ENCLOSURE 2
ATTACHMENT 5

SHINE MEDICAL TECHNOLOGIES, INC.

SHINE MEDICAL TECHNOLOGIES, INC. APPLICATION FOR CONSTRUCTION PERMIT
RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

CALC-2013-0007, REVISION 5
ANNUAL EMISSIONS DURING CONSTRUCTION, OPERATION, AND DECOMMISSIONING ACTIVITIES

31 pages follow

Table of Contents

ATTACHMENTS:

ATTACHMENT 1 – Average Annual Emissions and Fuel Consumption for Gasoline-Fueled Passenger Cars and Light Trucks (6 Pages)

ATTACHMENT 2 – Gasoline and Industrial Engines United States Environmental Protection Agency Fifth Edition Compilation of Air Pollutant Emissions Factors, Volume 1: Stationary Point and Area Sources, Fifth Edition, Section 3.3 (9 Pages)

ATTACHMENT 3 – SHINE Medical Isotope Production Facility Emergency Diesel Generator and Building Heating Emissions Evaluation (20 Pages)

ATTACHMENT 4 – Heavy Construction Operations United States Environmental Protection Agency Fifth Edition Compilation of Air Pollutant Emissions Factors, Volume 1: Stationary Point and Area Sources, Fifth Edition, Section 13.2.3 (7 Pages)

ATTACHMENT 5 – Direct Emissions from Mobile Construction Sources (36 pages)

ATTACHMENT 6 – External Combustion Sources: Natural Gas Combustion United States Environmental Protection Agency Fifth Edition Compilation of Air Pollutant Emissions Factors, Volume 1: Stationary Point and Area Sources, Fifth Edition, Section 1.4 (10 pages)

ATTACHMENT 7 – Transportation Discipline Report Proposed SHINE Site Janesville, Wisconsin (2 pages)

1.0 Introduction

An Environmental Report (ER) was submitted to the U.S. Nuclear Regulatory Commission (NRC) in the spring of 2013 as part of an application for a construction permit for a radioisotope production facility. During an audit of that report, the NRC issued draft requests for additional information (RAIs) regarding the proposed SHINE facility.

The second part of the construction permit consisted of the Preliminary Safety Analysis Report (PSAR). The NRC sent draft RAIs regarding the PSAR, and three of these RAIs asked for clarification of previous responses for ER Air Quality RAIs that used this calculation as the basis for those responses.

1.1 Purpose

The original purpose of this calculation was to answer Air Quality Requests 1, 5, 6, and 10. These RAIs requested that the air and greenhouse gas (GHG) emissions during construction, operation, and decommissioning activities be quantified.

Revision 5 of this calculation provides information necessary to answer RAIs 19.2-2, 19.2-5, and 19.4-1. These RAIs request clarification with respect to duration of the construction, operations, and decommissioning phases; peak number of workers during all three phases of the project; the number of personnel vehicles; monthly truck deliveries, shipments, and off-site waste shipments; and fugitive dust. The assumptions used to calculate the air and greenhouse gas emissions and fugitive dust in Revision 5 also reflect the most recent information about the construction, operations, and decommissioning phases.

1.2 Scope

This calculation includes the air and GHG emissions from the equipment; trucks for the monthly deliveries, shipments, and off-site waste shipments; and personnel vehicles that will be in use during the construction, operations, and decommissioning phases. This calculation also includes the fugitive dust produced from the activities in the construction and decommissioning phases.

2.0 Design Inputs

Information concerning the type and amount of equipment used during the construction phase is found in RFI-AMEC-2011-0033.

Information about the amount of land permanently and temporarily affected by activities inside and outside the site boundaries during the construction and decommissioning phases is found in RFI-S&L-2011-0047. A total of 41.01 acres [ac.] was determined to be the amount of land that will be permanently and temporarily disturbed and will produce fugitive dust during the construction phase. The land that is permanently and temporarily disturbed during the construction phase is the following:

1. 25.67 ac. of permanently disturbed agricultural land within the site boundaries;
2. 0.18 ac. permanently disturbed developed open space within the site boundaries;
3. 14.54 ac. of temporarily disturbed agricultural land within the site boundaries; and
4. 0.62 ac. of temporarily disturbed agricultural land that is outside the site boundaries for the water line that will run to the facility.

A total of 25.85 ac. was determined to be the amount of land that will be permanently disturbed and will produce fugitive dust during the decommissioning phase (RFI-S&L-2011-0047). That land that is permanently disturbed during the decommissioning phase is the following:

1. 25.67 ac. of permanently disturbed agricultural land within the site boundaries; and
2. 0.18 ac. permanently disturbed developed open space within the site boundaries.

RFI-AMEC-2012-0014 Attachment 1 provides the peak number of workers during the construction phase, which is 451 workers.

References 1 and 2 provide the emission factors for greenhouse gases (GHG) and particulate matter for personnel vehicles; equipment used during the construction, operation, and decommissioning phases; and the trucks for the monthly deliveries, shipments, and off-site waste shipments.

Reference 3 provides the air emissions from the non-vehicular equipment that will be in use during the operations phase: the natural gas-fired boiler in the Production Facility Building and the natural gas-fired heaters in the Administration Building, Support Facility Building, Waste Staging & Shipping Building, and the Diesel Generator Building.

Reference 4 provides the fugitive dust emission rate that was used to calculate the total amount of fugitive dust that will be generated during the activities in the construction and decommissioning phases.

Additional greenhouse gas calculations for CH_4 and N_2O are provided in Appendix A. References 5 and 6 provide the emission factors for CH_4 and N_2O for the equipment that will be used during the construction and decommissioning phases; the non-vehicular equipment that will be used in the operations phase; the trucks for the monthly deliveries, shipments, and off-site waste shipments; and personnel vehicles. The analysis and assumptions that are used for these additional calculations are also provided in Appendix A.

Reference 7 provides the number of peak personnel vehicles and heavy trucks per day during the construction phase. Reference 7 states that the peak number of personnel vehicles during the construction phase will be 451 per day, which is consistent with the peak number of workers during the construction phase (451 workers) that was provided in RFI-AMEC-2012-0014. Reference 7 also states that there would be 14 heavy trucks per day (420 heavy trucks per month) at the site for deliveries.

Attachments 1 through 7 contain the references that were used to support this calculation.

2.1 Criteria

The criteria for this calculation are the following:

1. To quantify the amount of air and GHG emissions from the equipment; trucks for monthly deliveries, shipments, and off-site waste shipments; and personnel vehicles that will be in use during the construction, operation, and decommissioning phases; and
2. To quantify the amount of fugitive dust that will be produced during activities in the construction, operations, and decommissioning phases.

2.2 Assumptions

The following assumptions were made in this calculation:

General Assumptions:

1. The region of influence (ROI) has a 50 mile radius (PSAR Subsection 19.4.7.1.1). Workers who live inside the ROI are conservatively assumed to live on the edge of the 50 mile radius will have a total daily commute 100 miles. Workers who lived outside the ROI are assumed to live 100 miles from the center of the ROI and will have a daily commute to and from the site of 200 miles. This calculation assumes that no one carpools. Therefore, the number of personnel vehicles is equal to the number of personnel workers. The peak number of vehicles for each phase was used to calculate the air and greenhouse gas emissions (see Equation 4-4 in Section 4.0). A standard passenger vehicle is assumed as the type of personnel vehicle. The fuel for the passenger vehicles is assumed to be gasoline.
2. The trucks that will be used for deliveries, shipments, and off-site waste shipments during the construction, operations, and decommissioning phases are assumed to be semi-tractor/trailers that used diesel fuel. The use of diesel fuel is a bounding assumption as diesel fuel has higher emission rates than gasoline. The following parameters are used in this calculation:
   a. For the deliveries, shipments, and off-site waste shipments during the construction, operations, and decommissioning phases, it is assumed that each semi-tractor/trailer would make one trip per month.
   b. MapQuest was used to find the distances between the Southern Wisconsin Regional Airport (SWRA) in Janesville, WI, which is located 0.39 miles from the SHINE site (PSAR Table 2.2-5), and various destinations. The following options were chosen for each MapQuest search:
      i. The shortest time option was chosen when MapQuest calculated a route;
      ii. If there were two route choices for a destination, then the longer of the two routes was chosen; and
      iii. Major U.S. highways were not avoided.
   c. The number of miles between SWRA and the destinations were rounded up to the nearest hundred for additional conservatism.
   d. The semi-tractor/trailers will travel at an average of 55 miles per hour (mph) for each trip.
   e. Per trip, the amount of idle time for each semi-tractor/trailer with the engine running will be equal to the amount of driving time. The calculated driving time was rounded up to the nearest whole number, and this value was also used for the time spent idle with the engine running.
3. The equipment used for construction of the facility (first part of the construction phase) and decommissioning of the facility was assumed to use diesel fuel.

