REVISIONS TO THE STATE IMPLEMENTATION PLAN FOR THE CONTROL OF OZONE AIR POLLUTION

ATTAINMENT DEMONSTRATION FOR THE DALLAS/FORT WORTH OZONE NONATTAINMENT AREA

TEXAS NATURAL RESOURCE CONSERVATION COMMISSION
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DALLAS/FORT WORTH ATTAINMENT DEMONSTRATION
LIST OF ACRONYMS

AMS - Area and Mobile Source
ARACT - Alternate Reasonably Available Control Technology
ARPDB - Acid Rain Program Database
ASC - Area Source Categories
ATC - Air Traffic Control
AUTO-GC - Automated Gas Chromatographs
AVHRR - Advanced Very High Resolution Radiometer
BACT - Best Available Control Technology
BEIS-2 - Biogenic Emissions Inventory System, version 2
BELD - Biogenic Emissions Land cover Database
BIOME - Biogenic Model for Emissions
BLRID - Boiler ID
B-PA - Beaumont-Port Arthur
CAM - Compliance Assurance Monitoring
CAMS - Continuous Air Monitoring Stations
CAMx - Comprehensive Air Model with Extensions
CB-IV HC - Carbon Bond IV Hydrocarbon
CEMS - Continuous Emissions Monitoring System
CHMSPL - CHeMical SPLit
CNTLEM - CoNTroL EMissions
CO - Carbon Monoxide
COAST - Coastal Oxidant Assessment for Southeast Texas
CTG - Control Technique Guidelines
D-FW - Dallas-Fort Worth
D-FWN - Dallas-Fort Worth North
DFWRTM - Dallas-Fort Worth Regional Transportation Model
DOW - Day of Week
DRI - Desert Research Institute
EI - Emissions Inventory
EIQ - Emissions Inventory Questionnaire
ELP - El Paso
EGAS - Economic Growth Analysis System
EGU - Electric Generating Units
EMS-5 - Emissions Modeling System, 1995
EMSCVT - EMiSsions ConVerT
EPA - Environmental Protection Agency
EPN - Emission Point Number
EPS-2 - Emission Preprocessing System, Version 2
ETR - Employer Trip Reduction
FAA - Federal Aviation Administration
FCAA - Federal Clean Air Act
FDDA - Four-Dimensional Data Assimilation
FIPS - Federal Information Placement System
FMVCP - Federal Motor Vehicle Control Program
FTP - File Transfer Protocol

GIS - Geographic Information System
GMAQS - Gulf of Mexico Air Quality Study
GRDEM - GRiD EMissions
HAP - Hazardous Air Pollutants
H-GA - Houston-Galveston
HL&P - Houston Lighting & Power
HPMS - Highway Performance Monitoring System
HRM - Houston Regional Monitoring
HYSPLIT - HYbrid Single Particle Lagrangian Integrated Trajectory
IIP - Interim Implementation Plan
I/M - Inspection and Maintenance
INIT - Initial Condition Tracer
ITWS - Integrated Terminal Weather System
kg/ha - kilograms/hectare
km - Kilometers
LBASE - Link-BASEd emissions preprocessor
LDEQ - Louisiana Department of Environmental Quality
LEV - Low Emission Vehicle
LULC - Land Use Land Cover
m - Meters
MMS - Minerals Management Service
MRGUAM - MeRGe Urban Airshed Model ready files
NAAQS - National Ambient Air Quality Standard
NCDC - National Climatic Data Center
NCTCOG - North Central Texas Council of Governments
NDBC - National Data Buoy Center
NEGU - Non-electric Generating Units
NET - National Emission Trends
NO_x - Nitrogen Oxides
NO_y - Nitrogen Species
NSR - New Source Review
NWS - National Weather Service
OAQPS - Office of Air Quality Planning and Standards
OASIS - Online Access and Service Information System
OBD - On-Board Diagnostics
ODEQ - Oklahoma Department of Environmental Quality
ORISN - Acid Rain Program Facility Identifier
OSAT - Ozone Source Apportionment Technology
OTAG - Ozone Transportation Assessment Group
OZPK - Ozone Peak
O_3 - Ozone
PAMs - Photochemical Assessment Monitoring Sites
PEI - Periodic Emissions Inventory
PGM - Photochemical Grid Model
PiG - Plume-in-Grid
PLNAME - Plant Name
PM_{10} - Particulate Matter less than 10 microns
PPB - Parts Per Billion

PPBC - parts per billion carbon
PPMV - Parts Per Million by Volume
PREAM - PREprocessor for Area and Mobile source emissions
PREPNT - PREprocessor for PoiNT
PSDB - Point Source Database
QA/QC - Quality Assurance/Quality Control
RACT - Reasonably Available Control Technology
REMI - Regional Economic Modeling, Inc.
ROP - Rate-of-Progress
RSQE - Research Seminar in Quantitative Economics
SAI - Systems Applications International
SAIMM - Systems Applications International Meteorological Model
SB - Senate Bill
SCC - Source Classification Codes
SCRAM - Support Center for Regulatory Air Models
SIC - Standard Industrial Classification
SIP - State Implementation Plan
SO_2 - Sulfur Dioxide
SO_x - Sulfur Compounds
SOCMI - Synthetic Organic Chemical Manufacturing Industry
SumPol - Sum of identified PAMS target list compounds
TACB - Texas Air Control Board
TAFF - Texas Alternative Fuel Fleet
TAZ - Traffic Analysis Zone
TCAS - Texas Clean Air Strategy
TCF - Texas Clean Fleet
TCM - Transportation Control Measures
TIGER - Topographically Integrated Geographic Encoded Referencing System
TMPFAC - TemPoral FACtor
TMPRL - TeMPoRaL allocation processor
TNMOC - Total nonmethane organic compounds
TOMS - Total Ozone Mapping Spectrometers
TPOD - Tons Per Ozone Day
TPY - Tons Per Year
TSP - Total Suspended Particulates
TTI - Texas Transportation Institute
TUE - TU Electric
UAM - Urban Airshed Model
USDA - United States Department of Agriculture
USGS - United States Geological Survey
UTM - Universal Transverse Mercator
VMT - Vehicle Miles Traveled
VNR or VNRAT- VOC-NO_x ratios
VOC - Volatile Organic Compound
WDWE - Weekday/Weekend

DALLAS/FORT WORTH ATTAINMENT DEMONSTRATION
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Copies of the modeling appendices (A through F) can be obtained from Chris Kite by phone at (512) 239-1959, or by e-mail at ckite@tnrcc.state.tx.us. Appendices G through M can be obtained from Heather Evans by phone at (512) 239-1970, or by e-mail at hevans@tnrcc.state.tx.us.

VI: Ozone Control Strategy

A. INTRODUCTION

This Introduction is intended to provide the reader with a broad overview context of the SIP revisions that have been submitted to EPA by the State of Texas. Some sections may be obsolete or superseded by new revisions, but have been retained for the sake of historical completeness. The reader is referred to the body of the SIP for details on the current SIP revision.

Requirements for SIP specified in 40 CFR Part 51.12 provide that "...in any region where existing (measured or estimated) ambient levels of pollutant exceed the levels *specified* by an applicable national standard," the plan shall set forth a control strategy which shall provide for the degree of emission reduction necessary for attainment and maintenance of such national standard. Ambient levels of SO_2 and NO_x, as measured from 1975 through 1977, did not exceed the national standards set for these pollutants anywhere in Texas. Therefore, no control strategies for these pollutants were included in revisions to the Texas SIP submitted on April 13, 1979. Control strategies were submitted and approved for inclusion in the SIP for areas in which measured concentrations of ozone, TSP, or CO exceeded a NAAQS during the period from 1975 to 1977. On October 5, 1978, the Administrator of the EPA promulgated a lead ambient air quality standard. The FCAA Amendments of 1977 required that each state submit an implementation plan for the control of any new criteria pollutant. A SIP revision for lead was submitted in March 1981.

The control strategies submitted in 1979 provided by December 31, 1982 the amount of emission reductions required by EPA policy to demonstrate attainment of the primary NAAQS, except for ozone in the Harris County nonattainment area. For that area, an extension to December 31, 1987 was requested, as provided for in the FCAA Amendments of 1977.

Supplemental material, including emission inventories for VOC and TSP submitted with the 1979 SIP revisions, is included in Appendices H and O of the 1979 SIP submittal.

Proposals to revise the Texas SIP to comply with the requirements of the FCAA Amendments of 1977 were submitted to EPA on April 13, November 2, and November 21, 1979. On December 18, 1979 (44 FR 75830-74832), EPA approved the proposed revision to the Texas SIP relating to vehicle inspection and maintenance and extended the deadline for attainment of the NAAQS for ozone in Harris County until December 31, 1987. (See Appendix Q of the 1979 SIP submittal for the full text of the extension request and the approval notice.) On March 25, 1980 (45 FR 19231-19245), EPA approved and incorporated into the Texas SIP many of the remaining provisions included in the proposals submitted by the state in April and November 1979. The March 25, 1980 *Federal Register* notice also included conditional approval of a number of the proposed SIP revisions submitted by the state.

Additional proposed SIP revisions were submitted to EPA by the state on July 25, 1980 and July 20, 1981 to comply with the requirements of the March 25, 1980 conditional approvals. By May 31, 1982, all of the proposed revisions to the Texas SIP submitted to EPA in April and November 1979, July 1980, and July 1981, with the exception of provisions relating to the definition of major modification used in NSR and certain portions of the control strategy for TSP in Harris County, had been fully approved or addressed in a *Federal Register* notice proposing final approval. The NSR provisions were approved on August 13, 1984.

The FCAA Amendments of 1977 required SIPs to be revised by December 31, 1982 to provide additional emission reductions for those areas for which EPA approved extensions of the deadline for attainment of the NAAQS for ozone or CO. Paragraph B.5. of this section of the SIP contains the revision to the Texas SIP submitted to comply with the FCAA Amendments of 1977 and EPA rules for 1982 SIP revisions. Supplementary emissions inventory data and supporting documentation for the revision are included in Appendices Q through Z of the 1982 SIP submittal.

The only area in Texas receiving an extension of the attainment deadline to December 31, 1987 was Harris County for ozone. Proposals to revise the Texas SIP for Harris County were submitted to EPA on December 9, 1982. On February 3, 1983, EPA proposed to approve all portions of the plan except for the Vehicle Parameter I/M Program. On April 30, 1983, the EPA Administrator proposed sanctions for failure to submit or implement an approvable I/M program in Harris County. Senate Bill 1205 was passed on May 25, 1983 by the Texas Legislature to provide the Texas Department of Public Safety with the authority to implement enhanced vehicle inspection requirements and enforcement procedures. On August 3, 1984, EPA proposed approval of the Texas SIP pending receipt of revisions incorporating these enhanced inspection procedures and measures ensuring enforceability of the program. These additional proposed SIP revisions were adopted by the state on November 9, 1984. Final approval by EPA was published on June 26, 1985.

Although the control strategies approved by EPA in the 1979 SIP revisions were implemented in accordance with the provisions of the plan, several areas in Texas did not attain the primary NAAQS by December 31, 1982. On February 23, 1983, EPA published a *Federal Register* notice identifying those areas and expressing the intent to impose economic and growth sanctions provided in the FCAA. However, EPA reversed that policy in the November 2, 1983 *Federal Register*, deciding instead to call for supplemental SIP revisions to include sufficient additional control requirements to demonstrate attainment by December 31, 1987.

On February 24, 1984, the EPA Region 6 Administrator notified the Governor of Texas that such supplemental SIP revisions would be required within one year for ozone in Dallas, Tarrant, and El Paso Counties and CO in El Paso County. The TACB, predecessor agency to the commission, requested a 6-month extension of the deadline (to August 31, 1985) on October 19, 1984. EPA approved this request on November 16, 1984.

Proposals to revise the Texas SIP for Dallas, Tarrant, and El Paso Counties were submitted to EPA on September 30, 1985. However, the revisions for Dallas and Tarrant Counties did not provide sufficient reductions to demonstrate attainment of the ozone standard and on July 14, 1987, EPA published intent to invoke sanctions. Public officials in the two counties expressed a strong desire to provide additional control measures sufficient to satisfy requirements for an attainment demonstration.

A program of supplemental controls was taken to public hearings in late October 1987. As a result of testimony received at the hearings, a number of the controls were modified and several were deleted, but sufficient reductions were retained to demonstrate attainment by December 31, 1991. These controls were adopted by the TACB on December 18, 1987 and were submitted to EPA as proposed revisions to the SIP. Supplemental data and supporting documentation are included in Appendices AA through AO of the 1987 SIP submittal.

The FCAA Amendments of 1990 authorized EPA to designate areas failing to meet the NAAQS for ozone as nonattainment and to classify them according to severity. The four areas in Texas and their

respective classifications include: Houston/Galveston - severe, Beaumont/Port Arthur - serious, El Paso - serious, and Dallas/Fort Worth - moderate.

The FCAA Amendments required a SIP revision to be submitted for all ozone nonattainment areas classified as moderate and above by November 15, 1993 which described in part how an area intends to decrease VOC emissions by 15%, net of growth, by November 15, 1996. The amendments also required all nonattainment areas classified as serious and above to submit a revision to the SIP by November 15, 1994 which described how each area would achieve further reductions of VOC and/or NO_x in the amount of 3.0% per year averaged over three years and which includes a demonstration of attainment based on modeling results using the UAM. In addition to the 15% reduction, states were also required to prepare contingency rules that will result in an additional 3.0% reduction of either NO_x or VOC, of which up to 2.7% may be reductions in NO_x. Underlying this substitution provision is the recognition that NO_x controls may effectively reduce ozone in many areas and that the design of strategies is more efficient when the characteristic properties responsible for ozone formation and control are evaluated for each area. The primary condition to use NO_x controls as contingency measures is a demonstration through UAM modeling that these controls will be beneficial toward the reduction of ozone. These VOC and/or NO_x contingency measures would be implemented immediately should any area fall short of the 15% goal.

Texas submitted rules to meet the ROP reduction in two phases. Phase I consisted of a core set of rules comprising a significant portion of the required reductions. This phase was submitted by the original deadline of November 15, 1993. Phase II consisted of any remaining percentage toward the 15% net of growth reductions, as well as additional contingency measures to obtain an additional 3.0% of reductions. Phase II was submitted by May 15, 1994. The complete list of contingency measures was submitted by November 15, 1994. The appropriate compliance date was to be incorporated into each control measure to ensure that the required reductions will be achieved by the November 15, 1996 deadline. A commitment listing the potential rules from which the additional percentages and contingency measures were selected was submitted in conjunction with the Phase I SIP on November 15, 1993. That list of Phase II rules was intended to rank options available to the state and to identify potential rules available to meet 100% of the targeted reductions and contingencies. Only those portions of the Phase II rules needed to provide reasonable assurance of achieving the targeted reduction requirements were adopted by the commission.

The D-FW and El Paso areas achieved sufficient reductions with the 15% ROP SIP to demonstrate attainment by 1996. Attainment Demonstration SIP Revisions for these two areas were submitted on September 14, 1994.

The FCAA Amendments of 1990 classified the B-PA area as a serious nonattainment area. The B-PA nonattainment area includes Hardin, Jefferson, and Orange Counties. The B-PA nonattainment area has an ozone design value of 0.16 ppm, which places the area in the serious classification.

The FCAA Amendments of 1990 require a Post-96 ROP SIP revision and accompanying rules to be submitted by November 15, 1994. According to the FCAA Amendments, this submittal had to contain an Attainment Demonstration based on UAM. Additionally, the revision had to demonstrate how the H-GA and B-PA nonattainment areas intend to achieve a 3% per year reduction of VOC and/or NO_x until the year 2007, and additional reductions as needed to demonstrate modeled attainment. The plan was also required to carry an additional 3% of contingency measures to be implemented if the nonattainment area fails to meet a deadline. To use NO_x reductions for all or part of the Post-96 controls or the contingency

measures required a demonstration using UAM showing that NO_x controls would be beneficial in reducing ozone.

On November 9, 1994, the state submitted a SIP revision designed to meet the 3% per year ROP requirements for the years 1997-1999. This Post-96 ROP SIP revision detailed how the B-PA and H-GA nonattainment areas intend to achieve these three years' reductions of VOC (or 9% net-of-growth). Most of this amount was achieved by quantifying additional reductions due to existing rules and reductions due to federally-mandated rules. Rules to achieve the further reductions needed to meet the ROP SIP goal were submitted to EPA on January 11, 1995. This submittal included modeling demonstrating progress toward attainment, using a 1999 future year emissions inventory.

On August 14, 1994, the state submitted preliminary UAM modeling results for the B-PA and H-GA nonattainment areas that showed the relationship between emission levels of VOC and NO_x, and ozone concentrations. This modeling was conducted with a 1999 future year emissions inventory. Based on the results of this preliminary modeling, which showed that NO_x reductions might increase ozone concentrations, on April 12, 1995 the state received a temporary Section 182(f) exemption from all NO_x requirements including RACT, I/M, NO_x NSR, and transportation conformity requirements. Permanent §182(f) exemptions from all NO_x requirements were granted for D-FW and El Paso, and temporary exemptions until December 31, 1996 for H-GA and B-PA. The commission subsequently requested that EPA extend this date until December 31, 1997. EPA approved this 1-year extension on May 14, 1997.

On March 2, 1995, Mary Nichols, EPA Assistant Administrator for Air and Radiation, issued a memo which gave states some flexibility to design a phased Attainment Demonstration. It provided for an initial phase which was intended to continue progress in reducing levels of VOC and/or NO_x while giving states an opportunity to address scientific issues such as modeling and the transport of ozone and its precursor pollutants. The second phase was designed to draw upon the results of the scientific effort and design a plan to bring the area into attainment. To constitute Phase I under this approach, the EPA guidance required that states submit the following SIP elements by December 31, 1995:

- Control strategies to achieve reductions of ozone precursors in the amount of 3% per year from the 1990 baseline EI for the years 1997, 1998, and 1999.
- UAM modeling out through the year 1999, showing the effect of previously-adopted control strategies which were designed to achieve a 15% reduction in VOCs from 1990 through 1996.
- A demonstration that the state has met the VOC RACT requirements of the FCAA Amendments.
- A detailed schedule and plan for the "Phase II" portion of the attainment demonstration which will show how the nonattainment areas can attain the ozone standard by the required dates.
- An enforceable commitment to:

  - Participate in a consultative process to address regional transport,
  - Adopt additional control measures as necessary to attain the ozone NAAQS, meet ROP requirements, and eliminate significant contribution to nonattainment downwind, and
  - Identify any reductions that are needed from upwind areas to meet the NAAQS.

Texas submitted the first two of these required sections in November 1994. The remaining three, a VOC RACT demonstration, the required commitments, and a Phase II plan and schedule, were submitted on January 10, 1996 to EPA.

ROP SIP modeling was developed for the H-GA nonattainment area in two phases using the UAM. The first phase of ROP modeling was the modeling submitted in January 1995, as described above. The second phase of the ROP modeling was conducted using data obtained primarily from the COAST project, an intensive 1993 field study. The COAST modeling for H-GA and the associated SIP were projected to be completed by December 1996 for submittal in May of 1997. Control strategies developed in this second phase were planned to be based on a more robust data base, providing a higher degree of confidence that the strategies would result in attainment of the ozone NAAQS or target ozone value. A discussion of the schedule for the UAM modeling for the Phase II Attainment Demonstration can be found in Appendix 11-F of the January 10, 1996 submittal.

On January 29, 1996, the EPA proposed a limited approval/limited disapproval for the Texas 15% ROP SIP revision. The EPA proposed a limited approval because the SIP revision will result in significant emission reductions from the 1990 baseline, and will, therefore, improve air quality. Simultaneously, the EPA proposed a limited disapproval because they believe that the plan fails to demonstrate sufficient reductions to meet the 15% ROP requirements. They also proposed a limited approval/disapproval of the contingency plans (designed to achieve an additional 3% of reductions if needed because a milestone is missed) along the same lines as the 15% action. The EPA stated that some of the control measures submitted along with the SIP revision did not meet all of the requirements of the FCAA Amendments of 1990, and, therefore, cannot be approved. The EPA further stated that they were not making a determination at this time whether the state has met its requirements regarding RACT, or any other underlying FCAA Amendments of 1990 requirements. Finally, the EPA proposed approval of the Alternate Means of Control portion of the November 9, 1994 Post-96 SIP submittal, but did not propose action on any other portion of that submittal.

Additionally, on November 29, 1995, the President signed the National Highway Systems Designation Act, which, among other things, prohibited EPA from discounting the creditable emissions from a decentralized vehicle I/M testing program if an approvable conditional I/M SIP revision was submitted to EPA within 120 days of the bill's signature. EPA's Office of Mobile Sources issued guidance stating that they would accept an interim I/M SIP proposal and Governor's letter 120 days after signature of the bill in lieu of an adopted SIP revision. The SIP proposal and letter was submitted to the EPA prior to the March 27, 1996 deadline to meet the 120 day time frame. The final I/M SIP revision (Rule Log No. 96104-114-AI), commonly referred to as the "Texas Motorist's Choice Program," was adopted by the commission on May 29, 1996 and submitted to the EPA by the state on June 25, 1996. On October 3, 1996, EPA proposed (61 FR 51651-51659) conditional interim approval of the Texas Motorist's Choice Program based upon the state's good faith estimate of emission reductions and the program's compliance with the Clean Air Act.

Part of EPA's determination that the new I/M SIP is approvable depends on the program's ability to achieve sufficient creditable VOC reductions so that the 15% ROP can still be achieved. The commission designed the revised I/M program to fit in with the other elements of the 15% SIP to achieve the full amount of creditable reductions required. The I/M program also achieves creditable reductions for the Post-96 ROP SIP.

Changes to the I/M program have had an impact on the El Paso §818 Attainment Demonstration as well. This demonstration was predicated on the assumption that the I/M program would be implemented as adopted for the 15% SIP. An addendum to the §818 Demonstration shows that the basic underlying assumptions of the modeling still pertain despite the revisions to the I/M program.

The ETR program revision to the SIP and ETR rule were adopted in October 1992 by the TACB to meet the mandate established in the FCAA Amendments of 1990 (§182 (d) (1) (B)). This section of the FCAA required states with severe or extreme ozone nonattainment areas to develop and implement ETR programs in those areas. For Texas, the only area affected was the H-GA area. The ETR program required large employers (those with 100 or more employees) to implement trip reduction programs that would increase the average passenger occupancy rate of vehicles arriving at the workplace during the peak travel period by 25% above the average for the area.

Congress amended the FCAA in December of 1995 by passing House Rule 325. This amendment allows the state to require an ETR program at its discretion. It also allows a state to “remove such provisions (ETR program) from the implementation plan...if the state notifies the Administrator, in writing, that the state has undertaken, or will undertake, one or more alternative methods that will achieve emission reductions (1.81 tons/day) equivalent to those achieved by the removed...provisions.” As such, large employers will no longer be mandated to implement trip reduction programs. The H-GA ozone nonattainment area will, however, through the coordination of the Houston-Galveston Area Council, implement a voluntary regional initiative to reduce vehicle trips.

The 1990 Adjusted Base Year EI was submitted on November 12, 1993. It is the official inventory of all emission sources (point, area, on-road and off-road mobile) in the four nonattainment areas. There have been several changes to the EI due to changes in assumptions for certain area and non-road mobile source categories. Changes to the baseline EI have affected the target calculations and creditable assumptions made in the 15% and 9% SIPs.

In December of 1990, then-Texas Governor William Clements requested that the B-PA area be reclassified as a "moderate" ozone nonattainment area in accordance with Section 181(a)(4) of the FCAA Amendments of 1990. That request was denied on February 13, 1991. A recent review of the original request and supporting documentation has revealed that this denial was made in error. As provided by Section 110(k)(6) of the Act, the EPA Administrator has the authority to reverse a decision regarding original designation if it is discovered that an error had been made.

Monitoring data from a privately-funded, special purpose monitoring network which was not included in the Aerometric Information Retrieval System database was improperly used to deny this request. Furthermore, subsequent air quality trends demonstrated that B-PA is more properly classified as a moderate nonattainment area, and could attain the standard by the required date for moderate areas of November 15, 1996. Therefore, Governor Bush sent a letter and technical support to EPA on July 20, 1995, requesting that the B-PA area be reclassified to moderate nonattainment status. B-PA planned to demonstrate attainment one of the following ways:

- Monitored values showing attainment of the standard at state-operated monitors for the years 1994-1996, which is the time line the FCAA Amendments of 1990 specifies for moderate areas.
- UAM modeling showing attainment of the standard but for transport of ozone and/or precursors.

EPA Region VI verified the data submitted in support of this request, and concurred that it is valid. On June 3, 1996, the reclassification of the B-PA area became effective. Because the area was classified as serious, it was following the SIP submittal and permitting requirements of a serious area, which included the requirements for a Post-96 SIP. With the consolidated SIP submittal, the commission removed the B-PA area from the Post-96 SIPs, which became applicable to the H-GA nonattainment area only.

The State of Texas, in a committal SIP revision submitted to EPA on November 15, 1992, opted out of the Federal Clean Fuel Fleet program in order to implement a fleet emission control program designed by the state. In 1994, Texas submitted the state's opt-out program in a SIP revision to the EPA and adopted rules to implement the TAFF program. In 1995, the 74th Texas Legislature modified the state's alternative fuels program through passage of SB 200. In response to SB 200, the commission adopted regulations modifying the TAFF program to create the TCF program.

On June 29, 1994 the commission adopted a revision to the SO_2 SIP regarding emissions in Harris County. The SIP revision was required by EPA because of exceedances of the SO_2 NAAQS in 1986, 1988, and 1990. An EPA study conducted by Scientific Applications International Corporation also predicted SO_2 exceedances. On April 22, 1991 the EPA declared that portions of Harris County were potentially in nonattainment of the SO_2 NAAQS. Consequently, the HRM Corporation volunteered to find reductions in SO_2 in order to prevent being redesignated to nonattainment. HRM's efforts resulted in finding voluntary SO_2 reductions. These reductions were adopted in thirteen commission Agreed Orders and were included as part of the June 29, 1994 SIP revision. The EPA approved the Harris County SO_2 SIP on March 6, 1995 (60 FR 12125).

On May 14, 1997, the commission adopted an additional revision to the Harris County SO_2 SIP to incorporate modifications to two of the thirteen commission Agreed Orders. The remaining sections of the SIP remained the same. While on the scale of "minor technical corrections," the modified orders were submitted as a SIP revision because the new emission rates differ from what EPA had previously approved. The two agreed order modifications concerned grandfathered units at Simpson Pasadena Paper Company and Lyondell-Citgo Refining Company, Ltd. The commission approved changes to both Agreed Orders on July 24, 1996.

On May 14, 1997, the commission also adopted a revision to the SIP modifying the vehicle I/M program. This revision removed the test-on-resale component that had been included in the vehicle I/M program, as designed in July of 1996. Test-on-resale required persons selling their vehicles in the I/M core program areas to obtain emissions testing prior to the title transfer of such vehicles. Test-on-resale was not required to meet the FCAA Amendments of 1990 and did not produce additional emissions reduction benefits. The SIP revision also incorporated into the SIP the Memorandum of Understanding between the commissions and the Department of Public Safety, adopted by the commission on November 20, 1996.

The FCAA Amendments of 1990 required that, for severe and above ozone nonattainment areas, states develop SIP revisions that include specific enforceable TCMs, as necessary, to offset increases in motor vehicle emissions resulting from growth in VMT or the number of vehicle trips. This SIP revision would also satisfy reductions in motor vehicle emissions consistent with the 15% ROP and the Post-1996 ROP SIPs.

Therefore, the commission developed and submitted to EPA a committal SIP revision for the H-GA nonattainment area on November 13, 1992, and VMT Offset SIP revisions on November 12, 1993, and November 6, 1994, to satisfy the requirements of the 15% ROP SIP revision. The former SIP revision laid out a set of TCMs and other mobile source controls which reduced emissions below the modeled ceiling. The 1994 SIP revision did not require additional TCMs.

As a result of changes in the I/M and the ETR programs, it was necessary to do the 1997 VMT Offset SIP revision for the H-GA area, which was adopted on August 6, 1997. Additional TCMs were included:

High Occupancy Vehicle Lanes, Park and Ride Lots, Arterial Traffic Management Systems, Computer Transportation Management Systems, and Signalization. These TCMs were part of the "Super SIP" submitted to EPA on July 24, 1996.

Using the best technical guidance and engineering judgement available at the time, the state of Texas calculated emissions reductions available from the enhanced monitoring rule that was to be part of the Title V permitting program. The enhanced monitoring rule was later revised and transformed into the CAM Rule. Texas maintained that their calculation methodologies still accurately reflected the amount of creditable reductions available. EPA has indicated that they disagree with the calculation methodologies used by the state and intend to disapprove the 9% SIP as a result. EPA has also indicated that the emission reduction credits claimed for the Texas Clean Fuels Fleet program are not approvable due to a legislative change to the program. The state plans to submit a SIP revision for this program in a separate action, but has removed the credits claimed in the 9% SIP in this action. The state of Texas proposes to submit a revision to the 9% SIP which revises the reductions claimed by the state toward the 9% emissions target.

The State of Texas did not re-apply for an extension of the NO_x 182(f) waivers for H-GA and B-PA as discussed previously. Therefore, on December 31, 1997, it expired. The state will now be required to implement several NO_x control programs. Among them is a requirement for all major NO_x sources within the area to implement RACT. The state has proposed a revised compliance date for this program of November 30, 1999. The state believes that this program, taken in concert with the approvable VOC measures in the existing Post-96 SIP, will satisfy the ROP requirements of that SIP.

On July 18, 1997, EPA promulgated a new 8-hour NAAQS for ozone. This standard is intended to replace the previous 1-hour standard. However, EPA decided that areas would still have to attain the 1-hour standard before implementing controls to attain the new 8-hour standard. Therefore, on December 29, 1997, EPA issued guidance on requirements for areas that have not yet attained the 1-hour standard. In Texas, this includes D-FW, B-PA, El Paso, and H-GA. Among other elements, the guidance required a SIP revision for the HGA area to be submitted to EPA by April 1998. The state of Texas met this requirement by submitting a SIP revision which contained UAM modeling based on the COAST study described above, identification of the level of controls necessary to achieve attainment of the 1-hour ozone standard, identification of emissions sources for potential future control strategies, and a commitment schedule for future attainment demonstration SIP submittals.

The State of Texas, in a committal SIP revision adopted by the commission on June 3, 1998, and submitted to EPA on June 23, 1998, agreed to implement OBD checks as part of the I/M program by the federal deadline of January 1, 2001.

The State of Texas, in a committal SIP revision submitted to EPA on November 15, 1992, opted out of the Federal Clean Fuel Fleet program in order to implement a fleet emission control program designed by the state. In 1994, Texas submitted the state's opt-out program in a SIP revision to the EPA and adopted rules to implement the TAFF program. In 1995, the 74th Texas Legislature modified the state's alternative fuels program through passage of SB 200. In response to SB 200, the commission adopted regulations modifying the TAFF program to create the TCF program. In 1997, the 75th Texas Legislature modified the state's alternative program once again through passage of SB 681. On July 29, 1998, the commission adopted regulations and a revision of the TCF SIP to set forth the LEV requirements for mass transit fleets in each of the serious and above nonattainment areas, and for local

government and private fleets operated primarily within the serious and above nonattainment areas. These rules satisfy the state requirements to adopt rules to implement SB 681.

The D-FW area was classified as a moderate ozone nonattainment area in accordance with the FCAA Amendments of 1990. As a moderate nonattainment area, D-FW was to demonstrate, through monitoring, attainment of the 1-hour ozone standard by November 15, 1996, or face being "bumped-up" to the serious classification. Air quality data from the D-FW area ambient air quality monitors from the years 1994-96 show that the 1-hour NAAQS for ozone has been exceeded more than one day per year over this three-year period. On February 18, 1998 the EPA issued a final notice in the *Federal Register* that the D-FW area was being reclassified to the serious classification for failing to attain the NAAQS for ozone. As a result of this reclassification, the EPA has required that a new SIP demonstrating attainment of the ozone standard in D-FW be submitted by March 20, 1999. The accompanying SIP not only demonstrates how the D-FW area will attain the standard through the submission of an updated emissions inventory and photochemical modeling but also includes a 9% ROP target calculation in order to satisfy EPA's requirement of reasonable further progress in emission reductions for the D-FW area for the years 1997-99.

B. OZONE CONTROL STRATEGY

1. POLICY AND PURPOSE (Revised.)

a. Primary Purpose of the Plan (Revised.)

The primary purpose of this plan is in response to §181(b)(2)(A) of the FCAA Amendments of 1990 concerning the reclassification of an area for failing to attain the standard and to fulfill §182(c)(2) of the FCAA Amendments of 1990 concerning Attainment and Reasonable Further Progress Demonstrations, and various EPA guidance.

b.-d. (No change.)

2. SUMMARY OF THE PRINCIPAL ELEMENTS ADDRESSED WITHIN THIS PLAN (Revised.)

a.-c. (No change.)

d. Required Emission Reductions (Revised.)

This plan contains a revision to the emission reductions needed to achieve the 9% ROP SIP target. Details regarding this plan can be found in §VI.B.11.c.

This plan contains an estimate of the required levels of reductions of the ozone precursors VOC and NO_x necessary to achieve attainment of the 1-hour ozone standard in the D-FW nonattainment area. These estimates are based on EPA protocols for projecting the EI from the 1995 and 1996 photochemical modeling base case EI out to 1999. The CAMx model was the tool used to determine the required level of reductions. Details regarding this plan can be found in §VI.B 9.b.

e. Sources of Emission Reductions (Revised.)

Substantial quantities of VOC and NO_x are emitted by business, industry, consumer products, and motor vehicles. For the 9% SIP revision, this plan identifies the control strategies which will be used to meet requirements for the Rate of Progress for the years 1997-99. Because photochemical modeling shows that both VOC and NO_x reductions are effective in reducing ground level ozone in the D-FW area, this SIP also identifies, under separate rulemaking, NO_x Reasonably Available Control Technology and Nonattainment New Source Review requirements for NO_x . Also, as a result of being reclassified to serious, VOC Reasonably Available Control Technology rules are being modified due to the lower threshold level.

3. - 8. (No change.)

9. SIP REVISIONS FOR THE ATTAINMENT DEMONSTRATION (Revised. See attached Chapters 1-7)

   a. El Paso §818 Attainment Demonstration (No change.)
   b. Dallas/Fort Worth Attainment Demonstration (Revised.)

10. SIP REVISIONS FOR THE REDESIGNATION AND MAINTENANCE PLANS (No change.)

11. SIP REVISIONS FOR THE POST-96 RATE-OF-PROGRESS (No change.)

12. SOCIAL AND ECONOMIC CONSIDERATIONS OF THE PLAN (No change.)

13. FISCAL AND MANPOWER RESOURCES (No change.)

14. HEARING REQUIREMENTS (Revised.)

   a. - h. (No change.)

   i. The state conducted a public hearing for this SIP on December 1, 1998 at 7:00 p.m. at the City of Irving Central Library Auditorium, 801 West Irving Boulevard. Staff also conducted a question and answer period one-half hour prior to the start of the hearing. The close of the public comment period was December 7, 1998.

CHAPTER 1: BACKGROUND

The D-FW area was classified as a moderate ozone nonattainment area in accordance with the FCAA Amendments of 1990. As a moderate nonattainment area, D-FW was required to demonstrate attainment of the 1-hour ozone standard by November 15, 1996, or face being "bumped-up" to the serious classification. Air quality data from the D-FW area ambient air quality monitors from the years 1994-96 show that the 1-hour NAAQS for ozone has been exceeded more than one day per year over this three-year period. On February 18, 1998 EPA issued a final notice in the *Federal Register* that the D-FW area was being reclassified to the serious classification for failing to attain the NAAQS for ozone.

As a result of being reclassified, the EPA is requiring that a serious area SIP revision addressing attainment of the standard be submitted by March 20, 1999, which is 12 months from the effective date of the D-FW area's reclassification. The SIP will also include a 9% ROP target calculation and emission reductions toward satisfying EPA's requirement of reasonable further progress for the D-FW four county nonattainment area for the years 1997-99. In addition, the SIP contains photochemical modeling showing the level of reductions needed to attain the standard by 1999. The attainment deadline for serious areas is November 15, 1999. Because of numerous 1-hour ozone exceedances in 1997, it would not be possible for the D-FW area to attain the standard by that deadline. There is mounting technical data which suggests that D-FW is significantly impacted by transport and regional background levels of ozone. The State of Texas is currently developing a regional study to address this issue. However, it will take some time to develop the necessary rules to implement that program. Also, because of the short time period, there is not enough time to implement the rules necessary to bring reductions of ozone precursor emissions in the D-FW area. Therefore, the state proposes to submit, in March 2000, additional elements to a full Attainment Demonstration including the complete rule package necessary to attain the 1-hour ozone standard. Discussions between the state and the EPA continue in order to determine the timing and the future attainment deadline for a future SIP submittal.

Because of the reclassification from moderate to serious, and the modeling conducted to date which indicates that reductions of NO_x will be needed to attain the standard, there are certain rules that are necessary for inclusion with this SIP. However, these rules are being covered under separate rulemaking and include the following:

- RACT for NO_x.
- Nonattainment NSR for NO_x.
- Fix-ups from the change in the major source threshold for RACT for VOCs.

In June 1994, an Attainment Demonstration for the D-FW area was submitted to the EPA. This SIP revision incorporated the use of photochemical modeling to demonstrate that the D-FW area would attain the 1-hour ozone standard by implementing the VOC control strategies that were included in the 15% ROP SIP. The role of NO_x in the D-FW nonattainment area under that plan was never evaluated through modeling because it was determined that attainment could be reached by VOC controls alone. The current Attainment Demonstration also utilizes photochemical modeling and investigates the effectiveness of both VOC and NO_x reductions on reducing ground level ozone. The modeling results indicate that a combination of both NO_x and VOC reductions is the most effective at reducing ozone levels in the D-FW area. Because the 1994 Attainment Demonstration showed that attainment of the standard could be reached by VOC reductions alone, the D-FW area applied for and was granted a waiver from §182(f) of the FCAA regarding NO_x reductions on November 28, 1994. Because EPA's approval of

this waiver was conditional should future photochemical modeling show that NO_x reductions contribute toward attainment in the D-FW area, submittal of this modeling will result in EPA rescinding the NO_x waiver and reinstating the NO_x requirements for D-FW which are being addressed in separate but concurrent rulemaking. Under separate correspondence, a letter was submitted to the EPA on November 13, 1998 indicating that this most recent photochemical modeling has triggered their condition of the NO_x waiver and thus it should be rescinded.

CHAPTER 2: EMISSIONS INVENTORY

2.1 OVERVIEW

The 1990 Amendments to the FCAA require that EIs be prepared for ozone nonattainment areas. Because ozone is photochemically produced in the atmosphere when VOCs are mixed with NO_x and CO[1] in the presence of sunlight, it is important that the planning agency compile information on the important sources of these precursor pollutants. It is the role of the EI to identify the source types present in an area, the amount of each pollutant emitted and the types of processes and control devices employed at each plant or source category. The EI provides data for a variety of air quality planning tasks, including establishing baseline emission levels, calculating reduction targets, control strategy development for achieving the required emission reductions, emission inputs into air quality simulation models, and tracking actual emission reductions against the established emissions growth and control budgets. The total inventory of emissions of VOC, NO_x, and CO for an area is summarized from the estimates developed for five general categories of emissions sources, which are each explained below.

2.2 POINT SOURCES

Major point sources are defined for inventory purposes in nonattainment areas as industrial, commercial, or institutional which emit actual levels criteria pollutants in the following amounts. The levels are 10 tpy or more per year of VOC, 25 tpy of NO_x or 100 tpy of any of the other criteria pollutants, CO, SO_x, PM_{10}, or lead. For the remaining areas of the state, any company which emits a minimum of 100 tpy of any criteria pollutant must complete an inventory. Additionally, any source which generates or has the potential to generate at least 10 tpy of any single HAP or 25 tpy of aggregate HAP is also required to report emissions to the commission.

To collect emissions and industrial process operating data for these plants, the commission mails EIQs to all sources identified as having the triggering level of emissons. Companies are asked to report not only emissions data for all emissions generating units and emission points, but also the type and, for a representative sample of sources, the amount of materials used in the processes which result in emissions. Information is also requested in the EIQ on process equipment descriptions, operation schedules, emissions control devices currently in use, abatement device control efficiency, and stack parameters such as location, height, and exhaust gas flow rate. All data submitted via the EIQ is then subjected to rigorous quality assurance procedures by the technical staff of the Industrial Emissions Assessment Section and entered into the PSDB by the Data Services Section.

2.3 AREA SOURCES

To capture information about sources of emissions that fall below the point source reporting levels and are too numerous or too small to identify individually, calculations have been performed to estimate emissions from these sources on a source category or group basis. Area sources are commercial, small-scale industrial, and residential categories of sources which use materials or operate processes which can generate emissions. Area sources can be divided into two groups characterized by the emission mechanism: hydrocarbon evaporative emissions or fuel combustion emissions. Examples of evaporative

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[1]CO plays a relatively minor role in ozone formation compared with VOC and NO_x.

losses include: printing, industrial coatings, degreasing solvents, house paints, leaking underground storage tanks, gasoline service station underground tank filling, and vehicle refueling operations. Fuel combustion sources include stationary source fossil fuel combustion at residences and businesses, as well as outdoor burning, structural fires and wildfires. These emissions, with some exceptions, may be calculated by multiplication of an established emission factor (emissions per unit of activity) times the appropriate activity or activity surrogate responsible for generating emissions. Population is the most commonly used activity surrogate for many ASCs, while other activity data include amount of gasoline sold in an area, employment by industry type, and acres of cropland.

2.4 ON-ROAD MOBILE SOURCES

On-road mobile sources consist of automobiles, trucks, motorcycles, and other motor vehicles traveling on public roadways in the nonattainment area. Combustion related-emissions are estimated for vehicle engine exhaust; evaporative hydrocarbon emissions are estimated for the fuel tank and other evaporative leak sources on the vehicle. Emission factors have been developed using the EPA's mobile emissions factor model, MOBILE5a. Various inputs are provided to the model to simulate the vehicle fleet driving in each particular nonattainment area. Inputs include such parameters as vehicle speeds by roadway type, vehicle registration by vehicle type and age, percentage of vehicles in cold start mode, percentage of miles traveled by vehicle type, type of I/M program in place, and gasoline vapor pressure. All of these inputs have an impact on the emission factor calculated by the MOBILE model, and every effort is made to input parameters reflecting local conditions. To complete the emissions estimate the emission factors calculated by the MOBILE model must then be multiplied by the level of vehicle activity, VMT. The level of vehicle travel activity is developed from travel demand models run by the Texas Department of Transportation or the local council of governments. The travel demand models have been validated against a large number of ground counts of traffic passing over counters placed in various locations throughout each county. Estimates of VMT are often calibrated to outputs from the federal HPMS, which is a model built from a smaller number of traffic counters. Finally, roadway speeds, which are required for the MOBILE model’s input, are calculated by a post-processor to the travel demand model.

2.5 NON-ROAD MOBILE SOURCES

Non-road mobile sources are a subset of the area source category. This subcategory includes aviation aircraft, marine vessels, recreational boats, railroad locomotives, and a very broad category that includes everything from the engines on construction equipment and tractors to trimmers. Calculation methods for emissions from non-road engine sources vary considerably because of the differences in usage patterns, but in general are based on manufacturer supplied information about engine horsepower, load factor, emission factors, usage, and equipment sales and distribution. Emission estimates for all sources in the non-road category except aircraft were originally developed by a contractor to EPA's Office of Mobile Sources, and subsequently commission staff have “grown” the emission levels using an econometric model (EGAS). Aircraft emissions were estimated with landings and takeoff data for airports in each area multiplied by EPA developed emission factors for aircraft operations.

2.6 BIOGENIC SOURCES

Biogenic sources are another subset of area source which includes hydrocarbon emissions from crops, lawn grass, and forests as well as a small amount of NO_x emissions from soils. Plants are sources of VOC such as isoprene, monoterpene, and alpha-pinene. Tools for estimating emissions include satellite imaging for mapping of vegetative types, field biomass surveys, and computer modeling of emissions estimates based on emission factors by plant species (PCBEIS-2). Emissions from biogenic sources are subtracted from the inventory prior to determining any required reductions for a rate of progress plan. However, the biogenic emissions are important in determining the overall emissions profile of an area and therefore are required for regional air quality dispersion modeling.

2.7 EMISSIONS SUMMARY

The 1990 base year emissions inventory summary for the D-FW four-county ozone nonattainment area is included in Figures 2.7-1 (VOC) and 2.7-2 (NO_x). It is evident from the pie charts that the greatest emissions contribution in the D-FW area is from mobile sources. Contribution from VOC emission sources in ranking order include the following: On-road mobile sources make up 37% of the inventory; area source emissions are 32%; non-road mobile sources are 19%; and point sources make up 12% of the inventory. Contribution from NO_x emissions sources include the following: On-road mobile 50%; non-road mobile 28%; point sources 19%; and area sources 3%.

The 1999 emission inventory for the D-FW nonattainment area is summarized in Figures 2.7-3 (VOC) and 2.7-4 (NO_x). The 1999 emissions inventory is an estimation that is projected forward from the 1990 base year inventory using specific procedures approved by the EPA. The contribution from VOC sources in the 1999 inventory include the following: Area sources 38%; on-road mobile sources 33%; non-road mobile sources 24%; and point sources 5%. Contribution from NO_x includes the following: On-road mobile sources 50%; non-road mobile sources 36%; point sources 10%; and area sources 4%.
The percentages of the source categories of the 1999 emissions inventory shows a change in the D-FW area since 1990. In comparison, the percentages for both the 1999 VOC and NO_x emissions inventory for on-road mobile source dropped or stayed the same, area source and non-road emissions increased, and the point source emissions were lower.

Figure 2.7-1 thru 2.7-4

CHAPTER 3: PHOTOCHEMICAL MODELING

3.1 INTRODUCTION

This section of the SIP document summarizes procedures and results of photochemical modeling conducted in support of the attainment demonstration for the D-FW ozone nonattainment area. The purpose of the modeling was to determine the necessary level of reductions of ozone precursors for demonstrating attainment of the 1-hour ozone NAAQS in the area by 1999, the attainment year for serious ozone nonattainment areas.

Topics that will be discussed in the following sections include:

- Overview of photochemical modeling process
- Quality assurance/quality control
- Policy and technical oversight committees
- Overview of 1996 summer field study
- Model selection
- Modeling domain
- Initial and boundary conditions
- Meteorological and air quality data considerations
- Modeling episode selection
- Meteorological model selection
- Meteorological modeling
- Base case emissions inventory development and data
- Base case modeling
- Model performance evaluation
- Future year inventory development
- Future year modeling—procedures, results, and conclusions
- Data access

3.2 OVERVIEW OF THE PHOTOCHEMICAL MODELING PROCESS

3.2.1 Ozone Photochemistry

Ozone is a secondary pollutant — it is not emitted directly into the atmosphere. Ozone is formed by a complex photochemical process involving the chemical interaction of NO_x, VOCs, and energy from sunlight. NO_x is a shorthand term representing the sum of two major nitrogen compounds (nitric oxide and nitrogen dioxide) that participate in the ozone reaction. NO_x emissions emanate primarily from anthropogenic combustion sources such as industrial facilities, power plants, automobiles, and other engines.

VOCs are all of the VOCs that participate in the ozone chemistry. VOC emissions emanate from combustion sources, leaks at industrial facilities (fugitive emissions), and evaporation of fuel and solvents. A large amount of VOC emissions come from vegetation, particularly oak and pine trees

(biogenic emissions). Although we can reduce anthropogenic emissions of VOCs, control of the biogenic portion of the emissions is not considered feasible.

Ozone problems tend to occur during the summer months because, in addition to being dependent upon emissions of NO_x and VOC, ozone formation is enhanced by summer meteorological conditions. For example, the sun is higher on the horizon, which increases the temperature and the ultraviolet radiation available to the chemical reactions that form ozone. The higher temperatures increase biogenic activity as well as evaporation of VOCs. Finally, the lighter winds allow ozone and the pollutants that form it to accumulate.

3.2.2 Model Input

Because ozone photochemistry is an extraordinarily complex process, sophisticated computer models are necessary to simulate ozone formation in a region and to evaluate the effectiveness of candidate control strategies. An enormous amount of data is required to support the model, all of which must be carefully prepared and thoroughly quality assured. Some of the model input data is measured, some is generated using engineering estimates, and some is output from other models, which are often quite sophisticated in their own right. For example, estimating mobile source emissions requires using the traffic demand model used for highway planning to calculate the number of vehicle miles traveled on each section of roadway at each applicable time period of the day. A second model predicts emission rates of various types of vehicles based on speed, ambient temperature, and fleet age. The results of these two models are combined to produce the motor vehicle emissions input to the photochemical model. In fact, most of the data input into a photochemical model is itself the result of preliminary modeling. Therefore the input and output of all these preliminary models must be carefully quality assured before being used in the photochemical model.

The three main categories of data input to a photochemical model are: emissions, meteorological, and air quality. Since only a small number of emissions sources have direct measurements, most of the emissions data input into photochemical models are themselves the result of emissions models. The EPA has developed a number of standardized procedures and techniques for making these estimates, but it also allows the use of improved methods and data when available. Similarly, the limited number of meteorological monitors cannot adequately describe complex three-dimensional meteorology required by the photochemical model to simulate the movement and mixing of ozone and its precursors. Therefore, sophisticated meteorological models are employed to furnish the photochemical model with the required atmospheric dynamics.

Finally, air quality data (pollutant measurements) are required for two reasons. First, the data can be used directly in the modeling process for defining the conditions at the start of the simulation (initial conditions), and for defining the concentrations of various pollutants at the outside edges of the modeling domain (boundary conditions). Because air quality data measurements are typically very sparse, especially in rural areas, it may be impossible to accurately define the initial and boundary conditions for a modeling application. The impact of uncertain initial conditions on the model results can be mitigated by starting the simulation two or more days prior to the onset of the ozone episode being modeled (these prior days are usually called “ramp-up” days). Similarly, use of very-large-scale modeling domains reduces the impact of uncertain boundary conditions on the modeling results.

The second reason air quality data are essential to the modeling process is their use in validating the model’s input and output. A critical step in any modeling application is the validation of the modeled

inputs relative to measured emissions, meteorology and precursor data whenever and wherever they are available. Even more critical is the comparison of model-predicted ozone concentrations versus monitored ozone concentrations. If the model's estimates of ozone closely match the measured values, then we have reason to believe the model is accurately simulating ozone formation during the episode being modeled. Measured concentrations of NO_x, VOC, and CO are also compared with modeled concentrations to provide insight into the model's behavior and to help identify possible problem areas.

3.2.3 Photochemical Models

Several photochemical models are specifically designed to simulate ozone formation in urban areas. The EPA has in the past recommended the use of the UAM-IV. However, recently the UAM-IV has been supplanted by newer models that have improved model chemistry, better treatment of vertical diffusion, and more realistic treatment of plumes. In addition, these next-generation models allow the use of variable grid size, which in turn allows the use of much larger modeling domains and facilitates studies of long-range pollutant transport. Based on these improvements, the commission modeling staff has selected the CAMx for attainment demonstration modeling.

All PGMs are extremely complex. They simulate both the meteorological processes that contribute to ozone formation (e.g., wind flow, atmospheric mixing, sunlight) and the photochemical reactions involving NO_x and VOC. PGMs characterize the atmosphere over an area of interest with a three-dimensional grid that may include thousands of individual grid cells in the horizontal and vertical (see Figure 3.2-1). A powerful computer is required to keep track of the meteorological conditions in each cell, to add in emissions from every source in the grid, to calculate the amount of solar energy available, to solve the chemical and physical equations that describe the formation of ozone in each grid cell, and to transport the new emissions and ozone to adjacent cells.

3.2.4 Modeling Process

The general PGM modeling process is shown in Figure 3.2-2. The procedure for the modeling starts with developing a modeling protocol, defining a modeling domain, and selecting one or more historical ozone episodes to represent typical high ozone occurrences. Then, the historical data required for running the model for the episodes (emissions, meteorological, and air quality data) are collected, developed, quality-assured, and input to the model. The results of executing the model on the historical information is usually called the "base case" modeling. Once the model is run for the base case, a performance evaluation is conducted to compare the model output to the measured air quality data and to determine how well the model predicted the ozone levels that actually occurred.

It is extremely important to verify that the photochemical grid model is developing ozone in the correct amounts at the right times and places in the area of interest. Performance is evaluated using EPA-approved evaluation criteria and performance limits. If performance is not acceptable, the model inputs are examined and may be modified, provided the adjustments are technically defensible.

