land use records were current as of June 2002. Thirteen land-use source groups plus 15,210 acres with no end-use assignment (NODATA) were identified from a GIS layer generated from existing land use in and around Las Vegas, as shown in Table 4.7. These land-use source groups were regrouped into nine land development or end-use groups: (1) single-family housing, (2) multifamily housing (e.g., apartment complexes), (3) office buildings, (4) retail (e.g., convenience stores), (5) moderate-sized casinos and hotels, (6) industry (i.e., light industry, warehouses), (7) recreation (e.g., city parks), (8) religious (synagogues and churches), and (9) public facilities (e.g., schools, hospitals, police and fire stations, public garages). The assumptions used in emission projections for the federal land-use source groups are summarized in Appendix D. This appendix also contains a detailed breakdown of the proposed emission factors associated with the source groups.

Construction emissions are estimated for one year of interest (2000, 2009, and 2018). Operation emissions include those caused by operations on BLM lands disposed since 1998. PM_{10} emissions from construction and emissions of criteria pollutants, VOCs, and CO_2 from operations are estimated through application of emission factors. In particular, operation emissions consist of two parts: energy use/wind erosion and vehicular traffic. Composite emission factors (in [tons/yr]/acre) for energy use/wind erosion were developed by using emission factors derived from assumed activities categorized according to land use. Composite emission factors ([tons/yr]/[mi/d]) for vehicle exhaust and paved-road dust were derived from the MOBILE6 model and from emission factors developed for the PM_{10} SIP (Clark County 2001), respectively, for non-BLM vehicular traffic. These factors were derived on the basis of the assumed typical activities presented in Appendix D.

The land use data include a NODATA category, for which future planned or zoned land use was not known. To estimate the construction and operation emissions associated with BLM land disposal, acreages under the NODATA category were redistributed to known land use categories on the basis of the assumed breakout (based on current RTC land use data through June 2002, as shown in Table 4.7). The BLM rate of land disposal from 1998 through 2003 averaged approximately 4,000 acres/yr, and it varied from 600 acres in 2000 to more than 8,000 acres in 1999. However, development of this land proceeded at a rate of less than 1,000 acres/yr, with a total of 1,700 acres being developed by January 1, 2001. This figure represents an overall rate of development of approximately 21% of the total available developable land (minus ROWs and open space).

TABLE 4.7 BLM Land Use Data Used in the Analysis

Land Use Category Identified from RTC GIS Coverage of Existing Land Use	Final Land Use Source Group	BLM Disposed Area (acres)						Assumed NODATA (% assigned to each end use)[a]
			2001–2005		2006–2018			
		1998–2000	Before[a]	After[a]	Before[a]	After[a]	Average Annual Rate	
RESID_SNG	Single-family housing	1,344.6	9,506.0	12,234.8	14,009.2	20,578.3	1,860.5	61.1
RESID_MULT	Multifamily housing	43.9	209.3	593.6	519.4	1,444.7	130.6	8.6
OFFICE	Office buildings	50.1	871.3	1,036.0	1,648.7	2,045.2	184.9	3.7
RETAIL	Retail	19.4	395.1	700.0	1,052.4	1,786.3	161.5	6.8
HOTEL	Moderate-sized casinos/hotels	0.1	13.4	78.1	35.3	191.1	17.3	1.5
INDUSTRY/WAREHOUSE	Industry	89.8	75.5	421.1	1,427.7	2,259.2	204.3	8.8
RECREATION	Recreation	61.8	22.0	310.8	581.4	1,276.6	115.4	6.5
RELIGIOUS	Religious	74.9	0.0	37.5	10.2	100.4	9.1	0.8
PUBLIC FACILITY/SCHOOL	Public facilities	16.1	34.6	176.1	454.7	795.3	71.9	3.2
RIGHTOFWAY	NA[b]	724.2	597.0	597.0	1,042.6	1,042.6	94.3	0.0
VACANT	NA	6,433.8	2,580.3	2,580.3	12,721.9	12,721.9	1,150.2	0.0
NODATA	a	0.0	4,463.9	0.0	10,746.1	0.0	0.0	NA
Total		**8,858.7**	**18,768.3**	**18,768.3**	**44,241.6**	**44,241.6**	**4,000.0**	**100.0**

[a] "Before" and "After" denote the acreage before and after the "NODATA" category was redistributed by using the assumed land use breakout in the last column.

[b] NA = not applicable.

Because BLM plans for land sales are available only through 2005, the size, location, and timing of future BLM land sales are unknown. It is assumed that future BLM land disposal rates (2006 and beyond) would continue at the average rate of disposal over the first 5 years of BLM land disposition, or 4,000 acres/yr. It is further assumed that future land development rates (2003 and beyond) would be slightly higher (at 1,200 acres/yr) than those that occurred over the first 3 years. Because the research team did not know when and where disposal and development would occur after 2005, a composite emission factor (by land use category) was used to represent a single year and multiplied by 13 years to get total development-related emissions through 2018, while an average development rate of 1,230 acres/yr was maintained. Construction and operation emissions are related to land development in the year of interest, as well as undeveloped land disposal from previous years. For example, if the BLM lands were conveyed in December 2010, emissions from construction and operation would be zero in 2010. However, if the BLM lands were patented in June 2010, development of some parts of this land was assumed to occur in 2010 and development of other parts was assumed to occur in 2011, so emissions from construction and operation could spread over both 2010 and 2011.

4.2.1 Construction-Related Emissions

The analysis assumed that construction startup or groundbreaking occurs 1 month after the BLM land disposition patent date and that the construction duration ranges from 3 months (e.g., schools, churches, hospitals) to 6 months (e.g., residential housing) for each project. These assumptions are consistent with the assumptions and recommendations made by the DAQEM for new source activities.[7] Because PM_{10} is typically assumed to be the pollutant of primary concern for activities associated with the types of development projects considered here, construction emissions of PM_{10} were estimated. Emissions of other criteria pollutants released from construction equipment and vehicles were assumed to be relatively small for these types of projects and were included only implicitly in this analysis.

Fugitive dust emissions were estimated for construction activities such as grading and backfilling. For general construction sites involving cut-and-fill areas, large-scale earth-moving operations, or heavy traffic volumes (projects involving airports, flood detention, highways, public works, underground utility operations, etc.), an emission factor of 0.42 ton/acre/month was applied. For general construction sites that do not involve cut-and-fill areas, large-scale earth-moving operations, or heavy traffic volumes, an emission factor of 0.11 ton/acre/month was applied. Construction projects associated with commercial facilities, public parks, public buildings, or residential homes might or might not include heavy activities. To account for this variation, an average emission factor of 0.265 ton/acre/month ([0.11 + 0.42]/2) was used (see pages B-58 and B-59 in the PM_{10} SIP) (Clark County 2001).

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[7] The classification of construction project types and the construction project type database were provided by the Clark County Department of Air Quality and Environmental Management (DAQEM) (Davis 2003). Data concerning the number of months under active construction, percent of sites implementing controls, overall control efficiency, and emission factors were taken from Table B-65 of the PM_{10} SIP (Clark County 2001).

The DAQEM regulations require PM emission control at construction sites. The dust control measure used is generally water spraying, which is assumed to achieve 50% control efficiency (EPA 1988). The DAQEM enforcement officers provided compliance rates for each type of construction activity. On the basis of an emission factor, the activity level (including the construction period and disturbed acreage), and the overall control efficiency, the research team calculated the PM emission inventory associated with BLM land sales.

4.2.2 Operation-Related Emissions

Air emission sources for operation (or use) of facilities developed on land disposed of by the BLM include energy use (natural gas and electricity), wind erosion, and vehicular traffic (on-road vehicle exhaust and paved-road dust). The VMT values specific to the development or land use types, energy use assumptions, and emission factors are given in Appendix D. Nine source groups, based on land-use development type, were identified on the basis of land disposition during the baseline period and the specific land-use types or groups associated with that disposition. These development types were based on a GIS layer generated for existing land use in and around Las Vegas (RTC 2003).[8] The major emissions associated with each of the land-use source groups identified in this study were assumed to result primarily from a combination of vehicle and electric power use. All other land use emissions were dominated by vehicle use. Emissions from vehicle use were based on factors derived from the MOBILE6 model and the AP-42 emission factors (EPA 2003e).

Emission factors for natural gas use, such as space heating and cooking, were based on Chapter 1.4 of AP-42 (EPA 2003e). Wind-generated PM_{10} emissions from new development were accounted for by using the AP-42 emission factor, with the assumption that paved surfaces, buildings, and lawns reduce dust generation by 68%. Electricity used in the Valley comes from power plants burning coal or gas, hydroelectric plants, and renewable energy generators (especially in the future years). The Mohave Generating Station, rated at 1,580 MW and one of the dirtiest coal-fired power plants in the United States, is scheduled for shutdown in 2006. On the other hand, several gas-fired, combined-cycle power plants, rated at a total of about 4,500 MW, are under construction or planned to be constructed, and renewable-energy (using solar and wind energy) plants rated at over 600 MW are expected to operate in and around Clark County in the near future.

For the BLM-related electricity generation, emission factors for base and future years were developed on the basis of annual total emissions from power plants operating in the Valley and their annual power generation rates. Emission factors for the base year, including those at coal-fired plants such as Reid Gardner and Mohave, would be higher. However, emission factors for future years, when combined-cycle power plants are equipped with more advanced emission control technologies (e.g., dry low-NOx combustor and selective catalyst reduction [SCR]) and

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8 The Clark County RTC uses its own specific land-use codes and identifiers, which differ from those used in this report and listed in Table 4.8. Appendix D shows which RTC codes were grouped into the source groupings listed in Table 4.7.

the Mohave Generating Station has been shut down, would be lower, as shown in Table 4.8. Power generation rates in the Valley would be relatively steady because shortfalls in electricity would be imported from the electric grid. In other words, total emissions related to electricity generation are as much as power generation capacities in the Valley. It is conservatively assumed that BLM-related emissions are from the power plants in the Valley, and non-BLM-related emissions are those from the power plants in the Valley (minus BLM-related emissions) and/or from the electric grid.

Emission factors for on-road mobile exhaust emissions were derived from MOBILE6, as were those for the non-BLM sources. Composite emission factors for paved-road dust were estimated on the basis of the methodology developed in the PM_{10} SIP. Table 4.8 provides the calculated composite emission factors for criteria pollutants, VOCs, and CO_2 for each project development type associated with BLM land sales. The composite factor reflects the total emissions for each pollutant resulting from vehicle and energy use plus the wind erosion associated with developed land. Project types are distinguished or grouped in the table for private development end uses and R&PP end uses.

Emissions estimates of criteria pollutants, VOCs, and CO_2 associated with BLM land sales were based on composite emission factors and activity levels, such as average vehicle traffic commuting distances, electric power use, and space and water heating use.

4.2.3 Baseline (2000) and Future Projected Emissions

Except for the Clark County DAQEM construction permits issued in the baseline period (from October 1998 through December 2000), the air emissions associated with BLM land disposal actions are not explicitly reflected in the current PM_{10} and CO SIP emissions inventories for these sources. The baseline air emission estimates were calculated for BLM land disposal actions that result in a change in land use that could generate new emissions that are reasonably quantifiable as being of potential significance. Land that is patented (for which title is transferred) and remains vacant or includes ROWs (e.g., roads) was not counted, because air emissions would not change significantly. Assumptions for the emission estimates for these sources relied on published AP-42 emission factors for 9 broad end-use source groups that are typical of land sales in the Las Vegas area. For land sales for residential, commercial, or public land use, the research team assumed an average land sale size, based on sales to date, and a typical energy use for each of the nine land-use source groups. The specific assumptions are summarized in Appendix D.

Table 4.9 provides a summary of lands conveyed by the BLM, by owner and by the public law authorizing the disposition, from passage of the SNPLMA through December 2000, according to the patent date (SNPLMA 1998). The land conveyance within the designated BLM disposal boundary over the baseline analysis period was 8,861 acres. Approximately 19% of this acreage was under construction or fully developed and in use. Figure 4.1 shows the locations and the relative sizes of these conveyances. The land conveyances during this period for which construction had been initiated or for which the target end use had been attained before December 31, 2000, were counted in the baseline air emissions assessment.

TABLE 4.8 Composite BLM Land Disposal Emission Factors[a]

Source Type	Final Land Use Source Group	LU Code	Year	Composite Emission Factor ([tons/yr]/acre or [tons/yr]/[mi/d])							VMT Factor
				SO_2	NO_x	CO	VOCs	PM_{10}	$PM_{2.5}$	CO_2	([mi/d]/acre)[b]
Energy use and wind erosion	**Private Development Uses**										
	Single-family housing	PD-1	2000	0.24	0.23	0.02	0.003	0.08	0.04	137	214
			2009/2018	0.01	0.08	0.03	0.004	0.07	0.03	115	
	Multifamily housing	PD-2	2000	0.61	0.56	0.05	0.01	0.10	0.05	328	900
			2009/2018	0.02	0.18	0.06	0.01	0.08	0.05	271	
	Office buildings	PD-3	2000	0.48	0.40	0.03	0.003	0.09	0.04	210	125
			2009/2018	0.02	0.11	0.03	0.01	0.08	0.04	167	
	Retail	PD-4	2000	1.27	1.06	0.07	0.01	0.14	0.07	541	1,763
			2009/2018	0.04	0.27	0.08	0.01	0.10	0.06	424	
	Moderate-sized casinos/hotels	PD-5	2000	1.06	0.90	0.06	0.01	0.13	0.06	478	2,118
			2009/2018	0.04	0.24	0.07	0.01	0.10	0.05	381	
	Industry	PD-6	2000	0.02	0.02	0.001	0.0001	0.06	0.03	8.4	20
			2009/2018	0.001	0.004	0.001	0.0002	0.06	0.02	6.7	
	R&PP Development Uses										
	Recreation	PP-1	2000	0.01	0.01	0.0004	0.0001	0.06	0.02	3.2	26
			2009/2018	0.0002	0.002	0.0005	0.0001	0.06	0.02	2.5	
	Religious	PP-2	2000	0.24	0.20	0.01	0.002	0.08	0.03	105	119
			2009/2018	0.01	0.05	0.02	0.003	0.07	0.03	83	
	Public facilities	PP-3	2000	0.14	0.12	0.01	0.001	0.07	0.03	63	60
			2009/2018	0.01	0.03	0.01	0.002	0.07	0.03	50	
On-road vehicle exhaust	All[c]	All	2000	9.49E-06	6.54E-04	6.81E-03	6.15E-04	1.63E-05	1.02E-05	NA[d]	
	All	All	2009	3.32E-06	2.93E-04	3.87E-03	2.50E-04	1.18E-05	6.11E-06	NA	
	All	All	2018	3.32E-06	1.34E-04	2.88E-03	1.37E-04	1.05E-05	4.93E-06	NA	
Paved-road dust	All	All	2000	NA	NA	NA	NA	1.61E-03	NA	NA	
	All	All	2009	NA	NA	NA	NA	1.53E-03	NA	NA	
	All	All	2018	NA	NA	NA	NA	1.55E-03	NA	NA	

[a] Total emission rates for each source type were estimated by using the following methods:

(1) Energy use and wind erosion — composite emission factors (in [tons/yr]/acre) were multiplied by non-vacant and non-right-of-way acreages that were disposed of from October 1998 to the year of interest.
(2) On-road vehicle exhaust — composite emission factors (in [tons/yr]/[mi/d]), which were derived from the MOBILE62 model for non-BLM on-road sources, were multiplied by VMT factors ([mi/d]/acre) and non-vacant and non-right-of-way acreages that were disposed of from October 1998 to the year of interest.
(3) Paved-road dust — composite emission factors (in [tons/yr]/[mi/d]), which were derived for non-BLM on-road sources, were multiplied by VMT factors (in [mi/d]/acre) and non-vacant and non-right-of-way acreages that were disposed of from October 1998 to the year of interest.

[b] Calculated based on daily VMT and parcel lot size (see Table D.1).

[c] Applied to all land use source groups.

[d] NA = not available or not applicable.

TABLE 4.9 Baseline (2000) Assessment: Land Sales and Exchanges from October 1998 through December 2000

Land Authorization/New Owner (Parcel No.)	Effective Patent/ Sale Date	Conveyed Land (acres)
BLM Sales		
SNPLMA/FLPMA and McCarran CMA[a]		
General SNPLMA (PL 105-263)/FLPMA (Sec. 203 & 209) Conveyances	1998–2000	180
McCarran CMA (SNP MA, PL 105-263)	1998–2000	4,998[b]
Subtotal, SNPLMA/FLPMA and McCarran CMA		**5,178**
Sale, public lands, FLPMA		
City of Las Vegas (N-53366)	1998–2000	37
Fire Station, Clark County (N-63066)	3/23/2000	3
Subtotal, public lands, FLPMA		**40**
Sale, recreational, and public purposes (R&PP)		
City Park, City of Las Vegas (N-37119 02)	1998–2000	26
City Park, City of Las Vegas (N-50827-02)	1998–2000	21
City Park, City of Las Vegas (N-51517 02)	1998–2000	10
Calvary Church (N-57599 02)	1998–2000	10
Society of St. Pius X (N-57698 02)	1998–2000	4
Shadow Hills Baptist Church (N-58742 02)	1998–2000	20
West Valley Assembly of God (N-58750 02)	1998–2000	15
Las Vegas Church of Christ (N-58886 02)	1998–2000	5
W Charleston Baptist Church (N-61449 02)	1998–2000	20
Subtotal, R&PP		**131**
BLM exchanges (Sec. 206, FLPMA)		
Volkmar 1, Mojave Sunrise Trust (N-58563 F1)	1998–2000	237
Volkmar 2, Mojave Sunrise Trust (N-58563 FD)	1998–2000	499
Del Webb (N-60167 FD/N-60167 F3)	1998–1999	2,576
Subtotal, BLM exchanges		**3,312**
Total Baseline Land Conveyances (Sales + Exchanges)		**8,661**

[a] SNPLMA = Southern Nevada Public Land Management Act; FLPMA = Federal Land Policy Management Act; McCarran CMA = McCarran Cooperative Management Area.

[b] Excludes conveyed acreage for mineral rights and land designated as vacant or ROW. Total acreage for the McCarran CMA conveyance is 20,399 acres.

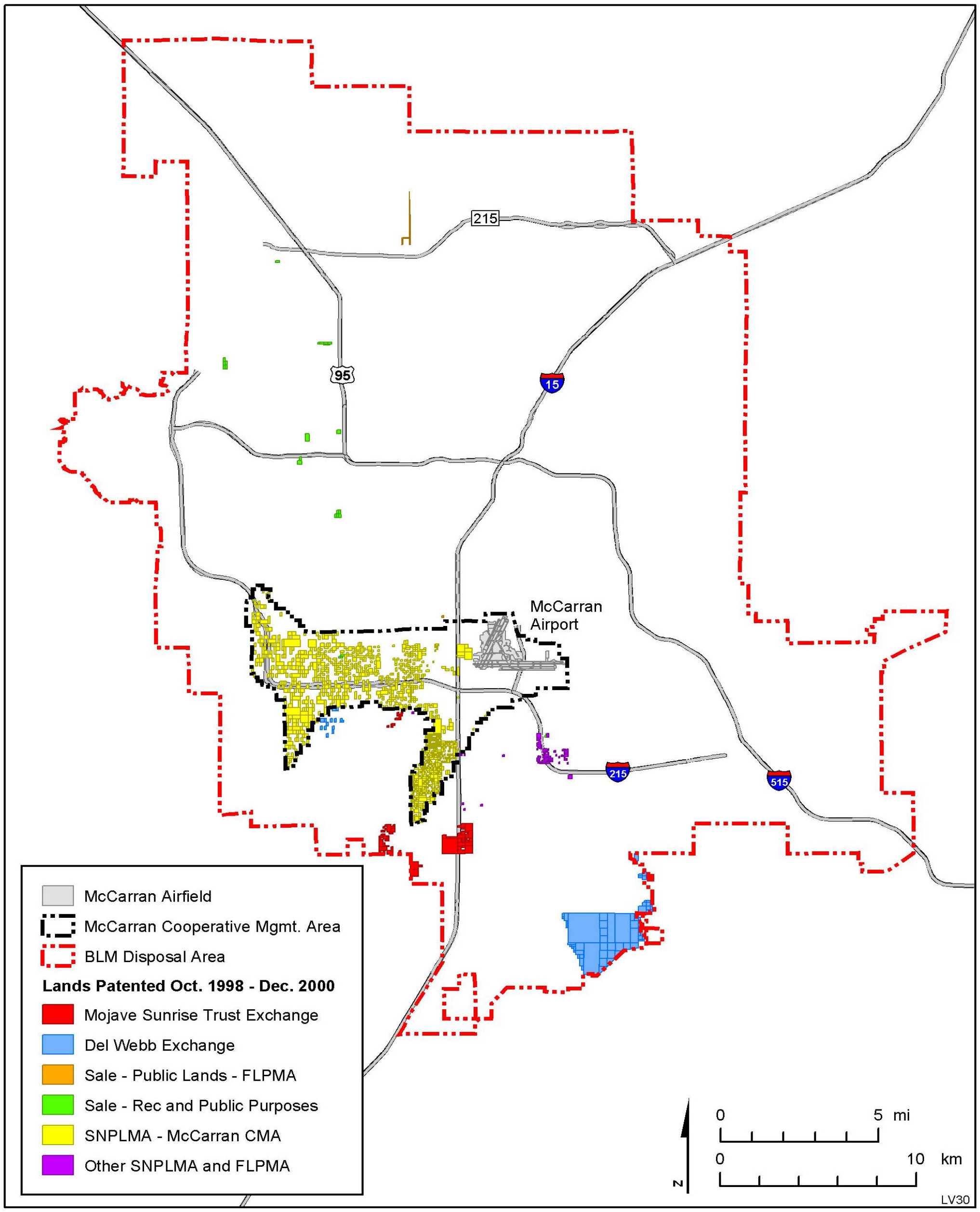

FIGURE 4.1 Baseline Land Conveyances within the BLM Disposal Boundary (patent dates October 1998 through December 2000)

The baseline BLM conveyance air emission acreage includes disposition resulting in known or anticipated land use subsequent to the issuance of the land patent. It does not include mineral rights (primarily in the McCarran Cooperative Management Area [CMA]) (Figure 4.2), ROWs, and known vacant lots. Records available from the Clark County RTC and the assumptions regarding lag time (between conveyance and groundbreaking) and construction durations used for this study indicate that some sort of land development (i.e., initiation or completion of construction) occurred before the end of the baseline period on approximately 21% of the total land conveyed during the period, less land designated as ROWs (e.g., roads).

The data regarding baseline criteria air pollutant emissions associated with this development on previously owned federal land are shown in Table 4.10. The baseline PM_{10} emissions from construction in 2000 were estimated at about 199 tons/yr — low compared with those for future years. This is because only a small number of land parcels and only small parcels of land were patented in 2000 and because the large parcels of land (more than 3,000 acres) patented in November 1999 included primarily vacant lands. The annual PM_{10} and CO emissions from developed projects are estimated to be approximately 1,187 and 4,005 tons/yr, respectively, which are about 1.4% of Clark County's baseline emissions. The O_3 precursor (NO_x and VOC) emissions attributable to BLM-conveyed and BLM-developed land amount to more than

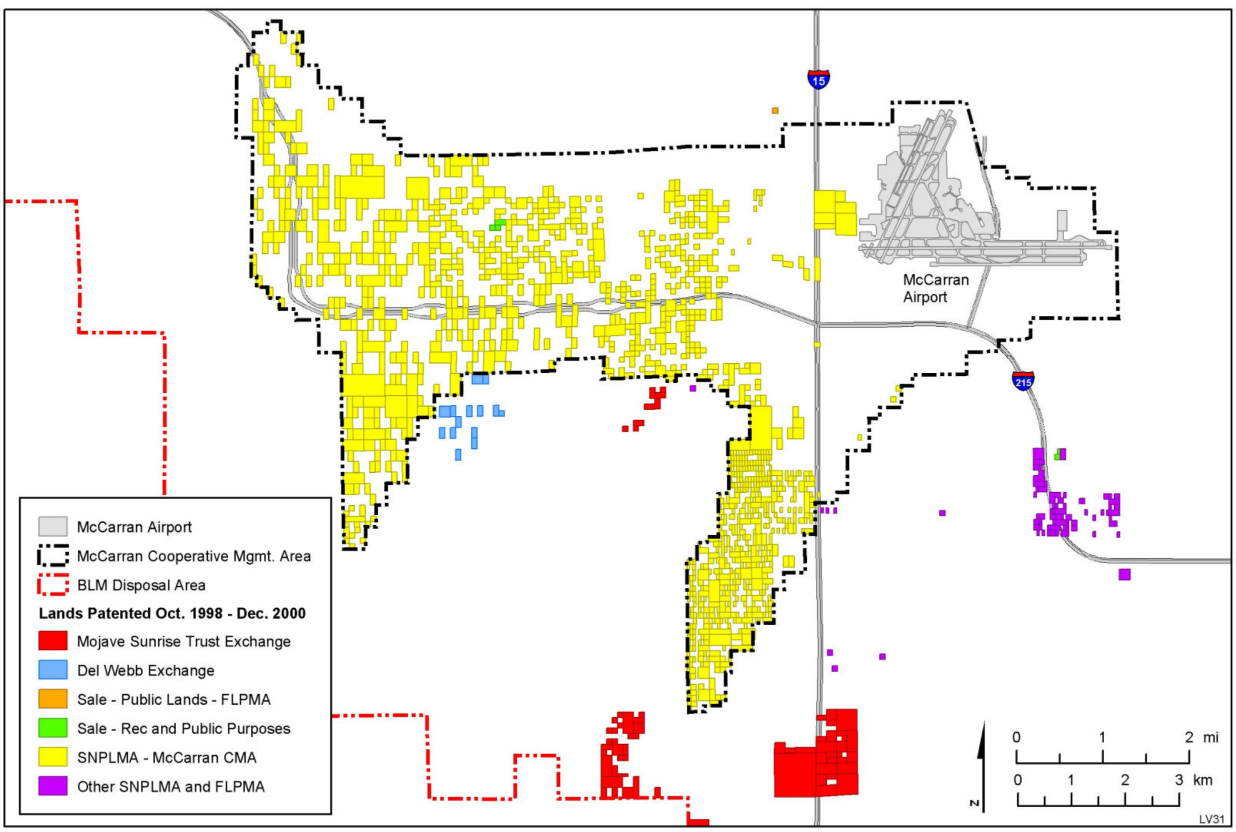

FIGURE 4.2 Baseline Land Conveyances within and next to the McCarran Cooperative Management Area (patent dates October 1998 through December 2000)

TABLE 4.10 Baseline (October 1998 through December 2000) BLM Land Sale Emissions by Development Type during Construction and Operation in 2000

Final Land Use Source Group	Emissions (tons/yr)						
	PM_{10}	CO	NO_x	VOCs	$PM_{2.5}$	SO_2	CO_2
Private Development Uses							
1. Single-family housing	696.6	1,892.7	470.0	172.1	47.5	312.5	175,298
2. Multifamily housing	70.9	169.9	31.5	15.4	1.6	17.0	8,990
3. Office buildings	15.8	43.4	23.9	4.0	2.1	23.6	10,399
4. Retail	35.3	138.3	25.4	12.5	1.0	14.8	6,228
5. Moderate-sized casinos/hotels	0.2	0.5	0.1	0.0[a]	0.0	0.0	16
6. Industry	9.3	12.3	2.6	1.1	2.3	1.7	757
R&PP Development Uses							
7. Recreation	10.5	10.6	1.4	1.0	1.5	0.4	190
8. Religious	29.0	51.5	17.4	4.7	2.1	15.0	6,547
9. Public facilities	2.6	6.3	2.4	0.6	0.5	2.2	960
BLM — Direct Total[b]	870.3	2,325.5	574.6	211.3	58.6	387.3	209,383
BLM — Indirect Total[c]	316.7	1,679.8	216.1	159.9	17.5	3.7	NA[d]
BLM Total	1,186.9	4,005.3	790.7	371.2	76.1	391.0	NA
% of Total Clark County Baseline Emissions	**1.4**	**1.4**	**1.0**	**1.3**	**NA**	**0.8**	**NA**

[a] 0.0 = value is less than 0.05.

[b] Direct emission increases associated with BLM land sales (as presented above) include those from energy use (gas and electricity), vehicle use (on-road mobile exhaust and paved-road dust), and wind erosion around building structures.

[c] Indirect emission increases associated with BLM land sales (e.g., nonroad engine exhaust) were estimated on the basis of an emissions inventory developed from the Clark County PM_{10} and CO SIPs and BLM-related population growth.

[d] NA = not applicable.

791 tons/yr and 371 tons/yr, respectively, which represent the largest fractional increase (approximately 1.3%) of the total non-BLM county NO_x and VOC emissions. SO_2 emissions associated with BLM land disposition increase county totals by less than 1%. These emissions are based on an estimate that approximately 1,700 acres of land associated with BLM land disposition were under development or in use through December 2000. The cumulative impacts associated with the baseline disposition are discussed in Section 5 of this report.

4.2.4 Future-Year (2009 and 2018) Projected Emissions

Projected emissions for the post-baseline years (2009 and 2018) were spatially located by using GIS layers of land disposal and land use. The development of those layers is described in Appendixes B and C, respectively. Table 4.11 summarizes actual BLM land conveyances from January 1, 2001, through December 31, 2003, and the planned BLM sales for 2004 and 2005.

TABLE 4.11 Projection Year (2009 and 2018) Assessments: Land Sales, Transfers, and Exchanges

BLM Land Authorization: Conveyed and Planned	Effective Patent/Sale Date	Actual and Planned BLM Land Conveyances (Acres)[a]	Remaining BLM Acreage
Baseline BLM Land Disposal[a]	1998–2000	**8,860**	63,010
2001-2002 Sales and Exchanges			
General SNPLMA [**PL 105-263]**	2001–2002	2,520	
Buffalo/Washington LLC (N-63198) [**PL 105-263, SNPL MA-SB]**	May 2001	13	
Clark Co (N-29499 02)	Jan. 2001	15	
City Park, City of Las Vegas (N-43395 02)	Dec. 2002	600	
Lake Las Vegas (N-59905 FD)	Jan. 2001	345	
Total Patented Sales or Exchanges in 2001 and 2002		**3,493**	59,517
2003 Sales and Transfers			
General SNPLMA [**PL 105-263]**	2003	2,802	
Hughes Exchange (N-76717FD)	May 2003	2,171	
City of Las Vegas (N-76518) [**PL 105-263, SNPL MA-HSE]**	May 2003	15	
City of Las Vegas (N-76598) [**PL 105-263, SNPL MA-HSE]**	Apr. 2003	10	
Armory, State of NV (N-63252 02)	July 2003	40	
Shooting Range # 1 (Transfer, NW Portion of BLM Boundary)[b]		*2,950*	
November Public Land Sale, Auction (assumed patented in 2004)	Nov. 2003	(734)	
Total Patented Sales or Transfers in 2003		**7,987**	51,530
Total Land Conveyances, Oct. 1998 through Dec. 2003		**20,340**	
2004 Planned Sales[b]			
Lake Las Vegas direct sale (assumed patented in 2004)	May 2004	982	
June 2004 public land sale, auction (assumed patented in 2004)	June 2004	2,177	
Total Patented Sales in 2004		**3,894**	47,636
Total Land Conveyances, Oct. 1998 through Dec. 2004		**24,234**	
2005 Planned Sales			
North Las Vegas (assumed patented in 2005)		2,300	
Kyle Canyon (assumed patented in 2005)		1,664	
Total Patented Sales in 2005		**3,964**	43,672
Total Land Conveyances, Oct. 1998 through Dec. 2005		**28,198**	
Remaining BLM Disposal Acreage: 2006 to End Projected Disposal		43,674	
Conveyed in:	2006	4,000	39,674
Conveyed in:	2007–2012	24,000	15,674
Conveyed in:	2013–2016	16,412	
Remaining BLM Disposal Acreage as of Jan. 2016		0.0	
Total BLM Disposal Acreage Resulting in Change in Land Use[b,c]		**71,870**	

[a] Includes Del Webb and two Mojave Sunrise Trust Exchanges (see Table 4.7).

[b] BLM land used as a shooting range of 2,880 acres in the northwest portion of the BLM boundary was transferred (under PL 107-350/PL 107-283) to the Las Vegas Police Department to be used as a shooting range. This table excludes this shooting range.

[c] BLM land used as shooting a range (160 acres) in the northeast portion of the BLM boundary near Nellis Air Force Base was transferred (under PL 107-350/PL 107-283) to the Las Vegas Police Department to be used as a shooting range. This table excludes this shooting range.

The table shows the status of BLM-owned acreage within the BLM boundary starting on January 1, 2001, and ending in November 2015. About 12% of the BLM land was disposed of during the baseline period from October 1998 through 2000. Land disposal data from January 2001 through December 2003 are based on actual land conveyance records (e.g., patents and announced sale, transfer, and exchange records). The data presented for 2004 and 2005 are based on BLM land disposal plans as of February 2004 (Fry 2004). Data on acreage, location (on the fine-grid modeling system), and patent date (by land use) for BLM lands from 1998 to 2005 are provided in Table 4.11. Data on BLM land disposal after 2006 include acreage and location by land use and no patent dates. For 2006 and later, an annual disposal rate of 4,000 acres/yr is used, which results in all of the remaining lands being disposed of by 2016. Construction and operation emissions associated with BLM-conveyed land development and use with an unknown disposal date were proportioned uniformly over their extent and incremented on the basis of a 4,000-acres/yr disposal rate. Figure 4.3 shows the locations of actual, planned, and projected BLM conveyances within the BLM disposal boundary starting in January 2001 and ending in November 2015, when all of the land has been disposed of. Although BLM land disposal will end before 2018 (based on the disposal rate of 4,000 acres/yr), it is assumed that land development will continue at a constant rate through the end of 2018. The assumed future disposal rate of 4,000 acres/yr is consistent with the historical rate of BLM land disposal from October 1998 through December 2003.

Table 4.12 shows the assumed land disposition and development data used for estimating future-year emissions associated with BLM land disposition actions. The "known" end-use land acreage shown as developable BLM land is future-conveyed land for each land use category that is not reserved for a ROW or open space. The end-use assignments are based on the best available data for projecting future land end use from the Clark County RTC. Although these land end-use assignments consider local zoning restrictions, the restrictions are not "set in stone" and can be changed through local laws governing zoning change petitions. However, the use of the best available data on known land use is a well-established practice that is followed by transportation and community planners to plan for new highways and roadways and extensions to existing ones.

Approximately 47,000 of the 63,000 acres of BLM land available for future disposition (2001–2018) are considered to be developable federal land. As previously noted for the derived data on end use, the acreage for each land use category was adapted from the assigned land end uses provided in the RTC transportation planning database. Some lands lacked a specific designation with regard to current or future land use because the source data (RTC 2003) for land use did not cover the full disposal area. For these lands, the known land use for more than 100,000 acres of vacant land within the BLM boundary as of June 2002 was used in large part to allocate the percentages for the land end-use categories.[9] The land-use-weighted average proportions range from 0.5% for public facilities (e.g., RP&P such as schools, parks, and hospitals) to 61% for single-family housing. This breakout was based on available planned or

[9] The Clark County RTC assigned land-use categories or groups for patented land tracked for real estate tax purposes by the Clark County Assessors Office. The RTC used its own assigned end-use categories in planning for county-wide transportation needs over the next 10 to 20 years on the basis of projections of county growth.

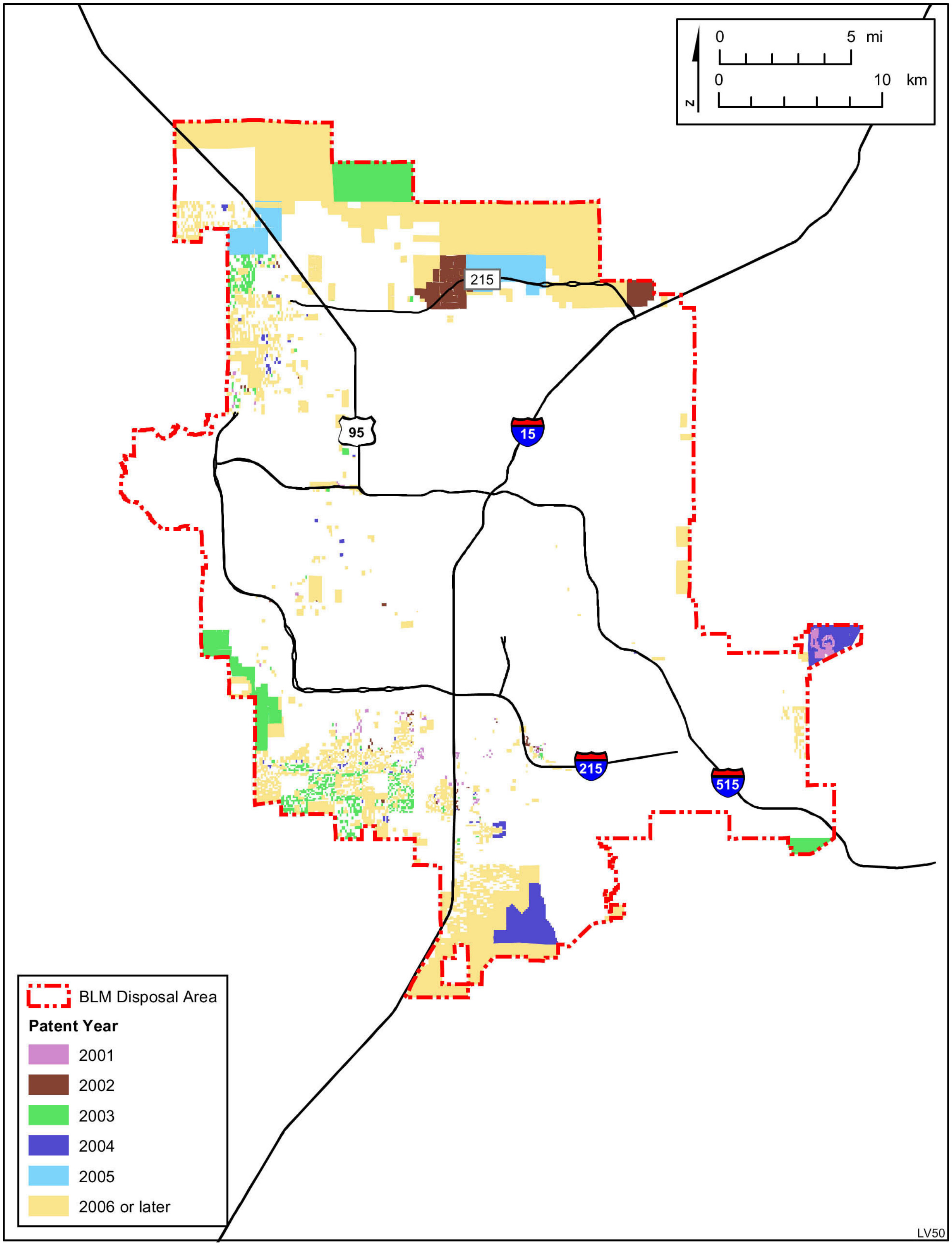

FIGURE 4.3 Post-Baseline Actual BLM Land Conveyances (including lands patented from January 1, 2001, through December 31, 2003) and Projected Future Conveyances (2003–2016)

TABLE 4.12 Projections and Assumptions for Future Land Disposition and Development[a]

Final Land Use Source Group	Developable BLM Land (RTC Planned End Use) (acres)	Assumed Developed BLM Land (Known End Use) (acres)	Assumed Prorated Development (Known Use) (%)	Developable BLM Land (Unknown End Use) (acres)	Assumed Developed BLM Land (Unknown End Use) (acres)	Assumed Prorated Development (Unknown Use) (%)	Total Future (2001–2018) BLM Land Development (acres)	Future Overall Prorated Development (%)	Total Developed Land for 20-Year Period, 1998–2018 (acres)	Overall Actual Plus Future Prorated Development (%)	Development Rate (acres/yr)
Single-family housing	23,600	7,600	32	9,300	2,400	25	10,000	30	11,400	40	600
Multifamily housing	800	400	50	1,400	700	50	1,100	50	1,200	60	70
Office buildings	2,600	2,300	85	600	600	85	2,900	91	3,000	90	160
Retail	1,500	1,300	85	1,100	1,000	85	2,300	88	2,400	90	130
Moderate-sized hotels/casinos	100	100	100	300	300	100	400	100	500	100	30
Industry	1,500	1,500	100	1,200	1,200	100	2,700	100	2,800	100	150
Recreation	700	700	100	1,000	1,000	100	1,700	100	1,800	100	100
Religious	100	100	100	200	200	100	300	100	400	90	30
Public facilities	500	500	100	500	500	100	1,000	100	1,100	100	60
Overall land development		14,500			7,900		22,400	48	24,600	45	1,230
Developable land	31,400			15,600			47,000		55,200		

[a] The developable and developed acreages are rounded to the nearest 100 acres. The development rate is rounded to the nearest 10 acres.

zoned land use data from July 2002 in the RTC current land use layer. Approximately 67% of the land available for future land development has a known or planned future end use. For analysis purposes, we assumed that approximately 50% of the total disposed-of federal land would be developed by 2018. The development percentages shown in Table 4.12 for the known and unknown end-use acreages were prorated to achieve this overall development rate. When the actual 1,700 acres of land developed during the baseline period (1998–2000) is accounted for, it is assumed that overall, approximately 45% (or 24,600 acres) of land will be developed by December 31, 2018. This equates to an average development rate of approximately 1,230 acres/yr. The overall development within each of the land-use categories listed in Table 4.10 ranged from 40% to 100% of the total category-specific developable land. The percentage of land for each end-use category for the baseline year of 2000 and the resource management plan end year of 2018 is shown in Figures 4.4 and 4.5, respectively.

The research team estimated projected emissions for future years (2009 and 2018). Construction emissions for a future year include the year of interest. Operation emissions include emissions from all sources patented from 1998 up to the year of interest.

The team projected that the average rate of emissions from construction in 2009 and 2018 would be less than 1,300 tons/yr, and that single-family housing would be a predominant contributor to these emissions (Table 4.13). For the modeling runs, these emissions are distributed onto known grid cells based on the acreage of available lands. Operation emissions would be higher because of cumulative emissions from sources patented since 1998, when the first disposal began. In 2009, BLM-related emissions would represent less than 10% of the Clark County total (see Table 4.13). Among direct emissions, emissions from single-family housing and retail would be comparable; these two categories would be major contributors to emission increases. Emissions from other land use categories would be relatively insignificant. These emission increases would be offset by a reduction in the amount of vacant land, which is a major sources of windblown dust.

The BLM contribution to CO, VOCs, and PM_{10} emissions would represent about 1.3% to 1.4% for 2000, 9.0% to 9.7% for 2009, and 14.3% to 15.7% for 2018, of the Clark County total (Table 4.13). These pollutants are related to vehicle traffic, such as on-road mobile exhaust and paved road dust. These contributions are commensurate with population (1.4% for 2000, 10.1% for 2009, and 16.2% for 2018) associated with BLM land sales. On the other hand, the BLM contribution to SO_2 emissions, primarily resulting from energy use (gas or electricity), are much lower than vehicle traffic-related contributions. It is postulated that available power generation capacity at full load in and around Clark County would be more than sufficient to meet electricity demand, even considering population growth. The BLM contribution to NO_x emissions, linked to both energy use and traffic use, is between the two.

The electricity shortfall caused by the closure of the Mohave Generating Station would most likely be met by the newly built natural-gas-burning power plants in the Las Vegas Valley or by imports from outside the Valley via the electric power grid system.

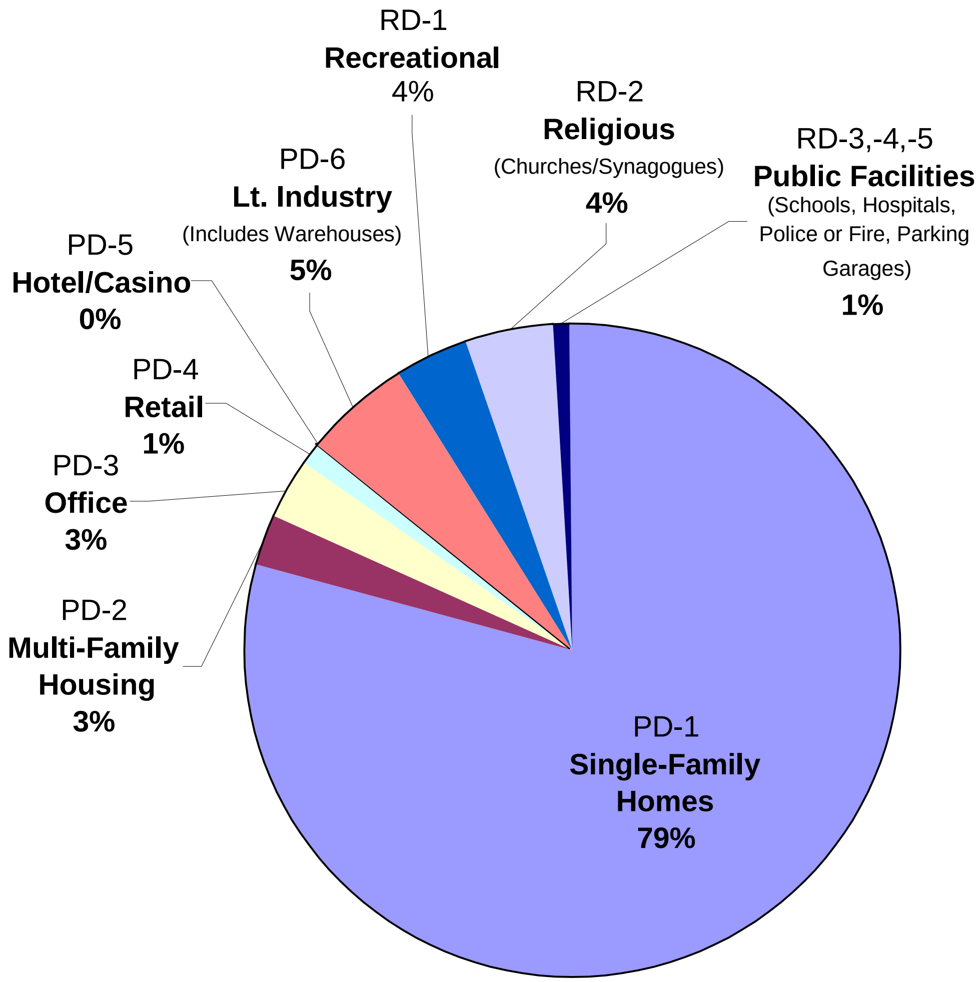

FIGURE 4.4 Baseline End-Use Development of BLM Land Conveyances (patent dates October 1998 through December 2000)

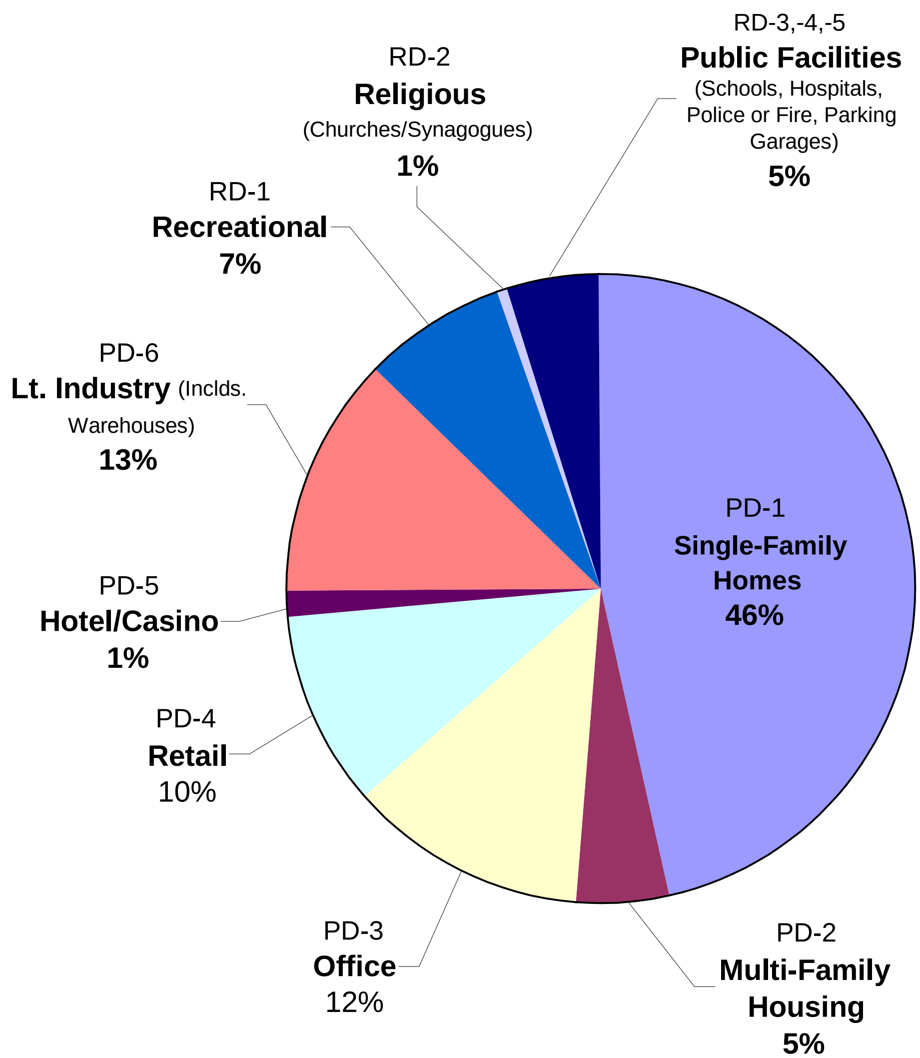

FIGURE 4.5 Projected End-Use Development of BLM Future Land Conveyances (2001 through 2018)

TABLE 4.13 Future-Year (2009 and 2018) BLM Land Sale Emissions (Construction and Operation) by Development Type[a]

Final Land Use Source Groups	Year	Emissions (tons/yr)							
		SO_2	NO_x	CO	VOCs	PM_{10}[b]		$PM_{2.5}$	CO_2
1. Single-family housing	2000	312.5	470.0	1,892.7	172.1	696.6	(151.6)	47.5	175,298.3
	2009	55.1	823.1	5,032.1	338.9	2,905.3	(555.4)	199.6	669,388.4
	2018	93.2	1,052.9	6,455.2	333.5	4,623.3	(555.4)	333.1	1,130,752.6
2. Multifamily housing	2000	17.0	31.5	169.9	15.4	70.9	(27.8)	1.6	8,989.5
	2009	13.3	242.9	1,944.8	128.8	883.7	(78.0)	27.4	146,415.0
	2018	27.1	336.9	3,006.9	150.8	1,772.3	(78.0)	54.8	299,242.7
3. Office buildings	2000	23.6	23.9	43.4	4.0	15.8	(1.3)	2.1	10,398.7
	2009	24.1	202.2	735.0	52.1	532.9	(150.0)	54.3	235,064.8
	2018	46.7	341.5	1,106.0	62.8	917.8	(150.0)	105.9	461,122.4
4. Retail	2000	14.8	25.4	138.3	12.5	35.3	(0.8)	1.0	6,227.7
	2009	57.3	848.9	7,258.5	478.3	3,047.5	(82.0)	78.5	428,363.3
	2018	131.2	1,242.6	11,785.7	585.2	6,655.1	(82.0)	174.5	902,683.6
5. Moderate-sized casinos/hotels	2000	0.0	0.1	0.5	0.0	0.2	(0.1)	0.0	15.5
	2009	5.8	114.7	1,101.5	72.2	462.9	(16.5)	8.9	49,887.4
	2018	12.5	150.0	1,777.8	87.1	999.8	(16.5)	18.4	106,681.5
6. Industry	2000	1.7	2.6	12.3	1.1	9.3	(0.8)	2.3	756.8
	2009	1.2	11.5	92.8	6.0	304.0	(196.8)	28.9	7652.7
	2018	3.5	19.4	178.2	8.4	471.9	(196.8)	73.6	19465.3
7. Recreation	2000	0.4	1.4	10.6	1.0	10.5	(4.3)	1.5	189.6
	2009	0.2	6.7	74.7	4.8	184.1	(110.1)	18.1	1,840.3
	2018	0.2	8.5	133.2	6.4	287.9	(110.1)	43.1	4,369.7
8. Religious	2000	15.0	17.4	51.5	4.7	29.0	(12.1)	2.1	6,546.7
	2009	1.3	12.8	67.5	4.6	41.5	(5.4)	4.7	12,244.4
	2018	2.1	16.7	80.3	4.3	64.0	(5.4)	7.7	20,450.9

Table 4.13 (Cont.)

