Notice of Construction Application Supporting Information Report MWH-03/04/05/06 Data Center Quincy, Washington

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Prepared for

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MWH-03/04/05/06 Data Center
Quincy, Washington

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LIST OF ABBREVIATIONS AND ACRONYMS

μg/m^3	microgram per cubic meter
AERMAP	AMS/EPA regulatory model terrain pre-processor
AERMET	AERMOD meteorological pre-processor
AERMOD	AMS/EPA regulatory model
AMS	American Meteorological Society
ASIL	acceptable source impact level
BACT	best available control technology
CAT	Caterpillar
CFR	Code of Federal Regulations
CO	carbon monoxide
DEEP	diesel engine exhaust particulate matter
DOC	diesel oxidation catalyst
DPF	diesel particulate filter
Ecology	Washington State Department of Ecology
EPA	US Environmental Protection Agency
g/kWm-hr	grams per mechanical kilowatt-hour
GEP	good engineering practice
HAP	hazardous air pollutant
ISC	Industrial Source Complex
LAI	Landau Associates, Inc.
MW	megawatt
MWe	megawatts electrical
m	meter
NAAQS	National Ambient Air Quality Standards
NESHAP	National Emission Standards for Hazardous Air Pollutants
NO_2	nitrogen dioxide
NOC	Notice of Construction
NO_x	nitrogen oxides
NSPS	New Source Performance Standard
NWS	National Weather Service
PM	particulate matter
$PM_{2.5}$	PM with an aerodynamic diameter less than or equal to 2.5 microns
PM_{10}	PM with an aerodynamic diameter less than or equal to 10 microns
ppm	parts per million
PVMRM	Plume Volume Molar Reaction Model
RCW	Revised Code of Washington
RICE	reciprocating internal combustion engine

LIST OF ABBREVIATIONS AND ACRONYMS (CONTINUED)

SCR	selective catalytic reduction
SO_2	sulfur dioxide
SQER	small-quantity emission rate
TAP	toxic air pollutant
tBACT	BACT for toxic air pollutants
TDS	total dissolved solids
USGS	US Geological Survey
VOC	volatile organic compound
WAAQS	Washington Ambient Air Quality Standards
WAC	Washington Administrative Code
WSU	Washington State University

1.0 EXECUTIVE SUMMARY

Microsoft is proposing to expand the existing MWH Data Center complex in Quincy, Washington (Figure 1). This document has been prepared to support the submittal of a Notice of Construction (NOC) application for installation and operation of new emergency generators and evaporative fluid coolers, under air quality regulations promulgated by the Washington State Department of Ecology (Ecology). The MWH Data Center complex is located on Grant County Parcel No. 313769000, at 1515 NW Port Industrial Parkway, in Quincy, Washington.

The data center expansion will include:

- MWH-03 – (8) 3-megawatt (MW) emergency generators, (1) emergency generator that is 1.5 MW or less, and 16 fluid coolers
- MWH-04 – (20) 3-MW emergency generators, (1) 1.5-MW emergency generator, and 40 fluid coolers
- MWH-05 – (20) 3-MW emergency generators, (1) 1.5-MW emergency generator, and 40 fluid coolers
- MWH-06 – (20) 3-MW emergency generators, (1) 1.5-MW emergency generator, and 40 fluid coolers.

A site map for the proposed development is provided on Figure 2.

The list of equipment that was evaluated for this NOC application consists of the following:

- Four (4) Cummins Model 1500DQGAF or Caterpillar (CAT) Model 3512C generators. The 1,500-kilowatt electrical generators will have a combined capacity of 6.0 megawatts electrical (MWe).
- Sixty-eight (68) Cummins Model C3000 D6e or CAT Model C175 generators. The 68 3.0-MWe generators will have a combined capacity of 204 MWe.
- All generators will be Tier 2-certified and will be equipped with a catalyzed diesel particulate filter (DPF) and urea-based selective catalytic reduction (SCR) to meet EPA Tier 4 emission standards.
- One hundred thirty-six (136) Baltimore Aircoil Company (BAC) Model HXV-1012C-24T-L-2 evaporative fluid coolers or an equivalent cooling tower model.

