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# NETL Life Cycle Inventory Data

## Process Documentation File

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Light Fuel Oil [Crude Oil Products]

*Light fuel oil (from crude oil) needed for ANFO explosives*

### Tracked Output Flows:

Rosebud Coal [Hard Coal Products]

*Coal mine production flow for Rosebud subbituminous coal*

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## Section II: Process Description

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### Associated Documentation

This unit process is composed of this document and the data sheet (DS) *DS\_Stage1\_O\_CoalMine\_Rosebud\_2012.01.xls*, which provides additional details regarding calculations, data quality, and references as relevant.

### Goal and Scope

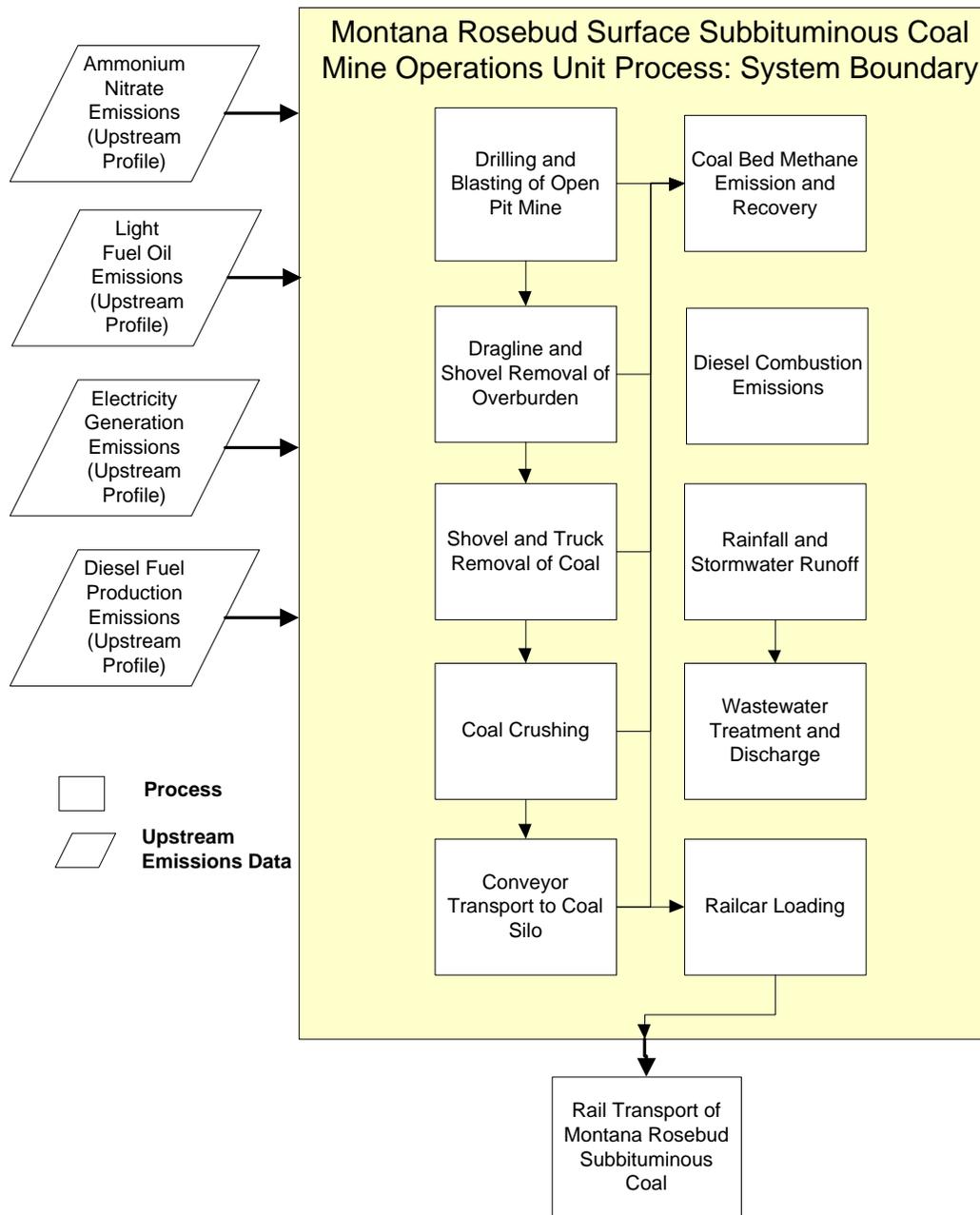
The scope of this process covers the production of coal during operation of a surface mine for Rosebud subbituminous coal, from resource extraction to the boundary for LC Stage #2 (e.g., transport of coal). The process is based on the reference flow of 1 kg of cleaned, crushed (to approximately 3 inches) Rosebud coal, as described below, and in **Figure 1**. Considered are the consumption of electricity, consumption of diesel, emissions of methane associated with off-gassing from the coal/coal mine, particulate matter emissions associated with fugitive coal dust, water input flows required for mining and cleaning operations, wastewater flows including stormwater, emissions of criteria air pollutants, and air emissions of mercury and ammonia.

