FINAL

2000 AIR EMISSIONS INVENTORY

GRAND CANYON NATIONAL PARK
ARIZONA

U.S. NATIONAL PARK SERVICE

SEPTEMBER 2002

DRAFT

2000 AIR EMISSIONS INVENTORY

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ARIZONA

Prepared for..

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Cover Photo: Liquefied Natural Gas (LNG), Compressed Natural Gas (CNG), and Electric Powered Shuttle Buses on the South Rim (NPS Photo)

CONTENTS

CONTENTS (Continued)

FIGURES

TABLES

1. INTRODUCTION

1.1 BACKGROUND

In August of 1999, the National Park Service (NPS) embarked on the Natural Resource Challenge, a major effort to substantially improve how the NPS manages the natural resources under its care. As part of Natural Resource Challenge, the NPS Air Resources Division (ARD) was tasked with the responsibility of expanding efforts to monitor and understand air quality and related values in the parks. In addition, the NPS Environmental Leadership policy directs the NPS to manage the parks in a manner "that demonstrates sound environmental stewardship by ¡mplementing sustainable practices in all aspects of NPS management...." In order to achieve both of these objectives, it is necessary to gain an understanding of air pollution emissions that result from activities within the park. Development of an in-park air emissions inventory for Grand Canyon National Park (NP) serves three functions. First, it provides an understanding of the sources and magnitude of in-park emissions and a basis for contrasting them with emissions from the surrounding area. Second, it identifies existing and potential strategies to mitigate in-park air emissions. Finally, it evaluates and ensures the compliance status of the park relative to state and federal air pollution regulations.

1.2 TYPICAL AIR EMISSION SOURCES

Typical air emission sources within NPS units include stationary, area, and mobile sources. Stationary sources can include fossil fuel-fired space and water heating equipment, generators, fuel storage tanks, paint and chemical usage, and woodworking equipment. Area sources may include prescribed burning, campfires, wastewater treatment plants, highway maintenance, and miscellaneous visitor activities. Mobile sources may include vehicles operated by visitors, tour operators, and NPS and concessioner employees, and nonroad vehicles and equipment.

1.3 INVENTORY METHODOLOGY

The methodology.to accomplish the air emissions inventory consisted of a site survey in October 2001, interviews with Grand Canyon NP' and concessionaire personnel, review of applicable park records, emission calculations, and report preparation. The data were used in conjunction with a number of manual and computer software computational tools to calculate emissions. Computational tools included U.S. Environmental Protection Agency (USEPA) emission factors such as the Factor Information Retrieval System (FIRE) database, USEPA *TANKS 4.0* model,

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U.S. Forest Service *First Order Fire Effects Model (FOFEM) 4.0* model, USEPA *MOBILE5band PARTS* mobile source emissions model, and Federal Aviation *Administration Emissions and Dispersion Modeling System (EDMS).* The year 2000 was selected as the basis for the air emission inventory since data for that year were the most recent available at the park. It should be noted that emissions are expected to vary from year to year due to fluctuations in visitation, prescribed and wildland fires, and other activities. Additional information on emission estimation methodology, including emission factors, is provided in Appendix A.

1.4 PARK DESCRIPTION

Grand Canyon NP is located in the northwest corner of Arizona, close to the borders of Utah and Nevada. The Colorado River flows through the canyon and drains water from seven states. Adjacent lands are administered by other units of the NPS (Glen Canyon National Recreation Area and Lake Mead National Recreation Area), the NPS and Bureau of Land Management (Grand Canyon-Parashant National Monument), the U.S. Forest Service (Kaibab National Forest) or neighboring Indian tribes (the Havasupai, Hualapai, and Navajo Indian Reservations). These areas are depicted in Figure 1 [2].

The park includes 1,218,376 acres or 1,904 square miles and is 277 miles long. It begins at Lees Ferry and ends at Grand Wash Cliffs. The Colorado River is longer than the Grand Canyon, flowing 1,450 miles from the Rocky Mountains of Colorado to the Gulf of California in Mexico. The width and depth of the canyon vary from place to place. At the South Rim, near Grand Canyon Village, it's a vertical mile or about 5,000 feet from the rim to the Colorado River. At its deepest, it is 6,000 vertical feet from the rim to the Colorado River. The width of the canyon at Grand Canyon Village is 10 miles from rim to rim, and in other places, it is as much as 18 miles wide. A trip to the bottom of the canyon and back (on foot or by mule) is a two-day journey. Rim-to-rim hikers generally take three days one-way to get from the North Rim to the South Rim. A trip through Grand Canyon by raft can take two weeks or longer, while experienced backpackers have spent weeks in the more remote areas of the canyon.

There are no dams within Grand Canyon NP, although dams bordering the park have a profound effect on the canyon. At the upper end of the canyon, 15 miles above Lees Ferry, is Lake Powell, which was formed by the waters behind Glen Canyon Dam. At the lower end of the canyon is Lake Mead, formed by the waters behind Hoover Dam. The controlled release of water from Glen Canyon Dam at the upstream end affects the water that flows through Grand Canyon, while

[2] All figures courtesy of the NPS.

waters from Lake Mead flood the lower 40 miles of Grand Canyon when the lake is full. The South Rim is the most visited and developed area of the park (Figure 2) and is open all year. As discussed in the section on mobile source emissions, the park operates an extensive shuttle bus system within the South Rim. The East Entrance at Desert View on the South Rim (Figure 3) also has limited visitor services, including the only public gasoline service station in the South Rim. The North Rim (Figure 4), which is a 200 mile drive from the South Rim, has significantly lower visitation and is closed from mid-October until mid-May.

Infoiniation on these developed areas is summarized in Table 1. Commercial services in the park that are authorized under concession contracts, including Xanterra the principal concessionaire, that may generate air emissions include lodging, food services, campstores and other retail establishments, motor boats on the Colorado River, and air tours.

TABLE 1: GRAND CANYON NP DEVELOPED AREAS

Name/Location	Function/Facilities
Grand Canyon Village (South Rim)	Canyon View Visitor Center and Bookstore, Park Headquarters, Market Plaza (bank, post office, and store), Yavapai Lodge, Trailer Village, Mather Campground, Medical Clinic, Train Depot, Ranger Office, Verkamps Curios, Hopi House, El Tovar Hotel, Kachina Lodge. Thunderbird Lodge, Bright Angel Lodge, Lookout Studio, Kolb Studio, Community Building, Backcountry Information Center, Maswik Lodge, Kennels, NPS Maintenance Shops, NPS Garage, Employee Housing
Hermits Rest (South Rim)	Store
East Entrance Desert View (South Rim)	Information and Bookstore, Trading Post, Marketplace, Gasoline Service Station, Campground, Tusayan Ruin and Museum
North Rim (mid-May to mid-October)	Visitor Center, Grand Canyon Lodge, Store, Groceries, Gasoline Service Station, Campground

1.5 AIR QUALITY STATUS

The majority of Grand Canyon NP is located in Coconino County, AZ, with a small western portion located in Mohave County. The Arizona Department of Environmental Quality (DEQ), Air Quality Division is the governing authority for regulating air pollution from stationary sources in Arizona. Coconino and Mohave Counties are both in attainment for all national and state ambient air quality standards (AAQS), including ozone and particulate matter (PM10).

Clean, clear air is essential to preserve the resources in Grand Canyon National Park, as well as for visitors to appreciate those resources. Expansive vistas within the Park include landmarks scores of miles distant, as well as the vibrant colors and intricate textures of the Canyon itself. Grand Canyon National Park is a federally-mandated Class I area under the Clean Air Act. As

such, air in the Park receives the most stringent protection against increases in air pollution and in further degradation of air quality related values. The Act then sets a further goal of natural visibility conditions, free of human-caused haze. Air quality in the Park is generally quite good. Pollution levels monitored in the Park fall below the levels established by the Environmental Protection Agency to protect human health and welfare. However, the ability to see through the air (visibility) is usually well below natural levels because of air pollution. Most of this pollution originates far outside the Park's boundaries and arrives in the Park as a well-mixed regional haze, rather than as distinct plumes.

Regional conditions strongly influence air quality on the Canyon's North and South Rims. During the spring and summer, pollution levels are higher. Most of this increase is due to the prevailing south to southwest winds, which carry pollutants from industrial and metropolitan sources in southern parts of Arizona, Nevada, and California, and northern Mexico. Efforts to reduce these seasonal pollution loads require regional cooperation, as suggested in the Grand Canyon Visibility Transport Commission's *Recommendations for Improving Western Vistas* (June 10, 1996).

Locations within the Grand Canyon experience higher pollution levels (on average) than sites on the rims. These higher levels are often the result of air pollution draining into the Canyon, and becoming trapped there by temperature inversions and eddies. These effects are strongest in the winter. During colder seasons, there is insufficient solar heating to generate updrafts. These updrafts are needed to ventilate the Canyon, lifting air high enough above the rim for pollution to be dispersed by prevailing winds. Winds from the north may also trap air within the Canyon in eddies. Generally, cool down-slope winds from the South Rim can combine with warm up-slope winds on the North Rim to help ventilate the Canyon. However, a prevailing wind from the north can change this pattern into an eddy within the Canyon, as rising air in the north is blown back south, where it can cool and descend back into the Canyon. Prevailing winds from the south, on the other hand, can encourage ventilation of the Canyon by augmenting the south-to-north, downslope-upslope pattern. During the winter months, cold fronts are responsible for most of the Canyon's ventilation. Although wind speed in a weak front may not mix air throughout the Canyon, a strong cold front tends to thoroughly mix and ventilate the Canyon. In general, the very best visibility in the Grand Canyon occurs immediately after the passage of a strong winter cold front.

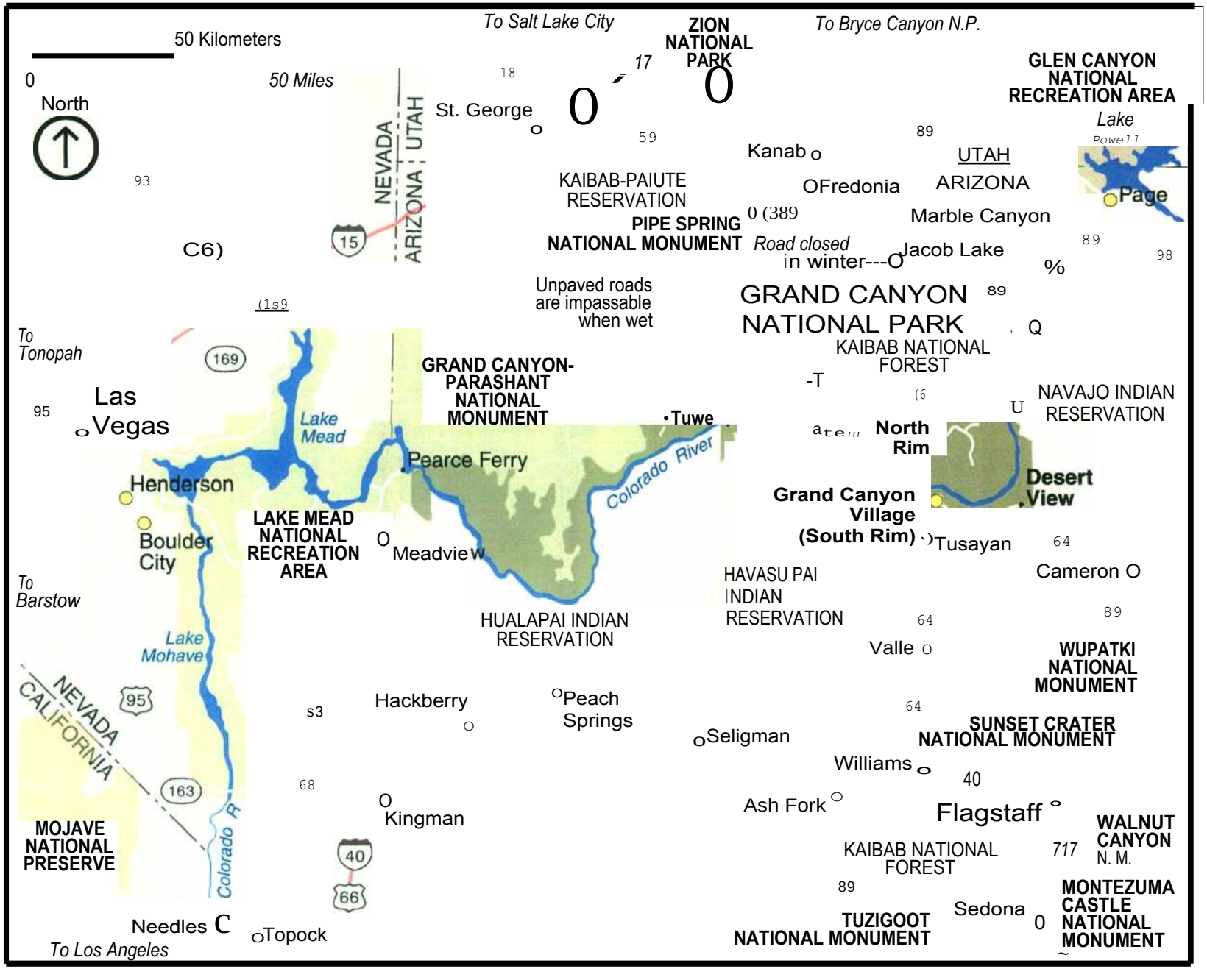
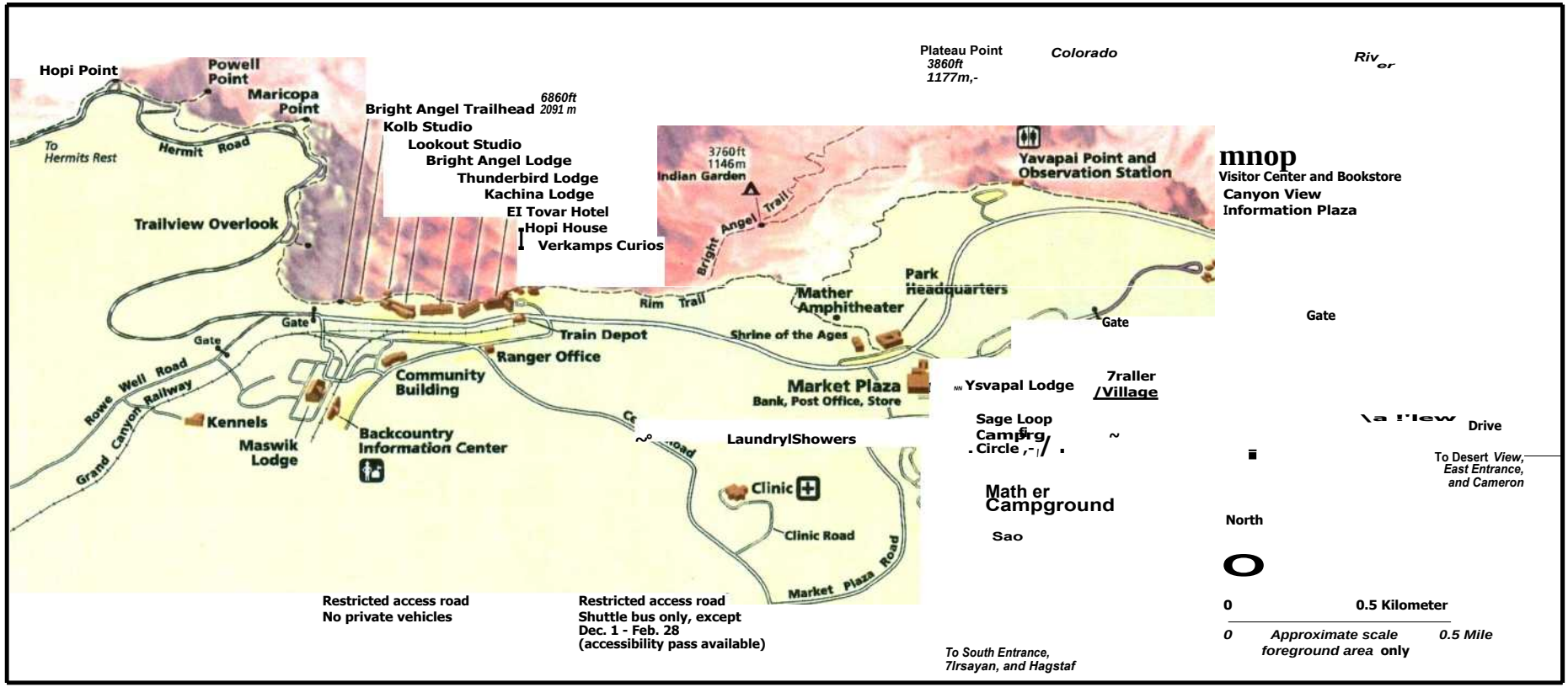

50 Kilometers
0
50 Miles
North
To Salt Lake City
ZION NATIONAL PARK
To Bryce Canyon N.P.
GLEN CANYON NATIONAL RECREATION AREA
Lake Powell
Page
St. George
Kanab
UTAH
ARIZONA
NEVADA
ARIZONA
UTAH
KAIBAB-PAIUTE RESERVATION
OFredonia
PIPE SPRING NATIONAL MONUMENT
Road closed in winter---
Jacob Lake
Marble Canyon
Unpaved roads are impassable when wet
GRAND CANYON NATIONAL PARK
KAIBAB NATIONAL FOREST
NAVAJO INDIAN RESERVATION
To Tonopah
Las Vegas
GRAND CANYON-PARASHANT NATIONAL MONUMENT
Lake Mead
Tuwe
Pearce Ferry
Colorado River
North Rim
Desert View
Grand Canyon Village (South Rim)
Tusayan
Cameron
Henderson
Boulder City
LAKE MEAD NATIONAL RECREATION AREA
Meadview
To Barstow
HUALAPAI INDIAN RESERVATION
HAVASU PAI INDIAN RESERVATION
Valle
WUPATKI NATIONAL MONUMENT
Lake Mohave
NEVADA
CALIFORNIA
Hackberry
Peach Springs
Seligman
SUNSET CRATER NATIONAL MONUMENT
Williams
Ash Fork
Flagstaff
WALNUT CANYON N. M.
KAIBAB NATIONAL FOREST
MOJAVE NATIONAL PRESERVE
Kingman
Colorado R
Needles
Topock
To Los Angeles
Sedona
TUZIGOOT NATIONAL MONUMENT
MONTEZUMA CASTLE NATIONAL MONUMENT

