

ADDENDUM D

Preliminary Emissions Inventory

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1.0 INTRODUCTION

A preliminary emissions inventory for the CUP was completed to estimate potential combustion and fugitive emissions during each of the four phases (construction, operation, aquifer restoration and decommissioning). The following provides an overview of the methods and the results of the preliminary emissions inventory.

2.0 EQUIPMENT SUMMARY

The equipment included in the preliminary emissions inventory was based on typical equipment anticipated for the various activities (i.e., well field drilling, access road construction, etc.). In order to estimate annual hours of operation, specific details of the proposed project were utilized. These included:

1. Area of disturbance associated with well fields, roads, CCP and satellite facilities, etc. (Section 4.1 of the ER)
2. Number of proposed wells (injection, production, and monitor from HRI)
3. Proposed project schedule (Section 2.1 of the ER and Section 1.4 of the COP)

Table 1 provides a summary of the anticipated equipment operating hours and estimated power rating for the equipment during each project phase. The make and model of each piece of equipment were based on typical construction equipment, while specific details such as power rating and gross vehicle weight were based on manufacturer specifications, when available. Actual equipment used at the CUP may differ from that presented in this report.

3.0 COMBUSTION EMISSIONS

Combustion emissions were calculated using emission factors obtained from the EPA NONROAD2008 emissions model (EPA 2010a). EPA originally developed the model in 2002 to assist state and local regulatory agencies in developing emission inventories. The model is primarily used to estimate emissions for a specific geographic area over a set period of time. In the case of the CUP, the emission factors were used in conjunction with estimated annual operating hours, presented in Table 1, to calculate combustion emissions. Combustion emissions using NONROAD2008 emission factors were calculated using the following equation:

$$E = \text{Power} \times \text{LF} \times A \times \text{EF} \times U$$

where: E = Emissions (tons/yr)
Power = Power rating (hp)
LF = Load factor (fraction of available power)
A = Activity (hrs/yr)
EF = Emission Factor (g/hp-hr)
U = Unit conversion (ton/2000 lb) (lb/453.6 g)

Inputs into the NONROAD2008 model were limited to the diesel sulfur content. In June 2010, EPA lowered the diesel fuel standard for non-road diesel fuel production from 500 ppm to 15 ppm. The lower sulfur fuel is known as ultra-low sulfur diesel (ULSD) and is required for diesel-powered engines constructed after 2007 to meet EPA's Tier 4 emission standards. Although older equipment will be capable of burning ULSD the Tier 4 emissions standards will not apply to pre-2007 diesel engines. To provide a conservatively high estimate of sulfur emissions, a sulfur content of 500 ppm was entered into the model.

Load factors for each piece of equipment were obtained from an EPA guidance document for the NONROAD2008 model (EPA 2010b). Table 2 provides the diesel engine emission factors generated from the NONROAD2008 model for the 2012 calendar year.

3.1 Preliminary Non-Transportation Combustion Emission Estimates using NONROAD2008

Results of the preliminary combustion emissions inventory for non-transportation-related activities are summarized in Table 3. Calculations of emissions by equipment and phase are provided in detail in Appendix A. The emissions presented in the table are meant to provide conservatively high estimates. For example, for the construction phase it was assumed that all proposed construction will be completed within the first year with the exception of the well fields, which will be developed over four years.

Table 3 shows that the construction and decommissioning phases are expected to generate the highest levels of combustion emissions, while operation and aquifer restoration will generate lower combustion emissions. Overall, drilling rigs associated with ISR well field development are expected to contribute the most (about 35% of the total combustion emissions) during the construction phase.

3.2 Preliminary Combustion Emission Estimates for Passenger Vehicles and Material Shipments

Section 4.2.1 of the ER describes the anticipated number of passenger vehicle and truck traffic estimates to and from the project areas during each phase of the project. In order to calculate combustion emissions, the annual operating duration and type of equipment associated with passenger vehicles and material shipment vehicles were estimated. This information is summarized in Tables 4 through 7. The passenger vehicle combustion emissions are conservatively high, since it is assumed that each worker will commute to and from the project areas alone instead of carpooling.

To calculate combustion emissions from semi-haul trucks and pickup trucks, AP-42 emission factors for stationary diesel engines were used (EPA 1995). These factors are conservatively high. For passenger vehicles, average highway emission factors for all pollutants except carbon monoxide (CO) are taken from an EPA emissions report (EPA 2000). CO emission factors are taken from AP-42 (Table 3.3-1 for gasoline engines, EPA 1995). Passenger vehicles were assumed to be passenger cars. Calculations of transportation-related combustion emissions by phase are provided in detail in Appendix B.

Tables 8 through 11 present the combustion emission estimates for passenger vehicles and material transport vehicles during each project phase. Table 12 presents the combustion emission for transportation sources and Table 13 provides the total combustion emissions for the CUP from transportation and non-transportation sources. On average, it is estimated that transportation-related combustion emissions will account for 15% of the total combustion emissions.

4.0 FUGITIVE EMISSIONS

Fugitive particulate matter emissions, as PM₁₀, were estimated for each project phase using the following chapters from the EPA AP-42 report:

Chapter 11.9	Western Surface Coal Mining
Chapter 13.2.2	Unpaved Roads
Chapter 13.2.3	Heavy Construction Equipment
Chapter 13.2.4	Aggregate Handling and Storage Piles

The fugitive emissions were calculated based on the operation summarized in Table 1 and the estimated daily travel distance for each piece of equipment. Additionally, during the construction and decommissioning phases, fugitive emissions also were calculated for activities associated with earthwork including construction of the well fields, roads and processing facilities. The

preliminary fugitive emissions results are summarized in Table 14. Appendix C presents the calculations and assumptions.

5.0 REFERENCES

EPA, 2010a, NONROAD Model. Available on the Internet as of May 2012 at:

<<http://www.epa.gov/oms/nonrdmdl.htm>>

_____, 2010b, Median Life, Annual Activity, and Load Factor Values for Nonroad Engine Emissions Modeling, EPA-420-R-10-016.

_____, 2000, Average Annual Emissions and Fuel Consumption for Passenger Cars and Light Trucks, EPA420-F-00-013, April 2000.

