APPENDIX H

Meteorological Conditions Associated with High Inhalable Particulate Matter (PM_{10}) Concentrations in El Paso

Background

In his book, "Mesometeorology at El Paso" (University of Texas at El Paso, 1971), Willis Webb noted that there are three primary meteorological mechanisms which cause elevated particulate matter levels in El Paso: mountain waves, thunderstorms, and inversions. Each of the three mechanisms, which are discussed and analyzed in detail in his book, has a distinctly different cause and is associated with a different season.

The first two causes, mountain waves and thunderstorms, are entirely related to meteorological factors. Both of these mechanisms are associated with strong, gusty surface winds which lift dust and cause dust storms or visible dust clouds in the area. These types of dust events would occur regardless of human occupation since the desert area has little vegetation to hold the soil.

The third mechanism, inversion formation and associated air stagnation, traps particulate matter in the air over the mountain basin in which El Paso is located. While inversions are naturally occurring meteorological events, man contributes to the pollutants which are trapped by inversions.

Mountain Waves

The Franklin Mountains stretch north from El Paso, and provide a significant barrier to the winds in the upper atmosphere. When strong upper air winds blow more or less perpendicularly across the Franklins, they form strong undulating wave patterns commonly characterized by the formation of lenticular clouds. These conditions generally occur in fall and spring as the jet stream and frontal boundary move past the El Paso area. The strong upper air winds can occur by themselves or they may be associated with an approaching cold front. In either case, the winds flow down the lee side of the mountains and form a turbulent region with gusty winds. These winds pick up dust and mix it several thousands of feet into the air, causing what is typically referred to as a dust storm.

It is likely that strong winds related to synoptic scale, tight pressure gradients would cause blowing dust in the El Paso area even if there were no mountains in the area. However, the downslope and channeling effects of the mountains increase wind speeds above what would exist in the absence of the mountains.

Thunderstorms

Thunderstorms most frequently occur in the summer months (July, August, and September) and are the primary source of rain for

El Paso. High winds associated with the downrush of rain and cold air pick up dust from the immediate area and cause local dust storms. Thunderstorm-induced dust storms tend to be short-term events, and may not occur if recent showers have dampened the soil.

Inversions

Stagnant air situations occur during the fall and winter months, starting in September when nights get longer. Stagnant air cases are most frequent in November, December, and January when there are long nights and short days. Since there is little moisture in the desert atmosphere during this time of year, strong night-time cooling occurs under the clear skies. The air near the surface of the earth cools more rapidly than the air aloft, and forms a nighttime inversion which traps pollutants, regardless of their source. During the morning, the strong desert heating begins to break the inversion. By the afternoon, the atmosphere is usually highly unstable and mixes (dilutes) the pollutants up into higher levels of the atmosphere.

Analysis

Writing in 1971, Webb considered mountain waves and thunderstorms as the primary dust storm mechanisms, since they both created large visible dust clouds. However, as measurement technology has improved and population has grown on both sides of the Rio Grande River, we have discovered that inhalable particulate matter (PM_{10}) events result from each of the three mechanisms and that exceedances of the PM_{10} National Ambient Air Quality Standard (NAAQS) can occur without gusty winds and the associated sudden dust clouds.

Information on exceedances of the PM_{10} NAAQS at each of the routinely operating monitoring sites in El Paso during the period 1986-1990 is provided in Table H-1. For each exceedance, the associated meteorological category is noted. An analysis of the PM_{10} exceedances shows that 72 percent occurred under stagnant air conditions (see data in Table H-2). Only 28 percent of the PM_{10} exceedances occurred during gusty wind (dust storm) conditions.

The worst single case, occurring on March 3, 1989 with a PM_{10} concentration of 412 micrograms per cubic meter ($\mu g/m^3$), was related to dust storm conditions caused by strong wind gusts. Also, during three out of five years for the time period 1986-1990, the maximum 24-hour PM_{10} concentration occurred with strong winds (gusts greater than or equal to 30 miles per hour).