Final Land Use Source Groups	Year	Emissions (tons/yr)							
		SO_2	NO_x	CO	VOCs	PM_{10}[b]		$PM_{2.5}$	CO_2
9. Public facilities	2000	2.2	2.4	6.3	0.6	2.6	(0.1)	0.5	959.7
	2009	2.3	21.5	98.3	6.9	108.6	(41.7)	13.0	22,511.2
	2018	6.2	46.8	189.6	10.8	218.2	(41.7)	35.1	60,476.4
BLM subtotal — direct[c]	2000	387.3	574.6	2,325.5	211.3	870.3	(198.9)	58.6	209,382.5
	2009	160.5	2,284.4	16,405.1	1,092.7	8,470.4	(1,235.9)	433.4	1,573,367.5
	2018	322.9	3,215.3	24,712.8	1,249.3	16,010.3	(1,235.9)	846.3	3,005,245.1
BLM subtotal — indirect[d]	2000	3.7	216.1	1,679.8	159.9	316.7		17.5	NA[e]
	2009	17.2	1,383.8	12,895.8	807.5	2,630.7		103.4	NA
	2018	29.5	1,589.9	23,234.0	1,222.4	4,570.9		107.1	NA
BLM total	2000	391.0	790.7	4,005.3	371.2	1,186.9		76.1	NA
	2009	177.8	3,668.2	29,301.0	1,900.1	11,101.1		536.8	NA
	2018	352.4	4,805.2	47,946.8	2,471.6	20,581.2		953.4	NA
Clark County total (BLM and non-BLM)	2000	47,036.3	77,751.8	294,274.7	28,125.5	87,895.6		3,269.1	NA
	2009	4,626.0	53,763.0	301,386.9	21,059.0	115,944.7		2,395.7	NA
	2018	4,673.2	44,921.5	305,508.5	17,332.7	135,380.4		2,053.8	NA
% of BLM to Clark County total	2000	0.8%	1.0%	1.4%	1.3%	1.4%		NA	NA
	2009	3.8%	6.8%	9.7%	9.0%	9.6%		NA	NA
	2018	7.5%	10.7%	15.7%	14.3%	15.2%		NA	NA

[a] Construction emissions applicable to PM_{10} only denote those occurring in the year of interest; operation emissions denote those occurring from BLM lands patented up to the year of interest since 1998.

[b] The first numbers are total (construction and operation) PM_{10} emissions; the numbers in parentheses are construction emissions only.

[c] Direct emission increases associated with BLM land sales (as presented above) include those from energy use (gas and electricity), vehicle use (on-road mobile exhaust and paved-road dust), and wind erosion around building structures.

[d] Indirect emission increases associated with BLM land sales (e.g., nonroad engine exhaust) were estimated on the basis of an emissions inventory developed from Clark County PM_{10} and CO SIPs and BLM-related population growth.

[e] NA = not applicable.

4.3 Windblown Dust and Other Natural Emission Sources

Major dust storms can significantly impact air quality and visibility in Las Vegas. These naturally occurring events are major sources of airborne PM, which is generally considered a long-range problem associated with wind-generated dust moving from the western Mojave Desert into Las Vegas. Geologic depressions, such as Owens Lake in California's Owens Valley, about 240 km (150 mi) west of Las Vegas, are considered a major source of windblown dust that can, under certain conditions, be a significant contributor to PM_{10} concentrations during major dust storm events in Las Vegas. Such large, naturally occurring events can significantly contribute to (and often are the major contributor to) exceedances of the PM_{10} NAAQS. A review of 7 years of Automated Surface Observing System (ASOS) data (1996–2003) from McCarran International Airport and Nellis Air Force Base indicates that only one event (on April 15, 2004) was officially designated as a "dust storm." Weather conditions recorded during this storm were steady west winds in excess of 25 mph for more than 9 consecutive hours.

Winds tend to pick up during spring, as the Las Vegas Valley makes the transition from winter to summer. Temperature and pressure contrasts between a warming desert and periodic cold fronts moving through the valley from northern climates often create strong winds during spring. During or prior to forecasts of high winds, the Clark County DAQEM issues an air pollution health advisory for blowing dust when peak wind gusts exceed 40 mph and average hourly wind speeds are greater than 25 mph. During an advisory, children, seniors, and people with chronic respiratory problems are urged to stay indoors. Health officials also recommend curtailment of outdoor activities that increase the respiratory rate, such as exercising or construction-related work, during high-wind periods.

Recognizing the effect that certain uncontrollable natural events (high winds, wildfires, etc.) can have on the NAAQS, the EPA issued a Natural Events Policy on May 30, 1996. An excerpted summary of the policy as it applies to high wind events is as follows:

> "By law, the usual consequence when pollutant levels in an area violate one of the NAAQS is that the area is declared nonattainment for that pollutant. The state must then develop and implement a plan for measures that will be taken to reduce emissions of the pollutant and bring the ambient levels of the pollutant back within the standards. Such plans must include stringent pollution control measures for new and existing industries and other sources of the pollutant.
>
> Federal law and policies recognize that declaring an area nonattainment and requiring stringent controls on industrial sources is not an appropriate response where natural events contribute significantly to exceedances of the standard. EPA's policy memorandum of May 30, 1996, sets forth requirements for a more appropriate approach to such natural events. The focus of this alternative approach is protection of public health.
>
> States may request that a moderate nonattainment area not be reclassified as serious if it can be demonstrated that the area would attain the standards by the

> statutory attainment date but for emissions caused by natural events. Similarly, States may request redesignation of nonattainment areas to attainment if it can be demonstrated that the area would be meeting the NAAQS but for the emissions caused by natural events. This policy applies to emissions caused by natural events that have occurred since January 1, 1994."

Because of the long-range transport associated with dust storms and the difficulty in quantifying dust generation over very large desert regions, the impact of such events is extremely difficult to quantify. However, windblown dust generated on days with more frequent lower wind speeds (i.e., nondust-storm or moderately windy days) is quantifiable over smaller areas than a large desert scale, such as the Mojave. It is therefore important to know the significance of moderately windy days from the perspectives of a cumulative air quality impact assessment and regulatory policy. Recognizing that much of the BLM land in Clark County is vacant, with certain areas within the Las Vegas Valley having a high degree of disturbance due to human activities, a field study was conducted to quantify the potential for generation of windblown dust over a wide variety of soil types and soil conditions.

4.3.1 Portable Wind-Tunnel Field Measurements

During the summer of 2003, a team from UNLV initiated a series of portable wind tunnel measurements to characterize the wind erodibility for a representative set of soil types and soil conditions within the Las Vegas BLM boundary. The study was conducted from July 31, 2003, to October 7, 2003. By collaborative consensus between UNLV and Argonne scientists, wind tunnel sites for the study were selected to correspond with the major Wind Erodibility Group (WEG) numbers 2 through 8 of the U.S. Department of Agriculture's (USDA's) Natural Resources Conservation Service. These WEG numbers were available for the Las Vegas Valley.

The WEGs are made up of soils that have similar properties affecting their resistance to wind erosion. The groups indicate the susceptibility of the soil to wind erosion and the amount of soil lost. Soils are grouped according to their content of stable 0.84-mm aggregates. These are represented idealistically by USDA textural classes. There can be soils containing rock fragments in any group. All of the Las Vegas soils have rock fragments. Table 4.14 gives a brief description of each of the WEGs. Soils in Las Vegas cover all but one, WEG 1, of the nine WEGs. The lower the WEG number, the greater the wind erodibility potential.

A total of 22 soil wind erosion test areas were selected to cover all eight WEG numbers identified in a mid-1980 Soil Conservation Service soil survey (Speck and McKay 1985) and a wide range of soil types and soil conditions. Two sites (WT 079R and WT 082R) were revisited after a rain event. Ten of the 22 sites were also revisited during the last part of the study to conduct a slightly different erosion procedure. Soil stability conditions were assessed in the field by using the "drop ball/steel ball" test as specified in Clark County regulator-approved procedures for soil stability determination (Section 90.4.1.1, Test Methods, Visible Crust Determination). Soil disturbance was assessed by on-site visual inspection of relevant areas (e.g., tire tracks). At sites with little or no disturbance, a rake was used to disturb a test area

TABLE 4.14 Description of Soil Wind Erodibility Groups

WEG 1	Sands, fine sands, and very fine sands. These soils are generally not suitable for crops. They are extremely erodible, and vegetation is difficult to establish.
WEG 2	Loamy sands, loamy fine sands, and loamy very fine sands. These soils are very highly erodible. Crops can be grown if intensive measures to control wind erosion are used.
WEG 3	Sandy loams, coarse sandy loams, fine sandy loams, and very fine sandy loams. These soils are highly erodible. Crops can be grown if intensive measures to control wind erosion are used.
WEG 4L	Calcareous loamy soils that are less than 35% clay and more than 5% finely divided calcium carbonate. These soils are erodible. Crops can be grown if intensive measures to control wind erosion are used.
WEG 4	Clays, silty clays, clay loams, and silty clay loams that are more than 35% clay. These soils are moderately erodible. Crops can be grown if measures to control wind erosion are used.
WEG 5	Loamy soils that are less than 18% clay and less than 5% finely divided calcium carbonate. Sandy clay loams and sandy clays that are less than 5% finely divided calcium carbonate. These soils are slightly erodible. Crops can be grown if measures to control wind erosion are used.
WEG 6	Loamy soils that are 18–35% clay and less than 5% finely divided calcium carbonate, except silty clay loams. These soils are very slightly erodible. Crops can easily be grown.
WEG 7	Silty clay loams that are less than 35% clay and less than 5% finely divided calcium carbonate. These soils are very slightly erodible. Crops can easily be grown.
WEG 8	Stony or gravelly soils and other soils not subject to wind erosion.

before testing, and the working section of the wind tunnel was placed over the manually disturbed soil. These methods and procedures were used at all sites to collect comprehensive wind tunnel data for all of the soil groups, types, and conditions represented in the Las Vegas Valley.

The test site locations were determined by using hand-held global positioning system (GPS) units (Magellan Trailblazer® and Garmin eTrex®). The major cross streets and compass directions relative to the nearest intersection (i.e., north of Buffalo and West Washington) were recorded, and uncorrected GPS coordinates were determined for each of the test sites. See Appendix E for further details on GPS measurements and the test sites. Site coordinates were mapped on the soil survey to confirm the identification of the soil WEG for each test site location. Because the wind tunnel testing was conducted during the Las Vegas monsoon season, an opportunity existed during the 2-month field measurement period to collect data for "wet" or rain-stabilized soil conditions.

To determine site locations relative to major soil group boundaries, site GPS coordinates were sent to the UNLV Transportation Research Center for site mapping with ESRI ArcInfo© software and a database of WEG boundaries. Table 4.15 lists the test sites by name, site identifier, GPS coordinates, soil erodibility condition class (SECC), soil type, and salinity content. The approximate locations of the sites across the valley are shown relative to major cross streets in Figure 4.6. See also Figure E.1, Appendix E.

TABLE 4.15 Summary of Portable Wind Tunnel Test Sites

Site Number	SECC[a]	Site Name	East Longitude	North Latitude	Street Intersection	Test Date	Soil Texture[b]	Max. Salinity[c] (%)
WT079/79R	2SU/2SUw	Sunset Park, Dry/Wet	115.1131	36.0628	Eastern & Warm Springs	8/11,19/2003	LFS	32
WT080	2UU	Sunset Hell Lot	115.1126	36.0632	Eastern & Warm Springs	8/11/2003	SIL	32
WT081	3SD	Pebble	115.1353	36.0303	Maryland & Pebble	8/12/2003	FSL	8
WT082/82R	3UD/3SDw	Pebble Raked, Dry/Wet	115.1353	36.0303	Maryland & Pebble	8/13,18/2003	FSL	8
WT083/084	4SU	Washington	115.2717	36.1789	Washington & Buffalo	8/14/2003	GR-FSL	4
WT084	4SD	Washington Raked	115.2761	36.1804	Washington & Buffalo	8/15/2003	GR-FSL	4
WT085	7SU	Losee	115.1064	36.2769	Losee & Centennial	8/21/2003	GRV-SCL	16
WT086	4LUD	Lamb-Bonanza	115.0794	36.1747	Lamb & Bonanza	8/21/2003	SIL	4
WT087	6SU	Lamb-215	115.0811	36.2881	Lamb & 215	8/22/2003	GRX-FSL	2
WT088	4SU	Durango-Alex	115.2811	36.2347	Durango & Alexander	8/25/2003	GR-FSL	4
WT089	5SUw	Durango-Craig	115.2812	36.2417	Durango & Craig	8/28/2003	GRV-FSL	0
WT090	UnSD	BermudaWind	115.1539	36.0425	Bermuda & Windmill	8/29/2003	LFS	4
WT091	2SD	Amigo	115.1503	36.0486	Amigo & Warm Springs	8/29/2003	LFS	4
WT092	3UU	Cheyenne	115.1947	36.2192	N Valley Drive & Cheyenne	9/3/2003	VFSL	8
WT093	8SD	Gibson	115.0294	36.0531	Gibson & Kelso Dunes	9/4/2003	CBX-FSL	0
WT094	5SD	Hollywood-Treatment	115.0142	36.1044	Hollywood & Treatment Plant	9/5/2003	GRV-SL	2
WT095	8SU	Pueblo-Racetrack	114.9502	36.0337	S Pueblo & W Burkholder/Racetrack	9/10/2003	CBX-FSL	2
WT096	6SU	Hollywood-Carey	115.0161	36.2028	N Hollywood & E Carey, 0.6 mi on Carey	9/11/2003	GRX-FSL	2
WT097	7SD	Las Vegas-Lamb	115.0722	36.2299	NW Las Vegas Blvd & N Lamb	9/12/2003	GRV-SCL	16
WT098	4LSD	5th Centennial	115.1355	36.2774	N Fifth Street & E Centennial P	9/15/2003	SIL	4
WT099	4SU	Buffalo-Blue	115.2607	36.0151	S Buffalo & W Blue Diamond, 0.3 mi S Buffalo	9/18/2003	GR-FSL	2

TABLE 4.15 (Cont.)

Site Number	SECC[a]	Site Name	East Longitude	North Latitude	Street Intersection	Test Date	Soil Texture[b]	Max. Salinity[c] (%)
WT100	3UD	Las Vegas-Pyle	115.1711	36.0033	LV Blvd & Pyle	9/19/2003	GR-LFS	2
WT101	3SU/3UU	Losee 2a/Losee 2b	115.1064	36.2769	Losee & Centennial	9/22/2003	GRV-SCL	16
WT102	5SU/5UU	Durango-Craig 2a/ Durango-Craig 2b	115.2812	36.2417	Durango & Craig	9/23/2003	GRV-FSL	0
WT103	4SD/4UD	Durango-Alex 2a/ Durango-Alex 2b	115.2811	36.2347	Durango & Alexander	9/24/2003	GR-FSL	4
WT104	2SD/2UD	Amigo 2a/Amigo 2b	115.1503	36.0486	Amigo & Warm Springs	9/25/2003	LFS	4
WT105	6SD/6UD	Hollywood-Carey 2a/ Hollywood-Carey 2b	115.0161	36.2028	N Hollywood & E Carey, 0.6 mi on Carey	9/26/2003	GRX-FSL	2
WT106	8SD/8UD	Pueblo-Racetrack 2a/ Pueblo-Racetrack 2a	114.9502	36.0337	S Pueblo & W Burkholder/Racetrack	9/29/2003	CBX-FSL	2
WT107	4LUD	Lamb-Bonanza	115.0794	36.1747	Lamb & Bonanza	9/30/2003	SIL	4
WT108	UnSD/UnUD	BermudaWind 2a/ BermudaWind 2b	115.1539	36.0425	Bermuda & Windmill	10/1/2003	LFS	4
WT109	6SD/6UD	Lamb-215 2a/Lamb-215 2b	115.0811	36.2881	Lamb & 215	10/7/2003	GRX-FSL	2
WT110	3SD/3UD	Cheyenne a/Cheyenne b	115.1947	36.2192	N. Valley Drive & Cheyenne	10/7/2003	VFSL	8

[a] The SECC indicates (1) the WEG number for the test site soil, (2) soil condition as stable (S) or unstable (U), and (3) soil condition as disturbed (D) or undisturbed (U), in that order. The Un designation indicates soils with an unknown or unassigned WEG.

[b] LFS = loamy fine sand, FSL = fine sandy loam, GR-LFS = gravelly loamy fine sand, GR-FSL = gravelly fine sandy loam, GRV-FSL = very gravelly fine sandy loam, GRV-SL = very gravelly sandy loam, GRV-SCL = very gravelly sandy clay loam, CRX-FSL = extremely gravelly sandy clay loam, CBX-FSL = extremely cobbly fine sandy loam, CBX-FSL = complex caliza, CBX-FSL = complex rocky, SICL = silty clay loam, SIL = silt loam.

[c] WT080 is sand dune, which is very erodible. Yet, 60 yards away is WT079, which was much more stable. Also the Natural Resources Conservation Service data are quite "coarse" in their spatial resolution, and there are small-scale phenomena that might differ from the salinity that is assigned to a polygon.

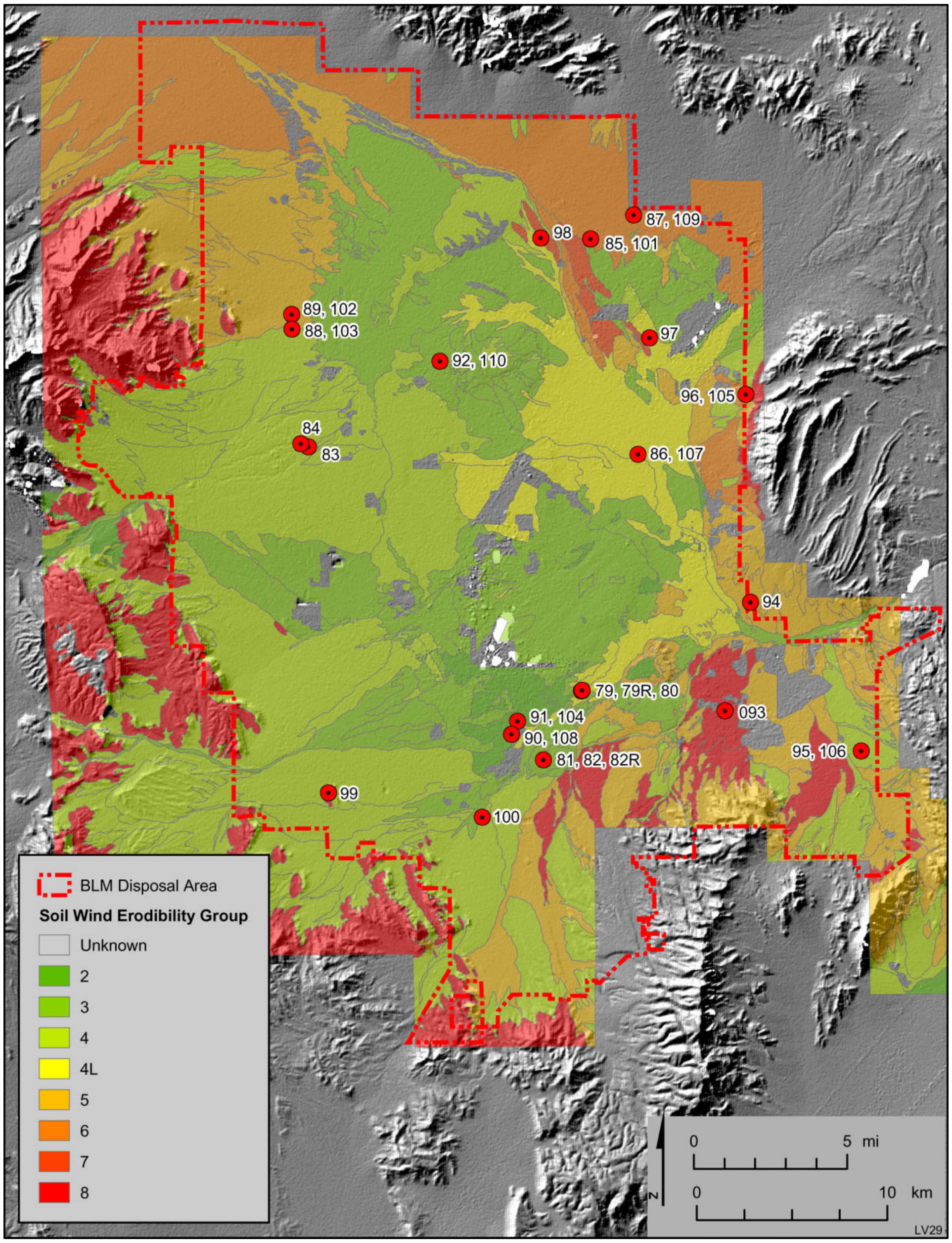

FIGURE 4.6 Locations of Wind Tunnel Test Sites Superimposed on Soil Areas Depicted by their Wind Erodibility Group

At each wind tunnel test site, three profile-erosion test runs were conducted. The data were used to create the wind tunnel test GIS layer to overlay with a GIS layer of soil characteristics for the Las Vegas area. The second layer was generated by using digital data obtained from the USDA's Natural Resources Conservation Service (USDA 1999). In addition, tabular data for wind tunnel sites and soils were joined into a single table. Figure 4.6 also shows the soil layers (symbolized by WEG) and the locations of the wind tunnel test sites listed in Table 4.15.

4.3.2 Soil Condition Classification

In addition to the WEG number, some soil conditions (stability, disturbance) and sheltering ability are important to characterize when estimating a soil's susceptibility to wind erosion and quantifying the PM_{10} windblown dust emissions in the Las Vegas Valley. The methods used to characterize soil stability, disturbance, and sheltering ability are described below.

4.3.2.1 Soil Stability

During and as a part of the field measurements, site stability was determined by the presence or absence of intact crust, by the predominant size fraction in surface soils, and by the proportion of vegetation present (using an average of three 100-ft transects and counting vegetation at every foot). The procedures used in the field to determine or characterize soil stability included a consideration of the geologic and biological features of each of the test site soils and the surrounding test site areas. A detailed description of these procedures is provided in Appendix E.

Because drop ball tests over a fully representative set of soils within the Las Vegas Valley were impractical, an alternative method was adopted to map soil stability, based in part on soil chemistry combined with the limited available drop ball test data. Consultation with a soil scientist at the Soil Conservation Service in Reno, Nevada, indicated that the one soil chemistry parameter that seemed to be a good marker of stability was alkalinity content (Lazaro 2003). McKay reported that soils with salinity greater than 16% tend to readily form stabilizing crusts. Soils over a large area covering the Las Vegas Wash typically have a salinity content greater than 16%.

The USDA digital soil data (USDA 1999) provided coverage for most of the Las Vegas Valley. The stability values coded in the grid cells were based on the percentage salinity coded in the digital soil data. Those with a minimum salinity content of less than 2% were mapped as 20% stable. Stability values increased proportionally with increasing salinity, up to 100% stable for salinity values of 16% or higher. For example, on a modeling grid cell basis, if grid cell 3340 contained 80% WEG 2 (~1.5 km^2) and 20% WEG 4L (~0.3 km^2) and if the soil salinity was less than 2% and 15.2%, respectively, the grid cell soils would be designated as 30% stable (the WEG 2 area would be multiplied by 0.2, and the WEG 4L area would be multiplied by 0.156, resulting in 0.54 km^2, which is 30% of the grid cell area). Figure 4.7 shows the mapped soil stability layer, as used by the windblown dust model (see Section 4.3.4) within the CMAQ model. This layer was not changed for future year modeling (2006, 2009, and 2018).

4.3.2.2 Soil Disturbance

Another soil condition characteristic important with regard to its dust generation potential is soil disturbance caused by human activities on vacant lots (e.g., use of off-road vehicles and construction). The magnitude of wind-dispersed dust from soils on undeveloped land can be highly influenced by the level of soil disturbance on that land. Discrete, digitized, high-spatial-resolution data on soil disturbance over a large area (e.g., data from satellite remote sensing) would be desirable but is not generally available.

During the field experiments, photographs were taken of each test site before each run. Included were aerial photographs (with the nearest landmarks) and a close-up of the soil surface under the working section of the tunnel. Site photographs were evaluated for large-scale vegetation density and evidence of removal of desert pavement by human traffic or construction. Removal of vegetation desert pavement generally results in an increase in the albedo of the surface. Sites with high albedo relative to the surrounding desert were classified as disturbed.

To extend the identification of soil disturbance beyond the areas in and around the test sites and to include a broader coverage of soil disturbance within the Las Vegas Valley and the inner modeling grid, aerial photographs were used to assign an estimate of the percentage disturbed to each modeling grid cell. Detailed digital color aerial photographs from the Clark County GIS Management Office, covering most of the disposal area, were used to classify soil disturbance over vacant lots. Aerial photographs taken in 2003 were used to identify soil disturbance, and photographs taken in 2003 and 2002 for a more limited but targeted area were used to identify changes in soil disturbance percentage. Such photographs are taken twice annually in flyovers covering most of the Las Vegas Valley. The photographs were viewed interactively in the GIS with the modeling grid superimposed. For each grid cell, a visual assessment was made to determine the percentage of disturbance. Areas with natural vegetation, drainage channels, developed property, and paved roads were designated as undisturbed areas. Unpaved roads, rights-of-way, gravel pits, construction sites, areas with intensive off-road vehicle use, land with no vegetation, and areas of rain runoff with possible human disturbance were designated as disturbed areas.

A detailed photographic analysis of the 2003 images provided a semiquantitative means for determining the percentage of the modeling grid cells that should be classified as containing disturbed soil. The aerial photos shown in Figures 4.8 through 4.11 are used to illustrate how the percentage of disturbed and undisturbed land within each modeling grid cell was determined. To calibrate the procedure, some areas of disturbance were measured at a more detailed level and used as a reference by the analysts. When grid cells were not fully covered by available aerial photographs, the level of disturbance was assumed to be similar for the rest of the cell. Such cells occurred at the edges of the disposal area, where disturbance was minimal. To assess the change

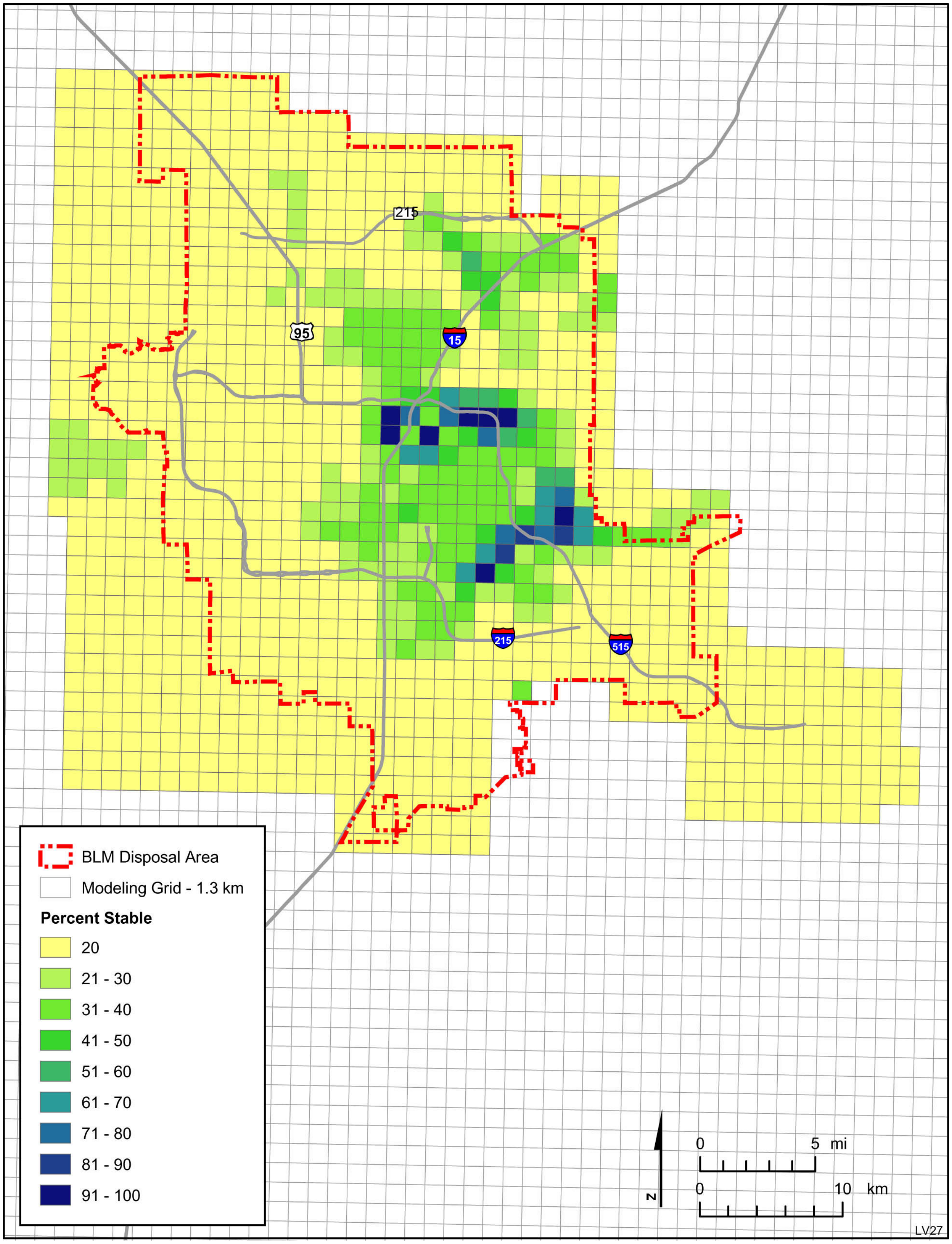

FIGURE 4.7 Mapped Soil Stability Used for the Windblown Dust Model Input Layer on the 1.3-km-Resolution Grid

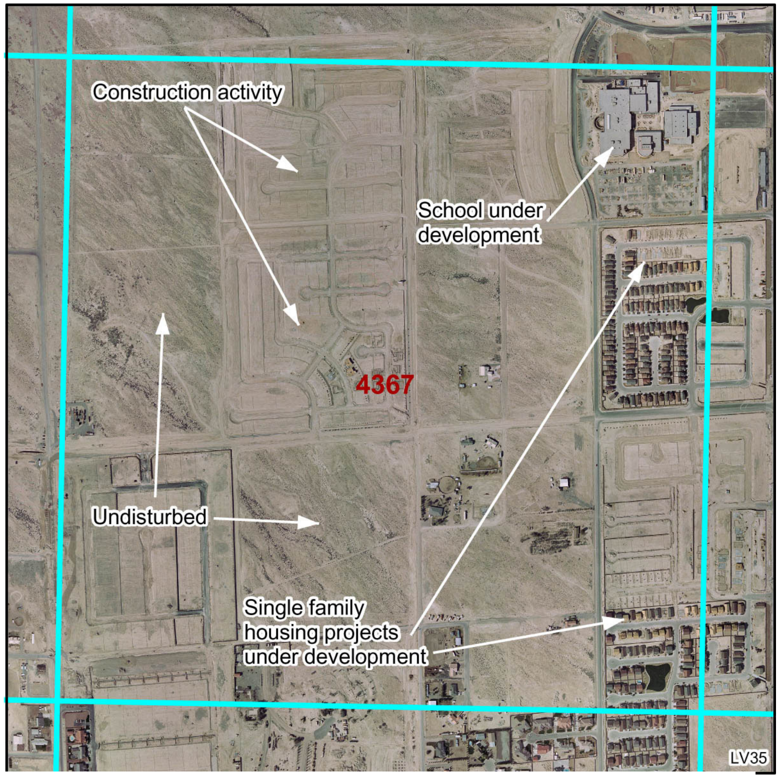

FIGURE 4.8 Aerial Photo Showing Disturbed and Undisturbed Areas in Modeling Grid Cell 4367

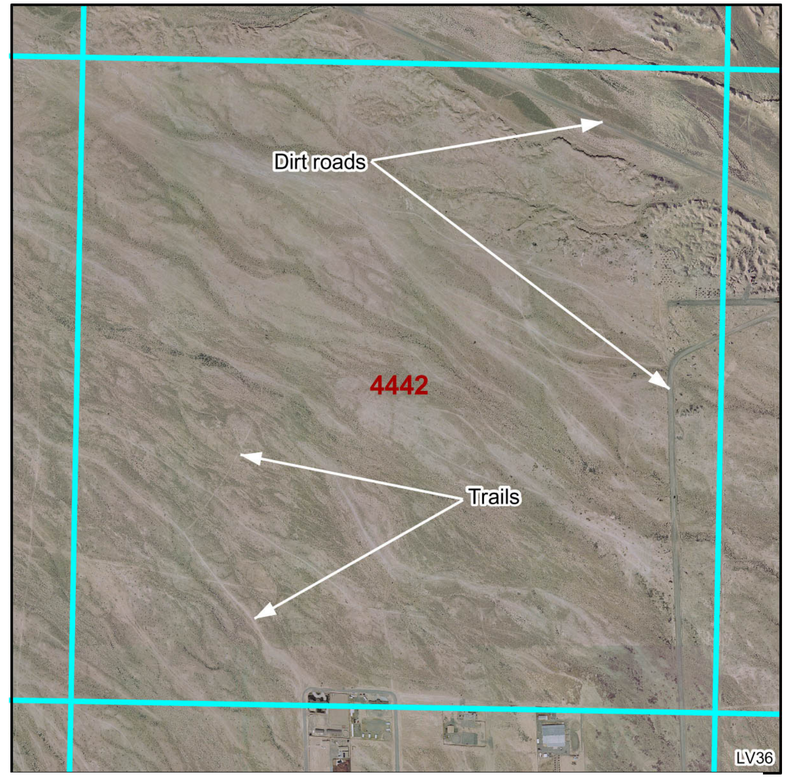

FIGURE 4.9 Aerial Photo Showing Disturbed and Undisturbed Areas in Modeling Grid Cell 4442

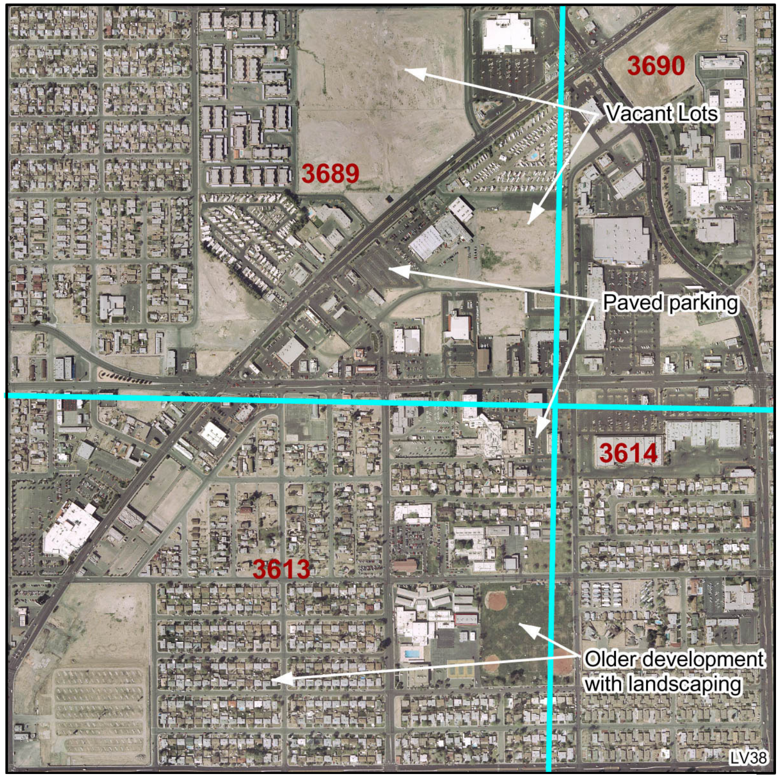

FIGURE 4.10 Aerial Photo Showing Disturbed and Undisturbed Areas in Modeling Grid Cells 3689, 3690, 3613, and 3614

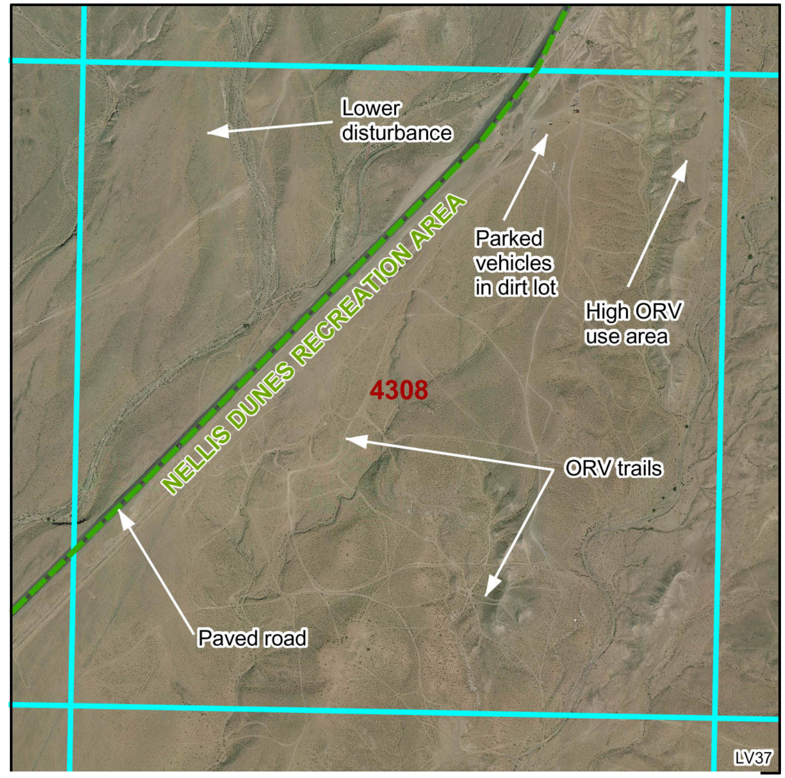

FIGURE 4.11 Aerial Photo Showing Disturbed and Undisturbed Areas in Modeling Grid Cell 4308

over time, 279 cells in the southwest quadrant of the study area for which there were photographs taken in 2002 were mapped with the same process. The Nellis Dunes Recreation Area, just outside the disposal area to the northeast, was an important area of concern that was not covered in the initial analysis. Photographs were obtained and processed to fill this data gap. Figure 4.12 shows the gridded disturbance data produced with this process. Each cell with available aerial photographic information was examined to identify the percent of disturbance. Criteria to use for assigning percentages of the grid as being disturbed or undisturbed were developed. Areas were

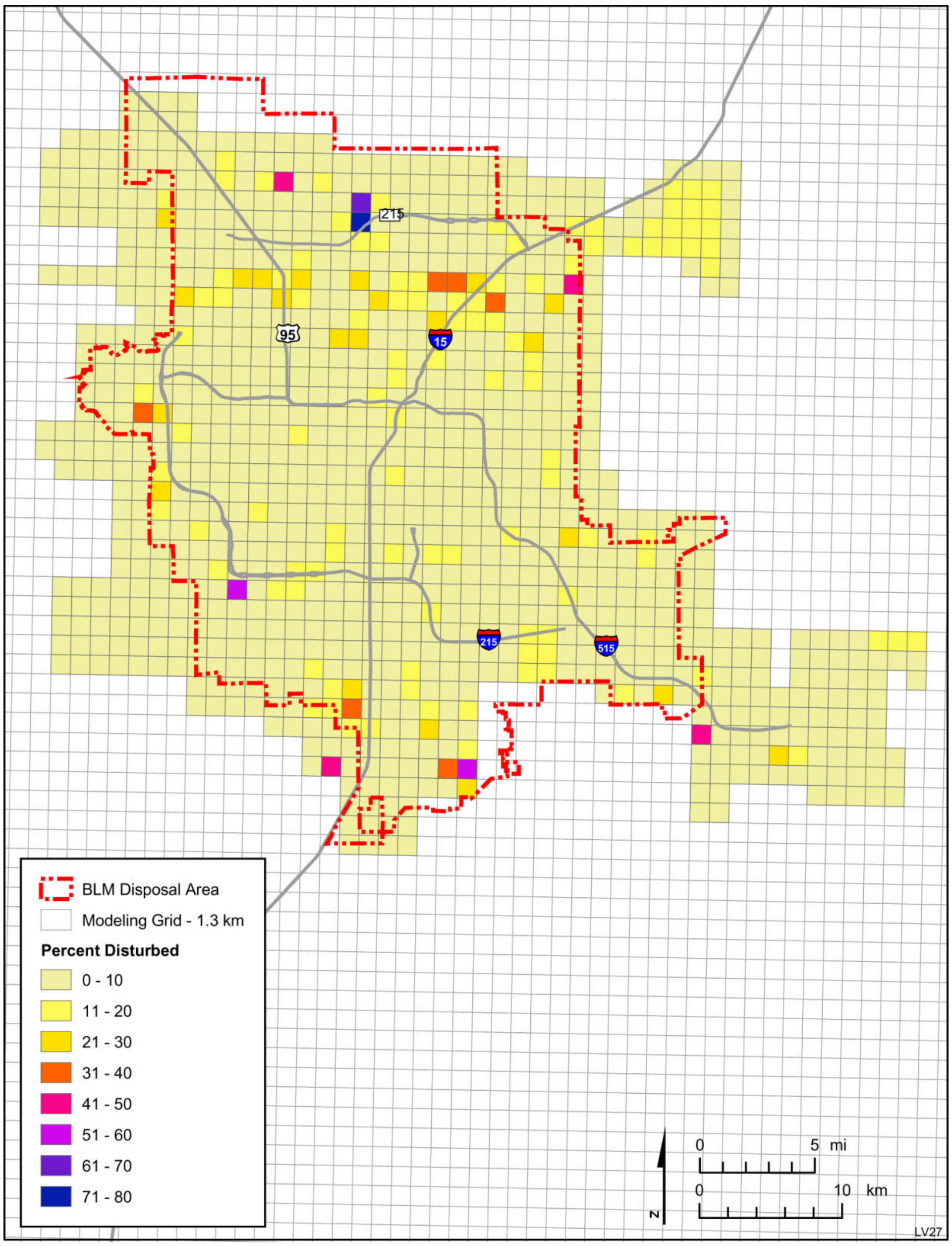

FIGURE 4.12 Baseline Soil Disturbance Dust Model Input Layer for the 1.3-km-Resolution Grid

classified as undisturbed if they had natural vegetation, rain runoff from the mountains, residential and commercial property, and paved roads. Areas were classified as disturbed if they contained identified unpaved roads, rights-of-way, gravel pits, construction sites, evidence of intensive off-road vehicle use, an absence of vegetation, or rain runoff with possible human disturbance. For cells not fully covered by aerial photographs, the percentage of disturbance in the photographed portion was determined by noting the percentage of the subcell-sized area that met the criteria for disturbance.

The full inner modeling grid has 5,776 cells, about 1,202 of which are within the disposal area boundary. The available 2003 aerial photographs completely covered only about 17% (1,011 cells) of the modeling grid and 70% (835 cells) of the disposal area. Partial aerial photographic coverage was available for another 151 cells.

A total of 106 of these cells have more than 50% coverage. To study the trends in development during the last 2 years, similar data were extracted for the northwest and southwest parts of the study area by using 2002 aerial photographs. This provided full coverage of 246 cells and partial coverage of 33 more.

Mapping disturbance for future modeling years obviously could not be done with aerial photographs. For this work, disturbance was modeled with current land use (RTC 2002) and planned land use (RTC 2003) data in conjunction with data and assumptions about BLM land conveyances and development rates. (See Appendixes B and C for information on the development of these layers.) Disturbance values for a particular location and date varied, depending on the land use (Figures C.1, C.2, and C.3) and the conveyance date (Figure 4.3). The land use type also determined the assumptions about the length of the construction period, level of disturbance during construction, and overall percentage of the lands that was developed. A lag of 1 month after the patent date was assumed for the first possible construction date. Since development could occur on all vacant lands within the disposal area, all vacant parcels were included rather than only the ones conveyed by BLM. There were two uncertainties in some of the data: (1) conveyance dates for specific parcels were unknown after 2005 and (2) portions of the BLM lands in the disposal area lacked data for current or planned land use. In cases for which the conveyance date was unknown, construction was averaged over the modeling period to reach the percentages expected to be developed by 2018. In cases for which the land use was unknown, the standard assumption was that 100% would be disturbed during a 6-month construction period. Such an approach spreads the construction-related disturbance over the extent of the developable land but does not require speculative assumptions that a particular area or region will be developed at a particular time, which might prove wrong even as soon as 2005. Figures 4.13 (C, D) and 4.14 (C, D) show portions of the modeling input data for disturbance and sheltering for 2000 and 2018.