_____, 1995, Compilation of Air Pollutant Emission Factors, Volume I: Stationary Point and Area Sources, AP-42.

Table 1. Estimated Power Rating and Operating Hours of Diesel Engine Construction Equipment

Equipment	Make/Model ¹	HP	Equipment Operation (hrs/yr)			
			Construction	Operation	Aquifer Restoration	Decommissioning
Cementing unit	Unknown	75	6,400	-	-	2,272
Drilling rig	Unknown	475	14,400	-	-	-
Pulling unit	SEMCO	75	6,400	2,600	1,300	1,136
Backhoe	CAT 420E	101	15,920	3,640	1,820	3,744
Bulldozer	CAT D7	235	1,840	-	-	3,240
Front end loader	CAT 420E	101	1,560	-	-	1,144
Grader	CAT 140M	183	2,460	-	-	2,528
Roller compactor	CAT 815F	253	1,060	-	-	672
Scraper	CAT 627	330	2,640	-	-	3,760
Trackhoe	CAT 953D	148	2,220	-	-	3,112
Trencher	Vermier RTX1250	120	3,175	-	-	40
Dump truck	Kenworth	260	1,985	-	-	1,600
Hydraulic crane	Link-Belt RTC-8050	174	385	-	-	-
Mix truck	Kenworth	260	1,020	-	-	-
Semi-haul truck	Kenworth	260	2,392	-	-	7,880
Water truck	Kenworth	260	10,705	-	-	2,232
Disc tractor	John Deere	101	560	-	-	1,016
Seed drill tractor	John Deere	101	536	-	-	680
Forklift	CAT RC60	83	7,305	520	520	-
Manlift	Genie S-60X	46	1,420	65	-	640
Picker	CAT TL1255	141	940	-	-	60
Skid-steer loader	CAT 256C	84	416	-	-	1,424
Welding machine	Perkins	10	3,660	780	780	-
Air compressor	Ingersoll-Rand	25	520	3,120	3,120	-
Generator	Wacker Newson GP4000	9	4,240	780	780	3,928
Integrity testing unit	Ford 350	350	6,400	3,120	1,560	-
Flat bed truck	Ford 450	390	219	-	-	-
Logging truck	Ford 350	350	4,800	-	-	-
Pickup truck	Ford 350	350	2,694	7,800	3,120	3,500
Swab rig	Ford 350	350	5,400	4,160	2,080	-

¹Typical make/model for anticipated type of equipment; actual equipment may vary

Table 2. EPA NONROAD2008 Emission Factors

Equipment	Emission Factors (g/hp-hr)					
	THC	NO _x	CO	PM ₁₀	SO ₂	CO ₂
Cementing unit	0.4477	4.6024	4.0350	0.6030	0.1822	594.7
Drilling rig	0.3837	5.7681	1.8598	0.3178	0.1600	529.8
Pulling unit	0.4477	4.6024	4.0350	0.6030	0.1822	594.7
Backhoe	0.9288	5.9484	3.8524	0.6954	0.1911	623.6
Bulldozer	0.2369	3.1904	1.0992	0.2476	0.1586	536.1
Front end loader	0.9288	5.9484	3.8524	0.6954	0.1911	623.6
Grader	0.2351	3.1595	1.0949	0.2470	0.1585	536.1
Roller compactor	0.2575	3.5428	1.1749	0.2625	0.1595	536.0
Scraper	0.2073	3.8871	1.6115	0.2491	0.1603	536.2
Trackhoe	0.2586	3.3247	1.4265	0.3437	0.1642	536.0
Trencher	0.3251	4.2397	1.6670	0.3611	0.1642	535.8
Dump truck	0.1955	2.5837	1.0311	0.2448	0.1550	536.2
Hydraulic crane	0.2878	4.0041	1.0028	0.2584	0.1624	530.1
Mix truck	0.4352	5.7512	1.6821	0.3270	0.1599	529.7
Semi-haul truck	0.1955	2.5837	1.0311	0.2448	0.1550	536.2
Water truck	0.1955	2.5837	1.0311	0.2448	0.1550	536.2
Disc tractor	0.3213	4.2044	1.6457	0.3590	0.1642	535.8
Seed drill tractor	0.3213	4.2044	1.6457	0.3590	0.1642	535.8
Forklift	2.1962	6.2593	8.1968	1.1762	0.2111	689.0
Manlift	2.1962	6.2593	8.1968	1.1762	0.2111	689.0
Picker	2.1962	6.2593	8.1968	1.1762	0.2111	689.0
Skid-steer loader	1.5859	6.5081	8.1442	1.2687	0.2117	690.9
Welding machine	2.0370	7.2416	10.6755	1.4502	0.2112	689.5
Air compressor	0.3916	4.8088	1.7272	0.3606	0.1806	589.3
Generator	0.9416	6.1520	4.7813	0.7367	0.1800	587.4
Integrity testing unit	0.3149	4.8867	2.3447	0.3428	0.1613	535.8
Flat bed truck	0.3149	4.8867	2.3447	0.3428	0.1613	535.8
Logging truck	0.3149	4.8867	2.3447	0.3428	0.1613	535.8
Pickup truck	0.3149	4.8867	2.3447	0.3428	0.1613	535.8
Swab rig	0.3149	4.8867	2.3447	0.3428	0.1613	535.8

Table 3. CUP Combustion Emissions Estimates using NONROAD2008 Model

Equipment Type	Maximum Combustion Emissions (short tons/yr)					
	THC	NO_x	CO	PM₁₀	SO₂	CO₂
Construction	4.9	55.1	25.1	4.3	2.0	6,524
Operation	0.9	11.8	6.1	0.9	0.4	1,305
Aquifer Restoration	0.4	5.2	2.8	0.4	0.2	579
Decommissioning	1.4	18.3	8.3	1.6	0.8	2,835

Table 4. Estimated Passenger Vehicles and Material Shipments to and from the Project Areas during Construction

Category	Equipment Type	Make/Model¹	HP	No. One-Way Trips per Day	Calculation Method	Duration of Operation per Trip² (hrs)	Equipment Operation (hrs/yr)
Worker transport	Passenger vehicle	Passenger Car	200	100	50 passenger vehicles x 2 round trips/day	0.083	3,030
Construction supplies and equipment	Semi-haul truck	Kenworth	260	8	4 shipments/day x 2 round trips/shipment	0.5	1,460
Chemicals and fuel	Semi-haul truck	Kenworth	260	8	4 shipments/day x 2 round trips/shipment	0.5	1,460

¹ Typical make/model for anticipated type of equipment. Actual equipment may differ.

