APPENDIX D

EMISSIONS INVENTORY

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Buys & Associates, Inc. **Environmental Consultants**	Project: Tumbleweed EA Date: 4/1/2009

1. Well Pad/Road Construction Emissions (Dozers and Backhoes

Assumptions:

Well Pad/RoadArea	12.49	acres initial disturbance per pad (Proposed Action)
Hours of Construction	10	days per well pad (Proposed Action)
	10	hours/day
	100	hours per well pad
Watering Control Efficiency	50	percent (Assumption)
Soil Moisture Content	7.9	percent (AP-42 Table 11.9-3, 10/98)
Soil Silt Content	6.9	percent (AP-42 Table 11.9-3, 10/98)

Equations: From AP-42 tables 11.9-1 and 11.9-3
Bulldozing Overburden Emissions, Western Surface Coal Mining, 10/98
AP-42 Table 13.2.3-1 Recommended Emission Factors for Construction Operations

Emissions (TSP lbs/hr) = 5.7 * (soil silt content %)$^{1.2}$ * (soil moisture content %)$^{-1.3}$ * Control Efficiency
Emissions (PM_{15} lbs/hr) = 1.0 * (soil silt content %)$^{1.5}$ * (soil moisture content %)$^{-1.4}$ * Control Efficiency

$PM_{2.5}$ Multiplier = 0.105 * TSP (AP-42 Table 11.9-1, 10/98)
PM_{10} Multiplier = 0.75 * PM_{15} (AP-42 Table 11.9-1, 10/98)

Emissions = 1.97 lbs TSP/hour/piece of equipment

Emissions = 0.50 lbs PM_{15}/hour/piece of equipment

	Dozer and Backhoe Emissions [a]		
	lbs/hr	**tons/well**	**tons/yr** [b]
TSP	7.88	0.3941	2.76
PM_{15}	2.01	0.1004	0.70
PM_{10}	1.51	0.0753	0.53
$PM_{2.5}$	0.83	0.0414	0.29

[a] Assumes one dozer and one backhoe. Backhoe emissions are conservatively estimated as equivalent to Dozer emissions.

[b] Assumes maximum development scenario

Buys & Associates, Inc. **Environmental Consultants**	Project: Tumbleweed EA Date: 4/1/2009

2. Well Pad/Road Construction Emissions (Grader)

Assumptions:

Grading Length	3.67	Miles	(Note = Grader Road length + Grader Pad Length)
		Grader road length = Access road length x 3 (# of 10-ft swath for 32' ROW)	
		Grader Pad Length = (10 ft swath for 350 ft * 16 lengths) = 5,600 ft	
Hours of Construction	6	day grading per well pad and road (Estimate)	
	10	hours/day	
	60	hours per well pad	
Watering Control Efficiency	50	percent (Assumption)	
Average Grader Speed	7.1	mph (Typical value AP-42 Table 11.9-3, 10/98)	
Distance Graded	3.67	miles	

Equations: From AP-42 tables 11.9-1 and 11.9-3
Bulldozing Overburden Emissions, Western Surface Coal Mining, 10/98
AP-42 Table 13.2.3-1 Recommended Emission Factors for Construction Operations

Emissions (TSP lbs) = 0.040 * (Mean Vehicle Speed)$^{2.5}$ * Distance Graded * Control Efficiency

Emissions (PM_{15} lbs) = 0.051 * (Mean Vehicle Speed)$^{2.0}$ * Distance Graded * Control Efficiency

PM_{10} Multiplier = 0.6 * PM_{15} (AP-42 Table 11.9-1, 10/98)
$PM_{2.5}$ Multiplier = 0.031 * TSP (AP-42 Table 11.9-1, 10/98)

Emissions = 9.87 lbs TSP/well

Emissions = 4.72 lbs PM_{15}/well

	Grader Construction Emissions			
	lbs/well pad	**lbs/hr**	**tons/well pad**	**tons/yr [a]**
TSP	9.87	0.16	0.2962	2.07
PM_{15}	4.72	0.08	0.0000	0.00
PM_{10}	2.83	0.05	0.0709	0.50
$PM_{2.5}$	0.31	0.01	1.53E-04	1.07E-03

[a] Assumes maximum development scenario

Buys & Associates, Inc. **Environmental Consultants**	Project: Tumbleweed EA Date: 4/1/2009

3. Well Pad/Road Construction Heavy Equipment Tailpipe Emissions

Assumptions:

Hours of Operation 100 hours/site (Proposed Action)

Development Rate 7 new pads per year (Proposed Action)

Load Factor 0.4 (Assumed typical value)

Backhoe Size 129 hp (Mid-sized typical value + Class 125)

Dozer Size 686 hp (Largest D6 series+Class 988)

Motor Grader Size 158 hp (Largest D12 series)

Equations:

$$\text{Emissions (tons/year)} = \frac{\text{Emission Factor (g/hp-hr)} * \text{Rated Horsepower (hp)} * \text{Operating Hours (hrs)} * \text{Load Factor (Dimensionless)}}{453.6\ \text{(g/lb)} * 2000\ \text{(lb/tons)}}$$

Heavy Const. Vehicles	**Backhoe**			**Dozer**			**Grader**		
	E. Factor [a] (g/hp-hr)	Emissions (lb/hr)	Emissions[e] (tons/yr)	E. Factor [a] (g/hp-hr)	Emissions (lb/hr)	Emissions[e] (tons/yr)	E. Factor [b] (g/hp-hr)	Emissions (lb/hr)	Emissions[e] (tons/yr)
NOx	8.15	0.927	0.324	8.15	4.930	1.726	7.14	0.995	0.348
CO	2.28	0.259	0.091	2.28	1.379	0.483	1.54	0.215	0.075
VOC [c]	0.37	0.042	0.015	0.37	0.224	0.078	0.36	0.050	0.018
PM_{10} [d]	0.5	0.057	0.020	0.5	0.302	0.106	0.63	0.088	0.031
$PM_{2.5}$ [d]	0.5	0.057	0.020	0.5	0.302	0.106	0.63	0.088	0.031
SO_2	0.22	0.025	0.009	0.22	0.133	0.047	0.22	0.031	0.011
Formaldehyde	0.22	0.025	0.009	0.22	0.133	0.047	0.12	0.017	0.006

Heavy Const. Vehicles	**Total**	
	Emissions (lb/hr)	Emissions[e] (tons/yr)
NOx	6.852	2.398
CO	1.853	0.649
VOC [c]	0.316	0.111
PM_{10} [d]	0.447	0.156
$PM_{2.5}$ [d]	0.447	0.156
SO_2	0.189	0.066
Formaldehyde	0.175	0.061

a AP-42 Volume II, Mobile Sources, Nonroad Vehicles, Table 11-7.1 Off-highway truck
b AP-42 Volume II, Mobile Sources, Nonroad Vehicles, Table 11-7.1 Motor Grader
c Emission Factor represents total Hydrocarbon Emissions
d All emitted particulate matter assumed to be $PM_{2.5}$
e Assumes maximum development scenario

4. Pipeline Installation Tailpipe Emissions (Pipelayer)

Assumptions:

Hours of Operation 20 hours/site (Proposed Action)

Development Rate 7 new pads per year (Proposed Action)

Load Factor 0.4 (Typical value)

Pipelayer Size 240 hp (Typical value)

Equations:

$$\text{Emissions (tons/year)} = \frac{\text{Emission Factor (g/hp-hr)} * \text{Rated Horsepower (hp)} * \text{Operating Hours (hrs)} * \text{Load Factor (Dimensionless)}}{\text{453.6 (g/lb)} * \text{2000 (lb/tons)}}$$

Heavy Const. Vehicles	Pipelayer		
	E. Factor [a] (g/hp-hr)	Emissions (lb/hr)	Emissions[e] (tons/yr)
NOx	8.15	1.725	0.121
CO	2.28	0.483	0.034
VOC [c]	0.37	0.078	0.005
PM_{10} [d]	0.5	0.106	0.007
$PM_{2.5}$ [d]	0.5	0.106	0.007
SO_2	0.22	0.047	0.003
Formaldehyde	0.22	0.047	0.003

[a] AP-42 Volume II, Mobile Sources, Nonroad Vehicles, Table 11-7.1 Off-highway truck
[b] AP-42 Volume II, Mobile Sources, Nonroad Vehicles, Table 11-7.1 Motor Grader
[c] Emission Factor represents total Hydrocarbon Emissions
[d] All emitted particulate matter assumed to be $PM_{2.5}$
[e] Assumes maximum development scenario

Buys & Associates, Inc. **Environmental Consultants**	Project: Tumbleweed EA Date: 4/1/2009

5. Interim Reclamation Fugitive Dust Emissions

Assumptions:

Hours of Reclamation	2	days per well pad (Estimate)
	8	hours/day
	16	hours per well pad
Pieces of Equipment	1	- Dozer
Watering Control Efficiency	50	percent (assumption)
Soil Moisture Content	7.9	percent (AP-42 Table 11.9-3, 10/98)
Soil Silt Content	6.9	percent (AP-42 Table 11.9-3, 10/98)

Equations: From AP-42 tables 11.9-1 and 11.9-3
Bulldozing Overburden Emissions, Western Surface Coal Mining, 10/98

Emissions (TSP lbs/hr) = 5.7 * (soil silt content %)$^{1.2}$ * (soil moisture content %)$^{1.3}$* Control Efficiency
Emissions (PM15 lbs/hr) = 1.0 * (soil silt content %)$^{1.5}$ * (soil moisture content %)$^{1.4}$ * Control Efficiency

PM_{10} Multiplier = 0.75 * PM_{15} (AP-42 Table 11.9-1, 10/98)
$PM_{2.5}$ Multiplier = 0.105 * TSP (AP-42 Table 11.9-1, 10/98)

Emissions = 1.97 lbs TSP/hour/piece of equipment

Emissions = 0.50 lbs PM_{15}/hour/piece of equipment

	Fugitive Dust Emissions[a]		
	lbs/hr	**tons/well pad**	**tons/yr [b]**
TSP	1.97	0.0158	0.11
PM_{15}	1.51	0.0060	0.04
PM_{10}	1.13	0.0090	0.06
$PM_{2.5}$	0.21	0.0017	0.01

[a] Assumes maximum construction rate specified by Proponent

Note: The majority of new pipeline will be installed adjacent to proposed access roads and will not result in significant additional surface disturbance.

