NETL Life Cycle Inventory Data
Process Documentation File

Process Name: North American Petroleum, Production

Reference Flow: 1 kg of North American Petroleum

Brief Description: This process includes all inputs for the raw material acquisition for 1 kg of North American crude oil entering U.S. refineries.

Section I: Meta Data

Geographical Coverage: US **Region:** N/A

Year Data Best Represents: 2005

Process Type: Extraction Process (EP)

Process Scope: Cradle-to-Gate Process (CG)

Allocation Applied: No

Completeness: Individual 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:

Algeria	*The portion of crude oil entering refineries from Algeria*
Angola	*The portion of crude oil entering refineries from Angola*
Canada	*The portion of crude oil entering refineries from Canada*
CA_Oil Sands	*The portion of crude oil entering refineries from Canadian oil sands*
Ecuador	*The portion of crude oil entering refineries from Ecuador*

Iraq	*The portion of crude oil entering refineries from Iraq*
Kuwait	*The portion of crude oil entering refineries from Kuwait*
Mexico	*The portion of crude oil entering refineries from Mexico*
Nigeria	*The portion of crude oil entering refineries from Nigeria*
Other	*The portion of crude oil entering refineries from all other countries besides those listed explicitly*
Saudia_Arabia	*The portion of crude oil entering refineries from Saudi Arabia*
Venezuela	*The portion of crude oil entering refineries from Venezuela*

Tracked Input Flows:

None.

Tracked Output Flows:

North American Petroleum	*Petroleum extracted in North America for U.S. refining*

Section II: Process Description

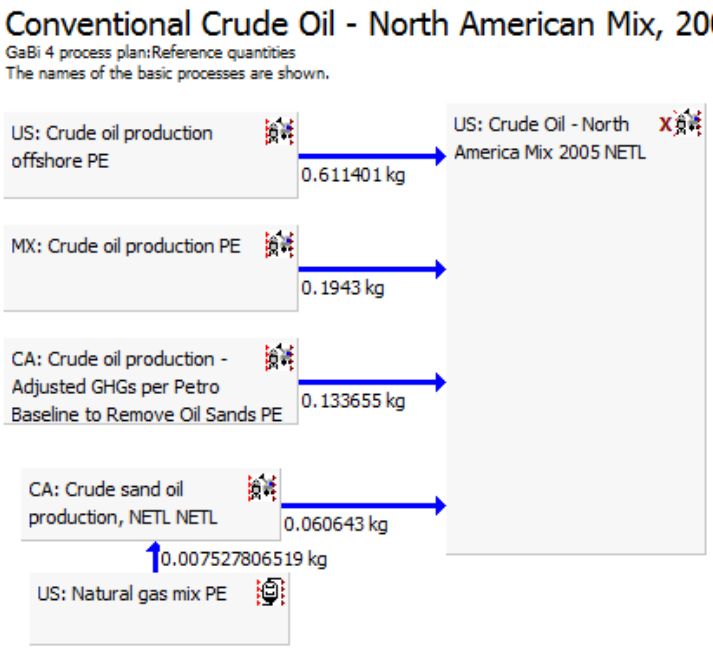
Associated Documentation

This unit process is composed of this document and the data sheet (DS) *DS_RMA_Petroleum_North_American_2011.02.xls*, which provides additional details regarding relevant calculations, data quality, and references.

Goal and Scope

The scope of this unit process covers all aspects of raw material acquisition (RMA) as seen in **Figure 1**. At the end, one kilogram of crude oil extracted internationally has been prepared for entry into life cycle (LC) Stage #2.

Figure 1: Plan for RMA of North American Petroleum



Boundary and Description

LC stage #1, RMA of crude oil, includes the two North American countries the U.S. imports from (Canada and Mexico) along with the U.S. produced crude oil and any initial processing of the oil. In addition to conventional crude imports from Canada, the U.S. also imports oil sands from the country. The North American mix was generated based on a modification of the Foreign Imports mix, including only imports for the corresponding countries.

The RMA of imported crude oil includes the operations of the different extraction wells. No construction data is included for this RMA.

The profiles and processes included in RMA are provided in **Table 1**. Those shown in bold face were developed by NETL.