Construction Phase:

1. The construction phase consists of two parts: 1) the construction of the facility, and 2) preoperational testing and commissioning of the facility. Construction of the facility is estimated to take 12 months, and preoperational testing and commissioning of the facility is estimated to take 6 months (PSAR Section 19.2). In total, the entire duration of the construction phase is estimated to be 18 months.
2. The daily shift duration is assumed to be 10 hours per day for the entire construction phase. The construction phase was assumed to occur 5 days per week for 50 weeks per year. For the construction equipment, it is assumed that the equipment will run for 5 hours each day.

From these assumptions, it was calculated that the construction equipment would be in use for 1250 hours annually. For the entire construction period, the total number of weeks the equipment is assumed to be in use is 75 weeks. From this assumption, it is assumed that the construction equipment will be in use for 1875 hours for the entire duration of the construction phase.

3. This calculation assumes that there will be 9 off-site waste shipments per month during construction (PSAR Section 19.2). Combined with the 420 heavy trucks per month used for deliveries and shipments, there will be 429 semi-tractor/trailers per month for deliveries, shipments, and off-site waste shipments during the construction phase.
4. The distance travelled by the semi-tractor/trailers during deliveries, shipments, and off-site waste shipments was calculated by finding the roundtrip distances between SWRA to various cities along the East Coast and then SWRA to various cities along the West Coast and dividing these distances in half. The cities that were chosen all had populations greater than 500,000 residents: Boston, MA; New York City, NY; Washington, D.C.; Charlotte, NC; Miami, FL; Seattle, WA; Portland, OR; San Francisco, CA; Los Angeles, CA; and San Diego, CA. The city farthest from SWRA was calculated to be San Francisco, CA. For a single semi-tractor/trailer, the total amount of distance travelled per trip is assumed to be 2200 miles. A single trip will take approximately 80 hours (40 hours driving time, 40 hours idle time with the engine running). For each semi-tractor/trailer, the total amount of distance traveled in one year will be 26400 miles (960 hours). For the duration of the construction phase, the total amount of distance traveled by each semi-tractor trailer will be 39600 miles (1440 hours).
5. Of the 451 workers travelling to and from the site each day, the number of workers commuting 100 miles daily is assumed to be 420 and the number of workers commuting 200 miles daily is assumed to be 31. The number of days per year that the workers will be commuting is assumed to be 250 (5 days per week for 50 weeks per year). The total number of days for the construction phase that the workers will be commuting is assumed to be 375 (5 days per week for 75 weeks).
6. This calculation assumes that the land that will be both permanently and temporarily disturbed, inside and outside the site boundary, will comprise the total acreage of land that will produce fugitive dust. It is assumed that the 0.62 ac. outside the SHINE facility represents the installation of a water line that will run to the SHINE facility. This calculation assumes that no mitigative actions will be taken for fugitive dust.

Operations Phase:

1. As stated in PSAR Section 19.2, there will be a monthly average of 36 truck deliveries and one off-site waste shipment.
    a. For the deliveries and shipments, the semi-tractor/trailers are assumed to travel to Lantheus, which is the farthest shipment facility from SHINE. The total distance (roundtrip) traveled was calculated to be 2300 miles and will take 84 hours per trip (42 hours driving time, 42 hours idle time with the engine running). For each semi-tractor/trailer, the total amount of distance travelled per year will be 27600 miles (1008 hours) per year.
    b. For the off-site waste shipments, it was assumed that all shipments are radiological waste and will be shipped to EnergySolutions. The roundtrip distance was calculated to be 3000 miles and will take 110 hours per trip (55 hours driving time, 55 hours idle time with the engine running). For the off-site waste shipments, the total amount of distance travelled per year for a single semi-tractor/trailer will be 36400 miles (1320 hours).

2. Of the 150 workers that will be commuting to and from the SHINE site daily,139 workers are assumed to commute 100 miles daily and 11 workers are assumed to commute 200 miles (PSAR Subsection 19.4.7.1.1).
3. The parking lots and access roads within the site boundaries and leading to the highway will be paved, so no fugitive dust is assumed to be created during the operations phase.

Decommissioning Phase:

1. The equipment used for decommissioning activities is found in PSAR Table 19.2.0-2. It is assumed that for each equipment type, the amount of equipment that will be used during decommissioning activities is equal to half the amount that will be used during construction activities (and rounded up to the nearest whole number value). This is a valid assumption because the duration of decommissioning activities is assumed to be half the duration of the first part of the construction phase (construction of the facility is 12 months). Therefore, the total duration of the decommissioning phase is 6 months (25 weeks).
2. It is assumed that the total amount of time that the equipment would be in operation during the decommissioning phase was equal to half the total amount of time the equipment was in operation during the construction phase. Therefore, the total amount of time the equipment will be in operation during the decommissioning phase is 625 hours.
3. This calculation assumes that there will be 72 truck deliveries/shipments and 191 off-site waste shipments per month during construction (PSAR Section 19.2).
    a. The calculation assumes that the distance and time travelled by the semi-tractor/trailers for deliveries and shipments will be the same as the distance and time provided in Assumption 4 under “Construction Phase.”
    b. This calculation assumes that all of the off-site waste shipments are radiological waste and will be shipped to EnergySolutions. See Assumption 1b under “Operations Phase” for the distance and time travelled by each semi-tractor/trailer per trip and per year.
4. Of the 261 workers that will be commuting to and from the SHINE site daily, 239 workers will commute 100 miles daily and 22 workers will commute 200 miles daily (PSAR Subsection 19.4.7.1.1).
5. This calculation assumes that a cap will be placed on the water line during decommissioning activities and the pipe will not be removed during this phase. Therefore, the 0.62 ac. is not counted in the amount of land to be disturbed during the decommissioning phase. Additionally, the total amount of acreage that may be disturbed during decommissioning activities was only the land that was permanently converted to industrial use during the construction phase. This calculation assumes that no mitigative actions were taken for fugitive dust.

3.0 References

1. Average Annual Emissions and Fuel Consumption for Gasoline-Fueled Passenger Cars and Light Trucks, United States Environmental Protection Agency, Website accessed: http://www.epa.gov/otaq/consumer/420f08024.pdf, Date accessed: July 23, 2013.
2. Gasoline and Industrial Engines, Chapter 3, Section 3.3, Table 3.3-1, United States Environmental Protection Agency Fifth Edition Compilation of Air Pollutant Emissions Factors, Volume 1: Stationary Point and Area Sources, AP-42, Fifth Edition, USEPA, Website accessed: http://www.epa.gov/ttn/chief/ap42/ch03/final/c03s03.pdf, Date accessed: July 22, 2013.
3. SHINE Medical Isotope Production Facility Emergency Diesel Generator and Building Heating Emissions Evaluation, SL-011348, Rev. 1, Sargent & Lundy, August 9, 2012.

4. Heavy Construction Operations, Chapter 13, Section 13.2.3, United States Environmental Protection Agency Fifth Edition Compilation of Air Pollutant Emissions Factors, Volume 1: Stationary Point and Area Sources, AP-42, Fifth Edition, USEPA, Website accessed: http://www.epa.gov/ttnchie1/ap42/ch13/final/c13s02-3.pdf, Date accessed: August 6, 2013.
5. Direct Emissions from Mobile Combustion Sources, Table A-1 and Table A-6, Appendix A, United States Environmental Protection Agency Report EPA430-K-08-004, USEPA, May 2008.
6. External Combustion Sources, Chapter 1, Section 1.4, Table 1.4-2, United States Environmental Protection Agency Fifth Edition Compilation of Air Pollutant Emissions Factors, Volume 1: Stationary Point and Area Sources, AP-42, Fifth Edition, USEPA, Website accessed: http://www.epa.gov/ttn/chief/ap42/ch01/final/c01s04.pdf, Date accessed: October 3, 2013.
7. Transportation Discipline Report Proposed SHINE Site Janesville, Wisconsin, Prepared for SHINE Medical Technologies by AMEC, August 31, 2012.

