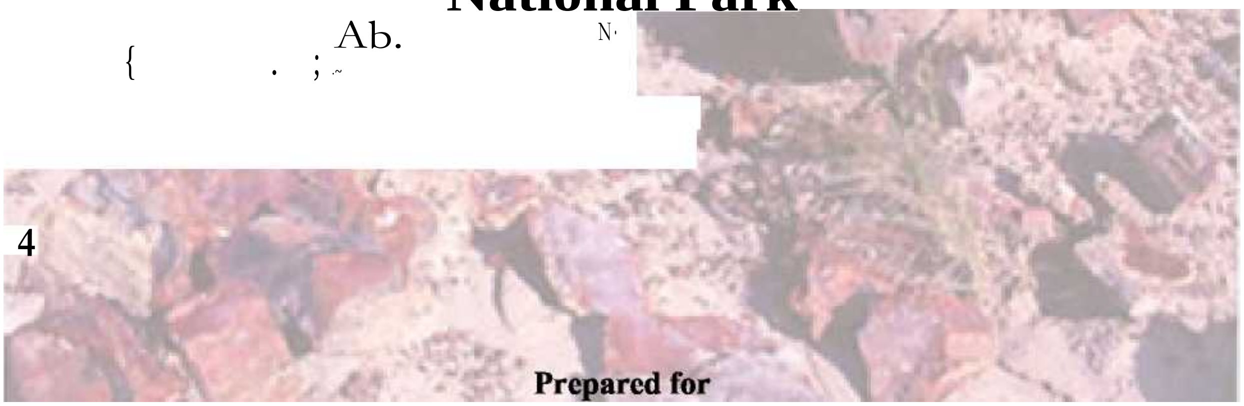
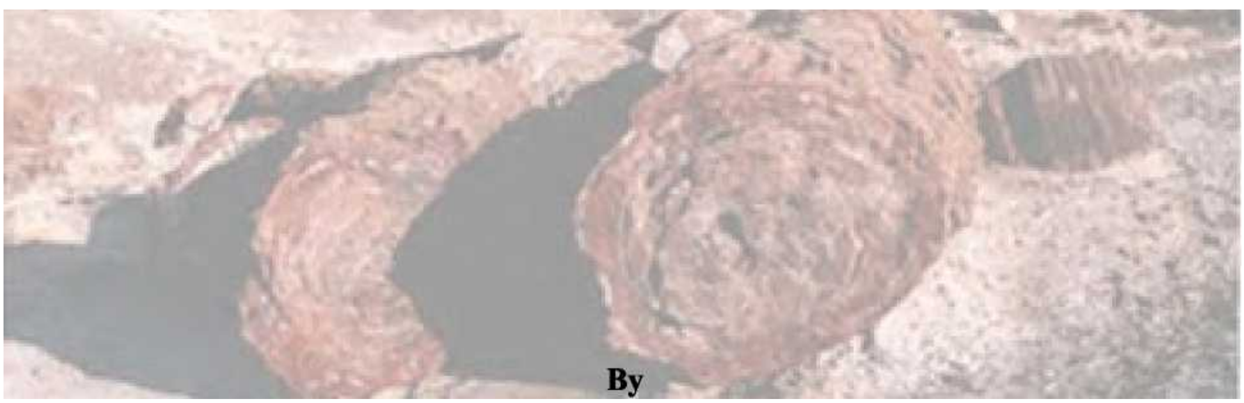
Final Report

Air Emissions Inventory for Petrified Forest National Park



Prepared for

The Western Governors' Association



By

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Chapter One - Introduction

In mid-August, 2000, the Center for Environmental Research and Technology within the College of Engineering at the University of California's Riverside Campus (CE-CERT) was contracted by the Western Governor's Association to inventory the air emissions of criteria pollutants within eight National Parks. The inventories are to include both stationary as well as mobile sources of emissions operating within Park boundaries. It was hypothesized that the vehicle fleet of visitors to National Parks and their in-Park driving patterns would be sufficiently different from national averages to have a significant impact on in-Park emissions estimates. To evaluate this hypothesis, it was necessary to characterize the vehicle fleet in terms of compositon and driving patterns. In consideration of the budget and the timeframe for preparing the inventories, it was mutually agreed that on-site data collection for characterization of the in-Park vehicle fleet would be limited to two Parks. It was also agreed that these two Parks would need to be surveyed on or before labor-day weekend in order to characterize the in-Park vehicle fleet during the summer visitation period. Zion and Arches National Parks were selected because they were felt to be generally representative of the other six parks.

The CE-CERT survey team initially visited Zion and Arches National Parks between August 16 and 22, 2000. This was the busiest time of the year for Park staff, and staff resources were especially strained due to efforts to control wildfires that were occurring in a number of the Western states. At the request of the National Park Service, CE-CERT's survey efforts were limited to direct data collection on the in-Park vehicle fleet composition and in-Park driving patterns at Zion and Arches. CE-CERT staff then visited Petrified Forest National Park on November 14-15, 2000 and met with Park staff to identify and obtain data related to stationary, area, and mobile source emissions within the Park.

Based on the data received during the in-Park visit, CE-CERT has developed an inventory of emissions occurring from sources operating within Petrified Forest National Park. The report is organized to first provide the reader with an overall sense of the total in-Park emissions, the contribution made by each source category, and the magnitude of the Park's total emissions to the totals for neighboring counties and overall state totals. (see Tables 1.1-1.5). Chapter Two provides a brief discussion of the history of Petrified Forest National Park. Chapters Three through Five provide individual descriptions of the three major emission source classifications; Stationary, Area, and Mobile. At the end of each chapter, spreadsheets are included that provide information on the individual emission sources and the calculations employed to develop a best estimate of their emissions. Within each of these chapters, the emissions have been calculated as monthly averages for two periods of the year: April through October (summer), and November through March (winter). The report concludes with Chapter Six, which contains the results of a review of Arizona's air regulations and their applicability to emissions sources within the Park. Appendix A provides a listing of the emission factors used to develop this emission inventory. Appendix B provides most of the Excel worksheets used to develop much of the data collected into the necessary formats (due to their size, worksheets 9 through 13 are available only on the CD). Appendix C provides the inputs used in the mathematical modeling conducted to develop the mobile source emission estimates. Appendix D is a compilation of data provided by Park personnel and MSDS sheets obtained through the internet that were used in the emissions determinations. A CD is also included in an envelope attached to the inside of the back cover of this report. The CD contains all of the report with the exception of Appendix D. The CD is intended to facilitate manipulation of the data into different groupings for further analyses. It also allows the inventory to be updated in the event that emission factors, used in this report, are updated, more exact information on in-Park sources is developed, or new sources are added to the Park's inventory. In addition, the CD contains a compilation of Arizona's air quality regulations.

Table 1.1: Summary of Summertime Emissions in Petrified Forest National Park

		TSP (lbs/month)		PM10 (lbs/month)	VOC (lbs/month)	NOX (lbs/month)	CO (lbs/month)	SOx (lbs/month)
Concessions	Painted Desert Oasis (North End) (Includes Propane)	52.20		0.35	406.24	12.37	1.68	8.84
	Rainbow Forest Oasis (South End) (Includes Propane)	16.55		0.93	202.02	32.69	4.44	23.35
	Sub-Total	68.75		1.29	608.26	45.06	6.12	32.19
Facilities	NPS In-Park Facilities (Includes all NPS Propane)	0.50		0.50	0.37	17.47	2.37	12.48
	Sub-Total	0.50		0.50	0.37	17.47	2.37	12.48
Residential	NPS Housing (Excluding Propane)	11.58		11.58	16.33	7.95	91.40	0.33
	Concessionaire Housing (Excluding Propane)	0.79		0.79	1.36	0.07	5.93	0.01
	Sub-Total	12.37		12.37	17.69	8.02	97.33	0.34
Evaporative	Solvent Use	0.00		0.00	27.1	0.00	0.00	0.00
	Road Paving	0.00	#	0.00	6,705.99	0.00	0.00	0.00
	Sub-Total	0.00		0.00	6,733.08	0.00	0.00	0.00
Other Area	Dirt Piles	0.87		0.42	0.00	0.00	0.00	0.00
	Pile Burning	2.54		1.70	0.00	0.36	15.09	0.00
	Sub-Total	3.40		2.12	0.00	0.36	15.09	0.00
On-Road	Visitor Passenger Vehicles	47.33		47.33	3942.37	1844.54	24658.25	0.00
	Tour Buses	2.66		2.66	17.65	33.87	62.56	0.00
	Government Vehicles	2.09		2.09	100.85	55.70	651.38	0.00
	Concessionaire Vehicles	0.08		0.08	6.64	3.87	51.73	0.00
	Re-entrained Dust, Tire, & Brake Wear	14118.59		2999.21	0.00	0.00	0.00	0.00
	Sub-Total	14170.74		3051.36	4067.51	1937.98	25423.92	0.00
Off-Road	Small Off-Road Equipment	5.98		5.98	237.79	4.49	771.25	0.83
	Large Off-Raod Equipment	12.73		12.73	18.59	159.71	52.87	13.40
	Sub-Total	18.71		18.71	256.38	164.20	824.12	14.23
Off-Road Evap	Off-Road Devices	0.00		0.00	3.28	0.00	0.00	0.00
	Sub-Total	0.00		0.00	3.28	0.00	0.00	0.00
	Total Summer Emissions from Park (lbs/month)	14,274.47		3,086.35	11,686.58	2,173.10	26,368.94	59.23
	Total Summer Emissions from Park (tons/day)	0.24		0.05	0.19	0.04	0.44	0.00
	Total Annual Tons of Emissions (Winter plus Summer)	68.34		14.73	63.44	10.66	125.90	0.38

Table 1.2: Summary of Summertime Percentages

		TSP (lbs/month)	PM10 (lbs/month)	VOC (lbs/month)	NOX (lbs/month)	CO (lbs/month)	SOx (lbs/month)
Concessions	Painted Desert Oasis (North End) (Includes Propane)	0.37%	0.01%	3.48%	0.57%	0.01%	14.92%
	Rainbow Forest Oasis (South End) (Includes Propane)	012%	003%	173%	150%	002%	3942%
	Sub-Total	0.48%	0.04%	5.20%	2.07%	0.02%	54.34%
Facilities	NPS In-Park Facilities (Includes all NPS Propane)	0.00%	0.02%	0.00%	0.80%	0.01%	21.07%
	Sub-Total	0.00%	0.02%	0.00%	0.80%	0.01%	21.07%
Residential	NPS Housing (Excluding Propane)	0.08%	0.38%	0.14%	0.37%	0.35%	0.55%
	Concessionaire Housing (Excluding Propane)	0.01%	0.03%	0.01%	0.00%	0.02%	0.02%
	Sub-Total	0.09%	0.40%	0.15%	0.37%	0.37%	0.57%
Evaporative	Solvent Use	0.00%	0.00%	0.23%	0.00%	0.00%	0.00%
	Road Paving	0.00% #	0.00%	57.38%	0.00%	0.00%	0.00%
	Sub-Total	0.00%	0.00%	57.61%	0.00%	0.00%	0.00%
Other Area	Dirt Piles	0.01%	0.01%	0.00%	0.00%	0.00%	0.00%
	Pile Burning	0.02%	0.05%	0.00%	0.02%	0.06%	0.00%
	Sub-Total	0.02%	0.07%	0.00%	0.02%	0.06%	0.00%
On-Road	Visitor Passenger Vehicles	0.33%	1.53%	33.73%	**84.88%**	93.51%	0.00%
	Tour Buses	0.02%	0.09%	0.15%	1.56%	0.24%	0.00%
	Government Vehicles	0.01%	0.07%	0.86%	2.56%	2.47%	0.00%
	Concessionaire Vehicles	0.00%	0.00%	0.06%	0.18%	0.20%	0.00%
	Re-entrained Dust, Tire, & Brake Wear	98.91%	97.18%	0.00%	0.00%	0.00%	0.00%
	Sub-Total	99.27%	98.87%	34.80%	89.18%	96.42%	0.00%
Off-Road	Small Off-Road Equipment	0.04%	0.19%	2.03%	0.21%	2.92%	1.40%
	Large Off-Raod Equipment	0.09%	0.41%	0.16%	7.35%	0.20%	22.62%
	Sub-Total	0.13%	0.61%	2.19%	7.56%	3.13%	24.02%
Off-Road Evap	Off-Road Devices	0.00%	0.00%	0.03%	0.00%	0.00%	0.00%
	Sub-Total	0.00%	0.00%	0.03%	0.00%	0.00%	0.00%
	Total Summer Emissions from Park (lbs/month)	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%

Table 1.3: Summary of Wintertime Emissions in Petrified Forest National Park

		TSP (lbs/month)		PM10 (lbs/month)	VOC (lbs/month)	NOX (lbs/month)	CO (lbs/month)	SOx (lbs/month)
Concessions	Painted Desert Oasis (North End) (Includes Propane)	16.30		0.69	2.30	24.09	3.27	17.21
	Rainbow Forest Oasis (South End) (Includes Propane)	0.25		0.25	0.18	8.60	1.17	6.14
	Sub-Total	16.55		0.93	2.48	32.69	4.44	23.35
Facilities	NPS In-Park Facilities (Includes all NPS Propane)	1.25		1.25	0.93	43.60	5.92	31.14
	Sub-Total	1.25		1.25	0.93	43.60	5.92	31.14
Residential	NPS Housing (Excluding Propane)	20.32		20.32	25.87	19.05	163.22	0.71
	Concessionaire Housing (Excluding Propane)	1.96		1.96	3.40	0.18	14.80	0.03
	Sub-Total	22.28		22.28	29.26	19.23	178.01	0.73
Evaporative	Solvent Use	0.00		0.00	27.1	0.00	0.00	0.00
	Road Paving	0.00	#	0.00	6,705.99	0.00	0.00	0.00
	Sub-Total	0.00		0.00	6,733.08	0.00	0.00	0.00
Other Area	Dirt Piles	0.87		0.42	n/a	n/a	n/a	n/a
	Pile Burning	3.55		2.38	0.00	0.50	21.13	0.00
	Sub-Total	4.42		2.80	0.00	0.50	21.13	0.00
On-Road	Visitor Passenger Vehicles	22.55		22.55	1878.09	878.72	11746.88	0.00
	Tour Buses	1.34		2.66	17.65	33.87	62.56	0.00
	Government Vehicles	1.79		1.79	86.54	47.79	558.92	0.00
	Concessionaire Vehicles	0.06		0.06	5.20	3.03	40.48	0.00
	Re-entrained Dust, Tire, & Brake Wear	7262.96		1496.65	0.00	0.00	0.00	0.00
	Sub-Total	7288.70		1523.70	1987.48	963.41	12408.85	0.00
Off-Road	Small Off-Road Equipment	5.98		5.98	237.79	4.49	771.25	0.83
	Large Off-Raod Equipment	12.73		12.73	18.59	159.71	52.87	13.40
	Sub-Total	18.71		18.71	256.38	164.20	824.12	14.23
Off-Road Evap	Off-Road Devices	0.00		0.00	3.28	0.00	0.00	0.00
	Sub-Total	0.00		0.00	3.28	0.00	0.00	0.00
	Total Winter Emissions from Park (lbs/month)	7,351.89		1,569.67	9,012.90	1,223.63	13,442.46	69.45
	Total Winter Emissions from Park (tons/day)	0.12		0.03	0.15	0.02	0.22	0.00
	Total Annual Tons of Emissions (Winter plus Summer)	68.34		14.73	63.44	10.66	125.90	0.38

Table 1.4: Summary of Wintertime Percentages

		TSP (lbs/month)		PM10 (lbs/month)	VOC (lbs/month)	NOX (lbs/month)	CO (lbs/month)	SOx (lbs/month)
Concessions	Painted Desert Oasis (North End) (Includes Propane)	0.22%		0.04%	0.03%	1.97%	0.02%	24.77%
	Rainbow Forest Oasis (South End) (Includes Propane)	0.00%		0.02%	0.00%	0.70%	0.01%	**8.85%**
	Sub-Total	0.23%		0.06%	0.03%	2.67%	0.03%	33.62%
Facilities	NPS In-Park Facilities (Includes all NPS Propane)	0.02%		0.08%	0.01%	3.56%	0.04%	44.84%
	Sub-Total	0.02%		0.08%	0.01%	3.56%	0.04%	44.84%
Residential	NPS Housing (Excluding Propane)	0.28%		1.29%	0.29%	1.56%	1.21%	1.02%
	Concessionaire Housing (Excluding Propane)	0.03%		0.12%	0.04%	0.01%	0.11%	0.04%
	Sub-Total	0.30%		1.42%	0.32%	1.57%	1.32%	1.06%
Evaporative	Solvent Use	0.00%		0.00%	0.30%	0.00%	0.00%	0.00%
	Road Paving	0.00%	#	0.00%	74.40%	0.00%	0.00%	0.00%
	Sub-Total	0.00%		0.00%	57.61%	0.00%	0.00%	0.00%
Other Area	Dirt Piles	0.01%		0.03%	n/a	n/a	n/a	n/a
	Pile Burning	0.05%		0.15%	0.00%	0.04%	0.16%	0.00%
	Sub-Total	0.06%		0.18%	0.00%	0.04%	0.16%	0.00%
On-Road	Visitor Passenger Vehicles	0.31%		1.44%	20.84%	71.81%	87.39%	0.00%
	Tour Buses	0.02%		0.17%	0.20%	2.77%	0.47%	0.00%
	Government Vehicles	0.02%		0.11%	0.96%	3.91%	4.16%	0.00%
	Concessionaire Vehicles	0.00%		0.00%	0.06%	0.25%	0.30%	0.00%
	Re-entrained Dust, Tire, & Brake Wear	**98.79%**		95.35%	0.00%	0.00%	0.00%	0.00%
	Sub-Total	99.14%		97.07%	22.05%	78.73%	92.31%	0.00%
Off-Road	Small Off-Road Equipment	0.08%		0.38%	2.64%	0.37%	5.74%	1.19%
	Large Off-Raod Equipment	0.17%		0.81%	0.21%	13.05%	0.39%	19.29%
	Sub-Total	0.25%		1.19%	2.84%	13.42%	6.13%	20.48%
Off-Road Evap	Off-Road Devices	0.00%		0.00%	0.04%	0.00%	0.00%	0.00%
	Sub-Total	0.00%		0.00%	0.04%	0.00%	0.00%	0.00%
	Total Winter Emissions from Park (lbs/month)	100.00%		100.00%	82.91%	100.00%	100.00%	100.00%

Table 1.5: Comparison of Petrified Forest National Park Emissions with Surrounding Counties

Region	Comment	Annual Emissions in Tons per Year					
		TSP	PM10	VOC	NOx	CO	SOx
Petrified Forest	Park-Wide Emissions	**68**	15	63	11	126	0.4
Apache	Contains most of Petrified Forest Park	no value	30,860	14,509	50,152	184,248	48,439
Navajo	Contains some of Petrified Forest Park	no value	38,431	25,246	63,857	238,793	53,126
Coconino	Adjoins Navajo Co. to the West	no value	30,312	18,467	67,337	208,333	10,803
Arizona	Entire state emissions	no value	366,793	300,277	486,754	2,164,359	199,271
Petrified Forest Park	Compared to Apache County	n/a	0.05%	0.44%	0.02%	0.07%	0.00%
Petrified Forest Park	Compared to Navajo County	n/a	0.04%	0.25%	0.02%	0.05%	0.00%
Petrified Forest Park	Compared to Coconino County	n/a	0.05%	0.34%	0.02%	0.06%	0.00%
Petrified Forest	Park Compared to Arizona	n/a	0.004%	0.021%	0.002%	0.006%	0.000%

Chapter Two - Park Background Information

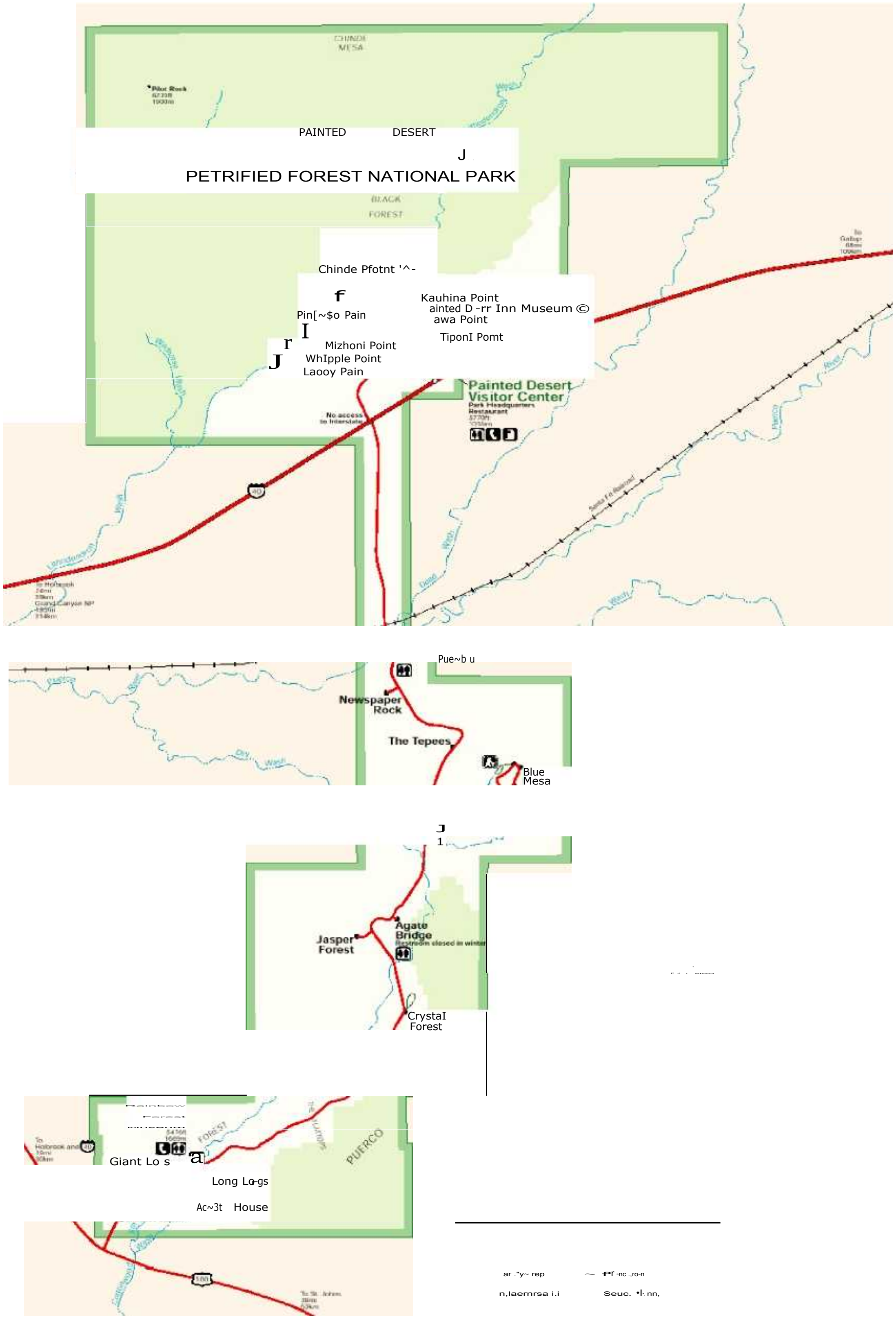
The Petrified Forest National Park encompasses some 93,533 acres in northeast Arizona. The Petrified Forest was first designated as a National Monument by President Theodore Roosevelt on December 8, 1906. On December 9, 1962, it was elevated by Congress to a National Park. The land upon which the National Park is situated was once a part of a vast floodplain. Large trees to the south fell and were washed into this floodplain by numbers of swollen streams. These trees were quickly covered by silt, mud, and volcanic ash that protected the trees from oxygen and slowed the rate of the logs' decay. Over time, silica-bearing ground waters seeped through the logs encasing the original wood tissues with silica deposits. The silica eventually crystallized into the mineral quartz preserving the logs as petrified wood. Since that period, some 225 million years ago, the land sank, was covered with water and sediment, and was later uplifted far above sea level. Over time, wind and water erosion have exposed petrified wood, as well as fossilized animal and plant remains from that time period. That erosion continues to expose petrified logs and fossils that, in some cases, exist in a layer that reaches a thickness of as much as 300 feet.

The Petrified Forest was established first as a National Monument and later as a National Park to preserve natural deposits of the petrified wood and fossils and protect them from further scavenging by souvenir hunters and commercial ventures. Also included within the Park's boundaries is the Painted Desert, a multi-hued example of the effects of erosion of the sediment formed during the period when the now high tableland was under water.

Puerco Pueblo, located within the Park provides evidence of man's existence in the area prior to the 1400's. The petroglyphs at what is now known as Newspaper Rock also located in the Park provide further insight into its earlier residents.