Once the PGM base case model performance meets the EPA performance criteria, then the work shifts to the "future case" to determine what ozone concentrations are likely with future emissions, and what controls will be required to meet the NAAQS for ozone. Emissions are projected to the attainment year applicable to the urban area. These future emissions are based on econometric forecasts that estimate the growth of population, traffic and industry in the future. The future inventory is also adjusted to reflect

any existing state or federal regulations which will take effect between the base year and the attainment year. At this point, the future inventory is a “future base inventory.”

The photochemical model is then run using the future base emissions inventory, using the same meteorology that was validated in the base case episodes. This modeling estimates the ozone that would occur with future emissions under the same meteorological conditions that produced the original base case episode. At this stage of the process, it is hoped that the state and federal regulations that are already in place will reduce ozone sufficiently for the area to meet the NAAQS by the attainment year. If the model does not show that the existing regulations are sufficient for the area to meet the NAAQS, then emissions reduction targets are determined. These targets will indicate what *further* reductions of VOC and/or NO_x are needed for the area to attain the ozone standard, and what emission source types should be controlled. Once a set of additional candidate controls are developed, the model is used to test how effective the control package is in bringing the area into attainment. This process continues until a successful control strategy is developed.

The modeling discussed in this document involves the above described processes through the step where emission reduction targets are determined. Subsequent modeling will be conducted to evaluate specific control strategies.

Fig 3.2-1 and Fig 3.2-2

3.3 QUALITY ASSURANCE/QUALITY CONTROL

Extensive QA/QC procedures were implemented as an essential element of the attainment demonstration modeling process for D-FW. QA/QC procedures were implemented for major attainment demonstration tasks including meteorological field development, emissions inventory preparation, model execution, and results interpretation. QA/QC procedures included internal peer review, reasonableness checks of input data and results, and application of statistical and graphical techniques, many of which were developed by commission staff.

Specific QA/QC procedures for model input data and model results are discussed in more detail in later sections of this document.

3.4 MODELING OVERSIGHT GROUP

Oversight for D-FW ozone modeling was provided by a large group consisting of members of the area's former Air Quality Advisory Committee as well as other persons who were expected to be affected by the SIP. The D-FW Oversight Committee included individuals with a broad spectrum of interests including government officials, environmentalists, academics, industrial representatives, consultants, and other interested individuals. The goals of the commission were to explain the ozone modeling process and deliver updates on the work in progress to a very diverse audience, and to develop community confidence in the modeling results.

Meetings began in March 1998 and were held approximately monthly at a variety of locations in the D-FW area. Typically 50 to 60 persons attended each meeting. Group meetings and their agendas were coordinated by the commission modeling staff with the assistance of the NCTCOG, which is the umbrella metropolitan planning organization for the communities in the D-FW nonattainment area. There are 124 names of individuals on the membership list. Because of its length, it is not included in this document; however, it is available from the commission SIP modeling staff upon request.

Meetings were generally preceded by a mailout of an agenda and various materials for review. During the meetings, the committee had an opportunity to evaluate episode selection, emissions inventory, sensitivity runs, and base case and future case modeling results. Individuals made suggestions, which were taken back to the commission for staff review.

3.5 1996 DALLAS-FORT WORTH SUMMER OZONE STUDY

During the summer of 1996, the commission conducted an ozone study in the D-FW area called the Dallas Summer Study. The existing air pollution and meteorology monitoring network in the D-FW area was augmented to include the following: two automated gas chromatographs were installed at three sites which measure hourly averages of hydrocarbons associated with the Photochemical Assessment Monitoring Sites program; three-hour multi-canister sampling was conducted at one location; a new ozone site was established in Midlothian; carbonyl samples were collected by the U.S. EPA at two sites; upper air meteorological data were collected at one site using an acoustic sounder; and an instrumented van was used to do roadside mobile monitoring and vehicle fleet emission estimations.

The data collected during the Dallas Summer Study have been used in the episode selection process for photochemical grid modeling. The availability of the additional data played a role in the ranking of candidate episodes (see Section 3.10, *Episode Selection*). The data have also been used to assess the state

of the air quality environment in the area. In addition, the data have provided insight into characterizing the important meteorological factors in ozone formation in the D-FW area, as well as the temporal distribution and chemical composition of hydrocarbon emissions. Much of the work is still ongoing and many of the results are not yet available. For a complete description of the Dallas Summer Study as well as other analyses, see Chapter 4, *Data Analysis*.

3.6 MODEL SELECTION

The EPA's *Guideline on Air Quality Models, Revised* defines the UAM as the preferred photochemical grid model for use in developing ozone attainment demonstration SIPs. The regulatory version of the UAM is UAM-IV (version 6.20). However, the commission modeling staff chose to use the CAMx for the D-FW SIP for several reasons, as follows:

- Vertical grid structure—A new vertical grid structure that allows higher resolution of vertical atmospheric layers near the surface, and permits more realistic treatment of nighttime vertical structures and elevated plumes.

- Three-dimensional inputs—Various meteorological parameters are allowed to vary temporally and spatially instead of being constant over space.

- Nested grid—The ability for the modeling domain to be defined with variable-sized grid cells. This "nested grid" feature allows the use of relatively small grid cells in domain areas where a detailed representation of meteorology, chemistry, and emissions is especially important to the modeling results. It allows the use of larger grid cells where detailed computations and results are not as important. Because variable grid cell sizing allows the use of larger cell sizes in outlying areas than in the critical areas of interest, computation time is reduced, and the use of a larger modeling domain is thus feasible. The use of a larger domain in turn helps minimize the influence of boundary conditions (pollutant concentrations along the outer edges of the modeling domain that can strongly influence the model results, but that may not be well-quantified).

- Plume in grid—Emissions from elevated stacks can be treated as plumes that disperse slowly, rather than immediately being released into the model's grid cells.

- Improved isoprene chemistry—Isoprene is a highly reactive VOC emitted primarily by trees. CAMx includes improved isoprene chemistry algorithms, which are more appropriate for state-of-the-science biogenic EIs, than are the analogous algorithms of UAM-IV.

- Public domain model—CAMx can be treated as a public domain model since the license from the model developer, ENVIRON, Inc., only requires acknowledgment of the model's authors. The selection of a public domain model will facilitate the comparison of the commission SIP modeling with other modeling studies currently under way in the near nonattainment areas of San Antonio and Tyler–Longview and allow various stakeholders to readily run the model.

- Chemical compiler mechanism—The CAMx code has increased flexibility over older UAM codes because of a separate Chemical Mechanism Compiler. This preprocessor program allows for easier evaluation of ozone reaction mechanisms because equations that contribute to ozone formation may be added or subtracted from an ASCII file without major modifications to the rest of CAMx.

- Ozone Source Apportionment Technology—CAMx has a separate diagnostic tool called OSAT. This software is expected to be very useful for identifying particular emissions categories or source regions that are especially accountable for ozone production. The development of NO_x or VOC emissions control strategies have often relied on a large series of "matrix" runs in which many scenarios of emissions reductions are tested. OSAT should help target which scenarios will be most effective.

- Job file structure—CAMx job files are more clearly structured and commented than job files for other photochemical grid models. This makes the documentation and project management much easier, faster, and clearer.

Commission modeling staff presented the above points in a letter to EPA Region 6 on April 13, 1998, which discussed the rationale for the use of CAMx in D-FW SIP modeling. An attachment to that letter provided the favorable results of a performance comparison between CAMx and UAM-IV for the 1993 episode used for the Houston-Galveston SIP, submitted in April 1998. The letter to EPA as well as EPA's response are included in *Appendix A, Model Selection - TNRCC/EPA Letters*. The results of the UAM IV-CAMx comparison for Houston-Galveston are discussed below.

For UAM-IV and CAMx, Table 3.6-1 compares the highest observed 1-hour ozone concentration with the modeled domain-wide maximum observed on each day during the September 1993 episode modeled for the H-GA SIP. By this measure, CAMx is closer to the observed maximum values on three of the four days, including the peak day of September 8, 1993. UAM-IV is outside the recommended relative difference for domain peak maximum on September 10.

Table 3.6-1. Comparison of UAM-IV and CAMx Simulated Domain Ozone Maximum for H-GA (recommended domain peak relative difference is 20%)

Date	Observed Peak 1-Hour Ozone (ppb)	UAM-IV Domain Max (ppb)	Relative Difference (%)	CAMx Domain Max (ppb)	Relative Difference (%)
9/8/93	214	178	-16.6	189	-11.9
9/9/93	195	193	-1.0	185	-5.1
9/10/93	162	209	28.9	185	14.2
9/11/93	189	171	-9.4	192	1.7

Statistics for the other two recommended EPA measures, normalized bias and normalized gross error, are presented in Table 3.6-2. Considering these two measures as well as the domain peak relative difference discussed above, the conclusion of these comparison studies is that CAMx version 1.13 has better performance than UAM-IV for the modeling of the September 1993 episode.

Table 3.6-2. Comparison of UAM-IV and CAMx for Normalized Bias and Gross Error (**%**)				
Episode Date	Normalized Bias		Gross Error	
	UAM-IV	CAMx	UAM-IV	CAMx
9/8/93	-11.4	9.2	29.0	24.3
9/9/93	3.4	12.7	32.8	28.1
9/10/93	-9.8	-2.7	29.5	23.7
9/11/93	-10.3	10.1	25.8	23.4
EPA Recommended Limit	±15		35	

In its letter of response dated May 6, 1998, the EPA agreed that because of time constraints, "the typical justification based upon a comparison of CAMx vs. UAM-IV for one or more of the current episodes being modeled for D-FW was not feasible. Therefore, the justification for the use of CAMx for the current D-FW SIP modeling was to be based upon a comparison between CAMx vs. UAM-IV for the recently completed H-GA SIP modeling."

3.7 DEFINITION OF THE DALLAS–FORT WORTH MODELING DOMAIN

The commission chose the modeling domain for the D-FW attainment demonstration to be large enough to minimize the influences of inherently uncertain boundary conditions on the modeling results, and at the same time to allow an assessment of the regional transport of ozone and its precursors. As seen in Figure 3.7-1, the domain stretches from West Texas to Georgia, and from Mexico to Kansas. Within this large grid are two nested grids, the larger of which covers most of East Texas, and the smaller, high resolution grid, which covers the D-FW area. The modeling domain was defined in relation to the UTM Zone 15 map projection.

The core domain was designed to encompass the area of most interest for this attainment demonstration (D-FW). The southwest corner of the core domain is 16 km easting and 3,524 km northing. It stretches 232 km to the east and 200 km to the north, so that the northeast corner is at 248 km easting and 3,724 km northing. The grid cell size for the core domain was selected to be relatively small (4 km x 4 km), since model results are more precise with small grid cell sizes, and since the core domain contains the areas of most interest where modeling precision is most important. It has 58 x 50 horizontal grid cells.

The middle, or transition, domain covers most of East Texas. The southwest corner of the transition domain is -124 km easting and 3,192 km northing. It stretches 576 km to the east and 640 km to the north, so that the northeast corner is at 452 km easting and 3,832 km northing. The grid cell size in the

transition domain (16 km x 16 km) was selected to be relatively coarse compared with the small core domain but finer than the large regional domain. It has 36 x 40 horizontal grid cells. This domain serves as the transition area between the small core domain and the large regional domain.

The regional domain covers Texas (except for far West Texas), Louisiana, Mississippi, Arkansas, most of Oklahoma and Alabama, and portions of Florida, Georgia, Tennessee, Kentucky, Missouri, and Kansas. The southwest corner of the regional domain is -300 km easting and 2,824 km northing. It stretches 1,504 km to the east and 1,312 km to the north, so that the northeast corner is at 1,204 km easting and 4,136 km northing. The grid cell size in the regional domain was selected to be relatively coarse: 32 km x 32 km. It has 47 x 41 horizontal grid cells. The large regional domain, as defined, serves two purposes: (1) to minimize the influence of modeling domain boundary conditions (the domain extends far beyond the core area of interest); and (2) to account for the potential impact of emissions from the regional areas on the D-FW area.

The number of vertical layers in the modeling domain is a compromise between including enough detail to accurately characterize the vertical layering of the atmosphere and managing the amount of computer resources required to run the model. Eight vertical layers were selected for use in this modeling (Table 3.7-1), with the top of the modeling domain set at 3,030 meters. The same vertical layer structure was used for all three nested domains.

Table 3.7-1. Vertical Layer Structure of D-FW CAMx Modeling Domain

	Height Above Ground Level		
Layer Number	**Layer Top (m)**	**Layer Center (m)**	**Layer Thickness (m)**
1	20	10	20
2	80	50	60
3	220	150	140
4	380	300	160
5	720	550	340
6	1,380	1,050	660
7	2,120	1,750	740
8	3,030	2,575	910

m = meters

Fig 3.7-1

3.8 BOUNDARY AND INITIAL CONDITIONS

3.8.1 Lateral Boundary Conditions

Lateral boundary conditions consist of hourly chemical concentrations distributed horizontally and vertically along the sides of the modeling domain. The lateral boundaries can be best visualized as "walls" surrounding the area modeled. Lateral boundary conditions, through physical and chemical processes, can have a significant influence on ozone concentrations in the areas of interest within the modeling domain. The D-FW regional modeling domain (see section entitled Definition of D-FW Modeling Domain) was selected to be sufficiently large to minimize the model sensitivity in the area of interest (D-FW) to boundary conditions.

The commission staff developed the D-FW regional domain boundary conditions using time-dependent monitored ozone concentrations where available, and data for other chemical species based on the results of regional modeling conducted for the Coastal Oxidant Study for Southeast Texas. Details of the development of these values can be found in *Final Report: Future-Year Boundary Conditions For Urban Airshed Modeling For The State of Texas* (*Yocke, et. al.*, 1996). The UAM-V boundary condition preprocessor (*SAI*, 1996), BNDARY, was used to create the boundary condition files. For the purpose of specifying boundary concentrations, the D-FW regional domain boundary was divided into three segments: western, southern, and northeastern segments, as shown in Figure 3.8-1. Note that even though the modeling grid extends into Mexico, the southwestern portion of the lateral boundary is defined to follow the international border defined by the Rio Grande. This lateral boundary definition was chosen to exclude northeastern Mexico from the modeling domain, since no reliable emissions inventory for that area is currently available. Following are the descriptions of these three boundary segments and data values used for the boundary conditions.

Southern Boundary Segment

The southern boundary segment extends across the southern portion of the regional domain and along the eastern regional boundary over the Gulf of Mexico. This boundary segment primarily reflects "clean" maritime conditions.

Boundary conditions developed for the GMAQS were considered appropriate for the southern boundary segment over the Gulf of Mexico, with the exception of CO. The CO concentration was selected to match the value used for modeling by the OTAG (Yocke, et. al., 1996). Constant values were assigned to all cells along the southern boundary segment, as shown in Table 3.8-1. Please note that a glossary is provided for the table.

Western Boundary Segment

The western boundary segment included the western half of the northern regional boundary, the the western edge of the regional boundary to the Mexican border, and the international boundary between Texas and Mexico. This boundary segment was characterized primarily by the more arid and more sparsely populated conditions found in the central plains and in West Texas. Within the mixed layer, the EPA default background air quality values were used along the western boundary segment with the exception of CO, NO, and NO_2 , whose representative values were based on the measurements from Yocke, et. al., 1996. Above the mixed layer, the same clean conditions used for the southern boundary segment, as shown in Table 3.8-1, were used for all cells along the western boundary segment. The same

boundary conditions were assumed to prevail along the Mexico/U.S. international border, since insufficient air quality data were available to estimate the levels of pollutants entering the U. S. from Mexico. See Table 3.8-1 for the summary of the concentration values.

Northeastern Boundary Segment

The northeastern boundary segment included the eastern half of the northern regional boundary and all of the eastern boundary over land. This segment is primarily influenced by biogenic and anthropogenic emissions characteristic of the southern United States. This boundary segment was considered the most important for transport from large regional sources that might affect Texas.

Time-dependent ozone data were obtained from 13 Aerometric Information Retrieval System monitoring sites along the northeastern boundary segment, and were determined to be representative of rural background conditions in Georgia, Alabama, Tennessee, Kentucky, Missouri, Arkansas, and Kansas (Figure 3.8-2). An inverse square distance ($1/r^2$, where r is the distance between the center of a cell on the boundary to a monitoring site) weighted average of ozone values from these sites was assigned to each cell along the northeastern boundary segment within the mixed layer. These interpolated ozone values are presented schematically in Figure 3.8-3 (June 18–20, 1995 episode) and Figure 3.8-4 (June 30–July 4, 1996 episode). Ozone concentrations above the mixed layer in the northeastern boundary segment were developed for two time periods: nighttime hours (1800–0600 CST), when ozone concentrations aloft are typically higher than surface values due to the lack of NO titration and absence of dry deposition (Yocke, et. al., 1996), and daytime hours (0700–1700 CST), when ozone concentrations above the mixed layer are typically lower than in the mixed layer levels. During the nighttime hours, ozone concentrations above the mixed layer increased from their mixed-layer values by 1.5, 2.0, or 2.5 times and tapered back down to the mixed-layer concentrations at the domain top. The BNDARY's standard vertical profile method, ABSPROFILE, was used for the nighttime ozone vertical profile. During the daytime hours, ozone concentrations above the mixed layer were interpolated between the mixed-layer values and the value at the domain top, which was set to the EPA default background value of 40 ppb. The BNDARY's standard vertical profile method, ABSPROFRAT, was used for the daytime ozone vertical profile.

For other chemical species within the mixed layer, concentrations were assigned to the EPA default background values with the exception of six chemical species, methanol, isoprene, ethanol, CO, NO, and NO_2, the representative values of which were obtained from measurements at Kinterbish, Alabama (Golden, et. al., 1995). Above the mixed layer, concentrations were assigned the clean values used for the southern boundary segment, as shown in Table 3.8-1.

As noted above, air quality concentration values used in the lateral boundary conditions are provided in Table 3.8-1. Boundary ozone concentration contour plots for selected hours are included in *Appendix B, Boundary and Initial Conditions*.

Table 3.8-1. Summary of Concentrations Specified along each Boundary Segment

Chemical Species	Concentrations in Each Boundary Segment (ppb)		
	Northeast	**West**	**South**
Ozone	Spatially interpolated	40	40
CO	200	200	100
NO	0.1	0.1	0.01
NO_2	1.0	1.0	0.5
NXOY	0.0001	0.0001	0.0001
HNO3	0.001	0.001	0.001
HONO	0.001	0.001	0.001
ALD2	0.555	0.555	0.05
ETH	0.51	0.51	0.15
FORM	2.1	2.1	0.05
OLE	0.3	0.3	0.05
PAR	14.94	14.94	7.6
TOL	0.18	0.18	0.0786
XYL	0.0975	0.0975	0.0688
ISOPRENE	3.6	0.1	0.001
CRES	0.001	0.001	0.001
MGLY	0.001	0.001	0.001
OPEN	0.001	0.001	0.001
PAN	0.001	0.001	0.001
PNA	0.001	0.001	0.001
H2O2	0.001	0.001	0.001
MEOH	8.5	0.000001	0.000001
ETHANOL	1.1	0.00001	0.00001

Glossary for Table 3.8-1

CO	carbon monoxide
NO	nitric oxide
NO_2	nitrogen dioxide
NXOY	nitrogen oxides
HNO3	nitric acid
HONO	nitrous acid
ALD2	high molecular weight aldehydes
ETH	ethane

FORM	formaldehyde
OLE	olefin
PAR	paraffin
TOL	toluene
XYL	xylene
ISOP	isoprene
CRES	cresol
MGLY	methylglyoxal
OPEN	open-ring hydrocarbon
PAN	peroxyacetylnitrate
PNA	peroxynitric acid
H2O2	hydrogen peroxide
MEOH	methanol
ETOH	ethanol

Since the East Texas sub-domain and the D-FW core domain are nested inside the regional domain, no boundary condition input files are needed for the fine-grid subdomains. One of the principal advantages of using a nested grid model such as CAMx is that the fine grid subdomains and coarse grid regional domain are modeled simultaneously, with the model calculating the boundary conditions for the subdomains directly from the results of the regional domain or parent domain modeling. This prevents the modeling results in the fine grid subdomains from being drastically influenced by the kind of rough assumptions that often have to be made when estimating boundary conditions.

3.8.2 Top Boundary Conditions

The concentrations over the entire top boundary of the modeling domain were set to constant values corresponding to the clean boundary conditions shown for the southern boundary segment in Table 3.8-1. The top boundary condition file is a simple ASCII file; no special preprocessor program was needed to develop the file.

3.8.3 Initial Conditions

The modeling initial conditions consist of hourly chemical concentrations in all coarse grid cells at the starting time of the simulation. These chemical concentrations can have a significant influence on ozone concentrations later in the simulation. The modeling ramp-up period (the period between the start of the simulation and the first exceedance day) should be long enough to avoid significant influence of the initial conditions on modeled ozone concentrations during the modeled exceedance days. Two ramp-up days were used in the D-FW CAMx modeling of both the June, 1995 and July, 1996 episodes. The UAM-V standard initial condition preprocessor (SAI, 1996), AIRQUL, was used to develop the initial conditions input files to the D-FW CAMx modeling (see *Appendix B, Boundary and Initial Conditions*, for AIRQUL input data files).

Monitored surface ozone, NO, NO_2, and CO concentration data were used to develop the initial conditions for the D-FW modeling. Monitored data of four hours around the model start time of 0000 CST on June 18, 1995, for the June 18–22, 1995, episode (from 2200 CST on June 17 to 0100 CST on June 18) and around the model start time of 0000 CST, June 30, 1996, for the June 30–July 4, 1996, episode (from 2200 CST on June 29 to 0100 CST on June 30) were averaged and used as input to

AIRQUL for spatial interpolation into the entire modeling domain. The interpolated values were assigned to the grid cells within the mixed layer. Default values of ozone, NO, NO_2, and CO concentrations for those cells that had no nearby monitoring sites were set to 20, 0.1, 1.0, and 200 ppb respectively. The default ozone value of 20 ppb was chosen because it represents the midnight background surface ozone concentration in Texas (EPA Aerometric Information Retrieval System database). The mixed-layer initial condition ozone, NO, NO_2, and CO concentration contour plots can be found in *Appendix B, Boundary and Initial Conditions*. Other chemical concentrations within the mixed layer were assigned to relatively clean values identified for the western boundary segment as shown in Table 3.8-1. All chemical concentrations above the mixed layer were assigned the same values as the top boundary.

References

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SAI, 1996: *User's Guide – Preprocessors for Preparation of UAM-V Initial and Boundary Concentration Data Files*, Systems Applications International, Inc., San Rafael, California, SYSAPP-96/86

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Fig 3.8-1 thru 3.8-4

3.9 METEOROLOGICAL AND AIR QUALITY DATA

The following subsections describe sources of meteorological and air quality data utilized in the current D-FW attainment demonstration modeling. Meteorological data are used in the air quality modeling system as inputs to the meteorological model, which simulates atmospheric conditions associated with the formation, transport, and diffusion of ozone and its precursor pollutants. Meteorological data is also used for creating meteorologically sensitive portions of the emissions inventory, such as evaporative and biogenic emissions.

Air quality measurements may be used to establish initial conditions and boundary conditions for the air quality model and as ground truth values for model performance. Air quality data also plays an important role in the selection of modeling episodes and the evaluation of emissions inventories.

Meteorological and photochemical modeling was conducted over two domains, a regional domain and a nested core domain. The regional domain covers much of the Gulf of Mexico, South Central and Southeast U.S., generally from West Texas on the western edge to the Alabama/Georgia state line on the east, and from Southern Missouri on the north to the Rio Grande on the south. The D-FW nested urban core domain covers much of North Central Texas, including all or parts of 33 counties (see Figure 3.9-1).

3.9.1 Spatial Coverage of Surface Monitoring Sites

The majority of air quality and meteorological surface monitoring sites were located in and near highly populated metropolitan areas such as D-FW, Houston, Atlanta, and Oklahoma City (see Figures 3.9-1 and 3.9-2). The rural, forested, and agricultural areas in the modeling domain had fewer monitors. Buoy meteorological data provided substantial meteorological observational coverage over the Gulf of Mexico.

3.9.2 Surface Measurements

Regional Domain

Air quality data was obtained from the EPA's AIRS observation network and the commission's CAMS network. Regionally, air quality data were used only for establishing boundary conditions.

A number of federal agencies provided the regional domain meteorological data, including the EPA (AIRS database), the NCDC, and the NDBC. The NCDC archives both the FAA surface meteorological data, and the NWS surface and upper air meteorological data. The NCDC provides user access to all collected data including horizontal wind, temperature, and humidity information. The NCDC's meteorological data used in this modeling were downloaded in ASCII format using the OASIS. The OASIS interface FTPs specific data by latitude/longitude and time period. The archived buoy meteorological surface data was downloaded from the NDBC web site.

Initially, the raw surface data were processed through a quality assurance routine, developed by SAI, that checked and flagged surface wind and temperature data that were found to be outside predetermined limits. For example, data were flagged that had ten or more missing consecutive values, that fell outside the range of lower and upper percentiles (0.10 and 0.90, respectively), that had data values that did not change for three hours or more, and that had data values that changed suddenly in a 1-hour time step. Staff meteorologists checked all flagged data to determine its validity.

Staff meteorologists also performed a graphical analyses of the preprocessor input files. Any observed parameters not in agreement with the general weather pattern were examined to determine validity and removed from the database if, in the judgement of the meteorologists, the data values were atypical.

Core Domain

In the core domain, meteorological data collected by state and local government complemented the AIRS, NWS and FAA data. The commission routinely measures meteorological parameters, as well as O_3 and NO_x concentrations at a number of CAMS throughout Texas including Dallas, Tarrant, Collin and Denton counties. The CAMS meteorological data consist of hourly average vector resultant horizontal wind speeds and directions, and hourly average temperatures. CAMS sites use a reporting method that assigns the hourly average measurements to the beginning of the 1-hour measurement duration. Also, the City of Dallas measures various meteorological parameters along with O_3 and NO_x concentrations.

The NWS data, collected once each hour, is not consistent with the standard convention for reporting hourly average data collected by other networks (e.g., CAMS and AIRS). The NWS data is usually measured at 5 to 15 minutes before the hour and reported as the observation at the hour. Given the inconsistency of incorporating 5 to 15 minute NWS data with hourly-averaged CAMS data into the air quality model, the NWS data were used only in data-sparse areas where no CAMS data were available. The commission's Monitoring Data Management and Analysis Section's analysis of the Hinton and Dallas North CAMS monitors showed erratic wind vectors, possibly due to poor siting considerations. Therefore, the Hinton and Dallas North CAMS monitors were not included in both the 1995 and 1996 data base.

In addition to the commission CAMS network, the commission added two continuous gas chromatographs to measure VOC concentrations at the Hinton and Keller sites.

All monitoring performed in the area followed the measurement and quality assurance procedures defined by the EPA. Staff meteorologists performed additional QA/QC procedures on the core domain meteorological data, just as described above for the regional domain.

3.9.3 Upper Air Measurements

Regional Domain

The NWS takes twice-daily upper air soundings at a limited number of widely scattered sites across the U.S. (See Figure 3.9-3). These soundings measure pressure, temperature, humidity and horizontal wind direction and speed at various levels in the atmosphere, from near the surface to as high as 25 km. These soundings are launched at 6:00 A.M. (CST) and 6:00 P.M. (CST) every day, seven days a week. Like the surface data, the OASIS makes these upper air data attainable through the NCDC web site.

Core Domain

The only NWS upper air rawinsonde site in the core domain is located in Fort Worth. During the 1996 episode, an acoustic sounder located at the Hinton site supplemented the Fort Worth NWS upper air sounding. The acoustic sounder measured horizontal wind direction and velocity at various altitudes from 75 meters to approximately 300 meters in 25 meter increments. Also during the 1996 episode, an

additional noon-time NWS upper air sounding supplemented the routine morning and evening NWS upper air sounding measurements.

Additional upper wind data was also used during the 1996 episode (see Figure 3.9-4). The MIT Lincoln Laboratory collected ITWS terminal horizontal winds (every five minutes) at nine fixed locations and at different altitudes. The locations were based on the needs of the D-FW Airport ATC users. This wind information is used by the ATC users to detect wind shear and gust fronts. Typically, the areas of interest to the ATC users are the airport arrival and departure gates and the turn-on to final approaches for aircraft. These data were also incorporated in the 1996 meteorological modeling process.

To check the validity of the upper air meteorological data, staff meteorologists used graphical techniques to determine whether the general upper air flow represented by the data agreed with the synoptic pattern.

A complete listing and description of the core and regional meteorological and air quality data used in the attainment demonstration modeling is available in *Appendix C, Meteorological and Air Quality Data.*

Fig 3.9-1 thru 3.9-4

3.10 EPISODE SELECTION

3.10.1 Overview

This section describes the process used by the commission staff to select episodes to model for the D-FW SIP. The first part of this section describes criteria used by the commission to select episodes. Later sections address the selection of specific episodes and the rationale for their selection. Since these episodes were selected based on 8-hour ozone exceedances, the rationale for using these 8-hour episodes to address the 1-hour ozone NAAQS is provided.

3.10.2 Background

In January - February 1997, when the commission was selecting episodes for the D-FW modeling, the EPA had not yet finalized the revisions to the ground-level ozone NAAQS. At that time the EPA's proposed IIP indicated that because the ozone standard would be changed from a 1-hour standard based on peak ozone to an 8-hour standard based on an average, those state and local agencies charged with planning should cease activities related to the 1-hour standard and begin to revise their procedures in protocols to plan for an 8-hour standard. Recognizing the amount of effort this would entail, the commision staff adjusted accordingly. During February 1997, in accordance with the guidance outlined in the proposed IIP, the commission selected two D-FW episodes based primarily upon the 8-hour standard of 0.08 ppm (see Table 3.10-1 below; 1-hour and 8-hour exceedances are marked in bold text). One episode occurred during June 1995, while the other occurred during July 1996. These two episodes include the primary and secondary predominant wind directions associated with 8-hour ozone events, have exceedances of both the 8-hour and 1-hour standards, and represent both locally-generated and transport-driven ozone situations.

Table 3.10-1. Episodes Selected for D-FW Modeling

Date	Case	Morning Wind Direction	8-Hour Average Ozone (ppb)	1-Hour Peak Ozone (ppb)
June 20, 1995	Local	Calm	**111**	119
June 21, 1995	Local	Calm	**125**	**144**
June 22, 1995	Local	Calm	**120**	**135**
July 1, 1996	Transport	SSW	**102**	112
July 2, 1996	Transport	SSW	**96**	114
July 3, 1996	Transport	WNW	**117**	**144**
July 4, 1996	Transport	WSW	**110**	116

The EPA formally adopted the new 8-hour ozone standard of 0.08 ppm on July 17, 1997, well after the commission had made its episode selection. Later that year, on December 29, 1997, EPA announced new guidance explaining how the transition from the 1-hour to the 8-hour standard would be managed. This new guidance indicated that a region's attainment status would continue to be evaluated by the 1-hour standard until the region met the 1-hour standard. This new guidance implied that episodes selected for

the 1-hour modeling should be based on the old episode selection procedures rather than selecting episodes that would address the new 8-hour standard.

By this time, the commission had already conducted a considerable amount of work on the two episodes that had been selected with the 8-hour standard as a basis (e.g., meteorological modeling). Due to constraints with time and resources, the commission could not afford to repeat the episode selection process without seriously affecting the modeling schedule. As a result, the commission staff elected to continue work on the two 8-hour ozone episodes already selected.

Since the time of that decision, the commission staff has evaluated the suitability of these two episodes relative to the 1-hour standard, and believes these episodes are not only suitable episodes for addressing the 8-hour standard but are also suitable for modeling for a 1-hour standard.

3.10.3 Episode Selection Criteria

The EPA, in its "*Guideline for Regulatory Application of the Urban Airshed Model*" (EPA, 1991), suggests an approach for selecting 1-hour ozone episodes that includes identifying the meteorological wind patterns associated with recent high ozone events and ranking them according to the magnitude of the observed ozone. The EPA recommends that candidate episodes have relatively high measured ozone approximating the design value of the area being modeled and representing typical meteorological flow patterns. The EPA recommends selecting three primary episode days and that these episode days reflect both stagnant conditions (light or poorly defined wind flow) and transport conditions (relatively persistent wind flow). The *Guideline* also acknowledges that data quality and availability are extremely important considerations in episode selection. This means that a lower ranked or less frequent type of episode may be selected in some cases if a substantial amount of high quality, specialized data are available.

Since at the time of episode selection the EPA had not issued any 8-hour episode selection guidance, the commission developed an episode selection methodology for 8-hour episodes, based upon the concepts underlying the EPA's 1-hour episode selection procedures and similar to the procedures previously approved for the H-GA modeling. The D-FW 8-hour procedure considered not only the morning wind directions and 8-hour average ozone concentration, but included a severity metric to account for the magnitude, temporal duration and spatial extent of high ozone. The following criteria were used to assess candidate episodes:

- Representativeness — The meteorological patterns considered for 8-hour modeling should be typical of high ozone days in the area, rather than extreme, unusual, or unique. The pool of candidate episodes should include both stagnant and transport cases.

- Severity—The episodes should have relatively high ozone concentrations for the years being evaluated, but close to the design value that must be controlled. Modeling of a mild or moderate episode could result in underestimating the controls needed to bring about attainment. Similarly, modeling extremely high episodes might result in unnecessarily stringent controls. Severity should be measured not only by the magnitude of the exceedance but also by the temporal and spatial extent of the exceedance.

- Recent Occurrence—The episodes should be fairly recent, so that they accurately represent the emissions generated in the urban areas involved. When possible, multi-day episodes are favored because of their ability to represent more than one high-ozone scenario.

- Data Availability—The ozone episodes should have sufficient air quality, meteorological, and emissions inventory data to support modeling. Adequate data allows the meteorological modeling to be based on real data and the ozone model output to be compared to real air quality measurements rather than to rough estimates and default values.

As per EPA's recommendation, episode selection was made by a team of scientists, including meteorologists who were familiar with the local and regional meteorological patterns occurring in the D-FW area. The pool of potential 8-hour episodes was reduced to include only the 1995 and 1996 episodes because the recent data was more representative, and could also take advantage of a special field study that occurred during the summer of 1996. The team then evaluated the remaining 8-hour candidate episodes for meteorological representativeness using morning wind categories, episode severity, recency of occurrence, and data availability.

3.10.4 Episode Selection Process

As noted previously, the June 1995 and July 1996 episodes were selected against 8-hour criteria because at the time, EPA guidance was that we were to be conducting air quality planning for an 8-hour standard. However, for this SIP, the EPA requires that modeling be conducted for the 1-hour ozone standard. Thus, it is important to demonstrate that the 8-hour episodes are also appropriate for modeling relative to the 1-hour ozone standard.

The first step in the EPA-recommended episode selection procedure is to generate a table of wind directions for the ozone exceedance days. Table 3.10-2, below, was constructed by averaging the morning wind directions (7:00–10:00 a.m. Central Standard Time) at commission CAMS stations for each ozone exceedance day (for maximum monitored ozone >125 ppb) occurring between 1988–1997. If the average wind was less than 1.5 meters per second (approximately 3 miles per hour), the event was assigned to a separate calm category. The first column indicates the wind direction, the second column indicates the frequency of events for that wind direction, and the third column converts that frequency to percent. The table indicates that the most frequent category of morning wind directions for the 1-hour ozone measurements is Calm, with 52 occurrences and 70 percent of the total exceedance events. The second most frequent morning wind direction is south-southwest, with ten occurrences and 14 percent of the events. The third most frequent morning wind direction is south-southeast. Other 1-hour categories represent five percent or less of the total events. A somewhat similar pattern is evident in the 8-hour data for the highest through third highest wind direction frequencies. Clearly, the morning Calm category is the most important meteorological category associated with both 1-hour and 8-hour episodes. However, from observation of the data in Table 3.10-2, it is evident that the episodes selected for D-FW modeling should include morning winds from both the Calm and Southerly (SSE or SSW) wind categories.

Table 3.10-2. Morning Wind Directions Associated with High Ozone Events				
Wind Direction	1-hour (1988-1997)		8-hour (1990-1996)	
	Frequency	Percent	Frequency	Percent
Calm	52	**70%**	105	**48%**
NNE	0	0	4	2
ENE	0	0	6	3
ESE	3	4	12	5
SSE	5	**7**	34	**16**
SSW	10	**14**	40	**18**
WSW	0	0	11	5
WNW	4	5	3	1
NNW	0	0	4	2
Totals	74	100%	219	100%

Table 3.10-3 presents the list of candidate episode days for modeling, both from a 1-hour and 8-hour standpoint. Episodes occurring prior to 1995 were eliminated from consideration to insure that the modeled episodes would be representative of recent conditions, and to minimize uncertainties as the base case inventory was projected to the 1999 attainment year. Episodes after 1996 were not included because the episode selection decision was made in early 1997, before the 1997 ozone season had begun.

The third column in the table shows the magnitude of the 8-hour ozone severity metric for each potential episode day. This metric is calculated by taking into account not only the 8-hour average concentration, but also the number of stations recording exceedances, the number of hours that the ozone concentration exceeded 84 ppb, and the degree to which the standard was exceeded (i.e., the number of ppb above 84 ppb for each hour at each station). Although this metric was designed primarily to estimate severity for the 8-hour standard, it takes into account the hourly temporal and spatial extent of the ozone as well as the magnitude, as is recommended by the EPA *Guidance*.

Stagnation Episode

As Table 3.10-3 shows, June 21, 1995 and June 22, 1995 have Calm winds (the highest frequency among morning wind categories), very high values of the 8-hour severity metric, and are among the episode-days with the highest 1-hour observed maximum ozone concentrations (close to the 1-hour design value). These two episode days have exceedances at several CAMS stations and have six to seven hours in which ozone exceeds the 1-hour standard, so they also satisfy the EPA requirements for pervasiveness and persistence. The June 20 - 22, 1995 episode, which includes the two days discussed above, is clearly an appropriate one for modeling from the standpoint of both the 8-hour and 1-hour ozone standards. This episode provides two primary ozone days.

Transport Episode

Since the June 20 - 22, 1995 episode satisfied the need for a stagnant episode, the next episode selected should represent a transport case. A transport episode must be associated with non-calm winds (greater than 3 mph). The two transport-related episodes considered were July 10-14, 1995 and July 1-4, 1996. Both had days with high 8-hour and 1-hour ozone levels. Both had several days of transport, including days with a south-southwest morning wind direction, the second most frequent morning wind direction category. Thus, these two episodes were both good candidates for modeling transport relative to both ozone standards. It is noted that the July 1995 episode had higher overall ozone levels than the July 1996 episode, including a higher 8-hour ozone severity index and higher peak 1-hour ozone level on the peak days. However, the July 1996 episode occurred during the 1996 D-FW special study period when additional ambient monitoring data was available. The EPA *Guideline* indicates that it is appropriate to select a lower-ranking episode if it has better observational data available with which to compare the modeling results. Therefore, overall, the commission staff believes that the selection of the July 1996 episode over the July 1995 episode was appropriate.

Table 3.10-3. Episode Selection Matrix					
Date	Morning wind direction	8-hour ozone severity	8-hour average O3 (ppb)	1-hour max O3 (ppb)	Remarks
6/03/95	Calm	NA	56	**135**	
6/13/95	Calm	.378	**110**	**135**	
6/20/95	Calm	.326	**111**	119	
6/21/95	Calm	**.713**	**125**	**144**	
6/22/95	Calm	**.697**	**120**	**135**	
7/10/95	WNW	.076	**105**	**129**	
7/11/95	WNW	.371	**115**	**134**	
7/12/95	SSW	**.770**	**124**	**146**	
7/13/95	Calm	.296	**115**	**159**	
7/14/95	Calm	.121	**109**	**126**	
7/28/95	SSW	.057	**102**	**126**	
8/26/95	Calm	.366	**121**	**144**	
6/18/96	Calm	.128	**110**	122	Special Study: Two gas chromatographs Two wind profilers
6/19/96	SSE	NA	84	104	
6/20/96	ESE	.033	**93**	102	
6/21/96	SSE	.050	**99**	107	
6/30/96	SSW	.020	**91**	112	Special Study: Two gas chromatographs One wind profiler
7/01/96	SSW	.139	**102**	112	
7/02/96	SSW	.112	**96**	114	
7/03/96	WNW	**.527**	**117**	**144**	
7/04/96	WSW	.228	**110**	116	
7/05/96	WSW	.107	**99**	109	
9/04/96	Calm	.007	**88**	106	Special Study: Two gas chromatographs Two wind profilers
9/05/96	ENE	.023	**93**	107	
9/06/96	Calm	.378	**116**	**139**	
9/07/96	SSW	.110	**96**	114	

During the Summer of 1996, extra rawinsonde soundings were launched from Fort Worth's Meacham Field airport and extra monitoring equipment was positioned, including an acoustic sounder and two continuous gas chromatographs. The vertical profiler provided data on winds aloft and the gas chromatograph provided VOC data which could be used to validate the VOC/NO_x ratios in the model, and which would allow independent verification of both the anthropogenic and biogenic components of the VOC emissions inventory. This special meteorological and VOC data was not available for any of the 1995 episodes.

In summary, to take advantage of the additional data, the July 1996 episode was chosen as the second episode and provides a third 1-hour primary episode day (July 3). Table 3.10-3 indicates that of all the episode days with non-calm winds during the morning, the July 3, 1996 episode-day ranks second based on the 8-hour severity metric, and third based on the maximum 1-hour ozone concentration. It is also among the most persistent of the 1-hour exceedance events, with ozone sustained above 125 ppb for five hours. It should also be noted that the maximum 1-hour concentration (144 ppb on July 3, 1996) is very close to the D-FW 1-hour design value of 139 ppb. Overall, then, this episode is appropriate for modeling for both the 1-hour and 8-hour standards.

3.10.5 Meteorological Summary of Selected Episodes

June 20-22, 1995

This episode represented a typical summertime meteorological wind flow pattern. A weak high pressure system dominated the area both at the surface and aloft, resulting in generally clear skies and light winds. Beginning June 18th, the surface and upper level high pressure areas began to weaken, resulting in weaker pressure gradients (producing lighter winds) later in the episode. By June 21st, the winds were nearly calm all day, resulting in a stagnant wind pattern. Aside from some clouds and isolated showers on June 19th, no significant weather was recorded.

July 1-4, 1996

The winds during this episode represent a transport case with somewhat stronger surface winds from the south-southwest to south-southeast on the leading days of the episode. This surface wind pattern is quite common during the summer in the D-FW area. During this episode the pressure gradient was generally weak across the area, resulting in winds that were just slightly stronger than during the June 20-22, 1995 episode, but meeting EPA criteria for a non-calm episode. There was a stationary front stretching from the Texas Panhandle across the D-FW area into Oklahoma. On July 3rd, the weak front was manifested as a convergence zone associated with light and variable winds in the D-FW. Some clouds and showers developed on this day.

3.10.6 Correlation between 1-hour and 8-hour Ozone Occurrences

It is generally well accepted that the 8-hour ozone standard will be more difficult to attain than the 1-hour standard. The scatter plots in Figure 3.10-1 show the maximum 1-hour and 8-hour ozone measurements for the D-FW area for every day in 1995 and 1996. These plots show that there is a strong relationship between 1-hour and 8-hour ozone levels in the D-FW area. In the figure, it can be seen that the set of 8-hour exceedances (above the 80 ppb line) includes all of the 1-hour exceedances (to the right of the 120 line) for both years. And, every 1-hour exceedance day is an 8-hour exceedance day. This provides evidence that controlling for the 8-hour standard should also control for the 1-hour exceedances.

Therefore, modeling based on episodes selected with the 8-hour standard as a basis should be appropriate relative to the 1-hour standard.

3.10.7 Summary

Two episodes, with three primary days, were selected to represent both stagnant and transport episodes for the 8-hour ozone standard. The two episodes were selected from ozone events recorded during the 1995 - 1996 summer ozone seasons. Both episodes had relatively high 8-hour and 1-hour ozone measurements, and both episodes are appropriate for both 8-hour and 1-hour ozone modeling.

Reference

U.S. EPA, 1991. *Guideline for Regulatory Application of the Urban Airshed Model*. U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, 450/4-9-013. Research Triange Park, NC.

Figure 3.10-1

3.11 METEOROLOGICAL MODEL SELECTION

3.11.1 Overview

Air quality models require meteorological information to characterize pollutant transport and mixing in the atmosphere. Meteorological information is also involved, to some extent, in an air quality model's chemistry. Therefore, it is important to chose a meteorological model that can produce accurate meteorologically-based inputs for the air quality model.

Previously, the EPA has recommended use of diagnostic methods which have simply interpolated and smoothed the available meteorological data. However, such methods may have inadequacies in their representation of the complex meteorological variations found in expansive regions such as the D-FW region. On the other hand, prognostic models can predict values of meteorological parameters based upon the physical interrelationships of atmospheric variables such as temperature, pressure, and moisture, using limited actual meteorological data. This makes prognostic models particularly useful for large modeling domains which may have vast data-sparse areas at all levels of the atmosphere.

The commission elected to use an improved prognostic meteorological model, the SAIMM, to create the meteorological variables/parameters required by the chosen air quality model, CAMx. SAIMM has several advantages over diagnostic methods in the way the model assimilates observed meteorological data into calculations. An outline of SAIMM technical considerations, as well as a discussion of some of the important output SAIMM produces for CAMx, is presented in this chapter.

3.11.2 Prognostic Versus Diagnostic Models

SAIMM is a prognostic meteorological model that predicts meteorological variables from the physical interrelationships of moisture, temperature, and wind. One of the advantages of a prognostic meteorological model, using these interrelationships, is that dynamic balance is maintained between the meteorological variables; this is not the case for interpolated fields generated by diagnostic methods.

Prognostic models, with dynamic balance, can better simulate meteorological variables in data-sparse areas. The advantage of dynamic balance (with a prognostic model) is that the variables created are more representative than the interpolated data produced from diagnostic methods. This is particularly important for the D-FW regional and core domains where most meteorological sites are clustered near cities, leaving relatively large intervening areas without representative data. Thus, a prognostic meteorological model is needed to more accurately replicate the mesoscale features such as intra-area transport associated with the modeling episodes for the D-FW nonattainment area.

3.11.3 Selection of the Systems Application International Mesoscale Model

The SAIMM is a three-dimensional prognostic meteorological model that uses a set of differential equations to predict meteorological variables, using the assumptions that the atmosphere is incompressible and hydrostatic. These assumptions are acceptable for the type of predictions required for this application of the model. SAIMM was selected for the D-FW study for several reasons: SAIMM is formulated to incorporate real data into the modeling simulation (nudging); it is compatible with the CAMx, which uses vertical exchange coefficients (K_V) that better simulates vertical mixing; and SAIMM was used in earlier SIP modeling for the H-GA area, providing commission meteorologists with experience in using the model..

3.11.4 Nudging

Nudging is a continuous data assimilation method that relaxes the model state toward the observed state by adding an artificial tendency term to one or more of the prognostic equations. A fundamental presumption of nudging is that if the modeled results can be made more consistent with some number of real observations, the dynamical balance provided by a prognostic model will more reliably represent all variables throughout the entire modeling domain. Although prognostic meteorological models dynamically balance the meteorological parameters (moisture, temperature, and winds), the numerical integration scheme used to solve the differential equations may produce accumulated errors over time. Most prognostic meteorological models, including SAIMM, have incorporated various nudging methodologies, in part, to minimize discrepancies between modeled results and measured data.

Additional information on the nudging process can be found in Stauffer and Seaman (1990) and Stauffer, Seaman, and Binkowski (1991).

3.11.5 Vertical Exchange Coefficient

The SAIMM-compatible CAMx is a variable grid air quality model, which accommodates the use of K_V and fixed vertical layers rather than mixing heights and variable vertical layers. Continuous meteorological equations cannot be simulated on a grid of finite resolution, therefore parameterizations must be made for some important aspects of the small scale physics that cannot be resolved on the scale used with this modeling. Vertical exchange coefficients, K_V, are the coefficients that result from a pair of simplifying assumptions applied to the equations of fluid mechanics and thermodynamics. These equations represent the parameterization of vertical eddy diffusion (vertical exchange) needed in order to make meteorological equations tractable. Without the simplification introduced by using $K_{V,}$ about 10^{15} grid points would be required to resolve the turbulent flow, which is impractical.

The values of K_V are specified in the SAIMM by relating the K_V to the turbulent kinetic energy. The turbulent kinetic energy depends upon mean wind shear, buoyancy, and convection. A more detailed explanation, regarding the development of turbulent kinetic energy, can be found in the SAIMM User's Guide (Kessler and Douglas, 1993).

3.11.6 Fixed Vertical Layers

The use of fixed vertical layers is another feature of CAMx which takes advantage of SAIMM compatibility. This application of SAIMM was set up with 18 vertical layers of varying depth up to an altitude of 8 km, well above the expected afternoon mixing height (approximately 2-2.5 km). The depths of the SAIMM layers increase from the surface (10 meters) to the top of the domain (8,000 meters), consistent with the layer structure to be used in the CAMx. Although the top of the CAMx modeling domain (3,400 meters) is not typically set as high as the SAIMM (8,000 meters), the fixed layer structure of the SAIMM was configured to be consistent with the 8 fixed CAMx layers, to the top of the CAMx domain.

In configuring the SAIMM layers for consistency with the CAMx, consideration was given to the fact that the SAIMM simulates the u-v horizontal velocity components at the layer interfaces, but the temperature and water vapor are simulated at the layer centers. In CAMx, all the input parameters are assumed to be for the layer centers. Therefore, to use the SAIMM output for the CAMx input requires that either the winds or the thermodynamic parameters (temperature and moisture) undergo an interpolation. For

example, if the corresponding SAIMM layer height is identical to the CAMx structure (the layer heights are exactly the same), then the u-v horizontal velocity components would need to be interpolated to get layer-centered values for CAMx. However, due to the relative importance of winds, the SAIMM and CAMx layer structures were specifically offset (the SAIMM layer interfaces are configured to coincide with the CAMx layer-centers), so that the thermodynamic parameters were interpolated to get layer centered values, in lieu of the winds.

3.11.7 Summary

A prognostic meteorological model was chosen to more adequately replicate the meteorology in the relatively data sparse regional/core domains for the D-FW ozone modeling. The selected model, SAIMM, has desirable enhancements to perform nudging and facilitates the use of the vertical exchange coefficient $K_{V,}$ with an associated fixed vertical layer structure that is compatible with the CAMx.

References

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3.12 METEOROLOGICAL MODELING: JUNE 19–22, 1995 AND JUNE 30–JULY 4, 1996 EPISODES

3.12.1 Overview

As noted in a previous section of this report, the CAMx was selected for the air quality modeling for the D-FW SIP submittal. The CAMx requires two major categories of inputs—emissions inventory and meteorology—to calculate ozone concentrations over the region of interest. The purpose of this report section is to explain the SAIMM methodology and to discuss the resulting meteorological inputs created by SAIMM for CAMx.

For this round of modeling, the scope was expanded beyond what was used in previous D-FW modeling. The CAMx nested grid capability was used to create more refined boundary conditions than were available for the previous D-FW modeling, where EPA default ozone/precursor concentrations were used along the domain boundaries. This expansion in air quality modeling required that the scope of the meteorological modeling also be expanded.

To accomplish the expanded scope for the modeling, the SAIMM, for both the 1995 and 1996 episodes, was run over a large coarse grid domain (regional domain) to create representative meteorological boundary conditions for the inner domain (core domain). Then, SAIMM was used again to calculate meteorological data for the fine grid core domain. The regional domain covered most of the southeast United States, while the core domain encompassed the nonattainment counties and many other counties around the D-FW area (see Section 3.7, *Definition of the Dallas–Fort Worth Modeling Domain*). This two-stage process was necessary since the CAMx needs accurate meteorological boundary conditions along the core/regional domain interface to compute accurate ozone concentrations for the D-FW area nonattainment counties.

This report section will address meteorological modeling for both the June 1995 and July 1996 episodes, with a discussion of both regional and core domains where pertinent. The various subsections will describe techniques, methodologies, and quality assurance procedures used to process meteorological data into CAMx-ready input files. In other subsections, the weather patterns for both the large scale (synoptic) and smaller scale (mesoscale) will be covered, as will the modeling results for both episodes.

3.12.2 Quality Assurance Techniques

QA of wind, temperature and humidity data was performed by checking the raw and processed meteorological data for horizontal and vertical consistency. A PV-WAVE plotting program was used to display data for the meteorological data analysis. The program displayed color presentations for all the meteorological variables in four views: the normal plan (map) view, time versus height, height versus x/y-direction cross-sections and trajectories. Many of these views could be animated, further enhancing the meteorological QA process by highlighting any hour-to-hour inconsistencies.

