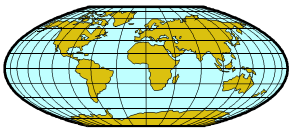
Paso del Norte

Environmental Group



Development of GIS-based Maps for the Ciudad Juárez Area Source Emissions Inventory Project

FINAL

Prepared for:

Texas Commission on
Environmental Quality

Subcontract Work Order:
TCEQ-34730-pneg/1
Under Prime Contract Number:
582-0-34730

August 31, 2003

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1.0 Introduction

Geographic information system (GIS) applications are valuable tools in providing spatial information regarding a multitude of data including the analysis of industrial emissions. GIS thematic maps of the Paso del Norte Region, including Ciudad (Cd.) Juárez, were developed to display emission estimates and source information on criteria pollutant emissions from area sources designated in the Cd. Juárez Fine PM and VOC Area Source Emissions Inventory (EI) Project.

This work was conducted under Texas Commission for Environmental Quality (TCEQ) Work Order No. 34730-03-57 (W.O. #57) of Contract No. 582-0-3470 by the Paso del Norte Environmental Group (PNEG) under subcontract to Eastern Research Group, Inc.(ERG). The EI conducted by ERG for the base year 2002 provided information from a variety of sources located throughout Cd. Juárez. This 2002 EI was prepared under TCEQ Work Order No. 34730-03-55 (W.O. #55). Thematic maps of area sources in Cd. Juárez were prepared for all sources and source categories identified in the 2002 area source database. Existing street basemaps were provided by local governmental authorities.[1] A gridding system was developed encompassing the entire Paso del Norte Region to assist in estimating pollutant emissions within specific quadrants of the study area.

Development of an EI for the Cd. Juárez area has been under discussion for many years

[1]IMIP - EL Paso

by the Joint Advisory Committee (JAC) for the Improvement of Air Quality in the Paso del Norte Air Basin. These projects conducted under TCEQ W.O. #55 and W.O. #57 represent the first major step in obtaining emissions estimates for sources in Cd. Juárez and identifying their specific location. This information will assist future air quality research efforts.

1.1 Report Organization

Section 1 provides a brief overview of GIS and its uses, the scope of the project, and the quality assurance (QA) methods that were used in this project.

Section 2 discusses the GIS-based maps that were developed for this project. Also, Section 2 describes the three types of gridding systems that were prepared, as well as the methods used to describe industry specific sources using the North American Industry Classification System (NAICS) and the ground proofing activities undertaken via a systematic drive of all streets in Juárez to identify as many area sources as possible.

Section 3 discusses data obtained from the ground proofing such as the number of facilities obtained, the GIS thematic maps prepared, and other special features of ArcView 3.2 which were utilized.

Section 4 discusses the methods used to allocate emissions.

Section 5 discusses the methods used to allocate emissions to the nested grids.

Section 6 provides the conclusions obtained by this project including data that was unavailable or difficult to obtain by this project.

1.2 Scope

The intended audience for this report includes EI staff of federal, state, and local agencies in both the U.S. and Mexico responsible for air quality planning in Cd. Juárez. Agencies include SEMARNAT - Secretariat of the Environment and Natural Resources; Chihuahua DGDUE -General Directorate for Urban Development and Ecology for the State of Chihuahua; Cd. Juárez DGDUE - General Directorate for Urban Development and Ecology for Cd. Juárez. Participating agencies interested in air quality planning in Cd. Juárez include U.S. EPA - US Environmental Protection Agency; TCEQ; and EPCCHED - El Paso City County Health and Environmental District. Other entities and groups are supportive of this project. One group such as the JAC has an agenda which calls for identifying sources of air pollution and seeking ways of improving air quality through emissions reductions.

Researchers applied site specific information obtained for facilities surveyed under this project. Emissions estimates calculated for surveyed facilities were applied to similar sources within the same source category. One issue involved applying emissions data to facilities within the same source category when the range of data was substantial. Every effort was undertaken to apply as accurate an emissions estimate to sources to the best extent possible.

1.3 Quality Assurance

As part of the QA aspect of this project, investigators verified over 270 facilities specified by PNEG. A separate team of investigators conducted site visits to assure an impartial review of sites was completed. Slightly over 10% of all facilities identified on the entire database of area sources were physically identified and revisited to assure the sites were located at the site specified during the the initial review. Results were compared, and all facilities reported on the initial list of streets in Cd. Juárez were found during the QA review by area surveillance.

Three means of data validation were used for identifying site information. A spreadsheet, a tape recording, and a digital image of the facility being identified. The purpose of the digital images was to be certain that the facility exists at the time when the data is entered into the database. The PNEG project manager reviewed the digital images provided by the investigator and compared the image to the facility database to assure it was accurately reported. The tape recording was used to trace the route taken by the field investigator to ensure he was in the sectors required to be reviewed and reported. Thus, the tape recording of the facility information provided a record that the database was accurately and efficiently developed. Also, the tape was stored for review at a later date in case there is any question related to the information reported on the data set.

2.0 Development of GIS Base Maps

2.1 Development of Base Maps

The ArcView 3.2 GIS application was utilized in preparing all thematic maps. Maps of Cd. Juárez were obtained from the Instituto Municipal de Investigacion y Planeacion (IMIP - Municipal Institute on Planning and Research) in Cd. Juárez and the City of El Paso Planning Department. GIS spatial maps were prepared in a Lambert Conformal Conic (LCC) projection, which complies with TCEQ preferred mapping methodologies. "Shape files" in GIS terminology are specific files which contain geometric attribute information such as points, lines, or polygons. For example, these three attributes may identify streets (lines), a specific location such as a metal foundry (point), or a grid (polygon).

A database was developed for each specific source category identified in the 2002 area source EI. Individual shape files were developed whereby each category was assigned a code obtained from the North American Industry Classification System (NAICS).[2] PNEG specified each business process using the 6-digit NAICS code when possible in naming shape files for each thematic map. For example: Tortilla Manufacturing facilities were identified as 311830 and autobody shops were listed as 811121. When a 6-digit code was unavailable or not specified in the NAICS database, a pseudo-code was provided as a placeholder. All pseudo-codes were listed as 99999x where "x" is an arbitrary text or numeric character. Appendix I provides the list of industries reviewed along with the 6-digit

[2] http://www.census.gov/epcd/www/naics.html

NAICS code.

2.2 Grids and Nested Grids

A series of grids encompassing the entire Paso del Norte region was developed. Initially a domain grid was established over the entire region. The extent of the region includes El Paso County, south-central Doña Ana County, New Mexico, and the Municipality of Cd. Juárez. This domain grid encompasses 4,900 square kilometers (km^2) with dimensions of 70 kilometers (km) x 70 km.