The Painted Desert museum was first constructed in the 1920's. It was rebuilt by the Civilian Conservation Corps (CCC) in the late 1930's. In 1987, this structure was designated as a National Historic Landmark. At present, there are 35 miles of paved roadway within the Park. The northernmost entrance located off U.S. Interstate 40 provides access to the visitor center, Painted Desert museum, service station, gift shop, and restaurant as well as the Park administrative offices, maintenance yard, and employee residences. The southernmost entrance, located off U.S. highway 180 provides access to the Rainbow Forest museum, as well as a gift shop and soda fountain. There are no campgrounds within the Park. Wilderness camping is allowed within the Painted Desert Wilderness Area. However, no campfires are allowed within the Wilderness Area. Of the roughly 650,000 visitors per year to the Park, less than 600 took advantage of the wilderness experience during FY 2000[1].

[1] Based upon U.S. DOI Monthly Public Use Reports (Form 10-157) covering 10/1/99 – 9/30/00.


PAINTED DESERT
PETRIFIED FOREST NATIONAL PARK
CHINDE MESA
BLACK FOREST
Kauhina Point
Mizhoni Point
Painted Desert Visitor Center
Park Headquarters
Restaurant
No access to Interstate
Newspaper Rock
The Tepees
Blue Mesa
Jasper Forest
Agate Bridge
Restroom closed in winter
Crystal Forest
Giant Logs
Long Logs
PUERCO

Chapter Three - Stationary Sources

Potential stationary sources within Petrified Forest National Park were identified as: the Concessionaire facilities (gifts shops, service station, and restaurant); NPS Facilities consisting of the Visitor Center, Park Administrative Offices, Park maintenance yard, Painted Desert Museum, and Rainbow Forest Museum; and, NPS and Concessionaire Residential areas,

Concessionaire Facilities

The concessionaire facilities within the Park are managed by the Fred Harvey Trading Company, an AmFac company. The facilities consists of a gift shop, full restaurant, and service station located next to the visitor center at the north entrance to the Park, and a gift shop and soda fountain located next to the Rainbow Forest Museum at the south entrance to the Park. The sources of emissions are propane combustion for heating and cooking, the grilling, charbroiling, and deep fat frying of meats, and the loading and dispensing of gasoline and diesel.

Propane supplier records provided by Fred Harvey Trading Company show that 13,076 gallons of propane were purchased during FY 2000 for their facilities and employee housing at the north end of the Park and 4,584 gallons of propane were purchased for their facilities at the south end of the Park. This inventory assumes that the amount of propane purchased during that period equates to the amount of propane combusted for space heating, water heating, and cooking. To better apportion the provided annual propane usage figures to seasonal average monthly values, a heating month approach was utilized (see Worksheet 2). The difference between 65 degrees farenheit and the average low temperature for each month was calculated and monthly percentages were subsequently established. These monthly percentages were then applied to the annual fuel usage data. The totals for April through October (summer) and November through March (winter) time periods were then averaged for each time period. As noted below, the calculated emissions from propane combustion also include the propane used by concessionaire residences.

Records provided by the concessionaire indicate that, on an annual basis, 1900 pounds of hamburger is charbroiled, 1068 pounds of beef is grilled, 397 pounds of chicken are deep fat fried as is 310 pounds of fish. Vents located over the grills, broilers, and deep fat fryers are equipped with metalbestos filters that are cleaned weekly. A considerable amount of various types of meat are cooked by other means such as ovens and hot dog rollers. Some of this is simply pre-cooked meat that is reheated rather than cooked. Emission calculations only reflect cooking that takes place either over an open fire or on a hot surface that would cause the evaporation of fats. The total amount of meat cooked was apportioned based on monthly visitation rates to approximate the amounts cooked during individual months.

The service station is equipped with three underground storage tanks: One 10,000 gallon tank for unleaded gasoline, one 6,000 gallon tank for supreme unleaded gasoline, and one

6,000 gallon tank for diesel. The station has six fuel dispensing pumps, two for diesel and four combination pumps that can dispense regular and supreme unleaded gasoline. No vapor recovery equipment is employed. The frequency of fuel loading into the underground storage tanks was calculated based on the average monthly dispensing rate compared to the size of the tank. On an annual basis, the station dispenses 135,386 gallons of regular unleaded gasoline, 21,509 gallons of supreme unleaded gasoline, and 6,455 gallons of diesel. Seasonal dispensing data provided by the concessionaire were divided by the appropriate number of months to approximate the volume dispensed during individual months.

NPS Facilities

The NPS facilities consists of the Visitor Center, Administrative Offices, the Painted Desert Museum, the Rainbow Forest Museum, and the Maintenance Yard. Sources of emissions consist of propane combustion for space heating, water heating, and cooking. To better apportion the provided annual propane usage figure to seasonal average monthly values, a heating month approach was utilized (see Worksheet 2). The difference between 65 degrees and the average low temperature for each month was calculated and monthly percentages were subsequently established. These monthly percentages were then applied to the annual fuel usage data. The totals for April through October (summer) and November through March (winter) time periods were then averaged for each time period. As noted below, the calculated emissions from propane combustion also include the propane used by NPS residences.

NPS and Concessionaire Residential Areas

The sources of emissions within the residential areas are: propane combustion for space heating, water heating and cooking; combustion of wood in woodstoves for space heating; and, the combustion of wood pellets in pellet stoves for space heating. Data provided by Park staff and the concessionaire did not distinguish between the amounts of propane consumed for residential use and other uses. The total propane usage reported by NPS was apportioned to each month using the above described “heating month” approach and the calculated emissions, included those from residential propane combustion are reported in the category of “NPS Facilities.” Park staff estimated the annual consumption of wood to be 6 cords. This amount was then apportioned to each month using the previously described “heating month” approach. Park staff also estimated the annual consumption of wood pellets to be 10 tons. This value was similarly apportioned on a monthly basis in order to develop seasonal emissions estimates. The concessionaire reported residential consumption of wood in woodstoves to one-half cord per year. This amount was also apportioned to each month and seasonal estimates of emissions were calculated.

Table 3.1: Emissions from Concessionaire Facilities

Concessions	N Latitude	W Longditude	Elevation (ft)	Season	Energy Unit 1	Control	Fuel Use (gal/month)	Cooking 1	Control	Amount Cooked (lbs)		
Painted Desert Oasis (North End)	35°4.013'	109°46.890'	5821	Summer	Propane	None	667.7	Broiler-Beef	Filter	1460		
Cooking 2	Control	Amount Cooked (lbs)	Cooking 3	Control	Amount Cooked (lbs)	Cooking 4	Control	Amount Cooked (lbs)				
Grill-Beef	Filter	821	Deep Fat Fryer Chicken	Filter	540	Deep Fat Fryer Fish	Filter	238				
Source	TSP Factor	TSP (lbs/month)	PM10 Factor	PM10 (lbs/month)	VOC Factor	VOC (lbs/month)	NOx Factor	NOX (lbs/month)	CO Factor	CO (lbs/month)	SOx Factor	SOx (lbs/month)
Energy Unit 1	0.4	0.27	0.4	0.27	0.3	0.20	14.0	9.35	1.9	1.27	10	6.68
Cooking 1	32.65	47.68	**N/A**		3.9	5.75	**N/A**		N/A		N/A	
Cooking 2	5.08	4.17	**N/A**		0.07	0.06	**N/A**		N/A		N/A	
Cooking 3	BDL		**N/A**		0.12	0.06	**N/A**		N/A		N/A	
Cooking 4	BDL		N/A		0.14	0.03	N/A		N/A		N/A	
Subtotal		52.12		0.27		6.11		9.35		1.27		6.68
Concession	N Latitude	W Longditude	Elevation (ft)	Season	Energy Unit 1	Control	Fuel Use (gal/month)					
Rainbow Forest Oasis (South End)	34°48.813'	109°52.010'	5525	Summer	Propane	None	215.9					
Source	TSP Factor	TSP (lbs/month)	PM10 Factor	PM10 (lbs/month)	VOC Factor	VOC (lbs/month)	NOx Factor	NOX (lbs/month)	CO Factor	CO (lbs/month)	SOx Factor	SOx (lbs/month)
Energy Unit 1	0.4	0.09	0.4	0.09	0.3	0.06	14.0	3.02	1.9	0.41	10	2.16
Emission Totals	Summer	TSP (lbs/month)		PM10 (lbs/month)		VOC (lbs/month)		NOX (lbs/month)		CO (lbs/month)		SOx (lbs/month)
Subtotal		0.09		0.09		0.06		3.02		0.41		2.16
Summer Total		52.20		0.35		6.17		12.37		1.68		8.84
Concession	N Latitude	W Longditude	Elevation (ft)	Season	Energy Unit 1	Control	Fuel Use (gal/month)	Cooking 1	Control	Amount Cooked (lbs)		
Painted Desert Oasis (North End)	35°4.013'	109°46.890'	5821	Winter	Propane	None	1720.7	Broiler-Beef	Filter	440		
Cooking 2	Control	Amount Cooked (lbs)	Cooking 3	Control	Amount Cooked (lbs)	Cooking 4	Control	Amount Cooked (lbs)				
Grill-Beef	Filter	247	Deep Fat Fryer Chicken	Filter	163	Deep Fat Fryer Fish	Filter	72				
Source	TSP Factor	TSP (lbs/month)	PM10 Factor	PM10 (lbs/month)	VOC Factor	VOC (lbs/month)	NOx Factor	NOX (lbs/month)	CO Factor	CO (lbs/month)	SOx Factor	SOx (lbs/month)
Energy Unit 1	0.4	0.69	0.4	0.69	0.3	0.52	14.0	24.09	1.9	3.27	10	17.21
Cooking 1	32.65	14.36	**N/A**		3.9	1.73	**N/A**		N/A		N/A	
Cooking 2	5.08	1.26	**N/A**		0.07	0.02	**N/A**		N/A		N/A	
Cooking 3	BDL		**N/A**		0.12	0.02	**N/A**		N/A		N/A	
Cooking 4	BDL		N/A		0.14	0.01	N/A		N/A		N/A	
Subtotal		16.30		0.69		2.30		24.09		3.27		17.21
Concession	N Latitude	W Longditude	Elevation (ft)	Season	Energy Unit 1	Control	Fuel Use (gal/month)					
Rainbow Forest Oasis (South End)	34°48.813'	109°52.010'	5525	Winter	Propane	None	614.4					
Source	TSP Factor	TSP (lbs/month)	PM10 Factor	PM10 (lbs/month)	VOC Factor	VOC (lbs/month)	NOx Factor	NOX (lbs/month)	CO Factor	CO (lbs/month)	SOx Factor	SOx (lbs/month)
Energy Unit 1	0.4	0.25	0.4	0.25	0.3	0.18	14.0	8.60	1.9	1.17	10	6.14
Emission Totals	Winter	TSP (lbs/month)		PM10 (lbs/month)		VOC (lbs/month)		NOX (lbs/month)		CO (lbs/month)		SOx (lbs/month)
Subtotal		0.25		0.25		0.18		8.60		1.17		6.14
Winter Total		16.55		0.93		2.48		32.69		4.44		23.35

Table 3.1: Emissions from Concessionaire Facilities (cont)

Fuel Dispensing		N Latitude	W Longditude	Elevation (ft)	Season							
Painted Desert Oasis (North End)		35°4.013'	109°46.890'	5821	Summer	Gasoline Refueled (gal/month)	Control	Gasoline Loaded (gal/month)	Control	Diesel Loaded (gal/month)	Control	
						16524	None	16524	None	5955	None	
Evaporation	TSP Factor	(lbs/month)	Factor	(lbs/month)	VOC Factor	(lbs/month)	NOx Factor	(lbs/month)	CO Factor	(lbs/month)	SOx Factor	(lbs/month)
Gasoline Ref.	n/a	n/a	n/a	n/a	12.7	209.86	n/a	n/a	n/a	n/a	n/a	n/a
Gasoline Load.	n/a	n/a	n/a	n/a	11.5	190.03	n/a	n/a	n/a	n/a	n/a	n/a
Diesel Load.	n/a	n/a	n/a	n/a	0.03	0.18	n/a	n/a	n/a	n/a	n/a	n/a
Totals		(lbs/month)		(lbs/month)		(lbs/month)		(lbs/month)		(lbs/month)		(lbs/month)
Summer Total		0.00		0.00		400.07		0.00		0.00		0.00
Painted Desert Oasis (North End)		35°4.013'	109°46.890'	5821	Winter	Gasoline Refueled (gal/month)	Control	Gasoline Loaded (gal/month)	Control	Diesel Loaded (gal/month)	Control	
						8245	None	8245	None	500	None	
Evaporation	TSP Factor	(lbs/month)	Factor	(lbs/month)	VOC Factor	(lbs/month)	NOx Factor	(lbs/month)	CO Factor	(lbs/month)	SOx Factor	(lbs/month)
Gasoline Ref.	n/a	n/a	n/a	n/a	12.7	104.71	n/a	n/a	n/a	n/a	n/a	n/a
Gasoline Load.	n/a	n/a	n/a	n/a	11.5	94.82	n/a	n/a	n/a	n/a	n/a	n/a
Diesel Load.	n/a	n/a	n/a	n/a	0.03	0.02	n/a	n/a	n/a	n/a	n/a	n/a
Totals		TSP (lbs/month)		PM10 (lbs/month)		VOC (lbs/month)		NOX (lbs/month)		CO (lbs/month)		SOx (lbs/month)
Winter Total		0.0		0.0		199.54		0.0		0.0		0.0
Total Fuel Disp		0.00		0.00		599.61		0.00		0.00		0.00

Concessionaire Totals

Season:	**Summer**	**TSP** (lbs/mo)	**PM10 (lbs/mo)**	VOC **(lbs/mo)**	**NOX (lbs/mo)**	**CO** (lbs/mo)	**SOx** (lbs/mo)
		52.2	**0.35**	**406.2**	**12.37**	**1.68**	**8.84**
Season:	**Winter**	**TSP (lbs/mo)**	PM10 **(lbs/mo)**	VOC **(lbs/mo)**	**NOX (lbs/mo)**	**CO (lbs/mo)**	**SOx (lbs/mo)**
		16.5	**0.93**	**202.0**	**32.69**	**4.44**	**23.35**

Table 3.2: Emissions from NPS Facilities

Facility		N Latitude	W Longditude	Elevation (ft)	Season	Energy Unit 1	Control	Fuel Use (gal/month)				
NPS In-Park Facilities					Summer	Propane	None	1248				
Energy Unit	TSP Factor	TSP (lbs/month)	PM10 Factor	PM10 (lbs/month)	VOC Factor	VOC (lbs/month)	NOx Factor	NOX (lbs/month)	CO Factor	CO (lbs/month)	SOx Factor	SOx (lbs/month)
Unit 1	0.4	0.50	0.4	0.50	0.3	0.37	14.0	17.47	1.9	2.37	10.0	12.48
Totals	Summer	TSP (lbs/month)		PM10 (lbs/month)		VOC (lbs/month)		NOX (lbs/month)		CO (lbs/month)		SOx (lbs/month)
		0.50		0.50		0.37		17.47		2.37		12.48
Facility		N Latitude	W Longditude	Elevation (ft)	Season	Energy Unit 1	Control	Fuel Use (gal/month)				
NPS In-Park Facilities					Winter	Propane	None	3114				
Energy Unit	TSP Factor	TSP (lbs/month)	PM10 Factor	PM10 (lbs/month)	VOC Factor	VOC (lbs/month)	NOx Factor	NOX (lbs/month)	CO Factor	CO (lbs/month)	SOx Factor	SOx (lbs/month)
Unit 1	0.4	1.25	0.4	1.25	0.3	0.93	14.0	43.60	1.9	5.92	10.0	31.14
Totals	Winter	TSP (lbs/month)		PM10 (lbs/month)		VOC (lbs/month)		NOX (lbs/month)		CO (lbs/month)		SOx (lbs/month)
		1.25		1.25		0.93		43.60		5.92		31.14

Facilities Totals

Season:	**Summer**	**TSP (lbs/month)**	PM10 (lbs/month)	VOC (lbs/month)	NOX (lbs/month)	CO (lbs/month)	SOx (lbs/month)
		0.50	0.50	0.37	17.47	2.37	12.48
Season:	**Winter**	TSP (lbs/month)	PM10 (lbs/month)	VOC (lbs/month)	NOX (lbs/month)	CO (lbs/month)	SOx (lbs/month)
		1.25	1.25	0.93	43.60	5.92	31.14

[redacted]

Residencial Area	N Latitude	Longditude	Elevation (ft)	Season	Energy Unit 1	Control	Wood Use (Tons/month)	Energy Unit 2	Control	Wood Use (Tons/month)
Park-Wide NPS Housing				Summer	Wood Stove	None	0.31	Pellet Stove	None	0.51

Heating Units	TSP Factor	TSP (lbs/month)	PM10 Factor	PM10 (lbs/month)	VOC Factor	VOC (lbs/month)	NOx Factor	NOX (lbs/month)	CO Factor	CO (lbs/month)	SOx Factor	SOx (lbs/month)
Unit 1	30.6	9.4	30.6	9.4	53	16.3	2.8	0.9	231	71.2	0.4	0.1
Unit 2	4.2	2.2	4.2	2.2	n/a	0.0	13.8	7.1	39.4	20.2	0.4	0.2
Totals	Summer	11.6		11.6		16.3		7.9		91.4		0.3

Residencial Area	N Latitude	Longditude	Elevation (ft)	Season	Energy Unit 1	Control	Fuel Use (gal/month)	Energy Unit 2	Control	Wood Use (Tons/month)
Park-Wide NPS Housing				Winter	Wood Stove	None	0.49	Wood Pellet	None	1.28

Heating Units	TSP Factor	TSP (lbs/month)	PM10 Factor	PM10 (lbs/month)	VOC Factor	VOC (lbs/month)	NOx Factor	NOX (lbs/month)	CO Factor	CO (lbs/month)	SOx Factor	SOx (lbs/month)
Unit 1	30.6	14.9	30.6	14.9	53	25.9	2.8	1.4	231	112.7	0.4	0.2
Unit 2	4.2	5.4	4.2	5.4	n/a	0.0	13.8	17.7	39.4	50.5	0.4	0.5
Totals	Winter	20.3		20.3		25.9		19.0		163.2		0.7

Residencial Area	N Latitude	W Longditude	Elevation (ft)	Season	Energy Unit 1	Control	Wood Use (Tons/month)
Park-Wide Concessionaire				Summer	Wood Stove	None	0.03

Heating Units	TSP Factor	TSP (lbs/month)	PM10 Factor	PM10 (lbs/month)	VOC Factor	VOC (lbs/month)	NOx Factor	NOX (lbs/month)	CO Factor	CO (lbs/month)	SOx Factor	SOx (lbs/month)
Unit 1	30.6	0.8	30.6	0.8	53	1.4	2.8	0.1	231	5.9	0.4	0.01
Totals	Summer	0.8		0.8		1.4		0.1		5.9		0.01

Residencial Area	N Latitude	Longditude	Elevation (ft)	Season	Energy Unit 1	Control	Wood Use (Tons/month)
Park-Wide Concessionaire				Winter	Wood Stove	None	0.06

Heating Units	TSP Factor	TSP (lbs/month)	PM10 Factor	PM10 (lbs/month)	VOC Factor	VOC (lbs/month)	NOx Factor	NOX (lbs/month)	CO Factor	CO (lbs/month)	SOx Factor	SOx (lbs/month)
Unit 1	30.6	2.0	30.6	2.0	53	3.4	2.8	0.2	231	14.8	0.4	0.03
Totals	Winter	2.0		2.0		3.4		0.2		14.8		0.03

Residential Emissions

		TSP (lbs/month)	PM10 (lbs/month)	VOC (lbs/month)	NOX (lbs/month)	CO (lbs/month)	SOx (lbs/month)
Season:	**Summer**	12.4	12.4	17.7	8.0	97.3	0.3
Season:	**Winter**	22.3	22.3	29.3	19.2	178.0	0.7

Chapter Four - Area Sources

Miscellaneous Solvent Usage

MSDS sheets were located via internet searches for the materials identified in use within the Park by Park and concessionaire staff. The specific gravity and volatile content identified in the MSDS sheets, coupled with the usage amounts provided by Park staff and concessionaire staff were used to calculate the VOC emissions. These emissions were then apportioned equally throughout the year.

Road Maintenance

Park staff reported using 200 tons of cold mix asphalt for road maintenance during the year. Emissions of volatile organics from the asphalt were calculated using AP-42 emission factors and apportioned equally over the entire year. Park staff also indicated that 858 gallons of road oil had been purchased. For the purpose of this emissions inventory, it is assumed that all 858 gallons are used within the year.

Dirt Storage Pile

Within the bone yard, a pile of what appeared to be dirt was visually estimated to be 6 feet high by 12 feet wide by 30 feet long. For emission estimation, a moisture content of 3% was assumed along with an average wind speed of 3 mph. The AP-42 emission factor for crushed limestone was used in order to best approximate the emissions. Although not observed by CE-CERT staff, a large pile of dirt (road barrow) was reported by Park staff after the on-site survey to be located in the vicinity of the picnic area. Because no estimate of the size of the pile was available, estimates of the particulate emissions could not be included in this inventory. Also within the bone yard, a small gravel screening operation utilizing a front loader and a coarse screen was also observed in conjunction with two small gravel piles. No estimate could be provided of the type or amount of material screened and, as a result, no estimate of the particulate emissions from this activity are included in this inventory. However, both the dirt pile and the gravel screening activity would be additional sources of airborne particulate.

Pile Burning

Within the bone yard a pile of wood, wood waste materials, and bagged waste was observed. Park staff report burning of approximately 2500 pounds of this material is conducted during one or two burns each year. For the emission estimate contained in this report, it was assumed that two burns were conducted – one in the summer and one in the winter – with each consuming one-half of the total amount of waste material.

Prescribed Burning

Park staff reported there is little to no prescribed burning conducted within the Park. No estimate of emissions associated with prescribed open burning are included in this emission inventory.

Wildfires

Park staff reported there have been no wildfires within the Park and no estimates of wildfire emissions are included in this emission inventory..

Re-entrained Road Dust, Tire & Brake Wear

Paved Roadways

Monthly vehicle counts from the Monthly Public Use Report (form 10-157), in-Park measurements of the paved roadways, and assumptions on driving patterns based on the point of entry and assumed directions of travel upon leaving the park were used to estimate total in-Park driving on paved roads. Emission factors were developed from the Part5 model and AP-42. Using an on-board GPS unit, CE-CERT staff measured the total distance between the two entrances, including all paved access roads to points of interest in between, as 35 miles. For visitors entering the park via the Interstate 40 entrance the assumptions are as follows:
(1) There is a 50:50 split between visitors traveling east-west and west-east on both I-40 and Highway 180.
(2) 50% of I-40 east-west visitors will travel the entire 35 miles of paved roadways from the north entrance to the south entrance of the park; 25% will travel to the Blue Mesa and then eturn, exiting back on to I-40 for a total of 42 miles; 25% will travel south to the museum and then return to the north entrance for a total of 68 miles.
(3) 50% of I-40 west-east visitors will travel south to the Rainbow Forest museum and return to the north entrance for a total of 68 miles; 50% will travel to Blue Mesa and return to the north entrance for a total of 42 miles. Based on these assumptions, the average in-Park miles traveled by each visitor vehicle entering the Park at the I-40 entrance was estimated to be 49.8 miles.

For visitors entering the park via the Highway 180 entrance the assumptions are as follows:
(1) 75% of Highway 180 east-west visitors will travel the entire 35 miles of paved roadwys from the south entrance to the north entrance of the park; 25% will travel to Newspaper Rock and return to the south entrance for a total of 46.4 miles.
(2) 50% of Highway 180 west-east visitors will travel to the visitor center and return to the south entrance for a total of 69.6 miles; 50% will travel to Newspaper Rock and return to the south entrance for a total of 46.4 miles. Based on these assumptions, the average in-Park miles traveled by each visitor vehicle entering the Park at the Highway 180 entrance was estimated to be 47.9 miles.

In addition, there are a number of vehicles that are recorded as entering the park property from I-40 that do not show up in the numbers recorded for vehicles passing through the fee booths. It is logical that these vehicles belong to travelers who either only visit the visitors' center or use the concessionaire facilities located next to the visitor center. The round trip in-Park distance traveled in this case was measured to be 0.6 miles per vehicle.

It was also assumed that all tour buses would travel the entire 35 miles of in-Park paved roads regardless of whether they entered from the south (Highway 180) or north (I-40) entrances. The combination of these measurements and assumptions resulted in an estimate of 8,073,559 miles traveled on paved roads within the Park during fiscal year 2000. Monthly and seasonal vehicle miles traveled were calculated based upon the monthly vehicle counts recorded on the 10-157 forms.

Unpaved Roadways

Public access within the Park is limited to paved roads. The unpaved roads routinely used by Park staff and frequency of use were identified through discussions with Park personnel and distances traveled were estimated from available maps. Monthly usage was estimated as follows: Adamana roadway is used once per month for a total distance of 0.6 miles; all water pipeline access roads (18 miles) are traveled once each week for a total of (4.33 x 18) 78 miles a month; The roadway to the horse corral (2 miles) is traveled round trip three times per day for a total of (2 x 2 x 3 x30) 360 miles per month; and lastly, the road to the bone yard (1 mile) is traveled round trip once per day for a total of (1 x 2 x 30) 60 miles per month. Total monthly travel on unpaved roads was estimated at 499 miles.