Consistent with the recent approach to permitting data centers in Quincy—in which the worst-case emissions are evaluated to allow permitting on a cumulative hours basis rather than on a scenario- and load-specific basis—Microsoft is requesting the following Approval Order conditions for the MWH-03/04/05/06 emergency generators:

1. The following runtime limits:
    a. 86 hours per year, per generator for the proposed 3.0-MWe generators.
    b. 86 hours per year, per generator for the proposed generators with a power rating of 1.5 MWe or less.

    c. Compliance with the operating hour limits in Conditions 1.a and 1.b is based on a 3-year rolling average of 12-month runtime totals, averaged over all generators in service.

2. Operation of more than five generators for more than 18 hours per generator in any 24-hour period shall not occur more than three times in any 3 calendar year period.
3. The operation of more than five generators, operating concurrently at any one time, shall not occur on more than 18 calendar days in any 3 calendar year period.
4. The operation of between three and five generators operating concurrently at any one time shall not occur on more than 24 calendar days in any 3 calendar year period. Operation during this scenario is limited to daytime hours only (7:00 a.m. to 7:00 p.m.).
5. The operation of two generators operating concurrently at any one time shall not occur on more than 144 calendar days in any 3 calendar year period. Operation during this scenario is limited to daytime hours only (7:00 a.m. to 7:00 p.m.).
6. There is no limit on the number of days that operation of one generator at a time can occur, but operation under this scenario is limited to daytime hours only (7:00 a.m. to 7:00 p.m.).
7. Concurrent operation of generators occurs when two or more generators operate at exactly the same moment. Generators are considered to operate concurrently even on occasions when the operational overlap occurs for just a short period of time (e.g., 1 minute or less). Sequential operation of generators is not considered concurrent operation even if multiple generators operate in the same minute, hour, or day.
8. Compliance with annual generator fuel use limitations will be based on a 3-year rolling average of 12-month fuel usage totals, averaged over all generators in service.
9. The Approval Order conditions will not assign specific fuel or runtime limits to each individual runtime activity (e.g., unplanned power outages).

Air pollutant emission rate estimates were calculated based on vendor-provided “not-to-exceed” or “potential site variation” emission factors or emission factors from the EPA’s AP-42 Volume I, Chapter 3.4 (EPA 1995). Microsoft is requesting flexibility to operate the generators at any load; therefore, the emission rates used for this evaluation were based on emission factors for the highest emitting load for each pollutant. In order to account for slightly higher emissions during the first minute of each engine startup, the estimated emission rates of pollutants associated with startup were scaled up using a “black-puff” emission factor.

Based on the results of this evaluation, the recommended Best Available Control Technology for criteria pollutants (BACT) and toxic air pollutants (tBACT) is emission limitations consistent with the EPA’s Tier 2 emission standards, which is achieved with combustion controls and the use of ultra-low sulfur diesel fuel. The basis for this recommendation is that the cost of EPA Tier 4-compliant emission controls is disproportionate to the benefit (i.e., emission reduction) achieved. Subject to Ecology’s review and approval, the evaluations presented in this NOC application support the proposal of the following emission limitations as BACT for the emergency generators to be installed at the proposed MWH-03/04/05/06 data center expansion:

Best Available Control Technology Proposal

Pollutant(s)	BACT and tBACT Proposal
Particulate matter (PM), carbon monoxide (CO), volatile organic compounds (VOC), and nitrogen oxides (NO_x)	Use of EPA Tier 2-certified engines when installed and operated as emergency engines, as defined by 40 CFR 60.4219. Compliance with the operation and maintenance restrictions of 40 CFR Part 60, Subpart III.
Sulfur dioxide (SO_2)	Use of ultra-low sulfur diesel fuel containing no more than 15 parts per million (ppm) by weight of sulfur.
Toxic air pollutants, including CO, acrolein, acetaldehyde, benzene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(a)anthracene, chrysene, indeno(1,2,3-cd)pyrene, dibenz(a,h)anthracene, naphthalene, propylene, 1,3-butadiene, diesel engine exhaust particulate matter (DEEP), formaldehyde, xylenes, nitrogen dioxide (NO_2) and SO_2.	Compliance with the proposed BACT requirements for PM, CO, VOCs, NO_x, and SO_2.