FIGURE 1

Grand Canyon Village Map
South Rim

National Park Service
US Department of the Interior

Grand Canyon National Park



CD Ranger Station

O Campground

A Primitive Campground

® Telephone

an Restrooms

Trail

FIGURE 2

East Rim Drive Map
South Rim

National Park Service
US Department of the Interior

Grand Canyon National Park

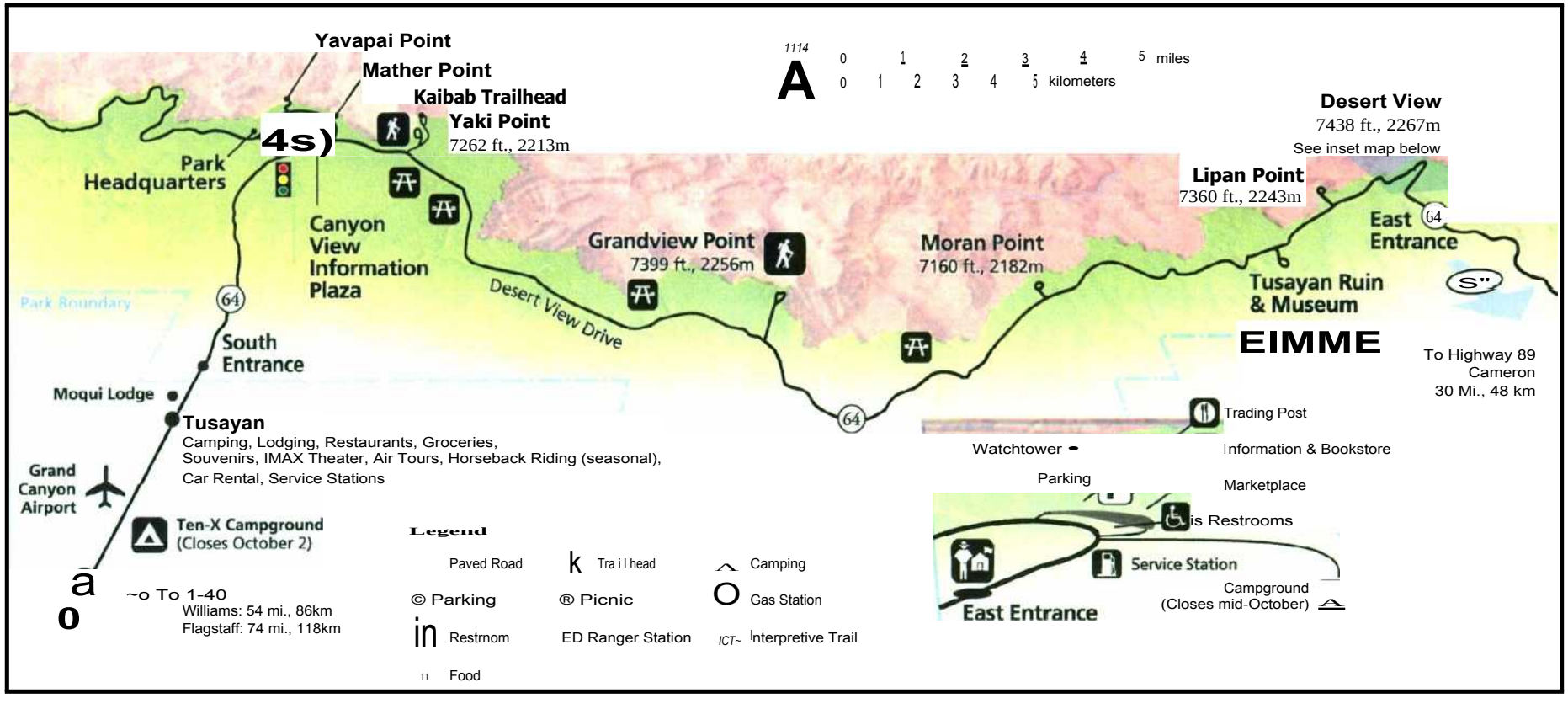
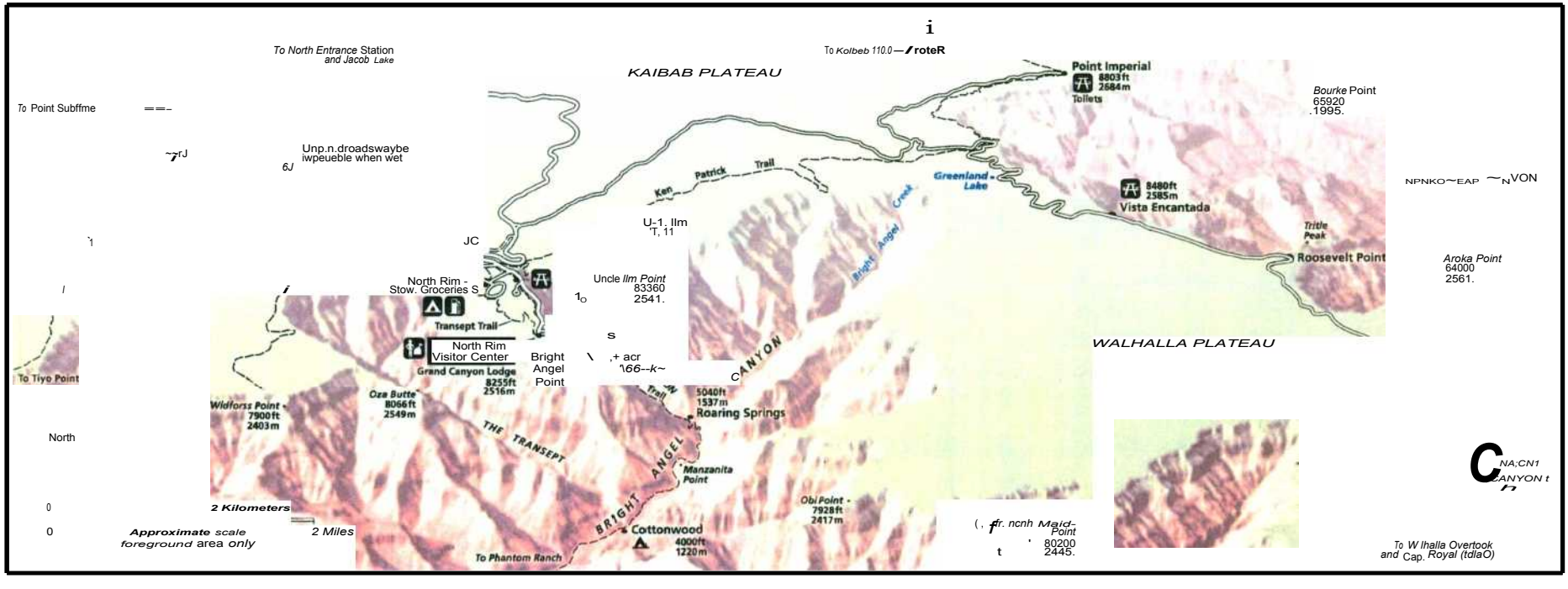


FIGURE 3

North Rim Map

National Park Service
US Department of the Interior

Grand Canyon National Park



Ranger Station

Campground

Primitive Campground

Gas Station

Unpaved road. High clearance vehicles recommended.

Trail

FIGURE 4

2. STATIONARY AND AREA SOURCE EMISSIONS

This section summarizes emissions from stationary and area sources at Grand Canyon NP for the year 2000. The discussion is divided into sections covering emissions from combustion sources, fuel storage sources, and area sources. The following emissions were calculated for each source: particulate matter (PM10), sulfur dioxide (SO2), nitrogen oxides (NO_X), carbon monoxide (CO), and volatile organic compounds (VOCs).

2.1 STATIONARY SOURCES

2.1.1 Space And Water Heating Equipment

Stationary combustion sources at Grand Canyon NP include approximately 260 NPS No. 2 fuel oil and propane space and water heating units, including approximately 200 employee housing heating units. The principal concessionaire, Zanterra (formerly Amfac Parks & Resorts), operates an additional 52 heating units. Table 2 provides an inventory of these heating units.

Criteria air emissions were calculated using the appropriate residential and commercial unit emission factors. For example, PM emissions from a No. 2 fuel oil boiler at the Albright Training Center in Grand Canyon Village are calculated as follows:

$$20{,}150\ gal/yr \times \frac{2.0\ lb\ PM}{1{,}000\ gal} = 40\ lb\ PM/yr$$

Actual criteria pollutant emissions from space and water heating equipment are summarized in Table 3. Potential emissions also were calculated by assuming that the heating units were operated continuously during the year or 8,760 hours per year, and these emissions are summarized in Table *4.*

TABLE 2: HEATING EQUIPMENT AT GRAND CANYON NP

Location	Capacity (Btu/hr)	Number	Fuel Type
Grand Canyon National Park			
Albright Training Center	940,000		No. 2 Fuel Oil
Headquarters	960,000	2	No. 2 Fuel Oil
Maintenance Shot	1,512,000	2	No. 2 Fuel Oil
Fee Collection	1,160,000	1	No. 2 Fuel Oil
Ranger Operations	344,000	1	No. 2 Fuel Oil
Boat Kitchen	75,000	1	No. 2 Fuel Oil
Shrine of the Ages	250,000	4	No. 2 Fuel Oil
Wastewater Treatment Plant	85,000	2	No. 2 Fuel Oil
North Rim	Unknown		No. 2 Fuel Oil
Housing	80,000	25	No. 2 Fuel Oil
Medical Clinic	1,825,000	2	Propane
Boat Shop	84,000	1	Propane
Paint Shop	84,000		Propane
Blacksmith Shop	84,000	1	Propane
Library	100,000	3	Propane
South Rim Housing	85,000	153	Propane
Miscellaneous	Unknown		Propane
School Building 600	85,000	6	Propane
High School	600,000	2	Propane
School Building 500	475,000	1	Propane
School Building 300	1,300,000	1	Propane
School Building 200	570,000	1	Propane
Elementary School	570,000	2	Propane
School Housing	80,000	40	Propane
Zanterra			
Bright Angel Lodge	2,009,000	2	No. 2 Fuel Oil
El Tovar Hotel	3,348,000	2	No. 2 Fuel Oil
Yavapai Motor Lodge	786,000	1	No. 2 Fuel Oil
Yavapai Buildings 01-09	380,000	9	No. 2 Fuel Oil
Camper Services	5,022,000	1	Propane
General Offices	1,446,000	1	Propane
Main Laundry	5,060,000	1	Propane
Main Laundry	5,230,000	1	Propane
Maswik Lodge	2,400,000	1	Propane
Maswik Buildings	380,000	12	Propane
North Rim Lodge	2,600,900	1	No. 2 Fuel Oil
North Rim Lodge	2,913,000	1	No. 2 Fuel Oil
North Rim Employee Dining Room (EDR)	200,000	1	No. 2 Fuel Oil
North Rim Showers	608,000	1	Propane
Delaware North Park Services			
Desert View Store	Unknown	1	Propane

TABLE *3: 2000* ACTUAL CRITERIA EMISSIONS FROM HEATING EQUIPMENT AT GRAND CANYON *NP*

Location	Fuel Type	Consumption (gal/yr)	PM (lbs/vr)	SO_2 (lbs/vr)	NO_X (lbs/vr)	CO (ibs/vr)	VOC 1bs/yr)
National Park Service							
Albright Training Center	Fuel Oil	20,150	40	1,431	403	101	
Headquarters	Fuel Oil	10,118	20	718	202	51	3
Maintenance Shop	Fuel Oil	25,592	51	1,817	512	128	9
Fee Collection	Fuel Oil	1,485	3	105	30	7	1
Ranger Operations	Fuel Oil	6,141	12	436	123	31	
Boat Kitchen	Fuel Oil	254	0	18	5	1	0
Shrine of the Ages	Fuel Oil	72,760	29	5,166	1,310	364	52
Wastewater Treatment Plant	Fuel Oil						
North Rim Miscellaneous	Fuel Oil	2,800	1	199	50	14	2
Housing	Fuel Oil	8,300	3	589	149	42	6
	Subtotal	147,600	159	1,050	2,784	739	82
Medical Clinic	Propane	33,529	13	0	469	67	10
Boat Shop	Propane	772	0	0	11	2	0
Paint Shop	Propane	772	0	0	11	2	
Blacksmith Shop	Propane	772	0	0	11	2	0
Library	Propane	2 756	1	0	39	6	1
South Rim Housing	Propane	52,800	21	0	739	106	16
Miscellaneous	Propane	7,958	3	0	111	16	2
School Building 600	Propane	1,774	1	0	25	4	1
High School	Propane	4,174	2	0	58	8	1
School Building 500	Propane	1,652	1	0	23	3	0
School Building 300	Propane	4,522	2	0	63	9	1
School Building 200	Propane	1,983	1	0	28	4	1
Elementary School	Propane	3,965	2	0	56	8	1
School Housing	Propane	11,130	4	0	156	22	3
	Subtotal	128,558	52	2	1,800	339	39
	NPS Totals		212	10,482	4,584	995	120

Location	**Fuel** Type	**Consumption (gal/yr)**	**PM (lbs/yr)** Zanterra	**SO_2 (ibs/yr)**	NO_X **(lbs/yr)**	**CO (lbs/yr)**	**VOC** (ibs/yr)
Bright Angel Lodge	Fuel Oil	47,720	95	3,388	954	239	*16*
El Tovar Hotel	Fuel Oil	79,526	159	5,646	1,591	398	27
Yavapai Motor Lodge	Fuel Oil	9,335	19	663	187	47	3
Yavapai Buildings 01-09	Fuel Oil	40,618	81	2,884	812	203	14
North Rim Lodge	Fuel Oil	10,469	21	743	209	52	4
North Rim Lodge	Fuel Oil	11,726	23	833	235	59	4
North Rim Employee Dining Room (EDR)	Fuel Oil	805	2	57	16	4	0
	Subtotal	200,200	631	14,214	9,222	2,087	202
Camper Services	Propane	159,423	64	3	2,232	319	48
General Offices	Propane	45,903	18	1	643	92	14
Main Laundry	Propane	160,629	64	3	2,249	321	48
Main Laundry	Propane	166,026	66	3	2,324	332	50
Maswik Lodge	Propane	76,188	30	1	1,067	152	23
Maswik Buildings	Propane	144,757	58	3	2,027	290	43
North Rim Showers	Propane	53,000	21	1	742	106	16
	Subtotal	600,600	322	15	11,283	1,612	242
	Zanterra Totals		953	14,229	20,505	3,698	444
	Delaware North Park Services						
Desert View Store	Propane	500		0	8		0
	Grand Canyon NP Totals		1,165	25,096	25,096	4,695	564

TABLE 4: 2000 POTENTIAL CRITERIA EMISSIONS FROM HEATING EQUIPMENT AT GRAND CANYON NP

Location	Fuel Type	Consumption (gal/yr)	PM (lbs/yr)	SO_2 (lbs/vr)	NO_x (lbs/vr)	CO (lbs/vr)	VOC (lbs/vr)
National Park Service							
Albright Training Center	Fuel Oil	352,903	706	25,056	7,058	1,765	120
Headquarters	Fuel Oil	120,137	240	8,530	2,403	601	41
Maintenance Shop	Fuel Oil	189,216	378	13,434	3,784	946	64
Fee Collection	Fuel Oil	72,583	145	5,153	1,452	363	25
Ranger Operations	Fuel Oil	21,525	43	1,528	430	108	7
Boat Kitchen	Fuel Oil	4,693	2	333	84	23	3
Shrine of the Ages	Fuel Oil	62,571	25	4,443	1,126	313	45
Wastewater Treatment Plant	Fuel Oil	10,637	4	755	191	53	8
North Rim Miscellaneous	Fuel Oil	2,800	1	199	50	14	2
Housing	Fuel Oil	125,143	50	8,885	2,253	626	89
	Subtotal	962,208	1,595	68,317	18,832	4,811	404
Medical Clinic	Propane	355,267	142	6	4,974	711	107
Boat Shop	Propane	8,176	3	0	114	16	
Paint Shop	Propane	8,176	3	0	114	16	
Blacksmith Shop	Propane	8,176	3	0	114	16	2
Library	Propane	29,200	12	1	409	58	9
South Rim Housing	Propane	52,800	21	1	739	106	16
Miscellaneous	Propane	7,958	3	0	111	16	2
School Building 600	Propane	49,640	20	1	695	99	15
High School	Propane	116,800	47	2	1,635	234	35
School Building 500	Propane	46,233	18	1	647	92	14
School Building 300	Propane	126,533	51	2	1,771	253	38
School Building 200	Propane	55,480	22	1	777	111	17
Elementary School	Propane	110,960	44	2	1,553	222	33
School Housing	Propane	311,467	125	6	4,361	623	93
	Subtotal	1,286,866	515	15	18,017	2,574	386
		NPS Totals	2,110	68,340	36,849	7,385	790

Location	**Fuel Type**	**Consumption (gal/yr)**	**PM (lbs/yr)** Zanterra	**SO_2 (lbs/yr)**	**NO_X** (lbs/yr)	**CO (lbs/yr)**	**VOC** (lbs/yr)
Bright Angel Lodge	Fuel Oil	251,412	503	17,850	5,028	1,257	85
El Tovar Hotel	Fuel Oil	418,978	838	29,747	8,380	2,095	142
Yavapai Motor Lodge	Fuel Oil	49,181	98	3,492	984	246	17
Yavapai Buildings 01-09	Fuel Oil	213,994	428	15,194	4,280	1,070	73
North Rim Lodge	Fuel Oil	162,742	325	11,555	3,255	814	55
North Rim Lodge	Fuel Oil	182,271	365	12,941	3,645	911	62
North Rim Employee Dining Room (EDR)	Fuel Oil	12,514	25	889	250	63	4
	Subtotal	1,291,093	5,188	91,668	80,038	16,321	1,601
Camper Services	Propane	488,808	196	9	6,843	978	147
General Offices	Propane	140,744	56	3	1,970	281	42
Main Laundry	Propane	492,507	197	9	6,895	985	148
Main Laundry	Propane	509,053	204	9	7,127	1,018	153
Maswik Lodge	Propane	233,600	93	4	3,270	467	70
Maswik Buildings	Propane	443,840	178	8	6,214	888	133
North Rim Showers	Propane	59,179	24	1	829	118	18
	Subtotal	2,367,731	947	42	33,148	4,735	710
	Zanterra Totals		6,135	91,710	113,186	21,057	2,311
		Delaware North Park Services					
Desert View Store	Propane	7,787	3		109	16	2
	Grand Canyon NP Totals		8,248	160,050	150,144	28,457	3,104

2.1.2 Generators

2.1.2.1 Generator Emissions - Actual

Emissions were calculated by multiplying the unit rating (kW) of the generators by an estimated annual run time (hr/yr) to get the kW-hr/yr, and the appropriate emission factors were then applied. For example, actual PM emissions from the 175 kW diesel generator at the North Rim are calculated as:

$$175\ kW\ x\ \frac{92\ hours}{year}\ x\ \frac{1.34\ hp}{kW}\ x\ \frac{0.00220\ lb\ PM}{hp\text{ - }hr} = 47\ lb\ PM/yr$$

Actual generator criteria emissions are summarized in Table 5.

2.1.2.2 Generator Emissions - Potential

Potential emissions were also calculated for the generators, and the same emission factors that were used to calculate the actual emissions were used to calculate these potential emissions. To calculate potential emissions, EPA guidance on the number of hours of operation to assume was adopted:

> EPA does not recommend the use of 8,760 hours per year (i.e., full-year operation) for calculating PTE (potential to emit) for emergency generators ... The EPA believes that 500 hours is an appropriate default assumption for estimating the number of hours that an emergency generator could be expected to operate under worst-case conditions.'

Actual operating hours were used for generators that were actually operated more than 500 hours a year. Potential criteria generator emissions are summarized in Table 6.

' *Calculating Potential to Emit (PTE) for Emergency Generators,* Office of Air Quality Planning and Standards (MD-10), U.S. Environmental Protection Agency, 06 September 1995.

TABLE 5: 2000 ACTUAL GRAND CANYON NP GENERATOR CRITERIA EMISSIONS

Facility	**Fuel**	**Rating (kW)**	**Run Time (hrs/yr)**	**Output (kW-hr/yr)**	**PM (lbs/yr)**	**SO_2 (lbs/yr)**	NO_X **(lbs/yr)**	**CO (lbs/yr)**	**VOC (lbs/yr)**
National Park Service									
North Rim	Diesel	*175*	*92*	*16,100*	*47*	44	*669*	*144*	*54*
North Rim	Diesel	*400*	*92*	*36,800*	*108*	101	*1,529*	*329*	*124*
North Rim	Diesel	*600*	*92*	*55,200*	*163*	299	*2,293*	*494*	*186*
Diesel Generator Totals					*319*	*445*	*4,490*	*968*	*364*
Medical Clinic	Propane	*75*	*104*	*7,800*	*2*	*14*	*37*	*9*	*2*
CVIP	Propane	*35*	*104*	*3,640*	*1*	*7*	*17*	*4*	*1*
Headquarters	Propane	*25*	*104*	*2,600*	*1*	*5*	*12*	*3*	*1*
South Rim Lift Station	Propane	*50*	*104*	*5,200*	*1*	*9*	*25*	*6*	*1*
Tuweap	Propane	*9.5*	*2,500*	*23,750*	*5*	*43*	*112*	*27*	*6*
Phantom Ranch	Propane	*35*	*800*	*28,000*	*6*	*51*	*132*	*32*	*7*
Propane Generator Totals					*15*	*129*	*336*	*82*	*18*
NPS Totals					*333*	*573*	*4,826*	*1,049*	*382*

TABLE 6: 2000 POTENTIAL GRAND CANYON NP GENERATOR CRITERIA EMISSIONS

Facility	Fuel	Rating (kW)	Run Time (hrs/yr)	Output (kW-hr/yr)	PM (lbs/yr)	SO_2 (lbs/yr)	NO_x (lbs/yr)	CO (lbs/yr)	VOC (Ibs/yr)
				National Park Service					
North Rim	Diesel	175	500	87,500	258	240	3,635	783	294
North Rim	Diesel	400	500	200,000	590	549	8,308	1,790	673
North Rim	Diesel	600	500	300,000	884	1,626	12,462	2,685	1,009
				Diesel Generator Totals	1,732	2,416	24,405	5,259	1,976
Medical Clinic	Propane	75	500	37,500	8	68	177	43	10
CVIP	Propane	35	500	17,500	4	32	83	20	5
Headquarters	Propane	25	500	12,500	3	23	59	14	3
South Rim Lift Station	Propane	50	500	25,000	5	45	118	29	6
Tuweap	Propane	9.5	2,500	23,750	5	43	112	27	6
Phantom Ranch	Propane	35	800	28,000	6	51	132	32	7
				Propane Generator Totals	30	262	683	166	37
				NPS Totals	1,762	2,678	25,087	5,425	2,013

2.1.3 Fuel Storage Tanks

Grand Canyon NP operates several gasoline and diesel fuel underground storage tanks (USTs) and aboveground storage tanks (ASTs) that serve NPS and concessionaire vehicles and other motorized equipment. The only gasoline service stations that serve the general public are at Desert View at the east end of the South Rim and a station at the North Rim visitor area. Both of these stations are operated by concessionaires and are open only during the summer season. There are also numerous No. 2 fuel oil, diesel fuel, and propane tanks that serve heating equipment and generators throughout the park.

There are two basic types of VOC emissions from storage tanks: working losses and standing losses. Working losses are composed of both withdrawal and refilling loss emissions. Withdrawal loss emissions result from the vaporization of liquid fuel residue on the inner surface of tank walls as the liquid levels in the tank are decreased and air is drawn into the tank. Refilling losses refer to fuel vapor releases to the air during the process of refilling the tank as the liquid level in the tank increases and pressurizes the vapor space. Standing losses describe those tank emissions from the vaporization of the liquid fuel in storage due to changes in ambient temperatures. VOC losses are also a direct function of the annual product throughput or tank turnovers.

VOC emissions from the park fuel storage tanks were calculated using the USEPA *TANKS4* software program. *TANKS4* is based on the emission estimation procedures from Chapter 7 of EPA's Compilation of Air Pollutant Emission Factors (AP-42) and uses chemical, meteorological, and other data to generate emission estimates for different types of storage tanks. Emissions from No. 2 and diesel fuel tanks are extremely small since the volatility of these fuels is extremely low compared to gasoline. Therefore, only emissions from gasoline USTs and ASTs were calculated and are summarized in Table 7.