Table 4.1: Emissions from Solvent Usage

	Solvent Usage				
	Concessionaire				
Name of Material		Amount (gals/year)	Specific Gravity	% Volatile Content (by weight)	VOC (lbs/month)
	Summer				
Latex Paint		44	n/a	0.83	3.0
Oil Based Paint		6	1.29	8.3%	0.5
Spray Paint		0.25	0.85	100%	0.1
Paint Thinner		3	0.83	72.0%	1.3
Varnish		2	0.89	59%	0.7
	Sub-Total				5.6
Name of Material		Amount (gals/year)	Specific Gravity	% Volatile Content (by weight)	VOC (lbs/month)
	Winter				
Latex Paint		44	n/a	0.83	3.0
Oil Based Paint		6	1.29	8.3%	0.5
Spray Paint		0.25	0.85	100%	0.1
Paint Thinner		3	0.83	72.0%	1.3
Varnish		2	0.89	59%	0.7
	Sub-Total				5.6

Table 4.1: Emissions from Solvent Usage (cont)

Solvent Usage

NPS-Petrified Forest

Name of Material	Amount (gals/year)	Specific Gravity	% Volatile Content (by weight)	VOC (lbs/month)
Summer				
Latex Acryllic Paint	1846	1.62	80%	1680
Neugenic 4175	30	0.794	85%	14.2
Polyproethenol	0	0.79	90%	0.0
Weld-on P68 (Primer for PVC Pipe)	0.25	0.845	70%	0.1
Weld-on 705 (Adhesive for PVC Pipe)	0.25	0.92	73%	0.1
Garlan or Garlon	15	1.08	61.6%	7.0
Sub-Total				21.5

Solvent Usage

NPS-Petrified Forest

Name of Material	Amount (gals/year)	Specific Gravity	% Volatile Content (by weight)	VOC (lbs/month)
Winter				
Latex Acryllic Paint	1846	1.62	80%	1680
Neugenic 4175	30	0.794	85%	14.2
Polyproethenol	0	0.79	90%	0.0
Weld-on P68 (Primer for PVC Pipe)	0.25	0.845	70%	0.1
Weld-on 705 (Adhesive for PVC Pipe)	0.25	0.92	73%	0.1
Garlan or Garlon	15	1.08	61.6%	7.0
Sub-Total				21.5

Table 4.2: Emissions from Road Paving

Road Paving

Name of Material		Amount (tons/month)	Specific Gravity	VOC Factor	VOC (lbs/month)
	Summer				
Cold Mix Asphalt		16.7	n/a	0.2	6,666.7
Road Oil		0.04	n/a	0.5	39.3
	Sub-Total				6,706.0
Name of Material		Amount (gals/year)	Specific Gravity	VOC Factor	VOC (lbs/month)
	Winter				
Cold Mix Asphalt		16.7	n/a	0.2	6,666.7
Road Oil		0.04	n/a	0.5	39.3
	Sub-Total				6,706.0

Total Evaporative Emissions from Solvent Use and Road Paving

	VOC (lbs/month)
Summer	6,733.1
Winter	6,733.1

Table 4.3: Emissions from Other Area Sources

Item	N Latitude	W Longditude	Elevation (ft)	Season	Pile Surface Area (sqft)	Number of Piles
Dirt Pile	35°04.347'	109°46.084'	5849	Summer	360	1

	TSP Factor	TSP (lbs/month)	PM10 Factor	PM10 (lbs/month)	VOC Factor	VOC (lbs/month)	NOx Factor	NOX (lbs/month)	CO Factor	CO (lbs/month)	SOx Factor	SOx (lbs/month)
Dirt Pile	3.5	0.9	1.7	0.4	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

Totals	*Summer TSP (lbs/month)*	*PM10 (lbs/month)*	*VOC (lbs/month)*	*NOX (lbs/month)*	*CO (lbs/month)*	*SOx (lbs/month)*
	0.9	0.4				

Item	N Latitude	W Longditude	Elevation (ft)	Season	Pile Surface Area (sqft)	Number of Piles
Dirt Pile	35°04.347'	109°46.084'	5849	Winter	360	1

	TSP Factor	TSP (lbs/month)	PM10 Factor	PM10 (lbs/month)	VOC Factor	VOC (lbs/month)	NOx Factor	NOX (lbs/month)	CO Factor	CO (lbs/month)	SOx Factor	SOx (lbs/month)
Dirt Pile	3.5	0.9	1.7	0.4	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

Totals	Winter	TSP (lbs/month)	PM10 (lbs/month)	VOC (lbs/month)	NOX (lbs/month)	CO (lbs/month)	SOx (lbs/month)
		0.9	0.4				

Item	N Latitude	W Longditude	Elevation (ft)	Season	Type Burning	Tons Burned
Pile Burning	35°04.347'	109°46.084'	5849	Summer	Woodwaste	0.09

	TSP Factor	TSP (lbs/month)	PM10 Factor	PM10 (lbs/month)	VOC Factor	VOC (lbs/month)	NOx Factor	NOX (lbs/month)	CO Factor	CO (lbs/month)	SOx Factor	SOx (lbs/month)
woodwaste	28.4	2.5	19	1.7			4	0.4	169	15.1		0.0

Totals	*Summer TSP (lbs/month)*	*PM10 (lbs/month)*	*VOC (lbs/month)*	*NOX (lbs/month)*	*CO (lbs/month)*	*SOx (lbs/month)*
	2.5	1.7	0.0	0.4	15.1	0.0

Item	N Latitude	W Longditude	Elevation (ft)	Season	Type Burning	Tons Burned
Pile Burning	35°04.347'	109°46.084'	5849	Winter	Woodwaste	0.13

	TSP Factor	TSP (lbs/month)	PM10 Factor	PM10 (lbs/month)	VOC Factor	VOC (lbs/month)	NOx Factor	NOX (lbs/month)	CO Factor	CO (lbs/month)	SOx Factor	SOx (lbs/month)
woodwaste	28.4	3.6	19	2.4			4	0.5	169	21.1		0.0

Totals	Winter	TSP (lbs/month)	PM10 (lbs/month)	VOC (lbs/month)	NOX (lbs/month)	CO (lbs/month)	SOx (lbs/month)
		3.6	2.4	0.0	0.5	21.1	0.0

Total from Piles and General Fires

Season:		TSP (lbs/month)	PM10 (lbs/month)	VOC (lbs/month)	NOX (lbs/month)	CO (lbs/month)	SOx (lbs/month)
Season:	**Summer**	3.4	2.1	0.0	0.4	15.1	0.0
Season:	**Winter**	4.4	2.8	0.0	0.5	21.1	0.0

Chapter Five - Mobile Sources

The estimation of mobile source emissions represents the most complex data gathering and data analyses of this entire inventory. As described below in significant detail, it was necessary to first determine the composition of the in-Park vehicle fleet, and the driving patterns of vehicles operating within the Park. As noted earlier in this report, the composition of the in-Park visitor vehicle fleet was determined for both Arches and Zion National Parks. The combined vehicle fleet composition is then considered to represent the in-Park visitor vehicle fleet for all of the National Parks included in this survey effort. Driving patterns were established for both Arches and Zion National Parks. Based on in-Park observations, one of the two driving patterns was subsequently used to best represent the driving patterns occurring in each of the other six Parks. This information was then used as input in EPA's Mobile 5b model to develop emission factors applicable to Petrified Forest National Park. These factors were then used in conjunction with the records of the number of vehicles entering the Park to determine the total emissions (both evaporative and exhaust) generated by mobile sources operating within the Park. It is estimated that visitor driving patterns within Petrified Forest National Park are best represented by those observed within Arches National Park.

Need for Characterization of the In-Park Vehicle Fleet

Use of the standard inputs for emission modeling of mobile sources within a National Park may be inaccurate in two main areas: the vehicle fleet and the driving behavior. Large differences in emissions rates have been observed across model years in an in-use vehicle fleet, resulting from the large reductions in emissions with improvements in emission control technology. [Calvert, et. al., 1993] Improvements in fuel control and catalyst technology, particularly with the advent of the Tier 1 emissions standards starting in 1994, have resulted in far lower emissions from typical vehicles. Accurate characterization of the vehicle fleet is essential for proper estimation of emissions because of these large differences in emission rates.

Need for Characterization of In-Park Driving Patterns

Driving behavior can also have a large influence on emissions of vehicles, particularly with newer vehicles because of command enrichment of the air/fuel mixture. Emissions can vary by an order of magnitude within the space of a few seconds, with the response frequently non-linear because of enrichment or enleanment of the air-fuel mixture. Enrichment occurs in modern computer-controlled vehicles based on proprietary engine control strategies. The computer enriches the air-fuel mixture at high power to protect the catalytic converter from heat damage, resulting in short-term spikes in emissions. The size and timing of the emissions increases vary from vehicle to vehicle, even for identical models. Enleanment occurs in some modern computer-controlled vehicles during coast down and braking events. The various factors present in the national parks that may influence mobile source emissions are summarized in Table 5.1.

Table 5.1 Summary of Factors That Have the Potential to Influence Mobile Source Emissions in National Parks

Factor	Expected Result
Vehicle Distribution – Higher Proportion of New Vehicles	Lower Emissions
Vehicle Distribution – Higher Proportion of Trucks and *SUV's*	Higher Emissions
Vehicle Driving Patterns – Absence of High Speed (> 50 mph) Driving	Lower Emissions
Vehicle Driving Patterns – Lower Average Speed	Potential for Lower or Higher Emissions
Vehicle Driving Patterns – Milder Accelerations/Decelerations	Lower Emissions
Vehicle Load – Higher Proportion of Vehicles Having Trailers	Higher Emissions
Vehicle Load – Higher Road Grade Than Typical Driving	Higher Emissions

Description of Evaporative and Tailpipe Emissions

Pollution from vehicles is typically broken into two components denoted evaporative emissions and tailpipe emissions. Evaporative emissions involve emissions of volatile organic compounds (VOC) resulting from the evaporation of gasoline and diesel fuel from parked and moving vehicles. Evaporative emissions also occur when vehicles are being refueled, but for purposes of this study, these emissions will be considered to be stationary source emissions and will be treated in a different section of the report. It should be noted that the evaporation of diesel fuel is very small and is thus typically ignored. Tailpipe emissions are of course associated with the combustion of fuel in the engine and consist primarily of VOC, NOx, SOx, CO, and PM2.5.

Evaporative emissions are dependent upon the volatility of the fuel involved, the ambient temperature that the fuel is subjected to and the nature of any onboard control that exists on vehicles. Newer vehicles have more elaborate and of course newer control systems that typically function better to prevent evaporative emissions. It has more recently been found that small seeps can occur in fuel line hoses and connections that can be undetectable by vehicle owners and automotive maintenance personnel but can represent substantial additional evaporative emissions. Steps have been taken in the manufacture of newer vehicles to eliminate these seeps by using improved materials and connectors. Again, the age distribution of the fleet of vehicles being analyzed combined with the ambient temperature is the key determinate of the amount of evaporative emissions from vehicles.

Most tailpipe emissions, with the exception of nitrogen oxides, are the result of the incomplete combustion of fuels in vehicle engines. Nitrogen oxides result from the high temperatures that occur in engine cylinders and tend to be produced at maximum quantity when an engine is running under optimum power conditions. The actual emissions from an engine at a point in time depend upon the amount of fuel injected into the engine cylinders combined with the air to fuel ratio and the pressures in the cylinders. These emissions are further exacerbated by leaks around valves and pistons and reduced by control equipment in the exhaust stream. The amount of fuel injected into the engine cylinders is a function of the power demand on the engine. Thus, emissions from vehicles are continuously changing as a vehicle is taken through various load situations by the driver and vary from vehicle to vehicle depending upon engine design and age, exhaust treatment, terrain and altitude.

In order to deal with the complexities of evaporative and tailpipe emissions, the U.S. EPA and the California Air Resources Board along with other private and public laboratories have carried out considerable in-use vehicle testing under various driving conditions and ages. Using these data, three important vehicle emissions models have been developed for use in air pollution control planning. The U.S. EPA produces a model designated as the "MOBILE" model to estimate VOC, NOx, and CO and the "Part5" model to estimate particulate matter from vehicles. The California Air Resources Board produces a model denoted "EMFAC," which is designed specifically for California and estimates VOC, NOx, CO, and particulate matter. These models have undergone many revisions to try and improve their accuracy. The latest version of MOBILE is MOBILE5b; although, a version 6 has been promised within the next few months. The latest version of the particulate model is Part5. The U.S. EPA has indicated that they intend to include particulate estimates in Mobile 6 in 2001. The latest version of the California model is EMFAC2000, which is still in the beta testing mode.

All of these models are focused on estimating emissions in urban non-attainment areas where the greatest air quality problems have traditionally occurred. They are based on specific driving patterns selected to be typical of modern urban driving. These models include emission adjustments based on average vehicle speed, which have been developed through subsequent urban testing. These emission estimates and speed corrections are questionable when applied to driving situations that may not be typical of general urban driving. To address the limitations in the MOBILE and EMFAC models for analysis of specific highway situations or non-urban areas with differing patterns, or modes, of driving, several modal models have been developed. In late 1995, the Bourns College of Engineering, Center for Environmental Research and Technology (CE-CERT) at the University of California, Riverside undertook a cooperative investigation with the University of Michigan and Lawrence Berkeley National Laboratory in order to develop a comprehensive modal emissions model (CMEM). CMEM provides an alternate means for estimating vehicle emissions for situations where non-standard driving patterns may be the norm. [Barth et al. (1996), Barth et al. (1997), and An et al. (1997).] CMEM and all of the other presently available modal models are relatively new and have not received the full range of review accorded the MOBILE, Part5, and EMFAC models. However, as part of the model development process, CMEM was given a full validation, including a bootstrap analysis of the model bias on a second-by-second basis for independent test cycles. [Schulz et al, 2000.] CMEM is based on specific measurements conducted on about 400 in-use vehicles where specific driving patterns were established to facilitate modal model development. The resulting CMEM model has been demonstrated to provide accurate emission estimates for normally operating vehicles driven under a wide range of EPA facility cycles and for some types of malfunctioning vehicles. [Levine et al, 2000]

The approach selected to estimate emissions from vehicles in this study is to use the latest available versions of the MOBILE and PART5 models as the core emissions models. Adjustments will then be made to these model results based on additional analysis provided by the CMEM model as described in succeeding sections.

Data Collection Methodologies

As noted in the introduction, an important component in estimating vehicle emissions is the type of vehicles operating in the analysis region. The EPA and most State governments provide vehicle distribution data on a national, state, or county level. It was felt, however, that the distribution of vehicles in national parks would not normally follow these national or state default distributions. Vehicles arrive at national parks from many states with some bias toward the state in which the park is located, and it was expected that park visitors will tend to use their most modern and comfortable vehicles to travel to and through national parks thus skewing the vehicle distribution from the default values selected to be typical of urban areas. Thus, a key element of this study is to analyze the vehicle fleet presently operating in the national parks of interest.

A second critical link in estimating vehicle emissions is the driving patterns and resulting loads that vehicles are subjected to during operations. These driving patterns potentially consist of a cold start inside of or outside of the park, driving in the park with potentially frequent stops and subsequent warm starts of the vehicle. Driving behavior has a large effect on emissions of motor vehicles, with emissions of newer vehicles increasing by a factor of 10 to 100 during enrichment events. The lower posted speed limits in the national parks, combined with the frequent stops for sightseeing are expected to have an influence on the driving patterns in the parks. The relative proportion of hard accelerations and decelerations in national park driving in comparison with "typical" driving represented in the standard emission models has the potential to significantly increase or decrease the estimated emissions within the parks. During the planning phase of this project it was envisioned that driving patterns within National Parks are significantly different from the typical urban driving simulated in the conventional U.S. EPA and California models. For this reason, CE-CERT employed data collection methodologies in order to construct and compare in-park driving patterns with the typical urban driving patterns used in these conventional models.

In-Park Vehicle Fleet Results

To determine the vehicle distribution in Petrified Forest National Park, data collected from Zion and Arches National Park were combined to create a fleet distribution representative of the in-park vehicle fleet. A digital video camera was set up at different locations and different times in the two Parks in order to photograph a representative sample of the vehicles traveling within the Parks. Over 3,000 vehicles were videotaped within the two Parks. These vehicles were subsequently identified and classified according to their vehicle type and age.

The vehicles were categorized into 7 classes used in the MOBILE model (Table 5.2). Most of the recreational vehicles were classed in the LDGT2 or the HDGV category, depending on size. Table 5.3 displays the national default fleet distribution and the results of the Park-derived fleet distribution. This national fleet distribution is also used by the State of Utah to prepare their emissions inventory. As expected, the fraction of light duty vehicles, heavy light duty trucks (LDGT2) and motorcycles was higher in the Parks, and the fraction of heavy-duty diesel vehicles was lower.

Table 5.2 Vehicle Class Definitions

Vehicle Class	Abbreviation	GVWR
Light Duty Gasoline Vehicle	LDGV	
Light Duty Gasoline Trucks 1	LDGT1	Up to 6000 lbs
Light Duty Gasoline Trucks 2	LDGT2	6001-8500 lbs
Heavy Duty Gasoline Vehicles	HDGV	Greater than 8500 lbs
Light Duty Diesel Vehicles	LDDV	
Light Duty Diesel Trucks	LDDT	Up to 8500 lbs
Heavy Duty Diesel Vehicles	HDDV	Greater than 8500 lbs
Motorcycles	MC	

Table 5.3 Vehicle Distribution Measured in National Parks Compared to National Default Values

Vehicle Type	Default	Parks
LDGV	0.616	0.701
LDGT1	0.191	0.137
LDGT2	0.086	0.106
HDGV	0.031	0.008
LDDV	0.002	0.000
LDDT	0.001	0.003
HDDV	0.068	0.016
MC	0.006	0.028
Total	1.00	1.00

In addition, the approximate age of the vehicle was recorded and a model year distribution for each vehicle class was devised. Due to the difficulty in identifying the exact year of manufacture of each vehicle, the vehicles were grouped into three to four year groupings and attributed equally to the ages in each groups. Table 5.4 compares the Park's distribution to the MOBILE5b default age distribution. As expected, a larger fraction of newer vehicles is present in the Parks data set.

Table 5.4 -Vehicle Age Distribution Measured in National Parks Compared to National Default Values

	LDV		LDT	
Age	Default	Parks	Default	Parks
0	0.049	0.158	0.063	0.161
1	0.079	0.158	0.084	0.161
2	0.083	0.158	0.084	0.161
3	0.082	0.158	0.084	0.161
4	0.084	0.059	0.084	0.043
5	0.081	0.059	0.069	0.043
6	0.077	0.059	0.059	0.043
7	0.056	0.059	0.044	0.043
8	0.050	0.025	0.036	0.025
9	0.051	0.025	0.031	0.025
10	0.050	0.025	0.030	0.025
11	0.054	0.010	0.052	0.018
12	0.047	0.010	0.046	0.018
13	0.038	0.010	0.046	0.018
14	0.024	0.004	0.036	0.010
15	0.019	0.004	0.028	0.010
16	0.014	0.004	0.017	0.010
17	0.015	0.004	0.022	0.010
18	0.011	0.002	0.017	0.004
19	0.008	0.002	0.014	0.004
20	0.006	0.002	0.009	0.004
21	0.005	0.000	0.008	0.001
22	0.004	0.000	0.008	0.001
23	0.003	0.000	0.005	0.001
24	0.010	0.000	0.024	0.000
Total	1.00	1.00	1.00	1.00

In-Park Driving Pattern Results

Driving pattern data was collected using an instrumented 1997 Ford Expedition as a chase car. The data collection was accomplished by selecting random Zion and Arches National Park visitors for following during their in-Park visit. The chase car driver manually matched the speed of the target vehicles and care was taken to stay far enough from the followed vehicle to not disturb the driver's normal vehicle driving pattern. The driving data collected is not an exact match to the target vehicle because of small errors introduced by the chase car driver, however the slow speeds and moderate accelerations of vehicles within the park provide optimal conditions for this type of data collection. The primary data collection was accomplished using a Garmin Differential GPS unit mounted in the vehicle and connected to a laptop computer, with backup provided through a second laptop linked to the On-Board Diagnostic (OBD) system of the chase car, which also recorded vehicle speed. In the event that satellite signals to the GPS unit were interrupted while driving in narrow canyons or through tunnels, the OBD monitoring system would continue to provide the vehicle speed and a means to determine the engine load.

Data from the GPS unit was transmitted at 2-second intervals. This data included time, vehicle speed, location, and altitude. These data were imported into Excel files for each vehicle followed and then analyzed. Because of the sheer volume of the GPS data it will be made available electronically upon request.

In-Park Driving Pattern Results

Since the driving patterns within Petrified Forest are considered to be more similar to those found to exist in Arches National Park, the discussion of driving pattern results, in this report, is limited to the work performed at Arches National Park.

Arches National Park

Seven vehicles were followed in Arches National Park. This is fewer than is normally desired for this type of analysis, but it was believed that this amount of data will, at a minimum, provide insight into typical park driving patterns at Arches. Figure 5.1 represents the collection of all accelerations and speeds measured for the seven vehicles combined. The vertical scale is the fraction of time spent at a given speed/acceleration event. As can be seen, the primary driving event is a higher speed of 31 to 40 miles per hour with little acceleration (i.e. constant speed). Accelerations varied but were almost all captured in the range of ±2 miles per hour/second.

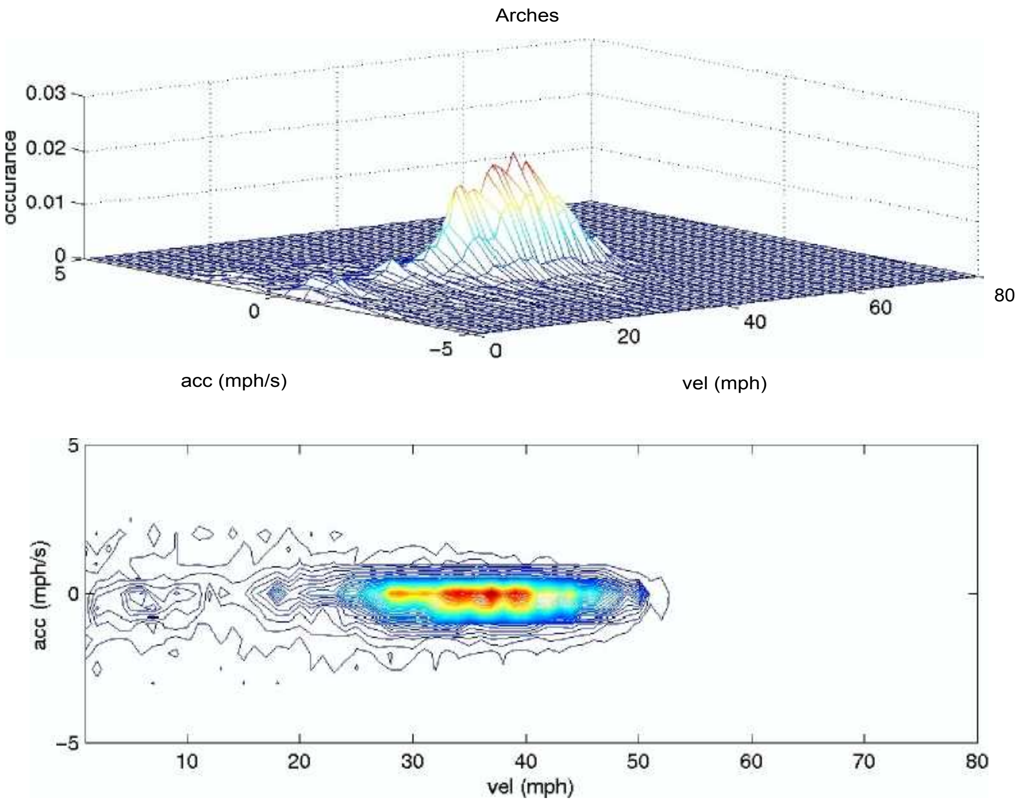


Figure 5.1 Driving Patterns of Seven Vehicles Followed at Arches National Park

Comparison With Federal Test Procedure (FTP)

The traditional driving pattern used for the development of emission factors for both Mobile and EMFAC is the Federal Test Procedure (FTP). This driving pattern was first designed in the 1970s. In recent years this driving pattern has been criticized for not being representative of modern driving patterns, which typically have higher speeds and harder accelerations. A new pattern, the US06, is in use as a supplement to the FTP. This driving pattern contains more hard accelerations and higher speeds compared to the FTP increasing predicted urban emissions. For comparison purposes, the FTP was used since it is still the primarily used driving pattern. Figure 5.2 breaks the FTP driving cycle into speed/acceleration events to compare with the data collected in Arches National Park.