Note, while the recommendation for the BACT and tBACT emission limitations is consistency with the EPA's Tier 2 emission standards, Microsoft will voluntarily equip the generators with a selective catalytic reduction (SCR) and catalyzed diesel particulate filter (DPF) controls to meet EPA Tier 4 emission standards.

Air dispersion modeling was conducted for criteria air pollutants and toxic air pollutants (TAPs). The results of modeling demonstrate that ambient criteria pollutant concentrations that result from operations at MWH-03/04/05/06, and other local and regional background sources, are below the National Ambient Air Quality Standards (NAAQS). Additionally, the results of modeling demonstrate that ambient TAP concentrations that result from operations at MWH-03/04/05/06 are below Washington acceptable source impact levels (ASILs), with the exception of NO_2 and DEEP. Because modeled NO_2 and DEEP concentrations exceed ASILs, a second-tier health impact assessment has been prepared and is being submitted to Ecology under separate cover.

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2.0 INTRODUCTION

Landau Associates, Inc. (LAI) prepared this document on behalf of Microsoft to support the submittal of a Notice of Construction (NOC) application for installation and operation of new emergency generators and evaporative coolers, under air quality regulations promulgated by the Washington State Department of Ecology (Ecology). The proposed Microsoft MWH-03/04/05/06 data center expansion will be located within the existing MWH data center complex on Grant County Parcel No. 313769000, at 1515 NW Port Industrial Parkway, in Quincy, Washington. The legal description of the property is as follows: PARCEL 'C' OXFORD SP 28-8.

The project will include the construction of multiple computer server buildings and the installation of 72 emergency generators (68 generators for server building backup and 4 house generators serving the office and support areas of MWH-03/04/05/06) and 136 evaporative coolers.

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3.0 PROJECT DESCRIPTION

(Section III of NOC application form)

3.1 Facility Description

Microsoft's existing MWH data center (MWH-01/02) includes eight server buildings and additional ancillary buildings. The proposed expansion (MWH-03/04/05/06) would include multiple new buildings on the site, which is located at 1515 NW Port Industrial Parkway, north of F Street SW and west of Road R NW, approximately ¾ mile southwest of the existing Dell Western Technology Center. Vicinity maps are provided on Figures 1 and 3. The site is accessible by NW Port Industrial Parkway, from Road R NW to the east of the site.

A site map for the proposed project is provided on Figure 2.

3.1.1 Diesel-Powered Emergency Generators

This section describes emissions from the exhaust stacks of the diesel-fired engines that are included with each emergency generator. The emergency generator includes a diesel-powered engine that drives an alternator section to produce electricity. The alternator section does not emit any air pollutants, so the overall emissions from a diesel generator are produced only from the diesel engine. State and federal air quality regulations apply only to the emissions from the diesel engines. The terms "generator" and "engine" are used interchangeably in this report.

Each generator will be operated only as an emergency generator, with generator usage and runtime hours limited to those for "emergency generators" by the federal New Source Performance Standard (NSPS) Subpart IIII. NSPS Subpart IIII requires that emergency engines satisfy EPA Tier 2 emission standards for emergency engines as defined by the federal regulations (40 CFR Part 89). Microsoft will use Tier 2-certified generators and will voluntarily equip them with a catalyzed diesel particulate filter (DPF) and urea-based selective catalytic reduction (SCR) to meet the more restrictive EPA Tier 4 emission standards. Also, all MWH emergency generators will use ultra-low sulfur diesel fuel (15 ppm sulfur content).

Each of the emergency generators will be housed within enclosures at the locations shown on Figure 2. Specifications and manufacturer-provided emissions data for the proposed Cummins or CAT 3.0-MWe and 1.5-MWe diesel generators are provided in Appendix A. The equipment evaluated for this NOC application consists of four (4) Cummins Model 1500DQGAF or CAT Model 3512C generators, and 68 Cummins Model C3000 D6e or CAT Model C175 generators. If model numbers change in future years during the planned phased construction, specification sheets for the updated generator or engine models will be provided to Ecology. The generators have the following specifications:

- Four (4) 1.5-MWe generators with a combined capacity of 6.0 MWe. The engines will have a displacement of 50.2-liters over 16 cylinders, or 3.1375 liters per cylinder.