² Within project areas; assumes 5 min. for passenger vehicles and pickup truck trips and 30 min. for semi-haul truck trips (including idling during loading/unloading).

Table 5. Estimated Passenger Vehicles and Material Shipments to and from the Project Areas during Operation

Category	Equipment Type	Make/Model ¹	HP	No. One-Way Trips per Day	Calculation Method	Duration of Operation per Trip ² (hrs)	Equipment Operation (hrs/yr)
Worker transport	Passenger vehicle	Passenger Car	200	140	70 passenger vehicles x 2 round trips/day	0.083	4,240
Yellowcake	Semi-haul truck	Kenworth	260	0.41	75 shipments/yr x 2 round trips/shipment	0.5	75
Chemicals and fuel	Semi-haul truck	Kenworth	260	1.10	200 shipments/yr x 2 round trips/shipment	0.5	200
Loaded resin or yellowcake slurry	Semi-haul truck	Kenworth	260	2	1 shipment/day for each satellite facility x 1 satellite facility x 2 round trips /shipment	0.5	365
11e.(2) byproduct material	Semi-haul truck	Kenworth	260	0.03	6 shipments/yr x 2 round trips/shipment	0.5	5
Solid waste	Semi-haul truck	Kenworth	260	0.35	63 shipments/yr x 2 round trips/shipment	0.5	64
Hazardous waste	Pickup truck	Ford 350	350	0.01	1 shipment/yr x 2 round trips/shipment	0.083	0.3

¹ Typical make/model for anticipated type of equipment. Actual equipment may differ.

² Within project areas; assumes 5 min. for passenger vehicles and pickup truck trips and 30 min. for semi-haul truck trips (including idling during loading/unloading).

Table 6. Estimated Passenger Vehicles and Material Shipments to and from the Project Areas during Aquifer Restoration

Category	Equipment Type	Make/Model¹	HP	No. One-Way Trips per Day	Calculation Method	Duration of Operation per Trip² (hrs)	Equipment Operation (hrs/yr)
Worker transport	Passenger vehicle	Passenger Car	200	20	10 passenger vehicles x 2 round trips/day	0.083	606
Material transport	Semi-haul truck	Kenworth	260	2	1 shipments/day x 2 round trips/shipment	0.5	365

¹ Typical make/model for anticipated type of equipment. Actual equipment may differ.

² Within project areas; assumes 5 min. for passenger vehicles and pickup truck trips and 30 min. for semi-haul truck trips (including idling during loading/unloading).

Table 7. Estimated Passenger Vehicles and Material Shipments To and From the Project Areas during Decommissioning

Category	Equipment Type	Make/Model¹	HP	No. One-Way Trips per Day	Calculation Method	Duration of Operation per Trip² (hrs)	Equipment Operation (hrs/yr)
Worker transport	Passenger vehicle	Passenger Car	200	44	22 passenger vehicles x 2 round trips/day	0.083	1,335
Material transport	Semi-haul truck	Kenworth	260	4	2 shipments/day x 2 round trips/shipment	0.5	730

¹ Typical make/model for anticipated type of equipment. Actual equipment may differ.

² Within project areas; assumes 5 min. for passenger vehicles and pickup truck trips and 30 min. for semi-haul truck trips (including idling during loading/unloading).

Table 8. Estimated Passenger Vehicle and Material Transport Tailpipe Emissions during Construction

Category	Equipment Type	Operating Hours	Combustion Emissions (tons/yr)					
			THC	NO _x	CO	PM ₁₀	SO ₂	CO ₂
Worker transport	Passenger vehicle	3,030	0.51	0.26	0.84	0.08	0.07	76.31
Construction supplies and equipment	Semi-haul truck	1,460	0.20	2.53	0.55	0.18	0.17	93.86
Chemicals and fuel	Semi-haul truck	1,460	0.20	2.53	0.55	0.18	0.17	93.86

Table 9. Estimated Passenger Vehicle and Material Transport Tailpipe Emissions during Operation

Category	Equipment Type	Operating Hours	Combustion Emissions (tons/yr)					
			THC	NO _x	CO	PM ₁₀	SO ₂	CO ₂
Worker transport	Passenger vehicle	4,240	0.72	0.36	1.18	0.12	0.10	106.84
Yellowcake	Semi-haul truck	75	0.01	0.13	0.03	0.01	0.01	4.81
Chemicals and fuel	Semi-haul truck	200	0.03	0.35	0.07	0.02	0.02	12.91
Loaded resin or yellowcake slurry	Semi-haul truck	365	0.05	0.63	0.41	0.04	0.04	23.46
11e.(2) byproduct material	Semi-haul truck	5	0.00	0.01	0.00	0.00	0.00	0.35
Solid waste	Semi-haul truck	64	0.01	0.11	0.02	0.01	0.01	4.11
Hazardous waste	Pickup truck	0.3	0.00	0.00	0.00	0.00	0.00	0.02

Table 10. Estimated Passenger Vehicle and Material Transport Tailpipe Emissions during Aquifer Restoration

Category	Equipment Type	Operating Hours	Combustion Emissions (tons/yr)					
			THC	NO _x	CO	PM ₁₀	SO ₂	CO ₂
Worker transport	Passenger vehicle	606	0.10	0.05	0.17	0.02	0.01	15.26
Material transport	Semi-haul truck	365	0.05	0.63	0.14	0.04	0.04	23.46

Table 11. Estimated Passenger Vehicle and Material Transport Tailpipe Emissions during Decommissioning

Category	Equipment Type	Operating Hours	Combustion Emissions (tons/yr)					
			THC	NO _x	CO	PM ₁₀	SO ₂	CO ₂
Worker transport	Passenger vehicle	1,335	0.23	0.11	0.37	0.04	0.03	33.58
Material transport	Semi-haul truck	730	0.10	1.27	0.27	0.09	0.08	46.93