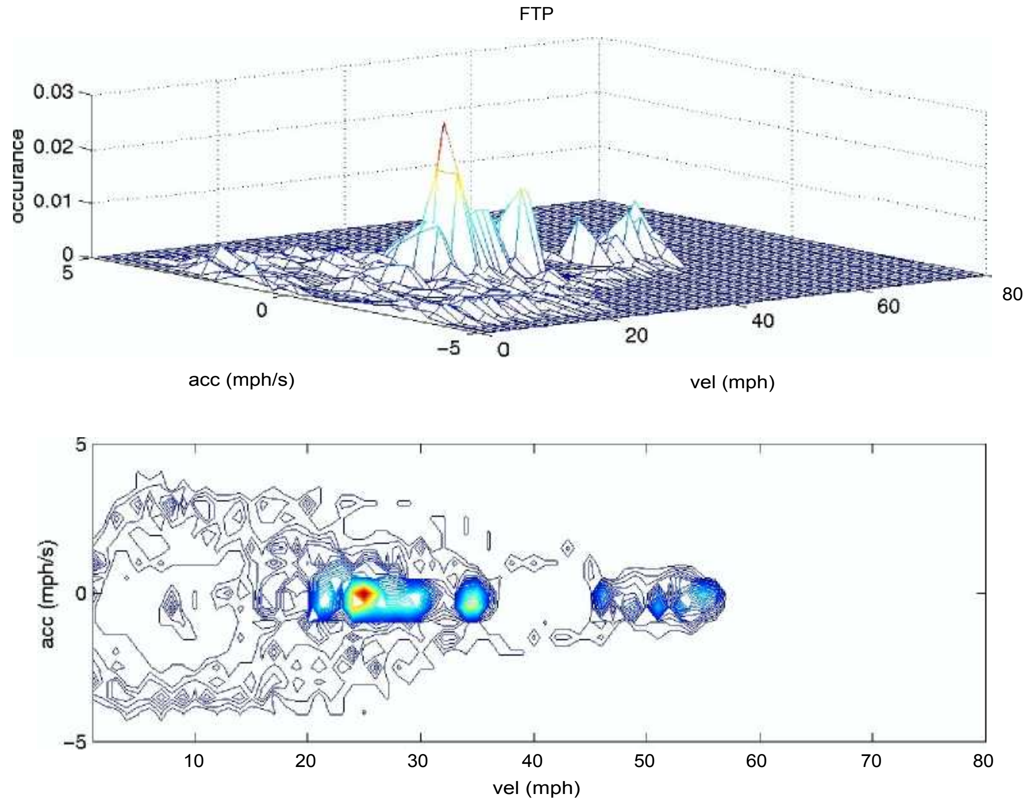


Figure 5.2 - FTP Driving Pattern Used for Vehicle Emissions Analysis

As can be clearly noted, the FTP cycle contains much higher speeds than were measured in Arches National Park and uses a much wider range of accelerations and decelerations than were observed in the Park. The new US06 cycle will exacerbate this difference even further.

Speed Distribution Testing

The differences in distributions in speeds observed between parks and between the FTP in the preceding sections were tested for statistical significance using the Kolmogorov-Smirnov two sample test (Siegel, 1956). The test is a non-parametric test for differences in distribution which is sensitive to all types of differences and does not assume any particular underlying statistical distribution. The distribution of speeds at Zion National Park is significantly different ($p<0.0001$) from the distribution of speeds at Arches National Park. In addition, both parks have distributions of speeds that are significantly different from those of the FTP ($p<0.0001$). These results are summarized in Table 5.5.

Table 5.5 Summary Statistics and K-S Test Results for Zion and Arches Speed Distributions

Speed Interval (mph)	Zion Cumulative (Percent)	Arches Cumulative (Percent)
0 – 5	34.15	27.82
5 - 10	37.89	30.79
10 - 15	42.26	33.06
15 – 20	58.80	36.60
20 – 25	79.88	41.03
25 – 30	93.01	50.62
30 – 35	97.64	64.57
35 – 40	99.14	80.51
40 – 45	99.99	93.25
45 - 50	100.00	98.96
50 - 55	100.00	100.00

Comparison of Emission Calculations

The CMEM model is specifically designed to analyze emissions from a specified sequence of speed/acceleration events. This allows the comparison of projected emissions associated with the driving patterns measured in Arches National Park with the FTP pattern. The results are shown in Table 5.6. Results were calculated for two types of vehicles. Category 11 vehicles in the CMEM model refer to newer high power to weight gasoline-powered vehicles (e.g. a 1998 Ford Taurus), which is similar to the dominant passenger cars observed in the parks. Category 17 vehicles in the CMEM model refer to newer full sized pickup trucks and SUVs, which are representative of the dominant larger vehicles in the parks. As can be seen in Table 5.6, the relative results between the two categories of vehicles are very similar.

Table 5.6 Projected Tailpipe Emissions (grams/mile) for Measured Driving Cycles and Comparisons with the FTP Driving Cycle

Vehicle Category	Emission	**FTP**	Arches	**Arches/FTP Ratio**
CMEM Cat 11	HC (g/mi)	0.012	0.009	0.750
CMEM Cat 17	HC (g/mi)	0.059	0.041	0.695
CMEM Cat 11	CO (g/mi)	0.37	0.25	0.676
CMEM Cat 17	CO (g/mi)	0.89	0.61	0.685
CMEM Cat 11	NOx (g/mi)	0.14	0.08	0.571
CMEM Cat 17	NOx (g/mi)	0.21	0.12	0.571
CMEM Cat 11	Fuel (g/mi)	137.8	99.7	0.724
CMEM Cat 17	Fuel (g/mi)	176.3	127.9	0.725

As can be seen in Table 5.6, emissions in Arches are projected to be significantly lower than those of the standard FTP driving cycle.This analysis illustrates the problem of simply applying the traditional MOBILE and EMFAC models to park situations.

Overall Estimated Vehicle Emissions

Both the fleet distribution and driving patterns can significantly affect vehicular emissions. The US EPA's MOBILE5b model was used to estimate several scenarios; using a base case, using Park derived fleet distribution data, and using Park derived fleet distribution data and Park derived driving pattern data (EPA, 1994). Both a summer time and a wintertime scenario were calculated for Petrified Forest National Park.

The input data for the baseline scenario was obtained from the Arizona AQMD (Hyde, 2001). For estimating the mobile source inventory for the nonattainment counties, the AQMD they assumes 90 percent I/M and 10 percent non-I/M. Because the Petrified Forest is in attainment counties yet has many visitors from urban areas, it was assumed that the fleet mix in the forest would contain 80 percent I/M and 20 percent non-I/M. Arizona's site-specific registration distribution was used for the baseline scnenario. For all estimates, high altitude was used and temperatures were obtained from the Petrified forest website www.petrified.forest.national-park.com/weather.htm. For modeling the Petrified Forest, estimates of the Park specific VMT and fleet profile were used. Appendix C shows the MOBILE and PART5 input files used for each scenario. The national default for all other inputs, such as the fraction of cold start, warm start and running emissions, were used where no other data was available or Arizona's modeling was consistent with the national default.

The effect of fleet distribution was first estimated independently from driving behavior. Tables 5.7-5.10 show emissions resulting from the EPA and Arizona's default fleet distribution, compared with emissions with the Park-specific vehicle type and model year distribution. Emissions at two speeds are shown to demonstrate this effect is relatively speed independent. The speeds selected here are 20 and 57 mph, these correspond to the speeds used for the Local and Freeway speeds used to estimate mobile emissions. This analysis was limited to the in-park private vehicle fleet, which excluded propane operated shuttle buses, gasoline and diesel government vehicles, as well as tour buses and off-road equipment. Emissions from these additional vehicles are included in the final emission analysis below.

The difference in the age and vehicle class distribution of the Parks' vehicle fleet results in lower emissions for all pollutants and vehicle classes at all speeds. VOC and CO emissions range from about 37 to 53 percent lower than the baseline case, and NOx emissions are 40-60 percent lower than the baseline (Table 5.7). Particulate matter emissions are not affected by speed or temperature changes. Emissions throughout this section will be compared with a "baseline" estimate, which is designated as the MOBILE derived emission factors without driving or fleet corrections applied.

Table 5.7 - Percent Change in Emissions from Baseline using National Park Fleet Distribution Data

	20 mph		57 mph	
	Summer	Winter	Summer	Winter
VOC	-44%	-53%	-37%	-39%
CO	-41%	-40%	-45%	-45%
NOx	-66%	-64%	-40%	-40%
PM	-22%	-22%	-22%	-22%

The effects of driving patterns on emissions were addressed in two ways. First, the average speed of the Parks' consolidated driving trace was modeled in MOBILE5b. This is an oversimplification of the complex effect of acceleration and driving pattern but gives an idea of the potential impact on emissions. Table 5.8 displays the percent change in emissions for the driving pattern observed at the park compared with the FTP driving trace.

Table 5.8 - Comparison of Average Speed to Emissions Using National Park Fleet Distribution and MOBILE emissions model compared with the FTP Cycle

	Summer	Winter
VOC	-8%	-11%
CO	-13%	-13%
NOx	1%	1%

The MOBILE model predicts that VOC and CO emissions will be slightly lower in the Park than the FTP trace. NOx emissions are virtually unaffected.

The impact of the variations in the driving pattern can also be illustrated using the results of the CMEM model. Since the MOBILE model estimates emissions based on the FTP cycle, the ratio of the emissions from the Park-specific driving cycle to the FTP driving cycle estimated in CMEM (shown in Table 5.6) can be applied to the MOBILE calculated emissions at the average speed of the FTP cycle. The driving cycle correction for Category 11 was applied to LDGV, and Category 17 corrections were applied to LDGTs. While the CMEM and MOBILE categories are not an exact match, this is the closest approximation possible. Other MOBILE categories were not corrected for driving pattern data in the table seen below. The emissions are displayed in Table 5.9.

Table 5.9 - Effect of Driving cycle as calculated by CMEM on vehicle emissions using the National Park Fleet Distribution compared with the FTP cycle

	Summer	Winter
VOC	-23%	-22%
CO	-27%	-27%
NOx	-35%	-36%

To estimate the on-road emissions within the park, it is necessary to include emissions from government operated vehicles in the park, and other vehicles, and to obtain an estimate of the number of miles traveled by each vehicle within the fleet.

Independent Tour Buses

Independent Tour Buses, which were not included in the fleet distribution, were estimated separately. Emission factors were estimated from MOBILE and the VMT and other factors are documented in Appendix C. The tour buses were assumed to be heavy-duty diesel trucks. The overall emissions for tour buses are shown in Table 5.10. The VOC emissions documented here include evaporative and tailpipe emissions.

Table 5.10 - Emissions from Tour Buses in Petrified Forest National Park (Tons/day)

	Summer		Winter	
	Baseline	Parks	Baseline	Parks
VOC	0.0020	0.0018	0.0007	0.0006
CO	0.0076	0.0063	0.0026	0.0022
NOx	0.0043	0.0034	0.0015	0.0012
PM	0.0003	0.0003	0.0001	0.0001

Government Vehicle Fleet

Park personnel provided the make, model and mileage for each government-leased vehicles (see worksheet 14). The average vehicle type and VMT was calculated and his information was used to estimate emission factors in MOBILE (Table 5.11). The VOC emissions documented here include evaporative and tailpipe emissions.

Table 5.11 - Emissions from On-Road Government Vehicles in Petrified Forest National Park, Tons/day

	Summer		Winter	
	Baseline	Parks	Baseline	Parks
VOC	0.0029	0.0016	0.0013	0.0007
CO	0.0191	0.0107	0.0169	0.0094
NOx	0.0013	0.0009	0.0013	0.0009
PM	0.0000	0.0000	0.0000	0.0000

Concessionaire Vehicle Fleet

Based on information provided by the Concessionaire, their vehicle fleet consists of three light duty gasoline vehicles (see worksheet 15). Fuel economy was based on was assumed to be 21 mpg. These values were used to calculate their in-Park miles traveled in conjunction with the concessionaire's estimate of in-Park fuel usage. Emission factors were estimated in MOBILE. The VOC emissions documented here include evaporative and tailpipe emissions.

Table 5.12 - Emissions from On-Road Concessionaire Vehicles in Petrified Forest National Park, Tons/day

	Summer		Winter	
	Baseline	Parks	Baseline	Parks
VOC	0.00023	0.00011	0.00010	0.00005
CO	0.00170	0.00086	0.00140	0.00090
NOx	0.00009	0.00006	0.00008	0.00007
PM	0.00000	0.00000	0.00000	0.00000

Private Vehicle Fleet

The private vehicles entering Petrified Forest National Park are calculated to travel a total of 28,622 miles per day during the summer and over 13,600 miles per day during the winter. The park specific vehicle class and age distributions were used in conjunction with MOBILE to calculate emission factor specific for Petrified Forest National Park, whereas the Baseline estimate uses EPA and SIP standard fleet distribution data. The activity data from the parks combined with the emission factors gives an estimate of the average daily on-road emissions (Table 5.13). The VOC emissions documented here include evaporative and tailpipe emissions.

Table 5.13 - Emissions from Privately Owned Vehicles in ParkName National Park, Tons/day

	Summer		Winter	
	Baseline	Parks	Baseline	Parks
VOC	0.127	0.066	0.034	0.014
CO	0.798	0.411	0.381	0.200
NOx	0.091	0.031	0.046	0.016
PM	0.001	0.0008	0.000	0.0004

Total Inventory of Vehicle Emissions

The sum of the privately owned vehicles, government vehicles, and tour buses make up the overall on-road inventory in each park (Table 5.14-5.15). The tables display a range of inventory options. The baseline scenario uses national fleet distributions. The Park scenarios use Park-specific fleet distributions and an average speed correction factor calculated by the driving data collected at each Park.

Table 5.14- Daily On-Road Emissions for Petrified Forest National Park (tons/day)

	Summer		Winter	
Pollutant	Baseline	Zion	Baseline	Zion
VOC	0.132	0.069	0.036	0.016
CO	0.826	0.429	0.402	0.212
NOx	0.096	0.035	0.049	0.019
PM	0.0011	0.0011	0.0005	0.0005

Off-Road Mobile Emissions

Park personnel provided estimated hours of operation for off-road equipment. It was assumed that, on average, fuel consumption by this equipment is 1 gallon per hour. Based on this assumption, total fuel consumption was estimated and used in conjunction with AP-42 off-road emission factors to approximate emissions from off-road equipment. The calculated emissions were apportioned equally throughout the year.

Table 5.17: Summary of Emissions from On-Road Mobile Sources

Item		Season	Visitor Miles per Month	Tour Bus Miles per Month	Government Miles per Month	Concessionaire vehicle miles per month	Total Miles					
On-Road Mobile		Summer	858,652	1,865	23,326	1,628	885,470					
	TSP Factor	TSP (lbs/month)	PM10 Factor	PM10 (lbs/month)	VOC Factor	VOC (lbs/month)	NOx Factor	NOx (lbs/month)	CO Factor	CO (lbs/month)	SOx Factor	SOx (lbs/month)
Visitor Vehicles	0.025	47.3	0.025	47.3	2.08	3,942.4	0.97	1,844.5	13.03	24,658.3		0.0
Tour Buses	0.65	2.7	0.65	2.7	4.29	17.6	8.24	33.9	15.22	62.6		0.0
Government Vehicles	0.04	2.09	0.04	2.09	1.96	100.85	1.08	55.70	12.67	651.38		0.0
Concessionaire Vehicles	0.02	0.08	0.02	0.08	1.85	6.64	1.08	3.87	14.41	51.73		0.0
Totals	Summer	TSP (lbs/month)		PM10 (lbs/month)		VOC (lbs/month)		NOx (lbs/month)		CO (lbs/month)		SOx (lbs/month)
		52.1		52.1		4,067.5		1,938.0		25,423.9		0.0
Item		Season	Visitor Miles per Month	Tour Bus Miles per Monts	Government Miles per Month	Concessionaire vehicle miles per month	Total Miles					
On-Road Mobile		Winter	409,051	938	20,015	1,274	431,278					
	TSP Factor	TSP (lbs/month)	PM10 Factor	PM10 (lbs/month)	VOC Factor	VOC (lbs/month)	NOx Factor	NOx (lbs/month)	CO Factor	CO (lbs/month)	SOx Factor	SOx (lbs/month)
Visitor Vehicles	0.025	22.5	0.025	22.5	2.0826	1,878.1	0.9744	878.7	13.026	11,746.9		0.0
Tour Buses	0.646	1.3	0.646	1.3	4.292	8.9	8.238	17.0	15.216	31.5		0.0
Government Vehicles	0.04	1.79	0.04	1.79	1.96	86.54	1.08	47.79	12.67	558.92		0.0
Concessionaire Vehicles	0.022	0.1	0.022	0.1	1.8512	5.2	1.0772	3.0	14.4132	40.5		0.0
Totals	Winter	TSP (lbs/month)		PM10 (lbs/month)		VOC (lbs/month)		NOx (lbs/month)		CO (lbs/month)		SOx (lbs/month)
		25.7		25.7		1,978.7		946.6		12,377.7		0.0
Item		N Latitude	W Longditude	Elevation (ft)	Season	Miles of Paved Road	Miles Driven on Paved per Month	Miles of Unpaved Road	Miles Drinve on Unpaved per Month			
Reintrained Road Dust					Summer	34.98	885,470	21.6	498.9			
	TSP Factor	TSP (lbs/month)	PM10 Factor	PM10 (lbs/month)	VOC Factor	VOC (lbs/month)	NOx Factor	NOx (lbs/month)	CO Factor	CO (lbs/month)	SOx Factor	SOx (lbs/month)
Paved Roads	6.8	13,262.6	1.4	2,691.5	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Unpaved Roads	779.0	856.0	280.0	307.7	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Totals	Summer	TSP (lbs/month)		PM10 (lbs/month)		VOC (lbs/month)		NOx (lbs/month)		CO (lbs/month)		SOx (lbs/month)
		14,118.6		2,999.2								
Item		N Latitude	W Longditude	Elevation (ft)	Season	Miles of Paved Road	Miles Driven on Paved per Month	Miles of Unpaved Road	Miles Drinve on Unpaved per Month			
Reintrained Road Dust		0.000	0.000	0	Winter	34.98	431,278	21.6	498.9			
	TSP Factor	TSP (lbs/month)	PM10 Factor	PM10 (lbs/month)	VOC Factor	VOC (lbs/month)	NOx Factor	NOx (lbs/month)	CO Factor	CO (lbs/month)	SOx Factor	SOx (lbs/month)
Paved Roads	6.8	6,459.7	1.4	1,310.9	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Unpaved Roads	731	803.3	169.0	185.7	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Totals	Winter	TSP (lbs/month)		PM10 (lbs/month)		VOC (lbs/month)		NOx (lbs/month)		CO (lbs/month)		SOx (lbs/month)
		7,263.0		1,496.6								
Total On-Road Emissions												
Season:	Summer	TSP (lbs/month)		PM10 (lbs/month)		VOC (lbs/month)		NOx (lbs/month)		CO (lbs/month)		SOx (lbs/month)
		14,118.6		2,999.2		4,067.5		1,938.0		25,423.9		0.0
Season:	Winter	TSP (lbs/month)		PM10 (lbs/month)		VOC (lbs/month)		NOx (lbs/month)		CO (lbs/month)		SOx (lbs/month)
		7,263.0		1,496.6		1,978.7		946.6		12,377.7		0.0

Table 5.18: Emissions from Off-Road Mobile Sources

Item		Season	Number of Chainsaws	Average Use (hours/month)	No. of Weed Wackers	Average Use (hours/month)	Number of Lawnmowers	Average Use (hours/month)	Number of Rototillers	Average Use (hours/month)	Compressors	Use (hours/mont
Small Off-Road Equipment		Winter	6	29.2	6	29.2	2	17.4	1	2.5	1	20
Item		Season	Number of Augers	Average Use (hours/month)	Number of Yard Vacuums	Average Use (hours/month)	Number of Rock Saws	Average Use (hours/month)	rvu. of Portable Water Tanks	Average Use (hours/month)	Number of Paint Stripers	Average Use (hours/month)
Small Off-Road Equipment		Winter	4	12.5	1	4.4	2	4.4	1	8.7	1	2
Item		Season	Steam Cleaners (diesel)	Average Use (hours/month)	Number of Welders	Average Use (hours/month)	Number of Water Pumps	Average Use (hours/month)	Number of Crack Sealers	Average Use (hours/month)	Number of Trail Rollers	Use (hours/month)
Small Off-Road Equipment		Winter	1	2	2	8.0	1	10	1	2	1	16
Item		Season	No. of Generators	Average Use (hours/month)	Number of Leaf Blowers	Average Use (hours/month)						
Small Off-Road Equipment		Winter	4	16.0	1	12.5						
	TSP Factor	TSP (lbs/month)	PM10 Factor	PM10 (lbs/month)	VOC Factor	VOC (lbs/month)	NOx Factor	NOX (lbs/month)	CO Factor	CO (lbs/month)	SOx Factor	SOx (lbs/month)
Chainsaws	22.5	1.4	22.5	1.4	922.11	59.2	3.59	0.2	2726.3	175.1	1.8	0.1
Weed Wackers	22.5	1.4	22.5	1.4	922.11	59.2	3.59	0.2	2726.3	175.1	1.8	0.1
Lawnmower	1.87	0.1	1.87	0.1	100.55	3.9	11.91	0.5	2093.28	80.2	2.37	0.1
Rotatiller	22.5	0.1	22.5	0.1	922.11	5.1	3.59	0.0	2726.3	15.0	1.8	0.0
Compressor	0.16	0.0	0.16	0.0	6.2	0.3	0.02	0.0	17	0.7		0.0
Auger	22.5	0.6	22.5	0.6	922.11	25.4	3.59	0.1	2726.3	75.1	1.8	0.0
Yard Vacuum	22.5	0.2	22.5	0.2	922.11	8.8	3.59	0.0	2726.3	26.1	1.8	0.0
Rock Saw	22.5	0.2	22.5	0.2	922.11	8.8	3.59	0.0	2726.3	26.1	1.8	0.0
Portable Water Tank	0.16	0.0	0.16	0.0	6.2	0.2	0.02	0.0	17	0.6		0.0
Paint Striper	22.5	0.1	22.5	0.1	922.11	4.1	3.59	0.0	2726.3	12.0	1.8	0.0
(diesel)	9.324	0.2	9.324	0.2	16.28	0.4	142.08	3.1	28.12	0.6	12.876	0.3
Welder	0.16	0.0	0.16	0.0	6.2	0.1	0.02	0.0	17	0.3		0.0
Water Pump	0.16	0.0	0.16	0.0	6.2	0.1	0.02	0.0	17	0.4		0.0
Crack Sealer	22.5	0.1	22.5	0.1	922.11	4.1	3.59	0.0	2726.3	12.0	1.8	0.0
Trail Roller	22.5	0.8	22.5	0.8	922.11	32.5	3.59	0.1	2726.3	96.1	1.8	0.1
Generators	0.16	0.0	0.16	0.0	6.2	0.2	0.02	0.0	17	0.6		0.0
Leaf Blowers	22.5	0.6	22.5	0.6	922.11	25.4	3.59	0.1	2726.3	75.1	1.8	0.0
Totals	Winter	TSP (lbs/month)		PM10 (lbs/month)		VOC (lbs/month)		NOX (lbs/month)		CO (lbs/month)		SOx (lbs/month)
		6.0		6.0		237.8		4.5		771.2		0.8
Item		Season	Number of Chainsaws	Average Use (hours/month)	No. of Weed Wackers	(hours/month)	Number of Lawnmowers	(hours/month)	Number of Rototillers	Average Use (hours/month)	Compressors	Use (hours/mont
Small Off-Road Equipment		Summer	6	29.2	6	29.2	2	17.4	1	2.5	1	20
Item		Season	Number of Augers	Average Use (hours/month)	Number of Yard Vacuums	Average Use (hours/month)	Number of Rock Saws	Average Use (hours/month)	Portable Water Tanks	Average Use (hours/month)	Number of Paint Stripers	Use (hours/month)
Small Off-Road Equipment		Summer	4	12.5	1	4.4	2	4.4	1	8.7	1	2
Item		Season	Steam Cleaners (diesel)	Average Use (hours/month)	Number of Welders	Average Use (hours/month)	Number of Water Pumps	Average Use (hours/month)	Number of Crack Sealers	Average Use (hours/month)	Number of Trail Rollers	Use (hours/month)
Small Off-Road Equipment		Summer	1	2	2	8.0	1	10	1	2	1	16
Item		Season	No. of Generators	Average Use (hours/month)	Number of Leaf Blowers	Average Use (hours/month)						
Small Off-Road Equipment		Summer	4	16.0	1	12.5						
	TSP Factor	TSP (lbs/month)	PM10 Factor	PM10 (lbs/month)	VOC Factor	VOC (lbs/month)	NOx Factor	NOX (lbs/month)	CO Factor	CO (lbs/month)	SOx Factor	SOx (lbs/month)
Chainsaws	22.5	1.4	22.5	1.4	922.11	59.2	3.59	0.2	2726.3	175.1	1.8	0.1
Weed Wackers	22.5	1.4	22.5	1.4	922.11	59.2	3.59	0.2	2726.3	175.1	1.8	0.1
Lawnmower	1.87	0.1	1.87	0.1	100.55	3.9	11.91	0.5	2093.28	80.2	2.37	0.1
Rotatiller	22.5	0.1	22.5	0.1	922.11	5.1	3.59	0.0	2726.3	15.0	1.8	0.0
Compressor	0.16	0.0	0.16	0.0	6.2	0.3	0.02	0.0	17	0.7		0.0
Auger	22.5	0.6	22.5	0.6	922.11	25.4	3.59	0.1	2726.3	75.1	1.8	0.0
Yard Vacuum	22.5	0.2	22.5	0.2	922.11	8.8	3.59	0.0	2726.3	26.1	1.8	0.0
Rock Saw	22.5	0.2	22.5	0.2	922.11	8.8	3.59	0.0	2726.3	26.1	1.8	0.0
Portable Water Tank	0.16	0.0	0.16	0.0	6.2	0.2	0.02	0.0	17	0.6		0.0
Paint Striper	22.5	0.1	22.5	0.1	922.11	4.1	3.59	0.0	2726.3	12.0	1.8	0.0
(diesel)	9.324	0.2	9.324	0.2	16.28	0.4	142.08	3.1	28.12	0.6	12.876	0.3
Welder	0.16	0.0	0.16	0.0	6.2	0.1	0.02	0.0	17	0.3		0.0
Water Pump	0.16	0.0	0.16	0.0	6.2	0.1	0.02	0.0	17	0.4		0.0
Crack Sealer	22.5	0.1	22.5	0.1	922.11	4.1	3.59	0.0	2726.3	12.0	1.8	0.0
Trail Roller	22.5	0.8	22.5	0.8	922.11	32.5	3.59	0.1	2726.3	96.1	1.8	0.1
Generators	0.16	0.0	0.16	0.0	6.2	0.2	0.02	0.0	17	0.6		0.0
Leaf Blowers	22.5	0.6	22.5	0.6	922.11	25.4	3.59	0.1	2726.3	75.1	1.8	0.0
Totals	Summer	TSP (lbs/month)		PM10 (lbs/month)		VOC (lbs/month)		NOX (lbs/month)		CO (lbs/month)		SOx (lbs/month)
		6.0		6.0		237.8		4.5		771.2		0.8