Once QA was completed for the raw data, additional processing prepared the data for gridding on the three-dimensional regional/core modeling domain. The domains included a 19-level variably spaced vertical grid extending up to 8 kilometers, and either a 16-kilometer horizontal (regional) grid or 4-kilometer horizontal (core) grid.

The initial processing stages interpolated the data to the appropriate vertical level and converted the data to the input format required for the interpolation preprocessor. The interpolation preprocessor interpolated the meteorological data to the horizontal grid points for each level. The output of the interpolation preprocessor was then utilized as target values for SAIMM to nudge toward. In the final step, the SAIMM output was converted to CAMx-ready format appropriate for use in air quality modeling.

At each phase of the process, output was reviewed and compared to the raw data to keep errors from accumulating.

3.12.3 SAIMM Data Analysis Process

The SAIMM is a prognostic meteorological model that was used to calculate meteorological variables in all portions of the regional and core domains. Section 3.11, *Meteorological Model Selection*, provides a complete discussion regarding model choice and reasoning for choosing the SAIMM over diagnostic and other prognostic meteorological models.

The SAIMM was exercised with the OBS4DA gridded fields for wind, temperature, and humidity. SAIMM output wind vectors, at all levels, were compared to observed wind vectors and the mesoscale

patterns produced by OBS4DA. Modeled temperatures and humidities at all levels were compared with their respective monitored values. Vertical diffusivities were also examined for reasonableness and compared qualitatively to the expected June mixing heights.

Integrating the Regional and Core Domains

SAIMM was run independently for the regional and core domains. This created wind patterns unique to respective domains because the domains were different sizes and therefore, different data went into the regional/core modeling runs. This resulted in some mismatches of wind information along the regional/core domain interface. These discrepancies were rectified using a blending technique to smooth the two wind fields at the interface. Adjusted wind fields were created with the following algorithm:

Closer to the boundary more influence was assigned to the regional wind. Further into the core, more influence was assigned to the core wind. Specifically, the commission staff post-processed the core domain CAMx-ready wind data with the following two steps:

Step 1. The SAIMM regional domain wind data was converted into CAMx-ready wind data for the core domain.

Step 2. The wind data generated from Step 1 was merged into the core domain CAMx- ready wind data by weighted averaging of the six row/column cells along the core domain boundary. The weighting factors for the original core domain wind data were, beginning from the cells farthest from the core/regional domain interface: 0.1, 0.2, 0.3, 0.5, 0.7, and 0.9. The weighting factors for the regional wind data in the same six row/column cells were: 0.9, 0.8, 0.7, 0.5, 0.2, and 0.1.

After these adjustments were made, the SAIMM analysis and findings were peer reviewed by modeling staff.

CAMx Data Analysis Process

When the SAIMM stage was completed, the meteorological parameters were ready for the next step, processing SAIMM output data into final CAMx-ready form. CAMx-ready fields were produced from the SAIMM wind, temperature, humidity, and vertical diffusivity variables. The MM2CAMx preprocessor was used to interpolate the 19 levels of SAIMM meteorological data into 8 CAMx layers. The CAMx meteorological variables were again examined for consistency as described in the SAIMM analysis above.

3.12.4 Meteorological Modeling Results for June 19–22, 1995 Episode

Overview

This section describes the general weather patterns that dominated during the June 19–22, 1995, modeling episode. This episode was selected to represent a stagnant air ozone episode. The meteorology during the episode, at least after June 19, was typical for stagnation, with a nearly stationary dome of high pressure in the area, clear skies, light winds, and relatively little transport.

On June 19, the surface air flow in Texas was dominated by a strong synoptic scale high pressure area located in the eastern portion of the United States. On June 20, this high pressure area weakened significantly and by June 22, there was little synoptic scale forcing in the regional domain. As a result, surface winds changed from southerly and fairly strong on June 19 to light and variable between June 20 and June 22.

In the upper air, the same basic pattern prevailed as with the surface pressure systems. The upper air flow indicated a generally stronger higher pressure area aloft that weakened as the episode progressed. The high was located between two upper level low pressure areas on the east and west coasts, thus creating a blocking pattern that inhibited movement of pressure systems. The upper level ridge of high pressure reinforced the surface high pressure, producing subsidence (which contributes to stagnation) and relatively clear skies.

The meteorology for each of the episode days is discussed in the following subsections with additional detail for June 21 and June 22, the primary episode days.

June 19, 1995 (No Ozone Exceedance)

The regional and core domain meteorology was strongly influenced by a surface high pressure area centered in southern Missouri. The high pressure area extended over most of the eastern half of the United States. The surface high pressure was reinforced by upper level high pressure that was positioned between two upper level lows on the east and west coasts. The upper level low in the east was centered in Georgia, covered the southeastern states and influenced the meteorology in the eastern portion of the regional domain.

The SAIMM surface wind field—for the most part—replicated the measured surface winds and the weather pattern, as shown in Figure 3.12-1. Note from the figure that the model captured the wind directional shift from north-northeast in Arkansas to southerly in Oklahoma, indicative of the location of the surface high pressure area.

At upper levels the modeled high pressure also simulated the observed upper level ridge of high pressure. Notice in Figure 3.12-2 that the wind shift occurred as indicated with the surface winds as described above.

June 20, 1995 (No Ozone Exceedance)

The surface high pressure area began to weaken and the observed winds began to decrease. The high was now centered in western Missouri and had decreased in size, covering only a narrow area from Wisconsin

to eastern Oklahoma. Figure 3.12-3 shows that the modeled winds matched the observed winds, since in both cases the winds were weaker and the pattern was less well defined than on June 19.

The upper air pattern was correctly simulated by the model. Figure 3.12-4 shows that both the upper level ridge and the location of the eastern upper low were accurately predicted.

June 21, 1995, Primary Episode Day (Maximum Ozone of 144 ppb at Dallas North)

Regional Scale Meteorology

A very weak pressure gradient existed across the entire southeastern U.S., resulting in an absence of large-scale forcing across the regional domain. Figure 3.12-5 shows an example of the resulting light and variable surface winds that existed at 1100 CST over most of the regional domain. This wind pattern persisted for the entire 24-hour period. A small low pressure area formed along the Mississippi coast and created clouds and showers over portions Mississippi and Alabama. High temperatures in that area only reached into the low to middle 80s, while in Louisiana and Texas high temperatures reached the low 90s.

Core Domain Meteorology

The wind pattern observed in the regional domain is also evident in the core domain. Figure 3.12-6 shows an example at 1100 CST, when light and variable winds were observed across most of the core domain. The winds along the boundaries were uniform since they were created by blending the regional winds with the core winds, as discussed earlier. There were few clouds, resulting in temperatures reaching the low 90s.

The observed upper level winds and temperatures from the Fort Worth rawinsonde were compared to the model output in Figures 3.12-6a and 3.12-6b. Modeled wind predictions were generally representative in the vertical up to around 4,000 meters. In the upper levels between 4,000 meters and 8,000 meters, predictions did not compare well with measured values. However, the modeled winds used in the CAMx are all below 3,400 meters and therefore, the poor upper level predictions have little impact on ozone predictions.

Temperatures were typically under predicted by 3 to 4 degrees Celsius, especially in the lower to middle vertical layers of the model. This would perhaps result in less overall vertical mixing (since cooler air temperatures would represent air that would be less buoyant and therefore would not have as much of a tendency to rise), but a realistic magnitude of the effect of this deviation in temperature is unknown. It has been deduced from previous modeling that errors in temperature in the 2 to 3 degree range had no appreciable impact on ozone predictions.

Vertical Diffusivities

A time versus height cross section of SAIMM vertical diffusivities (Kv) for the Dallas North site is depicted in Figure 3.12-7. This sample is typical of the temporal and spatial characteristics of Kv in the D-FW area on this day. The Kv values increase during the morning until early afternoon and then decrease sharply in the late afternoon. Kv generally responded correctly to diurnal temperature changes, stability changes and vertical motion. However, a sharp drop in afternoon Kv values occurred about two hours early. This feature is inherent in the model formulation for SAIMM, but sensitivity runs indicate that this feature has little effect on ozone predictions in CAMx.

Trajectories

Figures 3.12-8, 3.12-9 and 3.12-10 show back-trajectory plots of the SAIMM-predicted source and path of air parcels that arrived over the D-FWN CAMS site at heights of 10 meters, 100 meters and 200 meters, respectively. The trajectories start at midnight and end at 1600 CST when the maximum ozone (144 ppb) was recorded at D-FWN. The trajectories indicate that near the surface the air parcel traveled only a short distance, while aloft the air came from counties south of the D-FW area.

June 22, 1995, Primary Episode Day (Maximum Ozone of 135 ppb at Colony)

On June 22 the pattern continued to be similar to that for June 21, since there was no large scale system dominating the eastern portion of the U.S. This absence of a strong weather system continued to support a weather pattern of light winds, both at the surface and aloft.

Figure 3.12-11 shows that these weak surface winds were predicted by the model. Notice also the almost random wind directions, also indicating the absence of strong large-scale forcing.

The upper air pattern was also very random as can be seen from the left hand panel of the vertical profile in Figure 3.12-12. The winds changed from southwest in the lowest level to southeast back to southwest, then east and then westerly at the highest levels of the modeling domain.

Summary of June 19–22, 1995 Episode

After thorough analysis and review of the 1995 episode intermediate and final products the meteorological fields were found to be representative and consistent with the raw meteorological data. CAMx model performance was also found to be excellent for this episode, and will be discussed in detail later in this document.

3.12.5 Meteorological Modeling Results for June 30—July 4, 1996 Episode

Overview

This five-day episode was selected to represent meteorological transport conditions for the D-FW area. During this episode, weak high pressure was centered over the Southeastern U.S., causing hot afternoon temperatures and light southeasterly wind flow across Texas. On July 3, the ozone exceedance day, a weak convergence zone moved into the D-FW area from the northeast, contributing to the day's high ozone concentrations. Radar observed widely scattered afternoon showers in the vicinity of D-FW on this day.

During this episode, a significant number of surface and upper air measurements supplemented the normal meteorological measurements provided by the NWS. An acoustic sounder located at the Hinton site measured the horizontal wind flow from near the surface up to approximately 300 meters. A Doppler radar located at the D-FW airport provided additional horizontal wind measurements in nine vertical atmospheric slices of various depths over specific locations around the airport. Finally, the NWS launched a supplemental rawinsonde at 1200 CST each day of the episode. Seven commission CAMS sites located in the D-FW immediate vicinity provided supplemental surface wind and temperature measurements.

The next few sections discuss the surface and upper air flow characteristics for each day of the episode as measured by these instruments and as simulated by the SAIMM prognostic meteorological model.

June 30, 1996 (No Ozone Exceedance)

On June 30, 1996, a weak surface trough separated two high pressure areas. One area of high pressure was located over the upper Midwest, while the second area was centered over the Southeastern U.S. The surface trough located between these two areas of high pressure extended from near Amarillo northeastward across southeastern Kansas toward the Great Lakes region.

The SAIMM meteorological model simulated the surface regional wind pattern quite well on this day (see Figure 3.12-13). The simulated winds show the clockwise circulation over the southeastern U.S. with westerly winds across Tennessee circulating clockwise to easterly winds across Alabama. The center of the high with its accompanying light and variable winds was located over northern Mississippi. This general circulation pattern resulted in light southeasterly wind flow across East Texas and the D-FW region.

The synoptic pattern aloft indicated a general clockwise pattern as well, suggesting high pressure at the upper levels. The modeled winds aloft were generally out of the west over Tennessee and out of the east over southern Alabama, simulating high pressure aloft (see Figure 3.12-14). Southeasterly simulated winds prevailed over Texas at the upper levels also.

The SAIMM simulated vertical wind profile over the D-FW area was chaotic. The morning and early evening wind profiles showed southerly winds near the surface changing to southwesterly winds aloft to 1800 m, while the midday and early afternoon wind profile showed a consistent southeasterly flow from the surface to 1,800 m, probably due to lifting of a well-mixed layer by afternoon heating (see Figure 3.12.15).

The surface and upper air wind flow patterns characterized the day with weak southeasterly winds in the D-FW area along with warm air advection at the surface and aloft.

The afternoon high temperature recorded at the D-FW airport was 96 degrees Fahrenheit.

July 1, 1996 (No Ozone Exceedance)

On July 1, 1996, the high in the upper Midwest moved southeast to eastern Iowa, while the southeastern U.S. high remained stationary. In response, the weak surface trough drifted further to the north extending from south central Kansas across central Missouri to southern Illinois.

The meteorological model was able to simulate the surface wind flow around the southeastern U.S. high, producing a weak pressure gradient over D-FW. The simulated winds across the D-FW area, and East and South Texas, were generally light southeasterly to southerly for most of the day (see Figure 3.12.16).

Like the previous day, the upper level regional winds, as simulated by the meteorological model, flowed in a general clockwise pattern around an upper level high pressure area (see Figure 3.12-17). The modeled winds aloft on this day were notably weaker than the previous day's upper air winds. The vertical wind profiles over the D-FW area were similar to the profiles for the previous day. The morning and early evening wind profile showed the wind shift from the south to the southwest with height through 1800

meters. The midday and early afternoon wind profile showed more of a consistent wind direction with height (see Figure 3.12-18).

On this day, both the surface and upper air wind flow patterns suggested that wind speed was somewhat weaker than the previous day.

The afternoon high temperature recorded at the D-FW airport was 98 degrees Fahrenheit, a few degrees warmer than the previous day's high temperature.

July 2, 1996 (No Ozone Exceedance)

The upper Midwest high retreated northward to North Dakota, while the southeast high remained fairly stationary for the third day of this episode. Early on July 2, 1996, the weak surface trough remained north of the D-FW area extending from north central Kansas across northern Missouri to southern Illinois. During the afternoon, the surface trough pushed southward into central Oklahoma and central Arkansas, only to retreat northward again during the evening hours.

The 1400 CST modeled surface winds reproduced easterly winds across northern Oklahoma, or north of the surface trough, and southerly winds over southern Oklahoma, or south of the surface trough (see Figure 3.12-19). This simulated wind flow around a surface trough is a reasonable representation of the synoptic wind flow pattern.

A slightly tighter surface pressure gradient produced by the proximity of the surface trough resulted in stronger southerly winds over the D-FW area than the previous two days of this episode.

The simulated upper level regional winds below 1,800 meters flowed across the D-FW area from the southeast (see Figure 3.12-20), while the higher winds flowed from the northeast to the southwest in response to a ridge northwest of Texas (see Figure 3.12-21). Upper level winds increased notably on this day. The northerly component of the upper level winds helped push the surface trough southward from the Midwest to Oklahoma. The vertical profile winds over the D-FW area changed direction from a southerly wind near the surface to northeasterly at the higher levels. The morning low level winds were southwesterly, while the afternoon low levels winds were southeasterly due to a greater mixing depth (see Figure 3.12-22).

The afternoon high temperature continued the warming trend to 99 degrees Fahrenheit, or one degree warmer than the previous day's recorded high temperature.

July 3, 1996, Primary Episode Day (Maximum Ozone of 144 ppb at Redbird)

Regional Scale Meteorology

A clockwise circulation around a high pressure system over Southeast Texas helped provide a morning southeast flow across the D-FW area. By early morning the surface trough that remained north of the Red River over the previous few days moved southward into Texas. By 1000 CST the trough extended from northern Louisiana to the D-FW area and then northward into western Oklahoma (see Figure 3.12-23). The meteorological model shows a zone of light winds stretching across central Louisiana and into north central Texas and then extending northward into east central Oklahoma (see Figure 3.12-24). This light wind pattern is the model's representation of the surface trough.

The surface trough across the D-FW area triggered widely scattered showers across north central Texas. However, no shower activity was observed in the immediate D-FW metropolitan area until a few hours after the peak ozone concentration was recorded.

Showers were observed as early as 0730 CST about 45 nautical miles north and northwest of the D-FW airport. By 1030 CST most of the shower activity dissipated, only to redevelop by 1400 CST. At that time isolated showers were located 35 nautical miles north and northeast of the airport, and 45 nautical miles southwest of the D-FW airport. The majority of the shower activity dissipated quickly, however, the north northeast shower complex persisted. Three hours after the observed peak ozone concentration (at about 1700 CST), a thunderstorm was observed about 5 nautical miles east of the D-FW airport and quickly dissipated within the hour.

The simulated upper level wind pattern across the D-FW area had a strong northeast wind component at and above 1,800 meters in response to the West Texas ridge and an upper level low to the east (see Figure 3.12-25). The simulated upper level winds were relatively strong on this day pushing the surface trough slightly past the D-FW metropolitan area. Below 800 meters the simulated vertical wind pattern over the D-FW area had a southerly and westerly component during the morning hours and an easterly component during the afternoon hours becoming southerly during the evening (see Figure 3.12.25).

The afternoon high temperature continued the warming trend to 102 degrees Fahrenheit, or three degrees warmer than the previous day's recorded high temperature.

Core Domain Meteorology

The core meteorology on this day was complicated by a number of small-scale features that conceivably had a large impact on the day's ozone concentrations. A weak surface trough or convergence zone moved into the D-FW metropolitan area during the late morning hours. The converging winds triggered showers and thunderstorms as well as producing mostly cloudy conditions across the region. (As noted earlier, the showers did not occur in the immediate D—FW area until after the peak ozone was measured.)

The weak surface trough or convergence zone passed through the area about midday. Prior to the arrival of the convergence zone, the simulated winds at Redbird were westerly (see Figure 3.12-26). As the convergence zone moved south of Redbird at approximately 1100 CST, the winds reversed direction, becoming easterly (see Figure 3.12-27).

Convergence Zones

The flow reversal over the Redbird monitor on this day appears to be an important factor in ozone formation by the model. It is hypothesized that ozone precursors from the Dallas area were carried southward into the Redbird area with the convergence zone, along with additional ozone precursors from the Fort Worth area during the early morning hours, returning to the Redbird monitor during the early afternoon with the wind flow reversal. This situation could be the cause of the very high modeled ozone concentrations on this day.

The role of convergence zones in contributing to high ozone concentrations in the southeastern U.S. has been documented recently (McNider, et al, The Role of Convergence Zones in Producing Extreme Concentration Events, American Meteorological Society, 10th Conference on Air Pollution Meteorology, 1998). One primary contributing factor to the high ozone concentrations appears to be the light horizontal wind speeds common to convergence zones. The lighter wind speeds allow accumulation of precursors providing for a greater potential of high ozone. Convergence zones also present a difficult problem for meteorological models, which perform best at simulating steady state wind flow.

The SAIMM model was able to replicate the wind flow reversal, but did not appear to bring the surface trough far enough south to cross the Redbird area. The 0800 CST modeled winds were westerly (see Figure 3.12-28), and by 1400 CST the model simulated easterly winds (see Figure 3.12-29). A vertical profile of the simulated winds over the D-FW airport reflect the wind reversal up to 800 meters (see Figure 3.12-30). Also the modeled winds reflected the lighter wind speeds in the convergence zone across the D-FW region (see Figure 3.12-29).

The SAIMM model simulated the surface and upper air temperatures within the D-FW metropolitan area fairly well when compared to the gridded observed values, although the simulated temperatures were consistently cooler than the gridded observed temperatures at all levels throughout the day.

Temperature Replication

The greatest temperature differences were observed during the morning hours when the differences ranged from -3.91 to -0.72 degrees Celsius. The afternoon and evening temperature differences were notably less and ranged from -0.06 to -0.89 degrees Celsius. For the day the average simulated temperatures were -0.99 degrees Celsius cooler than the gridded observed surface temperatures (see Table 3.12-1).

The greatest simulated and observed temperature differences aloft (approximately 1,000 meters) were observed during the afternoon hours when the temperature differences ranged from -1.07 degrees Celsius to -0.25 degrees Celsius. For the day the simulated temperatures were -0.49 degrees Celsius cooler than the gridded observed surface temperatures (see Table 3.12-1).

Based on previous modeling sensitivity runs, we believe the differences between the simulated and observed temperatures across the D-FW metropolitan areas are acceptable.

Wind Field Modeling

As stated earlier, this episode was meteorologically quite complex, with a convergence zone moving across the domain, surface wind flow reversal and isolated showers in the region. However, an abundance of surface and upper air meteorological observational data was available to help the model simulate the meteorology. The most critical data set was the supplemental wind data from two Doppler radars at the D-FW airport. This data was processed through the ITWS to identify shear zones and produce horizontal winds at various points and altitudes for the D-FW airport ATC users.

During the initial run the CAMx ozone model did not perform at acceptable levels. The model developed an area of high ozone concentrations considerably north of the observed ozone maximum at Redbird. Staff meteorologists deduced that the meteorological model did not bring the surface trough far enough south into the core domain. This spatial error over emphasized the southerly transport component of the winds and did not position the light winds associated with the convergence zone correctly. Without this weakening of the southerly winds, the simulated ozone cloud formed north of the observed monitored data.

Table 3.12-1. D-FW Metro Area Surface and Upper Air Temperature - July 3, 1996

Hour	Surface (ºC)	Upper Air (ºC)
	Model-Observed	Model-Observed
0	-3.91	-0.52
1	-3.14	-0.32
2	-2.17	-0.22
3	-1.26	-0.03
4	-0.57	-0.15
5	-0.14	-0.24
6	-1.34	-0.00
7	-2.02	-0.19
8	-1.13	-0.41
9	-0.72	-0.50
10	-0.96	-0.69
11	-1.39	-0.91
12	-0.95	-1.07
13	-0.66	-0.90
14	-0.52	-0.76
15	-0.59	-0.78
16	-0.62	-0.87
17	-0.89	-1.01
18	-0.40	-0.82
19	-0.19	-0.67
20	-0.27	-0.55
21	-0.24	-0.44
22	-0.06	-0.34
23	-0.20	-0.25
Daily Average	-0.99	-0.49

Following the initial ozone model run, the meteorology staff learned about the ITWS horizontal upper air wind data. The detailed terminal wind data allowed the meteorological model to nudge towards the newly

acquired upper level wind measurements. A second run of the air quality model using the updated meteorology proved considerably more successful. The wind field developed a weaker southerly component allowing the high ozone cloud to settle further south bringing the air quality model performance within acceptable EPA performance standards.

July 4, 1996 (No Ozone Exceedance)

The surface trough extended from central Kansas southeastward across East Texas and into Louisiana. A high developed over southwest Texas, while the upper Midwest high grew stronger and moved eastward to the Great Lakes region, which pushed a cold front into the Florida Panhandle.

A weak pressure gradient over the D-FW area produced light southerly surface winds on this day. Surface winds increased after sunset when the pressure gradient tightened. The surface trough retreated northeastward locating itself across central Louisiana and into eastern Oklahoma. The meteorological model simulated winds show the clockwise circulation across the domain, with northerly flow over the eastern portion of the domain and southerly flow across the west (see Figure 3.12-31). The model correctly located the surface trough through central Oklahoma.

The simulated winds aloft indicated the upper level ridge line was located from eastern Texas northeastward through eastern Arkansas and into southern Illinois (see Figure 3.12-32). Below 1,800 meters, the upper level winds over the D-FW area were generally out of the southwest during the early morning hours becoming more southerly during the afternoon and southeasterly during the evening hours.

The afternoon high temperature was 101 degrees Fahrenheit, which was a degree cooler than the high temperature recorded the previous day.

Summary of June 30–July 4, 1996 Episode

The July 1996 D-FW high ozone episode was a complex episode from both meteorological and simulation points of view. On the day when the ozone concentrations exceeded the NAAQS, the meteorology included a surface trough across the domain, a morning to afternoon reversal of the surface wind, high cloudiness, and widely scattered rain showers in the vicinity. The SAIMM model used to simulate these different weather characteristics is a hydrostatic prognostic model, which includes a FDDA capability.

Because hydrostatic models limit vertical motion, the SAIMM was unable to represent the vertical motions associated with the rain shower activity and surface trough, and therefore, mass continuity becomes a concern. In the convergence zone the addition of Doppler wind data allowed the FDDA nudging mechanism to better represent the wind flow, the arrival of the surface trough and its associated convergence zone.

Clearly, the SAIMM model used for the meteorological simulations was challenged by the complexity of the day. However, in spite of the limitations, the model was able to represent the July, 1996 episode meteorology well enough to deliver a satisfactory ozone simulation that meets EPA statistical criteria. Those results will be discussed later in this document.

Figures 3.12-1 thru 3.12-32 (and some a’s and b’s)

3.13 BASE CASE MODELING EMISSIONS INVENTORY DEVELOPMENT

3.13.1 Introduction

For the D-FW attainment demonstration, the commission has developed one of the most sophisticated modeling emissions inventories ever produced. In every aspect of the inventory, commission staff used state-of-the-science methodologies to improve on the standard practices. For example, the commission contracted with the NCTCOG to develop hourly on-road mobile source emission estimates for each episode day using the D-FWRTM. In addition the NCTCOG developed improved spatial allocations for hot soak and diurnal emissions, rather than employing the standard approach of simply assuming that these emissions occur along roadways. Biogenic emissions were estimated using data collected in an extensive, recent field study. Area and off-road mobile source emissions were enhanced through fieldwork performed by the NCTCOG, also under contract with the commission. Point source emissions were improved through the use of CEM data retrieved from the National Acid Rain Database. Spatial and temporal allocation of emissions in all categories were accomplished using the best available data, including new information collected by NCTCOG. Finally, chemical speciation was enhanced through the use of profiles developed by nationally-recognized emissions modeling experts under contract to the commission.

3.13.2 Hierarchical Emissions Inventory Development

Figure 3.7-1 (in Section 3.7, *Definition of the Dallas–Fort Worth Modeling Domain*) shows the D-FW modeling domain with the two nested grids (16 km X 16 km) and (4 km X 4 km) used in this attainment demonstration. The finer grids allow the photochemical model to produce more refined, spatially precise predictions than in the larger girds. Similarly, the fine grids require more accurate emissions inputs than do the coarser grids. In this attainment demonstration, the development of the modeling inventory closely parallels the grid nesting of the modeling domain. For example, within the fine grid (4 km X 4 km) hourly on-road mobile source emissions were developed using a sophisticated travel-demand model for the five counties contained in the D-FWRTM region (Dallas, Rockwall, Collin, Tarrant, and Denton). In the remainder of the fine grid, the NCTCOG estimated daily county total emissions using day-specific temperature data. The emissions in these areas were allocated to highways and populated areas using geographic surrogates.

In fact, daily mobile source emissions were developed for several counties to the south of the fine grid (see Figure 3.13-1). At one time, the commission had intended to include these counties in the fine grid, but computer resource issues caused these counties to be placed into the medium-resolution (16 km X 16 km) grid instead. However, for the two episodes modeled, these counties are generally upwind of the D-FW area, so it is still desirable to use especially high-quality emissions data in this area.

Outside the fine grid area, the medium-resolution (16 km X 16 km) grid is seen to cover most of eastern Texas. Mobile source emissions for this region (in fact for all of Texas within the modeling domain) were either obtained from recently-developed NET data or were extrapolated from link-based emissions developed by the TTI for the COAST project. Finally, in the coarse grid (32 km X 32 km) corresponding roughly with areas outside of Texas, only standard NET data downloaded from the NET web site were used.

This hierarchical philosophy was used for area and nonroad mobile, point, and biogenic sources as well. Because pollutants can travel over distances of hundreds of kilometers, it is necessary to account for

distant sources in the photochemical model. However, sensitivity studies conducted by the commission show that the response of the model in D-FW decreases as the distance to sources increases, so it is most prudent to apply the largest share of resources to the inventory closest to the area of interest, while using less resource-intensive procedures farther away.

Subsequent sections of this report describe in some detail the development of the modeling emissions inventory for four major categories: on-road mobile, area, point, and biogenic sources.

3.13.3 Emissions Processing Software

The commission primarily relied on the EPS-2 for emissions preparation of the modeling inventory.[2] In addition to EPS-2, the commission also used the BEIS-2 and BIOME, as well as numerous utility programs written by the commission modeling staff in the fourth-generation languages SAS and PV-WAVE, and in the ARC/Info GIS.

3.13.4 On-Road Mobile Source Emissions Development

Introduction

On-road mobile source emissions for the D-FW attainment demonstration modeling were developed for five separate regions, with the level of detail decreasing with distance from the nonattainment area. The regions are:

- The five county D-FWRTM region (Collin, Rockwall, Tarrant, Dallas, and Denton counties).
- The 32-county region surrounding and to the south of the D-FWRTM (called the D-FW Study Area).
- The eleven counties in the Houston–Galveston and Beaumont–Port Arthur nonattainment areas.
- The remainder of Texas within the modeling domain, and
- The remaining states within the modeling domain.

Details of the emissions development for each of these areas are provided below:

[2]The commission actually used an enhanced proprietary version of EPS-2 developed by Systems Applications, International and sold as Fast-EPS. The user interface of Fast-EPS is nearly identical to that of the more widely-used, public-domain EPS-2, including names of the individual software programs.

The D-FWRTM region

The D-FWRTM region consists of the four D-FW nonattainment counties (Dallas, Collin, Denton, and Tarrant), plus Rockwall (see Figure 3.13-1).

Data Sources

For the five-county D-FWRTM area, emissions were developed by the NCTCOG using a travel-demand model and MOBILE5a. Emissions were developed for each of the episode days June 19-23, 1995, and June 30-July 4, 1996 (note that June 23, 1995, was not actually modeled for this attainment demonstration). Hourly temperatures for each day were provided by the commission for input into MOBILE5a.

To improve the spatial and temporal allocation of the emissions, local street, diurnal, and hot soak emissions were allocated by NCTCOG to TAZs, while the remaining emissions were allocated to the appropriate roadway links. Emissions were estimated for each of fifteen time periods: each hour from 6 AM to 8 PM CDT, plus one overnight period. Details of the emissions modeling performed by NCTCOG, including the MOBILE5a setups, are provided in the document *1995/96 & 1999 On-Road Mobile Source Episodic Emission Inventories for the Dallas-Fort Worth 37-County Modeling Domain, Sept 5, 1998, NCTCOG*. Copies of this report are available from the commission upon request.

Other data used in developing emissions for the D-FWRTM, including hydrocarbon speciation profiles, are discussed in the following sections.

Spatial Allocation

Endpoints of the roadway links in the D-FWRTM were provided to the commission in an Arc/Info format file. These link definitions were merged with the link-based emissions data using a SAS program written by the commission staff. The SAS program output the emissions in the format required by the LBASE module of EPS-2.

A separate Arc/Info file from NCTCOG which provided the spatial definition of the TAZs was processed using Arc/Info to produce a surrogate file suitable for input into the GRDEM module of EPS-2. Each TAZ was treated as a “county” in the surrogate development, with the TAZ ID replacing the FIPS five-digit county code in the surrogate file. The TAZ-based emissions in the PREAM input stream were identified by TAZ, rather than by FIPS code. A commission-developed SAS program was used to format the local street, diurnal, and hot soak emissions into a file formatted for input into PREAM.

Temporal Allocation

For the hours from 6:00 until 20:00 CDT, emissions supplied by the NCTCOG were already temporally resolved by day and hour. For the overnight period, the emissions were disaggregated by the above-mentioned SAS programs, using factors supplied by NCTCOG (separate disaggregation factors were provided for weekday, Sunday, and Independence Day emissions).

Chemical Speciation

Hydrocarbon emissions were divided into four categories for speciation purposes: gasoline-vehicle exhaust (including crankcase emissions), diesel-vehicle exhaust, gasoline vapor (composed of diurnal, hot soak, running loss components), and liquid gasoline (composed of resting loss). Speciation profiles for these categories were provided to the commission as part of a contract performed by ENVIRON, Inc. to develop speciation profiles for a number of sources in the D-FW area. The profiles were developed by Dr. Eric Fujita of DRI, a subcontractor to ENVIRON, and were based on analysis of data collected in the Sepulveda Tunnel Study. Copies of the ENVIRON/DRI report, *Final Report, Speciated VOC Emissions for the Dallas/Fort Worth Nonattainment Area, October 17, 1997*, are available from the commission upon request.

The profiles obtained from DRI were converted to Carbon-Bond IV species using the EMSCVT utility module of EPS-2, and were applied to the mobile source emissions using the CHMSPL module of EPS-2.

The D-FW Study Area

The D-FW Study area consists of the five D-FWRTM counties plus thirty-two Texas counties surrounding the D-FWRTM and extending south to near Austin (again, refer to Figure 3.13-1). Note that in the remainder of this section, discussions of emissions development within the Study Area are understood to exclude the five D-FWRTM counties. This area is called the D-FW Study Area because several categories of emissions were studied extensively in this area for the purpose of this SIP. In particular, daily on-road mobile source emissions by county were developed by NCTCOG, using commission-supplied daily temperatures.

Note that the rectangular area shown in Figure 3.13-1 roughly corresponding to the D-FW Study Area is the region for which inventory data were gridded at 4 km X 4 km[3]. In this section, we will call this rectangular area the Study Area *Grid* to distinguish it from the counties comprising the actual Study Area. To complete emissions development for the Study Area Grid, daily total emissions by county developed by the TTI were used. A more detailed discussion of this data, and its use both within and outside the Study Area Grid, is provided below in the section entitled “Remaining Texas Counties”.

Data Sources

Using the daily temperature data from the commission and HPMS county-level VMT by functional class, NCTCOG estimated county total emissions for each episode day using MOBILE5a. The MOBILE5a input files for each county in the region are available from the commission upon request. Additional data used to develop emissions in this region are discussed below.

[3]In the original protocol for the D-FW modeling, this region was designed as the fine grid for the photochemical modeling, but the protocol was later revised to include only the northern half (approximately) of this region in the fine grid, as shown in Figure 3.7-1.

Spatial Allocation

In the D-FW Study Area (as well as in much of the remainder of Texas), emissions associated with major functional classes of roads were allocated to links developed by the commission from TIGER line file data from the U.S. Census Bureau. Because the TIGER line file classifications differed somewhat from the HPMS classes used by NCTCOG in developing the inventory, it was necessary to assign each HPMS functional class to a TIGER classification. Table 3.13-1 shows the association developed to map HPMS functional classes onto TIGER classes:

Table 3.13-1: Assignment of HPMS Functional Classifications to TIGER Classes.

HPMS Functional Classification	TIGER Classification
11. Urban Interstate	Interstate Highway
12. Urban Freeway/Expressway	State or U.S. Highway
14. Urban Other Principal Arterial	State or U.S. Highway
1. Rural Interstate	Interstate Highway
2. Rural Principal Arterial	State or U.S. Highway
6. Rural Minor Arterial	State or U.S. Highway
7. Rural Major Collector	State or U.S. Highway
All Other Classes (8, 9, 16, 17, 19)	Not Assigned

Emissions from HPMS functional classes 11, 12, 14, 1, 2, 6, and 7 were aggregated into two TIGER classifications as shown in the above table. The emissions were then allocated to each link based on its length; for example, if a county contains twenty-five miles of Interstate highway, and total county emissions of some pollutant for this type of road is 250 pounds, then a one-mile segment of Interstate highway is assigned ten pounds of emissions. Emissions were allocated to roadways using Arc/Info, then reformatted for input int LBASE using a commission-developed SAS program.

Emissions associated with minor roadway classifications (HPMS classes 8, 9 16 17 and 19), as well as hot soak and diurnal emissions, were processed separately from the major roadway emissions. These data were formatted for input into PREAM using a commission-developed SAS program. The emissions were later allocated spatially to a 4 km X 4 km gridded population surrogate (see the subsection on area and nonroad mobile sources for details on surrogate development) using the GRDEM processor.

Temporal Allocation

Daily total emissions for the counties of the Study Area were allocated to hours using the EPS-2 TMPRL allocation processor. Hourly emission fractions for VOC, CO, and NO_x were based on work previously performed in the COAST study (TNRCC, 1998). The emissions are assumed to be distributed by the same pattern as that of the three-county Beaumont–Port Arthur nonattainment area, which contains a relatively small urban area. This model is more appropriate for the Study Area (which contains several smaller

urban areas as well as a large rural area) than would be a model based on emissions in either D-FW or H–G. Note that a separate weekend profile was used for Sunday, June 30, 1996, and also for Thursday, July 4, 1996, since weekend (and holiday) traffic follows a significantly different diurnal profile than does weekday traffic. The temporal profiles used in this attainment demonstration are available upon request from the commission.

Chemical Speciation

Chemical speciation for the Study Area was performed by the CHMSPL module of EPS-2, using EPA default speciation profiles supplied with EPS-2.

H-GA and B-PA Nonattainment Counties

This area consists of the eight counties in the H-GA ozone nonattainment area (Harris, Brazoria, Fort Bend, Liberty, Waller, Galveston, Montgomery, and Chambers) plus the three counties in the B-PA nonattainment area (Hardin, Jefferson, and Orange).

Data Sources

Gridded hourly emissions for the eleven counties in the H-GA and B-PA areas were developed by the TTI during the COAST project for three ozone episodes in 1993 and another in 1992. In addition to the base year emissions, TTI also developed gridded hourly emissions for future years 1996, 1999, and 2007. To take advantage of the high-quality, highly detailed emissions developed by TTI for COAST, the commission staff decided to use emissions for a representative day from the 1996 "future" inventory in the D-FW attainment demonstration base case modeling. Since August 19, 1993 recorded that year's peak ozone concentration (231 ppb at Aldine), emissions projected to 1996 for this day were chosen as representative of ozone-forming conditions. Note that the emissions were not adjusted for the June, 1995 episode (i.e. the 1996 emissions were used in both base case episodes).

Spatial allocation

Since the emissions data received from TTI were already gridded (at 2 km X 2 km), the only spatial allocation necessary was to re-grid the emissions into the 16 km X 16 km grid. The TTI-developed emissions were reformatted using a commission-developed SAS program into the format required by a utility program called MEDUAM. MEDUAM is actually a component of the DTIM system used in California (not EPS-2), and is designed specifically to process already-gridded emissions data.

Temporal Allocation

Since emissions were originally developed by hour, no additional diurnal allocation was necessary. Day-of-week adjustments were applied to develop emissions for Sunday, June 30, 1996, Wednesday, July 3, 1996 (treated as a Friday), and Thursday, July 4, 1996 (treated as a Sunday). Otherwise, the August 19 emissions projected to 1996 were used for the remaining base case days. Day-of-week adjustments were made in the SAS program used to reformat the data for input to MEDUAM.

Chemical Speciation

Chemical speciation was performed by MEDUAM, using the reformulated gasoline profiles supplied by ENVIRON/DRI.

Remaining Texas Counties

Data Sources

Data for the remaining Texas counties was obtained from TTI, which prepared 1996 typical ozone-season daily total emissions by county for inclusion in the 1996 NET inventory. Emissions were developed by HPMS functional class for each attainment county in Texas (nonattainment county emissions were developed separately), using typical summertime temperatures and VMT. Note that the 1996 emissions were used for both the 1995 and 1996 episodes.

Spatial Allocation

Emissions were distributed spatially using a scheme similar to that employed for the Study Area, except that diurnal and hot soak emissions were not treated separately from the other emissions categories (hence were allocated spatially the same way as all other classes of emissions). Major highway emissions, including their respective portions of the diurnal and hot soak emissions, were allocated to roadway links developed from TIGER line files. The minor roadway emissions, including the remaining diurnal and hot soak emissions, were allocated to a regional population surrogate, gridded at 16 km X 16 km and covering the entire modeling domain. The regional population surrogate data file was developed for the commission by ENVIRON during the COAST project (ENVIRON, 1996).

These county-level total emissions data were also used to fill in the areas of the Study Area Grid not covered by the 37 (32 excluding the D-FWRTM) Study Area counties (once again refer to Figure 3.13-1). In these areas, major highway emissions were allocated to 4 km X 4 km links using Arc/Info, while minor roadway emissions were allocated to the 4 km X 4 km population surrogate discussed earlier.

Temporal Allocation

The county-level emissions received from TTI represent typical ozone season daily totals. These were used for each weekday in the two episodes. Emissions were adjusted (using factors developed during COAST) to reflect day-of-week VMT variation for Sunday, September 30, and on July 3 and 4, 1996. July 3 was treated as a Friday, and July 4 as a Sunday. In inland areas, the temporal allocations were the same as those described above for the Study Area counties. However, counties along the Gulf coastline were treated separately from non-coastal counties since - based on the COAST data - in coastal counties, weekend traffic is typically higher than weekday traffic (in inland counties, weekend traffic is typically lower than on weekdays). In both inland and coastal areas Friday has the highest traffic (hence emissions) of any day of the week.

Emissions were allocated to hours using diurnal profiles developed in COAST. Separate diurnal profiles were used for coastal and inshore counties. Temporal allocation was performed using the TMPRL processor of EPS-2, except that the day-of-week adjustments for major roadway emissions was performed in the SAS preprocessing routines (this was required because of an inconsistency in the handling of input emissions between LBASE and PREAM).

Chemical Speciation

Chemical speciation for the remaining Texas counties was similar to that performed for the D-FWRTM, except that the profiles were developed for non-reformulated gasoline. These profiles were based on analysis of data collected during the Mt. Baker Tunnel Study. Because these profiles were not applicable to the D-FW nonattainment counties, they were not provided as part of the ENVIRON/DRI speciation contract, but were provided later, courtesy of Dr. Fujita of DRI.

Remaining States

The remaining states in the modeling domain include all or part of the following: Louisiana, Arkansas, Oklahoma, Tennessee, Alabama, Mississippi, and Florida. Also, small portions of southern Missouri and Kentucky were included.

Data Sources

County total emissions for each of the above states was downloaded from the 1996 NET inventory. These emissions were used for both the 1995 and 1996 episodes. Information on the NET inventory can be found at the website: *www.epa.gov/oar/oaqps/efig/ei/*.

Spatial Allocation

Emissions were allocated using the GRDEM processor to the regional population surrogate developed by ENVIRON as a part of the COAST modeling. Note that no emissions were allocated to links in states other than Texas.

Temporal Allocation

Emissions were allocated by hour using the same diurnal profiles used for the Texas counties outside the nonattainment areas (i.e. different diurnal profiles were used for inshore versus coastal counties). No day-to-day variation in emissions was assumed (i.e. typical weekday emissions were used for all episode days).

Chemical Speciation

Chemical speciation of hydrocarbon emissions in states other than Texas was performed by CHMSPL, using EPA default speciation profiles.

HPMS Adjustment

To provide consistency with the HPMS, emissions were adjusted to account for differences between the VMT generated by the D-FWRTM and those maintained by HPMS for the region. The EPA requires that this adjustment be made to ensure consistency from region to region, since HPMS is considered the nationwide standard for VMT data. The adjustment was applied in the final processing step for the on-road mobile source portion of the modeling inventory, the merging together of all the various components, which is accomplished using the EPS-2 processor MRGUAM-ready files. In the control file for MRGUAM, the commission specified a scaling factor to apply to the link-based and zone-based emissions developed for the five D-FWRTM counties. The scaling factor, agreed to by EPA, was 1.056, representing

a 5.6% increase over the originally-modeled emissions for the D-FWRTM. This factor was applied to all emissions of NO_x, VOC, and CO uniformly across the five D-FWRTM counties.

Emissions Summary

Graphical analysis of emissions data are a powerful quality assurance tool, and provides an intuitive means of assessing the significant characteristics of the modeling inventory. *Appendix D, Base Case Modeling Emissions Inventory Development,* provides a complete set of emissions tileplots of CO, NO_x, and CB-IV HC[4] for two episode days for the various grids, showing the spatial and temporal distribution of emissions and providing summary totals. At the end of this section, we present a selected subset of tileplots designed to convey the essential nature of the modeling inventory.

Figures 3.13-2 and 3.13-3 show tileplots of on-road mobile source emissions of NO_x and CB-IV HC for June 20, 1995 (a weekday) for the D-FW 4 km X 4 km fine grid. Figure 3.13-4 shows emissions of on-road mobile source NO_x for July 4, 1996 (a holiday). Note particularly the difference in diurnal emissions distribution between the weekday and the holiday, as well as the difference in total daily emissions. Figure 3.13-5 shows June 20, 1995 emissions of the NO_x across the 16 km X 16 km intermediate grid (covering East Texas), and Figure 3.13-6 shows June 20, 1995 emissions of the NO_x across the 32 km X 32 km coarse grid covering the entire modeling domain.

Tables 3.13-10a, 3.13-10b, and 3.13-10c, presented at the end of the discussion of base case modeling inventory development, show the on-road mobile source emissions daily totals for both episodes for each of the four D-FW nonattainment counties (along with emissions from the remaining categories). Emissions for June 23, 1995 are not shown, since that day was not included in the photochemical modeling. It should be noted that on-road mobile source emissions for Sunday, June 30, 1996 were used for modeling Sunday, June 18, 1995, the first of two ramp-up days modeled for the 1995 episode[5]. Emission totals in Tables 3.13-10a, 3.13-10b, and 3.13-10c were calculated by post-processing the gridded, hourly, model-ready emissions data files, and are not expected to match exactly the input emissions. In particular, hydrocarbon emissions (CB-IV HC in the table) are calculated from the Carbon Bond IV species used in the photochemical model, and may vary from the input by as much as ten percent. *Appendix D, Base Case Modeling Emissions Inventory Development*, contains tables and figures showing daily total emissions for portions of the modeling domain outside the D-FW nonattainment area.

3.13.5 Area and Nonroad Mobile Sources

Introduction

Area and nonroad mobile sources collectively are composed of a variety of minor emission sources too numerous to account for individually in the emissions model. Examples of area sources include solvent

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[4] The tileplot program shows emissions of CB-IV HC, instead of VOC. The CHMSPL program transforms VOC emissions into CB-IV species, prior to input into the photochemical model. The photochemical model then uses the CB-IV representations to simplify the chemistry calculations.

[5]The use of a Sunday from 1996 to represent a Saturday from 1995 introduces some uncertainty in the modeling. However, doing this allows the use of two ramp-up days, instead of one, which reduces the model's dependence on initial conditions developed from sparse air quality data.

use, asphalt paving, dry cleaning, gas station refueling, and surface coating application, while nonroad mobile sources include power boats, aircraft, construction equipment, lawn & garden equipment, locomotives, and airport support equipment. The two broad categories, area and nonroad mobile, were processed together for convenience, since they are treated identically by the emissions preprocessing software.

Consistent with the other inventory components, the development of area and nonroad mobile source emissions input was focused most intensely closest to the area of interest, specifically the four-county D-FW nonattainment area, with correspondingly less emphasis placed on the inventory in more distant areas. The area and nonroad mobile source emissions inventory was developed for the modeling domain in three pieces, corresponding to three geographical regions:

- The D-FW Study Area Grid, which is represented as a rectangle in Figure 3.13-7. This region was originally designed as the 4 km X 4 km fine grid for the photochemical model, but later the fine grid area was reduced in size (the final grid system as shown in Figure 3.7-1). Within this rectangular region, three sub-areas received somewhat different treatment, although the overall processing of emissions in the Study Area Grid region was similar. The three sub-areas (shown in Figure 3.13-7) are: the four-county D-FW nonattainment area (Dallas, Tarrant, Collin, and Denton counties), the remaining 33 counties in the D-FW Study Area, and the counties which intersect the Study Area Grid but are not in the Study Area. Note the difference between Figures 3.13-1 and 3.13-7: in the former, Rockwall County is darkly shaded as part of the D-FWRTM, while in the latter, Rockwall County is lightly shaded, since it is not part of the nonattainment area.

- The offshore (Gulf of Mexico) region, and

- The remainder of the modeling domain (rest of Texas and the remaining states in the modeling domain).

Details of the area and nonroad mobile source emissions development for each of these geographic regions are provided in the following sections:

The D-FW Study Area Grid

Area source emissions are generally reported as ozone-season daily county totals (although in this application, NCTCOG reported certain categories of emissions for alternative geopolitical regions, as will be discussed below). Thus, daily total emissions for each area and nonroad mobile source category were developed for each of the 56 counties contained (wholly or in part) in the Study Area Grid.

Data Sources

There were two separate sources of emissions data used to model area source emissions in the Study Area Grid:

- The NCTCOG, under contract to the commission, and
- The commission's EI staff.

Maximum effort was put forth to develop the most accurate emissions inventory possible for the 37 counties comprising the D-FW Study Area, with particular emphasis placed on emissions in the four nonattainment counties. The NCTCOG conducted special studies for several major emission categories of area and nonroad mobile sources: aircraft, railroads, recreational boating, residential lawn mowing, construction equipment, and gasoline stations. These studies also included investigation of a previously uninventoried category, non-driven vehicles, primarily unregistered vehicles on new and used car lots. Copies of the final report from NCTCOG, *1995 and 1996 Episodic Non-Road Mobile and Area Source Emission Inventories for the Dallas-Fort Worth Modeling Domain,* are available from the commission upon request.

The NCTCOG provided daily emissions for the above ASCs for each of the 37 counties in the Study Area. The commission Modeling staff extended these estimates to the remaining counties in the Study Area Grid by ratioing each ASC's emissions to the corresponding emission values for Collin County based on county population.

Emissions for the categories not provided by NCTCOG were developed by the commission EI staff. For the nonattainment and surrounding counties, these emissions were the same as reported to EPA in the 1996 PEI. Emissions for the remaining counties in the Study Area Grid were developed by ratioing each ASC's emissions to the corresponding PEI values for Collin County based on county population.

Additional data used to perform spatial and temporal allocation and chemical speciation are discussed in the respective sections which follow.

Spatial Allocation

The NCTCOG provided data for the categories they surveyed by FIPS code and by postal ZIP code. A FIPS represents an entire county (every county in the nation has a unique FIPS code), while a ZIP code typically represents a much smaller region than a county, at least in urban areas, but may span county lines. Emissions from locomotives, lawn mowers, service stations, and airport activities were reported by ZIP code, enabling excellent spatial resolution for these major ASCs. Emissions for recreational boating in the D-FW Study Area was reported by lake. The commission Modeling staff developed special spatial surrogates for these emission categories, using data provided by the NCTCOG. These data were spatially allocated using the GRDEM processor, but with a special surrogate file using ZIP codes and lake codes in place of the usual FIPS codes.

Aircraft support equipment emissions were reported as county totals (by the commission EI staff), but logically should be located in airports in proportion to the amount of aircraft activity. This factor is especially important in Dallas County, which contains half (i.e., the airport straddles the county boundary between Tarrant and Dallas Counties) of the very busy D-FW International airport, as well as a second

busy airport (Love Field). Thus, the commission Modeling staff used the aircraft ZIP-based emissions data to develop a special FIPS-based surrogate to spatially allocate aircraft support equipment emissions.

County-total emissions for the remaining ASCs were appropriately allocated to one of the following surrogates: urban, residential, urban-residential, rural, forest, agricultural, or water using the GRDEM program. These surrogates were developed for the 4 km X 4 km Study Area Grid using LULC data supplied by NCTCOG and from the USGS LULC data. NCTCOG has developed an enhanced LULC database covering Dallas and Tarrant counties, as well as significant portions of the surrounding counties, by starting with LULC data, then enhancing it with updated and higher-resolution information. This data was used to develop surrogates where it was available. For the remainder of the Study Area Grid, the standard USGS LULC data were used.

Temporal Allocation

NCTCOG provided day-specific emissions for the special study ASCs, so for these categories no day-of-week allocation was necessary. NCTCOG also provided diurnal temporal allocation profiles for several of these ASCs, including aircraft operations and recreational boating.

The commission modeling staff assigned day-of-week and diurnal profiles developed during the detailed COAST study to the remaining ASCs. For detailed discussions of the development of the COAST temporal profiles and associated cross-reference files, see (TNRCC, 1998). Temporal allocation was accomplished using the TMPRL processor.

Chemical Speciation

Hydrocarbon speciation data came from two sources of data:

- The ENVIRON/DRI Report previously referenced, and
- COAST speciation profiles (compiled from profiles developed by Systems Applications International in a bottom-up area source study (SAI, 1995), profiles from the commission COAST special inventory, and EPA defaults).

Under contract to the commission, ENVIRON and DRI updated speciation profiles for ASCs comprising 83 percent of the total estimated area source VOC emissions in the four-county nonattainment area. These categories included surface coating operations, gasoline marketing, domestic solvent use, auto body repair, graphic arts printing, aircraft landing and takeoff, etc. Copies of the ENVIRON/DRI report are available from the commission upon request.

The ASCs not covered by the new ENVIRON/DRI speciation profiles were assigned the COAST speciation profiles (the same speciation profiles used in the 1993 COAST study), which includes many EPA defaults. All chemical speciation was performed using the CHMSPL processor.

Offshore

The offshore region consists of the northern Gulf of Mexico, from approximately Brownsville, Texas to the Florida Panhandle. Offshore sources include shipping, commercial and recreational fishing, offshore aircraft trips, offshore oil and gas exploration and production, and others.