Buys & Associates, Inc.
Environmental Consultants

Project: Tumbleweed EA
Date: 4/1/2009

6a. Development Traffic Fugitive Dust Emissions (Non-mancamp based travel)

- Note Drill crews would be housed in nearby mancamp, as an Applicant-Commited Environmental Protection Measure)

Calculation AP-42, Chapter 13.2.2
November 2006

Paved Roads

$E(PM_{10}) / VMT = 0.016 * (sL/2)^{0.65} * (W/3)^{1.5} - 0.00047 * (1-(P/(365*4))$

$E(PM_{10}) / VMT = 0.0024 * (sL/2)^{0.65} * (W/3)^{1.5} - 0.00036 * (1-(P/(365*4))$

Silt Loading (sL) 0.33 grains/square foot

W = average weight in tons of vehicles traveling the road

Precipitation Days (P) 73 days per year**

Round Trip Miles 62 miles***

***Estimate of round trip miles on paved roads from Vernal

Unpaved Roads

$E(PM_{10}) / VMT = 1.5 * (S/12)^{0.9} * (W/3)^{0.45} * (365-P)/365)*(1-0.5)$

$E(PM_{2.5}) / VMT = 0.15 * (S/12)^{0.9} * (W/3)0.45 * (365-P)/365)*(1-0.5)$

Silt Content (S) 8.5 % AP-42, Table 13.2.2-1 Construction Sites

W = average weight in tons of vehicles traveling the road

Precipitation Days (P) 73 days per year**

Round Trip Miles 98 miles‡

(1-0.5) is for 50% efficiency of operator committed dust suppression for drilling and completion applied to 8 miles (of the 98) estimated average round trip miles in the project area

**(WRCC data for Nutters Ranch Annual >0.01, UT 1963-1986)

http://www.wrcc.dri.edu/summary/Climsmut.html

‡Estimate of round trip miles on unpaved roads from Vernal

Number of well pads = 7
Construction (days/pad and road) = 10

Vehicle Type	Average Weight (lbs)	Round Trips per Well		PM_{10} (lb/VMT)	PM_{10}/Pad (lbs/well)	PM_{10}/Pad (lb/day)	$PM_{2.5}$ (lb/VMT)	$PM_{2.5}$/Pad (lbs/well)	$PM_{2.5}$/Pad (lb/day)
Semi: Hvy Equip Hauler	120,000	4							
Haul Trucks: Material/Fuel/Water	40,000	6	**Unpaved**	2.50	2821.4	282.1	0.25	282.1	28.2
Pickup Truck: Crew[a]	7,000	2	**Paved**	0.15	113.6	11.36	0.02	16.8	1.7
Mean Vehicle Weight/Round Trip	61,167	12	**Total**		2935.0	293.5		298.9	29.9

[a] Assume 1 round trip per well per crew during initial deployment

PM_{10}/Annual Pads (tons/yr) 10.3

$PM_{2.5}$/Annual Pads (tons/yr) 1.0

Number of Vertical Wells = 6
Drilling (days/well) = 21
-Vertical Wells

Vehicle Type	Average Weight (lbs)	Round Trips per Well		PM_{10} (lb/VMT)	PM_{10}/Pad (lbs/well)	PM_{10}/Pad (lb/day)	$PM_{2.5}$ (lb/VMT)	$PM_{2.5}$/Pad (lbs/well)	$PM_{2.5}$/Pad (lb/day)
Semi: Hvy Equip Hauler	60,000	60							
Haul Trucks: Equipment/Fuel/Water	40,000	46	**Unpaved**	1.20	12909.0	614.7	0.24	1290.9	61.5
Pickup Truck: Crew[b]	7,000	8	**Paved**	0.13	951.9	45.3	0.02	140.1	6.7
Mean Vehicle Weight/Round Trip	56,281	114	**Total**		13860.8	660.0		1431.0	14.1

[b] Assume 1 trip per well per crew approximately every 10 days

PM_{10}/Annual Wells (tons/yr) 41.6

$PM_{2.5}$/Annual Wells (tons/yr) 4.3

Number of Directional Wells = 3
Drilling (days/well) = 31
-Directional Wells

Vehicle Type	Average Weight (lbs)	Round Trips per Well		PM_{10} (lb/VMT)	PM_{10}/Pad (lbs/well)	PM_{10}/Pad (lb/day)	$PM_{2.5}$ (lb/VMT)	$PM_{2.5}$/Pad (lbs/well)	$PM_{2.5}$/Pad (lb/day)
Semi: Hvy Equip Hauler	60,000	60							
Haul Trucks: Equipment/Fuel/Water	40,000	68	**Unpaved**	1.20	15737.2	507.7	0.24	1573.7	50.8
Pickup Truck: Crew[c]	7,000	12	**Paved**	0.13	1142.4	54.4	0.02	168.1	5.4
Mean Vehicle Weight/Round Trip	55,454	140	**Total**		16879.6	562.1		1741.8	56.2

[c] Assume 1 trip per well per crew approximately every 10 days

PM_{10}/Annual Wells (tons/yr) 25.3

$PM_{2.5}$/Annual Wells (tons/yr) 2.6

Total number of wells = 9
Completion (days/well) = 21

Vehicle Type	Average Weight (lbs)	Round Trips per Well		PM_{10} (lb/VMT)	PM_{10}/Pad (lbs/well)	PM_{10}/Pad (lb/day)	$PM_{2.5}$ (lb/VMT)	$PM_{2.5}$/Pad (lbs/well)	$PM_{2.5}$/Pad (lb/day)
Pickup: Completion Rig Crew[d]	7,000	2	**Unpaved**	0.93	700.2	33.3	0.19	70.0	3.3
Pickup Truck: Crew[d]	40,000	6	**Paved**	0.06	28.2	1.3	0.01	4.0	0.2
Mean Vehicle Weight/Round Trip	31,750	8	**Total**		728.3	34.7		74.1	3.5

[d] Assume 1 trip per well per crew approximately every 10 days

PM_{10}/Annual Wells (tons/yr) 3.3

$PM_{2.5}$/Annual Wells (tons/yr) 0.3

Number of well pads = 7
Interim Reclamation (days/well) = 2

Vehicle Type	Average Weight (lbs)	Round Trips per Well		PM_{10} (lb/VMT)	PM_{10}/Pad (lbs/well)	PM_{10}/Pad (lb/day)	$PM_{2.5}$ (lb/VMT)	$PM_{2.5}$/Pad (lbs/well)	$PM_{2.5}$/Pad (lb/day)
Pickup: Crew	7,000	5	**Unpaved**	1.22	690.4	345.2	0.12	69.0	34.5
Haul Trucks: Equipment	40,000	1	**Paved**	0.01	5.1	2.55	1.67E-03	0.6	0.3
Mean Vehicle Weight/Round Trip	12,500	6	**Total**		695.5	347.8		69.7	34.8

PM_{10}/Annual Wells (tons/yr) 2.4

$PM_{2.5}$/Annual Wells (tons/yr) 0.2

	PM_{10}		$PM_{2.5}$	
Annual Development Traffic Fugitive Dust Emissions, Non-mancamp based travel (tons/year)	**82.9**	**(tons/yr)**	**8.5**	**(tons/yr)**

Construction Material round trip estimates includes trips to account for soil/gravel loading/unloading emissions per AP-42 Table 13.2.3-1 Recommended Emission Factors for Construction Operations
Drilling and Completion water and fuel trucks per well based on 2 acre-feet /well (Ch2) 60-percent for completion with 160 bbl per truck and fuel trucks every three days.