Table 1: Profiles and Processes Included in RMA for North American Petroleum

Crude Oil - Foreign Import Mix, 2005
- Crude oil - Canada NETL, 2005
  - CA: Crude oil Canadian (Conventional) NETL
  - CA: Crude sand oil production, NETL NETL
  - CA: Natural gas mix PE
- MX: Crude oil production PE
- US: Crude Oil - Foreign Import Mix, 2005 NETL
- US: Crude oil mix PE

Parameters and Balances

The parameters for the highest level modeling plan for RMA of North American petroleum are shown in **Table 2**. These parameters may or may not include the adjustable parameters shown previously, depending on how the model was created. The North American mix was generated based on a modification of the Foreign Imports plan. As seen in **Table 2**, only North American countries are given non-zero values; other countries on the plan are shown as zeros as they are not in the region. **Table 3** presents the input and output balances for resources and emissions of interest for the RMA plan.

Table 2: Adjustable Parameters for RMA of North American Petroleum

Plan	Parameter	Value	Comment
LC Stage #1			
Crude Oil – Foreign Import Mix, 2005	Algeria	0	[fraction] Portion of petroleum imported from Algeria
Crude Oil – Foreign Import Mix, 2005	Angola	0	[fraction] Portion of petroleum imported from Angola
Crude Oil – Foreign Import Mix, 2005	Canada	0.1337	[fraction] Portion of petroleum imported from Canada
Crude Oil – Foreign Import Mix, 2005	CA_Oil_Sand	0.0606	[fraction] Portion of petroleum imported from Canadian oil sands
Crude Oil – Foreign Import Mix, 2005	Ecuador	0	[fraction] Portion of petroleum imported from Ecuador
Crude Oil – Foreign Import Mix, 2005	Iraq	0	[fraction] Portion of petroleum imported from Iraq
Crude Oil – Foreign Import Mix, 2005	Kuwait	0	[fraction] Portion of petroleum imported from Kuwait
Crude Oil – Foreign Import Mix, 2005	Mexico	0.1943	[fraction] Portion of petroleum imported from Mexico
Crude Oil – Foreign Import Mix, 2005	Nigeria	0	[fraction] Portion of petroleum imported from Nigeria
Crude Oil – Foreign Import Mix, 2005	Saudi_Arabia	0	[fraction] Portion of petroleum imported from Saudi Arabia
Crude Oil – Foreign Import Mix, 2005	other	0	[fraction] Portion of petroleum from other countries
Crude Oil – Foreign Import Mix, 2005	United States	0.6114	[fraction] Portion of petroleum from the U.S.
Crude Oil – Foreign Import Mix, 2005	Venezuela	0	[fraction] Portion of petroleum imported from Venezuela

Table 3: Inputs and Output Balances for RMA of North American Petroleum (kg/kg produced)

Process or Category	Cradle to Gate (RMA)
Inputs	
Flows	1.877E+00
Resources	1.877E+00
Energy resources	1.076E+00
Non renewable energy resources	1.076E+00
Crude oil (resource)	1.011E+00
Crude oil Algeria	1.565E-04
Crude oil Angola	1.882E-04

Process or Category	Cradle to Gate (RMA)
Crude oil Argentina	3.123E-05
Crude oil Australia	2.856E-05
Crude oil Austria	8.758E-06
Crude oil Bolivia	1.599E-10
Crude oil Brazil	4.239E-05
Crude oil Brunei	1.132E-10
Crude oil Bulgaria	1.319E-11
Crude oil Cameroon	3.991E-05
Crude oil Canada	1.929E-01
Crude oil Chile	1.231E-10
Crude oil China	7.533E-06
Crude oil CIS	1.278E-03
Crude oil Colombia	1.002E-04
Crude oil Czech Republic	5.874E-07
Crude oil Denmark	2.670E-04
Crude oil Ecuador	4.312E-05
Crude oil Egypt	3.580E-05
Crude oil France	1.268E-05
Crude oil Gabon	7.304E-05
Crude oil Germany	4.357E-05
Crude oil Greece	1.744E-06
Crude oil Hungary	5.001E-09
Crude oil India	2.527E-12
Crude oil Indonesia	2.275E-05
Crude oil Iran	2.461E-04
Crude oil Iraq	3.372E-04
Crude oil Ireland	5.476E-11
Crude oil Italy	5.601E-05
Crude oil Kuwait	1.442E-04
Crude oil Libya	3.895E-04
Crude oil Malaysia	5.614E-11
Crude oil Mexico	1.951E-01
Crude oil Netherlands	3.429E-05
Crude oil New Zealand	6.845E-07
Crude oil Nigeria	4.115E-04
Crude oil Norway	1.158E-03

