EXECUTIVE SUMMARY

The U.S. Environmental Protection Agency, the National Park Service, and the Texas Commission on Environmental Quality sponsored the Big Bend Regional Aerosol and Visibility Observational (BRAVO) Study, with technical support provided by the Electric Power Research Institute. The BRAVO Study involved a four-month intensive monitoring period from July through October 1999, followed by a four-year data analysis and modeling effort to assess the causes of haze in Big Bend National Park (BBNP), Texas. The study was specifically designed to use extensive measurements with multiple independent attribution methods to estimate haze contributions from source regions and source types. However, the BRAVO Study was not designed as a regulatory study; and it is beyond the scope of the study to evaluate or to recommend potential control strategies for visibility improvement at the Park.

The purpose of this executive summary is to concisely state the most important results and conclusions in a form that is usable to policy makers and the public. These results and conclusions are as follows:

1. Visibility impairment at BBNP is dominated by fine particles, but can have significant contributions from coarse particles.

2. Fine particles sampled in the BBNP region during the BRAVO Study consist, on average, mainly of ammoniated sulfate, organic carbon, and soil dust, with black carbon and nitrate as minor factors. Coarse particles appear to be mainly soil dust and, to a lesser degree, carbon and nitrate.

3. The haziest days at BBNP tend to occur during the seven months April through October. Occasionally during spring, high smoke and dust concentrations impact Big Bend, leading to the haziest conditions. The BRAVO study period consisted of only four of these months, July through October, so its attribution results are most applicable to those months.

4. Particulate carbon contributions tend to peak in the spring when smoke from fires in Mexico and Central America can impact BBNP. Fine and coarse soil contributions tend to peak during the spring and summer. Dust from Africa impacts BBNP primarily during the summer.

5. On average, ammoniated sulfate is the most important contributor to visibility impairment at BBNP, but visibility is also materially impaired by organic carbon and coarse particles.

6. The sulfur-oxide sources that influence BBNP visibility vary greatly during the year. During late summer and early fall sulfur-oxide can be attributed to sources to the southeast of BBNP along the U.S. Mexico border under prevailing flow from the southeast, and from eastern U.S. and east Texas sources under less frequent northeasterly wind conditions.

7. The most intense ammoniated-sulfate-dominated haze episodes during the

BRAVO Study tended to include significant contributions from sulfur dioxide sources in the eastern U.S. and east Texas. Sources in Mexico contribute more persistently and tended to be dominant contributors to ammoniated sulfate during less intense sulfate haze episodes during the BRAVO Study period.

8. The two *Carbón* power plants, located in Mexico about 225 km southeast of BBNP, were the single largest contributors to ammoniated sulfate haze at BBNP during the BRAVO Study period.

9. Clearest visibility conditions at BBNP occur most frequently in the winter when flow is most often from the north or west over areas of relatively low emissions density. During the summer and fall, the clearest visibility conditions coincide with airflow from the southeast that brings marine air from the Gulf of Mexico rapidly over northeastern Mexico.

10. The results of this study are limited in time and focus on sulfur oxides. To assess haze conditions and causes more broadly, particle composition and air flow patterns during the BRAVO Study period were compared with those from the same periods in other years, and for other times of the year. Inferences from these comparisons entailed certain assumptions about the dominance of air transport in characterizing BBNP haze. In the absence of better information, the resulting conceptual model of haze conditions at BBNP is consistent and logical.

11. The study is limited in not dealing with non-sulfur dioxide sources of PM and visibility reduction. If sulfur dioxide emissions were significantly reduced in the source regions affecting BBNP, these components would become increasingly important. The investigation of organic carbon was not sufficiently robust in BRAVO to address this important PM constituent.

12. The BRAVO study indicated that unqualified confidence cannot be placed in any single method for establishing regional or local sources of visibility reducing pollutants. Despite advances in air quality modeling and the use of tracer studies, there remain uncertainties in the modeling results that require empirical adjustments to correspond to a "standard" based on observations. The estimates of sources of haze during the BRAVO study appear to be credible based on a weight of observational and analytical evidence.

Additional summary information is provided in Chapter 1 (Technical Overview) and Chapter 12 (Attribution Reconciliation, Conceptual Model, and Lessons Learned) of the report.