



NETL Life Cycle Inventory Data

Process Documentation File

Process Name: Coal Bed Methane Natural Gas, Water Use and Water Quality
Reference Flow: 1 kg of Natural Gas, Coal Bed Methane
Brief Description: This unit process quantifies water use and water quality emissions resulting from the production of natural gas from a Coal Bed Methane (CBM) natural gas well.

Section I: Meta Data

Geographical Coverage: United States **Region:** Rocky Mountain States, US
Year Data Best Represents: 2010
Process Type: Extraction Process (EP)
Process Scope: Gate-to-Gate Process (GG)
Allocation Applied: No
Completeness: All Relevant Flows Captured

Flows Aggregated in Data Set:

Process Energy Use Energy P&D Material P&D

Relevant Output Flows Included in Data Set:

Releases to Air: Greenhouse Gases Criteria Air Pollutants Other
Releases to Water: Inorganic Emissions Organic Emissions Other
Water Usage: Water Consumption Water Demand (throughput)
Releases to Soil: Inorganic Releases Organic Releases Other

Adjustable Process Parameters:

Waterprod *Produced water for natural gas extraction per kg natural gas extracted.*

Tracked Input Flows:

N/A

Tracked Output Flows:

Natural Gas, Coal Bed Methane *Reference flow*



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Section II: Process Description

Associated Documentation

This unit process is composed of this document and the data sheet (DS) *DS_Stage1_O_Water_CBM_NG_2011.02.xlsx*, which provides additional details regarding relevant calculations, data quality, and references.

Goal and Scope

The scope of this unit process covers produced water and water quality emissions associated with produced water in support of natural gas produced from coal bed methane extraction activities, as described below. This unit process considers only water and water quality related flows. For an evaluation of energy, materials, and airborne emissions associated with coal bed methane extraction, please refer to separate unit processes for natural gas extraction and on-site processing. The calculations presented for this unit process are based on the reference flow of 1 kg of natural gas, coal bed methane, as described below and shown in **Figure 1**.

This unit process is used under Life Cycle (LC) Stage #1 in support of the extraction of coal bed methane natural gas. Water use and water quality emissions for other natural gas profiles are contained in separate unit processes. This unit process is combined with other relevant equipment for LC Stage #1 in a separate operations assembly process, *DF_Stage1_O_Assembly_Natural_Gas_2011.01.doc*. The assembly process quantifies the relevant flows and emissions associated with each portion of the natural gas extraction profile being modeled, in order to complete extraction and in-field processing of 1 kg of natural gas.

Boundary and Description

Coal bed methane extraction results in the production of a substantial amount of water, and does not require water inputs for methane extraction (U.S. Geological Survey 2000). Instead, natural gas wells for coal bed methane require the removal of formation waters before significant volumes of coal bed methane can be extracted. Following installation of a coal bed methane well system, the formation is initially pumped to draw groundwater from the system. Withdrawing groundwater lowers the water table, allowing methane release from the coal bed formation. Thus, over time, as more water is pumped, the rate of release of methane increases. The water use and quality data used by this analysis are based on a series of surveys completed by the US Environmental Protection Agency, the US Geological Survey, and the Montana Bureau of Mines and Geology, in regards to produced water volumes and produced water quality management, within the U.S. Rocky Mountain states (EPA 2010; U.S. Geological Survey 2000; Van Voast 2003).

Produced water values were estimated based on weighted average surface discharge values from seven different western and midwestern coal basins where coal bed methane is being actively extracted: Appalachian, Black Warrior, Cahaba, Green River,

Illinois, Powder River, and Raton (EPA 2010). The data do not include produced water that is injected into deep wells for disposal; however, the injected water is not expected to have an environmental impact and so are ignored. Water quality effluent loads were calculated on the basis of 1 kg of coal bed methane natural gas produced, based on the volume of produced water that is discharged to surface waters. Water quality associated with produced water that is disposed of in a deep underground well is not further considered.

Figure 1 provides an overview of the boundary of this unit process. As shown, no inputs to the unit process are considered. Produced water occurs as a result of natural gas extraction operations, and therefore is considered within the boundary of the unit process. Also within the system boundary, produced water volume data are used to calculate produced water emissions to surface water, and also pollutant loading rates for each of the water quality constituents considered. This unit process is combined with other natural gas extraction unit processes in a natural gas operations assembly unit process.