4.0 Analysis

Information concerning the type and amount of equipment used during the construction phase was found in RFI-AMEC-2011-0033. The information in RFI-AMEC-2011-0033 was also used to estimate the type and amount of equipment that would be needed for decommissioning activities. RFI-AMEC-2011-0033 assumed that the construction phase would be 24 months long. However, this calculation assumes that the construction phase has two parts and will be 18 months long. All of the equipment in RFI-AMEC-2011-0033 was tallied and used for the amount of equipment needed during the construction phase, despite this RFI using a 24 month schedule instead of an 18 month schedule. RFI-AMEC-2011-0033 includes equipment that will be used for both parts of the construction phase. The total amount of each type of equipment was averaged for a time period of one month. Emission factors from Reference 2 were used to calculate the annual emissions [Tons/year {T/yr}] for carbon monoxide (CO), nitrogen oxide and nitrogen dioxide (NO_x), particulate matter (PM), hydrocarbons, sulfur dioxide (SO_2), and carbon dioxide (CO_2). For decommissioning, this calculations assumes that half of the equipment used during construction will be required and that the duration of the decommissioning phase was 6 months (half the duration of the first part of the construction phase).

Equation 4-1 was used to calculate the annual emissions for equipment used in the construction phase and the decommissioning phase:

$$\mathrm{AER} = \mathrm{EF} \times \frac{1\ \mathrm{Ton}}{2000\ \mathrm{lbs}} \times \mathrm{hp} \times \mathrm{t} \times \mathrm{V} \qquad \text{(Equation 4-1)}$$

Where,

AER = Annual Emission Rate [T/yr]
EF = Emission Factor [lb/hp-hr]
hp = Horsepower of the equipment [hp]
t = number of hours the equipment is assumed to be used in one year [hr]
V = equipment utilization factor (see Equations 4-2 and 4-3)

The equipment utilization factor (V) is the monthly average of the equipment needed for the construction and decommissioning phases and was calculated using the following equation:

$$\mathrm{Vc} = \frac{\sum_1^{18} \mathrm{v-m}}{18\ \mathrm{months}} \qquad \text{(Equation 4-2)}$$

$$\mathrm{Vd} = \frac{\sum_1^6 \mathrm{v{-}m}}{6\ \mathrm{months}} \qquad \text{(Equation 4-3)}$$

Where,

V_c = construction phase equipment utilization factor [unitless]
V_d = decommissioning phase equipment utilization factor [unitless]
v-m = equipment operation months [total amount of equipment]

To calculate the total emissions from the equipment that will be used in the construction phase, Equation 4-1 used the total number of hours that the equipment will be in use (Assumption 2 under "Construction Phase" in Section 2.2).

Equation 4-1 was used to calculate the annual emissions for the semi-tractor/trailers that are assumed to be used for the deliveries, shipments, and off-site waste shipments during the construction, operations, and decommissioning phases. The total emissions from the semi-tractor/trailers that will be used for the monthly deliveries, shipments, and off-site waste shipments used the total number of hours that each semi-tractor/trailer will be in use for these purposes during the duration of the construction phase (Assumption 4 under "Construction Phase" in Section 2.2).

To calculate personnel vehicle emissions, Equation 4-4 was used:

$$\mathrm{AVER} = \mathrm{EFg} \times \mathrm{d} \times \mathrm{V} \times \frac{1\ \mathrm{lb}}{453.592\ \mathrm{grams}} \times \frac{1\ \mathrm{Ton}}{2000\ \mathrm{lbs}} \times \frac{250\ \mathrm{work\ days}}{\mathrm{vehicles{-}1\ year}} \qquad \text{(Equation 4-4)}$$

Where,

AVER = Annual Emissions Rate for personnel vehicles [T/yr]
EFg = Emission Factor for gasoline [grams/mile]
d = distance driven [miles]
V = number of personnel vehicles per day [vehicles/day]

To calculate the total emissions from the personnel vehicles during the construction phase, the total number of days that workers will be commuting to and from the site was used (Assumption 5 under "Construction Phase" in Section 2.2).

Equation 4-5 was used to calculate the amount of fugitive dust during the construction and decommissioning phases (Reference 4):

$$\mathrm{E} = \mathrm{EFF}\left[\frac{\mathrm{tons}}{\mathrm{number\ of\ ac.{-}number\ of\ months}}\right] \times \mathrm{a} \times \mathrm{m} \qquad \text{(Equation 4-5)}$$

Where,

E = fugitive dust emissions [T]
EFF = fugitive dust emissions factor = 1.2 tons/acre-month of activity
a = amount of acreage [ac.]
m = number of months [month]

For the construction phase, 18 months was used in Equation 4-5 to calculate the fugitive dust emissions for the entire duration of the construction phase. For decommissioning, 6 months was used in Equation 4-5 to calculate the fugitive dust emissions for the entire duration of decommissioning.

5.0 Calculations and Results

Microsoft Excel file 'Air Emissions calculations.xlsx' used the equations in Section 4.0 to calculate the air and GHG emissions that are provided in this section.

The results of this calculation are provided in Tables 1 through 12. For the construction phase, the emissions are provided as annual emissions [T/yr] and total emissions [T]. For the decommissioning phase, the total emissions [T] are provided since the duration of the decommissioning phase is only 6 months

Table 12 provides the total annual emissions for equipment; semi-tractor/trailers used for deliveries, shipments, and off-site waste shipments; and personnel vehicles for the construction, operations, and decommissioning phases. Table 12 includes the total annual emissions from PSAR Table 19.4.2-8 for non-vehicular combustion (standby diesel generator and natural gas boiler and heaters) sources that will be in use during the operations phase.

The total amount of fugitive dust generated for the entire duration of the construction phase is 890 T. The amount of fugitive dust generated from the 25.85 ac. of land affected during the decommissioning phase is 190 T.

The assumptions, analysis, and results for methane (CH_4) and nitrous oxide (N_2O) emissions calculations can be found in Appendix A.

Table 1: Annual Emissions for Equipment Used During the Construction Phase

Type of Vehicle	Fuel Type	Engine Horsepower (hp)	Total Amount of Equipment (18 month period)	Average per Month	CO[(a)]	NO_x[(a)]	PM[(a)]	Hydrocarbons[(a)]	SO_2[(a)]	CO_2[(a)]
Asphalt Compactor Cat CB434C	Diesel	107	5	0.28	1.24E-01	5.76E-01	4.09E-02	4.59E-02	3.81E-02	2.14E+01
Asphalt Paver, Barber Greene AP-1000	Diesel	174	5	0.28	2.02E-01	9.36E-01	6.65E-02	7.46E-02	6.19E-02	3.47E+01
Backhoe/Loader Cat 430	Diesel	105	67	3.72	1.63E+00	7.57E+00	5.37E-01	6.03E-01	5.01E-01	2.81E+02
Boom Lift JLG 800AJ	Diesel	65	76	4.22	1.15E+00	5.32E+00	3.77E-01	4.24E-01	3.52E-01	1.97E+02
Concrete Pump Putzmeister 47Z-Meter	Diesel	300	29	1.61	2.02E+00	9.36E+00	6.65E-01	7.46E-01	6.19E-01	3.47E+02
Crane (Lattice Boom, Manitowoc 8000 - 80t)	Diesel	205	13	0.72	6.18E-01	2.87E+00	2.04E-01	2.29E-01	1.90E-01	1.06E+02
Crane (Picker, Grove RT530E-2 30t)	Diesel	160	55	3.06	2.04E+00	9.47E+00	6.72E-01	7.55E-01	6.26E-01	3.51E+02
Crane (Picker, Grove RT600E-50t)	Diesel	173	11	0.61	4.41E-01	2.05E+00	1.45E-01	1.63E-01	1.35E-01	7.60E+01
Dump, Dual axel (15 cy) Mack	Diesel	350	47	2.61	3.82E+00	1.77E+01	1.26E+00	1.41E+00	1.17E+00	6.57E+02
Excavator (Large, Cat 345D L)	Diesel	380	5	0.28	4.41E-01	2.05E+00	1.45E-01	1.63E-01	1.35E-01	7.59E+01