A major grid system was then developed within the domain grid. The major grid system contains 49 - 10 km x 10 km grids. Each 100 km^2 grid contains a series of nested grids. Dimensions for each nested grid are 4 km^2 (i.e., identified in the ArcView 3.2 program as 2 km grids). Nested grids were developed only for regions of Cd. Juárez containing area and industrial source information obtained from the 2002 EI. This gridding system was arbitrarily selected to encompass the entire Paso del Norte region. The corner coordinate points for the domain grid are the following:

1. Northwest Limit: 370,000 W, 1,112,000 N
2. Northeast Limit: 440,000 W, 1,112,000 N
3. Southwest Limit: 370,000 W, 1,042,000 N
4. Southeast Limit: 440,000 W, 1,042,000 N

The region is also specified in the Appendix to Annex V of the La Paz Agreement[3]. According to the original Appendix to Annex V to the La Paz Agreement prior to establishment of the JAC, the region is defined as El Paso County, Texas; that part of the State of New Mexico that is both south of latitude 32 degrees 00 minutes North and east of longitude 106 degrees 40 minutes West; and that part of the State of Chihuahua that is both north of latitude 31 degrees 20 minutes North and east of longitude 106 degrees 40 minutes West. To the nearest approximation the geographic boundaries of this project include the following: The northern boundary of El Paso County, Texas which is latitude 32 degrees 00 minutes North; a part of Doña Ana County, New Mexico which is approximately 16km west of the western boundary of El Paso County and south of latitude 32 degrees 00 minutes North, the southern boundary of the Municipio of Cd. Juárez, and the eastern boundary of El Paso County, Texas.

2.3 Ground Proofing

Prior to initiation of the GIS mapping aspect of this project, over 1,100 facilities were screened and 165 small industrial facilities (i.e., defined as "area" sources) were surveyed in Cd. Juárez under W.O. #55. This GIS mapping project under W.O. #57 called for a systematic and complete review of all streets and neighborhoods of Cd. Juárez to locate area sources not specified in the EI database developed under W.O. #55 . Through this process, the location of over 1,100 additional facilities were identified ensuring the greatest

[3] Appendix I to Annex V of the Mexico-United States Agreement for Cooperation for the Protection and Improvement of the Environment in the Border Area, commonly known as the La Paz Agreement. The full agreement can be viewed at http://www.epa.gov/usmexicoborder/2001/ef.htm.

number of facilities would be included in the gridded area source EI for Cd. Juárez. After all sources were located and plotted on the GIS application, 2,242 facilities were identified.

A systematic sweep of Cd. Juárez roadways was conducted by utilizing the grid system overlay developed for this project. Each grid cell was systematically toured in search of all area source facilities. The investigator carried a tape recorder and a digital camera to document each site. While traversing the streets of Cd. Juárez information pertaining to each facility identified for this project was recorded onto tape including the sector being investigated, street address, nearest corner intersections, and any other identifiable descriptors. At the end of the day, tape recorded field data was transferred onto an Excel spreadsheet. Spreadsheets were sorted by source category to build a database for each type of industry under review.

3.0 Area Source Facilities

The area source EI conducted under W.O. #55 resulted in emissions estimates for 35 area source categories. PNEG developed GIS shape files for all source categories, which are identified in Table 1. Table 1 provides a sum of emissions based on the number of facilities surveyed and reported under W.O. #55.

The GIS "project", which is a file containing all thematic information related to sources, grids, icons, colors, etc. identifies the path where all files and directory structure related to the project are located. Each source category was developed into a unique database and GIS shape file located in a specific file directory. A directory was also developed containing all pictures taken of all sites identified in the GIS database. A CD containing all information related to the GIS aspect of this project may be obtained by contacting PNEG.

One aspect of ArcView 3.2 allows the addition of an image onto the working GIS map. Digital images taken by the field surveyor were inserted into specific directories. Using the Hot-Link icon in ArcView 3.2, one can activate a source category shape file by using the Hot-Link icon to click on the point and generate a GIF image of the facility. This allows the operator of the ArcView 3.2 GIS program to view images of the facility. The original image size was maintained in order to view a large-sized image of the facility. Sometimes GIS project development allows the operator to reduce the image size to a thumbnail image, but in general this project provides the full-screen image of the facility.

Table 1: Annual Emissions by Source Type 2002 Tons/Year									
Source Type	**Source Category**	**Number of Facilities Surveyed**	**NOx**	**SOx**	**CO**	**VOC**	**PM_{10}**	**$PM_{2.5}$**	**NH_3**
Industrial[$]	Asphalt	1	9.53	32.57	23.54	4.89	248.5	15.13	
Industrial	Autobody Shops	25				3.2			
Industrial	Bakeries	6	0.03		0.03	1.28			
Industrial	Brick Kilns[+]	285	28.5		1682.7	371.5	269.8	269.8	
Industrial	Concrete	2					4.74	3.2	
Industrial	Drycleaners	4				33.42			
Industrial	Foundries	3	0.2	0	27.6	0.1	13.1	9.6	
Industrial	Gas/Diesel Marketing	13				198.06			
Industrial	Grain Mills	2					684.2	0.3	
Industrial	Graphic Arts	11				1.4			
Industrial	Ice Plants	1							1.1
Industrial	Landfill	1					6	3.3	
Industrial	LPG Marketing	3				237.5			
Industrial	Restaurants	7	0.406		16.66	0.485	3.99	3.19	
Industrial	Rock Quarries	1					1.38	0.28	
Industrial	Street Vendors	73	0.31		15.86	1	7.97	6.37	
Industrial	Woodworking	5	0	0	0	0.003	0	0	
Industrial	WWTF	5	0.4	0.03	0.09	1352.89	0.03	0.03	
Area[*]	Ag Burning	NA			168	14	18	17	
Area	Ag Tilling	NA					581.1	128.8	
Area	Border Crossings	NA	128.2		9339.1	814.6			
Area	Construction (2000)	NA					77.4	16.1	
Area	Consumer Solvents	NA				4781.57			
Area	Domestic NH_3	NA							1118.7
Area	Fuel Comb (C/I)	NA	252.8	833.9	82.1	7.9	18.2	12.1	
Area	Fuel Comb (Res)	NA	973.1	52.2	28915.9	6629.3	3843.8	3701.5	
Area	Open Burning	NA	34.5	5.8	489	43.6	193.5	177.2	
Area	Fertilizers	NA							34.1
Area	Pesticides	NA				3.4			
Area	Feedlots/Dairies	NA					1011.6	151.7	
Area	Livestock	NA							2536.2
Area	Structural Fires	NA	0.1		5.2	0.3	0.3	0.3	
Area	Wind Erosion	NA					3687.8	817.6	
Area	Paved Roads	NA					3,689.6	882.3	
Area	Unpaved Roads	NA					14,981.2	2,189.6	

[$] Industrial sources: Emission totals of surveyed facilities.

[+]Total number of brick kilns reported in census indicated in footnote 2; emissions are based on 285 kilns and an average of 16.92 firings per kiln-year

*Area sources: Annual emissions averaged emissions by population.