TABLE 7: GRAND CANYON NP GASOLINE STORAGE TANK EMISSIONS

Location	Type	Volume (gal)	Throughput (gal/vr)	VOC (lbs/yr)	
National Park Service					
North Rim Maintenance	AST	6,000	19,740	1,025	
South Rim Maintenance	AST	6,000	60,000	1,257	
	AST	6,000	60,000	1,257	
		NPS Total	139,740	3,539	
TW Services					
North Rim Service Station	UST	10,000	23,813	130	
	UST	10,000	23,813	130	
	UST	6,000	14,288	78	
	UST	6,000	14,288	78	
		TW Services Total	76,200	416	
Zanterra					
Desert View Service Station – South Rim	UST	U?n	; , IiiU	97	
		Grand Canyon NP Total	215,940	lbs	4,952
				tons	2.48

2.1.4 Wastewater Treatment Plants

The NPS operates three wastewater treatment facilities in Grand Canyon NP. Using a VOC emission factor of 8.9 lbs VOC/million gallons of influent treated, the estimated actual emissions are summarized in Table 12. Potential emissions based on the design capacity of the plant also are noted in Table 8.

TABLE 8: 2000 GRAND CANYON NP
WASTEWATER TREATMENT PLANT EMISSIONS

Location	Design Capacity (gal/day)	Wastewater Treated (gal/yr)	VOC (lbs/yr)	
			Actual	**Potential**
South Rim	750,000	177,937,500	1,584	2,436
North Rim	125,000	19,687,500	175	406
Phantom Ranch	5,000	1,916,250	17	17
	Totals	199,541,250	1,776	2,859

2.2 AREA SOURCES

2.2.1 Woodstoves/Fireplaces

Park officials estimated that approximately 50 NPS and concessionaire employee residences in the park had operational woodstoves and consumed approximately three cords of wood per household per year. There are also fireplaces in a number of the lodge lobbies, and

concessionaire officials indicated that together they consumed approximately 100 cords per year. The estimated emissions are summarized in Table 9.

TABLE 9: WOODSTOVE AND FIREPLACE AIR EMISSIONS FROM GRAND CANYON NP

Location	Number	Fuel Consumption	PM (lbs/yr)	SO_2 (lbs/yr)	NO_x (lbs/yr)	CO (lbs/yr)	VOC (lbs/vr)
Woodstoves							
Et» Icn r>		165 cords/yr			4SU	46,680	42.319
Fireplaces							
Lodges		100 cords/yr	3,875		291	28,2 ')l	**48**
Totals							
Total		265 cords/yr	**10,269**	119	772	74,972	67,967

2.2.2 Campfires

There are five campgrounds with about 550 campsites where campfires are allowed. The Grand Canyon NP Monthly Public Use Reports provided monthly statistics on the number of camping visitors. Assuming that approximately 2.5 campers occupy a campsite, 90 percent had an evening or morning campfire at each campsite, and that each campfire consumes approximately 15 lbs of wood, air emissions from campsites are summarized in Table 10.

TABLE 10: 2000 GRAND CANYON NP CAMPFIRE EMISSIONS

Campers	Campsites	Campfires	Fuel tons/ r	PM_{10} lbs/ r	SO_2 lbs/ r	NO_x lbs/ r	Co lbs/ r	VOC lbs/ r
318,560	**127,424**	**63,712**	319	**11,022**	127	**828**	**80,468**	**72,950**

2.2.3 Prescribed and Wildland Fires

Wildland fires are ignited naturally, usually by lightening and are typically suppressed, while prescribed fires are ignited intentionally in order to achieve fire management objectives. Prescribed burning is a land treatment process to accomplish natural resource management objectives, including reducing the potential for destructive wildfires, eliminating excessive fuel buildup, controlling insects and disease, improving wildlife habitat and forage production, maintaining natural succession of plant communities, and restoring natural processes. Only prescribed burning emissions are considered as anthropogenic emissions; however, to the extent that prescribed burning is conducted to achieve ecological benefits, the emissions could be considered natural.

The total acreage of wildland and prescribed fires has been fairly constant in the 1999-2001 time period, although the mix of fire types has varied greatly. For example, in 2001 the DOI, imposed

restrictions on prescribed fires in all NPS units. Fire data for the year 2000 were supplied by the park's Office of Fire and Aviation, and the First Order Fire Effects Model (FOFEM) was used to estimate emissions. FOFEM is a computer program developed by the Intermountain Fire Sciences Lab, U.S. Forest Service to predict the effects of prescribed fire and wildfire in forests and rangelands throughout the U.S. In particular, it quantifies emissions of $_{PM10,}$ PM2.5, CH4, and CO, which are summarized in Table 11 for prescribed fires.

TABLE 11: PRESCRIBED FIRE AIR EMISSIONS FROM GRAND CANYON NP

Fuel Type	Acres	PM_{10} (lbs/yr)	$PM_{2.5}$ (lbs/yr)	VOC' (ibs/yr)	CO (lbs/yr)
		Prescribed Fires			
Gambel Oak	14	588	504	154	1,260
Ponderosa Pine	1,002	196,392	167,334	98,196	2,117,226
Pinyon Pine-Juniper	338	70,980	60,164	35,490	763,542
Pinyon Pine-Gambel Oak	118	14,868	12,626	6,844	138,591
Pinyon Pine-Ponderosa Pine-Gambel Oak	176	26,283	22,352	12,555	261,771
Total	1,634	308,523	262,476	153,085	3,281,130

' As methane (CH_4)

2.2.4 Miscellaneous Area Sources

Miscellaneous area sources include food preparation, degreasers, paints and other surface coatings, lighter fluid consumption, consumer solvents, propane use by visitors in recreational vehicles, and highway maintenance, such as paving materials. However, data were not available for these relatively minor sources.

2.3 SUMMARY OF STATIONARY AND AREA SOURCE EMISSIONS

Table 12 summarizes the stationary and area source emissions calculated above in a format that allows comparison between the various sources as well as providing totals for each pollutant or pollutant category under consideration.

TABLE 12: SUMMARY OF 2000 STATIONARY AND AREA SOURCE EMISSIONS AT GRAND CANYON NP

Activity	Particulates		Sulfur Dioxide		Nitrogen Oxides		Carbon Monoxide		VOCs	
	lbs/yr	tons/yr	lbs/yr	tons/yr	lbs/yr	tons/yr	lbs/yr	tons/yr	lbs/yr	tons/yr
Stationary Sources										
Space and Water Heating Units	1,165	0.58	25,096	12.55	25,100	12.55	4,695	2.35	564	0.28
Generators	333	0.17	573	0.29	4,826	2.41	1,050	0.53	382	0.19
Gasoline Storage Tanks									4,952	2.48
Wastewater Treatment Plants									1,776	0.89
Subtotal	1,498	0.75	25,669	12.84	29,926	14.96	5,745	2.87	7,674	3.84
Area Sources										
Woodstoves/Fireplaces	10,269	5.13	119	0.06	772	0.39	74,972	37.49	67,967	33.98
Campfires	11,022	5.51	127	0.06	828	0.41	80,468	40.23	72,950	36.48
Prescribed Burning	308,523	154.26					3,281,130	1,640	153,085[1]	76.54[1]
Subtotal	329,814		246	0.12	1,600	0.80	3,436,570		294,002	147.00
Totals										
	Particulates		Sulfur Dioxide		Nitrogen Oxides		Carbon Monoxide		VOCs	
	lbs/yr	tons/yr	lbs/yr	tons/yr	lbs/yr	tons/yr	lbs/yr	tons/yr	lbs/yr	tons/yr
Totals without Prescribed Burning	22,789	11.39	25,919	12.96	31,526	15.76	161,185	80.59	148,591	74.30
Totals with Prescribed Burning	331,312	165.66	25,919	12.96	31,526	15.76	3,442,315	1,721.16	301,676	150.84

[1] As methane

3. MOBILE SOURCE EMISSIONS

This section summarizes emissions from mobile sources at Grand Canyon NP for 2000. Mobile emission sources include highway and nonroad vehicles, including snowmobiles.

3.1 HIGHWAY VEHICLES

3.1.1 Visitor Vehicles

An estimated 1,348,442 visitor vehicles and 30,043 tour buses entered the park through several entrances. The park maintains total vehicle counts and separate bus counts at each of four entrances on a monthly basis. Some visitor survey data on visitor entering and exiting patterns also were available. Using these data and roadway distances to principal destination points, the vehicle miles traveled by visitor vehicles were calculated and are presented in Table 13.

TABLE 13: ESTIMATED VISITOR VEHICLE TRAVEL IN GRAND CANYON NP

Traffic Pattern	Trip Length (mi)	Vehicle Miles Traveled	
		Summer	Winter
Tuweep	16.0	128,800	9,360
North Rim	40.0	4,065,400	0[1]
East Entrance-South Entrance	37.5	6,038,650	682,250
East Entrance-East Entrance	56.0	278,898	31,510
South Entrance-East Entrance	37.5	6,267,395	1,045,879
South Entrance-South Entrance	19.0	14,466,077	2,414,043
Hermits Rest	16.0	0[2]	2,709,392
	Subtotals	31,245,221	6,892,434
	Total	38,137,654	

[1] Closed in winter
[2] Open to visitor vehicles in winter only

The majority of mobile source emissions can be categorized as either exhaust or evaporative emissions. Exhaust emissions are related to the combustion of fuel in the engine and include VOC, NOx, CO, and PM10. Exhaust emissions are dependent on a number of factors, including engine load, engine design and age, combustion efficiency, emissions equipment such as catalytic converters, and other factors. Evaporative emissions, which can occur while the vehicle is running or at rest, are related to the volatilization of fuel from vapor expansion, leaks and seepage, and fuel tank vapor displacement. Evaporative emissions are primarily dependent on daily temperature cycles and fuel volatility. In addition to vehicle exhaust, PM10 emissions also result from brake and tire wear, as well as the re-entrainment of dust from paved and unpaved roads (referred to as fugitive dust).

Emission factors produced by the USEPA MOBILE5b model were used in conjunction with VMT data in order to estimate mobile source emissions for VOC (both exhaust and evaporative), NO_x, and CO for visitor vehicles. Similarly, emission factors produced by the PART5 model were used in conjunction with VMT data to estimate PMIO emissions. MOBILE5b produces exhaust and evaporative emission factors for the following classes of vehicles: Light Duty Gasoline Vehicles (LDGV), Light Duty Gasoline Trucks 1 (LDGTI), Light Duty Gasoline Trucks 2 (LDGT2), Heavy Duty Gasoline Vehicles (HDGV), Light Duty Diesel Vehicles (LDDV), Light Duty Diesel Trucks (LDDT), Heavy Duty Diesel Vehicles (HDDV), and Motorcycles. It also produces a composite emission factor for all vehicles based on the vehicle VMT mix supplied to the model. Inputs to the model include average vehicle speed, vehicle VMT mix, annual mileage accumulation rates and registration distributions by age, inspection and maintenance (UM) program information, fuel information, ambient temperature data, and others.

Both the MOBILE5b and PART5 models are typically used to support planning and modeling efforts in urban or regional areas and include default inputs suited for these applications. Therefore, it is suitable for applications over large, regional transportation networks. Application of the MOBILE5b model required the utilization of unique inputs that were representative of mobile source activity within the park. In particular, it was necessary to utilize unique inputs for the visitor vehicle VMT mix and the vehicle age distribution. The Center for Environmental Research and Technology within the College of Engineering at the University of California's Riverside Campus (CE-CERT) established park-specific vehicle fleet characterizations in developing air emission inventories for Zion National Park (CE-CERT, 2001). CE-CERT found that the distribution of vehicle ages in the park reflected a larger fraction of newer vehicles compared to the general vehicle population. The park-specific mix vehicle types and vehicle age distribution developed by CE-CERT have been applied in the mobile modeling for Grand Canyon NP.

In addition to park-specific age distribution, CE-CERT also developed park-specific modeling inputs for driving patterns that differ significantly from the default driving patterns typically used in mobile modeling, such as the Federal Test Procedure (HP). In particular, they found that the FTP reflects both higher speeds and a wider range of speeds than observed in national parks. However, since the MOBILESb model is not designed to readily incorporate unique driving pattern data, the default driving cycle remains the basis for the mobile source emission estimates provided here.

Other important mobile modeling inputs that can significantly affect mobile emission factors are the average speed, fuel characteristics, and I/M program parameters. The average speed input to the mobile model was 35 mph, fuel volatility was assumed to be Reid vapor pressure (RVP) 9, and reformulated gasoline (RFG) was not assumed to be present. Finally, I/M program inputs were not included since there are no UM programs in the areas near the park.

In order to account for seasonal differences in mobile emissions, separate MOBILE5b runs were performed to produce emission factors for winter and summer. A composite emission factor for each season, reflecting a park specific VMT mix adapted from CE-CERT, served as the basis for mobile source emission estimates. Additional particulate emissions (or entrained road dust) from vehicles operating on paved roads in Grand Canyon NP also were calculated based on VMT.

A summary of visitor vehicle emissions is provided in Table 19 at the end of this section.

3.1.2 GSA/NPS and Concessionaire Highway Vehicles

Grand Canyon NP operates a fleet of highway vehicles that are owned by the NPS or leased from the General Services Administration (GSA), and the principal concessionaire, Amfac Parks & Resorts, operates a fleet of tour buses and vans. Among the NPS-owned vehicles is a fleet of shuttle buses that serve visitors on three routes throughout the developed areas in the South Rim. A concessionaire operates the shuttle bus fleet, which consists of 12 diesel buses, seven compressed natural gas (CNG) buses, and five liquefied natural gas (LNG) buses. These alternative fuel buses entered service in 1999, and in January 2002, a full-service refueling facility began operations. Since there is no natural gas pipeline to the park, natural gas is delivered to the park by truck. There are also three electric shuttle buses, but their use is limited by their low carrying capacity. A summary of NPS, GSA, and concessionaire vehicles and their estimated annual mileage is provided in Table 14, and emissions are summarized in Table 18 at the end of this section.

TABLE 14: NPS, GSA, AND CONCESSIONAIRE ROAD VEHICLES AT GRAND CANYON NP

Vehicle Type	Number	Annual Usage (mi/yr)
NPS/GSA		
Sedans	45	237,885
Vans	23	133,875
Pickups	129	540,570
SUVs	40	264,310
Medium Duty Trucks	30	243,215
Heavy Duty Trucks	41	166,014
Shuttle Buses-Diesel	12	198,721
Shuttle Buses-Natural Gas	12	397,113
Total	336	2,148,800
Amfac Parks & Resorts		
Tour Vans	8	258,175
Tour Buses	24	129,150
Total	32	387,325

N.A. - Not Available

3.2 NPS NONROAD VEHICLES

The NPS also owns and operates nonroad motorized equipment that is used to maintain roads and grounds and for other purposes. There are records of the Grand Canyon NP equipment inventory, and the larger pieces of equipment for which there are usage data are noted in Table 17. Annual usage and mission factors from the USEPA nonroad emission database were used to calculate annual emissions that are provided in Table 15.

TABLE 15: NPS NONROAD VEHICLES AT GRAND CANYON NP

Vehicle Type	Number	Annual Usage (hrs/yr)
Tractors	5	623
Backhoe	4	480
Dozer	1	414
Grader	3	548
Sweeper	4	450
Forklift	3	225
Roller/Compactor	1	23
Loader	10	2,532

The NPS also operates a fleet of approximately 16 2-stroke engine snowmobiles. Park records indicated that these machines were operated a total of approximately 6,000 hrs/yr, and emission estimates from NPS snowmobiles are provided in Table 18 at the end of this section.

3.3 MARINE VESSELS

Sixteen commercial operators provide river trips down the Colorado River through the park, and the majority of these are motorized boats. Park records indicated that there were 541 motorized commercial trips and an additional 21 private river trips in FY 2001. Previous river use surveys indicated that the average motor boat trip lasted 9 days, and the motor was operated 6 hours per day. Emissions were calculated using emission factors for newer 4-stroke engines that are now required for commercial operators to obtain a park permit, and these are summarized in Table 16.

TABLE 16: GRAND CANYON NP MARINE VESSEL EMISSIONS

Marine Vessels	No. of Engines	Engine Power (hp)	Hours of Operation	HC (lb/yr)	CO (lb/yr)	NO,, (lb/yr)	PM (lb/yr)	SO_2 (lb/yr)
Commercial River Use								
Motor Boat'	1.6[2]	30	29,214	9,673	219,900	4,837	39	
Private River Use								
Motor Boat	1.6[2]	30	1,134	375	8,536	1 88		
			Total	**10,048**	**220,088**	5,025	41	

1 Four-stroke gasoline engines 2 Average

3.4 RAILWAY

The privately operated Grand Canyon Railway operates from Williams, Arizona to the South Rim of the park. The total trip is 65 miles one way, and operates along 7.5 miles within the park boundary. Propulsion is provided by diesel engines from Labor Day until Memorial Day, and steam engines, sometimes assisted by pusher diesel engines, are operated during the popular summer months. Operating records indicated that steam and diesel engines made 131 and 691 trips, respectively, in 2001. Emissions were calculated for diesel engines were calculated using U.S. EPA locomotive emission factors, and large No. 2 oil boiler emission factors were used for steam engines. These are summarized in Table 17.

TABLE 17: GRAND CANYON RAILWAY EMISSIONS

Engine Type	Trips/Yr	Miles/Yr	Gal/Mi	Gal/Yr	PM (lb/yr)	NO,, (lb/yr)	CO (lb/yr)	HC (lb/yr)
Diesel	**691**	5,183	6.7	**34,723**	510	**20,625**	**2,030**	**764**
Steam	131	**983**	7.2	7,074	14	141	35	1
			Total	41,797	**524**	**20,766**	**2,065**	765

3.5 AIRCRAFT

In FY2001, 15 commercial air tour companies operated approximately 39,000 scenic tour flights over the park. All scenic air tour operators are based outside of the park, and they offer both fixed-wing and helicopter tours of the Grand Canyon region daily. Six air tour operators are located at Grand Canyon Airport, just south of Tusayan, and other companies operate tours out of California, Nevada, Utah, New Mexico, and Arizona. The approved method for calculating emissions from aircraft is based on the Federal Aviation Administration (FAA) model titled *Emissions and Dispersion Model System (EDMS),* and this model calculates emissions only during the take-off and landing cycle. Although there are no take-off and landing operations conducted inside the park boundaries, approximately 85 percent or 33,485 fixed wing and helicopter flights originate from Grand Canyon Airport, which is approximately six miles south of the park's south entrance. Due the close proximity to the park, these take-off and landing emissions were calculated using *EDMS,* and they are summarized in Table 18.

3.6 SUMMARY OF MOBILE SOURCE EMISSIONS

Table 18 summarizes the mobile source emissions calculated above in a format that allows comparison between the various sources as well as providing totals for each pollutant or pollutant category under consideration.

TABLE 18: SUMMARY OF 2000 MOBILE SOURCE EMISSIONS AT GRAND CANYON NP

Activity	Particulates'		Sulfur Dioxide		Nitrogen Oxides		Carbon Monoxide		VOCs	
	lbs/yr	tons/yr	lbs/yr	tons/yr	lbs/yr	tons/yr	lbs/yr	tons/yr	lbs/yr	tons/yr
Road Vehicles										
Visitor Vehicles	76,352	38.18	--	--	80,294	40.15	943,353	471.68	92,576	46.29
NPS/GSA Road Vehicles	3,573	1.77	--	--	8,466	4.23	44,273	22.14	5,288	2.64
NPS Shuttle Buses-Natural Gas	80	0.04	--	--	3,879	1.94	2,589	1.29	522	0.26
Amfac Parks & Resorts Vehicles	922	0.46	--	--	7,400	3.70	7,820	3.91	1,353	0.68
Road Vehicle Emission Subtotal	80,927	40.46	--	--	100,039	50.02	998,035	499.02	99,739	49.87
Nonroad *Vehicles*										
NPS Nonroad Vehicles	738	0.37	--	--	4,553	2.28	2,218	1.11	862	0.43
NPS Snowmobiles	582	0.29	--	--	185	0.09	64,627	32.31	23,700	11.85
Commercial Marine Vessels	185	0.09	--	--	14,964	7.48	402,890	201.44	16,116	8.06
Private Marine Vessels	7	<0.01	--	--	580	0.29	15,640	7.82	626	0.31
Grand Canyon Railway	525	0.26	510	0.26	20,767	10.38	2,067	1.03	765	0.38
Aircraft	--	--	890	0.44	8,348	4.17	32,630	16.32	4,550	2.28
Nonroad Vehicle Emission Subtotal	2,037	1.01	1,400	0.70	49,397	24.69	520,072	260.04	46,619	23.31
Totals										
	Particulates'		Sulfur Dioxide		Nitrogen Oxides		Carbon Monoxide		VOCs	
	lbs/ r									tons/ r
Totals	82,964	41.48	1,400	0.70	149,436	74.72	1,518,107	759.05	146,358	73.18

' Includes exhaust PM_{to} and road dust

4. GRAND CANYON NP AND REGIONALEMISSION SUMMARY

4.1 GRAND CANYON NP SUMMARY

A summary of Grand Canyon NP emissions is provided in Table 19.