The model-ready emissions files used in the D-FW modeling were the same as those developed by ENVIRON for the COAST boundary conditions modeling (ENVIRON, 1996). Therefore, no discussion of file development beyond a description of the data sources is provided here.

Data Sources

There was one source of emissions data that was used for modeling of offshore sources. The MMS, of the U.S. Department of the Interior, provided 1992 emissions data for Gulf of Mexico area and nonroad mobile sources. The MMS contractor, SAI processed the data from this GMAQS and provided updates during the use of these data for the COAST modeling. No growth adjustments (from 1992 to 1995 or 1996) were made to these offshore sources for the D-FW modeling study.

Remainder of the Modeling Domain

The remainder of the modeling domain includes everything outside of the D-FW Study Area Grid and the offshore region. This area includes much of eastern Texas, all of Louisiana, all of Arkansas, all of Oklahoma except the extreme western panhandle, all of Mississippi, all of Alabama except the extreme southeastern corner, the western two-thirds of Tennessee, the southernmost 100 km of Missouri, the southwestern corner of Kentucky, and the westernmost few counties of the Florida panhandle. See Figure 3.7-1 for a picture of the entire regional modeling domain.

Data Sources

There was one source of emissions data used for modeling of regional area and nonroad mobile sources. County-total emissions for the regional domain were downloaded from the 1996 NET inventory, which is maintained by EPA. Each state was individually downloaded from the NET and processed separately through EPS-2. Information on the NET inventory can be found at the website: *www.epa.gov/oar/oaqps/efig/ei/*.

Spatial Allocation

Emissions were spatially allocated using the 16 km X 16 km spatial surrogates originally developed by ENVIRON as part of the COAST Boundary Conditions study. Spatial allocation was performed using the GRDEM processor.

Temporal Allocation

Emissions in the remainder of the regional domain were temporally allocated similarly to the D-FW study region perimeter counties, using TMPRL. Temporal profiles developed for COAST, which included many EPA defaults, were used across the regional domain, as well as for the D-FW perimeter. These profiles provided both day-of-week and diurnal variation in emissions. Note that the national holiday, Thursday, July 4, 1996 was treated as a Sunday for temporal allocation purposes.

Chemical Speciation

Speciation of emissions for area sources in the remainder of the modeling domain used the same speciation profiles as those used for the COAST study. Chemical speciation was performed using CHMSPL.

Emissions Summary

Figures 3.13-8 and 3.13-9 show tileplots of area and nonroad mobile source emissions of NO_x and CB-IV HC (VOC) for June 20, 1995 (a weekday) for the D-FW 4 km X 4 km fine grid. Figure 3.13-10 shows a tileplot of area and nonroad mobile source CB-IV HC emissions for July 4, 1996 (a holiday). Note particularly the difference in the spatial distribution of hydrocarbon emissions between the weekday and the holiday, with lake outlines clearly seen on the latter (due to powerboat emissions). Figure 3.13-11 shows June 20, 1995 emissions of CB-IV HC across the 16 km X 16 km intermediate grid (covering East Texas), and Figure 3.13-12 shows these emissions across the 32 km X 32 km coarse grid covering the entire modeling domain. A complete set of base case area and nonroad mobile source emissions tileplots for two episode days is provided in *Appendix D, Base Case Modeling Emissions Inventory Development*.

Tables 3.13-10a, 3.13-10b, and 3.13-10c, presented at the end of the discussion of base case modeling inventory development, show the area and nonroad mobile source emissions daily totals for both episodes for each of the four D-FW nonattainment counties (along with emissions from the remaining categories). Emission totals in Tables 3.13-10a, 3.13-10b, and 3.13-10c were calculated by post-processing the gridded, hourly, model-ready emissions data files, and are not expected to match exactly the input emissions. In particular, hydrocarbon emissions (CB-IV HC in the table) are calculated from the Carbon Bond IV species used in the photochemical model, and may vary from the input by as much as ten percent. *Appendix D, Base Case Modeling Emissions Inventory Development*, contains tables and figures showing daily total emissions for portions of the modeling domain outside the D-FW nonattainment area.

3.13.6 Point Source Emissions Development

Introduction

Point source emissions include emissions from large-scale industrial processes, boilers, stationary engines, large coating/painting operations, storage tanks, fugitives (e.g., leaking pipes), and many others. Point source emissions for the D-FW attainment demonstration modeling were developed in such a way that the level of precision decreases with distance from the nonattainment area. The point source EI was developed for the modeling domain by subdividing the domain into four geographical regions:

- The state of Texas within the modeling domain,
- The offshore (Gulf of Mexico) region,
- The state of Louisiana, and
- The remaining states within the modeling domain.

Details of the emissions development for each of these geographic regions are provided in sections to follow. Within these geographic regions, the point source inventory was split into two industrial categories:

- EGUs--generally power plants--which have a SIC of 4911, and

- NEGUs--every other point source.

Most EGUs are required to report hourly emissions data to the EPA under the Acid Rain Program, and the OTAG NO_x SIP Call EI modeled EGUs separately. For consistency as well as for convenience, the commission modeling staff chose to process the EGUs and NEGUs separately.

Texas

Figure 3.7-1 shows the modeling domain, and in particular the portion of Texas within the modeling domain. Because high-quality point source inventory data are available for the entire state (and because elevated point source emissions may potentially travel over long distances), all Texas point sources were treated the same (with the exception of use of local speciation data for D-FW-area point sources).

Data Sources

There were three separate sources of data that contributed to the modeling inventory in Texas. These sources are listed in ascending order of preference; when data for a single emission source was contained in more than one of these data sources, data from the highest numbered data source was used:

1. The commission PSDB,

2. The ARPDB,

3. Hourly emissions data from specific EGUs owned by TUE and HL&P.

Since the latter two sources of data only apply to EGUs, emission rates for all Texas NEGUs were extracted from the PSDB.

Spatial Allocation

June 18-22, 1995, and June 30-July 4, 1996 were the modeled episode days for this study. Since the growth between 1995 and 1996 was small, and since the 1996 commission PEI would be expected to have better accuracy and a higher reporting percentage than the regular 1995 EI, the commission modeling staff chose to concentrate on obtaining and quality-assuring a comprehensive extract of the all the point sources from the PSDB for the year 1996. Hence, this 1996 extract was used as the base inventory for both the 1995 and 1996 episodes (for many EGUs, the base emissions were later replaced with hourly emissions for both the 1995 and 1996 episodes, as discussed in the following section). Ozone season tons per day emissions of NO_x, VOC, and CO were extracted for every point source in Texas and prepared for input to the EPS-2 programs. This PSDB extract provided all of the spatial allocation of point sources, both EGUs and NEGUs, for the state of Texas.

In addition to the geographic location of point sources, stack parameters (stack height, diameter, exit gas temperature, and exit gas velocity) for all point sources is provided by the PSDB. The model calculates the plume rise from each stack using the temperature and stack parameters. This vertical component is of considerable importance for point sources, since this value determines which vertical layer of the model the emissions will be released into. The EPS-2 PREPNT sources performs a nominal plume rise

calculation to screen sources with effective plume rise lower than a cutoff value, specified by the commission as 20 meters. Such sources are assigned to the "low-level" point source data file and are treated much as area sources. Point sources with an effective plume rise of more than 20 meters are passed to the model as "elevated" points.

To assist in more accurately dispersing the elevated emissions, the model allows selected elevated sources to be modeled with an optional PiG treatment, whereby the individual source plumes are maintained over time and released gradually into downwind grid cells. These PiG sources must be flagged in a specific manner before the model will perform these special calculations for these selected stacks. Because of the greatly increased computer processing time required by these algorithms of the model, the number of PiG sources was kept to fewer than 100 over the entire modeling domain. The entire list of PiGs selected for the full modeling domain is available from the commission upon request. A total of 187 PiGs were selected over the entire domain, but 88 of the PiG stacks were co-located to another one of the PiG stacks, resulting in a total of 99 distinct PiG sources. This co-location of PiG stacks procedure changed the stack ID of one or more sources to that of another source at the same plant, such that the number of stacks would be reduced (with the emissions summed). Elevated point sources not flagged as PiGs are assumed by the model to disperse their emissions evenly over an entire grid cell immediately upon release. The CAM-x model uses an adaptation of the PiG treatment called Greatly Reduced Execution and Simplified Dynamic Plume in Grid. A large percentage of the total number of PiG sources chosen were selected in the area in and around the D-FW nonattainment area. The perceived gain in downwind plume reactivity accuracy afforded by this PiG treatment comes at a great cost of formatting, processing, and quality assuring the data, resulting in a large increase in both the man-hours required for point source preprocessing and in the computation time required by the model. Since EGUs generally have very tall boiler stacks, the majority of PiGs selected were EGUs, but a few NEGUs were also selected.

Elevated point sources are not spatially allocated *per se*; the physical location of each stack is passed to the photochemical model, which determines where in the three-dimensional modeling grid the emissions should be placed at each hour. Low-level point source emissions are allocated to grid cells by the GRDEM processor.

Temporal Allocation

Emissions data provided by the PSDB for the D-FW nonattainment area and adjacent counties is a seasonal (ozone season) average daily emission rate for each point source, given in pounds per day. The remaining counties within the D-FW region have emission rates from the PSDB given as total annual emissions in tons per year. This is true of both EGUs and NEGUs. The PSDB contains weekly operating schedule, daily operating hours, start hour, and quarterly throughput for each point. These data are read by the EPS-2 utility program TMPFAC, which develops monthly (used only for sources not reporting ozone-season daily emissions), day-of-week, and diurnal profiles for each point source. These profiles are read by the TMPRL processor and used to allocate emissions by day and hour.

To improve the temporal allocation of a large portion of the total NO_x emissions for the state of Texas, including the D-FW area, the commission SIP modeling staff incorporated the ARPDB into the EGU portion of the Texas point source EI. Since the EGUs represent about half of the point source NO_x emissions in the state, it would be ideal to be able to know exactly how much NO_x was being emitted from each EGU boiler stack during each hour of the modeled episode. All EGUs subject to the Acid Rain Program of Title IV of the Clean Air Act are required to report hourly emissions to the EPA on a quarterly basis, although not every EGU qualifies as an Acid Rain source, since it may not exceed the threshold

levels necessary to require compliance with the Acid Rain program. However, only a small percentage of the EGU emissions for the state of Texas are not reported to the ARPDB.

The vast majority of the EGUs are required to measure their NO_x emissions with a CEM located on each boiler stack. Hence, the quality of the data within the ARPDB should be very good. Mr. Henry Clarius of the EPA Acid Rain Program, Washington D.C., was very instrumental in providing guidance and data to the commission modeling staff. The Acid Rain Program home page can be accessed at *www.epa.gov/acidrain/ardhome.html*. Hourly data can be downloaded from this site, but only the most recent few quarters are available. Mr. Henry Clarius was able to guide the commission modeling staff to the location on the EPA computer system for download of quarterly SAS data sets of hourly data that he formatted and performed preliminary QA upon. The commission was the first organization to request such data from Mr. Clarius.

Because mechanisms did not previously exist for cross referencing and converting ARPDB hourly data, much effort was expended by the commission modeling staff to properly incorporate the ARPDB emissions into a modeling inventory for each episode. For each Texas EGU boiler in the ARPDB, hourly emissions records were substituted over the corresponding daily records for that boiler stack prior to any EPS-2 preprocessing. See Tables 3.13-2 and 3.13-3 for two cross reference tables relating all of the Texas ARPDB boilers with corresponding boiler stacks from the PSDB. ARPDB hourly data provides actual measured hourly emissions, instead of emissions based on default assumptions.

Table 3.13-2. Acid Rain Program Boiler ID for Texas Cross Reference
(ordered by FIPS)

ORISN	BLRID	FIPS	PLANT	STACK	POINT	EPN	PLNAME
6183	SM-1	48013	0007	0001	001	STACK1	San Miguel
3601	1	48021	0002	0001	001	UNIT 1	Sim Gideon
3601	2	48021	0002	0002	002	BLR-2	Sim Gideon
3601	3	48021	0002	0003	003	BLR-3	Sim Gideon
3609		48029					Leon Creek
3610		48029					Mission Road
3611	1	48029	0063	0019	022	E-1	O W Sommers
3611	2	48029	0063	0020	020	E-2	O W Sommers
3612	1	48029	0005	0002	006	E-1	V H Braunig
3612	2	48029	0005	0004	004	E-2	V H Braunig
3612	3	48029	0005	0005	005	E-3	V H Braunig
3613	1	48029	0006	0005	005	E-1	W B Tuttle
3613	2	48029	0006	0002	002	E-2	W B Tuttle
3613	3	48029	0006	0003	003	E-3	W B Tuttle
3613	4	48029	0006	0004	004	E-4	W B Tuttle
6181	1	48029	0063	0002	004	E-3	J T Deely
6181	2	48029	0063	0002	002	E-2	J T Deely
7097	**1	48029	0063	0016	017	U-5	J K Spruce
3561	6	48041	0001	0003	003	9	Bryan
6243	1	48041	0010	0004	004	4	Dansby
3436	1	48057	0005	0001	001	1	E S Joslin
3442	7	48061	0001	0009	009	LAP7	La Palma
3460	CBY1	48071	0003	0001	001	CB1	Cedar Bayou
3460	CBY2	48071	0003	0002	002	CB2	Cedar Bayou
3460	CBY3	48071	0003	0003	003	CB3A	Cedar Bayou
3460	CBY3	48071	0003	0017	003	CB3B	Cedar Bayou
3504	1	48073	0002	0001	001	SC-S1A	Stryker Creek
3504	1	48073	0002	0002	001	SC-S1B	Stryker Creek
3504	2	48073	0002	0003	002	SC-S2A	Stryker Creek
3504	2	48073	0002	0004	002	SC-S2B	Stryker Creek
3523	1	48081	0003	0001	001	OC-1	Oak Creek
3500	1	48085	0002	0001	001	C0-S1A	Collin
3500	1	48085	0002	0002	001	C0-S1B	Collin
3576	BW2	48085	0015	0001	001	STACK-BW2	Ray Olinger

ORISN	BLRID	FIPS	PLANT	STACK	POINT	EPN	PLNAME
3576	BW3	48085	0015	0003	004	STACK-BW3	Ray Olinger
3576	CE1	48085	0015	0004	005	STACK-CE1	Ray Olinger
3526	5	48105	0001	0004	004	RP5	Rio Pecos
3526	6	48105	0001	0001	001	RP6	Rio Pecos
3451		48113					Dallas Station
3452	1	48113	0009	0002	006	LH-S1	Lake Hubbard
3452	2	48113	0009	0003	008	LH-S2	Lake Hubbard
3453	6	48113	0010	0008	010	MT-S6A	Mountain Creek
3453	6	48113	0010	0009	010	MT-S6B	Mountain Creek
3453	7	48113	0010	0010	011	MT-S7A	Mountain Creek
3453	7	48113	0010	0011	011	MT-S7B	Mountain Creek
3453	8	48113	0010	0012	012	MT-S8	Mountain Creek
3454	1	48113	0012	0005	005	NL-S1A	North Lake
3454	1	48113	0012	0006	005	NL-S1B	North Lake
3454	2	48113	0012	0007	006	NL-S2A	North Lake
3454	2	48113	0012	0008	006	NL-S2B	North Lake
3454	3	48113	0012	0009	007	NL-S3A	North Lake
3454	3	48113	0012	0010	007	NL-S3B	North Lake
3455	1	48113	0011	0006	006	PD-S1A	Parkdale
3455	1	48113	0011	0007	006	PD-S1B	Parkdale
3455	2	48113	0011	0008	007	PD-S2A	Parkdale
3455	2	48113	0011	0009	007	PD-S2B	Parkdale
3455	3	48113	0011	0010	008	PD-S3A	Parkdale
3455	3	48113	0011	0011	008	PD-S3B	Parkdale
3574	BW5	48113	0007	0004	004	STACK-BW5	C E Newman
4266	4	48121	0002	0004	004	S-4	Spencer
4266	5	48121	0002	0005	005	S-5	Spencer
3456	1	48141	0008	0001	001	S1	Newman
3456	2	48141	0008	0002	002	S2	Newman
3456	3	48141	0008	0003	003	S3	Newman
3456	**4	48141	0008	0004	004	S4-1	Newman
3456	**5	48141	0008	0005	012	S4-2	Newman
3508	1	48147	0001	0001	001	VA-B1SA	Valley
3508	1	48147	0001	0002	001	VA-B1SB	Valley
3508	2	48147	0001	0003	002	VA-B2S	Valley
3508	3	48147	0001	0005	004	VA-B3S	Valley

ORISN	BLRID	FIPS	PLANT	STACK	POINT	EPN	PLNAME
6179	1	48149	0005	0007	007	FPP-1	Sam Seymour
6179	2	48149	0005	0008	008	FPP-2	Sam Seymour
6179	3	48149	0005	0016	016	3-1B	Sam Seymour
3470	WAP1	48157	0005	0023	002	WAP1A	W A Parish
3470	WAP1	48157	0005	0065	002	WAP1B	W A Parish
3470	WAP2	48157	0005	0024	003	WAP2A	W A Parish
3470	WAP2	48157	0005	0066	003	WAP2B	W A Parish
3470	WAP3	48157	0005	0044	004	WAP3A	W A Parish
3470	WAP3	48157	0005	0067	004	WAP3B	W A Parish
3470	WAP4	48157	0005	0026	005	WAP4	W A Parish
3470	WAP5	48157	0005	0006	006	WAP5	W A Parish
3470	WAP6	48157	0005	0007	007	WAP6	W A Parish
3470	WAP7	48157	0005	0008	008	WAP7	W A Parish
3470	WAP8	48157	0005	0018	014	WAP8	W A Parish
3497	1	48161	0002	0010	010	50	Big Brown
3497	2	48161	0002	0011	011	51	Big Brown
3630		48163					Pearsall
3466	PHR1	48167	0006	0002	002	PHR1A	P H Robinson
3466	PHR1	48167	0006	0014	002	PHR1B	P H Robinson
3466	PHR2	48167	0006	0003	003	PHR2A	P H Robinson
3466	PHR2	48167	0006	0015	003	PHR2B	P H Robinson
3466	PHR3	48167	0006	0004	004	PHR3	P H Robinson
3466	PHR4	48167	0006	0006	005	PHR4	P H Robinson
6178	1	48175	0002	0001	001	1	Coleto Creek
3476	2	48183	0007	0003	003	2	Knox Lee
3476	3	48183	0007	0004	004	3	Knox Lee
3476	4	48183	0007	0005	005	4	Knox Lee
3476	5	48183	0007	0006	006	5	Knox Lee
6136	1	48185	0002	0002	002	BOILER1ST	Gibbons Creek
3521		48197					Lake Pauline
3461	DWP9	48201	0044	0005	007	DPW3A	Deepwater
3461	DWP9	48201	0044	0007	007	DPW3B	Deepwater
3464	GBY5	48201	0046	0005	005	GB5	Greens Bayou
3468	SRB1	48201	0041	0003	003	SRB1A	Sam Bertron
3468	SRB1	48201	0041	0024	003	SRB1B	Sam Bertron
3468	SRB2	48201	0041	0005	004	SRB2A	Sam Bertron
3468	SRB2	48201	0041	0025	004	SRB2B	Sam Bertron
3468	SRB3	48201	0041	0007	005	SRB3A	Sam Bertron

ORISN	BLRID	FIPS	PLANT	STACK	POINT	EPN	PLNAME
3468	SRB3	48201	0041	0008	005	SRB3B	Sam Bertron
3468	SRB4	48201	0041	0009	006	SRB4A	Sam Bertron
3468	SRB4	48201	0041	0010	006	SRB4B	Sam Bertron
3469	THW2	48201	0042	0020	016	THW2A	T H Wharton
3469	THW2	48201	0042	0027	016	THW2B	T H Wharton
3471	WEB3	48201	0043	0008	004	WEB3A	Webster
3471	WEB3	48201	0043	0010	004	WEB3B	Webster
7325	SJS1	48201	1444	0004	006	SJS1	San Jacinto St
7325	SJS2	48201	1444	0003	003	SJS2	San Jacinto St
7902	1	48203	0022	0001	001	16	Pirkey
3524	1	48207	0001	0001	001	PC-1	Paint Creek
3524	2	48207	0001	0002	002	PC-2	Paint Creek
3524	3	48207	0001	0003	003	PC-3	Paint Creek
3524	4	48207	0001	0004	004	PC-4	Paint Creek
3507	9	48213	0002	0003	003	TR-S3	Trinidad
3438	1	48215	0002	0001	001	1	J L Bates
3438	2	48215	0002	0002	002	2	J L Bates
8063	1	48221	0001	0005	005	DC-B1S	Decordova
4938	1	48253	0009	0001	001	FP-1	Fort Phantom
4938	2	48253	0009	0002	002	FP-2	Fort Phantom
3485	111B	48279	0004	0003	003	1	Plant X
3485	112B	48279	0004	0004	004	2W	Plant X
3485	112B	48279	0004	0005	004	2	Plant X
3485	113B	48279	0004	0006	001	3W	Plant X
3485	113B	48279	0004	0001	001	3	Plant X
3485	114B	48279	0004	0008	006	4	Plant X
6194	171B	48279	0018	0001	001	1-1	Tolk Station
6194	172B	48279	0018	0002	002	2-1	Tolk Station
298	LIM1	48293	0010	0002	002	LMS1	Limestone
298	LIM2	48293	0010	0003	003	LMS2	Limestone
4937	1	48299	0002	0001	001	STACK 1	T C Ferguson
3482	151B	48303	0003	0001	001	1	Jones Station
3482	152B	48303	0003	0002	002	2	Jones Station
3602	1	48303	0001	0007	006	STB1	Holly Ave
3602	2	48303	0001	0008	007	STB2	Holly Ave
3502	1	48309	0003	0002	002	LC-S1	Lake Creek
3502	2	48309	0003	0003	003	LC-S2A	Lake Creek
3502	2	48309	0003	0004	003	LC-S2B	Lake Creek

ORISN	BLRID	FIPS	PLANT	STACK	POINT	EPN	PLNAME
3506	1	48309	0004	0005	005	TH-B1S	Tradinghouse
3506	2	48309	0004	0006	006	TH-B2S	Tradinghouse
3478	1	48315	0001	0003	003	ST-1	Wilkes
3478	2	48315	0001	0001	001	ST-2	Wilkes
3478	3	48315	0001	0002	002	ST-3	Wilkes
6648	4	48331	0005	0016	015	S03	Sandow
3492	4	48335	0001	0003	003	MC-S4	Morgan Creek
3492	5	48335	0001	0004	004	MC-S5A	Morgan Creek
3492	5	48335	0001	0005	004	MC-S5B	Morgan Creek
3492	6	48335	0001	0006	013	MC-S6	Morgan Creek
3457	1	48339	0007	0001	001	B-1	Lewis Creek
3457	2	48339	0007	0002	002	B-2	Lewis Creek
3477	1	48343					Lone Star
3440	1	48355	0015	0001	001	1	Lon C Hill
3440	2	48355	0015	0002	002	2	Lon C Hill
3440	3	48355	0015	0005	003	3A	Lon C Hill
3440	3	48355	0015	0006	003	3B	Lon C Hill
3440	4	48355	0015	0004	004	4	Lon C Hill
3441	5	48355	0014	0005	005	5	Nueces Bay
3441	6	48355	0014	0003	003	6	Nueces Bay
3441	7	48355	0014	0004	004	7	Nueces Bay
4939	1	48355	0047	0002	002	1	Barney M. Davi
4939	2	48355	0047	0003	003	2	Barney M. Davi
3459	1	48361	0007	0002	002	1A	Sabine
3459	1	48361	0007	0013	002	1B	Sabine
3459	2	48361	0007	0003	003	2A	Sabine
3459	2	48361	0007	0014	003	2B	Sabine
3459	3	48361	0007	0004	004	3A	Sabine
3459	3	48361	0007	0015	004	3B	Sabine
3459	4	48361	0007	0005	005	4	Sabine
3459	5	48361	0007	0006	006	5	Sabine
3628	1	48363	0001	0002	002	RWM-B1	R W Miller
3628	2	48363	0001	0003	003	RWM-B2	R W Miller
3628	3	48363	0001	0001	001	RWM-B3	R W Miller
3628	**4	48363	0001	0005	005	RWM-B5	R W Miller
3628	**5	48363	0001	0006	006	RWM-B6	R W Miller
3627	3	48367	0027	0003	003	NT-B3	North Texas
3484	141B	48375	0004	0001	004	1	Nichols Statio

ORISN	BLRID	FIPS	PLANT	STACK	POINT	EPN	PLNAME
3484	142B	48375	0004	0002	005	2	Nichols Statio
3484	143B	48375	0004	0003	006	3	Nichols Statio
6193	061B	48375	0022	0007	004	1-1	Harrington Sta
6193	062B	48375	0022	0008	005	2-1	Harrington Sta
6193	063B	48375	0022	0009	007	3-1	Harrington Sta
3503		48387					River Crest
7030	U1	48395	0013	0021	021	1-1	TNP One
7030	U2	48395	0013	0017	017	2-1	TNP One
6146	1	48401	0011	0005	006	S-1	Martin Lake
6146	2	48401	0011	0006	007	S-2	Martin Lake
6146	3	48401	0011	0007	008	S-3	Martin Lake
3489	1	48439	0006	0004	004	EM-S1&2	Eagle Mountain
3489	2	48439	0006	0004	006	EM-S1&2	Eagle Mountain
3489	3	48439	0006	0002	007	EM-B3	Eagle Mountain
3491	2	48439	0007	0011	010	HA-S2	Handley
3491	3	48439	0007	0012	011	HA-S3A	Handley
3491	3	48439	0007	0013	011	HA-S3B	Handley
3491	4	48439	0007	0004	003	HA-S4	Handley
3491	5	48439	0007	0005	004	HA-S5	Handley
3493		48439					North Main
3517		48441					Abilene
6139	1	48449	0005	0013	012	1	Welsh
6139	2	48449	0005	0012	011	2	Welsh
6139	3	48449	0005	0011	010	3	Welsh
6147	1	48449	0003	0007	007	S1	Monticello
6147	2	48449	0003	0009	009	S2	Monticello
6147	3	48449	0003	0010	010	S3	Monticello
3527	1	48451	0003	0001	001	SAPS-1	San Angelo
3527	2	48451	0003	0007	002	SAPS-2	San Angelo
3548	1	48453	0002	0001	001	D1	Decker Creek
3548	2	48453	0002	0002	002	D2	Decker Creek
3549	1	48453	0003	0001	001	H1	Holly Street
3549	2	48453	0003	0002	002	H2	Holly Street
3549	3	48453	0003	0003	003	H3	Holly Street
3549	4	48453	0003	0004	004	H4	Holly Street
3550		48453					Seaholm
3443	7	48469	0003	0008	004	5	Victoria
3443	8	48469	0003	0009	005	6	Victoria

ORISN	BLRID	FIPS	PLANT	STACK	POINT	EPN	PLNAME
3631		48469					Sam Rayburn
3494	5	48475	0004	0006	006	PB-S5A	Permian Basin
3494	5	48475	0004	0007	006	PB-S5B	Permian Basin
3494	6	48475	0004	0008	007	PB-S6	Permian Basin
3439	1	48479	0002	0002	002	1	Laredo
3439	2	48479	0002	0003	003	2	Laredo
3439	3	48479	0002	0004	004	3	Laredo
127	1	48487	0010	0002	002	1	Oklaunion
3490	1	48503	0001	0001	001	GR-S1A	Graham
3490	1	48503	0001	0002	001	GR-S1B	Graham
3490	2	48503	0001	0003	002	GR-S2	Graham

Notes:

1. Every Texas EGU in the Acid Rain Database is included in this list.
2. A facility without a BLRID indicates that the Acid Rain Database did not have entries for that facility in 1995 or 1996.
3. The FIPS/PLANT/STACK/POINT Ids are EPA identifiers from the PSDB and uniquely identify an emission point.
4. The EPN is included to help identify one stack from the next using names that the facilities report to the the commission.

Table 3.13-3. Acid Rain Program Boiler ID for Texas Cross Reference No. 2
(ordered by FIPS)

FIPS	ORISN	ARPDB BLRID	PLANT_NAME	COUNTY	ACCOUNT	OWNER
48013	6183	SM-1	SAN MIGUEL	Atascosa Co	AG0007G	SAN MIGUEL ELECTRIC COOPERATIVE, INC.
48021	3601	1, 2, 3	SIM GIDEON	Bastrop Co	BC0015L	LOWER COLORADO RIVER AUTHORITY
48029	3610		MISSION ROAD	Bexar Co	?	?
48029	3613	1, 2, 3, 4	W B TUTTLE	Bexar Co	BG0187G	CITY PUBLIC SERVICE
48029	3609		LEON CREEK	Bexar Co	?	?
48029	3612	1, 2, 3	V H BRAUNIG	Bexar Co	BG0186I	CITY PUBLIC SERVICE
48029	7097	**1	J K SPRUCE	Bexar Co	BG0057U	CITY PUBLIC SERVICE
48029	6181	1, 2	J T DEELY	Bexar Co	BG0057U	CITY PUBLIC SERVICE
48029	3611	1, 2	O W SOMMERS	Bexar Co	BG0057U	CITY PUBLIC SERVICE
48041	6243	1	DANSBY	Brazos Co	BM0009Q	CITY OF BRYAN MUNICIPAL ELECTRIC SYSTEM
48041	3561	6	BRYAN	Brazos Co	BM0010I	CITY OF BRYAN MUNICIPAL ELECTRIC SYSTEM
48057	3436	1	E S JOSLIN	Calhoun Co	CB0008C	CENTRAL & S.W. SERVICES, INC.
48061	3442	7	LA PALMA	Cameron Co	CD0013K	CENTRAL & S.W. SERVICES, INC.
48061	3559		SI RAY	Cameron Co	CD0009B	BROWNSVILLE PUBLIC UTILITIES BOARD
48071	3460	CBY1-CBY3	CEDAR BAYOU	Chambers Co	CI0012D	HOUSTON LIGHTING & POWER COMPANY
48073	3504	1, 2	STRYKER CREEK	Cherokee Co	CJ0026J	TEXAS UTILITIES ELECTRIC COMPANY
48081	3523	1	OAK CREEK	Coke Co	CN0005T	CENTRAL & S.W. SERVICES, INC.
48085	3576	BW2,BW3,CE1	RAY OLINGER	Collin Co	CP0026M	GARLAND MUNICIPAL POWER AND LIGHT
48085	3500	1	COLLIN	Collin Co	CP0065C	TEXAS UTILITIES ELECTRIC COMPANY
48105	3526	5, 6	RIO PECOS	Crockett Co	CZ0017A	CENTRAL & S.W. SERVICES, INC.
48113	3574	BW5	C E NEWMAN	Dallas Co	DB0384A	GARLAND MUNICIPAL POWER AND LIGHT
48113	3452	1, 2	LAKE HUBBARD	Dallas Co	DB0249H	TEXAS UTILITIES ELECTRIC COMPANY
48113	3451		DALLAS STATION	Dallas Co	DB0250W	TEXAS UTILITIES ELECTRIC COMPANY

FIPS	ORISN	ARPDB BLRID	PLANT_NAME	COUNTY	ACCOUNT	OWNER
48113	3453	6, 7, 8	MOUNTAIN CREEK	Dallas Co	DB0252S	TEXAS UTILITIES ELECTRIC COMPANY
48113	3455	1, 2, 3	PARKDALE	Dallas Co	DB0253Q	TEXAS UTILITIES ELECTRIC COMPANY
48113	3454	1, 2, 3	NORTH LAKE	Dallas Co	DB0251U	TEXAS UTILITIES ELECTRIC COMPANY
48121	4266	4, 5	SPENCER	Denton Co	DF0012T	DENTON MUNICIPAL UTILITIES
48141	3456	1,2,3,**4,**5	NEWMAN	El Paso Co	EE0029T	EL PASO ELECTRIC COMPANY
48147	3508	1, 2, 3	VALLEY	Fannin Co	FB0025U	TEXAS UTILITIES ELECTRIC COMPANY
48149	6179	1, 2, 3	SAM SEYMOUR	Fayette Co	FC0018G	LOWER COLORADO RIVER AUTHORITY
48157	3470	WAP1-WAP8	W A PARISH	Fort Bend Co	FG0020V	HOUSTON LIGHTING & POWER COMPANY
48161	3497	1, 2	BIG BROWN	Freestone Co	FI0020W	TEXAS UTILITIES ELECTRIC COMPANY
48163	3630		PEARSALL	Frio Co	FJ0012P	MEDINA ELECTRIC COOP
48167	3466	PHR1-PHR4	P H ROBINSON	Galveston Co	GB0037T	HOUSTON LIGHTING & POWER COMPANY
48175	6178	1	COLETO CREEK	Goliad Co	GF0002R	CENTRAL & S.W. SERVICES, INC.
48183	3476	2, 3, 4, 5	KNOX LEE	Gregg Co	GJ0043K	CENTRAL & S.W. SERVICES, INC.
48185	6136	1	GIBBONS CREEK	Grimes Co	GK0012K	TEXAS MUNICIPAL POWER AGENCY
48197	3521		LAKE PAULINE	Hardeman Co	?	?
48201	3468	SRB1-SRB4	SAM BERTRON	Harris Co	HG0358Q	HOUSTON LIGHTING & POWER COMPANY
48201	3469	THW2	T H WHARTON	Harris Co	HG0357S	HOUSTON LIGHTING & POWER COMPANY
48201	3461	DWP9	DEEPWATER	Harris Co	HG0356U	HOUSTON LIGHTING & POWER COMPANY
48201	7325	SJS1,SJS2	SAN JACINTO STEAM	Harris Co	HG4955K	HOUSTON LIGHTING & POWER COMPANY
48201	3464	GBY5	GREENS BAYOU	Harris Co	HG0353D	HOUSTON LIGHTING & POWER COMPANY
48201	3471	WEB3	WEBSTER	Harris Co	HG0355W	HOUSTON LIGHTING & POWER COMPANY
48203	7902	1	PIRKEY	Harrison Co	HH0037F	CENTRAL & S.W. SERVICES, INC.
48207	3524	1, 2, 3, 4	PAINT CREEK	Haskell Co	HJ0022B	CENTRAL & S.W. SERVICES, INC.
48213	3507	9	TRINIDAD	Henderson Co	HM0017H	TEXAS UTILITIES ELECTRIC COMPANY
48215	3438	1, 2	J L BATES	Hidalgo Co	HN0013E	CENTRAL & S.W. SERVICES, INC.
48221	8063	1	DECORDOVA	Hood Co	HQ0012T	TEXAS UTILITIES ELECTRIC COMPANY
48253	4938	1, 2	FORT PHANTOM	Jones Co	JI0030K	CENTRAL & S.W. SERVICES, INC.

FIPS	ORISN	ARPDB BLRID	PLANT_NAME	COUNTY	ACCOUNT	OWNER
48279	3485	111B-114B	PLANT X	Lamb Co	LB0046P	SOUTHWESTERN PUBLIC SERVICE COMPANY
48279	6194	171B,172B	TOLK STATION	Lamb Co	LB0047N	SOUTHWESTERN PUBLIC SERVICE COMPANY
48293	298	LIM1,LIM2	LIMESTONE	Limestone Co	LI0027L	HOUSTON LIGHTING & POWER COMPANY
48299	4937	1	T C FERGUSON	Llano Co	LL0006O	LOWER COLORADO RIVER AUTHORITY
48303	3602	1, 2	HOLLY AVE	Lubbock Co	LN0057V	LUBBOCK POWER & LIGHT
48303	3482	151B,152B	JONES STATION	Lubbock Co	LN0081B	SOUTHWESTERN PUBLIC SERVICE COMPANY
48309	3502	1, 2	LAKE CREEK	Mc Lennan Co	MB0117A	TEXAS UTILITIES ELECTRIC COMPANY
48309	3506	1, 2	TRADINGHOUSE	Mc Lennan Co	MB0116C	TEXAS UTILITIES ELECTRIC COMPANY
48315	3478	1, 2, 3	WILKES	Marion Co	ME0006A	CENTRAL & S.W. SERVICES, INC.
48331	6648	4	SANDOW	Milam Co	MM0023J	TEXAS UTILITIES ELECTRIC COMPANY
48335	3492	4, 5, 6	MORGAN CREEK	Mitchell Co	MO0014L	TEXAS UTILITIES ELECTRIC COMPANY
48339	3457	1, 2	LEWIS CREEK	Montgomery Co	MQ0009F	GULF STATES UTILITIES COMPANY
48343	3477	1	LONE STAR	Morris Co	MS0011T	CENTRAL & S.W. SERVICES, INC.
48355	3440	1, 2, 3, 4	LON C HILL	Nueces Co	NE0025C	CENTRAL & S.W. SERVICES, INC.
48355	4939	1, 2	BARNEY M DAVIS	Nueces Co	NE0024E	CENTRAL & S.W. SERVICES, INC.
48355	3441	5, 6, 7	NUECES BAY	Nueces Co	NE0026A	CENTRAL & S.W. SERVICES, INC.
48361	3459	1, 2, 3, 4, 5	SABINE	Orange Co	OC0013O	ENTERGY GULF STATES, INC.
48363	3628	1,2,3,**4,**5	R W MILLER	Palo Pinto Co	PA0003W	BRAZOS ELECTRIC POWER COOPERATIVE
48367	3627	3	NORTH TEXAS	Parker Co	PC0005T	BRAZOS ELECTRIC POWER COOPERATIVE
48375	6193	061B-063B	HARRINGTON STATION	Potter Co	PG0041R	SOUTHWESTERN PUBLIC SERVICE COMPANY
48375	3484	141B-143B	NICHOLS STATION	Potter Co	PG0040T	SOUTHWESTERN PUBLIC SERVICE COMPANY
48387	3503		RIVER CREST	Red River Co	RE0012M	TEXAS UTILITIES ELECTRIC COMPANY
48395	7030	U1,U2	TNP ONE	Robertson Co	RI0035C	TEXAS NEW MEXICO POWER COMPANY
48401	6146	1, 2, 3	MARTIN LAKE	Rusk Co	RL0020K	TEXAS UTILITIES ELECTRIC COMPANY

FIPS	ORISN	ARPDB BLRID	PLANT_NAME	COUNTY	ACCOUNT	OWNER
48439	3493		NORTH MAIN	Tarrant Co	TA0354E	TEXAS UTILITIES ELECTRIC COMPANY
48439	3491	2, 3, 4, 5	HANDLEY	Tarrant Co	TA0353G	TEXAS UTILITIES ELECTRIC COMPANY
48439	3489	1, 2, 3	EAGLE MOUNTAIN	Tarrant Co	TA0352I	TEXAS UTILITIES ELECTRIC COMPANY
48441	3517		ABILENE	Taylor Co	?	?
48449	6139	1, 2, 3	WELSH	Titus Co	TF0012D	CENTRAL & S.W. SERVICES, INC.
48449	6147	1, 2, 3	MONTICELLO	Titus Co	TF0013B	TEXAS UTILITIES ELECTRIC COMPANY
48451	3527	1, 2	SAN ANGELO	Tom Green Co	TG0044C	CENTRAL & S.W. SERVICES, INC.
48453	3550		SEAHOLM	Travis Co	TH0005B	CITY OF AUSTIN
48453	3549	1, 2, 3, 4	HOLLY STREET	Travis Co	TH0006W	CITY OF AUSTIN
48453	3548	1, 2	DECKER CREEK	Travis Co	TH0004D	CITY OF AUSTIN
48469	3631		SAM RAYBURN	Victoria Co	?	?
48469	3443	7, 8	VICTORIA	Victoria Co	VC0003D	CENTRAL & S.W. SERVICES, INC.
48475	3494	5, 6	PERMIAN BASIN	Ward Co	WC0028Q	TEXAS UTILITIES ELECTRIC COMPANY
48479	3439	1, 2, 3	LAREDO	Webb Co	WE0005G	CENTRAL & S.W. SERVICES, INC.
48487	127	1	OKLAUNION	Wilbarger Co	WI0025C	CENTRAL & S.W. SERVICES, INC.
48503	3490	1, 2	GRAHAM	Young Co	YB0017V	TEXAS UTILITIES ELECTRIC COMPANY

NOTE: A "?" indicates that the commission modeling staff could not uniquely identify this facility in the 1995 or 1996 PSDB, which does not truly matter, because those facilities did not report to the ARPDB in 1995 or 1996.

Using this technique, a single EGU boiler stack NO_x emissions record in the PSDB extract was replaced with 120 (5 days per episode and 24 hours per day) emissions records from the ARPDB prior to EPS-2 preprocessing. The ARPDB supplied hourly NO_x emissions, but not VOC or CO. Since EGUs are combustion sources, it is appropriate to assume that VOC and CO emissions increase as NO_x emissions increase for these boilers. The assumption was thus made that VOC and CO emissions are proportionate to NO_x emissions. This would not be exactly correct at unit startup and shutdown, but should be a reasonably good approximation over the course of a typical day. Hence, for each ARPDB stack, daily total VOC and CO emissions in the PSDB were apportioned to hours in proportion to the hourly NO_x emissions. This procedure led to the substitution of three daily records (NO_x, VOC, and CO) in the PSDB extract with 360 hourly records, for every ARPDB stack. Slightly different substitution criteria were used for the 1995 episode than for the 1996 episode, since the 1995 ARPDB was not as complete (not as many CEMs on-line, not as many properly-functioning CEMs, not as many participating facilities, etc.) as the 1996 ARPDB. The commission's modeling staff wrote a complex SAS program to automate these substitutions.

One method the commisison modeling staff used to QA the completeness of the ARPDB and its emissions was to ask for similar hourly NO_x emissions data from the two largest owners of EGUs in Texas: TUE and HL&P. Indeed, in 1995, many natural gas-fired boiler units were not reporting to the ARPDB, and the commission modeling staff was provided with hourly emissions data for those units directly from the facilities. Additionally, the facilities reported that some data used in the ARPDB was not completely accurate, because during rare CEM outages, the ARPDB substituted inappropriate default data. The facilities reported to the commission actual operational data that permitted the recalculation of NO_x emissions. In all of these circumstances, if TUE or HL&P reported data that differed from the ARPDB, these unit-specific data were added to or substituted over the ARPDB values. These procedures were incorporated into the same SAS program that performed the substitutions of ARPDB emissions over PSDB emissions.

If a Texas EGU stack was not in the ARPDB, then it received a commission "composite" EGU temporal profile. The commission's modeling staff developed this composite profile from an emissions-weighted average profile of all of the ARPDB stacks in the state. Again, this was only applied to EGU sources not in the ARPDB. NEGU emissions were allocated temporally according to operating schedule information in the PSDB extract.

Chemical Speciation

Hydrocarbon emissions, given as VOC, were converted to Carbon-Bond IV using the EMSCVT utility module of EPS-2, and applied to the point source emissions using the EPS-2 preprocessor program, CHMSPL. Speciation profiles for some SCCs were provided to the commission as part of the above-referenced contract completed by ENVIRON/DRI, ENVIRON and DRI developed speciation profiles for 297 sources from 151 different facilities in the D-FW nonattainment area, which represented a total of 115 different SCCs. The profiles were developed by ENVIRON from the commission contamination codes reported by the facilities in the PSDB.

Profiles for SCCs representing EGUs were not included in the ENVIRON compilation, because the relative amount of VOC emitted from the combustion of natural gas or coal in boilers is very small; therefore, EGUs received the EPA default chemical speciation profiles. The commission's modeling staff wrote SAS programs to create files of source-specific profiles for input to EMSCVT. Additionally, the commission modeling staff wrote a SAS program to create "generic" profiles by SCC, derived from

source-specific profiles developed by ENVIRON and from the COAST 1993 Special Inventory profiles. These generic profiles were developed to provide a substantial improvement over the EPA default profiles. D-FW area NEGUs which did not have speciation profiles developed directly by ENVIRON, as well as all point sources in the remainder of Texas, received these generic profiles according to their SCCs.

Offshore

The offshore region consists of point sources in the northern Gulf of Mexico, primarily offshore oil and gas production platforms. The files used for offshore modeling have not been modified since COAST modeling was performed in 1993.

The model-ready emissions files used in the D-FW modeling were the same as those developed by ENVIRON for the COAST boundary conditions modeling (ENVIRON, 1996). Therefore, no discussion of file development beyond a description of the data sources is provided here.

Data Sources

There was one source of emissions data that was used for modeling of offshore sources. The MMS, of the U.S. Department of the Interior, provided 1992 emissions data for Gulf of Mexico area and nonroad mobile sources. The MMS contractor, SAI processed the data from this GMAQS and provided updates during the use of these data for the COAST modeling. No growth adjustments (from 1992 to 1995 or 1996) were made to these offshore sources for the D-FW modeling study.

Louisiana

Data Sources

The LDEQ was very cooperative in response to the requests of the commission for access to emissions data. When the commission modeling staff first contacted LDEQ regarding sources of point source data for Louisiana, LDEQ staff indicated that the NET inventory was not very accurate or complete. This conclusion was shared by Texas and Oklahoma EI staff. The commission modeling staff thus discarded the NET inventory as an acceptable inventory of point sources for Louisiana, since LDEQ agreed to supply superior emissions data.

LDEQ supplied their 1996 PEI in NET format to the commission modeling staff. Since the commission modeling staff had done much analysis on the quality and completeness of various versions of the NET inventory, the commission modeling staff easily converted the LDEQ 1996 point source PEI to EPS-2-ready format. This inventory was used for the 1995 and 1996 modeling episodes.

Spatial Allocation

The PEI that LDEQ supplied to the commission contained all of the necessary spatial data for accurate lateral and vertical allocation. A few of the LDEQ sources met the criteria for PiG selection and were modeled as such. Low-level sources were allocated to grid cells using GRDEM.

Temporal Allocation

The PEI that LDEQ supplied to the commission contained all of the necessary temporal allocation, since it was provided in NET format. The commission modeling staff went one step farther for Louisiana EGUs, just as it did for every state in the modeling domain.

It would have been very difficult and time-consuming for the commission modeling staff to associate every Louisiana ARPDB boiler with an individual stack in the LDEQ PEI, in an attempt to produce hourly records for EGUs. Instead, the commission modeling staff used the same procedure that it did for the Texas EGUs not in the ARPDB. Each Louisiana EGU was assigned a "composite" EGU temporal profile. The commission modeling staff developed this Louisiana-specific composite profile from an emissions-weighted average profile of all of the Louisiana stacks in the ARPDB. Temporal allocation was performed using TMPRL.

Chemical Speciation

The chemical (hydrocarbon) speciation of emissions for Louisiana used only EPA default profiles for the SCCs included in the LDEQ 1996 PEI. Speciation was performed using CHMSPL.

Remaining States

The remaining states in the modeling domain include all of Arkansas, all of Oklahoma except the extreme western panhandle, all of Mississippi, all of Alabama except the extreme southeastern corner, the western two-thirds of Tennessee, the southernmost 100 km of Missouri, the southwestern corner of Kentucky, and the westernmost few counties of the Florida panhandle.

Data Sources

As discussed above, the commission first considered the NET inventory as a regional point source EI. This approach was abandoned due to a consensus that the NET was not yet a comprehensive modeling inventory. The commission modeling staff contacted the ODEQ, in hopes of obtaining a 1996 point source PEI, like the one provided by LDEQ, but ODEQ was not able to provide their PEI within a time frame that would allow the commission modeling staff to incorporate it into the D-FW modeling.

The commission modeling staff resorted to the "next best" inventory -- an inventory that other states or group of states were using as a regional modeling inventory. The commission modeling staff decided to use the same regional inventory that was being used for the OTAG NO_x SIP Call. The commission's modeling staff downloaded this NO_x SIP Call EI from an FTP site maintained by E.H. Pechan and Associates. Five EGU files and five NEGU files for each state were downloaded, representing 1995-96 emissions, so the commission modeling staff felt comfortable using this data for the two modeling episodes. First, these point source files required conversion from EMS-95 format to EPS-2 format. The commission wrote a SAS program to perform the conversions, pre-processed each state into individual EGU and NEGU files (one EGU file for each state, and one NEGU file for each state), saved the EGU files for special temporal allocation calculations, then concatenated all of the EGU and NEGU files for all of the states together to create one "regional" EPS-2 input file.

Spatial Allocation

These regional point source files (one for each state) contained all of the necessary spatial data for accurate lateral and vertical allocation. A few of the tallest stacks with high NO_x emissions (e.g., the Tennessee Valley Authority's EGUs in Alabama and Tennessee) were selected as PiG sources and were modeled as such. Low-level point sources were allocated to grid cells using GRDEM.

Temporal Allocation

The NO_x SIP Call EI, as converted for EPS-2 use, contained all of the necessary temporal allocation, since it was provided in the EMS-95 format. The commission modeling staff went one step farther for the EGUs of each state, just as it did for Louisiana.

Because it would have been very difficult for the commission modeling staff to associate every ARPDB boiler of each state with an individual stack in the NO_x SIP Call EI, the commission modeling staff used the same procedure that it did for the Louisiana EGUs. Each EGU in each state was assigned a "composite" EGU temporal profile specific for that state. The commission modeling staff developed this state-specific composite profile from an emissions-weighted average temporal profile of all of the ARPDB boilers for that state. Since only small portions of Missouri, Kentucky, and Florida were in the regional modeling domain, the composite temporal profiles for these three states were generated together. Temporal allocation was performed using TMPRL.

Chemical Speciation

The chemical (hydrocarbon) speciation of emissions for the regional domain consisted of only EPA default profiles for the SCCs included in the NO_x SIP Call EI. Chemical speciation was performed with CHMSPL.

Emissions Summary

Figures 3.13-13 and 3.13-14 show tileplots of point source emissions of NO_x and VOC for June 20, 1995 (only one day is shown here, since point source emissions vary little from day to day) for the D-FW 4 km X 4 km fine grid. Figure 3.13-15 shows June 20, 1995 emissions of NO_x across the 16 km X 16 km intermediate grid (covering East Texas), and Figure 3.13-16 shows these emissions across the 32 km X 32 km coarse grid covering the entire modeling domain. A complete set of base case point source emissions tileplots for two episode days is provided in *Appendix D, Base Case Modeling Emissions Inventory Development.*

Tables 3.13-10a, 3.13-10b, and 3.13-10c, presented at the end of the discussion of base case modeling inventory development, show the point source emissions daily totals for both episodes for each of the four D-FW nonattainment counties (along with emissions from the remaining categories). Emission totals in Tables 3.13-10a, 3.13-10b, and 3.13-10c were calculated by post-processing the gridded, hourly, model-ready emissions data files, and are not expected to match exactly the input emissions. In particular, hydrocarbon emissions (CB-IV HC in the table) are calculated from the Carbon Bond IV species used in the photochemical model, and may vary from the input by as much as ten percent. *Appendix D, Base Case Modeling Emissions Inventory Development*, contains tables and figures showing daily total emissions for portions of the modeling domain outside the D-FW nonattainment area.

3.13.7 Biogenic Emissions

Biogenic emissions have been recognized as an important part of the emissions inventory since 1988 (Chameides et al., 1988). The magnitude of biogenic emissions can influence the effectiveness of ozone control strategies. If the modeled biogenic emissions are smaller than the actual emissions, VOC controls might appear to be more effective than they actually are, which could result in the selection of an inappropriate strategy for reducing ozone. Likewise, if the modeled biogenic emissions are greater than the actual emissions, NO_x controls may seem more effective than they actually are. It is therefore very important to estimate the biogenic emissions as accurately as possible. The commission staff have taken several steps to ensure the most accurate biogenics inventory possible:

- Used a high-resolution land use database for modeling the D-FW metropolitan area;
- In a field study, collected data describing the species composition and leaf biomass density of the urban and rural land use categories;
- Used a vegetation database that accurately depicted plant communities (rather than using general-purpose land use data) in the four-county nonattainment area and surrounding counties;
- Used the best currently available emission factors, from the BEIS-2 emissions model;
- Performed sensitivity analyses, in which the biogenic emissions estimates were altered to see what the effect would be on choice of control strategy.

Methodology

The D-FW Study Area

Biogenics Modeling Domain

Because the commission commissioned a field study to improve the biogenic emissions inventory in North Central Texas, we had to define a domain over which the field work was to be done. This area consists of the four nonattainment counties, plus 33 counties immediately surrounding and to the south of the nonattainment area. Because this area was studied intensively for not only biogenics but for certain categories of area, on- and off-road mobile sources, it is called the “D-FW Study Area” in this report. The Study Area is depicted in Figure 3.13-17. Note that the area depicted in Figure 3.13-17 is slightly different from the Study Area defined earlier for on-road mobile and area sources. The difference is that two of the counties which NCTCOG surveyed for on-road mobile and area source emissions, namely, Falls and Bell, were not surveyed for biogenic emissions.

