Section 7.8 COUNTY-SPECIFIC DIURNAL TEMPERATURE PROFILES

This section describes how the average monthly and episodic hourly county specific diurnal temperature profiles were developed for EMFAC2000.

7.8.1 Introduction

Diurnal, resting loss and hot soak emission factors used in the Motor Vehicle Emission Inventory (MVEI) model require county-specific, diurnal temperature profiles. The previous model (MVEI7G) averaged hourly ambient temperature data for monitoring stations in the State to produce county-specific summer or winter temperature profiles, aggregated into six time periods (0000-0600, 0600-0900, 0900-1200, 1200-1500, 1500-1800, 1800-2400 hours). Hourly temperature data used in development of these profiles were obtained for the period 1987-1989 from the following sources: ARB and District monitoring stations, the National Weather Service (NWS), the California Irrigation Management Information System (CIMIS), and the California Data Exchange Center (CDEC). By averaging temperature data for either the ten highest ozone (O_3) or carbon monoxide (CO) days, the summer and winter temperature profiles were supposed to reflect temperature conditions during O_3- and CO-episodes, respectively. Slightly different methodologies were used in developing county-specific summer and winter temperature profiles. Summer temperature profiles were calculated by averaging all the hourly temperature data within an air basin and then assigning that profile to all counties or portions of counties within that air basin. In contrast, county-specific winter temperature profiles were based solely on data from stations within each county. For those counties containing no temperature monitoring stations, temperature profiles from neighboring counties within the same air basin were assigned.

There were a number of possible flaws in the previous methodology for calculating county-specific temperature profiles. First, the previous temperature profiles reflect O_3- or CO-episode temperature conditions rather than <u>average</u> summer or winter temperatures. This may leaded to inaccurate estimation of evaporative emissions for inventory purposes. Second, the previous methodology calculates county-specific temperatures by taking a simple arithmetic average of all the station data within a given county, without regard for the spatial distribution of monitoring stations. For counties with no monitoring stations, temperature profiles were assigned the temperature profile of an adjacent county with monitoring stations. County-specific temperature profiles developed in this manner reflect the temperatures in the immediate vicinity of the monitoring station, not necessarily the ambient temperatures experienced by the vehicle fleet in a given county. Third, aggregating the hourly temperature data into six periods reduced the temporal resolution inherent in the original database. This increased the difficulty of accurately defining the breakpoint between diurnal and resting loss portions of the diurnal profile. In addition, performing multi-day diurnal evaporative emissions tests requires hourly diurnal temperature profiles, as opposed to the previous aggregated diurnal profiles. Fourth, the previous summer and winter temperature profiles were not representative of either spring or fall temperature conditions, thus yielding inaccurate evaporative emissions estimates for these seasons.

7.8.2 Methodology

This section describes a revised methodology for producing spatially- and temporally-resolved average monthly, as well as O_3- and CO-episode day, diurnal temperature profiles for California. Implementation of this methodology required the use of ARC/INFO, a geographic information system (GIS) software package used for spatial data analysis and modeling, and SAS, a statistical software package.

7.8.3 Development of Average Monthly Diurnal Temperature Profiles

Specific steps involved in development of average monthly diurnal temperature profiles are described below and illustrated in Figure 7.8-1.

1. Hourly temperature data from a total of 323 meteorological stations were compiled as the basis for the spatially- and temporally-resolved temperature profiles. The following data sources were used: 1) 94 CIMIS agricultural stations for the period 1988-1993; 2) 195 California Department of Forestry (CDF) meteorological stations for the period 1992-1993; 3) 17 NWS weather buoys for the period 1992-1993; and 4) 16 National Climatic Data Center (NCDC) meteorological stations for various years between 1949 and 1970. In addition, for those few boundary areas where no actual stations existed, 2 boundary condition or "pseudo" stations were established, using temperature data from the nearest CIMIS or NCDC station, such that spatial interpolation beyond the boundaries of California could be completed.

2. For each station, all available days of hourly temperature data were averaged by hour and month using SAS to produce station-specific monthly diurnal temperature profiles.

