Appendix A

PINEDALE ANTICLINE PROJECT

EMISSIONS INVENTORY

Air Sciences Inc.	PROJECT TITLE: Pinedale Anticline Project	BY: C. Fraundorfer	FILE: inv_0199.xls
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ENGINEERING CALCULATIONS	SUBJECT: Emissions Calculation	DATE: May 12, 1999	

I. Construction Emissions

A. Well Pad Construction

Assumptions:			
	Active pad size	2.5 acres	Jonah II EIS
	Hours of Operation	5 days	Jonah II EIS
		8 hours/day	Jonah II EIS
	Emission factor	1.2 tons/acre-month	AP-42, Section 13.2.3 (Heavy Construction Operations, 1/95)
	Watering control efficiency	50%	Wyoming DEQ (from Jonah II EIS)
	PM_{10} multiplier	0.35	AP-42, Section 13.2.4 (Aggregate handling and storage piles, 1/95)
	$PM_{2.5}$ multiplier	0.11	AP-42, Section 13.2.4 (Aggregate handling and storage piles, 1/95)

Controlled TSP Emissions Calculation:

1.2 tons / acre-mo	2.5 acres	5 days / wellsite	1 month / 30 days	50% =	0.25 tons PM_{10} / wellsite

	Well Pad Construction Emissions	
	tons/wellsite	lb/hour - max
TSP	0.25	12.50
PM_{10}	0.0875	4.38
$PM_{2.5}$	0.0275	1.38

B. Resource Road Construction

Assumptions:			
	Road length:	0.4 miles	Jonah II EIS
	Road width:	40 feet	Jonah II EIS
	Hours of Operation	5 days	Jonah II EIS
		8 hours	Jonah II EIS
	Emission factor	1.2 tons/acre-month	AP-42, Section 13.2.3 (Heavy Construction Operations, 1/95)
	Watering control efficiency	50%	Wyoming DEQ (from Jonah II EIS)
	PM_{10} multiplier	0.35	AP-42, Section 13.2.4 (Aggregate handling and storage piles, 1/95)
	$PM_{2.5}$ multiplier	0.11	AP-42, Section 13.2.4 (Aggregate handling and storage piles, 1/95)

Controlled TSP Emissions Calculation:

40 feet	0.4 miles	5280 feet / 1 mile	1 acre / 43560 ft2	=	1.94 acres

1.20 tons / acre-mo	1.94 acres	5 days / wellsite	1 month / 30 days	50%	=	0.19 tons PM_{10} / wellsite

	Resource Road Construction	
	tons/wellsite	lb/hour - max
TSP	0.19	9.70
PM_{10}	0.07	3.39
$PM_{2.5}$	0.02	1.07

I. Construction Emissions (continued)

C. Resource Road Traffic

Assumptions:			
	Road Length	5 miles	Jonah II EIS
	Watering control efficiency	50%	Wyoming DEQ (from Jonah II EIS)
	Road silt content	5.1 %	Jonah II EIS
	Moisture	0.2 %	AP-42, Section 13.2.2 (9/98), default value

$PM_{10}/PM_{2.5}$ Emission Factor Equation (AP-42, Section 13.2.2-3, 9/98)

$$E[lb/VMT] = \frac{k(s/12)^a (W/3)^b}{(M/0.2)^c}$$

E = size-specific emission factor (lb/VMT)

s = surface material silt content (%)

W = mean vehicle weight (tons)

M = surface material moisture content (%)

	PM_{10}	$PM_{2.5}$
k	2.6	0.38
a	0.8	0.8
b	0.4	0.4
c	0.3	0.3

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I. Construction Emissions (continued)