Type of Vehicle	Fuel Type	Engine Horsepower (hp)	Total Amount of Equipment (18 month period)	Average per Month	CO[(a)]	NO_x[(a)]	PM[(a)]	Hydrocarbons[(a)]	SO_2[(a)]	CO_2[(a)]
Excavator (Medium, Cat 321D LCR)	Diesel	148	13	0.72	4.46E-01	2.07E+00	1.47E-01	1.65E-01	1.37E-01	7.68E+01
Extended Forklift Lull 1044C-54	Diesel	115	97	5.39	2.59E+00	1.20E+01	8.52E-01	9.57E-01	7.94E-01	4.45E+02
Fuel Truck, Mack MP6	Diesel	150	14	0.78	4.87E-01	2.26E+00	1.60E-01	1.80E-01	1.49E-01	8.39E+01
Material Truck 2-1/2t F-650	Diesel	270	31	1.72	1.94E+00	9.01E+00	6.39E-01	7.18E-01	5.96E-01	3.34E+02
Mechanic's Truck 2-1/2t F-650	Diesel	270	27	1.50	1.69E+00	7.85E+00	5.57E-01	6.25E-01	5.19E-01	2.91E+02
Motor Grader Cat 140M	Diesel	183	15	0.83	6.37E-01	2.95E+00	2.10E-01	2.35E-01	1.95E-01	1.10E+02
Pickup Truck F-250	Diesel	300	183	10.17	1.27E+01	5.91E+01	4.19E+00	4.71E+00	3.91E+00	2.19E+03
Semi-Tractor/ Trailer (20 cy) Mack MP8	Diesel	450	69	3.83	7.20E+00	3.34E+01	2.37E+00	2.66E+00	2.21E+00	1.24E+03
Skidsteer Loader Case SR200	Diesel	75	79	4.39	1.37E+00	6.38E+00	4.53E-01	5.08E-01	4.22E-01	2.37E+02
Tracked Dozer Cat D6	Diesel	150	21	1.17	7.31E-01	3.39E+00	2.41E-01	2.70E-01	2.24E-01	1.26E+02
Tracked Dozer Cat D7	Diesel	235	26	1.44	1.42E+00	6.58E+00	4.67E-01	5.24E-01	4.35E-01	2.44E+02
Tracked Dozer Cat D8	Diesel	310	19	1.06	1.37E+00	6.34E+00	4.50E-01	5.05E-01	4.19E-01	2.35E+02
Tracked Loader CAT 973C	Diesel	242	43	2.39	2.41E+00	1.12E+01	7.95E-01	8.92E-01	7.41E-01	4.16E+02

Type of Vehicle	Fuel Type	Engine Horsepower (hp)	Total Amount of Equipment (18 month period)	Average per Month	CO[(a)]	NO_x[(a)]	PM[(a)]	Hydrocarbons[(a)]	SO_2[(a)]	CO_2[(a)]
Vibratory Soil Compactor Cat C874	Diesel	156	14	0.78	5.07E-01	2.35E+00	1.67E-01	1.87E-01	1.55E-01	8.72E+01
Water Truck Mack MP6	Diesel	150	11	0.61	3.83E-01	1.78E+00	1.26E-01	1.42E-01	1.17E-01	6.59E+01
Portable Air Compressors	Diesel	50	54	3.00	6.26E-01	2.91E+00	2.06E-01	2.32E-01	1.92E-01	1.08E+02
Portable Generators	Diesel	50	61	3.39	7.07E-01	3.28E+00	2.33E-01	2.62E-01	2.17E-01	1.22E+02
Portable Welders	Diesel	50	45	2.50	5.22E-01	2.42E+00	1.72E-01	1.93E-01	1.60E-01	8.98E+01
Walk Behind Compactor	Diesel	50	23	1.28	2.67E-01	1.24E+00	8.78E-02	9.86E-02	8.19E-02	4.59E+01
Total			1158	64.33	5.05E+01	2.34E+02	1.66E+01	1.87E+01	1.55E+01	8.70E+03

a) The units for annual emissions are in T/yr

Table 2: Total Emissions for Equipment Used During the Construction Phase

Type of Vehicle	Fuel Type	Engine Horsepower (hp)	Total Amount of Equipment (18 month period)	Average per Month	CO[(a)]	NO_x[(a)]	PM[(a)]	Hydrocarbons[(a)]	SO_2[(a)]	CO_2[(a)]
Asphalt Compactor Cat CB434C	Diesel	107	5	0.28	1.86E-01	8.64E-01	6.13E-02	6.88E-02	5.71E-02	3.20E+01
Asphalt Paver, Barber Greene AP-1000	Diesel	174	5	0.28	3.03E-01	1.40E+00	9.97E-02	1.12E-01	9.29E-02	5.21E+01
Backhoe/Loader Cat 430	Diesel	105	67	3.72	2.45E+00	1.14E+01	8.06E-01	9.05E-01	7.51E-01	4.21E+02
Boom Lift JLG 800AJ	Diesel	65	76	4.22	1.72E+00	7.98E+00	5.66E-01	6.36E-01	5.27E-01	2.96E+02
Concrete Pump Putzmeister 47Z-Meter	Diesel	300	29	1.61	3.03E+00	1.40E+01	9.97E-01	1.12E+00	9.29E-01	5.21E+02
Crane (Lattice Boom, Manitowoc 8000 - 80t)	Diesel	205	13	0.72	9.27E-01	4.30E+00	3.05E-01	3.43E-01	2.85E-01	1.60E+02
Crane (Picker, Grove RT530E-2 30t)	Diesel	160	55	3.06	3.06E+00	1.42E+01	1.01E+00	1.13E+00	9.40E-01	5.27E+02
Crane (Picker, Grove RT600E-50t)	Diesel	173	11	0.61	6.62E-01	3.07E+00	2.18E-01	2.45E-01	2.03E-01	1.14E+02
Dump, Dual axel (15 cy) Mack	Diesel	350	47	2.61	5.72E+00	2.66E+01	1.88E+00	2.12E+00	1.76E+00	9.85E+02
Excavator (Large, Cat 345D L)	Diesel	380	5	0.28	6.61E-01	3.07E+00	2.18E-01	2.44E-01	2.03E-01	1.14E+02

Type of Vehicle	Fuel Type	Engine Horsepower (hp)	Total Amount of Equipment (18 month period)	Average per Month	CO[(a)]	NO_x[(a)]	PM[(a)]	Hydrocarbons[(a)]	SO_2[(a)]	CO_2[(a)]
Excavator (Medium, Cat 321D LCR)	Diesel	148	13	0.72	6.69E-01	3.11E+00	2.20E-01	2.48E-01	2.05E-01	1.15E+02
Extended Forklift Lull 1044C-54	Diesel	115	97	5.39	3.88E+00	1.80E+01	1.28E+00	1.44E+00	1.19E+00	6.68E+02
Fuel Truck, Mack MP6	Diesel	150	14	0.78	7.31E-01	3.39E+00	2.41E-01	2.70E-01	2.24E-01	1.26E+02
Material Truck 2-1/2t F-650	Diesel	270	31	1.72	2.91E+00	1.35E+01	9.59E-01	1.08E+00	8.94E-01	5.01E+02
Mechanic's Truck 2-1/2t F-650	Diesel	270	27	1.50	2.54E+00	1.18E+01	8.35E-01	9.38E-01	7.78E-01	4.37E+02
Motor Grader Cat 140M	Diesel	183	15	0.83	9.55E-01	4.43E+00	3.15E-01	3.53E-01	2.93E-01	1.64E+02
Pickup Truck F-250	Diesel	300	183	10.17	1.91E+01	8.86E+01	6.29E+00	7.06E+00	5.86E+00	3.29E+03
Semi-Tractor/ Trailer (20 cy) Mack MP8	Diesel	450	69	3.83	1.08E+01	5.01E+01	3.56E+00	3.99E+00	3.32E+00	1.86E+03
Skidsteer Loader Case SR200	Diesel	75	79	4.39	2.06E+00	9.57E+00	6.79E-01	7.62E-01	6.33E-01	3.55E+02
Tracked Dozer Cat D6	Diesel	150	21	1.17	1.10E+00	5.09E+00	3.61E-01	4.05E-01	3.36E-01	1.89E+02
Tracked Dozer Cat D7	Diesel	235	26	1.44	2.13E+00	9.87E+00	7.00E-01	7.86E-01	6.52E-01	3.66E+02
Tracked Dozer Cat D8	Diesel	310	19	1.06	2.05E+00	9.51E+00	6.75E-01	7.58E-01	6.29E-01	3.53E+02
Tracked Loader CAT 973C	Diesel	242	43	2.39	3.62E+00	1.68E+01	1.19E+00	1.34E+00	1.11E+00	6.23E+02