Buys & Associates, Inc.
Environmental Consultants

Project: Tumbleweed EA
Date: 4/1/2009

6b. Development Traffic Fugitive Dust Emissions (Travel from Mancamp to Well Sites)

- Note Drill crews would be housed in nearby mancamp, as an Applicant-Commited Environmental Protection Measure)

Calculation AP-42, Chapter 13.2.2
November 2006

Paved Roads
No paved roads anticipated between the well sites and the man camp

Unpaved Roads

$E\ (PM_{10})\ /\ VMT = 1.5 * (S/12)^{0.9} * (W/3)^{0.45} * (365-P)/365)*(1-0.5)$

$E\ (PM_{2.5})\ /\ VMT = 0.15 * (S/12)^{0.9} * (W/3)0.45 * (365-P)/365)*(1-0.5)$

Silt Content (S) 8.5 % AP-42, Table 13.2.2-1 Construction Sites
W = average weight in tons of vehicles traveling the road
Precipitation Days (P) 73 days per year**
Round Trip Miles 10 miles (estimated)
(1-0.5) is for 50% efficiency of operator committed dust suppression for drilling and completion applied to 8 miles of the estimated average round trip miles in the project area.
**(WRCC data for Nutters Ranch Annual >0.01, UT 1963-1986)

Number of well pads = 7
Construction (days/pad and road) = 10

Vehicle Type	Average Weight (lbs)	Round Trips per Well
Pickup Truck: Crew	7,000	16

	PM_{10} (lb/VMT)	PM_{10}/Pad (lbs/well)	PM_{10}/Pad (lb/day)	$PM_{2.5}$ (lb/VMT)	$PM_{2.5}$/Pad (lbs/well)	$PM_{2.5}$/Pad (lb/day)
Unpaved	0.94	90.5	9.1	0.09	9.1	0.9
Total		90.5	9.1		9.1	0.9

PM_{10}/Annual Pads (tons/yr)	$PM_{2.5}$/Annual Pads (tons/yr)
0.32	0.03

Number of Vertical Wells = 6
Drilling (days/well) = 21
-Vertical Wells

Vehicle Type	Average Weight (lbs)	Round Trips per Well
Pickup Truck: Rig Crew	7,000	88

	PM_{10} (lb/VMT)	PM_{10}/Pad (lbs/well)	PM_{10}/Pad (lb/day)	$PM_{2.5}$ (lb/VMT)	$PM_{2.5}$/Pad (lbs/well)	$PM_{2.5}$/Pad (lb/day)
Unpaved	0.94	497.9	23.7	0.09	49.8	2.4
Total		497.9	23.7		49.8	2.4

PM_{10}/Annual Wells (tons/yr)	$PM_{2.5}$/Annual Wells (tons/yr)
1.5	0.1

Number of Directional Wells = 3
Drilling (days/well) = 31
-Directional Wells

Vehicle Type	Average Weight (lbs)	Round Trips per Well
Pickup Truck: Rig Crew	7,000	88

	PM_{10} (lb/VMT)	PM_{10}/Pad (lbs/well)	PM_{10}/Pad (lb/day)	$PM_{2.5}$ (lb/VMT)	$PM_{2.5}$/Pad (lbs/well)	$PM_{2.5}$/Pad (lb/day)
Unpaved	0.94	497.9	16.1	0.09	49.8	1.6
Total		497.9	16.1		49.8	1.6

PM_{10}/Annual Wells (tons/yr)	$PM_{2.5}$/Annual Wells (tons/yr)
0.7	0.1

Total number of wells = 9
Completion (days/well) = 21

Vehicle Type	Average Weight (lbs)	Round Trips per Well
Pickup: Completion Rig Crew	7,000	18
Haul Trucks: Equipment/Fuel/Water	40,000	65
Mean Vehicle Weight/Round Trip	32,777	
Total Round Trips	83	

	PM_{10} (lb/VMT)	PM_{10}/Pad (lbs/well)	PM_{10}/Pad (lb/day)	$PM_{2.5}$ (lb/VMT)	$PM_{2.5}$/Pad (lbs/well)	$PM_{2.5}$/Pad (lb/day)
Unpaved	1.89	943.2	44.9	0.19	94.3	4.5
Total		943.2	44.9		94.3	4.5

PM_{10}/Annual Wells (tons/yr)	$PM_{2.5}$/Annual Wells (tons/yr)
4.2	0.4

	PM_{10}		$PM_{2.5}$	
Annual Development Traffic Fugitive Dust Emission, Mancamp based travel (tons/year)	**6.8**	**(tons/yr)**	**0.7**	**(tons/yr)**
Annual Development Traffic Fugitive Dust Emissions, Non-mancamp based travel (tons/year)	**82.9**	**(tons/yr)**	**8.5**	**(tons/yr)**
Total Annual Development Fugitive Dust Emissions	**89.7**		**9.2**	

Construction Material round trip estimates includes trips to account for soil/gravel loading/unloading emissions per AP-42 Table 13.2.3-1 Recommended Emission Factors for Construction Operations
Drilling and Completion water and fuel trucks per well based on 2 acre-feet /well (Ch2) 60-percent for completion with 160 bbl per truck and fuel trucks every three days.

Buys & Associates, Inc. **Environmental Consultants**	Project: Tumbleweed EA Date: 4/1/2009

7. Wind Erosion Fugitive Dust Emissions

Assumptions

Threshold Friction Velocity U_t* 1.02 m/s (2.28 mph) for well pads (AP-42 Table 13.2.5-2 Overburden - Western Surface Coal Mine
1.33 m/s (2.97 mph) for roads (AP-42 Table 13.2.5-2 Roadbed material)

Initial Disturbance Area 33.5 acres total initial disturbance for roads/pipelines (Proposed Action)
135,569 square meters total initial disturbance for roads/pipelines

9.1 acres total initial disturbance for well pads (Proposed Action)
36,826 square meters total initial disturbance for well pads

43 acres total disturbance

Exposed Surface Type Flat

Meteorological Data: 2002 Grand Junction (obtained from NCDC website)

Fastest Mile Wind Speed U_{10}^+ 20.1 meters/sec (45 mph) reported as fastest 2-minute wind speed for Grand Junction (2002)

Number soil of disturbances 2 for well pads (Assumption, disturbance at construction and reclamation)
Constant for dirt roads

Development Period 1 years (Proposed Action)

Equations

Friction Velocity $U^* = 0.053\ U_{10}^+$

Erosion Potential P (g/m^2/period) = $58*(U^*-U_t^*)^2 + 25*(U^*-U_t^*)$ for $U^*>U_t^*$, P = 0 for $U^*< U_t^*$

Emissions (tons/year) = Erosion Potential(g/m^2/period)*Disturbed Area(m^2)*Disturbances/year*(k)/(453.6 g/lb)/2000 lbs/ton/Develop Period

Particle Size Multiplier (k)		
30 um	**<10 um**	**<2.5 um**
1.0	0.5	0.075

Maxium U_{10}^+ Wind Speed (m/s)	**Maximum U* Friction Velocity m/s**	**Well U_t* Threshold Velocity[a] m/s**	**Well Pad Erosion Potential g/m^2**	**Road U_t* Threshold Velocity[a] m/s**	**Road Erosion Potential g/m^2**
20.12	1.07	1.02	1.28	1.33	0.00

Wind Erosion Emissions

Particulate Species	**Wells (tons/year)**	**Roads/Pipelines (tons/year)**
TSP	0.104	0.000
PM_{10}	0.052	0.000
$PM_{2.5}$	0.008	0.000

Buys & Associates, Inc. **Environmental Consultants**	Project: Tumbleweed EA Date: 4/1/2009

8. Well Construction Tailpipe Emissions

Assumptions:

Average Round Trip Distance 98.0 miles (Estimated from project area and existing road system)

Hours of Construction 100 hours per site (Proponent)

Number of Heavy Diesel Truck Trips 10 (Proponent)

Number of Pickup Trips 2 (Proponent)

Diesel Fuel sulfur content 0.05 % (Typical value)

Diesel Fuel density 7.08 lbs/gallon (Typical value)

Heavy Haul Diesel Fuel Efficiency 10 miles/gallon (Typical value)

Heavy Duty Pickup Fuel Efficiency 15 miles/gallon (Typical value)

Equations:

For NOx, CO and VOC:

$$\text{Emissions (tons/year)} = \frac{\text{Emission Factor (g/mile)} * \text{\# Trips} * \text{Trip Distance (miles)}}{453.6\ \text{(g/lb)} * 2000\ \text{(lb/tons)}}$$

The NOx, CO and VOC emission factors for the above equation are from AP-42, while the SO_2 emissions are calculated on a mass balance basis utilizing the following equation:

$$SO_2\ \text{E. Factor (g/mi)} = \frac{\text{Fuel Density (lb/gal)} * 453.6\ \text{(g/lb)} * \text{Fuel Sulfur Content} * 2\ (S / SO_2)}{\text{Vehicle Fuel Efficiency (miles/gal)}}$$

Construction Vehicles	**Heavy Haul Trucks**			**Heavy Duty Pickups**			**Total** [d]	
	E. Factor [a] (g/mile)	Emissions (lb/hr)	Emissions (tons/yr/well)	E. Factor [b] (g/mile)	Emissions (lb/hr)	Emissions (tons/yr/well)	Emissions (lb/hr)	Emissions (tons/yr)
NOx	8.13	0.176	0.009	3.03	0.013	0.001	0.189	0.085
CO	17.09	0.369	0.018	33.64	0.145	0.007	0.515	0.232
VOC [c]	4.83	0.104	0.005	1.84	0.008	0.000	0.112	0.051
SO_2	0.32	0.007	3.47E-04	0.21	0.001	4.63E-05	0.008	0.004
CH_4 [e]	0.230	0.005	2.48E-04	0.184	0.001	3.98E-05	0.006	0.003

[a] AP-42 Table 7.1.2 - H.D. Diesel Powered Vehicles, High Altitude, 1991 - 1997 Model Year, 50,000 miles (6/95)

[b] AP-42 Table 4.1A.2 - H.D. Gasoline Vehicles, High Altitude, 1991 - 1997 Vehicle Year, 50,000 miles (6/95)

[c] Emission factor is for total Hydrocarbons.