4.3.2.3 Soil Sheltering

Many landscape features, such as vegetation, pavement, and structures, have a sheltering effect that diminishes the area from which windblown dust can be generated. These effects are

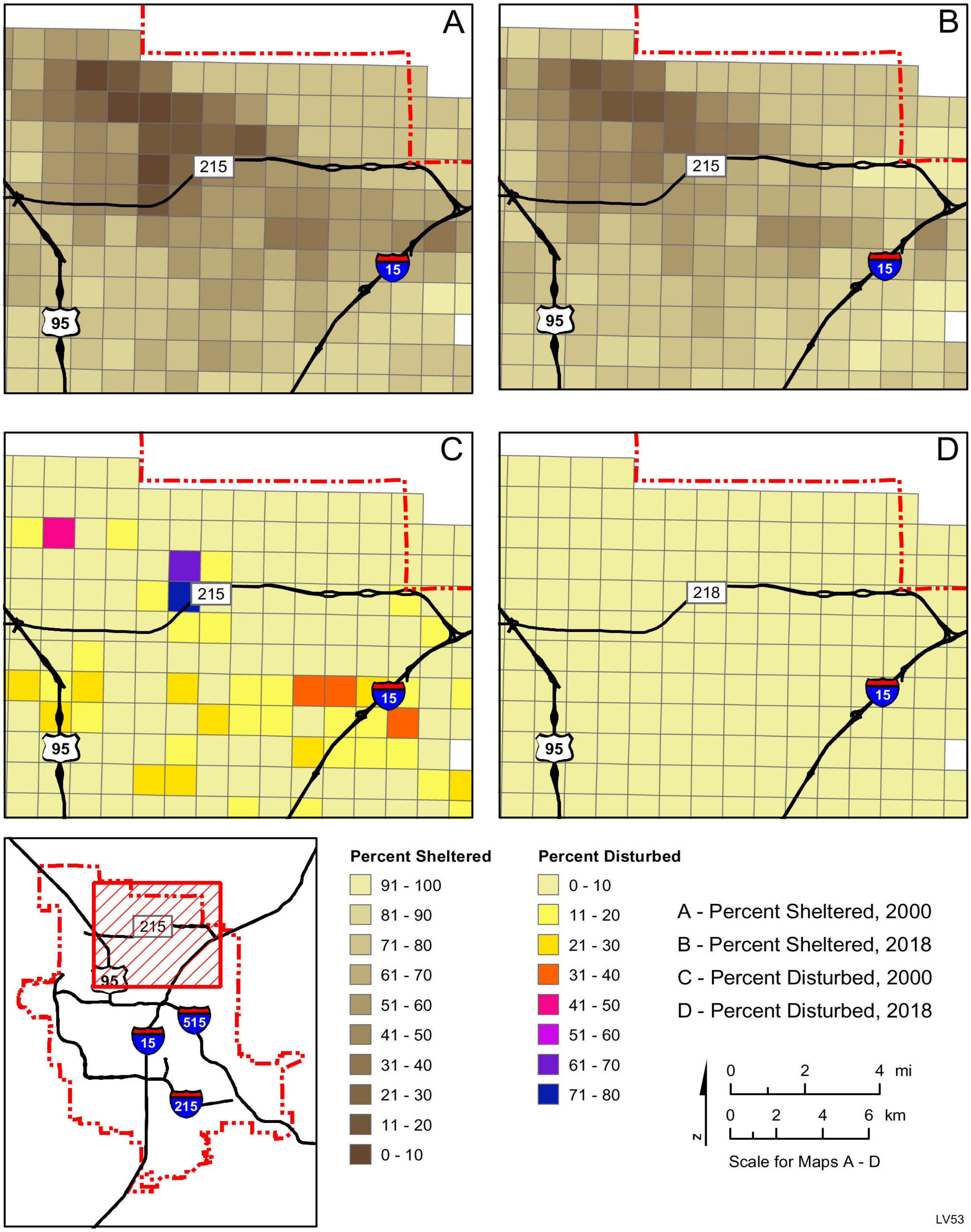

FIGURE 4.13 Model Input Data for the North-Central Portion of the Disposal Area, Including Sheltering Ability in 2000 (A) and 2018 (B) and Soil Disturbance in 2000 (C) and 2018 (D)

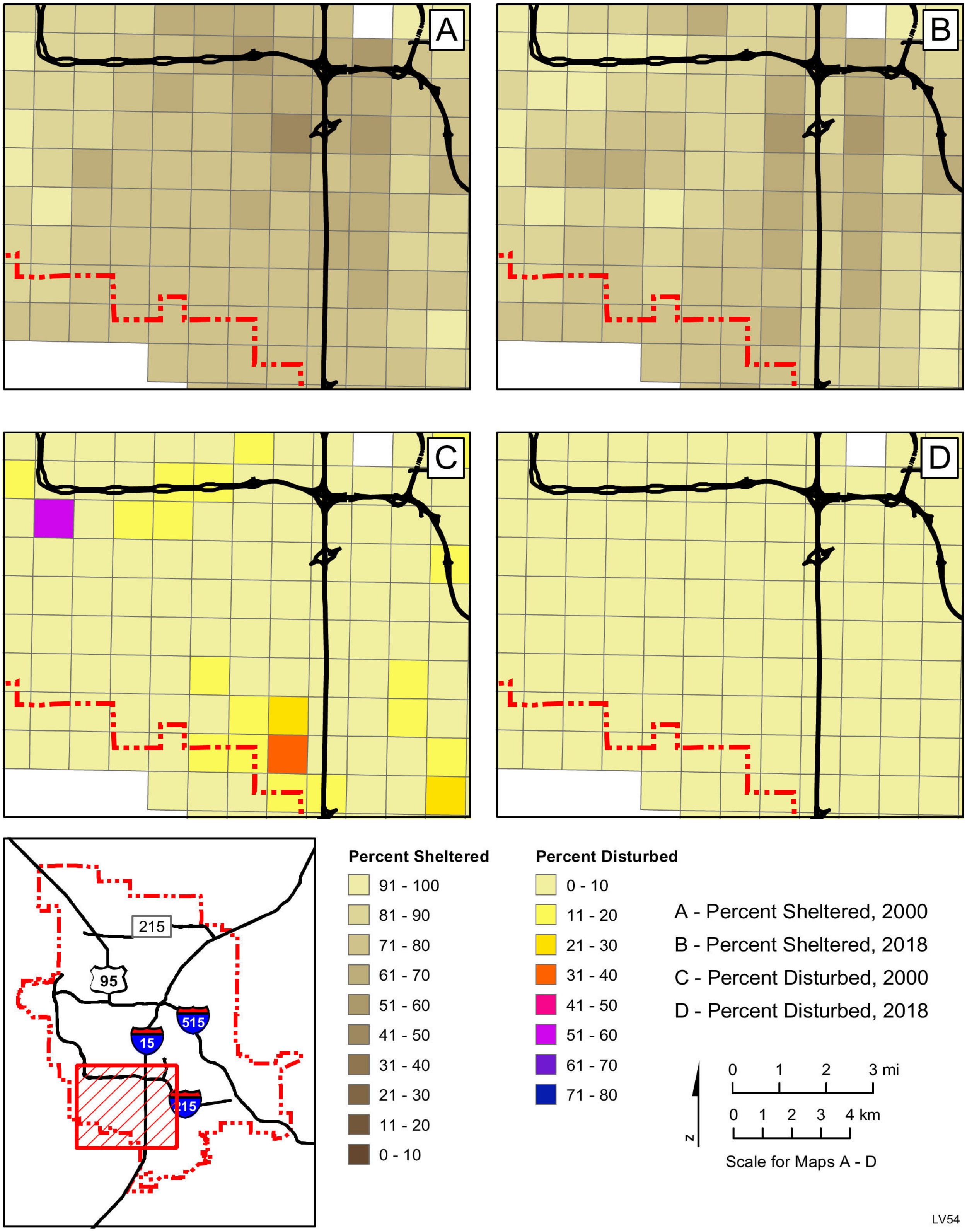

FIGURE 4.14 Model Input Data for the Southwest Portion of the Disposal Area, Including Sheltering Ability in 2000 (A) and 2018 (B) and Soil Disturbance in 2000 (C) and 2018 (D)

generally very localized (e.g., the sheltering from a single shrub and its root mass) and therefore difficult to assess for large regions. Two available sources of land cover data were considered for this work.

The first source was BELD3 (EPA 2004a), the spatial data source for the EPA Biogenic Emissions Inventory System (BEIS) (EPA 2004b). This source was initially thought to be the best, because it was developed by the EPA for air quality modeling, especially the assessment of biogenic sources. The data are resolved in 1-km cells, coded with values for the percent forested, percent agricultural, and percent other, with a cover type designation. A related table includes a detailed breakdown of land cover by species; however, this table does not resolve the information below the county level and was therefore inadequate as input for the modeling work. In addition, the land use codes for the 1-km cells were derived from a more detailed source (described below) that was used in its original form rather than the generalized version found in BELD3.

The second data source, the National Land Cover Database (NLCD); (U.S. Geological Survey [USGS] 1992), provided a higher-resolution cell size (30 m) and a much more detailed set of land cover classes than did BELD3. The main drawbacks of this data source were that (1) the source imagery from which it was derived date from 1988 to 1992 and (2) the predominant land cover type of "shrubland" was not subdivided into the density classes needed to adequately assess the level of sheltering for most of the study area. Therefore, for each land cover class, the level of sheltering was estimated and coded into the layer. The NLCD grid was then resampled to the 1.3-km modeling grid, taking the mean sheltering value. Table 4.16 lists the land use classes, the percentage covered by the class, and the sheltering value used. Figure 4.15 shows the NLCD image with the land use classes.

Within the disposal area, land sheltering values were adjusted on the basis of land use by using RTC current land use data (RTC 2002). Table 4.17 lists the sheltering values assumed for each land use. Image-based sheltering values in each cell were adjusted with composite sheltering values derived from land use according to the proportion of the cell covered by the land use data. Lands designated as vacant or open space were omitted from this work. Figure 4.16 shows the resulting sheltering levels for the 1.3-km modeling grid.

The classification of more detailed images, such as large-scale aerial photographs or higher-resolution satellite images, would improve the level of refinement for soil sheltering. It would also improve the identification of disturbed areas and provide a means to track disturbance over time, which would be of benefit not only for refining windblown dust estimates but also for implementing soil stabilization mitigation or corrective actions to enforce or deter illegal land use activities (i.e., restrictions on off-road vehicle use).

For the future years of 2006, 2009, and 2018, sheltering was mapped by using cumulative development to adjust the 2000 values. The same data and assumptions described previously for disturbance mapping were used. Sheltering assumptions varied by land use type (Table 4.17) and included both previous development and the sheltering from construction completed in the target year. Figures 4.13 (A, B) and 4.14 (A, B) show portions of the modeling input data for sheltering for 2000 and 2018.

TABLE 4.16 NLCD Land Cover Classes Showing the Percentage of Area Covered and the Sheltering Value Used for Modeling

Land Cover Name	Land Cover Description	Percent of Area Covered	Sheltering Value
Deciduous forest	Areas dominated by trees where 75% or more of the tree species shed foliage simultaneously in response to seasonal change.	0.13	100
Evergreen forest	Areas characterized by trees where 75% or more of the tree species maintain their leaves all year. Canopy is never without green foliage.	3.46	100
Mixed forest	Areas dominated by trees where neither deciduous nor evergreen species represent more than 75% of the cover present.	0.25	100
Low-intensity residential	Includes areas with a mix of constructed materials and vegetation. Constructed materials are 30% to 80% of cover. Vegetation may cover 20% to 70%. Usually include single-family housing units. Population densities are lower than those in high-intensity residential areas.	1.88	100
High-intensity residential	Includes heavily built-up urban centers where people reside in high numbers. Examples include apartment complexes and row houses. Vegetation accounts for less than 20% of the cover. Constructed materials account for 80% to 100% of the cover.	0.74	100
Urban/recreational grasses	Vegetation (primarily grasses) planted in developed settings for recreation, erosion control, or aesthetic purposes. Examples include parks, lawns, golf courses, airport grasses, and industrial site grasses.	0.19	100
Commercial/industrial/ transportation	Includes infrastructure (e.g., roads, railroads) and all highways and all developed areas not classified as high-intensity residential.	1.40	100
Open water	Areas of open water, generally with less than 25% water cover (per pixel).	1.45	100
Quarries/strip mines/gravel pits[a]	Areas of extractive mining activities with significant surface expression.	0.02	100
Shrubland	Dominated by shrubs; shrub canopy is 25% to 100% of cover. Shrub cover is generally >25% when tree cover is <25%. Shrub cover may be <25% when other life forms (e.g., herbaceous or tree) are <25% and shrub cover is more than the cover of other life forms.	79.50	80
Grasslands/ herbaceous	Areas dominated by upland grasses and forbs. In rare cases, herbaceous cover is less than 25% but greater than the combined cover of woody species present. These areas are not subject to intensive management, but they are often utilized for grazing.	4.11	80
Pasture/hay	Areas of grasses, legumes, or grass-legume mixtures planted for livestock grazing or the production of seed or hay crops.	0.08	80
Row crops	Areas used for the production of crops, such as corn, soybeans, vegetables, tobacco, and cotton.	0.02	50
Small grains	Areas used for the production of graminoid crops such as wheat, barley, oats, and rice.	0.01	50
Bare rock/sand/clay	Perennially barren areas of bedrock, desert, pavement, scarps, talus, slides, volcanic material, glacial debris, and other accumulations of earthen material.	6.74	0

[a] Sheltering for quarries, strip mines, and gravel pits was set to 100% because this source was included in the model in a different way.

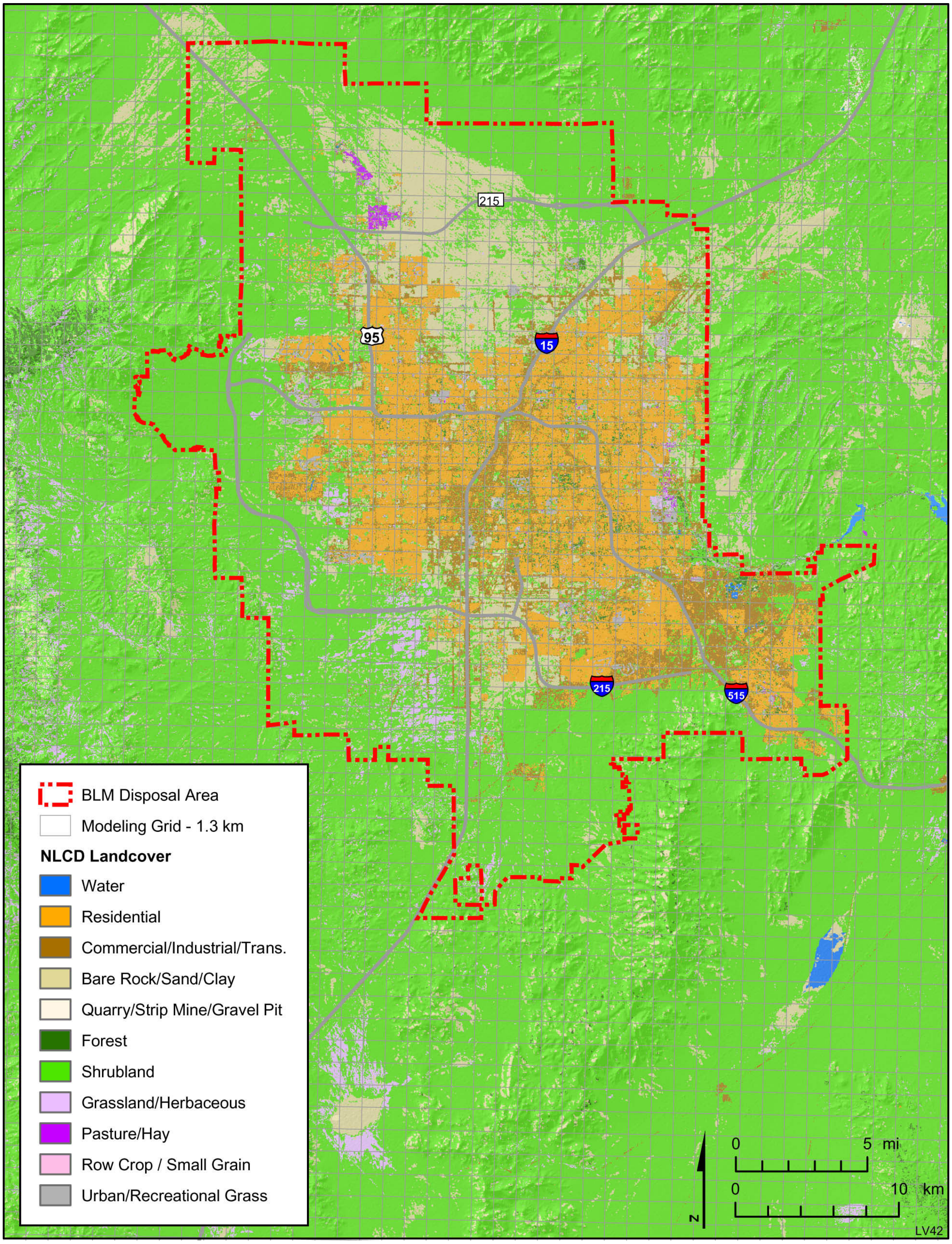

FIGURE 4.15 NLCD Land Cover Classes in and around the Disposal Area

TABLE 4.17 Assumed Sheltering Percentages by Land Use Type

Land Use	Percent Sheltered during Construction	Percent Sheltered after Construction
Agriculture/mining	25	25
Residential	0	100
Office	0	100
Retail	0	100
Hotel/casino	0	100
Industry	0	100
Recreation (indoor)	0	100
Recreation (outdoor)	10	75
Religious	0	100
School	0	100
Public facility	0	100
Open space/vacant	Omitted	Omitted
Right of way	0	75

Overall sheltering in these data layers increases over time because of the increase in developed lands. At the scale of individual grid cells, however, there were some unexpected trends, especially for 2006. This proved to be an artifact of using several different data sources together that were not always consistent. For example, image-based sheltering values in the central part of the Las Vegas area probably overestimated the sheltering level because of the lack of nondeveloped land cover categories. Also, most rights-of-way were too small to resolve in the image, and that category in the image was blended with commercial and industrial land. If land use data indicated development would occur in part of that cell, then the construction or post-construction sheltering values could be lower and have the effect of lowering the value for that cell. Over the longer time range of 2000 to 2018, these effects are much less prevalent, and the trend of increased sheltering in developed areas is more obvious and consistent. Use of more detailed imagery and more refined land cover categories would improve these results, both inside the disposal area (where land use changes can be applied) and outside (where the NLCD data provided little differentiation of the variation in vegetation cover).

4.3.3 General Description of the Portable Wind Tunnel

The UNLV wind tunnel used in the 2003 field study is a modification of the draw-through design developed in the early 1990s by Duane Ono at Great Basin Unified Air Pollution Control District, Bishop, California, and Chatten Cowherd at Midwest Research Institute, Kansas City, Missouri. Major components of the tunnel are shown schematically in Figure 4.17. Modifications to the UNLV tunnel include a 6-in.-diameter working section instead of a 4-in.

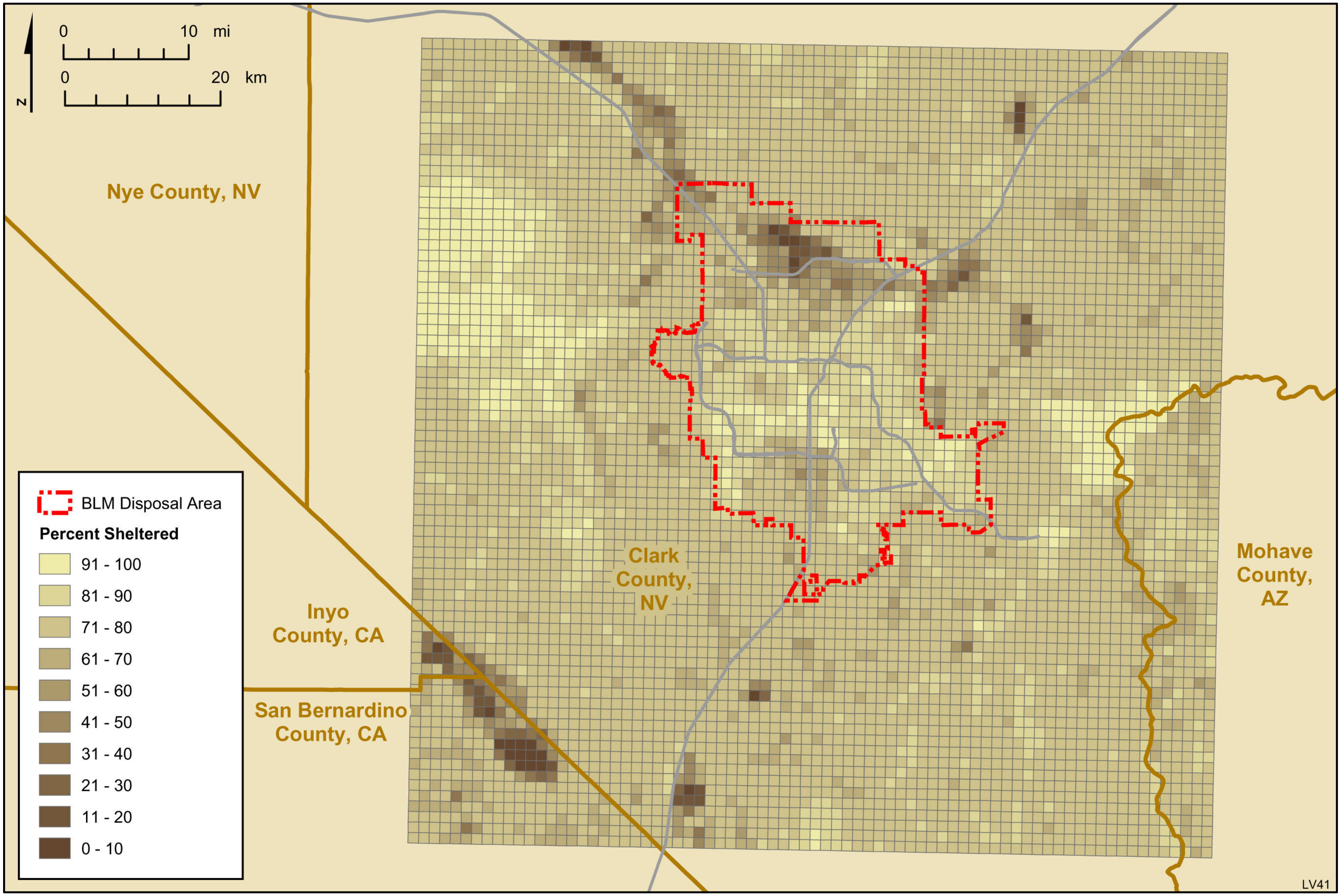

FIGURE 4.16 Baseline Soil Sheltering Dust Model Input Layer for the 1.3-km-Resolution Grid

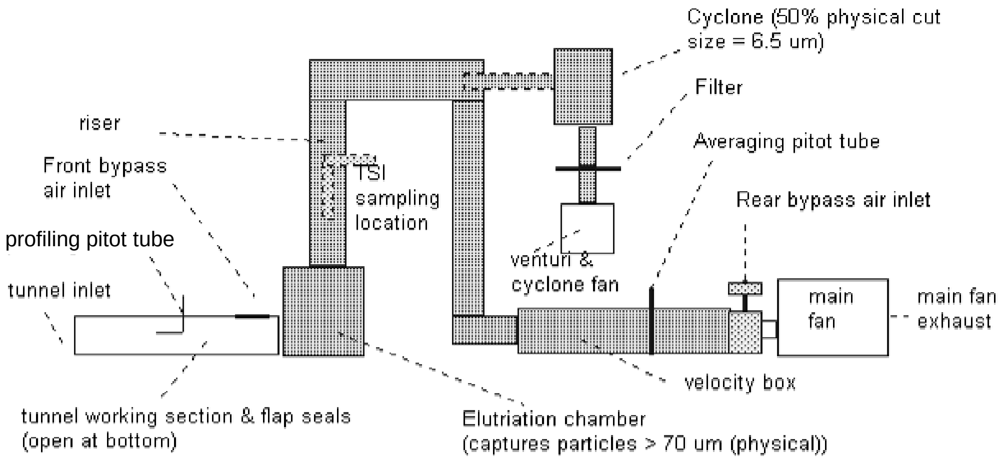

FIGURE 4.17 Schematic Diagram of the UNLV Portable Wind Tunnel

section and the addition of a DUSTTRAK™ PM_{10} monitor (TSI Incorporated, Model 8520) in the riser section. Heavy-gauge plastic flaps (3 in. wide); open-cell foam; and 2-in.-diameter, 6-ft-long cloth draft tubes filled with coarse sand were used to seal the tunnel to the soil surface. A rear air bypass and a constant-speed motor were used to control averaging flow, instead of a venturi and an electronic motor speed controller. The working section of the tunnel was 6 in. wide by 6 in. high by 60 in. long. Not shown in Figure 4.17 is a 60-in.-long flow-conditioning section installed ahead of the working section of tunnel, with a honeycomb flow diffuser at the front end, which gives the incoming air 10 tunnel diameters in which to develop a turbulent profile before it passes into the tunnel working section. A detailed description of the wind tunnel components and a process flow diagram are given in Appendix E.

4.3.4 Windblown Dust Model

Functional relationships between vertical PM_{10} soil erosion flux and wind speed are developed by using parametrically fitted equations to Las Vegas wind tunnel field measurements collected during the summer of 2003. These relationships generally depend on the specific physical and chemical characteristics of the soil, which can be determined by identifying the soil's condition (such as stable or unstable and disturbed or undisturbed) and WEG. The key experimentally derived dust parameters are the horizontal soil particle (PM_{10}) flux, erosion velocity, threshold friction velocity (TFV), and vertical PM_{10} flux. Details on the measurements, including the experimental procedures, quantification of measurement uncertainty, and data reduction and tabulation, can be found in Appendixes E and F.

At each tested wind tunnel test site area, a series of three wind tunnel erosion runs were performed, each at a successively higher tunnel-damper-adjusted air-flow speed. The first run was done at a damper setting that would correspond to a 10-m wind speed of approximately 20 mph, with the second and third runs at successively higher wind speeds of approximately 30 and 40 mph, respectively. For the first 24 wind tunnel test areas (Sites WT 079 through

WT 100), the goal was to conduct three sampling runs per test site area, with every run in a different spot and each one at three different, successively higher wind speeds. For sites WT 101 through WT 110, a fourth run was added that corresponded to a step-by-step increasing progression of wind speeds, all done in one place within one run.

The measured wind tunnel erosion velocity is defined as the reference friction velocity u_* within the portable wind tunnel. The friction velocity can simply be defined as the near-surface friction-influenced wind shear velocity. It is an indirect measure of mechanically induced turbulence and a direct measure of the friction forces of the wind near the surface. Its value is set at a distance from the surface at which the surface-influenced velocity shear is equal to the von Karman constant ($k = 0.4$) times the mean velocity shear. This velocity can be calculated by using the standard logarithmic wind profile if the surface roughness height z_o is known. This reference height is determined experimentally from the slope and intercept of the wind tunnel velocity profile (see Appendix E for details). As a general rule of thumb, the friction velocity is approximately one-tenth of the mean wind speed at 10 m.

The TFV is a key parameter necessary for estimating the onset of soil wind erosion. The wind-tunnel-derived TFVs reflect the degree of capacity of a soil to be eroded by wind. This capacity depends on the soil’s physical and compositional characteristics and condition. Two TFVs are derived from the experimental data. The first is called the ambient threshold and is defined as the wind velocity necessary to move soil particles horizontally along the surface. The ambient threshold is determined when the measured PM_{10} concentration from the elutriation chamber (EC) reaches the ambient concentration or background level. The second is called the effective threshold friction velocity (u_{*teff} or TFV_{eff}) and is defined as the velocity at which the wind-friction force-induced inertia on loose surface-soil particles is fast enough to lift them to an elevation high enough to suspend the PM_{10} as downwind transportable windblown dust. The TFV_{eff} is estimated by plotting the captured particle mass from the EC for each of the three wind tunnel runs at each site against the computed friction velocity set for each wind tunnel run. If a plot of captured mass versus u_* showed a large increase in slope between two of the pre-set u_* values, then the slope increase was assumed to exceed the threshold for saltation-sized particles (>70 μm in physical diameter). Saltation is defined as a horizontal movement of loose soil particles with enough momentum to knock loose soil attached or soil-crusted particles by impaction. An example calculation is provided in Appendix E and illustrated in Figure E.6.

The horizontal flux of saltation-sized particles (captured in the EC) is estimated as the mass of particles flowing over the sample soil surface area (wind tunnel working or open floor area) divided by the sampling time. The particle mass is the mass of particles collected in the wind tunnel EC. The wind-tunnel-derived TFVs range from 0.78 to 0.27 m/s (0.85 to 1.75 mph) for SECC 2SD and 8SD soils, respectively. The corresponding friction velocities (at a 10 m height) ranged from 12 to 21 m/s (26 to 48 mph). The TFVs for the full set of SECC soils are tabulated in Appendix E.

The PM_{10} concentration generated by the flow within the working section of the tunnel is measured by using the DUSTTRAK aerosol monitor. The monitor is a light-scattering laser photometer that uses a laser diode and optical backscatter principle to determine dust concentrations. It is calibrated by using a zero checking mechanism provided by the manufacturer. Wind tunnel soil flux and velocity data for each of the 165 experimental runs at 22 test site areas is summarized in Appendix E.

The vertical dust flux generated in the wind tunnel experiments is estimated from the measured concentration in the aerosol monitor above the tunnel EC and the measured tunnel flow rate. This PM_{10} surface flux or surface dust emission rate (μg/s/m^2) is calculated by using the following formula:

$$F = (Q + 40)\left(\overline{C}_{spike\_corrPM_{10}} - \overline{C}_{PM_{10}amb}\right)/A_T$$

where

Q	= tunnel flow rate (actual ft^3/min or ACFM),
$\overline{C}_{spike\_corrPM_{10}}$	= initial average spike corrected PM_{10} concentration (mg/m^3),
$\overline{C}_{PM_{10}amb}$	= adjusted average PM_{10} concentration (mg/m^3), and
A_T	= tunnel floor area (m^2).

Subsequent to data reduction, parametric regressions were determined by plotting the vertical dust flux (*F*) with the measured wind tunnel velocity. A set of semiempirical/theoretical dust emission relationships was developed. Based on their “goodness of fit” (with correlation coefficients, r >0.7), measurements for each combination of soil type and soil conditions were fitted “directly” to a vertical flux (*F*)-velocity relationship, or they were fitted with a combined empirical/theoretical model as a surrogate if there were not enough experimental data. The derived parametric dust flux or emission factor formulas were generated from best fits of *F* versus $u_*(u_*^2 - u_{*t}^2)$. This relationship is based on the experimentally verified theory of Owen and Gillette (1985).

Good fits were obtained for three soil conditions (SD, SU, and UD) and soils in three WEGs (2, 3, and 4). These fits produced eight parametrically fitted equations derived directly from the empirical Las Vegas wind tunnel measurements. They cover SECC soils 2SD, 2SU, 3SD, 2UD, 4SD, and 4SU, which are referred to as the Las Vegas windblown dust (LVWBD) model. The magnitude of the estimated flux calculations was tested for each equation in terms of the volume-averaged concentration produced of over a 1.3-km-resolution CMAQ grid cell. This was done by using the upper-limit wind tunnel velocity to calculate the maximum flux for each test run (i.e., run 3 or run c). The ratio of the calculated flux to a 50-m depth over each grid cell was used to estimate the layer-averaged concentration over the cell. Since ratios greater than 2 to 3 were found to produce extremely high 1-hour CMAQ concentrations, this was used as a cutoff point to determine if the parametric fit should be eliminated. All other cases, including cases where there were insufficient data or data outliers,[10] used the Gillette et al. (1996) model for horizontal dust flux and an experimentally derived vertical-to-horizontal flux ratio, called the K factor (see Gillette et al. 2004 for a discussion of K factors) as a surrogate. Gillette’s model

[10] Outliers, such as negative flux values or high flux values at low u_*, were probably due to tunnel runs with leaks or other experimental measurement anomalies.

follows the theoretical formulation of Owen and Gillette (1985) from his solution of the equations of mass and momentum conservation. The eight equations derived from the parametrically fitted data and those using the K factor as an experimental surrogate are largely based on semiempirical fits to Owen's theory.

Figure 4.18 shows the variation of vertical flux with friction velocity and identifies three distinct zones typified by the field measurements. In Zone 1, the no erosion zone, TSI-measured PM_{10} concentrations are below or at ambient levels, and no salting particle soil particle flow is observed in the working section of the tunnel. (TSI refers to the PM_{10} monitor.) The flow velocities in this zone are less than the ambient TFV determined for each soil type and SECC. In Zone 2, concentrations are measured above ambient background, with erosion velocities exceeding u_{*amb} but less than the u_{*eff}. The flow velocities are high enough to initiate movement of soil particles along the surface, but not necessarily strong enough to make saltation evident. Finally, Zone 3 is where erosion velocities exceed the effective TFV necessary for generating vertical PM_{10} dust flux. Horizontal saltating dust flux and vertical dust flux occur simultaneous in this zone.

Examples of the parametric fits for four of the eight equations derived directly from the regression fits are given in Figures 4.18 and 4.19. Each figure shows the valid wind speed (friction velocity) range used in applying the model equations. The lower limit is set to the soil-derived TFV, while the upper limit is set midway between the low and the high maximum tunnel velocities for the paired plots with the same soil WEG. Figure 4.18 shows the power function fits for WEG 2 soils with soil conditions that are stable-disturbed and stable-undisturbed. The figure clearly shows that the rate of erosion expected for disturbed soil is faster than what would be expected for undisturbed soils. In Figure 4.19, data for SECC 6SD and SECC 6UD soils shows the influence of the soil's stability condition on wind erosion. In this case, the difference between stable versus unstable soil conditions is less clear than the difference between disturbed and undisturbed soils. For wind speeds greater than the friction velocity but less than approximately 13 mph (6 m/s, or $u_* = 0.63$ m/s), wind erosion is greater for unstable soils than for stable soils as would be expected. However, at wind speeds greater than 13 mph, the erosion rate exceeds and diverges away from the erosion rate exhibited by unstable soils.

Table 4.18 shows the final parametric fit equations for each tested SECC soil group developed for the Las Vegas windblown dust model. The K factor surrogate relationship from using the Las Vegas experimentally derived flux ratios along with Gillette's windblown dust model are also shown in the table.

4.4 Source Disaggregation

Windblown dust and fugitive dust emissions generated by human activities were spatially and temporally aggregated for input to the CMAQ simulations by using a GIS-based model. It was similar to the UNLV routine developed for Clark County, which used Thiessen polygons around each wind speed monitoring station (Pulugurtha and James 2002). This approach was

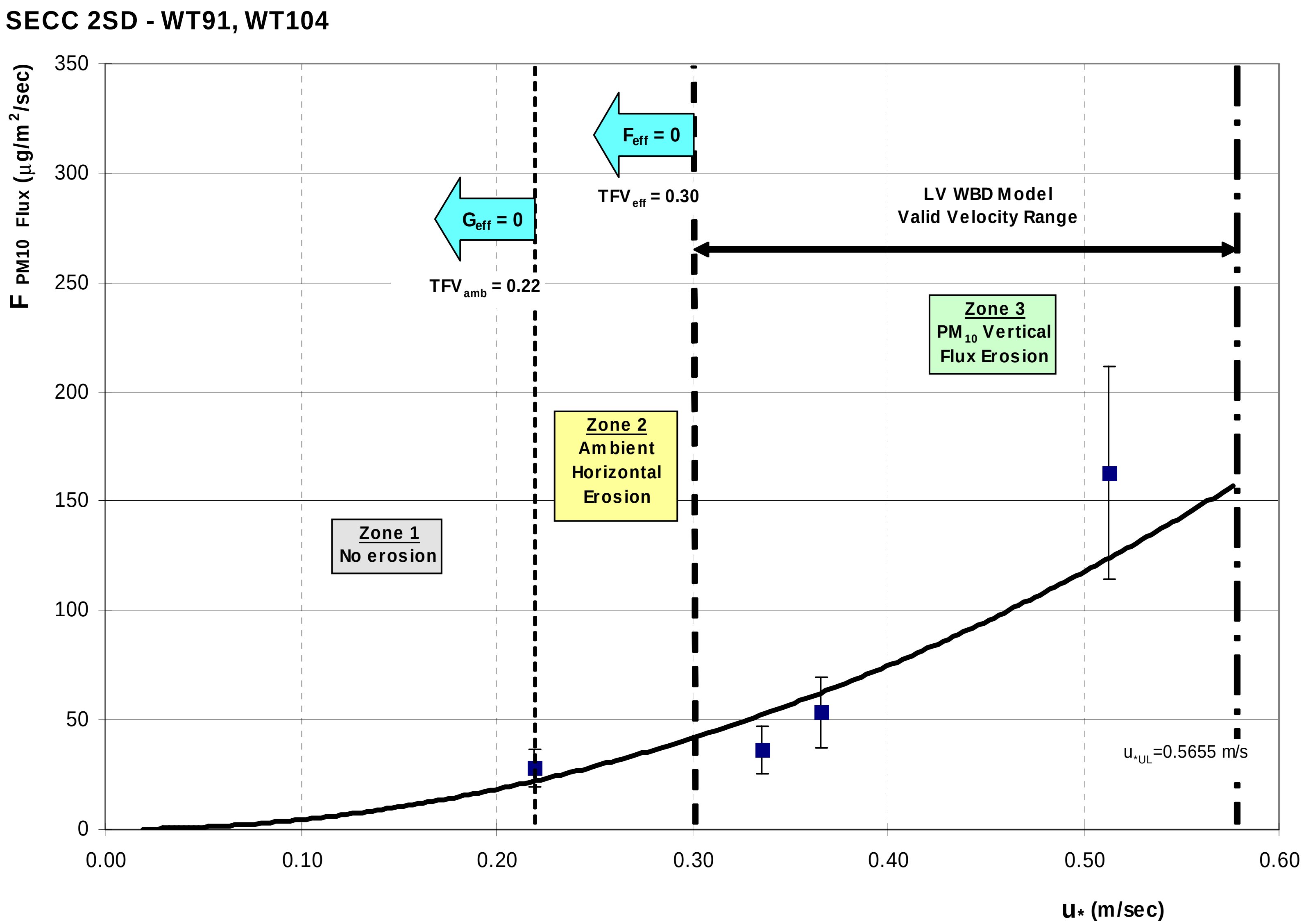

FIGURE 4.18 Vertical PM_{10} Soil Flux as a Function of the Erosion and Threshold Friction Velocities Cubed for WEG 2, Stable Disturbed and Undisturbed Soils

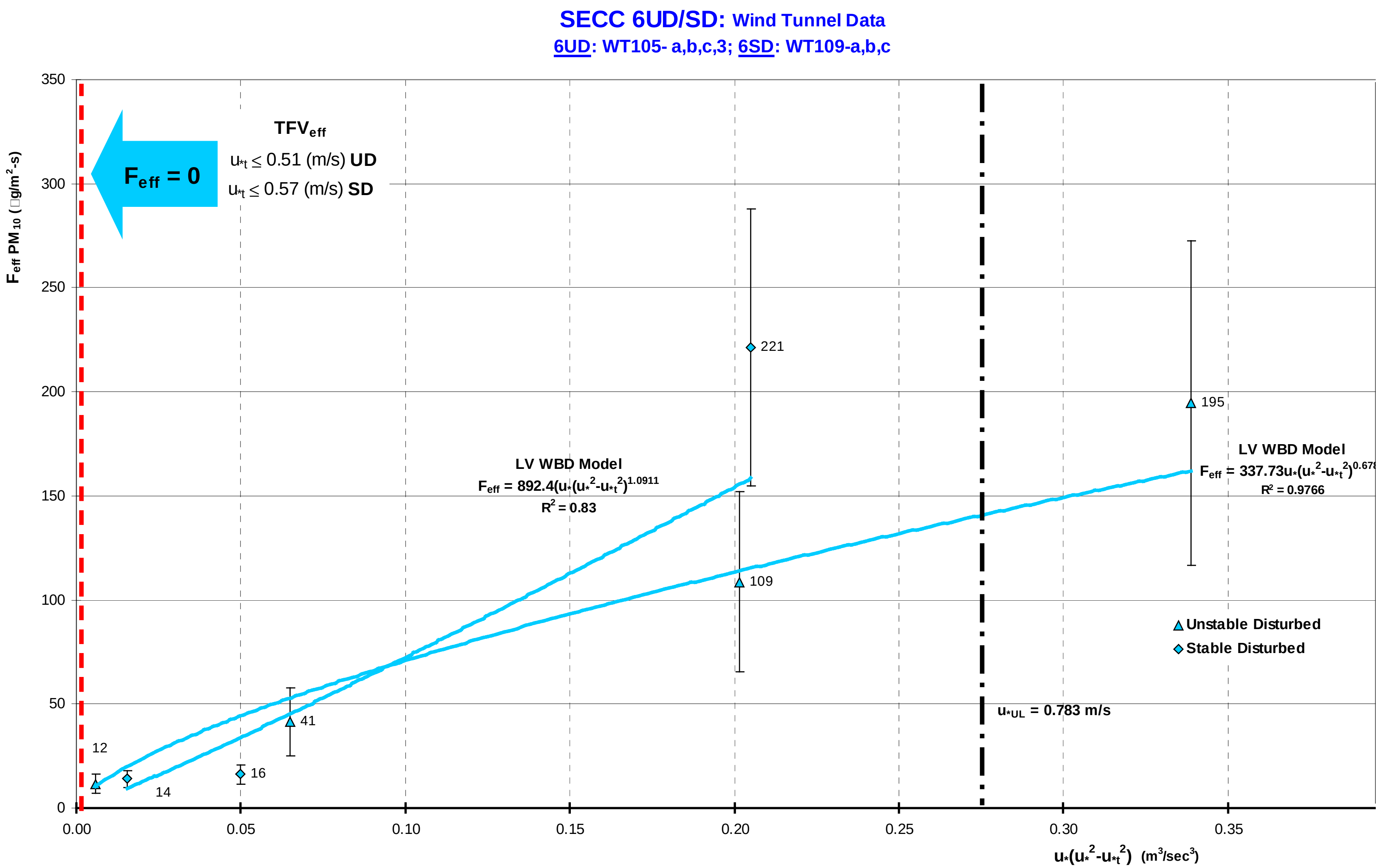

FIGURE 4.19 Vertical PM_{10} Soil Flux as a Function of the Erosion Friction and Threshold Velocities Cubed for WEG 6, Stable Disturbed and Undisturbed Soils

TABLE 4.18 Las Vegas Windblown Dust Model Equations

Model/Parametric Fit Type	**SECC**	**Vertical Dust Flux Expression**	**r**
LV_WBD/Power	2SD	$F = 328.43\,[u_*(u_*^2 - u_{*t}^2)]^{0.4032}$	0.88
LV_WBD/Power	2SU	$F = 378.43\,[u_*(u_*^2 - u_{*t}^2)]^{0.519}$	0.98
LV_WBD/Second-Order Polynomial	3SD	$F = 0.234\exp(149.35u_*(u_*^2 - u_{*t}^2))$	0.99
LV_WBD/Power	3UD	$F = 334.49\,[u_*(u_*^2 - u_{*t}^2)]^{0.8532}$	1.00
LV_WBD/Power	4SD	$F = 47.349\,[u_*(u_*^2 - u_{*t}^2)]^{0.3379}$	0.38[a]
LV_WBD/Power	4SU	$F = 141.53\,[u_*(u_*^2 - u_{*t}^2)]^{0.2818}$	0.71
LV_WBD/Power	6SD	$F = 892.4\,[u_*(u_*^2 - u_{*t}^2)]^{1.0911}$	0.91
LV_WBD/Power	6UD	$F = 337.73\,[u_*(u_*^2 - u_{*t}^2)]^{0.6785}$	0.95
K Factor Surrogate Relationships			**K (1/m)**
LV-KfG	2UD	$F = 407.49\ u_*(u_*^2 - u_{*t}^2)$	1.07E-03
LV-KfG	2UU	$F = 171\ u_*(u_*^2 - u_{*t}^2)$	6.68E-03
LV-KfG	4LSD	$F = 72.5\ u_*(u_*^2 - u_{*t}^2)$	2.30E-04
LV-KfG	3UU	$F = 341.8\ u_*(u_*^2 - u_{*t}^2)$	1.08E-03
LV-KfG	4LUD	$F = 1541.3\ u_*(u_*^2 - u_{*t}^2)$	4.56E-03
LV-KfG	4UD	$F = 134\ u_*(u_*^2 - u_{*t}^2)$	4.23E-04
LV-KfG	5SD	$F = 32.7\ u_*(u_*^2 - u_{*t}^2)$	1.07E-04
LV-KfG	5SU	$F = 6.0\ u_*(u_*^2 - u_{*t}^2)$	1.97E-05
LV-KfG	5UD	$F = 72.3\ u_*(u_*^2 - u_{*t}^2)$	2.66E-04
LV-KfG	6SU	$F = 657\ u_*(u_*^2 - u_{*t}^2)$	2.16E-03
LV-KfG	7SD	$F = 29.3\ u_*(u_*^2 - u_{*t}^2)$	1.22E-04
LV-KfG	7SU	$F = 749.7\ u_*(u_*^2 - u_{*t}^2)$	3.44E-03
LV-KfG	7UD	$F = 92.5\ u_*(u_*^2 - u_{*t}^2)$	3.54E-04
LV-KfG	8SD	$F = 42.8\ u_*(u_*^2 - u_{*t}^2)$	1.97E-04
LV-KfG	8SU	$F = 63.2\ u_*(u_*^2 - u_{*t}^2)$	3.23E-04
LV-KfG	8UD	$F = 68.6\ u_*(u_*^2 - u_{*t}^2)$	2.86E-04
LV-KfG	UN_SD	$F = 30.6\ u_*(u_*^2 - u_{*t}^2)$	1.41E-04
LV-KfG	UN_UD	$F = 71.0\ u_*(u_*^2 - u_{*t}^2)$	2.33E-04

[a] Although the regression correlation is less than 0.7 for this parametric fit, a comparative plot with the K factor surrogate relationship showed them to be nearly indistinguishable.

developed by UNLV but was not completed in time to be included in the UNLV reports that were submitted in support of the PM_{10} SIP (James 2003). Aerial photographs and high-resolution satellite images were used to refine and improve the variations in land use and soil characteristics within polygons.

4.5 Growth Projections — Spatial and Temporal Refinements

The evaluation of land use in this project involved examining recent (1998–2002) and projected (2003–2018) development trends for Clark County (which includes the cities of Henderson and North Las Vegas and unincorporated Clark County), the southeastern portion of Nye County, and the southern portion of Lincoln County. The focus was on characterizing recent and future development in terms of the same nine land use categories discussed in Section 4.2. Each category has different impacts on regional air quality, during both construction (primarily fugitive dust) and subsequent use (PM and other impacts, such as vehicle emissions). Land use categories, in acres, were estimated for both the land conveyed from the BLM for development and all other developed land. These estimates enabled the total air quality impacts, as well as the contribution made by land provided by the BLM, to be identified.

The approach used to characterize land use relied on comprehensive planning efforts by the six cities and county government entities to identify geographic patterns and amounts of land assigned to each use category. Because of the large amount of growth experienced in the greater southern Nevada area over the past two decades, comprehensive planning receives considerable attention in this region. Established zoning in these areas influences geographic patterns of land use development, including federal land currently administered by the BLM. Some comprehensive plans, such as that of Henderson, already project land use patterns that include tracts administered by the BLM but not yet conveyed. Patterns of land use were documented for the past 5 years to identify trends in development for land conveyed from the BLM and for other land. The effort used data from pertinent government agencies, augmented (as necessary) with data from involved developers. In addition to agreement with comprehensive plans and documented past trends, patterns of future land use were checked for consistency with recent long-term population projections for Clark County and its various entities (as prepared by the UNLV Center for Business and Economic Research) and for Lincoln and Nye Counties (as prepared by the Nevada State Demographer). Results of the projected land use patterns, in terms of acreage assigned to the six categories of use, were checked for accuracy and appropriateness with planning agencies from each of the pertinent government agencies.

In addition, future land use projections considered development in the local jurisdictions of the cities of Las Vegas, Henderson, and North Las Vegas. Beyond these cities, projections were limited to the southeastern portion of Nye County and the southern portion of Lincoln County. Each of these local governments has its own zoning regulations and planning department to guide future development patterns. Data obtained from local planning agencies provided information on recent historic development and likely future trends, land availability (from various sources), and the general development environment in each local jurisdiction. In all cases, the land use planning component of this project attempted to distinguish between development on former BLM-administered lands versus lands from other sources. The result is projections of patterns of overall development that, in aggregate, contribute to total air quality impacts in the region, with an ability to isolate the portion contributed by former BLM lands.

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5 Cumulative Modeling Assessment of Las Vegas Valley Urban-Scale and Regional-Scale Air Pollution

The cumulative air quality impacts were assessed from known operating (i.e., permitted) and future planned air pollutant emission sources for a baseline year (2000) and three future years: 2006, 2009, and 2018. The emissions inventory used in the assessment is described in Section 4 and again, in more detail, in Appendix A. The base-year analysis serves as a benchmark to assess future cumulative impacts within the Las Vegas Valley. The future impacts reflect conditions assuming full compliance with existing regulatory requirements (i.e., emission controls or limitations) spelled out in approved SIPs applicable to Clark County, Nevada, and assuming use of RFG for motor vehicles, along with the phase-in of national clean-engine standards beginning in 2004. In addition, the modeled 2009 and 2018 ozone impacts reflect a minimally anticipated control on vehicle exhaust emissions, using RFG, within the Las Vegas Valley. Completion of this part of the analysis was required in light of the recent (April 15, 2004) EPA decision to designate Clark County as an 8-hour ozone nonattainment area.

Section 5.1 identifies the modeling domain used in assessing the contributions from distant, regional, and local air emission sources. Section 5.2 addresses the basis for the selection of the air quality model used in assessing cumulative impacts, and Section 5.3 describes the Models-3 system used in the assessment. The results from the baseline and future year assessments are discussed in Sections 5.4.

5.1 Modeling Domain

The modeling domain for the criteria air pollutants, including PM_{10} and CO, addressed air pollution sources in Clark County, which covers the Las Vegas Valley (U.S. Department of the Interior, U.S. Geological Survey Hydrographic Unit 212) and portions of other hydrologic units. The O_3 modeling also accounted for regional transport into the Las Vegas Valley from VOC and NO_x source emitters within the SCAQMD jurisdiction, which includes Los Angeles, California.

Grids were produced at three levels of resolution, each three times more detailed than the previous grid and all aligned with one another. The grids were based on a Lambert equal-area projection with standard parallels at 30° N and 60° N, a central meridian of 117° W, and a latitude of origin of 37º N. The grids are measured in meters and use the North American Datum of 1983 (NAD 83).[11] This projection is centered in Clark County, Nevada.

Figure 5.1 shows the locations and extents of the three modeling grids, the BLM disposal area, and state and county boundaries. The large outer or regional-scale grid covers the greater

[11] NAD 83 is the geographic coordinate system of the NOAA, National Geodetic Survey. It is the official legal coordinate reference system in the United States.