Type of Vehicle	Fuel Type	Engine Horsepower (hp)	Total Amount of Equipment (18 month period)	Average per Month	CO[(a)]	NO_x[(a)]	PM[(a)]	Hydrocarbons[(a)]	SO_2[(a)]	CO_2[(a)]
Vibratory Soil Compactor Cat C874	Diesel	156	14	0.78	7.60E-01	3.53E+00	2.50E-01	2.81E-01	2.33E-01	1.31E+02
Water Truck Mack MP6	Diesel	150	11	0.61	5.74E-01	2.66E+00	1.89E-01	2.12E-01	1.76E-01	9.88E+01
Portable Air Compressors	Diesel	50	54	3.00	9.39E-01	4.36E+00	3.09E-01	3.47E-01	2.88E-01	1.62E+02
Portable Generators	Diesel	50	61	3.39	1.06E+00	4.92E+00	3.49E-01	3.92E-01	3.26E-01	1.83E+02
Portable Welders	Diesel	50	45	2.50	7.83E-01	3.63E+00	2.58E-01	2.89E-01	2.40E-01	1.35E+02
Walk Behind Compactor	Diesel	50	23	1.28	4.00E-01	1.86E+00	1.32E-01	1.48E-01	1.23E-01	6.89E+01
Total			1158	64.33	7.58E+01	3.52E+02	2.50E+01	2.80E+01	2.33E+01	1.30E+04

a) The units for annual emissions are in T

Table 3: Annual Emissions for Deliveries, Shipments, and Off-site Waste Shipments During the Construction Phase

Type of Vehicle	Fuel Type	Engine Horsepower (hp)	Monthly Average	CO[(a)]	NO_x[(a)]	PM[(a)]	Hydrocarbons[(a)]	SO_2[(a)]	CO_2[(a)]
Semi-Tractor/ Trailer (20 cy) Mack MP8	Diesel	450	420[(b)]	6.06E+02	2.81E+03	2.00E+02	2.24E+02	1.86E+02	1.04E+05
Semi-Tractor/ Trailer (20 cy) Mack MP8	Diesel	450	9[(c)]	1.30E+01	6.03E+01	4.28E+00	4.80E+00	3.99E+00	2.24E+03
Total			429	6.19E+02	2.87E+03	2.04E+02	2.29E+02	1.90E+02	1.07E+05

a) The units for annual emissions are in T/yr
b) Deliveries and shipments – see Section 2.2 for assumptions regarding distance/number of hours travelled.
c) Off-site waste shipments – see Section 2.2 for assumptions regarding distance/number of hours travelled.

Table 4: Total Emissions for Deliveries, Shipments, and Off-site Waste Shipments During the Construction Phase

Type of Vehicle	Fuel Type	Engine Horsepower (hp)	Monthly Average	CO[(a)]	NO_x[(a)]	PM[(a)]	Hydrocarbons[(a)]	SO_2[(a)]	CO_2[(a)]
Semi-Tractor/ Trailer (20 cy) Mack MP8	Diesel	450	420[(b)]	9.09E+02	4.22E+03	2.99E+02	3.36E+02	2.79E+02	1.56E+05
Semi-Tractor/ Trailer (20 cy) Mack MP8	Diesel	450	9[(c)]	1.95E+01	9.04E+01	6.42E+00	7.20E+00	5.98E+00	3.35E+03
Total			429	9.28E+02	4.31E+03	3.06E+02	3.43E+02	2.85E+02	1.60E+05

a) The units for annual emissions are in T
b) Deliveries and shipments – see Section 2.2 for assumptions regarding distance/number of hours travelled.
c) Off-site waste shipments – see Section 2.2 for assumptions regarding distance/number of hours travelled.

Table 5: Annual Emissions for Personnel Vehicles During the Construction Phase

Type of Vehicle	Fuel Type	Engine Horsepower (hp)	Number of Vehicles	CO[(a)]	NO_x[(a)]	Hydrocarbons[(a)]	PM-10[(a)]	PM-2.5[(a)]	CO_2[(a)]
Standard Passenger Vehicle	Gasoline	150	420[(b)]	1.09E+02	8.02E+00	1.25E+01	5.09E-02	4.75E-02	4.26E+03
Standard Passenger Vehicle	Gasoline	150	31[(c)]	1.61E+01	1.18E+00	1.84E+00	7.52E-03	7.01E-03	6.29E+02
Total			451	1.25E+02	9.21E+00	1.43E+01	5.84E-02	5.45E-02	4.89E+03

a) The units for annual emissions are in T/yr
b) The number of personnel vehicles that will have a daily total commute of 100 miles.
c) The number of personnel vehicles that will have a daily total commute of 200 miles.

Table 6: Total Emissions for Personnel Vehicles During the Construction Phase

Type of Vehicle	Fuel Type	Engine Horsepower (hp)	Number of Vehicles	CO[(a)]	NO_x[(a)]	Hydrocarbons[(a)]	PM-10[(a)]	PM-2.5[(a)]	CO_2[(a)]
Standard Passenger Vehicle	Gasoline	150	420[(b)]	1.63E+02	1.20E+01	1.87E+01	7.64E-02	7.12E-02	6.40E+03
Standard Passenger Vehicle	Gasoline	150	31[(c)]	2.41E+01	1.78E+00	2.76E+00	1.13E-02	1.05E-02	9.44E+02
Total			451	1.87E+02	1.38E+01	2.15E+01	8.77E-02	8.17E-02	7.34E+03

a) The units for annual emissions are in T
b) The number of personnel vehicles that will have a daily total commute of 100 miles.
c) The number of personnel vehicles that will have a daily total commute of 200 miles.

Table 7: Annual Emissions for Deliveries, Shipments, and Off-site Waste Shipments During the Operations Phase

Type of Vehicle	Fuel Type	Engine Horsepower (hp)	Monthly Average	CO[(a)]	NO_x[(a)]	PM[(a)]	Hydrocarbons[(a)]	SO_2[(a)]	CO_2[(a)]
Semi-Tractor/ Trailer (20 cy) Mack MP8	Diesel	450	36[(b)]	5.45E+01	2.53E+02	1.80E+01	2.02E+01	1.67E+01	9.39E+03
Semi-Tractor/ Trailer (20 cy) Mack MP8	Diesel	450	1[(c)]	1.98E+00	9.21E+00	6.53E-01	7.34E-01	6.09E-01	3.42E+02
Total			37	5.65E+01	2.62E+02	1.86E+01	2.09E+01	1.73E+01	9.73E+03

a) The units for annual emissions are in T/yr
b) Deliveries and shipments – see Section 2.2 for assumptions regarding distance/number of hours travelled.
c) Off-site waste shipments – see Section 2.2 for assumptions regarding distance/number of hours travelled.

Table 8: Annual Emissions for Personnel Vehicles During the Operations Phase

Type of Vehicle	Fuel Type	Engine Horsepower (hp)	Number of Vehicles	CO[(a)]	NO_x[(a)]	Hydrocarbons[(a)]	PM-10[(a)]	PM-2.5[(a)]	CO_2[(a)]
Standard Passenger Vehicle	Gasoline	150	139[(b)]	3.60E+01	2.65E+00	4.13E+00	1.69E-02	1.57E-02	1.41E+03
Standard Passenger Vehicle	Gasoline	150	11[(c)]	5.70E+00	4.20E-01	6.53E-01	2.67E-03	2.49E-03	2.23E+02
Total			150	4.17E+01	3.07E+00	4.78E+00	1.95E-02	1.82E-02	1.63E+03

a) The units for annual emissions are in T/yr
b) The number of personnel vehicles that will have a daily total commute of 100 miles.
c) The number of personnel vehicles that will have a daily total commute of 200 miles.