[d] Assumes maximum development scenario

[e] AP-42 Append. H Tables 7.10A.2 and 4.10A.2 H.D. Methane Offsets, High Altitude, 1986+ and 1988+ Vehicle Year

Buys & Associates, Inc. **Environmental Consultants**	Project: Tumbleweed EA Date: 4/1/2009

9. Drilling Tailpipe Emissions

Assumptions:

Average Round Trip Distance 98.0 miles (Estimated from project area and existing road system)

Hours of Operation 584.0 hours per site (Proposed Action)

Number of Heavy Diesel Truck Trips 106 (Proponent)

Number of Pickup Trips 8 (Proponent)

Diesel Fuel sulfur content 0.05 % (Typical value)

Diesel Fuel density 7.08 lbs/gallon (Typical value)

Heavy Haul Diesel Fuel Efficiency 10 miles/gallon (Typical value)

Heavy Duty Pickup Fuel Efficiency 15 miles/gallon (Typical value)

Equations:

For NOx, CO and VOC:

$$\text{Emissions (tons/year)} = \frac{\text{Emission Factor (g/mile)} * \text{\# Trips} * \text{Trip Distance (miles)}}{453.6\ \text{(g/lb)} * 2000\ \text{(lb/tons)}}$$

The NOx, CO and VOC emission factors for the above equation are from AP-42, while the SO_2 emissions are calculated on a mass balance basis utilizing the following equation:

$$SO_2\ \text{E. Factor (g/mi)} = \frac{\text{Fuel Density (lb/gal)} * 453.6\ \text{(g/lb)} * \text{Fuel Sulfur Content} * 2\ (S / SO_2)}{\text{Vehicle Fuel Efficiency (miles/gal)}}$$

Drilling Vehicles	**Heavy Haul Trucks**			**Heavy Duty Pickups**			**Total [d]**	
	E. Factor [a] (g/mile)	Emissions (lb/hr)	Emissions (tons/yr/well)	E. Factor [b] (g/mile)	Emissions (lb/hr)	Emissions (tons/yr/well)	Emissions (lb/hr)	Emissions (tons/yr)
Criteria Pollutants & VOC								
NOx	8.13	0.319	0.093	3.03	0.009	0.003	0.33	0.86
CO	17.09	0.670	0.196	33.64	0.100	0.029	0.77	2.02
VOC [c]	4.83	0.189	5.53E-02	1.84	5.45E-03	1.59E-03	0.19	0.51
SO_2	0.32	1.26E-02	3.68E-03	0.21	6.34E-04	1.85E-04	1.32E-02	3.48E-02
Greenhouse Gases								
CH_4 [e]	0.230	9.02E-03	2.63E-03	0.184	5.45E-04	1.59E-04	9.56E-03	2.51E-02

[a] AP-42 Append. H Table 7.1.2 - H.D. Diesel Powered Vehicles, High Altitude, 1991 - 1997 Model Year, 50,000 miles (6/95)

[b] AP-42 Append. H Table 4.1A.2 - H.D. Gasoline Vehicles, High Altitude, 1991 - 1997 Vehicle Year, 50,000 miles (6/95)

[c] Emission factor is for total Hydrocarbons - Methane Offset

[d] Assumes construction rate specified by Proponent

[e] AP-42 Append. H Tables 7.10A.2 and 4.10A.2 H.D. Methane Offsets, High Altitude, 1986+ and 1988+ Vehicle Year

Buys & Associates, Inc. **Environmental Consultants**	Project: Tumbleweed EA Date: 4/1/2009

10. Completion Tailpipe Emissions

Assumptions:

Average Round Trip Distance 98.0 miles (Estimated from project area and existing road system)

Hours of Operation 210 hours per site (Proponent)

Number of Heavy Diesel Truck Trips 6 (Proponent)

Number of Pickup Trips 2 (Proponent)

Diesel Fuel sulfur content 0.05 % (Typical value)

Diesel Fuel density 7.08 lbs/gallon (Typical value)

Heavy Haul Diesel Fuel Efficiency 10 miles/gallon (Typical value)

Heavy Duty Pickup Fuel Efficiency 15 miles/gallon (Typical value)

Equations:

For NOx, CO and VOC:

$$\text{Emissions (tons/year)} = \frac{\text{Emission Factor (g/mile)} * \text{\# Trips} * \text{Trip Distance (miles)}}{453.6\ \text{(g/lb)} * 2000\ \text{(lb/tons)}}$$

The NOx, CO and VOC emission factors for the above equation are from AP-42, while the SO_2 emissions are calculated on a mass balance basis utilizing the following equation:

$$SO_2\ \text{E. Factor (g/mi)} = \frac{\text{Fuel Density (lb/gal)} * 453.6\ \text{(g/lb)} * \text{Fuel Sulfur Content} * 2\ (S / SO_2)}{\text{Vehicle Fuel Efficiency (miles/gal)}}$$

Completion Vehicles	**Heavy Haul Trucks**			**Heavy Duty Pickups**			**Total [d]**	
	E. Factor [a] (g/mile)	Emissions (lb/hr)	Emissions (tons/yr/well)	E. Factor [b] (g/mile)	Emissions (lb/hr)	Emissions (tons/yr/well)	Emissions (lb/hr)	Emissions (tons/yr)
NOx	8.13	0.050	0.005	3.03	0.006	0.001	0.056	0.053
CO	17.09	0.105	0.011	33.64	0.069	0.007	0.175	0.165
VOC [c]	4.83	0.030	0.003	1.84	0.004	0.000	0.034	0.032
SO_2	0.32	0.002	0.000	0.21	0.000	0.000	0.002	0.002
CH_4 [e]	0.230	0.001	0.000	0.184	0.000	0.000	0.002	0.001

a AP-42 Table 7.1.2 - H.D. Diesel Powered Vehicles, High Altitude, 1991 - 1997 Model Year, 50,000 miles (6/95)
b AP-42 Table 4.1A.2 - H.D. Gasoline Vehicles, High Altitude, 1991 - 1997 Vehicle Year, 50,000 miles (6/95)
c Emission factor is for total Hydrocarbons.
d Assumes maximum development scenario
e AP-42 Append. H Tables 7.10A.2 and 4.10A.2 H.D. Methane Offsets, High Altitude, 1986+ and 1988+ Vehicle Year

Buys & Associates, Inc. **Environmental Consultants**	Project: Tumbleweed EA Date: 4/1/2009

11. Interim Reclamation Tailpipe Emissions

Assumptions:

Average Round Trip Distance 98.0 miles (Estimated from project area and existing road system)

Hours of Operation 20 hours per site (Assumption)

Number of Heavy Diesel Truck Trips 1 (Assumption)

Number of Pickup Trips 5 (Assumption)

Diesel Fuel sulfur content 0.05 % (Typical value)

Diesel Fuel density 7.08 lbs/gallon (Typical value)

Heavy Haul Diesel Fuel Efficiency 10 miles/gallon (Typical value)

Heavy Duty Pickup Fuel Efficiency 15 miles/gallon (Typical value)

Equations:

For NOx, CO and VOC:

$$\text{Emissions (tons/year)} = \frac{\text{Emission Factor (g/mile)} * \text{\# Trips} * \text{Trip Distance (miles)}}{453.6\ \text{(g/lb)} * 2000\ \text{(lb/tons)}}$$

The NOx, CO and VOC emission factors for the above equation are from AP-42, while the SO_2 emissions are calculated on a mass balance basis utilizing the following equation:

$$SO_2\ \text{E. Factor (g/mi)} = \frac{\text{Fuel Density (lb/gal)} * 453.6\ \text{(g/lb)} * \text{Fuel Sulfur Content} * 2\ (S / SO_2)}{\text{Vehicle Fuel Efficiency (miles/gal)}}$$

Development Vehicles	**Heavy Haul Trucks**			**Heavy Duty Pickups**			**Total [d]**	
	E. Factor [a] (g/mile)	Emissions (lb/hr)	Emissions (tons/yr/well)	E. Factor [b] (g/mile)	Emissions (lb/hr)	Emissions (tons/yr/well)	Emissions (lb/hr)	Emissions (tons/yr)
Criteria Pollutants & VOC								
NOx	8.13	0.088	8.78E-04	3.03	0.164	1.64E-03	0.25	1.76E-02
CO	17.09	0.185	1.85E-03	33.64	1.817	1.82E-02	2.00	0.14
VOC [c]	4.83	5.22E-02	5.22E-04	1.84	0.099	9.94E-04	0.15	1.06E-02
SO_2	0.32	3.47E-03	3.47E-05	0.21	1.16E-02	1.16E-04	1.50E-02	1.05E-03
Greenhouse Gases								
CH_4 [e]	0.230	2.48E-03	2.48E-05	0.184	9.94E-03	9.94E-05	1.24E-02	8.70E-04

[a] AP-42 Append. H Table 7.1.2 - H.D. Diesel Powered Vehicles, High Altitude, 1991 - 1997 Model Year, 50,000 miles (6/95)

[b] AP-42 Append. H Table 4.1A.2 - H.D. Gasoline Vehicles, High Altitude, 1991 - 1997 Vehicle Year, 50,000 miles (6/95)

[c] Emission factor is for total Hydrocarbons - Methane Offset

[d] Assumes construction rate specified by Proponent

[e] AP-42 Append. H Tables 7.10A.2 and 4.10A.2 H.D. Methane Offsets, High Altitude, 1986+ and 1988+ Vehicle Year

Buys & Associates, Inc. **Environmental Consultants**	Project: Tumbleweed EA Date: 4/1/2009