- Sixty-eight (68) 3.0-MWe generators with a combined capacity of 204 MWe. The engines will have a displacement of 95.3-liters over 16 cylinders, or 5.9625 liters per cylinder.
- All generators will be Tier 2-certified and will be equipped with a catalyzed diesel particulate filter (DPF) and urea-based selective catalytic reduction (SCR) to meet EPA Tier 4 emission standards.

Microsoft will not install any other diesel engines for use as fire pumps or for building safety generators.

3.1.2 Evaporative Cooling Units

Evaporative fluid coolers or equivalent cooling towers will reject heat generated by the computer equipment. The evaporative fluid coolers will conservatively be assumed to operate continuously throughout the year at their rated capacity. The equipment evaluated for this NOC application consists of BAC Model HXV-1012C-24T-L-2 or an equivalent cooling tower model. The coolers will be operated using drift eliminators certified to reduce the drift droplet rate to at most 0.0005 percent of the recirculation water flow rate.

3.2 Generator Runtime Scenarios

The emission estimates and ambient impact modeling presented in this NOC application are based on emissions at “full-variable load,” which corresponds to the characteristic worst-case emission load of each pollutant. Emission estimates are discussed in more detail in Section 4.0.

On an annual basis, Microsoft requests that compliance with per-generator runtime limits be demonstrated by summing total actual operating hours for all generators in service and comparing that to the total number of permitted hours for all generators in service. Additionally, Microsoft is requesting that compliance with the annual fuel usage and operating hour limitations be averaged over a 3-year period using monthly rolling totals. For example, total fuel and operating hours will be summed for the 3-year period and an annual average for that period will be calculated and compared to the annual fuel and hour limits. To demonstrate that these requests will result in facility operations and air pollutant emissions that are below regulatory thresholds, this evaluation proposes the following annual runtime limits for MWH-03 to 06 engines:

- An **annual runtime limit** of 86 hours per year, per generator.
- A **“theoretical maximum year”** addresses the worst-case consideration that, for fuel usage and hour limitations to be averaged over a 3-year period, there is potential for emitting the 3-year maximum entirely within a single year, or 258 hours per generator. This unlikely but possible event is considered the ultra-worst case scenario for project-related emissions from the emergency generators and was used for demonstration of compliance with the annually averaged NAAQS and Washington State TAP standards with an annual averaging period.

Generator operating scenarios for MWH-03/04/05/06 are as follows:

- **Non-emergency monthly operation**: Routine operation and maintenance on the emergency generators will be conducted on a monthly basis. This runtime activity will be conducted on one or more emergency generators at a time for up to 20 minutes per generator, per month. However, on rare occasions when a generator requires diagnosis and repair, it may be necessary to operate it longer than 20 minutes per month.
- **Non-emergency semiannual operation**: Additional routine operation and maintenance on the emergency generators will be conducted two times each year. This runtime activity will be conducted on one or more emergency generators at a time for up to 3 hours per generator, twice per year.
- **Non-emergency triennial operation**: Two electrical bypass events will occur every 3 years and will involve five or fewer generators operating concurrently under full-variable load for up to 2 hours.
- **Unplanned power outage**: During a power outage at the site, all installed generators will activate in order to supplement power to the server system and the administrative offices. At full buildout, all 72 generators will operate concurrently under full-variable load.
- **Generator startup and commissioning**: After a new generator is installed, that generator will require commissioning, which includes up to 50 hours of operation under a range of loads, averaged over all project engines commissioned in that year. During commissioning, up to two generators will operate at a time for up to 40 hours per generator, followed by a site integration test in which all generators associated with one cell (up to four) will operate concurrently for up to 10 hours.
- **Stack testing**: It is anticipated that Ecology will require exhaust stack emission testing of a single generator of each make/model and size once every 5 years in order to demonstrate continued compliance with air quality standards. It is assumed that each stack test can take up to 6 hours. The worst-case scenario would be if the stack test failed, requiring a second, follow-up test in the same year, in which case two additional generators would need to be tested for up to 6 hours each. The worst-case runtime that could occur in a single year from stack testing would be operation of three 3.0-MWe generators and three 1.5-MWe generators, one at a time, for 6 hours each.