   Of the 323 stations used, the majority were located below 1000 ft (330 m) elevation, however, the mean elevation for the State is 2900 ft (880 m). As temperature generally decreases with increasing elevation, a simple spatial interpolation using the reported average station temperatures would result in an overestimation of interpolated temperature in mountainous portions of California. Therefore, prior to spatial interpolation of the temperature data, the averaged station temperatures were corrected to sea-

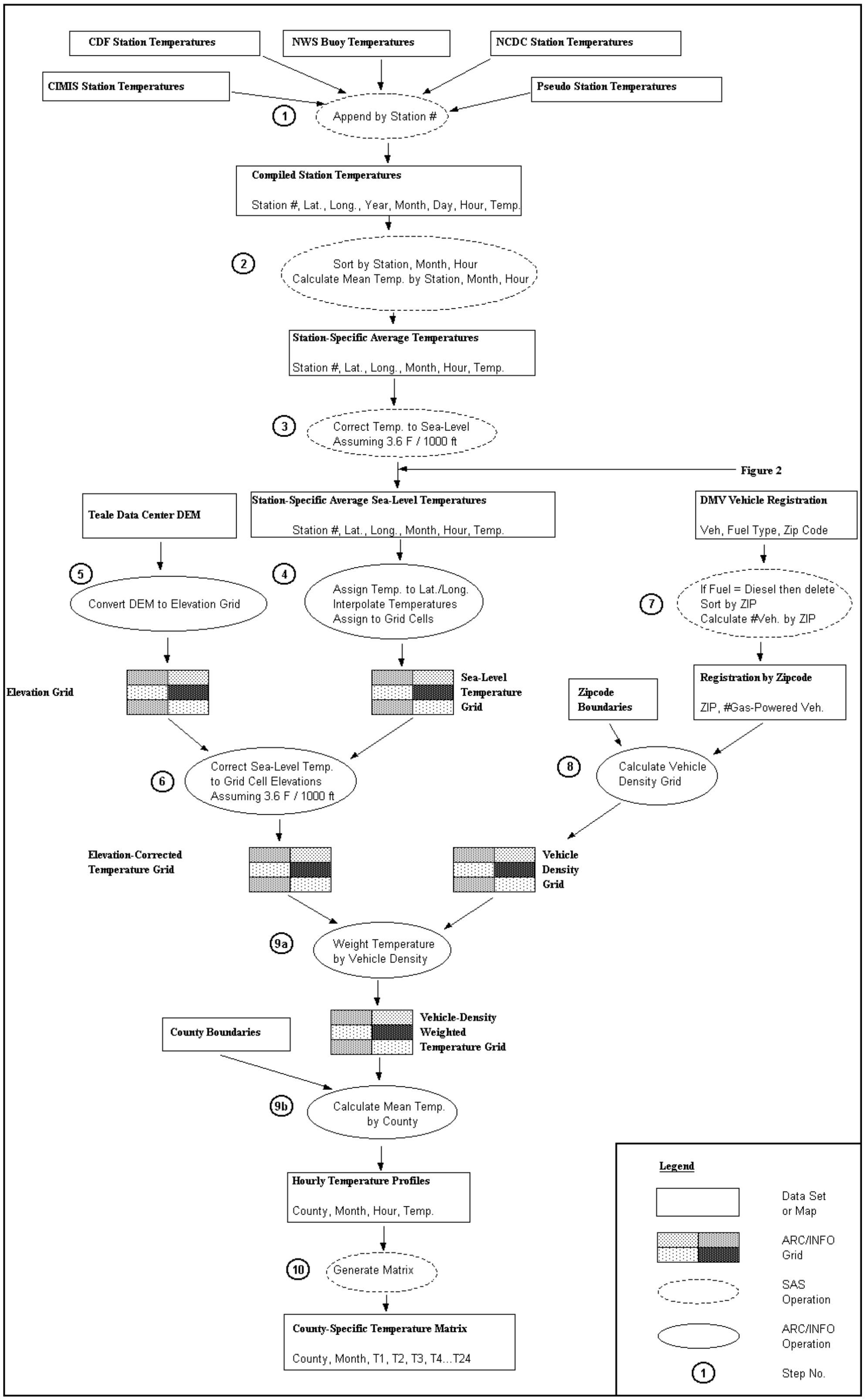

Figure 7.8-1 Flowchart showing methodology used in developing hourly, county-specific diurnal temperature profiles, corrected for elevation effects and vehicle density.

level, using the known elevations of the stations and calculated monthly temperature lapse rates.