Process or Category	Cradle to Gate (RMA)
Crude oil Oman	8.074E-06
Crude oil Poland	2.045E-06
Crude oil Qatar	3.850E-06
Crude oil Romania	3.504E-06
Crude oil Saudi Arabia	1.099E-03
Crude oil Slovakia	1.142E-11
Crude oil South Africa	8.509E-11
Crude oil Spain	2.907E-06
Crude oil Syria	7.342E-11
Crude oil Trinidad and Tobago	2.706E-05
Crude oil Tunisia	1.591E-05
Crude oil Turkey	1.131E-15
Crude oil United Arab Emirates	4.851E-06
Crude oil United Kingdom	1.602E-03
Crude oil USA	6.141E-01
Crude oil Venezuela	6.663E-04
Hard coal (resource)	3.195E-03
Hard coal Australia	9.094E-05
Hard coal Belgium	1.247E-08
Hard coal Bosnia and Herzegovina	1.091E-09
Hard coal Brazil	3.643E-07
Hard coal Canada	1.007E-03
Hard coal Chile	1.284E-08
Hard coal China	1.535E-05
Hard coal CIS	2.100E-05
Hard coal Colombia	1.545E-04
Hard coal Czech Republic	8.771E-06
Hard coal France	2.489E-07
Hard coal Germany	1.885E-04
Hard coal India	5.606E-17
Hard coal Indonesia	8.040E-06
Hard coal Italy	3.320E-10
Hard coal Japan	5.209E-12
Hard coal Malaysia	1.982E-12
Hard coal Mexico	2.131E-05
Hard coal New Zealand	1.066E-08

Process or Category	Cradle to Gate (RMA)
Hard coal Poland	5.493E-05
Hard coal Portugal	1.022E-09
Hard coal South Africa	9.408E-05
Hard coal Spain	7.765E-06
Hard coal Turkey	5.230E-12
Hard coal United Kingdom	6.860E-06
Hard coal USA	1.470E-03
Hard coal Venezuela	4.398E-05
Hard coal Vietnam	8.674E-07
Lignite (resource)	1.516E-03
Lignite Australia	3.926E-05
Lignite Austria	1.299E-06
Lignite Bosnia and Herzegovina	2.425E-09
Lignite Bulgaria	7.478E-09
Lignite Canada	2.115E-04
Lignite CIS	9.236E-07
Lignite Czech Republic	4.942E-06
Lignite France	4.528E-08
Lignite Germany (Central Germany)	8.510E-04
Lignite Germany (Lausitz)	1.106E-04
Lignite Germany (Rheinisch)	1.999E-04
Lignite Greece	1.443E-06
Lignite Hungary	2.061E-08
Lignite India	1.121E-17
Lignite Macedonia	4.953E-09
Lignite Poland	1.756E-06
Lignite Romania	4.709E-10
Lignite Serbia and Montenegro	1.934E-08
Lignite Slovakia	1.823E-09
Lignite Slovenia	1.601E-08
Lignite Spain	1.632E-05
Lignite Turkey	1.402E-13
Lignite USA	7.648E-05
Natural gas (resource)	6.042E-02
Natural gas Algeria	3.864E-05
Natural gas Angola	2.394E-05

Process or Category	Cradle to Gate (RMA)
Natural gas Argentina	3.083E-06
Natural gas Australia	6.142E-06
Natural gas Austria	1.217E-06
Natural gas Bolivia	3.214E-07
Natural gas Brazil	5.496E-06
Natural gas Brunei	9.835E-07
Natural gas Bulgaria	2.068E-12
Natural gas Cameroon	9.925E-06
Natural gas Canada	1.570E-02
Natural gas Chile	2.929E-08
Natural gas China	8.576E-07
Natural gas CIS	1.927E-04
Natural gas Colombia	1.092E-05
Natural gas Czech Republic	4.406E-08
Natural gas Denmark	2.366E-05
Natural gas Ecuador	4.803E-06
Natural gas Egypt	3.614E-06
Natural gas France	1.186E-06
Natural gas Gabon	1.078E-05
Natural gas Germany	8.596E-05
Natural gas Greece	1.167E-07
Natural gas Hungary	2.483E-09
Natural gas India	2.525E-13
Natural gas Indonesia	1.141E-06
Natural gas Iran	2.814E-05
Natural gas Iraq	3.403E-05
Natural gas Ireland	1.221E-07
Natural gas Italy	5.878E-06
Natural gas Japan	1.016E-12
Natural gas Kuwait	1.376E-05
Natural gas Libyan	1.052E-05
Natural gas Malaysia	9.639E-07
Natural gas Mexico	1.081E-02
Natural gas Netherlands	1.009E-04
Natural gas New Zealand	4.542E-08
Natural gas Nigeria	8.019E-05