Table 2: Total Emissions by Source Category*									
2002 Tons/Year									
Source Category	**NAICS #**	**Number of Facilities ID'd**	**NOx**	**SOx**	**CO**	**VOC**	**PM10**	**PM2.5**	**NH3**
Asphalt	324121	3	28.59	97.71	70.62	14.67	745.5	45.4	0.0
Autobody Shops	811121	182	0.0	0.0	0.0	23.3	0.0	0.0	0.0
Bakeries	311812	142	0.71	0.0	0.71	29.82	0.0	0.0	0.0
Brick Kilns	327121	285	28.5	0.0	1682.7	371.5	269.8	269.8	
Concrete	327230	11	0.0	0.0	0.0	0.0	52.14	17.6	0.0
Drycleaners	812320	41	0.0	0.0	0.0	342.6	0.0	0.0	0.0
Foundries	331511	3	0.2	0.0	27.6	0.1	13.1	9.6	0.0
Gas/Diesel Marketing	447190	99	0.0	0.0	0.0	1508.8	0.0	0.0	0.0
Grain Mills	311211	2	0.0	0.0	0.0	0.0	684.2	0.3	0.0
Graphic Arts	323116	75	0.0	0.0	0.0	9.55	0.0	0.0	0.0
Ice Plants	312113	6	0.0	0.0	0.0	0.0	0.0	0.0	6.6
Landfill	562212	1	0.0	0.0	0.0	0.0	6.0	3.3	0.0
LPG Marketing	454312	27	0.0	0.0	0.0	2137.6	0.0	0.0	0.0
Restaurants	722211	416	24.13	0.0	990.1	29.12	237.12	189.7	0.0
Rock Quarries	327122	9	0.0	0.0	0.0	0.0	12.42	2.7	0.0
Street Vendors	722330	894	3.8		194.23	12.25	97.6	78.01	0.0
Woodworking	321999	21	0.0	0.0	0.0	0.013	0.0	0.0	0.0
WWTF	221310	5	0.4	0.03	0.09	1352.9	0.03	0.03	0.0
Ag Burning	999994	NA			168	14	18	17	
Ag Tilling	999995	NA					581.1	128.8	
Border Crossings		NA	128.2		9339.1	814.6			
Construction (2000)		NA					77.4	16.1	
Consumer Solvents		NA				4781.57			
Domestic NH_3		NA							1118.7
Fuel Comb (C/I)		NA	252.8	833.9	82.1	7.9	18.2	12.1	
Fuel Comb (Res)		NA	973.1	52.2	28915.9	6629.3	3843.8	3701.5	
Open Burning	999990	NA	34.5	5.8	489	43.6	193.5	177.2	
Fertilizers	115112	NA							34.1
Pesticides	999993	NA				3.4			
Feedlots/Dairies	112120	NA					1011.6	151.7	
Livestock	115210	NA							2536.2
Structural Fires	999991	NA	0.1		5.2	0.3	0.3	0.3	
Wind Erosion	999996	NA					3687.8	817.6	
Paved Roads		NA					3,689.6	882.3	
Unpaved Roads		NA					14,981.2	2,189.6	
TOTALS			1,475.03	989.64	41,965.4	18,126.9	30,220.41	8,710.64	3,695.6

*Refer to Table 1: Industrial Sources: Averaged emissions by # of facilities. Brick kiln averages reported on Table 1 on a per-kiln basis. Area sources: Averaged emissions by population.

4.0 Emissions Allocation

Emissions from sources surveyed were summed and aggregated to the nested grids. Sources of information were the emissions estimates from the W.O. #55 EI report (*Development of an Area Source Emissions Inventory for Ciudad Juárez, Mexico; ERG, August 2003)*. Table 1 provides annual emissions estimates (tons per year) of criteria pollutants for each type of area source. Where emissions are profiled (i.e., identified under W.O. #57 but not surveyed under W.O. #55) an appropriate surrogate was used to assign emissions to similar facilities.

A challenge in assigning emissions was determining how emissions should be allocated to facilities where a high degree of uncertainty existed regarding the processes of the unsurveyed sources. For instance, in assigning emissions to gasoline stations where a broad range of annual sales (reported in millions of liters) was observed, a decision was made to allocate average emissions (as determined by the 2002 area source EI) to each facility identified, but not surveyed. PNEG visited all the gas stations in Juárez and counted dispensing nozzles to determine if a correlation may exist between annual volume sales and number of nozzles. Results of this survey will be provided in a follow-up report. PNEG also has undertaken a review of tortillerias in Cd. Juárez to add this category to the mix of area sources.

As observed in Table 1 and Table 2, the Cd. Juárez brick kilns are an important source of particulate matter 10 micrometers (μm) in aerodynamic diameter or smaller (PM_{10}), particulate matter 2.5 μm or smaller ($PM_{2.5}$), and carbon monoxide (CO). El Paso Electric

Company provided brick kiln emissions data.[4] EPE also conducted a census of brick kilns and developed emissions factors for this source category.[5] Cd. Juárez brick kilns each generate 1,682 tons per year (TPY) CO, 371 TPY of volatile organic compounds (VOC), 270 TPY of PM_{10}, and 270 of TPY $PM_{2.5}$. As noted in the gridded allocation of emissions in the next section, this source emits a high concentration of emissions in a small spatial area.

Another category identified as a potentially significant source of criteria air pollutants is open burning. While emissions may appear small as a function of individual source, the degree to which open burning by private individuals occurs within this city of 2 million inhabitants may indicate a public health issue is present given the materials burned. Included are plastics such as milk jugs, grocery bags, and diapers, plus other items such as news print, foam, food scraps, as well as used tires. While no visible signs of open burning were observed by the ground proofing team under W.O. #57 (although open burning was observed by the survey team under W.O. #55), the sweeps were conducted during the day while most open burning occurs during nighttime hours.

Another source for which data was not readily available was agriculture tilling as well as the spatial location of agricultural farming in Cd. Juárez and the adjacent Municipalities of of Guadalupe and P. Guerrero. The Secretariate of Agriculture (SAGARPA) has indicated an interest in providing this information at the nearest date practicable.

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[4] EPE, 2002. El Paso Electric Company. "Proposal for Using Credits from Emission Reductions Resulting from Brick Kiln Conversions in Ciudad Juárez, Mexico to Meet NOx Allowance Obligations under TNRCC's Senate Bill 7 Rules." El Paso, August, 2002.

[5] Census Update of Brick Producers in Ciudad Juárez, Chihuahua, ETM Consultores, S.A. de C.V.

5.0 Nested Grid Emissions Allocations

Emissions from each source category were allocated to all facilities under the similar source category. GIS shape files providing the allocation of emissions across the nested grids can be found in Appendix E. Three separate types of emissions allocation themes were developed. One shape file contains emissions information for each facility after being averaged. This process is discussed below. This particular shape file contains address, ID, grid location, a image path, and emissions values. A second shape file contains the allocated emissions of all similar source category facilities by grid. A final data set contains the summarized emissions of all facilities for specific emissions types (VOC or PM) within each specific grid.