### Boundary and Description

Operations of the coal mine are based on operations from a compilation of the three largest producers of Powder River Basin coal (Peabody Energy's North Antelope-Rochelle mine, Arch Coal, Inc.'s Black Thunder Mine, and Kennecott Energy's Cordero Rojo Operation), of which Rosebud is a coal seam. The Rosebud is located in Montana. Sources reviewed in assessing coal mine operations include facility and equipment needs, production rates, electricity usage, particulate air emissions, methane emissions, explosives usage, and additional governmental publications on coal and mines.

**Figure 1** provides an overview of the boundary of this unit process. As shown, upstream emissions associated with the production and delivery of electricity and diesel fuel, ammonium nitrate, and light fuel oil are accounted for outside of the boundary of this unit process.

Figure 1: Unit Process Scope and Boundary



Coal is extracted from a surface Rosebud coal seam through an open pit mining process. Blasting with ammonium nitrate fuel oil (ANFO) explosives occurs in drilled holes to remove the overburden and expose the coal seam for extraction. The removal of the overburden occurs with the use of draglines, powered by electricity, which pile the overburden in a different location to enable extraction of the coal. After the dragline has removed as much as possible, large electric shovels are used for the removal of the remaining overburden. The coal is removed using a truck and shovel approach. The trucks move the coal 3.2 km (2 miles) to the preparation facility for grinding and crushing to the proper size for transport. No cleaning of the coal occurs based on the

coal properties. A conveyor belt carries the crushed coal from the preparation facility to the loading silo. The coal is then loaded into rail cars for transport (LC Stage #2) to the plant (LC Stage #3).

Coalbed methane emissions from the coal mine, and from the extracted coal during processing and storage, were estimated based on U.S. EPA estimates of methane release for the Rosebud coal mine (U.S. EPA 2008). No methane is capture from the Rosebud coal mine prior to coal mining (U.S. EPA 2008). It is assumed that all emitted methane is released to the atmosphere. The Rosebud mine has 39-40 standard cubic feet per short ton (U.S. EPA 2008). Other types of coal may have up to 360 standard cubic feet per short ton of emissions.

Electricity and diesel use were based on data points published by Peabody Energy in reference to their North Antelope Rochelle Mine in Wyoming (Burley 2008 and Peabody 2005). The data were scaled such that they were applicable to the size of the mine being modeled.

Emissions of criteria pollutants were based on emissions associated with the use of diesel. U.S. EPA Tier 4 diesel standards for non-road diesel engines were used, since these standards would go into effect within a few years of commissioning of the mine for this study (U.S. EPA 2004). Diesel is assumed to be ultra low sulfur diesel (ULSD; 15 ppm sulfur). Emissions of particulate matter included those due to the combustion of diesel, as well as fugitive coal dust from the mining process. Total coal dust emissions were obtained from the EPA's AP 42's Mineral Products Industry section (EPA 2009).

Water use was estimated based on an environmental impact study completed on West Antelope II mine located in the Powder River Basin of Wyoming (BLM 2008). Water emissions, including flows and concentrations of relevant inorganic constituents and solids entering the waterstream, were taken from available National Pollutant Discharge Elimination System permit reporting documentation (NPDES 2009).

Properties of Rosebud coal relevant to this unit process are indicated in **Table 1**. **Table 2** provides a summary of modeled input and output flows. Additional details regarding input and output flows, including calculation methods, are contained in the associated DS sheet.