The temperature lapse rates used were empirically derived based on the hourly CDF dataset. This dataset was used because the large number of stations included (195) were located at a wide range of elevations and the data were collected for the same time period. Average monthly lapse rates were calculated by averaging all available days of hourly temperature data by station and then a linear regression model was used to estimate change in temperature with elevation. The average monthly temperature lapse rates used in this analysis are shown in Table 7.8-1.

Table 7.8-1 Monthly and O3- and CO-episode temperature lapse rates estimated from hourly CDF temperature data for the period 1992-1993.

		degrees F/1000 feet
Monthly	January	2.2
	February	3.3
	March	3.0
	April	2.5
	May	2.1
	June	2.2
	July	1.7
	August	1.6
	September	1.7
	October	2.4
	November	2.8
	December	2.8
Episodic	O_3	2.1
	CO	2.6

3. For each hour of each month, the following procedure was repeated using ARC/INFO:

   a. The station-specific, averaged sea-level temperatures were assigned to the geographic location of each station.

   b. Using an inverse-distance weighted algorithm, the sea-level temperatures were interpolated between stations, producing a gridded sea-level temperature map with a 500 m resolution and approximately 1,635,000 grid cells total.

5. Based on a digital elevation model (DEM) of California obtained from the Teale Data Center (TDC), a gridded elevation map with a 72 m resolution was produced.

6. For each hour of each month, the following procedure was repeated:

   a. Applying empirically-derived temperature lapse rate (Table 7.8-1) used in the correction of the average station temperatures to sea-level , the sea-level temperature map was overlayed over the elevation map to produce a gridded elevation-corrected temperature map.

7. Using a July 1995 Department of Motor Vehicles (DMV) database, the number of gasoline-powered vehicles (with current and lapsed registration) in each of the 1551 ZIP codes in the State was calculated.

8. Based on the zipcode-specific vehicle registrations and a map of ZIP code boundaries, a gridded vehicle-density map of California with a 500 m resolution was produced.

9. For each hour of each month, the following procedure was repeated:

   a. The vehicle-density map was overlaid over the elevation-corrected temperature map and the temperature of each grid cell was weighted by the number of vehicles in that grid cell.

   b. A map of county boundaries was overlaid over the elevation-corrected, vehicle-density weighted temperature map, and the mean temperature of all grid cells falling within the boundaries of each county was calculated. The resultant county-specific temperature is an area-weighted average of all the grid cells within a given county, taking into account the effects of elevation on temperature, as well as the density distribution of vehicles in the county.

10. The results were compiled to produce a matrix of hourly average ambient temperature, grouped by month and county.

7.8.4 Development of O_3- and CO-episode Day Diurnal Temperature Profiles

County-specific diurnal temperature profiles for O_3- and CO-episode days were calculated by selecting from the compiled temperature dataset those days of temperature data coinciding with documented O_3- and CO-episode days. The specific steps involved in developing O_3- and CO-episode day diurnal temperature profiles are described below and shown in Figure 7.8-2.