12. Drill Rig Engine Emissions

Assumptions:

Hours of Operation 584.0 hours/well (Proposed Action)

Development Rate 9 wells per year (Proposed Action)

Load Factor 0.4 (Assumed typical value)

Rig Size 1725 hp (Proponent Estimate x 1.5 to account for mud pumps)

Diesel Fuel Sulfur Content 0.05 % (typical value)

Equations:

$$\text{Emissions (tons/year)} = \frac{\text{Emission Factor (lb/hp-hr)} * \text{Rated Horsepower (hp)} * \text{Operating Hours (hrs)} * \text{Load Factor (Dimensionless)}}{\text{2000 (lb/tons)}}$$

SO_2 E. Factor (lb/hp-hr) = Fuel sulfur content * 0.00809

	Drill Rig Emissions					Emissions
Species	E. Factor (g/hp-hr)	E. Factor (lb/hp-hr)	Emissions (lb/hr)	Emissions[h] (tons/yr)	Tier 0 E. Factor[a] (lb/hp-hr)	**Reduction[i] (tons/yr)**
Criteria Pollutants & VOC						
NOx [Tier II]	4.8	0.010582	7.3	19.2	0.024	24.3
CO [Tier II]	2.6	5.73E-03	3.955	10.39		
VOC [a,b]		7.05E-04	0.486	1.28		
PM_{10} [Tier II]	0.15	3.31E-04	0.228	0.60		
$PM_{2.5}$ [a,d]		4.79E-04	0.331	0.87		
SO_2 [a]		4.05E-04	0.279	0.73		
Hazardous Air Pollutants						
Benzene [e]		1.97E-06	1.36E-03	3.58E-03		
Toluene [e]		7.15E-07	4.93E-04	1.30E-03		
Xylenes [e]		4.91E-07	3.39E-04	8.91E-04		
Formaldehyde [e]		2.01E-07	1.39E-04	3.64E-04		
Acetaldehyde [e]		6.41E-08	4.43E-05	1.16E-04		
Acrolein [e]		2.01E-08	1.38E-05	3.64E-05		
Naphthalene [f]		3.31E-07	2.28E-04	6.00E-04		
Total PAH [f,g]		5.40E-07	3.72E-04	9.78E-04		
Greenhouse Gases						
CO_2 [a]		1.16	800	2103		
CH_4 [a,b]		7.05E-04	0.486	1.28		

[Tier II] Tier II Emission Factors, hp>750
[a] AP-42 Volume I, Large Stationary Diesel Engines Table 3.4-1, 10/96
[b] Emission Factor represents total Hydrocarbon Emissions
[d] Total particulate emission factor is 0.0007, $PM_{2.5}$ fraction determined from Table 3.4-2
[e] AP-42 Volume I, Large Stationary Diesel Engines Table 3.4-3, 10/96 converted using boiler conversion factor from Appendix A
[f] AP-42 Volume I, Large Stationary Diesel Engines Table 3.4-4, 10/96 converted using boiler conversion factor from Appendix A
[g] PAH (Polycyclic Aromatic Hydrocarbons) includes naphthalene and are a HAP because they are polycyclic organic matter (POM)
[h] Assumes maximum development scenario
[i] Based on Applicant-Committed Environmental Protection Measures

Buys & Associates, Inc. **Environmental Consultants**	Project: Tumbleweed EA Date: 4/1/2009

13. Well Fracturing Pump and Generator Engines

Assumptions:

Average Hours of Operation 8 Hours/Well

Development Rate 9 wells per year (Proposed Action)

Load Factor 0.65

Frac Pump Engine Horsepower 725 Horsepower
Temporary Generator Horsepower 300 Horsepower

Diesel Fuel Sulfur Content 0.05 % (typical value)

Equations:

$$\text{Emissions (tons/year)} = \frac{\text{Emission Factor (lb/hp-hr)} * \text{Rated Horsepower (hp)} * \text{Operating Hours (hrs)} * \text{Load Factor (Dimensionless)}}{\text{2000 (lb/tons)}}$$

SO_2 E. Factor (lb/hp-hr) = Fuel sulfur content * 0.00809

Species	Frac Pump Engine Emissions		
	E. Factor (lb/hp-hr)	Emissions (lb/hr)	Emissions[i] (tons/yr)
Criteria Pollutants & VOC			
NOx [a]	0.024	11.310	0.41
CO [a]	5.50E-03	2.592	0.09
VOC [a,b]	7.05E-04	0.332	1.20E-02
PM_{10} [a,c]	5.73E-04	0.270	9.72E-03
$PM_{2.5}$ [a,d]	4.79E-04	0.226	8.13E-03
SO_2 [a]	4.05E-04	0.191	6.86E-03
Hazardous Air Pollutants			
Benzene [e]	1.97E-06	9.31E-04	3.35E-05
Toluene [e]	7.15E-07	3.37E-04	1.21E-05
Xylenes [e]	4.91E-07	2.31E-04	8.33E-06
Formaldehyde [e]	2.01E-07	9.46E-05	3.41E-06
Acetaldehyde [e]	6.41E-08	3.02E-05	1.09E-06
Acrolein [e]	2.01E-08	9.45E-06	3.40E-07
Naphthalene [f]	3.31E-07	1.56E-04	5.61E-06
Total PAH [f]	5.40E-07	2.54E-04	9.15E-06
Greenhouse Gases			
CO_2 [a]	1.16	547	19.68
CH_4 [a]	7.05E-04	0.332	1.20E-02

Species	Generator Engine Emissions		
	E. Factor (lb/hp-hr)	Emissions (lb/hr)	Emissions[i] (tons/yr)
Criteria Pollutants			
NOx [g]	0.031	6.045	0.22
CO [g]	6.68E-03	1.303	0.05
VOC [b,g]	2.47E-03	0.482	1.73E-02
PM_{10} [g]	2.20E-03	0.429	1.54E-02
$PM_{2.5}$ [g]	2.20E-03	0.429	1.54E-02
SO_2 [g]	2.05E-03	0.400	1.44E-02
Hazardous Air Pollutants			
Benzene [h]	2.37E-06	4.63E-04	1.67E-05
Toluene [h]	1.04E-06	2.03E-04	7.31E-06
Xylenes [h]	7.25E-07	1.41E-04	5.09E-06
Formaldehyde [h]	3.00E-06	5.86E-04	2.11E-05
Acetaldehyde [h]	1.95E-06	3.81E-04	1.37E-05
Acrolein [h]	2.35E-07	4.59E-05	1.65E-06
1,3-Butadiene [h]	9.95E-08	1.94E-05	6.99E-07
Naphthalene [h]	2.16E-07	4.21E-05	1.52E-06
Total PAH [h]	4.28E-07	8.34E-05	3.00E-06
Greenhouse Gases			
CO_2 [g]	1.15	224	8.07
CH_4 [b,g]	2.47E-03	0.482	1.73E-02

[a] AP-42 Volume I, Large Stationary Diesel Engines Table 3.4-1, 10/96
[b] Emission Factor represents total Hydrocarbon Emissions
[c] Total particulate emission factor is 0.0007, PM_{10} fraction determined from Table 3.4-2
[d] Total particulate emission factor is 0.0007, $PM_{2.5}$ fraction determined from Table 3.4-2
[e] AP-42 Volume I, Large Stationary Diesel Engines Table 3.4-3, 10/96 converted using boiler conversion factor from Appendix A
[f] AP-42 Volume I, Large Stationary Diesel Engines Table 3.4-4, 10/96 converted using boiler conversion factor from Appendix A
[g] AP-42 Table 3.3-1, Emission Factors for Uncontrolled Gasoline and Diesel Industrial Engines, 10/96
[h] AP-42 Table 3.3-2 Speciated Organic Compound Emission Factors for Uncontrolled Diesel Engines, 10/96 converted using boil conversion factor from Appendix A
[i] Assumes maximum development scenario

Buys & Associates, Inc. Environmental Consultants	Project: Tumbleweed EA Date: 4/1/2009

14. Average Produced Gas Characteristics

Inlet Wet Gas Sample Dated August 23, 2006 from Miller Dyer Flat Rock Field used with permission

Gas Heat Value (wet): 1028.1 Btu/scf

C1-C2 Wt. Fraction: 0.8772
VOC Wt. Fraction: 0.0612
Non-HC Wt. Fraction: 0.0616
Total: 1.0000