TABLE 19: ESTIMATED ANNUAL EMISSIONS FROM GRAND CANYON **NP**

Source	**PM,$_0$ (tons)**	SO_2 **(tons)**	NO_X **(tons)**	**CO (tons)**	**VOCs (tons)**
		Point Sources			
Space and Water Heaters	0.58	12.55	12.55	2.35	0.28
Generators	0.17	0.29	2.41	0.53	0.19
Gasoline Storage Tanks					2.48
Wastewater Treatment Plant					0.89
Subtotal	0.75	12.84	14.96	2.87	3.84
		Area Sources			
Woodstoves/ Fireplaces	5.13	0.06	0.39	37.49	33.98
Campfires	5.51	0.06	0.41	40.23	36.48
Prescribed Burning	154.26			1,640	76.54[1]
Subtotal	164.91	0.12	0.80	1.718.29	147.00
		Mobile Sources			
Road Vehicles	40.46		50.02	499.02	49.87
Nonroad Vehicles	0.94	0.70	19.44	165.00	19.96
Subtotal	41.41	0.70	69.45	664.00	69.83
		Totals			
Totals	207.07	13.66	85.21	2,385.16	220.67

[1] As methane

4.2 Regional Air Emissions

Emission estimates for Coconino and Mohave Counties and the state of Arizona were obtained from the 1999 National Emission Inventory (NEI) maintained by USEPA. It is important to note that differences may exist between the methodologies used to generate the park emission inventory and those used to generate the NEI. For example, here gasoline storage tanks have been included as stationary sources, while the NEI treats them as area sources. Table 20 provides a comparison of Grand Canyon NP emissions with those from the surrounding counties and the state. For all pollutants, Grand Canyon NP emissions account for less than 1 percent of the surrounding county point source emissions.

TABLE 20: ESTIMATED ANNUAL EMISSIONS FROM GRAND CANYON NP, SURROUNDING COUNTIES, AND THE STATE OF ARIZONA

Area	PM_{10} (tons/yr)	SO_2 (tons/yr)	NO_X (tons/yr)	CO (tons/yr)	VOC (tons/yr)
Point Sources					
Grand Canyon National Park Total	0.75	12.84	14.96	2.87	3.84
Coconino County	44	828	14,900	2,370	1,417
Mohave County	17	3	670	62	79
Surrounding County Total	61	831	15,570	2,432	1 496
Arizona Total	32,013	175,796	173,171	26,577	22,718
Ar a Sources					
Grand Canyon National Park Total	164.91	0.12	0.80	1,718.29 (	147.00
Coconmo County	971	52	945	7,297	3,346
Mohave County	399	69	966	3,730	2,849
Surrounding County Total	1,370	121	1,911	11,027	6,195
Arizona Total	18,226	3,259	51,240	163,548	106,814
Mobile Sources					
Grand Canyon National Park Total	41.41	0.70	69.45	664.00	69.83
Coconino County	399	454	9,608	43,782	5,076
Mohave County	379	528	8,765	47,358	5,307
Surrounding County Total	778	982	18,373	91,140	10,383
Arizona Total	13,757	19,231	236,151	1,263,163	137,114

5. COMPLIANCE AND RECOMMENDATIONS

5.1 COMPLIANCE

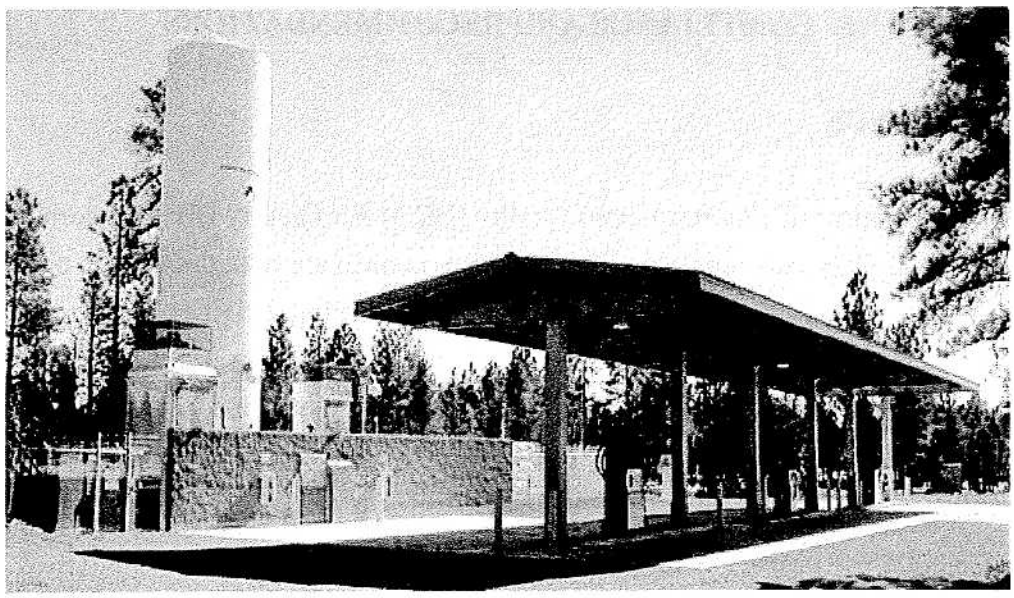
The Arizona Department of Environmental Quality (DEQ) Air Quality Division administers air quality regulations. Park personnel should continue to coordinate with the agency on permit issues relating to stationary sources, as well as prescribed burning activities. Prior to replacing or adding relatively large heating units, generators, and fuel storage tanks, the Arizona Administrative Code should be consulted regarding the need to obtain a permit to construct or a permit to operate such sources. According to the Title 18 Chapter 2 of the AZ Administrative Code, current exemptions to these permits include:

- Fuel burning equipment of less than 1 million Btu per hour heat input
- Stationary rotating machinery of greater than 325 brake horsepower.

5.2 ALTERNATIVE FUEL VEHICLE INITIATIVES

The park has successfully initiated a number of alternative fuel vehicle initiatives. The principal initiative is the operation of a fleet of natural gas shuttle buses. The NPS owns seven compressed natural gas (CNG) buses and five liquefied natural gas (LNG) buses that entered service in *1999.* These 12 dedicated CNG and LNG buses constitute 50 percent of the shuttle bus fleet that is operated by a concessionaire to serve visitors on three routes throughout the developed areas in the South Rim. There are plans to add three additional LNG buses to the fleet in 2002. There are also three electric shuttle buses, but their use is limited by their low passenger carrying capacity.

In January 2002, the first natural gas refueling station in a National Park Service area was completed. The refueling facility was constructed adjacent to the existing diesel fuel shuttle bus bulk fuel storage and refueling station, which is located south of Center Road on the South Rim. The station has two LNG refueling stands and one slow-fill CNG refueling stand. Since there is no natural gas pipeline to the park, natural gas is delivered to the park by truck in a liquefied form. In 2000, approximately 30 truck trips delivered 122,600 gallons of LNG to the park, and these numbers rose to 47 trips and 193,500 gallons in 2001.



NPS Photo

The station also supplies fuel to U.S. Forest Service vehicles and also will provide "pipeline" gas to a South Rim maintenance facility. The park also has two dedicated CNG dump trucks and nine dedicated and bi-fuel CNG sedans and vans. Implementation of biodiesel fuel for diesel fuel vehicles also is planned in 2002, and discussions are being held with the Grand Canyon Railway regarding the feasibility of utilizing biodiesel fuel in its diesel engines.

5.3 RECOMMENDATIONS

Actions to promote sustainable development in the design, retrofit, and construction of park facilities have associated air quality benefits. These include actions that reduce or replace consumption of conventional fossil fuels and/or reduce the consumption of other resources. Reductions in potable and non-potable water consumption also achieve concurrent reductions in energy consumption and associated air emissions. Acquisition of energy efficient appliances whenever possible also is an incremental energy saving measure that has associated air quality benefits.

The park has implemented a photovoltaic (PV) and propane generator energy system at the Tuweep Ranger Station in the remote western portion of the park. In addition to reducing the consumption of conventional fossil fuels, renewable energy systems obviate the need to transport, handle, and store fossil fuels and the associated potential for fuel spills. Of the park's stationary air emission sources, residential woodstoves are estimated to be the largest emitters. Park officials are aware of this issue and have discussed measures that include woodstove removal, phase-out, and/or replacement with units that meet USEPA New Source Performance

Standards for residential woodstoves. In recent years, the park and principal concessionaire also have switched from No. 2 fuel oil to cleaner burning propane as heating equipment is replaced.

In 2001, Amfac Parks & Resorts received the U.S. Department of Interior's 2001 Environmental Achievement Award. The DOI presents this award to recognize the achievements of its bureaus, employees, and contractors in a broad range of environmental areas such as pollution prevention, recycling, sustainable design, environmentally preferable purchasing, environmental stewardship, auditing, environmental management systems and educational outreach. Amfac was selected for its efforts to minimize environmental impact while operating concessions at national parks with special recognition paid to Grand Canyon (South Rim), Yellowstone, and Zion National Parks. DOI judges singled out several park initiatives, including:

- Reducing emissions at the Grand Canyon's South Rim by installing clean-burning propane boilers to heat buildings and hydrous alcohol injectors on diesel tour buses
- Establishing a corporate-wide policy on purchasing seafood only from sustainable fisheries
- Using environmentally preferable cleaning products
- Developing energy-conservation projects
- Instituting aggressive recycling, waste reduction and composting programs.

The removal of the public gasoline service station from Grand Canyon Village has drastically reduced VOC emissions from an estimated 11.7 tons/yr in 1993 (Radian 1994) to an estimated 2.5 tons/yr in 2000. Since employee residential woodstoves account for approximately 95 percent of the park's stationary source PM_{10} and CO emissions, measures to reduce their use or replace them with new units that meet the USEPA New Source Performance Standards for residential woodstoves should be investigated

With respect to mobile sources, emissions from visitor vehicles are the largest sources. The implementation of the natural gas shuttle buses have made a significant contribution to lowering emissions from these vehicles. The implementation of a mass transit system to bring visitors to the South rim from the town of Tusayan just south of the park would further reduce these emissions.

With respect to nonroad vehicles, commercial motor boat trips are estimated to generate the most NOx and CO emissions, while the NPS snowmobiles generate the most VOC emissions. Air emissions from motorized boats should be a major issue when 1989 Colorado River Management Plan (CRMP) is updated beginning this year. A recent settlement to initiate a public process to update the CRMP directs planners to study impacts of motorized watercraft and potential

mitigation of those impacts, including technological improvements to motors (Williams-GC News 2002). Electric motors may be one possible alternative technology.

Phasing in new 4-stroke engine machines or other low emission machines that are now being introduced into the marketplace can reduce emissions from snowmobiles. Information on these technologies should be available from park officials at Yellowstone NP since they operate the largest snowmobile fleet of any park unit.

6. REFERENCES

College of Engineering at the University of California's Riverside Campus (CE-CERT). 2001. *Air Emissions Inventory for Zion National Park*.

Colorado State University and National Park Service. 1997. *Status of Air Quality and Related Values in Class I National Parks and Monuments of the Colorado Plateau*. April.

EA Engineering, Science, and Technology. 2001. *Air Emission Inventory Preparation Plan.* Prepared for the National Park Service. November.

Grand Canyon National Park. 1992. *Fire Management Plan, Grand Canyon National Park*.

Grand Canyon National Park. 1995. *Draft General Management Plan and Environmental Impact Statement.* March.

Grand Canyon National Park. 1997. *Final Environmental Assessment, Mather Point Orientation/Transit Center and Transit System. July*.

Grand Canyon National Park. 1999. *Evaluation of the Effects of Five Mass Transit Alternatives on the Natural Resources of Grand Canyon National Park*. Science Center. 26 October.

Grand Canyon National Park. 2002. *Greenway Trail Segments in Undisturbed Areas, Grand Canyon National Park, Coconino County, Arizona, Revised Environmental Assessment, Assessment of Effect.* April.

Radian Corporation. 1994. *Technical Memorandum, Development of a Micro Inventory of Air Pollutant Emissions for Grand Canyon National Park, Arizona.* 07 October.

USEPA, 1995. *Compilation of Air Pollution Emission Factors AP-42, Fifth Edition, Volume I: Stationary Point and Area Sources.*

USEPA, 1995b. *Highway Vehicle Particulate Emission Modeling Software "PARTS"*. Office of Transportation and Air Quality.

USEPA, 1997. *MOBILE5b Vehicle Emissions Modeling Software.* Office of Transportation and Air Quality.

USEPA, 2000. *Factor Information REtrieval (FIRE) Data System*. Office of Air Quality Planning and Standards.

USEPA, 2000b. *TANKS 4.09a.* Office of Air Quality Planning and Standards.

Williams-Grand Canyon News 2002. *River Planning: Big Issue Will Be Motors.* February.

APPENDIX

FUEL DATA, EMISSION FACTORS, AND EMISSION CALCULATIONS

FUEL DATA

Fuel	Heating Value	Sulfur Content
No. 2 Distillate Fuel Oil/Diesel	140,000 Btu/gal	0.05% by weight
Natural Gas	1,050 Btu/ft^3	2,000 grains/10^6 ft^3
Propane	91,500 Btu/gal	0.18 grains/100 ft^3

STATIONARY SOURCE EMISSION FACTORS - BOILERS/HEATING UNITS

DISTILLATE OIL (DF-2) - CRITERIA POLLUTANTS

Combustor Type	Emission Factor (lb/1,000 gal fuel burned)				
	PMla)	50_2 (b,	NO,;(·)	CO	VOC (d,
Residential Furnace (e)	0.4	142S	18		0.713
Boilers < 100 Million Btu/hr (Commercial/Institutional Combust. ffl)	2	142S	20	5	0.34
Boilers < 100 Million Btu/hr (Industrial Boilers (',))	2	142S	20	5	0.2
Boilers > 100 Million Btu/hr (Utility Boilers (h))	2	157S	24	5	--

Source: AP-42, 5th Edition, Supplements A, B, C, D, and E, Tables 1.3-1 and 1.3-3.

NATURAL GAS - CRITERIA POLLUTANTS

Combustor Type (MMBtu/hr Heat Input)	Emission Factor (lb/10^6 ft^3 fuel burned)				
	PM 01	SO_2	NO,,(`)	CO	VOC
Residential Furnaces (<0.3)					
-Uncontrolled	7.6	0.6	94	40	5.5
Tangential-Fired Boilers (All Sizes)					
-Uncontrolled	7.6	0.6	170	24	5.5
-Controlled-Flue gas recirculation	7.6	0.6	76	98	5.5
Small Boilers (<100)					
-Uncontrolled	7.6	0.6	100	84	5.5
-Controlled-Low NO,, burners	7.6	0.6	50	84	5.5
-Controlled-Low NO,, burners/Flue gas recirculation	7.6	0.6	32	84	5.5
Large Wall-Fired Boilers (>100)					
-Uncontrolled (Pre-NSPS) lk)	7.6	0.6	280	84	5.5
-Uncontrolled (Post-NSPS) lk)	7.6	0.6	190	84	5.5
-Controlled-Low NO, burners	7.6	0.6	140	84	5.5
-Controlled-Flue gas recirculation	7.6	0.6	100	84	5.5

Source: AP-42, 5th Edition, Supplements A, B, C, D, and E, Tables 1.4-1 and 1.4-2.

STATIONARY SOURCE EMISSION FACTORS - BOILERS/HEATING UNITS (Continued)

PROPANE (LPG) - CRITERIA POLLUTANTS					
Comb ustor Type	Emission Factor (lb/1,000 gal fuel burned)				
	PM [a]	S02 [b]	NO_X [c]	C O	VOC [d]
Commercial Boilers [f]	0.4	O.lOS	14	1 .9	0.3
Industrial Boilers [g]	0.6	O.lOS	19	3.2	0.3
Source: AP-42, 5th Edition, Supplements A, B, C, D, and E, Table 1.5-1.					

STATIONARY SOURCE EMISSION FACTORS - GENERATORS

For generators rated at less than or equal to 448 kW (600 hp):

Fuel Type	Emission Factor (lb/hp-hr)				
	PM	So,,	*NO,.*	CO	VOC
DF-2	2.20 E-03	2.05 E-03	0.031	6.68 E-03	2.51 E-03
Gasoline	7.21 E-04	5.91 E-04	0.011	0.439	0.022
Natural Gas/Propane	1.54 E-04	7.52 E-03(S)	3.53 E-03	8.6 E-04	1.92 E-04
Source: AP-42, 5th Edition, Supplements A, B, C, D, and E, Table 3.3-1 and 3.1-1					

For generators rated at greater than 448 kW (600 hp):

Fuel Type	Emission Factor (lb/hp-hr)				
	PM	SO_X [b]	NO,,	CO	VOC
DF-2	0.0007	(8.09 E-03)S	0.024	5.5 E-03	6.4 E-04
Source: AP-42, 5th Edition, Supplements A, B, C, D, and E, Table 3.4-1.					

FIREPLACE EMISSION FACTORS

Fuel Type	Emission Factor (lb/ton)				
	PM' [a]	SO_X	NO,,(`)	CO	VOC
Wood	34.6	0.4	2.6	252.6	229.0
Source: AP-42, 5th Edition, Supplements A, B, C, D, and E, Table 1.9-1.					

WOODSTOVE EMISSION FACTORS

Stove Type	Emission Factor (lb/ton)				
	PMO)	SO,	NO„(')	CO	VOC
Conventional	30.6	0.4	2.8	230.8	53
Noncatalytic	19.6	0.4	--	140.8	12
Catalytic	20.4	0.4	2.0	104.4	15
Source: AP-42, 5th Edition, Supplements A, B, C, D, and E, Table 1.10-1.					

STATIONARY SOURCE EMISSION FACTORS - SURFACE COATING OPERATIONS

Surface Coating Type	VOC Emission Factor (lb/gal)
Paint: Solvent Base	5.6
Paint: Water Base	1.3
Enamel: General	3.5
Lacquer: General	6.1
Primer: General	6.6
Varnish/Shellac: General	3.3
Thinner: General	7.36
Adhesive: General	4.4
Source: *Calculation Methods for Criteria Air Pollutant Emission Inventories,* AL/OE-TR-1994-0049, July 1994. Armstrong Laboratory.	

(a) PM = Filterable Particulate Matter.

(b) These factors must be multiplied by the fuel sulfur content (for example, if the sulfur content is 0.05%, then S equals 0.05).

(c) Expressed as NO_2.

(d) Emission factors given in AP-42 are actually for non-methane total organic compounds (NMTOC) which includes all VOCs and all exempted organic compounds (such as ethane, toxics and HAPs, aldehydes and semivolatile compounds) as measured by EPA reference methods.

(e) Unit Rating <300,000 Btu/hr.

(f) Unit Rating 3300,000 Btu/hr, but <10,000,000 Btu/hr.

(g) Unit Rating 310,000,000 Btu/hr, but <100,000,000 Btu/hr.

(h) Unit Rating 3100,000,000 Btufhr.

(i) POM = Particulate POM only.

(j) PM = Filterable Particulate Matter + Condensible Particulate Matter.

(k) NSPS = New Source Performance Standard as defined in 40 CFR 60 Subparts D and Db. Post-NSPS units are boilers with greater than 250 MMBtu/hr of heat input that commenced construction, modification, or reconstruction after August 17, 1971, and units with heat input capacities between 100 and 250 MMBtu/hr that commenced construction, modification, or reconstruction after June 19, 1984.

(1) Emission factors are given on a fuel input basis (lb/MMBtu). To convert to a power output basis (lb/hp-hr), use an average brake-specific fuel consumption (BSFC) of 7,000 Btu/hp-hr.