Process or Category	Cradle to Gate (RMA)
Natural gas Norway	9.706E-05
Natural gas Oman	2.340E-06
Natural gas Poland	1.371E-07
Natural gas Qatar	1.548E-05
Natural gas Romania	2.238E-07
Natural gas Saudi Arabia	1.017E-04
Natural gas Slovakia	1.080E-10
Natural gas South Africa	3.068E-09
Natural gas Spain	4.269E-07
Natural gas Syria	7.890E-12
Natural gas Trinidad and Tobago	6.437E-05
Natural gas Tunisia	2.083E-06
Natural gas Turkey	1.144E-16
Natural gas United Arab Emirates	7.932E-07
Natural gas United Kingdom	1.203E-04
Natural gas USA	3.272E-02
Natural gas Venezuela	6.287E-05
Pit Methane	1.430E-05
Uranium (resource)	4.593E-08
Uranium natural	4.593E-08
Renewable energy resources	1.621E-06
Primary energy from geothermics	0.000E+00
Primary energy from hydro power	0.000E+00
Primary energy from solar energy	0.000E+00
Primary energy from wind power	0.000E+00
Wood	1.621E-06
Material resources	8.016E-01
Non renewable elements	3.097E-11
Iron	6.951E-13
Lead	1.119E-17
Sulphur	3.028E-11
Non renewable resources	3.691E-01
Barium sulphate	1.147E-15
Basalt	5.299E-05
Bauxite	8.604E-06
Bentonite	6.589E-03

Process or Category	Cradle to Gate (RMA)
Calcium chloride	1.174E-13
Chromium ore (39%)	3.775E-08
Clay	3.915E-04
Colemanite ore	2.362E-09
Copper ore (0.14%)	8.044E-07
Copper ore (4%)	2.389E-15
Copper ore (sulphidic, 1.1%)	2.834E-12
Dolomite	7.212E-09
Ferro manganese	5.595E-18
Fluorspar (calcium fluoride; fluorite)	1.044E-08
Gypsum (natural gypsum)	2.356E-04
Heavy spar (BaSO4)	1.594E-02
Inert rock	3.269E-01
Iron ore (56,86%)	4.834E-03
Iron ore (65%)	1.878E-07
Kaolin ore	2.587E-09
Lead - zinc ore (4.6%-0.6%)	1.285E-03
Limestone (calcium carbonate)	1.133E-02
Magnesit (Magnesium carbonate)	4.648E-09
Magnesium chloride leach (40%)	9.481E-05
Manganese ore	7.219E-09
Manganese ore (R.O.M.)	5.038E-05
Molybdenite (Mo 0,24%)	4.509E-10
Natural Aggregate	4.557E-04
Nickel ore (1,5%)	6.825E-12
Nickel ore (1.6%)	1.776E-04
Olivine	6.155E-17
Peat	8.557E-06
Phosphate ore	4.014E-09
Phosphorus minerals	4.325E-09
Potassium chloride	2.116E-09
Precious metal ore (R.O.M)	2.109E-09
Quartz sand (silica sand; silicon dioxide)	1.233E-04
Raw pumice	2.513E-10
Slate	1.035E-16
Sodium chloride (rock salt)	3.545E-06

Process or Category	Cradle to Gate (RMA)
Sodium sulphate	7.863E-12
Soil	2.737E-04
Sulphur (bonded)	1.467E-11
Talc	1.956E-09
Tin ore	9.947E-17
Titanium ore	1.635E-05
Zinc - copper ore (4.07%-2.59%)	2.134E-04
Zinc - lead - copper ore (12%-3%-2%)	8.892E-05
Zinc - lead ore (4.21%-4.96%)	8.157E-16
Zinc ore (sulphidic, 4%)	2.861E-15
Renewable resources	4.325E-01
Water	2.875E-01
Water (ground water)	1.444E-01
Water (sea water)	8.366E-03
Water (surface water)	1.347E-01
Air	1.448E-01
Carbon dioxide	2.139E-04
Nitrogen	7.224E-11
Oxygen	6.335E-16
Output	
Flows	4.022E-01
Resources	9.593E-02
Material resources	9.593E-02
Renewable resources	9.593E-02
Water	9.593E-02
Water (ground water)	0.000E+00
Water (river water)	9.494E-02
Water (sea water)	0.000E+00
Water (wastewater)	9.912E-04
Emissions to air	2.775E-01
Heavy metals to air	1.169E-07
Antimony	1.311E-10
Arsenic (+V)	1.132E-09
Arsenic trioxide	8.839E-13
Cadmium (+II)	2.836E-10
Chromium (+III)	1.833E-10