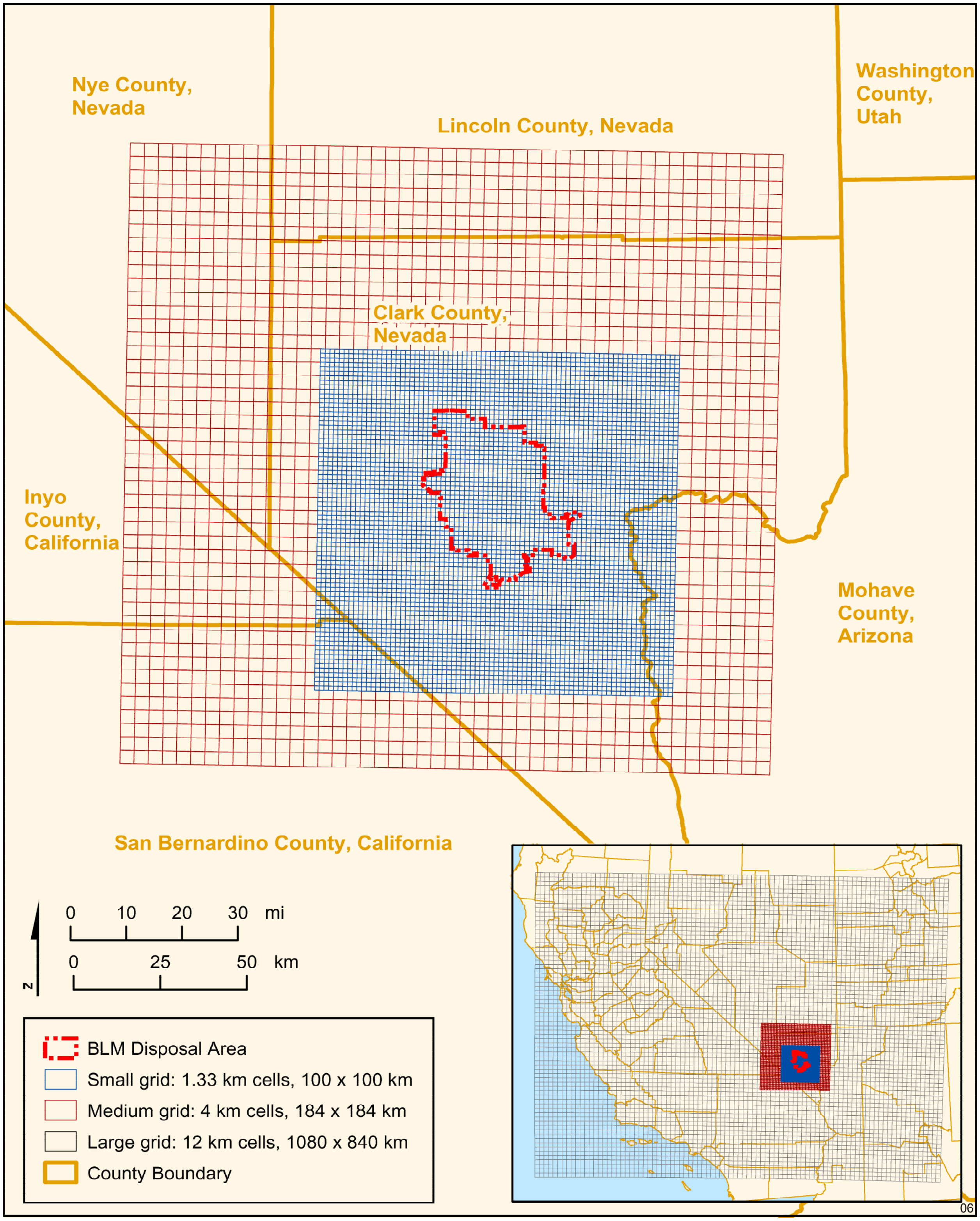

FIGURE 5.1 Nested Modeling Grid

region around the study area with 12-km cells; it includes most of southern California, southern Nevada, southwest Utah, and northwest Arizona. This grid has 90 columns and 70 rows, covering an extent of a 1080×840 km. The origin is centered at 540000, –420000.

The intermediate or mesoscale grid is centered on the Las Vegas area and has a 4-km cell size. It covers the full extent of the EPA nonattainment area and the BLM disposal area around the city of Las Vegas. This grid has 46 rows and columns, covering an extent of 184×184 km. The origin is centered at +56000, –172000. The small inner grid is also centered on the Las Vegas area and has a 1.3-km cell size. The inner grid covers the full extent of the BLM disposal area around the city of Las Vegas. It has 76 rows and columns, covering an extent of 100×100 km. The origin is centered at +110666.667, –149333.333.

Each grid was assigned a unique identifier (i.e., row and column numbers), area; coordinate of the cell center point, and set of "surrogate" fields to allow for data processing and data conversion into the air quality models. "Surrogates" are data on human activities or land use that represent more precise locations for emission source category groups. A "gridded surrogate ratio" is the ratio of the amount of a surrogate (e.g., number of housing units, length of major highways, urban size or area) in a modeling grid cell to the total amount of that surrogate in a county.

Further discussion on the modeling domain, assembly of the GIS-based model data layers, and development of surrogate ratios can be found in Appendix G.

5.2 Basis for Selecting the Air Quality Model

Of the six criteria pollutants regulated by the EPA, the three of primary interest for this study are PM_{10}, CO, and O_3. PM_{10} includes all particulate matter in the atmosphere with a nominal aerodynamic diameter of 10 µm or less. Thus, even though a large number of atmospheric particles originate from diesel fuel combustion and other activities related to fossil fuel combustion, the largest contributions to PM_{10} are from windblown soil erosion, fugitive emissions from paved and unpaved surfaces caused by vehicular traffic, and construction activities. For the most part, PM_{10} sources in the Las Vegas region are direct or primary emission sources. Secondary sulfates and nitrates do not appear to play an important role in contributing to particulate matter nonattainment in Las Vegas (Chow et al. 1999). The combustion of fossil fuels is the primary source of direct CO emissions to the atmosphere, but CO is also formed in the atmosphere by oxidation of VOCs. O_3 is a product of photochemistry involving NO_x and VOCs.

The small particles, up to 10 µm in size, that make up PM_{10} are transported over various distances through the atmosphere. Particles in this size range that are suspended or resuspended at or near the surface are carried by prevailing winds to heights of 50 m or more and remain suspended for approximately 1 hour before they settle near the surface (~10 m above the ground) or are deposited on the ground (Noll et al. 2001). The mean wind speed of 5 m/s in the Las Vegas Valley may transport PM_{10} particles more than 15 km. Thus, transport is an important factor to consider with regard to PM_{10} particles, particularly when studying neighborhoods with an urbanwide spatial scale like the Las Vegas Valley region. Even though anthropogenic PM_{10} particles contribute little to the overall mass PM_{10} because of the large (natural-source) contribution from windblown dust in the Las Vegas Valley region, the anthropogenic contributions to PM_{10} nonattainment here could play a critical role in making any refinements to abatement strategies that might become necessary in the future.[12]

Receptor or "rollback" models typically used by regulatory agencies for demonstrating attainment are not designed to address the atmospheric physics (e.g., interactions of the wind velocity field with the surface) and chemistry (e.g., gas-phase transformations) of the pollutants of concern. Such models cannot address areawide cumulative air impacts associated with BLM land use authorizations in the Las Vegas Valley. Therefore, air dispersion models had to be applied to assess these impacts. In general, Gaussian steady-state models are simple and easy to use but are not effective in resolving spatial and temporal variations resulting from the complex terrain or the influence of complex weather conditions. These constraints limited the choice of dispersion models to non-steady-state Lagrangian models or Eulerian models, such as UAM-V (Douglas et al. 1996) or CMAQ. Such models are equipped with state-of-the-art transport-chemistry-deposition algorithms. In general, Eulerian models are well suited for simulating pollution episodes typically associated with urban or regional O_3 issues and for conducting areawide CO assessments, for which requirements are specified in the EPA modeling guidance (*Code of Federal Regulations*, Title 40, Part 51 [40 CFR Part 51]; *Federal Register* [FR], April 15, 2003).

With regard to PM_{10}, however, because of existing violations of annual average NAAQS at one monitoring point near a high-traffic-volume highway, at least an entire year of simulations would be required to assess areawide compliance with the annual NAAQS for PM_{10}. This situation would make the use of an Eulerian model impractical. As an alternative, the Lagrangian non-steady-state model, which is a compromise between Gaussian steady-state models and Eulerian models, is the most practical choice for assessing annual average cumulative PM_{10} impacts for at least a 1-year meteorological period.

The episodic and seasonally driven observed high-concentration periods for O_3, PM_{10} (short-term averages), and CO required a more comprehensive set of modeling tools capable of addressing mesoscale meteorological influences. Exceedances or violations of the NAAQS for these pollutants are primarily episodic in nature or seasonal events. For example, Las Vegas experiences regular episodes of high-wind-speed PM_{10}. The O_3 and CO problem are seasonally episodic. Elevated O_3 concentrations typically occur during high temperatures and intense solar radiation or insolation, predominantly in the summer months of June, July, and August. High observed CO concentrations occur during low-inversion-height days, predominantly during the winter.

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[12] The current Clark County SIP for PM_{10}, for instance, proposes a 3–4% decrease in PM_{10} emissions in order to reach the NAAQS, which coincidently corresponds to roughly the mass of aerosols with sizes less than 2.5 μm. These almost always tend to result exclusively from human activities.

5.3 Models-3 System

On the basis of the above considerations, the EPA's Models-3 modeling system was selected to assess baseline and future projected air quality impacts in the Las Vegas Valley. Models-3 is a third-generation multipollutant modeling system with applications ranging from urban to regional scales. The system includes a source emissions processor called SMOKE, a mesoscale meteorological model called MM5, and a three-dimensional Eulerian transport and atmospheric chemistry model called CMAQ. Models-3 (Byun 1999) was selected and used for assessing the episodic PM_{10} 24-hour impacts and the seasonally driven O_3 and CO episodes. The model is uniquely capable of simultaneously addressing multiple scales and reactive air pollution episodes. The dynamics for the chemical-transport model CMAQ were generated by using the latest version of MM5, version 3.6. The advantages of using MM5 for the meteorological fields and CMAQ for modeling CO, O_3 and PM_{10} — versus using Gaussian plume models, source receptor models, and coarse grid episodic models — are that this modeling approach has the unique ability to:

- Perform comprehensive simulations, covering the effects of long-range transport, chemistry, deposition, emissions, and gas-to-particle conversions, by using a single modeling tool;

- Generate seasonal and annual impact assessments, unlike the usual single-episode, event-based case studies possible with other Eulerian models like UAM or CAMx;

- Deal with diurnal and seasonal changes and with loss and production processes in an integrated fashion, as compared with the capabilities of seasonal-mean and annual-mean source-receptor models;

- Simulate multiple spatial and time scales with the same modeling framework, avoiding the need for multiple models with differing underlying modeling assumptions and parameterizations, which make cross-time and cross-spatial comparisons impractical; and

- Run the models on modern parallel and distributed computers, with multiple processors, providing rapid turnaround for computing.

5.3.1 SMOKE

The SMOKE (Sparse Matrix Operator Kernel Emissions) model (EPA 2001; University of North Carolina 2003) did the preprocessing of source emissions data used by CMAQ. SMOKE is primarily an emissions processing system and not an emissions inventory preparation system. This means that, except for mobile sources, its purpose is to provide a tool for converting emissions inventory data into the formatted emissions files required by CMAQ. For mobile sources, SMOKE also computed an emissions inventory from mobile-source activity data, by using emission factors. SMOKE is intended to allow emissions-data-processing methods to integrate high-performance-computing sparse-matrix algorithms. The SMOKE preprocessor generates emissions inventories for point, area, and biogenic sources. The inventories can be prepared by using input at the county level, as provided by the National Emissions Inventory (EPA 2003c), or by using more detailed data sets collected by the county and available at the facility level. The second critical data set developed for SMOKE was a detailed description of the distribution of surrogates that are unique to emissions from a given source for the region of interest, gridded for the model domain. The emissions inventory data were spatially allocated into the model grid by using surrogate ratios related to each of the appropriate categories. If the spatial location for the source emission was available, as it was for point sources and certain area sources like airports, the emissions from these sources were allocated to the grid location corresponding to the given spatial location. A third level of processing involved speciation of VOC emissions into a set of lumped hydrocarbon species, defined by the chemical mechanism employed in CMAQ.

Gridded emissions from mobile sources were generated by using data on vehicular activity, such as speed and vehicle miles traveled (VMT), for sections of a roadway system (known as linked data sets) or for specified road types. MOBILE6.2 was used to generate an emission factor file for each road, vehicle type, and speed combination within the SMOKE model. The emission factors were then used with either the linked data set or a surrogate road distribution (generated as described in Appendix G if such data were not available) to generate a gridded emissions inventory from mobile sources. The VOC emissions were speciated on the basis of the chemical scheme used in CMAQ. Emissions from nonroad vehicular activity were provided as an inventory, similar to inventories for area sources, and SMOKE used surrogate ratios to distribute these emissions to the model grid.

The biogenic sources in the model were generated by using the BEIS 3.0 model with the BELD3 data set (EPA 2004a,b). The BELD3 data set describes the vegetative distribution for more than 200 different plant species at a resolution of 1×1 km. The BELD3 data set was interpolated over the grid selected for the model. The BEIS 3.0 model describes the emission factors as a function of plant type, solar insolation, and surface temperature for the selected grid. The meteorological data needed to calculate the mobile, biogenic, and point emissions — such as temperature, radiation, and wind velocities — were obtained from the MM5 model simulations, as described in Section 5.3.3.

5.3.2 CMAQ

The use of “wide-area” gridded Eulerian models, such as CMAQ, to assess air quality over urban, regional, and global scales has proven to yield flexible, reliable, comprehensive assessments of air pollution. The adoption of Eulerian models for air quality studies has spread rapidly over the past few years as the computing power available on an average desktop has increased. It is now feasible to use these fairly complex numerical models over large domains and over extended periods of time with fairly moderate computing resources. This has provided an alternative to the more frequent application of simple Gaussian plume models or Lagrangian puff models. The new-generation Eulerian air quality models offer the added flexibility of making calculations over multiple spatial resolutions and for multiple pollutants with no model modifications, allowing the modeler to focus on detailed, high-spatial-resolution atmospheric physics and chemistry for a limited industrial area, a wider urban area, or both, while taking into account influences of regional transport and chemistry processes.

The CMAQ model (version 4.3) (EPA 1999) was developed as a highly adaptable tool for air quality modeling, with options for using different chemical schemes to drive the chemical processor in the model and different meteorological model outputs to drive the model dynamics. These added capabilities, especially the detailed surface-layer physics and mesoscale chemistry, make the application of a third-generation Eulerian model to the Las Vegas Valley particularly attractive. Figure 5.2 shows the land use map for the outer coarse-grid-resolution modeling domain, generated by the Pleim-Xiu land surface model used in MM5 and passed through to CMAQ (USGS 2003, 2004).

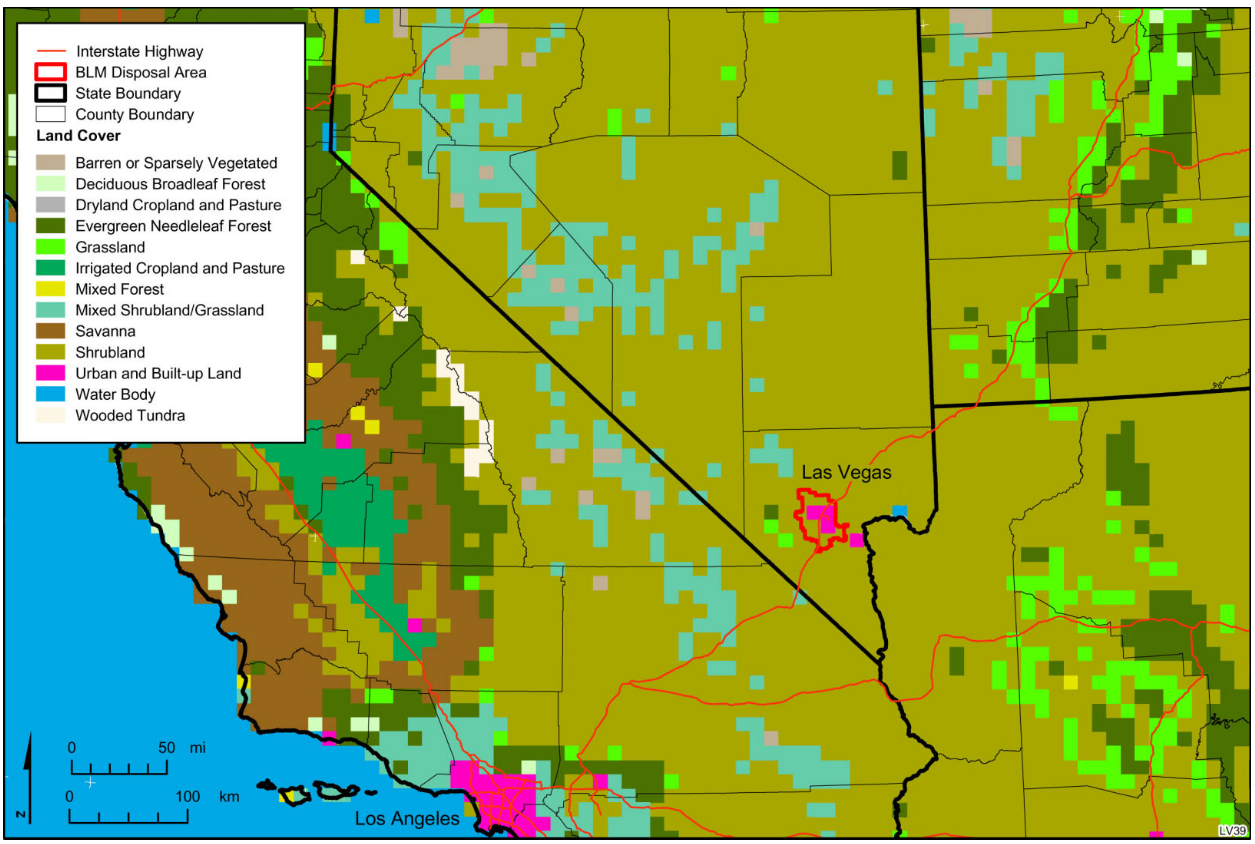

FIGURE 5.2 Land Use Type and Domain for the Coarse-Grid-Resolution Run with MM5 and CMAQ Models (Urban areas are denoted in red, with Los Angeles at the bottom left, Phoenix at the bottom right, and Las Vegas toward the top, near the middle of the frame. Blue indicates the Pacific Ocean.)

In its standard form, CMAQ uses MM5-derived meteorological inputs to drive the model dynamics and carbon bond (CB-4) scheme (Gery et al. 1989) to simulate the chemistry of the planetary boundary layer (PBL); (Kotamarthi et al. 2002). In this configuration, the model has 46 trace gases and approximately 100 reactions. Representation of aerosol processes (Binkowski and Roselle 2003) and aqueous-phase chemistry adopted from the Regional Acid Deposition Model are also available (Byun 1999). Dry deposition is based on the procedure developed by Argonne National Laboratory (Wesely 1989). Photolysis rates are precalculated by using a two-stream radiation model (Madronich 1987). The aerosol module in CMAQ was reviewed and compared to other formulations of aerosol dynamics by Zhang et al. (1999).

The output from the MM5 model was processed to obtain the relevant dynamic inputs for CMAQ, which operated on the grid shown in Figure 5.1. The model resolution and domain were inherited from the MM5 model setup. The MM5 output was processed to obtain eddy mixing coefficients, PBL height, dry deposition velocities, cloud cover, and rainfall information, in addition to the wind and temperature data required by the CMAQ preprocessor. The CMAQ model operated with the CB-4 carbon bond chemical mechanism, which has more than 40 gas-phase chemical species and an aerosol scheme with approximately 25 different species in three different size groups: nucleating (submicron or <0.1 μm), accumulating (fine or between 0.1 and 2.5 μm), and coarse (>2.5 μm).

The gas-phase constituents included all the criteria pollutants, such as CO, O_3, and NO_2, and VOCs. Two aerosol sizes corresponding to $PM_{2.5}$ and PM_{10}, used to define the particle size distribution, were included in the model simulation. The $PM_{2.5}$ range was further divided into a nucleation mode and an accumulation mode to distinguish the size ranges primarily affected by direct emission versus size ranges that result from condensation and evaporation in the atmosphere. The PM_{10} mode consists of soil dust, sea salt, and other relatively large particles emitted directly into the atmosphere. Because of the interest in collecting further data on the size distribution of windblown dust, a field study was conducted with the help of UNLV, in which a portable wind tunnel was deployed at more than 30 different soil sites (Section 4.3). The field measurements were designed to characterize the wind erodibility of the soil in the Las Vegas urban area. The principal objective was to quantify soil-derived PM_{10} as a function of wind speed. Unfortunately, the wind tunnel was not instrumented to disaggregate the size fractions of the PM_{10} samples over a representative set of soil types within the Las Vegas Valley.

CO is a relatively long-lived trace gas in the atmosphere. During winter, its lifetime of more than 3 months allows for transport over a wide range of spatial scales. This relatively long residence time would favor assessing CO impacts on a seasonal basis rather than over short episodic periods of several days or over disconnected episodic periods of expected high-CO events. The long-range transport of CO from distant sources can increase background concentrations that would be added to the CO generated locally in the Las Vegas Valley. The use of simulation results from short runs (typically 2-3 days) by Eulerian models would ultimately lead to a focus on specific events that might or might not be important over the extended period of time considered for policy making. Thus, a modeling tool capable of simulating multiple spatial and temporal scales would be ideal for modeling CO. The CMAQ models can be exercised over a seasonal cycle (such as the entire 3 months of a meteorological season), with greater resolution in the vertical and horizontal directions. The finer vertical structure in the model is especially important in the winter, because the nocturnal and daytime boundary layer heights are shallower in winter than in summer. Because CMAQ uses output from a high-end mesoscale meteorological model such as MM5, the wintertime circulation patterns, such as the stronger northeasterly wind flow, are better represented in this modeling system. The model resolution can be increased to nearly 1 km in the horizontal for selected episodic calculations to generate further details for transportation corridors and point sources.

O_3 is a product of photochemical reactions in the atmosphere involving directly emitted precursor gases such as NO_x and VOCs. As a result, the production of O_3 lags behind the production of primary emissions in time and often in space. The model requirements are more stringent than for CO modeling, because both the transport processes and the chemistry and mixing of the primary pollutants in the atmosphere need to be represented adequately. O_3 production in a plume of air can continue for a long time as the polluted air travels away from its source. In fact, O_3 production in urban plumes can continue for 2 or 3 days before the O_3 concentrations in the plume start decreasing. Therefore, long-range transport considerations and boundary values for O_3 and precursor gases are crucial in evaluating the pollution impacts of O_3. Consequently, long seasonal simulations lead to a quantitatively better assessment of O_3 conditions in an urban environment than do episodic simulations.

5.3.3 MM5

Developed by Anthes et al. (1987), MM5, in its current version (version 3), is a widely used research tool for mesoscale weather simulation and forecasting (Grell et al. 1995). The model has been extensively evaluated (Dudhia and Bresch 2002) for applications ranging from an urban scale to a global scale. The introduction of a nonhydrostatic version of MM5 (Dudhia 1993) has made it possible to use the model on grid scales ranging down to 1×1 km. The latest version of MM5 is driven by analysis data and includes the Community Climate Model (CCM, version 2) radiation code and the Oregon State University land surface model (Chen and Dudhia 2001). These improvements enable version 3 of MM5 to predict the temperature and moisture in four different soil layers, surface runoff, underground runoff, and vegetative canopy moisture and to provide a suite of routine outputs from a mesoscale dynamic meteorological model. In addition, the model has been tested, and improvements have been made in mountain-valley circulation scenarios (Zangl 2002), such as those encountered in Las Vegas Valley.

The mesoscale meteorological model is driven at the boundaries by the National Weather Service's National Centers for Environmental Prediction (NCEP)-U.S. Department of Energy (DOE) reanalysis-2 data sets for the period chosen. The NCEP data set is a four-dimensional data assimilation (FDDA) product in a global data set of the twice-daily, upper-air sounding stations throughout the world. There are approximately 70 such stations in the United States. These observations are then processed with a physical-process-based model to produce a 6-hour data set of wind field velocity, temperature, relative humidity, precipitation, soil skin temperature, and surface pressure — among about 20 different variables — at the mandatory surface, troposphere, and upper-air pressure levels in the atmosphere. The DOE reanalysis-2 attempts to recreate the NCEP data set for the past 50 years and for the current period by using improved process-scale models that recently became available. The boundary conditions and initial conditions for the

MM5 simulation performed here were derived from the NCEP-DOE reanalysis-2 data set. The boundary conditions, updated every 6 hours, set the general-circulation-imposed constraints for the mesoscale model to operate within the prescribed domain.

The MM5 preprocessors were used to generate the boundary and initial conditions for the outer domain of the current study (with 12-km grid cells). At the start of the simulation, the boundary and initial conditions for the inner two domains were derived from this data set by interpolation, then during the rest of the simulation period, they were derived from the results for the outer domain. In addition to constraints provided by these data sets, additional constraints on the MM5 model simulation were imposed by independently using the National Center for Atmospheric Research (NCAR) automatic data processing (ADP) upper-air soundings from approximately 20 stations within the coarse-model boundaries to perform grid-level FDDA. This implies that the model was nudged toward the observed upper-air soundings at these 20 stations, at all grid points from the surface to the top of the model. Surface observations from the NCAR ADP data set were also used for surface-level FDDA in the 12-km-grid and 4-km-grid domains. In the innermost domain of the model, local observations at the surface from about 12 Clark County monitoring stations were employed to perform observational FDDA. A number of sensitivity tests showed that updating the observations every 3 hours gave the best comparison of model observations. All MM5 calculations with grid-level FDDA were thus performed with data updates every 6 hours, and observational FDDA over the Las Vegas region in the innermost grid was performed with data updates every 3 hours.

At present, generating future meteorological fields with the global-scale chemical-transport models at 12-km resolution and lower is not feasible. The best available resolution for global-scale climate models is on the order of 100×100 km. The process of obtaining additional information on future climates from these runs is termed “downscaling.” The currently available options are limited to statistical downscaling and simulations on a regional scale with a primitive version of MM5, with boundary and initial conditions from a climate model or a global circulation model (GCM), the NCAR Community Climate Model (CCM3). Several projects are currently underway at the National Aeronautics and Space Administration (NASA) and at NCAR to create CCM3 output in NCEP reanalysis format to perform these downscaling runs with the current generation of mesoscale meteorological models. For immediate application to the problem under consideration, we decided to adopt an approach based on the statistical downscaling principles. The CCM3 output for the appropriate time period was analyzed to derive the temperature increase over the Las Vegas-Clark County region over the summer period. This increase in temperature in the CCM3 model, compared to 2000, was then applied to MM5-generated output for the summer of 2000. The diurnal increase or decrease in temperature from 2000 to the future dates in the CCM3 was used to scale the MM5-generated temperature for 2000.

Model MM5 (version 3) is operational for applications on the new Linux cluster computer at Argonne’s Mathematics and Computer Science Division. This cluster has 350 processors for handling the very large computational requirements of the CMAQ-MM5 simulations. The models MM5 and CMAQ are operational at Argonne on multiple processors.

Results from the MM5 simulations and some data-model comparisons for the summer of 2000 and for GCM-temperature-nudged forecasted meteorological conditions for future years (2006, 2009, and 2018) are presented in Section 5.4.3.1.

5.4 Assessment of Cumulative Air Quality Impacts

5.4.1 Assessment Measures

To evaluate the significance of predicted air quality impacts, the results of air quality modeling are compared here with applicable standards and criteria. The potential total concentrations estimated in this study (i.e., the cumulative contributions to the concentration from both the proposed BLM-related emissions and the non-BLM-related emissions, plus the background concentrations) are compared here with applicable ambient air quality standards. Health- and welfare-related NAAQS have been established for six criteria pollutants: SO_2, NO_2, CO, O_3, particulate matter (PM_{10} and $PM_{2.5}$), and lead (Pb). Nevada has its own State Ambient Air Quality Standards (SAAQS) that are generally based on federal standards (NDEP 2002). In addition to the state standards for the criteria pollutants, Nevada has air quality standards for hydrogen sulfide (H_2S) and visibility. A noncriteria pollutant, H_2S is a toxic gas with a disagreeable odor that is generally limited to the vicinity of industrial sources. The NAAQS and Nevada SAAQS are listed in Table 5.1.

Although Nevada has not officially adopted the new federal standards for $PM_{2.5}$ and 8-hour O_3 that were promulgated by EPA on September 16, 1997, these federal standards are the required minimum health and welfare protection levels in all 50 states. Aside from these 1997 national standards, the Nevada standards and the national primary standards are the same or approximately the same, except for O_3 in the Lake Tahoe basin and CO above an elevation of 5,000 ft, for which the state standards are more stringent. However, Clark County, which is operating its own air quality program independently from the state, has exactly the same ambient air quality standards as the NAAQS (Clark County 2004).

Given the insignificant levels of potential Pb emissions and low observed concentrations of SO_2 and NO_2 (well below the NAAQS and the SAAQS), these pollutants will not be discussed further in the remainder of this report.

Prevention of significant deterioration (PSD) regulations (40 CFR 52.21), which are designed to protect ambient air quality in Class I and Class II attainment areas, apply to major new sources or modifications of an existing major source in an attainment or unclassified area. The PSD regulations limit the maximum allowable incremental increases in ambient concentrations of SO_2, NO_2, and PM_{10} above established baseline levels. The allowable PSD increments for Class I and Class II areas are given in Table 5.1.

TABLE 5.1 National Ambient Air Quality Standards (NAAQS), Nevada State Ambient Air Quality Standards (SAAQS), and Maximum Allowable Increments for Prevention of Significant Deterioration (PSD)

		NAAQS[b]			PSD Increments ($\mu g/m^3$)[d]	
Pollutant[a]	**Averaging Time**	**Value**	**Type[c]**	**Nevada SAAQS**	**Class I**	**Class II**
PM_{10}	24-hour	150 $\mu g/m^3$	P, S	150 $\mu g/m^3$	8	30
	Annual	50 $\mu g/m^3$	P, S	50 $\mu g/m^3$	4	17
$PM_{2.5}$	24-hour	65 $\mu g/m^3$	P, S	-[e]	-	-
	Annual	15 $\mu g/m^3$	P, S	-	-	-
CO	1-hour	35 ppm (40 mg/m^3)	P	40,000 $\mu g/m^3$ (35 ppm)	-	-
CO, <5,000 ft above MSL	8-hour	9 ppm (10 mg/m^3)	P	10,000 $\mu g/m^3$ (9 ppm)	-	-
CO, ≥5,000 ft above MSL				6,670 $\mu g/m^3$ (6 ppm)		
O_3	1-hour	0.12 ppm (235 $\mu g/m^3$)	P, S	235 $\mu g/m^3$ (0.12 ppm)	-	-
O_3 – Lake Tahoe Basin, #90				195 $\mu g/m^3$ (0.10 ppm)		
O_3	8-hour	0.08 ppm (157 $\mu g/m^3$)	P, S	-	-	-
NO_2	Annual	0.053 ppm (100 $\mu g/m^3$)	P, S	100 $\mu g/m^3$ (0.05 ppm)	2.5	25
SO_2	3-hour	0.50 ppm (1,300 $\mu g/m^3$)	S	1,300 $\mu g/m^3$ (0.5 ppm)	25	512
	24-hour	0.14 ppm (365 $\mu g/m^3$)	P	365 $\mu g/m^3$ (0.14 ppm)	5	91
	Annual	0.03 ppm (80 $\mu g/m^3$)	P	80 $\mu g/m^3$ (0.03 ppm)	2	20
Pb	Calendar quarter	1.5 $\mu g/m^3$	P, S	1.5 $\mu g/m^3$	-	-
Visibility	Observation	-	-	In sufficient amount to reduce the prevailing visibility[f] to <30 mi when humidity is <70%	-	-
H_2S	1-hour	-	-	112 $\mu g/m^3$ [g] (0.08 ppm)	-	-

[a] CO = carbon monoxide, H_2S = hydrogen sulfide, MSL = mean sea level, NO_2 = nitrogen dioxide, O_3 = ozone, Pb = lead, $PM_{2.5}$ = particulate matter ≤2.5 μm, PM_{10} = particulate matter ≤10 μm, and SO_2 = sulfur dioxide.

[b] The SO_2 (3-hour and 24-hour) and CO standards are attained when the average is not exceeded more than once per year. The SO_2 (annual), NO_2, and Pb standards are attained when the average is not exceeded. The O_3 (1-hour) standard is attained when the number of exceedances is less than or equal to three in three years. The O_3 (8-hour) standard is attained when the 3-year average of the annual fourth-highest daily maximum 8-hour average concentrations is not exceeded. The PM_{10} (annual) and $PM_{2.5}$ (annual) standards are attained when the 3-year averages of the annual arithmetic means are not exceeded. The PM_{10} (24-hour) standard is attained when the 3-year average of the 99th percentile values is not exceeded. The $PM_{2.5}$ (24-hour) standard is attained when the 3-year average of the annual 98th percentile values is not exceeded.

Cont.

TABLE 5.1 (Cont.)

[c] P = primary standard whose limits were set to protect public health; S = secondary standard whose limits were set to protect public welfare.

[d] Class I areas are specifically designated areas in which degradation of air quality is severely restricted under the Clean Air Act; Class II areas have a somewhat less stringent set of allowable emissions.

[e] A hyphen indicates that no standard exists.

[f] Prevailing visibility means the greatest visibility attained or surpassed around at least half of the horizon circle, but not necessarily in continuous sectors.

[g] The Nevada SAAQS for H_2S does not include naturally occurring background concentrations.

Sources: 40 CFR 50; NDEP (2002); 40 CFR 52.21.

The Jarbidge Wilderness Area in the northeast corner of Nevada is the only PSD Class I area in the state; accordingly, no PSD Class I area exists in Clark County. Most of Clark County is classified as PSD Class II areas. The nearest PSD Class I area is Grand Canyon National Park in Arizona, about 60 mi east of the Las Vegas city center. Because most of the estimated air emissions associated with development projects connected with BLM disposition actions and the subsequent actual and projected land use are expected to be from near-surface emitting sources, such as automobile traffic and natural gas consumption (e.g., area and mobile sources), these actions would not be a PSD concern at Grand Canyon National Park.

5.4.2 Baseline Cumulative Air Quality Impacts

This section discusses the assessment of cumulative air quality impacts during baseline conditions (2000) and during forecasted conditions based on known and projected or anticipated development on disposed federal and private lands in future years (2006, 2009, and 2018). These simulations used emission inventories for sources outside of Clark County that were processed from data coming from the NEI data set and from NO_x, VOCs, CO, and PM_{10} data obtained from the SCAQMD. The baseline results from these simulations are discussed below and shown in Figures 5.10 and 5.11 for the 12-km domain and in Figures 5.12 and 5.13 for the inner 1.3-km domain. The results for 2006 and 2018 are discussed in Section 5.4.3 and displayed as difference plots between base and projection years.

The additional analysis conducted to demonstrate the effectiveness of implementing an RFG program in Las Vegas to address measured violations of the 8-hour O_3 standard included compliance simulations for 2009 and 2018. The 8-hour average O_3 simulations discussed in Section 5.4.4 used an updated WRAP data set that more recently became available in June 2004. The only variation in the inner-grid emissions for Clark County were to test the difference in the windblown-dust-model-generated PM_{10} fluxes, one assuming a large, nearly unlimited surface soil dust reservoir and the other assuming that the reservoir depletes or nearly depletes after the first hour of sustained winds over soil type and condition threshold levels.

5.4.2.1 Seasonal and Episodic Meteorological Conditions

The mesoscale and regional climatic conditions that typically produce air pollution episodes and the time of the year the episodes occur (i.e., when measured air pollutant concentrations are at their highest levels) were considered in selecting the meteorological periods during the year that are conducive to the formation of air pollution episodes. The focus was on summer episodic conditions for all criteria air pollutants. It is most likely that the highest O_3 concentrations will occur in summer, while the highest CO concentrations will occur in winter. For PM_{10}, the highest monitored readings (the highest through the fourth-highest measurements) occurred on May 10, August 12 and 13, and June 29 in 2000. Figure 5.3 shows the variations in measured PM_{10} 24-hour concentration readings at the 16 PM_{10} monitors that reported data during the year. Because the very high May 10 monitored PM_{10} reading occurred during a high-wind regional dust storm, this day was eliminated as not being representative of a local or valleywide PM_{10} air pollution episode. High winds are prevalent over most of the Mojave Desert, a condition that typically causes desert-origin dust episodes over the region. The meteorological data for all three summer months were used in estimating the 24-hour PM_{10} concentrations and 8-hour CO and O_3 concentrations.

The southern part of Nevada and the southeastern part of California are considered to belong to the same arid climate region. As such, the weather conditions in the Mojave Desert regions of these two states are quite similar. The weather during the summer of 2000 in the Western United States was dominated by extreme heat and drought. A number of forest fires occurred in the Southwestern States. The dominant weather pattern during the early days of June 2000 was marked by a surface low-pressure area over southern California near Nevada, bringing southwesterly flow to Nevada and parts of California (Figure 5.4). Nevada experienced high temperatures during this period. The 500-mb weather pattern showed a dominant westerly flow for much of June 2000 (Figure 5.5). At this time, at the surface, Las Vegas experienced southeasterly flow, depending on the location of the low-pressure system. During the latter part of June, a high-pressure system was established at 500 mb over the eastern Pacific off the coast of northern California, and the surface wind fields near Las Vegas were southwesterly to southerly. Figure 5.6 shows a time when the low-pressure system moved southeast of Las Vegas, resulting in southwesterly flow into Las Vegas.

During July 2000, the low-pressure system over southern California shifted northward, straddling the Sierra Nevada region and covering much of Las Vegas and surrounding regions. This led to mainly southerly and southwesterly surface winds in July. The 500-mb region showed a high-pressure system occupying much of the Western United States, which resulted in mostly southerly to southeasterly flow at the higher altitudes. The weather patterns in August were largely similar to those in July.

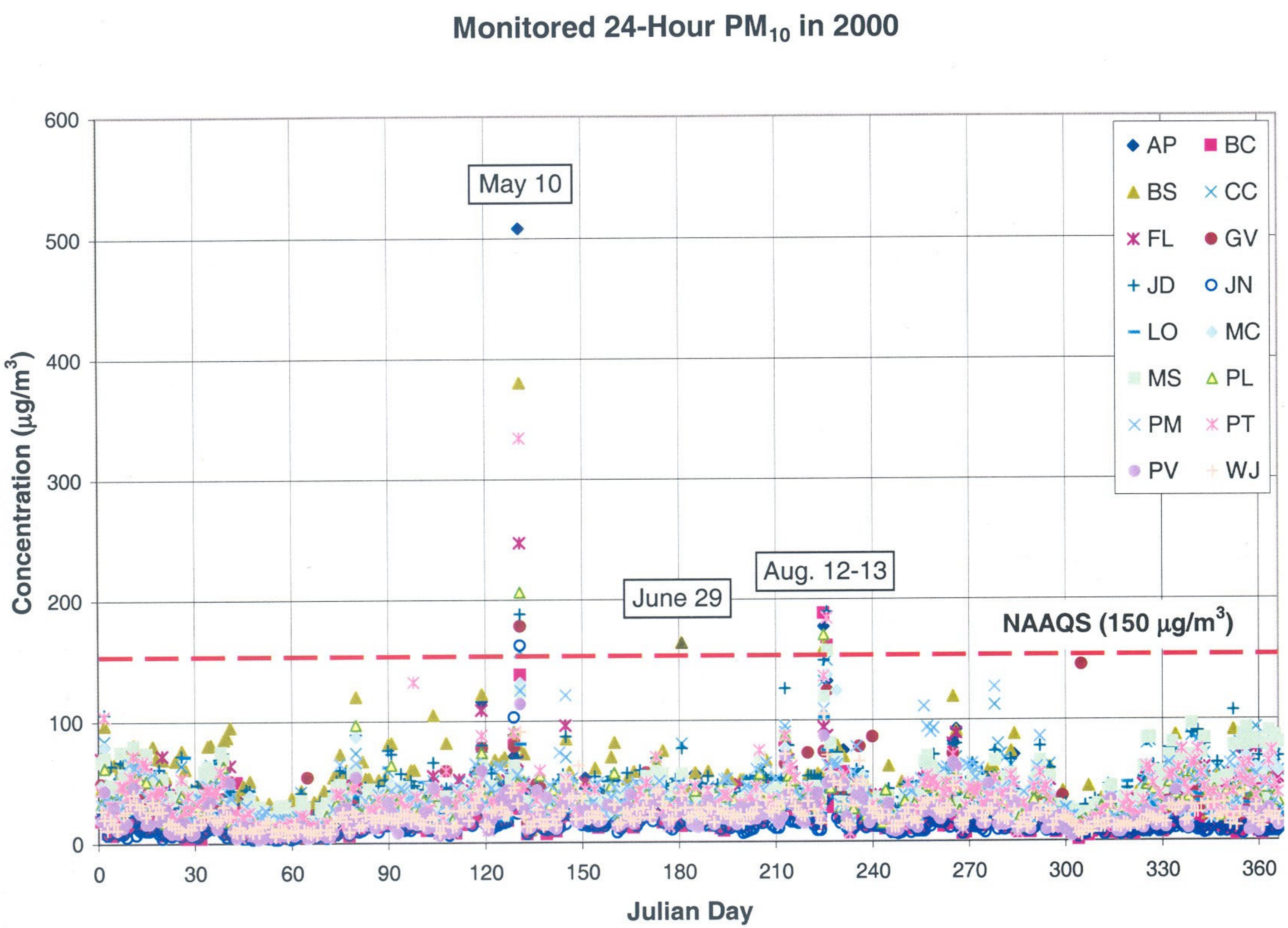

FIGURE 5.3 Clark County 24-Hour Average PM_{10} Monitoring Network Measurements in 2000

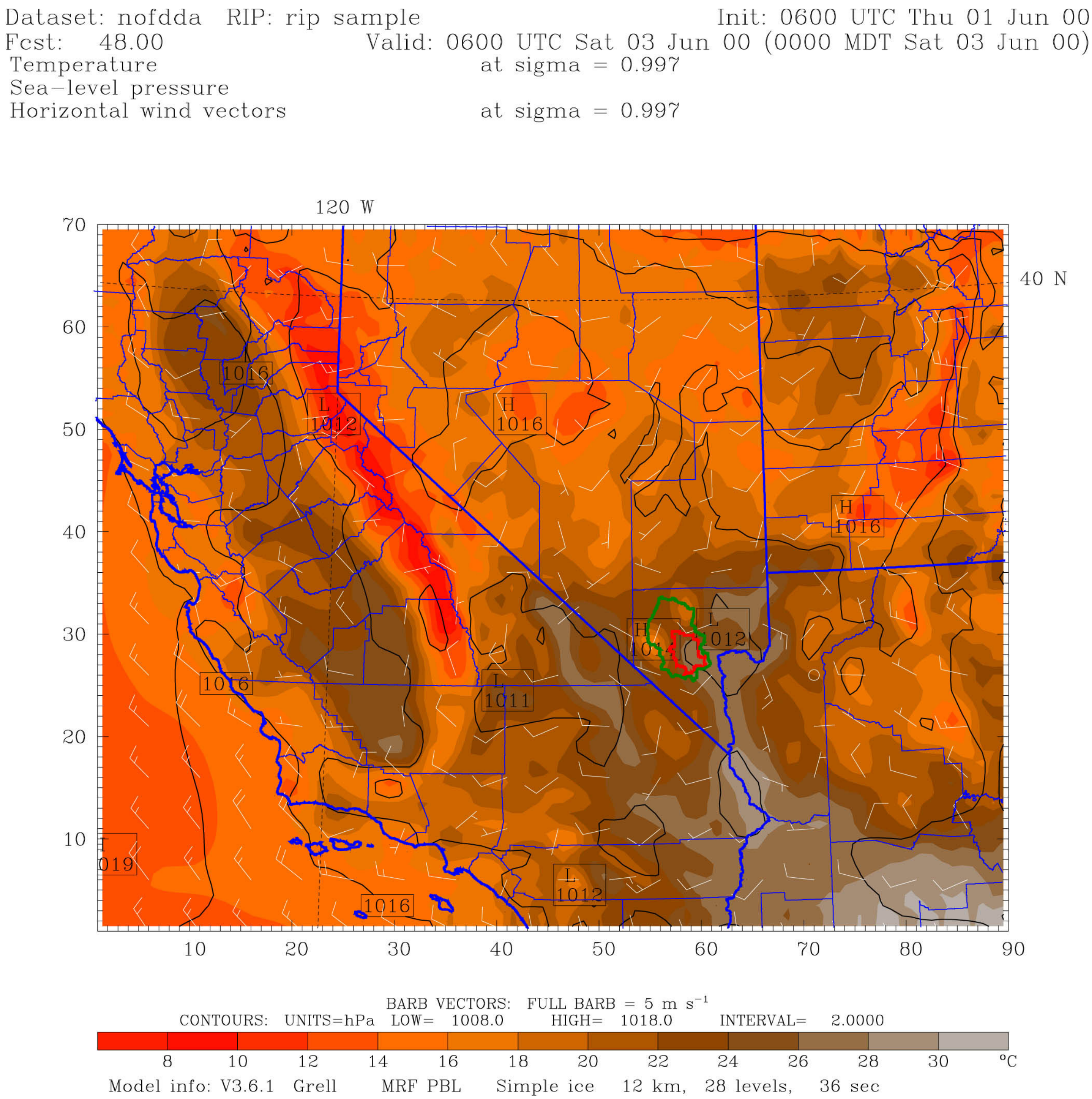

FIGURE 5.4 MM5-Generated Surface Wind Fields and Pressure and Temperature Contours on a Summer Night (June 2, 2000, at 10:00 p.m. local standard or Pacific time) for the Regional-Scale Grid (12-km resolution outer domain)

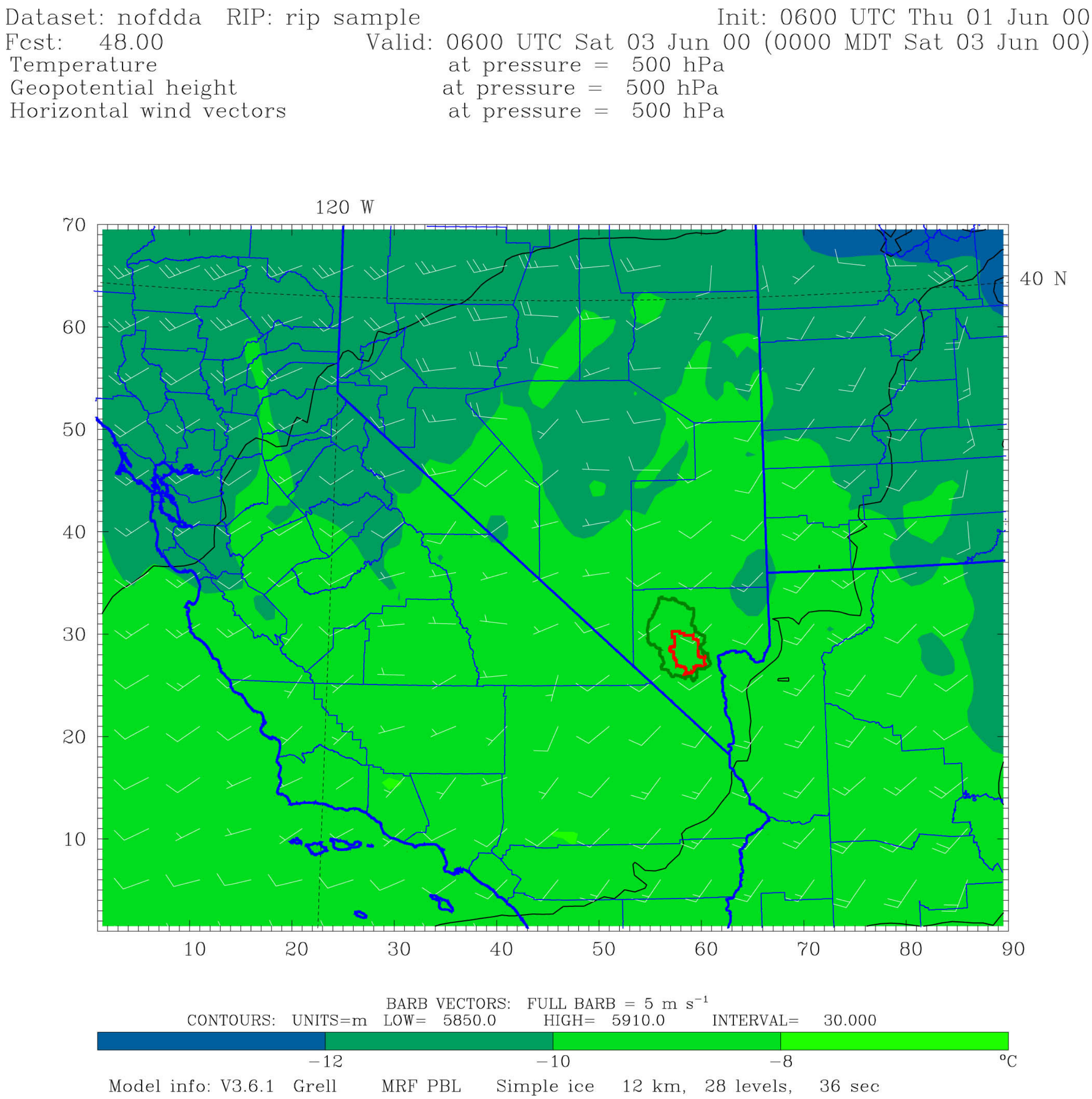

FIGURE 5.5 MM5-Generated Upper-Air (500 mb) Wind Fields and Pressure and Temperature Contours on a Summer Night (June 2, 2000, at 10:00 p.m. local standard or Pacific time) for the Regional-Scale Grid (12-km resolution outer domain)

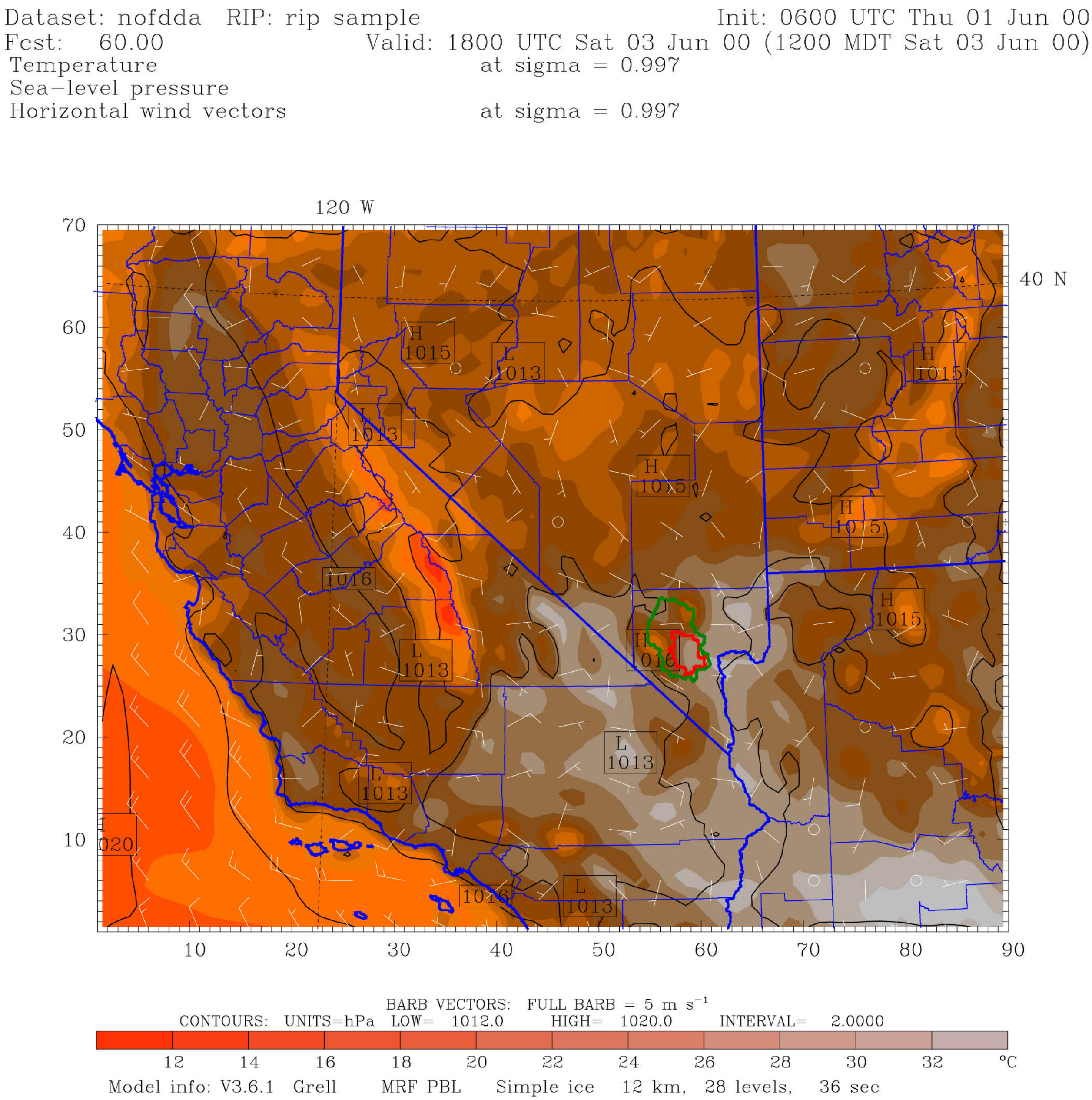

FIGURE 5.6 MM5-Generated Surface Wind Fields and Pressure and Temperature Contours on a Summer Morning (June 3, 2000, at 10:00 a.m. local standard or Pacific time) for the Regional-Scale Grid (12-km resolution outer domain)

In the Las Vegas metropolitan region, the local weather patterns are determined by the large-scale or synoptic flows described above. In addition, diurnal flow is induced by the local valley-mountain terrain that is characteristic of the Las Vegas Valley. An example of this can be seen in Figures 5.7 through 5.9. Figure 5.7 shows wind flow in the Las Vegas Valley at 4 p.m. local standard time on July 2, 2000. The wind flow over most of the valley and the mountains to the west and north was westerly to southwesterly. At 2 a.m. the next morning (Figure 5.8), the wind flow close to the mountain ranges to the northwest became westerly to northeasterly. The wind flow to the west of the mountains remained westerly. This is an example of nocturnal drainage flow, which is induced by the terrain. By 10 a.m. on this second day, the wind flow was again westerly, and the drainage flow was absent (Figure 5.9). This cycle is repeated on most days.