Table 9: Total Emissions for Equipment Used During the Decommissioning Phase

Type of Vehicle	Fuel Type	Engine Horsepower (hp)	Total Amount of Equipment (6 month period)	Monthly Average	CO[(a)]	NO_x[(a)]	PM[(a)]	Hydrocarbons[(a)]	SO_2[(a)]	CO_2[(a)]
Backhoe/Loader Cat 430	Diesel	105	34	5.67	1.24E+00	5.76E+00	4.09E-01	4.59E-01	3.81E-01	2.14E+02
Boom Lift JLG 800AJ	Diesel	65	38	6.33	8.59E-01	3.99E+00	2.83E-01	3.18E-01	2.64E-01	1.48E+02
Crane (Lattice Boom, Manitowoc 8000 - 80t)	Diesel	205	7	1.17	4.99E-01	2.32E+00	1.64E-01	1.85E-01	1.53E-01	8.60E+01
Crane (Picker, Grove RT530E-2 30t)	Diesel	160	28	4.67	1.56E+00	7.23E+00	5.13E-01	5.76E-01	4.78E-01	2.68E+02
Crane (Picker, Grove RT600E- 50t)	Diesel	173	6	1.00	3.61E-01	1.68E+00	1.19E-01	1.34E-01	1.11E-01	6.22E+01
Dump, Dual axel (15 cy) Mack	Diesel	350	24	4.00	2.92E+00	1.36E+01	9.63E-01	1.08E+00	8.97E-01	5.03E+02
Excavator (Large, Cat 345D L)	Diesel	380	3	0.50	3.97E-01	1.84E+00	1.31E-01	1.47E-01	1.22E-01	6.83E+01
Excavator (Medium, Cat 321D LCR)	Diesel	148	7	1.17	3.60E-01	1.67E+00	1.19E-01	1.33E-01	1.11E-01	6.21E+01
Extended Forklift Lull 1044C-54	Diesel	115	49	8.17	1.96E+00	9.10E+00	6.46E-01	7.25E-01	6.02E-01	3.38E+02
Fuel Truck, Mack MP6	Diesel	150	7	1.17	3.65E-01	1.70E+00	1.20E-01	1.35E-01	1.12E-01	6.29E+01
Material Truck 2-1/2t F-650	Diesel	270	16	2.67	1.50E+00	6.98E+00	4.95E-01	5.56E-01	4.61E-01	2.59E+02
Mechanic's Truck 2-1/2t F-650	Diesel	270	14	2.33	1.32E+00	6.10E+00	4.33E-01	4.86E-01	4.04E-01	2.26E+02
Motor Grader Cat 140M	Diesel	183	8	1.33	5.09E-01	2.36E+00	1.68E-01	1.88E-01	1.56E-01	8.77E+01
Pickup Truck F-250	Diesel	300	92	15.33	9.60E+00	4.46E+01	3.16E+00	3.55E+00	2.95E+00	1.65E+03

Type of Vehicle	Fuel Type	Engine Horsepower (hp)	Total Amount of Equipment (6 month period)	Monthly Average	CO[(a)]	NO_x[(a)]	PM[(a)]	Hydrocarbons[(a)]	SO_2[(a)]	CO_2[(a)]
Semi-Tractor/Trailer (20 cy) Mack MP8	Diesel	450	35	5.83	5.48E+00	2.54E+01	1.80E+00	2.03E+00	1.68E+00	9.43E+02
Skidsteer Loader Case SR200	Diesel	75	40	6.67	1.04E+00	4.84E+00	3.44E-01	3.86E-01	3.20E-01	1.80E+02
Tracked Dozer Cat D6	Diesel	150	11	1.83	5.74E-01	2.66E+00	1.89E-01	2.12E-01	1.76E-01	9.88E+01
Tracked Dozer Cat D7	Diesel	235	13	2.17	1.06E+00	4.93E+00	3.50E-01	3.93E-01	3.26E-01	1.83E+02
Tracked Dozer Cat D8	Diesel	310	10	1.67	1.08E+00	5.01E+00	3.55E-01	3.99E-01	3.31E-01	1.86E+02
Tracked Loader CAT 973C	Diesel	242	22	3.67	1.85E+00	8.60E+00	6.10E-01	6.85E-01	5.68E-01	3.19E+02
Vibratory Soil Compactor Cat C874	Diesel	156	7	1.17	3.80E-01	1.76E+00	1.25E-01	1.40E-01	1.17E-01	6.54E+01
Water Truck Mack MP6	Diesel	150	6	1.00	3.13E-01	1.45E+00	1.03E-01	1.16E-01	9.61E-02	5.39E+01
Portable Air Compressors	Diesel	50	27	4.50	4.70E-01	2.18E+00	1.55E-01	1.74E-01	1.44E-01	8.09E+01
Portable Generators	Diesel	50	31	5.17	5.39E-01	2.50E+00	1.78E-01	1.99E-01	1.65E-01	9.28E+01
Portable Welders	Diesel	50	23	3.83	4.00E-01	1.86E+00	1.32E-01	1.48E-01	1.23E-01	6.89E+01
Walk Behind Compactor	Diesel	50	12	2.00	2.09E-01	9.69E-01	6.88E-02	7.72E-02	6.41E-02	3.59E+01
Total				95	3.69E+01	1.71E+02	1.21E+01	1.36E+01	1.13E+01	6.35E+03

a) The units for annual emissions are in T

Table 10: Total Emissions for Deliveries, Shipments, and Off-site Waste Shipments During the Decommissioning Phase

Type of Vehicle	Fuel Type	Engine Horsepower (hp)	Monthly Average	CO[(a)]	NO_x[(a)]	PM[(a)]	Hydrocarbons[(a)]	SO_2[(a)]	CO_2[(a)]
Semi-Tractor/ Trailer (20 cy) Mack MP8	Diesel	450	72[(b)]	5.19E+01	2.41E+02	1.71E+01	1.92E+01	1.59E+01	8.94E+03
Semi-Tractor/ Trailer (20 cy) Mack MP8	Diesel	450	191[(c)]	1.89E+02	8.79E+02	6.24E+01	7.01E+01	5.81E+01	3.26E+04
Total			263	2.41E+02	1.12E+03	7.95E+01	8.93E+01	7.41E+01	4.16E+04

a) The units for annual emissions are in T
b) Deliveries and shipments – see Section 2.2 for assumptions regarding distance/number of hours travelled.
c) Off-site waste shipments – see Section 2.2 for assumptions regarding distance/number of hours travelled.

Table 11: Total Emissions for Personnel Vehicles During the Decommissioning Phase

Type of Vehicle	Fuel Type	Engine Horsepower (hp)	Number of Vehicles	CO[(a)]	NO_x[(a)]	Hydrocarbons[(a)]	PM-10[(a)]	PM-2.5[(a)]	CO_2[(a)]
Standard Passenger Vehicle	Gasoline	150	239[(b)]	6.19E+01	4.56E+00	7.09E+00	2.90E-02	2.70E-02	2.43E+03
Standard Passenger Vehicle	Gasoline	150	22[(c)]	1.14E+01	8.40E-01	1.31E+00	5.34E-03	4.97E-03	4.47E+02
Total			261	7.33E+01	5.40E+00	8.40E+00	3.43E-02	3.20E-02	2.87E+03

a) The units for annual emissions are in T
b) The number of personnel vehicles that will have a daily total commute of 100 miles.
c) The number of personnel vehicles that will have a daily total commute of 200 miles.

Table 12: Annual Emissions for Equipment; Deliveries, Shipments, and Off-site Waste Shipments; and Personnel Vehicles During the Construction, Operations, and Decommissioning Phases

	Annual Emissions (T/yr)		
Emission	**Construction**	**Operation[a]**	**Decommissioning[c]**
CO	7.94E+02	1.09E+02	3.52E+02
NO_x	3.12E+03	2.78E+02	1.30E+03
PM[b]	2.21E+02	1.96E+01	9.17E+01
Hydrocarbons	2.62E+02	2.65E+01	1.11E+02
SO_2	2.05E+02	1.74E+01	8.54E+01
CO_2	1.20E+05	2.70E+04	5.08E+04

a) The annual emissions includes the emissions from PSAR Table 19.4.2-8.
b) The data for particulate matter for personnel vehicles (PM-10 and PM-2.5) was added to calculate the total particulate matter data for personnel vehicles.
c) The decommissioning phase has a duration of 6 months, so the calculated annual emissions for the decommissioning phase are the total emissions from the 6 month duration of the decommissioning phase.

Appendix A
Calculations for CH_4 and N_2O Emissions During the Construction, Operations, and Decommissioning Phases

(9 Pages)

1.0 Purpose

The purpose of this appendix is to provide additional calculations for greenhouse gas emissions for CH_4 and N_2O for construction, operation, and decommissioning activities.

Revision 5 corrected the N_2O (controlled low NOx burner) emission factor to 0.64 lb/10^6scf. Revision 4 erroneously used 0.064 lb/10^6scf as the emission factor.