Process or Category	Cradle to Gate (RMA)
Chromium (unspecified)	6.974E-10
Cobalt	3.582E-10
Copper (+II)	2.973E-09
Heavy metals to air (unspecified)	7.817E-12
Hydrogen arsenic (arsine)	7.336E-11
Iron	1.639E-09
Lanthanides	2.419E-13
Lead (+II)	1.342E-08
Manganese (+II)	5.241E-09
Mercury (+II)	4.946E-10
Molybdenum	1.066E-10
Nickel (+II)	1.566E-08
Palladium	3.250E-18
Rhodium	3.138E-18
Selenium	1.466E-09
Silver	4.104E-19
Tellurium	2.443E-11
Thallium	1.798E-10
Tin (+IV)	6.511E-10
Titanium	1.416E-11
Vanadium (+III)	6.321E-08
Zinc (+II)	8.988E-09
Inorganic emissions to air	2.125E-01
Ammonia	4.050E-06
Ammonium	4.064E-14
Ammonium nitrate	8.604E-14
Barium	1.004E-05
Beryllium	6.628E-11
Boron compounds (unspecified)	1.246E-08
Bromine	5.181E-09
Carbon dioxide	1.942E-01
Carbon dioxide (biotic)	1.327E-05
Carbon disulphide	7.924E-13
Carbon monoxide	4.440E-04
Chloride (unspecified)	1.914E-08
Chlorine	4.311E-12

Process or Category	Cradle to Gate (RMA)
Cyanide (unspecified)	6.352E-10
Fluoride	1.250E-09
Fluorides	8.218E-09
Fluorine	7.776E-12
Helium	2.867E-09
Hydrogen	6.837E-07
Hydrogen bromine (hydrobromic acid)	1.998E-10
Hydrogen chloride	4.196E-07
Hydrogen cyanide (prussic acid)	7.393E-11
Hydrogen fluoride	6.780E-08
Hydrogen iodide	9.583E-15
Hydrogen phosphorous	3.388E-14
Hydrogen sulphide	3.072E-06
Lead dioxide	4.288E-15
Nitrogen (atmospheric nitrogen)	4.860E-05
Nitrogen dioxide	9.411E-16
Nitrogen monoxide	3.071E-11
Nitrogen oxides	7.192E-04
Nitrous oxide (laughing gas)	5.564E-06
Oxygen	1.597E-04
Scandium	1.219E-13
Steam	1.600E-02
Strontium	4.644E-12
Sulphur dioxide	8.398E-04
Sulphur hexafluoride	3.005E-13
Sulphuric acid	4.720E-09
Tin oxide	3.728E-16
Zinc oxide	7.460E-16
Zinc sulphate	1.849E-09
Organic emissions to air (group VOC)	2.600E-03
Group NMVOC to air	4.865E-04
Group PAH to air	4.456E-08
Anthracene	2.051E-10
Benzo{a}anthracene	1.032E-10
Benzo{a}pyrene	4.507E-11
Benzo{ghi}perylene	9.207E-11

Process or Category	Cradle to Gate (RMA)
Benzofluoranthene	1.841E-10
Chrysene	2.535E-10
Dibenz(a)anthracene	5.736E-11
Indeno[1,2,3-cd]pyrene	6.850E-11
Naphthalene	2.154E-08
Phenanthrene	6.767E-09
Polycyclic aromatic hydrocarbons (PAH)	1.524E-08
Halogenated organic emissions to air	2.485E-09
Dichloromethane (methylene chloride)	4.541E-17
Dioxins (unspec.)	7.238E-15
Halogenated hydrocarbons (unspecified)	2.250E-17
Polychlorinated biphenyls (PCB unspecified)	1.612E-10
Polychlorinated dibenzo-p-dioxins (2,3,7,8 - TCDD)	6.011E-15
R 11 (trichlorofluoromethane)	3.013E-10
R 114 (dichlorotetrafluoroethane)	3.086E-10
R 12 (dichlorodifluoromethane)	6.477E-11
R 13 (chlorotrifluoromethane)	4.068E-11
R 22 (chlorodifluoromethane)	7.082E-11
Tetrafluoromethane	9.823E-11
Vinyl chloride (VCM; chloroethene)	1.440E-09
Acetaldehyde (Ethanal)	1.964E-08
Acetic acid	1.201E-08
Acetone (dimethylcetone)	1.758E-08
Acrolein	1.447E-09
Aldehyde (unspecified)	5.895E-10
Alkane (unspecified)	2.919E-08
Alkene (unspecified)	1.906E-08
Aromatic hydrocarbons (unspecified)	1.064E-09
Benzene	1.794E-07
Butadiene	3.442E-14
Butane	4.341E-05
Butane (n-butane)	1.172E-08
Cyclohexane (hexahydro benzene)	1.816E-11
Diethylamine	1.016E-18
Ethane	1.162E-04
Ethanol	5.556E-09