C. Resource Road Traffic (continued)

	Average Weight (lb)	Round-trips	Hours/ Wellsite	Controlled Emission Factors (lb/VMT)*		PM_{10} Emissions lb/hr -		$PM_{2.5}$ Emissions lb/hr -	
				PM_{10}	$PM_{2.5}$	max	ton/well	max	ton/well
Semi: Hvy Equip Hauler	74,000	3	40	1.79	0.26	1.34	0.03	0.20	0.00
Haul Truck: Gravel Haul	48,000	33	40	1.51	0.22	12.43	0.25	1.82	0.04
Pickup Trucks: Crews	7,000	47	40	0.70	0.10	8.19	0.16	1.20	0.02
Construction Total						**21.96**	**0.44**	**3.21**	**0.06**
Semi: Rig Transport	60,000	22	192	1.65	0.24	1.89	0.18	0.28	0.03
Haul: Fuel Truck	48,000	13	192	1.51	0.22	1.02	0.10	0.15	0.01
Haul: Mud Truck	48,000	2	192	1.51	0.22	0.16	0.02	0.02	0.00
Haul: Logging Truck	20,000	1	192	1.06	0.16	0.06	0.01	0.01	0.00
Haul: Water Truck	20,000	22	192	1.06	0.16	1.22	0.12	0.18	0.02
Pickup: Rig Crews	8,000	44	192	0.74	0.11	1.69	0.16	0.25	0.02
Pickup: Rig Mechanic	8,000	4	192	0.74	0.11	0.15	0.01	0.02	0.00
Picup: Company Supervisor	7,000	9	192	0.70	0.10	0.33	0.03	0.05	0.00
Pickup: Tool Pusher	8,000	9	192	0.74	0.11	0.34	0.03	0.05	0.00
Pickup: Mud Logger	8,000	9	192	0.74	0.11	0.34	0.03	0.05	0.00
Pickup: Mud Engineers	8,000	44	192	0.74	0.11	1.69	0.16	0.25	0.02
Pickup: Engineer's Truck	8,000	1	192	0.74	0.11	0.04	0.00	0.01	0.00
Pickup: Drill Bit Deliveries	8,000	1	192	0.74	0.11	0.04	0.00	0.01	0.00
Pickup: Miscellaneous	8,000	12	192	0.74	0.11	0.46	0.04	0.07	0.01
Drilling Total						**9.41**	**0.90**	**1.38**	**0.13**
Semi_Casing Haulers	74,000	1	120	1.79	0.26	0.15	0.01	0.02	0.00
Semi_:Cementer	74,000	1	120	1.79	0.26	0.15	0.01	0.02	0.00
Semi:Completion	74,000	1	120	1.79	0.26	0.15	0.01	0.02	0.00
Semi: Fracing	80,000	2	120	1.85	0.27	0.31	0.02	0.05	0.00
Semi: Pumping/Tank Battery	74,000	3	120	1.79	0.26	0.45	0.03	0.07	0.00
Haul: Cementer	48,000	1	120	1.51	0.22	0.13	0.01	0.02	0.00
Haul: Comletion	48,000	1	120	1.51	0.22	0.13	0.01	0.02	0.00
Haul: Rig Mechanic	48,000	1	120	1.51	0.22	0.13	0.01	0.02	0.00
Haul: Perforators	20,000	4	120	1.06	0.16	0.35	0.02	0.05	0.00
Haul: Anchor	48,000	1	120	1.51	0.22	0.13	0.01	0.02	0.00
Haul: Fracing, tank	48,000	8	120	1.51	0.22	1.00	0.06	0.15	0.01
Haul: Service Tools	20,000	1	120	1.06	0.16	0.09	0.01	0.01	0.00
Haul: Fracing, pump	48,000	20	120	1.51	0.22	2.51	0.15	0.37	0.02
Haul: Fracing, chemical	44,000	4	120	1.45	0.21	0.48	0.03	0.07	0.00
Haul: Fracing, sand	44,000	32	120	1.45	0.21	3.88	0.23	0.57	0.03
Haul: Fracing, other	44,000	24	120	1.45	0.21	2.91	0.17	0.43	0.03
Welders	48,000	1	120	1.51	0.22	0.13	0.01	0.02	0.00
Water Truck	20,000	16	120	1.06	0.16	1.41	0.08	0.21	0.01
Pickup: Cementer	7,000	1	120	0.70	0.10	0.06	0.00	0.01	0.00
Pickup: Casing Crew	7,000	1	120	0.70	0.10	0.06	0.00	0.01	0.00
Pickup: Completion Crew	7,000	4	120	0.70	0.10	0.23	0.01	0.03	0.00
Pickup: Competion, pusher	7,000	4	120	0.70	0.10	0.23	0.01	0.03	0.00
Pickup: Perforators, engineer	7,000	1	120	0.70	0.10	0.06	0.00	0.01	0.00
Pickup: fracing	7,000	4	120	0.70	0.10	0.23	0.01	0.03	0.00
Pickup: Company Supervisor	7,000	4	120	0.70	0.10	0.23	0.01	0.03	0.00
Pickup: Misc Supplies	8,000	2	120	0.74	0.11	0.12	0.01	0.02	0.00
Pickup: Roustabout Crew	7,000	2	120	0.70	0.10	0.12	0.01	0.02	0.00
Completion/Testing Total						**15.82**	**0.95**	**2.31**	**0.14**