TABLE H-1

El Paso PM_{10} Exceedances and Associated Meteorological Category
1986-1990

Site	Date	PM_{10} ($\mu g/m^3$)	Meteorological Category
1986			
Tillman	01/30/86	323	Stagnation
Tillman	03/09/86	240	Dust Storm
Tillman	04/02/86	204	Dust Storm
Tillman	01/04/86	194	Stagnation
Tillman	03/06/86	164	Dust Storm
Tillman	01/11/86	163	Stagnation
Tillman	01/10/86	161	Stagnation
Tillman	04/05/86	154	Stagnation
1987			
Tillman	12/05/87	202	Dust Storm
Tillman	12/23/87	153	Dust Storm
1988			
Tillman	04/21/88	263	Dust Storm
Tillman	12/25/88	227	Stagnation
Tillman	01/29/88	217	Stagnation
Vilas School	11/15/88	215	Dust Storm
Vilas School	12/25/88	210	Stagnation
Tillman	12/23/88	204	Dust Storm
Tillman	09/29/88	190	Stagnation
Tillman	12/24/88	189	Stagnation
Tillman	11/23/88	184	Stagnation
Tillman	03/10/88	177	Dust Storm
Tillman	01/28/88	169	Stagnation
Tillman	09/28/88	168	Stagnation
Vilas School	11/11/88	167	Stagnation
Vilas School	10/30/88	163	Stagnation
Tillman	10/24/88	163	Stagnation
Tillman	11/13/88	159	Stagnation

TABLE H-1 (CONTINUED)

El Paso PM_{10} Exceedances and Associated Meteorological Category
1986-1990

Site	Date	PM_{10} ($\mu g/m^3$)	Meteorological Category
<u>1989</u>			
Vilas School	03/03/89	412	Dust Storm
Tillman	03/03/89	272	Dust Storm
Vilas School	01/02/89	222	Stagnation
Tillman	02/24/89	204	Stagnation
Vilas School	03/11/89	196	Stagnation
Tillman	03/11/89	186	Stagnation
Tillman	10/14/89	182	Stagnation
Tillman	03/08/89	167	Stagnation
Tillman	12/27/89	167	Stagnation
Tillman	11/11/89	163	Stagnation
Vilas School	12/24/89	161	Stagnation
<u>1990</u>			
Tillman	12/08/90	229	Stagnation
Tillman	12/01/90	179	Stagnation
Vilas School	12/01/90	176	Stagnation
Tillman	01/14/90	168	Stagnation
Vilas School	05/19/90	165	Dust Storm
Tillman	11/19/90	157	Stagnation

TABLE H-2

Number of PM_{10} Exceedances at El Paso
Under Stagnation and Dust Storm Conditions
1986-1990

Year	Stagnation	Dust Storm	Total
1986	5	3	8
1987	0	2	2
1988	11	4	15
1989	8	1	9
1990	4	1	5
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Totals	28	11	39
Percent of total	71.7%	28.2%	100%

The graph in Figure H-1 shows the monthly distribution of PM_{10} exceedances by type. It is clear that most of the PM_{10} exceedances occur under stagnant conditions during the fall and winter months. Wind-related exceedances occur during the late fall, and again during spring, with fronts and the large scale movement of weather systems from north to south. There were no PM_{10} exceedances in June or July during the five-year period of record. However, there may have been short-term, thunderstorm-induced local dust storms which did not produce particulate levels sufficiently elevated to result in PM_{10} exceedances.