Process or Category	Cradle to Gate (RMA)
Ethene (ethylene)	4.732E-09
Ethyl benzene	2.128E-08
Fluoranthene	6.680E-10
Fluorene	2.120E-09
Formaldehyde (methanal)	3.674E-08
Heptane (isomers)	1.502E-06
Hexamethylene diamine (HMDA)	2.024E-15
Hexane (isomers)	2.228E-06
Mercaptan (unspecified)	1.912E-08
Methanol	5.352E-09
NMVOC (unspecified)	6.443E-05
Octane	8.263E-07
Pentane (n-pentane)	1.455E-05
Phenol (hydroxy benzene)	3.766E-13
Propane	2.427E-04
Propene (propylene)	1.684E-09
Propionic acid (propane acid)	3.130E-12
Styrene	2.012E-14
Toluene (methyl benzene)	6.344E-08
Trimethylbenzene	3.633E-15
Xylene (dimethyl benzene)	1.163E-07
Methane	2.006E-03
Organic chlorine compounds	4.306E-14
VOC (unspecified)	1.076E-04
Other emissions to air	6.234E-02
Exhaust	6.116E-02
non used primary energy from wind power	0.000E+00
Particulate Matter, unspecified	1.816E-05
Unused primary energy from solar energy	0.000E+00
Used air	1.164E-03
Waste heat	0.000E+00
Particles to air	2.806E-05
Dust (PM10)	4.260E-06
Dust (PM2.5)	1.388E-05
Dust (unspecified)	9.921E-06
Metals (unspecified)	1.256E-13

Process or Category	Cradle to Gate (RMA)
Wood (dust)	1.376E-13
Radioactive emissions to air	3.952E-10
Antimony (Sb124)	0.000E+00
Argon (Ar41)	0.000E+00
Carbon (C14)	0.000E+00
Cesium (Cs134)	0.000E+00
Cesium (Cs137)	0.000E+00
Cobalt (Co58)	0.000E+00
Cobalt (Co60)	0.000E+00
Hydrogen (H3)	0.000E+00
Iodine (I129)	0.000E+00
Iodine (I131)	0.000E+00
Krypton (Kr85)	0.000E+00
Krypton (Kr85m)	0.000E+00
Plutonium (Pu alpha)	0.000E+00
Radon (Rn222)	0.000E+00
Uranium (total)	3.952E-10
Uranium (U234)	0.000E+00
Uranium (U235)	0.000E+00
Uranium (U238)	0.000E+00
Xenon (Xe131m)	0.000E+00
Xenon (Xe133)	0.000E+00
Xenon (Xe133m)	0.000E+00
Xenon (Xe135)	0.000E+00
Xenon (Xe135m)	0.000E+00
Xenon (Xe137)	0.000E+00
Xenon (Xe138)	0.000E+00
Emissions to fresh water	4.080E-03
Analytical measures to fresh water	5.270E-05
Adsorbable organic halogen compounds (AOX)	2.459E-07
Biological oxygen demand (BOD)	3.789E-06
Chemical oxygen demand (COD)	4.432E-05
Solids (dissolved)	5.711E-08
Total dissolved organic bounded carbon	2.305E-14
Total organic bounded carbon	4.281E-06
Heavy metals to fresh water	5.400E-06

Process or Category	Cradle to Gate (RMA)
Antimony	7.084E-16
Arsenic (+V)	2.359E-08
Cadmium (+II)	7.230E-08
Chromium (+III)	1.058E-10
Chromium (+VI)	1.009E-16
Chromium (unspecified)	3.021E-08
Cobalt	5.723E-11
Copper (+II)	2.317E-07
Heavy metals to water (unspecified)	8.361E-11
Iron	4.622E-06
Lead (+II)	5.342E-08
Manganese (+II)	7.838E-09
Mercury (+II)	1.249E-09
Molybdenum	1.053E-09
Nickel (+II)	6.366E-08
Selenium	2.705E-10
Silver	3.749E-11
Strontium	2.389E-07
Thallium	3.098E-11
Tin (+IV)	4.043E-11
Titanium	4.915E-10
Vanadium (+III)	6.157E-10
Zinc (+II)	5.206E-08
Inorganic emissions to fresh water	1.026E-03
Acid (calculated as H+)	1.179E-09
Aluminum (+III)	3.360E-08
Ammonia	7.641E-09
Ammonium / ammonia	1.186E-06
Barium	1.519E-07
Beryllium	1.172E-12
Boron	9.387E-09
Bromine	7.925E-11
Calcium (+II)	1.674E-06
Carbonate	9.550E-06
Chloride	9.086E-04
Chlorine (dissolved)	1.130E-07