The evaluation documented in this NOC application demonstrates that the above-described operating scenarios will result in facility operations and air pollutant impacts that are in compliance with all federal and state laws and regulations. In summary, we request the following Approval Order conditions to allow for minimum operational needs:

1. The following runtime limits:
    a. 86 hours per year, per generator for the proposed 3.0-MWe generators.
    b. 86 hours per year, per generator for the proposed generators with a power rating of 1.5 MWe or less.
    c. Compliance with the operating hour limits in Conditions 1.a and 1.b is based on a 3-year rolling average of 12-month runtime totals, averaged over all generators in service.

2. Operation of more than five generators for more than 18 hours per generator in any 24-hour period shall not occur more than three times in any 3 calendar year period.
3. The operation of more than five generators, operating concurrently at any one time, shall not occur on more than 18 calendar days in any 3 calendar year period.
4. The operation of between three and five generators operating concurrently at any one time shall not occur on more than 24 calendar days in any 3 calendar year period. Operation during this scenario is limited to daytime hours only (7:00 a.m. to 7:00 p.m.).
5. The operation of two generators operating concurrently at any one time shall not occur on more than 144 calendar days in any 3 calendar year period. Operation during this scenario is limited to daytime hours only (7:00 a.m. to 7:00 p.m.).
6. There is no limit on the number of days that operation of one generator at a time can occur, but operation under this scenario is limited to daytime hours only (7:00 a.m. to 7:00 p.m.).
7. Concurrent operation of generators occurs when two or more generators operate at exactly the same moment. Generators are considered to operate concurrently even on occasions when the operational overlap occurs for just a short period of time (e.g., 1 minute or less). Sequential operation of generators is not considered concurrent operation even if multiple generators operate in the same minute, hour, or day.
8. Compliance with annual generator fuel use limitations will be based on a 3-year rolling average of 12-month fuel usage totals, averaged over all generators in service.
9. The Approval Order conditions will not assign specific fuel or runtime limits to each individual runtime activity (e.g., unplanned power outages).

The evaluation in this NOC application and the evaluation that will be presented in the second-tier health impact assessment have been completed to allow for Approval Order conditions that do not assign specific fuel or runtime limits to each individual runtime activity (e.g., unplanned power outages).

3.3 Compliance with State and Federal Regulations

The MWH-03/04/05/06 data center expansion will comply with the following applicable air regulations, in accordance with the federal and state Clean Air Acts. These requirements are specified in:

- Chapter 70.94 Revised Code of Washington (RCW) (Washington Clean Air Act)
- Chapter 173-400 Washington Administrative Code (WAC) (General Regulations for Air Pollution Sources)
- Chapter 173-460 WAC (Controls for New Sources of Toxic Air Pollutants)
- 40 Code of Federal Regulations (CFR) Part 60 Subpart A (General Provisions)
- 40 CFR Part 60 Subpart IIII (Stationary Compression Ignition Internal Combustion Engines)
- 40 CFR Part 63 Subpart ZZZZ (National Emission Standards for Hazardous Air Pollutants [NESHAP] for Reciprocating Internal Combustion Engines [RICEs]).

Specifically, the project includes sources of air contaminants and will follow applicable air contaminant regulations as listed in:

- RCW 70.94.152
- WAC 173-400-113
- WAC 173-460-040.

The project is located in an attainment area for all Clean Air Act criteria pollutants. Facilities that produce more than 100 tons per year of any criteria pollutant are considered major sources under the federal regulation 40 CFR Part 70 and the state regulation WAC 173-410 et seq. Since the facility-wide potential-to-emit for NO_x will be more than 100 tons per year (see Table 5), the permittee will submit a Title V major source application within 12 months of issuance of the Approval Order. Potential-to-emit estimates provided in Section 4.0 demonstrate that the facility will emit:

- Less than 250 tons per year of NO_x
- Less than 100 tons per year of any criteria pollutant (PM, CO, NO_2, SO_2, and VOCs)
- Less than 10 tons per year of any EPA hazardous air pollutant (HAP)
- Less than 25 tons per year of total HAPs.