Model Selection

For the Study Area domain, the two accepted biogenic emissions models are BEIS-2 and the BIOME. Both of these models have been used successfully in developing biogenics emissions inventories (EIIP, 1997; Wilkinson et al., 1996; Estes et al., 1997). The BIOME model has been approved for use in Texas by EPA (Wayland, 1997). The primary differences between BEIS-2 and BIOME are (1) canopy models, (2) emissions factors, and (3) ability to use locally-derived leaf biomass, species composition, and land use data.

Canopy Models

Since biogenic VOC emissions depend on sunlight and temperature, it is particularly important to estimate these parameters accurately. A canopy model depicts the behavior of sunlight and heat as they interact with the forest canopy. Several canopy models have been used in biogenic emission models, from very simple "look-up table" models that reduce the solar radiation and temperature by fixed amounts as you proceed deeper into the canopy (Guenther et al., 1993, 1994; Geron et al., 1994), to extremely complex energy balance models that calculate the temperatures based on many meteorological variables (Vogel et al., 1995). In an important recent study, however, Lamb et al. (1996) concluded that there is little practical difference between the temperature and solar radiation profiles developed by simple and complex canopy models. It is much more important to accurately estimate the species composition and leaf biomass density of the forest in question; compared to these parameters, the choice of canopy model has relatively little effect on the accuracy of the biogenic emissions estimate. Therefore, the different canopy models embedded in BIOME and BEIS-2 did not affect our choice of biogenics model.

Base-Rate Emission Factors

BEIS-2 and BIOME are accompanied by their own base-rate biogenic emission factor databases. The term "base-rate" indicates emissions at 30°C and full sunlight. However, it is possible to use either set of emission factors with each model. Based on conversations with Alex Guenther, commission staff chose to use the BEIS-2 emission factors, given that these factors have been estimated with the greatest degree of rigor (Guenther et al., 1993, 1994; Geron et al., 1994), and that BEIS-3 (the planned successor to BEIS-2) emission factors are still in development.

Use of Local Data

The version of BEIS-2 available when the biogenic model was chosen could not readily accept any land use, species composition, or leaf biomass density data other than the default BELD database. Therefore, the commission decided to use BIOME, which has been successfully used in the past with domain-specific data as input, including use in the COAST project (Estes et al., 1997).

Base-Rate Emission Factor Data

The BEIS-2 base-rate emission factors for tree genera were used to calculate the North Central Texas biogenics inventory. To use these emission factors in BIOME, it was necessary to convert the emission factors from units of emission flux ($\mu g/m^2/hr$) to units of emissions per gram of biomass (µg C/g biomass/hr). This conversion was effected using the unit leaf biomass densities in Geron et al. (1994) and EIIP (1996). BEIS-2 emission factors were missing for some genera in the domain. These genera included *Albizia, Callicarpa, Ficus, Firminia, Hibiscus, Koelreuteria, Lagerstroemia, Ligustrum, Myrica, Photinia, Pyrus, Pistacia, Rhus, Sapindus, Sophora, Xanthoxylum,* and *Zelkova*. Fortunately, many of these genera were not native and none were common in the domain. The commission used the taxonomic family average emission factor for missing genera, a technique used by Benjamin et al. (1997, 1998) and by the commission in the 1993 COAST modeling. For some genera, BEIS-2 emission factors were not available for any member of their taxonomic families. In these cases, the commission used emission factors from Wilkinson et al. (1995), from Benjamin and Winer (1998), or from an average of the emission factors of genera in same taxonomic order. Table 3.13-4 shows the base-rate emission factors assigned to these genera.

For crops, the commission staff used the COAST crop leaf biomass densities (Radian and VRC, 1994) to convert from the BEIS-2 emission flux units to BIOME units of emission per gram of leaf biomass.

Land Use data

Land use data used for biogenics modeling in the D-FW metropolitan area were acquired from the North Central Texas Council of Governments (circa 1990). The data were developed from urban planning data, zoning maps, digital ortho-quads, and remote sensing data. The data set includes all of Dallas and Tarrant counties, more than half of Collin, Denton and Rockwall counties, and portions of Kaufman, Ellis, Johnson, Hood, Parker and Wise counties. An updated data set was under development at the time of modeling, but was not ready for public distribution. Electronic copies of the land use data are available upon request from the commission.

Land use for the rural portions of the study area was derived from Texas Parks and Wildlife Department data (McMahan et al., 1984). This data set is actually a combination of land use and vegetation data; thus it is particularly well-suited to biogenics modeling. It not only distinguishes among different land uses (e.g., urban, cropland, rangeland, forest), but also among plant communities (e.g., post oak, elm-hackberry, loblolly pine, live oak-Ashe juniper, mesquite), and among vegetation densities (e.g., forest, wood, park, scrub, grassland). Table 3.13-5 presents definitions of the terms describing vegetation densities.

Table 3.13-4. Assigned Emission Factors for Genera not Having a BEIS-2 Emission Factor				
Genus	Data source for emission factor	Isoprene emission factor (μg/g-biomass/ hour)	Monoterpene emission factor (μg/g-biomass/ hour)	Other VOC emission factor (μg/g-biomass/hour)
Albizia	Benjamin & Winer, 1998	1.37	0.53	1.9
Callicarpa	Verbenaceae family average	0.13	0.11	1.9
Ficus	Benjamin & Winer, 1998	8.61	0.08	1.9
Firminia	None found	NA	NA	NA
Hibiscus	Malvales order average	0.1	0.1	1.9
Koelreuteria	Benjamin & Winer, 1998	16.23	0	1.9
Lagerstroemia	Benjamin & Winer, 1998	0	0	NA
Ligustrum	Benjamin & Winer, 1998	0	0	1.9
Myrica	Benjamin & Winer, 1998	6.76	0.79	1.2
Photinia	Rosaceae family average	0.13	0.11	1.9
Pistacia	Benjamin & Winer, 1998	0	3.39	1.9
Pyrus	Benjamin & Winer, 1998	0	0	1.9
Rhus	Benjamin & Winer, 1998	0	0	1.9
Sapindus	Sapindales order average	0.1	0.57	1.9
Sophora	Benjamin & Winer, 1998	1.37	0.53	1.9

Viburnum	Benjamin & Winer, 1998	0	0.08	NA
Xanthoxylum	Wilkinson et al., 1995	0	1.49	1.9
Zelkova	Benjamin & Winer, 1998	0	0	1.9

Table 3.13-5. Definitions of the Vegetation Density Terms Used in the Texas Parks and Wildlife Department Vegetation Database (from McMahon et al., 1984)

Community Type	**Description**
Grassland	Herbs (grasses, forbs, and grasslike plants) dominant; woody vegetation lacking or nearly so (generally 10% or less woody canopy coverage).
Shrub	Individual woody plants generally less than nine feet tall scattered throughout arid or semi-arid regions (less than 30% woody canopy coverage).
Brush	Woody plants mostly less than nine feet tall dominant and growing as closely spaced individuals, clusters or closed canopied stands (greater than 10% canopy cover).
Parks	Woody plants mostly equal to or greater than nine feet tall generally dominant and growing as clusters, or as scattered individuals within continuous grass or forbs (11% to 70% woody canopy cover overall).
Woods	Woody plants mostly 9 - 30 feet tall with closed crowns or nearly so (71% to 100% canopy cover); midstory usually lacking.
Forest	Deciduous or coniferous trees dominant; mostly greater than 30 feet tall with closed crowns or nearly so (71% to 100% canopy cover); midstory generally apparent except in managed monoculture.

Leaf Biomass Density Data

See Yarwood et al. (1997) for details regarding the field survey methods. The following is a brief summary of the survey work performed.

The land use maps described above were used as guides for selecting appropriate field sites. Representative sampling sites were chosen in each of the most important land use types. At each sampling site, transects were laid out and all trees located along the transect were identified and measured for parameters from which the leaf biomass density could be estimated. The average leaf biomass density for each species was calculated by averaging across the entire transect; if more than one transect was sampled within a land use category, the average leaf biomass density for each species was calculated across all transects.

Note that the results of the field study were extended to a few counties outside the original study area, to complete the rectangular area shown in Figure 3.13-17 (this rectangular area is referred to as the Study Area Grid)[6]. This area was modeled using BIOME, while BEIS-2 was used elsewhere. For these additional counties, the commission assumed that the known leaf biomass densities for the vegetation categories in surveyed counties could also be applied to nearby unsurveyed counties. Cropland was not surveyed; instead, cropland species distribution was derived from county-wide crop harvest data collected by the U.S. Department of Agriculture National Agricultural Statistics Service in 1995. These data provided crop harvest information for each county, from which the crop species and biomass distribution were estimated.

Solar Radiation Data

The algorithms included in earlier versions of BEIS-2 (E/CR Incorporated, 1995) were used for calculating a gridded solar radiation field for in the domain, based upon latitude, time of year, time of day, and cloud cover (Iqbal, 1983). No ambient solar radiation data were available for biogenic emissions modeling of the two D-FW episodes. Cloud cover data from ground-based observers was obtained for the specific episode days from the NCDC. This cloud cover database was used to calculate solar radiation for both the study area and the regional domain. For the June 1995 episode, cloud cover observations were available for every hour; for the July 1996 episode, however, observations were available for every hour on June 30, but only every six hours beginning on July 1. This change in the observation schedule occurred nationwide, because the National Weather Service changed its method of observing and reporting cloud cover data beginning on July 1, 1996. For the 1996 episode, beginning July 1 observations were temporally extrapolated so that each observation was used for a six-hour period (the hour of observation, plus three hours before and two hours after the time of observation).

The amount of transmittance through the cloud cover was calculated by considering cloud thickness, sky coverage, and cloud height (Iqbal, 1983; Pierce and Waldruff, 1991). This method is based on observations that are not continuous in space or time, and are interpolated between weather stations, but the data are the best available. A comprehensive satellite photo study is expensive, and it would be difficult to estimate transmittance through the clouds based on observations of cloud tops.

As a sensitivity check, the commission also ran the biogenics emissions model with no cloud cover to evaluate the difference. Solar radiation increased greatly in the absence of clouds, and therefore isoprene emissions were substantially higher when no clouds were assumed.

A QC check was performed by creating contour plots of solar radiation to ensure the solar radiation field was reasonable. The fields so generated appeared reasonable: sunset and sunrise occurred in west and east, respectively, and maximum radiation occurred at solar noon.

Temperature Data

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[6]Where no ambiguity is likely to arise, we will use the term Study Area to refer both to the thirty-seven counties which were intensively surveyed and to the rectangular Study Area Grid modeled with BIOME.

Temperature data were obtained from the NCDC. A gridded temperature field was created from interpolated temperature observations measured at stations across the domain. A QC check was performed to see if contour plots of the temperature field made sense; the QC check indicated no anomalies.

Other Meteorological Parameters Needed for the BIOME Canopy Model

The wind data needed for BIOME's canopy model were obtained from the output of the SAIMM meteorological model (see the *Meteorological Modeling* section for more details). Likewise, specific humidity data were also taken from the SAIMM meteorological modeling.

Regional Domain

Model Selection

Model selection for the regional domain was simple, in that the only readily-available biogenics land use database for areas outside of Texas is the BELD database (Kinnee et al., 1997), which is formatted for input to BEIS-2. Therefore, BEIS-2 was used to model the biogenic emissions for the regional domain. The commission used the most recent version of BEIS-2, published in October 1997, and downloaded from the Support Center for Regulatory Air Models (SCRAM) bulletin board (http://www.epa.gov/scram001/index.htm). In the course of testing the model, the commission staff found and corrected several bugs in the program. The corrections that the commission made are now posted on the SCRAM bulletin board under the "What's New" section (Baldridge, 1997).

Land Use Data

The BELD data can be downloaded from ftp://monsoon.rtpnc.epa.gov (Kinnee et al., 1997). This database was developed from several different sources. In the western U.S., the database was developed from the USGS Land Cover Characteristic data set, which is based upon interpretation of Advanced Very High Resolution Radiometer (AVHRR) satellite data collected in 1990. In the eastern U.S., the land cover data are derived from the U.S. Department of Agriculture (USDA) Forest Service Forest Inventory Analysis Eastwide database (Hansen et al., 1992). Because the division between the eastern and western U.S. lies in Texas, data from both sources have been incorporated into the regional land use database. Although the BELD database contains data for Mexican vegetation, these data are suspect, because in a sensitivity analysis they generated much higher biogenic VOC emissions than were seen in similarly-vegetated areas across the border in Texas. Mexican data were therefore not used (the boundaries of the photochemical model are drawn along the Mexican border, so there is no loss of information due to the exclusion of the Mexican vegetation data).

Solar Radiation Data

Because there were no ambient solar radiation data available for the regional domain, a gridded solar radiation field was calculated as described earlier. The BEIS-2 algorithms described above were used for the regional domain as well as for the study area (Iqbal, 1983).

Temperature Data

Temperature data were obtained from the NCDC. A gridded temperature field was interpolated from temperature observations measured at stations across the domain. A QC check was performed to see if contour plots of the temperature field made sense; the QC check indicated no anomalies.

Biogenic NO_x Calculation for Entire Domain (Study Area and Regional Domain)

Biogenic NO_x emissions for the entire domain were based upon the results of the BEIS-2 model. In the urban areas where anthropogenic NO_x emissions are high, biogenic NO_x represented less than ten percent of the total NO_x inventory, but in rural areas where total NO_x emissions were not as high, biogenic NO_x comprised over ten percent of the NO_x inventory. Biogenic NO_x emission rates are higher for crops than for urban land, due to the large amounts of nitrogen fertilizer applied to the cropland (Aneja et al, 1995; Thornton and Shurpali, 1996; Kim et al., 1994; Sullivan et al., 1996).

Results

Leaf Biomass Density

Tables 3.13-6 and 3.13-7 summarize the results of the leaf biomass density surveys performed for the D-FW Study area. Table 3.13-6 presents the average leaf biomass density in kilograms/hectare (kg/ha) for all of the rural vegetation categories, as measured by Yarwood et al. (1997). Also presented is the average leaf biomass densities of all oak species in each vegetation category. The oaks are singled out because of the high isoprene emission rates observed by these species (Geron et al., 1994; Guenther et al., 1993, 1994). Table 3.13-7 presents the same information for the urban land use classes.

Biogenic VOC Emissions by Land Use and Compound

Table 3.13-8 presents the biogenic VOC emissions for two of the primary episode days, June 21, 1995 and July 3, 1996. The emissions are subdivided by VOC species and by broad land use category. These data indicate that the biogenic compound with the largest emissions in the D-FW Study area is isoprene; isoprene contributes 89.6% of the mass of biogenic VOC emissions on June 21, 1995, and 90.0% on July 3, 1996. Isoprene emissions are the largest category of biogenic VOC emissions for both the urban and rural land use categories, but monoterpenes are the largest compound class emitted by croplands. Biogenic VOC emissions for the July episode are notably higher than for the June episode, probably due to the higher temperatures observed during the July episode.

Table 3.13-6. Summary of Rural Leaf Biomass Density Data (from Yarwood et al., 1997)		
Vegetation Category	Average leaf biomass density (kg/ha)	Average oak leaf biomass density (kg/ha)
Post oak woods, forests and grasslands	1563	1342
Post oak woods and forests	3250	1714
Post oak parks and woods	2510	2304
Live oak & Ashe juniper woods	3390	443
Live oak & Ashe juniper parks	1525	88
Oak, mesquite & juniper parks and woods	3257	33
Elm-hackberry parks and woods	3941	2260
Pine hardwood forests	4958	822
Ashe juniper parks and woods	3550	498
Bluestem grassland	651	126
Cottonwood-hackberry-saltcedar brush and woods	1563	1342
Mesquite brush	1250	0
Mesquite-lotebush brush	1250	0
Silver-bluestem-Texas wintergrass grassland	625	537
Water oak-elm-hackberry forest	3712	1699
Willow oak-water oak-blackgum forest	3712	1699

Table 3.13-7. Summary of Urban Leaf Biomass Density Data (from Yarwood et al., 1997)		
Urban land use category	Average leaf biomass density (kg/ha)	Average oak leaf biomass density (kg/ha)
Residential	422	101
Parks and recreation	783	140
Commercial	149	82
Industrial	32	18
Institutional	114	30

Table 3.13-8. Biogenic VOC Emissions for the Study Area (tons/day)			
June 21, 1995			
Land Use	Monoterpenes	Other VOC species	Isoprene
Urban	1.0	4.0	41.0
Non-crop Rural	117.0	464.7	5075.8
Cropland	5.9	4.0	2.6
Total	123.9	472.9	5119.4
July 3, 1996			
Land Use	Monoterpenes	Other VOC	Isoprene
Urban	1.5	6.3	62.9
Non-crop Rural	163.3	656.5	7495.6
Cropland	8.5	5.8	3.7
Total	173.3	668.7	7562.3

Emissions Summary

Figure 3.13-18 shows a tileplot of biogenic emissions of CB-IV HC for June 20, 1995 for the D-FW 4 km. X 4 Km. fine grid. Figure 3.13-19 shows June 20, 1995 emissions of CB-IV HC pollutants across the 16 km X 16 km intermediate grid (covering East Texas), and Figure 3.13-20 shows these emissions across the 32 km X 32 km coarse grid covering the entire modeling domain. In these latter plots, the discontinuity surrounding the Study Area can be seen (caused by use of different methodologies). A complete set of biogenic emission tileplots for two episode days is provided in *Appendix D, Base Case Modeling Emissions Inventory Development.*

Tables 3.13-10a, 3.13-10b, and 3.13-10c, presented at the end of the discussion of base case modeling inventory development, show the biogenic emissions daily totals for both episodes for each of the four D-FW nonattainment counties (along with emissions from the remaining categories). Emission totals in Tables 3.13-10a, 3.13-10b, and 3.13-10c were calculated by post-processing the gridded, hourly, model-ready emissions data files, and are not expected to match exactly the input emissions. In particular, hydrocarbon emissions (CB-IV HC in the table) are calculated from the Carbon Bond IV species used in the photochemical model, and may vary from the input by as much as ten percent. *Appendix D, Base Case Modeling Emissions Inventory Development*, contains tables and figures showing daily total emissions for portions of the modeling domain outside the D-FW nonattainment area.

Table 3.13-9 shows biogenic emissions for selected episode days in each of the nonattainment counties, and provides emissions estimates over the same area developed using BEIS-2 for comparison. The highest biogenic VOC emissions in the nonattainment counties were seen in Denton County, which contained substantial acreage of post oak woods, forests and grasslands. Overall, relatively low emissions were observed across the nonattainment counties.

Table 3.13-9. Biogenic (CB-IV) Hydrocarbon Emissions for Primary Episode Days, as Calculated by BIOME Using New North Central Texas Biogenics Database

Date	Emissions by county (tons/day)					
	Dallas	Tarrant	Denton	Collin	Total D-FW	Study area total
6/21/95	53.56	85.14	136.22	19.49	294.4	6,643
6/22/95	58.21	92.72	151.66	21.95	324.5	7,288
7/3/96	79.60	128.46	213.35	31.15	452.6	9,635
BEIS-2 CB-IV Emissions (not used in study area modeling; provided only for comparison)						
6/21/95	61.55	44.78	20.51	31.26	158.1	2,937

Within the remainder of the Study Area, the highest biogenic VOC emissions were seen in Ellis, Navarro, and Limestone counties, which are dominated by elm-hackberry forests (Table 3.13-6 above shows that elm-hackberry forest has a high percentage of oak leaf biomass). Emissions were also high in Jack and Wise counties, which are dominated by post oak parks and woods. The latter result is significantly different from BEIS-2 results; the BELD land use database does not show substantial oak forests in those counties (Yarwood et al., 1997). Figure 3.13-21 presents a tileplot of biogenic VOC emissions for the entire Study Area Grid developed with BIOME and gridded at 4 km X 4 km. Figure 3.13-22 shows a tile plot of the BEIS-2 results at 16 km x 16 km grid resolution for the same area. The BEIS-2 results do not show the biogenic VOC hot spots seen in the BIOME results. In the BEIS-2 results, the highest biogenic VOC emissions are seen in areas farther east and south from the D-FW area. The differing geographic distribution could be significant when the biogenic modeling results are used in photochemical modeling.

The lowest biogenic VOC emissions in the study area were seen in McLennan, Hill, Falls, and Bell counties, which are dominated by crops.

In the portion of the modeling domain outside the Study Area, the biogenic emissions are similar to BEIS-2 emissions calculated for regional modeling conducted by ENVIRON to develop boundary conditions for the COAST study (ENVIRON, 1996).

3.13.8 Quality Assurance

The commission follows many quality assurance procedures to ensure that emissions input into the photochemical model accurately represent the data provided to the modeling staff. First, the staff check the messages output by the various processing routines to look for error and warning messages. While it is normal to receive some such messages under certain circumstances, it is important that each message be explained in terms of the process it represents. Output emissions totals are compared with inputs to ensure that no emissions have been lost (or gained) through errors in the processing.

Next, the most important QA step is visual analysis of graphical output. Tileplots similar to those shown in previous sections are produced for each episode day and for each component of the inventory. These plots should show that emissions occur primarily in densely populated areas and along major roadways. Also, the diurnal profiles shown on the tileplots should represent reasonable traffic patterns for each day modeled.

Commission staff have found that the EPA's PAVE software provides an extremely useful tool for examining emissions data. This interactive tool allows the analyst to quickly open any gridded model-ready emissions data file and to examine any hour or sub-region easily.

The final step in QA of emissions data occurs in the documentation phase, where emissions from all sources are tabulated and examined. Previously undiscovered discrepancies in the data often become obvious when arrayed in a side-to-side format.

None of the QA steps above can resolve differences between actual emissions and inventoried emissions, however, since the former quantities cannot be known with absolute certainty. However, there are a number of techniques available to compare emissions inventory data with pollutant concentrations measured in ambient air. These analyses can help to identify potential errors in the basic emissions estimation techniques themselves. The commission employed several of these techniques with favorable results in the COAST study, and plans to repeat many of these same analyses for the D-FW area in the near future. While initial work on ambient-EI reconciliation has begun, results are not available as of this writing.

3.13.9 Base Case Emissions Totals

Tables 3.13-10a, 3.13-10b, and 3.13-10c summarize base-case emissions by emission category for NO_x, CB-IV HC (VOC), and CO by region for each episode day.

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Table 3.13-10a. Summary of NO_x Emissions in D-FW Nonattainment Counties by Category (Tons/Day)

NO_x		June 1995 Episode					July 1996 Episode				
		6/18	6/19	6/20	6/21	6/22	6/30	7/1	7/2	7/3	7/4
		Sun.	Mon.	Tues.	Wed.	Thurs.	Sun.	Mon.	Tues.	Wed.	Thurs.
On-Road Mobile Sources	Dallas	115.7	156.0	156.5	155.9	158.1	115.7	152.1	151.6	161.3	115.6
	Tarrant	73.5	98.5	98.9	98.7	100.2	73.5	96.4	96.2	102.4	73.2
	Collin	17.9	24.6	24.6	24.3	24.7	17.9	23.8	24.2	25.9	18.0
	Denton	18.0	24.7	24.8	24.5	25.1	18.0	23.6	24.2	25.7	17.9
	Total	225.1	303.8	304.7	303.5	308.2	225.1	295.9	296.2	315.4	224.8
Area and Nonroad Mobile Sources	Dallas	23.6	62.9	63.1	63.1	63.1	23.6	63.5	63.7	63.8	22.5
	Tarrant	26.0	47.7	47.8	47.8	47.7	26.0	47.7	48.6	48.5	26.7
	Collin	4.0	7.8	7.8	7.8	7.8	4.0	8.2	8.2	8.2	3.9
	Denton	4.7	8.0	8.0	8.0	8.0	4.7	8.3	8.3	8.7	4.9
	Total	58.4	126.4	126.6	126.7	126.6	58.4	127.7	128.8	129.2	58.1
Point Sources	Dallas	20.0	30.4	41.0	42.2	47.0	42.0	52.6	60.4	62.4	50.9
	Tarrant	8.4	10.0	19.4	28.0	23.0	17.4	30.0	27.3	27.4	24.1
	Collin	5.1	6.1	5.5	8.9	6.0	6.3	6.8	7.3	8.0	7.4
	Denton	2.9	3.1	3.1	4.3	5.3	6.6	6.2	7.1	6.0	8.4
	Total	36.5	49.5	69.1	83.4	81.2	72.3	95.7	102.2	103.7	90.8
Biogenic Sources	Dallas	2.3	2.4	2.5	2.6	2.7	3.0	3.1	3.2	3.3	3.3
	Tarrant	1.8	1.9	1.9	2.0	2.1	2.4	2.4	2.6	2.6	2.6
	Collin	2.7	2.8	2.9	3.0	3.1	3.6	3.7	3.9	3.9	3.9
	Denton	2.3	2.4	2.5	2.6	2.6	3.1	3.2	3.4	3.4	3.4
	Total	9.1	9.5	9.7	10.1	10.5	12.0	12.3	13.0	13.1	13.1
All Sources	Dallas	161.7	251.7	263.1	263.8	270.9	184.3	271.3	278.9	290.7	192.3
	Tarrant	109.8	158.1	167.9	176.5	173.0	119.3	176.6	174.7	180.9	126.6
	Collin	29.7	41.2	40.7	44.0	41.6	31.8	42.4	43.6	46.0	33.2
	Denton	27.9	38.2	38.4	39.3	41.0	32.4	41.3	43.0	43.7	34.7
	Total	329.1	489.3	510.1	523.6	526.5	367.8	531.6	540.2	561.4	386.8

Table 3.13-10b. Summary of CB-IV HC (VOC) Emissions in D-FW Nonattainment Counties by Category (Tons/Day)

CB-IV HC (VOC)		June 1995 Episode					July 1996 Episode				
		6/18	6/19	6/20	6/21	6/22	6/30	7/1	7/2	7/3	7/4
		Sun.	Mon.	Tues.	Wed.	Thurs.	Sun.	Mon.	Tues.	Wed.	Thurs.
On-Road Mobile Sources	Dallas	80.1	106.5	106.8	109.7	112.0	80.1	113.5	119.0	129.5	81.5
	Tarrant	46.8	60.9	61.1	62.8	64.1	46.8	64.9	68.0	73.7	47.6
	Collin	11.5	15.3	15.3	15.6	15.9	11.5	16.5	18.7	17.1	11.7
	Denton	10.3	13.5	13.6	13.8	14.1	10.3	14.5	16.5	14.8	10.4
	Total	148.7	196.2	196.9	202.0	206.1	148.7	209.4	222.2	235.1	151.1
Area and Nonroad Mobile Sources	Dallas	179.5	125.7	125.8	126.1	126.1	179.5	129.8	130.7	134.5	98.8
	Tarrant	73.8	81.5	81.6	81.8	81.8	73.8	84.3	85.0	94.3	142.4
	Collin	35.8	18.1	18.1	18.1	18.1	35.8	19.1	19.2	21.5	16.9
	Denton	46.7	25.7	25.7	25.8	25.8	46.7	26.9	27.1	37.5	39.5
	Total	335.9	251.0	251.1	251.8	251.8	335.9	260.0	262.0	287.8	297.5
Point Sources	Dallas	6.7	12.8	12.9	12.8	12.8	6.8	12.9	12.9	12.9	6.8
	Tarrant	5.6	13.7	13.7	13.8	13.8	5.7	13.8	13.7	13.7	5.7
	Collin	0.5	1.1	1.1	1.1	1.1	0.5	1.1	1.1	1.1	0.5
	Denton	0.5	1.4	1.4	1.4	1.4	0.5	1.4	1.4	1.4	0.5
	Total	13.4	29.1	29.1	29.1	29.1	13.4	29.2	29.1	29.1	13.5
Biogenic Sources	Dallas	43.1	46.3	48.9	54.4	59.2	73.3	75.3	79.7	80.9	80.9
	Tarrant	64.9	69.1	75.3	83.8	91.3	113.4	117.2	124.0	126.5	127.0
	Collin	18.0	18.9	19.9	22.1	24.9	33.4	34.0	36.3	35.4	29.8
	Denton	106.9	114.6	122.7	135.9	151.2	200.5	203.3	219.2	212.6	193.6
	Total	232.8	249.0	266.8	296.2	326.6	420.6	429.7	459.3	455.4	431.3
All Sources	Dallas	309.4	291.4	294.3	303.0	310.1	339.7	331.5	342.2	357.8	268.0
	Tarrant	191.1	225.3	231.7	242.2	251.0	239.7	280.1	290.8	308.2	322.6
	Collin	65.8	53.4	54.5	57.0	60.0	81.2	70.7	75.4	75.1	59.0
	Denton	164.4	155.2	163.3	176.9	192.5	258.0	246.0	264.2	266.3	244.0
	Total	730.7	725.2	743.9	779.1	813.5	918.6	928.3	972.6	1007.4	893.5

Table 3.13-10c. Summary of CO Emissions in D-FW Nonattainment Counties by Category (Tons/Day)

CO	June 1995 Episode					July 1996 Episode				
	6/18	6/19	6/20	6/21	6/22	6/30	7/1	7/2	7/3	7/4

		Sun.	Mon.	Tues.	Wed.	Thurs.	Sun.	Mon.	Tues.	Wed.	Thurs.
On-Road Mobile Sources	Dallas	618.3	840.3	842.6	856.9	872.3	618.3	856.7	871.4	949.3	624.9
	Tarrant	377.1	498.3	499.5	509.1	517.5	377.1	507.0	516.8	558.3	381.7
	Collin	91.9	123.6	124.2	124.7	127.0	91.9	129.5	131.5	142.8	92.0
	Denton	90.5	120.3	121.0	122.1	124.2	90.5	124.0	126.3	135.0	90.2
	Total	1177.9	1582.5	1587.2	1612.8	1641.0	1177.9	1617.2	1645.9	1785.4	1188.8
Area and Nonroad Mobile Sources	Dallas	598.3	405.1	407.5	407.0	406.9	598.3	416.1	417.8	426.2	338.5
	Tarrant	255.4	284.5	286.4	286.1	286.1	255.4	292.8	294.9	313.6	461.4
	Collin	123.1	64.7	64.9	65.1	64.8	123.1	68.5	68.5	73.2	62.8
	Denton	136.7	73.2	73.5	74.0	73.3	136.7	75.4	76.2	97.8	105.5
	Total	1113.6	827.4	832.3	832.2	831.1	1113.6	852.8	857.4	910.7	968.3
Point Sources	Dallas	5.3	6.8	7.3	5.6	5.6	6.6	8.0	8.0	8.0	6.6
	Tarrant	1.8	2.1	3.3	3.9	3.9	3.6	4.0	3.7	3.7	3.8
	Collin	1.9	2.1	2.1	2.1	2.1	2.2	2.4	2.4	2.4	2.3
	Denton	0.7	0.5	0.5	0.7	0.7	0.7	0.7	0.7	0.7	0.7
	Total	9.7	11.5	13.2	12.4	12.3	13.1	15.1	14.8	14.8	13.4
All Sources	Dallas	1222.0	1252.2	1257.4	1269.5	1284.8	1223.2	1280.7	1297.2	1383.5	970.0
	Tarrant	634.3	784.9	789.1	799.2	807.5	636.1	803.9	815.4	875.6	846.9
	Collin	217.0	190.4	191.2	191.9	193.8	217.2	200.4	202.4	218.3	157.2
	Denton	228.0	194.0	195.0	196.9	198.2	228.0	200.1	203.1	233.5	196.4
	Total	2301.2	2421.5	2432.7	2457.4	2484.3	2304.6	2485.2	2518.1	2710.9	2170.5

Notes:
1. All values are based on aggregated grid cell totals which approximate geopolitical boundaries.
2. Hydrocarbon emissions are based on Carbon Bond IV transformed emissions.
3. Biogenic CO emissions are always assumed to be zero, hence are not reported.

Figures 3.13-1 thru 3.13-22

3.14 BASE CASE MODELING AND PERFORMANCE EVALUATION

3.14.1 Introduction

In addition to the meteorological and emissions data files (discussed in previous sections of this report), a number of other input files are required to run the CAMx. The first part of this section describes the development of these additional input files, followed by a discussion of the modeling of the D-FW base case episodes. The remainder of the section discusses the evaluation of model performance for two base case episodes, June 18 – 22, 1995 and June 30 – July 4, 1996.

3.14.2 Model Input Data

Figure 3.14-1 provides an overview of the CAMx input and output files. The development of the meteorological and emissions data files is summarized in preceding sections of this document. Brief descriptions of the development of the remaining model input files are provided below.

Boundary Condition File

The lateral boundary conditions file contains hourly chemical concentrations distributed horizontally and vertically along the sides of the regional modeling domain. This file allows pollutants generated outside the regional modeling domain to be accounted for in the simulation. The top boundary conditions file is used to define chemical concentrations at the top of the modeling domain for each hour of the simulation. Chemicals can also enter the modeling domain through this route. More detailed information on the development of boundary conditions for the D-FW modeling is provided in Section 3.8, *Boundary and Initial Conditions.*

Initial Condition File

The initial condition file is a three-dimensional array of chemical concentrations characterizing air quality at the beginning of the model simulation. More detailed information on development of initial conditions for the D-FW modeling is provided in Section 3.8, *Boundary and Initial Conditions*.

Surface Characteristics File

The CAMx requires surface characteristics data for the model's deposition process (the removal of airborne chemicals through contact with surface features such as trees). The surface characteristics file contains the distribution of land-use types for each horizontal grid cell. Surface characteristics may vary spatially but not temporally. The surface characteristics input file for the D-FW CAMx modeling were developed from the USGS *Land Use and Land Cover* database.

Terrain Heights File

This file defines the ground level altitude (above sea level) of each horizontal coarse grid location. The CAMx uses terrain data only to calculate altitudes for certain radiative calculations. All other terrain influence is communicated to the CAMx through the meteorological inputs. Terrain inputs vary spatially but not temporally.

Chemistry Parameters File

The chemistry parameters file contains chemical information for the simulation, including chemical reaction rate constants. The CAMx provides a choice of three gas phase chemical mechanisms (Environ, 1997): (1) Mechanism 1 - compatible with the EPA regulatory version of UAM-IV, but not recommended due to inadequate radical termination reactions; (2) Mechanism 2 - improved chemical mechanism with the original isoprene chemistry; (3) Mechanism 3 - the improved chemical mechanism with the newer (less reactive) Carter isoprene chemistry, which is compatible with UAM-V version 1.24. Mechanism 3 was used in the D-FW CAMx modeling.

Photolysis Rates File

The photolysis rates file contains tabulated photolysis rates for four key reactions: photolysis of NO_2, HCHO, ozone and ALD2. The rates of these reactions vary spatially and temporally; the rates are functions of solar zenith angle, altitude, ultraviolet albedo, turbidity, and ozone column density. The data are used in the model's chemistry solver.

Albedo/Haze/Ozone Column Density File

The photochemistry in the CAMx depends upon the amount of solar radiation entering each vertical layer of the modeling domain. The CAMx calculates the amount of radiation at each vertical layer based on surface reflectivity (albedo), atmospheric turbidity (haze), and the amount of stratospheric ozone that sunlight must pass through (ozone column density). Albedo is derived from the CAMx Land Use file described above, and varies across the modeling domain based upon local characteristics of the land surface, but does not vary over time. Turbidity is set at 0.094, a value typical of the rural conditions which dominate the modeling domain. The model does not allow this parameter to vary in space or time. The ozone column density data are obtained from the National Space Science Data Center, which archives data from Nimbus 7 satellite-based TOMS. Ozone column density varies spatially and temporally.

Job Control File

The job control file contains information required to execute the modeling program, including the modeling domain definition parameters and the names of various input and output data files.

OSAT Parameters and Emissions Input Files

One of the advantages of CAMx is that it has an optional feature called OSAT. The OSAT allows the CAMx to attribute the ozone formed in a user-specified region to emission sources in the modeling domain. The optional OSAT runs simultaneously with the normal CAMx model simulation, and the OSAT parameters are specified in a CAMx job control file. Separate emissions input files must be provided for each user-defined emission group.

3.14.3 Model Execution

Once the required files were developed and quality-assured, the model was executed and the output was examined to check for gross errors. After the model executed satisfactorily and the output files appeared reasonable, then the model output was compared with ambient air quality measurements to evaluate its performance. If the model accurately replicates the observed ozone concentrations, it is reasonable to

believe the model can be reliably used to evaluate future control strategies (although the possibility that the model is "getting the right answer for the wrong reason" must always be considered). If, however, the model cannot replicate the observed ozone concentrations, then little confidence can be placed in its ability to correctly evaluate future control strategies.

It should be noted that in modeling each of the two episodes of primary interest for D-FW, the commission staff used three “ramp-up” days (i.e., non-exceedance days preceding the actual exceedance days) to minimize any effects due to initial conditions. Model performance is discussed for the ramp-up days, but is not considered as important as model performance on the actual exceedance days.

3.14.4 Performance Evaluation Tools

Model performance evaluation tools fall into two categories: statistical and graphical analyses. The statistical analysis provides objective numerical performance measures which can be compared with predetermined performance criteria, but offer limited help in understanding model behavior. Graphical and visualization analysis techniques, on the other hand, can offer great insight into the workings of the model, but are not well suited for objective comparison with established performance criteria. Both types of evaluation tools have been used in evaluating the D-FW CAMx model performance. The tools used to evaluate model performance for D-FW were developed in-house at the commission, but all are based on methods recommended in the EPA’s *Guideline for Regulatory Application of the Urban Airshed Model* (hereafter *Guideline*) (*EPA*, 1991).

Statistical Analysis

The EPA *Guideline* recommends three particular statistics for ozone photochemical model performance evaluation. These statistics are the unpaired peak accuracy, the normalized bias, and the normalized gross error. The formulae for calculation of these statistical measures are provided in the *Guideline*.

Each of the recommended statistics provides useful information about the overall performance of the model. The unpaired peak accuracy compares highest simulated 1-hour ozone concentration with the highest monitored 1-hour ozone concentration irrespective of location and time. This statistic gives an overall indication of the model’s ability to replicate measured peak ozone. In particular, this statistic can be used to determine whether the model significantly underestimates the observed ozone levels. However, this statistic cannot be used to diagnose over-prediction by the model. The true ozone peak on any day will most likely exceed the monitored peak on that day, since only a few discrete locations within the domain are monitored. Thus when the model accurately simulates peak ozone, the peak modeled ozone concentration will exceed the peak measured value unless the peak happens to occur at a monitoring location.

The other two statistics match simulated and observed 1-hour ozone concentrations paired in space and time, for data pairs where measured ozone concentrations are greater than or equal to 60 ppb. The normalized bias indicates whether the model tends to over-predict or under-predict the observed values. This statistic is the difference between simulated and observed ozone concentrations at each monitor for each hour, averaged over all hours and all stations for which measured ozone is greater than or equal to 60 ppb. The normalized bias is negative if the model consistently under-predicts ozone levels, positive if the model consistently over-predicts ozone levels, and near zero if the model, on average, tends to predict the observed ozone levels. A value of normalized bias near zero does not necessarily mean that the model is predicting the observed ozone concentrations correctly, however; only that the tendency to over-predict in

some circumstances is balanced by a tendency towards under-prediction in others. The normalized gross error measures the overall level of agreement between the model and monitored data, regardless of whether the differences are positive or negative. This statistic is the absolute value of the difference between simulated and observed values, averaged over all hours and all stations for which measured ozone is greater than or equal to 60 ppb. The normalized gross error is always positive; the smaller the gross error, the better the model replicates observations. However, unlike the bias, the gross error offers no information about whether the model has a consistent tendency to overestimate or underestimate observed ozone concentrations.

The *Guideline* also describes additional statistics that are useful in assessing model performance. The commission calculates these as well as several others routinely when assessing model performance. The model performance summaries found in *Appendix E, Base Case Modeling and Performance Evaluation*, include the complete set of statistics calculated for each model run.

The *Guideline* emphasizes the need for an adequate monitoring network from which to draw statistical inferences. Eight air quality monitoring sites inside the D-FW core domain (i.e. the 4 km X 4 km fine-grid) were used to calculate the CAMx ozone performance evaluation statistics. A map of these eight monitoring sites is provided in Figure 3.14-2. Descriptions of station codes and their associated geographical coordinates are listed in Table 3.14-1.

Table 3.14-1. Air Quality Monitoring Sites in D-FW Nonattainment area.

Site Code	UTM Zone 15 (km)		Site and Location Description
	Easting	Northing	
DANC	144.1	3648.5	CAM05, North Dallas, Dallas Co., Texas
DCLC	139.9	3665.5	Colony, Denton Co., Texas
DHIC	138.9	3637.5	Hinton, Dallas, Dallas Co., Texas
DMAC	109.3	3681.5	CAM56, Denton, Denton Co., Texas
FRIC	146.8	3671.4	CAM31, Frisco, Collin Co., Texas
FWMC	92.2	3637.7	Fort Worth, Tarrant Co., Texas
KELC	100.0	3650.3	Not in a city, Tarrant Co., Texas
TX44	136.9	3621.7	Dallas, Dallas Co., Texas

Graphical and Visualization Analysis

Descriptive statistical methods such as those described above reduce the original data into a few understandable numbers, but obviously a massive amount of information in the model outputs is lost when a multi-megabyte data set is summarized by a handful of statistics. Graphical and visualization techniques, while lacking the precision of numerical measures, are invaluable tools for the analyst, because they can depict many thousands of data values in a single picture, conveying a depth of understanding much greater than the analyst can gain from a table of statistical data. The commission modeling staff utilized several graphical and visualization techniques to analyze the CAMx output data, including contour plots and time series plots.

Contour Plot

The most often-used graphical analysis technique for studying the ozone photochemical model results is plotting isopleths (similar to contour lines) of simulated ozone concentrations over a map of the modeling domain. These isopleths (commonly referred to as contour plots) of ozone concentrations depict both the areal extent and intensity of ozone concentrations across the domain. The commission staff uses two types of ozone contour plots: an hourly ozone contour plot which represents simulated ozone levels for a particular hour, and a daily maximum ozone contour plot which represents the maximum ozone levels over 24 hours of a particular day. The daily maximum ozone plots are used in the model evaluation portion of this section, since these plots summarize daily high ozone better than any single 1-hour contour plot. They are considered more useful for comparing the effectiveness of various emission reduction strategies.

Time Series Plot

A second graphical technique useful in analyzing ozone photochemical modeling results is generating plots of simulated ozone concentrations at a fixed location (usually at a monitoring station) as a function of time, known as time series plots. When both observed and simulated concentrations are plotted, time series plots show graphically the hourly differences between observation and prediction. These differences, at station locations, form the basis for most of the performance statistics described in the preceding section.

Time series plots offer insights that cannot be gleaned from statistics alone. One particularly interesting comparison is the shape of the predicted concentration time series versus that of observations, disregarding the relative magnitude of the two. In other words, does the predicted concentration rise when the observed concentration rises, fall when the observed falls, and show the same "peaks", "valleys", and "plateaus" as the observations? If the shapes are similar, but the predicted concentrations are higher or lower than the observations, then there is evidence that the meteorological formulation for the model is adequate but that there might be problems in the emissions inventory. A second informative comparison between predicted and observed ozone concentrations is to look for a time shift or lag. In other words, would the predicted time series match the observed if it were shifted right or left by one or more hours? If so, then there is evidence that either the meteorological formulation or the temporal allocation of the emissions is incorrect.

The time series can also be used to evaluate precursor concentrations as an additional check on model performance. However, the EPA *Guideline* does acknowledge a well known caveat:

> Performance measures should also be considered for ozone precursors wherever possible, based upon availability of monitored data. Obvious problems exist in comparing model predictions with observed values. The UAM output represents volumetric (e.g., 25 km^3), 1-hour average concentrations, but air quality data represent point locations with various sampling periods. This “incommensurability” may lead to considerable uncertainty in the comparisons, especially for precursor species that are not buffered chemically and may have been sampled at locations not representative of area wide concentrations. (Page 50 of the *Guideline*).

It should be noted that the previous statement specifically refers to the regulatory model UAM-IV. While the caveat still applies to CAMx, the level of “incommensurability” may not be as great, due to use of

advanced treatment of vertical mixing, plume-in-grid treatment of point sources, and nested-grid capabilities which allow the use of smaller horizontal grid sizes. However, monitors are still subject to sub-grid scale variability in concentrations of freshly-emitted pollutants (for example, a monitor may be located a few hundred meters from a busy intersection) which the model is incapable of replicating.

There is no quantitative measure of how large an area each monitor represents; given the amount of monitoring data currently available, only qualitative assessments are possible. An urban monitor cannot automatically be assumed to represent the average concentration of even a shallow 4 km x 4 km grid cell (such as used in this CAMx modeling exercise) due to the heterogeneity of emissions sources and local turbulence effects present in an urban environment. Therefore, comparisons of urban point monitors and average 4 km x 4 km grid cell concentrations can only be approximate, since they are not a comparison of the same entity.

Because of difficulties in comparing measured and modeled concentrations, and because of additional technical concerns, the commission does not believe it is appropriate to base model evaluation on ozone precursor performance. The precursor comparisons are, however, very valuable in gaining insight into the model's operation. Note that while the above concerns about incommensurability also apply to ozone concentrations, ozone is a secondary pollutant not directly emitted into the atmosphere. It is therefore likely that sub-grid scale variability of ozone concentrations is much lower than that of directly-emitted pollutants.

3.14.5 Base Case Model Performance

As noted in Section 3.10, *Episode Selection*, the commission selected two ozone episodes that were of particular significance to the D-FW nonattainment area. These episodes were June 18 – 22, 1995 and June 30 – July 4, 1996. The following sections discuss base case model performance for these two episodes and will focus primarily on the three primary episode days, June 21 and 22, 1995 and July 3, 1996. The model performance was evaluated on the D-FW core domain (see Section 3.7, *Definition of the Dallas–Fort Worth Modeling Domain)* and is presented here in three types of analyses:

Ozone performance statistics: The normalized bias and gross error for ozone observations greater than 60 ppb, and unpaired peak prediction accuracy for each episode day are presented in a table, together with the EPA-recommended levels of acceptable model performance. Also included in the same table are the simulated and observed domain-wide daily maximum ozone concentrations. The model-simulated concentrations at each site were bilinearly interpolated from the four cells nearest to that site.

Ozone time-series: Time series plots of model-simulated and observed ozone concentrations are presented for eight D-FW monitoring sites (see Table 3.14-1 and Figure 3.14-2) over the entire episode. The time-series plots include not only the simulated ozone concentration at each monitoring site, but also the maximum and minimum simulated ozone concentrations found in the 9 grid cells (a 3×3 square centered on the site) surrounding the monitor. In comparing the modeled and monitored concentrations, three aspects will be noted: whether the peak is over- or under-predicted, whether the model properly depicts the observed diurnal variation, and whether there is a shift in time between the monitored and modeled concentrations. Simulated concentrations at each monitoring site were calculated by bilinearly interpolating the simulated ozone from the four cells nearest to that site.

Daily maximum ozone concentration: Daily maximum ozone concentration contour plots are presented for each primary episode day. These plots also have the observed daily maximum ozone concentration values printed at the locations of monitoring sites. The model-simulated area of ozone exceedance (greater than 124 ppb) is shaded in the plots.

The full model performance evaluation package for each episode is provided in *Appendix E, Base Case Modeling and Performance Evaluation*, including the ozone performance statistics table and bar chart plots, time-series plots of ozone, NO, NO_2, VOC, CO concentrations and the NO_x/VOC ratio, and daily maximum ozone contour plots for each episode day. The electronic version of the model performance evaluation packages, including MPEG animations of the model-simulated layer-one ozone concentrations, may be obtained from the commission via FTP.

June 18 – 22, 1995 Episode

Ozone Performance Statistics

The CAMx base case modeling of the June 18 – 22, 1995 episode showed excellent performance, as demonstrated by the ozone performance statistics shown in Table 3.14-2. Except for the first ramp-up day, all statistics are well within EPA's levels of acceptance. For the two primary episode days, the simulated domain-wide daily maximum ozone concentrations are slightly lower than the observed values on June 21, 1995, and higher on June 22, 1995.

Table 3.14-2. CAMx D-FW Base Case Ozone Performance Statistics for June 18 – 22, 1995 Episode

Episode Date	Normalized Bias (±5–15%)	Normalized Gross Error (30–35%)	Unpaired Peak Accuracy (±15–20%)	Domain-wide Peak Ozone (ppb)	
				Simulated	Observed
06/18/95	-27.0	**28.0**	**-3.8**	74.0	77
06/19/95	**0.2**	**8.8**	**-1.8**	110.0	113
06/20/95	**-2.5**	**13.0**	**13.2**	134.7	119
06/21/95	**-3.0**	**10.5**	**-0.9**	142.6	144
06/22/95	**-2.6**	**10.4**	**10.2**	148.8	135

Ozone Time-Series

The ozone concentration time-series plots at eight air quality monitoring sites in the D-FW core domain, shown in Figure 3.14-3, also indicate that the model performed very well in simulating ozone concentrations at these sites.

For June 21, 1995, three sites (DCLC, DHIC, and FWMC) had simulated peak ozone concentrations that were greater than or equal to the observed values; four sites (DANC, DMAC, KELC, and TX44) had model-simulated peak ozone concentrations slightly lower than observed values; and the FRIC site did not have observed ozone data on this day. The model-simulated peak ozone levels on June 21 occurred within only one or two hours of the observed peak values. The diurnal variations of simulated ozone levels match fairly well with the observations, except that simulated ozone levels tend to vary smoothly and thus did not replicate the sharp ozone dips and bursts as shown in observed data at some sites (e.g., 1200 CST at site FWMC).

For June 22, 1995, five sites (DCLC, DHIC, FWMC, KELC, and TX44) had simulated peak ozone concentrations that were greater than or equal to observed values; two sites (DANC and DMAC) had slightly lower simulated peak ozone concentrations than the observed values; and the FRIC site again did not have observed ozone data on this day. The model-simulated peak ozone levels on this day occurred within one or two hours of the observed peak values. The diurnal variations of simulated ozone levels matched fairly well with the observations.

For the three ramp-up days, the simulated ozone also matched very well with the observations, with the exception of the first 12 hours of the episode, during which the simulated ozone levels were much lower than observed levels at all eight sites. The lower simulated ozone concentrations at the start-up hours may be due to the relatively high initial NO concentrations (see Section 3.8, *Boundary and Initial Conditions*), which probably resulted in modeled ozone titration at these hours.

Daily Maximum Ozone Concentrations

Figure 3.14-4 shows the daily maximum ozone concentrations in the D-FW core domain for June 21, 1995. The simulated ozone exceedance area covered portions of Denton, Dallas and Collin counties, but missed the three monitoring sites (DANC in north Dallas County, DMAC in Denton County, and KELC in north Tarrant County) where ozone levels at or above 124 ppb were observed.

Figure 3.14-5 shows the daily maximum ozone concentrations in the D-FW core domain for June 22, 1995. The model-simulated ozone exceedance area covers portions of Denton, Dallas and Collin counties, including the two sites (DANC and DCLC) which recorded ozone levels above 124 ppb.

June 30 – July 4, 1996 Episode

Ozone Performance Statistics

The June 30 – July 4, 1996 episode had acceptable statistical model performance, as shown in Table 3.14-3. The normalized bias and gross error fall within the acceptable levels on all episode days except the first ramp-up day. The model simulated higher domain-wide peak ozone concentrations for July 1 – 4, 1996 than the observed values, and the unpaired peak accuracies were above 20 percent for July 3-4, 1996. As discussed before, the high positive values of this statistic may merely reflect the fact that it is not possible

to monitor air quality at every point in the region, rather than indicating over prediction by the model. In other words, an overestimation of peak ozone is not inconsistent with good model performance.

Table 3.14-3. CAMx Base Case Ozone Performance Statistics for June 30 – July 4, 1996 Episode

Episode Date	Normalized Bias (±5–15%)	Normalized Gross Error (30–35%)	Unpaired Peak Accuracy (±15–20%)	Domain-wide Peak Ozone (ppb)	
				Simulated	Observed
06/30/96	-25.8	**25.8**	**-19.4**	90.3	112
07/01/96	**-13.1**	**14.3**	**0.5**	112.6	112
07/02/96	**-6.7**	**12.5**	**7.7**	122.8	114
07/03/96	**12.3**	**20.8**	**20.2**	173.1	144
07/04/96	**7.2**	**11.2**	**23.1**	142.8	116

Ozone Time-Series

The time-series plots at eight air quality monitoring sites in the D-FW core domain (Figure 3.14-6) also indicate that the model performed very well in simulating ozone concentrations at these sites.

For July 3, 1996, seven sites, DANC, DCLC, DHIC, DMAC, FRIC, FWMC, and KELC, showed higher simulated peak ozone concentrations than were observed; the site TX44 showed slightly lower ozone than the observed. The diurnal variations of simulated ozone levels match fairly well with the observations, except that at DCLC and FRIC, the simulated ozone peaked in the morning rather than in the afternoon as observed. At other sites, the simulated ozone peaked two or three hours earlier than observed.