5.4.2.2 Spatial and Temporal Distributions of Dominant Las Vegas Criteria Air Pollutants (O_3, CO, PM_{10})

The regional-scale chemistry-transport model was used to simulate the transport and chemistry of a large suite of trace gases and to generate spatial and temporal patterns for O_3, CO, PM_{10}, and more than 70 other gases and aerosol components. Calculations for the outer (12-km-resolution) domain were used to generate boundary conditions for the inner (1.3-km-resolution) domain over the Las Vegas region. The time period simulated covers the climatological summer of the year 2000, corresponding to the months of June, July, and August. A discussion of the results from the outer domain simulations is provided below first, followed by the model results for the inner domain.

The larger domain (12 km) includes the southern California urban areas and Phoenix, which are potential contributors to the background O_3 and CO concentrations in the Las Vegas Valley region. Figure 5.10 shows an example of the CO concentration distribution at the surface for a CO transport event that started in southern California and spread toward Las Vegas. The figure shows CO mixing ratios (concentrations) of up to 150 parts per billion (ppb) entering Nevada from southern California, a phenomenon that occurs with wind directions like those shown in Figure 5.4. The results in Figure 5.10 are CO concentrations at 7 p.m. local time on July 1, 2000. The elevated CO corresponds to CO emitted in the region and then transported over the day. The higher values of CO locally in Las Vegas result from local emissions during the evening traffic conditions. Thus, a fraction of the CO in Las Vegas under these conditions (approximately 30%) could be a result of long-range transport.

The entire region from southern California to Las Vegas experiences elevated O_3 on high-O_3 days. An example is shown in Figure 5.11, which shows large areas of O_3 at levels of more than 50 parts per billion by volume (ppbv), with embedded hot spots (70–80 ppbv) over urban areas in southern California, Nevada, and Arizona. Such events occur often and demonstrate the regional nature of O_3 production. The results shown in Figure 5.11 are for July 31, 2000, at 4 p.m. local time. Figures 5.10 and 5.11 show the importance of properly accounting for the boundary conditions when simulating the flow of the criteria pollutants CO and O_3 into the Las Vegas urban area by using a high-resolution model (the inner 1.3-km-resolution grid in this case).

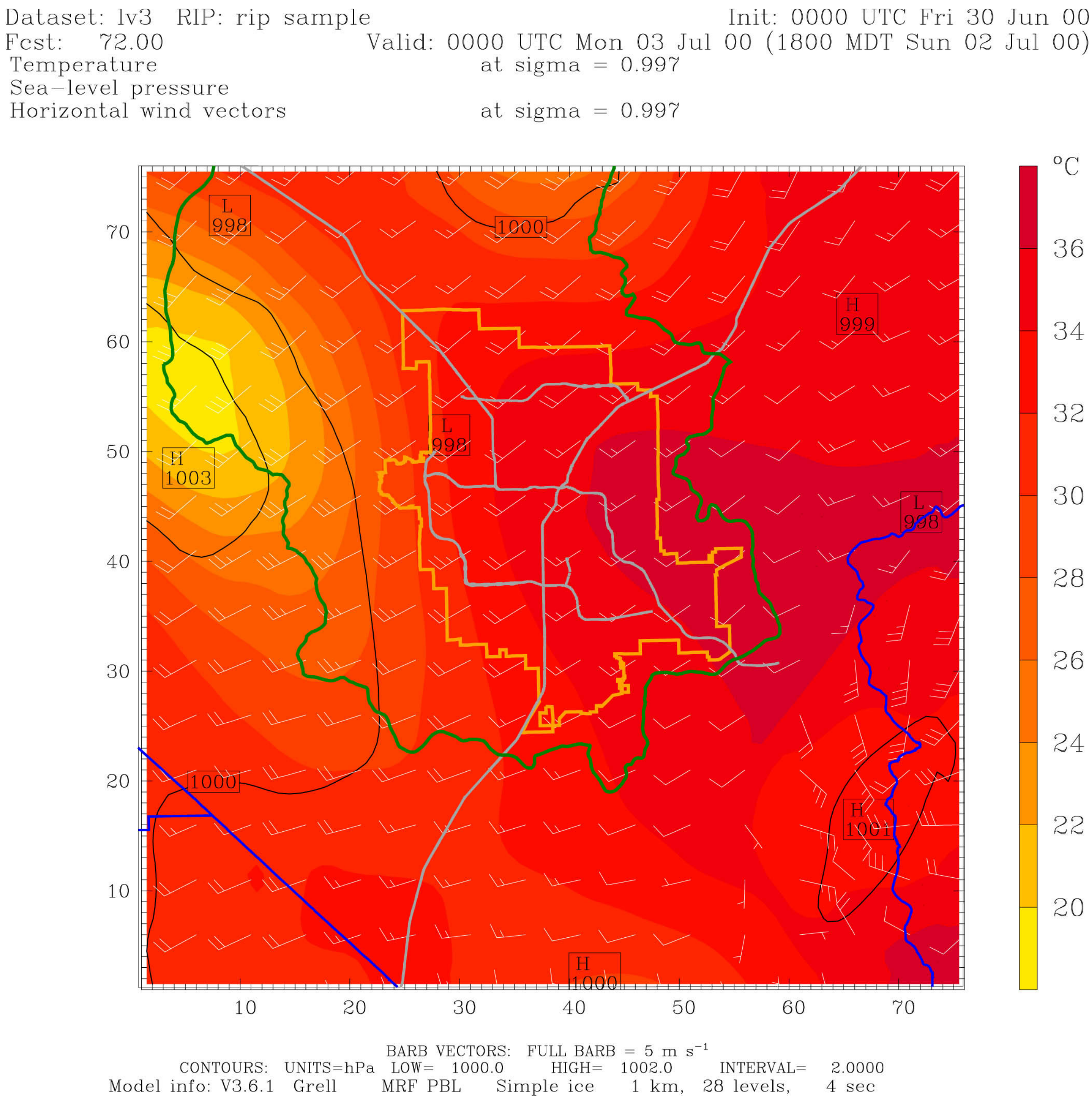

FIGURE 5.7 MM5-Generated Surface Wind Fields and Pressure and Temperature Contours on a Summer Afternoon (July 2, 2000, at 4:00 p.m. local or Pacific standard time) for the Local to Urban Valley Grid, 1.3-km-Resolution Inner Domain (The colors represent temperatures shown on the color scale next to the figure, and the contours represent surface pressure. Each full wind barb represents a velocity of 5 m/s.)

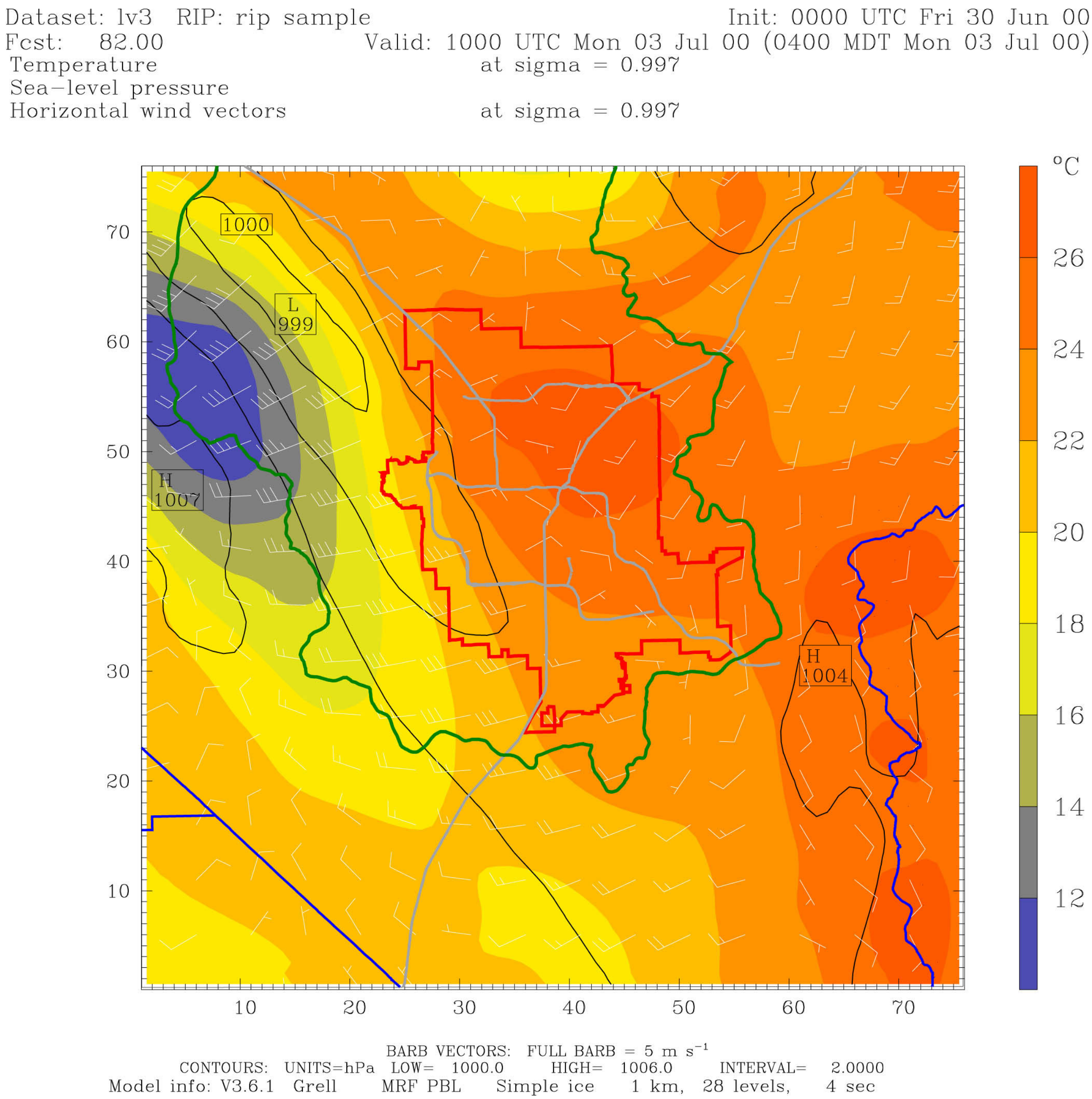

FIGURE 5.8 MM5-Generated Surface Wind Fields and Pressure and Temperature Contours on an Early Summer Morning (July 3, 2000, at 2:00 a.m. local or Pacific standard time) for the Local to Urban Valley Grid, 1.3-km-Resolution Inner Domain (The colors represent temperatures shown on the color scale next to the figure, and the contours represent surface pressure. Each full wind barb represents a velocity of 5 m/s.)

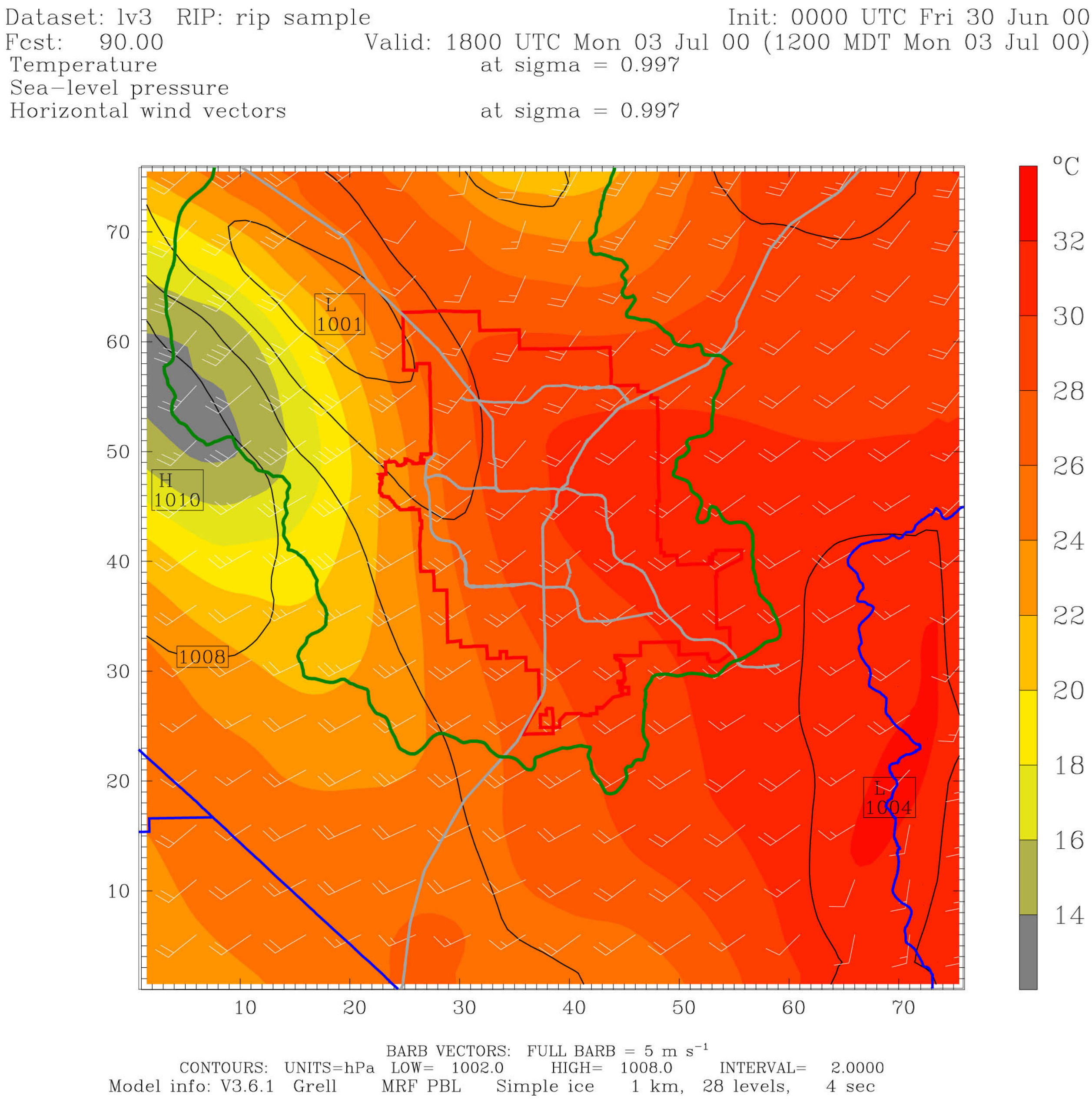

FIGURE 5.9 MM5-Generated Surface Wind Fields and Pressure and Temperature Contours on a Summer Morning (July 3, 2000, at 10:00 a.m. local or Pacific standard time) for the Local to Urban Valley Grid, 1.3-km-Resolution Inner Domain (The colors represent temperatures shown on the color scale next to the figure, and the contours represent surface pressure. Each full wind barb represents a velocity of 5 m/s.)

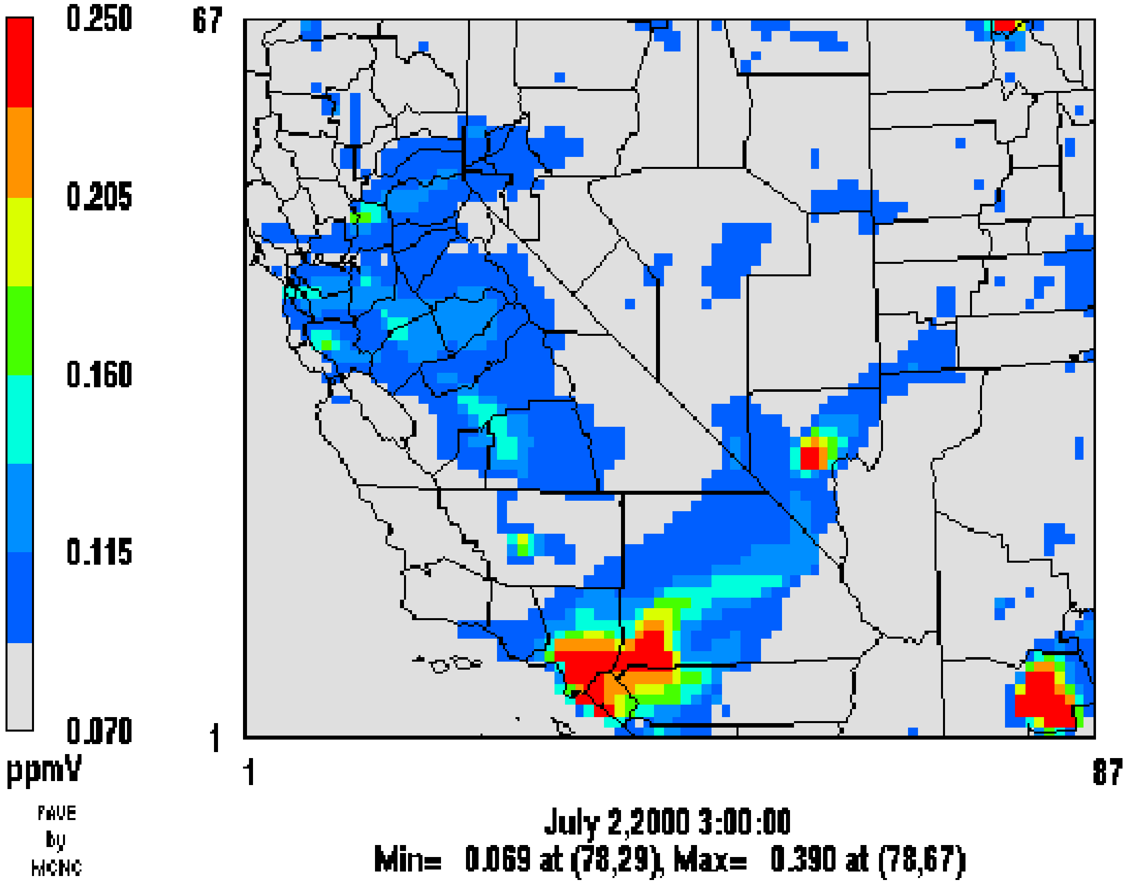

FIGURE 5.10 CMAQ-Generated CO Distribution for the 12-km-Resolution Outer Domain at the Surface (July 1, 2000, at 7:00 p.m. local or Pacific standard time), Showing Transport of CO from Southern California to Nevada and the Las Vegas Region

For the boundary and initial conditions for the inner grid over Las Vegas generated by using the CMAQ calculations for the outer 12-km-resolution domain, we also performed calculations for a nested grid situated over the Las Vegas urban area with a spatial resolution of 1.3 km. These calculations covered the same summer 2000 period (June, July, and August) discussed for the coarse domain. The emissions for these calculations included both BLM and non-BLM sources for the grid domain, prepared as discussed in Section 4.

The results from the model simulations for the inner 1.3-km-resolution domain are discussed below. These simulations used emissions inventories for sources outside of Clark County that were processed from data coming from the NEI data set and from NO_x, VOC, CO, and PM_{10} data obtained from the SCAQMD. The baseline results from these simulations are shown in Figures 5.10 and 5.11 for the 12-km domain and in Figures 5.12 and 5.13 for the inner 1.3-km domain. The results for 2006 and 2018 are discussed in Section 5.4.3.2 and displayed as difference plots between base and projection years. The 8-hour-average O_3 simulations discussed

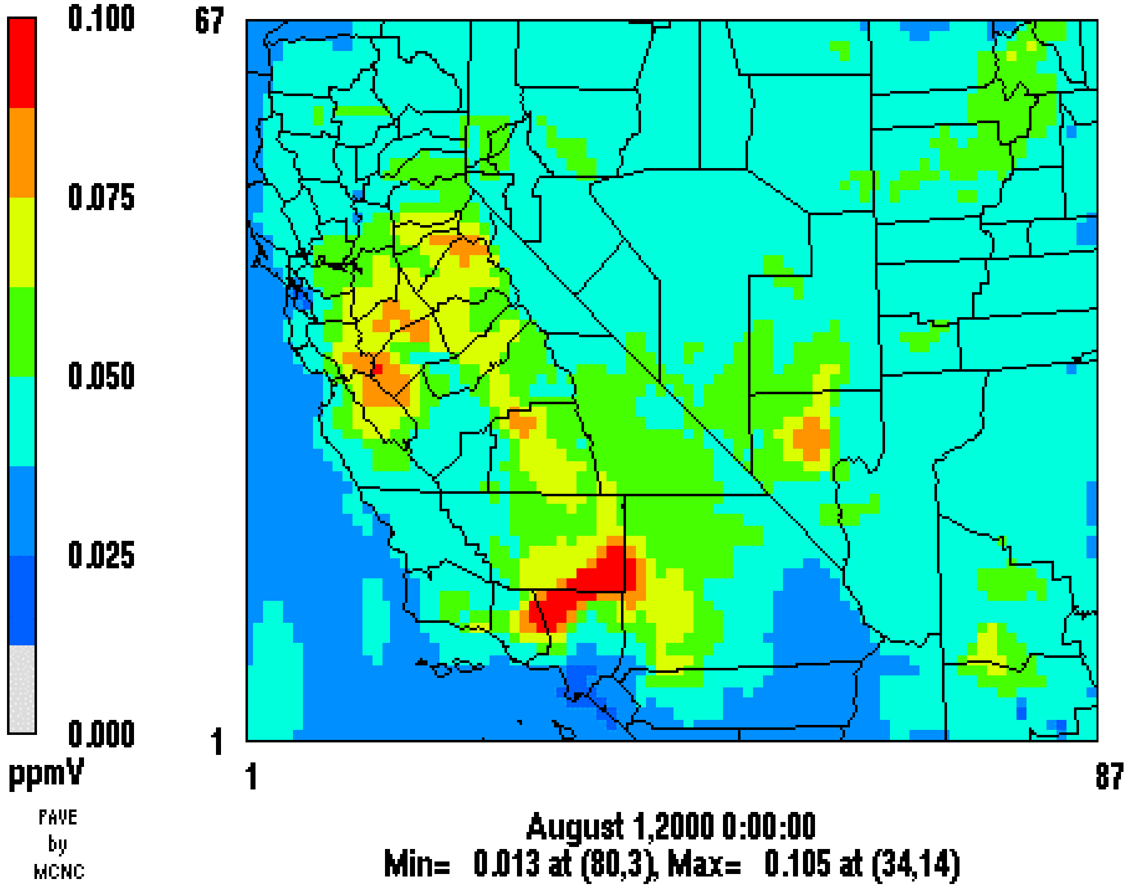

FIGURE 5.11 The CMAQ-Generated O_3 Distribution for the 12-km-Resolution Outer Domain at the Surface (July 31, 2000, at 4:00 p.m. standard or Pacific local time), Showing Transport of Generally Elevated O_3 Levels from Southern and Central California to Nevada, with Hot Spots over Urban Regions

in Section 5.4.4 used an updated WRAP data set that more recently (June 2004) became available. The only variations in the inner-grid emissions for Clark County were to test the difference in the windblown-dust-model-generated PM_{10} fluxes — one assuming a large, nearly unlimited, surface soil dust reservoir and the other assuming that the reservoir depletes or nearly depletes after the first hour of sustained winds over soil type and condition threshold levels.

The general flow, emissions, and chemical processing of the primary pollutant emitted (CO) and the secondary pollutant emitted (O_3) are discussed first. Figure 5.12 shows the model-calculated CO over a 4-hour period on June 21, 2000, starting at 7:00 p.m. local time, after the local evening rush hour. The drainage flow patterns discussed above become apparent after about 8:00 p.m. local time. The result is that the CO that is emitted mainly by mobile sources in the urban region is pushed southeastward, along the direction of wind flow. This movement of CO appears to be a dominant signature during the evening hours.

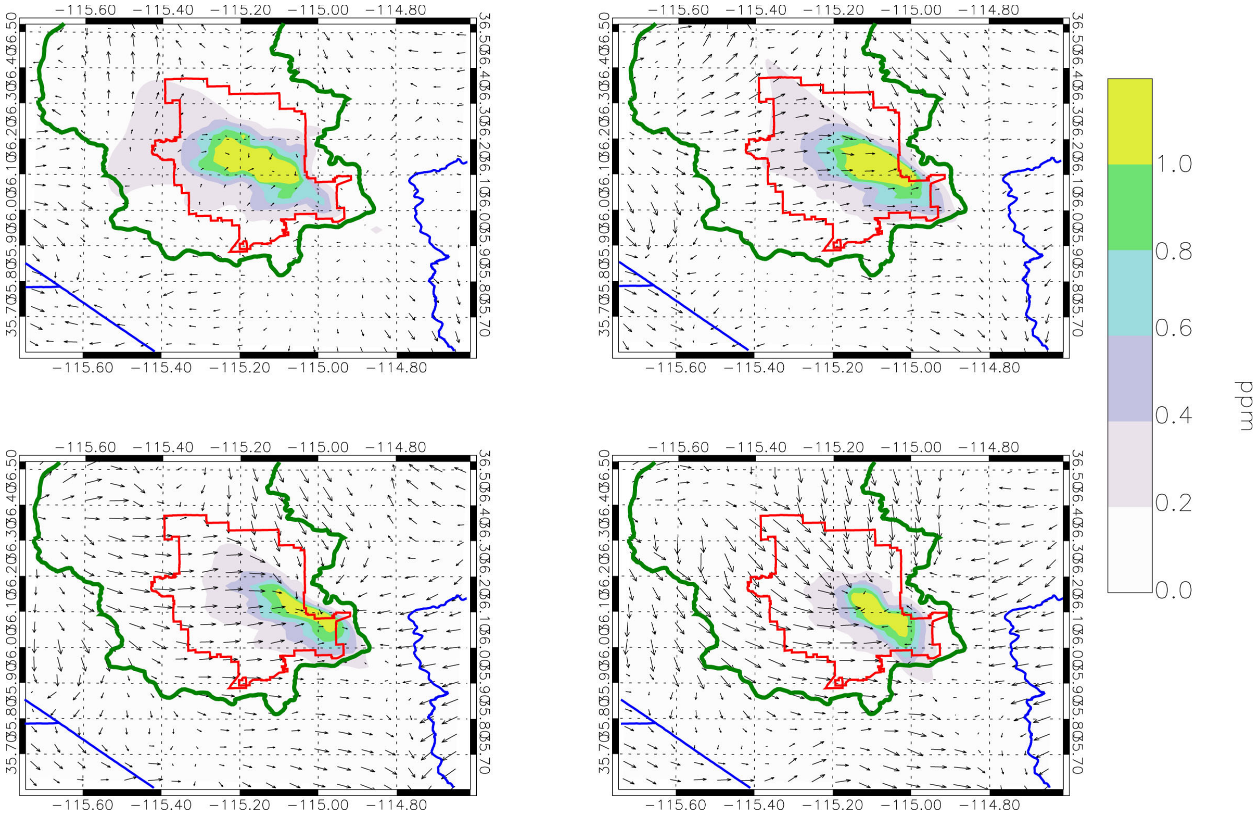

FIGURE 5.12 Calculated CO Mixing Ratios (in ppmv) for a 4-Hour Period (June 21, 2000) for the 1.3-km-Resolution Inner Domain (Top left shows results for 7:00 p.m., top right for 8:00 p.m., bottom left for 9:00 p.m., bottom right for 10:00 p.m., local or Pacific standard time. Velocity vectors are drawn at every fourth grid point in the domain.)

Local O_3 production peaks in the late afternoon and occurs mostly at a distance from the urban center. Figure 5.13 shows such an event, displaying O_3 levels at the surface on June 23, 2000, from noon to 3:00 p.m. local time. At noon (top right panel), generally high background levels of O_3, with mixing ratios over 50 ppb, enter the modeling domain from its southwest corner. O_3 production also starts to increase in the northern section of the domain, as the wind fields drive emissions from the urban center in that direction. During the next 3 hours, O_3 production peaks in the northeast corner in the direction of the wind flow, away from the urban center and out of the domain. This appears to be a typical pattern of O_3 generation in the Las Vegas urban region.

The days of highest predicted 24-hour average PM_{10} concentrations occurred in June (June 2 and June 25) and in August (August 24 and August 28) over the south-central and southwest portion of the BLM boundary, respectively. The model-predicted dust concentrations show exceedances of the PM_{10} NAAQS on June 25 and August 24. Although these air pollution episodes are predicted to occur in different regions of the Las Vegas Valley, both have naturally occurring windblown dust as a common source, but the contributions to high PM_{10} levels from windblown dust appear to be more dominant in the southwest region than the southeast region.

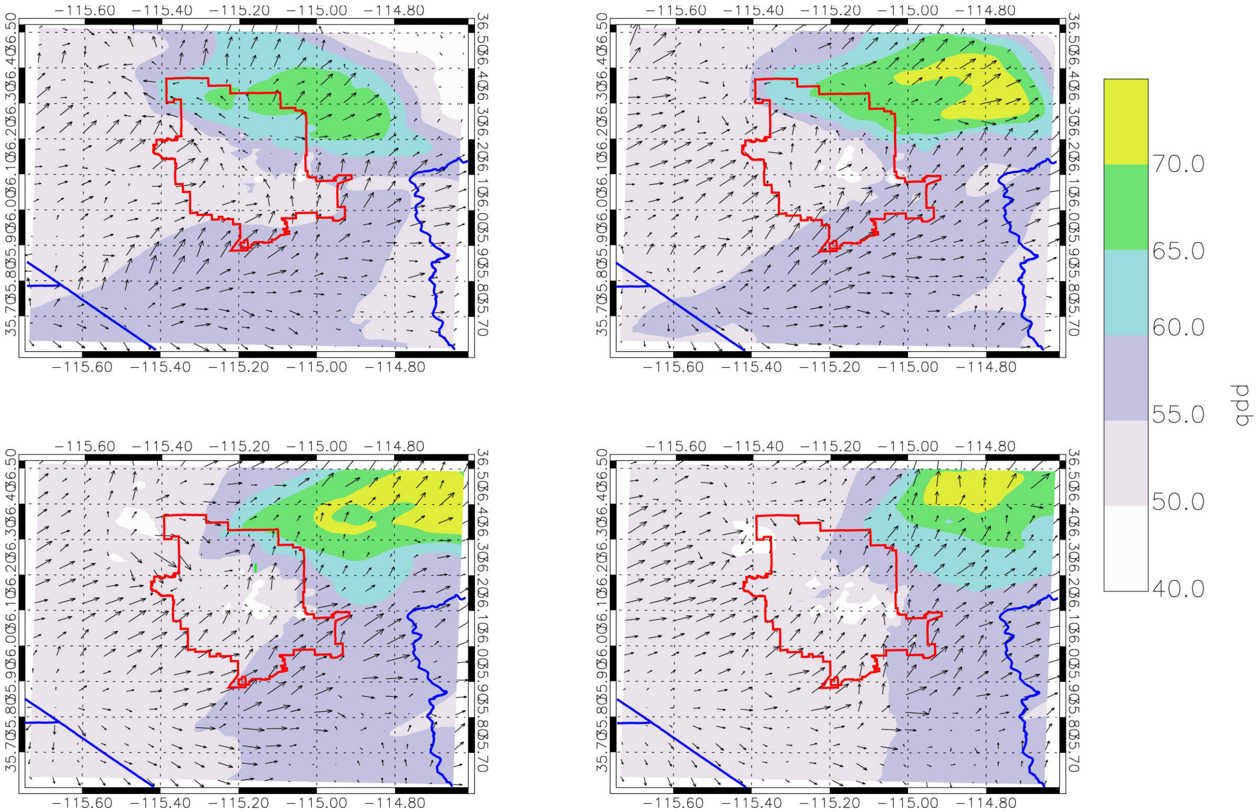

FIGURE 5.13 Calculated O_3 Mixing Ratios (in ppbv) for a 4-Hour Period (June 23, 2000) for the 1.3-km-Resolution Inner Domain (Top left shows results for noon, top right for 1:00 p.m., bottom left for 2:00 p.m., and bottom right for 3:00 p.m., local or Pacific standard time. Velocity vectors are drawn at every fourth grid point in the domain.)

In the southwest, the highest predicted PM_{10} concentrations ranged from 150 to 200 $\mu g/m^3$ and occurred over largely undeveloped land on August 24. This episode appears to be characteristic of an undeveloped rural area with wind-erodible soil and with periodically persistent, elevated surface winds. Figure 5.14 shows the 24-hour average PM_{10} concentration contours for the day (August 24). Concentrations exceeding 150 $\mu g/m^3$ covered an 80-km^2 (~20,000-acre) area. This region of the Las Vegas Valley lies between the Spring Mountain range (which serves as the western boundary ridge for the Las Vegas Valley) and the McCollough Mountain range to the south, forming a channel or drainage zone between the two mountain ranges. Channeled flow between these ranges occurs throughout the year but particularly during the Las Vegas monsoon season (July–September), when the intense heat and moisture (predominantly from the Gulf of California) contribute to the formation of a convergence zone between the flows from the southwest and the flow from the northwest along the eastern side of the Spring Mountain range (Czyzyk 2004). Referred to as the Las Vegas Convergence Zone, this arc-shaped zone has been repeatedly observed to form in the low-level Las Vegas Valley wind fields. The development and structure of this convergence zone has been documented by Runk (1996, 1999). The generation of moderate to strong surface winds associated with the formation of the convergence zone

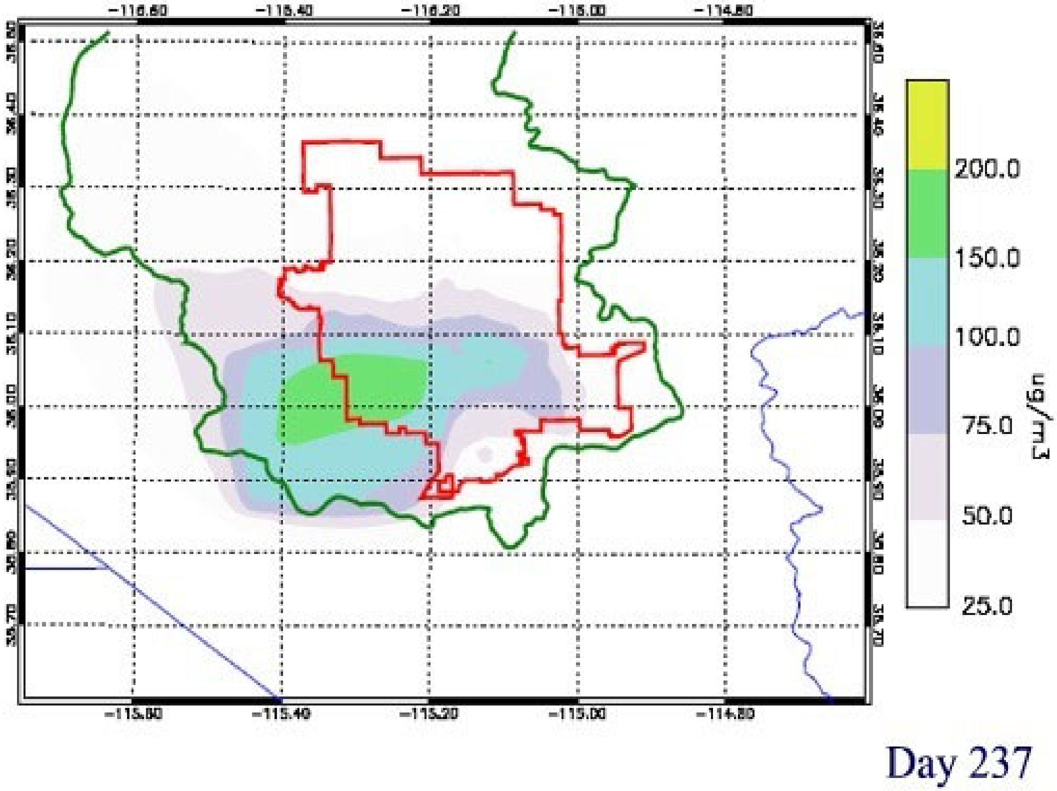

FIGURE 5.14 Maximum Baseline PM_{10} 24-Hour Concentrations on August 24, 2000 (Julian day 237)

preceeds the explosive convective growth of thunderstorms associated with a fully developed convergence zone. This meteorology, along with a large, open area of exposed, moderately wind-erodible soils (SECC 4SU), appear to point to windblown dust as being the major contributor to the PM_{10} exceedances. Since there is no air quality monitoring currently being conducted in this region of the Las Vegas Valley, it was not possible to compare our model predictions over this area with observations. The nearest PM_{10} monitor, the Jean site, is located more than 13 mi south of the predicted high PM_{10} contour levels shown in Figure 5.14. In 2000, the maximum 24-hour PM_{10} measurement (40 $\mu g/m^3$) occurred at the Jean site on June 14. In lieu of other major source contributors, naturally occurring windblown dust appears to be the prime contributor to these PM_{10} exceedances.

The diurnal variation of PM_{10} in the southwest region is shown in Figure 5.15. Figure 5.15 (top left panel) shows the PM_{10} concentration at 4:00 a.m. local time. For the entire domain, the lowest and highest values are observed on the western side of the domain marked by stagnant wind fields. Figure 5.15 (top right panel) shows the PM_{10} concentration at 12:00 p.m. The western section of the model domain is marked by high wind velocities and an increase in PM_{10}. This is followed by a further increase in PM_{10} at 8:00 p.m. and a redistribution of concentrations as the dust plume gets entrained in the circulation with high wind velocities at the southwestern edge of the model domain (Figure 5.15 [bottom left panel]). The cycle is completed

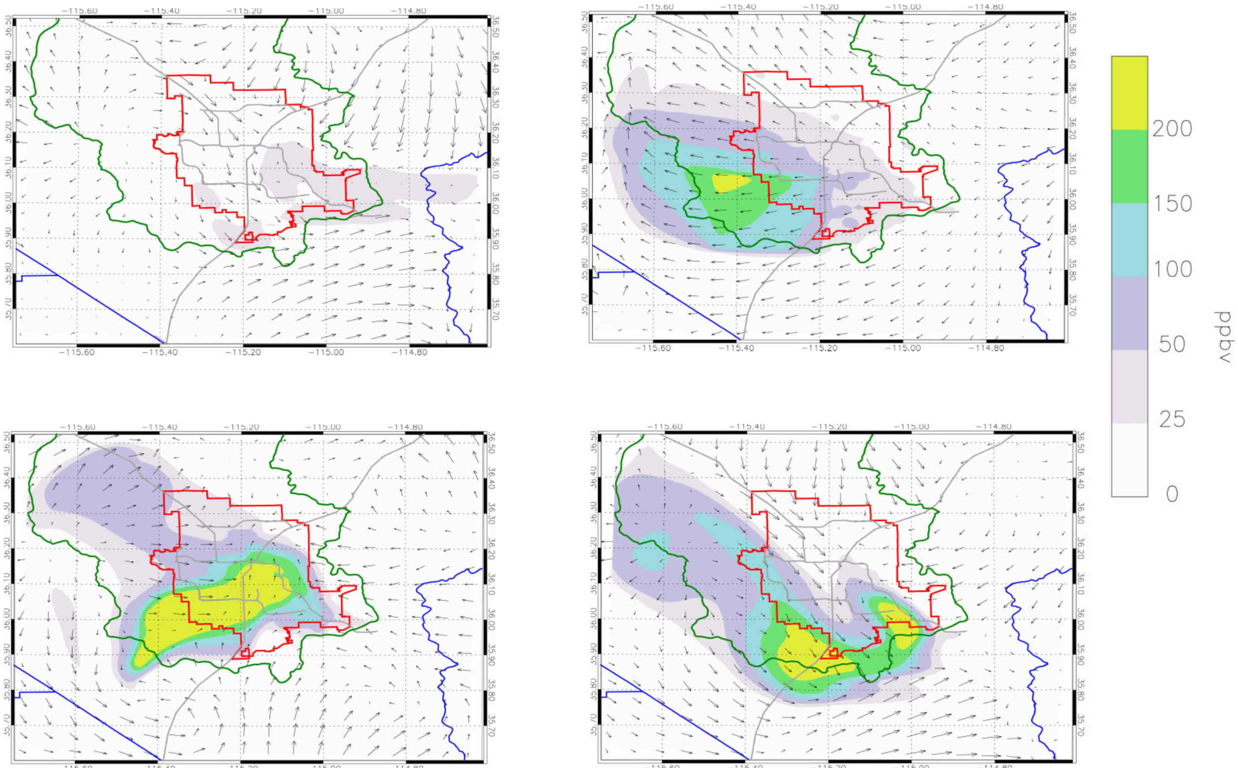

FIGURE 5.15 PM_{10} Hourly Average Concentrations for the 1.3-km-Resolution Inner Domain on August 24/25, 2000 (day 237) (Top left panel show results for 4:00 a.m. local time on August 24, top right for 12:00 p.m. local time on August 24, bottom left for 8:00 p.m. local time on August 24, and bottom right for 12:00 a.m. local time on August 25.)

at 12:00 a.m. as the wind flowing from the northwest corner of the domain rapidly pushes the plume to the southern edge of the domain and away from windblown dust sources (Figure 5.15 [bottom right panel]). This leads to the dust plume's dilution and eventual dissipation. This phenomenon can be observed on several of the high-PM_{10}-incidence days in the southwest corner of the domain. It is possible that some of the dust concentrations calculated resulted from the parametric equations used, which led to higher dust estimates. However, it is likely that the higher PM_{10} concentrations may be endemic to this area as a result of the wind field and land use conditions.

Figure 5.16 shows the south-central location of the peak or highest 24-hour average concentrations on June 25, 2000. Two areas of concentrations above 125 $\mu g/m^3$ are shown, one to the southwest and the other one to the east, in a south-central location. The south-central location, near the intersection of Interstates 215 and 515, is where the model predicts the highest concentration, 143 $\mu g/m^3$, on this day. Unlike the high PM_{10} concentrations in the southwest portion of the boundary on August 25 (see Figure 5.14), in this area, the general location of the predicted high is in the vicinity of three PM_{10} monitors (Green Valley, Pittman, and South East Valley; see Figure 3.2). The initial model comparisons with measurements at these sites using

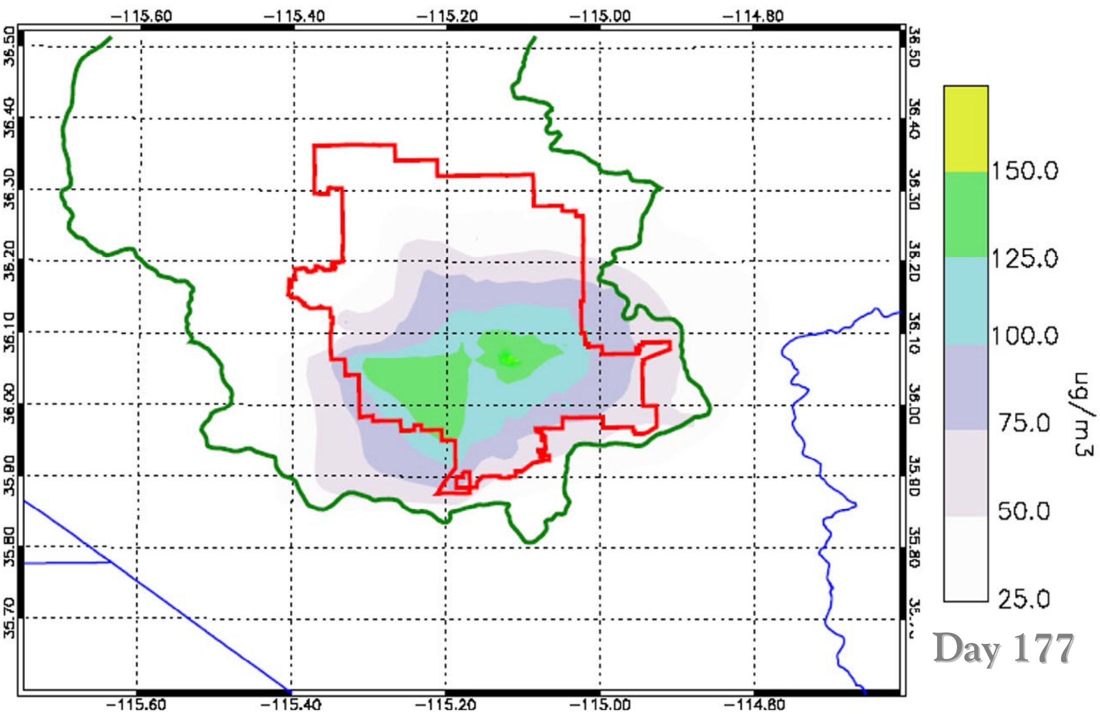

FIGURE 5.16 Maximum Baseline PM_{10} 24-Hour Concentrations on June 25, 2000 (Julian day 177)

both an unlimited and a limited soil reservoir assumption in the WBD model show a strong positive bias tendency (see Figure 5.44 for the limited reservoir assumption at end of this section). Model predictions on August 25 are greater than observations by a factor of three or more. This could be due to errors or uncertainty in estimating the magnitude and time history of construction-related fugitive dust and on-road vehicle dust from nearby Interstates 215 and 515, uncertainties in the paved road dust emission factors, or uncertainty associated with the windblown dust algorithm. Identification of predominant soil types and conditions in and around the three modeling sites indicates that these soils have relatively low wind erodibility potential. This is evident from the maximum estimates from the windblown dust model of less than 2 $\mu g/s\text{-}m^2$. Compared to the 75 to 85 $\mu g/s\text{-}m^2$ fluxes from unstable SECC 3 and 2 soils, these are very small fluxes and indicate that errors in estimating windblown resuspension are not responsible for the CMAQ model's overprediction at the Green Valley, Pittman, and South East Valley monitoring sites.