Figure 1: Unit Process Scope and Boundary

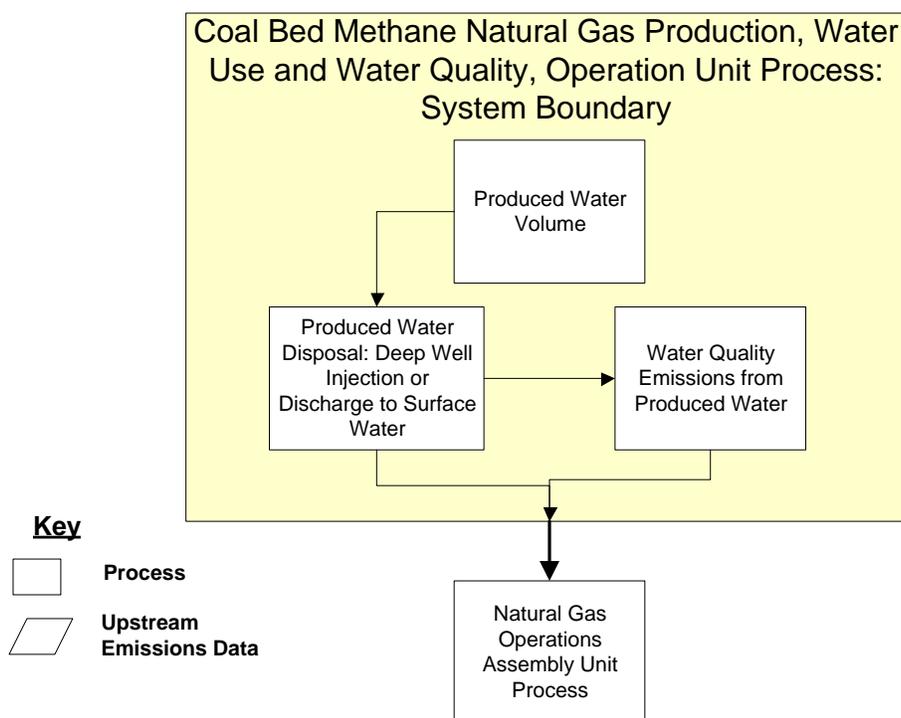


Table 1 provides a summary of modeled input and output flows. Additional detail regarding input and output flows, including calculation methods, is contained in the associated DS.

Table 1: Unit Process Input and Output Flows

Flow Name	Value	Units (Per Reference Flow)
Inputs		
N/A	N/A	N/A
Outputs		
Natural Gas, Coal Bed Methane	1.00	kg
Water (wastewater) [Water]	4.28	kg
Barium [Inorganic emissions to water]	2.66E-05	kg
Bicarbonate [Inorganic emissions to water]	1.88E-02	kg
Calcium [Inorganic emissions to water]	4.60E-04	kg
Chloride [Inorganic emissions to water]	9.24E-03	kg
Magnesium [Inorganic emissions to water]	1.52E-04	kg
Manganese [Inorganic emissions to water]	1.37E-06	kg
Sodium [Inorganic emissions to water]	8.89E-03	kg
Sulfate [Inorganic emissions to water]	3.73E-05	kg
Total Dissolved Solids [Inorganic emissions to water]	3.79E-02	kg

* **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

- USGS 2000 U.S. Geological Survey. 2000. Water Produced with Coal-Bed Methane. pubs.usgs.gov/fs/fs-0156-00/fs-0156-00.pdf (Accessed June 10, 2010)
- Van Voast 2003 Van Voast, W. 2003. Geochemical Signature of Formation Waters Associated with Coalbed Methane. AAPG Bulletin 87(4): 667-676.
- EPA 2010 U. S. Environmental Protection Agency. 2010. Coalbed Methane Extraction: Detailed Study Report. http://water.epa.gov/lawsregs/lawsguidance/cwa/304m/upload/cbm_report_2011.pdf (Accessed 4/12/2013)

Section III: Document Control Information

- Date Created:** April 06, 2011
- Point of Contact:** Timothy Skone (NETL), Timothy.Skone@NETL.DOE.GOV
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| 12APR2013 | Water use updated to newer data |
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