Process or Category	Cradle to Gate (RMA)
Cyanide	1.047E-10
Fluoride	3.304E-06
Fluorine	9.642E-09
Hydrogen chloride	1.845E-10
Hydrogen fluoride (hydrofluoric acid)	6.174E-11
Hydroxide	5.067E-09
Magnesium (+III)	9.328E-07
Magnesium chloride	8.842E-13
Nitrate	1.389E-07
Nitrogen	3.240E-09
Nitrogen organic bounded	1.338E-07
Phosphate	1.253E-08
Phosphorus	1.276E-07
Potassium	3.361E-08
Silicate particles	4.023E-11
Sodium (+I)	7.879E-05
Sodium hypochlorite	1.196E-12
Sulphate	1.969E-05
Sulphide	1.769E-06
Sulphite	2.189E-09
Sulphur	1.146E-09
Sulphuric acid	2.379E-08
Organic emissions to fresh water	2.079E-05
Halogenated organic emissions to fresh water	1.168E-10
1,2-Dibromoethane	4.267E-15
Chlorinated hydrocarbons (unspecified)	3.618E-17
Chloromethane (methyl chloride)	1.168E-10
Dichloropropane	1.625E-18
Polychlorinated dibenzo-p-dioxins (2,3,7,8 - TCDD)	1.088E-22
Hydrocarbons to fresh water	6.846E-07
Acenaphthene	2.510E-11
Acenaphthylene	1.076E-11
Acetic acid	3.279E-09
Acrylonitrile	1.188E-13
Anthracene	4.601E-11
Aromatic hydrocarbons (unspecified)	3.795E-08

Process or Category	Cradle to Gate (RMA)
Benzene	5.762E-08
Benzo{a}anthracene	2.940E-12
Benzofluoranthene	4.845E-13
Chrysene	1.102E-11
Cresol (methyl phenol)	2.969E-11
Ethyl benzene	3.205E-09
Fluoranthene	3.343E-12
Hexane (isomers)	3.242E-12
Hydrocarbons (unspecified)	1.384E-09
Methanol	3.927E-08
Oil (unspecified)	4.284E-07
Phenol (hydroxy benzene)	5.933E-08
Polycyclic aromatic hydrocarbons (PAH, unspec.)	1.834E-09
Toluene (methyl benzene)	3.530E-08
Xylene (isomers; dimethyl benzene)	1.695E-08
Carbon, organically bound	2.011E-05
Naphthalene	1.792E-09
Organic chlorine compounds (unspecified)	4.323E-14
Organic compounds (unspecified)	4.933E-24
Other emissions to fresh water	0.000E+00
non used primary energy from water power	0.000E+00
Unused primary energy from geothermal	0.000E+00
Waste heat	0.000E+00
Particles to fresh water	2.974E-03
Metals (unspecified)	3.547E-12
Soil loss by erosion into water	1.082E-09
Solids (suspended)	2.974E-03
Radioactive emissions to fresh water	0.000E+00
Americium (Am241)	0.000E+00
Antimony (Sb124)	0.000E+00
Antimony (Sb125)	0.000E+00
Carbon (C14)	0.000E+00
Cesium (Cs134)	0.000E+00
Cesium (Cs137)	0.000E+00
Cobalt (Co58)	0.000E+00
Cobalt (Co60)	0.000E+00

Process or Category	Cradle to Gate (RMA)
Curium (Cm alpha)	0.000E+00
Hydrogen (H3)	0.000E+00
Iodine (I129)	0.000E+00
Iodine (I131)	0.000E+00
Manganese (Mn54)	0.000E+00
Plutonium (Pu alpha)	0.000E+00
Radium (Ra226)	0.000E+00
Ruthenium (Ru106)	0.000E+00
Silver (Ag110m)	0.000E+00
Strontium (Sr90)	0.000E+00
Uranium	0.000E+00
Emissions to sea water	2.472E-02
Analytical measures to sea water	2.073E-04
Adsorbable organic halogen compounds (AOX)	1.493E-11
Biological oxygen demand (BOD)	1.647E-05
Chemical oxygen demand (COD)	1.743E-04
Total organic bounded carbon	1.647E-05
Heavy metals to sea water	5.081E-05
Arsenic (+V)	3.544E-08
Cadmium (+II)	3.049E-08
Chromium (unspecified)	4.508E-08
Cobalt	2.011E-08
Copper (+II)	9.634E-07
Iron	2.707E-06
Lead (+II)	3.175E-07
Manganese (+II)	2.676E-07
Mercury (+II)	4.904E-09
Molybdenum	1.913E-08
Nickel (+II)	2.635E-07
Silver	5.674E-08
Strontium	4.571E-05
Tin (+IV)	6.797E-08
Titanium	6.923E-09
Vanadium (+III)	2.245E-08
Zinc (+II)	2.764E-07
Inorganic emissions to sea water	1.134E-02