2000 ACTUAL CRITERIA EMISSIONS FROM HEATING UNITS AT GRAND CANYON NATIONAL PARK

Emission Source	Location	Facilities	Fuel	Number of Sources	Capacity (Btu/hr)		Consumption (gal/yr)	PM" (Ibs/yr)	SO, (Ibs/yr)	NOx (Ibs/yr)	CO, (Ibs/yr)	CO (Ibs/yr)	VOC (lbs/yr)
boiler	uu Village	Aibright iratmngtenter	No.2Fuel Oil	Nu	l l rk.1u it	940,000	5,640,000	20,150	40	1,431	403	433,225	101	
Boiler	GC Village	Headquarters	No. 2 Fuel Oil	2	960,000	1,920,000	10,118	20	718	202	217,537	51	3
Boiler	GC Village	Maintenance Shop	No. 2 Fuel Oil	2	1,512,000	3,024,000	25,592	51	1,817	512	550,228	128	9
Boiler	GC Village	Fee Collection	No. 2 Fuel Oil	1	1,160,000	1,160,000	1,485	3	105	30	31,928	7	1
Boiler	GC Village	Ranger Operations	No.2 Fuel Oil	1	344,000	344,000	6,141	12	436	123	132,032	31	2
Boiler	GC Village	Boat Kitchen	No. 2 Fuel Oil	1	75,000	75,000	254	0	18	5	5,461	1	0
			Subo al	13	4,991,000	12,163,000	63,740	127	4,526	1,274	1,370,410	319	22
Boiler	GC Village	Shrine of the Ages	No. 2 Fuel Oil	4	250,000	1,000,000	62,188	25	4,415	1,119	1,337,043	311	44
Boiler	GC Village	Wastewater Treatment Plant	No. 2 Fuel Oil	2	85,000	170,000	10,572	4	751	190	227,297	53	8
			Subotal		335,000	1,170 000	72,760	29	5,166	1,310		364	52
Furnace	North Rim	Miscellaneous	No. 2 Fuel Oil			0	2,800	1	199	50	60,200	14	2
Furnace	South Rim	Housing	No. 2 Fuel Oil	25	80,000	2,000,000	8,300	3	589	149	178,450	42	6
			Totals	44	10,732,000		147,600	161	10,480	2,784	178,450	738	82
Emission Factors from AP-42, Tables 1.3-1 and 1.3-3 for residential furnaces (<300,000 Btu/hr) S = 0.5 percent								0.4	142S	18.0	21,500	5.0	0.7
Emission Factors from AP-42, Tables 1.3-1 and 1.3-3 for furnaces (>300,000 Btu/hr) S = 0.5 percent								2.0	142S	20.0	21,500	5.0	0.3
Formula = Consumption (gal/yr) * Emission Factor (16/1,000 gal)													
Boiler	GC Village	Medical Clinic	Propane	2	1,825,000	3,650,000	33,529	13	1	469	419,116	67	10
Furnace	GC Village	Boat Shop	Propane	1	84,000	84,000	772	0	0	11	9,645	2	0
Furnace	GC Village	Paint Shop	Propane	1	84,000	84,000	772	0	0	11	9,645	2	0
Furnace	GC Village	Blacksmith Shop	Propane	1	84,000	84,000	772	0	0	11	9,645	2	0
Furnace	GC Village	Library	Propane	3	100,000	300,000	2,756	1	0	39	34,448	6	1
Furnace	South Rim	Housing	Propane	153			52,800	21	1	739	660,000	106	16
Furnace	North Rim	Miscellaneous	Propane				7,958	3	0	111	99,475	16	2
			Totals	161		4,202,000	99,358	40	2	1,391	822,859	199	30
Emission Factors from AP-42, Tables 1.5-1 for commercial boilers, S = 0.18 grains/cu ft								0.4	0.1 *S	14.00	12,500	1.90	0.30
Formula = Consumption (gal/yr) * Emission Factor (lb/1,000 gal)													
Grand Canyon School Buildings - South Rim													
Furnace	GC Schools	Bldg 600	Propane	6	85,000	510,000	1,774	1	0	25	22,174	4	1
Furnace	GC Schools	High School	Propane	2	600,000	1,200,000	4,174	2	0	58	52,174	8	1
Furnace	GC Schools	Bldg 500	Propane	1	475,000	475,000	1,652	1	0	23	20,652	3	0
Furnace	GC Schools	Bldg 300	Propane	1	1,300,000	1,300,000	4,522	2	0	63	56,522	9	1
Furnace	GC Schools	Bldg 200	Propane	1	570,000	570,000	1,983	1	0	28	24,783	4	1
Furnace	GC Schools	Elementary School	Propane	2	570,000	1,140,000	3,965	2	0	56	49,565	8	1
Furnace	GC Schools	Housing	Propane	40	80,000	3,200,000	11,130	4	0	156	139,130	22	3
			Totals	53		8,395,000	29,200	12	1	409	365,000	58	9
Emission Factors from AP-42, Tables 1.5-1 for commercial boilers, S = 0.18								0.4	0.1 *S	14.00		1.90	0.30
Formula = Consumption *(gal/yr)* * Emission Factor (lb/1,000 gal)													
Total National Park Service Heating Units				258				212	10,482	4,584	1,366,309	995	1201

Emission -e	Location	Facilities	Fuel	Number of Sources	Capacity (Btu/hr)		Consumption (n?t/vr)	PM10 (ths/sw)	SO, (lhs/vr)	NO_x (ths/vr)	CO, lths/v 1	CO (Ihc/vrt	VOC (Ihs/vr)
				1l {f.ic P;n 6	South Rim								
Boiler	UC Village	Bright Angel Lodge	No. 2 Fuel Oil	2	2,UU9,000	4,010,00V	4/,/20	92	2,388	924	1,025,`9`90	229	t o
Boiler	GC Village	El Tovar Hotel	No. 2 Fuel Oil	2	3,348,000	6,696,000	79,526	159	5,646	1,591	1,709,814	398	27
Boiler	GC Village	Yavapai Motor Lodge	No. 2 Fuel Oil	l	786,000	786,000	9,335	l9	663	l87	200,704	47	3
Hot Water	GC Village	Yavapai Bldgs 01-09	No. 2 Fuel Oil	9	380,000	3,420,000	40,618	81	2,884	812	873,292	203	14
			Subtotal	l 4	6,523,000	14,920,000	l77,200	585	12,581	8,762	3,809,800	1,972	l94
					Amfac Parks & Resorts - North Rim								
Boiler	North Rim	Lodge	No. 2 Fuel Oil	l	2,600,900	2,600,900	l 0,469	21	743	209	225.091	52	
Boiler	North Rim	Lodge	No. 2 Fuel Oil	l	2,913,000	2,913,000	11,726	23	833	235	252,101	59	4
Boiler	North Rim	Employye Dining Room (EDR)	No. 2 Fuel Oil	l	200,000	200,000	805	2	57	16	17,309	4	0
			Subtotal	3	5,713,900	5,713,900	23,000	46	1,633	460	494,500	115	
			Totals	34	12,236,900		200,200	631	l4,214	9,222	4,304,300	2,087	202
Emission Factors from AP-42, Tables 1.3-I and 1.3-3 for residential furnaces (<300,000 Btu/hr) S = 0.5 percent								0.4	142S	18.0	21,500	5.0	0.7
Emission Factors from AP-42, Tables 1.3-1 and 1.3-3 for furnaces (>300,000 Btu/hr) S = 0.5 percent								2.0	142S	20.0	21,500	5.0	0.3
Formula = Consumption (gaUyr) Emission Factor (lb/1,000 gal)													
					lmfac Parks & Resorts - South Rint								
rsoder	OIL village	Lamperservices	Fropane	l	5,022,000	5,022,001)	*129,412*	04		*2,232*	l,s92,78a	319	48
Boiler	GC Village	General Offices	Propane	I	1,446,000	1,446,000	45,903	18	1	643	573,790	92	14
Boiler	GC Village	Main Laundry	Propane	l	5,060,000	5,060,000	160,629	64	3	2,249	2,007,867	321	48
Boiler	GC Village	Main Laundry	Propane	l	5,230,000	5,230,000	166,026	66	3	2,324	2,075,325	332	50
Heater	GC Village	Maswik Lodge	Propane	1	2,400,000	2,400,000	76,188	30	I	1,067	952,348	152	23
Hot Water	GC Village	Maswik Buildings	Propane	12	380,000	4,560,000	144,757	58	3	2,027	1,809,461	290	43
			Subtotal	17	13,070.000	l 7,250,000	547,600	301	14	10,541	9,411,577	1,506	226
					: ~n1fac.Parks & Resin tN - North Rim								
Hot Vva er	Norcil Kim	onowers	ropane	l	6va,vuO	60o,uuv	JJ 0Uu	z	1	742	662,500	l06	l6
			Totals	l8			600,600	322	l 5	11 283	10,07 077	l 612	2421
Emission Factors from AP-42, Tables 1.5-I for commercial boilers, S = 0.18 grains/cu ft								0.4	O. l *S	14.00	12,500	1.90	0.30
Formula = Consumption (gal/yr) * Emission Factor (lb/1,000 gal)													
		Total Amfac Resorts & Parks Heatin Units		52			lbs/yr	953	14,229	20,505	14,378,377	3 698	4441
					Delaware North Park Services								
Hot Water	North Rim	Showers	Propane	1			560				7,000		
			Park Totals	310			lbs/yr	1,165	24,711	25,096	15,751,686	4,695	564
							tons/yr	0.58	12.36	12.55		2.35	0.28

2000 POTENTIAL CRITERIA EMISSIONS FROM HEATING UNITS AT GRAND CANYON NATIONAL PARK

Emission So rce	Location	Facilities	Fuel	Number of Sources	Capacity (Btu/hr)		Consumption *(gal/yr)*	PM10 (16c/7)	SO, Qhclvrl	NO_x (lhc/~rl	CO Qhclvrl	VOC fthe/vrl
			M1ut[on: I I arl.Srl Siee									–
Botier	vt. Village	Albright Training Center	No. 2 Fuel Oil	6	940,000	5,040,000	352,903	/U6	25,056	1,055	1,/65	12U
Boiler	GC Village	Headquarters	No.2 Fuel Oil	2	960,000	1,920,000	120,137	240	8,530	2,403	601	41
Boiler	GC Village	Maintenance Shop	No. 2 Fuel Oil	2	1,512,000	3,024,000	189,216	378	13,434	3,784	946	64
Boiler	GC Village	Fee Collection	No.2 Fuel Oil	1	1,160,000	1,160,000	72,583	145	5,153	1,452	363	25
Boiler	GC Village	Ranger Operations	No. 2 Fuel Oil	1	344,000	344,000	21,525	43	1,528	430	108	7
Boiler	GC Village	Boat Kitchen	No. 2 Fuel Oil	1	75,000	75,000	4,693	2	333	84	23	3
			Subotal	13	4,991,000	12,163,000	761,056	1,515	54,035	15,212	3,805	261
Boiler	GC Village	Shrine of the Ages	No. 2 Fuel Oil	4	250,000	1,000,000	62,571	25	4,443	1,126	313	45
Boiler	GC Village	Wastewater Treatment Plant	No. 2 Fuel Oil	2	85,000	170,000	10,637	4	755	191	53	8
			Subotal	6	335,000	1,170,000	73,209	29	5,198	1,318	366	52
Furnace	North Rini	Miscellaneous	No. 2 Fuel Oil			0	2,800	1	199	50	14	2
Furnace	South Rim	Housing	No. 2 Fuel Oil	25	80,000	2,000,000	125,143	50	8,885	2,253	626	89
			Totals	44	10,732,000		962,208	1,595	68,317	18,832	4,811	404
Emission Factors from AP-42, Tables 1.3-1 and 1.3-3 for residential furnaces (<300,000 Btu/hr) S = 0.5 percent								0.4	142S	18.0	5.0	0.7
Emission Factors from AP-42, Tables 1.3-I and 1.3-3 for furnaces (>300,000 Btu/Itr) S = 0.5 percent								2.0	I42S	20.0	5.0	0.3
Formula = Consumption (gal/yr) * Emission Factor (lb/1,000 gal)												
Boiler	GC Village	Medical Clinic	Propane	2	1,825,000	3,650,000	355,267	142	6	4,974	711	107
Furnace	GC Village	Boat Shop	Propane	1	84,000	84,000	8,176	3	0	114	16	2
Furnace	GC Village	Paint Shop	Propane	1	84,000	84,000	8,176	3	0	114	16	2
Furnace	GC Village	Blacksmith Shop	Propane	1	84,000	84,000	8,176	3	0	114	16	2
Furnace	GC Village	Library	Propane	3	100,000	300,000	29,200	12	1	409	58	9
Furnace	South Rim	Housing	Propane	153			52,800	21	1	739	106	16
Furnace	North Rim	Miscellaneous	Propane				7,958	3	0	ill	16	2
			Totals	161		4,202,000	469,753	188	8	6,577	940	141
Emission Factors from AP-42, Tables 1.5-1 for commercial boilers, S = 0.18 grains/cu ft								0.4	0.1 *S	14.00	1.90	0.30
Formula= Consumption (gal/yr) * Emission Factor (lb/1,000 gal)												
Grand Canyon School Buildings - South Rim												
Furnace	GC Schools	Bldg 600	Propane	6	85,000	510,000	49,640	20	1	695	99	15
Furnace	GC Schools	High School	Propane	2	600,000	1,200,000	116,800	47	2	1,635	234	35
Furnace	GC Schools	Bldg 500	Propane	1	475,000	475,000	46,233	18	1	647	92	14
Furnace	GC Schools	Bldg 300	Propane	1	1,300,000	1,300,000	126,533	51	2	1,771	253	38
Furnace	GC Schools	Bldg 200	Propane	1	570,000	570,000	55,480	22	1	777	Ill	17
Furnace	GC Schools	Elementary School	Propane	2	570,000	1,140,000	110,960	44	2	1,553	222	33
Furnace	GC Schools	Housing	Propane	40	80,000	3,200,000	311,467	125	6	4,361	623	93
			Totals	53		8,395,000	817,113	327	15	11,440	1,634	245
Emission Factors from AP-42, Tables 1.5-I for co mmercial boilers, S = 0.18 grains/cu ft								0.4	0.1 *S	14.00	1.90	0.30
Formula = Consumption (gal/yr) * Emission Factor (lb/1,000 gal)												
1		Total National Park Service Heating Units		258				2,110	68,340	36,849	7,385	790

Emission Source	Location	Facilities	Fuel	Number of Sources	Capacity (Btu/h)		Consumption (pal/vr)	PM 15 (1 s/vr)	SO_2 (ths/vr)	NO_X (lhs/vr)	CO llhs/vrl	VOC (lhs/)
			Amfic l' ri,c & RchortS-South Liin									
Boiler	GC Village	Bright Angel Lodge	No. .c Fuel Oil	2	2,009,uuu	4,ulb,uuU	L5i,4i2	5 3	17,8 0	i,u2d	1,257	85
Boiler	GC Village	El Tovar Hotel	No. 2 Fuel Oil	2	3,348,000	6,696,000	418,978	838	29,747	8,380	2,095	142
Boiler	GC Village	Yavapai Motor Lodge	No. 2 Fuel Oil	l	786,000	786,000	49,181	98	3,492	984	246	17
Hot Water	GC Village	Yavapai Bldgs 01-09	No. 2 Fuel Oil	9	380,000	3,420,000	213,994	428	15,194	4,280	1,070	73
			Subtotal	14	6,523,000	14,920,000	933,566	4,473	66,283	72,887	14,534	1,480
			__ Amfic l'.irks& tls its-North Rim									
Boner	North Rim	Lodge	No. 2 Fuel Oil	l	2,600,900	2,600,900	162,742	325	11,555	3,255	814	55
Boiler	North Rim	Lodge	No. 2 Fuel Oil	l	2,913,000	2,913,000	182,271	365	12,941	3,645	911	62
Boiler	North Rim	Employye Dining Room (EDR)	No 2 Fuel Oil	l	200,000	200,000	12,514	25	889	250	63	4
			Subtotal	3	5,713,900	5,713,900	357,527	715	25,384	7,151	1,788	122,
			Totals	34	12,236,900		1,291,093	5,188	91,668	80,038	16,321	1,6011
Emission Factors from AP-42, Tables 1.3-1 and 1.3-3 for residential furnaces (<300,000 Btu/hr) S = 0.5 percent								0.4	1425	18.0	5.0	0.7
Emission Factors from AP-42, Tables 1.3-1 and 1.3-3 for furnaces (>300,000 Btu/hr) S = 0.5 percent								2.0	1425	20.0	5.0	0.3
Formula= Consumption (gal/yr)' Emission Factor (lb/1,000 gal)												
			:',nifae P,irks ~- WL arts-South Run									
Boiler	GC Village	Camper Services	Fropane		5,022,uuu	s,022,000	488,bub	196	9	6,843	9/8	147
Boiler	GC Village	General Offices	Propane	l	1,446,000	1,446,000	140,744	56	3	1,970	281	42
Boiler	GC Village	Main Laundry	Propane	l	5,060,000	5,060,000	492,507	197	9	6,895	985	148
Boiler	GC Village	Main Laundry	Propane	l	5,230,000	5,230,000	509,053	204	9	7,127	1,018	153
Heater	GC Village	Maswik Lodge	Propane	l	2,400,000	2,400,000	233,600	93	4	3,270	467	70
Hot Water	GC Village	Maswik Buildings	Propane	12	380,000	4,560,000	443,840	178	8	6,214	888	133
r			Subtotal	17	13,070,000	17,250,000	2,308,552	923	42	32,320	4,617	693
+			A if Parks & R sorts-tiorNi Rim									
'Hot Water	North Rim	oiiowers	Propane		o a, u	6U6, U	59,119			829	8	
			To als	18			2,367,731	947	43	33 148	4,735	710
Emission Factors from AP-42, Tables 1.5-I for commercial boilers, S = 0.18 grains/cu R								0.4	0.1 4 S	14.00	1.90	0.30
Formula = Consumption *(gal/yr)* * Emission Factor (lb/1,000 gal)												
		otal Amfac Resorts & Parks Heating Units		52			lbs/y	6 135	91,710	l 3,186	21,057	2,311
			l aL tiare North ParkScrr									
Hot Water	Desert View	Desert view Store	Propane	l		80,000	7,787	3	0	109	16	
			Park Totals	310			lbs/yr	8,248	160,050	150,144	28,457	3,104
							tons/yr	4.12	80.03	75.07	14.23	1.55

2000 ACTUAL CRITERIA EMISSIONS FROM GENERATORS AT GRAND CANYON NATIONAL PARK

Emission Source	Location	Fuel	Number of Sources	Rating (kW)	Run Time (hrs/yr)	Output (kW-hr/yr)	PM (lbs/yr)	SO_2 (lbs/yr)	NO, (Ibs/yr)	CO, (Ibs/yr)	CO (lbs/yr)	VOC (lbs/yr)
						National Park Service						
Generator	Medical Clinic	Propane	1	75	104	7,800	2	4	37		9	
Generator	CVIP	Propane	1	35	104	3,640	1	7	17		4	1
Generator	Headquarters	Propane	1	25	104	2,600	1	5	12		3	1
Generator	South Rim Lift Station	Propane	1	50	104	5,200	1	9	25		6	1
Generator	Tuweap	Propane	1	9.5	2,500	23,750	5	43	112		27	6
Generator	Phantom Ranch	Propane	1	35	800	28,000	6	51	132		32	7
	Propane Generator Totals			229.5	3,716	70,990	15	129	336		82	18
Emission Factors from AP-42, Chapter 3.1-1 for natural gas large uncontrolled gas turbines (lb/hp-hr), S=.18 Formula = Emission Factor (lb/hp-hr) * 608 (g/kW-hr / lb/hp-hr) * Output (kW-hr/yr) / 453.6 (g/lb)							1.54E-04	7.52E-03*S	3.53E-03		8.60E-04	1.92E-04
Generator	North Rim	Diesel	1	175	92	16,100	47	44	669	24,810	144	54
Generator	North Rim	Diesel	1	400	92	36,800	108	101	1,529	56,709	329	124
Generator	North Rim	Diesel	1	600	92	55,200	163	299	2,293	85,063	494	186
	Diesel Generator Totals		3		276	108,100	319	445	4,490	166,582	968	364
Emission Factors from AP-42, Chapter 3.3 Table 3.3-1 for diesel generators rated less than 448 kW							2.20E-03	0.00205	3.10E-02	1.15E+00	6.68E-03	2.51 E-03
Emission Factors from AP-42, Chapter 3.4 Table 3.4-1 for diesel generators rated greater than 448 kW, S=0.5 Formula = Output (kW-hr/yr) * 1.34 (hp/kW) * Emission Factor (lb/hp-hr)							7.00E-04	0.00809*S	2.40E-02	1.15E+00	5.50E-03	6.40E-04
						Park Totals (lbs/yr)	333	573	4,826	166,582	1,049	382
						Park Totals (tons/yr)	0.17	0.29	2.41	83.29	0.52	0.19

2000 POTENTIAL CRITERIA EMISSIONS FROM GENERATORS AT GRAND CANYON NATIONAL PARK

Emission Source	Location	Fuel	Number of Sources	Rating (kW)	Run Time (hrs/yr)	Output (kW-hr/yr)	PM (lbs/yr)	SO_2 (lbs/yr)	NO_X (lbs/yr)	CO, (lbs/yr)	CO (lbs/yr)	VOC (lbs/yr)
					National Park Service							
Generator	Medical Clinic	Propane	1	75	500	37,500	8	68	177		43	10
Generator	CVIP	Propane	1	35	500	17,500	4	32	83		20	5
Generator	Headquarters	Propane	1	25	500	12,500	3	23	59		14	3
Generator	South Rim Lift Station	Propane	1	50	500	25,000	5	45	118		29	6
Generator	Tuweap	Propane	1	9.5	2,500	23,750	5	43	112		27	6
Generator	Phantom Ranch	Propane	1	35	800	28,000	6	51	132		32	7
	Propane Generator Totals		6	229.5	5,300	144,250	30	262	683		166	37
Emission Factors from AP-42, Chapter 3.1-1 for natural gas large uncontrolled gas turbines (lb/hp-hr), S=.18 Formula = Emission Factor (lb/hp-hr) * 608 (g/kW-hr / lb/hp-hr) * Output (kW-hr/yr) / 453.6 (g/lb)							1.54E-04	7.52E-03*S	3.53E-03		8.60E-04	1.92E-04
Generator	North Rim	Diesel	1	175	500	87,500	258	240	3,635	134,838	783	294
Generator	North Rim	Diesel	1	400	500	200,000	590	549	8,308	308,200	1,790	673
Generator	North Rim	Diesel	1	600	500	300,000	884	1,626	12,462	462,300	2,685	1,009
	Diesel Generator Totals		3		1,500	587,500	1,732	2,416	24,405	905,338	5,259	1,976
Emission Factors from AP-42, Chapter 3.3 Table 3.3-1 for diesel generators rated less than 448 kW							2.20E-03	0.00205	3.10E-02	1.15E+00	6.68E-03	2.51 E-03
Emission Factors from AP-42, Chapter 3.4 Table 3.4-1 for diesel generators rated greater than 448 kW, S=0.5 perc Formula = Output (kW-hr/yr) * 1.34 (hp/kW) * Emission Factor (lb/hp-hr)							7.00E-04	0.00809*S	2.40E-02	1.15E+00	5.50E-03	6.40E-04
					Park Totals (lbs/yr)		1,762	2,678	25,087	905,338	5,425	2,013
					Park Totals (tons/yr)		0.88	1.34	12.54	452.67	2.71	1.01