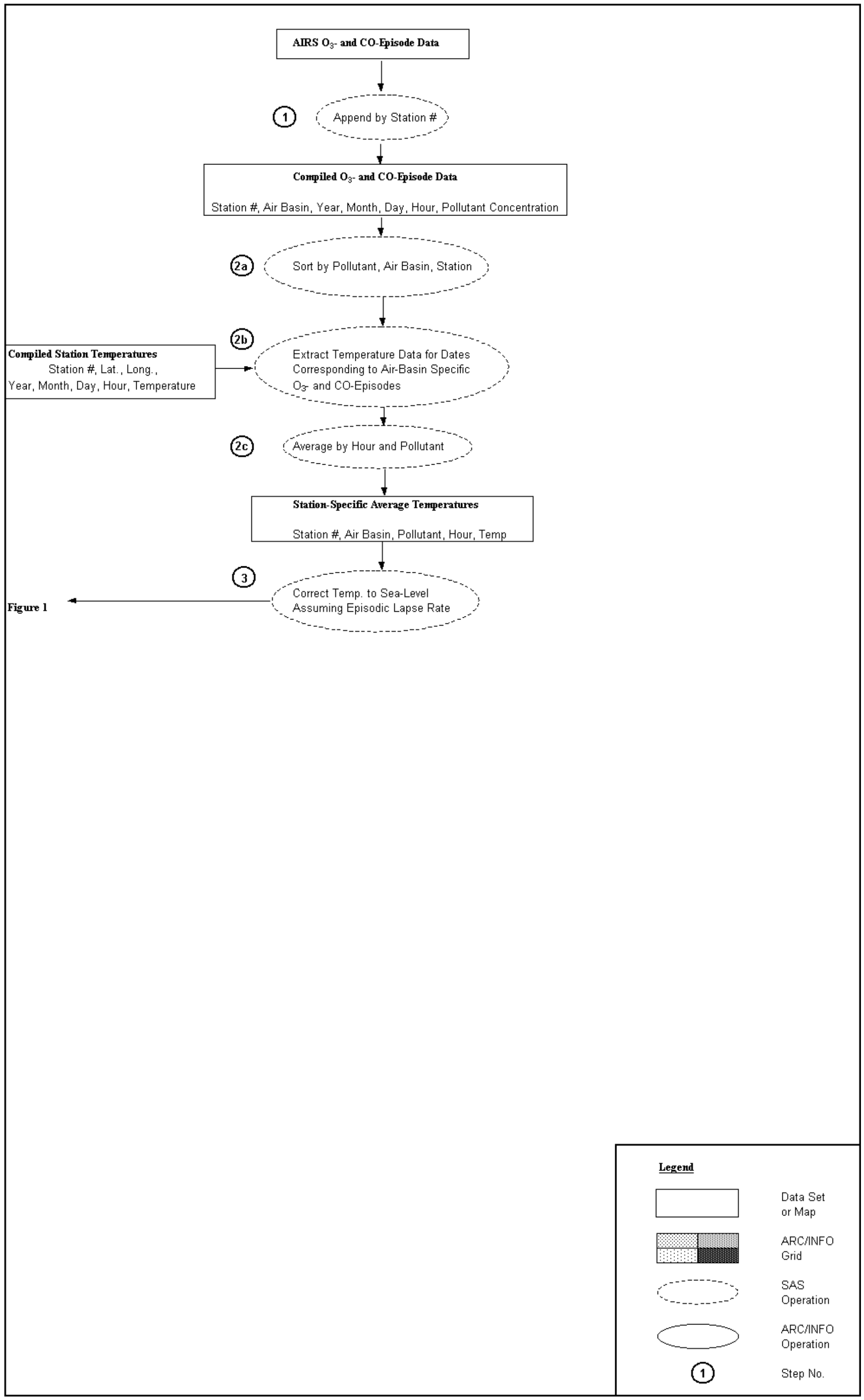

Figure 7.8-2 Flowchart showing methodology used in extracting temperature data for use in developing episodic, county-specific diurnal temperature profiles.

1. Aerometric Information Retrieval System (AIRS) Yearly Maximum Values reports for the period 1988 through 1992 were obtained from the United States Environmental Protection Agency (USEPA). The Yearly Maximum Values reports requested include the dates and pollutant concentrations for the ten worst O_3- and CO-episode days for each of the 241 ambient air monitoring stations in California.

    a. The compiled air quality data were sorted by pollutant, air basin, and station.

    b. For each air basin, hourly temperature data for those dates corresponding to the documented O_3- and CO-episode days were extracted from the temperature dataset compiled for development of monthly diurnal temperature profiles.

    c. For each meteorological station, the extracted hourly temperature data were averaged by hour and pollutant to produce station-specific O_3- and CO-episode day diurnal temperature profiles.

2. The averaged station temperatures were corrected to sea-level, using the known elevations of the stations and O_3- and CO-episode temperature lapse rates.

    The O_3- and CO-episode temperature lapse rates were calculated based on the monthly temperature lapse rates, weighted by the number of O_3- and CO-episodes occurring in each month. The O_3- and CO-episode lapse rates used in this analysis are shown in Table 7.8-1.

The remaining steps involved in developing county-specific, O_3- and CO-episode day diurnal temperature profiles were the same as described previously in steps 4 through 10 for development of monthly temperature profiles.

7.8.5 <u>Results</u>

County-specific monthly, as well as O_3- and CO-episode day, diurnal temperature profiles were developed into a matrix format. For each of the 58 counties in California, the matrices provide average temperature by time of day aspresented in Table 7.8-2.