5.1 Procedure to Allocate Source Category Emissions to Grids

Allocation of emissions to individual nested grids followed this procedure. Figures related to autobody shops can be viewed in Appendix B.

1. A spreadsheet is prepared for each source category (Figure B-1).
2. Emissions values are inserted into each source for each source category.
3. The working Excel spreadsheet is saved as a DBF file and placed in a directory specifying each specific source category.
4. The DBF file is joined to the point attribute shape file for the specific source category in order to attach emissions data to the GIS emissions (point) shape file.
5. The GEOPROCESSING Wizard found in ArcView 3.2 spatially joins the

emissions data to the 2 km grids.

6. Upon opening the point attribute table, data is summarized by grid identifier.
7. The emissions information is summarized by “sum”.
8. A sum*xxxxxx.dbf* file is created and placed into the specific source category folder (Figure B-2); The *xxxxxx* represent the NAICS code.
9. A copy of the 2 km shape file is copied and pasted into the ArcView 3.2 Table of Contents.
10. The copy of the 2 km shape file is opened and the data from the sum*xxxxxx*.dbf file is joined to the 2 km shape file (Figure B-3).
11. The attribute table that is created thru the join provides values of the total emissions of each source category within each grid (Figure B-4).

5.2 Procedure to Allocate Emissions by Population

Emissions from sources such as fuel combustion (from commercial, institutional and residential sources), consumer solvents, and domestic ammonia (NH_3) were allocated by population to the grids using the following procedure.

1. The AGEB (Area Geografica de Estadistica Basica - Basic Statistical Geographic Area - a U.S. census block group equivalent) thematic map for Cd. Juárez is opened along with the 2 km grid theme. Attributes of each AGEB polygon in the AGEB theme include population information.
2. Each AGEB is joined to the grid in which its centroid is located. Several AGEBs may be joined to each 2 km grid.

3. Population information for all AGEBs within each grid is summed to obtain a total population value for each grid.
4. Population values are assigned to each grid by normalizing the grid population to total population. This provides a percentage of total population to each grid.
5. Total emission values reported in Table 1 for population-based emissions are allocated to each 2 km grid by multiplying the normalized grid population value to the emissions value. This provides a total emissions value across all grids in Cd. Juárez.

5.3 Procedure to Allocate Emissions by Roadway Classification

Allocation of Cd. Juárez roadway dust emissions followed this procedure.

1. The Cd. Juárez street basemap theme is opened under the 2 km grid theme.
2. The Cd. Juárez street basemap attribute showing paved and unpaved street classifications is displayed.
3. Street segments are joined to the grid in which they are located.
4. Length of segments for each specific classification (paved or unpaved) are summed up in each grid and the length of segments of each classification in each grid are normalized to the total length of segments for each classification. This provides a percentage of classification segments.
5. Total emissions reported in Table 1 are allocated to each grid based on the percentage of street lengths allocated to each grid.

5.4 Procedure to Allocate Emissions Across All Source Categories

Allocation of emissions from all sources to individual nested grids representing all criteria pollutants followed this procedure. Maps representing emissions allocations for all pollutants are found in Appendix F.

1. A spreadsheet is prepared which includes all emissions values for all source categories.
2. Emissions values from the area source EI are inserted into each source in order to provide an average value across the board for each source category.
3. The working Excel spreadsheet is saved as a DBF file and placed in a directory specifying each specific source category.
4. The DBF file is joined to the point attribute shape file for the specific source category in order to attach emissions data to the GIS emissions (point) shape file.
5. The GEOPROCESSING Wizard found in ArcView 3.2 spatially joins the emissions data to the 2 km grids (Figure 3).
6. Upon opening the point attribute table, data is summarized by grid identifier;
7. The emissions information is summarized by “sum”.
8. A sum*xxxx.*dbf file is created which is placed into the specific source category folder for all sources;
9. A copy of the 2 km shape file is copied and pasted into the ArcView 3.2 Table of Contents;

10. The copy of the 2 km shape file is opened and the data from the sum*xxxx*.dbf file is joined to the 2 km shape file;

11. Separate shape files are prepared for each criteria pollutant.

12. Emissions allocations obtained under sections 5.2 and 5.3 for populations and street segments are added to emissions from the point thematic maps to present total emissions allocations.

6.0 Conclusions and Recommendations

This project demonstrates the ability of GIS software to allocate small industrial and area-wide source emissions within the Cd. Juárez region. This ability to allocate emissions will be an important tool in developing data for input to air dispersion models as well as for photochemical models used to predict concentrations of such as ozone.

Also, pollutants such as CO, NO_x, and SO_2 (in addition to PM_{10} and $PM_{2.5}$) were presented in separate gridded maps for all the identified source categories. It is recommended that several issues related to additional area source EI development and spatial allocation of emissions be examined as part of any future update to this inventory; these include:

- Development of more accurate data in order to allocate pollutants where source volumes vary to a high degree. Among these are gasoline stations as indicated earlier.
- Estimation of emissions from some source types which have not previously be inventoried and spatially located, and which may contribute to atmospheric photochemical interactions. These include water wells where 1,000 liter chlorine tanks are deployed for water disinfection. Also, previously undetected chlorine fugitive emissions may be spatially located throughout Cd. Juárez for possible addition to the mix of area sources.
- Air quality planning agencies may consider continuing efforts to obtain GPS coordinates for as many sources as possible in order to more accurately identify the specific points of all emissions.

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APPENDIX

Appendix A: Source Identification using NAICS

Table 3: Industry Listing by NAICS and Identifier			
Identifier	**Type of Industry**	**NAICS**	**Total**
ASPH	Batch and Asphalt Plant	324121	3
AUTO	Paint Bodyshops	811121	182
BAKE	Bakeries	311812	142
BRIC	Brick kilns	327121	325
BUST	Bus Terminals (National & Local)	488490	1
CONC	Cement / Concrete Manufacturing	327230	11
DRYC	Drycleaning	812320	41
FERT	Ag. Fertilizer Application	115112	16
GASD	Gasoline Stations	447190	99
GRAF	Graphic Arts	323116	75
GRAI	Grain Mills	311211	2
ICE	Ice Manufacturing	312113	6
LPGM	LP Gas Distributing	454312	27
LUMB	Dimensional Lumber	321113	24
META	Metal Foundries	331511	3
QUAR	Quarries	327122	9
REST	Restaurants	722211	416
TORT	Tortilla manufacturing	311830	188
VEND	Street Vendors using Charcoal	722330	894
WOOD	Woodworking	321999	21
WWTP	Water Treatment Plant	221310	5
Q	Open Burning of Trash	999990	0
S	Landfills	562212	1
#	Structural Fires	999991	0
±	Agricultural Cultivation	999992	0
V	Ag. Pesticide Application	999993	0
W	Ag Burning	999994	0
Y	Dairy	112120	0
Z	Livestock	115210	0

Source: North American Industry Classification System (NAICS) URL: http://www.census.gov/epcd/www/naics.html

ASPHALT MANUFACTURING / BATCH PLANTS

324121 Asphalt Paving Mixture and Block Manufacturing
This U.S. industry comprises establishments primarily engaged in manufacturing asphalt and tar paving mixtures and blocks from purchased asphaltic materials.