*This emission factor represents a short term emission factor that does not take into account annual precipitation (i.e., (365-p)/365)

I. Construction Emissions (continued)

D. Tailpipe Emissions: Haul Trucks

Assumptions:		
Road length	5 miles	Jonah II EIS
Number of roundtrips:		
Equipment haul trucks	3	Jonah II EIS
Gravel haul trucks	33	Jonah II EIS
Drill trucks	100	Jonah II EIS
Trucks during complet./test.	75	Jonah II EIS
Diesel fuel sulfur content:	0.05%	Pinedale-specific assumption
Diesel fuel density	7.08 lb/gal	Jonah II EIS
Mileage	10 mi/gal	Jonah II EIS

Haul Trucks

	Emission Factors g/mile	Emissions per Well Construction lb/hr - max[1]	Emissions per Well Construction tons/year	Emissions per Well Drilling lb/hr - max[2]	Emissions per Well Drilling tons/year	Emissions per Well Completion lb/hr - max[3]	Emissions per Well Completion tons/year
Hours of Operation		40		192		120	
Number of roundtrips		36		100		75	
NO_x [4]	8.13	0.16	0.003	0.09	0.009	0.11	0.007
CO [4]	17.09	0.34	0.007	0.20	0.019	0.24	0.014
VOCs[4,5]	4.83	0.10	0.002	0.06	0.005	0.07	0.004
SO_2 [6]	0.32	0.006	0.000	0.004	0.000	0.004	0.000

[1]Based on 5 days, 8 hours/day

[2] Based on 24 days, 8 hours/day

[3] Based on 15 days, 8 hours/day

[4]AP-42, Volume II, Mobile Sources, Highway Vehicles, Appendix H, Heavy-Duty Diesel Trucks, Model 1991-1997, 50,000 Mile Emission Level (6/95)

[5]Emission factor represents total organic compounds.

[6]Mass balance

I. Construction Emissions (continued)

E. Tailpipe Emissions: Heavy Equipment

Assumptions:

Hours of Operation:

Backhoe, Dozer, Grader	5 days	Jonah II EIS
	8 hrs/day	Jonah II EIS
Drilling	20 days	Jonah II EIS
	24 hrs/day	Jonah II EIS

Load Factor:

Backhoe, Dozer, Grader	0.4	Jonah II EIS
Drilling	0.42	Jonah II EIS

	Emission Factors (g/hp-hr)			
	Backhoe[1]	Dozer[1]	Grader[2]	Drilling[3]
Size (hp)	70	150	135	1,000
Load Factor	0.40	0.40	0.40	0.42
Hours of Operation	40	40	40	480
NOx	8.15	8.15	7.14	11.01
CO	2.28	2.28	1.54	4.60
VOCs[4]	0.37	0.37	0.36	1.01
PM_{10}[5]	0.50	0.50	0.63	0.90
$PM_{2.5}$[6]	0.50	0.50	0.63	0.90
SO2	0.22	0.22	0.22	0.23
Formaldehyde	0.22	0.22	0.12	0.20

	Backhoe		Dozer		Grader		Drilling	
Size (hp)	70		150		135		1,000	
Load factor	0.40		0.40		0.40		0.42	
Hours of operation	40		40		40		480	
	lb/hr - max	ton/yr	lb/hr - max	ton/yr	lb/hr - max	ton/yr	lb/hr - max	ton/yr
NOx	0.50	0.01	1.08	0.02	0.85	0.02	10.19	2.45
CO	0.14	0.00	0.30	0.01	0.18	0.00	4.26	1.02
VOCs[4]	0.02	0.00	0.05	0.00	0.04	0.00	0.94	0.22
PM_{10}[5]	0.03	0.00	0.07	0.00	0.07	0.00	0.84	0.20
$PM_{2.5}$[6]	0.03	0.00	0.07	0.00	0.07	0.00	0.84	0.20
SO2	0.01	0.00	0.03	0.00	0.03	0.00	0.22	0.05
Formaldehyde	0.01	0.00	0.03	0.00	0.01	0.00	0.19	0.05

[1] AP-42, Volume II, Mobile Sources, Nonroad Vehicles, Table II-7.1, Off-highway truck

[2] AP-42, Volume II, Mobile Sources, Nonroad Vehicles, Table II-7.1, Motor grader

[3] AP-42, Volume II, Mobile Sources, Nonroad Vehicles, Table II-7.1, Miscellaneous

[4] Emission factor represents total hydrocarbons.