Process or Category	Cradle to Gate (RMA)
Aluminum (+III)	2.229E-07
Ammonia	6.623E-06
Barium	1.994E-06
Beryllium	9.242E-11
Boron	3.604E-06
Calcium (+II)	3.936E-04
Carbonate	1.254E-04
Chloride	1.031E-02
Magnesium	9.787E-05
Nitrate	1.626E-07
Sodium (+I)	3.289E-04
Sulphate	5.326E-05
Sulphide	2.283E-05
Sulphur	1.928E-06
Organic emissions to sea water	7.174E-06
Hydrocarbons to sea water	7.142E-06
Acenaphthene	7.752E-10
Acenaphthylene	2.956E-10
Acetic acid	1.887E-10
Anthracene	1.936E-10
Aromatic hydrocarbons (unspecified)	1.647E-07
Benzene	8.650E-07
Benzo{a}anthracene	1.746E-10
Benzofluoranthene	1.942E-10
Chrysene	9.882E-10
Cresol (methyl phenol)	4.995E-08
Ethyl benzene	2.058E-08
Fluoranthene	2.029E-10
Hexane (isomers)	5.453E-09
Oil (unspecified)	5.074E-06
Phenol (hydroxy benzene)	1.966E-07
Toluene (methyl benzene)	7.067E-07
Xylene (isomers; dimethyl benzene)	5.574E-08
Naphthalene	3.226E-08
Particles to sea water	1.311E-02
Solids (suspended)	1.311E-02

Process or Category	Cradle to Gate (RMA)
Emissions to industrial soil	3.872E-05
Heavy metals to industrial soil	1.054E-05
Arsenic (+V)	1.080E-11
Cadmium (+II)	1.181E-10
Chromium (+III)	1.721E-12
Chromium (unspecified)	2.505E-08
Cobalt	4.471E-10
Copper (+II)	2.293E-10
Iron	3.432E-08
Lead (+II)	8.575E-12
Manganese (+II)	5.232E-09
Mercury (+II)	4.645E-13
Nickel (+II)	6.735E-09
Strontium	1.047E-05
Zinc (+II)	2.562E-09
Inorganic emissions to industrial soil	2.817E-05
Aluminum (+III)	2.602E-08
Ammonia	1.588E-05
Bromide	3.832E-09
Calcium (+II)	4.512E-09
Chloride	4.471E-06
Fluoride	1.278E-07
Magnesium (+III)	6.766E-10
Phosphorus	1.702E-06
Potassium (+I)	2.838E-06
Sodium (+I)	3.857E-10
Sulphate	4.445E-07
Sulphide	2.667E-06
Organic emissions to industrial soil	1.307E-08
Oil (unspecified)	1.307E-08

Embedded Unit Processes

None.

References

None.

Section III: Document Control Information

Date Created: September 16, 2011

Point of Contact: Timothy Skone (NETL), Timothy.Skone@NETL.DOE.GOV

Revision History:

31MAY2012	Updated to revised model results.

How to Cite This Document: This document should be cited as:

NETL (2011). *NETL Life Cycle Inventory Data – Unit Process: North American Petroleum, Production.* U.S. Department of Energy, National Energy Technology Laboratory. Last Updated: May 2012 (version 02). www.netl.doe.gov/energy-analyses (http://www.netl.doe.gov/energy-analyses)

Section IV: Disclaimer

Neither the U.S. Department of Energy (DOE) National Energy Technology Laboratory (NETL) nor any person acting on behalf of these organizations:

A. Makes any warranty or representation, express or implied, with respect to the accuracy, completeness, or usefulness of the information contained in this document, or that the use of any information, apparatus, method, or process disclosed in this document may not infringe on privately owned rights; or

B. Assumes any liability with this report as to its use, or damages resulting from the use of any information, apparatus, method, or process disclosed in this document.

Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by NETL. The views and opinions of the authors expressed herein do not necessarily state or reflect those of NETL.