GRAND CANYON NP GASOLINE TANKS

Location	Tank Type	Tank Size	Tank Color	Throughput (gal/yr)
National Park Service				
North Rim	AST	6,000	white	19,740
Maintenance	AST	6,000	white	60,000
Maintenance	AST	6,000	white	60,000
				120,000
Desert View				
	UST			183,000
TW Services - North Rim				
Service Station	UST	10,000		23,813
	UST	10,000		23,813
	UST	6,000		14,288
	UST	6,000		14,288
		32,000		76,200

TANKS 4.0
Emissions Report - Detail Format
Tank Identification and Physical Characteristics

Identification

User Identification:	NPS North Rim
City:	Flagstaff
State:	Arizona
Company:	NPS
Type of Tank:	Horizontal Tank
Description:	White, 6,000 Gallon AST

Tank Dimensions

Shell Length (ft):	16.00
Diameter (ft):	8.00
Volume (gallons):	6,000.00
Turnovers:	0.00
Net Throughput (gal/yr):	19,740.00
Is Tank Heated (y/n):	N
Is Tank Underground (y/n):	N

Paint Characteristics

Shell Color/Shade:	White/White
Shell Condition:	Good

Breather Vent Settings

Vacuum Settings (psig):	-0.03
Pressure Settings (psig):	0.03

Meteorological Data used in Emissions Calculations: Flagstaff, Arizona (Avg Atmospheric Pressure = 11.43 psia)

TANKS 4.0
Emissions Report - Detail Format
Liquid Contents of Storage Tank

Mixture/Component	Month	Daily Liquid Surf. Temperatures (deg F) Avg.	Min.	Max.	Liquid Bulk Temp. (deg F)	Vapor Pressures (psia) Avg.	Min.	Max.	Vapor Mol. Weight	Liquid Mass Fract.	Vapor Mass Fract.	Mol. Weight	Basis for Vapor Pressure Calculations
Gasoline (RVP 9)	All	47.94	40.49	55.38	45.76	3.6163	3.0945	4.2071	67.0000			92.00	Option 4: RVP=9, ASTM Slope=3

TANKS 4.0
Emissions Report - Detail Format
Detail Calculations (AP-42)

Annual Emission Calculations	
Standing Losses (lb):	910.6128
Vapor Space Volume (cu ft):	512.2597
Vapor Density (lb/cu ft):	0.0445
Vapor Space Expansion Factor:	0.1934
Vented Vapor Saturation Factor:	0.5660
Tank Vapor Space Volume	
Vapor Space Volume (cu ft):	512.2597
Tank Diameter (ft):	8.0000
Effective Diameter (ft):	12.7694
Vapor Space Outage (ft):	4.0000
Tank Shell Length (ft):	16.0000
Vapor Density	
Vapor Density (lb/cu ft):	0.0445
Vapor Molecular Weight (lb/lb-mole):	67.0000
Vapor Pressure at Daily Average Liquid Surface Temperature (psia):	3.6163
Daily Avg. Liquid Surface Temp. (deg. R):	507.6080
Daily Average Ambient Temp. (deg. F):	45.7375
Ideal Gas Constant R (psia cult / (lb-mol-deg R)):	10.731
Liquid Bulk Temperature (deg. R):	505.4275
Tank Paint Solar Absorptance (Shell):	0.1700
Daily Total Solar Insulation Factor (Btu/sgft day):	1,630.1861
Vapor Space Expansion Factor	
Vapor Space Expansion Factor:	0.1934
Daily Vapor Temperature Range (deg. R):	29.7737
Daily Vapor Pressure Range (psia):	1.1126
Breather Vent Press. Setting Range(psia):	0.0600
Vapor Pressure at Daily Average Liquid Surface Temperature (psia):	3.6163
Vapor Pressure at Daily Minimum Liquid Surface Temperature (psia):	3.0945
Vapor Pressure at Daily Maximum Liquid Surface Temperature (psia):	4.2071
Daily Avg. Liquid Surface Temp. (deg R):	507.6080
Daily Min. Liquid Surface Temp. (deg R):	500.1646
Daily Max. Liquid Surface Temp. (deg R):	515.0515
Daily Ambient Temp. Range (deg. R):	30.5750
Vented Vapor Saturation Factor	
Vented Vapor Saturation Factor:	0.5660
Vapor Pressure at Daily Average Liquid Surface Temperature (psia):	3.6163
Vapor Space Outage (ft):	4.0000
Working Losses (lb):	113.8764
Vapor Molecular Weight (lb/lb-mole):	67.0000
Vapor Pressure at Daily Average Liquid Surface Temperature (psia):	3.6163
Annual Net Throughput (gallyr.):	19,740.0000
Annual Turnovers:	0.0000
Turnover Factor:	1.0000
Tank Diameter (ft):	8.0000
Working Loss Product Factor:	1.0000
Total Losses (lb):	1,024.4893

TANKS 4.0
Emissions Report - Detail Format
Individual Tank Emission Totals

Annual Emissions Report

	Losses(lbs)		
Components	Working Loss	Breathing Loss	Total Emissions
Gasoline (RVP 9)	113.88	910.61	1,024.49

TANKS 4.0
Emissions Report - Detail Format
Tank Identification and Physical Characteristics

Identification

User Identification:	Maintenance
City:	Flagstaff
State:	Arizona
Company:	NPS
Type of Tank:	Horizontal Tank
Description:	White, 6,00 Gal AST

Tank Dimensions

Shell Length (ft):	16.00
Diameter (ft):	8.00
Volume (gallons):	6,000.00
Turnovers:	0.00
Net Throughput (gal/yr):	60,000.00
Is Tank Heated (y/n):	N
Is Tank Underground (y/n):	N

Paint Characteristics

Shell Color/Shade:	White/White
Shell Condition:	Good

Breather Vent Settings

Vacuum Settings (psig):	-0.03
Pressure Settings (psig):	0.03

Meteorological Data used in Emissions Calculations: Flagstaff, Arizona (Avg Atmospheric Pressure = 11.43 psia)

TANKS 4.0
Emissions Report - Detail Format
Liquid Contents of Storage Tank

Mixture/Com onent	Month	Daily Liquid Surf. Temperatures (deg F) Av	Min.	Ma	Liquid Bulk Temp. de F	Vapor Pressures (psia) Av	Min.	Max.	Vapor Mol. Wei ht	Liquid Mass Fract.	Vapor Mass Fract.	Mol. Wei ht	Basis for Vapor Pressure Calculations
Gasoline (RVP 9)	All	47.94	40.49	55.38	45.76	3.6163	3.0945	4.2071	67.0000			92.00	Option 4: RVP=9, ASTM Slope=3

TANKS 4.0
Emissions Report - Detail Format
Detail Calculations (AP-42)

Annual Emission Calculations	
Standing Losses (lb):	910.6128
Vapor Space Volume (cu ft):	512.2597
Vapor Density (lb/cu ft):	0.0445
Vapor Space Expansion Factor:	0.1934
Vented Vapor Saturation Factor:	0.5660
Tank Vapor Space Volume	
Vapor Space Volume (cu ft):	512.2597
Tank Diameter (ft):	8.0000
Effective Diameter (ft):	12.7694
Vapor Space Outage (ft):	4.0000
Tank Shell Length (ft):	16.0000
Vapor Density	
Vapor Density (lb/cu ft):	0.0445
Vapor Molecular Weight (lb/lb-mole):	67.0000
Vapor Pressure at Daily Average Liquid Surface Temperature (psia):	3.6163
Daily Avg. Liquid Surface Temp. (deg. R):	507.6080
Daily Average Ambient Temp. (deg. F):	45.7375
Ideal Gas Constant R (psia cult / (lb-mol-deg R)):	10.731
Liquid Bulk Temperature (deg. R):	505.4275
Tank Paint Solar Absorptance (Shell):	0.1700
Daily Total Solar Insulation Factor (Btu/sqft day):	1,630.1861
Vapor Space Expansion Factor	
Vapor Space Expansion Factor:	0.1934
Daily Vapor Temperature Range (deg. R):	29.7737
Daily Vapor Pressure Range (psia):	1.1126
Breather Vent Press. Setting Range(psia):	0.0600
Vapor Pressure at Daily Average Liquid Surface Temperature (psia):	3.6163
Vapor Pressure at Daily Minimum Liquid Surface Temperature (psia):	3.0945
Vapor Pressure at Daily Maximum Liquid Surface Temperature (psia):	4.2071
Daily Avg. Liquid Surface Temp. (deg R):	507.6080
Daily Min. Liquid Surface Temp. (deg R):	500.1646
Daily Max. Liquid Surface Temp. (deg R):	515.0515
Daily Ambient Temp. Range (deg. R):	30.5750
Vented Vapor Saturation Factor	
Vented Vapor Saturation Factor:	0.5660
Vapor Pressure at Daily Average Liquid Surface Temperature (psia):	3.6163
Vapor Space Outage (ft):	4.0000
Working Losses (lb):	346.1289
Vapor Molecular Weight (lb/lb-mole):	67.0000
Vapor Pressure at Daily Average Liquid Surface Temperature (psia):	3.6163
Annual Net Throughput (gal/yr.):	60,000.0000
Annual Turnovers:	0.0000
Turnover Factor:	1.0000
Tank Diameter (ft):	8.0000
Working Loss Product Factor:	1.0000
Total Losses (lb):	1,256.7418

TANKS 4.0
Emissions Report - Detail Format
Individual Tank Emission Totals

Annual Emissions Report

	Losses(lbs)		
Components	Working Loss	Breathing Loss	Total Emissions
Gasoline (RVP 9)	346.13	910.61	1,256.74

TANKS 4.0
Emissions Report - Detail Format
Tank Identification and Physical Characteristics

Identification

User Identification:	North Rim Service Station
City:	Flagstaff
State:	Arizona
Company:	NPS
Type of Tank:	Horizontal Tank
Description:	10,000 Gal UST

Tank Dimensions

Shell Length (ft):	26.50
Diameter (ft):	8.00
Volume (gallons):	10,000.00
Turnovers:	0.00
Net Throughput (gal/yr):	23,813.00
Is Tank Heated (y/n):	N
Is Tank Underground (y/n):	Y

Paint Characteristics

Shell Color/Shade:	
Shell Condition:	

Breather Vent Settings

Vacuum Settings (psig):	0.00
Pressure Settings (psig):	0.00

Meteorological Data used in Emissions Calculations: Flagstaff, Arizona (Avg Atmospheric Pressure = 11.43 psia)

TANKS 4.0
Emissions Report - Detail Format
Liquid Contents of Storage Tank

Mixture/Component	Month	Daily Liquid Surf. Temperatures (deg F) Avg.	Min.	Max.	Liquid Bulk Temp. (deg F)	Vapor Pressures (psia) Avg.	Min.	Max.	Vapor Mol. Weight	Liquid Mass Fract.	Vapor Mass Fract.	Mol. Weight	Basis for Vapor Pressure Calculations
Gasoline (RVP 9)	All	45.18	45.18	45.18	44.74	3.4150	3.4150	3.4150	67.0000			92.00	Option 4: RVP=9, ASTM Slope=3

TANKS 4.0
Emissions Report - Detail Format
Detail Calculations (AP-42)

Annual Emission Calculations	
No Standing Losses: Underground Tank	
Working Losses (lb):	129.7285
Vapor Molecular Weight (lb/lb-mole):	67.0000
Vapor Pressure at Daily Average Liquid Surface Temperature (psia):	3.4150
Annual Net Throughput (gal/yr.):	23,813.0000
Annual Turnovers:	0.0000
Turnover Factor:	1.0000
Tank Diameter (ft):	8.0000
Working Loss Product Factor:	1.0000
Total Losses (lb):	129.7285

TANKS 4.0
Emissions Report - Detail Format
Individual Tank Emission Totals

Annual Emissions Report

	Losses(lbs)		
Components	Working Loss	Breathing Loss	Total Emissions
Gasoline (RVP 9)	129.73	0.00	129.73

TANKS 4.0
Emissions Report - Detail Format
Tank Identification and Physical Characteristics

Identification

User Identification:	North Rim Service Stationl
City:	Flagstaff
State:	Arizona
Company:	
Type of Tank:	Horizontal Tank
Description:	6,000 Gal UST

Tank Dimensions

Shell Length (ft):	16.00
Diameter (ft):	8.00
Volume (gallons):	6,000.00
Turnovers:	0.00
Net Throughput (gal/yr):	14,300.00
Is Tank Heated (y/n):	N
Is Tank Underground (y/n):	Y

Paint Characteristics

Shell Color/Shade:	
Shell Condition:	

Breather Vent Settings

Vacuum Settings (psig):	0.00
Pressure Settings (psig):	0.00

Meteorological Data used in Emissions Calculations: Flagstaff, Arizona (Avg Atmospheric Pressure = 11.43 psia)

TANKS 4.0
Emissions Report - Detail Format
Liquid Contents of Storage Tank

Mixture/Component	Month	Daily Liquid Surf. Temperatures (deg F) Avg.	Min.	Max.	Liquid Bulk Temp. (deg F)	Vapor Pressures (psia) Avg.	Min.	Max.	Vapor Mol. Weight	Liquid Mass Fract.	Vapor Mass Fract.	Mol. Weight	Basis for Vapor Pressure Calculations
Gasoline (RVP 9)	All	45.18	45.18	45.18	44.74	3.4150	3.4150	3.4150	67.0000			92.00	Option 4: RVP=9, ASTM Slope=3

TANKS 4.0
Emissions Report - Detail Format
Detail Calculations (AP-42)

Annual Emission Calculations	
No Standing Losses: Underground Tank	
Working Losses (lb):	77.9035
Vapor Molecular Weight (lb/lb-mole):	67.0000
Vapor Pressure at Daily Average Liquid Surface Temperature (psia):	3.4150
Annual Net Throughput (gal/yr.):	14,300.0000
Annual Turnovers:	0.0000
Turnover Factor:	1.0000
Tank Diameter (ft):	8.0000
Working Loss Product Factor:	1.0000
Total Losses (lb):	77.9035

TANKS 4.0
Emissions Report - Detail Format
Individual Tank Emission Totals

Annual Emissions Report

	Losses(lbs)		
Components	Working Loss	Breathing Loss	Total Emissions
Gasoline (RVP 9)	77.90	0.00	77.90

TANKS 4.0
Emissions Report - Detail Format
Tank Identification and Physical Characteristics

Identification

User Identification:	Desert View
City:	Flagstaff
State:	Arizona
Company:	NPS
Type of Tank:	Horizontal Tank
Description:	10,000 Gal UST

Tank Dimensions

Shell Length (ft):	26.50
Diameter (ft):	8.00
Volume (gallons):	10,000.00
Turnovers:	0.00
Net Throughput (gal/yr):	183,000.00
Is Tank Heated (y/n):	N
Is Tank Underground (y/n):	Y

Paint Characteristics

Shell Color/Shade:	
Shell Condition:	

Breather Vent Settings

Vacuum Settings (psig):	0.00
Pressure Settings (psig):	0.00

Meteorological Data used in Emissions Calculations: Flagstaff, Arizona (Avg Atmospheric Pressure = 11.43 psia)

TANKS 4.0
Emissions Report - Detail Format
Liquid Contents of Storage Tank

Mixture/Component	Month	Daily Liquid Surf. Temperatures (deg F) Avg.	Min.	Max.	Liquid Bulk Temp. (deg F)	Vapor Pressures (psia) Avg.	Min.	Max.	Vapor Mol. Weight	Liquid Mass Fract.	Vapor Mass Fract.	Mol. Weight	Basis for Vapor Pressure Calculations
Gasoline (RVP 9)	All	45.18	45.18	45.18	44.74	3.4150	3.4150	3.4150	67.0000			92.00	Option 4: RVP=9, ASTM Slope=3

TANKS 4.0
Emissions Report - Detail Format
Detail Calculations (AP-42)

Annual Emission Calculations
No Standing Losses: Underground Tank

Working Losses (lb):	996.9474
Vapor Molecular Weight (lb/lb-mole):	67.0000
Vapor Pressure at Daily Average Liquid Surface Temperature (psia):	3.4150
Annual Net Throughput (gal/yr.):	183,000.0000
Annual Turnovers:	0.0000
Turnover Factor:	1.0000
Tank Diameter (ft):	8.0000
Working Loss Product Factor:	1.0000
Total Losses (lb):	996.9474

TANKS 4.0
Emissions Report - Detail Format
Individual Tank Emission Totals

Annual Emissions Report

	Losses(lbs)		
Components	Working Loss	Breathing Loss	Total Emissions
Gasoline (RVP 9)	996.95	0.00	996.95

GRCA WASTEWATER TREATMENT PLANTS

Location	Capacity Actual gal/day	Actual gal/yr	Potential	VOCs (lbs/yr)	
South Rim	750,000	177,937,500	273,750,000	1,584	2,436
North Rim	125,000	19,687,500	45,625,000	175	406
Phantom Ranch	5,000	1,916,250	1,916,250	17	17
		199,541,250	321,291,250	1,776	2,859

2000 PRESCRIBED FIRE EMISSIONS AT GRAND CANYON NATIONAL PARK

	Acres	PM10 (lbs/yr)	PM2.5 (lbs/yr)	CH4 (lbs/yr)	CO (lbs/yr)	PM10 (lbs/acre)	PM2.5 (lbs/acre)	CH4 (lbs/acre)	CO (lbs/acre)
Gambel Oak	14	588	504	154	1,260	42	36	11	90
Pondarosa Pine	1,002	196,392	167,334	98,196	2,117,226	196	167	98	2,113
Pinyon Pine-Juniper	338	70,980	60,164	35,490	763,542	210	178	105	2,259
Pinyon Pine-Gambel Oak	118	14,868	12,626	6,844	138,591	126	107	58	1,175
Pinyon Pine-Ponderosa Pine-Gambel Oak	176	26,283	22,352	12,555	261,771	149	127	71	1,487
Totals	1,634	308,523	262,476	153,085	3,281,130				
			tons/yr						
		154	131	77	1,641				

2000 WILDLAND FIRES EMISSIONS AT GRAND CANYON NATIONAL PARK

Fire Name	Acres	PM10 (lbs/yr)	PM2.5 (lbs/yr)	CH4 (lbs/yr)	CO (lbs/yr)	PM10 (lbs/acre)	PM2.5 (lbs/acre)	CH4 (lbs/acre)	CO (lbs/acre)
Aspen	5	1,030	870	515	11,190	206	174	103	2,238
Gambel Oak	127	5,334	4,572	1,397	11,430	42	36	11	90
Grass	158	31,126	26,386	15,484	334,012	197	167	98	2114
Pondarosa Pine	86	16,856	14,362	8,428	181,718	196	167	98	2,113
Pondarosa Pine-Aspen	926	186,126	157,883	93,063	2,014,513	201	171	101	2,176
Pondarosa Pine-Gambel Oak	7	833	711	382	7,711	119	102	55	1,102
Pondarosa Pine-White Fir-Aspen	2,238	1,272,676	1,078,716	649,766	14,190,412	569	482	290	6,341
Pondarosa Pine-White Fir-Gambel Oak	0	103	87	52	1,125	514	436	260	5,625
Pinyon Pine-Juniper	82	17,220	14,596	8,610	185,238	210	178	105	2,259
Spruce-Fir	4,008	4,328,640	3,667,320	2,212,416	48,284,376	1,080	915	552	12,047
White Fir-Aspen	42	31,710	26,859	16,233	355,089	755	640	387	8,455
White Fir-Aspen-Gambel Oak	7	3,621	3,068	1,829	39,664	517	438	261	5,666
White Fir-Ponderosa Pine	33	24,750	20,988	12,672	276,936	750	636	384	8,392
White Fir-Ponderosa Pine-Gambel Oak	35	17,990	15,260	9,088	196,863	514	436	260	5,625
Totals	7,754	5,938,015	5,031,678	3,029,935	66,090,277				
			tons/yr						
		2,969	2,516	1,515	33,045				
			Totals						
lbs/yr	9,388	6,246,538	5,294,154	3,183,020	69,371,407				
tons/yr	5	3,123	2,647	1,592	34,686				

E: Results of FOFEM model execution on date: 4/26/2002

FUEL CONSUMPTION CALCULATIONS

agion: Interior West
D---;r Type: SAF/SRM - SAF 237 - Interior Ponderosa Pine
• Type: Natural
Reference: FOFEM 011

FUEL CONSUMPTION TABLE

oi..,ponent sme	Preburn Load (t/acre)	Consumed Load (t/acre)	Postburn Load (t/acre)	Percent Reduced (%)	Equation Reference Number	Moisture
I :er	1.40	1.40	0.00	100.0	999	
o'„a (0-1/4 inch)	0.07	0.07	0.00	100.0	999	
ood (1/4-1 inch)	0.63	0.63	0.00	100.0	999	25.0
o-- (1-3 inch)	0.80	0.32	0.48	39.4	999	
of 3 (3+ inch) Sound	4.50	0.32	4.18	7.1	999	20.0
3->6	1.12	0.17	0.95	0.2		
6->9	1.12	0.09	1.04	0.1		
9->20	1.12	0.04	1.08	0.0		
20->	1.12	0.02	1.11	0.0		
o_1 (3+ inch) Rotten	0.50	0.10	0.40	19.1	999	20.0
3->6	0.12	0.05	0.08	0.4		
6->9	0.12	0.03	0.10	0.2		
9->20	0.12	0.01	0.11	0.1		
20->	0.12	0.01	0.12	0.1		
uff	5.00	2.05	2.95	41.1	2	100.0
arbaceous	0.20	0.20	0.00	100.0	22	
• ibs	0.40	0.24	0.16	60.0	23	
rrn foliage	6.00	0.00	6.00	0.0	37	
rown branchwood	0.70	0.00	0.70	0.0	38	
• it Fuels	20.20	5.32	14.88	26.4		

fl EFFECTS ON FOREST FLOOR COMPONENTS

orest Floor omponent	Preburn Condition	Amount Consumed	Postburn Condition	Percent Reduced	Equation Number
• : Depth (in)	0.6	0.2	0.4	30.8	6
in Soil Exp (%)	.0	21.9	21.9	21.9	10

s iff' (tons/acre) and 'Duff Depth (in)' burned are computed using different equations, sometimes this may cause an inconsistancy in the 'Percent Reduced' shown on this report.
D' "f (tons/acre) consumed is best suited for predicting smoke production, *is* le Duff Depth (in) may be better related to fire severity and soil heating