Revision 5 also calculates the greenhouse gas emissions from CH_4 and N_2O for the deliveries, shipments, and off-site waste shipments that will occur during the construction and decommissioning phases.

2.0 Design Input

References 5 and 6 provide the emission factors for CH_4 and N_2O.

2.1 Assumptions

The assumptions that apply to the calculation for the construction, operations, and decommissioning phases apply to the calculations done in this appendix. The following are additional assumptions that were used to calculate CH_4 and N_2O.

Construction Phase:

1. The construction phase has two parts: the construction of the facility; and preoperational testing and commissioning. The duration of the first part of the construction phase, the construction of the facility, is assumed to be 12 months. Per PSAR Section 19.2, the amount of diesel fuel used during construction of the facility will be 24,587 gallons of diesel fuel per month, which equals 295,044 gallons of diesel fuel over the duration of the first part of the construction phase. The second part of the construction phase, the preoperational testing and commissioning, is assumed to have a duration of 6 months. Per PSAR Section 19.2, the amount of diesel fuel used during preoperational testing and commissioning will be 11,721 gallons of diesel fuel per month, which equals 70,326 gallons of diesel fuel over the duration of the second part of the construction phase. The total amount of diesel fuel for the entire construction phase (18 months) is 365,370 gallons of diesel fuel. Averaging the total amount of diesel fuel used for the entire construction phase and multiplying by 12, the amount of diesel fuel used per year during the construction phase is assumed to be 243,580 gallons per year.

Operations Phase:

1. Emission factors for CH_4 and N_2O from Reference 6 are used to calculate CH_4 and N_2O emissions from the natural gas-fired boiler in the Production Facility Building and the natural gas-fired heaters in the Administration Building, Support Facility Building, Waste Staging & Shipping Building, and the Diesel Generator Building. The boiler and heaters are assumed to operate for 8400 hours/year (50 weeks per year, 7 days per week, 24 hours per day).

Decommissioning Phase:

1. Per PSAR Section 19.2, the amount of diesel fuel used during the decommissioning phase will be 28,607 gallons of diesel fuel per month, which is 171,642 gallons of diesel for the duration of decommissioning activities (6 months).

3.0 Analysis

The following equation was used to calculate the CH_4 and N_2O emissions for construction and decommissioning equipment:

$$\mathrm{AER} = \mathrm{EF} \times \mathrm{G} \times \frac{1\ \mathrm{lb}}{453.59\ \mathrm{g}} \times \frac{1\ \mathrm{Ton}}{2000\ \mathrm{lbs}} \qquad \text{(Equation A-1)}$$

Where,

AER = Annual Emission Rate [T/yr]
EF = Emission Factor for diesel fuel [grams/gallon]
G = Number of gallons of diesel fuel used per year [gallons/year]

As stated in Assumption 1 for Construction Phase in Section 2.1, the entire duration of the construction phase is 18 months and consists of two parts. Each part had a separate amount of diesel fuel used per month. The total amount of fuel was calculated for the entire 18 month duration of the construction phase, and then the average was found. This average was multiplied by 12 in order to find the amount of diesel fuel used in a single year. This amount is the number used for "G" in Equation A-1. To calculate the total CH_4 and N_2O emissions for the construction phase, the total amount of diesel fuel is used (see Assumption 1 under "Construction Phase" in Section 2.1 of this appendix).

As stated in Assumption 1 for Decommissioning Phase in Section 2.1, the duration of the decommissioning phase is 6 months. Therefore, the amount of diesel fuel used per month was multiplied by 6 months, and the total amount of diesel fuel used over the 6 month duration of the decommissioning phase was the number used for "G" in Equation A-1 (See Assumption 1 under "Decommissioning Phase" in Section 2.1 of this appendix).

The following equation was used to calculate the CH_4 and N_2O emissions from the boiler and heaters that will be used during operation:

$$\mathrm{AER} = \mathrm{EF} \times \frac{1\frac{\mathrm{lb}}{10^6\ \mathrm{scf}}}{1{,}020\frac{\mathrm{lb}}{\mathrm{MMBtu}}} \times \mathrm{DFR} \times \frac{1\ \mathrm{Ton}}{2000\ \mathrm{lbs}} \times \frac{8400\ \mathrm{hours\ of\ operation}}{\mathrm{year}} \qquad \text{(Equation A-2)}$$

Where,

AER = Annual Emission Rate [T/yr]
EF = Emission Factor [lb/10^6 scf]
DFR = Design Firing Rate [MMBtu/hr]

Dividing the emission factor in Equation A-2 by 1020 converts EF from [lb/10^6 scf] to [lb/MMBtu] (Reference 6).

Equation A-3 was used to calculate the CH_4 and N_2O emissions from passenger vehicles used during construction, operation, and decommissioning. The quantities of vehicles that will be in

use during the construction, operation, and decommissioning phase were provided in Section 2.2 of the calculation.

$$\mathrm{AVER} = \mathrm{EFg} \times \mathrm{d} \times \mathrm{V} \times \frac{1\ \mathrm{lb}}{453.592\ \mathrm{grams}} \times \frac{1\ \mathrm{Ton}}{2000\ \mathrm{lbs}} \times \frac{250\ \mathrm{work\ days}}{\mathrm{vehicles}-1\ \mathrm{year}} \qquad \text{(Equation A-3)}$$

Where,

AVER = Annual Emissions Rate for personnel vehicles [T/yr]
EFg = Emission Factor for gasoline [grams/mile]
d = distance driven [miles]
V = number of personnel vehicles per day [vehicles/day]

To calculate the total CH_4 and N_2O emissions from personnel vehicles during the construction phase, the total number of work days for the construction phase was used in Equation A-3 (see Assumption 5 under "Construction Phase" in Section 2.2 of the calculation).

The following equation was used to calculate the CH_4 and N_2O emissions from the monthly shipments, deliveries, and off-site waste shipments:

$$\mathrm{ATER} = \mathrm{EF} \times \mathrm{d} \times \mathrm{N} \times \frac{1\ \mathrm{lb}}{453.92\ \mathrm{g}} \times \frac{1\ \mathrm{Ton}}{2000\ \mathrm{lbs}} \times t \qquad \text{(Equation A-4)}$$

Where,

ATER = Annual Emissions Rate for trucks [T/yr]
EF = Emission factor for diesel fuel [grams/mile]
d = Distance driven [miles]
N = Average number of trucks per month [unitless]
t = Number of months the equipment is assumed to be used in one year [months]

To calculate the total CH_4 and N_2O emissions from the monthly shipments, deliveries, and off-site waste shipments for the construction phase, the total number of miles each semi-tractor/trailer will travel for the construction phase was used in Equation A-4 (see Assumption 4 under "Construction Phase" in Section 2.2 of this calculation).

4.0 Calculations and Results

Microsoft Excel file 'Air Emissions calculations.xlsx' used the equations in Section 3.0 of this appendix to calculate the CH_4 and N_2O emissions that are provided in this section.

Tables A1 – A10 provide the results of the CH_4 and N_2O emissions calculations.

Table A1: Annual CH_4 and N_2O Emissions for Construction Equipment During the Construction Phase

	Emission Factor (grams/gallon)	Average Number of Gallons of Diesel Fuel (per year)	Annual Emissions (T/yr)
CH_4	5.85E-01	243,580	1.56E-01
N_2O	2.60E-01	243,580	6.98E-02

For the duration of the construction phase, the total emissions from the equipment used for CH_4 are 2.34E-01 T and the total emissions for N_2O are 1.05E-01 T.

Table A2: Annual CH_4 and N_2O Emissions for Deliveries, Shipments, and Off-site Waste Shipments During the Construction Phase

		Annual Emissions (T/yr)
	Emission Factor (grams/mile)	**Semi-Tractor/Trailer (429 shipments/deliveries/ off-site waste shipments per month)[(a)]**
CH_4	5.10E-03	6.37E-02
N_2O	4.80E-03	5.99E-02

a) Since the shipments, deliveries, and off-site waste shipments are all travelling to and from the same location, the emissions calculated the total CH_4 and N_2O emissions for all 429 semi-tractor/trailers.

The total CH_4 emissions from the semi-tractor/trailers used for deliveries, shipments, and off-site waste shipments for the construction phase are 9.55E-02 T. The total N_2O emissions from the semi-tractor/trailers used for deliveries, shipments, and off-site waste shipments for the construction phase are 8.969E-02 T.