Table 1: Properties of Rosebud Coal (NETL 2011)

Proximate Analysis	Dry Basis, %	As Received, %
Moisture	0	25.77
Ash	11.04	8.19
Volatile Matter	40.87	30.34
Fixed Carbon	48.09	35.7
Total	100	100
Ultimate Analysis	Dry Basis, %	As Received, %
Carbon	67.45	50.07
Hydrogen	4.56	3.38
Nitrogen	0.96	0.71
Sulfur	0.98	0.73
Chlorine	0.01	0.01
Ash	11.03	8.19
Moisture	0	25.77
Oxygen (Note A)	15.01	11.14
Total	100	100
Heating Value	Dry Basis, (Dulong Calc.)	As Received, %
HHV, kJ/kg	26,787	19,920
HHV, Btu/lb	11,516	8,564
LHV, kJ/kg	25,810	19,195
LHV, Btu/lb	11,096	8,252

Notes: (A) the proximate analysis assumes sulfur as volatile matter; (B) by difference.

Table 2: Unit Process Input and Output Flows

Flow Name*	Value	Units (Per Reference Flow)
<b>Inputs</b>		
<b>Ammonium nitrate [Inorganic intermediate products]</b>	<b>1.4544E-03</b>	<b>kg</b>
<b>Diesel [Crude oil products]</b>	<b>8.9284E-04</b>	<b>kg</b>
<b>Light fuel oil [Crude oil products]</b>	<b>1.0111E-04</b>	<b>kg</b>
<b>Power [Electric power]</b>	<b>1.4028E-03</b>	<b>kWh</b>
Water (ground water) [Water]	3.0347E-02	kg
<b>Outputs</b>		
Rosebud Subbituminous Coal [Resource]	1	kg
Carbon dioxide [Inorganic emissions to air]	2.809E-03	kg/kg coal
Carbon monoxide [Inorganic emissions to air]	3.666E-11	kg/kg coal
Methane [Organic emissions to air (group VOC)]	8.489E-04	kg/kg coal
Nitrous Oxide [Inorganic emissions to air]	2.173E-08	kg/kg coal
Nitrogen dioxide [Inorganic emissions to air]	2.490E-05	kg/kg coal
Sulphur dioxide [Inorganic emissions to air]	2.676E-11	kg/kg coal
Particulate Matter, unspecified [Other emissions to air]	4.676E-04	kg/kg coal
Volatile Organic Carbons [Organic emissions to air]	3.476E-07	kg/kg coal
Mercury - Heavy Metals to Air	1.396E-13	kg/kg coal
Ammonia - Emissions to Air	1.156E-07	kg/kg coal
Lead - Heavy Metals to Air	5.607E-16	kg/kg coal
Ammonium / ammonia [Inorganic emissions to fresh water]	3.000E-05	kg/kg coal
Nitrogen [Inorganic emissions to fresh water]	9.039E-05	kg/kg coal
Phosphorus [Inorganic emissions to fresh water]	8.940E-07	kg/kg coal
Aluminium [Heavy metals to fresh water]	2.479E-06	kg/kg coal
Selenium [inorganic emissions to fresh water]	1.115E-07	kg/kg coal
Sulfate [inorganic emissions to fresh water]	4.201E-02	kg/kg coal
Total Dissolved Solids [inorganic emissions to fresh water]	8.752E-02	kg/kg coal
Total Suspended Solids [inorganic emissions to fresh water]	2.567E-03	kg/kg coal
Arsenic [Heavy metals to fresh water]	1.324E-07	kg/kg coal
Copper [Heavy metals to fresh water]	1.345E-07	kg/kg coal
Iron [Heavy metals to fresh water]	4.320E-05	kg/kg coal
Lead [Heavy metals to fresh water]	5.348E-08	kg/kg coal
Manganese [Heavy metals to fresh water]	1.211E-05	kg/kg coal
Nickel [Heavy metals to fresh water]	4.890E-07	kg/kg coal
Water (wastewater) [Water]	4.890E-02	kg/kg coal

\* **Bold face** clarifies that the value shown *does not* include upstream environmental flows. Upstream environmental flows were added during the modeling process using GaBi modeling software, as shown in Figure 1.

## Embedded Unit Processes

None.

## References

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**Section III: Document Control Information**

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**Date Created:** May 3, 2012  
**Point of Contact:** Timothy Skone (NETL), Timothy.Skone@NETL.DOE.GOV  
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