[5] Emission factor represents total particulate matter.

[6] All particulate matter assumed to be PM2.5

I. Construction Emissions (continued)

F. Flaring

Assumptions:			
	Hours of operation	3 days	Jonah II EIS
		24 hours/day	Jonah II EIS
	Gas flared	5 MMCFD	Jonah II EIS
	Gas heat content	1000 Btu/scf	Jonah II EIS

	Emission Factors	Emissions Per Well	
	lb/MMCF	lb/hr - max	tons/well
NOx [1]	68.00	14.17	0.51
CO [1]	370.00	77.08	2.78
VOCs [1]	63.00	13.13	0.47
PM_{10} [2]	7.60	1.58	0.06
$PM_{2.5}$ [2]	7.60	1.58	0.06
SO_2	0.00	0.00	0.00
Benzene[2]	0.0021	0.0004	0.0000
Formaldehyde[2]	0.0750	0.02	0.00
Hexane[2]	1.80	0.38	0.01
Toluene[2]	0.0034	0.0007	0.0000

[1]AP-42, Tables 13.5-1 and 13.5-2, 9/91.

[2]AP-42, Tables 1.4-2 and 1.4-3 (3/98)

II. Production Emissions

A. Three-Phase Separator Heater (October - April only)[4]

Assumptions:

Size	0.75 MMBtu/hour	Jonah II EIS
Fuel heat content	1,000 Btu/SCF	Jonah II EIS
Time	5,088 hours/year	Jonah II EIS, October - April
	15 minutes/hr	

Pollutant	Emission Factors lb/MMCF		Emissions per Well lb/hr - max	tons/year
NOx	100.00	1	0.02	0.048
CO	84.00	1	0.02	0.040
VOCs	5.50	1	0.001	0.003
PM10	7.60	1	0.001	0.004
PM2.5	7.60	3	0.001	0.004
SO2	0.60	1,2	1.13E-04	0.000
Hexane	1.80	1	3.38E-04	0.001
Benzene	2.10E-03	1	3.94E-07	1.00E-06
Toluene	3.40E-03	1	6.38E-07	1.62E-06
Formaldehyde	7.50E-02	1	1.41E-05	3.58E-05

[1]AP-42, Tables 1.4-1 and 1.4-2.

[2]Assumes 2000 grains S/MMCF gas

[3] All particulate matter assumed to be $PM_{2.5}$

[4]Emissions from May - September will be zero.

B. Dehydration Heater

Assumptions:

Size	0.13 MMBtu/hour	Jonah II EIS
Fuel heat content	1,000 Btu/SCF	Jonah II EIS
Time	8,760 hours/year	Jonah II EIS
	15 minutes/hr	

Pollutant	Emission Factors lb/MMCF		Emissions per Well lb/hr - max	tons/year
NOx	94.00	1	0.003	0.013
CO	40.00	1	0.001	0.005
VOCs	5.50	1	1.72E-04	0.001
PM10	7.60	1	2.38E-04	0.001
PM2.5	7.60	3	2.38E-04	0.001
SO2	0.60	1,2	1.88E-05	8.21E-05
Hexane	1.80	1	5.63E-05	2.46E-04
Benzene	2.10E-03	1	6.56E-08	2.87E-07
Toluene	3.40E-03	1	1.06E-07	4.65E-07
Formaldehyde	7.50E-02	1	2.34E-06	1.03E-05

[1]AP-42, Tables 1.4-1 and 1.4-2.

[2]Assumes 2000 grains S/MMCF gas

[3] All particulate matter assumed to be $PM_{2.5}$

II. Production Emissions (continued)

C. Dehydration VOC Emissions - GLYCALC

Total field gas production rate: 350.0 MMCF/day — BLM, Bill McMahan, 3/99, represents maximum year

	Emission Factor[1] lb/MMCF	PAP Emissions lb/hr	ton/yr
VOCs	29.73	433.50	1,898.72
Benzene	3.65	53.28	233.36
Toluene	9.09	132.49	580.32
Ethylbenzene	0.60	8.79	38.50
Xylenes	7.75	113.02	495.03
n-Hexane	0.28	4.13	18.11

[1]Emission factors developed from GLYCALC runs from McMurry Oil (3/99).