AUTOBODY REFINISHING

811121 Automotive Body, Paint, and Interior Repair and Maintenance
This U.S. industry comprises establishments primarily engaged in repairing or customizing automotive vehicles, such as passenger cars, trucks, and vans, and all trailer bodies and interiors; and/or painting automotive vehicles and trailer bodies.

BAKERIES

311812 Commercial Bakeries
This U.S. industry comprises establishments primarily engaged in manufacturing fresh and frozen bread and bread-type rolls and other fresh bakery (except cookies and crackers) products.

BRICK MANUFACTURING

327121 Brick and Structural Clay Tile Manufacturing
This U.S. industry comprises establishments primarily engaged in manufacturing brick and structural clay tiles.

BUS TERMINALS

488490 Other Support Activities for Road Transportation
This industry comprises establishments primarily engaged in providing services (except motor vehicle towing) to road network users.

CATTLE FEEDLOTS & DAIRIES (PM10)

112120 Dairy Cattle and Milk Production
This industry comprises establishments primarily engaged in milking dairy cattle.

CHARBROILING (BEEF/CHICKEN/PORK)

112320 Broilers and Other Meat Type Chicken Production
This industry comprises establishments primarily engaged in raising broilers, fryers, roasters, and other meat type chickens.

CONCRETE BATCH PLANTS

327320 Ready-Mix Concrete Manufacturing
This industry comprises establishments, such as batch plants or mix plants, primarily engaged in manufacturing concrete delivered to a purchaser in a plastic and unhardened state. Ready-mix concrete manufacturing establishments may mine, quarry, or purchase sand and gravel.

DRY CLEANING

812320 Dry cleaning and Laundry Services (except Coin-Operated)
This industry comprises establishments primarily engaged in one or more of the following: (1) providing drycleaning services (except coin-operated); (2) providing laundering services (except linen and uniform supply or coin-operated); (3) providing dropoff and pickup sites for laundries and/or drycleaners; and (4)

providing specialty cleaning services for specific types of garments and other textile items (except carpets and upholstery), such as fur, leather, or suede garments; wedding gowns; hats; draperies; and pillows. These establishments may provide all, a combination of, or none of the cleaning services on the premises.

FERTILIZER APPLICATION

115112 Soil Preparation, Planting, and Cultivating
This U.S. industry comprises establishments primarily engaged in performing a soil preparation activity or crop production service, such as plowing, fertilizing, seed bed preparation, planting, cultivating, and crop protecting services.

GASOLINE MARKETING & DISTRIBUTION

447110 Gasoline Stations with Convenience Stores
This industry comprises establishments engaged in retailing automotive fuels (e.g., diesel fuel, gasohol, gasoline) in combination with convenience store or food mart items. These establishments can either be in a convenience store (i.e., food mart) setting or a gasoline station setting. These establishments may also provide automotive repair services.

447190 Other Gasoline Stations

This industry comprises establishments known as gasoline stations (except those with convenience stores) primarily engaged in one of the following: (1) retailing automotive fuels (e.g., diesel fuel, gasohol, gasoline) or (2) retailing these fuels in combination with activities, such as providing repair services; selling automotive oils, replacement parts, and accessories; and/or providing food services.

GRAIN MILLS

311211 Flour Milling

This U.S. industry comprises establishments primarily engaged in (1) milling flour or meal from grains (except rice) or vegetables and/or (2) milling flour and preparing flour mixes or doughs.

GRAPHIC ARTS

323117 Books Printing

This U.S. industry comprises establishments primarily engaged in printing or printing and binding books and pamphlets without publishing.

323116 Manifold Business Forms Printing

This U.S. industry comprises establishments primarily engaged in printing special forms, including checkbooks, for use in the operation of a business. The forms may be in single and multiple sets, including carbonized, interleaved with carbon, or otherwise processed for multiple reproduction.

ICE PLANTS

312113 Ice Manufacturing

This U.S. industry comprises establishments primarily engaged in manufacturing ice.

LANDFILL

562212 Solid Waste Landfill

This U.S. industry comprises establishments primarily engaged in (1) operating landfills for the disposal of nonhazardous solid waste or (2) the combined activity of collecting and/or hauling nonhazardous waste materials within a local area and operating landfills for the disposal of nonhazardous solid waste.

LPG MARKETING & DISTRIBUTION

454312 Liquefied Petroleum Gas (Bottled Gas) Dealers

This U.S. industry comprises establishments primarily engaged in retailing liquefied petroleum (LP) gas via direct selling.

LIVESTOCK NH3

115210 Support Activities for Animal Production

This industry comprises establishments primarily engaged in performing support activities related to raising livestock (e.g., cattle, goats, hogs, horses, poultry, sheep). These establishments may perform one or more of the following: (1) breeding services for animals, including companion animals (e.g., cats, dogs, pet birds); (2) pedigree record services; (3) boarding horses; (4) dairy herd improvement activities; (5) livestock spraying; and (6) sheep dipping and shearing.

LUMBER MANUFACTURING / MILL OPERATIONS

321113 Sawmills

This U.S. industry comprises establishments primarily engaged in sawing dimension lumber, boards, beams, timbers, poles, ties, shingles, shakes, siding, and wood chips from logs or bolts. Sawmills may plane the rough lumber that they make with a planing machine to achieve smoothness and uniformity of size.

METALWORKING FOUNDRIES

331511 Iron Foundries

This U.S. industry comprises establishments primarily engaged in pouring molten pig iron or iron alloys into molds to manufacture castings, (e.g., cast iron man-hole covers, cast iron pipe, cast iron skillets). Establishments in this industry purchase iron made in other establishments.

OPEN BURNING

RESTAURANTS

722211 Limited-Service Restaurants

This U.S. industry comprises establishments primarily engaged in providing food services (except snack and nonalcoholic beverage bars) where patrons generally order or select items and pay before eating. Food and drink may be consumed on premises, taken out, or delivered to the customer's location. Some establishments in this industry may provide these food services in combination with selling alcoholic beverages

ROCK QUARRIES

327122 Ceramic Wall and Floor Tile Manufacturing

This U.S. industry comprises establishments primarily engaged in manufacturing ceramic wall and floor tiles.

327123 Other Structural Clay Product Manufacturing

This U.S. industry comprises establishments primarily engaged in manufacturing clay sewer pipe, drain tile, flue lining tile, architectural terra-cotta, and other structural clay products.

STREET VENDORS

722330 Mobile Food Services

This industry comprises establishments primarily engaged in preparing and serving meals and snacks for immediate consumption from motorized vehicles or nonmotorized carts. The establishment is the central location from which the caterer route is serviced, not each vehicle or cart. Included in this industry are establishments primarily engaged in providing food services from vehicles, such as hot dog carts, and ice cream trucks.