Table 12. Summary of Estimated Transportation-Related Emissions from Combustion

Project Phase	Transportation Combustion Emissions (short tons/yr)					
	THC	NO_x	CO	PM₁₀	SO₂	CO₂
Construction	0.9	5.3	1.9	0.4	0.4	264
Operation	0.8	1.6	1.5	0.2	0.2	152
Aquifer Restoration	0.2	0.7	0.3	0.1	0.1	39
Decommissioning	0.3	1.4	0.6	0.1	0.1	81

Table 13. Summary of Estimated Non-Transportation and Transportation-Related Emissions from Combustion

Equipment Type	Estimated Combustion Emissions (short tons/yr)					
	THC	NO_x	CO	PM₁₀	SO₂	CO₂
Construction	5.8	60.4	27	4.7	2.4	6,788
Operation	1.7	13.4	7.6	1.1	0.6	1,457
Aquifer Restoration	0.6	5.9	3.1	0.5	0.3	618
Decommissioning	1.7	19.7	8.9	1.7	0.9	2,916

Table 14. PM₁₀ Fugitive Emissions Estimates

Phase	PM₁₀ Emissions (short tons/yr)
Construction	61.6
Operation	17.4
Aquifer Restoration	7.3
Decommissioning	33.5

APPENDIX A
NON-TRANSPORTATION COMBUSTION
EMISSION ESTIMATES
BY EQUIPMENT/PHASE

CUP
Equipment Summary and Emission Factors
Construction

Equipment Type	Total Operating Hours	NONROAD2008 Combustion Emissions (tons/yr) ¹					
		THC	NO _x	CO	PM ₁₀	SO ₂	CO ₂
Cementing Unit	6,400	0.14	1.44	1.26	0.19	0.06	185.7
Drilling rig	14,400	1.71	25.66	8.27	1.41	0.71	2,356.9
Deep Drilling rig	0	0.00	0.00	0.00	0.00	0.00	0.0
Pulling Unit	6,400	0.14	1.44	1.26	0.19	0.06	185.7
Backhoe	15,920	0.35	2.21	1.43	0.26	0.07	232.1
Bulldozer	1,840	0.07	0.90	0.31	0.07	0.04	150.8
Front end loader	1,560	0.03	0.22	0.14	0.03	0.01	22.7
Grader	2,460	0.07	0.93	0.32	0.07	0.05	157.0
Roller compactor	1,060	0.04	0.62	0.20	0.05	0.03	93.5
Scraper	2,640	0.12	2.20	0.91	0.14	0.09	303.8
Trackhoe	2,220	0.06	0.71	0.30	0.07	0.04	114.5
Trencher	3,175	0.08	1.05	0.41	0.09	0.04	132.8
Dump truck	1,985	0.07	0.87	0.35	0.08	0.05	180.0
Hydraulic crane	385	0.01	0.13	0.03	0.01	0.01	16.8
Mix truck	1,020	0.05	0.72	0.21	0.04	0.02	66.6
Semi-haul truck	2,392	0.08	1.05	0.42	0.10	0.06	216.9
Water truck	10,705	0.35	4.68	1.87	0.44	0.28	970.6
Disc tractor	560	0.01	0.15	0.06	0.01	0.01	19.7
Seed drill tractor	536	0.01	0.15	0.06	0.01	0.01	18.9
Forklift	7,305	0.87	2.47	3.23	0.46	0.08	271.7
Manlift	1,420	0.03	0.09	0.12	0.02	0.00	10.4
Picker	940	0.07	0.19	0.25	0.04	0.01	21.1
Skid-steer loader	416	0.01	0.05	0.07	0.01	0.00	5.6
Welding machine	3,660	0.02	0.06	0.09	0.01	0.00	5.8
Air compressor	520	0.00	0.03	0.01	0.00	0.00	3.6
Generator	4,240	0.02	0.11	0.09	0.01	0.00	10.6
Integrity testing unit	6,400	0.09	1.45	0.69	0.10	0.05	158.8
Flat bed truck	219	0.02	0.27	0.13	0.02	0.01	29.8
Logging truck	4,800	0.07	1.09	0.52	0.08	0.04	119.1
Pickup truck	2,694	0.19	3.00	1.44	0.21	0.10	328.6
Swab rig	5400	0.08	1.22	0.59	0.09	0.04	134.0
TOTAL		4.85	55.14	25.05	4.31	1.95	6,523.8

¹ Combustion emissions calculated using EPA NONROAD2008 Emission Factors

CUP
Equipment Summary and Emission Factors
Operation

Equipment Type	Total Operating Hours	NONROAD2008 Combustion Emissions (tons/yr) ¹					
		THC	NO _x	CO	PM ₁₀	SO ₂	CO ₂
Pulling unit	2,600	0.06	0.58	0.51	0.08	0.02	75.4
Backhoe	3,640	0.08	0.51	0.33	0.06	0.02	53.1
Forklift	520	0.06	0.18	0.23	0.03	0.01	19.3
Manlift	65	0.00	0.00	0.01	0.00	0.00	0.5
Welding machine	780	0.00	0.01	0.02	0.00	0.00	1.2
Air compressor	3,120	0.01	0.18	0.06	0.01	0.01	21.8
Fusion machine	520	0.00	0.00	0.00	0.00	0.00	0.0
Generator	780	0.00	0.02	0.02	0.00	0.00	2.0
Integrity testing unit	3,120	0.05	0.71	0.34	0.05	0.02	77.4
Pickup truck	7,800	0.56	8.68	4.16	0.61	0.29	951.3
Swab rig	4,160	0.06	0.94	0.45	0.07	0.03	103.2
TOTAL		0.89	11.80	6.13	0.91	0.39	1,305.2

¹ Combustion emissions calculated using EPA NONROAD2008 Emission Factors

CUP
Equipment Summary and Emission Factors
Aquifer Restoration

Equipment Type	Total Operating Hours	NONROAD2008 Combustion Emissions (tons/yr) ¹					
		THC	NO _x	CO	PM ₁₀	SO ₂	CO ₂
Pulling unit	1,300	0.03	0.29	0.26	0.04	0.01	37.7
Backhoe	1,820	0.04	0.25	0.16	0.03	0.01	26.5
Forklift	520	0.06	0.18	0.23	0.03	0.01	19.3
Welding machine	780	0.00	0.01	0.02	0.00	0.00	1.2
Air compressor	3,120	0.01	0.18	0.06	0.01	0.01	21.8
Fusion machine	520	0.00	0.00	0.00	0.00	0.00	0.0
Generator	780	0.00	0.02	0.02	0.00	0.00	2.0
Integrity testing unit	1,560	0.02	0.35	0.17	0.02	0.01	38.7
Pickup truck	3,120	0.22	3.47	1.67	0.24	0.11	380.5
Swab rig	2,080	0.03	0.47	0.23	0.03	0.02	51.6
TOTAL		0.43	5.23	2.81	0.42	0.18	579.4