	Emissions -- lbs/acre flaming	smoldering	total
K 0	11	185	196
1 .5	10	157	167
3'' 4	3	95	98
D	24	2089	2113
D+„;	6626	8501	15127

	Consumption tons/acre	Duration hour:min:sec
Flaming:	1.86	00:01:00
Smoldering:	3.46	00:22:15
Total:	5.32	

ITLE: Results of FOFEM model execution on date: 4/26/2002

FUEL CONSUMPTION CALCULATIONS

agion: Interior West
over Type: SAF/SRM - SRM 412 - Juniper - Pinyon Woodland (also SRM 504, SAF 239)
uel Type: Natural
uel Reference: FOFEM 381

FUEL CONSUMPTION TABLE

uel omponent ame	Preburn Load (t/acre)	Consumed Load (t/acre)	Postburn Load (t/acre)	Percent Reduced (o)	Equation Reference Number	Moisture
itter	1.00	1.00	0.00	100.0	999	
ood (0-1/4 inch)	0.00	0.00	0.00	0.0	999	
ood (1/4-1 inch)	0.00	0.00	0.00	0.0	999	25.0
ood (1-3 inch)	0.00	0.00	0.00	0.0	999	
ood (3+ inch) Sound	0.00	0.00	0.00	0.0	999	20.0
3->6	0.00	0.00	0.00	0.0		
6->9	0.00	0.00	0.00	0.0		
9->20	0.00	0.00	0.00	0.0		
20->	0.00	0.00	0.00	0.0		
ood (3+ inch) Rotten	0.00	0.00	0.00	0.0	999	20.0
3->6	0.00	0.00	0.00	0.0		
6->9	0.00	0.00	0.00	0.0		
9->20	0.00	0.00	0.00	0.0		
20->	0.00	0.00	0.00	0.0		
uff	9.00	3.70	5.30	41.1	2	100.0
erbaceous	0.20	0.20	0.00	100.0	22	
hrubs	1.30	0.78	0.52	60.0	23	
rown foliage	0.00	0.00	0.00	0.0	37	
rown branchwood	0.00	0.00	0.00	0.0	38	
otal Fuels	11.50	5.68	5.82	49.4		

IRE EFFECTS ON FOREST FLOOR COMPONENTS

orest Floor omponent	Preburn Condition	Amount Consumed	Postburn Condition	Percent Reduced	Equation Number
uff Depth (in)	0.4	0.1	0.3	24.2	6
in Soil Exp (%)	.0	21.9	21.9	21.9	10

te:
'Duff' (tons/acre) and 'Duff Depth (in)' burned are computed using
different equations, sometimes this may cause an inconsistancy in
the 'Percent Reduced' shown on this report.
Duff (tons/acre) consumed is best suited for predicting smoke production,
while Duff Depth (in) may be better related to fire severity and soil heating

	Emissions -- lbs/acre flaming	smoldering	total
M 10	12	198	210
M 2.5	10	168	178
H 4	3	102	105
O	26	2233	2259
0 2	7043	9088	16131

	Consumption tons/acre	Duration hour:min:sec
Flaming:	1.98	00:01:00
Smoldering:	3.70	00:29:00
Total:	5.68	

I¯'~E: Results of FOFEM model execution on date: 4/26/2002

FUEL CONSUMPTION CALCULATIONS

• ion: Interior West
Over Type: SAF/SRM - SAF 016 - Aspen
uel Type: Natural
• 1 Reference: FOFEM 561

FUEL CONSUMPTION TABLE

uel c, Donent a	Preburn Load (t/acre)	Consumed Load (t/acre)	Postburn Load (t/acre)	Percent Reduced (%)	Equation Reference Number	Moisture
itter	0.90	0.90	0.00	100.0	999	
c-l (0-1/4 inch)	0.20	0.20	0.00	100.0	999	
• 3 (1/4-1 inch)	0.80	0.80	0.00	100.0	999	25.0
c-d (1-3 inch)	1.00	0.43	0.57	42.9	999	
ood (3+ inch) Sound	2.70	0.20	2.50	7.5	999	20.0
3->6	0.67	0.11	0.57	0.2		
6->9	0.67	0.05	0.62	0.1		
9->20	0.67	0.03	0.65	0.0		
20->	0.67	0.01	0.66	0.0		
o''3 (3+ inch) Rotten	0.30	0.06	0.24	19.4	999	20.0
3->6	0.08	0.03	0.05	0.4		
6->9	0.08	0.02	0.06	0.2		
9->20	0.08	0.01	0.07	0.1		
20->	0.08	0.00	0.07	0.1		
• E	5.00	2.05	2.95	41.1	2	100.0
e. Daceous	0.30	0.30	0.00	100.0	22	
hrubs	0.50	0.30	0.20	60.0	23	
rnwn foliage	0.00	0.00	0.00	0.0	37	
• nrn branchwood	0.00	0.00	0.00	0.0	38	
otal Fuels	11.70	5.24	6.46	44.8		

IRE EFFECTS ON FOREST FLOOR COMPONENTS

• ast Floor o` :)onent	Preburn Condition	Amount Consumed	Postburn Condition	Percent Reduced	Equation Number
uff Depth (in)	0.5	0.1	0.4	28.1	6
i,- Soil Exp (%)	. 0	21.9	21.9	21.9	10

te:
'Duff' (tons/acre) and 'Duff Depth (in)' burned are computed using
• Eferent equations, sometimes this may cause an inconsistancy in
• a 'Percent Reduced' shown on this report.
Duff (tons/acre) consumed is best suited for predicting smoke production,
while Duff Depth (in) may be better related to fire severity and soil heating

	Emissions -- lbs/acre flaming	smoldering	total
M" i0	10	196	206
M 2.5	8	166	174
H 1	2	101	103
0	20	2218	2238
0 2	5577	9029	14606

	Consumption tons/acre	Duration hour :min: sec
Flaming:	1.57	00:01:00
Smoldering:	3.68	00:21:45
Total:	5.24	

'TLE: Results of FOFEM model execution on date: 4/26/2002

FUEL CONSUMPTION CALCULATIONS

agion: Interior West
)ver Type: SAF/SRM - SRM 413 - Gambel Oak - ex from Clary and Tiedemann '86
iel Type: Natural
iel Reference: SMFDB 229
iditionall Reference: PMS-832

FUEL CONSUMPTION TABLE

iel)mponent ime	Preburn Load (t/acre)	Consumed Load (t/acre)	Postburn Load (t/acre)	Percent Reduced (%)	Equation Reference Number	Moisture
_tter	2.30	2.30	0.00	100.0	999	
)od (0-1/4 inch)	0.00	0.00	0.00	0.0	999	
>od (1/4-1 inch)	0.00	0.00	0.00	0.0	999	25.0
Dod (1-3 inch)	0.00	0.00	0.00	0.0	999	
Dod (3+ inch) Sound	0.00	0.00	0.00	0.0	999	20.0
3->6	0.00	0.00	0.00	0.0		
6->9	0.00	0.00	0.00	0.0		
9->20	0.00	0.00	0.00	0.0		
20->	0.00	0.00	0.00	0.0		
)od (3+ inch) Rotten	0.00	0.00	0.00	0.0	999	20.0
3->6	0.00	0.00	0.00	0.0		
6->9	0.00	0.00	0.00	0.0		
9->20	0.00	0.00	0.00	0.0		
20->	0.00	0.00	0.00	0.0		
iff	0.00	0.00	0.00	0.0	2	100.0
_rbaceous	0.45	0.45	0.00	100.0	22	
irubs	6.92	4.15	2.77	60.0	23	
gown foliage	0.00	0.00	0.00	0.0	37	
rown branchwood	0.00	0.00	0.00	0.0	38	
Dtal Fuels	9.67	6.90	2.77	71.4		

IRE EFFECTS ON FOREST FLOOR COMPONENTS

crest Floor Dmponent	Preburn Condition	Amount Consumed	Postburn Condition	Percent Reduced	Equation Number
.iff Depth (in)	0.0	0.0	0.0	0.0	6
in Soil Exp (%)	.0	21.9	21.9	21.9	10

	Emissions -- lbs/acre flaming	smoldering	total
X 10	42	0	42
X 2.5	36	0	36
H 4	11	0	11
3	90	0	90
3 2	24550	0	24550

	Consumption tons/acre	Duration hour:min:sec
Flaming:	6.90	00:01:00
Smoldering:	0.00	00:00:00
Total:	6.90	

I"hE: Results of FOFEM model execution on date: 4/26/2002

FUEL CONSUMPTION CALCULATIONS

• ion: Interior-West
c„er Type: SAF/SRM - SAF 211 - White Fir
uel Type: Natural
i t Reference: FOFEM 061

FUEL CONSUMPTION TABLE

uel c¨nonent • S	Preburn Load (t/acre)	Consumed Load (t/acre)	Postburn Load (t/acre)	Percent Reduced (%)	Equation Reference Number	Moisture
itter	0.60	0.60	0.00	100.0	999	
c-d (0-1/4 inch)	0.23	0.23	0.00	100.0	999	
6d (1/4-1 inch)	0.67	0.67	0.00	100.0	999	25.0
c_'d (1-3 inch)	0.90	0.90	0.00	100.0	999	
ood (3+ inch) Sound	18.00	8.88	9.12	49.3	999	20.0
3->6	4.50	3.98	0.52	0.9		
6->9	4.50	2.60	1.90	0.6		
9->20	4.50	1.57	2.93	0.3		
20->	4.50	0.72	3.78	0.2		
q^d (3+ inch) Rotten	2.00	1.35	0.65	67.5	999	20.0
3->6	0.50	0.50	0.00	1.0		
6->9	0.50	0.43	0.07	0.9		
9->20	0.50	0.29	0.21	0.6		
20->	0.50	0.14	0.36	0.3		
• f	30.00	12.33	17.67	41.1	2	100.0
s baceous	0.15	0.15	0.00	100.0	22	
hrubs	0.35	0.21	0.14	60.0	23	
rown foliage	6.00	0.00	6.00	0.0	37	
• n branchwood	3.90	0.00	3.90	0.0	38	
otal Fuels	62.80	25.32	37.48	40.3		

IRE EFFECTS ON FOREST FLOOR COMPONENTS

• est Floor • ponent	Preburn Condition	Amount Consumed	Postburn Condition	Percent Reduced	Equation Number
uff Depth (in)	1.6	0.6	1.0	39.0	6
i Soil Exp (%)	.0	21.9	21.9	21.9	10

	Emissions -- lbs/acre flaming	smoldering	total
N,' LO	6	1298	1304
N, 2.5	5	1100	1105
H° 4	2	668	670
0	14	14657	14671
C' 2	3691	59659	63350

	Consumption tons/acre	Duration hour:min:sec
Flaming:	1.04	00:01:00
Smoldering:	24.28	01:46:00
Total:	25.32	

t

ITLE: Results of FOFEM model execution on date: 4/26/2002

FUEL CONSUMPTION CALCULATIONS

egion: Interior West
over Type: SAF/SRM - SAF 201 - White Spruce ex from photoseries PMS-831
uel Type: Natural
uel Reference: PMS-831

FUEL CONSUMPTION TABLE

uel omponent ame	Preburn Load (t/acre)	Consumed Load (t/acre)	Postburn Load (t/acre)	Percent Reduced (o)	Equation Reference Number	Moisture
itter	3.08	3.08	0.00	100.0	999	
ood (0-1/4 inch)	0.40	0.40	0.00	100.0	999	
ood (1/4-1 inch)	0.70	0.70	0.00	100.0	999	25.0
ood (1-3 inch)	2.00	2.00	0.00	100.0	999	
ood (3+ inch) Sound	0.27	0.10	0.17	35.6	999	20.0
3->6	0.07	0.05	0.02	0.7		
6->9	0.07	0.03	0.04	0.4		
9->20	0.07	0.02	0.05	0.2		
20->	0.07	0.01	0.06	0.1		
ood (3+ inch) Rotten	0.03	0.02	0.01	56.4	999	20.0
3->6	0.01	0.01	0.00	1.0		
6->9	0.01	0.01	0.00	0.7		
9->20	0.01	0.00	0.00	0.4		
20->	0.01	0.00	0.01	0.2		
uff	30.90	12.70	18.20	41.1	2	100.0
erbaceous	0.00	0.00	0.00	0.0	22	
hrubs	1.31	0.79	0.52	60.0	23	
rown foliage	0.00	0.00	0.00	0.0	37	
rown branchwood	0.00	0.00	0.00	0.0	38	
otal Fuels	38.69	19.78	18.91	51.1		

IRE EFFECTS ON FOREST FLOOR COMPONENTS

crest Floor omponent	Preburn Condition	Amount Consumed	Postburn Condition	Percent Reduced	Equation Number
uff Depth (in)	3.4	1.4	2.0	41.6	6
in Soil Exp (%)	.0	21.9	21.9	21.9	10

	Emissions -- lbs/acre flaming	smoldering	total
M 10	26	830	856
M 2.5	22	703	725
H 4	7	427	434
O	56	9367	9423
0 2	15152	38128	53280

	Consumption tons/acre	Duration hour :min: sec
Flaming:	4.26	00:01:15
Smoldering:	15.52	01:39:00
Total:	19.78	

;TLE: Results of FOFEM model execution on date: 4/26/2002

FUEL CONSUMPTION CALCULATIONS

'on: Interior West
r;)r Type: SAF/SRM - SRM 110 - Ponderosa Pine Grasslands
ie Type: Natural
iel Reference: FOFEM 011

FUEL CONSUMPTION TABLE

ic t)mponent	Preburn Load (t/acre)	Consumed Load (t/acre)	Postburn Load (t/acre)	Percent Reduced (%)	Equation Reference Number	Moisture
LL,er	1.40	1.40	0.00	100.0	999	
Dod (0-1/4 inch)	0.07	0.07	0.00	100.0	999	
1 (1/4-1 inch)	0.63	0.63	0.00	100.0	999	25.0
1 (1-3 inch)	0.80	0.32	0.48	39.4	999	
wi (3+ inch) Sound	4.50	0.32	4.18	7.1	999	20.0
3->6	1.12	0.17	0.95	0.2		
6->9	1.12	0.09	1.04	0.1		
9->20	1.12	0.04	1.08	0.0		
20->	1.12	0.02	1.11	0.0		
Dod (3+ inch) Rotten	0.50	0.10	0.40	19.1	999	20.0
3->6	0.12	0.05	0.08	0.4		
6->9	0.12	0.03	0.10	0.2		
9->20	0.12	0.01	0.11	0.1		
20->	0.12	0.01	0.12	0.1		
	5.00	2.05	2.95	41.1	2	100.0
a<.)aceous	0.50	0.50	0.00	100.0	22	
ibs	0.10	0.06	0.04	60.0	23	
rown foliage	6.00	0.00	6.00	0.0	37	
rrwn branchwood	0.70	0.00	0.70	0.0	38	
▷ it Fuels	20.20	5.44	14.76	26.9		

E EFFECTS ON FOREST FLOOR COMPONENTS

Drest Floor ▷ Donent	Preburn Condition	Amount Consumed	Postburn Condition	Percent Reduced	Equation Number
aff Depth (in)	0.6	0.2	0.4	30.8	6
in Soil Exp (%)	.0	21.9	21.9	21.9	10

'Duff' (tons/acre) and 'Duff Depth (in)' burned are computed using
different equations, sometimes this may cause an inconsistancy in
t'E~ 'Percent Reduced' shown on this report.
D--'=f (tons/acre) consumed is best suited for predicting smoke production,
while Duff Depth (in) may be better related to fire severity and soil heating

-	Emissions -- lbs/acre flaming	smoldering	total
MJ L0	12	185	197
M 2.5	10	157	167
H 4	3	95	98
0	26	2088	2114
0i	7053	8501	15554

	Consumption tons/acre	Duration hour:min:sec
Flaming:	1.98	00:01:00
Smoldering:	3.46	00:22:15
Total:	5.44	

GRAND CANYON NATIONAL PARK VISITOR VEHICLE EMISSIONS

Summer VMT	Winter VMT
31,245,221	6,892,433

	Emission Factors (g/mi)				Emissions (tons/yr)			
	NOx	**CO**	**VOC**	**PM10**	**NOx**	**CO**	**VOC**	**PM10**
Summer	0.91	9.70	1.06	0.91	31.28	333.39	36.43	31.28
Winter	1.17	18.24	1.30	0.91	8.87	138.29	9.86	6.90
				Total	40.15	471.68	46.29	38.18
					Emissions (lbs/yr)			
					80,294	943,353	92,576	76,352

TOTAL GRAND CANYON VISITOR VEHICLES

	South Entrance			East Entrance			North Rim			Tuweep
	Vehicles	Cars	Buses	Vehicles	Cars	Buses	Vehicles	Cars	Buses	Cars
Jan	50,195	48,659	1,536	5,343	5,228	115	0	0	0	222
Feb	38,950	37,403	1,547	6,304	6,128	176	0	0	0	186
Mar	98,315	96,098	2,217	13,119	12,849	270	0	0	0	594
Apr	100,823	98,272	2,551	17,845	17,487	358	0	0	0	1,158
May	117,225	114,272	2,953	18,569	18,095	474	11,851	11,805	46	1,232
Jun	117,447	114,580	2,867	22,346	21,843	503	15,377	15,291	86	650
Jul	134,097	131,107	2,990	25,226	24,715	511	21,689	21,613	76	1,748
Aug	118,253	115,087	3,166	24,369	23,861	508	20,266	20,192	74	600
Sep	89,037	86,896	2,141	18,845	18,469	376	18,531	18,441	90	850
Oct	85,178	83,440	1,738	15,935	15,675	260	11,158	11,073	85	722
Nov	68,128	66,915	1,213	9,757	9,631	126	2,763	2,763	0	496
Dec	65,800	64,880	920	7,109	7,039	70	0	0	0	177
	1,083,448	1,057,609	25,839	184,767	181,020	3,747	101,635	101,178	457	8,635

Grand Canyon Winter Visitor Vehicles

	South Entrance			East Entrance			North Rim			Tuweep
	Vehicles	Cars	Buses	Vehicles	Cars	Buses	Vehicles	Cars	Buses	Cars
Jan	50,195	48,659	1,536	5,343	5,228	115	0	0	0	222
Feb	38,950	37,403	1,547	6,304	6,128	176	0	0	0	186
Dec	65,800	64,880	920	7,109	7,039	70	0	0	0	177
	154,945	150,942	4,003	18,756	18,395	361	0	0	0	585

Grand Canyon Summer Visitor Vehicles

	South Entrance			East Entrance			North Rim			Tuweep
	Vehicles	Cars	Buses	Vehicles	Cars	Buses	Vehicles	Cars	Buses	Cars
Mar	98,315	96,098	2,217	13,119	12,849	270	0	0	0	594
Apr	100,823	98,272	2,551	17,845	17,487	358	0	0	0	1,158
May	117,225	114,272	2,953	18,569	18,095	474	11,851	11,805	46	**1,232**
Jun	117,447	114,580	2,867	22,346	21,843	503	15,377	15,291	86	650
Jul	134,097	131,107	2,990	25,226	24,715	511	21,689	21,613	76	1,748
Aug	118,253	115,087	3,166	24,369	23,861	508	20,266	20,192	74	600
Sep	89,037	86,896	2,141	18,845	18,469	376	18,531	18,441	90	850
Oct	85,178	83,440	1,738	15,935	15,675	260	11,158	11,073	85	**722**
Nov	68,128	66,915	1,213	9,757	9,631	126	2,763	2,763	0	496
	928,503	906,667	21,836	166,011	162,625	3,386	101,635	101,178	457	8,050

	Hermits Rest Traffic		
Jan	48,659		5,228
Feb	37,403		6128
Dec	64,880		7,039
	150,942		18,395
		Total	169,337

GRAND CANYON TOTAL VISITOR VM1

Entrance	Exit	Vehicles	Percent	Vehicles	Length	Annual VMT	Comments
Tuweep	Tuweep	8,635	100	8,635	16.0	138,160	Dirt Road
North Rim	North Rim	101,635	100	101,635	40.0	4,065,400	
East Entrance	South Entrance	184,767	97	179,224	37.5	6,720,900	
	East Entrance		3	5,543	56.0	310,409	
South Entrance	East Entrance	1,083,448	18	195,021	37.5	7,313,274	
	South Entrance		82	888,427	19.0	16,880,120	
Hermits Rest (Dec-Feb)				169,337	16.0	2,709,392	All Cars
						38,137,654	

GRAND CANYON WINTER VISITOR VMT

Entrance	Exit	Vehicles	Percent	Vehicles	Length	Annual VMT	Comments
Tuweep	Tuweep	585	100	585	16.0	9,360	Dirt Road
North Rim	North Rim	0	100	0	40.0	0	
East Entrance	South Entrance	18,756	97	18,193	37.5	682,250	
	East Entrance		3	563	56.0	31,510	
South Entrance	East Entrance	154,945	18	27,890	37.5	1,045,879	
	South Entrance		82	127,055	19.0	2,414,043	
Hermits Rest (Dec-Feb)				169,337	16.0	2,709,392	All Cars
						6,892,433	