Table 7.8-2. Format of county-specific temperature matrices.

	Hour						
County	T0	T1	T2	………..	T21	T22	T23
1	46.7	46.0	45.6	………..	48.3	47.7	47.2
2	55.5	53.8	52.5	………..	61.2	59.1	57.3
3	53.5	51.6	50.0	………..	60.1	57.7	55.6
:	:	:	:	:	:	:	:
56	57.0	56.8	56.6	………..	58.6	57.9	57.5
57	57.3	56.9	56.7	………..	59.0	58.3	57.8
58	62.5	62.0	61.2	………..	64.8	64.3	63.6

Figure 7.8-3 contrasts statewide average O_3- and CO-episode day diurnal temperature profiles developed for EMFAC2000 with the methodology described here to the temperature profiles previously assumed in MVEI7G. This figure suggests the existing temperature profile for CO-episode days approximates reasonably well the temperature profile developed in this analysis. However, the previous temperature profile for O_3-episode days appears to overestimate the temperature experienced by vehicles in the State by approximately 5-10° F. The magnitude of the offset in the existing and proposed episodic temperature profiles are consistent from county to county throughout the State. Work is currently being performed to identify whether the offset is due to the use of different hourly temperature data or specific methodological differences.

The methodology described here is a significant improvement over the previous method for developing diurnal temperature profiles. Specifically, by using a GIS, it is possible to produce gridded temperature maps which take into account station location, elevation effects, and vehicle distribution within a county. The county-specific temperatures calculated based on these gridded temperature maps reflect the average of all the grid cells within a county rather than the average of a relatively small number of monitoring stations. Therefore, the temperature profiles developed using this methodology more accurately reflect the temperatures experienced by vehicles within a county.

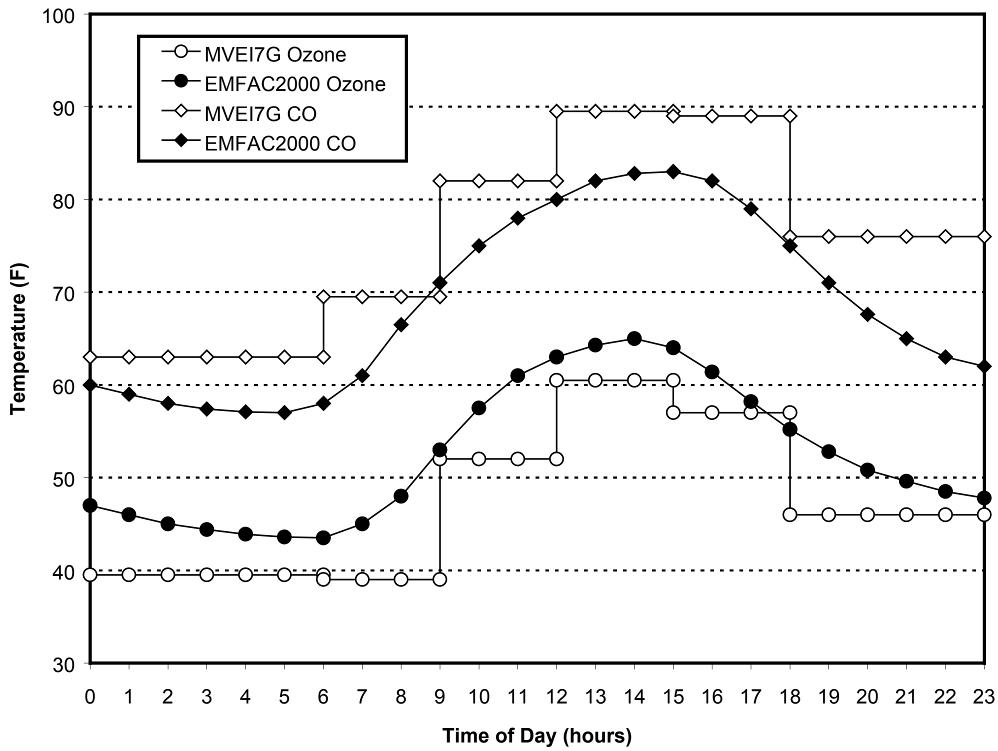

Figure 7.8-3 Comparison of MVEI7G and EMFAC2000 statewide average episodic temperature profiles.