¹ Combustion emissions calculated using EPA NONROAD2008 Emission Factors

CUP
Equipment Summary and Emission Factors
Decommissioning

Equipment Type	Total Operating Hours	NONROAD2008 Combustion Emissions (tons/yr) ¹					
		THC	NO _x	CO	PM ₁₀	SO ₂	CO ₂
Cementing unit	2,272	0.05	0.51	0.45	0.07	0.02	65.9
Pulling unit	1,136	0.02	0.26	0.22	0.03	0.01	33.0
Backhoe	3,744	0.08	0.52	0.34	0.06	0.02	54.6
Bulldozer	3,240	0.12	1.58	0.54	0.12	0.08	265.5
Front End Loader	1,144	0.02	0.16	0.10	0.02	0.01	16.7
Grader	2,528	0.07	0.95	0.33	0.07	0.05	161.3
Roller compactor	672	0.03	0.39	0.13	0.03	0.02	59.3
Scraper	3,760	0.17	3.14	1.30	0.20	0.13	432.7
Trackhoe	3,112	0.08	1.00	0.43	0.10	0.05	160.6
Trencher	40	0.00	0.01	0.01	0.00	0.00	1.7
Dump truck	1,600	0.05	0.70	0.28	0.07	0.04	145.1
Semi-haul truck	7,880	0.26	3.44	1.37	0.33	0.21	714.5
Water truck	2,232	0.07	0.98	0.39	0.09	0.06	202.4
Disc tractor	1,016	0.02	0.28	0.11	0.02	0.01	35.8
Seed drill tractor	680	0.01	0.19	0.07	0.02	0.01	23.9
Manlift	640	0.01	0.04	0.06	0.01	0.00	4.7
Picker	60	0.00	0.01	0.02	0.00	0.00	1.3
Skid-steer loader	1,424	0.04	0.18	0.23	0.04	0.01	19.1
Generator	3,928	0.02	0.10	0.08	0.01	0.00	9.8
Pickup truck	3,500	0.25	3.89	1.87	0.27	0.13	426.9
TOTAL		1.40	18.33	8.32	1.57	0.84	2,834.5

¹ Combustion emissions calculated using EPA NONROAD2008 Emission Factors

APPENDIX B
TRANSPORTATION COMBUSTION
EMISSIONS BY PHASE

CUP
Transportation Emission Factors

Passenger Car	THC	CO	NO_x	CO₂	Light Truck	THC	CO	NO_x	CO₂
emission factor (g/mile)	2.8	20.9	1.39	415.86	emission factor (g/mile)	3.51	27.7	1.81	522.1
gal/mile	0.0465	0.0465	0.0465	0.0465	gal/mile	0.0581	0.0581	0.0581	0.0581
hp rating	200	200	200	200	hp rating	200	200	200	200
load factor	0.4	0.4	0.4	0.4	load factor	0.4	0.4	0.4	0.4
average speed (mph)	55	55	55	55	average speed (mph)	75	75	75	75
g/hp-hr	1.925	14.36875	0.9556	285.91	g/hp-hr	3.2906	25.969	1.69688	489.47
lb/hp-hr calculated	0.0042	0.0316	0.0021	0.6298	lb/hp-hr calculated	0.0072	0.0572	0.0037	1.0781
lb/hp-hr AP-42	0.0216	0.0070	0.0110	1.0800	lb/hp-hr AP-42	0.0216	0.0070	0.0110	1.0800

Assumed Emission Factors (lb/hp-hr)

Vehicle Type	HP	Load Factor	THC	NO_x	CO¹	PM₁₀	SO₂	CO₂	Source
Passenger Car	200	0.4	0.0042	0.0021	0.00696	0.0007	0.0006	0.6298	1
Light Truck	200	0.4	0.0072	0.0037	0.00696	0.0007	0.0006	1.0781	1
Kenworth	260	0.43	0.0025	0.031	0.0067	0.0022	0.0021	1.15	2
Ford F-350	350	0.59	0.0025	0.031	0.0067	0.0022	0.0021	1.15	2

¹ CO for Light Truck taken from AP-42, Table 3.3-1 since 27.7 g/mile >> 3.4 g/mi listed in EPA-450/3079-006

Sources:

EPA, Average Annual Emissions and Fuel Consumption for Passenger Cars and Light Trucks, April 2000

EPA AP-42, Compilation of Air Pollutant Emission Factors, Table 3.3-1, January 1995

CUP
Estimated Transportation-Related Combustion Emissions

CONSTRUCTION	Equipment Type	Make/Model	HP	No. One-Way Trips per Day	Calculation Method	Duration of Operation per Trip (hrs)	Equipment Operation (hrs/yr)	Combustion Emissions (tons/yr)					
Category								THC	NO _x	CO	PM ₁₀	SO ₂	CO ₂
Worker transport	Passenger vehicle	Passenger Car	200	100	50 passenger vehicles x 2 round trips/day	0.083	3,030	0.51	0.26	0.84	0.08	0.07	76.31
Construction supplies and equipment	Semi-haul truck	Kenworth	260	8	4 shipments/day x 2 round trips/shipment	0.5	1,460	0.20	2.53	0.55	0.18	0.17	93.86
Chemicals and fuel	Semi-haul truck	Kenworth	260	8	4 shipments/day x 2 round trips/shipment	0.5	1,460	0.20	2.53	0.55	0.18	0.17	93.86