SUPERMARKETS

445110 Supermarkets and Other Grocery (except Convenience) Stores

This industry comprises establishments generally known as supermarkets and grocery stores primarily engaged in retailing a general line of food, such as canned and frozen foods; fresh fruits and vegetables; and fresh and prepared meats, fish, and poultry. Included in this industry are delicatessen-type establishments primarily engaged in retailing a general line of food.

TORTILLERIAS

311830 Tortilla Manufacturing

This industry comprises establishments primarily engaged in manufacturing tortillas.

WASTEWATER TREATMENT

221310 Water Supply and Irrigation Systems

This industry comprises establishments primarily engaged in operating water treatment plants and/or operating water supply systems. The water supply system may include pumping stations, aqueducts, and/or distribution mains. The water may be used for drinking, irrigation, or other uses.

WOODWORKING / WOOD COATING

321999 All Other Miscellaneous Wood Product Manufacturing

This U.S. industry comprises establishments primarily engaged in manufacturing wood products (except establishments operating sawmills and preservation facilities; establishments manufacturing veneer, engineered wood products, millwork, wood containers, pallets, and wood container parts; and establishments making manufactured homes (i.e., mobile homes) and prefabricated buildings and components).

321912 Cut Stock, Resawing Lumber, and Planing

This U.S. industry comprises establishments primarily engaged in one or more of the following: (1) manufacturing dimension lumber from purchased lumber; (2) manufacturing dimension stock (i.e., shapes) or cut stock; (3) resawing the output of sawmills; and (4) planing purchased lumber. These establishments generally use woodworking machinery, such as jointers, planers, lathes, and routers to shape wood.

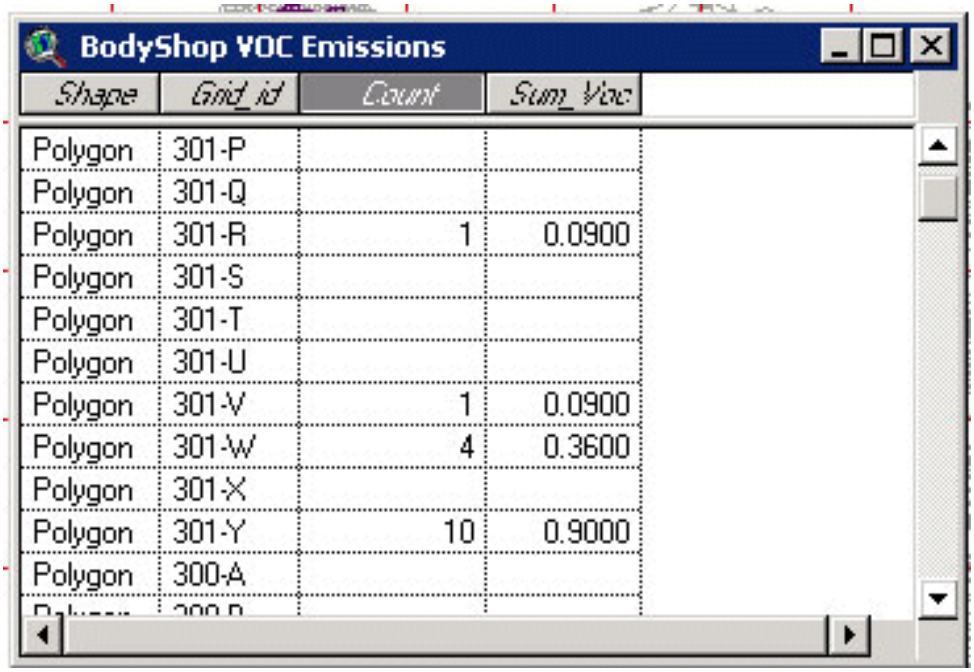
Appendix B: Allocation of Criteria Pollutant Emissions by Source Category

Figure B-1: Source Category Attribute Information

F10

	A	B	C
1	**ID**	**Production**	**VOC**
2	AUTO-013	52	0.021
3	AUTO-006	52	0.022
4	AUTO-001	52	0.035
5	AUTO-022	104	0.037
6	AUTO-017	117	0.044
7	AUTO-002	9	0.053
8	AUTO-021	52	0.054
9	AUTO-003	117	0.056
10	AUTO-004	208	0.061
11	AUTO-010	141	0.062
12	AUTO-015	156	0.065
13	AUTO-025	104	0.069
14	AUTO-014	52	0.070
15	AUTO-007	156	0.072
16	AUTO-024	117	0.077
17	AUTO-009	208	0.098
18	AUTO-008	176	0.099
19	AUTO-023	65	0.100
20	AUTO-005	52	0.103
21	AUTO-012	52	0.158
22	AUTO-016	141	0.162
23	AUTO-011	156	0.218
24	AUTO-019	208	0.344
25	**Average**		**0.090**
26			

Figure B-2: Source Category Emissions Allocated to Grids



Shape	Grid_id	Count	Sum_Voc
Polygon	301-P		
Polygon	301-Q		
Polygon	301-R	1	0.0900
Polygon	301-S		
Polygon	301-T		
Polygon	301-U		
Polygon	301-V	1	0.0900
Polygon	301-W	4	0.3600
Polygon	301-X		
Polygon	301-Y	10	0.9000
Polygon	300-A		