The highest 24-hour average PM_{10} concentration using the reservoir-limited windblown dust model was calculated for June 25, 2000. The 24-hour average calculated value was 187 $\mu g/m^3$. The high-PM_{10} regions correspond to regions to the south and southwest of the city and include some of the BLM disposal regions, as shown in Figure 5.17. Figure 5.18 shows the evolution of these episodes during the day. The figure shows the PM_{10} mixing ratios at four different hours of the day and the corresponding wind fields for that hour. Particularly strong

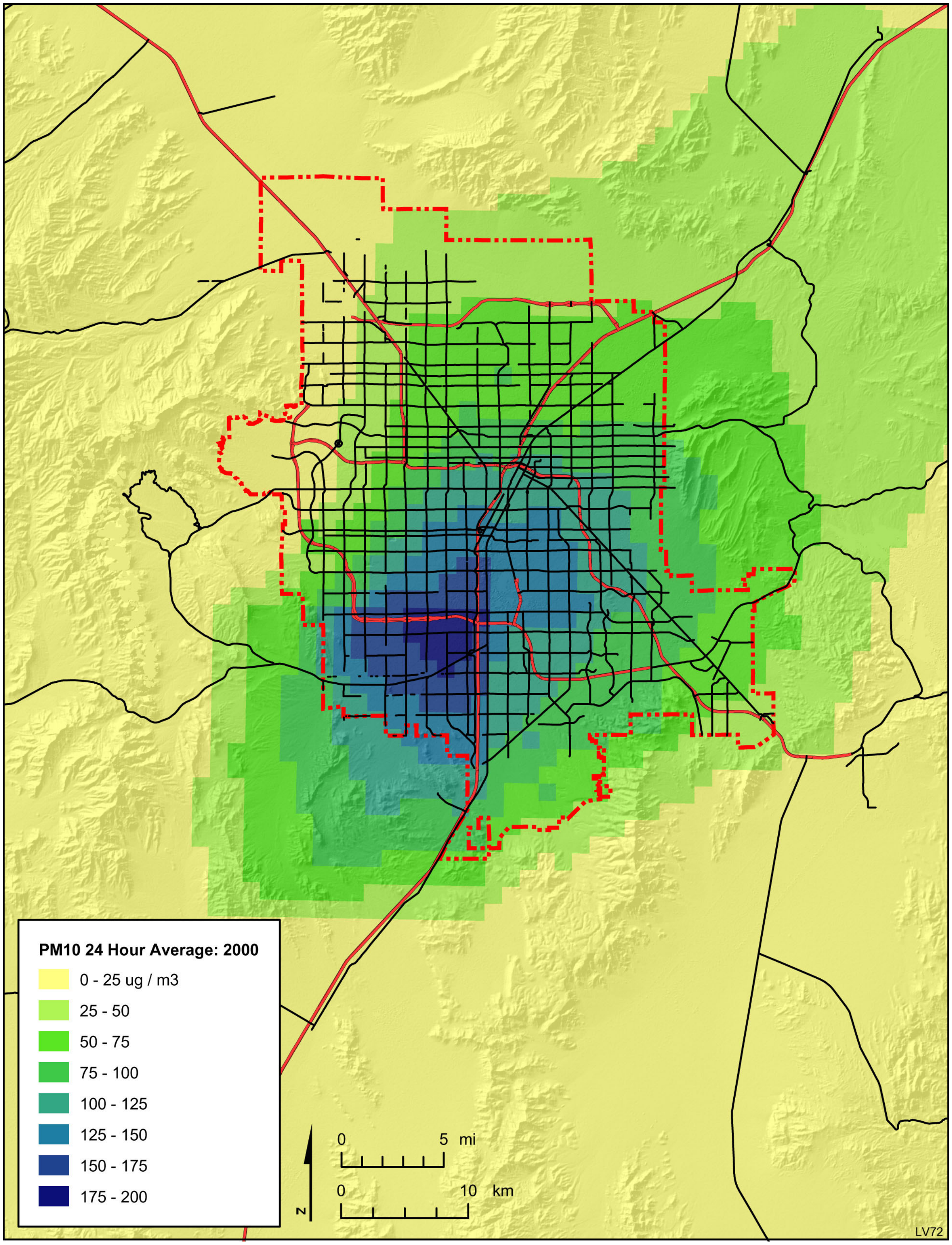

FIGURE 5.17 Calculated PM_{10} for July 25, 2000. Results Shown are 24-Hour Average Values for the Day.

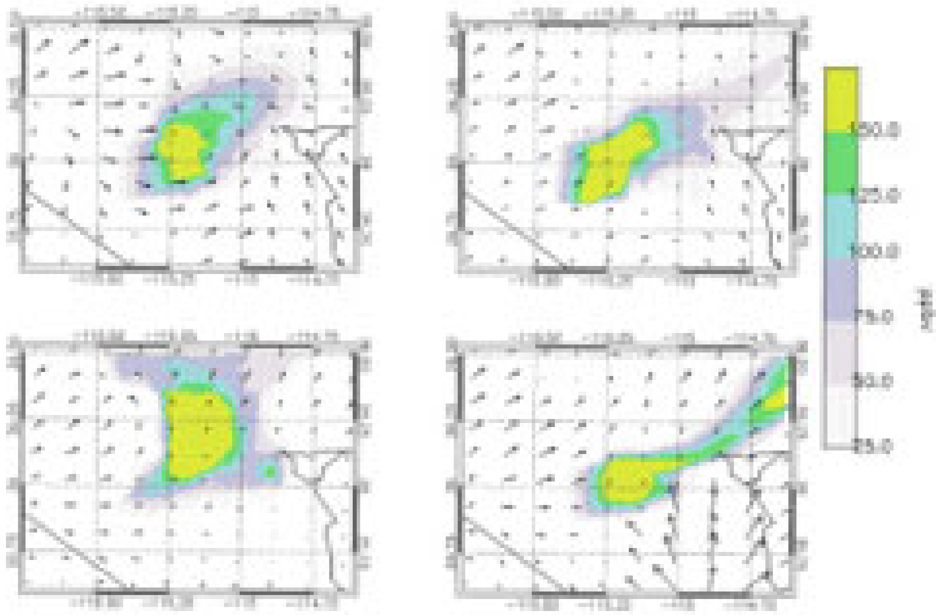

FIGURE 5.18 Evolution of the PM_{10} Episode Calculated for July 25. The Arrows Show the Wind Velocity Vectors at the Surface, and the Smallest Arrow Corresponds to 5 m/sec. (The top left corner shows the PM_{10} and wind vectors at 4:00 a.m., the top right corner at 8:00 a.m., the bottom left at 12:00 p.m., and the bottom right at 4:00 p.m.)

wind fields (of over 20 m/sec) were computed by the model during the day. Additional model calculations with the windblown dust algorithm switched off have shown that more than 40% of the PM_{10} in the valley is attributable to windblown dust. The future-year simulations generated slightly more PM_{10} for this episode.

5.4.3 Future Cumulative Air Quality Impacts

5.4.3.1 Seasonal and Episodic Meteorological Conditions

Surface air temperatures were adjusted by using the projected forecasts based on results from a global climate GCM. The wind and pressure fields used for the 2006, 2009, and 2018 CMAQ simulations were identical to those used in the baseline runs. The GCM-forecasted increase in the median surface temperature is shown in Figure 5.19.

5.4.3.2 Spatial and Temporal Distribution of Criteria Pollutants

Figures 5.20 and 5.21 show the projected changes in Las Vegas Valley CO and O_3 concentrations in 2006 and 2018 from the concentrations estimated during the base year (2000)

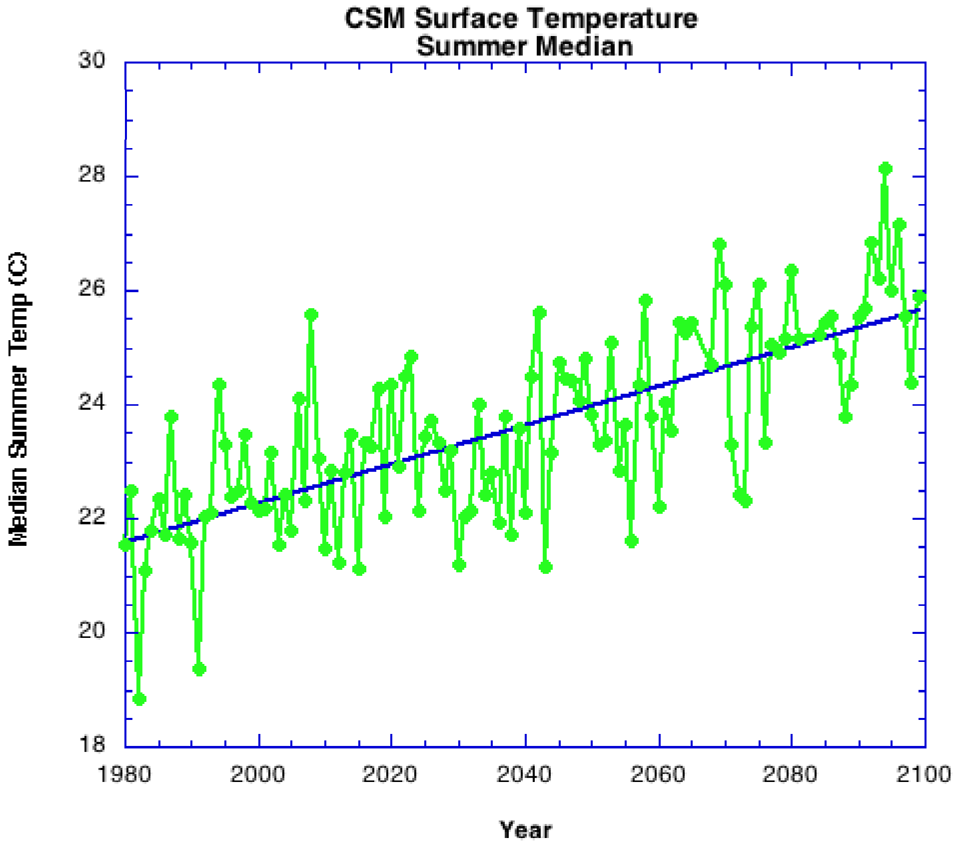

FIGURE 5.19 Future-Year Surface Temperature Changes

for the time periods calculated to have the highest differences in CO and O_3 concentrations from those of the base case. The maximum 1-hour average increase in 2006 is estimated to be no more than 0.5 ppm for CO and 2 ppb for O_3. The increase in CO is confined to a relatively small area within the BLM boundary. Most of the areas showing increased levels in 2006 have increases of less than 0.25 ppm for CO and less than 2 to 3 ppb for O_3. By 2018, the maximum projected increases over baseline conditions are 1.75 ppm for CO and 12 ppb for O_3. Most of areas showing increased levels in 2018 have increases of less than 0.45 ppm for CO and less than 5 ppb for O_3. These increases can be attributed to mobile source emissions, primarily from an estimated additional 8 million total VMT above the VMT in 2000 (336,000 VMT), attributed to BLM land disposition and development. Most of the Las Vegas Valley air quality is unaffected by the growth associated with BLM-related land development. Both baseline and future-year projections indicate that even under worst-case air pollution episodes, no violations to the CO and O_3 NAAQS would be expected.

Calculated CO over a 6-day period (8-hour running average) for the Apex, City Center, and Jean sites is presented in Figure 5.22 for the year 2000 and two future years. The highest model-predicted increases in the 8-hour average CO levels in 2006 and 2018 over the baseline predictions are 40 to 50 ppb at the two rural or background monitoring stations (Apex and Jean).

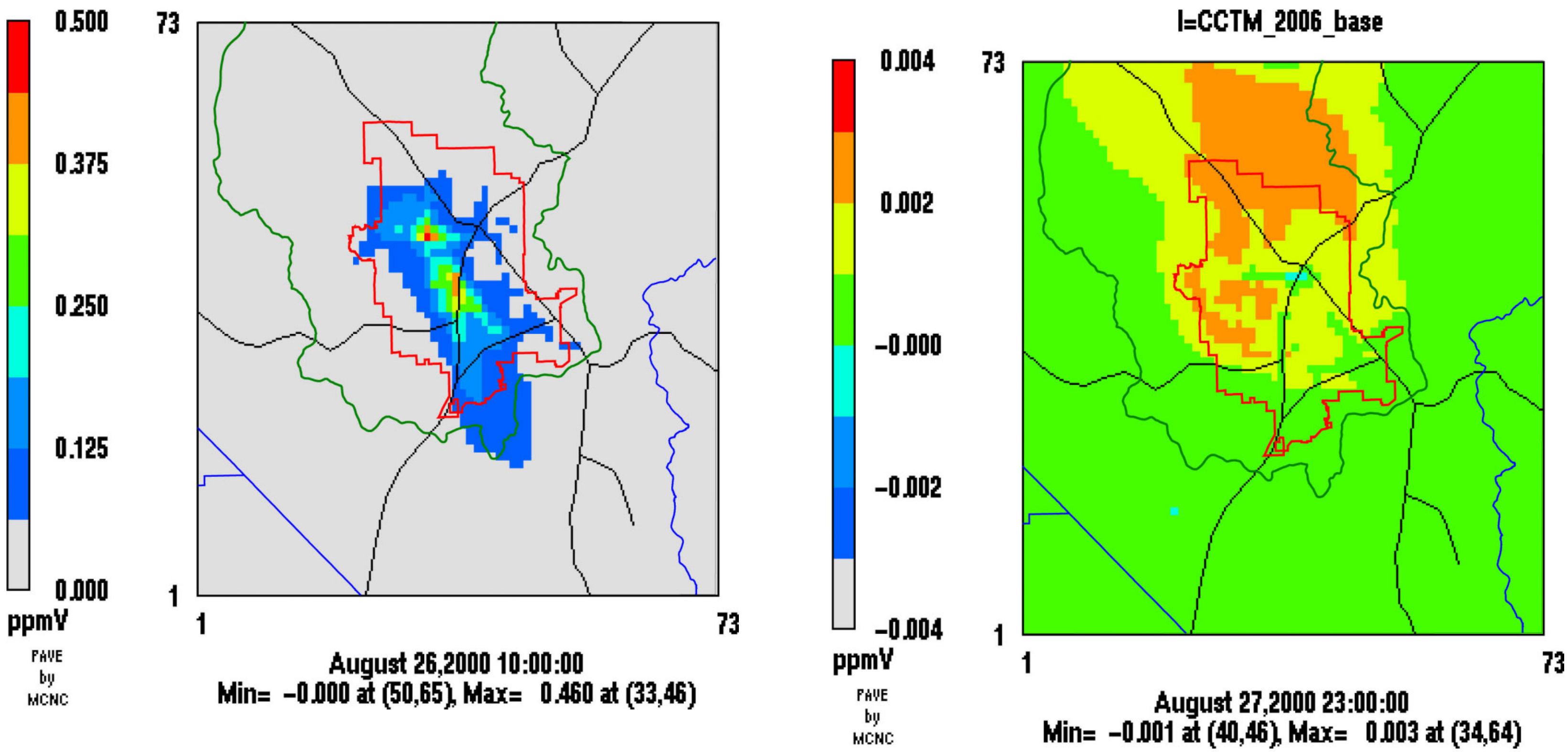

FIGURE 5.20 Projected Changes in CO (left) and O_3 (right) Concentrations from 2000 to 2006 (The figures shown are for Greenwich mean time [GMT], with the maximum differences in CO and O_3 for the days shown.)

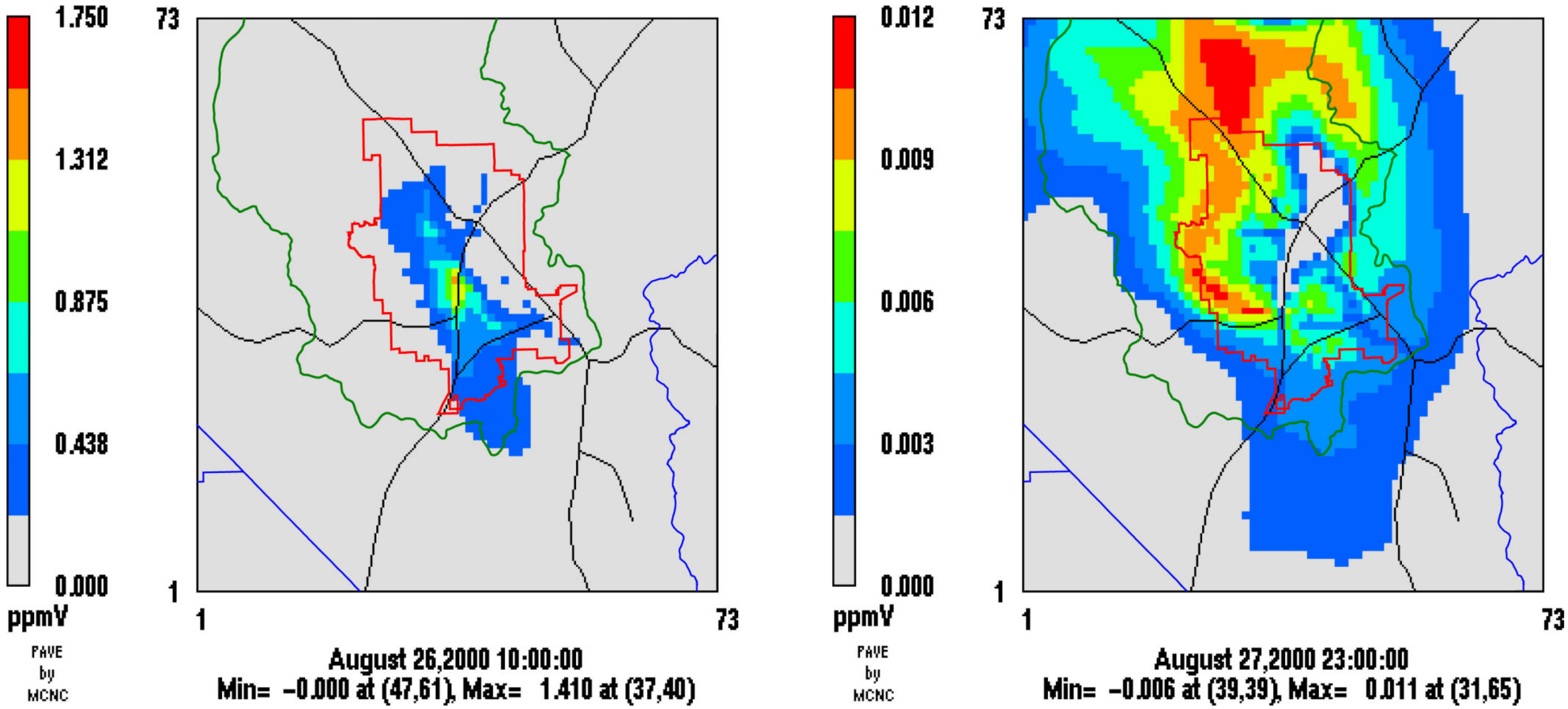

FIGURE 5.21 Projected Changes in CO (left) and O_3 (right) Concentrations from 2000 to 2018 (The figures shown are for GMT, with the maximum differences in CO and O_3 for the days shown.)

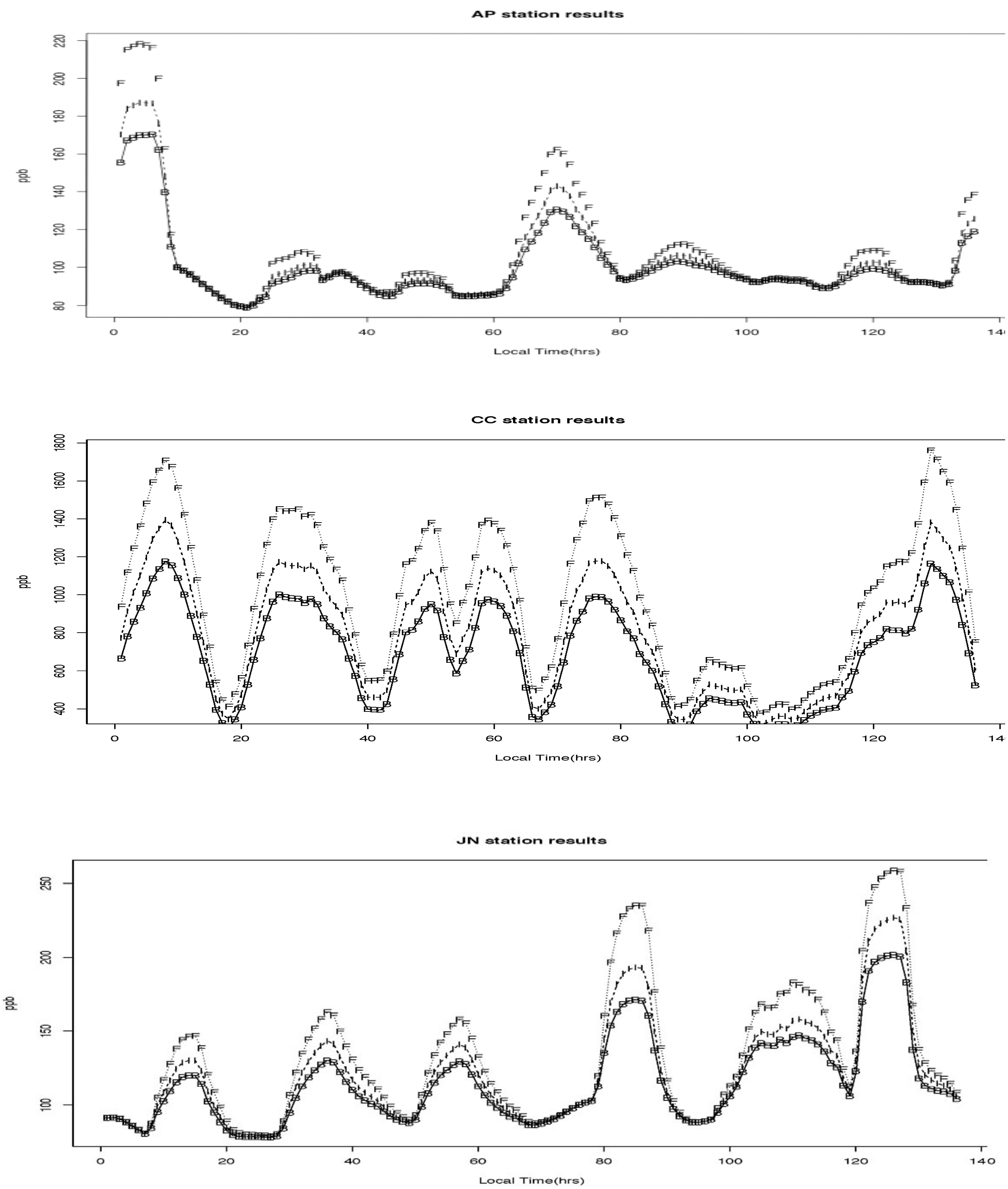

FIGURE 5.22 Calculated 8-Hour Running Average of CO Mixing Ratios at Apex (a), City Center (b), and Jean (c) Monitoring Stations for 2000 (symbol B), 2006 (symbol I), and 2018 (symbol F) (The results shown are for 6 days starting day 236, August, 23, 2000.)

The predicted increases for the city center are much higher: increases of 200 ppb by 2006 and up to 600 ppb by 2018. However, these increases would still put the Las Vegas Valley well below the 8-hour EPA standard of 9 ppm (9,000 ppb).

Figure 5.23 shows future-year, 2006, and 2018 1-hour average PM_{10} concentration difference plots compared with the baseline (2000) the PM_{10} levels for the period with the largest differences. Since the concentrations reflect the difference between the baseline run (year 2000) minus the future-year runs (2006 and 2018), areas showing positive differences in PM_{10} levels represent a potential region where the PM_{10} would be expected to decrease in the future, whereas the areas where the PM_{10} differences are shown as negative correspond to regions of an expected future PM_{10} increase. These figures show where future PM_{10} levels are expected to decrease and where they are expected to increase. An hourly average decrease in projected PM_{10} levels of less than 5 $\mu g/m^3$ is projected for 2006 and a decrease of less than 30 $\mu g/m^3$ is projected for 2018. Most of the region is predicted to have PM_{10} readings showing no increase or a decrease of less than 7 $\mu g/m^3$. The areas of largest 24-hour average concentration changes are expected to be much smaller than the 1-hour average concentration change shown in Figure 5.23. Reductions in 24-hour average PM_{10} levels in 2006 from the level in 2000 (from 3 to 11 $\mu g/m^3$) are evident over large areas inside the BLM disposal boundary (Figure 5.24). These predicted decreases are also evident in 2018 (Figure 5.25). These PM_{10} reductions can be attributed to a reduction in windblown dust source areas as a result of BLM land development. Windblown dust fluxes from native soils decreases as the amount of exposed vacant land is decreased and sheltering (e.g., addition of vegetative cover) increases.

The PM_{10} concentrations calculated for the future years using the reservoir-limited windblown model show an increase of less than 10% in approximately similar regions for the years 2009 and 2018 (Figure 5.26). There are also regions where a decrease in PM_{10} is predicted in future years for this episode day. However, the net impact is an increase in PM_{10} concentrations for the episode day in regions south of the city.

5.4.4 Cumulative O_3 Impacts Reflecting Local and Regional Controls on O_3 Precursor Emissions — Model Sensitivity

5.4.4.1 Baseline 2000: 8-Hour Averages

As described in Sections 4.1 and 4.2, to support our assessment of the role of RFG in the attainment of the 8-hour O_3 NAAQS in Clark County, the research team prepared an updated and improved emissions inventory for the current and future scenarios for both Las Vegas and the surrounding states. The NEI-derived emissions from Arizona and California were updated with newly developed data for the ongoing WRAP assessment of regional haze in the western United States. The WRAP inventory for California employed recently available data developed by the CARB that included mobile source NO_x emissions for 2002. Adjustments were also made to reflect the 12-km gridded emissions consistent with the 2000 base year for this study and more

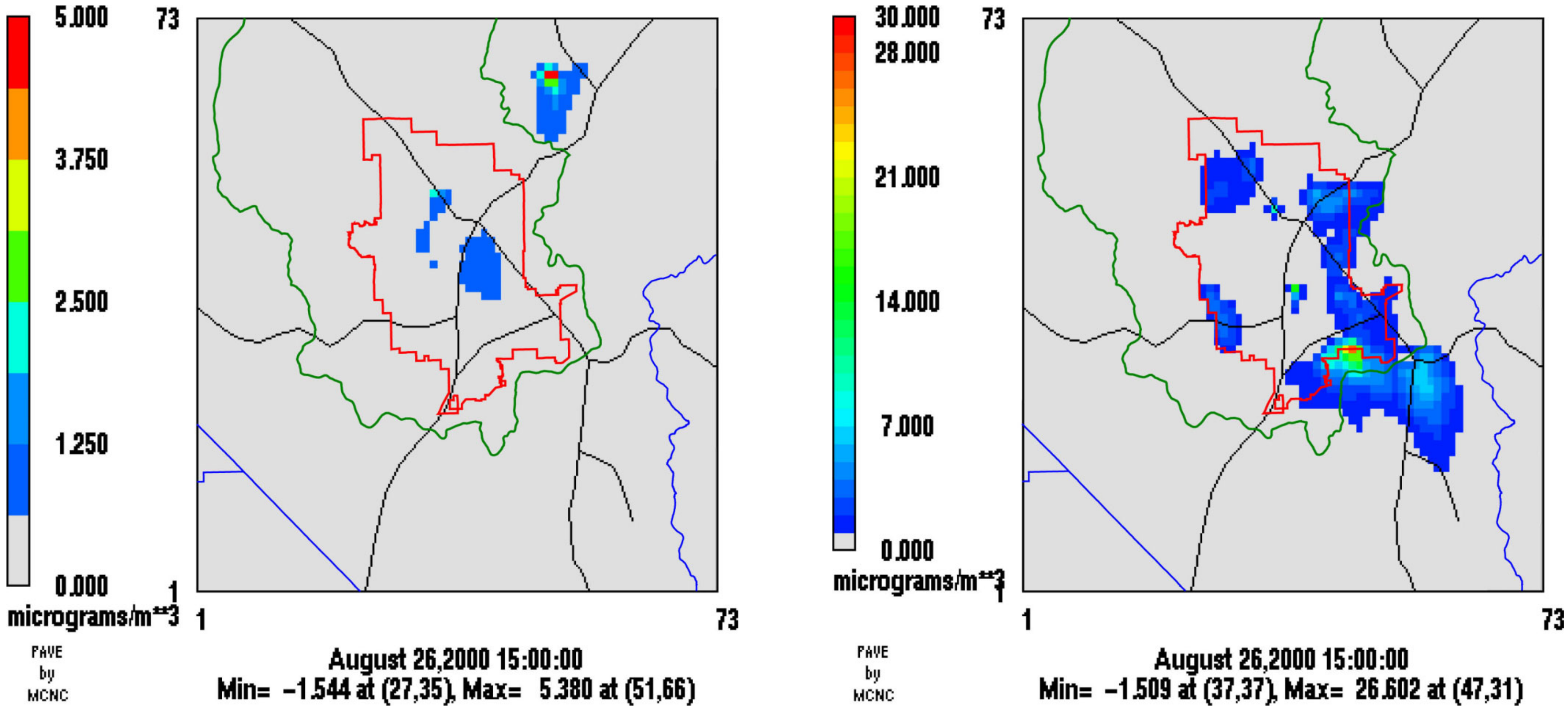

FIGURE 5.23 Projected Changes in PM_{10} Concentrations from 2000 to 2006 (left) and 2000 to 2018 (right). The 1-Hour Average Values Correspond to the Highest Levels Calculated for the Day.

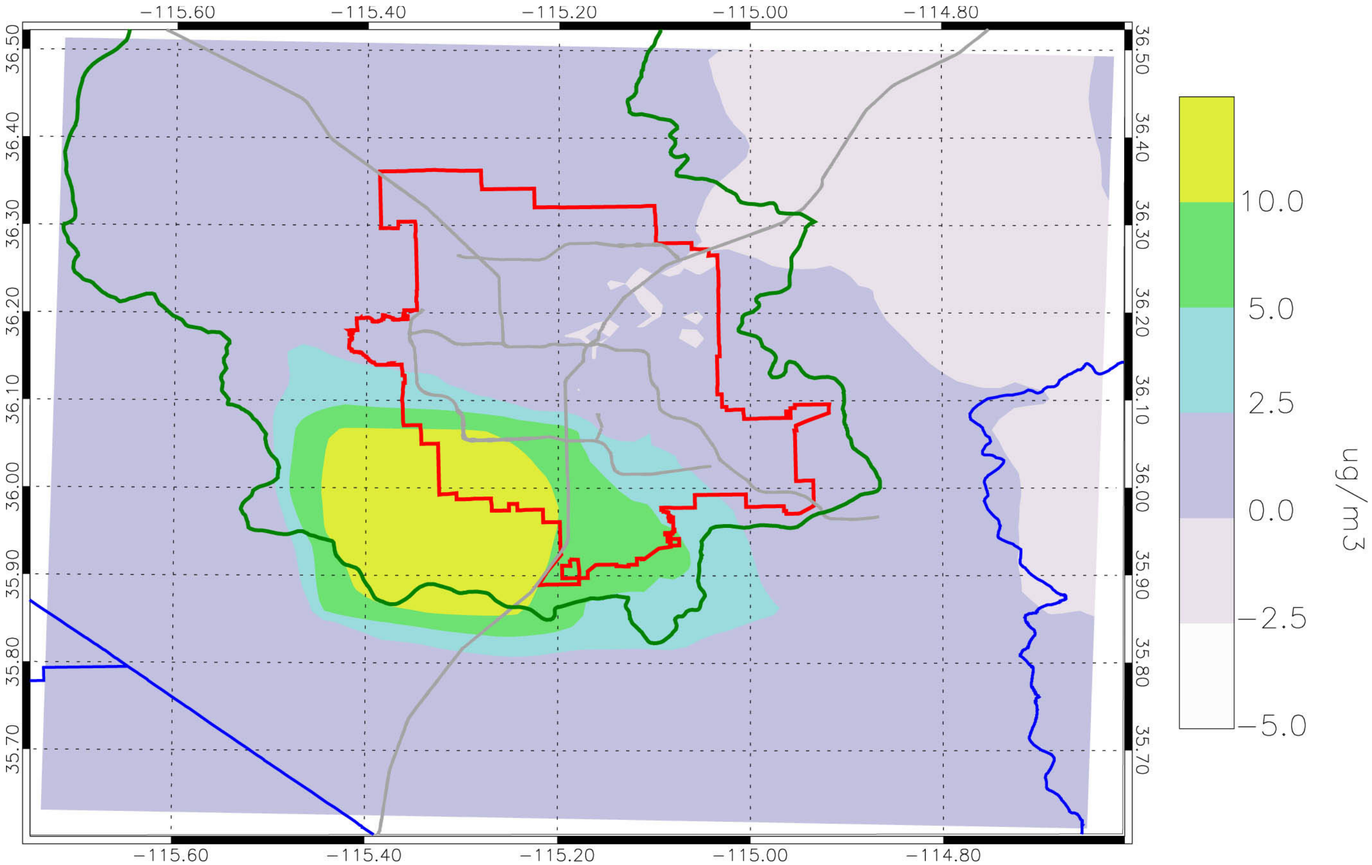

FIGURE 5.24 Differences in PM_{10} between the Base Year 2000 and Future Year 2006 (The regions with positive values signify regions where the PM_{10} concentration will be lower in 2006 than in 2000.)

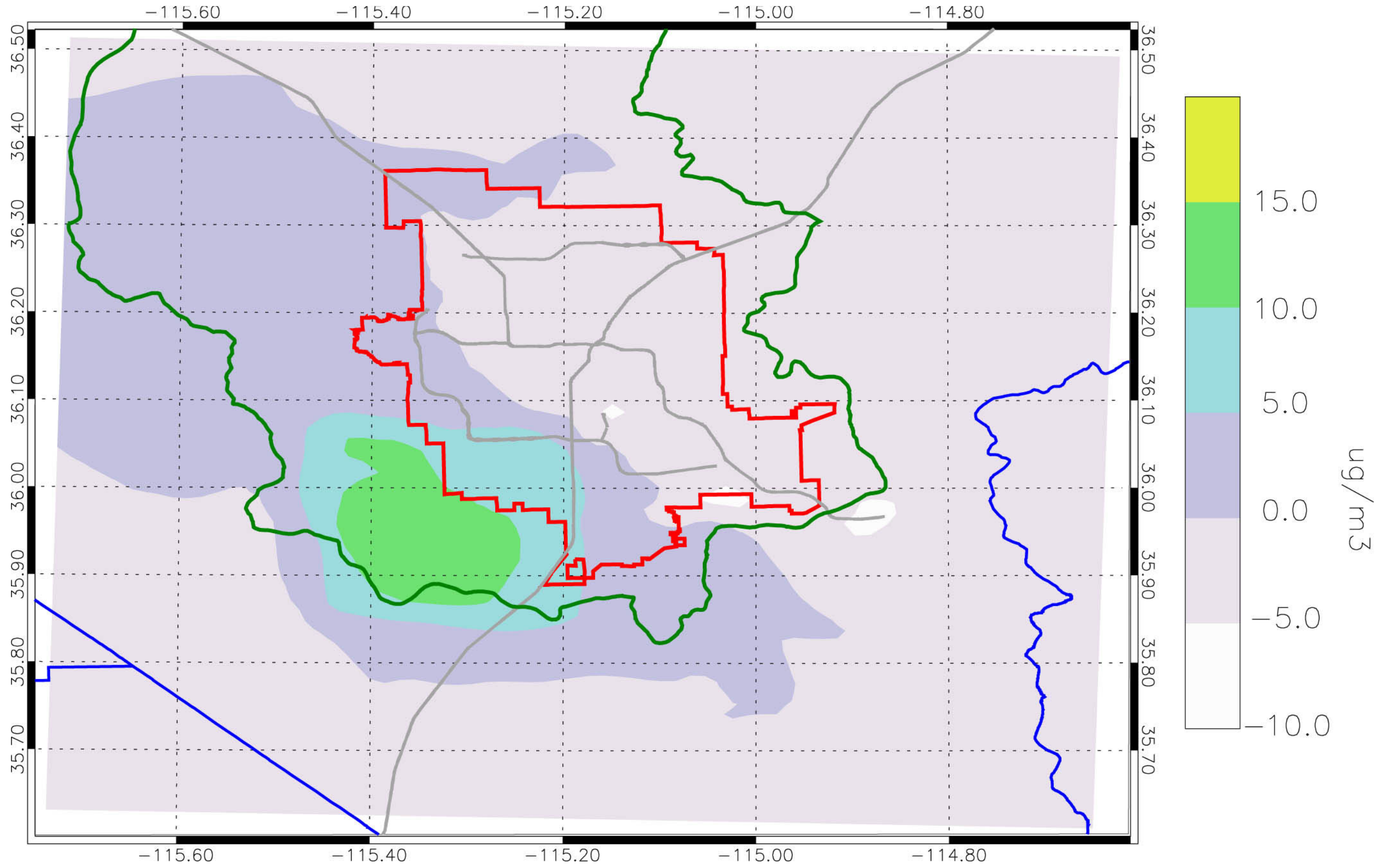

FIGURE 5.25 Differences in PM_{10} between the Base Year 2000 and Future Year 2018 (The regions with positive values signify regions where the PM_{10} concentration will be lower in 2018 than in 2000.)

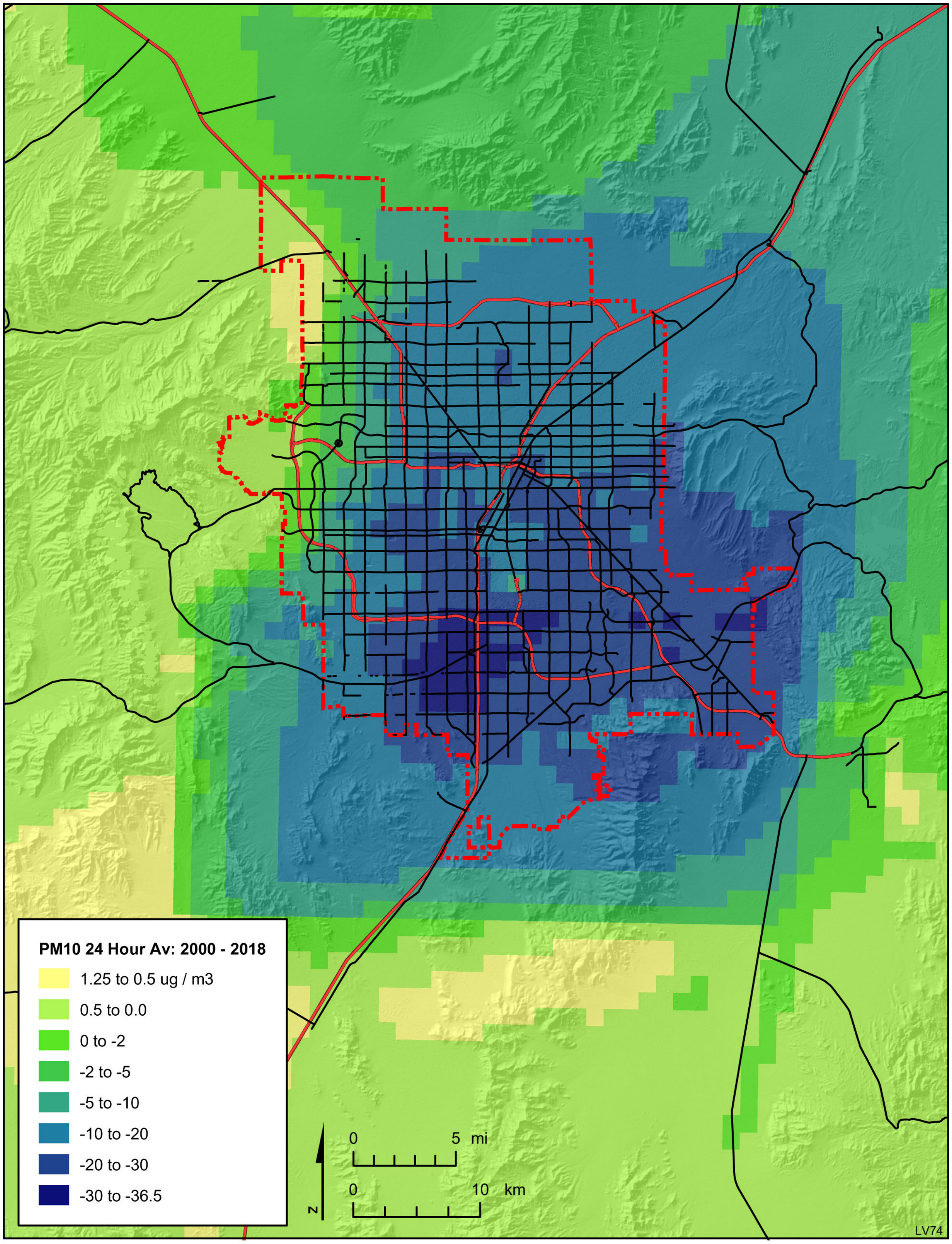

FIGURE 5.26 Difference in PM_{10} Calculated for July 25 between the Years 2000 and 2018 (The Difference for the Year 2000 to 2009 is similar since there were no changes in the emissions or wind fields in the model between the 2009 and 2018 case that would directly affect PM_{10}.)

stringent California engine controls expected for 2009 and 2018.[13] The Clark County emissions for 2009 and 2018 were modified to reflect the use of RFG with low RVPs. A total of 18 days, extending from July 24, 2000, to August 10, 2000, on a Greenwich mean time (GMT) basis — corresponding to a period of higher ozone in the Las Vegas Valley — were assessed to evaluate the effectiveness of RFG use in Las Vegas.

Figure 5.27 shows the differences in 2000 versus 2009 NO emissions from both local (i.e., Las Vegas area) and regional (e.g., California) sources for weather conditions at 4 p.m. for July 24. The future-year mobile emissions from California were reduced by approximately 40–70% for the years 2009 and 2018. The differences are mainly attributable to imposition of very stringent low-emissions vehicle (LEV) II standards in California and the use of RFG in Las Vegas. The emissions calculated for the base year and for 2009 and 2018 for the inner 1.3-km domain are discussed in detail in Sections 4.1 and 4.2. In the outer grid, the reduced emissions from California, attributable to more stringent vehicle engine exhaust controls, can be

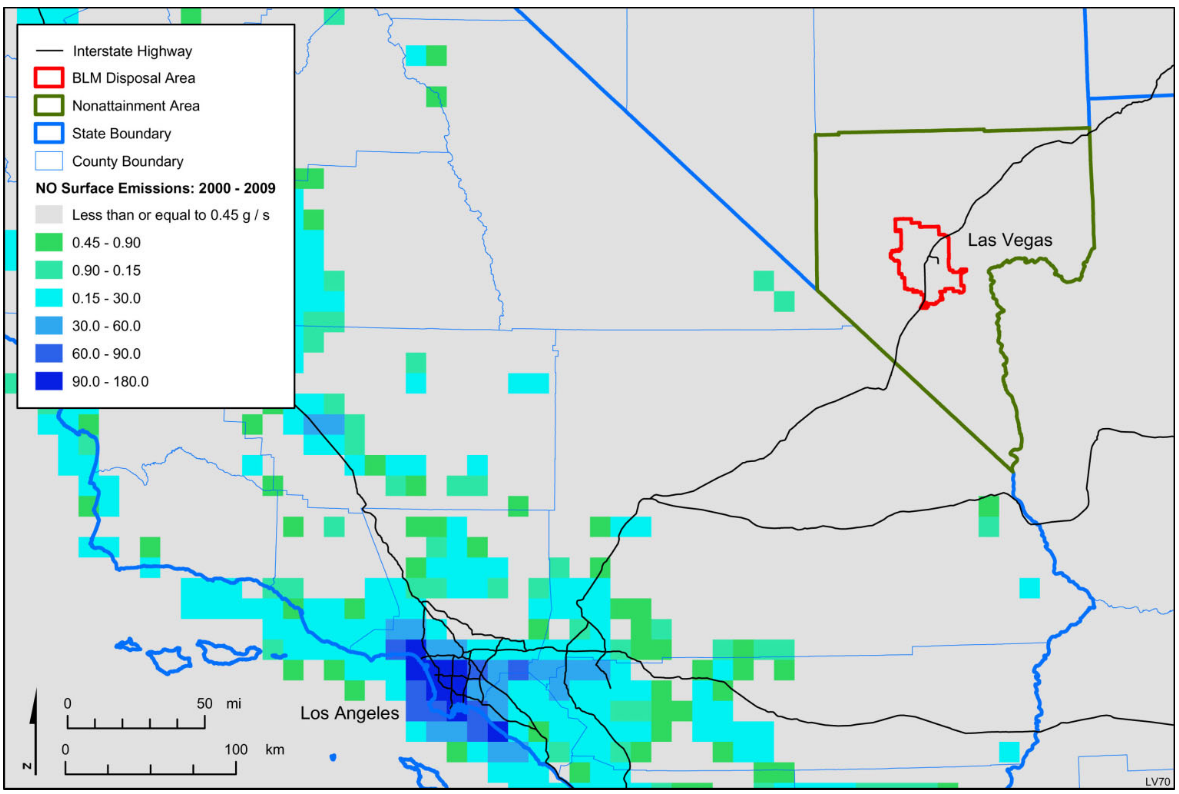

FIGURE 5.27 Difference in NO emissions at 4:00 p.m. Local Time on July 24 between the NEI-Based Inventory Calculations and Those Obtained by Using the WRAP Data. The Differences are Mainly Due to the Updated Mobile Emission Inventory Used for California.

13 Although a more stringent RFG requirement was implemented in California in 2004, establishing a flat RVP of 6.9 psi with a cap of 7.2 psi, the WRAP inventory was based on an RVP of 7.8 psi.

expected to decrease the CMAQ-generated boundary conditions[14] (e.g., horizontal and vertical O_3 concentration distribution on a plane at the outer edge of the inner grid) for the Las Vegas metropolitan area.

Figure 5.28 shows the emission reductions modeled for Las Vegas for 2009 compared with 2000 for the inner domain. The emissions for 2000 are higher by about 2.9–5.1 g/sec compared to those for 2009. These values represent mobile source NO emission reductions of approximately 20% for the compliance year (2009) and approximately 60% by 2018 compared to the base year (2000). These reductions are attributable primarily to the imposition of the federally required Tier 2 program that introduces lower-emitting vehicle engines, along with use of low-sulfur gasoline (to ensure the effectiveness of emission-control technologies and to protect catalysts in vehicle catalytic converters). The effect on O_3 as a result of this decrease is discussed later in the section. Similar decreases (30% by 2009 and 50% by 2018) in VOC emissions were also obtained assuming the use of RFG in Las Vegas for future years.

The coarse grid emissions impact the boundary conditions for the inner domain and, combined with the changes in the inner-domain emissions, result in a decrease in O_3 over much of the Valley from the base year to the future years. The results discussed in Section 5.4.3 were obtained by using available NEI emissions for California, Arizona, and Utah. The WRAP-calculated NO emissions over California are higher than those calculated using NEI data at a few selected grid locations. The impact of boundary conditions changes as a result of the switch from NEI to WRAP emissions in the new model runs, as shown in Figure 5.29, which illustrates a time series of 8-hour-averaged O_3 for the City Center monitoring site. The newer results are higher by selected episode days. Because the only difference between the new and old runs is emissions for the outer domain, we can assume that much of the calculated difference in O_3 is a result of a change in the outside emissions, i.e., boundary conditions. It also seems likely that boundary conditions (i.e., transport from Los Angeles) contribute to the high-O_3 episode days in the Las Vegas Valley calculated by the model.

To more fully explore the impacts of boundary conditions, we performed additional model runs for the period from August 1 to August 6, 2000. This time, the model boundary conditions were set to “continental background” conditions as shown in Figure 30, for the duration of the simulation. The continental background corresponds to about 30 ppbv O_3 (Logan et al. 1981) at the boundary of the inner domain and is fixed throughout the 6 days of simulation.

The difference in the model-calculated O_3 concentrations obtained by using the WRAP boundary conditions and the concentration calculated by using continental background conditions varies between 8 ppbv and 18 ppbv for noontime conditions and between 20 ppbv and less for nighttime background O_3. The contribution to high-O_3 days from boundary conditions could be 20% or much higher during the nighttime.

[14] Boundary conditions are conditions imposed by CMAQ for the outer grid and used in CMAQ to perform simulations in the inner grid to represent an influence on or contribution to the predicted concentration in Las Vegas caused by emissions from California. These boundary conditions are set on a vertical surface perpendicular to the perimeter boundary of the inner grid.

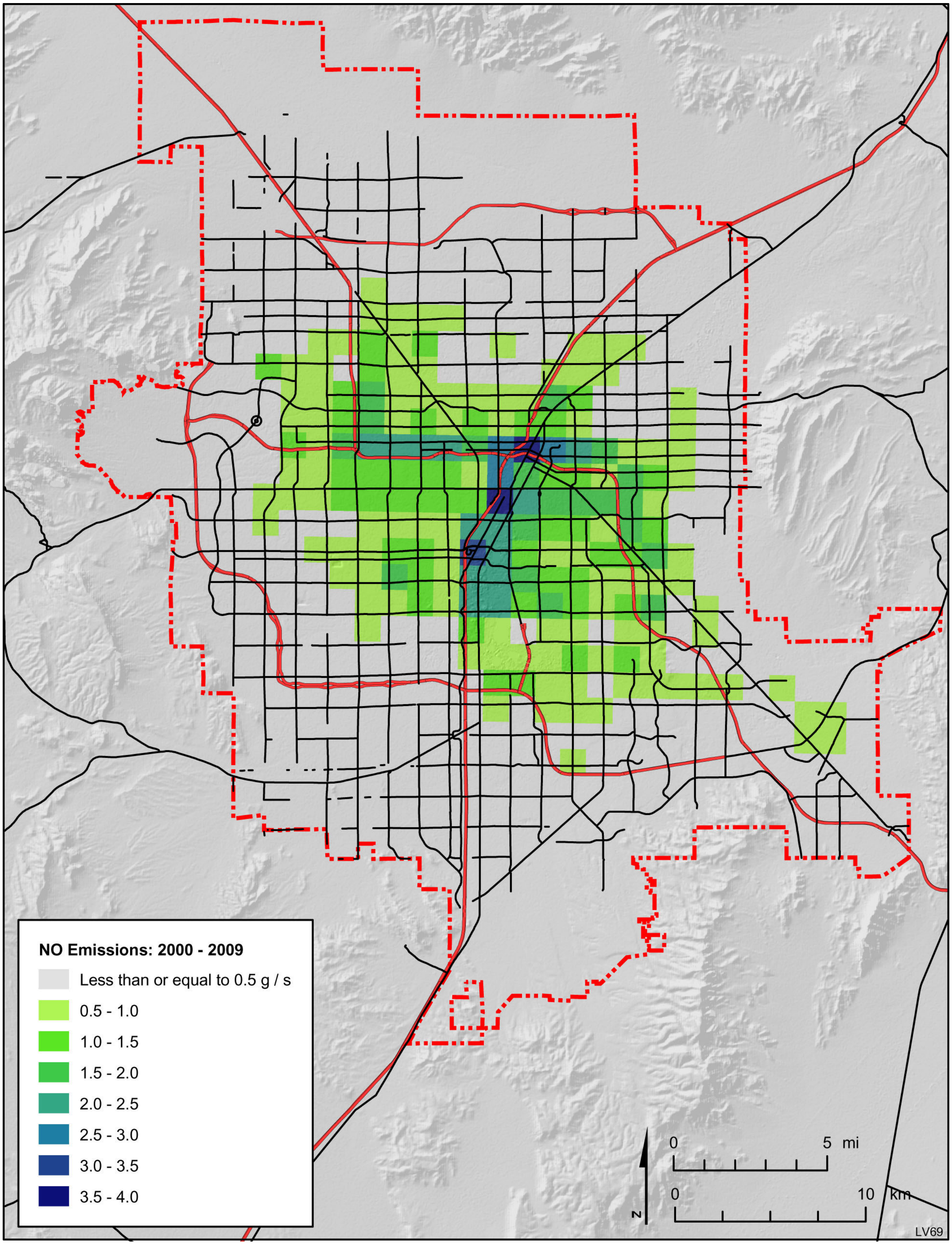

FIGURE 5.28 Difference in NO Emissions at 4:00 p.m. Local Time on July 24 between 2000 (base year) and 2009 Estimated for the Las Vegas Metropolitan Area.