Table A3: Annual CH_4 and N_2O Emissions for Personnel Vehicles During the Construction Phase

		Annual Emissions (T/yr)	
	Emission Factor (grams/mile)	**Standard Passenger Vehicle (100 mile daily commute)**	**Standard Passenger Vehicle (200 mile daily commute)**
CH_4	1.73E-02	2.00E-01	2.96E-02
N_2O	3.60E-03	4.17E-02	6.15E-03

The total CH_4 emissions from personnel vehicles for the construction phase are 3.45E-01 T. The total N_2O emissions from personnel vehicles for the construction phase are 7.17E-02 T.

Table A4 provides the CH4 and N2O emissions from the stationary sources (boiler and heaters) that will be in use during the operations phase. Calculations were done to determine the CH_4, N_2O (Uncontrolled), and N_2O (Controlled Low NOx Burner) emissions based on the information provided in Reference 3. The CH_4, N_2O (Uncontrolled), and N_2O (Controlled Low NOx Burner) annual emissions were found to be 4.71E-03 T/yr, 4.51E-03 T/yr, and 1.31E-03 T/yr. The total annual N2O emissions from the standby diesel generator are 5.82E-03 T/yr.

Table A4: CH_4 and N_2O Emissions for Natural Gas-Fired Boiler and Natural-Gas Fired Heaters Used During the Operations Phase

Natural Gas Fired Boiler – Production Facility Building						
	Emission Factor	Units	Source	Annual Emissions (T/yr)	Hourly Emissions (lb/hr)	Hourly Emissions (lb/MMBtu)
CH_4	2.3	lb/10^6 scf	Reference 6	2.84E-01	6.76E-02	2.25E-03
N_2O (Uncontrolled)	2.2	lb/10^6 scf	Reference 6	2.72E-01	6.47E-02	2.16E-03
N_2O (Controlled Low NOx Burner)	0. 64	lb/10^6 scf	Reference 6	7.91E-02	1.88E-02	6.27E-04
Design Firing Rate	30 MMBtu/hr					
Heating Value for Natural Gas	1020 MMBtu/hr					
Maximum Fuel Firing Rate	29,412 scf/hr					
Natural Gas Fired Heater – Administration Building						
	Emission Factor	Units	Source	Annual Emissions (T/yr)	Hourly Emissions (lb/hr)	Hourly Emissions (lb/MMBtu)
CH_4	2.3	lb/10^6 scf	Reference 6	2.75E-03	6.54E-04	2.25E-03
N_2O (Uncontrolled)	2.2	lb/10^6 scf	Reference 6	2.63E-03	6.25E-04	2.16E-03
N_2O (Controlled Low NOx Burner)	0.64	lb/10^6 scf	Reference 6	7.64E-04	1.82E-04	6.27E-04
Design Firing Rate	290,000 Btu/hr (0.29 MMBtu/hr)					
Heating Value for Natural Gas	1020 MMBtu/hr					
Maximum Fuel Firing Rate	284.3 scf/hr					
Natural Gas Fired Heater – Support Facility Building						
	Emission Factor	Units	Source	Annual Emissions (T/yr)	Hourly Emissions (lb/hr)	Hourly Emissions (lb/MMBtu)
CH_4	2.3	lb/10^6 scf	Reference 6	3.98E-03	9.47E-04	2.25E-03
N_2O (Uncontrolled)	2.2	lb/10^6 scf	Reference 6	3.80E-03	9.06E-04	2.16E-03
N_2O (Controlled Low	0.64	lb/10^6 scf	Reference 6	1.11E-03	2.64E-04	6.27E-04

Table A4: CH_4 and N_2O Emissions for Natural Gas-Fired Boiler and Natural-Gas Fired Heaters Used During the Operations Phase

NOx Burner)						
Design Firing Rate	420,000 Btu/hr (0.42 MMBtu/hr)					
Heating Value for Natural Gas	1020 MMBtu/hr					
Maximum Fuel Firing Rate	411.8 scf/hr					
Natural Gas Fired Heater – Waste Staging & Shipping Building						
	Emission Factor	Units	Source	Annual Emissions (T/yr)	Hourly Emissions (lb/hr)	Hourly Emissions (lb/MMBtu)
CH_4	2.3	lb/10^6 scf	Reference 6	1.70E-03	4.06E-04	2.25E-03
N_2O (Uncontrolled)	2.2	lb/10^6 scf	Reference 6	1.63E-03	3.88E-04	2.16E-03
N_2O (Controlled Low NOx Burner)	0.64	lb/10^6 scf	Reference 6	4.74E-04	1.13E-04	6.27E-04
Design Firing Rate	180,000 Btu/hr (0.18 MMBtu/hr)					
Heating Value for Natural Gas	1020 MMBtu/hr					
Maximum Fuel Firing Rate	176.5 scf/hr					
Natural Gas Fired Heater – Diesel Generator Building						
	Emission Factor	Units	Source	Annual Emissions (T/yr)	Hourly Emissions (lb/hr)	Hourly Emissions (lb/MMBtu)
CH_4	2.3	lb/10^6 scf	Reference 6	6.82E-04	1.62E-04	2.25E-03
N_2O (Uncontrolled)	2.2	lb/10^6 scf	Reference 6	6.52E-04	1.55E-04	2.16E-03
N_2O (Controlled Low NOx Burner)	0.64	lb/10^6 scf	Reference 6	1.90E-04	4.52E-05	6.27E-04
Design Firing Rate	72,000 Btu/hr (0.072 MMBtu/hr)					
Heating Value for Natural Gas	1020 MMBtu/hr					
Maximum Fuel Firing Rate	70.6 scf/hr					

Table A5: Annual CH_4 and N_2O Emissions for Personnel Vehicles During the Operations Phase

		Annual Emissions (T/yr)	
	Emission Factor (grams/mile)	**Standard Passenger Vehicle (100 mile daily commute)**	**Standard Passenger Vehicle (200 mile daily commute)**
CH_4	1.73E-02	6.63E-02	1.05E-02
N_2O	3.60E-03	1.38E-02	2.18E-03

Table A6: Annual CH_4 and N_2O Emissions for Deliveries, Shipments, and Off-site Waste Shipments During the Operations Phase

		Annual Emissions (T/yr)	
	Emission Factor (grams/mile)	**Semi-Tractor/Trailer (36 shipments/ deliveries per month)**	**Semi-Tractor/Trailer (1 waste shipment per month)**
CH_4	5.10E-03	5.59E-03	2.02E-04
N_2O	4.80E-03	5.26E-03	1.90E-04

Table A7: Total CH_4 and N_2O Emissions for Decommissioning Equipment During the Decommissioning Phase

	Emission Factor (grams/gallon)	**Gallons of Diesel Fuel (duration of Decommissioning Phase is 6 months)**	**Total Emissions (T)**
CH_4	5.85E-01	171,642	1.10E-01
N_2O	2.60E-01	171,642	4.92E-02

Table A8: Total CH_4 and N_2O Emissions for Deliveries, Shipments, and Off-site Waste Shipments During the Decommissioning Phase

		Total Emissions (T)	
	Emission Factor (grams/mile)	**Semi-Tractor/Trailer (72 shipments/ deliveries per month)**	**Semi-Tractor/Trailer (191 off-site waste shipments per month)**
CH_4	5.10E-03	5.34E-03	1.93E-02
N_2O	4.80E-03	5.03E-03	1.82E-02

Table A9: Total CH_4 and N_2O Emissions for Personnel Vehicles During the Decommissioning Phase

		Annual Emissions (T/yr)	
	Emission Factor (grams/mile)	**Standard Passenger Vehicle (100 mile daily commute)**	**Standard Passenger Vehicle (200 mile daily commute)**
CH_4	1.73E-02	1.14E-01	2.10E-02
N_2O	3.60E-03	2.37E-02	4.37E-03

Table A10: Total CH_4 and N_2O Emissions During the Construction, Operations, and Decommissioning Phases

	Annual Emissions (T/yr)		
	Construction	**Operations**	**Decommissioning[(a)]**
CH_4	4.49E-01	3.80E-01	2.69E-01
N_2O	1.78E-01	3.89E-01	1.00E-01

a) Since the duration of the decommissioning phase is only 6 months, the annual emissions are the total emissions for the 6 month duration of the decommissioning phase.