For other episode days, the model also matched very well with the observations, except during the first few hours of model simulation, when the simulated ozone levels were much lower than observed levels at all eight sites. The lower simulated ozone concentrations during the start-up hours may be due to the high initial NO levels (see Section 3.8, *Boundary and Initial Conditions*) which resulted in modeled ozone titration at these hours.

Daily Maximum Ozone Concentrations

Figure 3.14-7 shows the daily maximum ozone concentrations in the D-FW core domain for July 3, 1996. The model-simulated ozone exceedance area covered most of the Dallas and Tarrant counties, where ozone levels above 124 ppb were observed. The simulated peak ozone levels tended to be higher than the observed peak values.

3.14.6 Evaluation of Diagnostic Runs

The goal of diagnostic testing is to determine whether the model exhibits expected behavior under extreme changes to its input. Diagnostic tests check for spurious behavior that would indicate problems in the model formulation. Of course, diagnostic tests alone do not constitute a complete validation of the CAMx for a given episode, but rather provide opportunities for the model to fail. Following are the three diagnostic tests we conducted for the two D-FW episodes:

Initial and boundary condition tracers – In this diagnostic run, all the emission inputs, both low level and elevated, were turned off and six inert tracer species were set up for the CAMx: the INIT, the four lateral boundary condition tracers (NORTH, SOUTH, EAST, and WEST), and the top boundary condition tracer (TOP). The INIT tracer concentration was set at 1000 ppb for all cells of all layers; the concentrations of four lateral boundary tracers were set at 1000 ppb for all regional domain boundary cells at all layers throughout the entire modeling episode; the TOP tracer concentration was also set at 1000 ppb throughout the entire modeling episode. The purpose of such a tracer run was to investigate how much the initial and boundary conditions potentially influence the interior of the modeling domain, particularly the D-FW core area. Since the tracer run is conducted in the absence of chemical reactions (inert chemistry), emission inputs, and deposition, the modeled tracer concentrations reflect only the effect of meteorological conditions presented by the meteorological input data. The core domain layer-one tracer concentration plots for selected hours will be discussed in this report. Additional plots are available in *Appendix E, Base Case Modeling and Performance Evaluation*. The MPEG animations of the hourly layer-one tracer concentrations of both episodes may be obtained from the commission via FTP.

Zero Anthropogenic Emissions – In this diagnostic run, all anthropogenic emissions in the entire D-FW modeling domain were set to zero. Thus, the only emissions simulated were those produced by biogenic sources. This modeling run was expected to produce very low ozone concentrations across the modeling domain, except in cases where the boundary conditions contributed significantly to the modeled ozone values. The ozone concentrations simulated by this modeling run can be regarded as background ozone levels in the absence of man-made emissions in the modeling domain. The daily maximum ozone concentration contour plots of the primary episode days (June 21 and 22, 1995, and July 3, 1996) will be discussed in this report; plots of other episode days are available in *Appendix E, Base Case Modeling and Performance Evaluation*.

Zero Initial and Lateral Boundary and Top Boundary Conditions – In this diagnostic run, the initial conditions, lateral boundary conditions, and top boundary conditions were set equal to zero for all chemical species. The purpose of this modeling run was to investigate the model behavior in the absence of any influence from outside of the modeling domain and prior to the beginning of modeling episode. The daily maximum ozone concentration contour plots of the primary episode days (June 21 and 22, 1995, and July 3, 1996) will be discussed in this report; the plots of other episode days are available in *Appendix E, Base Case Modeling and Performance Evaluation*.

June 18 – 22, 1995 Episode

Initial and Boundary Condition Tracers

The modeling results for the tracer diagnostic runs showed no significant influence to the D-FW area from the west and south regional domain boundaries through the entire episode, but some influences from the north and east regional domain boundaries on the last two episode days. The influence of the north regional domain boundary reached the D-FW area on the afternoon of June 21, 1995, and NORTH tracer concentrations reached about 200 ppb (representing 20 percent of the tracer's concentration at its origin) at 1600 CST (Figure 3.14-8); on the next day, June 22, 1995, at 1600 CST, the NORTH tracer concentrations were around 200 ppb (Figure 3.14-9). The east boundary also influenced the core D-FW area. EAST tracer concentrations reached around 100 ppb at 1600 CST on June 21, 1995 (Figure 3.14-8) and about the same level at 1600 CST of the next day (Figure 3.14-9).

The top boundary condition showed minimal influence to the D-FW area in the last two episode days. TOP tracer concentrations were typically less than 100 ppb in this area (Figures 3.14-8 and 3.14-9).

The result also showed strong influence from the initial conditions even on the last two episode days. The INIT tracer concentrations were around 500 ppb in the D-FW area on June 21, 1995, 1600 CST (Figure 3.14-8) and around 400 ppb on the next day at the same hour (Figure 3.14-9). This indicates that building a correct initial condition file is very important to this episode. As a result of this diagnostic analysis, the commission staff developed new CAMx initial condition files for this episode by incorporating observed ozone, NO, NO_2, and CO concentration data, replacing the default initial conditions used in early model runs (see Section 3.8, *Boundary and Initial Conditions*).

Zero Anthropogenic Emissions

The model performed as expected. The daily maximum ozone concentrations at the layer one were about 30 ppb in the D–-FW core domain for June 21 and 22, 1995 (Figures 3.14-10 and 3.14-11).

Zero Initial and Lateral Boundary and Top Boundary Conditions

Overall, the model-simulated ozone levels are lower than the base case results, which is expected in the absence of influences from outside the modeling domain or prior to the episode. On the primary days, June 21 and 22, 1995, the model-simulated ozone exceedance areas are significantly smaller as compared to the base case, and the domain-wide peak ozone concentrations are about 10 ppb lower relative to the base case results (Figures 3.14-12 and 3.14-13).

June 30 – July 4, 1996 Episode

Initial and Boundary Condition Tracers

The modeling results showed no significant influence to the D-FW area from the north, west and east regional domain boundaries through the entire episode, but did show some influences from the south. The influence of the south boundary reached the D-FW area on early July 2, 1996 and the SOUTH tracer concentrations reached about 200 ppb at 1600 CST on July 3, 1996 (Figure 3.14-14).

The top boundary condition influenced the D-FW area slightly on the last two episode days. The TOP tracer concentrations were typically less than 200 ppb in this area (Figure 3.14-14).

The results also show strong influence from the initial conditions even on the last two episode days. The INIT tracer concentrations are around 600–700 ppb in the D-FW area on July 3, 1996, 1600 CST (Figure 3.14-14). This indicates that building a correct initial condition file is very important to this episode also. As for the June 1995 episode, the commission staff developed the CAMx initial condition file for this episode by incorporating observed ozone, NO, NO_2, and CO concentration data (see Section 3.8, *Boundary and Initial Conditions*).

Zero Anthropogenic Emissions

The model performed as expected. The daily maximum ozone concentrations at layer one were around 30–40 ppb in the D-FW core domain for July 3, 1996 (Figure 3.14-15).

Zero Initial and Lateral Boundary and Top Boundary Conditions

Overall, the model-simulated ozone levels are lower than the base case results, which is expected in the absence of influences from outside the modeling domain or before the beginning of the episode. On the primary day of this episode, July 3, 1996, the model-simulated ozone exceedance area is smaller as compared with the base case, and the domain-wide peak ozone concentration is about 10 ppb lower than the base case result (Figure 3.14-16).

3.14.7 Evaluation of Sensitivity Runs

The classic function of sensitivity analysis is to assess the stability of a complex physical model across a range of possible input parameters. The model should respond to small changes in critical input parameters, but not in an extreme or erratic fashion. Either lack of responsiveness or a tendency to respond excessively to realistic perturbations can indicate possible problems with a particular simulation. In addition, sensitivity analyses also show the modeler which variables cause the model to respond vigorously or passively, and hence which variables are the most and least critical to estimate correctly. When model performance is poor, the primary purpose of sensitivity analysis is to provide vital information to the modeler about which variables need improvement. When model performance is good, as in this application, the results of sensitivity analysis are used to identify those input data that have a significant effect on model results, and to provide reasonable bounds for the model's output.

In this section, results from a series of sensitivity model runs are presented. Ozone performance statistics for every episode day and daily maximum ozone contour plots for primary episode days (June 21 and 22, 1995 and July 3, 1996) are provided for each sensitivity run, along with difference plots. Difference plots show the difference (at each grid cell in the modeling domain) between daily maximum ozone simulated for a particular sensitivity test and the daily maximum at that grid cell simulated for the base case. The difference plots are useful because they show the geographic regions where the peak ozone increased and decreased relative to the base case. The full model performance evaluation package for each sensitivity run, including ozone performance statistics, time-series plots, daily maximum ozone contour plots, and daily maximum ozone contour difference plots, is provided in *Appendix E, Base Case Modeling and Performance Evaluation*. The list of sensitivity runs performed and a discussion of modeling results are presented below.

Default EPA Background Values for Initial and Boundary Conditions – In this sensitivity analysis modeling run, initial conditions, lateral boundary conditions, and top boundary conditions were set equal to the default EPA background concentrations of all chemical species (*EPA*, 1991). This modeling run tested the model's response to an alternative set of initial, lateral boundary, and top boundary conditions.

Regional SAIMM Wind Data for D-FW Core Domain – This sensitivity analysis was performed to assess the model's response to variations in the wind fields used in the CAMx model. In this sensitivity analysis modeling run, the wind field inputs to the CAMx for the D-FW fine-grid core domain were replaced by wind data from the regional SAIMM coarse-grid modeling results. Besides the size of the modeling domains, there are two major differences between the SAIMM modeling runs for the regional and D-FW core domains: (1) The regional SAIMM simulation used grid cells of size 16×16 km, whereas the D-FW core domain SAIMM used grid cells of size 4×4 km; (2) The regional SAIMM simulation used spatially-constant surface characteristics data, whereas the D-FW core domain SAIMM simulation used spatially-variable surface characteristics data. These differences in SAIMM simulation resulted in differences in the wind fields generated by the simulations. The detailed discussion of the D-FW SAIMM modeling is provided in the Section 3.12, *Meteorological Modeling*. Statistics comparing the two wind fields, and wind vector plots of selected hours are provided in *Appendix E, Base Case Modeling and Performance Evaluation.*

75 Percent Biogenic VOC Emissions – In this sensitivity analysis modeling run, the biogenic VOC emissions were reduced by 25 percent. Although biogenic emission estimates have improved over the last few years, substantial uncertainties remain. The current biogenic emission models are unable to account for all relevant variables. For example, the models may accurately depict the emissions' dependence on temperature, solar radiation intensity, leaf biomass density, and plant species (Guenther et al., 1993, 1994), but do not account for how emissions may change with leaf age or drought (Monson et al., 1995). An overestimate in biogenic VOC emissions was assumed instead of an underestimate because the isoprene concentrations measured by auto-gc during the 1996 episode were lower than modeled isoprene concentrations, suggesting that the biogenic models may be overestimating isoprene emissions. The purpose of this sensitivity analysis is to test the model's response to the 25 percent reduction of biogenic VOC emissions.

June 18 – 22, 1995 Episode

Default EPA Background Values for Initial and Boundary Conditions

As shown in Table 3.14-4, the ozone performance statistics of this sensitivity run indicate good model performance; they are not much different from the base case result (Table 3.14-2). The daily maximum ozone concentration plots of the two primary episode days (Figures 3.14-17a and 3.14-17b) also display a pattern similar to those of the base case (Figures 3.14-18a and 3.14-18b). This sensitivity analysis indicates that the CAMx is not very sensitive to this degree of change in the initial and boundary conditions for the base case modeling of the June 18 – 22, 1995 episode, despite the persistence of the initial conditions discussed earlier.

Table 3.14-4. Ozone Performance Statistics for June 18 – 22, 1995 Episode Sensitivity Analysis: Default EPA Background Values for Initial and Boundary Conditions

Episode Date	Normalized Bias (±5–15%)	Normalized Gross Error (30–35%)	Unpaired Peak Accuracy (±15–20%)	Domain-wide Peak Ozone (ppb)	
				Simulated	Observed
06/18/95	-27.0	**27.0**	**-14.5**	65.8	77
06/19/95	**-5.6**	**9.9**	**-5.3**	107.0	113
06/20/95	**-4.3**	**13.3**	**12.0**	133.2	119
06/21/95	**-1.9**	**10.2**	**-0.4**	143.5	144
06/22/95	**1.3**	**10.6**	**14.0**	153.8	135

Regional SAIMM Wind Data for D-FW Core Domain

The model displayed large changes in simulated ozone levels due to the change of wind data in the D-FW core domain. Although the model performance was still very good relative to EPA's acceptance criteria (Table 3.14-5), overall performance degraded compared with the base case result (Table 3.14-2). The daily maximum ozone concentration plots also showed somewhat different patterns for two primary episode days (Figures 3.14-19a and 3.14-19b). Difference plots showed differences of approximately 10 ppb in daily maximum ozone levels for June 21, 1995 (Figure 3.14-20a) and of greater than 20 ppb for June 22, 1995 (Figure 3.14-20b).

Table 3.14-5. CAMx Base Case Sensitivity Ozone Performance Statistics for June 18 – 22, 1995 Episode: Regional SAIMM Wind Data for D-FW Core Domain

Episode Date	Normalized Bias (±5–15%)	Normalized Gross Error (30–35%)	Unpaired Peak Accuracy (±15–20%)	Domain-wide Peak Ozone (ppb)	
				Simulated	Observed
06/18/95	-27.7	**27.7**	**-7.2**	71.5	77
06/19/95	**-7.4**	**12.4**	**-11.4**	100.1	113
06/20/95	**-9.5**	**15.3**	**2.0**	121.4	119
06/21/95	**-1.9**	**11.3**	**-3.2**	139.3	144
06/22/95	**-2.6**	**10.5**	**7.6**	145.3	135

75% Biogenic VOC Emissions

In this sensitivity, the model performance was still very good as shown in Table 3.14-6, but degraded somewhat compared to the base case result (Table 3.14-2), suggesting that the uncertainty in biogenic VOC estimates for the June 1995 episode may be less than 25% (assuming there are no compensating errors elsewhere in the model formulation). As shown in Figures 3.14-21a and 3.14-21b, the model-simulated ozone exceedance areas was significantly smaller for the two primary episode days, June 21 and

22, 1995, compared with the base case. The difference plots (Figures 3.14-22a and 3.14-22b) show a 5 to 10 ppb decrease of daily maximum ozone levels in the D-FW area relative to the base case.

Table 3.14-6. CAMx Base Case Sensitivity Ozone Performance Statistics for June 18 – 22, 1995 Episode: 75% Biogenic VOC Emissions

Episode Date	Normalized Bias (±5–15%)	Normalized Gross Error (30–35%)	Unpaired Peak Accuracy (±15–20%)	Domain-wide Peak Ozone (ppb)	
				Simulated	Observed
06/18/95	-29.8	**30.1**	**-7.0**	71.6	77
06/19/95	**-5.4**	**8.9**	**-6.8**	105.3	113
06/20/95	**-9.4**	**14.4**	**6.2**	126.4	119
06/21/95	**-10.1**	**13.0**	**-7.6**	134.4	144
06/22/95	**-9.9**	**12.8**	**3.4**	139.6	135

June 30 – July 4, 1996 Episode

Default EPA Background Value for Initial and Boundary Conditions

The ozone performance statistics for this sensitivity analysis modeling run (Table 3.14-7) show slightly better performance for the first three episode days and slightly worse for the last two days, relative to the base case performance (Table 3.14-2). Although the daily maximum ozone concentration contour plot of the primary episode day, July 3, 1998 (Figure 3.14-23) shows a similar pattern to that of the base case, there is a large area within which this sensitivity run produced an increase of more than 5 ppb in the daily maximum ozone levels above the base case (Figure 3.14-24). However, overall, the model exhibited only slightly different behavior from the base case.

Table 3.14-7. CAMx Base Case Sensitivity Ozone Performance Statistics for June 30 – July 4, 1996 Episode: Default EPA Background Values for Initial and Boundary Conditions

Episode Date	Normalized Bias (±5–15%)	Normalized Gross Error (30–35%)	Unpaired Peak Accuracy (±15–20%)	Domain-wide Peak Ozone (ppb)	
				Simulated	Observed
06/30/96	-25.1	**25.1**	**-16.7**	93.3	112
07/01/96	**-12.8**	**14.8**	**3.8**	116.2	112
07/02/96	**-2.4**	**12.9**	**12.1**	127.7	114
07/03/96	16.6	**23.1**	24.3	179.0	144
07/04/96	**10.8**	**13.4**	25.0	145.0	116

Regional SAIMM Wind Data for D-FW Core Domain

Simulated ozone levels changed greatly when the fine-grid wind field in the D-FW core domain was swapped for the coarse-grid wind field. Model performance degraded on the last two episode days (Table 3.14-8) compared to the base case results (Table 3.14-2). The daily maximum ozone concentration plots also showed somewhat different patterns for the primary episode day (Figure 3.14-25). The simulated ozone exceedance area shifted about 10 km to the north. The difference plot (Figure 3.14-26) shows that maximum ozone levels in the northern half of the domain increased by 10 to 50 ppb and decreased 10 to 30 ppb in the southern part of the domain for July 3, 1996. These results are consistent with the fact that the regional SAIMM winds tend to be more southerly than the D-FW core SAIMM winds.

Table 3.14-8. CAMx Base Case Sensitivity Ozone Performance Statistics for June 30 – July 4, 1996 Episode: Regional SAIMM Wind Data for D-FW Core Domain

Episode Date	Normalized Bias (±5–15%)	Normalized Gross Error (30–35%)	Unpaired Peak Accuracy (±15–20%)	Domain-wide Peak Ozone (ppb)	
				Simulated	Observed
06/30/96	-26.7	26.7	**-23.9**	85.3	112
07/01/96	**-11.8**	**13.6**	**0.5**	112.6	112
07/02/96	**-5.3**	**13.7**	**7.0**	121.9	114
07/03/96	23.4	**32.4**	**19.4**	171.9	144
07/04/96	17.9	**18.5**	22.5	142.1	116

75 Percent Biogenic VOC Emissions

The model performance was very good, as shown in Table 3.14-9, and for the last two episode days was slightly improved compared with the base case result (Table 3.14-2), suggesting the possibility that biogenic VOC emissions may be overestimated somewhat for this episode (assuming that there are no compensating errors elsewhere in the model formulation). The simulated ozone exceedance area on July 3, 1996 is somewhat smaller than that of the base case and the simulated daily maximum ozone levels are about 5 to 10 ppb lower than for the base case in the D-FW area (Figure 3.14-27). The difference plots (Figure 3.14-28) show a 5 to 20 ppb decrease of daily maximum ozone levels in the D-FW area relative to the base case.

Table 3.14-9. CAMx Base Case Sensitivity Ozone Performance Statistics for June 30 – July 4, 1996 Episode: 75% Biogenic VOC Emissions

Episode Date	Normalized Bias (±5–15%)	Normalized Gross Error (30–35%)	Unpaired Peak Accuracy (±15–20%)	Domain-wide Peak Ozone (ppb)	
				Simulated	Observed
06/30/96	-29.6	29.6	-22.7	86.6	112
07/01/96	-18.9	19.0	-4.6	106.9	112
07/02/96	-13.4	15.4	1.1	115.2	114
07/03/96	2.0	16.1	11.5	160.6	144
07/04/96	0.1	9.7	17.5	136.3	116

3.14.8 Conclusions

Base Case Modeling and Performance

Overall, model performance for both the June 18 – 20, 1995 and the June 30 – July 4, 1996 episodes were very good, including performance on the second and third ramp-up days. The fact that the model exhibits consistently good performance across a number of days for two different episodes which encompass different meteorological regimes gives confidence that the model can be reliably used to develop control strategies.

Diagnostic Tests

June 18-22, 1995 episode

The inert tracer diagnostic run showed that the INIT and NORTH tracers held the potential for the greatest influence on the core domain, and that the TOP tracer was moderately important. The tracer runs only indicate potential influence, however, because the tracer is not reactive; the results should be interpreted as showing the upper bound of potential influence. The zero anthropogenic emission diagnostic run showed appropriate background level ozone concentrations of 30-40 ppb, which indicated that the biogenic VOC and NO_x emissions generated a realistic background ozone concentration.

June 30 - July 4, 1996 episode

The inert tracer diagnostic run showed that the INIT and SOUTH tracers held the potential for the greatest influence on the core domain. The tracer runs only indicate potential influence, however, because the tracer is not reactive; the results should be interpreted as showing the upper bound of potential influence. The zero anthropogenic emission diagnostic run showed appropriate background level ozone concentrations of 30-40 ppb, which indicated that the biogenic VOC and NO_x emissions generated a realistic background ozone concentration.

Sensitivity Analyses

The model was not very sensitive to small changes in the initial and boundary conditions, nor to a 25% change in the biogenic VOC emissions. Performance of the July 1996 episode did improve slightly when biogenic VOCs were reduced by 25%, and this may be indicative of an overestimation in biogenic emission estimates for this episode. Overall, however, the results imply that small uncertainties in initial and boundary conditions and biogenic emissions probably do not affect the model output seriously. The model, however, was quite sensitive to moderate changes in the wind vector field. Although the magnitude of the maximum ozone concentration did not change very much, the spatial distribution of ozone did change notably compared to the base case. This result implies that in order for the model to accurately reproduce the spatial distribution of ozone, the wind speed and direction data generated by the meteorological model must have a fairly high degree of accuracy.

Finally, the commission recognizes that there are many factors involved in the formation of ozone in D-FW area, and that much remains to be learned. The commission will continue to collect and analyze monitoring and emissions inventory data and develop improved characterizations of the meteorology and emissions in the region, and will continue to improve its modeling approaches. Subsequent modeling for D-FW will provide an opportunity for the commission to apply modeling enhancements to future SIP development.

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Figure 3.14-1 thru 3.14-28 (plus some a’s and b’s)

3.15 1999 FUTURE YEAR MODELING INVENTORY DEVELOPMENT

3.15.1 Introduction

The goal of this modeling study was to determine the level of reductions of ozone precursors necessary for demonstrating attainment of the 1-hour ozone NAAQS in the D-FW nonattainment area by the federally mandated attainment year of 1999. In order to accurately assess the ozone concentrations for the area when emissions are at the predicted 1999 levels, the commission developed an EI that best represents (in the time available) the level of emissions expected in the year 1999 for the entire modeling domain. This inventory can be referred to as the "base" future year inventory. This is the EI projected to 1999 which reflects controls already in place or required by existing rules or regulations to be put in place, and also reflects the growth (or decline) of industrial emissions and population throughout the modeling domain. The base 1999 EI does not include additional controls which may be required to bring the D-FW nonattainment area into attainment.

As in the 1995-96 base case inventory, the future year (or "projected") modeling inventory is composed of point source, on-road mobile source, area and nonroad mobile source, and biogenic emissions. Future year modeling was performed for the same episodes as in the base case, with five days in each episode. Emissions for each of these ten days were projected to the attainment year of 1999, then modeled using the same meteorological characterization as was used in the base case. Later sections of this document will discuss modifications made to the base future year inventory in order to determine the reduction targets for ozone precursors necessary to demonstrate attainment of the 1-hour ozone NAAQS.

In subsection 3.15.2 below, we describe the development of growth factors used to project emissions of point, area, and nonroad mobile sources, and then discuss the application of these growth factors to the base year modeling inventory. Subsection 3.15.3 discusses the application of control factors to point, area, and nonroad mobile sources. Subsection 3.15.4 discusses the development of the future-year on-road mobile source inventory. No discussion of biogenic emissions is provided here, since biogenic emission sources were assumed to remain unchanged from the base year.

3.15.2 Projection of Point, Area, and Nonroad Mobile Sources to Future Year 1999

Growth Factor Development

Future emissions inventories for point and area/nonroad mobile sources are "grown" from current inventories using factors based on projections for future industrial activity and population growth. REMI developed a series of regional economic models which it uses to prepare a wide range of economic projections for its clients. EGAS, a public domain model available through the EPA, is an emissions growth factor development tool produced for the EPA to help states reasonably predict emissions growth for SIP development purposes. The commission EI staff utilized a hybrid of these two tools to prepare the most accurate and timely growth factors available.

The commission procured a 31-region economic model of Texas from REMI. The sixteen nonattainment area counties and five near-nonattainment counties in the state of Texas were treated as unique economic regions in the economic model, while each of the remaining counties in the state were assigned to one of ten regions based on the Texas State Comptroller's Economic Regional Boundaries map. Within each economic region, the REMI model categorized industry into 53 separate groups (according to 2-digit SIC groups). It also used the U.S. Bureau of Labor Statistics national economic forecast for 1992-2005

(trended by natural labor force), and it used an updated short-term forecast from the University of Michigan's RSQE. The RSQE forecast used as model input had a release date of November 16, 1995.

The REMI model was executed for the period 1991 through 2015. The modeled results, which consisted of economic forecasts specific to each of the 53 economic sectors for each of the 31 Texas regions, were then used as input files to the growth factor module of EGAS, version 3.0. This module took the categorized economic forecast data from REMI and converted them into emissions growth factors classified by AMS code or SCC, which are the codes the emissions processor EPS-2 uses to identify sources by process/emissions type. The growth factors were then written to one of seven ASCII output file types, based on source type. These files for Texas were originally generated by the commission EI staff for use by the commission modeling staff for the Houston-Galveston SIP submittal of April 1998 (in the H-GA SIP, growth was projected from a base year of 1993 to the H-GA attainment year of 2007).

The traditional method of developing these growth factors would be through the use of EGAS alone, yet the commission took that method several steps further in an effort to obtain more accurate factors. The commission used the additional REMI economic data and most current forecast data (from RSQE) to gain a high degree of local and industrial differentiation, to improve on the EGAS regional defaults. This combined approach is hereafter referred to as REMI-EGAS.

Finally, the factors used to project emissions from 1996 to 1999 were calculated by simply extracting the 1996 and 1999 growth factors for each region/source category applicable to each part of Texas within the modeling domain, then dividing each 1999 factor by the corresponding 1996 factor. The resulting factors (the 1996 to 1999 growth factors) were, in turn, converted to a format suitable for input to the EPS-2 program, CNTLEM. Because 1996 emission levels differed from 1995 levels by only a few percent, and because much of the 1995 base case modeling inventory used 1996 PEI data anyway, the decision was made to only develop a single set of growth factors (from 1996 to 1999). This set of growth factors was applied to both the 1995 and 1996 episodes.

Emissions growth factors for point, area, and nonroad mobile sources in the remaining states in the regional modeling domain were derived through execution of the EGAS model alone. Growth factors for the other states (Louisiana, Oklahoma, Arkansas, Mississippi, Alabama, and Tennessee) were developed separately via individual runs of EPA's EGAS model. Growth factors for point source 8-digit SCCs and for area source 10-digit ASCs are provided in the output of each EGAS run. As in the processing of the 1995-96 emissions, 1999 Louisiana emissions were processed in a separate file, and the rest of the states were also processed in separate files. EGAS factors were not generated for Missouri, Kentucky, and Florida, because only very small portions of these states are included in the domain and they are far from the D-FW area. Hence, these three states received no growth.

Application of Growth Factors

The point, area, and nonroad mobile source emissions from the 1995-96 base case were "grown" to 1999 through application of the CNTLEM program, using growth factors described above. Emissions growth was based solely on econometric forecasts, and did not account for any offsets required by the FCAA, nor were such factors as maximum allowable emission rates, physical facility capacities, or planned startups and/or shutdowns accounted for explicitly. Emissions were quality-assured after every step.

As in the processing of 1995-96 Texas emissions, 1999 EGU and NEGU point sources were processed separately. No growth was assumed for offshore sources, which is consistent with the assumptions of OTAG.

Because the growth factor files are quite lengthy, they are not provided in this report. Growth factor files contain the FIPS code, SCC (point sources) or ASC (area and nonroad mobile sources), and the 1996-to-1999 growth factor, for each SCC (ASC) in every county. The growth factor files can be obtained from the commission upon request.

3.15.3 Modeling of Controls on Point, Area, and Nonroad Mobile Source Emissions

After base year emissions had been grown to 1999 levels, the next step was to apply any adopted controls which would become effective before 1999. Controls that took effect prior to July 1996 were assumed to have been in effect during the base year modeling, so were specifically excluded from the controls applied. Any adopted controls scheduled to take effect after July 1996 were applied to this point source inventory.

NO_x RACT

At the time the future base case inventory was developed (summer 1998), the point source controls planned for adoption were NO_x RACT for the four-county D-FW nonattainment area. RACT is an emission limitation on existing sources in nonattainment areas, defined by EPA in CTG which are adopted and implemented by states. In the D-FW nonattainment area, the 34 affected stacks and corresponding control factors are listed in Table 3.15-1 at the end of this section. In this table, a control factor of 0.9 corresponds to a reduction of 10 percent, and a control factor of 0.6 corresponds to a 40 percent NO_x reduction for that source category. It was assumed that RACT would be fully in place in the D-FW nonattainment area in the future case inventory.

These future controls were applied to the projected 1999 point source NO_x EI subsequent to the application of growth factors. No controls were assumed for point sources outside the 4-county D-FW nonattainment area, either in the remainder of Texas or in the remaining states in the modeling domain. Control factors were applied to the 1999 projected emissions using the CNTLEM processor.

Federal Small Engine Rules

At the time the future base case inventory was developed (summer 1998), the only controls applicable to the future area and nonroad mobile source inventory were the Federal Small Engine Rules. Since this is a federal rule it applies to every area source in the modeling domain. The affected small engine (area and off-road mobile) ASCs (268 of them) are listed in Table 3.15-2 at the end of this section. The FIPS code of 00000 in this table indicates that this rule applies to the entire nation. The main categories affected are off-road gasoline engines (2- and 4-stroke) off-road diesel engines, and recreational boating engines.

These Small Engine Rules are to be phased-in over the years 1996 to 2007, and the control factors in Table 3.15-2 represent the expected control factor that the engines should have by 1999. In fact, according to this table, a gasoline engine may have a NO_x control factor of 1.796. This means that the NO_x emission rate for that type of engine will be 79.6 percent higher in 1999 than in 1996. The first wave of engine tuning controls are being applied to VOC, which is expected to have an adverse effect on NO_x emissions. This explains the 79.6 percent increase in NO_x emissions and simultaneous 22.9 percent reduction in VOC emissions for these gasoline engines. It would seem that CO emissions would change during this phased-

in re-tuning of the engines, but the EPA reports do not reference CO changes, so CO control factors have been tabulated as 1.0. Diesel engine re-tuning does not seem as severe as gasoline, since the typical control factors are 0.992 (0.8 % reduction) for NO_x and 1.0 for VOC. Recreational boat engines also show a small change for the year 1999: typically 1.008 NO_x control factor, and a 0.998 VOC control factor.

These future controls were applied to the projected 1999 area source EI subsequent to the application of growth factors by CNTLEM.

3.15.4 Development of the 1999 On-Road Mobile Source Emissions

As in the base case, future emissions for on-road mobile sources were developed by region:

The D-FWRTM

In the D-FWRTM counties (see Figure 3.13-1), the 1999 future year projected on-road mobile source emissions were developed by NCTCOG as part of the contract which supplied the base case emissions data. The work is described in detail in NCTCOG's final report, *1995/96 & 1999 On-Road Mobile Source Episodic Emission Inventories for the Dallas-Fort Worth 37-County Modeling Domain, Sept 5, 1998, NCTCOG.* Copies of this report are available from the commission upon request.

In developing the future year on-road mobile source emissions, NCTCOG accounted for both growth (projected 1999 roadway network and projected VMT) and FMVCP controls (through application of MOBILE5a with appropriate input parameters. However, to reduce the considerable expense of executing the D-FWRTM for each episode day using 1999 projections, the NCTCOG applied a technique called *pivot-point analysis*. This technique allowed the D-FWRTM to be executed for only one day (June 19, 1995) with the projected roadway network and VMT, with emissions for the remaining days calculated through application of a series of ratios:

- Daily VMT adjustment by HPMS functional class - accounts for the day-to-day variation in VMT (for example, Sunday VMT is lower than typical weekday VMT).

- Time-of-day VMT adjustment - accounts for differing driving patterns between days of the week, such as between Sunday and a weekday.

- Emission factor adjustments for NO_x, VOC, and CO by day, county, and HPMS functional class - account for both temperature and average speed variations (both of which affect MOBILE5a emissions factors) over time and space.

- Daily adjustment factors for diurnal and hot-soak emissions - account for temperature-driven variations in diurnal and hot-soak emissions.

Beginning with the complete link-based emissions data file for June 19, 1995 supplied by NCTCOG (projected to 1999), the commission staff applied the above ratios to create projected emissions for all ten episode days using a series of the commission-developed SAS programs.

The emissions were processed as described for the base case. A minor software error which caused an incorrect hourly allocation of emissions during the overnight period on Sundays in the base case modeling was corrected for the future case modeling.

The D-FW Study Area

In the Study Area counties, excluding the D-FWRTM (see Figure 3.13-1), NCTCOG provided county-level projected 1999 daily emissions for each episode day. Processing of this data was similar to that described in the base case inventory discussion, with one exception. In the base case, chemical speciation of emissions in this area had been carried out using EPA default profiles. In the future case modeling, these were replaced with the improved non-RFG profiles supplied by Dr. Eric Fujita of DRI.

The Houston-Galveston and Beaumont-Port Arthur Nonattainment Areas

As part of the COAST work, TTI had previously developed gridded 1999 projected emissions for both the Houston-Galveston and Beaumont-Port Arthur nonattainment areas. As in the base case, emissions for August 19, 1993 (projected to 1999) were used; however, in the base case the emissions for this day were used as is for each episode day modeled. In the future case modeling, these emissions were adjusted to reflect day-of-week and diurnal VMT variations, much as corresponding pivot factors were applied in the D-FWRTM as discussed above. A total of three representative days were created: a weekday (no VMT adjustments), a Sunday, and a Friday. The representative weekday was used for all weekday episode days, while the Sunday was used when modeling June 30, 1996, June 18, 1995 (both Sundays) and for July 4, 1996 (a holiday), and the Friday was used when modeling July 3, 1996 (the eve of July 4).

An additional correction was made in the 1999 emissions data: emissions in the eight Houston-Galveston nonattainment area counties were adjusted to account for reformulated gasoline usage, and Harris County emissions were further adjusted to account for vehicle I/M. The emissions for these eleven counties were then processed as in the base case using MEDUAM, except that three representative days were processed instead of one.

The Remainder of Texas

For the remaining Texas counties in the modeling domain, the commission Emissions Inventory staff developed a county-level VMT projection factor by averaging yearly VMT change for the years 1992 through 1996, then multiplied by three to forecast 1999 VMT by county. Then MOBILE5b was run with default parameter settings and an average speed of 30 miles/hour for both 1996 and 1999, to develop emission factor adjustments for NO_x, VOC, and CO.

These adjustment factors were applied to the base case emissions using CNTLEM.

Other States

A composite 1996-1999 adjustment factor was developed by first merging all Texas projected 1999 on-road mobile source emissions files using MRGUAM for one episode day. The Texas total emissions of NO_x, VOC, and CO were ratioed to their 1996 base year counterparts. The resulting factors were applied uniformly to on-road mobile source emissions in other states during the final merge (using MRGUAM) of on-road mobile source emissions.

HPMS Adjustment

As in the base case, an HPMS adjustment was applied to emissions in the D-FWRTM during the final merge (using MRGUAM) of on-road mobile source emissions. However, after discussion with Mr. Herb Sherrow of EPA Region VI, a slightly different adjustment was applied in the future case. The link-based emissions, which correspond to the roadways monitored by HPMS, were increased by 6.6%, while the zone-based emissions, which include local traffic, were increased by 5.6%.

3.15.5 Quality Assurance

Quality assurance procedures similar to those employed for the base case modeling were again used to ensure that no significant errors were made in processing the future year emissions.

3.15.6 Emissions Summary

Projected 1999 emissions for the four D-FW nonattainment counties are tabulated in Tables 3.15-3a, 3.15-3b, and 3.15-3c. *Appendix F, 1999 Future Year Modeling Inventory Development*, provides tables and figures showing projected 1999 emissions for the remaining portions of the modeling domain.

Table 3.15-1 NO_x RACT Controls for Existing Point Sources in the D-FW Nonattainment Area

FIPS	PLANT	STACK	POINT	SCC	NO_x	VOC	CO	Owner	Account	EPN
48085	2	1	1	10100604	0.9	1.0	1.0	Texas Utilities Electric Company	CP0065C	C0-S1A
48085	0002	0002	001	10100604	0.9	1.0	1.0	Texas Utilities Electric Company	CP0065C	C0-S1B
48113	0009	0002	006	10100601	0.9	1.0	1.0	Texas Utilities Electric Company	DB0249H	LH-S1
48113	0009	0003	008	10100601	0.5	1.0	1.0	Texas Utilities Electric Company	DB0249H	LH-S2
48113	0012	0005	005	10100601	0.9	1.0	1.0	Texas Utilities Electric Company	DB0251U	NL-S1A
48113	0012	0006	005	10100601	0.9	1.0	1.0	Texas Utilities Electric Company	DB0251U	NL-S1B
48113	0012	0007	006	10100601	0.9	1.0	1.0	Texas Utilities Electric Company	DB0251U	NL-S2A
48113	0012	0008	006	10100601	0.9	1.0	1.0	Texas Utilities Electric Company	DB0251U	NL-S2B
48113	0012	0009	007	10100601	0.6	1.0	1.0	Texas Utilities Electric Company	DB0251U	NL-S3A
48113	0012	0010	007	10100601	0.6	1.0	1.0	Texas Utilities Electric Company	DB0251U	NL-S3B
48113	0010	0008	010	10100601	0.9	1.0	1.0	Texas Utilities Electric Company	DB0252S	MT-S6A
48113	0010	0009	010	10100601	0.9	1.0	1.0	Texas Utilities Electric Company	DB0252S	MT-S6B
48113	0010	0010	011	10100601	0.9	1.0	1.0	Texas Utilities Electric Company	DB0252S	MT-S7A
48113	0010	0011	011	10100601	0.9	1.0	1.0	Texas Utilities Electric Company	DB0252S	MT-S7B
48113	0010	0012	012	10100601	0.9	1.0	1.0	Texas Utilities Electric Company	DB0252S	MT-S8
48113	0011	0006	006	10100601	0.9	1.0	1.0	Texas Utilities Electric Company	DB0253Q	PD-S1A
48113	0011	0007	006	10100601	0.9	1.0	1.0	Texas Utilities Electric Company	DB0253Q	PD-S1B
48113	0011	0008	007	10100601	0.9	1.0	1.0	Texas Utilities Electric Company	DB0253Q	PD-S2A
48113	0011	0009	007	10100601	0.9	1.0	1.0	Texas Utilities Electric Company	DB0253Q	PD-S2B
48113	0011	0010	008	10100601	0.9	1.0	1.0	Texas Utilities Electric Company	DB0253Q	PD-S3A
48113	0011	0011	008	10100601	0.9	1.0	1.0	Texas Utilities Electric Company	DB0253Q	PD-S3B
48121	0002	0001	001	10100604	0.8	1.0	1.0	Denton Municipal Utilities	DF0012T	S-1
48121	0002	0002	002	10100604	0.8	1.0	1.0	Denton Municipal Utilities	DF0012T	S-2
48121	0002	0003	003	10100604	0.6	1.0	1.0	Denton Municipal Utilities	DF0012T	S-3
48121	0002	0004	004	10100601	0.6	1.0	1.0	Denton Municipal Utilities	DF0012T	S-4
48121	0002	0005	005	10100601	0.6	1.0	1.0	Denton Municipal Utilities	DF0012T	S-5
48439	0006	0004	004	10100601	0.9	1.0	1.0	Texas Utilities Electric Company	TA0352I	EM-S1&2
48439	0006	0004	006	10100601	0.9	1.0	1.0	Texas Utilities Electric Company	TA0352I	EM-S1&2
48439	0006	0002	007	10100601	0.9	1.0	1.0	Texas Utilities Electric Company	TA0352I	EM-S3
48439	0007	0011	010	10100601	0.9	1.0	1.0	Texas Utilities Electric Company	TA0353G	HA-S2

48439	0007	0012	011	10100601	0.6	1.0	1.0	Texas Utilities Electric Company	TA0353G	HA-S3A
48439	0007	0013	011	10100601	0.6	1.0	1.0	Texas Utilities Electric Company	TA0353G	HA-S3B
48439	0007	0004	003	10100601	0.9	1.0	1.0	Texas Utilities Electric Company	TA0353G	HA-S4
48439	0007	0005	004	10100601	0.9	1.0	1.0	Texas Utilities Electric Company	TA0353G	HA-S5

Table 3.15-2 Federal Small-Engine Rule Controls for Area and Nonroad Mobile Sources

FIPS	ASC	NO_x	VOC	CO	DESCR 1	DESCR 2	DESCR 3
00000	2260000000	1.796	0.771	1.000	OFF-HIGHWAY VEHICLE	GASOLINE, 2-STROKE	OFF-HIGHWAY VEHICLES
00000	2260001000	1.000	1.000	1.000	OFF-HIGHWAY VEHICLE	GASOLINE, 2-STROKE	RECREATIONAL VEHICLES
00000	2260001010	1.000	1.000	1.000	OFF-HIGHWAY VEHICLE	GASOLINE, 2-STROKE	MOTORCYCLES, OFF-ROAD
00000	2260001020	1.000	1.000	1.000	OFF-HIGHWAY VEHICLE	GASOLINE, 2-STROKE	SNOWMOBILES
00000	2260001030	1.000	1.000	1.000	OFF-HIGHWAY VEHICLE	GASOLINE, 2-STROKE	ALL TERRAIN VEHICLES
00000	2260001040	1.000	1.000	1.000	OFF-HIGHWAY VEHICLE	GASOLINE, 2-STROKE	MINIBIKES
00000	2260001050	1.796	0.771	1.000	OFF-HIGHWAY VEHICLE	GASOLINE, 2-STROKE	GOLF CARTS
00000	2260001060	1.796	0.771	1.000	OFF-HIGHWAY VEHICLE	GASOLINE, 2-STROKE	SPECIALTY VEHICLE CARTS
00000	2260002000	1.796	0.771	1.000	OFF-HIGHWAY VEHICLE	GASOLINE, 2-STROKE	CONSTRUCTION EQUIPMENT
00000	2260002003	1.000	1.000	1.000	OFF-HIGHWAY VEHICLE	GASOLINE, 2-STROKE	ASPHALT PAVERS
00000	2260002006	1.796	0.771	1.000	OFF-HIGHWAY VEHICLE	GASOLINE, 2-STROKE	TAMPERS/RAMMERS
00000	2260002009	1.796	0.771	1.000	OFF-HIGHWAY VEHICLE	GASOLINE, 2-STROKE	PLATE COMPACTORS
00000	2260002012	1.000	1.000	1.000	OFF-HIGHWAY VEHICLE	GASOLINE, 2-STROKE	CONCRETE PAVERS
00000	2260002015	1.000	1.000	1.000	OFF-HIGHWAY VEHICLE	GASOLINE, 2-STROKE	ROLLERS
00000	2260002018	1.000	1.000	1.000	OFF-HIGHWAY VEHICLE	GASOLINE, 2-STROKE	SCRAPERS
00000	2260002021	1.796	0.771	1.000	OFF-HIGHWAY VEHICLE	GASOLINE, 2-STROKE	PAVING EQUIPMENT
00000	2260002024	1.796	0.771	1.000	OFF-HIGHWAY VEHICLE	GASOLINE, 2-STROKE	SURFACING EQUIPMENT
00000	2260002027	1.796	0.771	1.000	OFF-HIGHWAY VEHICLE	GASOLINE, 2-STROKE	SIGNAL BOARDS
00000	2260002030	1.000	1.000	1.000	OFF-HIGHWAY VEHICLE	GASOLINE, 2-STROKE	TRENCHERS
00000	2260002033	1.000	1.000	1.000	OFF-HIGHWAY VEHICLE	GASOLINE, 2-STROKE	BORE/DRILL RIGS
00000	2260002036	1.000	1.000	1.000	OFF-HIGHWAY VEHICLE	GASOLINE, 2-STROKE	EXCAVATORS
00000	2260002039	1.796	0.771	1.000	OFF-HIGHWAY VEHICLE	GASOLINE, 2-STROKE	CONCRETE/INDUSTRIAL SAWS
00000	2260002042	1.796	0.771	1.000	OFF-HIGHWAY VEHICLE	GASOLINE, 2-STROKE	CEMENT & MORTAR MIXERS
00000	2260002045	1.000	1.000	1.000	OFF-HIGHWAY VEHICLE	GASOLINE, 2-STROKE	CRANES
00000	2260002048	1.000	1.000	1.000	OFF-HIGHWAY VEHICLE	GASOLINE, 2-STROKE	GRADERS
00000	2260002051	1.000	1.000	1.000	OFF-HIGHWAY VEHICLE	GASOLINE, 2-STROKE	OFF-HIGHWAY TRUCKS
00000	2260002054	1.000	1.000	1.000	OFF-HIGHWAY VEHICLE	GASOLINE, 2-STROKE	CRUSHING/PROC EQUIPMENT
00000	2260002057	1.000	1.000	1.000	OFF-HIGHWAY VEHICLE	GASOLINE, 2-STROKE	ROUGH TERRAIN FORKLIFTS
00000	2260002060	1.000	1.000	1.000	OFF-HIGHWAY VEHICLE	GASOLINE, 2-STROKE	RUBBER TIRE LOADERS
00000	2260002063	1.000	1.000	1.000	OFF-HIGHWAY VEHICLE	GASOLINE, 2-STROKE	RUBBER TIRE DOZERS
00000	2260002066	1.000	1.000	1.000	OFF-HIGHWAY VEHICLE	GASOLINE, 2-STROKE	TRACTORS/LOADERS/BACKHOES
00000	2260002069	1.000	1.000	1.000	OFF-HIGHWAY VEHICLE	GASOLINE, 2-STROKE	CRAWLER TRACTORS
00000	2260002072	1.000	1.000	1.000	OFF-HIGHWAY VEHICLE	GASOLINE, 2-STROKE	SKID STEER LOADERS

00000	2260002075	1.000	1.000	1.000	OFF-HIGHWAY VEHICLE	GASOLINE, 2-STROKE	OFF-HIGHWAY TRACTORS
00000	2260002078	1.796	0.771	1.000	OFF-HIGHWAY VEHICLE	GASOLINE, 2-STROKE	DUMPERS/TENDERS
00000	2260002081	1.000	1.000	1.000	OFF-HIGHWAY VEHICLE	GASOLINE, 2-STROKE	OTHER CONSTR. EQUIP.
00000	2260003000	1.000	1.000	1.000	OFF-HIGHWAY VEHICLE	GASOLINE, 2-STROKE	INDUSTRIAL EQUIPMENT
00000	2260003010	1.000	1.000	1.000	OFF-HIGHWAY VEHICLE	GASOLINE, 2-STROKE	AERIAL LIFTS
00000	2260003020	1.000	1.000	1.000	OFF-HIGHWAY VEHICLE	GASOLINE, 2-STROKE	FORKLIFTS
00000	2260003030	1.000	1.000	1.000	OFF-HIGHWAY VEHICLE	GASOLINE, 2-STROKE	SWEEPERS/SCRUBBERS
00000	2260003040	1.796	0.771	1.000	OFF-HIGHWAY VEHICLE	GASOLINE, 2-STROKE	OTHER GENERAL INDUST. EQUIP.
00000	2260003050	1.000	1.000	1.000	OFF-HIGHWAY VEHICLE	GASOLINE, 2-STROKE	OTHER MAT. HANDLING EQUIP.
00000	2260004000	1.796	0.771	1.000	OFF-HIGHWAY VEHICLE	GASOLINE, 2-STROKE	LAWN & GARDEN EQUIPMENT
00000	2260004010	1.796	0.771	1.000	OFF-HIGHWAY VEHICLE	GASOLINE, 2-STROKE	LAWN MOWERS
00000	2260004015	1.796	0.771	1.000	OFF-HIGHWAY VEHICLE	GASOLINE, 2-STROKE	ROTARY TILLERS < 5 HP
00000	2260004020	1.796	0.771	1.000	OFF-HIGHWAY VEHICLE	GASOLINE, 2-STROKE	CHAIN SAWS < 4 HP
00000	2260004025	1.796	0.771	1.000	OFF-HIGHWAY VEHICLE	GASOLINE, 2-STROKE	TRIMMERS/EDGERS/BRUSH CUT
00000	2260004030	1.796	0.771	1.000	OFF-HIGHWAY VEHICLE	GASOLINE, 2-STROKE	LEAFBLOWERS/VACUUMS
00000	2260004035	1.796	0.771	1.000	OFF-HIGHWAY VEHICLE	GASOLINE, 2-STROKE	SNOW BLOWERS
00000	2260004040	1.796	0.771	1.000	OFF-HIGHWAY VEHICLE	GASOLINE, 2-STROKE	REAR ENGINE RIDING MOWERS
00000	2260004045	1.796	0.771	1.000	OFF-HIGHWAY VEHICLE	GASOLINE, 2-STROKE	FRONT MOWERS
00000	2260004050	1.796	0.771	1.000	OFF-HIGHWAY VEHICLE	GASOLINE, 2-STROKE	SHREDDERS < 5 HP
00000	2260004055	1.796	0.771	1.000	OFF-HIGHWAY VEHICLE	GASOLINE, 2-STROKE	LAWN & GARDEN TRACTORS
00000	2260004060	1.796	0.771	1.000	OFF-HIGHWAY VEHICLE	GASOLINE, 2-STROKE	WOOD SPLITTERS
00000	2260004065	1.000	1.000	1.000	OFF-HIGHWAY VEHICLE	GASOLINE, 2-STROKE	CHIPPERS/STUMP GRINDERS
00000	2260004070	1.796	0.771	1.000	OFF-HIGHWAY VEHICLE	GASOLINE, 2-STROKE	COMMERCIAL TURF EQUIPMENT
00000	2260004075	1.796	0.771	1.000	OFF-HIGHWAY VEHICLE	GASOLINE, 2-STROKE	OTHER LAWN & GARDEN EQUIP.
00000	2260005000	1.796	0.771	1.000	OFF-HIGHWAY VEHICLE	GASOLINE, 2-STROKE	FARM EQUIPMENT
00000	2260005010	1.796	0.771	1.000	OFF-HIGHWAY VEHICLE	GASOLINE, 2-STROKE	2-WHEEL TRACTORS
00000	2260005015	1.000	1.000	1.000	OFF-HIGHWAY VEHICLE	GASOLINE, 2-STROKE	AGRICULTURAL TRACTORS
00000	2260005020	1.000	1.000	1.000	OFF-HIGHWAY VEHICLE	GASOLINE, 2-STROKE	COMBINES
00000	2260005025	1.000	1.000	1.000	OFF-HIGHWAY VEHICLE	GASOLINE, 2-STROKE	BALERS
00000	2260005030	1.796	0.771	1.000	OFF-HIGHWAY VEHICLE	GASOLINE, 2-STROKE	AGRICULTURAL MOWERS
00000	2260005035	1.000	1.000	1.000	OFF-HIGHWAY VEHICLE	GASOLINE, 2-STROKE	SPRAYERS
00000	2260005040	1.796	0.771	1.000	OFF-HIGHWAY VEHICLE	GASOLINE, 2-STROKE	TILLERS > 5 HP
00000	2260005045	1.000	1.000	1.000	OFF-HIGHWAY VEHICLE	GASOLINE, 2-STROKE	SWATHERS
00000	2260005050	1.796	0.771	1.000	OFF-HIGHWAY VEHICLE	GASOLINE, 2-STROKE	HYDRO POWER UNITS
00000	2260005055	1.000	1.000	1.000	OFF-HIGHWAY VEHICLE	GASOLINE, 2-STROKE	OTHER AGRICULTURAL EQUIP.
00000	2260006000	1.796	0.771	1.000	OFF-HIGHWAY VEHICLE	GASOLINE, 2-STROKE	LIGHT COMMERCIAL
00000	2260006005	1.796	0.771	1.000	OFF-HIGHWAY VEHICLE	GASOLINE, 2-STROKE	GENERATOR SETS < 50 HP