Item	Season	Number of Forklifts	Average Use (hours/month)	Number of All Terrain Vehicles	Average Use (hours/month)	Number of JD Backhoes	Average Use (hours/month)	Number of Front Loader	Average Use (hours/month)	Number of Sweepers	Average Use (hours/month)
Large Off-Road Equipment	Summer	1	4.8	1	15.0	1	23.8	1	23.9	1	1.9

Item	Season	Number of Graders	Average Use (hours/month)	Number of Rollers	Average Use (hours/month)	Number of Bobcats	Average Use (hours/month)
Large Off-Road Equipment	Summer	1	25.6	1	1.1	1	34.9

	TSP Factor	TSP (lbs/month)	PM10 Factor	PM10 (lbs/month)	VOC Factor	VOC (lbs/month)	NOx Factor	NOX (lbs/month)	CO Factor	CO (lbs/month)	SOx Factor	SOx (lbs/month)
Forklift	9.32	0.50	9.32	0.50	16.28	0.87	142.08	7.56	28.12	1.50	12.88	0.69
All Terrain Vehicle	0.07	0.00	0.07	0.00	4.68	0.15	0.01	0.00	11.89	0.39		0.00
JD Backhoe	18.80	4.92	18.80	4.92	26.05	6.81	176.27	46.11	108.63	28.41	12.58	3.29
Front Loader	9.32	2.46	9.32	2.46	16.28	4.29	142.08	37.42	28.12	7.41	12.88	3.39
Sweeper	13.32	0.28	13.32	0.28	14.95	0.32	162.95	3.44	68.08	1.44	13.76	0.29
Grader	9.32	2.63	9.32	2.63	16.28	4.59	142.08	40.03	28.12	7.92	12.88	3.63
Roller	9.32	0.11	9.32	0.11	16.28	0.19	142.08	1.70	28.12	0.34	12.88	0.15
Bobcat	11.99	1.84	11.99	1.84	8.88	1.37	152.44	23.45	35.52	5.46	12.73	1.96
Totals	Summer	TSP (lbs/month)		PM10 (lbs/month)		VOC (lbs/month)		NOX (lbs/month)		CO (lbs/month)		SOx (lbs/month)
		12.73		12.73		18.59		159.71		52.87		13.40

Item	Season	Number of Forklifts	Average Use (hours/month)	Number of All Terrain Vehicles	Average Use (hours/month)	Number of JD Backhoes	Average Use (hours/month)	Number of Front Loader	Average Use (hours/month)	Number of Sweepers	Average Use (hours/month)
Large Off-Road Equipment	Winter	1	4.8	1	15.0	1	23.8	1	23.9	1	1.9

Item	Season	Number of Graders	Average Use (hours/month)	Number of Rollers	Average Use (hours/month)	Number of Bobcats	Average Use (hours/month)
Large Off-Road Equipment	Winter	1	25.6	1	1.1	1	34.9

	TSP Factor	TSP (lbs/month)	PM10 Factor	PM10 (lbs/month)	VOC Factor	VOC (lbs/month)	NOx Factor	NOX (lbs/month)	CO Factor	CO (lbs/month)	SOx Factor	SOx (lbs/month)
Forklift	9.32	0.50	9.32	0.50	16.28	0.87	142.08	7.56	28.12	1.50	12.88	0.69
All Terrain Vehicle	0.07	0.00	0.07	0.00	4.68	0.15	0.01	0.00	11.89	0.39		0.00
JD Backhoe	18.80	4.92	18.80	4.92	26.05	6.81	176.27	46.11	108.63	28.41	12.58	3.29
Front Loader	9.32	2.46	9.32	2.46	16.28	4.29	142.08	37.42	28.12	7.41	12.88	3.39
Sweeper	13.32	0.28	13.32	0.28	14.95	0.32	162.95	3.44	68.08	1.44	13.76	0.29
Grader	9.32	2.63	9.32	2.63	16.28	4.59	142.08	40.03	28.12	7.92	12.88	3.63
Roller	9.32	0.11	9.32	0.11	16.28	0.19	142.08	1.70	28.12	0.34	12.88	0.15
Bobcat	11.99	1.84	11.99	1.84	8.88	1.37	152.44	23.45	35.52	5.46	12.73	1.96
Totals	Winter	TSP (lbs/month)		PM10 (lbs/month)		VOC (lbs/month)		NOX (lbs/month)		CO (lbs/month)		SOx (lbs/month)
		12.73		12.73		18.59		159.71		52.87		13.40

Off-Road

Season:		TSP (lbs/month)	PM10 (lbs/month)	VOC (lbs/month)	NOX (lbs/month)	CO (lbs/month)	SOx (lbs/month)
Season:	**Summer**	18.7	18.7	256.4	164.2	824.1	14.2
Season:	**Winter**	18.7	18.7	256.4	164.2	824.1	14.2

Chapter Six – Arizona Air Quality Rules Review

Arizona Air Quality Regulations Applied to Sources in Petrified Forest National Park

Chapter 2 of Title 18 of the Arizona Administrative Code was reviewed for applicability of state air quality control requirements on activities occurring within Petrified Forest National Park. No point or mobile source activities within the Park appear to be of sufficient size or type to be governed by permit or control requirements. Four rules were noted that could have applicability to area source activities occurring within the Park. Excerpts of those four rules are as follows:

R18-2-602. Unlawful Open Burning

A. Notwithstanding the provisions of any other rule in this Chapter, it is unlawful for any person to ignite, cause to be ignited, permit to be ignited, or suffer, allow or maintain any open outdoor fire.

B. "Open outdoor fire", as used in this rule, means any combustion of combustible material of any type outdoors, in the open where the products of combustion are not directed through a flue. "Flue", as used in this rule, means any duct or passage for air, gases or the like, such as a stack or chimney.

C. The following fires are excepted from the provisions of this rule:

1. Fires used only for cooking of food or for providing warmth for human beings or for recreational purposes or the branding of animals or the use of orchard heaters for the purpose of frost protection in farming or nursery operations.

2. Any fire set or permitted by any public officer in the performance of official duty, if such fire is set or permission given for the purpose of weed abatement, the prevention of a fire hazard, or instruction in the methods of fighting fires.

3. Fires set by or permitted by the state entomologist or county agricultural agents of the county for the purpose of disease and pest prevention.

4. Fires set by or permitted by the federal government or any of its departments, agencies or agents, the state or any of its agencies, departments or political subdivisions, for the purpose of watershed rehabilitation or control through vegetative manipulation.

D. Permission for the setting of any fire given by a public officer in the performance of official duty under subsections (C)(2), (3), or (4) shall be given, in writing, and a copy of such written permission shall be transmitted immediately to the Director of the Department of Environmental Quality and the control officer, if any, of the county, district or region in which such fire is allowed. The setting of any such fire shall be constructed in a manner and at such time as approved by the Director, unless doing so would defeat the purpose of the exemption.

E. The following fires may be excepted from the provisions of this Section when permitted in writing by the Director of the Department of Environmental Quality or the control officer of the county, district or region in which such fire is allowed:

1. Fires set for the disposal of dangerous materials where there is no safe alternative method of disposal.

a. "Dangerous material" is any substance or combination of substances which is able or likely to inflict bodily harm or property loss unless neutralized, consumed or otherwise disposed of in a controlled and safe manner.

b. Fires set for the disposal of dangerous materials shall be permitted only when there is no safe alternative method of disposal, and when the burning of such materials does not result in the emission of hazardous or toxic substances either directly or as a product of combustion in amounts which will endanger health or safety.

2. Open outdoor fires for the disposal of ordinary household trash in an approved waste burner in nonurban areas of less than 100 well spread out dwelling units per square mile where no refuse collection and disposal service is available.

a. An "approved waste burner" is an incinerator constructed of fire resistant material with a cover or screen which is closed when in use having openings in the sides or top no greater than 1 inch in diameter.

b. Open burning of the following materials is forbidden: Garbage resulting from the processing, storage, service or consumption of food; asphalt shingles; tar paper; plastic and rubber products (such as waste crankcase oil, transmission oil and oil filters); transformer oils; and hazardous material containers including those that contained inorganic pesticides, lead, cadmium, mercury, or arsenic compounds.

F. The Director of the Department of Environmental Quality or the air pollution control officer, if any, of the county, district, or region may delegate the authority for the issuance of allowable open burning permits to responsible local officers. Such permits shall contain conditions limiting the manner and the time of the setting of such fires as specified in the Arizona Guidelines for Open Burning and shall contain a provision that all burning be extinguished at the discretion of the Director or his authorized representative during periods of inadequate atmospheric smoke dispersion, periods of excessive visibility impairment which could adversely affect public safety, or periods when smoke is blown into populated areas so as to create a public nuisance. Any local officer delegated the authority for issuance of open burning permits shall maintain a copy of all currently effective permits issued including a means of contacting the person authorized by the permit to set an open fire in the event that an order for extinguishing of open burning is issued.

G. Nothing in this rule is intended to permit any practice which is a violation of any statute, ordinance, rule or regulation.

R18-2-605. Roadways and Streets

A. No person shall cause, suffer, allow or permit the use, repair, construction or reconstruction of a roadway or alley without taking reasonable precautions to prevent excessive amounts of particulate matter from becoming airborne. Dust and other particulates shall be kept to a minimum by employing temporary paving, dust suppressants, wetting down, detouring or by other reasonable means.

B. No person shall cause, suffer, allow or permit transportation of materials likely to give rise to airborne dust without taking reasonable precautions, such as wetting, applying dust suppressants, or covering the load, to prevent particulate matter from becoming airborne. Earth or other material that is deposited by trucking or earth moving equipment shall be removed from paved streets by the person responsible for such deposits.

R18-2-606. Material Handling

No person shall cause, suffer, allow or permit crushing, screening, handling, transporting or conveying of materials or other operations likely to result in significant amounts of airborne dust without taking reasonable precautions, such as the use of spray bars, wetting agents, dust suppressants, covering the load, and hoods to prevent excessive amounts of particulate matter from becoming airborne.

Historical Note

Section R18-2-606 renumbered from R18-2-406 effective November 15, 1993 (Supp. 93-4).

R18-2-607. Storage Piles

A. No person shall cause, suffer, allow, or permit organic or inorganic dust producing material to be stacked, piled, or otherwise stored without taking reasonable precautions such as chemical stabilization, wetting, or covering to prevent excessive amounts of particulate matter from becoming airborne.

B. Stacking and reclaiming machinery utilized at storage piles shall be operated at all times with a minimum fall of material and in such manner, or with the use of spray bars and wetting agents, as to prevent excessive amounts of particulate matter from becoming airborne.

Appendix A

Emission Factors for Estimation of Park Emissions

Some of the most critical parameters for estimating emissions from the National Parks are the emission factors for the various processes that take place in the park. The development of emission factors for on-road mobile sources is discussed in detail elsewhere and will not be discussed in this portion of the report. Sources in Petrified Forest National Park for which factors must be determined are shown in Table A.1.

Table A.1: Source Types found in Petrified Forest National Park

On-Road Mobile Sources		
	Light Duty Passenger Vehicles	Heavy Duty Trucks
	Light Duty Trucks	Diesel Powered Buses
	Medium Duty Trucks	
Off-Road Mobile Sources		
	Lawn Mowers	All Terrain Vehicles
	Weed Whackers	Front Loader
	Chain Saws	Backhoe
	Rotatillers	Road Sweeper
	Compressor	Road Grader
	Augers	Roller
	Yard Vacuum	Bobcat
	Rock Saws	Crack Sealer
	Portable Water Tank	Water Pump
	Paint Striper	Trail Roller
	Steam Cleaner	Generators
	Welder	Leaf Blowers
Propane Burning in Stationary Sources		
	Space Heating	Water Heating
Wood Burning		
	Campfires	Refuse Pile
	Wood Stoves	Pellet Stoves
Fuel Handling		
	Gasoline Tank Filling	Gasoline Vehicle Fueling (On- & Off-Road)
	Diesel Tank Filling	
Food Preparation		
	Broiling	Grilling
	Deep Fat Frying	
Fugitive Dust		
	Re-entrained Dust from Paved Roads	Re-entrained Dust from Unpaved Roads
	Dust from Dirt Pile	
Road Maintenance		
	Surfacing Paved Roads	
Solvent Use		
	Use of paints and other solvents	

Off-Road Mobile

Emission factors for off-road mobile sources are some of the most difficult to determine. Interest in emissions from these sources is relatively recent, and inadequate measurements have been made in many cases to characterize emissions. The emission factors for these emission sources were derived from two U.S. EPA studies conducted in 1991 and 1998. Values used and sources of the factors used for off-road mobile sources are shown in Table A.2.

Table A.2: **Emission Factors for Off-Road Mobile Sources**

Lawnmower-4 Cycle Engine (grams emitted per gallon of fuel used)	TSP	Reference	PM10	Reference	VOC	Reference
	1.87	1	1.87	1	1.49	1
	NOx	Reference	CO	Reference	SOx	Reference
	11.9	1	2093	1	2.37	1
Weed Wacker-2 Cycle Engine (grams emitted per gallon of fuel used)	TSP	Reference	PM10	Reference	VOC	Reference
	22.5	1	22.5	1	922	1
	NOx	Reference	CO	Reference	SOx	Reference
	3.59	1	2726	1	1.8	1
Chainsaw-2-Cycle Engine (grams emitted per gallon of fuel used)	TSP	Reference	PM10	Reference	VOC	Reference
	22.5	1	22.5	1	922	1
	NOx	Reference	CO	Reference	SOx	Reference
	3.59	1	2726	1	1.8	1
All Terrain Vehicles[2] (grams emitted per kilowatt hour of energy consumed)	TSP	Reference	PM10	Reference	VOC	Reference
	3.22	2	3.22	2	206	2
	NOx	Reference	CO	Reference	SOx	Reference
	0.63	2	523	2	--	--
Tractor-Gasoline (grams emitted per gallon of fuel used)	TSP	Reference	PM10	Reference	VOC	Reference
	8	1	8	1	1.25	1
	NOx	Reference	CO	Reference	SOx	Reference
	151	1	32600	1	5.31	1
Front Loader-Diesel (grams emitted per gallon of fuel used)	TSP	Reference	PM10	Reference	VOC	Reference
	45.7	1	45.7	1	62.3	1
	NOx	Reference	CO	Reference	SOx	Reference
	439	1	175	1	31.2	1
Compressor (grams emitted per gallon of fuel used)	TSP	Reference	PM10	Reference	VOC	Reference
	0.16	1	0.16	1	6.2	1
	NOx	Reference	CO	Reference	SOx	Reference
	0.02	1	17	1	--	--

Propane Burning in Stationary Sources

Propane is used at stationary sources primarily for space heating and for water heating. The same factor was used for both cases since it was unclear if the water heating boilers and space heating units were always separate. Further, gas usage factors supplied by the Park were combined and there was no way to determine how much was used for water heating and how much was used for space heating, and how much was used for cooking. Factors used are shown in Table A.3

[2] These emission rates were converted to grams emitted per gallon of fuel used using the brake specific fuel consumption of 665 grams per kilowatt-hour provided in the reference. A gasoline density of 6.2 pounds per gallon was used (Ref. 6, page 3-89)

Table A.3: Emission Factors for Propane Combustion at Stationary Sources

Space, Water Heating, and Cooking (grams emitted per 1000 gallons of fuel used)	*TSP*	Reference	PM10	Reference	VOC	Reference
	0.4	4	0.4	4	0.3	4
	NOx	Reference	CO	Reference	SOx	Reference
	14	4	1.9	4	10	4

Wood Burning

Wood burning is one of the most difficult to estimate due to the variety of situations in which wood is burned, the individual fire management practices of the user. The type of wood can also have an impact; although, present emission factors ignore this issue. The various emission factors used for this study are shown in Table A.4.

Table A.4: Emission Factors for Wood Burning Activities

Refuse Piles (pounds of emissions per ton of wood burned)	*TSP*	Reference	PM10	Reference	VOC	Reference
	34.6	4, Chap 1.9	34.6	4, Chap 1.9	229	4, Chap 1.9
	NOx	Reference	CO	Reference	SOx	Reference
	2.6	4, Chap 1.9	253	4, Chap 1.9	0.4	4, Chap 1.9
Wood Stoves (pounds of emissions per ton of wood burned)	*TSP*	Reference	PM10	Reference	VOC	Reference
	30.6	4, Chap 1.10	30.6	4, Chap 1.10	53	4, Chap 1.10
	NOx	Reference	CO	Reference	SOx	Reference
	2.8	4, Chap 1.10	231	4, Chap 1.10	0.4	4, Chap 1.10
Pellet Stoves (pounds of emissions per ton of wood burned)	*TSP*	Reference	PM10	Reference	VOC	Reference
	4.2	4, Chap 1.10	4.2	4, Chap 1.10	n/a	4, Chap 1.10
	NOx	Reference	CO	Reference	SOx	Reference
	13.8	4, Chap 1.10	39.4	4, Chap 1.10	0.4	4, Chap 1.10

Fuel Handling

The fuel-handling category covers the filling of both large and small tanks. It also covers the fueling for vehicles. No vapor recovery is used for any fuel filling in Petrified Forest National Park. The emission factors used are shown in Table A.5.

Table A.5: Emission Factors for Fuel Handlin

Propane Tank Filling (pounds emitted per 1000 gallons filled)	TSP	Reference	PM10	Reference	VOC	Reference
	n/a	--	n/a	--	17	5
	NOx	Reference	CO	Reference	SOx	Reference
	n/a	--	n/a	--	n/a	--
Gasoline Tank Filling (pounds emitted per 1000 gallons filled)	TSP	Reference	PM10	Reference	VOC	Reference
	n/a	--	n/a	--	11.5	4, Chap 5.2
	NOx	Reference	CO	Reference	SOx	Reference
	n/a	--	n/a	--	n/a	--
Diesel Tank Filling (pounds emitted per 1000 gallons filled)	TSP	Reference	PM10	Reference	VOC	Reference
	n/a	--	n/a	--	0.03	4, Chap 5.2
	NOx	Reference	CO	Reference	SOx	Reference
	n/a	--	n/a	--	n/a	--
Gasoline Vehicle Fueling (pounds emitted per 1000 gallons filled)	TSP	Reference	PM10	Reference	VOC	Reference
	n/a	--	n/a	--	12.7	4, Chap 5.2
	NOx	Reference	CO	Reference	SOx	Reference
	n/a	--	n/a	--	n/a	--
Propane Vehicle Fueling (pounds emitted per 1000 gallons filled)	TSP	Reference	PM10	Reference	VOC	Reference
	n/a		n/a		3	5
	NOx	Reference	CO	Reference	SOx	Reference
	n/a	--	n/a	--	n/a	--

Food Preparation

Emission factors for food preparation are in the developmental phase. CE-CERT has done much of the national work date to quantify emissions associated with broiling and grilling meats. Broiling meat refers to cooking the meat over an open flame where the fat from the meat is allowed to drip into the flame. Grilling meat refers to cooking the meat in a frying pan or on a griddle with no direct contact with the flame. The factors derived for beef broiling were used to represent high fat meat and the factors derived for chicken were used to represent low fat meats. Emission factors used for the study are shown in Table A.7.

Table A.7: **Emission Factors for Food Preparation**

Broiling Meat (beef) (pounds emitted per 1000 pounds of meat cooked)	TSP	Reference	PM10	Reference	VOC	Reference
	32	*7*	*32*	7	3.8	7
	NOx	Reference	CO	Reference	SOx	Reference
Broiling Meat (chicken) (pounds emitted per 1000 pounds of meat cooked)	TSP	Reference	PM10	Reference	VOC	Reference
	2	*7*	*2*	7	0.3	7
	NOx	Reference	CO	Reference	SOx	Reference
Grilling Meat (pounds emitted per 1000 pounds of meat cooked)	TSP	Reference	PM10	Reference	VOC	Reference
	5	7	5	7	0.2	7
	NOx	Reference	CO	Reference	SOx	Reference
	--	7	--	7	--	7
Deep Fat Frying Chicken (pounds emitted per 1000 pounds of meat cooked)	TSP	Reference	PM10	Reference	VOC	Reference
	BDL	7	BDL	7	0.12	7
	NOx	Reference	CO	Reference	SOx	Reference
	--	7	--	7	--	7
Deep Fat Frying Fish (pounds emitted per 1000 pounds of meat cooked)	TSP	Reference	PM10	Reference	VOC	Reference
	BDL	7	BDL	7	0.14	7
	NOx	Reference	CO	Reference	SOx	Reference
	--	7	--	7	--	7

Fugitive Dust

The fugitive dust in the Park is associated with re-entrained dust from both paved and unpaved roads. This category of emissions is one of the largest both in the Park and in all urban areas. Because of this, considerable work has been done in an attempt to quantify emissions. Accurate re-entrained emission estimates require explicit knowledge concerning the moisture content of the silt on the road and the average weight of silt on the road surface. The emission factors were developed using the Part5 Model developed by the U.S. EPA (Ref. 8). Since no actual measurements were made in this study, factors used for the state of 0.29 grams per square meter were assumed. The number of days with rainfall above 0.01 inches was estimated from Chambers and Holbrook counties from the American Weather Service and CNN (http://www.aws.com/corp/default.asp?zipsch=86502&getwx=GO and http://www.cnn.com/WEATHER/sw/AZ/ChambersUSNM53.html).

For the case of the dirt pile, AP42 provides an emission factor based simply on the size of the pile of the material.

Emission factors used in this study are shown in Table A.8.

Table A.8: Emission Factors for Re-entrained Dust

Re-entrained Dust from Unpaved Roads (grams emitted per mile driven on the road)	TSP	Reference	PM10	Reference	VOC	Reference
	6.8	4, Chap. 3.2.1	1.4	4, Chap. 3.2.1	n/a	--
	NOx	Reference	CO	Reference	SOx	Reference
	n/a	--	n/a	--	n/a	--
Re-entrained Dust from Paved Roads (grams emitted per mile driven on the road)	*TSP*	Reference	PM10	Reference	VOC	Reference
	779		280		n/a	--
	NOx	Reference	CO	Reference	SOx	Reference
	n/a	--	n/a	--	n/a	--
Dust from Dirt Piles (pounds emitted per acre of exposed pile per day)	TSP	Reference	PM10	Reference	VOC	Reference
	3.5	4, Chap 8.19.1	1.7	4, Chap 8.19.1	n/a	--
	NOx	Reference	CO	Reference	SOx	Reference
	n/a	--	n/a	--	n/a	--

Road Maintenance

Road maintenance is a regular part of Park operations. AP42 was used. To make the estimates assumptions had to be made concerning diluent content of the asphalt, which was assumed to be 30%, diluent density, which was assumed to be 0.7 kilograms per liter, an asphalt density of 1.1 kilograms per liter, and the amount of VOC to evaporate of 95%. These values were selected from the mid-range of values in AP42. The resulting emission factors are shown in Table A.9.