D. Flashing Emissions - HYSIM

Total field condensate production rate:	3,150 BBL/day	BLM, Bill McMahan, 3/99, represents maximum year
	0.11 MMCF gas/bbl condensate	BLM, Bill McMahan, 3/99
Pressure	700 psig	McMurry Oil, Robin Smith, 3/99
Flare efficiency	98%	Assumption

	Emission Factor[1] lb/bbl	PAP Emissions w/BACT[2] lb/hr	ton/yr	PAP Emissions w/o BACT[2] lb/hr	ton/yr	PAP Emissions Total lb/hr	ton/yr
VOCs	11.31	5.94	26.01	1,188	5,203	1,194	5,229
Benzene	0.01	0.01	0.03	1.38	6.06	1.39	6.09
Toluene	0.00	0.00	0.00	0.01	0.05	0.01	0.05
Ethylbenzene	0.00	0.00	0.01	0.27	1.18	0.27	1.18
Xylenes	0.00	0.00	0.00	0.10	0.43	0.10	0.44
n-Hexane	0.54	0.28	1.24	57	248	57	249

[1]Emission factors developed from HYSYS runs from McMurry Oil, 3/99.

[2]Assume 20% of condensate production is coming from wells with BACT.

II. Production Emissions (continued)

E. Flare on Flashing Vent

Average gas flared for wells with BACT:	302.74 scf/bbl	Jonah II EIS
	0.19 MMSCF/day	Assume 20% of condensate production is coming from wells with BACT.
Gas heat content	1000 Btu/scf	Jonah II EIS

Combustion Emissions - Flare

	Emission Factors lb/MMCF	Volume of Gas Flared lb/hr	tons/year
NOx [1]	68.00	0.54	2.37
CO [1]	370.00	2.94	12.88
PM_{10} [2]	7.60	0.06	0.265
$PM_{2.5}$ [2]	7.60	0.06	0.265
SO_2	0.00	0.00	0.00

[1]AP-42, Tables 13.5-1 and 13.5-2, 9/91.

[2]AP-42, Tables 1.4-2 and 1.4-3 (3/98)

III. Erosion Emissions

(Summary from Jonah II EIS)

Assumptions:

Friction velocity [m/s]	0.053 * hourly averaged wind speed [m/s]	AP-42, Section 13.2.5-5 (Equation 4)
Threshold friction velocity	1.33 m/s	AP-42, Table 13.2.5-2 (1/95), Scoria
Total area exposed	17,823 m^2	
Roughness height	0.5 cm	
Meteorological data	1995 - Rock Springs	
Surface Type	Flat	
PM10 multiplier (k):	0.5	
PM2.5 multiplier (k):	0.2	

Erosion potential function (to be calculated for each hour):

$P=58(u^*-u_t^*)2+25(u^*-u_t^*)$,$u^* > u_t^*$

0 ,$u^* \leq u_t^*$

.Total erosion emissions (E) [g/m2]:

E=sum of (kP) over all hours

	Erosion Emissions	
	lb/hour	tons/year
PM_{10}	0.03	0.12
$PM_{2.5}$	0.01	0.05

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IV. Fieldwide Compression

Pollutant	Emission Factor g/hp-hr	16,000 hp Emissions lb/hr	16,000 hp Emissions tons/yr	26,000 hp Emissions lb/hr	26,000 hp Emissions tons/yr
NOx	1.50 [1]	52.91	231.75	85.98	376.59
	1 [1]	35.27	154.50	57.32	251.06
	0.7 [1]	24.69	108.15	40.12	175.74
CO	3 [1]	105.82	463.50	171.96	753.19
VOCs	0.31 [2]	11.04	48.36	17.94	78.58
PM10	0.10 [2]	3.52	15.42	5.72	25.05
PM2.5	0.10 [3]	3.52	15.42	5.72	25.05
SO2	0.002 [2]	0.07	0.29	0.11	0.48
Benzene	0.0030 [2]	0.11	0.47	0.17	0.76
Ethylbenzene	0.0002 [2]	0.01	0.03	0.01	0.04
n-Hexane	0.0027 [2]	0.10	0.42	0.16	0.68
Toluene	0.0009 [2]	0.03	0.13	0.05	0.22
Xylenes	0.0002 [2]	0.01	0.03	0.01	0.05
Formaldehyde	0.1497 [2]	5.28	23.13	8.58	37.58

[1] Specified emission factor

[2] AP-42, Table 3.2-2 (draft section), (2/97)

[3] All particulate matter assumed to be $PM_{2.5}$