Figure B-3: Datasets required to allocate Emissions to Grids

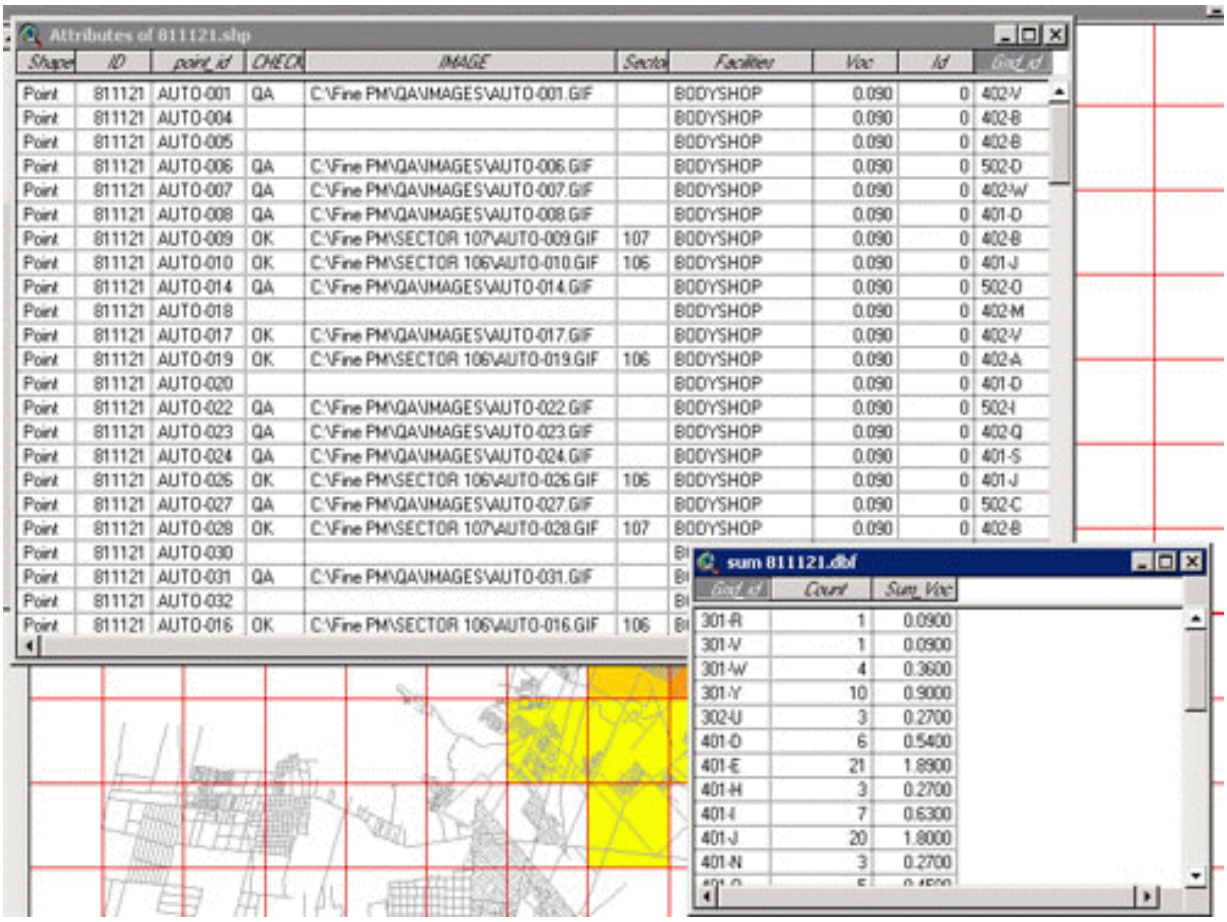
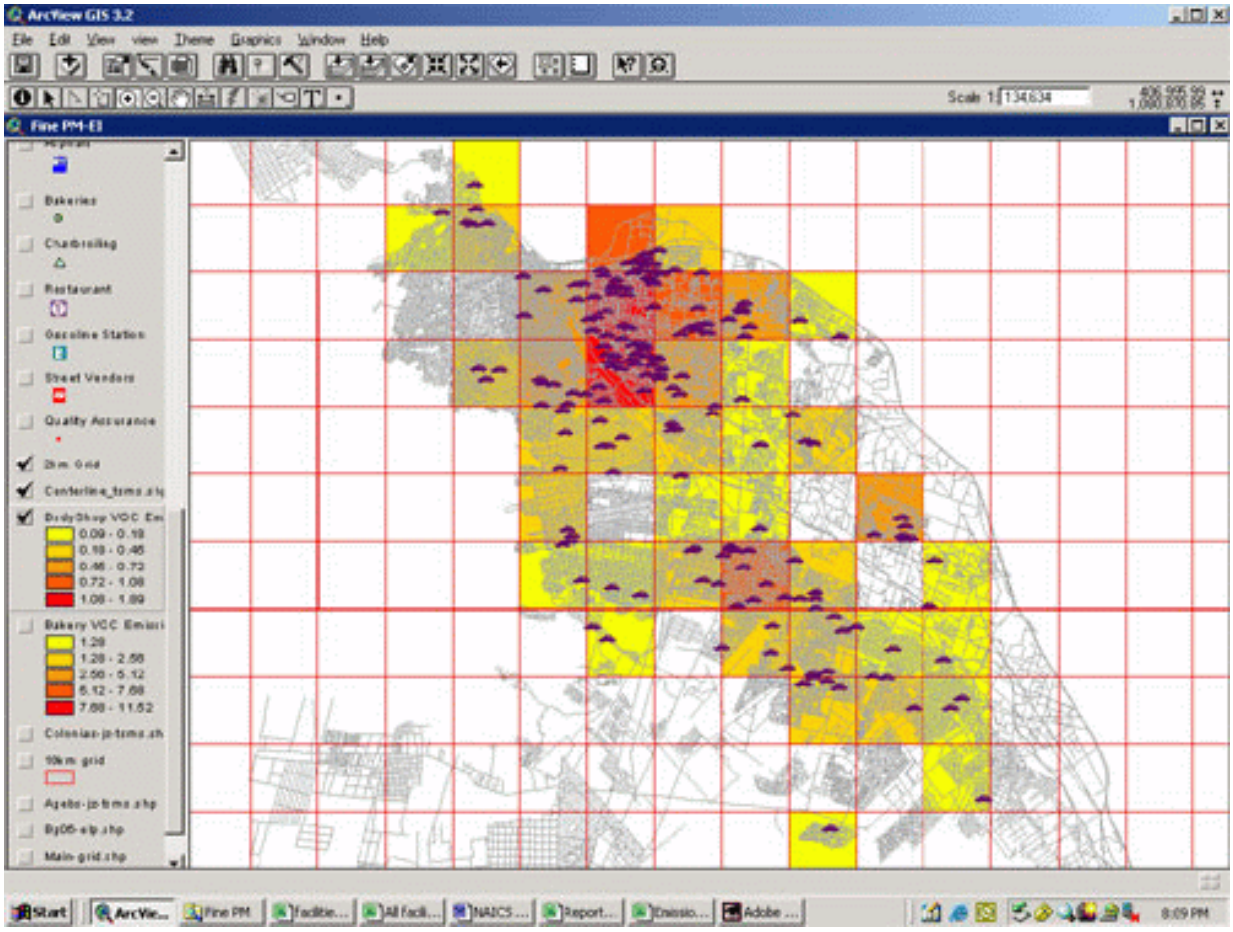


Figure B-4: Final Product - Emissions Allocations to Grids by Source Category



Appendix C: Cd. Juárez Basemap and Grids

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Map C-1: Cd. Juárez Base Map

Map C-2: Domain Grid

Map C-3: Major Grids 100Km^2

Map C-4: Nested Grids 4Km^2

Appendix D: Location of Industrial Facilities by Source Category

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Map D1: Points of All Sources
Map D2: Asphalt
Map D3: Auto Bodyshops
Map D4: Bakeries
Map D5: Brick kilns
Map D6: Bus Stations
Map D7: Concrete
Map D8: Dairies
Map D9: Dimensional Lumber
Map D10: Dry Cleaners
Map D11: Fertilizer
Map D12: Foundries
Map D13: Gasoline Stations
Map D14: Grain Mills
Map D15: Graphic Arts
Map D16: Ice Plants
Map D17: International Bridges
Map D18: Landfills
Map D19: LP Gas
Map D20: Quality Assurance
Map D21: Restaurants
Map D22: Rock Quarries
Map D23: Street Vendors
Map D24: Tortillerias
Map D25: Water Treatment
Map D26: Woodworking