Table A.9: Emission Factors for Road Pavin

Road Paving (pounds of emissions per ton of surface material supplied)	TSP	Reference	PM10	Reference	VOC	Reference
	n/a	--	n/a	--	0.2	4, Chap. 4.5
	NOx	Reference	CO	Reference	SOx	Reference
	n/a	--	n/a	--	n/a	--

Solvent Use

Solvent use emissions were determined by using actual VOC contents of the paints and solvents used in the Park. The names and manufacturers of the types of materials in use by the Park were collected during Park visits and MSDS sheets were located via internet searches in order to obtain specific gravity and percentage of volatile compounds.

References

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2. U.S. EPA, Exhaust Emission Factors for Nonroad Engine Modeling—Spark Ignition, June 1998, Report Number NR-010A.

3. U.S. EPA, Exhaust Emission Factors for Nonroad Engine Modeling—Compression Ignition, June 1998, Report Number NR-009A.
4. U.S. EPA, Compilation of Air Pollutant Emission Factors AP-42, Fifth Edition, Volume I: Stationary Point and Area Sources, October 1996. (www.epa.gov/ttn/chief/ap42/index.html)
5. U.S. EPA, Refueling Emissions for Nonroad Engine Modeling, August 1998, Report Number NR-013.
6. Perry, John H., Chemical Engineers' Handbook, McGraw-Hill, New York, 1963, Library of Congress Number 61-13168.
7. Welsh, B., Development of Emission Test Methods and Emission Factors for Various Commercial Cooking Operations, American Society of Heating, Refrigeration, and Air Conditioning, June 1997.
8. U.S. EPA, Part5 Model Draft User Guide, February 1995 (www.epa.gov/oms/part5.htm).
9. Wasatch Front Regional Council and Mountain Lands Association of Governments, Mobile Source Emissions Inventory Protocol PM10 SIP Development, May 2000.
10. Pope, D., C. Brough (Utah Climate Center), Utah's Weather and Climate, 1996, Publishers Press, 1900 West 2300 Street, Salt Lake City, Utah.

Appendix B

Data Worksheets (Excel)

Worksheet One
Apportionment by Visitation

FY2000 Visitor Totals

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Total
	52776	32203	21707	23566	26244	39530	49720	57095	91948	96217	77496	50517	619019
Monthly Visitor Percentages													
	0.085	0.052	0.035	0.038	0.042	0.064	0.080	0.092	0.149	0.155	0.125	0.082	1.000
Seasonal Visitor Percentage April through October =						0.62							
Seasonal Visitor Percentage November thru March =						0.38							

Fred Harvey Trading Company (AmFac) Restaurant Monthly Meat Usage Proportioned to Visitation (lbs)

Type Cooker	**Type Meat**	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Total
Broiler	**Beef**	**162**	**99**	67	72	81	121	153	175	282	295	238	155	**1900**
	Seasonal Cooking April through October =						1460		Average monthly usage - Summer =					**209**
	Seasonal Cooking November through March =						440		Average monthly usage - Winter =					**88**
Grill	Beef	91	56	37	41	45	**68**	**86**	**99**	**159**	**166**	**134**	87	**1068**
	Seasonal Cooking April through October =						821		Average monthly usage - Summer =					117
	Seasonal Cooking November through March =						247		Average monthly usage - Winter =					49
Deep Fat Fryer	Chicken	60	37	25	27	30	45	56	65	104	109	88	57	703
	Seasonal Cooking April through October =						540		Average monthly usage - Summer =					77
	Seasonal Cooking November through March =						163		Average monthly usage - Winter =					33
Deep Fat Fryer	Fish	26	16	11	12	13	20	25	29	46	48	39	25	310
	Seasonal Cooking April through October =						238		Average monthly usage - Summer =					34
	Seasonal Cooking November through March =						72		Average monthly usage - Winter =					14

Fred Harvey Trading Company (AmFac) Service Station

Use	**Material Type**	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Total
Refueling	Gasoline	16524	8245	8245	8245	8245	8245	16524	16524	16524	16524	16524	16524	156895
	Seasonal Fuel Usage April through October (gals) =						115671		Average monthly usage (gals) - Summer =					16524
	Seasonal Fuel Usage November through March (gals) =						41224		Average monthly usage (gals) - Winter =					8245
Refueling	Diesel	5955	500	500	500	500	500	5955	5955	5955	5955	5955	5955	44185
	Seasonal Fuel Usage April through October (gals) =						41685		Average monthly usage (gals) - Summer =					5955
	Seasonal Fuel Usage November through March (gals) =						2500		Average monthly usage (gals) - Winter =					500
Tank Loading	Gasoline	16524	8245	8245	8245	8245	8245	16524	16524	16524	16524	16524	16524	156895
	Seasonal Fuel Loading April through October (gals) =						115671		Average monthly loading (gals) - Summer =					16524
	Seasonal Fuel Loading November through March (gals) =						41224		Average monthly loading (gals) - Winter =					8245
Tank Loading	Diesel	5955	500	500	500	500	500	5955	5955	5955	5955	5955	5955	44185
	Seasonal Fuel Loading April through October (gals) =						41685		Average monthly loading (gals) - Summer =					5955
	Seasonal Fuel Loading November through March (gals) =						2500		Average monthly loading (gals) - Winter =					500

Worksheet Two

Heating Months - Monthly Fuel Usage

Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Total
High Average Monthly Temperature in ^0F												
47.6	54.3	60	**69.9**	**78.7**	**89**	**92.3**	**89.2**	**83.5**	72.3	58.5	48.3	
Low Monthly Average Temperature in ^0F												
21	24.6	29	35.4	43.3	52.2	60.2	59.1	52.1	40.2	28.4	21.5	
Difference Between Average Low and 65 ^0F												
44	40.4	36	29.6	21.7	12.8	4.8	5.9	12.9	24.8	36.6	43.5	313
Monthly Percentage of Total Annual Difference = Approximation of Proportion of Fuel Usage Per Month												
0.14	0.13	0.12	0.09	0.07	0.04	0.02	0.02	0.04	0.08	0.12	0.14	1.00
Monthly Percentage of Total Seasonal Difference (April through October) = Approximation of Proportion of Fuel Usage Per Month for Seasonal Residential												
0.00	0.00	0.00	0.26	0.19	0.11	0.04	0.05	0.11	0.22	0.00	0.00	1.00

Seasonal Factor for April through October = 0.36 Seasonal Factor for November through March = 0.64

Park-Wide Fuel Usage (NPS-only)

Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Total
Monthly Propane Usage in Gallons (based on 24,309 gallons/year)												
3417	3138	2796	2299	1685	994	373	458	1002	1926	2843	3378	24309
NPS Monthly Wood Usage in Tons (6 tons/year - weight based on assumption of 50% Pinon and 50% Juniper)												
0.8	0.8	0.7	0.6	0.4	0.2	0.1	0.1	0.2	0.5	0.7	0.8	6
NPS Monthly Wood Pellet Usage in Tons (10 tons/year per Park staff)												
1.4	1.3	1.2	0.9	0.7	0.4	0.2	0.2	0.4	0.8	1.2	1.4	10

Monthly Propane Usage:

Average Monthly Usage (April through October) = 1248

Average Monthly Usage (November through March) = 3114

NPS Monthly Wood Usage:

Average Monthly Usage (April through October) = 0.3

Average Monthly Usage (November through March) = **0.8**

NPS Monthly Wood Pellet Usage:

Average Monthly Usage (April through October) = 0.5

Average Monthly Usage (November through March) = 1.3

Concessionaire (AmFac) Fuel Usage

Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Total
AmFac Monthly Propane Usage in Gallons - North Complex (per monthly fuel records)												
1528.5	1373.2	1623.6	1818.6	0.0	410.0	0.0	1119.3	0.0	1326.1	0.0	4078.2	13278
AmFac Monthly Propane Usage in Gallons - South Complex (per monthly fuel records)												
301.0	0.0	778.3	824.2	0.0	600.0	0.0	87.4	0.0	0.0	0.0	1992.9	4584
AmFac Monthly Wood Usage in Tons (1/2 ton/year of pinewood)												
0.07	0.06	0.06	0.05	0.03	0.02	0.01	0.01	0.02	0.04	0.06	0.07	0.5

AmFac Monthly Propane Usage - North Complex:

Average Monthly Usage (April through October) = 667.7

Average Monthly Usage (November through March) = 1720.7

AmFac Monthly Propane Usage - South Complex:

Average Monthly Usage (April through October) = 215.9

Average Monthly Usage (November through March) = 614.4

AmFac Monthly Wood Usage:

Average Monthly Usage (April through October) = 0.03

Average Monthly Usage (November through March) = 60.25

Worksheet Three
Oct 1999 - Sept 2000 Vehicle Counts

Vehicle	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total	%	Total Miles	Annual Avg Mi/Veh
Painted Desert (North)	9,652	5,186	3,638	3,749	4,267	7,284	8,681	10,640	13,333	13,798	10,792	10,230	101,250		#######	49.8
Rainbow Forest (South)	4,713	6,193	3,471	2,300	2,418	3,035	4,880	6,621	6,851	7,593	7,999	6,365	62,439	0.30	#######	47.9
I-40 Crossing (VC only)	14,412	13,424	8,612	5,917	6,751	7,437	10,513	12,501	15,025	18,447	19,076	15,466	147,581	0.70	27,799	0.6
Visitor Vehicle Subtotal	19,125	19,617	12,083	8,217	9,169	10,472	15,393	19,122	21,876	26,040	27,075	21,831	210,020		#######	
Tour Bus																
North	28	33	23	4	4	12	19	24	37	44	28	30	286	0.56	10,010	35
South	42	28	14	6	3	7	12	12	20	27	21	29	221	0.44	7,735	35
subtotal	70	61	37	10	7	19	31	36	57	71	49	59	507			
															#######	

Average Monthly Mileage for Vehicles North Entrance April thru October =	**550572**
Average Monthly Mileage for Vehicles North Entrance November thru March	**242196**
Average Monthly Mileage for Vehicles South Entrance April thru October =	**308079**
Average Monthly Mileage for Vehicles South Entrance November thru March =	**166855**
Average Monthly Mileage for Unpaved Roadways April thru October =	**499**
Average Monthly Mileage for Unpaved Roadways November through March =	**499**
Average Monthly Mileage April Through October for Tour Buses =	**1865**
Average Monthly Mileage November through March for Tour Buses =	**938**

Worksheet Four
OffRoad Emission Factor Estimate

Revised 30-Dec

Equipment	Fuel	Fuel Density g/gal	BSFC g/kwhr	HC g/kwhr	CO g/kwhr	NOx g/kwhr	PM g/kwhr	HC g/gal	CO g/gal	NOx g/gal	PM g/gal
All Terrain Vehicles, snowmobiles etc	Gasoline	15.122	665	206	523	0.63	3.22	4.68	11.89	0.01	0.07
Compressor (new engine Phase 1)	Gasoline	15.122	720	295	805	1.05	7.7	6.20	16.91	0.02	0.16

Reference: Exhaust Emission Factors for Nonroad Engine Modeling --Spark Ignition Report No. NR -010b (EPA420-R-99-009)

Note: All other emission factors obtained directly from the NEVES study, in g/gal "Nonroad Engine and Vehicle Emission Study Report" (Publication no. EPA-21A-2001 or EPA460/3-91-002) http://www.epa.gov/otaq/nonrdmdl.htm#neves

			EF (g/bhp-hr)				DF			
	HP	LF	HC	CO	Nox	PM	HC	CO	Nox	PM
4 stroke Gasoline Pump	45	0.69	6.22	203.4	7.13	0.06	1.26	1.35	1.03	1

Updated Emission Modeling for Large SI Engines (EPA420-F-00-049)

	Emissions (g/hr)			
	HC	CO	Nox	PM
4 stroke Gasoline Pump	243	8526	228	2

Equipment	density	BSFC	In-Use Emission Factors (g/bhp-hr)					Emissions (g/gal)				
	lb/gal	(lb/hp-hr)	PM	HC	Nox	CO	Sox	PM	HC	Nox	CO	Sox
Forklift	6.28	0.5	0.06	6.22	7.13	203.4		0.7536	78.1232	89.5528	2554.7	
Ford Wildland Engine	6.28	0.5	0.06	6.22	7.13	203.4		0.7536	78.1232	89.5528	2554.7	
Water Tender	6.28	0.5	0.06	6.22	7.13	203.4		0.7536	78.1232	89.5528	2554.7	
Grader	7.4	0.5	0.63	1.1	9.6	1.9	0.87	9.324	16.28	142.08	28.12	12.876
Bobcat	7.4	0.5	0.81	0.6	10.3	2.4	0.86	11.988	8.88	152.44	35.52	12.728
Dozer	7.4	0.5	0.69	0.9	10.3	2.4	0.85	10.212	13.32	152.44	35.52	12.58
Broomsweeper	7.4	0.5	0.9	1.01	11R1-4	4.6	0.93	13.32	14.948	162.948	68.08	13.764
Snowblower	7.4	0.5	0.9	1.01	11.01	4.6	0.93	13.32	14.948	162.948	68.08	13.764
Backhoe	7.4	0.5	1.27	1.76	11.91	7.34	0.85	18.796	26.048	176.268	108.632	12.58

Worksheet Five

LPG Heavy Duty Emissions Calculation [1]

Light Yellow Background indicates assumed input num bers

Cummins B5.9-159LPG Engine Emissions

Pollutant	Emissions g/bhp-hr	DF(units)?	Emissions (g/mi)
VOC	0.8	1	3.44
CO	0.07	13.935	0.30
NOx	2.29	1.007	**9.85**
PM	0.013	1	0.06

Parameter	Value	Units	Source
density	6.2	lb/gal	Prop of Fuels, alt. Fuels binder
BSEC	6500	Btu/bhp-hr	Emfac7g Emissions Model
MPG	3.35	mi/gal	Zion Shuttle Bus Maintenance Log
LHV	15100	Btu/lb	Prop of Fuels, alt. Fuels binder
CF	4.3	bhp-hr/mi	
Travel	1827	VMT/day	Parks Data Excel Worksheet
Passenger	2994	p/day	Parks Data Excel Worksheet

Recreational Vehicle Emissions/Tour Bus Emissions

Gasoline	Baseline		Arches	
g/mi	Summer	Winter	Summer	Winter
VOC	8.0548	3.2148	3.7232	1.713
CO	66.9308	61.833	38.5458	31.973
NOx	3.0964	3.5472	2.6202	3.0596
PM	0.103	0.103	0.103	0.103
VMT				

Diesel	Baseline		Arches	
g/mi	Summer	Winter	Summer	Winter
VOC	4.907	4.907	4.292	4.292
CO	18.179	18.179	15.216	15.216
NOx	10.267	10.267	8.238	8.238
PM	0.646	0.646	0.646	0.646
VMT	377	132	377	132

Emissions from Diesel RVs/Tour Buses

	Baseline		Arches	
tons/day	Summer	Winter	Summer	Winter
VOC	0.0020	0.0007	0.0018	0.0006
CO	0.0076	0.0026	0.0063	0.0022
NOx	0.0043	0.0015	0.0034	0.0012
PM	0.0003	0.0001	0.000b-6	0.0001

Worksheet Six

Emission Comparison for Petrified Forest National Parks to the Baseline

Revised 9-May (all emissions for the park specific are using mobile's speeds corrections(MSCF))

Summary	Baseline, FTP, 19.6		Zion, 16.7		Arches, 22.8	
	S	W	S	W	S	W
VOC	4.0	2.3	2.7	1.20	2.1	1.0
Co	25.3	25.3	16.8	17.1	13.0	13.3
NOx	2.9	3.1	1.0	1.1	1.0	1.1
PM	0.025	0.025	0.025	0.025	0.025	0.025

Emission* Factors *for various vehicle Types (g/mi)

	Private Vehicles		Gov Vehicle		oncessionaire Vehicle		Tour Buses		Gasoline RV		Diesel RV	
PF	S	W	S	W	S	W	S	W	S	W	S	W
VOC	2.08	0.96	1.96	0.97	1.85	1.00	4.29	4.29	3.72	1.71	4.29	4.29
CO	13.03	13.28	12.67	12.94	14.41	14.97	15.22	15.22	38.55	31.97	15.22	15.22
NOx	0.97	1.09	1.08	1.20	1.08	1.24	8.24	8.24	2.62	3.06	8.24	8.24
PM	0.025	0.025	0.041	0.025	0.022	0.022	0.65	0.65	0.10	0.10	0.65	0.65

Government Vehicles in PF

Gov Veh PF	VMT/day	
	Gas	Diesel
	1	1
summer	719.8	43.2
winter	621.1	37.3

Government VMT in PF National Park

miles per summer month	23,326
miles per winter month	20,015
#days/sum mo.	30.57
#days/wint mo.	30.4
mileage from diesels	6%

Emissions from On-Road Government Vehicles in Petrified **Forest National Park**

g/day	Summer		Winter	
	Baseline	Arches	Baseline	Arches
VOC	2610	1496	1142	639
CO	17328	9665	15368	8523
NOx	1204	826	1162	793
PM	31	31	16	16

Tons/day	Summer		Winter	
	Baseline	Arches	Baseline	Arches
VOC	0.0029	0.0016	0.0013	0.0007
CO	0.0191	0.0107	0.0169	0.0094
NOx	0.0013	0.0009	0.0013	0.0009
PM	0.0000	0.0000	0.0000	0.0000

Worksheet Six (cont.)
Emission Comparison for Petrified Forest National Parks to the Baseline

Emissions from **On-Road Consessionaire Vehicles in Petrified Forest National Park**

g/day	Summer Baseline	Summer Arches	Winter Baseline	Winter Arches
VOC	210	100	**88**	42
CO	1539	782	**1274**	**813**
NOx	81	58	73	67
PM	1	1	1	1

Tons/day	Summer Baseline	Summer Arches	Winter Baseline	Winter Arches
VOC	0.00023	0.00011	0.00010	0.00005
CO	0.00170	0.00086	0.00140	0.00090
NOx	0.00009	0.00006	0.00008	0.00007
PM	0.00000	0.00000	0.00000	0.00000

1 Air Quality/Emissions Survey
2 Emfac7g, 2000 default run diesel:(.5hd .5ldt) gas:(.5ldv, .5ldt)
3 40 gallons fuel per month was subtracted for other uses
4 Summer is defined as April - October
5 Winter is defined as November - March

Private Vehicles

Emissions from Privately **Owned Vehicles in Zion National Park**

g/day	Summer Baseline	Summer Parks	Winter Baseline	Winter Parks
VOC	**115014**	**59608**	31003	13057
CO	723620	372826	345261	181100
NOx	**82167**	**27889**	41595	14928
PM	716	716	341	341

Tons/day	Summer Baseline	Summer Parks	Winter Baseline	Winter Parks
VOC	0.127	0.066	0.034	0.014
CO	0.798	0.411	0.381	0.200
NOx	0.091	0.031	0.046	0.016
PM	0.001	0.0008	0.000	0.0004

Decreased Private Vehicle Useage Due to Buses

Emissions if bus goers rode their own (Emissions offset) ton/sday	Zion	*Emissions from bus goers riding (Emissions Addition)* ton/sday	Zion
VOC	0.000	VOC	0.000
CO	0.000	CO	0.000
NOx	0.000	NOx	0.000
PM	0.0000	PM	0.000

VMT/day Summer	VMT/day Winter
28622	13635

Emissions Change from Shuttle bus Implementation

Tons/day	Zion	% of Total
VOC	0.000	0%
CO	0.000	0%
NOx	0.000	0%
PM	0.000	0%

All On-Road Emissions

Daily On-Road Emissions for Zion

Tons/day	Summer Baseline	Summer Zion	Winter Baseline	Winter Zion
VOC	0.132	0.069	0.036	0.016
CO	0.826	0.429	0.402	0.212
NOx	0.095	0.034	0.047	0.018
PM	0.0011	0.0011	0.0005	0.0005

Worksheet Seven

Effect of Driving Pattern on Mobile Emissions in the National Parks

Revised 9-May

all emsisions on this page calculated using Park specific fleet data
Light Yellow Background indicates assumed input numbers

Average Speed Effects on Emissions (Using CMEM)*

Emission	FTP, 19.6		Zion, 16.7		Arches, 22.8	
(g/mi)	S	W	S	W	S	W
VOC	2.25	1.07	2.27	1.07	1.74	0.84
CO	15.03	15.30	25.13	25.26	10.92	11.19
NOx	0.97	1.09	0.73	0.82	0.63	0.70

Change in Emissions from FTP cycle (19.6)

	Zion, 16.7		Arches, 22.8	
	S	W	S	W
VOC	1%	0%	-23%	-22%
CO	67%	65%	-27%	-27%
NOx	-25%	-25%	-35%	-36%

*effects only seen for light duty

Average Speed Effects on Emissions (Using Mobile5b)

Emission	FTP,	19.6	Zion, 16.7		Arches, 22.8	
g/mi	S	W	S	W	S	W
VOC	2.3	1.1	2.7	1.20	2.1	1.0
CO	15.0	15.3	16.8	17.1	13.0	13.3
NOx	1.0	1.1	1.0	1.1	1.0	1.1
PM	0.025	0.025	0.025	0.025	0.025	0.025

	Zion,	16.7	Arches, 22.8	
	S	W	S	W
VOC	19%	12%	-8%	-11%
CO	12%	12%	-13%	-13%
NOx	2%	2%	1%	1%

VMTmix

MOBILE	LDGV	LDGT1	LDGT2	LDGT	HDGV	LDDV	LDDT	HDDV	MC	ALL	
Base	0.528	0.166	0.067	0	0.071	0.002	0.001	0.16	0.005	1	
Parks	0.701	0.138	0.106	0.00000	0.008	0.00000	0.003	0.016	0.028	1.000	
PART5	LDGV	LDGT1	LDGT2	HDGV	MC	LDDV	LDDT	2BHDDV	LHDDV	MHDDV	HHDDV	BUSES
Base	0.615	0.191	0.086	0.031	0.006	0.0019	0.001	0.0146	0	0.0146	0.034	0.0049
Parks	0.7007	0.1372	0.1064	0.0079	0.0278	0.0004	0.0033	0.0035	0	0.0035	0.0081	0.0012

CMEM Driving Correction (from FTP)

		LDGV	LDGT1	LDGT2	LDGT	HDGV	LDDV	LDDT	HDDV	MC
	Arches	0.75	0.695	0.695	0	1	1	1	1	1
VOC	Zion	1.083	0.797	0.797	0	1	1	1	1	1
	Arches	0.696	0.685	0.685	0	1	1	1	1	1
CO	Zion	2	1.191	1.191	0	1	1	1	1	1
	Arches	0.571	0.571	0.571	0	1	1	1	1	1
NOx	Zion	0.714	0.667	0.667	0	1	1	1	1	1

Worksheet Seven Page 2

Effect of Driving Pattern on Mobile Emissions in the National Parks

Summarized Emission Factors Specific to Parks (g/mi)

PS

VOC	LDGV	LDGT1	LDGT2	LDGT	HDGV	LDDV	LDDT	HDDV	MC	All
FTP	2.05	2.1328	2.0074	2.078	4.0708	0.47	0.788	4.75	7.131	2.2548
Arches	1.881	1.9764	1.8512	1.922	3.7232	0.425	0.712	4.292	6.945	2.0826
Zion	2.5078	2.439	2.309	2.3826	4.8418	0.535	0.896	5.399	7.423	2.6748

PS

CO	LDGV	LDGT1	LDGT2	LDGT	HDGV	LDDV	LDDT	HDDV	MC	All
FTP	13.3016	16.4802	16.6372	16.5486	44.4526	0	2.631	17.456	36.646	15.0312
Arches	11.4164	14.3862	14.4132	14.3978	38.5458	0	2.294	15.216	33.994	13.026
Zion	14.857	18.305	18.3818	18.3378	53.7638	0	3.151	20.903	40.214	16.7894

PS

NOx	LDGV	LDGT1	LDGT2	LDGT	HDGV	LDDV	LDDT	HDDV	MC	All
FTP	0.7826	0.9306	1.073	0.9922	2.557	0	1.225	8.655	0.57	0.9692
Arches	0.7952	0.9368	1.0772	0.9974	2.6202	0	1.166	8.238	0.621	0.9744
Zion	0.789	0.945	1.0906	1.0086	2.4828	0	1.317	9.305	0.519	0.9864

PS

PM	LDGV	LDGT1	LDGT2	HDGV	MC	LDDV	LDDT	2BHDDV	LHDDV	MHDDV	HHDDV	BUSES	All Veh.
FTP	0.013	0.016	0.022	0.103	0.02	0.19	0.213	0.172	0	0.646	0.739	0.617	0.025
Arches	0.013	0.016	0.022	0.103	0.02	0.19	0.213	0.172	0	0.646	0.739	0.617	0.025
Zion	0.013	0.016	0.022	0.103	0.02	0.19	0.213	0.172	0	0.646	0.739	0.617	0.025