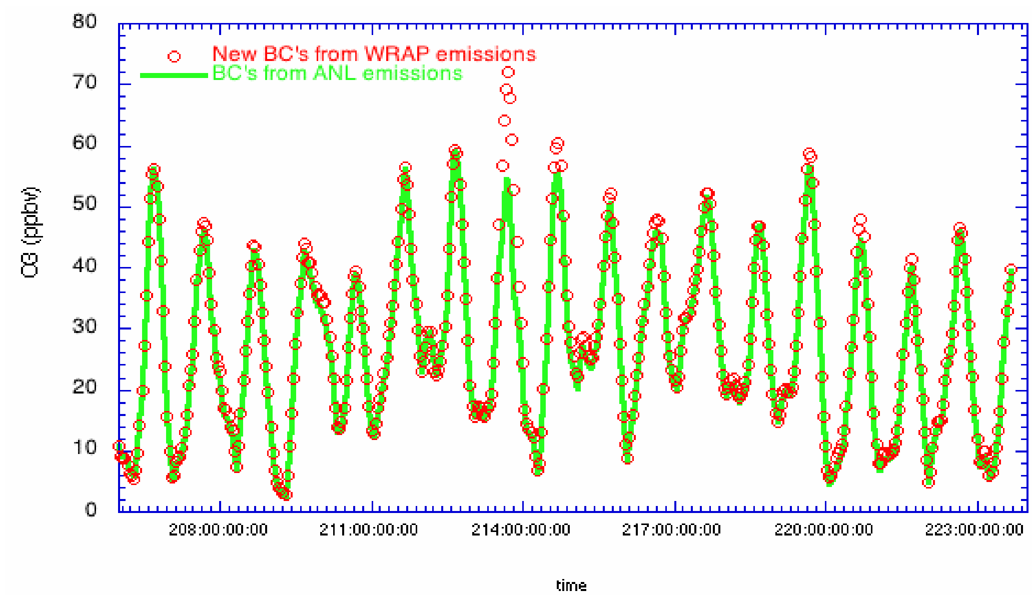

FIGURE 5.29 Calculated 8-Hour Average O_3 at the City Center Monitoring Station from July 24 to August 10, 2000 (Times shown are GMT. The circles represent the model simulations with WRAP-emission-inventory-generated boundary conditions; the green line represents ANL-emission-inventory-generated boundary conditions.)

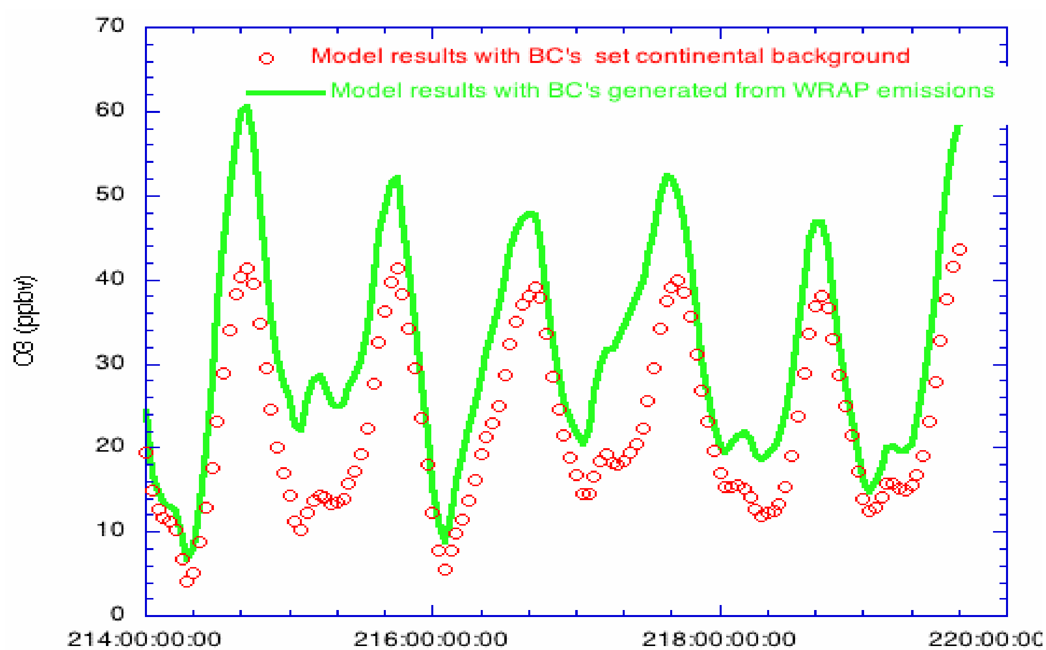

FIGURE 5.30 Calculated 8-Hour Average O_3 at the City Center Monitoring Station from August 1 to August 5, 2000 (The circles represent the model results with a continental background condition; the green line shows results with boundary conditions generated by using WRAP emissions.)

A more general domain-wide result is presented in Figure 5.31. Here, the differences between O_3 modeled with WRAP-generated boundary conditions vs. with continental background conditions are shown. Four times are shown: the top left corner results are for 12 GMT (4:00 a.m. local time), the right corner is for 16 GMT (8:00 a.m. local time), the lower left is for 20 GMT (12:00 p.m. local time), and the lower right is for 24 GMT (4:00 p.m. local time) for August 2, a day on which the model has the highest value of O_3, at about 70 ppbv. The differences shown are all for instantaneous values. The contribution from the boundaries is higher (about 20 ppbv) at nighttime; and at the time of highest O_3 (local) production in the Valley, it is only about 5 ppbv. A similar calculation was performed for the 2018 emission conditions, with boundary conditions set to continental background conditions and the base case using the estimated WRAP emissions for 2018, which were lower than 2000 emissions by approximately 70% for NO and VOCs.

5.4.4.2 O_3 Concentration Changes in Future Years — 2009 and 2018

The model was also used to calculate the changes in 8-hour-averaged and 1-hour-averaged O_3 from the base year (2000) to the future years (2009 and 2018). The changes at specific monitoring locations are discussed first, followed by the changes considering the entire modeling

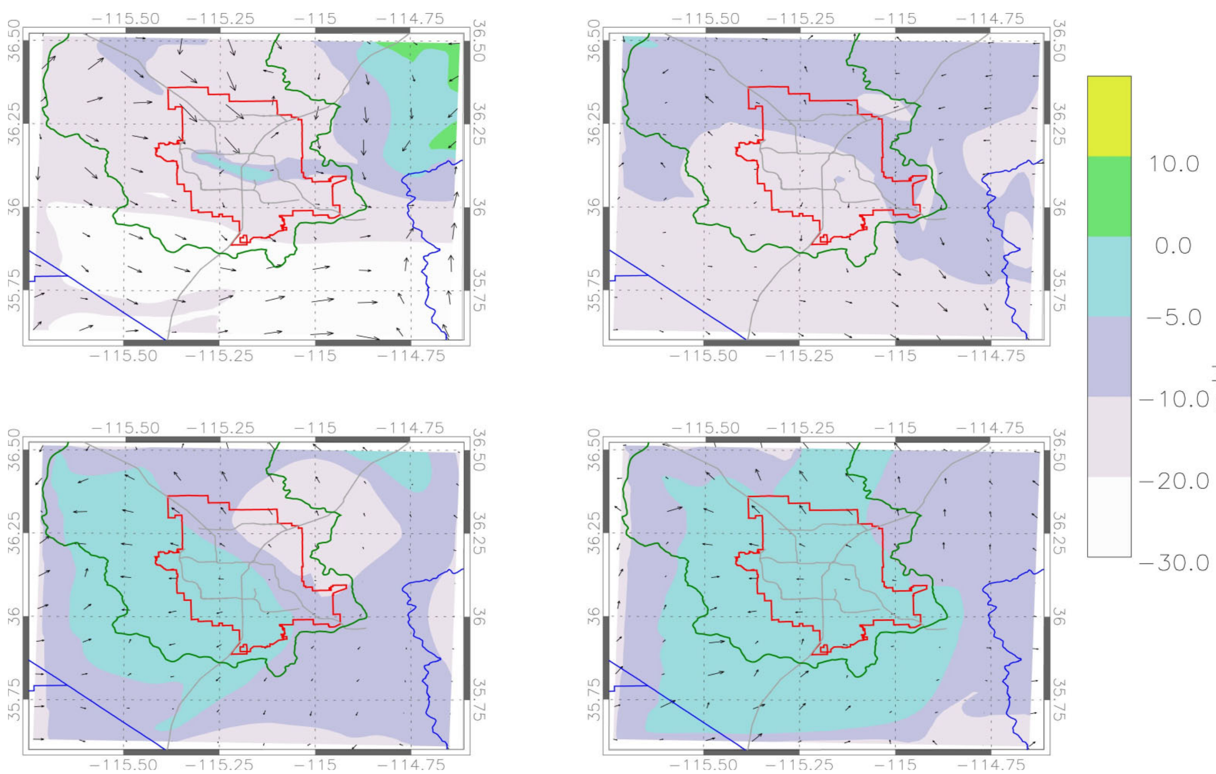

FIGURE 5.31 Calculated O_3 Difference in 2009 between a Simulation with Boundary Conditions Generated with Continental Background Conditions and Boundary Conditions Generated from WRAP Emissions for the Outer Domain during an August 2 Episode at Four Different Hours

domain. Figure 5.32 shows the calculated O_3 at the five sites for 2000, 2009, and 2018. At the Apex site (first panel), the maximum decrease in the predicted daily O_3 peak value is about 4 ppb for 2009 and 6 ppb for 2018 compared to 2000. At Boulder City (second panel), the predicted decrease in peak O_3 values is approximately 4 ppb by 2009 and extends to 8 ppb by 2018. The O_3 concentration at the City Center monitoring station (third panel), as discussed earlier, shows a small increase, on average about 3 ppb for 2009 and 9 ppb for 2018. The Jean site in the model (fourth panel) is entirely influenced by background air and flow from the boundary. Therefore the calculated differences in O_3 between the base and future years reflect the changes in emissions in the regions surrounding Las Vegas. The model predicts an average decrease of 2 ppb for 2009 and 3 ppb for 2019. The peak values are expected to decrease by 4 ppb by 2009 and 7 ppb by 2018. The Joe Neal monitoring site (fifth panel) also shows a decrease, by an average of 1 ppb by 2009 and 2 ppb by 2018. The peak O_3 values are expected to decrease by 4 ppb by 2009 and 6 ppb by 2018 at this site.

At the City Center monitoring station, changes in predicted 1-hour O_3 concentrations range from -2 to 8 ppb in 2009 and -1 to 18 ppb in 2018. Maximum daily peak values increase by about 3 ppb in 2009 and 11 ppb (maximum) in 2018. However, daily peak O_3 concentrations increase slightly for many days. NO_x is both a producer and a destroyer of O_3. In general, NO_x reductions result in decreased O_3 concentrations regionally, and VOC reductions result in decreased O_3 peaks (so-called “peak shaving”). At urban centers, which are typically VOC-limited areas, NO_x reductions only increase O_3 concentrations and VOC reductions only decrease O_3 concentrations. However, reductions in NO_X and VOC together could decrease or increase O_3 concentrations. Accordingly, balanced NO_x and VOC reductions could lower O_3 concentrations in urban centers and/or in downwind areas. The O_3 control policy should be determined by considering many underlying parameters, such as reductions in NO_X and VOC emissions, meteorology, spatial and temporal emission patterns, etc. for the area of interest. In addition, the best policy should be implemented in a way that will minimize total risks (e.g., reduce the number of people living in the upwind and downwind areas who are at risk).

Figure 5.33 shows the results from a decrease in California emissions from 2000 to 2018 for the same day and times as in Figure 5.31. This decrease leads to significant changes in the contribution of boundary conditions used in the O_3 simulations in Las Vegas Valley. Note that the figure shows the difference between O_3 levels generated for 2018 for two different boundary conditions, with emission reductions for Las Vegas included. As a result, the changes shown reflect the contribution of California air quality to the improvement of O_3 levels in Las Vegas. Ozone contributions from the boundaries are about 5–10 ppbv lower compared to the 2000 case (Figure 5.33) — an approximate 50% reduction in the contribution from the boundaries. However, its should be noted that O_3 production is quite complex; changes in the boundary conditions of O_3, as well as its precursors, do not necessarily relate linearly to the O_3 reductions in the Las Vegas Valley. The results should be considered as an indicator of the potential for future changes in Las Vegas air quality to be caused by changes in the quality of air in California.

An additional analysis was performed to evaluate the influence of future changes in emissions in the Las Vegas Valley on expected future local O_3 concentrations in the Valley. The O_3 concentration calculated for the base year (2000) with the boundary conditions set to

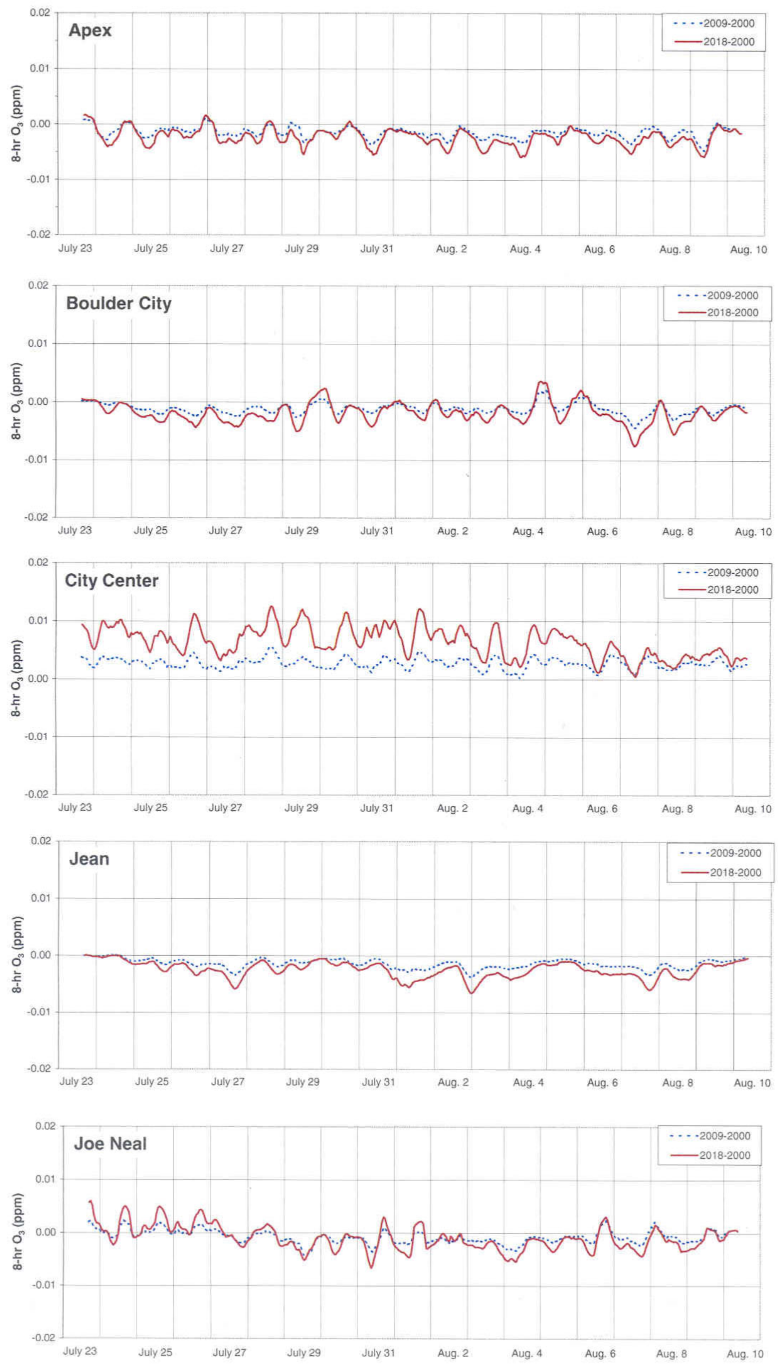

FIGURE 5.32 Differences in CMAQ-Calculated 8-Hour O_3 Levels (ppmv) in Future Years (2009 and 2018) from Base Year (2000) at Five Monitoring Sites in and around the Las Vegas Urban Region in June 23–August 10, 2000. (The series begins at 4:00 p.m. local time on June 23, 2000. Results are for the Apex site, northeast of the city [first panel]; the Boulder City site, southeast of the city [second panel]; the City Center [third panel]; the Jean site, southwest of the city [fourth panel]; and the Joe Neal site, northwest of the city [fifth panel].)

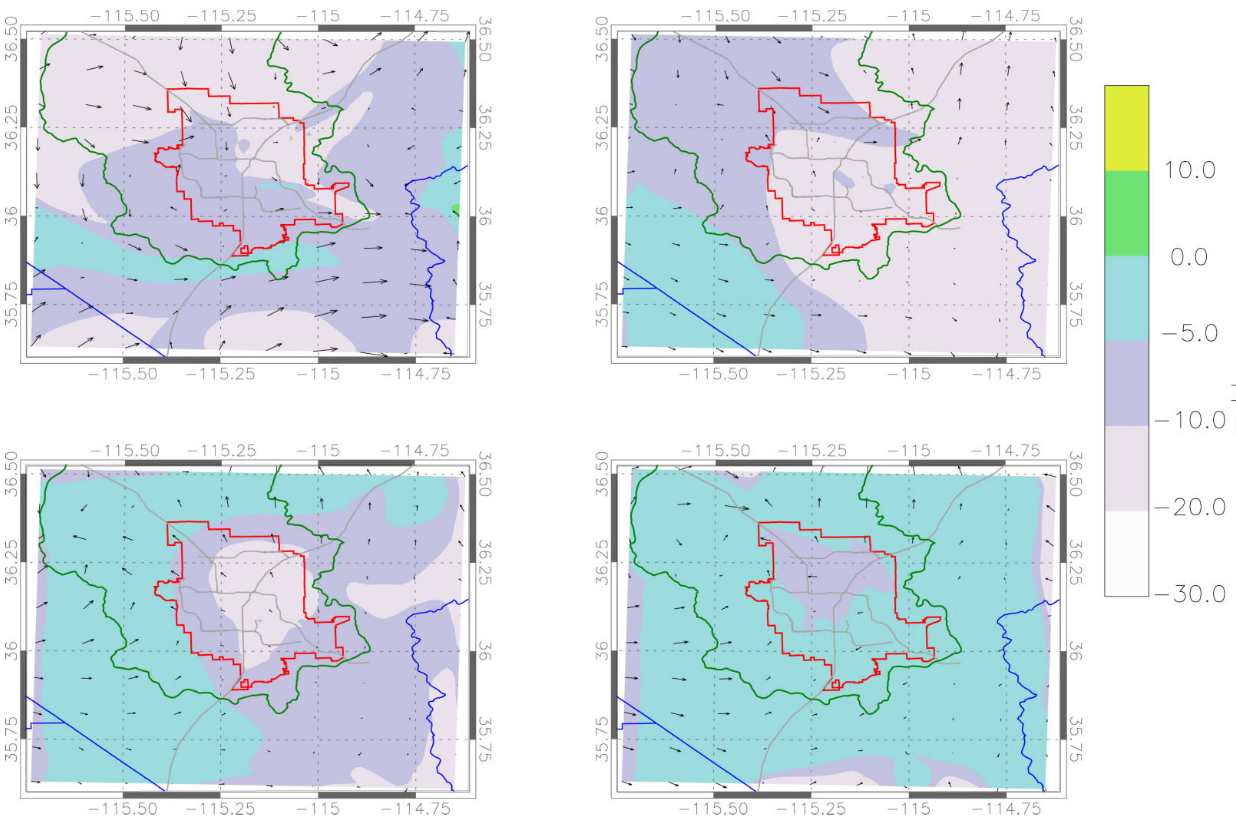

FIGURE 5.33 Calculated O_3 Difference in 2018 between a Simulation with Boundary Conditions Generated with Continental Background Conditions and Boundary Conditions Generated from WRAP Emissions for the Outer Domain for August 2 Episode at Four Different Hours

continental background conditions was subtracted from the O_3 level calculated for the year 2018 with similar continental background ozone boundary conditions. The only difference between these two calculations is the change in emissions in the Las Vegas region from 2000 to 2018, as shown in Figure 5.28.[15]

Figure 5.34 shows the difference in 8-hour average O_3 calculated for August 1 at noon for 2000 compared to the same date and time in 2018, with the modified boundary conditions and emissions as described above. The only change in the model conditions between these two calculations is the local emissions estimated for 2018 compared with 2000. Also shown in the figure is an O_3 increase in the center of the Las Vegas urban area, by values ranging from 2 to 10 ppbv, and decreases in areas to the west of the urban area by values ranging from 1 to 5 ppbv (positive values indicate that the 2000 O_3 concentration is higher than the 2018 O_3 concentration). The O_3 contours calculated for the year 2000 are also plotted in the figure for

[15] Although Figure 5.28 shows the NO differences between 2000 and 2009 emission levels, the spatial distribution for the NO change from 2000 to 2018 is similar. The magnitude of the overall reduction in 2018 is approximately 20% greater than in 2009.

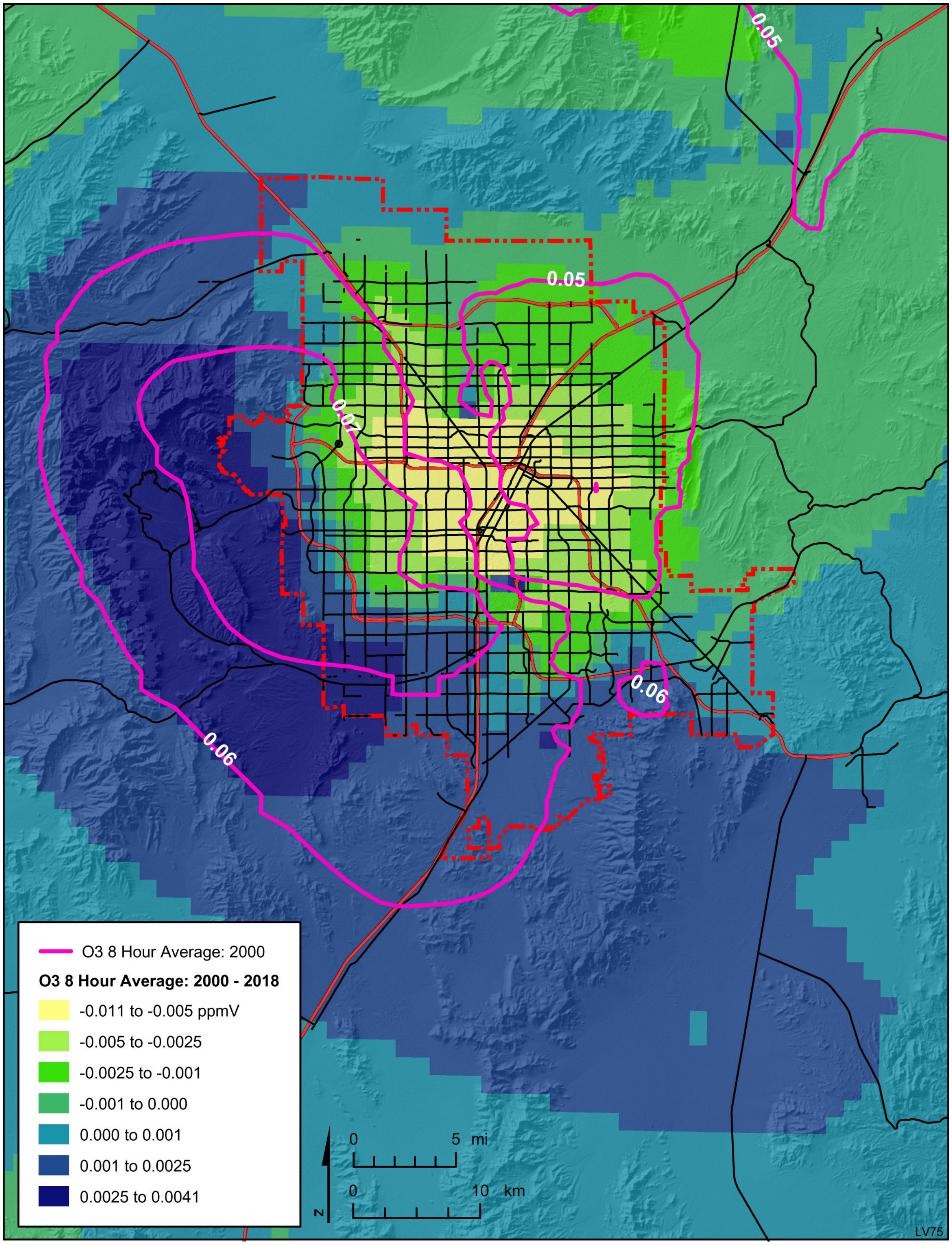

FIGURE 5.34 Change in 8-Hour Average O_3 Concentrations, 2000–2018, as Calculated by the Model for Daytime Conditions on August 1 at Noon Local Time

comparison. The urban center is marked by low O_3 concentrations of 30 ppbv or less. The areas to the west of the city, which show a decrease in O_3, have higher ozone concentrations — on the order of 60 ppbv or more. The maximum O_3 decreases (as a result of decreasing emissions) occur in the regions of highest O_3 production. Maximum increases in O_3 occur close to the City Center monitoring station, with significantly lower (by a factor of two) O_3 concentrations.

In general, as a result of emissions decreases, the nighttime O_3 values could be expected to increase over much of the urban domain, as shown in Figure 5.34. The figure shows the difference between a model case with boundary conditions set to continental background for the year 2000, compared to a model with boundary conditions set to continental background for the year 2018. The only change in the model conditions between these two calculations is the local emissions estimated for the year 2018 compared to those estimated for the year 2000.

The complicated behavior of O_3 results from the NO_X-O_3 chemical pathway. In the absence of sunlight and fresh NO emissions, NO titrates O_3 from the atmosphere. Thus, decreasing NO emissions at night in 2018 result in an increase in O_3, as seen in Figure 5.35. The chemical pathway for production of O_3 during daylight hours tends to produce O_3 from NO_X and available VOC after some chemical processing time, which could range between an hour and a half-day, depending on the availability of VOCs, water vapor, and ultraviolet light. As a result, peak O_3 levels are generally observed away from regions of highest NO/VOC emissions, such as in downtown areas. A decrease in NO emissions from mobile sources has the immediate effect of reducing the O_3 destruction pathway in the intense source regions (i.e., downtown areas) and, as a result, increasing O_3 in these regions. But away from the source region and regions where O_3 maxima are observed, after a certain amount of chemical processing, peak calculated values of O_3 decrease as a result of the decrease in NO_X and VOC emissions. Because the urban core generally contains much less O_3 during peak hours than the downwind areas, the overall impact of source reduction is beneficial to areas experiencing high-O_3 episodes.

A further illustration of this effect is provided in Figure 5.36, which shows results from the application of an enhanced CMAQ model that uses a decoupled direct method for three-dimensional model (DDM-3D) sensitivity analysis developed at the Georgia Institute of Technology. The analysis is used to calculate the first-order sensitivity of O_3 and other gases in the model to a change in precursor emissions. The figure shows the O_3 concentration change for a 100% increase in NO emissions, after approximately 36 hours from the start of the simulation. Contours show calculated O_3 levels in the same model at approximately noon local time for July 25, 2000. The model results indicate a large decrease in O_3 of up to 20 ppbv in the urban center and beyond and an increase of 7 ppbv or higher around the plume in the direction of the flow. In this case, regions further downwind of Las Vegas can expect even higher O_3 concentrations than the 7 ppbv indicated for areas immediately surrounding the urban plume.

The cumulative impacts of changing both the local emissions and boundary conditions, resulting from lowering emissions in California, were estimated by using a series of model runs. The base case for the year 2000 included boundary conditions generated by using emissions from the WRAP for the outer grid and local emissions for the 1.3-km domain. The future-year model runs (2009 and 2018) included emissions generated for the inner grid for these years based on

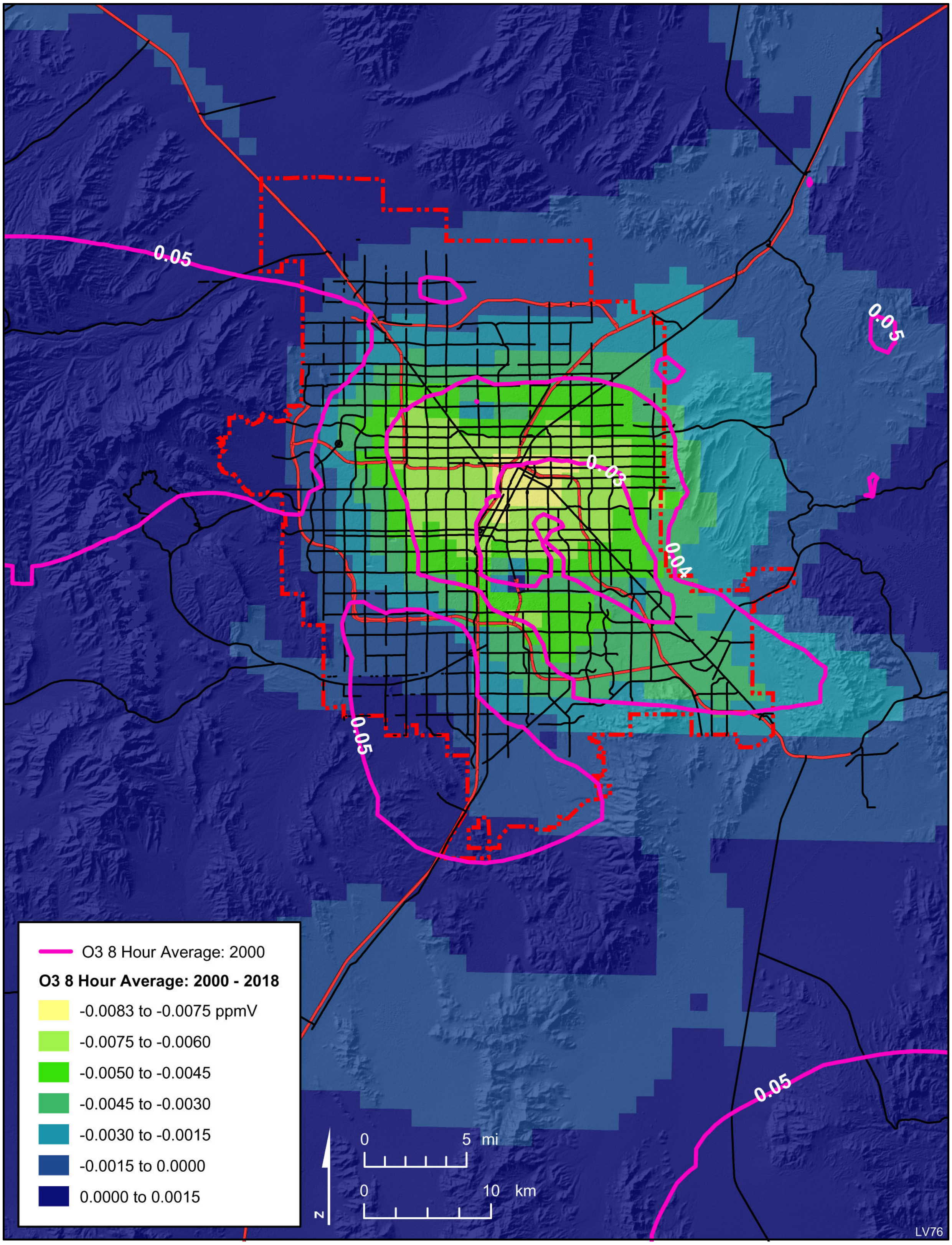

FIGURE 5.35 Change in 8-Hour Average O_3 Concentrations, 2000–2018, as Calculated by the Model for Nighttime Conditions on August 2 at 4:00 a.m. Local Time

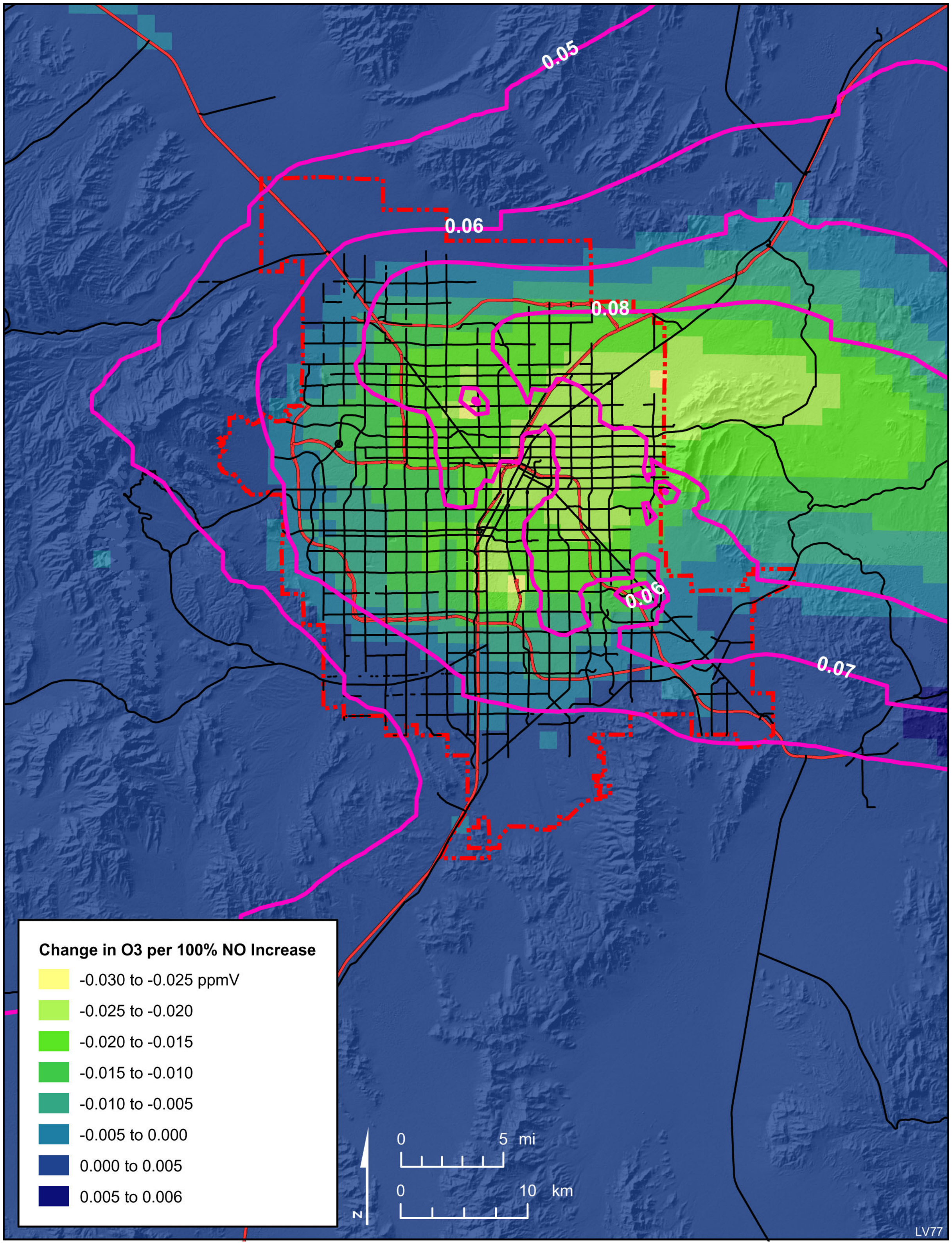

FIGURE 5.36 Computed First-Order Sensitivity Change (ppmv) in O_3 That Results from a 100% Increase in NO Emissions with CMAQ DDM-3D for Calculating Emission Sensitivities

data sets and projections provided by Clark County staff, as discussed in Section 4. The boundary conditions for these future years were generated by using an approximately 50% reduction in NO and VOC emissions for California from the year 2000 WRAP emissions, as explained previously. The results presented below illustrate the differences among the model-generated results for these three simulations and present the case of an ozone "event" calculated by the model for July 31 and the effect of future emission controls on ozone "episode" peak values under similar meteorological conditions.

To allow direct comparison with Figure 5.34, Figure 5.37 illustrates a calculated difference between year 2000 and 2018 8-hour average O_3 values at the surface for August 1 at noon local time. The regions where the 2000 O_3 values are higher are, as in Figure 5.34, to the west of the urban core. But now the change in O_3 is between 7 and 10 ppbv — greater than the 5-ppbv reductions obtained by emissions changes alone, as shown in Figure 5.34. Thus, the cumulative impact of local emission controls and emission controls in California will reduce the peak O_3 values from around 70 ppbv calculated for 2000 (as shown by the contours) to less than 60 ppbv in 2018. The increase in O_3 concentrations in the urban core is now greater — 7–14 ppbv compared to 6–10 ppbv for the emissions control alone, as shown in Figure 5.34. This increases the O_3 concentrations in the urban core to about 50 ppbv, compared to over 30 ppbv in Figure 5.34. Thus, the cumulative impact of boundary condition changes and local emission controls is to amplify the impact of emission controls alone, by an average of 5 ppbv in the same general direction (O_3 decreases in areas where O_3 decreased with emission controls alone and vice versa).

The highest O_3 concentration in the 18 days simulated with the WRAP-generated boundary conditions was obtained for July 31. Ozone values of greater than 90 ppbv were calculated at locations to the north and northeast of the city for 8-hour averages at approximately noon local time. It should be noted that the model calculates 8-hour averages by taking the average of 8-hour O_3 values calculated in front of the current hour. Thus the 8-hour average at 10:00 a.m. corresponds to O_3 averaged from values calculated between 10 and 18 hours local time. This, in effect, is the calculated daytime high of O_3 for the particular day. Figure 5.38 shows the difference in O_3 between the model calculation for 2000 and 2009 at 10:00 a.m. local time. Reductions in peak O_3 values of about 4 ppbv to 10 ppbv were obtained for the regions of highest calculated O_3. A similar comparison, shown in Figure 5.39 for 2000 to 2018, reveals an O_3 decrease of about 7 ppbv in the highest calculated O_3 region. Both difference plots (Figures 5.38 and 5.39) are during the time of highest 8-hour-averaged O_3 concentrations. Thus, for the model-generated peak O_3 episode, we calculate a decrease in the peak O_3 values for the two future cases. Also, as discussed earlier, there is an increase in O_3 for the future years in the urban core of 2–8 ppbv for 2009 and 7–14 ppbv for 2018 compared to 2000. However, these O_3 increases occur in generally low-O_3 regions and would not lead to O_3 standard violations in these regions.

In future years, O_3 precursor emissions, NO_x and VOC, would be reduced overall — most significantly in the mobile source category as a result of the introduction of Federal Tier 2 requirements and the assumed use of RFG. In addition, contributions from Los Angeles might cause an O_3 decrease in the Valley to some extent. At most stations except the City Center

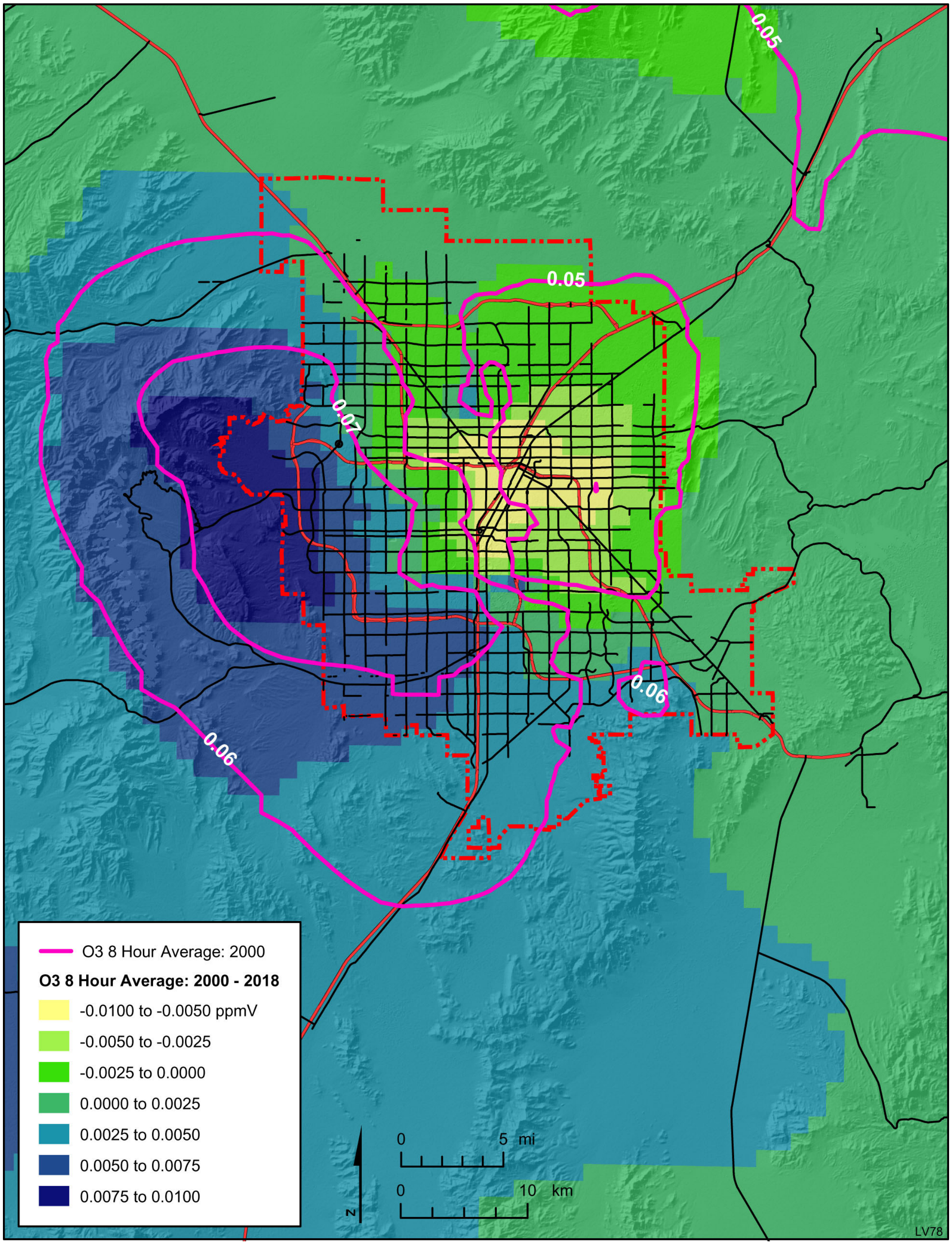

FIGURE 5.37 O_3 Change Calculated by the Model for August 1, 2000, Noon Local Time (8-hour average) (Figure shows the difference between a model case with boundary conditions calculated from outer-grid simulations using WRAP emissions for the year 2000, compared to a model with boundary conditions generated from lowered WRAP emissions for the year 2018 and a lower local emissions inventory.)

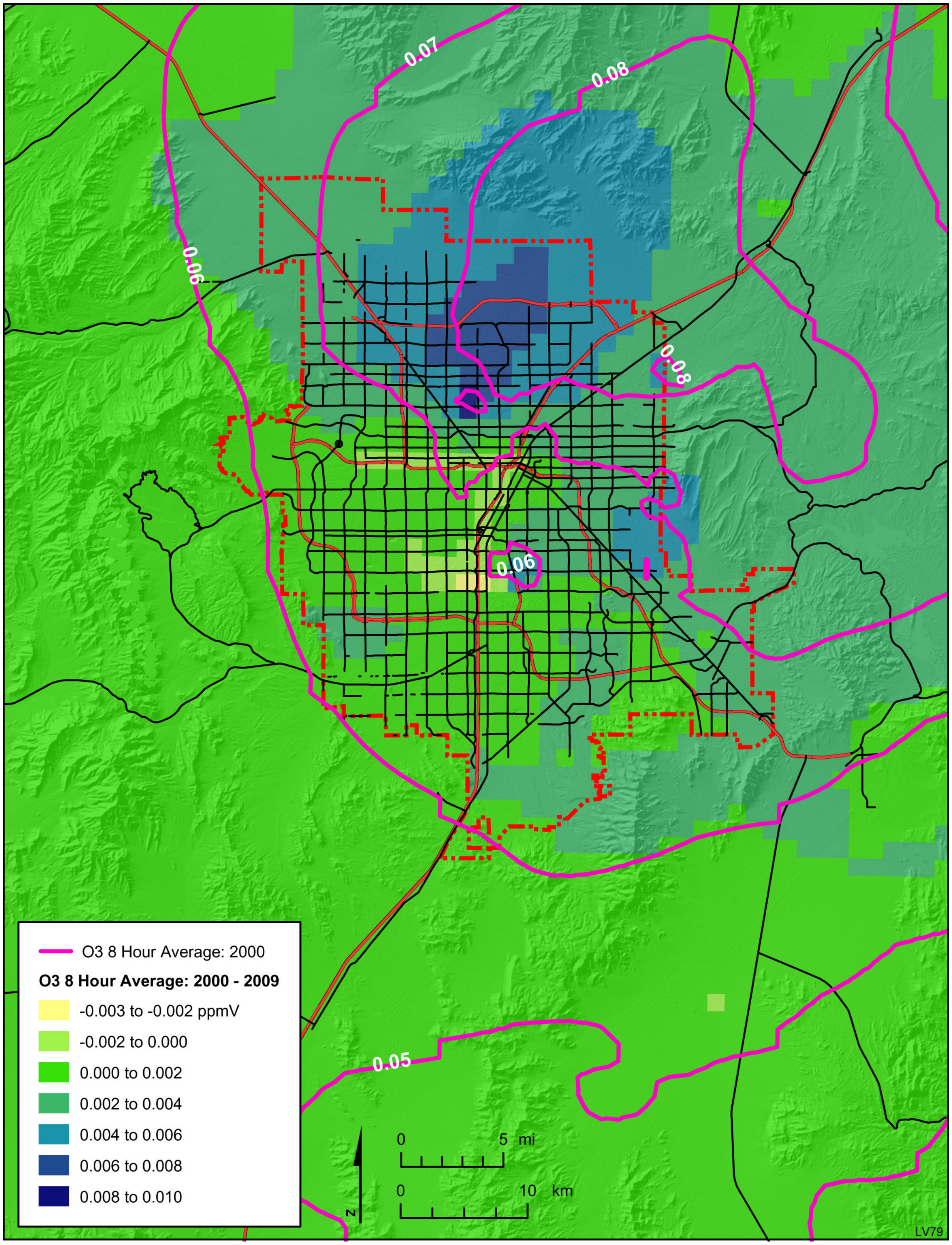

FIGURE 5.38 O_3 Change, 2000–2009, Calculated by the Model for July 31 at 10:00 a.m. Local Time (8-hour average).