Appendix E: Gridded Emissions Allocations by Category and Criteria Pollutant

Table 4: Index of Maps by Source Category and Emissions			
Source Category	**e-File Name**	**Pollutant**	**Location**
Asphalt	co asphalt.jpg	CO	Appendix E
Asphalt	nox asphalt.jpg	NOx	Appendix E
Asphalt	pm10 asphalt.jpg	PM10	Appendix E
Asphalt	pm25 asphalt.jpg	PM2.5	Appendix E
Asphalt	sox asphalt.jpg	SOx	Appendix E
Asphalt	vox asphalt.jpg	VOC	Appendix E
Auto Bodyshops	voc autobody shops.jpg	VOC	Appendix E
Bakeries	co bakeries.jpg	CO	Appendix E
Bakeries	nox bakeries.jpg	NOx	Appendix E
Bakeries	voc bakeries.jpg	VOC	Appendix E
Border Crossings	co border crossings.jpg	CO	Appendix E
Border Crossings	nox border crossings.jpg	NOx	Appendix E
Border Crossings	voc border crossings.jpg	VOC	Appendix E
Brick Kilns	co brick kilns.jpg	CO	Appendix E
Brick Kilns	nox brick kilns.jpg	NOx	Appendix E
Brick Kilns	pm10 brick kilns.jpg	PM10	Appendix E
Brick Kilns	pm25 brick kilns.jpg	PM2.5	Appendix E
Brick Kilns	voc brick kilns.jpg	VOC	Appendix E
Concrete	pm10 concrete.jpg	PM10	Appendix E
Concrete	pm25 concrete.jpg	PM2.5	Appendix E
Construction	pm10 construction.jpg	PM10	Appendix E
Construction	pm25 construction.jpg	PM2.5	Appendix E
Consumer Solvents	voc consumer solvents.jpg	VOC	Appendix E
Dairies	pm10 dairies.jpg	PM10	Appendix E
Dairies	pm25 dairies.jpg	PM2.5	Appendix E
Domestic NH3	nh3 domestic.jpg	NH3	Appendix E
Dry Cleaners	voc dry cleaners.jpg	VOC	Appendix E
Fertilizers	nh3 fertilizers.jpg	NH3	Appendix E
Foundries	co foundries.jpg	CO	Appendix E
Foundries	nox foundries.jpg	NOx	Appendix E
Foundries	pm10 foundries.jpg	PM10	Appendix E
Foundries	pm25 foundries.jpg	PM2.5	Appendix E
Foundries	voc foundries.jpg	VOC	Appendix E
Fuel Combustion (c/ i)	co fuel comb ci.jpg	CO	Appendix E
Fuel Combustion (c/ i)	nox fuel comb ci.jpg	NOx	Appendix E
Fuel Combustion (c/ i)	pm10 fuel comb ci.jpg	PM10	Appendix E
Fuel Combustion (c/ i)	pm25 fuel comb ci.jpg	PM2.5	Appendix E
Fuel Combustion (c/ i)	sox fuel comb ci.jpg	SOx	Appendix E
Fuel Combustion (c/ i)	voc fuel com ci.jpg	VOC	Appendix E
Fuel Combustion (res)	co fuel comb res.jpg	CO	Appendix E
Fuel Combustion (res)	nox fuel comb res.jpg	NOx	Appendix E
Fuel Combustion (res)	pm10 fuel comb res.jpg	PM10	Appendix E

Fuel Combustion (res)	pm25 fuel comb res.jpg	PM2.5	Appendix E
Fuel Combustion (res)	sox fuel comb res.jpg	SOx	Appendix E
Fuel Combustion (res)	voc fuel comb res.jpg	VOC	Appendix E
Gasoline	voc gasoline.jpg	VOC	Appendix E
Grain Mills	pm10 grain mills.jpg	PM10	Appendix E
Grain Mills	pm25 grain mills.jpg	PM2.5	Appendix E
Graphic Arts	voc graphic arts.jpg	VOC	Appendix E
Ice Plants	nh3 ice plants.jpg	NH3	Appendix E
Landfills	pm10 landfill.jpg	PM10	Appendix E
Landfills	pm25 landfill.jpg	PM2.5	Appendix E
Livestock	nh3 livestock.jpg	NH3	Appendix E
LP Gas	voc lp gas.jpg	VOC	Appendix E
Open Burning	co open burning.jpg	CO	Appendix E
Open Burning	nox open burning.jpg	NOx	Appendix E
Open Burning	pm10 open burning.jpg	PM10	Appendix E
Open Burning	pm25 open burning.jpg	PM2.5	Appendix E
Open Burning	sox open burning.jpg	SOx	Appendix E
Open Burning	voc open burning.jpg	VOC	Appendix E
Paved Roads	pm10 paved roads.jpg	PM10	Appendix E
Paved Roads	pm25 paved roads.jpg	PM2.5	Appendix E
Restaurants	co restaurants.jpg	CO	Appendix E
Restaurants	nox restaurants.jpg	NOx	Appendix E
Restaurants	pm10 restaurants.jpg	PM10	Appendix E
Restaurants	pm25 restaurants.jpg	PM2.5	Appendix E
Restaurants	voc restaurants.jpg	VOC	Appendix E
Rock Quarries	pm10 quarries.jpg	PM10	Appendix E
Rock Quarries	pm25 quarries.jpg	PM2.5	Appendix E
Street Vendors	co street vendors.jpg	CO	Appendix E
Street Vendors	nox street vendors.jpg	NOx	Appendix E
Street Vendors	pm10 street vendors.jpg	PM10	Appendix E
Street Vendors	pm25 street vendors.jpg	PM2.5	Appendix E
Structural Fires	co structural fires.jpg	CO	Appendix E
Structural Fires	nox structural fires.jpg	NOx	Appendix E
Structural Fires	pm10 structural fires.jpg	PM10	Appendix E
Structural Fires	pm25 structural fires.jpg	PM2.5	Appendix E
Structural Fires	voc structural fires.jpg	VOC	Appendix E
Unpaved Roads	pm10 unpaved roads.jpg	PM10	Appendix E
Unpaved Roads	pm25 unpaved roads.jpg	PM2.5	Appendix E
Water Treatment	co water treatment.jpg	CO	Appendix E
Water Treatment	nox water treatment.jpg	NOx	Appendix E
Water Treatment	pm10 water treatment.jpg	PM10	Appendix E
Water Treatment	pm25 water treatment.jpg	PM2.5	Appendix E
Water Treatment	sox water treatment.jpg	SOx	Appendix E
Water Treatment	voc water treatment.jpg	VOC	Appendix E
Woodworking	voc woodworking.jpg	VOC	Appendix E

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Appendix F: Gridded Allocation of All Emissions by Criteria Pollutant

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Map F-1: CO Emissions

Map F-2: NH_3 Emissions

Map F-3: PM_{10} Emissions

Map F-4: $PM_{2.5}$ Emissions

Map F-5: SO_2 Emissions

Map F-6: VOC Emissions