PW

VOC	LDGV	LDGT1	LDGT2	LDGT	HDGV	LDDV	LDDT	HDDV	MC	All
FTP	0.878	1.0938	1.1152	1.1032	2.0348	0.47	0.788	4.75	3.369	1.0738
Arches	0.777	0.9808	0.9976	0.9878	1.713	0.425	0.712	4.292	3.142	0.9576
Zion	0.9808	1.2252	1.2482	1.2354	2.534	0.535	0.896	5.399	3.727	1.2022

PW

CO	LDGV	LDGT1	LDGT2	LDGT	HDGV	LDDV	LDDT	HDDV	MC	All
FTP	13.045	17.42	17.2902	17.3638	36.8726	0	2.631	17.456	47.871	15.304
Arches	11.195	15.1976	14.9736	15.1	31.973	0	2.294	15.216	44.406	13.282
Zion	14.5732	19.345	19.1022	19.2394	44.5962	0	3.151	20.903	52.531	17.0814

PW

NOx	LDGV	LDGT1	LDGT2	LDGT	HDGV	LDDV	LDDT	HDDV	MC	All
FTP	0.8898	1.0762	1.2354	1.1452	2.9864	0	1.225	8.655	0.653	1.0876
Arches	0.9042	1.0834	1.2398	1.1516	3.0596	0	1.166	8.238	0.711	1.0948
Zion	0.8972	1.0936	1.256	1.1638	2.8992	0	1.317	9.305	0.595	1.1058

PW

PM	LDGV	LDGT1	LDGT2	HDGV	MC	LDDV	LDDT	2BHDDV	LHDDV	MHDDV	HHDDV	BUSES	All Veh.
FTP	0.013	0.016	0.022	0.103	0.02	0.19	0.213	0.172	0	0.646	0.739	0.617	0.025
Arches	0.013	0.016	0.022	0.103	0.02	0.19	0.213	0.172	0	0.646	0.739	0.617	0.025
Zion	0.013	0.016	0.022	0.103	0.02	0.19	0.213	0.172	0	0.646	0.739	0.617	0.025

Worksheet Seven Page 3
Effect of Driving Pattern on Mobile Emissions in the National Parks

Summarized Emission Factors- Baseline(g/mi)

BaseS										
VOC	LDGV	LDGT1	LDGT2	LDGT	HDGV	LDDV	LDDT	HDDV	MC	All
FTP	3.2432	3.648	4.443	3.877	8.0548	0.749	1.086	4.907	8.679	4.0184
Arches	2.9816	3.3866	4.1162	3.5974	7.4474	0.676	0.982	4.434	8.473	3.4338
Zion	3.876	4.1214	5.0142	4.3784	9.2562	0.851	1.235	5.578	9.002	4.1512

BaseS										
CO	LDGV	LDGT1	LDGT2	LDGT	HDGV	LDDV	LDDT	HDDV	MC	All
FTP	20.4926	26.371	33.261	28.3524	66.9308	1.889	3.164	18.179	37.679	25.2822
Arches	17.8212	23.2978	29.8502	25.1904	58.0374	1.647	2.758	15.846	34.951	21.0622
Zion	22.9972	29.4914	37.1636	31.6986	80.9502	2.262	3.788	21.768	41.346	26.23

BaseS										
NOx	LDGV	LDGT1	LDGT2	LDGT	HDGV	LDDV	LDDT	HDDV	MC	All
FTP	1.2388	1.4032	1.7004	1.4886	3.0964	1.388	1.466	10.267	0.57	2.8708
Arches	1.2586	1.419	1.728	1.5082	3.1726	1.321	1.396	9.773	0.621	2.0524
Zion	1.2474	1.4162	1.7102	1.5012	3.0068	1.492	1.576	11.038	0.519	1.6138

BaseS													
PM	LDGV	LDGT1	LDGT2	HDGV	MC	LDDV	LDDT	2BHDDV	LHDDV	MHDDV	HHDDV	BUSES	All Veh.
FTP	0.013	0.016	0.022	0.103	0.02	0.19	0.213	0.172	0	0.646	0.739	0.617	0.025
Arches	0.013	0.016	0.022	0.103	0.02	0.19	0.213	0.172	0	0.646	0.739	0.617	0.025
Zion	0.013	0.016	0.022	0.103	0.02	0.19	0.213	0.172	0	0.646	0.739	0.617	0.025

BaseW										
VOC	LDGV	LDGT1	LDGT2	LDGT	HDGV	LDDV	LDDT	HDDV	MC	All
FTP	1.436	1.8824	2.5182	2.0654	3.2148	0.749	1.086	4.907	3.726	2.2738
Arches	1.2754	1.6898	2.2842	1.8614	2.7074	0.676	0.982	4.434	3.474	1.7384
Zion	1.6154	2.1188	2.8212	2.3214	4.0028	0.851	1.235	5.578	4.121	1.971

BaseW										
CO	LDGV	LDGT1	LDGT2	LDGT	HDGV	LDDV	LDDT	HDDV	MC	All
FTP	20.418	27.7844	35.4804	29.9972	61.833	1.889	3.164	18.179	49.273	25.3216
Arches	17.7724	24.5636	31.9304	26.6918	53.6166	1.647	2.758	15.846	45.706	21.3416
Zion	22.9306	31.093	39.6224	33.5468	74.785	2.262	3.788	21.768	54.069	26.7154

BaseW										
NOx	LDGV	LDGT1	LDGT2	LDGT	HDGV	LDDV	LDDT	HDDV	MC	All
FTP	1.4186	1.6198	1.9544	1.7154	3.5472	1.388	1.466	10.267	0.653	3.0506
Arches	1.4416	1.6376	1.9852	1.7382	3.6346	1.321	1.396	9.773	0.711	2.2422
Zion	1.4292	1.6358	1.9674	1.7312	3.4438	1.492	1.576	11.038	0.595	1.8072

BaseW													
PM	LDGV	LDGT1	LDGT2	HDGV	MC	LDDV	LDDT	2BHDDV	LHDDV	MHDDV	HHDDV	BUSES	All Veh.
FTP	0.013	0.016	0.022	0.103	0.02	0.19	0.213	0.172	0	0.646	0.739	0.617	0.025
Arches	0.013	0.016	0.022	0.103	0.02	0.19	0.213	0.172	0	0.646	0.739	0.617	0.025
Zion	0.013	0.016	0.022	0.103	0.02	0.19	0.213	0.172	0	0.646	0.739	0.617	0.025

Worksheet Eight
Vehicle Emissions Comparison for AZ National Parks Fleet Distribution

Revised 9-May

Summer, 20 mph

	VOC		CO		Nox		PM	
	Base	Parks	Base	Parks	Base	Parks	Base	Parks
LDGV	3.24	2.05	20.49	13.30	1.24	0.78	0.013	0.013
LDGT1	3.65	2.13	26.37	16.48	1.40	0.93	0.016	0.016
LDGT2	4.44	2.01	33.26	16.64	1.70	1.07	0.022	0.022
HDGV	8.05	4.07	66.93	44.45	3.10	2.56	0.103	0.103
LDDV	0.75	0.47	1.89	0.00	1.39	0.00	0.190	0.190
LDDT	1.09	0.79	3.16	2.63	1.47	1.23	0.213	0.213
HDDV	4.91	4.75	18.18	17.46	10.27	8.66	0.016	0.016
MC	8.68	7.13	37.68	36.65	0.57	0.57	0.020	0.020
All	4.02	2.25	25.28	15.03	2.87	0.97	0.032	0.025

Summer, 57 mph

	VOC		CO		Nox		PM	
	Base	Parks	Base	Parks	Base	Parks	Base	Parks
LDGV	1.79	1.08	9.62	5.21	1.74	1.07	0.013	0.013
LDGT1	2.34	1.34	14.84	7.92	2.01	1.29	0.016	0.016
LDGT2	2.84	1.21	22.16	7.13	2.49	1.46	0.022	0.022
HDGV	4.99	2.31	40.92	27.18	4.11	3.39	0.103	0.103
LDDV	0.34	0.22	0.97	0.00	1.78	0.00	0.190	0.190
LDDT	0.50	0.36	1.63	1.36	1.88	1.57	0.213	0.213
HDDV	2.25	2.17	9.36	8.99	13.14	11.08	0.016	0.016
MC	7.85	6.38	31.22	30.36	1.08	1.08	0.020	0.020
All	2.07	1.30	12.21	6.72	2.20	1.32	0.032	0.025

Winter, 20 mph

	VOC		CO		Nox		PM	
	Base	Parks	Base	Parks	Base	Parks	Base	Parks
LDGV	1.44	0.88	20.42	13.05	1.42	0.89	0.013	0.013
LDGT1	1.88	1.09	27.78	17.42	1.62	1.08	0.016	0.016
LDGT2	2.52	1.12	35.48	17.29	1.95	1.24	0.022	0.022
HDGV	3.21	2.03	61.83	36.87	3.55	2.99	0.103	0.103
LDDV	0.75	0.47	1.89	0.00	1.39	0.00	0.190	0.190
LDDT	1.09	0.79	3.16	2.63	1.47	1.23	0.213	0.213
HDDV	4.91	4.75	18.18	17.46	10.27	8.66	0.016	0.016
MC	3.73	3.37	49.27	47.87	0.65	0.65	0.020	0.020
All	2.27	1.07	25.32	15.30	3.05	1.09	0.032	0.025

Winter, 57 mph

	VOC		CO		Nox		PM	
	Base	Parks	Base	Parks	Base	Parks	Base	Parks
LDGV	0.73	0.43	9.72	5.11	1.99	1.22	0.013	0.013
LDGT1	1.03	0.59	15.79	8.31	2.31	1.49	0.016	0.016
LDGT2	1.53	0.59	24.29	7.38	2.86	1.68	0.022	0.022
HDGV	0.95	0.60	37.80	22.54	4.70	3.96	0.103	0.103
LDDV	0.34	0.22	0.97	0.00	1.78	0.00	0.190	0.190
LDDT	0.50	0.36	1.63	1.36	1.88	1.57	0.213	0.213
HDDV	2.25	2.17	9.36	8.99	13.14	11.08	0.016	0.016
MC	2.71	2.45	40.82	39.66	1.23	1.23	0.020	0.020
All	0.91	0.55	12.67	6.95	2.47	1.49	0.032	0.025

Worksheet Eight, Page 2
Vehicle Emissions Comparison for Utah National Parks Fleet Distribution

Summer, 20 mph

	VMTmix	VOC	CO	Nox	PM
LDGV	14%	-37%	-35%	-37%	0%
LDGT1	-28%	-42%	-38%	-34%	0%
LDGT2	24%	-55%	-50%	-37%	0%
HDGV	-75%	-49%	-34%	-17%	0%
LDDV	-79%	-37%	-100%	-100%	0%
LDDT	233%	-27%	-17%	-16%	0%
HDDV	-76%	-3%	-4%	-16%	0%
MC	364%	-18%	-3%	0%	0%
All	0%	-44%	-41%	-66%	-22%

Summer, 57 mph

	VMTmix	VOC	CO	Nox	PM
LDGV	14%	-40%	-46%	-38%	0%
LDGT1	-28%	-43%	-47%	-36%	0%
LDGT2	24%	-57%	-68%	-41%	0%
HDGV	-75%	-54%	-34%	-17%	0%
LDDV	-79%	-37%	-100%	-100%	0%
LDDT	233%	-27%	-17%	-16%	0%
HDDV	-76%	-3%	-4%	-16%	0%
MC	364%	-19%	-3%	0%	0%
All	0%	-37%	-45%	-40%	-22%

Winter, 20 mph

	VMTmix	VOC	CO	Nox	PM
LDGV	14%	-39%	-36%	-37%	0%
LDGT1	-28%	-42%	-37%	-34%	0%
LDGT2	24%	-56%	-51%	-37%	0%
HDGV	-75%	-37%	-40%	-16%	0%
LDDV	-79%	-37%	-100%	-100%	0%
LDDT	233%	-27%	-17%	-16%	0%
HDDV	-76%	-3%	-4%	-16%	0%
MC	364%	-10%	-3%	0%	0%
All	0%	-53%	-40%	-64%	-22%

Winter, 57 mph

	VMTmix	VOC	CO	Nox	PM
LDGV	14%	-41%	-47%	-39%	0%
LDGT1	-28%	-43%	-47%	-36%	0%
LDGT2	24%	-62%	-70%	-41%	0%
HDGV	-75%	-37%	-40%	-16%	0%
LDDV	-79%	-37%	-100%	-100%	0%
LDDT	233%	-27%	-17%	-16%	0%
HDDV	-76%	-3%	-4%	-16%	0%
MC	364%	-10%	-3%	0%	0%
All	0%	-39%	-45%	-40%	-22%

Percent Change in Emissions from Baseline using National Parks Fleet Distribution **Data**

	20 mph		57 mph	
	Summer	Winter	Summer	Winter
VOC	-44%	-53%	-37%	-39%
CO	-41%	-40%	-45%	-45%
Nox	-66%	-64%	-40%	-40%
PM	-22%	-22%	-22%	-22%

VMTmix

Class	Base	Parks
LDGV	0.616	0.701
LDGT1	0.191	0.137
LDGT2	0.086	0.106
HDGV	0.031	0.008
LDDV	0.002	0.000
LDDT	0.001	0.003
HDDV	0.068	0.016
MC	0.006	0.028
All	1.00	1.00

Base/ Baseline	This is emissions estimated using national fleet distribution data (VMT mix, user reg), FTP driving cycle
P/Parks	This is emissions data using Park specific fleet distribution data & Temperatures

Note: Work Sheets Nine through Thirteen are too large to provide here and are available on the included CD.

Work Sheet Fourteen

GSA Leased Vehicles (gasoline)

vehicle	mileage
2000 Dodge Stratus	4351
2000 Ford Crown Vic	17708
1994 Ford Aerostar	4193
1998 Chevy S-10	7138
2001 Dodge Ram 1500	12385
1998 Dodge Ram 2500	8264
1998 Dodge Ram 2500	14630
1999 Dodge Ram 3500	9236
1996 Ford Crown Vic	1903
1994 Chevy S-10	4551
1995 Ford F-150	22056
1994 Dodge Ram 3500	9706
1995 Dump Truck	9857
~1995 Chevy PU	6668
1997 Ford F350	6684
1998 Jeep Cherokee	10623
1998 Jeep Cherokee	13010
1999 Dodge Dakota	7969
1999 Dodge Durango	24701
Chevy 1500 4x4	6697
1999 Chevy Tahoe	27432
1999 Dodge Durango	24786
1998 Dodge Ram 2500	17445
2000 Ford F450	13015
2000 Ford F150	6457
Subtotal	291465

GSA Leased Vehicles (diesel)

vehicle	mileage
1999 4900	10791
Subtotal	10791

DOI/Park Owned Vehicles (diesel)

Vehicle	mileage	hours of use
1995 Semi	3078	
1994 Daihaitzu		8
1988 RF Firetruck	171	
1982 PD Firetruck	867	
1991 Case Loader		287
1989 John Deere 210C		285
1987 Bobcat		419
1993 Grader		307
1990 Sweeper		23
1980 Roller		13
Subtotal	4116	1342

DOI/Park Owned Vehicles (gasoline)

Vehicle	mileage	hours of use
1992 Crown Vic	704	
Subtotal	704	

Calculated MPG for GSA Leased Vehicles (gasoline) = 14.3

Estimated gasoline usage (gals) = 20382

Assumed MPG for GSA Leased Vehicles (diesel) = 22

Estimated diesel usage (gals) = 491

Assume 15% of total gasoline mileage for GSA leased vehicles is out of park

In-Park mileage (GSA gasoline) = 247745

In-Park est. gasoline usage (gals) = 17325

Government vehicle on-road miles per summer month = 23,326

Government vehicle on-road miles per winter month = 20,015

DOI/Park Owned Vehicles (gasoline
Gasoline usage (gals)
reported as 40

DOI/Park Owned Vehilces (diesel)
Diesel usage (gals)
reported as 1707

Total on-road mileage in park by Government vehicles (gasoline) 248449

Total on-road mileage in park by Government vehicles (diesel) = 14907

Work Sheet Fifteen

Concessionaire Vehicles

Month	Vehicle Type 1 1994 Dodge Caravan Gasoline Used	Vehicle Type 2 1997 Dodge Truck Gasoline Used	Vehicle Type 3 2000 Dodge Cargo Van Gasoline Used	Total	Calculated miles traveled	% by month of miles traveled	Calculated in-Park miles traveled	Calculated in-Park fuel usage
January	89.9	78.2	48.9	217.0	4557	0.09	1606	76.5
February	68.3	131.9	26.4	226.6	4759	0.09	1677	79.9
March	79.7	150	62.3	292.0	6132	0.12	2162	102.9
April	49.4	103.3	28	180.7	3795	0.08	1338	63.7
May	71.6	131	45.8	248.4	5216	0.10	1839	87.6
June	112.2	193	70.8	376.0	7896	0.16	2783	132.5
July	80.2	36.7	55.4	172.3	3618	0.07	1275	60.7
August	47	96	44.7	187.7	3942	0.08	1389	66.2
September	49.4	81.4	69.5	200.3	4206	0.08	1483	70.6
October	37.5	88.2	48.4	174.1	3656	0.07	1289	61.4
November	13.9	71.4	39.6	124.9	2623	0.05	925	44.0
December	Not Provided	Not Provided	Not Provided					
Total	699.1	1161.1	539.8	2400.0	50400	1.00	17766	846
Percent Used in Park	10	25	90	35.2				
In Park Fuel Use	69.9	290.3	485.8	846.0				
In Park Mileage	1468	6096	10202	17766				

Average Summer Month In-Park Mileage = 1628 Average Summer Month In-Park Fuel Usage = 77.5

Average Winter Month In-Park Mileage = 1274 Average Winter Month In-Park Fuel Usage = 60.7

Appendix C

Inputs for Mobile Source Emission Modeling

Part5 Input File: PW2.in

```
2000 AZ PM10 1.3.01 (for fug dust, winter)
2    :VMFLAG (alternate VMT mixes)
1    :MYMRFG (alternate mileage accumulation rates & registration)
2    :IMFLAG (Inspection and maintenance)
1    :RFGFLG (2 to apply reformulated gasoline effects, 1 not to)
3    :OUTFMT (indicates type of output format)
2    :IDLFLG (2 to print, 1 not to print idle emission factors)
2    :SO2FLG (2 to print Gaseous SO2 emissions, 1 not to print them)
1    :PRTFLG (determines which pollutants to print out)
1    :BUSFLG (determines which alternative bus cycles to print out)
2 2000 1 20.0       : region, year, speed cycle, speed
08.9 0.29 2        : unpaved silt%, ind. silt g/m^2, WHEELFLG
77
Az Local                :scene name
10.   -- Particle size cutoff
4600
04
0.6600 0.2080 0.0840 0.0120 0.0050 0.0020
0.0010 0.0060 0.0000 0.0060 0.0140 0.0020
2 2000 1 20.0        : region, year, speed cycle, speed
08.9 0.29 2        : unpaved silt%, ind. silt g/m^2, WHEELFLG
77
Base                    :scene name
10.   -- Particle size cutoff
4600
04
0.6150 0.1910 0.0860 0.0310 0.0060 0.0019
0.0010 0.0146 0.0000 0.0146 0.0340 0.0049
2 2000 1 20.0 : region, year, speed cycle, speed
08.9 0.29 2        : unpaved silt%, ind. silt g/m^2, WHEELFLG
77
Parks               :scene name
10.   -- Particle size cutoff
4600
04
0.7007 0.1372 0.1064 0.0079 0.0278 0.0004
0.0033 0.0035 0.0000 0.0035 0.0081 0.0012
2 2000 1 19.6 : region, year, speed cycle, speed
08.9 0.29 2        : unpaved silt%, ind. silt g/m^2, WHEELFLG
77
Parks FTP             :scene name
10.   -- Particle size cutoff
4600
04
0.7007 0.1372 0.1064 0.0079 0.0278 0.0004
0.0033 0.0035 0.0000 0.0035 0.0081 0.0012
2 2000 1 22.8 : region, year, speed cycle, speed
08.9 0.29 2        : unpaved silt%, ind. silt g/m^2, WHEELFLG
77
Parks Arches              :scene name
10.   -- Particle size cutoff
4600
04
0.7007 0.1372 0.1064 0.0079 0.0278 0.0004
0.0033 0.0035 0.0000 0.0035 0.0081 0.0012
2 2000 1 16.7 : region, year, speed cycle, speed
08.9 0.29 2        : unpaved silt%, ind. silt g/m^2, WHEELFLG
74
Parks Zion                :scene name
10.   -- Particle size cutoff
4600
04
0.7007 0.1372 0.1064 0.0079 0.0278 0.0004
0.0033 0.0035 0.0000 0.0035 0.0081 0.0012
```

Part5 Input File: PS2.in

```
2000 PM10 1.3.01 (fugitive emissions estimate, Summer)
2    :VMFLAG (alternate VMT mixes)
1    :MYMRFG (alternate mileage accumulation rates & registration)
2    :IMFLAG (Inspection and maintenance)
1    :RFGFLG (2 to apply reformulated gasoline effects, 1 not to)
3    :OUTFMT (indicates type of output format)
2    :IDLFLG (2 to print, 1 not to print idle emission factors)
2    :SO2FLG (2 to print Gaseous SO2 emissions, 1 not to print them)
1    :PRTFLG (determines which pollutants to print out)
1    :BUSFLG (determines which alternative bus cycles to print out)
2 2000 1 20.0        : region, year, speed cycle, speed
08.9 0.29 2         : unpaved silt%, ind. silt g/m^2, WHEELFLG
50
Az Local                     :scene name
10.   -- Particle size cutoff
4600
04
0.6600 0.2080 0.0840 0.0120 0.0050 0.0020
0.0010 0.0060 0.0000 0.0060 0.0140 0.0020
2 2000  1 20.0        : region, year, speed cycle, speed
05.7   0.29 2        : unpaved silt%, ind. silt g/m^2, WHEELFLG
50
Base                         :scene name
10.   -- Particle size cutoff
4600
04
0.6150 0.1910 0.0860 0.0310 0.0060 0.0019
0.0010 0.0146 0.0000 0.0146 0.0340 0.0049
2 2000 1 20.0    : region, year, speed cycle, speed
08.9   0.29 2        : unpaved silt%, ind. silt g/m^2, WHEELFLG
50
Parks                  :scene name
10.   -- Particle size cutoff
4600
04
0.7007 0.1372 0.1064 0.0079 0.0278 0.0004
0.0033 0.0035 0.0000 0.0035 0.0081 0.0012
2 2000 1 19.6 : region, year, speed cycle, speed
08.9 0.29 2         : unpaved silt%, ind. silt g/m^2, WHEELFLG
50
Parks FTP               :scene name
10.   -- Particle size cutoff
4600
04
0.7007 0.1372 0.1064 0.0079 0.0278 0.0004
0.0033 0.0035 0.0000 0.0035 0.0081 0.0012
2 2000 1 22.8 : region, year, speed cycle, speed
08.9 0.29 2         : unpaved silt%, ind. silt g/m^2, WHEELFLG
55
Parks Arches                 :scene name
10.   -- Particle size cutoff
4600
04
0.7007 0.1372 0.1064 0.0079 0.0278 0.0004
0.0033 0.0035 0.0000 0.0035 0.0081 0.0012
2 2000 1 16.7 : region, year, speed cycle, speed
08.9 0.29 2         : unpaved silt%, ind. silt g/m^2, WHEELFLG
50
Parks Zion                   :scene name
10.   -- Particle size cutoff
4600
04
0.7007 0.1372 0.1064 0.0079 0.0278 0.0004
0.0033 0.0035 0.0000 0.0035 0.0081 0.0012
```