GRAND CANYON SUMMER VISITOR VMT

Entrance	Exit	Vehicles	Percent	Vehicles	Length	Annual VMT	Comments
Tuweep	Tuweep	8,050	100	8,050	16.0	128,800	Dirt Road
North Rim	North Rim	101,635	100	101,635	40.0	4,065,400	
East Entrance	South Entrance	166,011	97	161,031	37.5	6,038,650	
	East Entrance		3	4,980	56.0	278,898	
South Entrance	East Entrance	928,503	18	167,131	37.5	6,267,395	
	South Entrance		82	761,372	19.0	14,466,077	
Hermits Rest (Dec-Feb)				0	16.0	0	
						31,245,221	

Grand Canyon NP GSA Leased Vehicles

Department	Sedans	Vans	Pickups	SUVs	MDTs	HDTs	
South Rim							
Administration	0	2	1	1	0	0	
Concessions	0	1	2	1	0	0	
Fire	2	0	15	2	0	0	
Interpretaion	1	2	1	0	0	0	
Project Management	0	2	0	0	0	0	
Science Center	2	4	2	2	0	0	
Superintendent	0	0	0	2	0	0	
Maintenance	2	6	37	6	15	14	
Visitor Protection	13	0	18	22	6	2	
Total Vehicles	20	17	76	36	21	16	
						Total	
Total Miles	148,236	126,584	356,100	225,541	79,885	83,879	1,020,225

Emissions							lbs/yr	tons/yr
HC	267	298	783	496	262	552	2,659	1.33
CO	2,576	3,125	8,516	5,394	3,562	1,823	24,996	12.50
Nox	235	239	713	452	557	1,366	3,561	1.78
PM	297	253	713	452	160	168	2,042	1.02

North Rim							
Total Vehicles	4	0	12	4	3	1	
						Total	
Total Miles	21,775	0	93,536	38,771	14,427	608	169,117

Emissions							lbs/yr	tons/yr
HC	39	0	206	85	47	4	382	0.19
CO	378	0	2,237	927	643	13	4,199	2.10
Nox	34	0	187	78	101	10	410	0.20
PM	44	0	187	78	29	1	339	0.17

Total GSA Vehicles							
Total Vehicles	24	17	88	40	24	17	
						Total	
Total Miles	170,011	126,584	449,636	264,312	94,312	84,487	1,189,342

Grand Canyon NP DO[-Owned Vehicles

Vehicle Type	Number	VMT
Sedans	21	67,873
Ambulances	6	7,290
Buses	27	562,326
LDT	41	90,934
MDT	6	148,903
HDT	25	82,135

NPS Buses	Number	VMT
Diesel	12	198,721
CNG	5	210,863
LNG	7	186,250
Electric	3	343
	27	596,177

Emissions	Sedans	Ambulances	LDTs	MDTs	HDTs	Diesel Buses	CNG/LNG Buses	lbs/yr	tons/yr
HC	122	17	200	328	269	1,307	522	2,766	1.38
CO	1,180	180	2,175	3,561	3,663	4,319	2,589	17,667	8.83
Nox	108	14	182	383	573	3,235	3,879	8,374	4.19
PM	136	15	182	298	164	398	80	1,272	0.64

	Sedans	Vans	Pickups	SUVs	MDTs	HDTs	TOTALS		
Number	45	23	129	40	30	69	336		
Mileage	237,884	133,874	540,570	264,312	243,215	728,948	2,148,803		
								lbs/yr	tons/yr
HC								5,806	2.90
CO								46,862	23.43
Nox								12,345	6.17
PM								3,653	1.83

Amfac Tour Buses and Vans

	Number	Mileage
Buses	24	129,150
Vans- Gasoline	6	202,060
Vans-Diesel	2	56,115
	32	387,325

	Gas Vans LDTs	Diesel Vans LDDT	Diesel Buses	Totals lbs/yr	tons/yr
HC	445	59	850	1,353	0.68
CO	4,832	180	2,807	7,820	3.91
Nox	4,832	467	2,103	7,401	3.70
PM	405	259	259	922	0.46

2000 GRAND CANYON NP NONROAD VEHICLE EMISSIONS

		Emission Factors (gm/hp-hr)							Emissions (lbs/yr)			
Vehicle	No.	PM	Nox	CO	VOC	hp	load	hrs/yr	PM	Nox	CO	VOC
Utility Cart	0	2.04	1.03	2.31	2.19	15	0.55	0	0.0	0.0	0.0	0.0
Tractors	5	2.04	1.03	2.31	2.19	42.35	0.68	623	80.5	40.7	91.2	86.4
Backhoe	4	2.04	1.03	2.31	2.19	77	0.55	481	91.4	0.0 46.2	0.0 103.5	98.1
Riding Mower	0	1.11	10.3	4.8	1.3	15	0.55	0	0.0	0.0	0.0	0.0
Brush Mower	0	1.11	10.3	4.8	1.3	15	0.55	0	0.0	0.0	0.0	0.0
Bobcat	0	2.04	1.03	2.31	2.19	15	0.55	0	0.0	0.0	0.0	0.0
Dozer	1	2.04	1.03	2.31	2.19	77	0.55	414	78.7	39.7	89.1	84.5
Grader	3	1.06	9.6	3.8	1.43	172	0.61	548	134.1	1214.3	480.7	180.9
Power Pruner	0	3.99	0.9	4.8	1.3	5	0.55	0	0.0	0.0	0.0	0.0
Stihl Brushcutters	0	3.99	0.9	4.8	1.3	5	0.55	0	0.0	0.0	0.0	0.0
Stihl 14 Quick Cut Saw	0	3.99	0.9	4.8	1.3	5	0.55	0	0.0	0.0	0.0	0.0
Post Hole Digger	0	3.99	0.9	4.8	1.3	5	0.55	0	0.0	0.0	0.0	0.0
Case Plate Tamper	0	3.99	0.9	4.8	1.3	5	0.55	0	0.0	0.0	0.0	0.0
Tamper Rammer	0	3.99	0.9	4.8	1.3	5	0.55	0	0.0	0.0	0.0	0.0
Pionjar	0	3.99	0.9	4.8	1.3	5	0.55	0	0.0	0.0	0.0	0.0
Wacker Trash Pump	0	3.99	0.9	4.8	1.3	5	0.55	0	0.0	0.0	0.0	0.0
Generators	0	3.99	0.9	4.8	1.3	5	0.55	0	0.0	0.0	0.0	0.0
Welder-Arc-Generator	0	3.99	0.9	4.8	1.3	5	0.55	0	0.0	0.0	0.0	0.0
Emglo Air Compressor	0	3.99	0.9	4.8	1.3	5	0.55	0	0.0	0.0	0.0	0.0
Sweeper	4	1.7	14	6.06	1.46	30	0.68	450	34.3	282.7	122.4	29.5
Leaf Blowers	0	3.99	0.9	4.8	1.3	1.2	0.55	0	0.0	0.0	0.0	0.0
Chainsaws	0	3.6	0.96	4.8	1.3	3	0.55	0	0.0	0.0	0.0	0.0
Trimmer	0	3.99	0.9	4.8	1.3	1.2	0.55	0	0.0	0.0	0.0	0.0
Weed Wacker	0	3.99	0.9	4.8	1.3	1.2	0.55	0	0.0	0.0	0.0	0.0
50 gallon Sprayer	0	1.7	14	6.06	1.46	9	0.55	0	0.0	0.0	0.0	0.0
Forklift	3	1.06	9.6	3.8	1.43	172	0.61	225	55.1	498.6	197.4	74.3
Front End Loader	10	1.11	10.3	4.8	1.3	77	0.55	2,532.00	261.86	2,429.84	1,132.35	306.68
Roller/Compactor	1	2.04	1.03	2.31	2.19	30	0.55	23	1.7	0.9	1.9	1.8
Skid Loader	0	1.11	10.3	4.8	1.3	77	0.55	0	0.0	0.0	0.0	0.0
Chipper	0	3.99	0.9	1372	495	30	0.55	0	0.0	0.0	0.0	0.0
Crane	0	1.06	9.6	3.8	1.43	172	0.61	0	0.0	0.0	0.0	0.0
Snowplow	0	1	8	5	1.22	210	0.65	0	0.0	0.0	0.0	0.0
							Totals:	(lbs/yr)	738	4,553	2,218	862
								(tons/yr)	0.37	2.28	1.11	0.43
Snowmobiles	16	2.7	0.86	300	110	48	0.34	6,000	582	185	64,627	23,697
							Totals:	(lbs/yr)	582	185	64,627	23,697
								(tons/yr)	0.29	0.09	32.31	11.85

5/25/02

GRAND CANYON NP COMMERCIAL MARINE VESSEL EMISSIONS

Diesel Engine Emission Factors'

Units	HC	CO	$NO_{,,}$	PM	SO_2
(g/hp-hr)	1.26	1.91	8.92	0.563	0.352
(lb/hp-hr)	0.003	0.004	0.020	0.001	0.001

1 g = 0.0022016 lbs

BSFC = 0.367 lb/hp-hr

Source: Exhaust Emission Factors for Nonroad Engine Modeling -- Compression-ignition EPA Report No., NR-009A; Table 1

2-Stroke Gasoline Engine Emission Factors [3]

Units	HC	CO	$NO_{,,}$	PM	SO_2
(g/hp-hr)	116.38	231.26	1.19	7.7	0.000
(lb/hp-hr)	0.256	0.509	0.003	0.017	0.000

4-Stroke Gasoline Engine Emission Factors [3]

Units	HC	CO	$NO_{,}$	PM	SO_2
(g/hp-hr)	14.92	339.18	7.46	0.06	0.000
(lb/hp-hr)	0.033	0.747	0.016	0.0001	0.000

[3] Source: Nonroad Emission Inventory Model, Draft, June 17, 1998

Criteria Pollutant Emissions [°]

Commercial Trips	No. of Engines	Engine Power (hp)	Hours of Operation [§]	Load Factor	HC (lb/yr)	CO (lb/yr)	NO_3 (lb/yr)	PM (lb/yr)	SO_2 (lb/yr)
541	1.6	30	29,214	0.21	9,673	219,900	4,837	39	0

[4] Assumes 4-stroke engines

'Assumes average trip is 9 days and motors are operated 6 hours per day

HC (ton/yr)	CO (ton/yr)	NO_3 (ton/yr)	PM (ton/yr)	SO_2 (ton/yr)
4.84	109.95	2.42	0.02	0.00

Emissions = Emission Factor' No. of Engines * Engine Power * Hours of Operation *Load Factor

GRAND CANYON NP PRIVATE MARINE VESSEL EMISSIONS

Diesel Engine Emission Factors'

Units	HC	CO	NO,,	PM	SO_2
(g/hp-hr)	1.26	1.91	8.92	0.563	0.352
(lb/hp-hr)	0.003	0.004	0.020	0.001	0.001

1 g = 0.002202
BSFC = 0.367

' Source: Exhaust Emission Factors for Nonroad Engine Modeling -- Compression-Ignition EPA Report No., NR-009A; Table 1

2-Stroke Gasoline Engine Emission Factors[3]

Units	HC	CO	NO,,	PM	SO_2
(g/hp-hr)	116.38	231.26	1.19	7.7	0.000
(lb/hp-hr)	0.256	0.509	0.003	0.017	0.000

4-Stroke Gasoline Engine Emission Factors [3]

Units	HC	CO	NO,,	PM	SO_2
(g/hp-hr)	14.92	339.18	7.46	0.06	0.000
(lb/hp-hr)	0.033	0.747	0.016	0.0001	0.000

[3] Source: Nonroad Emission Inventory Model, Draft, June 17, 1998

Criteria Pollutant Emissions[4]

Private Trips	No. of Engines	Engine Power (hp)	Hours of Operation[5]	Load Factor	HC (lb/yr)	CO (lb/yr)	NO,, (lb/yr)	PM (lb/yr)	SO_2 (lb/yr)
21	1.6	30	1,134	0.21	375	8,536	188	2	0

[4]Assumes 4-stroke engines

[5]Assumes average trip is 9 days and motors are operated 6 hours per day

(ton/yr)	(ton/yr)	(ton/yr)	(ton/yr)	(ton/yr)
0.19	4.27	0.09	0.00	0.00

Emissions = Emission Factor * No. of Engines * Engine Power * Hours of Operation `Load Factor

EDMS 3.23 Emissions Inventory Report

Study Name: Grand canyon

Airport: GRAND CANYON NATIONAL PAR

Report Date: 08/29/02

SUMMARY

(Tons/Year)

↓AME	CO	HC	NOx	SOX	*PM10*
ircraft	16.315	2.275	4.174	.445	.000
GSE/AGE/APU	.000	.000	.000	.000	.000
Dtal	16.315	2.275	4.174	.445	.000

AIRCRAFT EMISSIONS

(Tons/Year)

Aircraft	Engine	Mode	CO	HC	NOx	SOX	PM10
AH-1	T400-CP-400	TAXI	.000	.000	.000	.000	.000
AH-1	T400-CP-400	TKOF	.000	.000	.000	.000	.000
AH-1	T400-CP-400	CLMB	.880	.060	1.634	.180	.000
AH-1	T400-CP-400	APCH	5.174	1.457	.519	.091	.000
AH-1	T400-CP-400	APU	.000	.000	.000	.000	.000
AH-1	T400-CP-400	GSE	.000	.000	.000	.000	.000
AH-1	T400-CP-400	TAXI	.000	.000	.000	.000	.000
AH-1	T400-CP-400	TKOF	.000	.000	.000	.000	.000
AH-1	T400-CP-400	CLMB	.047	.003	.088	.010	.000
AH-1	T400-CP-400	APCH	.279	.079	.028	.005	.000
AH-1	T400-CP-400	APU	.000	.000	.000	.000	.000
AH-1	T400-CP-400	GSE	.000	.000	.000	.000	.000
AH-1	T400-CP-400	TAXI	.000	.000	.000	.000	.000
AH-1	T400-CP-400	TKOF	.000	.000	.000	.000	.000
AH-1	T400-CP-400	CLMB	.197	.013	.366	.040	.000
AH-1	T400-CP-400	APCH	1.158	.326	.116	.020	.000
AH-1	T400-CP-400	APU	.000	.000	.000	.000	.000
AH-1	T400-CP-400	GSE	.000	.000	.000	.000	.000
Cessna 150	0-200	TAXI	.000	.000	.000	.000	.000
Cessna 150	0-200	TKOF	.209	.004	.001	.000	.000
Cessna 150	0-200	CLMB	3.489	.075	.018	.000	.000
Cessna 150	0-200	APCH	2.881	.081	.003	.000	.000
Cessna 150	0-200	APU	.000	.000	.000	.000	.000
Cessna 150	0-200	GSE	.000	.000	.000	.000	.000
DHC-6	PT6A-27	TAXI	.000	.000	.000	.000	.000
DHC-6	PT6A-27	TKOF	.007	.000	.053	.004	.000
DHC-6	PT6A-27	CLMB	.038	.000	.223	.017	.000
DHC-6	PT6A-27	APCH	.718	.067	.258	.017	.000
DHC-6	PT6A-27	APU	.000	.000	.000	.000	.000
DHC-6	PT6A-27	GSE	.000	.000	.000	.000	.000
DHC-6	PT6A-27	TAXI	.000	.000	.000	.000	.000
DHC-6	PT6A-27	TKOF	.011	.000	.086	.006	.000

HC-6	PT6A-27	CLMB	.062	.000	.362	.028	.000
,HC-6	PT6A-27	APCH	1.165	.110	.419	.027	.000
r"HC-6	PT6A-27	APU	.000	.000	.000	.000	.000
HC-6	PT6A-27	GSE	.000	.000	.000	.000	.000

Denotes User Created Aircraft

EDMS 3.23 Study Information Grand canyon

Date: Thursday, August 29, 2002
Study Created: Thursday, August 29, 2002
Study Pathname: C:\EDMS\GRAND CANYON\Grand canyon.EDM

Airport: GRAND CANYON NATIONAL PAR, AZ GCN
Airport Location ([at / lon): 35-57-08.445N 112-08-49.106W
Field elevation: 6606
Metric airport layout units selected
Average temperature: 58.
Mixing Height: 3000
Vehicle fleet year: 2002

Hourly Profiles:
DEFAULT

Hour	Fraction of Peak	Hour	Fraction of Peak	Hour	Fraction of Peak
1	1.000	9	1.000	17	1.000
2	1.000	10	1.000	18	1.000
3	1.000	11	1.000	19	1.000
4	1.000	12	1.000	20	1.000
5	1.000	13	1.000	21	1.000
6	1.000	14	1.000	22	1.000
7	1.000	15	1.000	23	1.000
8	1.000	16	1.000	24	1.000

Daily Profiles:
DEFAULT

Day	Fraction of Peak	Day	Fraction of Peak
Monday	1.000	Friday	1.000
Tuesday	1.000	Saturday	1.000
Wednesday	1.000	Sunday	1.000
Thursday	1.000		

Monthly Profiles:
DEFAULT

Month	Fraction of Peak	Month	Fraction of Peak
January	1.000	July	1.000
February	1.000	August	1.000
March	1.000	September	1.000
April	1.000	October	1.000
May	1.000	November	1.000
June	1.000	December	1.000

Aircraft:

Aircraft Name	Engine Type	Aircraft Category	Identification
Cessna 150	0-200	SGPP	Air Grand Canyon

Annual LTO: 000000001910
TGO: 0
Annual Average Taxi Time: 0.00
Annual Average Queue Time: 0.00
Hourly Profile: DEFAULT
Daily Profile: DEFAULT
Monthly Profile: DEFAULT

Assigned Gate:
Aircraft does not use configurations
Assigned Taxiway 1: -NONE-
Assigned Taxiway 2: -NONE-
Assigned Taxiway 3: -NONE-
Assigned Runway:
Assigned GSE/AGE:
GSE Op Time

Aircraft Name	Engine Type	Aircraft Category	Identification
DHC-6	PT6A-27	SCTP	Air Grand canyon1

Annual LTO: 000000001910
TGO: 0
Annual Average Taxi Time: 0.00
Annual Average Queue Time: 0.00
Hourly Profile: DEFAULT
Daily Profile: DEFAULT
Monthly Profile: DEFAULT
Assigned Gate:
Aircraft does not use configurations
Assigned Taxiway 1: -NONE-
Assigned Taxiway 2: -NONE-
Assigned Taxiway 3: -NONE-
Assigned Runway:
Assigned GSE/AGE:
GSE Op Time

Aircraft Name	Engine Type	Aircraft Category	Identification
DHC-6	PT6A-27	SCTP	Grand Canyon Airlines

Annual LTO: 000000003100
TGO: 0
Annual Average Taxi Time: 0.00
Annual Average Queue Time: 0.00
Hourly Profile: DEFAULT
Daily Profile: DEFAULT
Monthly Profile: DEFAULT
Assigned Gate:
Aircraft does not use configurations
Assigned Taxiway 1: -NONE-
Assigned Taxiway 2: -NONE-
Assigned Taxiway 3: -NONE-
Assigned Runway:
Assigned GSE/AGE:
GSE Op Time

Aircraft Name	Engine Type	Aircraft Category	Identification
AH-1	T400-CP-400	SMTH	PapillonI

AnnualLTO: 000000020790
TGO: 0
Annual Average Taxi Time: 0.00
Annual Average Queue Time: 0.00
Hourly Profile: DEFAULT
Daily Profile: DEFAULT
Monthly Profile: DEFAULT
Assigned Gate:
Aircraft does not use configurations
Assigned Taxiway 1: -NONE-

Assigned Taxiway 2: -NONE-
Assigned Taxiway 3: -NONE-
Assigned Runway:
Assigned GSE/AGE:
GSE Op Time

Aircraft Name	Engine Type	Aircraft Category	Identification
AH-1	T400-CP-400	SMTH	Kenaii

Annual LTO: 000000001120
TGO: 0
Annual Average Taxi Time: 0.00
Annual Average Queue Time: 0.00
Hourly Profile: DEFAULT
Daily Profile: DEFAULT
Monthly Profile: DEFAULT
Assigned Gate:
Aircraft does not use configurations
Assigned Taxiway 1: -NONE-
Assigned Taxiway 2: -NONE-
Assigned Taxiway 3: -NONE-
Assigned Runway:
Assigned GSE/AGE:
GSE Op Time

Aircraft Name	Engine Type	Aircraft Category	Identification
AH-1	T400-CP-400	SMTH	Air Star

Annual LTO: 000000004653
TGO: 0
Annual Average Taxi Time: 0.00
Annual Average Queue Time: 0.00
Hourly Profile: DEFAULT
Daily Profile: DEFAULT
Monthly Profile: DEFAULT
Assigned Gate:
Aircraft does not use configurations
Assigned Taxiway 1: -NONE-
Assigned Taxiway 2: -NONE-
Assigned Taxiway 3: -NONE-
Assigned Runway:
Assigned GSE/AGE:
GSE Op Time

Advanced Dispersion Settings
Urban vs. Rural flag set to urban
Aircraft Settings

Aircraft Size:	Small	Large	Heavy
Initial Sigma Y:	6	15	25
Initial Sigma Z:	2	4	7

Stationary Source Settings
Initial Sigma Y: 2
Initial Sigma Z: 2