OPERATION	Equipment Type	Make/Model	HP	No. One-Way Trips per Day	Calculation Method	Duration of Operation per Trip (hrs)	Equipment Operation (hrs/yr)	Combustion Emissions (tons/yr)					
Category								THC	NO _x	CO	PM ₁₀	SO ₂	CO ₂
Worker transport	Passenger vehicle	Passenger Car	200	140	70 passenger vehicles x 2 round trips/day	0.083	4,241	0.72	0.36	1.18	0.12	0.10	106.84
Yellowcake	Semi-haul truck	Kenworth	260	0.41	75 shipments/yr x 2 round trips/shipment	0.5	75	0.01	0.13	0.03	0.01	0.01	4.81
Chemicals and fuel	Semi-haul truck	Kenworth	260	1.1	200 shipments/yr x 2 round trips/shipment	0.5	201	0.03	0.35	0.07	0.02	0.02	12.91
Loaded resin or yellowcake slurry	Semi-haul truck	Kenworth	260	2	1 shipment/day for each satellite facility x 1 satellite facility x 2 round trips/shipment	0.5	365	0.05	0.63	0.14	0.04	0.04	23.46
11e.(2) byproduct material	Semi-haul truck	Kenworth	260	0.03	6 shipments/yr x 2 round trips/shipment	0.5	5	0.00	0.01	0.00	0.00	0.00	0.35
Solid waste	Semi-haul truck	Kenworth	260	0.35	63 shipments/yr x 2 round trips/shipment	0.5	64	0.01	0.11	0.02	0.01	0.01	4.11
Hazardous waste	Passenger vehicle	Light truck	260	0.01	1 shipment/yr x 2 round trips/shipment	0.083	0.3	0.00	0.00	0.00	0.00	0.00	0.02

RESTORATION	Equipment Type	Make/Model	HP	No. One-Way Trips per Day	Calculation Method	Duration of Operation per Trip (hrs)	Equipment Operation (hrs/yr)	Combustion Emissions (tons/yr)					
Category								THC	NO _x	CO	PM ₁₀	SO ₂	CO ₂
Worker transport	Passenger vehicle	Passenger Car	200	20	10 passenger vehicles x 2 round trips/day	0.083	606	0.10	0.05	0.17	0.02	0.01	15.26
Material transport	Semi-haul truck	Kenworth	260	2	1 shipments/day x 2 round trips/shipment	0.5	365	0.05	0.63	0.14	0.04	0.04	23.46

DECOMMISSIONING	Equipment Type	Make/Model	HP	No. One-Way Trips per Day	Calculation Method	Duration of Operation per Trip (hrs)	Equipment Operation (hrs/yr)	Combustion Emissions (tons/yr)					
Category								THC	NO _x	CO	PM ₁₀	SO ₂	CO ₂
Worker transport	Passenger vehicle	Passenger Car	200	44	22 passenger vehicles x 2 round trips/day	0.083	1,333	0.23	0.11	0.37	0.04	0.03	33.58
Material transport	Semi-haul truck	Kenworth	260	4	2 shipments/day x 2 round trips/shipment	0.5	730	0.10	1.27	0.27	0.09	0.08	46.93

APPENDIX C
FUGITIVE EMISSION
CALCULATIONS

CUP
Fugitive Dust Emission Factors

Inputs:

Satellite Facility Area Material Moisture Content (%) - Overburden	5 Grants NRCS Field Office
Satellite Facility Area Material Moisture Content (%) - Topsoil	5 Grants NRCS Field Office
Satellite Facility Area Material Silt Content (%) - Overburden	24 1987 HRI Soil Survey of the Church Rock Section 8 Project Area
Satellite Facility Area Material Silt Content (%) - Topsoil	22 1987 HRI Soil Survey of the Church Rock Section 8 Project Area
Mean Vehicle Speed (mph)	5 WWC Estimate
Well field Material Moisture Content (%) - Overburden	5 Grants NRCS Field Office
Well field Material Moisture Content (%) - Topsoil	5 Grants NRCS Field Office
Well field Material Silt Content (%) - Overburden	24 1987 HRI Soil Survey of the Church Rock Section 8 Project Area
Well field Material Silt Content (%) - Topsoil	22 1987 HRI Soil Survey of the Church Rock Section 8 Project Area
Average Wind Speed (mph)	6.7 NWS Gallup (1996 - 2011)
Scrapper Mean Vehicle Weight (tons)	41 CAT Spec Sheet
Road Base Material Moisture Content (%)	15 WWC Estimate

Site Preparation Satellite Facility

Activity	TSP <30 µm	< 15 µm	Scaling Factor		<10 µm	<5 µm	<2.5 µm	Rating Adjustment (Table 13.2.3-1)
			<10 µm	<2.5 µm				
Bulldozing overburden (AP-42, Table 11.9-1) lb/hr	31.88	12.35	0.52	0.03	6.42		0.96	-1/-2
Scrapers unloading topsoil (AP-42, Chapter 13.2.4, Eqn 1) lb/ton	0.0010	0.0006			0.0013	0.0008	0.0002	-1
Scrapers in travel (AP-42, Chapter 13.2.2, Eqn 1a) lb/VMT	8.61				2.21		0.22	-0/-1
Scrapers removing topsoil (AP-42, Table 13.2.3-1) lb/VMT					20.20			E
Truck dumping of fill material, road base, or other material (AP-42, Chapter 13.2.4, Eqn 1) lb/	0.0006	0.0004			0.0003	0.0002	0.0000	-0/-1
Compacting (AP-42, Table 11.9-1) lb/hr	31.88	12.35	0.52	0.03	6.42		0.96	-1/-2
Motor grading (AP-42, Table 11.9-1) lb/VMT	2.24	1.28	0.60	0.03	0.77		0.07	-1/-2

VMT - vehicle mile traveled

Site Preparation Well field

Activity	TSP <30 µm	< 15 µm	Scaling Factor		<10 µm	<5 µm	<2.5 µm	Rating Adjustment (Table 13.2.3-1)
			<10 µm	<2.5 µm				
Bulldozing overburden (AP-42, Table 11.9-1) lb/hr	31.88	12.35	0.52	0.03	6.42		0.96	-1/-2
Scrapers unloading topsoil (AP-42, Chapter 13.2.4, Eqn 1) lb/ton	0.0028	0.0018			0.0013	0.0008	0.0002	-1
Scrapers in travel (AP-42, Chapter 13.2.2, Eqn 1a) lb/VMT	8.61				2.21		0.22	-0/-1
Scrapers removing topsoil (AP-42, Table 13.2.3-1) lb/VMT					20.20			E
Truck dumping of fill material, road base, or other material (AP-42, Chapter 13.2.4, Eqn 1) lb/	0.0006	0.0004			0.0003	0.0002	0.0000	-0/-1
Compacting (AP-42, Table 11.9-1) lb/hr	31.88	12.35	0.52	0.03	6.42		0.96	-1/-2
Motor grading (AP-42, Table 11.9-1) lb/VMT	2.24	1.28	0.60	0.03	0.77		0.07	-1/-2