00000	2260006010	1.796	0.771	1.000	OFF-HIGHWAY VEHICLE	GASOLINE, 2-STROKE	PUMPS < 50 HP
00000	2260006015	1.796	0.771	1.000	OFF-HIGHWAY VEHICLE	GASOLINE, 2-STROKE	AIR COMPRESSORS < 50 HP
00000	2260006020	1.000	1.000	1.000	OFF-HIGHWAY VEHICLE	GASOLINE, 2-STROKE	GAS COMPRESSORS < 50 HP
00000	2260006025	1.796	0.771	1.000	OFF-HIGHWAY VEHICLE	GASOLINE, 2-STROKE	WELDERS < 50 HP
00000	2260006030	1.796	0.771	1.000	OFF-HIGHWAY VEHICLE	GASOLINE, 2-STROKE	PRESSURE WASHERS < 50 HP
00000	2260007000	1.000	1.000	1.000	OFF-HIGHWAY VEHICLE	GASOLINE, 2-STROKE	LOGGING EQUIPMENT
00000	2260007005	1.796	0.771	1.000	OFF-HIGHWAY VEHICLE	GASOLINE, 2-STROKE	CHAIN SAWS > 4 HP
00000	2260007010	1.796	0.771	1.000	OFF-HIGHWAY VEHICLE	GASOLINE, 2-STROKE	SHREDDERS > 5 HP
00000	2260007015	1.000	1.000	1.000	OFF-HIGHWAY VEHICLE	GASOLINE, 2-STROKE	SKIDDERS
00000	2260007020	1.000	1.000	1.000	OFF-HIGHWAY VEHICLE	GASOLINE, 2-STROKE	FELLERS/BUNCHERS
00000	2260008000	1.000	1.000	1.000	OFF-HIGHWAY VEHICLE	GASOLINE, 2-STROKE	AIRPORT SERVICE EQUIPMENT
00000	2260008005	1.000	1.000	1.000	OFF-HIGHWAY VEHICLE	GASOLINE, 2-STROKE	AIRPORT SUPPORT EQUIPMENT
00000	2260008010	1.000	1.000	1.000	OFF-HIGHWAY VEHICLE	GASOLINE, 2-STROKE	TERMINAL TRACTORS
00000	2265000000	1.796	0.771	1.000	OFF-HIGHWAY VEHICLE	GASOLINE, 4-STROKE	OFF-HIGHWAY VEHICLES
00000	2265001000	1.000	1.000	1.000	OFF-HIGHWAY VEHICLE	GASOLINE, 4-STROKE	RECREATIONAL VEHICLES
00000	2265001010	1.000	1.000	1.000	OFF-HIGHWAY VEHICLE	GASOLINE, 4-STROKE	MOTORCYCLES, OFF-ROAD
00000	2265001020	1.000	1.000	1.000	OFF-HIGHWAY VEHICLE	GASOLINE, 4-STROKE	SNOWMOBILES
00000	2265001030	1.000	1.000	1.000	OFF-HIGHWAY VEHICLE	GASOLINE, 4-STROKE	ALL TERRAIN VEHICLES
00000	2265001040	1.000	1.000	1.000	OFF-HIGHWAY VEHICLE	GASOLINE, 4-STROKE	MINIBIKES
00000	2265001050	1.796	0.771	1.000	OFF-HIGHWAY VEHICLE	GASOLINE, 4-STROKE	GOLF CARTS
00000	2265001060	1.796	0.771	1.000	OFF-HIGHWAY VEHICLE	GASOLINE, 4-STROKE	SPECIALTY VEHICLE CARTS
00000	2265002000	1.796	0.771	1.000	OFF-HIGHWAY VEHICLE	GASOLINE, 4-STROKE	CONSTRUCTION EQUIPMENT
00000	2265002003	1.000	1.000	1.000	OFF-HIGHWAY VEHICLE	GASOLINE, 4-STROKE	ASPHALT PAVERS
00000	2265002006	1.796	0.771	1.000	OFF-HIGHWAY VEHICLE	GASOLINE, 4-STROKE	TAMPERS/RAMMERS
00000	2265002009	1.796	0.771	1.000	OFF-HIGHWAY VEHICLE	GASOLINE, 4-STROKE	PLATE COMPACTORS
00000	2265002012	1.000	1.000	1.000	OFF-HIGHWAY VEHICLE	GASOLINE, 4-STROKE	CONCRETE PAVERS
00000	2265002015	1.796	0.771	1.000	OFF-HIGHWAY VEHICLE	GASOLINE, 4-STROKE	ROLLERS
00000	2265002018	1.000	1.000	1.000	OFF-HIGHWAY VEHICLE	GASOLINE, 4-STROKE	SCRAPERS
00000	2265002021	1.796	0.771	1.000	OFF-HIGHWAY VEHICLE	GASOLINE, 4-STROKE	PAVING EQUIPMENT
00000	2265002024	1.796	0.771	1.000	OFF-HIGHWAY VEHICLE	GASOLINE, 4-STROKE	SURFACING EQUIPMENT
00000	2265002027	1.796	0.771	1.000	OFF-HIGHWAY VEHICLE	GASOLINE, 4-STROKE	SIGNAL BOARDS
00000	2265002030	1.000	1.000	1.000	OFF-HIGHWAY VEHICLE	GASOLINE, 4-STROKE	TRENCHERS
00000	2265002033	1.000	1.000	1.000	OFF-HIGHWAY VEHICLE	GASOLINE, 4-STROKE	BORE/DRILL RIGS
00000	2265002036	1.000	1.000	1.000	OFF-HIGHWAY VEHICLE	GASOLINE, 4-STROKE	EXCAVATORS
00000	2265002039	1.796	0.771	1.000	OFF-HIGHWAY VEHICLE	GASOLINE, 4-STROKE	CONCRETE/INDUSTRIAL SAWS
00000	2265002042	1.796	0.771	1.000	OFF-HIGHWAY VEHICLE	GASOLINE, 4-STROKE	CEMENT & MORTAR MIXERS
00000	2265002045	1.000	1.000	1.000	OFF-HIGHWAY VEHICLE	GASOLINE, 4-STROKE	CRANES

00000	2265002048	1.000	1.000	1.000	OFF-HIGHWAY VEHICLE	GASOLINE, 4-STROKE	GRADERS
00000	2265002051	1.000	1.000	1.000	OFF-HIGHWAY VEHICLE	GASOLINE, 4-STROKE	OFF-HIGHWAY TRUCKS
00000	2265002054	1.000	1.000	1.000	OFF-HIGHWAY VEHICLE	GASOLINE, 4-STROKE	CRUSHING/PROC EQUIPMENT
00000	2265002057	1.000	1.000	1.000	OFF-HIGHWAY VEHICLE	GASOLINE, 4-STROKE	ROUGH TERRAIN FORKLIFTS
00000	2265002060	1.000	1.000	1.000	OFF-HIGHWAY VEHICLE	GASOLINE, 4-STROKE	RUBBER TIRE LOADERS
00000	2265002063	1.000	1.000	1.000	OFF-HIGHWAY VEHICLE	GASOLINE, 4-STROKE	RUBBER TIRE DOZERS
00000	2265002066	1.000	1.000	1.000	OFF-HIGHWAY VEHICLE	GASOLINE, 4-STROKE	TRACTORS/LOADERS/BACKHOES
00000	2265002069	1.000	1.000	1.000	OFF-HIGHWAY VEHICLE	GASOLINE, 4-STROKE	CRAWLER TRACTORS
00000	2265002072	1.000	1.000	1.000	OFF-HIGHWAY VEHICLE	GASOLINE, 4-STROKE	SKID STEER LOADERS
00000	2265002075	1.000	1.000	1.000	OFF-HIGHWAY VEHICLE	GASOLINE, 4-STROKE	OFF-HIGHWAY TRACTORS
00000	2265002078	1.796	0.771	1.000	OFF-HIGHWAY VEHICLE	GASOLINE, 4-STROKE	DUMPERS/TENDERS
00000	2265002081	1.000	1.000	1.000	OFF-HIGHWAY VEHICLE	GASOLINE, 4-STROKE	OTHER CONSTRUCTION EQUIP.
00000	2265003000	1.796	0.771	1.000	OFF-HIGHWAY VEHICLE	GASOLINE, 4-STROKE	INDUSTRIAL EQUIPMENT
00000	2265003010	1.000	1.000	1.000	OFF-HIGHWAY VEHICLE	GASOLINE, 4-STROKE	AERIAL LIFTS
00000	2265003020	1.000	1.000	1.000	OFF-HIGHWAY VEHICLE	GASOLINE, 4-STROKE	FORKLIFTS
00000	2265003030	1.000	1.000	1.000	OFF-HIGHWAY VEHICLE	GASOLINE, 4-STROKE	SWEEPERS/SCRUBBERS
00000	2265003040	1.796	0.771	1.000	OFF-HIGHWAY VEHICLE	GASOLINE, 4-STROKE	OTHER GENERAL INDUST. EQUIP.
00000	2265003050	1.000	1.000	1.000	OFF-HIGHWAY VEHICLE	GASOLINE, 4-STROKE	OTHER MAT. HANDLING EQUIP.
00000	2265004000	1.796	0.771	1.000	OFF-HIGHWAY VEHICLE	GASOLINE, 4-STROKE	LAWN & GARDEN EQUIPMENT
00000	2265004010	1.796	0.771	1.000	OFF-HIGHWAY VEHICLE	GASOLINE, 4-STROKE	LAWN MOWERS
00000	2265004015	1.796	0.771	1.000	OFF-HIGHWAY VEHICLE	GASOLINE, 4-STROKE	ROTARY TILLERS < 5 HP
00000	2265004020	1.796	0.771	1.000	OFF-HIGHWAY VEHICLE	GASOLINE, 4-STROKE	CHAIN SAWS < 4 HP
00000	2265004025	1.796	0.771	1.000	OFF-HIGHWAY VEHICLE	GASOLINE, 4-STROKE	TRIMMERS/EDGERS/BRUSH CUT
00000	2265004030	1.796	0.771	1.000	OFF-HIGHWAY VEHICLE	GASOLINE, 4-STROKE	LEAF BLOWERS/VACUUMS
00000	2265004035	1.796	0.771	1.000	OFF-HIGHWAY VEHICLE	GASOLINE, 4-STROKE	SNOW BLOWERS
00000	2265004040	1.796	0.771	1.000	OFF-HIGHWAY VEHICLE	GASOLINE, 4-STROKE	REAR ENGINE RIDING MOWERS
00000	2265004045	1.796	0.771	1.000	OFF-HIGHWAY VEHICLE	GASOLINE, 4-STROKE	FRONT MOWERS
00000	2265004050	1.796	0.771	1.000	OFF-HIGHWAY VEHICLE	GASOLINE, 4-STROKE	SHREDDERS < 5 HP
00000	2265004055	1.796	0.771	1.000	OFF-HIGHWAY VEHICLE	GASOLINE, 4-STROKE	LAWN & GARDEN TRACTORS
00000	2265004060	1.796	0.771	1.000	OFF-HIGHWAY VEHICLE	GASOLINE, 4-STROKE	WOOD SPLITTERS
00000	2265004065	1.000	1.000	1.000	OFF-HIGHWAY VEHICLE	GASOLINE, 4-STROKE	CHIPPERS/STUMP GRINDERS
00000	2265004070	1.796	0.771	1.000	OFF-HIGHWAY VEHICLE	GASOLINE, 4-STROKE	COMMERCIAL TURF EQUIPMENT
00000	2265004075	1.796	0.771	1.000	OFF-HIGHWAY VEHICLE	GASOLINE, 4-STROKE	OTHER LAWN & GARDEN EQUIP.
00000	2265005000	1.796	0.771	1.000	OFF-HIGHWAY VEHICLE	GASOLINE, 4-STROKE	FARM EQUIPMENT
00000	2265005010	1.796	0.771	1.000	OFF-HIGHWAY VEHICLE	GASOLINE, 4-STROKE	2-WHEEL TRACTORS
00000	2265005015	1.000	1.000	1.000	OFF-HIGHWAY VEHICLE	GASOLINE, 4-STROKE	AGRICULTURAL TRACTORS
00000	2265005020	1.000	1.000	1.000	OFF-HIGHWAY VEHICLE	GASOLINE, 4-STROKE	COMBINES

00000	2265005025	1.000	1.000	1.000	OFF-HIGHWAY VEHICLE	GASOLINE, 4-STROKE	BALERS
00000	2265005030	1.796	0.771	1.000	OFF-HIGHWAY VEHICLE	GASOLINE, 4-STROKE	AGRICULTURAL MOWERS
00000	2265005035	1.796	0.771	1.000	OFF-HIGHWAY VEHICLE	GASOLINE, 4-STROKE	SPRAYERS
00000	2265005040	1.796	0.771	1.000	OFF-HIGHWAY VEHICLE	GASOLINE, 4-STROKE	TILLERS > 5 HP
00000	2265005045	1.000	1.000	1.000	OFF-HIGHWAY VEHICLE	GASOLINE, 4-STROKE	SWATHERS
00000	2265005050	1.796	0.771	1.000	OFF-HIGHWAY VEHICLE	GASOLINE, 4-STROKE	HYDRO POWER UNITS
00000	2265005055	1.000	1.000	1.000	OFF-HIGHWAY VEHICLE	GASOLINE, 4-STROKE	OTHER AGRICULTURAL EQUIP.
00000	2265006000	1.796	0.771	1.000	OFF-HIGHWAY VEHICLE	GASOLINE, 4-STROKE	LIGHT COMMERCIAL
00000	2265006005	1.796	0.771	1.000	OFF-HIGHWAY VEHICLE	GASOLINE, 4-STROKE	GENERATOR SETS < 50 HP
00000	2265006010	1.796	0.771	1.000	OFF-HIGHWAY VEHICLE	GASOLINE, 4-STROKE	PUMPS < 50 HP
00000	2265006015	1.796	0.771	1.000	OFF-HIGHWAY VEHICLE	GASOLINE, 4-STROKE	AIR COMPRESSORS < 50 HP
00000	2265006020	1.000	1.000	1.000	OFF-HIGHWAY VEHICLE	GASOLINE, 4-STROKE	GAS COMPRESSORS < 50 HP
00000	2265006025	1.796	0.771	1.000	OFF-HIGHWAY VEHICLE	GASOLINE, 4-STROKE	WELDERS < 50 HP
00000	2265006030	1.796	0.771	1.000	OFF-HIGHWAY VEHICLE	GASOLINE, 4-STROKE	PRESSURE WASHERS < 50 HP
00000	2265007000	1.796	0.771	1.000	OFF-HIGHWAY VEHICLE	GASOLINE, 4-STROKE	LOGGING EQUIPMENT
00000	2265007005	1.796	0.771	1.000	OFF-HIGHWAY VEHICLE	GASOLINE, 4-STROKE	CHAIN SAWS > 4 HP
00000	2265007010	1.796	0.771	1.000	OFF-HIGHWAY VEHICLE	GASOLINE, 4-STROKE	SHREDDERS > 5 HP
00000	2265007015	1.000	1.000	1.000	OFF-HIGHWAY VEHICLE	GASOLINE, 4-STROKE	SKIDDERS
00000	2265007020	1.000	1.000	1.000	OFF-HIGHWAY VEHICLE	GASOLINE, 4-STROKE	FELLERS/BUNCHERS
00000	2265008000	1.000	1.000	1.000	OFF-HIGHWAY VEHICLE	GASOLINE, 4-STROKE	AIRPORT SERVICE EQUIPMENT
00000	2265008005	1.000	1.000	1.000	OFF-HIGHWAY VEHICLE	GASOLINE, 4-STROKE	AIRPORT SUPPORT EQUIPMENT
00000	2265008010	1.000	1.000	1.000	OFF-HIGHWAY VEHICLE	GASOLINE, 4-STROKE	TERMINAL TRACTORS
00000	2270000000	0.992	1.000	1.000	OFF-HIGHWAY VEHICLE	DIESEL	OFF-HIGHWAY VEHICLES
00000	2270001000	1.000	1.000	1.000	OFF-HIGHWAY VEHICLE	DIESEL	RECREATIONAL VEHICLES
00000	2270001010	1.000	1.000	1.000	OFF-HIGHWAY VEHICLE	DIESEL	MOTORCYCLES, OFF-ROAD
00000	2270001020	1.000	1.000	1.000	OFF-HIGHWAY VEHICLE	DIESEL	SNOWMOBILES
00000	2270001030	1.000	1.000	1.000	OFF-HIGHWAY VEHICLE	DIESEL	ALL-TERRAIN VEHICLES
00000	2270001040	1.000	1.000	1.000	OFF-HIGHWAY VEHICLE	DIESEL	MINIBIKES
00000	2270001050	1.000	1.000	1.000	OFF-HIGHWAY VEHICLE	DIESEL	GOLF CARTS
00000	2270001060	1.000	1.000	1.000	OFF-HIGHWAY VEHICLE	DIESEL	SPECIALTY VEHICLE CARTS
00000	2270002000	0.992	1.000	1.000	OFF-HIGHWAY VEHICLE	DIESEL	CONSTRUCTION EQUIPMENT
00000	2270002003	1.000	1.000	1.000	OFF-HIGHWAY VEHICLE	DIESEL	ASPHALT PAVERS
00000	2270002006	1.000	1.000	1.000	OFF-HIGHWAY VEHICLE	DIESEL	TAMPERS/RAMMERS
00000	2270002009	0.992	1.000	1.000	OFF-HIGHWAY VEHICLE	DIESEL	PLATE COMPACTORS
00000	2270002012	0.992	1.000	1.000	OFF-HIGHWAY VEHICLE	DIESEL	CONCRETE PAVERS
00000	2270002015	0.992	1.000	1.000	OFF-HIGHWAY VEHICLE	DIESEL	ROLLERS
00000	2270002018	0.992	1.000	1.000	OFF-HIGHWAY VEHICLE	DIESEL	SCRAPERS

00000	2270002021	1.000	1.000	1.000	OFF-HIGHWAY VEHICLE	DIESEL	PAVING EQUIPMENT
00000	2270002024	1.000	1.000	1.000	OFF-HIGHWAY VEHICLE	DIESEL	SURFACING EQUIPMENT
00000	2270002027	0.992	1.000	1.000	OFF-HIGHWAY VEHICLE	DIESEL	SIGNAL BOARDS
00000	2270002030	0.992	1.000	1.000	OFF-HIGHWAY VEHICLE	DIESEL	TRENCHERS
00000	2270002033	0.992	1.000	1.000	OFF-HIGHWAY VEHICLE	DIESEL	BORE/DRILL RIGS
00000	2270002036	0.992	1.000	1.000	OFF-HIGHWAY VEHICLE	DIESEL	EXCAVATORS
00000	2270002039	1.000	1.000	1.000	OFF-HIGHWAY VEHICLE	DIESEL	CONCRETE/INDUSTRIAL SAWS
00000	2270002042	0.992	1.000	1.000	OFF-HIGHWAY VEHICLE	DIESEL	CEMENT & MORTAR MIXERS
00000	2270002045	0.992	1.000	1.000	OFF-HIGHWAY VEHICLE	DIESEL	CRANES
00000	2270002048	0.992	1.000	1.000	OFF-HIGHWAY VEHICLE	DIESEL	GRADERS
00000	2270002051	0.992	1.000	1.000	OFF-HIGHWAY VEHICLE	DIESEL	OFF-HIGHWAY TRUCKS
00000	2270002054	0.992	1.000	1.000	OFF-HIGHWAY VEHICLE	DIESEL	CRUSHING/PROC. EQUIP
00000	2270002057	0.992	1.000	1.000	OFF-HIGHWAY VEHICLE	DIESEL	ROUGH TERRAIN FORKLIFTS
00000	2270002060	0.992	1.000	1.000	OFF-HIGHWAY VEHICLE	DIESEL	RUBBER TIRE LOADERS
00000	2270002063	0.992	1.000	1.000	OFF-HIGHWAY VEHICLE	DIESEL	RUBBER TIRE DOZERS
00000	2270002066	0.992	1.000	1.000	OFF-HIGHWAY VEHICLE	DIESEL	TRACTORS/LOADERS/BACKHOES
00000	2270002069	1.000	1.000	1.000	OFF-HIGHWAY VEHICLE	DIESEL	CRAWLER TRACTORS
00000	2270002072	0.992	1.000	1.000	OFF-HIGHWAY VEHICLE	DIESEL	SKID STEER LOADERS
00000	2270002075	1.000	1.000	1.000	OFF-HIGHWAY VEHICLE	DIESEL	OFF-HIGHWAY TRACTORS
00000	2270002078	0.992	1.000	1.000	OFF-HIGHWAY VEHICLE	DIESEL	DUMPERS/TENDERS
00000	2270002081	1.000	1.000	1.000	OFF-HIGHWAY VEHICLE	DIESEL	OTHER CONSTRUCTION EQUIP.
00000	2270003000	0.992	1.000	1.000	OFF-HIGHWAY VEHICLE	DIESEL	INDUSTRIAL EQUIPMENT
00000	2270003010	0.992	1.000	1.000	OFF-HIGHWAY VEHICLE	DIESEL	AERIAL LIFTS
00000	2270003020	0.992	1.000	1.000	OFF-HIGHWAY VEHICLE	DIESEL	FORKLIFTS
00000	2270003030	0.992	1.000	1.000	OFF-HIGHWAY VEHICLE	DIESEL	SWEEPERS/SCRUBBERS
00000	2270003040	0.992	1.000	1.000	OFF-HIGHWAY VEHICLE	DIESEL	OTHER GENERAL INDUST. EQUIP.
00000	2270003050	1.000	1.000	1.000	OFF-HIGHWAY VEHICLE	DIESEL	OTHER MAT. HANDLING EQUIP.
00000	2270004000	1.000	1.000	1.000	OFF-HIGHWAY VEHICLE	DIESEL	LAWN & GARDEN
00000	2270004010	1.000	1.000	1.000	OFF-HIGHWAY VEHICLE	DIESEL	LAWN MOWERS
00000	2270004015	1.000	1.000	1.000	OFF-HIGHWAY VEHICLE	DIESEL	ROTARY TILLERS < 5 HP
00000	2270004020	1.000	1.000	1.000	OFF-HIGHWAY VEHICLE	DIESEL	CHAIN SAWS < 4 HP
00000	2270004025	1.000	1.000	1.000	OFF-HIGHWAY VEHICLE	DIESEL	TRIMMERS/EDGERS/BRUSH CUT
00000	2270004030	1.000	1.000	1.000	OFF-HIGHWAY VEHICLE	DIESEL	LEAFBLOWERS/VACUUMS
00000	2270004035	1.000	1.000	1.000	OFF-HIGHWAY VEHICLE	DIESEL	SNOW BLOWERS
00000	2270004040	1.000	1.000	1.000	OFF-HIGHWAY VEHICLE	DIESEL	REAR ENGINE RIDING MOWERS
00000	2270004045	1.000	1.000	1.000	OFF-HIGHWAY VEHICLE	DIESEL	FRONT MOWERS
00000	2270004050	1.000	1.000	1.000	OFF-HIGHWAY VEHICLE	DIESEL	SHREDDERS < 5 HP

00000	2270004055	0.992	1.000	1.000	OFF-HIGHWAY VEHICLE	DIESEL	LAWN & GARDEN TRACTORS
00000	2270004060	0.992	1.000	1.000	OFF-HIGHWAY VEHICLE	DIESEL	WOOD SPLITTERS
00000	2270004065	1.000	1.000	1.000	OFF-HIGHWAY VEHICLE	DIESEL	CHIPPERS/STUMP GRINDERS
00000	2270004070	1.000	1.000	1.000	OFF-HIGHWAY VEHICLE	DIESEL	COMMERCIAL TURF EQUIPMENT
00000	2270004075	1.000	1.000	1.000	OFF-HIGHWAY VEHICLE	DIESEL	OTHER LAWN & GARDEN EQUIP.
00000	2270005000	0.992	1.000	1.000	OFF-HIGHWAY VEHICLE	DIESEL	FARM EQUIPMENT
00000	2270005010	0.992	1.000	1.000	OFF-HIGHWAY VEHICLE	DIESEL	2-WHEEL TRACTORS
00000	2270005015	0.992	1.000	1.000	OFF-HIGHWAY VEHICLE	DIESEL	AGRICULTURAL TRACTORS
00000	2270005020	0.992	1.000	1.000	OFF-HIGHWAY VEHICLE	DIESEL	COMBINES
00000	2270005025	1.000	1.000	1.000	OFF-HIGHWAY VEHICLE	DIESEL	BALERS
00000	2270005030	0.992	1.000	1.000	OFF-HIGHWAY VEHICLE	DIESEL	AGRICULTURAL MOWERS
00000	2270005035	1.000	1.000	1.000	OFF-HIGHWAY VEHICLE	DIESEL	SPRAYERS
00000	2270005040	0.992	1.000	1.000	OFF-HIGHWAY VEHICLE	DIESEL	TILLERS > 5 HP
00000	2270005045	1.000	1.000	1.000	OFF-HIGHWAY VEHICLE	DIESEL	SWATHERS
00000	2270005050	0.992	1.000	1.000	OFF-HIGHWAY VEHICLE	DIESEL	HYDRO POWER UNITS
00000	2270005055	1.000	1.000	1.000	OFF-HIGHWAY VEHICLE	DIESEL	OTHER AGRICULTURAL EQUIP.
00000	2270006000	0.992	1.000	1.000	OFF-HIGHWAY VEHICLE	DIESEL	LIGHT COMMERCIAL
00000	2270006005	1.000	1.000	1.000	OFF-HIGHWAY VEHICLE	DIESEL	GENERATOR SETS < 50 HP
00000	2270006010	1.000	1.000	1.000	OFF-HIGHWAY VEHICLE	DIESEL	PUMPS < 50 HP
00000	2270006015	1.000	1.000	1.000	OFF-HIGHWAY VEHICLE	DIESEL	AIR COMPRESSORS < 50 HP
00000	2270006020	1.000	1.000	1.000	OFF-HIGHWAY VEHICLE	DIESEL	GAS COMPRESSORS < 50 HP
00000	2270006025	1.000	1.000	1.000	OFF-HIGHWAY VEHICLE	DIESEL	WELDERS < 50 HP
00000	2270006030	1.000	1.000	1.000	OFF-HIGHWAY VEHICLE	DIESEL	PRESSURE WASHERS < 50 HP
00000	2270007000	0.992	1.000	1.000	OFF-HIGHWAY VEHICLE	DIESEL	LOGGING EQUIPMENT
00000	2270007005	1.000	1.000	1.000	OFF-HIGHWAY VEHICLE	DIESEL	CHAIN SAWS > 4 HP
00000	2270007010	0.992	1.000	1.000	OFF-HIGHWAY VEHICLE	DIESEL	SHREDDERS > 5 HP
00000	2270007015	0.992	1.000	1.000	OFF-HIGHWAY VEHICLE	DIESEL	SKIDDERS
00000	2270007020	1.000	1.000	1.000	OFF-HIGHWAY VEHICLE	DIESEL	FELLERS/BUNCHERS
00000	2270008000	0.992	1.000	1.000	OFF-HIGHWAY VEHICLE	DIESEL	AIRPORT SERVICE EQUIPMENT
00000	2270008005	0.992	1.000	1.000	OFF-HIGHWAY VEHICLE	DIESEL	AIRPORT SUPPORT EQUIPMENT
00000	2270008010	0.992	1.000	1.000	OFF-HIGHWAY VEHICLE	DIESEL	TERMINAL TRACTORS
00000	2282000000	1.008	0.998	1.000	MARINE VESSELS	RECREATIONAL	MARINE VESSELS, RECREAT.
00000	2282005000	1.008	0.998	1.000	MARINE VESSELS	RECREATIONAL	PLEASURE CRAFT, GAS 2-STRK
00000	2282005005	1.000	1.000	1.000	MARINE VESSELS	RECREATIONAL	INBOARDS
00000	2282005010	1.008	0.998	1.000	MARINE VESSELS	RECREATIONAL	OUTBOARDS
00000	2282005015	1.000	1.000	1.000	MARINE VESSELS	RECREATIONAL	STERNDRIVE
00000	2282005020	1.000	1.000	1.000	MARINE VESSELS	RECREATIONAL	SAILBOAT AUX INBOARD

00000	2282005025	1.008	0.998	1.000	MARINE VESSELS	RECREATIONAL	SAILBOAT AUX OUTBOARD
00000	2282010000	1.008	0.998	1.000	MARINE VESSELS	RECREATIONAL	PLEASURE CRAFT, GAS 4-STRK
00000	2282010005	1.000	1.000	1.000	MARINE VESSELS	RECREATIONAL	INBOARDS
00000	2282010010	1.008	0.998	1.000	MARINE VESSELS	RECREATIONAL	OUTBOARDS
00000	2282010015	1.000	1.000	1.000	MARINE VESSELS	RECREATIONAL	STERNDRIVE
00000	2282010020	1.000	1.000	1.000	MARINE VESSELS	RECREATIONAL	SAILBOAT AUX INBOARD
00000	2282010025	1.008	0.998	1.000	MARINE VESSELS	RECREATIONAL	SAILBOAT AUX OUTBOARD
00000	2282020000	1.000	1.000	1.000	MARINE VESSELS	RECREATIONAL	PLEASURE CRAFT, DIESEL
00000	2282020005	1.000	1.000	1.000	MARINE VESSELS	RECREATIONAL	INBOARDS
00000	2282020010	1.000	1.000	1.000	MARINE VESSELS	RECREATIONAL	OUTBOARDS
00000	2282020015	1.000	1.000	1.000	MARINE VESSELS	RECREATIONAL	STERNDRIVE
00000	2282020020	1.000	1.000	1.000	MARINE VESSELS	RECREATIONAL	SAILBOAT AUX INBOARD
00000	2282020025	1.000	1.000	1.000	MARINE VESSELS	RECREATIONAL	SAILBOAT AUX OUTBOARD

Table 3.15-3a. Summary of 1999 Projected NO_x Emissions in D–FW Nonattainment Counties by Category (Tons/Day)

NO_x		June 1995 Episode					July 1996 Episode				
		6/18	6/19	6/20	6/21	6/22	6/30	7/1	7/2	7/3	7/4
		Sun.	Mon.	Tues.	Wed.	Thurs.	Sun.	Mon.	Tues.	Wed.	Thurs.
On-Road Mobile Sources	Dallas	119.0	152.1	152.7	152.9	153.5	119.0	149.3	149.3	155.5	98.3
	Tarrant	74.5	96.8	97.2	97.2	97.5	74.5	94.8	94.9	100.4	60.8
	Collin	20.2	27.4	27.5	27.0	27.5	20.2	26.6	26.5	28.1	16.8
	Denton	18.6	25.4	25.5	25.0	25.5	18.6	24.2	24.4	26.2	15.5
	Total	232.4	301.6	302.9	302.1	303.9	232.4	294.9	295.0	310.2	191.4
Area and Nonroad Mobile Sources	Dallas	24.3	65.1	65.3	65.3	65.2	24.3	65.6	65.9	65.9	22.9
	Tarrant	26.4	48.9	48.9	48.9	48.9	26.4	48.7	49.7	49.6	27.2
	Collin	4.1	7.9	7.9	7.9	7.9	4.1	8.2	8.2	8.3	4.0
	Denton	4.8	8.2	8.2	8.2	8.2	4.8	8.5	8.5	8.8	5.0
	Total	59.5	129.9	130.1	130.2	130.1	59.5	131.1	132.3	132.7	59.1
Point Sources	Dallas	20.6	31.3	42.4	43.5	48.5	43.4	54.3	62.4	64.4	52.5
	Tarrant	8.7	10.3	20.0	28.9	23.7	18.0	31.0	28.2	28.3	24.9
	Collin	5.3	6.3	5.7	9.2	6.2	6.5	7.0	7.6	8.2	7.6
	Denton	3.0	3.2	3.3	4.5	5.4	6.9	6.4	7.4	6.2	8.7
	Total	37.6	51.1	71.3	86.1	83.9	74.7	98.8	105.5	107.1	93.7
Biogenic Sources	Dallas	2.3	2.4	2.5	2.6	2.7	3.0	3.1	3.2	3.3	3.3
	Tarrant	1.8	1.9	1.9	2.0	2.1	2.4	2.4	2.6	2.6	2.6
	Collin	2.7	2.8	2.9	3.0	3.1	3.6	3.7	3.9	3.9	3.9
	Denton	2.3	2.4	2.5	2.6	2.6	3.1	3.2	3.4	3.4	3.4
	Total	9.1	9.5	9.7	10.1	10.5	12.0	12.3	13.0	13.1	13.1
All Sources	Dallas	166.3	250.9	262.8	264.3	269.9	189.7	272.4	280.8	289.2	177.1
	Tarrant	111.4	157.8	168.1	177.0	172.1	121.3	177.0	175.3	180.9	115.4
	Collin	32.3	44.3	43.9	47.0	44.6	34.3	45.5	46.1	48.5	32.3
	Denton	28.8	39.1	39.3	40.2	41.7	33.4	42.3	43.7	44.6	32.6
	Total	338.7	492.1	514.1	528.5	528.4	378.7	537.2	545.9	563.2	357.3

Table 3.15-3b. Summary of 1999 Projected CB-IV HC (VOC) Emissions in D–FW Nonattainment Counties by Category (Tons/Day)

CB-IV HC (VOC)		June 1995 Episode					July 1996 Episode				
		6/18	6/19	6/20	6/21	6/22	6/30	7/1	7/2	7/3	7/4
		Sun.	Mon.	Tues.	Wed.	Thurs.	Sun.	Mon.	Tues.	Wed.	Thurs.
On-Road Mobile Sources	Dallas	64.4	83.0	83.3	86.7	88.3	64.4	90.8	96.2	104.5	58.7
	Tarrant	37.9	48.0	48.2	50.0	50.9	37.9	52.3	55.7	60.3	34.5
	Collin	10.9	13.9	14.0	14.1	14.4	10.9	15.3	16.2	17.6	9.9
	Denton	9.4	12.1	12.1	12.3	12.5	9.4	13.1	14.0	15.2	8.6
	Total	122.5	157.0	157.5	163.1	166.1	122.5	171.5	182.2	197.6	111.6
Area and Nonroad Mobile Sources	Dallas	156.8	122.1	122.1	122.4	122.4	156.8	126.3	127.1	131.1	93.5
	Tarrant	68.8	77.1	77.1	77.3	77.4	68.8	79.9	80.6	90.2	125.2
	Collin	31.0	16.9	17.0	17.0	17.0	31.0	17.9	18.0	20.3	15.7
	Denton	42.4	24.7	24.7	24.8	24.8	42.4	25.9	26.1	36.8	38.6
	Total	299.0	240.8	240.9	241.6	241.6	299.0	249.9	251.8	278.3	272.9
Point Sources	Dallas	7.0	13.4	13.4	13.3	13.3	7.1	13.4	13.4	13.4	7.1
	Tarrant	5.9	14.2	14.2	14.2	14.2	5.9	14.2	14.2	14.2	5.9
	Collin	0.5	1.2	1.2	1.2	1.2	0.5	1.2	1.2	1.2	0.6
	Denton	0.5	1.4	1.4	1.4	1.4	0.5	1.4	1.4	1.4	0.5
	Total	13.9	30.1	30.1	30.1	30.1	14.0	30.1	30.1	30.1	14.0
Biogenic Sources	Dallas	43.1	46.3	48.9	54.4	59.2	73.3	75.3	79.7	80.9	80.9
	Tarrant	64.9	69.1	75.3	83.8	91.3	113.4	117.2	124.0	126.5	127.0
	Collin	18.0	18.9	19.9	22.1	24.9	33.4	34.0	36.3	35.4	29.8
	Denton	106.9	114.6	122.7	135.9	151.2	200.5	203.3	219.2	212.6	193.6
	Total	232.8	249.0	266.8	296.2	326.6	420.6	429.7	459.3	455.4	431.3
All Sources	Dallas	271.3	264.8	267.6	276.9	283.2	301.6	305.7	316.5	329.9	240.1
	Tarrant	177.5	208.4	214.8	225.4	233.8	226.1	263.6	274.6	291.1	292.5
	Collin	60.4	51.0	52.0	54.3	57.4	75.7	68.3	71.7	74.4	56.0
	Denton	159.1	152.8	160.9	174.4	190.0	252.7	243.6	260.7	266.0	241.3
	Total	668.3	676.8	695.3	730.9	764.3	856.1	881.2	923.4	961.5	829.9

Table 3.15-3c. Summary of 1999 Projected CO Emissions in D–FW Nonattainment Counties by Category (Tons/Day)

CO	June 1995 Episode					July 1996 Episode				
	6/18	6/19	6/20	6/21	6/22	6/30	7/1	7/2	7/3	7/4

		Sun.	Mon.	Tues.	Wed.	Thurs.	Sun.	Mon.	Tues.	Wed.	Thurs.
On-Road Mobile Sources	Dallas	498.7	644.0	646.2	656.2	667.3	498.7	664.1	677.4	739.4	434.7
	Tarrant	322.7	388.5	390.0	394.3	401.2	322.7	398.4	407.0	441.3	270.3
	Collin	90.3	118.3	118.6	115.6	118.2	90.3	119.4	123.1	131.4	79.0
	Denton	79.8	106.0	106.3	104.9	106.8	79.8	102.8	110.3	120.4	70.4
	Total	991.6	1256.8	1261.0	1271.0	1293.5	991.6	1284.7	1317.7	1432.5	854.4
Area and Nonroad Mobile Sources	Dallas	621.2	422.9	425.5	424.9	424.8	621.2	434.3	436.3	444.8	353.4
	Tarrant	264.3	294.4	296.5	296.2	296.2	264.3	303.1	305.3	324.4	474.2
	Collin	129.4	68.0	68.2	68.4	68.1	129.4	72.0	72.0	76.8	65.9
	Denton	139.8	75.0	75.3	76.0	75.1	139.8	77.3	78.1	100.3	108.2
	Total	1154.7	860.2	865.6	865.4	864.2	1154.7	886.6	891.6	946.3	1001.7
Point Sources	Dallas	5.5	7.0	7.4	5.8	5.8	6.8	8.2	8.2	8.2	6.8
	Tarrant	1.8	2.1	3.4	4.1	4.0	3.7	4.2	3.8	3.8	3.9
	Collin	1.9	2.1	2.1	2.1	2.1	2.2	2.4	2.4	2.4	2.4
	Denton	0.8	0.6	0.6	0.8	0.8	0.8	0.8	0.8	0.8	0.8
	Total	10.0	11.8	13.5	12.7	12.6	13.4	15.5	15.2	15.2	13.8
All Sources	Dallas	1125.4	1073.9	1079.1	1086.9	1097.8	1126.7	1106.6	1121.8	1192.4	794.9
	Tarrant	588.8	685.1	689.9	694.5	701.4	590.6	705.6	716.1	769.5	748.4
	Collin	221.6	188.3	188.9	186.1	188.3	221.9	193.8	197.5	210.6	147.2
	Denton	220.4	181.6	182.2	181.7	182.7	220.4	180.8	189.1	221.5	179.4
	Total	2156.3	2128.8	2140.1	2149.1	2170.3	2159.7	2186.8	2224.5	2394.0	1869.9

Notes:
1. All values are based on aggregated grid cell totals which approximate geopolitical boundaries.
2. Hydrocarbon emissions are based on Carbon Bond IV transformed emissions.
3. Biogenic CO emissions are always assumed to be zero, hence are not reported.

3.16 MODEL RESULTS

3.16.1 Future Year Base Case Modeling

After applying growth and controls (NO_x RACT, national small engine rules, Federal Motor Vehicle Control Program) to the emissions data (see Section 3.15, *Future Year Modeling Inventory Development*), the CAMx model was ready to be executed in a predictive mode, to assess the likely state of the D-FW airshed in the 1999 future year and to evaluate strategies for bringing the area into attainment of the NAAQS. The two episodes, with the base case emissions replaced by 1999 projected emissions, are referred to as "future base cases" or "1999 base cases". The photochemical model was run for both of these future base cases and the results compared with those of the 1995 and 1996 base case modeling. The results were fairly similar to the base case modeling results, with some reduction (2-5 ppb) in peak predicted ozone seen on each day. Table 3.16-1 compares peak predicted 1-hour ozone concentrations for the base cases and future base cases. The largest difference is noted for July 3, 1996, where modeled peak 1-hour ozone dropped from 172.9 ppb to a 1999 base case value of 168.2 ppb.

Table 3.16-1. Comparison of Base Case and Future Base Case Peak Predicted 1-hour Ozone Concentrations in the D-FW Area

Episode Day	Base Case (1995 or 1996) Predicted Peak 1-hour Ozone Concentration (parts/billion)	Future Base Case (1999) Predicted Peak 1-hour Ozone Concentration (parts/billion)
6/20/95	135	133
6/21/95	143	140
6/22/95	149	145
7/2/96	123	120
7/3/96	173	168
7/4/96	140	138

Figures 3.16-1 through 3.16-3 show isopleth plots of modeled maximum ozone concentrations in the D-FW area for the three primary episode days (days when measured ozone exceeded 125 ppb) of June 21, 1995; June 22, 1995; and July 3, 1996. These graphs are similar to those produced for the base case (see Section 3.14, *Base Case Modeling and Performance Evaluation*), with slightly smaller areas shaded, indicating a small reduction in the area of ozone concentrations in exceedance of the 1-hour standard.

3.16.2 Directional Guidance

The results of the future base case modeling indicate that additional reductions will be necessary to bring the D-FW area into attainment of the 1-hour NAAQS. Once the need for additional reductions has been shown, the next step in the modeling process is to determine the appropriate path for reducing peak ozone: NO_x reductions, VOC reductions, or a combination of the two. To determine the appropriate path, a series of model runs was conducted wherein reductions of 50 percent were applied to VOC, NO_x, and both VOC

and NO_x emissions (note that the latter case represents a much greater level of reduction than the first two, since here the reductions are applied to both VOC *and* NO_x). These reductions were applied evenly across all sources within the four-county D-FW nonattainment area. Table 3.16-2 shows, for each primary day, peak modeled 1-hour ozone for each reduction scenario, along with the future base case values for comparison.

Table 3.16-2. Modeled Future-Case Peak 1-hour Ozone Concentrations After Reductions of VOC, NO_x, and Both VOC and NO_x

	Predicted 1999 Peak 1-hour Ozone Concentration (parts/billion)			
Episode Day	Future Base Case	50% VOC Reduction	50% NO_x Reduction	50% NO_x and 50% VOC Reduction
6/21/95	140	130	123	120
6/22/95	145	134	126	121
7/3/96	168	155	145	139

As shown in Table 3.16-2, the modeling indicates that NO_x reductions alone are significantly more effective than VOC reductions alone, while the combination of VOC and NO_x reductions provides additional reduction. However, the incremental benefit from adding a 50% VOC reduction to the NO_x reduction is shown to be relatively modest (3-6 ppb) considering the magnitude of VOC reductions applied. The guidance provided from the modeling, then, is that NO_x reductions are the more effective route to ozone control, but VOC reductions provide additional benefits.

3.16.2 Reduction Target Modeling

The third step in the future case modeling process is the determination of reduction targets; that is, how much reduction is necessary to demonstrate attainment of the NAAQS. The traditional approach to attainment demonstration is specified in the EPA Guideline for Regulatory Application of the Urban Airshed Model (EPA, 1991), and states:

> "To demonstrate attainment of the ozone NAAQS, there should be no predicted daily maximum ozone concentrations greater than 0.12[7] ppm anywhere in the modeling domain for each primary episode day modeled."

The goal of this portion of the modeling, then, was to determine the level of additional reductions to the future base case inventory necessary to ensure that the peak modeled ozone on each of the three primary

[7]The phrase "greater than 0.12 ppm" (ppm stands for parts/million) has been interpreted as "greater than 124 parts/billion" in recent SIP development. The standard rounding convention would round .124 ppm (124 ppb) down to .12 ppm, but would round .125 ppm (125 ppb) up to .13 ppm.

episode days is 124 ppb or less across the D-FW area[8]. Since the modeling described earlier indicated that NO_x emissions reductions are the most effective route to attainment, this portion of the modeling consisted of a series of model runs in which overall NO_x emissions in the four-county area were reduced by various amounts. Since VOC reductions are expected to continue to occur into the future as NO_x reductions are made, a moderate amount of VOC reduction (25%) was assumed at each level of NO_x reduction. VOC reductions of this level are expected in the next few years due to several factors, including RFG phase 2, the introduction of NLEVs or Tier 2 vehicles, and cleaner-running small engines. The reductions applied to the 1999 projected emissions inventory for reduction target determination are listed below in Table 3.16-3, along with D-FW area peak modeled 1-hour ozone concentration on the primary days for each run.

Table 3.16-3. Attainment Target Modeling: Reduction Levels and Peak Modeled Ozone

	Reduction		Peak Modeled Ozone (ppb)		
Model Run #	NO_x	VOC	6/21/95	6/22/95	7/3/96
1 (1999 Base)	0%	0%	140	145	168
2	30%	25%	130	135	154
3	40%	25%	126	129	149
4	50%	25%	122	124	142
5	60%	25%	116	118	134
6	70%	25%	109	110	127
7	80%	25%	100	99	120

The data in Table 3.16-3 are plotted in Figure 3.16-4. The dashed line in the figure represents 124 ppb, the level that must be reached to demonstrate attainment under EPA guidance. For both primary days in 1995, it is seen in the figure and in Table 3.16-3 that attainment is reached with less than 50% reduction of NO_x (together with the assumed 25% VOC reduction). However, as seen in figure 3.16-4, for July 3, 1996 NO_x reductions of approximately 74% would be required.

Two factors may somewhat mitigate the requirements for such a large reduction of NO_x in the four-county area. First, the modeling reported here assumes no reductions outside the four-county area. Reductions made within Texas as a result of the TCAS, reductions made in other states as a result of the OTAG SIP call, and new national rules will combine to reduce the incoming flux of ozone and its precursors into the D-FW area, reducing the amount of local reduction required. Second, as was seen in Section 3.14, *Base Case Modeling and Performance Evaluation*, the model exhibited a bias of +12.3% on July 3, 1996, meaning the model has a tendency to overpredict ozone on that day. In the ensuing discussion, we will utilize a design value-based method of demonstrating attainment which incorporates a built-in bias correction.

[8]Because the D-FW modeling was conducted across a very large regional domain, it is not reasonable to consider the domain-wide peak as specified in the Guidance, since maxima may occur in distant urban areas unaffected by reductions made in the D-FW area.

3.16.3 Design Value-Based Attainment Demonstration

EPA recently issued draft guidance for areas seeking transitional status under the new 8-hour ozone standard, allowing these areas to use a design value-based method for demonstrating attainment of the that standard. A related method was outlined in a July 10, 1998 memo from Bill Hunt of EPA's OAQPS for areas planning to use OTAG model results to demonstrate attainment of the 1-hour standard. While neither of these situations applies directly to the D-FW nonattainment area, the concept of a design value-based attainment demonstration is technically sound and provides a strong alternative to the reduction requirement calculations based on peak modeled ozone.

Before proceeding, the following discussion describes how the design value for an area is determined, and then how violations of the NAAQS are determined.

- First, the design value is calculated at each monitoring site in the region (provided sufficient data at the site are available). This value is the fourth-highest measured 1-hour average ozone concentration at the site recorded over the three most recent ozone seasons.

- The region's design value is the maximum of the individual monitoring sites' design values.

- If a region's design value exceeds .12 parts/million, then the region has violated the NAAQS and may be designated as nonattainment.

It has been recognized for several years that the Guideline attainment demonstration method is much more strict than the design value-based attainment demonstration process. The reasons for this disparity are:

- A region can experience up to three exceedances of the .12 ppm standard in three years, yet not violate the NAAQS. The Guideline modeled attainment test allows no exceedances on any day.

- The monitoring network in a region is concentrated in areas with high population densities, but large areas of any region are unmonitored. Thus, many exceedances potentially go undetected simply by occurring where no monitor exists. The Guideline modeled attainment test allows no exceedances anywhere in the modeling domain, even in sparsely populated areas.

- The Guideline method is sensitive to bias in the model's predictions. In particular, when ozone is overpredicted as is the case on July 3, 1996, then reduction requirements may be overstated.

Design value-based methodologies provide a reasonable alternative to the Guideline attainment demonstration method. The commission has adapted the method outlined in the draft guidance for transitional areas for use in this SIP. The approach followed is:

1. Determine the current 1-hour design value at each monitor in the region (i.e. the fourth highest 1-hour ozone concentration recorded in the years 1995-97). The D-FW area's design value of 139 ppb is the maximum of the monitor-specific design values.

2. For the base case, determine the baseline modeled average peak ozone at each monitoring site:

    a. First locate the 4 km X 4 km grid cell in which the monitor lies, along with the eight surrounding grid cells.

b. For each episode day, calculate the average of the peak modeled ozone in the nine grid cells surrounding the monitor.

c. Calculate a three-day average of the values computed in step 2.b. This is the baseline modeled average peak ozone at the monitoring site.

3. For a reduction scenario (e.g. 25% VOC, 60% NO_x reduction from the future base case emissions), determine the modeled average peak ozone at each monitoring site using the same procedure as in Step 2.

4. Find the ratio of modeled average peak ozone calculated for the reduction scenario to the baseline modeled average peak ozone at each monitor location. This ratio provides a measure of predicted ozone change at each monitor as a result of the modeled reductions.

5. Multiply each monitoring site's design value (discussed in Step 1) by the ratio calculated in Step 4 for that location. The result is the predicted design value for each site resulting from the modeled reductions.

6. The predicted design value for the nonattainment area, resulting from the modeled reductions, is then the maximum of the monitor-specific design values calculated in Step 5.

Table 3.16-4 presents predicted design values for the series of reduction percentages tabulated earlier in Table 3.16-3.

Table 3.16-4. Attainment Target Modeling: Reduction Levels and Predicted Design Values

Model Run #	Reduction		Predicted Design Value (ppb)
	NO_x	VOC	
1 (1999 Base)	0%	0%	139
2	30%	25%	128
3	40%	25%	124
4	50%	25%	121
5	60%	25%	116
6	70%	25%	109
7	80%	25%	100

The data in Table 3.16-4 are plotted in Figure 3.16-5. Using the design value-based approach, it is seen that attainment is reached with 40% reduction of NO_x (together with the assumed 25% VOC reduction). This contrasts with the reduction requirement of approximately 74% which would be required using the Guideline approach. It should be noted that in either case, reductions in areas outside the four-county area may significantly reduce the required reduction in the nonattainment area.

The design value-based approach has two distinct advantages over the Guideline method. First, it relates the attainment demonstration directly to the monitoring data-based process used to determine the attainment status of a region, and secondly, the ratioing step automatically adjusts for modeled bias.

3.16.4 Additional Ozone Metrics

This section provides additional measures of ozone pollution for the D-FW area, and shows how they each respond to the reduction scenarios discussed above. These measures are: area of ozone exceedance (the spatial extent, in km^2, where modeled 1-hour ozone exceeded 124 ppb); area-hours of ozone exceedance, (the area of ozone > 124 ppb weighted by the number of hours that ozone exceeded 124 ppb at each location); and exposure (area-hours weighted by the amount by which predicted ozone exceeded 124 ppb at each location). Descriptions of the methods used to calculate each of these metrics can be found in Smith and Durrenberger, 1997.

These metrics, presented in Table 3.16-5 below for the three primary days, help to quantify the benefits of emissions reductions even in cases where the Guideline attainment demonstration criterion is not met. In particular, the table row for Model Run #3 (40% NO_x, 25% VOC) shows the air quality benefit associated with reductions showing attainment under the design value-based attainment demonstration methodology. These measures show substantial improvement in all three measures on all three primary days. Specifically, area of ozone > 124 ppb is reduced between 37% (on July 3, 1996) and 92% (on June 21, 1995); area-hours > 124 ppb is reduced between 45% (on July 3, 1996) and 96% (on June 21, 1995), and exposure is reduced between 71% (on July 3, 1996) and 99.6% (on June 21, 1995). These measures show a substantial improvement in air quality even without taking into account the overprediction in the base

case on July 3, 1996. Thus, the reduction target derived using the design value-based attainment demonstration method, 40%, would provide a marked improvement in air quality, even if no reductions are assumed outside the four-county area. Reductions outside the nonattainment area are likely to further enhance the ozone benefits modeled with only local reductions.
Figures 3.16-6 through 3.16-8 show graphically the results of Table 3.16-5.

Reference

Smith, J.H., and Durrenberger, C.J. (1997). Ozone metrics for attainment demonstration, *Proceedings of the Air and Waste Management Association's 90th Annual Meeting and Exhibition*, June 1998.

Table 3.16-5. Additional Ozone Measures Predicted for Various Emission Reduction Levels

Model Run #	Reduction		Area of Ozone > 124 ppb (km^2)			Area-Hours > 124 ppb (km^2-hours)			Exposure (km^2-hours-ppb)		
	NO_x	VOC	6/21/95	6/22/95	7/3/96	6/21/95	6/22/95	7/3/96	6/21/95	6/22/95	7/3/96
1 (1999 Base)	0%	0%	800	848	4368	1888	2128	15936	9551	13959	207653
2	30%	25%	256	304	3248	400	608	10960	644	2030	92351
3	40%	25%	64	176	2752	80	208	8800	42	408	60563
4	50%	25%	0	0	2096	0	0	5664	0	0	29057
5	60%	25%	0	0	1152	0	0	1952	0	0	6714
6	70%	25%	0	0	64	0	0	64	0	0	57
7	80%	25%	0	0	0	0	0	0	0	0	0

3.17 ACCESS TO MODELING APPENDICES AND ELECTRONIC DATA FILES

3.17.1 Appendices

The modeling appendices referenced in this document may be obtained from Mr. Chris Kite of the commission staff. Mr. Kite can be reached by phone at (512) 239-1959 or by e-mail at ckite@tnrcc.state.tx.us.