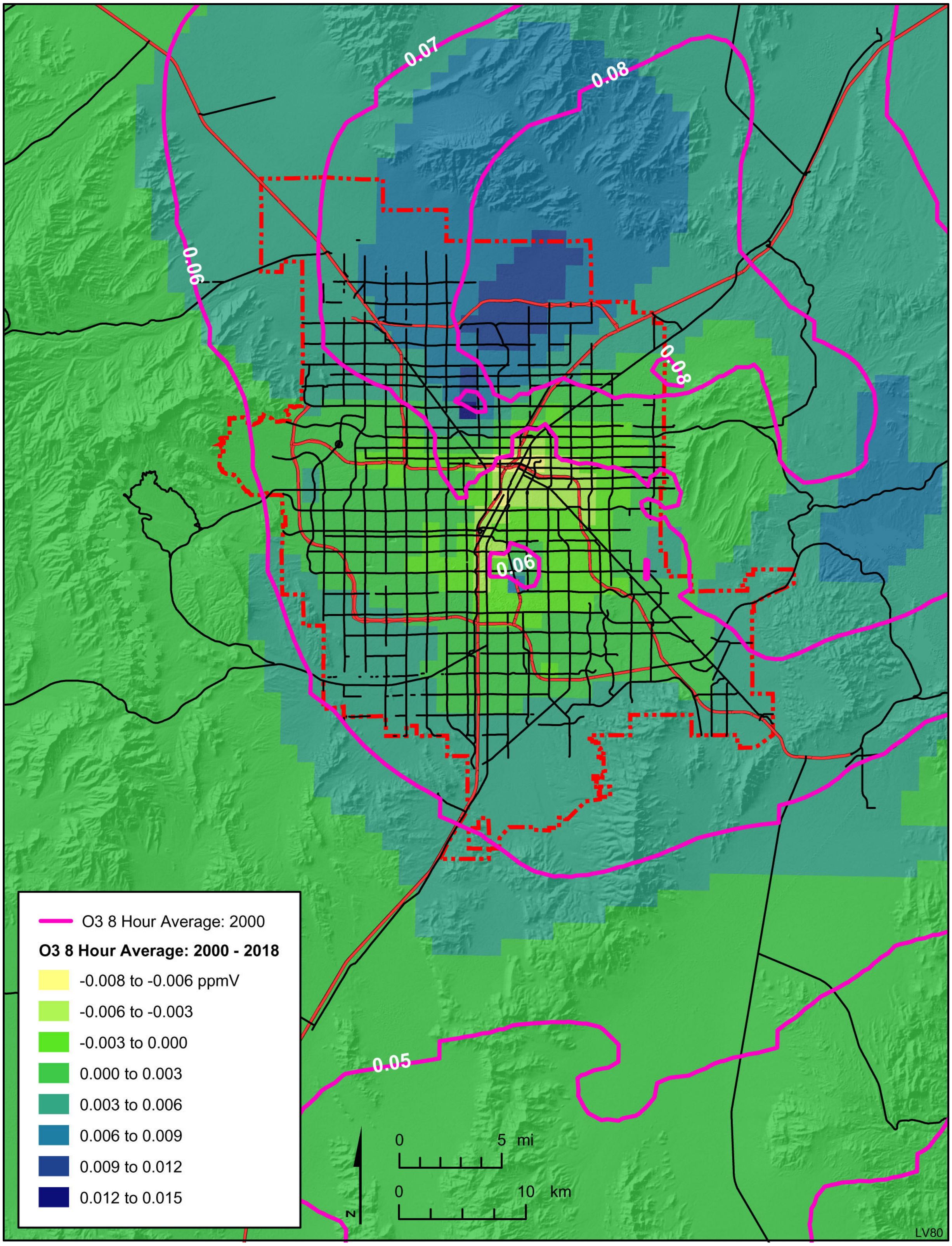

FIGURE 5.39 O_3 Change, 2000–2018, Calculated by the Model for July 31 at 10:00 a.m. Local Time (8-hour average).

monitoring station, O_3 levels show a downward trend in future years; more O_3 reductions were seen in 2018 than in 2009. At the Apex site, daily peak O_3 concentrations would be lower by 5 ppb in 2009 and by 9 ppb in 2018 than those in 2000. At the Boulder City site, the patterns of decrease in peak O_3 concentrations are similar, but less than, those at the Apex site. At the Jean site, where reductions in O_3 precursor emissions are less affected than those at other monitoring stations in and near Las Vegas, daily peak O_3 concentrations would be lower by 4 ppb in 2009 and 7 ppb in 2018 than those in 2000. At the Joe Neal site, O_3 concentrations in 2009 and 2018, when compared with those in 2000, would be higher and lower, depending on the hour of the day. In general, daily peak O_3 concentrations are lower in future years. However, O_3 concentrations at non-peak hours (late night or early morning) are sometimes higher; these results are believed to be associated with wind drainage flow in the valley.

5.4.5 Comparison of Model Predictions with Air Quality Measurements

Measured O_3 and PM_{10} concentrations at 15 and 16, respectively, DAQEM monitoring sites from July 24, 2000, to August 10, 2000, and from June 1 to August 31, 2000, for CO, were used to compare the model simulations with observations. The monitoring site locations ranged from Apex (northeast of the Las Vegas urban region) to Jean (southwest of the city).

Observed and modeled 1-hour and 8-hour average O_3 concentrations at five monitoring sites around the Las Vegas Valley are presented. Although the modeled O_3 concentrations for the simulation period were generally lower than the observed values, the differences were small — on average within 15% of the measured values. In general, modeled values capture typical diurnal patterns and peaks. During the simulation period, measured 1-hour and 8-hour peak O_3 concentrations were 0.107 and 0.086 ppm, respectively, and modeled 1-hour and 8-hour peak O_3 concentrations were only 0.003 ppm lower than measured values, although the peak concentrations (between measured and modeled) do not occur on the same days. Figure 3.2 shows the locations of the monitoring sites within the Las Vegas Valley. The following paragraphs discuss the comparisons made between model predictions and measurements of 1-hour and 8-hour O_3 and 24-hour PM_{10} concentrations for the base year (2000).

5.4.5.1 1-Hour O_3 Concentrations

One-hour measured and modeled O_3 concentrations at the Apex site, which is located 20 miles northeast of downtown Las Vegas near the Apex Industrial Complex, show excellent agreement for the simulation. Figure 5.40 (first panel) shows the observation versus prediction time series. Because the Apex site is often downwind from the urban area, it experiences a relatively high O_3 level, compared to the rest of the domain, during the hours of peak O_3 production in the afternoon.

Figure 5.40 (second panel) shows the time series of predicted and measured O_3 levels at Boulder City, which is located 20 miles southeast of downtown Las Vegas adjacent to Lake Mead. Monitoring data indicate that O_3 concentrations are about 40 ppb at night,

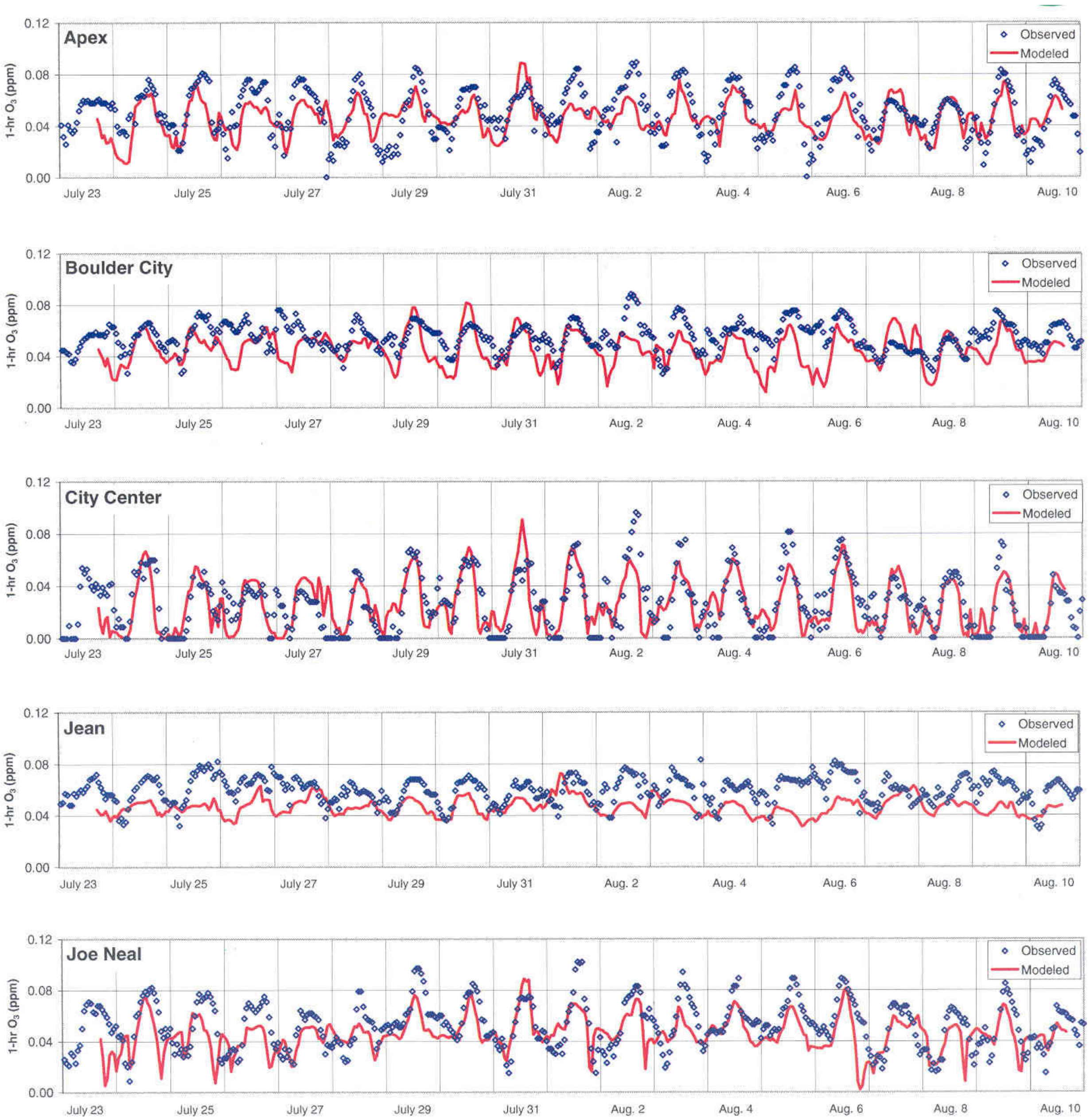

FIGURE 5.40 Time Series of Measured and CMAQ-Calculated O_3 Levels (ppmv) at Five Monitoring Sites in and around the Las Vegas Urban Region, July 23–August 10, 2000 (The series begins at 4:00 p.m. local time on July 23, 2000. Results are for the Apex site, northeast of the city [first panel]; the Boulder City site, southeast of the city [second panel]; the City Center site [third panel]; the J.D. Smith site, near the City Center site [third panel]; the Jean site, southwest of the city [fourth panel]; and the Joe Neal site, northwest of the city [fifth panel].)

suggesting that the site is typical of a background site. Minor secondary peaks were observed during many nights; these are believed to be associated with wind drainage patterns from Las Vegas.

Figure 5.40 (third panel) shows the time series of calculated and measured O_3 levels near the City Center monitoring station, which is located near the intersection of Highways 15, 95, and 515. For City Center, there is excellent agreement between the measurements and calculations, with the model capturing not only the peak O_3 values during the afternoon hours (2:00 p.m.) but also the low values observed during nighttime. These low (near-zero and zero) O_3 values in the urban center result from continued emissions of fresh NO into the urban core after sunset and the resulting titration of O_3 with fresh NO to produce NO_2.

Model calculations for the Jean site, which is located 20 miles southwest of downtown Las Vegas, indicate a background site (Figure 5.40, fourth panel). This site is downwind of Los Angeles and upwind of Las Vegas. Considering the prevalence of a southwesterly wind in the Valley, this site is one of the principal monitoring stations for examining long-range transport of O_3 and its precursors from Los Angeles. On average, the measured and modeled concentration levels are around 40 ppb at night, which suggests that the site is typified by background characteristics. Modeled concentrations at this site were underpredicted by a maximum of about 40 ppb, suggesting that contributions of O_3 and its precursors from Los Angeles were not reflected properly if southwesterly winds are prevalent during this period, particularly during the O_3 episode (August 1–6, 2000). This underprediction might be attributable, in part, to exclusion of nearby highway emissions in the model because the VMT data developed by the RTC for mobile sources are limited to the Las Vegas urban area.

The Joe Neal site is located about 6 miles northwest of the City Center. It is a typical suburban monitoring station in that both the daytime O_3 peak and the nighttime O_3 minimum concentrations are higher than at the City Center station. This site is the only station in the Valley that recorded an 8-hour O_3 violation in 2003 (at 86 ppb). As shown in Figure 5.40 (fifth panel), the model underestimates the peak O_3 values during the simulation, but the modeled behaviors are in good agreement with the observed ones. In particular, the model predicted the subtle fluctuations in O_3 concentrations that occur during non-peak hours. The site seems to be influenced by urban air during the simulation period — more than predicted by the model. The influence of urban air on this site during nighttime, however, seems minimal, according to both the measurements and the calculations, as would be expected from the direction of the nighttime wind drainage flow.

5.4.5.2 8-Hour O_3 Concentrations — Base Year (2000)

The 8-hour average values for modeled and measured O_3 were calculated for the June 24–August 10 time period for the year 2000. The 8-hour average smooths out the hourly short-term fluctuations and provides a more generalized view of O_3 concentrations in the Valley. Figure 5.41 shows the observed and modeled O_3 concentrations for five selected monitoring sites. These sites were chosen to represent the prevailing conditions at different locations in the

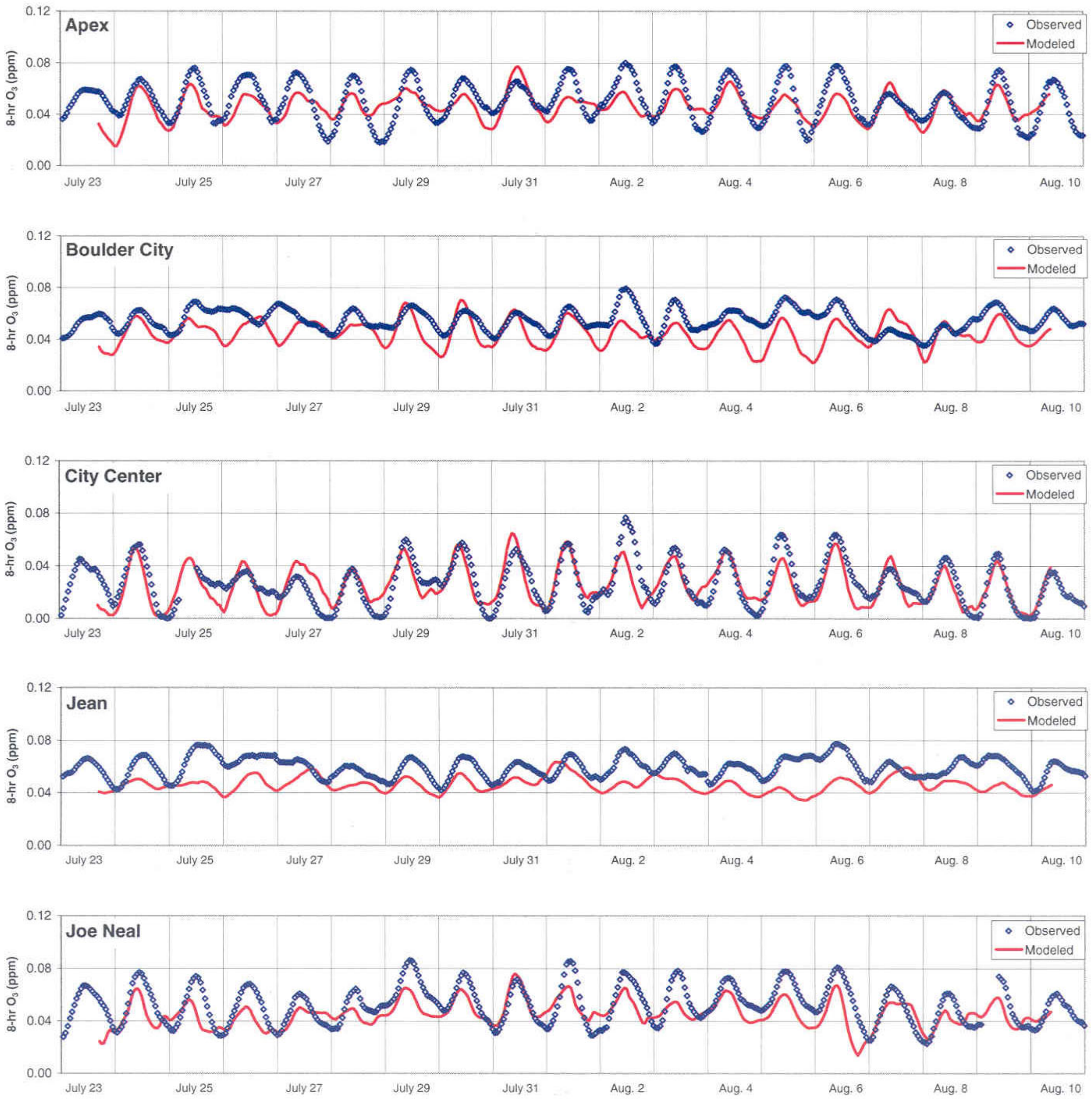

FIGURE 5.41 Time Series of Measured and CMAQ-Calculated 8-Hour O_3 Levels (ppmv) at Five Monitoring Sites in and around the Las Vegas Urban Region, June 23–August 10, 2000 (The series begins at 4:00 p.m. local time on June 23, 2000. Results are for the Apex site, northeast of the city [first panel]; the Boulder City site, southeast of the city [second panel]; the City Center site [third panel]; the Jean site, southwest of the city [fourth panel]; and the Joe Neal site, northwest of the city [fifth panel].)

Valley. The Apex site is located to the northeast of the city; it is downwind of the downtown area on a number of occasions during the summer O_3 period. The modeled and observed O_3 concentrations at this site are generally higher than the rest of the domain during the daytime. The model, in general, shows good agreement with the observations, with less than a few ppb difference between modeled and measured O_3 peaks for 65% of the days modeled. The differences between measured and modeled concentrations are in excess of 10 pbb for the reminder (35%) of the period.

The second panel in Figure 5.41 shows the 8-hour-averaged modeled and measured O_3 concentrations for the Boulder City monitoring station, located to the southeast of the urban center. The observed O_3 concentration here is representative of a background station with occasional downwind influence from the urban center. Typical of a station not experiencing fresh NO emissions, the nighttime O_3 does not decrease significantly, and the diurnal variation in O_3 is not as large as that experienced in the downtown region (shown in the next panel) or a suburban downwind wind location (such as Apex). The modeled O_3 concentrations generally follow the trends exhibited by the measured O_3 and the average modeled O_3 over the 16-day period.

Modeled and observed O_3 concentrations for the City Center monitoring station are shown in the third panel of Figure 5.41. The agreement is generally excellent, and the model reproduces both the measured daytime maxima and nighttime minima with sufficient accuracy. The measured O_3 peak on August 2 was underpredicted by about 25 ppb, and a few of the nighttime low O_3 values of near-zero ppb were not also reproduced by the model.

The fourth panel shows the modeled and measured 8-hour-averaged O_3 concentrations for the Jean monitoring station, which is located to the southwest of the city at an elevation of 3,000 ft (higher than the rest of the monitoring stations in the Valley). As noted before, the mobile sources considered did not include Highway 15, which is located close to the monitoring station. The modeled 8-hour O_3 concentration shows small diurnal variability, suggesting minimal local O_3 production. The measured O_3 shows much larger diurnal variability, suggesting possible local O_3 production. The exclusion of the local emissions and the possible modeled and real elevations of the station contributed to the underprediction of O_3 at this site.

The fifth panel shows the predicted and measured O_3 at the Joe Neal monitoring site, to the northwest of the downtown area. The modeled and measured O_3 are in good agreement, although the model is not able to reproduce the measured O_3 peaks during the first 3 days of August in particular. The model does reproduce the essential characteristics of the measured O_3, including the diurnal variation.

5.4.5.3 1-Hour CO Concentrations — Base Year (2000)

Calculated CO values show similarly good agreement with measurements. Figure 5.42 (first panel) shows CO values for the City Center. In general, the modeled CO is consistent with the measurements during the first part of the month, but the modeled values are lower by about 1.0 ppm later in June and the rest of the summer. The measurements are set to zero values at a

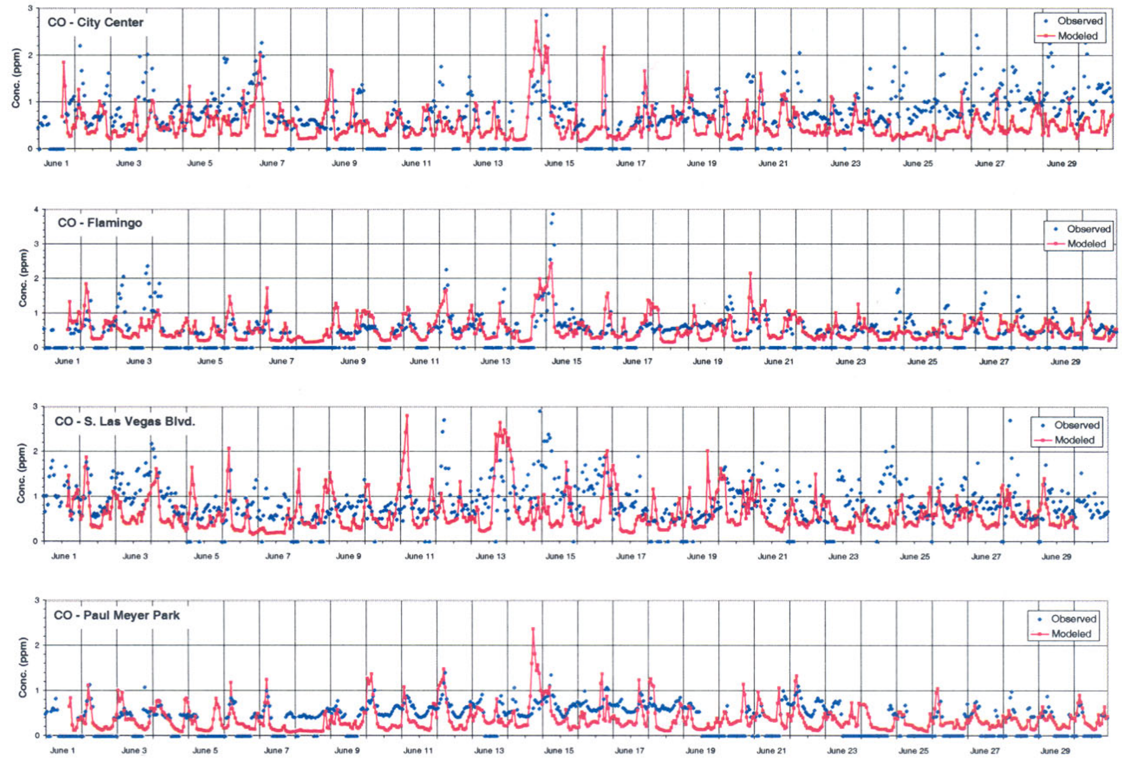

FIGURE 5.42 Time Series of Measured and CMAQ-Calculated CO Levels (ppmv) at Four Monitoring Sites in and around the Las Vegas Urban Region in June 2000 (The series begins at 4:00 p.m. local time on June 1, 2000. Results are for the City Center [first panel]; the Flamingo site, south of the City Center site [second panel]; the South Las Vegas Boulevard site, near the Flamingo site [third panel]; and the Paul Meyer Park site, southeast of the city and away from the urban area [fourth panel].)

detection limit of about 0.4 ppm; this gives the model results an apparent bias to lower values versus the measurements.

The next site with sufficient CO measurements is Flamingo, directly south of the city center. For this site, the modeled and measured CO values show excellent agreement (Figure 5.42, second panel). At the nearby South Las Vegas Boulevard site, there is also generally good agreement between measured and modeled CO (Figure 5.42, third panel). The South Las Vegas site experiences more CO than the Flamingo site and seems comparable to the city center. All of these sites near the urban core are significantly influenced by emissions from motor vehicles and from McCarran Airport.

Calculated and measured CO values for a site farther from the urban core are shown in the fourth panel of Figure 5.42. Overall, the CO levels at this site are lower than the measurements for sites near the urban core (top through third panels of Figure 5.42). The model again shows a tendency to have lower CO values at this background site (during the middle of the month), as shown in Figure 5.42 (fourth panel).

The CMAQ-predicted 24-hour average PM_{10} concentrations show good agreement at 9 of the 16 reporting Clark County monitoring sites in 2000; for more than 50% of the time, predictions agree with observations (well within a factor of two). Predictions at 4 of the 16 stations showed fair agreement with observations; for more than 30% of the time, predictions agree with observations (well within a factor of two). Predictions at 3 of the 16 stations showed poor agreement; for less than 30% of the time, predictions agree with observations (within a factor of two). In general, observed and modeled concentrations at monitoring stations located west of and along Highway 15 tend to be in good or fair agreement. Observed and modeled concentrations for stations located east of the Highway 15 tend to be in fair or poor agreement.

Figure 5.43 shows the observed and model-predicted PM_{10} time series beginning on July 24, 2000, and ending on August 9, 2000, for four sites at which CMAQ showed good agreement with observations and for one site where poor agreement was indicated. Out of four “good-agreement” sites, two “best-agreement” sites were included; at these sites, more than 90% of the time predictions agree with observations (well within a factor of two) over the 17-day simulation period. The predictions at the J.D. Smith site (near the center of the BLM boundary) and the Lone Mountain site (in the northwest) show the best overall agreement with observations (Figure 5.43, first and second panels), with over 90% of the comparisons agreeing within a factor of two. The agreement of model predictions and observations is relatively good at the City Center site, 80% of the time, and not as good at the Palo Verde site (near Interstate 215 at the far western edge of the boundary). Yet on 50% of the days, predictions agree with the measured readings within a factor of two (Figure 5.43, third and fourth panels). The model predictions are good only 20% of the time when compared with the measurements (Figure 5.43, fifth panel) at the Apex site (in the far northeast portion of Las Vegas Valley outside the boundary).

The CMAQ-predicted PM_{10} concentrations show fair and poor agreement (less 50% of the time, predictions agree with observations within a factor of two) at three sites in the southeast portion of the BLM boundary. The model predictions do not match well with the measurements at the Green Valley site (Figure 5.44, first panel); the predictions agree with observations within a factor of two only about 21% of the time, with the data showing a strong positive bias (more than a factor of three) the rest of the time. The comparisons with measurements at the Pittman and South East Valley sites are better, with predictions agreeing with observations within a factor of two about 31–44% of the time.

CMAQ PM_{10} simulations are highest, primarily as a result of windblown dust, over largely underdeveloped areas like the southwest portion of the BLM boundary. This region corresponds to areas for which the data needed to determine accurate levels of soil sheltering, disturbance, and stability were not readily available. The model predictions in these areas would therefore be more uncertain as a direct result of the uncertainty associated with the windblown dust estimates. Because the main question here relates to air quality impacts associated with future land use changes, the concern over the magnitude of the uncertainty associated with predicting these emissions in the future would be mitigated by the anticipated decrease in the areal extent of the source-emitting region. In other words, wind erosion of the native soil would decrease as a result of expected increases in soil sheltering at the time that the land would become more fully developed.

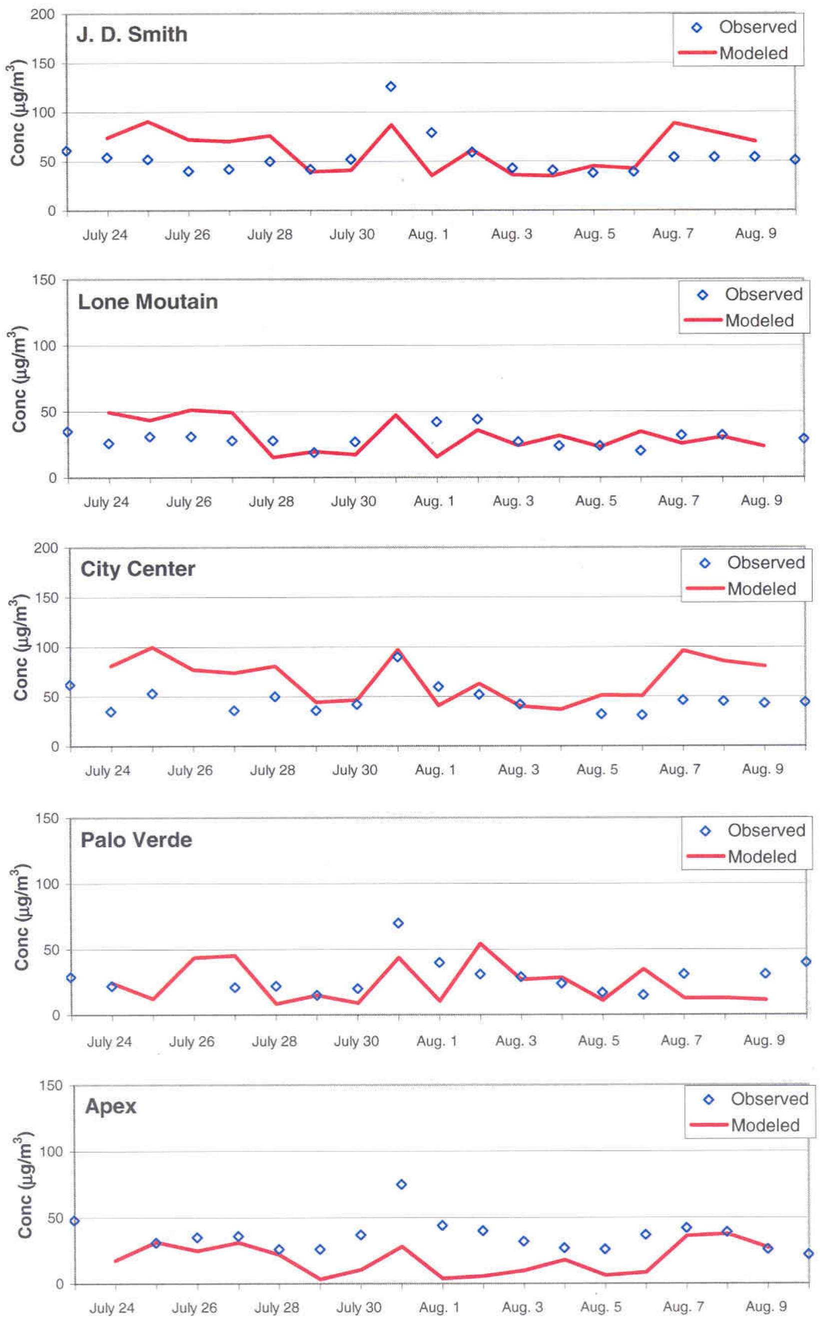

FIGURE 5.43 Time Series of Measured and CMAQ-Calculated PM_{10} Levels ($\mu g/m^3$) at Five Monitoring Sites in and around the Las Vegas Urban Region during the Simulation Period of July 24–August 9, 2000. (Results are for J.D. Smith, located 1.4 miles northeast of the City Center site [first panel]; Lone Mountain, located 8 miles northwest of the City Center site [second panel]; Palo Verde, located 11 miles west of the City Center site [third panel]; Apex, located 20 miles northeast of the City Center site [fourth panel]; and Jean, located 20 miles southwest of the City Center site [fifth panel].)

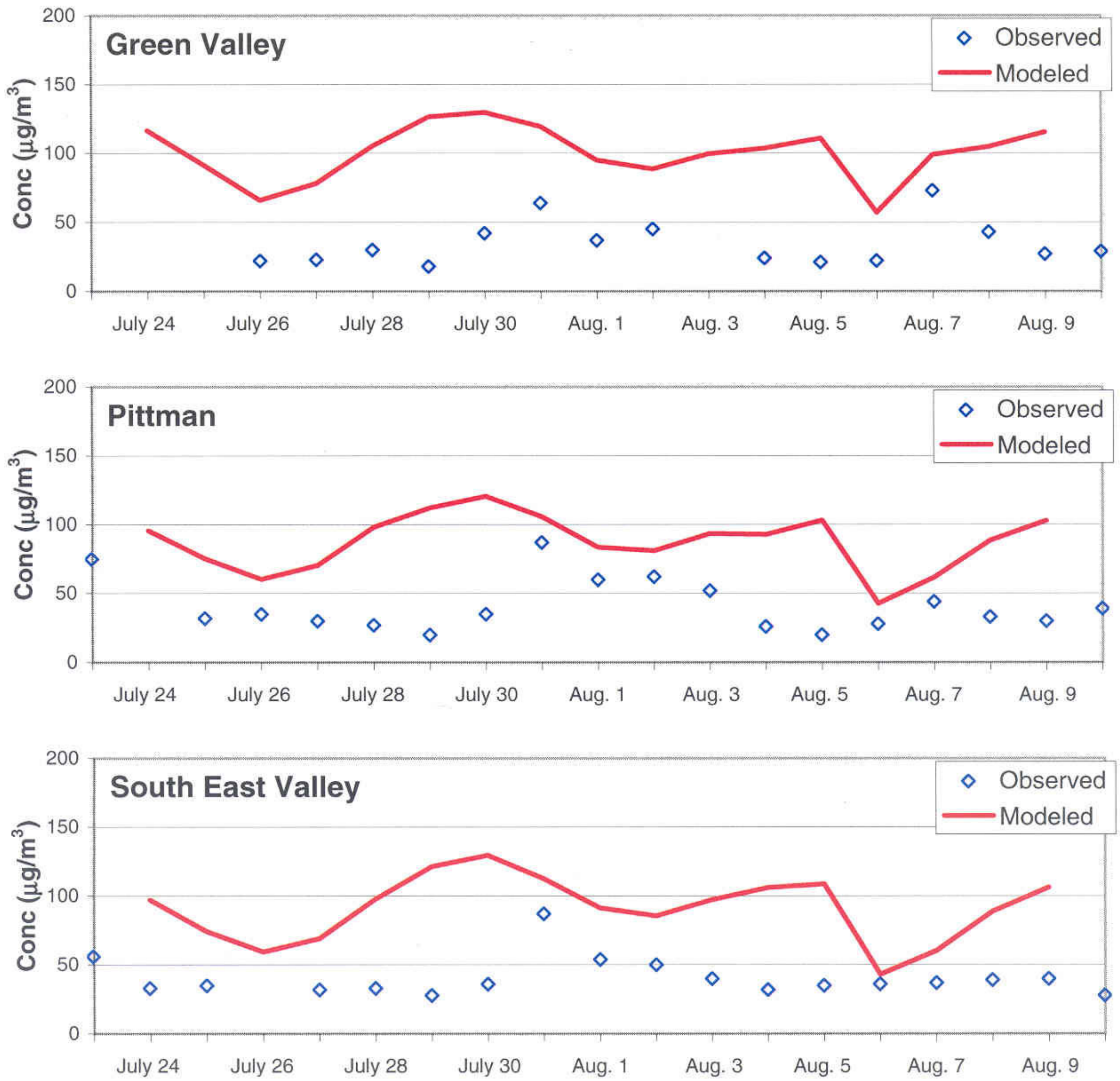

FIGURE 5.44 Time Series of Measured and CMAQ-Calculated PM_{10} Levels ($\mu g/m^3$) at Three Monitoring Sites in the Southeast BLM Boundary Area (Green Valley [first panel], Pittman [second panel], and South East Valley [third panel]) during the Simulation Period of July 24–August 9, 2000.

6 References

Anthes, R.A., et al., 1987, *Description of the Penn State/NCAR Mesoscale Model Version 4 (MM4)*, NCAR Technical Note NCAR/TN-282+STR, National Center for Atmospheric Research, Boulder, CO.

Archer, S., 2002, personal communication from Archer (U.S. Bureau of Land Management, Denver, Colo.) to J. Steinmetz (U.S. Bureau of Land Management, Las Vegas, NV), Aug. 1.

Binkowski, F.S. and S.J. Roselle, 2003, "Models-3 Community Multiscale Air Quality (CMAQ) Model Aerosol Component — 1. Model Description," *Journal of Geophysical Research-Atmospheres* 108(D6), Art. No. 4183, March 26.

BLM (Bureau of Land Management), 1998, *Proposed Las Vegas Resource Management Plan and Final Environmental Impact Statement*, BLM/LV/PL-98/012+1791, Final, Vols. I and II, U.S. Department of the Interior, Las Vegas Field Office, Las Vegas, NV, May.

BLM, 2004, *Quick Facts, Southern Nevada Public Land Management Act*. Available at http://www.nv.blm.gov/snplma/Sale/salequick.asp.

Byun, D.W., 1999, "Dynamically Consistent Formulations in Meteorological and Air Quality Models for Multiscale Atmospheric Studies. Part I: Governing Equations in a Generalized Coordinate System, and Part II, Mass Conservation Issues," *Journal of the Atmospheric Sciences*, 56(21):3789–3807, 3808–3820, Nov. 1.

California Air Resources Board (CARB), 2004, *On-Road Emissions from EMFAC2002 Release*, July 7. Available at http://www.arb.ca.gov/msei/on-road/emfac2002_output_table.htm.

Caliper Corporation, 2003, *TransCAD® Overview*. Available at http://www.caliper.com/tcovu.htm. Accessed Aug. 4, 2003.

CBER (Center for Business and Economic Research), 2000, *Clark County Population Forecast and Growth Rate: 2001 to 2035*, University of Las Vegas, Las Vegas, NV, Dec. 29. Available at http://www.co.clark.nv.us/Comprehensive_planning/Advanced/Demographics/HistoricalData/Smmary_Pop_Forecast.HTM.

CBER, 2003, *Clark County Population Forecast and Growth Rate: 2002 to 2035*, University of Las Vegas, Las Vegas, NV, Jan. 10. Available at http://www.co.clark.nv.us/Comprehensive_planning/Advanced/Demographics/PopulationForecasts/Pop_Forecast_2002to2035.htm.

Chen, F., and J. Dudhia, 2001, "Coupling an Advanced Land-Surface/Hydrology Model with the Penn State/NCAR MM5 Modeling System. Part I: Model Implementation and Sensitivity, *Monthly Weather Review* 129, 569–585.

Chow, J.C., et al., 1999, "Middle- and Neighborhood-Scale Variations of PM_{10} Source Contributions in Las Vegas, Nevada," *Journal of the Air & Waste Management Association* 49:641–654, June.

Clark County, 2000, *Carbon Monoxide State Implementation Plan, Las Vegas Valley Nonattainment Area, Clark County, Nevada*, Department of Comprehensive Planning, Las Vegas, NV, Aug. Available at http://www.co.clark.nv.us/Air_Quality/CO_SIP.htm.

Clark County, 2001, *PM_{10} State Implementation Plan for Clark County*, Department of Comprehensive Planning, Las Vegas, NV, June. Available at http://www.co.clark.nv.us/Air_Quality/PM10SIP.htm.

Clark County, 2004, *Clark County Air Quality Regulations, Section 11 — Ambient Air Quality Standards*, amended Oct. 21, 2003. Available at http://www.co.clark.nv.us/air_quality/Regs/SECT11%2010-21-03.pdf. Accessed Feb. 3, 2004.

Czyzyk, S., 2004, personal communication from Czyzyk (National Weather Service Forecast Office, Las Vegas, NV) to M. Lazaro (Argonne National Laboratory, Argonne, IL), Mar. 18.

Davis, J., 2003, personal communications from Davis (Clark County Department of Air Quality and Environmental Management, Las Vegas, NV) to Y.-S. Chang (Argonne National Laboratory, Argonne, IL), July 30 and Aug. 7.

Douglas, S.G., et al., 1996, *UAM Modeling Analysis of the Clark County/Las Vegas Area*, SYSAPP-96/03, prepared by Systems Applications International, Inc., San Rafael, CA, for Clark County Department of Comprehensive Planning, Las Vegas, NV, Mar.

Dudhia, J., 1993, "A Nonhydrostatic Version of the Penn State NCAR Mesoscale Model — Validation Tests and Simulation of an Atlantic Cyclone and Cold Front," *Monthly Weather Review* 121(5):1493–1513.

Dudhia, J., and J.F. Bresch, 2002, "A Global Version of the PSU-NCAR Mesoscale Model," *Monthly Weather Review* 130:2989–3007.

EPA (U.S. Environmental Protection Agency), 1988, *Control of Open Fugitive Dust Sources*, EPA-450/3-88-008, Research Triangle Park, NC, Sept.

EPA, 1992, *Nonroad Engine Emission Inventories for CO and Ozone Nonattainment Boundaries, Las Vegas Area*, prepared by Energy and Environmental Analysis, Inc., Arlington, VA, for EPA, Ann Arbor, MI.

EPA, 1999, *Science Algorithms of the EPA Models-3 Community Multiscale Air Quality (CMAQ) Modeling System*, EPA/600/R-99/030.

EPA, 2001, *SMOKE (Sparse Matrix Operator Kernel Emission) Tool for Models-3 Version 4.1 Structure and Operation Documentation*, EPA 600/R-01/048.

EPA, 2002, *User's Guide for the EPA Nonroad Emissions Model Draft NONROAD 2002*, EPA420-P-02-013, Dec. (Used the Draft NONROAD2004 program released on April 23, 2004.) Available at http://www.epa.gov/otaq/nonrdmdl/htm.

EPA, 2003a, *User's Guide to MOBILE6.1 and MOBILE6.2: Mobile Source Emission Factor Model*, EPA420-R-03-010, Aug. Available at http://www.epa.gov/otaq/m6.htm#m60.

EPA, 2003b, *Clean Air Markets*. Available at http://www.epa.gov/airmarkets. Accessed Sept. 10.

EPA, 2003c, *1999 National Emission Inventory Documentation and Data*. Available at http://www.epa.gov/ttn/chief/net/1999inventory.html. Accessed Sept. 9.

EPA, 2003d, "Revision to the Guideline on Air Quality Modes: Adoption of a Preferred Long-Range Transport Model and Other Revisions," *Federal Register,* Vol. 68, No. 72, 18440, Apr. 15.

EPA, 2003e, *Compilation of Air Pollutant Emission Factors, Volume I: Stationary Point and Area Sources,* AP-42, Fifth Ed. Available at http://www.epa.gov/ttn/chief/ap42/index.html.

EPA, 2004a, *Biogenic Emissions Inventory Data*. Available at ftp://ftp.epa.gov/amd/asmd/beld3/arcinfo. Accessed Feb. 2, 2004.

EPA, 2004b, *Biogenic Emissions Inventory System (BEIS)*. Available at http://www.epa.gov/asmdnerl/ biogen.html. Accessed Feb. 2.

Fry, J. 2003, *Final Nov 03 Matrix FMV 4.xls,* e-mail with spreadsheet of November 2003 auction with parcel descriptions, from Fry (U.S. Bureau of Land Management, Las Vegas, NV) to M. Lazaro (Argonne National Laboratory, Argonne, IL), Aug. 1.

Fry, J., 2004, *Legals for Large Disposal Areas*, e-mail with descriptions of parcels associated with the Gateway to Kyle Canyon planned land sale and information about the North Las Vegas planned land sale, from Fry (U.S. Bureau of Land Management, Las Vegas, NV) to M. Lazaro (Argonne National Laboratory, Argonne, IL), Feb. 9.

Gery, M.W., et al., 1989, "A Photochemical Kinetics Mechanism for Urban and Regional Scale Computer Modeling," *Journal of Geophysical Research* 94(D10): 12,925–12,956.

Gillette, D., et al., 1996, "Causes of the Fetch Effect in Wind Erosion," *Earth Surface Processes and Landforms* 21, 641-659.

Gillette, D., et al., 2004, "A Combined Modeling and Measurement Technique for Estimating Windblown Dust Emissions at Owens (Dry) Lake, California," *Journal of Geophysical Research* 109, F01003, 1-23.

Grell, G.A., et al., 1995, *A Description of the Fifth-Generation Penn State/NCAR Mesoscale Model (MM5)*, NCAR Technical Note NCAR/TN-398+STR, Mesoscale and Microscale Meteorology Division, National Center for Atmospheric Research, Boulder, CO, June.

Hoch, D., 2003, data received at site visit on May 30 and personal communication from Hoch (Clark County Department of Air Quality and Environmental Management, Las Vegas, NV) to Y.-S. Chang (Argonne National Laboratory, Argonne, IL), June 12.

Hoeft, B., 2003, personal communications from Hoeft (Regional Transportation Commission of Southern Nevada, Las Vegas, NV) to Y.-S. Chang (Argonne National Laboratory, Argonne, IL), Aug. 6-15.

Holland, A.P., and Z. Adelman, 2004, *Emissions Modeling Final Report: Pro02b-36*, prepared for the Western Regional Air Partnership Modeling Forum, Western Governor's Association, by University of North Carolina-Chapel Hill, Carolina Environmental Program, June 7.

James, D., 2003, personal communication from James (Department of Civil Engineering, University of Nevada, Las Vegas) to M. Lazaro (Argonne National Laboratory, Argonne, IL), Apr. 18.

Janssen, G., 2003, e-mail from Janssen (Office of Transportation and Air Quality, U.S. Environmental Protection Agency, Ann Arbor, MI) to Y.-S. Chang (Argonne National Laboratory, Argonne, IL), July 31.

Kelly, J., 2004, personal communication from J. Kelly (U.S. Environmental Protection Agency Region 9) to M. Lazaro (Argonne National Laboratory, Argonne, IL), April 15.

Kotamarthi, V.R., et al., 2002, "Diurnal Variation of NMHCs at a Downtown Site in Nashville: Model and Measurements," pp. 94–96 in *Preprints from the Fourth Conference on Atmospheric Chemistry*, Orlando, FL, sponsored by the American Meterological Society, Jan.

Lazaro, M., 2003, personal communication from M. Lazaro (Argonne National Laboratory, Argonne, IL) to T.R. McKay (Soil Conservation Service, Reno, NV), Nov.

Li, Z., 2003, personal communication from Z. Li (Clark County Department of Air Quality and Environmental Management, Las Vegas, NV) to Y.-S. Chang (Argonne National Laboratory, Argonne, IL), Dec. 9.

Logan, J.A., et al., 1981, "Tropospheric Chemistry: A Global Perspective." *J. Geophys. Res.* 86: 7210–7254.

Madronich, S., 1987, "Photodissociation in the Atmosphere: 1. Actinic Flux and the Effects of Ground Reflections and Clouds," *J. Geophysical Research* 92(D8):9740–9752.

NASA (National Aeronautics and Space Administration), 2004, *Western U.S. Wildfires 2000*. Available at http://ivanova.gsfc.nasa.gov/outreach/Terra_CD-01/docs/event.htm. Accessed Jan. 30, 2004.

NDEP (Nevada Division of Environmental Protection), 2002, *Ambient Air Quality Trends 1990–2001*. Available at http://ndep.nv.gov/baqp/Trend%20Report%202001.pdf.

NOAA (National Oceanic and Atmospheric Administration), 2004, *Storm Events*. Available at http://www4.ncdc.noaa.gov/cgi-win/wwcgi.dll?wwevent~storms. Accessed Jan. 29, 2004.

Noll, K.E., et al., 2001, "Development of an Atmospheric Particle Dry Deposition Model," *Aerosol Science and Technology* 35(2):627–636.

Owen, P., and D. Gillette, 1985, "Wind Tunnel Constraint on Saltation," p. 253 in Memoirs No. 8, Vol. 2 of *Proceedings of International Workshop on the Physics of Blown Sand*, Barndorff-Nielsen, O.E., et al. (editors), Aarhus, May 28–31.

Pulugurtha, S., and D. James, 2002, *A GIS-Based Methodology to Estimate Annual Valley-Wide PM-10 Emissions for Clark County, Nevada*, prepared by University of Nevada, Las Vegas, 11th International Emission Inventory, Atlanta, GA, April 15–18. Available at http://www.epa.gov/ttn/chief/conference/ei11/pm/pulugurtha.pdf.

Remer, G., 2003, personal communication from Remer (Nevada Bureau of Air Quality Planning) to M. Lazaro (Argonne National Laboratory, Argonne, IL), June 26.

RTC (Regional Transportation Commission of Southern Nevada), 2002, *Las Vegas Area Current Land Use as of June 2002*, GIS layer on CD-ROM, Las Vegas, NV.

RTC, 2003, *Las Vegas Area Planned Land Use*, 10 GIS layers on CD-ROM, Las Vegas, NV.

Runk, K.J., 1996, *The Las Vegas Conversion Zone: Its Development, Structure and Implications for Forecasting*, Western Region Technical Attachment 96-18, Aug. 13. Available at http://www.wrh.noaa.gov/wrhq/96TAs/TA9618/ta96-18.html.

Runk, K.J., 1999, *A Numerical Investigation of the Las Vegas Convergence Zone*, Eighth Conference on Mesoscale Processes, sponsored by the American Meteorological Society, Boulder, CO, June 28–July 1. Available at www.wrh.noaa.gov/lasvegas/projects/ni-lvcz.html.

SNPLMA (Southern Nevada Public Land Management Act), 1998, Public Law 105-263, 105th Congress, 112 Stat. 2343, Oct. 19.

Speck, R.L., and T.R. McKay, 1985, *Soil Survey of the Las Vegas Area, Nevada, Part of Clark County*, U.S. Department of Agriculture, Soil Conservation Service, in cooperation with the U.S. Department of the Interior, Bureau of Land Management, and the University of Nevada, Agricultural Experiment Station, July.

University of North Carolina, 2003, *SMOKE User's Manual*, Carolina Environmental Program. Available at http://www.cep.unc.edu/empd/products/smoke/index.shtml.

USDA (U.S. Department of Agriculture), 1999, *Soil Survey Geographic (SSURGO) Database for Virgin River Area Nevada and Arizona, Parts of Clark and Lincoln Counties Nevada, and Mohave County, Arizona*, Natural Resources Conservation Service. Available at http://www.ncgc.nrcs.usda.gov/branch/ssb/products/ssurgo/data/nv.html (nv608). Accessed Feb. 5, 2004.

USGS (U.S. Geological Survey), 1992, *National Land Cover Database*. Available at http://seamless.usgs.gov. Accessed Feb. 2, 2004.

USGS, 2003, *USGS Land Use and Land Cover Data*. Available at http://edc.usgs.gov/glis/hyper/guide/1_250_lulc. Accessed May 9, 2003.

USGS, 2004, *National Land Cover Characterization Project*. Available at http://landcover.usgs.gov/nationallandcover.asp. Accessed Feb. 2, 2004.

Wesely, M.L., 1989, "Parameterization of Surface Resistances to Gaseous Dry Deposition in Regional-Scale Numerical Models," *Atmospheric Environment* 23(6):1293–1304.

Wood, R.A. (editor), 1996, *Weather of U.S. Cities*, Fifth Ed., Gales Research, Detroit, MI.

Zangl, G., 2002, "An Improved Method for Computing Horizontal Diffusion in a Sigma-Coordinate Model and Its Application to Simulations over Mountainous Topography," *Monthly Weather Review* 130, 1423–1432.

Zhang, Y.C., et al., 1999, "Simulation of Aerosol Dynamics: A Comparative Review of Algorithms Used in Air Quality Models," *Aerosol Science and Technology* 31, 487–514.