VMT - vehicle mile traveled

CUP
Fugitive Dust Emission Factors

Vehicles Traveling Unpaved Roads (AP-42, 13.2.2 Eqn 1a)

Unpaved Surfaces at Industrial Sites, lb/VMT

Equipment	GVW (tons)	Emission Factor (lb/VMT)		
		PM _{2.5}	PM ₁₀	PM ₃₀
Backhoe	8	0.435215	4.35215	12.3766
Bulldozer	28	0.764777	7.64777	21.7487
Cementing unit	20	0.657321	6.57321	18.6929
Disc tractor	4	0.318596	3.18596	9.06024
Drilling rig	20	0.657321	6.57321	18.6929
Dump truck	20	0.657321	6.57321	18.6929
Forklift	14	0.55985	5.5985	15.921
Front end loader	8	0.435215	4.35215	12.3766
Grader	18	0.626883	6.26883	17.8273
Hydraulic crane	36	0.856347	8.56347	24.3528
Manlift	10	0.481187	4.81187	13.684
Mix truck	20	0.657321	6.57321	18.6929
Picker	18	0.626883	6.26883	17.8273
Pulling unit	8	0.435215	4.35215	12.3766
Roller compactor	23	0.699989	6.99989	19.9063
Scraper	41	0.907959	9.07959	25.8205
Seed drill tractor	4	0.318596	3.18596	9.06024
Semi-haul truck	20	0.657321	6.57321	18.6929
Skid-steer loader	4	0.318596	3.18596	9.06024
Trackhoe	17	0.610964	6.10964	17.3746
Trencher	7	0.409834	4.09834	11.6548
Water truck	20	0.657321	6.57321	18.6929

Vehicles Traveling Unpaved Roads (AP-42, 13.2.2 Eqn 1b) - Light Duty Vehicles

Unpaved Surfaces on Publicly Accessible Roads, lb/VMT

Surface silt content (%)

Surface moisture content (%)

Speed Limit (mph)

22 1987 HRI Soil Survey of the Church Rock Section 8 Project Area

5 Estimate

15 Planned

Equipment	Emission Factor (lb/VMT)		
	PM _{2.5}	PM ₁₀	PM ₃₀
Light duty vehicle	0.1468709	1.471839	4.47753

CUP
Estimated Fugitive Dust during Construction Phase

Construction Phase Estimated Total Fugitive PM₁₀ Emissions

61.64 tons/yr

Heavy Construction Operations (AP-42)

Activity		Site Preparation Satellite Facility	Well Field and Roads Preparation
Bulldozing	Emission Factor (lb/hr)	6.42	6.42
	Activity (hr/yr)	520	1,960
	Control Efficiency (%) ¹	50	50
	PM₁₀ Emissions (tons/yr)	0.84	3.15
Scraper Unloading Topsoil	Emission Factor (lb/ton)	0.0013	0.0013
	Area (ac/yr)	6	95
	Stripping Depth (ft)	0.5	0.5
	Topsoil (CY/yr)	4,840	76,633
	Density of Topsoil (tons/CY)	1.25	1.25
	Control Efficiency (%) ¹	50	50
	PM₁₀ Emissions (tons/yr)	0.00	0.03
Scrapers in Travel	Emission Factor (lb/VMT)	2.21	2.21
	Scraper VMT (mi/day)	4	4
	Scraper Operation (day/yr)	170	160
	Control Efficiency (%) ¹	50	50
	PM₁₀ Emissions (tons/yr)	0.38	0.35
Scrapers Removing Topsoil	Emission Factor (lb/VMT)	20.20	20.20
	Scraper VMT (mi/day)	2	2
	Scraper Operation (day/yr) ²	170	160
	Control Efficiency (%) ¹	50	50
	PM₁₀ Emissions (tons/yr)	1.717	1.62
Truck Dumping Fill Material	Emission Factor (lb/ton)	0.0003	0.0003
	Aggregate Material (CY)	2,800	8,000
	Material Density (tons/CY)	1.5	1.5
	Control Efficiency (%) ¹	50	50
	PM₁₀ Emissions (tons/yr)	0.60	1.70
Compacting	Emission Factor (lb/hr)	6.42	6.42
	Activity (hr/yr)	660	400
	Control Efficiency (%) ¹	50	50
	PM₁₀ Emissions (tons/yr)	1.06	0.64
Grading	Emission Factor (lb/hr)	0.77	0.77
	Activity (hr/yr)	540	3,840
	Control Efficiency (%) ¹	50	50
	PM₁₀ Emissions (tons/yr)	0.10	0.73
Heavy Construction Fugitive PM₁₀ Emissions (tons/yr)		4.69	8.23

¹ Assume 50% control efficiency

² Based on 8 hr work days

Fugitive Emissions from Vehicles Traveling Unpaved Roads (AP-42 13.2.2 Eqn 1a)

Equipment ¹	PM ₁₀ Emission Factor (lb/VMT)	Est Max Distance Traveled (mi/day)	Equipment Operating Days (days/yr)	VMT (mi/yr)	PM ₁₀ Emissions (tons/yr)
Cementing unit	6.57	0.5	800	400	0.66
Drilling rig	6.57	0.5	1,800	900	1.48
Pulling unit	4.35	0.5	800	400	0.44
Backhoe	4.35	3	1,990	5,970	6.50
Bulldozer	7.65	5	230	1,150	2.20
Front end loader	4.35	5	195	975	1.06
Grader	6.27	10	308	3,075	4.82
Roller compactor	7.00	5	133	663	1.16
Trackhoe	6.11	1	278	278	0.42
Trencher	4.10	1	397	397	0.41
Dump truck	6.57	8	248	1,985	3.26
Hydraulic crane	8.56	0.2	48	10	0.02
Mix truck	6.57	2	128	255	0.42
Semi-haul truck	6.57	10	299	2,990	4.91
Water truck	6.57	5	1,338	6,691	10.99
Disc tractor	3.19	5	70	350	0.28
Seed drill tractor	3.19	5	67	335	0.27
Forklift	5.60	0.5	913	457	0.64
Manlift	4.81	0.25	178	44	0.05
Picker	6.27	0.25	118	29	0.05
Skid-steer loader	3.19	2	52	104	0.08
Integrity testing unit	3.82	1	800	800	0.76
Flat bed truck	4.35	5	27	137	0.15
Logging truck	3.82	5	600	3,000	2.87
Pickup truck	3.82	15	337	5,051	4.83
Vehicle Traveling Unpaved Roads Fugitive PM₁₀ Emissions (tons/yr)					48.72