MOBILE5b Input file: BaseS.in

```
1       PROMPT
 AZ non-I/M summer 2000: Modified using Temps from Petrified Forest
1       TAMFLG
1       SPDFLG
2       VMFLAG - one vmt for each scenario
3       MYMRFG - reg dist local but def annual mileage accum
1       NEWFLG -
1       IMFLAG - no I/M program
1       ALHFLG - no extra load corrections, ac, towing
1       ATPFLG - no anti-tampering program, could change
5       RLFLAG - no refueling losses calculated
2       LOCFLG - one LAP for all scenarios
1       TEMFLG - use only ambient temp
6       OUTFMT - spreadsheet
4       PRTFLG - Print exhaust HC, CO and NOx results.
2       IDLFLG - idle calculated
3       NMHFLG - Calculate emissions for volatile organic hydrocarbons.
2       HCFLAG - Separate VOC and sum
.074 .089 .091 .077 .071 .059 .059 .056 .059 .053
.051 .047 .042 .032 .020 .015 .012 .010 .013 .012       LDGV
.009 .006 .003 .004 .036
.071 .090 .089 .084 .060 .047 .047 .042 .049 .044
.042 .057 .041 .032 .020 .017 .016 .012 .016 .016       LDGT1
.014 .010 .006 .008 .071
.075 .087 .094 .092 .070 .051 .045 .041 .053 .045
.030 .042 .035 .025 .014 .015 .017 .013 .023 .024       LDGT2
.021 .014 .009 .011 .054
.044 .062 .090 .074 .082 .037 .038 .039 .056 .060
.036 .046 .044 .032 .015 .018 .016 .021 .038 .023       HDGV
.020 .012 .016 .013 .067
.074 .089 .091 .077 .071 .059 .059 .056 .059 .053
.051 .047 .042 .032 .020 .015 .012 .010 .013 .012       LDDV
.009 .006 .003 .004 .036
.071 .090 .089 .084 .060 .047 .047 .042 .049 .044
.042 .057 .041 .032 .020 .017 .016 .012 .016 .016       LDDT
.014 .010 .006 .008 .071
.073 .098 . 121 .077 .066 .045 .045 .077 .068 .052      <- Unadj HDDV
.046 .047 .042 .033 .014 .013 .014 .014 .015 .010
.006 .004 .004 .003 .014
.053 .080 .073 .061 .059 .042 .032 .033 .034 .033
.040 .459 .000 .000 .000 .000 .000 .000 .000 .000       MC
.000 .000 .000 .000 .000
BaseS AZ non im C 49. 82. 12.1  12.1 92 1 1  1
2 00 57.0 70.5 20.6 27.3 20.6 01          57mph
.660.208.084.012.002.001.028.005            VMTmix-Loc
2 00 20.0 70.5 20.6 27.3 20.6 01          FTP
.528.166.067.071.002.001.160.005            VMTmix-Fwy
2 00 22.8 70.5 20.6 27.3 20.6 01          Arches
.610.192.078.034.002.001.078.005            VMTmix-Art
2 00 16.7 70.5 20.6 27.3 20.6 01          Zion
.660.208.084.012.002.001.028.005            VMTmix-Loc
00000000000000000000000000000000000000000000000000000000000000000000000000000
```

MOBILE5b Input file: BaseSim.in

```
1       PROMPT
 AZ I/M summer 2000: Modified using Temps from Petrified Forest
1       TAMFLG
1       SPDFLG
2       VMFLAG - one vmt for each scenario
3       MYMRFG - reg dist local but def annual mileage accum
1       NEWFLG -
3       IMFLAG - no I/M program
1       ALHFLG - no extra load corrections, ac, towing
1       ATPFLG - no anti-tampering program, could change
5       RLFLAG - no refueling losses calculated
2       LOCFLG - one LAP for all scenarios
1       TEMFLG - use only ambient temp
6       OUTFMT - spreadsheet
4       PRTFLG - Print exhaust HC, CO and NOx results.
2       IDLFLG - idle calculated
3       NMHFLG - Calculate emissions for volatile organic hydrocarbons.
2       HCFLAG - Separate VOC and sum
.074 .089 .091 .077 .071 .059 .059 .056 .059 .053
.051 .047 .042 .032 .020 .015 .012 .010 .013 .012      LDGV
.009 .006 .003 .004 .036
.071 .090 .089 .084 .060 .047 .047 .042 .049 .044
.042 .057 .041 .032 .020 .017 .016 .012 .016 .016      LDGT1
.014 .010 .006 .008 .071
.075 .087 .094 .092 .070 .051 .045 .041 .053 .045
.030 .042 .035 .025 .014 .015 .017 .013 .023 .024      LDGT2
.021 .014 .009 .011 .054
.044 .062 .090 .074 .082 .037 .038 .039 .056 .060
.036 .046 .044 .032 .015 .018 .016 .021 .038 .023      HDGV
.020 .012 .016 .013 .067
.074 .089 .091 .077 .071 .059 .059 .056 .059 .053
.051 .047 .042 .032 .020 .015 .012 .010 .013 .012      LDDV
.009 .006 .003 .004 .036
.071 .090 .089 .084 .060 .047 .047 .042 .049 .044
.042 .057 .041 .032 .020 .017 .016 .012 .016 .016      LDDT
.014 .010 .006 .008 .071
.073 .098 . 121 .077 .066 .045 .045 .077 .068 .052     <- Unadj HDDV
.046 .047 .042 .033 .014 .013 .014 .014 .015 .010
.006 .004 .004 .003 .014
.053 .080 .073 .061 .059 .042 .032 .033 .034 .033
.040 .459 .000 .000 .000 .000 .000 .000 .000 .000      MC
.000 .000 .000 .000 .000
77 28 67 20 04 03 097 111 2222 3122            Basic I/M
77 28 81 20 04 03 097 111 2221 4211 0.80 15.0 3.00 IM240 Program
TECH12.D
IMDATA4.D
BaseS AZ im     C 49. 82. 12.1 12.1 92 1 1 1
2 00 57.0 70.5 20.6 27.3 20.6 01          57mph
.660.208.084.012.002.001.028.005           VMTmix-Loc
2 00 20.0 70.5 20.6 27.3 20.6 01          FTP
.528.166.067.071.002.001.160.005           VMTmix-Fwy
2 00 22.8 70.5 20.6 27.3 20.6 01          Arches
.610.192.078.034.002.001.078.005           VMTmix-Art
2 00 16.7 70.5 20.6 27.3 20.6 01          Zion
.660.208.084.012.002.001.028.005           VMTmix-Loc
0000000000000000000000000000000000000000000000000000000000000000000000000000
```

MOBILE5b Input file: BaseW.in

```
1       PROMPT
 AZ non-I/M winter 2000
1       TAMFLG
1       SPDFLG
2       VMFLAG - one vmt for each scenario
3       MYMRFG - AZ reg distrib, def annual mileage accum
1       NEWFLG -
1       IMFLAG - no I/M program
1       ALHFLG - no extra load corrections, ac, towing
1       ATPFLG - no anti-tampering program, could change
```

5 RLFLAG - no refueling losses calculated
2 LOCFLG - one LAP for all scenarios
1 TEMFLG - use only ambient temp
6 OUTFMT - spreadsheet
4 PRTFLG - Print exhaust HC, CO and NOx results.
2 IDLFLG - idle calculated
3 NMHFLG - Calculate emissions for volatile organic hydrocarbons.
2 HCFLAG - Separate VOC and sum
.074 .089 .091 .077 .071 .059 .059 .056 .059 .053
.051 .047 .042 .032 .020 .015 .012 .010 .013 .012 LDGV
.009 .006 .003 .004 .036
.071 .090 .089 .084 .060 .047 .047 .042 .049 .044
.042 .057 .041 .032 .020 .017 .016 .012 .016 .016 LDGT1
.014 .010 .006 .008 .071
.075 .087 .094 .092 .070 .051 .045 .041 .053 .045
.030 .042 .035 .025 .014 .015 .017 .013 .023 .024 LDGT2
.021 .014 .009 .011 .054
.044 .062 .090 .074 .082 .037 .038 .039 .056 .060
.036 .046 .044 .032 .015 .018 .016 .021 .038 .023 HDGV
.020 .012 .016 .013 .067
.074 .089 .091 .077 .071 .059 .059 .056 .059 .053
.051 .047 .042 .032 .020 .015 .012 .010 .013 .012 LDDV
.009 .006 .003 .004 .036
.071 .090 .089 .084 .060 .047 .047 .042 .049 .044
.042 .057 .041 .032 .020 .017 .016 .012 .016 .016 LDDT
.014 .010 .006 .008 .071
.073 .098 . 121 .077 .066 .045 .045 .077 .068 .052 <- Unadj HDDV
.046 .047 .042 .033 .014 .013 .014 .014 .015 .010
.006 .004 .004 .003 .014
.053 .080 .073 .061 .059 .042 .032 .033 .034 .033
.040 .459 .000 .000 .000 .000 .000 .000 .000 .000 MC
.000 .000 .000 .000 .000
BaseW AZ non im C 25. 54. 12.1 12.1 92 1 1 1
2 00 57.0 42.5 20.6 27.3 20.6 01 57mph
.660.208.084.012.002.001.028.005 VMTmix-Loc
2 00 20.0 42.5 20.6 27.3 20.6 01 FTP
.528.166.067.071.002.001.160.005 VMTmix-Fwy
2 00 22.8 42.5 20.6 27.3 20.6 01 Arches
.610.192.078.034.002.001.078.005 VMTmix-Art
2 00 16.7 42.5 20.6 27.3 20.6 01 Zion
.660.208.084.012.002.001.028.005 VMTmix-Loc
00000000000000000000000000000000000000000000000000000000000000000000000000000000

MOBILE5b Input file: BaseWim.in

1 PROMPT
AZ I/M winter 2000
1 TAMFLG
1 SPDFLG
2 VMFLAG - one vmt for each scenario
3 MYMRFG - AZ reg distrib, def annual mileage accum
1 NEWFLG -
3 IMFLAG - 2 I/M program
1 ALHFLG - no extra load corrections, ac, towing
1 ATPFLG - no anti-tampering program, could change
5 RLFLAG - no refueling losses calculated
2 LOCFLG - one LAP for all scenarios
1 TEMFLG - use only ambient temp
6 OUTFMT - spreadsheet
4 PRTFLG - Print exhaust HC, CO and NOx results.
2 IDLFLG - idle calculated
3 NMHFLG - Calculate emissions for volatile organic hydrocarbons.
2 HCFLAG - Separate VOC and sum
.074 .089 .091 .077 .071 .059 .059 .056 .059 .053
.051 .047 .042 .032 .020 .015 .012 .010 .013 .012 LDGV
.009 .006 .003 .004 .036
.071 .090 .089 .084 .060 .047 .047 .042 .049 .044
.042 .057 .041 .032 .020 .017 .016 .012 .016 .016 LDGT1
.014 .010 .006 .008 .071
.075 .087 .094 .092 .070 .051 .045 .041 .053 .045
.030 .042 .035 .025 .014 .015 .017 .013 .023 .024 LDGT2

```
.021 .014 .009 .011 .054
.044 .062 .090 .074 .082 .037 .038 .039 .056 .060
.036 .046 .044 .032 .015 .018 .016 .021 .038 .023        HDGV
.020 .012 .016 .013 .067
.074 .089 .091 .077 .071 .059 .059 .056 .059 .053
.051 .047 .042 .032 .020 .015 .012 .010 .013 .012        LDDV
.009 .006 .003 .004 .036
.071 .090 .089 .084 .060 .047 .047 .042 .049 .044
.042 .057 .041 .032 .020 .017 .016 .012 .016 .016        LDDT
.014 .010 .006 .008 .071
.073 .098 .121 .077 .066 .045 .045 .077 .068 .052       <- Unadj HDDV
.046 .047 .042 .033 .014 .013 .014 .014 .015 .010
.006 .004 .004 .003 .014
.053 .080 .073 .061 .059 .042 .032 .033 .034 .033
.040 .459 .000 .000 .000 .000 .000 .000 .000 .000        MC
.000 .000 .000 .000 .000
77 28 67 20 04 03 097 111 2222 3122                  Basic I/M
77 28 81 20 04 03 097 111 2221 4211 0.80 15.0 3.00 IM240 Program
TECH12.D
IMDATA4.D
BaseW AZ im      C 25. 54. 12.1 12.1 92 1 1 1
2 00 57.0 42.5 20.6 27.3 20.6 01                  57mph
.660.208.084.012.002.001.028.005                    VMTmix-Loc
2 00 20.0 42.5 20.6 27.3 20.6 01                  FTP
.528.166.067.071.002.001.160.005                    VMTmix-Fwy
2 00 22.8 42.5 20.6 27.3 20.6 01                  Arches
.610.192.078.034.002.001.078.005                    VMTmix-Art
2 00 16.7 42.5 20.6 27.3 20.6 01                  Zion
.660.208.084.012.002.001.028.005                    VMTmix-Loc
0000000000000000000000000000000000000000000000000000000000000000000000000000000000
```

MOBILE5b Input file: PS.in

```
1       PROMPT
 Arizona: Petrified Forest summer 2000 non i/m.
1       TAMFLG
1       SPDFLG
2       VMFLAG - one vmt for each scenario
3       MYMRFG - def reg distrib, def annual mileage accum
1       NEWFLG -
1       IMFLAG - no I/M program
1       ALHFLG - no extra load corrections, ac, towing
1       ATPFLG - no anti-tampering program, could change
5       RLFLAG - no refueling losses calculated
2       LOCFLG - one LAP for all scenarios
1       TEMFLG - use only ambient temp
6       OUTFMT - spreadsheet
4       PRTFLG - Print exhaust HC, CO and NOx results.
2       IDLFLG - idle calculated
3       NMHFLG - Calculate emissions for volatile organic hydrocarbons.
2       HCFLAG - Separate VOC and sum
 .158 .158 .158 .158 .059 .059 .059 .059 .025 .025        registration dist. by age
 .025 .010 .010 .010 .004 .004 .004 .004 .004 .002     LDGV
 .002 .002 .000 .000 .000
 .161 .161 .161 .161 .043 .043 .043 .043 .025 .025        LDGT1
 .025 .018 .018 .018 .010 .010 .010 .010 .004 .004
 .004 .001 .001 .001 .000
 .000 .228 .228 .228 .049 .049 .049 .049 .026 .026        LDGT2
 .026 .011 .011 .011 .002 .002 .002 .002 .000 .000
 .000 .000 .000 .000 .000
 .183 .183 .183 .183 .050 .050 .050 .050 .022 .022        HDGV
 .022 .000 .000 .000 .000 .000 .000 .000 .000 .000
 .000 .000 .000 .000 .000
 .158 .158 .158 .158 .059 .059 .059 .059 .025 .025        LDDV
 .025 .010 .010 .010 .004 .004 .004 .004 .004 .002
 .002 .002 .000 .000 .000
 .161 .161 .161 .161 .043 .043 .043 .043 .025 .025        LDDT
 .025 .018 .018 .018 .010 .010 .010 .010 .004 .004
 .004 .001 .001 .001 .000
 .147 .147 .147 .147 .088 .088 .088 .088 .020 .020        HDDV
 .020 .000 .000 .000 .000 .000 .000 .000 .000 .000
```

```
 .000 .000 .000 .000 .000
 .100 .100 .100 .100 .100 .100 .100 .100 .050 .050          MC
 .050 .050 .000 .000 .000 .000 .000 .000 .000 .000
 .000 .000 .000 .000 .000
PetF S non im C 49. 82. 12.1 12.1 92 1 1  1
2 00 57.0 70.5 20.6 27.3 20.6 01                   57mph
.701.138.106.008.000.003.016.028                     VMT Park specific mix
2 00 20.0 70.5 20.6 27.3 20.6 01                   FTP
.701.138.106.008.000.003.016.028                     VMT Park specific mix
2 00 22.8 70.5 20.6 27.3 20.6 01                   Arches
.701.138.106.008.000.003.016.028                     VMT Park specific mix
2 00 16.7 70.5 20.6 27.3 20.6 01                   Zion
.701.138.106.008.000.003.016.028                     VMT Park specific mix
0000000000000000000000000000000000000000000000000000000000000000000000000000000
```

MOBILE5b Input file: PSim.in

```
1        PROMPT
 Arizona: Petrified Forest summer 2000 i/m.
1        TAMFLG
1        SPDFLG
2        VMFLAG - one vmt for each scenario
3        MYMRFG - def reg distrib, def annual mileage accum
1        NEWFLG -
3        IMFLAG - 2 I/M program
1        ALHFLG - no extra load corrections, ac, towing
1        ATPFLG - no anti-tampering program, could change
5        RLFLAG - no refueling losses calculated
2        LOCFLG - one LAP for all scenarios
1        TEMFLG - use only ambient temp
6        OUTFMT - spreadsheet
4        PRTFLG - Print exhaust HC, CO and NOx results.
2        IDLFLG - idle calculated
3        NMHFLG - Calculate emissions for volatile organic hydrocarbons.
2        HCFLAG - Separate VOC and sum
 .158 .158 .158 . 158 .059 .059 .059 .059 .025 .025          registration dist. by age
 .025 .010 .010 .010 .004 .004 .004 .004 .004 .002     LDGV
 .002 .002 .000 .000 .000
 .161 .161 .161 .161 .043 .043 .043 .043 .025 .025          LDGT1
 .025 .018 .018 .018 .010 .010 .010 .010 .004 .004
 .004 .001 .001 .001 .000
 .000 .228 .228 .228 .049 .049 .049 .049 .026 .026          LDGT2
 .026 .011 .011 .011 .002 .002 .002 .002 .000 .000
 .000 .000 .000 .000 .000
 .183 .183 .183 .183 .050 .050 .050 .050 .022 .022          HDGV
 .022 .000 .000 .000 .000 .000 .000 .000 .000 .000
 .000 .000 .000 .000 .000
 .158 .158 .158 .158 .059 .059 .059 .059 .025 .025          LDDV
 .025 .010 .010 .010 .004 .004 .004 .004 .004 .002
 .002 .002 .000 .000 .000
 .161 .161 .161 .161 .043 .043 .043 .043 .025 .025          LDDT
 .025 .018 .018 .018 .010 .010 .010 .010 .004 .004
 .004 .001 .001 .001 .000
 .147 .147 .147 .147 .088 .088 .088 .088 .020 .020          HDDV
 .020 .000 .000 .000 .000 .000 .000 .000 .000 .000
 .000 .000 .000 .000 .000
 .100 .100 .100 .100 .100 .100 .100 .100 .050 .050          MC
 .050 .050 .000 .000 .000 .000 .000 .000 .000 .000
 .000 .000 .000 .000 .000
77 28 67 20 04 03 097 111 2222 3122                Basic I/M
77 28 81 20 04 03 097 111 2221 4211 0.80 15.0 3.00 IM240 Program
TECH12.D
IMDATA4.D
PetrifedF Sim     C 49. 82. 12.1 12.1 92 1 1 1
2 00 57.0 70.5 20.6 27.3 20.6 01                   57mph
.701.138.106.008.000.003.016.028                     VMT Park specific mix
2 00 20.0 70.5 20.6 27.3 20.6 01                   FTP
.701.138.106.008.000.003.016.028                     VMT Park specific mix
2 00 22.8 70.5 20.6 27.3 20.6 01                   Arches
.701.138.106.008.000.003.016.028                     VMT Park specific mix
2 00 16.7 70.5 20.6 27.3 20.6 01                   Zion
```

.701.138.106.008.000.003.016.028 VMT Park specific mix
00000000000000000000000000000000000000000000000000000000000000000000000000000000

MOBILE5b Input file: PW.in

1 PROMPT
Arizona: Petrified Forest winter 2000 no im
1 TAMFLG
1 SPDFLG
2 VMFLAG - one vmt for each scenario
3 MYMRFG - def reg distrib, def annual mileage accum
1 NEWFLG -
1 IMFLAG - no I/M program
1 ALHFLG - no extra load corrections, ac, towing
1 ATPFLG - no anti-tampering program, could change
5 RLFLAG - no refueling losses calculated
2 LOCFLG - one LAP for all scenarios
1 TEMFLG - use only ambient temp
6 OUTFMT - spreadsheet
4 PRTFLG - Print exhaust HC, CO and NOx results.
2 IDLFLG - idle calculated
3 NMHFLG - Calculate emissions for volatile organic hydrocarbons.
2 HCFLAG - Separate VOC and sum
.158 .158 .158 . 158 .059 .059 .059 .059 .025 .025 registration dist. by age
.025 .010 .010 .010 .004 .004 .004 .004 .004 .002 LDGV
.002 .002 .000 .000 .000
.161 .161 .161 .161 .043 .043 .043 .043 .025 .025 LDGT1
.025 .018 .018 .018 .010 .010 .010 .010 .004 .004
.004 .001 .001 .001 .000
.000 .228 .228 .228 .049 .049 .049 .049 .026 .026 LDGT2
.026 .011 .011 .011 .002 .002 .002 .002 .000 .000
.000 .000 .000 .000 .000
.183 .183 .183 .183 .050 .050 .050 .050 .022 .022 HDGV
.022 .000 .000 .000 .000 .000 .000 .000 .000 .000
.000 .000 .000 .000 .000
.158 .158 .158 .158 .059 .059 .059 .059 .025 .025 LDDV
.025 .010 .010 .010 .004 .004 .004 .004 .004 .002
.002 .002 .000 .000 .000
.161 .161 .161 .161 .043 .043 .043 .043 .025 .025 LDDT
.025 .018 .018 .018 .010 .010 .010 .010 .004 .004
.004 .001 .001 .001 .000
.147 .147 .147 .147 .088 .088 .088 .088 .020 .020 HDDV
.020 .000 .000 .000 .000 .000 .000 .000 .000 .000
.000 .000 .000 .000 .000
.100 .100 .100 .100 .100 .100 .100 .100 .050 .050 MC
.050 .050 .000 .000 .000 .000 .000 .000 .000 .000
.000 .000 .000 .000 .000
PetF W non im C 25. 54. 12.1 12.1 92 1 1 1
2 00 57.0 42.5 20.6 27.3 20.6 01 57mph
.701.138.106.008.000.003.016.028 VMT Park specific mix
2 00 20.0 42.5 20.6 27.3 20.6 01 FTP
.701.138.106.008.000.003.016.028 VMT Park specific mix
2 00 22.8 42.5 20.6 27.3 20.6 01 Arches
.701.138.106.008.000.003.016.028 VMT Park specific mix
2 00 16.7 42.5 20.6 27.3 20.6 01 Zion
.701.138.106.008.000.003.016.028 VMT Park specific mix
00000000000000000000000000000000000000000000000000000000000000000000000000000000

MOBILE5b Input file: PWim.in

1 PROMPT
Arizona: Petrified Forest winter 2000 IM
1 TAMFLG
1 SPDFLG
2 VMFLAG - one vmt for each scenario
3 MYMRFG - def reg distrib, def annual mileage accum
1 NEWFLG -
3 IMFLAG - 2 I/M program
1 ALHFLG - no extra load corrections, ac, towing

```
1        ATPFLG - no anti-tampering program, could change
5        RLFLAG - no refueling losses calculated
2        LOCFLG - one LAP for all scenarios
1        TEMFLG - use only ambient temp
6        OUTFMT - spreadsheet
4        PRTFLG - Print exhaust HC, CO and NOx results.
2        IDLFLG - idle calculated
3        NMHFLG - Calculate emissions for volatile organic hydrocarbons.
2        HCFLAG - Separate VOC and sum
.158 .158 .158 .158 .059 .059 .059 .059 .025 .025       registration dist. by age
.025 .010 .010 .010 .004 .004 .004 .004 .004 .002    LDGV
.002 .002 .000 .000 .000
.161 .161 .161 .161 .043 .043 .043 .043 .025 .025       LDGT1
.025 .018 .018 .018 .010 .010 .010 .010 .004 .004
.004 .001 .001 .001 .000
.000 .228 .228 .228 .049 .049 .049 .049 .026 .026       LDGT2
.026 .011 .011 .011 .002 .002 .002 .002 .000 .000
.000 .000 .000 .000 .000
. 183 .183 .183 .183 .050 .050 .050 .050 .022 .022      HDGV
.022 .000 .000 .000 .000 .000 .000 .000 .000 .000
.000 .000 .000 .000 .000
. 158 .158 .158 .158 .059 .059 .059 .059 .025 .025      LDDV
.025 .010 .010 .010 .004 .004 .004 .004 .004 .002
.002 .002 .000 .000 .000
.161 .161 .161 .161 .043 .043 .043 .043 .025 .025       LDDT
.025 .018 .018 .018 .010 .010 .010 .010 .004 .004
.004 .001 .001 .001 .000
.147 .147 .147 .147 .088 .088 .088 .088 .020 .020       HDDV
.020 .000 .000 .000 .000 .000 .000 .000 .000 .000
.000 .000 .000 .000 .000
.100 .100 .100 .100 .100 .100 .100 .100 .050 .050       MC
.050 .050 .000 .000 .000 .000 .000 .000 .000 .000
.000 .000 .000 .000 .000
77 28 67 20 04 03 097 111 2222 3122              Basic I/M
77 28 81 20 04 03 097 111 2221 4211 0.80 15.0 3.00 IM240 Program
TECH12.D
IMDATA4.D
PetrifiedF W IM C 25. 54. 12.1 12.1 92 1 1  1
2 00 57.0 42.5 20.6 27.3 20.6 01               57mph
.701.138.106.008.000.003.016.028                 VMT Park specific mix
2 00 20.0 42.5 20.6 27.3 20.6 01               FTP
.701.138.106.008.000.003.016.028                 VMT Park specific mix
2 00 22.8 42.5 20.6 27.3 20.6 01               Arches
.701.138.106.008.000.003.016.028                 VMT Park specific mix
2 00 16.7 42.5 20.6 27.3 20.6 01               Zion
.701.138.106.008.000.003.016.028                 VMT Park specific mix
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Appendix D

Miscellaneous Documents Provided by Petrified Forest National Park Personnel and MSDS Sheets