COMPONENT	MOLE PERCENT	COMPONENT MOLE WEIGHT (lb/lb-mole)	NET MOLE WEIGHT (lb/lb-mole)	WEIGHT FRACTION	GROSS HEATING VALUE (BTU/scf)	NET DRY HEATING VALUE (BTU/scf)	LOWER HEATING VALUE (BTU/scf)	NET LOW HEATING VALUE (BTU/scf)
Methane	92.5150	16.043	14.842	0.830	1010.000	934.402	910.0	841.887
Ethane	2.8340	30.070	0.852	0.048	1769.800	50.156	1618.0	45.854
Propane	0.7530	44.097	0.332	0.019	2516.200	18.947	2316.0	17.439
i-Butane	0.2620	58.123	0.152	0.009	3252.100	8.521	3005.0	7.873
n-Butane	0.2030	58.123	0.118	0.007	3262.400	6.623	3013.0	6.116
i-Pentane	0.1350	72.150	0.097	0.005	4000.900	5.401	3698.0	4.992
n-Pentane	0.0590	72.150	0.043	0.002	4008.800	2.365	3708.0	2.188
Hexanes	0.2380	86.177	0.205	0.011	4756.200	11.320	4404.0	10.482
Heptanes	0.0211	100.204	0.021	0.001	5502.500	1.161	5100.0	1.076
Octanes+	0.0229	114.231	0.026	0.001	6249.100	1.431		0.000
Nonanes	0.0000	128.258	0.000	0.000	6996.400	0.000		0.000
Decanes	0.0000	142.285	0.000	0.000	7743.200	0.000		0.000
Benzene	0.0310	78.120	0.024	0.001	3715.500	1.152		0.000
Toluene	0.0260	92.130	0.024	0.001	4444.600	1.156		0.000
Ethylbenzene	0.0020	106.160	0.002	0.000	5191.500	0.104		0.000
Xylenes	0.0100	106.160	0.011	0.001	5183.500	0.518		0.000
n-Hexane	0.0454	86.177	0.039	0.002	4756.200	2.160		0.000
Helium	0.0000	4.003	0.000	0.000	0.000	0.000	0.0	0.000
Nitrogen	0.8970	28.013	0.251	0.014	0.000	0.000	0.0	0.000
Carbon Dioxide	1.9200	44.010	0.845	0.047	0.000	0.000	0.0	0.000
Oxygen	0.0210	32.000	0.007	0.000	0.000	0.000	0.0	0.000
Hydrogen Sulfide	0.0000	34.080	0.000	0.000	637.100	0.000	588.0	0.000
TOTAL	100.00		17.89	1.00		1045.41		937.91

Relative Mole Weight (lb/lb-mole) = [Mole Percent * Molecular weight (lb/lb-mole)] / 100

Weight Fraction = Net Mole Weight / Total Mole Weight

Buys & Associates, Inc. Environmental Consultants	Project: Tumbleweed EA Date: 4/1/2009

15. Well Development Venting

Assumptions: Following completion, wells are vented prior to connnection to the gathering pipeline

Venting Period 24 hours (Assumption)

Amount of Vented Gas: 0.1 MMscf (Assumption)

Development Rate: 9 Wells per year (Project Proponents)

COMPONENT	MOLECULAR WEIGHT (lb/lb-mole)	MOLE PERCENT	RELATIVE MOLE WEIGHT (lb/lb-mole)	WEIGHT Fraction	COMPONENT FLOW RATE (Mscf/day)	COMPONENT FLOW RATE (lb/hr)	COMPONENT FLOW RATE (tons/yr)
Methane	16.043	92.515	14.842	0.830	92.515	162.962	17.600
Ethane	30.07	2.834	0.852	0.048	2.834	9.357	1.011
Propane	44.097	0.753	0.332	0.019	0.753	3.646	0.394
i-Butane	58.123	0.262	0.152	0.009	0.262	1.672	0.181
n-Butane	58.123	0.203	0.118	0.007	0.203	1.295	0.140
i-Pentane	72.15	0.135	0.097	0.005	0.135	1.069	0.116
n-Pentane	72.15	0.059	0.043	0.002	0.059	0.467	0.050
Hexanes	86.177	0.238	0.205	0.011	0.238	2.252	0.243
Heptanes	100.204	0.021	0.021	0.001	0.021	0.232	0.025
Octanes	114.231	0.023	0.026	0.001	0.023	0.287	0.031
Nonanes	128.258	0.000	0.000	0.000	0.000	0.000	0.000
Decanes +	142.285	0.000	0.000	0.000	0.000	0.000	0.000
Benzene	78.12	0.031	0.024	0.001	0.031	0.266	0.029
Toluene	92.13	0.026	0.024	0.001	0.026	0.263	0.028
Ethylbenzene	106.16	0.002	0.002	0.000	0.002	0.023	0.003
Xylenes	106.16	0.010	0.011	0.001	0.010	0.117	0.013
n-Hexane	86.177	0.045	0.039	0.002	0.045	0.430	0.046
Helium	4.003	0.000	0.000	0.000	0.000	0.000	0.000
Nitrogen	28.013	0.897	0.251	0.014	0.897	2.759	0.298
Carbon Dioxide	44.01	1.920	0.845	0.047	1.920	9.278	1.002
Oxygen	32	0.021	0.007	0.000	0.021	0.074	0.008
Hydrogen Sulfide	34.08	0.000	0.000	0.000	0.000	0.000	0.000
VOC SUBTOTAL		**1.808396**	**1.095**	**0.061**	**1.808**	**12.020**	**1.298**
HAP SUBTOTAL		**0.114405**	**0.100**	**0.006**	**0.114**	**1.098**	**0.119**
TOTAL		**100.00**	**17.892**	**1.000**	**100**	**196.449**	**21.216**

16. Completion Flare Emissions

Assumptions

Hours of Operation 1 days (Typical)

Amount of Gas Flared 2.5 MMscf/well (Assumption)

Average Gas Heat Content 1028 Btu/scf (Wellsite Gas Composition)

Average Gas VOC Content 0.061 weight % (Wellsite Gas Composition)

Average Mole Weight 17.9 lb/lb-mole (Wellsite Gas Composition)

Development rate 9 gas wells per year

Equations

NOx/CO Emissions (lb/well) = Emission Factor (lb/MM Btu) * Gas Amount (MMscf/well) * Heat Content (Btu/scf)

PM/HAP Emissions (lb/well) = Emission Factor (lb/MMscf) * Gas Amount (MMscf/well)

$$\text{Flare Gas Wt. (lb/well)} = \frac{\text{Flare Gas Volume (MMscf/well)} * 10^6 \text{ (scf/MMscf)} * \text{Mole Weight (lb/lb-mole)}}{379.49 \text{ (scf/mole)}}$$

VOC Emissions (lb/well) = Flare Gas Wt. (lb/well) * VOC wt. % * 0.02 (Assumes 98% destruction Efficiency)

Species	Emission Factor (lb/MMBtu)	Well Emissions (lb/well)	Well Emissions (lb/hr/well)	Total Emissions [e] (tons/yr)
Criteria Pollutants & VOC				
NO_x [a]	0.068	174.8	7.28	0.79
CO [a]	0.37	951.0	39.62	4.28
VOC	-	1.4	0.06	0.01
SO_x [b]	0.00	0.0	0.00	0.00
TSP [c]	7.6	19	0.792	0.086
PM_{10} [c]	7.6	19	0.792	0.086
$PM_{2.5}$ [c]	7.6	19	0.792	0.086
Hazardous Air Pollutants				
Benzene [d]	0.0021	0.00525	0.0002	2.36E-05
Toluene [d]	0.0034	0.0085	0.0004	3.83E-05
Hexane [d]	1.8	4.5	0.1875	0.020
Formaldehyde [d]	0.075	0.1875	0.0078	8.44E-04
Greenhouse Gases				
CO_2 [c]	120,000	300,000	12,500	1,350
CH_4 [a]	0.14	359.8	14.99	1.62

a AP-42 Table 13.5-1, Emission Factors for Flare Operations, 9/91
b Assumes produced gas contains no sulfur
c AP-42 Table 1.4-2, Emission Factors for Natural Gas Combustion, 3/98 (All Particulates are $PM_{1.0}$)
d AP-42 Table 1.4-3, Emission Factors for Organic Compounds from Natural Gas Combustion, 3/98
e Assumes proposed development rate

Buys & Associates, Inc. Environmental Consultants	Project: Tumbleweed EA Date: 4/1/2009

17. Well Site Flare Emissions

Assumptions

Hours of Operation 8760 hrs/year

Development Total = 9 gas wells

Individual Well Emissions

Input Description	Flow Rate scf/hr	Heat Content btu/scf	Fuel Rate (MMBtu/hr)	Hours Of Operation (hrs/yr)	NOx Emissions (tons/yr)	CO Emissions (tons/yr)	VOC* Emissions (tons/yr)
Stock Tanks	**60.9**	**1334**	**0.081**	**8760**	**0.024**	**0.132**	
Pilot Light	**50**	**1028**	**0.051**	**8760**	**0.015**	**0.083**	**0.032**
				Totals	**0.040**	**0.215**	**0.032**

Emissions (tpy) = EF (lb/MMBtu) x Fuel Use (MMBtu/yr) / 2000 (lb/ton)

*VOC emissions from stock tanks reported on tank emission page

Project Emissions (at full development)

	NOx Emissions (tons/yr)	CO Emissions (tons/yr)	VOC Emissions (tons/yr)
Totals	**0.36**	**1.93**	**0.28**

Emission Factors from AP-42, 13.5-4, 9/91

Emissions Component	Emissions Factor (lb/MMBtu)
TOC (assumed for VOC)	0.14
CO	0.37
NOx	0.068

18. Wellsite Heater Emissions

Assumptions

Separator Heater Size 1000 Mbtu/hr
Wells Requiring Separators: 9

Firing Rate 8,760 hours/year

Fuel Gas Heat Value 1028 Btu/scf (Gas Analyses from Wellsite)

Fuel Gas VOC Content 0.061 by weight (Gas Analyses from well site)