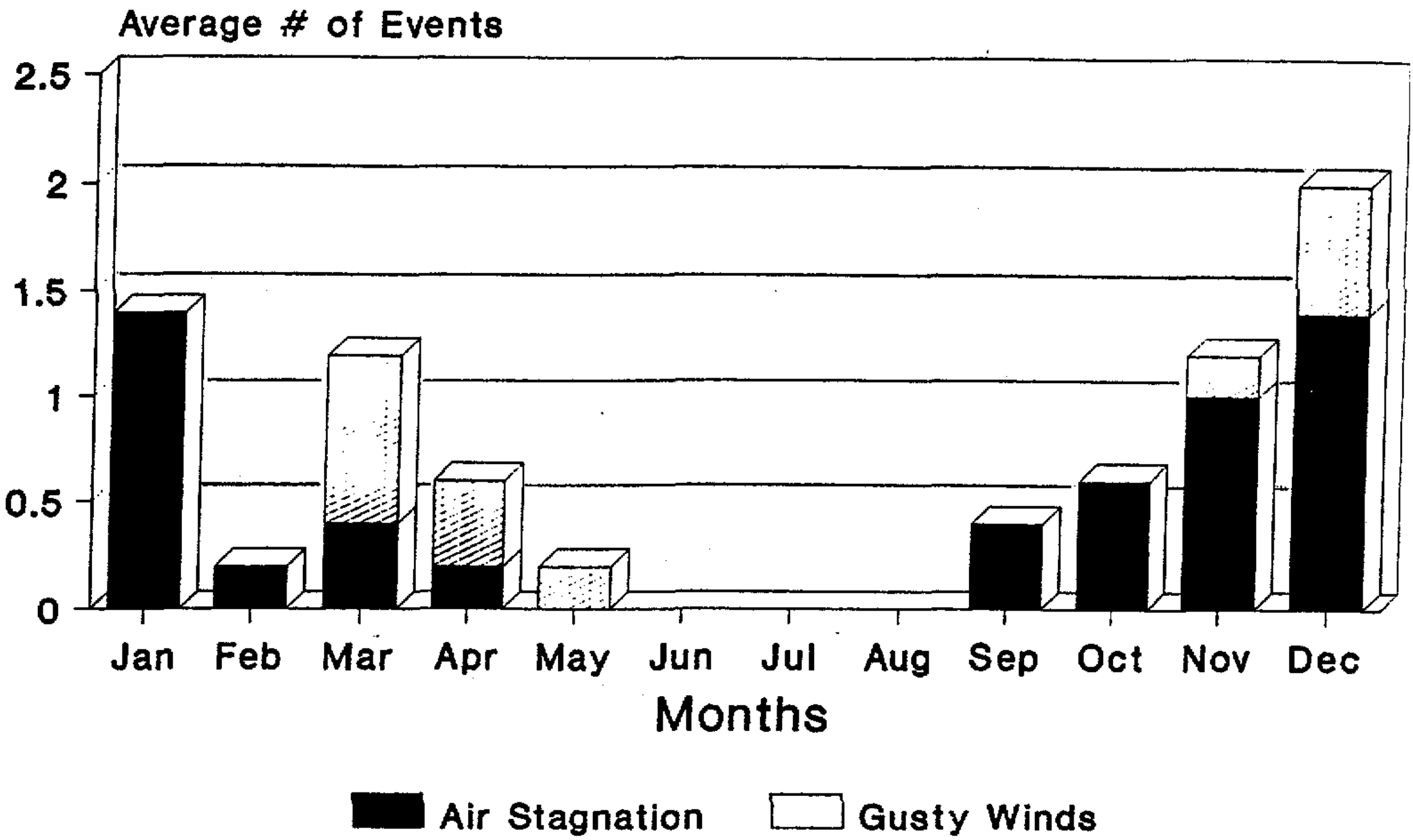
Conclusions:

- PM_{10} exceedances occur most frequently during the winter months.

- The majority of PM_{10} exceedances at El Paso are associated with inversion/stagnation conditions.

- A minority of PM_{10} exceedances are related to gusty winds.

FIGURE H-1



ive Years: 1986-1990)

El Paso PM_{10} Exceedance By Type and Month of Occurrence

- PM_{10} exceedances associated with inversion/stagnation conditions have an anthropogenic contribution, while those caused by high winds are primarily related to the natural lack of desert vegetation to hold the soil.