3.17.2 Electronic Data Files

Electronic data files can be obtained via anonymous FTP or through the World Wide Web. Please contact Mr. Chris Kite if you experience any difficulties or would like to request that additional data be placed on our FTP site.

Via Anonymous FTP

The address for the commission's FTP site is "ftp.tnrcc.state.tx.us". The files can be found under the directory "/pub/AirQuality/AirQualityPlanningAssessment/Modeling/D-FW" and its subdirectories.

Via World Wide Web

You may also use a World Wide Web browser to access electronic files on the the commission's FTP site. The FTP site's URL is:

"ftp://ftp.tnrcc.state.tx.us/pub/AirQuality/AirQualityPlanningAssessment/Modeling/D-FW".

CHAPTER 4: DATA ANALYSIS

4.1 INTRODUCTION

The effort to demonstrate attainment of a noncompliant area to a future year is a very complex and resource intensive process. Photochemical modeling has traditionally been the chief tool utilized, however, other important scientific methods are increasingly being added to augment the modeling in this process of determining an area's specific problem with respect to ground level ozone. Work is currently underway to include other types of analysis concerning ozone in the D-FW area and include the following:

- Dallas-Fort Worth Summer Ozone Study
- Corroborative Evidence on Directional Guidance from Ambient Air Data
- Wind Rose Analyses
- Back-trajectory Analyses
- Aircraft Sampling Analyses

When completed, the combination of these types of analyses being conducted, along with the photochemical modeling, will offer the most comprehensive investigation of ozone science available anywhere in the country.

4.2 OVERVIEW OF 1996 DALLAS–FORT WORTH SUMMER OZONE STUDY

During the summer of 1996, the commission conducted an ozone study in the D-FW area called the Dallas Summer Study, or DSS. The DSS was developed to answer the following technical questions, some of which relate directly to the photochemical modeling effort, or to the input data for the modeling:

1. Are the current mobile source VOC, NO_x, and CO emissions estimated correctly? Specifically:
   - Is the magnitude of each correct?
   - Are the diurnal emission profiles correct for each day of the week?
   - Are the VOC speciation profiles correct?
2. After the vehicle inspection and maintenance program has been implemented, can quantitative emission reductions be determined by ambient measurements and/or by source-oriented measurements near roads performed before and after implementation? If they can, what measurements must be made to determine the reductions?
3. Are there significant emission sources that have not been included in the inventory?

4. Have biogenic emissions been correctly estimated in magnitude, speciation, and diurnal profile?

5. Are maximum ozone concentrations in the D-FW area limited by VOC concentrations, NO_x concentrations, or by a combination of the two?

6. For days when high ozone is measured, what is the magnitude of pollutants (both ozone and ozone precursors) transported into the D-FW area and what is their role in formation of high ozone in the area? What is the importance of urban plumes, the summation of rural sources, and major combustion source emissions in generating the rural ozone and ozone-precursor concentrations?

7. What additional monitoring in the D-FW area is necessary to define the following?

   - The spatial variability in meteorological parameters adequate to provide the inputs needed to run photochemical modeling. In other words, if micrometeorology (on the scale of kilometers) is important to ozone formation and accumulation, is the baseline monitoring network dense enough to collect the necessary data?

   - The size and location of the ozone cloud and the spatial distribution of NO_x, NO_y, VOCs, and CO so that the performance of modeling can be evaluated objectively by comparing photochemical grid modeled results with ambient data, or by performing observational based methods.

To set about answering these questions, the commission augmented the existing air pollution and meteorology monitoring network in the area. Specifically, two auto-GCs were installed at three sites. Auto-GCs measure hourly averages of hydrocarbons associated with the PAMS program. One auto-GC operated near the Dallas urban core at Hinton Drive for the entire study period (June 1 - Sept. 30, 1996). A second auto-GC operated north of the Fort Worth urban core at Meacham Field until mid-July, after which it was moved to rural Denton County Airport.

In addition to the auto-GCs, three-hour multi-canister sampling was conducted at Meacham Field, at Nuestra Drive (Dallas North CAMS 5 monitor site), and in Midlothian (Tower monitor site). The EPA collected carbonyl samples at Nuestra Drive and Meacham Field. A new ozone site was established in Midlothian to serve as an upwind monitor on most days, and as a downwind monitor on days with northerly winds. Upper air meteorological data were collected at the Denton County Airport and Hinton Drive sites using acoustic sounders. An instrumented van was used to do roadside mobile monitoring and vehicle fleet emission estimations.

The data collected during the DSS have been used in the episode selection process for photochemical grid modeling (the availability of the additional data played a role in the ranking of candidate episodes; see Section 3.10, *Episode Selection*). The data have also been used to assess the state of the air quality environment in the area. In addition, the data have provided insight into characterizing the important meteorological factors in ozone formation in the D-FW area, as well as the temporal distribution and chemical composition of hydrocarbon emissions.

Much of the work needed to answer the seven questions posed above is still ongoing, so many of the results are not yet available. To date:

- The auto-GC data have been compared to the speciated emissions inventory to perform a qualitative assessment of the inventory (question 1). In particular, the ratio of acetylene to ethene upwind and downwind of major roadways matched expectations for the effectiveness of catalytic converters in the modern vehicle fleet, and combined gasoline and vehicle exhaust signatures could be derived from bar graphs of auto-GC data.

- A chemical mass balance study was conducted that found the Hinton Drive site to be dominated by vehicle emissions, but some other sources may also be present (questions 1 and 3).

- Ozone data collected at Midlothian helped to show the extent of the ozone cloud and transported background levels to improve model verification (questions 6 and 7).

- The collection of isoprene using auto-GCs has been important in assessing the accuracy of the biogenic emissions inventory used for modeling (question 4).

- In a later section of this document we describe how the data have been used to suggest which controls may be effective in controlling ozone in the area (question 5).

4.3 CORROBORATIVE EVIDENCE ON DIRECTIONAL GUIDANCE FROM AMBIENT AIR DATA

4.3.1 Introduction

This section combines various analyses of ambient data that provide a rationale for further NO_x and VOC emission controls in the D-FW area as a means to reduce ambient ozone levels. In subsections (1) and (2) we discuss the long-term trends in ambient VOC and NO_x, respectively, at urban sites in the area. In subsection (3) we discuss the VOC/NO_x ratios based on these long term trends and based on measurements taken in urban and rural areas during the 1996 Dallas Summer Study. Our conclusions are as follows:

- VOC levels have declined significantly in the Dallas urban core since 1984, but NO_x levels have remained flat.

- Further local and upwind VOC emissions reductions should be effective in controlling ozone in the urban core of the D-FW area. NO_x reductions should also reduce ozone in the urban core area.

- In areas north of Dallas and Fort Worth, where measured ozone concentrations tend to be highest, local and upwind NO_x reductions should lead to ozone reductions. Previous studies (e.g., *Rethinking the Ozone Problem in Urban and Regional Air Pollution*, National Research Council, 1991) suggest that NO_x is likely to be the limiting factor in other, unmonitored, downwind directions from D-FW.

4.3.2 Hinton Drive Historical VOC Trends

TNMOC data were collected by the EPA using daily morning (6-9 a.m. CDT) canister sampling near or at the current City of Dallas Hinton Drive monitoring site (see Figures 4.3.10 and 4.3.11 later in this chapter) during the mid-to-late 1980's and the mid 1990's. Morning TNMOC concentrations are of interest because of the combined effects of the morning rush hour and the low nighttime/morning mixing height. Together, these conditions typically lead to high hydrocarbon (and other primary pollutant) concentrations.

A time series of the daily concentrations of TNMOC at the Hinton Drive site has been plotted in Figure 4.3.1. There is a statistically significant downward trend in TNMOC concentrations, which can be quantified using regression as an average nine percent per year decrease. Overall, the drop from combined years 1985-1986 (823 ppbC) to combined years 1995-1996 (309 ppbC) was 62 percent. There was a slight increase in the mean levels for 1995 (278 ppbC) to 1996 (324 ppbC), which may be the result of year-to-year meteorological variations, and does not necessarily reflect a change in the trend observed over the longer time period.

When we look only at high ozone days over this period, we still see the downward TNMOC trend. Figure 4.3-2 shows the trend for days on which some ozone monitor in the D-FW area measured 100 parts per billion (ppb) or higher for a 1-hour average. This graph shows that despite the fact that the frequency of high ozone days has declined (see Figure 4.3-13), some high ozone readings have persisted even with the decline in TNMOC levels.

The conclusion of this analysis is that we have evidence that VOC concentrations have declined significantly in the Dallas urban core over the past fifteen years. One major cause for this decline is improvements in emissions controls from motor vehicles. A shortcoming of this analysis is that we do not have trends for other sites in the area. However, a separate earlier study of VOC concentrations in the Houston and Beaumont areas showed similar long-term downward trends, most likely due to combined vehicle and industrial emissions reductions. Since similar controls on vehicles have been in place in all three urban areas, we may conclude that concentrations are declining elsewhere in the D-FW area as well.

4.3.3 Dallas/Fort Worth Historical NO_x Trends

Figures 4.3-3 through 4.3-8 show the long term NO_x trends for the monthly average of mid-morning hours (5-8 a.m. CST) at six D-FW area sites. The Mockingbird site is close enough to the Hinton Drive site that their data may be combined for a single longer time series, as shown in Figure 4.3-9. A map of the six sites is shown in Figure 4.3-10. Also shown in gray are two sites added for the 1996 Dallas Summer Study. All graphs in Figures 4.3-3 through 4.3-8 are made on the same time and concentration scales to allow comparisons. We used the monthly average morning (5-8 a.m. CST) NO_x concentration as the statistic of interest. This statistic was selected to reduce the effect of day-to-day fluctuations caused by meteorology while maintaining enough data points to have statistical power of detecting trends over a period of several years. Note that the hours of 5-8 a.m. CST correspond to 6-9 a.m. CDT.

The conclusion of these trends is that in some locations NO_x has decreased, at some it has increased, and at others there is no appreciable change. The changes over time are small compared with the change in TNMOC at Hinton discussed above. The NO_x trends and means over the monitoring period at these sites are summarized in Table 4.3-1 below. As one might expect, average morning NO_x concentrations are higher in the urban core sites of Hinton/Mockingbird in Dallas and Fort Worth Downtown. Tests for significance of the trends were performed using standard linear regression with a qualitative examination

of the outliers, and a rejection level of 0.05 for significance. By “significant” we mean that given the variability of the data, the absolute value of the slope found by simple linear regression was large enough that is was unlikely to have resulted from chance alone.

Figure 4.3-11 shows the NO_x trend at Mockingbird (1984-1986) and Hinton (1986-1996) over the same high ozone days as those shown in Figure 4.3-2 for TNMOC at Hinton. As was the case in Figure 4.3-9, there is no significant trend for NO_x using these data.

Table 4.3-1. Summary Statistics for Morning NO_x Concentrations at Monitors in the D-FW Area

Figure	Monitoring Site	Period	Mean level	Trend	Statistical significance
4.3-3	Hinton	1986-1997	62 ppb	-1.37 ppb/yr	signif.
4.3-4	Mockingbird	1978-1986	61 ppb	+1.82 ppb/yr	not signif.
4.3-5	Bonnieview	1982-1994	29 ppb	+1.86 ppb/yr	signif.
4.3-6	Fort Worth NW	1978-1997	32 ppb	-0.30 ppb/yr	not signif.
4.3-7	Fort Worth Downtown	1978-1996, intermittent	70 ppb	-2.09 ppb/yr	signif.
4.3-8	Dallas North	1978-1997	36 ppb	-0.58 ppb/yr	signif.
4.3-9	Mockingbird/Hinton	1978-1997	62 ppb	-0.17 ppb/yr	not signif.

The main point to be taken from the NO_x and VOC trends analysis is that overall NO_x levels have not experienced meaningful change over time, while the VOC concentrations appear to have declined. One possible conclusion is that the steady levels of NO_x may account for the flattening out in the long-term trend toward ozone reductions in the area shown in Figures 4.3-12 and 4.3-13. However, as mentioned earlier, one possible fault in this conclusion is that we do not have long-term trend data for VOC over a wide area as we do with NO_x.

It is noteworthy to consider the specific geographic area which currently has the highest ozone levels and how that area is affected by the precursor source areas. The highest design value monitors and the monitors recording the most exceedances for the D-FW area in recent years have been the monitors north of the most heavily urbanized area: Denton County Airport, Keller, and Frisco. If one looks closely at the *near-downwind* urban monitor sites at Dallas North and Fort Worth NW (which are generally *upwind* of the aforementioned sites) one sees a reversal in the long-term weak downward NO_x trend, so that NO_x levels have actually been increasing since about 1990. This is shown in Figures 4.3-14 and 4.3-15. Consider these NO_x trends along with the trends shown for ozone in Figures 4.3-12 and 4.3-13, and the trends for VOCs shown in Figures 4.3-1 and 4.3-2. Taken together we have the following findings:

1. Flat recent ozone trends north of the heavily urbanized area following earlier years of decline;
2. Continuous long term VOC decline in the urban core, which is considered the primary precursor source region for ozone in the area north of the urban core;
3. Reversal in the long term decline in NO_X upwind of the monitors recording the maximum ozone.

The implications of these findings are three-fold:

1. VOC reductions in earlier years produced a decline in ozone levels at the design value monitors and area wide.

2. In more recent years, NO_x has been increasing upwind of the design value monitors, VOCs have been decreasing, and ozone has no longer been responding.
3. If the NO_x upward trend is reversed in the area upwind of the design value monitors and the long term downward trend restored, then ozone should respond by decreasing.

This third conclusion is explored from the VOC to NO_x ratio approach in the next section.

4.3.4 VOC-NO_x Ratios at 1996 auto-GC Sites

The ratio of VOCs to NO_x in emission rates or in ambient concentrations is often used to characterize the limiting factor in ozone formation. In general, using TNMOC in parts per billion carbon as the indicator for VOC, a ratio of 8/1 implies that either pollutant class or a combination of the two classes can be reduced to effect a decrease in ozone levels. At lower ratios, an area's ozone levels would be expected to respond better to VOC reductions, and is said to be VOC-limited. At higher ratios, an area's ozone levels would be expected to respond better to NO_x reductions, and is said to be NO_x limited. Using the generalized ozone isopleth approach credited to A. J. Haagen-Smit and described in *Rethinking the Ozone Problem in Urban and Regional Air Pollution* (National Research Council, 1991), an initial combination of 70 ppb NO_x and 1000 ppbC VOC in a typical large U.S. city would produce greater than 0.20 ppm of ozone and would respond best to NO_x reductions, but would also respond slowly to VOC reductions. These were typical morning concentrations at Hinton Drive in the mid-1980s for NO_x and VOC, and the design value at the nearby Mockingbird ozone monitor was 0.16 ppm during that period. Using the same model, an initial combination of 70 ppb NO_x and 300 ppbC VOC would lead to approximately 0.14 ppm of ozone and would respond best to VOC reductions, with disbenefits for NO_x reductions. This may be the current situation at Hinton Drive, where the 1996 design value was 0.12 ppm. This approach is predicated on a constrained air mass, which is rarely the situation in reality. In our case we have peak emissions within the urban core, with ozone formation and additional emission contributions as the urban plume moves downwind. By the time the polluted air mass has moved downwind to, say, central Denton County, biogenic emissions may have kept the VOC levels elevated, but NO_x concentrations will have decreased owing to dispersion and fewer local sources. In fact, as discussed below, the 1996 rural site at Denton County Airport had comparable levels of VOC and about one half the concentration for NO_x, but a higher 1994-1996 ozone design value (0.139) than at Hinton (0.121 ppm). This does not fit the Haagen-Smit model, because ozone and precursors at the Denton site are likely to have been transported from the upwind urban area. Thus, conclusions drawn from the ratio at that site might best be interpreted as how to reduce the *incremental* ozone production at that site, which is still of critical importance since it is the area-wide design-value monitor.

During the 1996 Dallas Summer Study, two auto-GCs were deployed at three sites shown in Figures 4.3-16 through 4.3-19. As shown in Table 4.3-2 below, a "permanent" site was operated at the heavily urbanized Hinton Drive monitoring site (AIRS 481130069) from June 4 through September 30, 1996. This site began operation in June, 1996 and has continued to operate since then. A temporary monitor which ran from May through mid-July of that year was installed at the Meacham Field/Fort Worth NW site (AIRS 484391002) in Fort Worth, Tarrant County. In late July this monitor was moved to the rural Denton County Airport site (AIRS 481210033) where it operated in August and September.

Table 4.3-2 contains a brief statistical summary of the 6-9 a.m. local time (CDT) VOC-NO_x ratios assessed at these three sites. We used the following methodology to perform the assessment. Hourly data with start times of 5:00, 6:00, and 7:00 (CST) for NO_x and VOCs were collected. NO_x data were downloaded from the AIRS database, and speciated VOCs were extracted from the commission's local

auto-GC database. As a surrogate for total VOCs, we used the sum of identified PAMS target list compounds, which we calculated from the data for each hourly record for which no more than four species had been invalidated. We call this variable "SumPol." Because of the poor relative precision for conventional NO_x analyzers at low concentrations, we deleted all NO_x data for which the three-hour average was less than 10 ppb. This resulted in dropping many observations from the rural sites. The morning VNR for each day were calculated by dividing the three-hour average SumPol by the three-hour average NO_x. At least two valid hours of data had to be present to calculate a three-hour average for either variable.

The data show a statistically significantly lower ratio at the urban Hinton site than at the Meacham and Denton sites. The means that the Meacham and Denton sites are not significantly different. The data imply that ozone levels at the Hinton site would be likely to decline with either VOC or NO_x reductions, whereas ozone at the Meacham and Denton sites would be more likely to decline if NO_x were reduced.

The graphs in Figures 4.3-20 through 4.3-22 show the relationship between early morning SumPol and NO_x at each site, along with the area-wide daily 1-hour maximum ozone levels. Each graph has the monitor's NO_x concentration on the left y-axis, the area-wide ozone peak on the right y-axis, and SumPol on the x-axis. Also shown are two lines: one representing a constant VNR of 4 (solid line) and the other a constant VNR of 15 (dotted line). The graphs show that when the concentrations of VOC and NO_x are high at Hinton, the ratios are low (closer to the solid line), whereas when the concentrations are high at Meacham and Denton, the ratios are high (closer to the dotted line). Tables 4.3-3 through 4.3-5 show the summary data for date, morning SumPol and NO_x, day of the week, weekday versus weekend classification, VNR (labeled "VNRAT"), the ozone high value for the day at that site, the ozone high value within the D-FW area, and the area-wide 8-hour high value, along with the name of the site at which the area-wide 1-hour peak was recorded. All days for which an area-wide 1-hour value of 100 ppb or higher was recorded are shown.

These tables imply that both VOC and NO_x controls would be effective at reducing ozone levels at Hinton. However, as the list of sites shows, the area-wide peak was likely to have been recorded at Meacham or Denton. Thus, NO_x controls as implied by the higher VNR (Table 4.3-2) would be more likely to reduce the area maximum.

Table 4.3-2. D-FW Summer Study 6-9 A.M. VOC-NO_x Ratio Statistical Summary

	Hinton	**Meacham**	**Denton**
No. of Observations	**98**	**30**	**27**
Mean VNR	**6.9**	**10.5**	**9.1**
Standard Error	**0.3**	**0.7**	**0.8**
Period	**6/4-9/30/96**	**6/4-7/14/96**	**8/9-9/30/96**

The overall conclusions of this analysis may be stated as follows:

- VOC emission controls in the urban core appear to have been effective.
- NO_x trends throughout the urban area are flat.
- The VOC to NO_x ratio in the urban area is lower than in the downwind rural areas.
- The VOC to NO_x ratio in the urban area indicates VOC and NO_x controls would be effective in reducing ozone.
- The VOC to NO_x ratios in the rural downwind areas indicates a NO_x control strategy will reduce ozone.

Table 4.3-3. Hinton Site SumPol, NO_x, and O_3 on High Ozone Days

DATE	SumPol avg	NO_x avg	DOW	WDWE	VNRAT	OZPK	Area 1hrpk	Area 8hrpk	Site
7/3/96	374	102	Wed	Wkday	3.67	124	144	116.6	Redbird
9/6/96	637	110	Fri	Wkday	5.79	100	139	116.3	Denton
7/8/96	178	35	Mon	Wkday	5.13	113	131	97.63	Denton
7/7/96	134	N/A	Sun	Wkend	N/A	94	120	87.88	Denton
7/4/96	289	62	Thu	Wkday	4.69	100	116	110.3	Dallas North
9/11/96	832	225	Wed	Wkday	3.70	90	116	89.75	Midlothian
7/2/96	207	46	Tue	Wkday	4.48	96	114	95.50	Frisco
9/7/96	372	94	Sat	Wkend	3.94	90	114	96.00	Frisco
6/30/96	187	20	Sun	Wkend	9.21	84	112	90.75	Denton
7/1/96	318	70	Mon	Wkday	4.53	81	112	101.5	Denton
9/12/96	785	261	Thu	Wkday	3.00	86	110	95.13	Keller
7/5/96	185	28	Fri	Wkday	6.60	82	109	98.63	Frisco
7/13/96	281	26	Sat	Wkend	10.81	100	108	80.13	Keller
9/10/96	532	182	Tue	Wkday	2.92	76	108	85.38	Midlothian
6/21/96	220	35	Fri	Wkday	6.21	64	107	99.00	Denton
9/5/96	426	94	Thu	Wkday	4.52	76	107	92.75	Keller
9/14/96	232	29	Sat	Wkend	8.09	69	107	89.75	Denton
9/4/96	411	56	Wed	Wkday	7.29	80	106	88.38	Keller
9/9/96	444	99	Mon	Wkday	4.48	73	101	79.63	Midlothian
8/1/96	261	38	Thu	Wkday	6.81	89	100	88.88	Dallas North
9/17/96	257	39	Tue	Wkday	6.58	69	100	82.75	Keller
Mean Hi	360.1	82.7			5.62	87.4	113.4	94.4	
MeanAll	262.9	49.3			6.93	56.8	78.9	64.7	

Table 4.3-4. Meacham Site SumPol, NO_x, and O_3 on High Ozone Days

DATE	SumPol avg	NO_x avg	DOW	WDWE	VNRAT	OZPK	Area 1hrpk	Area 8hrpk	Site
7/3/96	420	56	Wed	Wkday	7.55	127	144	116.6	Redbird
7/8/96	166	14	Mon	Wkday	11.84	126	131	97.63	Denton
6/18/96	883	60	Tue	Wkday	14.72	68	122	110.1	Frisco
7/7/96	158	N/A	Sun	Wkend	N/A	88	120	87.88	Denton
7/4/96	206	13	Thu	Wkday	15.84	89	116	110.3	Dallas North
7/2/96	175	16	Tue	Wkday	10.72	87	114	95.50	Frisco
6/30/96	196	17	Sun	Wkend	11.78	92	112	90.75	Denton
7/1/96	321	36	Mon	Wkday	8.92	79	112	101.5	Denton
7/13/96	361	52	Sat	Wkend	6.89	108	108	80.13	Keller
6/21/96	221	22	Fri	Wkday	9.90	78	107	99.00	Denton
6/19/96	241	28	Wed	Wkday	8.72	87	104	84.13	Denton
6/20/96	371	58	Thu	Wkday	6.43	102	102	89.75	Keller
Mean Hi	310.0	33.8			10.30	94.1	116.0	96.9	
MeanAll	248.1	27.8			10.55	69.4	89.9	75.0	

Table 4.3-5. Denton Site SumPol, NO_x, and O_3 on High Ozone Days

DATE	SumPol avg	NO_x avg	DOW	WDWE	VNRAT	OZPK	Area 1hrpk	Area 8hrpk	Site
9/6/96	161	40	Fri	Wkday	4.05	139	139	116.3	Denton
9/7/96	246	31	Sat	Wkend	7.94	109	114	96.00	Frisco
9/12/96	195	56	Thu	Wkday	3.47	98	110	95.13	Keller
9/10/96	378	21	Tue	Wkday	18.30	82	108	85.38	Midlothian
9/5/96	178	28	Thu	Wkday	6.36	80	107	92.75	Keller
9/14/96	195		Sat	Wkend		107	107	89.75	Denton
8/14/96	194	43	Wed	Wkday	4.51	90	104	92.88	Keller
9/9/96	168	11	Mon	Wkday	14.80	66	101	79.63	Midlothian
9/17/96	177	18	Tue	Wkday	10.10	93	100	82.75	Keller
Mean Hi	210	30.9			8.69	96.0	110.0	92.3	
MeanAll	183	24.8			9.14	70.1	77.3	62.8	

4.3.5 Note on the Limitations in VOC-NO_x Ratios

The following text is quoted from a paper by Rich Poirot, a data analyst for the State of Vermont (personal communication, 1998):

"It should also be cautioned that there are a number of limitations to, and potential biases in, the use of VOC to NO_x ratios. .... In cases ... where transport is a significant (dominant) factor, the precursor concentrations at upwind locations along the transport path need to be determined. It will ultimately be critical to distinguish between ozone contributions from local precursor emissions, from transported ozone formed in upwind locations, and from in-situ ozone production from transported upwind precursors.

There are also questions about which species should be included in a calculation of "total VOCs" and "total NO_x". There is a remarkable inconsistency in the literature among different calculations of total VOCs at different sites and time periods. In some cases methane is included (usually excluded). In other cases biogenics and/or carbonyls are included, excluded, not well quantified, or estimated. Traditional NO_x measurements include NO (generally quantified accurately) plus variable combinations of NO_2 and some (but not all) other reactive nitrogen species (NO_y).

Even if appropriate quantities of 'total VOC' and 'total NO_x (or NO_y)' could be quantified, the simple ratio of the two disregards the composition and reactivity of individual hydrocarbon and nitrogen compounds. During a multi-day episode, concentrations of total non-methane hydrocarbons may build to high concentrations under a stagnating high pressure system. However, without fresh injections of VOCs, the most reactive compounds will become depleted, leaving high VOC levels composed of less reactive species with little potential for ozone production. A variety of 'reactivity' schemes have been proposed and employed in different studies, but as yet, there is no consensus on which of these adjustment schemes is most appropriate.

Focusing exclusively on the 6 to 9 AM time frame may severely underestimate contributions from highly reactive VOC compounds like isoprene and formaldehyde - which tend to peak in mid-day (when most other reactive compounds have been depleted). Also, reactive nitrogen compounds like PAN, HONO and nitric acid exhibit diurnal patterns which differ from those of NO and NO_2."

References

National Research Council (1991). *Rethinking the ozone problem in urban and regional air pollution.* National Academy Press, Washington DC.

Poirot, Rich (1991). Personal communication.

Figure 4.3-1 thru 4.3-22 (more than 1 fig per page)

4.4 WIND ROSE ANALYSES

In order to more closely examine wind roses in an investigation of ozone and ozone precursor transport, various forms of analysis are underway. These include the following: comparisons between the Dallas and Fort Worth metropolitan statistical area to see how the two urban centers influence each other; comparisons between wind roses developed from individual CAMS sites, from aggregated CAMS sites, and from the NWS site at D-FW Airport to assess the variability of ensemble wind conditions across the consolidated metropolitan statistical area and the differences among types of wind sampling methods; comparisons between wind roses created from high ozone and low ozone days; and comparisons of the wind roses from past years with 1998, to assess the effect of new monitoring at Midlothian and Arlington on the types of wind conditions on detected high ozone days.

4.5 BACK-TRAJECTORY ANALYSES

Using the National Oceanic and Atmospheric Administration Atmospheric Resources Lab web site (www.arl.noaa.gov/ready) and HYSPLIT tool, assessment of back-trajectories from the D-FW area on high and low ozone days is currently being performed. The proposed approach is to run back-trajectories that begin at mid-afternoon on high ozone days and end the morning of the previous day. Areas contributing to regional ozone problems will be assessed by plotting groupings of trajectories. These data will be compiled and analyzed to try and help answer several questions: To what extent is there agreement between surface winds and mesoscale and synoptic-scale winds? Can HYSPLIT trajectories be effectively used along with surface wind data to do episode selection for photochemical grid modeling? To what extent does rural point source pollution in Texas contribute to elevated ozone in Texas' urban areas? Are HYSPLIT forecast trajectories useful in ozone forecasting? Finally, are HYSPLIT back trajectories a useful tool in explaining ozone transport in Texas?

4.6 AIRCRAFT SAMPLING ANALYSIS

In 1996, the commission entered into a partnership with Baylor University to conduct air monitoring by airplane. This monitoring allows for air profiling over a very broad area which can determine the depth and extent of pollutants in the atmosphere and in particular to determine the highest pollutant concentration in a given region and its location.

The airborne monitoring platform is a Beechcraft Inc. King Air A90 fixed wing turboprop aircraft maintained by the Baylor University, Department of Aviation Sciences. The aircraft has been structurally modified and has been approved by the FAA to operate in the experimental category for air pollution sampling.

Data from aircraft monitoring will be used in the future to help study the movement of pollutants and to characterize the changing chemistry within the plume. It will also be used to determine the extent to which an urban area such as D-FW is generating precursor emissions of ozone, receiving precursors of ozone via transport from other sources, or both.

CHAPTER 5: RATE OF PROGRESS

5.1 OVERVIEW

The D-FW ozone nonattainment area was classified as a moderate area as a result of the FCAA Amendments of 1990. As a moderate area, the State of Texas was required to submit a SIP demonstrating a 15% VOC emission reduction, net of growth, for the D-FW area for the years between 1990 and 1996. This 15% ROP SIP was adopted by the commission on November 10, 1993 and May 13, 1994 and submitted to the EPA. Because the D-FW area did not attain the 1-hour ozone standard by the November 1996 deadline, this SIP revision includes a 9% ROP plan toward satisfying EPA's requirement of reasonable further progress of 3% per year for the D-FW four-county nonattainment area for the years 1997-99.

EPA's method for calculating ROP targets involves growing emissions out to the future year of attainment. Because of the tremendous growth in the D-FW area over the last several years, the on-road and non-road mobile source emission estimates for NO_x from the years 1997, 98, and 99 outweigh the NO_x emission reductions from mobile source control strategies implemented in the area. As a result of this, the commission has decided to pursue the full 9% ROP through the use of VOC reductions.

However, since photochemical modeling for the D-FW area shows that NO_x reductions are necessary in bringing the area into attainment, the following actions have taken place. The State of Texas submitted to the EPA on November 13, 1998 a separate letter indicating that this most recent photochemical modeling has triggered their condition of the NO_x waiver and thus it should be rescinded. The EPA has initiated steps to rescind the exemption. In addition, the ROP portion of this SIP quantifies the NO_x estimates for the D-FW area and establishes a NO_x budget for conformity purposes.

5.2 CALCULATION OF THE 1999 TARGET LEVELS

Table 5.2-1 shows the amount of VOC reductions needed to achieve the ROP requirements. EPA has devised a complex method for calculating the rate of progress target. This process was developed to ensure that the rate of progress calculation reflected growth in the emissions inventory, and appropriately accounted for both creditable and non-creditable emission reductions achieved since 1990.

The VOC calculation in Table 5.2-1 starts with the 1990 Base Year EI (Step 1). This EI is then adjusted to remove non-creditable reductions that occurred since 1990 (Steps 2, 3, and 5). This new EI is called the "Adjusted Base Year EI". The ROP percentage of 9% in this case is taken from this new Adjusted Base Year EI (Step 4). The 1999 Target Level is calculated in Step 7 by subtracting Steps 4 and 5 from Step 6. This new target level can be thought of as an ROP budget for the area. In Step 8, the uncontrolled 1999 forecast emissions inventory is listed. Step 9 is the difference between where the area would be in 1999 without controls (Step 8) and where they are required to be (their Target Level in Step 7). Step 10 lists the creditable reductions made through the 15% SIP, and Step 11 calculates the difference between Steps 9 and 10, to yield the remaining needed reductions for the ROP demonstration, or the excess.

Table 5.2-1

1999 ROP Required VOC Emissions Target Calculations
Dallas/Fort Worth Ozone Nonattainment Area Ozone
Season VOC Tons Per Day January 18, 1999

Step	Emissions Basis	Stationary		Mobile		Total
		Point	Area	On-road	Non-road	
1	1990 ROP Nonattainment Area Base Year EI	63.80	174.02	306.60	105.19	649.61
2	Adjusted Base Year EI Relative to 1996	63.80	174.02	204.35	105.19	547.36
3	Adjusted Base Year EI Relative to 1999	63.80	174.02	192.59	105.19	535.60
4	9% of Adjusted Base Year EI Relative to 1999					48.20
5	RVP and Fleet turnover correction [steps (2-3)]			11.76		11.76
6	1996 Target Level					465.52
7	1999 Target Level [steps (6-5-4)]					405.56
8	1999 Emissions Forecast (Grown) With Pre-90 Control	25.10	182.02	247.75	119.35	574.22
9	Total Reductions Required by 1999 with growth [steps (8-7)]					168.66
10	Creditable Reductions (1990-1996)	0.00	50.99	76.40	12.59	139.98
11	***Required Reductions 1996-1999***					28.68

Notes for On-Road Mobile

1. Forecast in step 8 is 1999 Emissions Forecast (Grown) With Pre-90 Control
2. Base year on-road mobile emissions calculated with MOBILES for an ozone season weekday
3. Adjusted base year on road mobile emissions and 1999 forecast on-road mobile emissions calculated with MOBILE5A for an ozone season weekday
4. Point source reductions from step 10 have been removed to avoid double counting.

5.3 CONTROLS TO ACHIEVE THE RATE OF PROGRESS TARGET

A summary of the reductions toward achieving the 9% ROP target are included in Table 5.3-1. The table shows VOC reductions net of growth from the 1990 baseline by 1999. Table 5.3-2 shows NO_x net of growth reductions that will occur from the 1990 baseline by 1999. Contingency measures for VOCs are included as well as further NO_x reductions that will occur by 2001.

Table 5.3-1

VOC ESTIMATES TOWARDS 9% ROP SIP - DALLAS/FORT WORTH

Emissions Inventory	1990	Percent	Growth	1999	Percent
Area Sources	174.02	26.8%	4.6%	182.02	31.7%
Point Sources	63.80	9.8%	-60.7%	25.10	4.4%
On-road Mobile Sources	306.60	47.2%	-19.2%	247.75	43.1%
Off-road Mobile Sources	105.19	16.2%	13.5%	119.35	20.8%
TOTALS	**649.61**		**-11.6%**	**574.22**	

ESTIMATED VOC REDUCTIONS

Control Strategy	1999 Projected Tons Per Day	Reduction Tons Per Day	Percent of Requirement
Aircraft Engines	6.73	1.52	5.30%
TCM's	247.75	0.29	1.01%
Utility engine 1997-1999	68.45	2.37	8.26%
UST Remediation	1.81	1.81	6.31%
Tier I, I/M, RFG	161.47	16.82	58.65%
	Subtotal	**22.81**	**79.53%**
Contingency Strategy			
Commercial Bakeries	0.51	0.15	0.77%
Offset Printing	0.55	0.24	1.23%
I/M, Tier I, RFG Phase II	247.75	10.94	56.14%
Naphtha Dry Cleaners	4.77	2.41	12.37%
Utility Engine 2000	68.45	0.92	4.72%
	Subtotal	**14.66**	**75.22%**

Required Target	**28.68**	100.00%
Creditable Reductions	**22.81**	79.53%
Shortfall	**5.87**	20.5%
Required Contingency*	**19.49**	100.0%
Required Target + Contingency	**48.17**	100.0%
Total Reductions	**37.47**	77.8%
Shortfall	**10.70**	22.2%

Table 5.3-2

NO_x ESTIMATES FOR DALLAS-FORT WORTH

Emissions Inventory	1990	Percent	Growth	1999	Percent
Area Sources	19.99	3.6%	3.3%	20.64	3.1%
Point Sources	71.60	13.0%	0.1%	71.70	10.9%
On-road Mobile Sources	293.03	53.2%	16.2%	340.39	51.7%
Off-road Mobile Sources	166.05	30.2%	35.8%	225.54	34.3%
TOTALS	550.67		19.5%	658.27	

ESTIMATED NO_x REDUCTIONS

Control Strategy	1999 Projected Tons Per Day	Reduction Tons Per Day
TU Reductions (by 12/31/98)	71.70	10.45
RFG, I/M, FMVCP Tier I	340.39	56.25
Off-road Heavy-Duty Diesel	153.74	11.98
	Subtotal	**78.68**
Further Reductions by 2001		
NO_x RACT (by 3/31/01)		10.93
I/M, Tier I, RFG Phase II	271.96	5.29
	Subtotal	**16.22**
Total Reductions by 2001		**94.90**

Mobile Source reductions due to FMVCP Tier I, Vehicle I/M and Reformulated Gasoline occurred between 1990 and 1999 and are included in the calculation of the target level.

5.4 1999 MOTOR VEHICLE EMISSIONS BUDGETS

Motor Vehicle Emission Budgets for transportation conformity purposes are established at 154.24 tpd for VOC and 284.14 tpd for NO_x. These figures have been calculated by subtracting all on-road mobile source reductions from the 1999 on-road mobile source emissions forecast. These calculations are shown below:

	VOC	NO_x
1999 On-Road Emissions Forecast	247.75 tpd	340.39 tpd
1996 Tier1, I/M, RFG credits	69.46	0.00
1999 Tier1, I/M, RFG credits	16.82	56.25
1996 Transportation Control Measures	6.94	0.00
1999 Transportation Control Measures	0.29	0.00
1999 Motor Vehicle Emissions Budget	154.24 tpd	284.14 tpd

CHAPTER 6: REQUIRED CONTROL STRATEGY ELEMENTS

6.1 VOC RULE CHANGES

The 1990 FCAA Amendments require states to insure that RACT is in place for all major VOC sources in moderate and above ozone nonattainment areas. The commission completed a RACT analysis for all the state's ozone nonattainment areas, in July of 1995, which demonstrated that VOC RACT requirements had been met on required and major source categories. This demonstration was submitted to the EPA as part of the Post-1996 ROP SIP (for B-PA and H-GA Ozone Nonattainment Areas).

On March 20, 1998, the D-FW ozone nonattainment area, already targeted for RACT as a moderate area, was reclassified as a serious ozone nonattainment area. As a result, the major source definition for the area must be revised downward from 100 TPY of VOC emissions to 50 TPY of VOC emissions. The remainder of this section demonstrates that VOC RACT requirements are being met for those newly designated major sources between 50 and 100 TPY.

Storage Tanks The commission has existing rules (§§115.112-115.119) for storage tanks in D-FW. The rule is modeled upon CTGs issued in 1977-1978, and includes exemptions based on storage tank size and vapor pressure of the stored material, rather than annual emissions. The exemption levels in the rule ensure that each exempt storage tank will have emissions less than 50 TPY. Consequently, the revision of the major source definition from 100 TPY to 50 TPY does not necessitate a change to the rule to ensure that RACT is in place.

SOCMI Batch Processes The vent gas rule (§§115.121-115.129) requires 90% control of individual vents for all vent gas streams except those with emissions less than 100 pounds per 24-hour period or less than 612 ppmv. The EPA Alternative Control Technique document for SOCMI batch processes applied to SIC codes 2821, 2833, 2834, 2861, 2865, 2869, and 2879. A search of the emissions inventory for the 1995 RACT demonstration identified only one major source: Styrochem International Inc. A search of the 1996 EI, using these same SIC codes, for sources at or above 50 TPY, yielded the same single facility. As was reported in the 1995 RACT demonstration, this facility holds Air Permit No. 3069A and has therefore undergone a BACT review, which represents at least RACT. VOC emissions from this polystyrene bead manufacturing facility are controlled by use of a flare and a thermal oxidizer. Permit No. 3069A requires that the flare comply with 40 CFR 60.18 and that the thermal oxidizer maintain a destruction efficiency of 95%. Stack testing of the thermal oxidizer on December 21-22, 1993 revealed that the destruction efficiency was 98.2%. The controls required by Permit No. 3069A ensure that RACT or better is applied at this source.

SOCMI Reactor/Distillation The commission has adopted rules (§§115.121-115.129) for SOCMI reactor processes and distillation operations in D-FW. The rules are equivalent to the CTG's recommended level of RACT.

Bakeries The vent gas rule (§§115.121-115.129) currently requires a 30% control efficiency for bakeries, and is applicable to bakeries at or above 100 TPY in D-FW. All bakeries currently subject to the rule have installed catalytic incinerators which achieve at least 90% destruction efficiency. For the March 1999 SIP submittal, the commission is revising the vent gas rule to: 1) lower the applicability threshold from 100 TPY to 50 TPY for bakeries in D-FW; 2) raise the minimum required VOC reduction

from 30% to 80% for major source bakeries in D-FW; and 3) prohibit the banking of emission reductions in the 30% to 90% range for major source bakeries in the H-GA, D-FW, and El Paso areas. A search of major sources (50+ TPY) was conducted for D-FW using the 1996 EI. The SIC code used for the retrieval was 2051. Two D-FW bakeries were identified with emissions between 50 and 100 TPY. The revised rule will require that these bakeries submit initial control plans by March 31, 2000, and demonstrate emission reductions by December 31, 2000. These revisions will ensure that RACT is in place for these bakeries.

Industrial Wastewater The commission has adopted rules (§§115.140-115.149) for industrial wastewater in D-FW. The 1995 RACT demonstration showed that no major sources were identified at that time in D-FW. A search of the 1996 EI, for sources 50 - 100 TPY, using SIC codes 3-01-820-01 through 3-01-820-11, 3-06-005-03 through 3-06-005-06, and 3-06-005-14 through 3-06-005-22, also identified no major sources in D-FW.

Cleanup Solvents The commission has not adopted specific rules for cleanup solvents (other than for cleanup solvents used in offset printing). The commission's Chapter 115 includes RACT rules for cold solvent cleaning and vapor degreasing. The 1995 RACT demonstration identified three major sources in D-FW; however, the solvent cleaning at each of these facilities was regulated under the existing Chapter 115 rules. A search of the 1996 EI was conducted for sources at or above 50 TPY, using SCC codes associated with solvent cleaning (excluding cold solvent cleaning and vapor degreasing): 4-02-011-05, 4-02-013-05, 4-02-014-02 and -05, 4-02-015-02 and -05, 4-02-016-02 and -05, 4-02-017-02 and -05, 4-02-018-05, 4-02-020-02 and -05, 4-02-021-05, 4-02-022-02 and -05, 4-02-023-02 and -05, 4-02-024-02 and -05, 4-02-025-02 and -05, 4-02-026-02 and -05, 4-05-004-13 and -14, and 4-05-005-14. The retrieval identified three major sources; however, each facility shows less than 0.1 TPY attributed to the use of cleaning solvents.

Autobody Refinishing The commission has existing rules (§§115.421-115.429) for automobile refinishing in D-FW. The 1995 RACT demonstration did not identify any major sources in D-FW. Since the rule is has no exemption level, any sources between 50 and 100 TPY will be regulated.

Aerospace Coatings and Solvents The commission has existing rules (§§115.421-115.429) for coatings of miscellaneous metal parts and products in D-FW. However, topcoating of the exterior of fully assembled aircraft is exempt. The 1995 RACT demonstration identified two major sources in D-FW; Lockheed and Bell Helicopter. Both facilities operate under an ARACT, which establishes VOC coating limits and application standards. In March of 1998, the EPA issued a CTG for Aerospace Coatings. The commission expects to incorporate this CTG into Chapter 115 and simultaneously withdraw the Lockheed and Bell Helicopter ARACTs from the SIP.

Shipbuilding & Ship Repair Coatings No major sources.

Wood Furniture Coatings The commission has existing rules (§§115.421-115.429) for wood furniture coatings in D-FW that apply to wood furniture manufacturing facilities which emit 25 TPY or more. Consequently, sources at or above 50 TPY are regulated by the rule.

Plastic Parts Coating A search of major sources (50+ TPY) was conducted for D-FW using the 1996 Emissions Inventory. The SIC codes used for the retrieval were 3079 and 3089 (plastic products, nec); and SCC numbers: 4-02-022-01, -02, -03, -04, -05, and -99. The retrieval identified one major source

between 50 and 100 TPY: Lasco Bathware. However, Lasco manufactures fiberglass tubs and showers but does not apply surface coatings to these products.

Two plastic parts coating operations with total plantwide emissions greater than 100 TPY (Peterbilt (Denton County) and Nash Manufacturing (Tarrant County)) were addressed in the Post-1996 ROP SIP.

Offset Printing The Offset Lithographic Printing rule (§§115.442-115.449) has been a contingency measure for D-FW. The commission is implementing the rule for sources at or above 50 TPY in D-FW. The rule revision will ensure that RACT is in place for major source offset printers.

Petroleum Dry Cleaners The commission has existing rules (§§115.552-115.559) for petroleum dry cleaners. The rules are contingency in D-FW. The 1995 RACT demonstration did not identify any major sources in D-FW. A search of sources at or above 50 TPY was conducted for D-FW using the 1996 Emissions Inventory. The SIC and SCC codes used for the retrieval were SIC 7216 (dry cleaning plants, except rug) and 7218 (industrial launderers); and SCC 4-01-001-02, -04, and -98. No sources were identified.

Marine Vessel Loading No sources in D-FW.

6.2 NO_x RULE CHANGES

Section 182(f) of the FCAA requires NO_x RACT. This section states that the requirements for major stationary sources of VOC shall also apply to major stationary sources of NO_x. However, in contrast to VOC RACT, neither the FCAA nor the EPA specify presumptive NO_x RACT limits in the form of control technique guidelines (CTGs). However, as required by the FCAA, §183(c), the EPA issued alternative control technique documents (ACTs) for categories of stationary sources of VOC and NO_x that emit more than 25 tons per year. The NO_x ACTs were issued for nine categories: nitric and adipic acid manufacturing plants, stationary gas turbines, process heaters, internal combustion engines, utility boilers, cement manufacturing, iron and steel mills, glass manufacturing, and industrial/commercial/institutional boilers. These documents identify NO_x control technologies and costs, but do not establish a presumptive RACT. The EPA issued NO_x RACT guidance in October 1992, in the form of a supplement, or preamble, to their general Title I implementation guidance. The preamble states that for electric utility boilers, in the majority of cases, RACT will result in an overall level of control equivalent to 0.20 pound NO_x per million Btu (lb NO_x/MMBtu) for tangential-fired gas/oil units, and 0.30 lb NO_x/MMBtu for wall-fired gas/oil units, expressed as a 30-day rolling average. The preamble also acknowledges that area-wide, Btu-weighted averaging may be used. For source categories other than electric utility boilers, the preamble states that NO_x RACT will be set at levels that are comparable to the RACT guidance for electric utility boilers.

The only D-FW area NO_x requirements currently applicable to existing sources were established in the original Chapter 117 rules developed in 1972. These minimal requirements apply to the large gas-fired utility boilers and set a cap on peak emissions. For the March 1999 SIP submittal, the commission is extending to D-FW the April 1993 NO_x RACT requirements of Chapter 117, applicable in HGA and BPA. This “off-the-shelf” approach is a simple method of rapidly mandating point source NO_x reductions in the area. The Chapter 117 NO_x RACT rules are a first round rule which are designed with flexibility to allow later controls to build on, rather than replace, the required controls.

The D-FW area does not contain the large NO_x emitting sources characteristic of the HGA and BPA areas, with a petrochemicals and oil refining base. Analysis of the 1996 D-FW point source emissions inventory shows that of 138 accounts (or sites) reporting NO_x emissions, only 18 reported emissions above 50 TPY of NO_x, the "major" threshold for serious ozone nonattainment areas. Of these, only the electric utilities fundamentally rely on large quantities of fossil fuel thermal energy (the principal source of point source NO_x) for their principal product. The electric utilities appear to be the only sources which require emission reductions to comply with Chapter 117. The majority of these reductions occur from the predominant electric utility company in the area. The estimated reductions from NO_x RACT are 21 tpod from the 71.80 tpod total in the 1996 point source inventory, or about 30 %. In response to the commission's Clean Air Responsibility Enterprise (CARE) program, a voluntary program to encourage the participation of grandfathered facilities into the full air permitting program, the predominant electric utility has already initiated emission reduction projects for the boilers which will provide a substantial portion of the reductions significantly earlier than would otherwise have been feasible.

The remainder of this section demonstrates that NO_x RACT requirements are being met for the 18 major source accounts in D-FW with reported emissions above 50 TPY of NO_x. A list of the accounts and NO_x emissions identified in the 1996 emission inventory may be found in Appendix K.

Electric Utilities. The nine electric utility accounts with emissions above 50 TPY account for 65.26, or 91%, of the 71.80 tpod of reported point source NO_x emissions. The Chapter 117 NO_x RACT emission limits applicable to the power boilers at these sites are lower than EPA's recommended NO_x RACT, since Chapter 117 limits both wall and tangential-fired gas units to a 0.20 lb NO_x/MMBtu, 30-day average emission limit. The rule is consistent with EPA's recommendation to allow area-wide, Btu-weighted averaging for compliance.

Industrial, Commercial, and Institutional (ICI) Boilers. The emissions inventory contains 198 ICI boilers, with NO_x emissions of 2.62 tpod, or 3-4% of point source NO_x emissions. Seven of the nine non-utility accounts with emissions above 50 TPY include ICI boilers. The Chapter 117 NO_x RACT emission limits apply to boilers with capacity at or above 100 MMBtu heat input per hour. The inventory indicates that 1.62 tpod, or 62% of the total D-FW ICI boiler NO_x emissions in 1996, would be covered by this size cutoff. Four of the nine non-utility accounts with emissions above 50 tpod operated boilers with capacity above 100 MMBtu per hour. Two of these, Lockheed Martin and Texas Instruments, have replaced or are replacing these boilers, with BACT limits that are lower than the Chapter 117 RACT limits. The other two accounts, the University of Texas Southwest Medical Center and the D-FW International Airport, operate boilers which will be subject to the Chapter 117 NO_x RACT limits. The Chapter 117 emission limits for gas-fired ICI boilers without air preheat (consistent with the D-FW ICI boiler population) range from 0.10 to 0.20 lb NO_x/MMBtu. These levels meet or exceed EPA's stated guidance that NO_x limits for other source categories should be comparable to those for electric utility boilers.

Reciprocating Internal Combustion Engines (RICE) and Industrial Gas Turbines (IGT). The emissions inventory includes 55 RICE and 18 IGT emission units, with total NO_x emissions of 1.68 and 0.64 tpod, respectively, or about 3% of the point source emissions. These units are not subject to Chapter 117 NO_x RACT limits; either because of unit size, amount of use, or, for three engines, lean-burn cycle. One of these three engines has been removed since 1996. The majority (approximately 63) of the RICE and IGT emission units in the 1996 D-FW inventory are test cells or emergency engines.

Other Categories The emissions inventory includes 974 other emission units, not classifiable according to the above categories, with total NO_x emissions of 1.55 tpod, or about 1% of the point source inventory.

The sources are not covered by the remaining ACT categories. Few of the units are located at major sources of NO_x. The largest of these units includes metallurgical furnaces (not iron or steel), thermal incinerators for VOC control, and paint drying ovens.

CHAPTER 7: FUTURE ATTAINMENT PLANS

The EPA reclassified the D-FW ozone nonattainment area from moderate to serious effective March 20, 1998. The EPA stipulated that a serious area attainment demonstration be submitted no later than 12 months from the effective date, which is March 20, 1999. The deadline for serious areas to attain the NAAQS for ozone is November 15, 1999. To determine the compliance of an area, the EPA looks at the most current three-years of monitoring data. Data from the years 1997-99 would be examined to determine whether the area was in compliance with the 1-hour ozone standard. Because the D-FW area recorded several exceedances of the ozone standard in 1997 and 1998 the area will not meet the attainment deadline in November 1999.

Even though it is not possible to attain the ozone standard by the new deadline of November 1999, this SIP revision provides important information regarding the direction for future control strategy development and SIP submittals. The state commits to submitting another Attainment Demonstration SIP in March 2000 utilizing the current modeling episodes showing what controls will be needed to attain the standard by a future attainment date. This future SIP will also contain the adopted rules necessary to reduce ozone causing compounds so that attainment can be achieved by the target date. Discussions between the state and the EPA are continuing in order to determine the timing and the future attainment deadline.