Equations

$$\text{Fuel Consumption (MMscf/yr)} = \frac{\text{Heater Size (MBtu/hr)} * 1{,}000\ \text{(Btu/MBtu)} * \text{Hours of Operation (hrs/yr)}}{\text{Fuel Heat Value (Btu/scf)} * 1{,}000{,}000\ \text{(scf/MMscf)}}$$

$$\text{NOx/CO/TOC Emissions (tons/yr)} = \frac{\text{AP-42 E.Factor (lbs/MMscf)} * \text{Fuel Consumption (MMscf/yr)} * \text{Fuel heating Value (Btu/scf)}}{2{,}000\ \text{(lbs/ton)} * 1{,}000\ \text{(Btu/scf - Standard Fuel Heating Value)}}$$

Species	Wellsite Heater Emissions			
	Emission Factor (lb/MMscf)	Well Emissions (lb/hr/well)	Total Emissions (tons/yr)	Total Emissions (tons/yr)
Criteria Pollutants & VOC				
NO_x [a]	100	0.097	0.426	3.83
CO [a]	84	0.082	0.358	3.22
TOC [c]	11	0.011	0.047	0.42
VOC	5.5	0.005	0.023	0.21
SO_x [b]	0.00	0.000	0.000	0.00
TSP [c]	7.6	0.007	0.032	0.29
PM_{10} [c]	7.6	0.007	0.032	0.29
$PM_{2.5}$ [c]	7.6	0.007	0.032	0.29
Hazardous Air Pollutants				
Benzene [d]	0.0021	0.000	8.95E-06	0.00
Toluene [d]	0.0034	0.000	1.45E-05	0.00
Hexane [d]	1.8	0.002	0.008	0.07
Formaldehyde [d]	0.075	7.29E-05	3.20E-04	2.88E-03
Dichlorobenzene [d]	1.2E-03	0.000	5.11E-06	0.00
Naphthalene [d]	6.1E-04	0.000	2.60E-06	0.00
POM 2 [d,e,f]	5.9E-05	0.000	2.51E-07	0.00
POM 3 [d,g]	1.6E-05	0.000	6.82E-08	0.00
POM 4 [d,h]	1.8E-06	0.000	7.67E-09	0.00
POM 5 [d,i]	2.4E-06	0.000	1.02E-08	0.00
POM 6 [d,j]	7.2E-06	0.000	3.07E-08	0.00
POM 7 [d,k]	1.8E-06	0.000	7.67E-09	0.00
Greenhouse Gases				
CO_2 [c]	120,000	116.720	511	4601.09
CH_4 [c]	2.3	2.2E-03	9.80E-03	8.8E-02

[a] AP-42 Table 1.4-1, Emission Factors for Natural Gas Combustion, 7/98
[b] Assumes produced gas contains no sulfur
[c] AP-42 Table 1.4-2, Emission Factors for Natural Gas Combustion, 7/98 (All Particulates are PM1.0)
[d] AP-42 Table 1.4-3, Emission Factors for Organic Compounds from Natural Gas Combustion, 7/98
Technology Transfer Network website for the 1999 National-Scale Air Toxics Assessment at
benzo(g,h,i)perylene, fluoranthene, fluorene, phenanthrene, and pyrene.
[g] - POM 3 includes: 7,12-Dimethylbenz(a)anthracene.
[h] - POM 4 includes: 3-Methylchloranthrene.
[i] - POM 5 includes: Benzo(a)pyrene and dibenzo(a,h)anthracene.
indeno(1,2,3-cd)pyrene.
[k] - POM 7 includes: Chrysene.

19. Storage Tank Flash/Working/Standing Emissions

Assumptions:

Average Condensate Production Rate : 10.0 bbls condensate per day per well

Size of Development: 9 Producing Wells
7 Well pads with tanks
Separator Conditions : 970 psi and 83 F
API Gravity of Sales Oil: 46 estimate

Calculations:
Condensate tank flashing/working/breathing emissions estimated with E&P Tanks 2.0
Stewart Petroleum Liquid Sample Dated 9/10/08.

Emissions: Uncontrolled (before Applicant Committed Environmental Protection Measures

Component	Wellsite Flash/Work/Breathing (lb/hr/well)	Wellsite Flash/Work/Breathing (tons/year/well)	Total Emissions (tons/yr)
Total VOC	4.968	21.76	195.8
Hazardous Air Pollutants			
Benzene	0.168	0.737	6.63
Toluene	0.002	0.009	0.08
Ethylbenzene	0.001	0.004	0.04
Xylenes	0.011	0.047	0.42
n-Hexane	0.077	0.336	3.02
Greenhouse Gases			
CO_2	0.437	1.916	13.4
CH_4	5.968	26.141	183.0

[a] Assumes maximum development scenario

Emissions: Controlled
Emissions controlled with combustion device (95% reduction)

Component	Wellsite Flash/Work/Breathing (lb/hr/well)	Wellsite Flash/Work/Breathing (tons/year/well)	Controlled Total Emissions (tons/yr)	Emissions Reduction [b] (tons/yr)
Total VOC	0.248	1.09	9.8	186.0
Hazardous Air Pollutants				
Benzene	0.008	0.037	0.33	6.3
Toluene	0.002	0.009	0.08	0.0
Ethylbenzene	0.000	0.000	0.00	0.0
Xylenes	0.001	0.002	0.02	0.4
n-Hexane	0.004	0.017	0.15	2.9
Greenhouse Gases				
CO_2	0.437	1.916	13.4	0.0
CH_4	0.298	1.307	9.1	173.8

[b] Based on Applicant-Committed Environmental Protection Measures

Buys & Associates, Inc. **Environmental Consultants**	Project: Tumbleweed EA Date: 4/1/2009

20. Operations Tailpipe Emissions

Assumptions:

Number of New Pumpers:	1	(Assumption)
Pumper Mileage:	2,640	miles/pumper/month (Estimate)
Total Annual New Pumper Mileage:	31,680	miles/year
Number of Condensate Haul Truck Round Trips:	0.22	trips per day (Based on Peak Production Proposed Action)
Average Round Trip Mileage for Condensate Transport:	160	miles (Estimate based on distance from Ft. Duchesne)
Total Annual Condensate Truck Mileage:	13,031	miles/year
Number of Water Haul Truck Round Trips:	0.003	trips per day (Proponent)
Average Round Trip Mileage for Water Transport:	160	miles (Estimate based on distance from Ft. Duchesne)
Total Annual Water Truck Mileage:	160	miles/year
Daily Hours of Operation:	12	hours per day (Assumption)
Annual Hours of Operation:	4368	hours per year
Fuel sulfur content	0.05	% (Typical value)
Fuel density	7.08	lbs/gallon (Typical value)
Heavy Duty Pickup Fuel Efficiency	15	miles/gallon (Typical value)
Heavy Haul Diesel Fuel Efficiency	10	miles/gallon (Typical value)

Equations:

For NOx, CO and VOC:

$$\text{Emissions (tons/year)} = \frac{\text{Emission Factor (g/mile)} * \text{Vehicle Miles Traveled (miles/yr)}}{\text{453.6 (g/lb)} * \text{2000 (lb/tons)}}$$

The NOx, CO and VOC emission factors for the above equation are from AP-42, while the SO_2 emissions are calculated on a mass balance basis utilizing the following equation:

$$SO_2 \text{ E. Factor (g/mi)} = \frac{\text{Fuel Density (lb/gal)} * \text{453.6 (g/lb)} * \text{Fuel Sulfur Content} * 2\ (S / SO_2)}{\text{Vehicle Fuel Efficiency (miles/gal)}}$$

Pumper Vehicles	Heavy Duty Pickups			Heavy Haul Trucks			Total	
	E. Factor [a] (g/mile)	Emissions (lb/hr)	Emissions (tons/yr)	E. Factor [b] (g/mile)	Emissions (lb/hr)	Emissions (tons/yr)	Emissions (lb/hr)	Emissions (tons/yr)
NOx	3.03	0.048	0.106	8.13	5.40E-02	0.118	0.10	0.22
CO	33.64	0.538	1.175	17.09	1.13E-01	0.248	0.65	1.42
VOC [c]	1.84	0.029	0.064	4.600	3.05E-02	0.067	6.00E-02	0.13
SO_2	0.21	3.42E-03	0.007	0.32	2.13E-03	0.005	5.56E-03	1.2E-02
CH_4 [d]	0.184	2.94E-03	0.006	0.230	1.53E-03	0.003	4.47E-03	9.8E-03

[a] AP-42 Append H Table 4.1A.2 - H.D. Gasoline Vehicles, High Altitude, 1991 - 1997 Vehicle Year, 50,000 miles (6/95)

[b] AP-42 Append. H Table 7.1.2 - H.D. Diesel Powered Vehicles, High Altitude, 1991 - 1997 Model Year, 50,000 miles (6/95)

[c] Emission factor is for total Hydrocarbons - Methane Offset

[d] AP-42 Append. H Tables 7.10A.2 and 4.10A.2 H.D. Methane Offsets, High Altitude, 1986+ and 1988+ Vehicle Year

Buys & Associates, Inc.
Environmental Consultants

Project: Tumbleweed EA
Date: 4/1/2009

21. Operations Traffic Fugitive Dust Emissions

Calculation AP-42, Chapter 13.2.2
November 2006

365 days (Estimate)

Unpaved Roads

E (PM_{10}) / VMT = 1.5 * $(S/12)^{0.9}$ * $(W/3)^{0.45}$ * (365-p)/365)

E ($PM_{2.5}$) / VMT = 0.15 * $(S/12)^{0.9}$ * $(W/3)^{0.45}$ * (365-p)/365)