¹ Scraper not included, accounted for in Heavy Construction Operations Fugitive Emissions

CUP
Estimated Fugitive Dust during Operation Phase

Operation Phase Total Estimated Fugitive PM₁₀ Emissions

17.38 tons/yr

Fugitive Emissions from Vehicles Traveling Unpaved Roads (AP-42 13.2.2 Eqn 1a)

Equipment	PM₁₀ Emission Factor (lb/VMT)	Est Max Distance Traveled (mi/day)	Annual Operation¹ (hrs/yr)	Activity (mi/yr)	PM₁₀ Emissions (tons/yr)
Pulling unit	4.35	2	2,600	650	0.71
Backhoe	4.35	2	3,640	910	0.99
Forklift	5.60	0.25	520	16	0.02
Integrity testing unit	3.82	0.5	3,120	195	0.19
Pickup truck	3.82	15	7,800	14,625	13.98
Swab rig	3.82	3	4,160	1,560	1.49
Vehicle Traveling Unpaved Roads Fugitive PM₁₀ Emissions (tons/yr)					17.38

¹ Based on 8 hr work days

CUP
Estimated Fugitive Dust during Aquifer Restoration Phase

Aquifer Restoration Phase Total Estimated Fugitive PM₁₀ Emissions

7.28 tons/yr

Fugitive Emissions from Vehicles Traveling Unpaved Roads (AP-42 13.2.2 Eqn 1a)

Equipment	PM¹⁰ Emission Factor (lb/VMT)	Est Max Distance Traveled (mi/day)	Annual Operation¹ (hrs/yr)	Activity (mi/yr)	PM₁₀ Emissions (tons/yr)
Pulling unit	4.35	0.5	1,300	81	0.09
Backhoe	4.35	3	1,820	683	0.74
Forklift	5.60	0.25	520	16	0.02
Integrity testing unit	3.82	0.5	1,560	98	0.09
Pickup truck	3.82	15	3,120	5,850	5.59
Swab rig	3.82	3	2,080	780	0.75
Vehicle Traveling Unpaved Roads Fugitive PM₁₀ Emissions (tons/yr)					7.28

¹ Based on 8 hr work days

CUP
Estimated Fugitive Dust during Decommissioning Phase

Decommissioning Phase Total Estimated Fugitive PM₁₀ Emissions

33.50 tons/yr

Heavy Construction Operations (AP-42)

Activity		Site Preparation Satellite Facility	Well Field and Roads Preparation
Bulldozing	Emission Factor (lb/hr)	6.42	6.42
	Activity (hr/yr)	496	1608
	Control Efficiency (%) ¹	50	50
	PM₁₀ Emissions (tons/yr)	0.80	2.58
Scraper Unloading Topsoil	Emission Factor (lb/ton)	0.0013	0.0013
	Area (ac/yr)	6	95
	Stripping Depth (ft)	0.5	0.5
	Topsoil (CY/yr)	4840	76633
	Density of Topsoil (tons/CY)	1.25	1.25
	Control Efficiency (%) ¹	50	50
	PM₁₀ Emissions (tons/yr)	0.00	0.03
Scrapers in Travel	Emission Factor (lb/VMT)	2.21	2.21
	Scraper VMT (mi/day)	5	5
	Scraper Operation (day/yr) ²	120	270
	Control Efficiency (%) ¹	50	50
	PM₁₀ Emissions (tons/yr)	0.33	0.75
Compacting	Emission Factor (lb/hr)	6.42	6.42
	Activity (hr/yr)	152	413
	Control Efficiency (%) ¹	50	50
	PM₁₀ Emissions (tons/yr)	0.24	0.66
Grading	Emission Factor (lb/hr)	0.77	0.77
	Activity (hr/yr)	272	1499
	Control Efficiency (%) ¹	50	50
	PM₁₀ Emissions (tons/yr)	0.05	0.29
Heavy Construction Fugitive PM₁₀ Emissions (tons/yr)		1.43	4.31

¹ Assume 50% control efficiency

² Based on 8 hr work days

Fugitive Emissions from Vehicles Traveling Unpaved Roads (AP-42 13.2.2 Eqn 1a)

Equipment ¹	PM10 Emission Factor (lb/VMT)	Est Max Distance Traveled (mi/day)	Annual Operation ² (hrs/yr)	Activity (mi/yr)	PM10 Emissions (tons/yr)
Cementing unit	6.57	3	2272	852	1.40
Pulling unit	4.35	3	1136	426	0.46
Backhoe	4.35	3	3744	1404	1.53
Bulldozer	7.65	3	3240	1215	2.32
Front end loader	4.35	3	1144	429	0.47
Grader	6.27	5	2528	1580	2.48
Roller compactor	7.00	1	672	84	0.15
Trackhoe	6.11	0.5	3112	195	0.30
Trencher	4.10	0.5	40	3	0.00
Dump truck	6.57	3	1600	600	0.99
Semi-haul truck	6.57	5	7880	4925	8.09
Water truck	6.57	5	2232	1395	2.29
Disc tractor	3.19	5	1016	635	0.51
Seed drill tractor	3.19	5	680	425	0.34
Manlift	4.81	0.25	640	20	0.02
Picker	6.27	0.25	60	2	0.00
Skid-steer loader	3.19	1	1424	178	0.14
Pickup truck	3.82	15	3500	6563	6.27
Vehicle Traveling Unpaved Roads Fugitive PM₁₀ Emissions (tons/yr)					27.76

¹ Scraper not included, accounted for in Heavy Construction Operations Fugitive Emissions

² Based on 8 hr work days