Silt Content (S) 6.9 % AP-42, Table 11.9-3

W = average weight in tons of vehicles traveling the road

Round Trip Miles 98 Estimate from Vernal*

Precipitation Days (p) 73 days per year**

Vehicle Type	Ave. Weight (lbs)	Round Trips per Day
Pickup Truck: Crew	7,000	1.0
Haul Truck: Oil	48,000	0.22
Haul Truck: Water	48,000	0.003
Average Mean Weight/round trip (W)	14,554	lbs

Paved Roads

E (PM_{10}) / VMT = 0.016 * $(sL/2)^{0.65}$ * $(W/3)^{1.5}$ - 0.00047 * (1-(p/(365*4))

E ($PM_{2.5}$) / VMT = 0.0024 * $(sL/2)^{0.65}$ * $(W/3)^{1.5}$ - 0.00036 * (1-(p/(365*4))

Silt Loading (sL) 0.33 grains/square foot

W = average weight in tons of vehicles traveling the road

Round Trip Miles 62 Estimate from Vernal*

Precipitation Days (p) 73 days per year**

Round trips/day = 1.2

	PM_{10} (lb/VMT)	Total PM_{10} (lbs/yr)	PM_{10} (lb/day)	$PM_{2.5}$ (lb/VMT)	Total $PM_{2.5}$ (lbs/yr)	$PM_{2.5}$ (lb/day)
Unpaved	1.09	47645	130.5	0.11	4765	13.1
Paved	0.02	481	1.3	2.32E-03	64	0.2
Total		48126	132		4829	13

	PM_{10}	$PM_{2.5}$
Annual Operations Traffic Fugitive Dust Emissions (tpy)	**24.1**	**2.41**

*Round trip distance represents the round trip estimate within project area plus distance from Vernal
**(WRCC data for Nutters Ranch, UT 1906-2007) http://www.wrcc.dri.edu/summary/Climsmut.html

22. Well Development Emissions Sumary

Pollutant	Well Development Emissions (tons/year)[a]					Total Emissions (tons/yr)
	Construction	Drilling	Completion	Interim Reclamation	Wind Erosion	
Criteria Pollutants & VOC						
NO_x	2.60	20.0	1.46	1.76E-02		24.14
CO	0.91	12.4	4.58	0.14		18.1
VOC	0.17	1.79	1.37	1.1E-02		3.33
SO_2	0.07	0.77	2.6E-02	1.1E-03		0.87
PM_{10}	11.78	69.7	7.64	2.50	0.05	91.7
$PM_{2.5}$	1.53	8.00	0.87	0.26	7.78E-03	10.7
Hazardous Air Pollutants						
Benzene		3.58E-03	0.03			0.03
Toluene		1.30E-03	0.03			0.03
Ethylbenzene			2.52.E-03			2.52.E-03
Xylene		8.91E-04	1.26.E-02			1.3E-02
n-Hexane			0.07			0.07
Formaldehyde	0.06	3.64E-04	8.68E-04			0.06
Acetaldehyde		1.16E-04	1.48E-05			1.31E-04
Acrolein		3.64E-05	1.99E-06			3.84E-05
1,3-Butadiene			6.99E-07			6.99E-07
Naphthalene		6.00E-04	7.13E-06			6.07E-04
Total PAH, POM 1[b]		9.78E-04	1.22E-05			9.91E-04
Total HAPs	0.06	0.01	0.14			0.21
Greenhouse Gases						
CO_2		2,103	1,379			3482
CH_4	0.00	1.3	19.2	8.70E-04		20.6

a Emissions for Peak Field Development
b Polycyclic Aromatic Hydrocarbons (PAH), Polycyclic Organic Matter (POM)

23. Total Project Production Related Emissions Summary

Pollutant	Project Production Emissions (tons/year)[a]			
	Wellsite Storage Tanks + Flare	***Wellsite Heaters***	***Operations Vehicle***	**Total Well Production**
Criteria Pollutants & VOC				
NO_x	0.4	3.83	0.11	4.3
CO	1.9	3.22	1.17	6.3
VOC	10.1	0.21	0.06	10.4
SO_2		0.0	7.48E-03	7.5E-03
PM_{10}		0.29	24.1	24.4
$PM_{2.5}$		0.29	2.41	2.71
Hazardous Air Pollutants				
Benzene	0.33	8.1E-05		0.3
Toluene	0.08	1.3E-04		0.1
Ethylbenzene	0.00			0.0
Xylene	0.02			0.0
n-Hexane	0.15	0.07		0.2
Formaldehyde		2.9E-03		2.9E-03
Dichlorobenzene		4.6E-05		4.6E-05
Naphthalene		2.3E-05		2.3E-05
POM 2[b]		2.3E-06		2.3E-06
POM 3[c]		6.1E-07		6.1E-07
POM 4[d]		6.9E-08		6.9E-08
POM 5[e]		9.2E-08		9.2E-08
Benzo(b)fluoranthene/POM6[f]		2.8E-07		2.8E-07
Chrysene/POM7[g]		6.9E-08		6.9E-08
Total HAPs	***0.59***	***0.07***		***0.7***
Greenhouse Gases				
CO_2	13.41	4601		4615
CH_4	9.15	0.09	9.77E-03	9.25

[a] - Emissions for Peak Field Development
[b] - POM 2 includes: Acenaphthene, acenaphtylene, anthracene, 2-Methylnaphthalene, benzo(e)pyrene benzo(g,h,i)perylene, fluoranthene, fluorene, phenanthrene, and pyrene.
[c] - POM 3 includes: 7,12-Dimethylbenz(a)anthracene.
[d] - POM 4 includes: 3-Methylchloranthrene.
[e] - POM 5 includes: Benzo(a)pyrene and dibenzo(a,h)anthracene.
[f] - POM 6 includes: Benz(a)anthracene, benzo(b)fluoranthene, benzo(k)fluoranthene, and indeno(1,2,3-cd)pyrene.
[g] - POM 7 includes: Chrysene.

24. Total Project Emissions Summary

Pollutant	Well Development (tons/year)					Well Production (tons/year)	Total Emissions[i] (tons/year)
	Construction	Drilling	Completion	Interim Reclamation	Wind Erosion		
Criteria Pollutants & VOC							
NO_x	2.60	20.05	1.46	0.02		4.3	28.4
CO	0.91	12.4	4.58	0.14		6.3	24.4
VOC	0.17	1.79	1.37	0.01		10.4	13.7
SO_2	0.07	0.77	0.03	1.05E-03		7.5E-03	0.9
PM_{10}	11.78	69.7	7.6	2.50	0.05	24.4	116.1
$PM_{2.5}$	1.53	8.00	0.87	0.26	7.78E-03	2.7	13.4
Hazardous Air Pollutants							
Benzene	0	3.58E-03	0.03	0		0.3	0.4
Toluene	0	1.30E-03	0.03	0		0.1	0.1
Ethylbenzene	0	0	2.52E-03	0		0.00	0.0
Xylene	0	8.91E-04	0.01	0		0.0	0.0
n-Hexane	0	0	0.07	0		0.2	0.3
Formaldehyde	6.12E-02	3.64E-04	8.68E-04	0		2.9E-03	0.1
Acetaldehyde	0	1.16E-04	1.48E-05	0		0	0.0
Acrolein	0	3.64E-05	1.99E-06	0		0	0.0
1,3-Butadiene	0	0	6.99E-07	0		0	0.0
Dichlorobenzene	0	6.00E-04	7.13E-06	0		4.6E-05	0.0
Naphthalene	0	6.00E-04	7.13E-06	0		2.3E-05	0.0
PAH[a] -POM 1[b]	0	9.78E-04	1.22E-05	0		0	0.0
POM 2[c]	0	0	0	0		2.3E-06	0.0
POM 3[d]	0	0	0	0		6.1E-07	0.0
POM 4[e]	0	0	0	0		6.9E-08	0.0
POM 5[f]	0	0	0	0		9.2E-08	0.0
Benzo(b)fluoranthene/POM6[g]	0	0	0	0		2.8E-07	0.0
Chrysene/POM7[h]	0	0	0	0		6.9E-08	0.0
Total HAPs	***6.12E-02***	***0.01***	***0.14***	***0***		***0.7***	***0.9***
Greenhouse Gases							
CO_2	0	2103	1378.75	0		4,615	8,097
CH_4	0.00	1.30	19.25	8.70E-04		9.2	30

[a] Polycyclic Aromatic Hydrocarbons (PAH) defined as a HAP by Section 112(b) of the Clean Air Act because it is Polycyclic Organic Matter (POM) AP42 Table 1.4-3 footnotes.

[b] - POM grouped according to subgroups described at EPA's Technology Transfer Network website for the 1999 National-Scale Air Toxics Assessment at http://www.epa.gov/ttn/atw/nata1999/nsata99.html

[c] - POM 2 includes: Acenaphthene, acenaphtylene, anthracene, 2-Methylnaphthalene, benzo(e)pyrene, benzo(g,h,i)perylene, fluoranthene, fluorene, phenanthrene, and pyrene.

[d] - POM 3 includes: 7,12-Dimethylbenz(a)anthracene.

[e] - POM 4 includes: 3-Methylchloranthrene.

[f] - POM 5 includes: Benzo(a)pyrene and dibenzo(a,h)anthracene.

[g] - POM 6 includes: Benz(a)anthracene, benzo(b)fluoranthene, benzo(k)fluoranthene, and indeno(1,2,3-cd)pyrene.

[h] - POM 7 includes: Chrysene.

[i] Emissions for Peak Field Development