As a result, a Prevention of Significant Deterioration New Source Review pre-construction permit is not required. A Title V operating permit is required.

All of the generators will be operated in a manner that satisfies the definition of “emergency engines” according to the federal regulations NSPS Subpart IIII and NESHAP Subpart ZZZZ. Therefore, NSPS Subpart IIII requires that each generator shall be manufactured and certified to meet EPA Tier 2 emission limits. The applicable sections of NESHAP Subpart ZZZZ indicate that compliance with the NESHAP for emergency engines requires each generator to meet the EPA Tier 2 emission standards, and each generator must be operated and maintained in accordance with the requirements of NSPS Subpart IIII.

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4.0 AIR POLLUTANT EMISSION ESTIMATES

(Section VIII of NOC application form)

Air pollutant emission rates were calculated for the generators and coolers per the requirements of WAC 173-400-103 and WAC 173-460-050. Emission rates were calculated for criteria pollutants and TAPs based on peak hourly (worst-case maximum) and long-term (annual maximum) operating scenarios. For comparison of emission rate standards of short-term durations, such as 1-hour, 8-hour, or 24-hour averaging periods, the peak hourly rate was multiplied by the corresponding number of operating hours (i.e., maximum duration of a particular runtime scenario).

All generators will be Tier 2-certified and will be equipped with a catalyzed diesel particulate filter (DPF) and urea-based selective catalytic reduction (SCR) to meet EPA Tier 4 emission standards. The emergency generator manufacturer will be Cummins or Caterpillar. Manufacturer-reported not-to-exceed generator emission factors for CO, NO_x, PM, and ammonia (produced from the incomplete reaction of NO_x and urea by the SCR) were used to estimate emission rates. Additionally, the manufacturer-provided hydrocarbon emission rate was assumed to represent the emission rate for total VOC emissions.

4.1 Derivation of Emission Factors for Generators, Project-Only Emission Rates, and Fuel Usage

During all operations, the generators will activate at less than or equal to 100 percent load (full-variable load). Microsoft is requesting the flexibility to operate the emergency generators at any load, which will be set based on electrical demand. Considering that not all pollutant emission rates are maximum under the same operating load and because Microsoft is requesting the flexibility to operate at any load, the pollutant-specific maximum emission rate, under any load less than or equal to 100 percent, was assumed for calculating the worst-case emission rates. These vendor-reported worst-case emission rates are provided in Table 1 and were used in all compliance demonstrations.

Emissions of DEEP are conservatively assumed to be equal to the manufacturers' not-to-exceed emissions value for PM emission rates. The emission rates for PM with aerodynamic diameters of less than or equal to 10 microns (PM_{10}) and less than or equal to 2.5 microns ($PM_{2.5}$) include an estimate for "front-half" (filterable PM) and "back-half" (condensable PM) emissions for all modeling scenarios that demonstrate compliance with the NAAQS. The filterable PM estimate is equal to the manufacturers' not-to-exceed emission factor for PM. An estimate of condensable PM was developed based on a previous source test report for a similar size engine in which filterable PM was measured using EPA Method 5 and condensable PM was measured using EPA Method 202 (AMTEST 2012). The worst-case ratio of total PM to filterable PM (i.e., Total PM:Filterable PM) is multiplied by the manufacturers' not-to-exceed emissions value for PM emissions for this project to "scale up" the filterable PM estimate to an estimate of total PM.

All remaining pollutant emission rates, except for SO_2 and ammonia, were calculated using emission factors from the EPA's AP-42, Volume I, Chapter 3.4, which provides emission factors for HAPs from large internal combustion diesel engines (EPA 1995). These factors are based on fuel consumption. However, as listed in the generator specification sheets (provided in Appendix A), fuel consumption is highest at 100 percent load. Therefore, the maximum fuel consumption for full-variable load operations of all 72 generators would be 1,283,946 gallons of diesel fuel per year, averaged over 3 years. Table 2 summarizes the maximum fuel-based project-only emission estimates and fuel consumption rates.

The emission rate for SO_2 was calculated using a mass-balance approach based on the maximum sulfur content in the fuel (i.e., 15 ppm) and the maximum expected fuel usage. The emission rate for ammonia was calculated based on the manufacturer-reported not-to-exceed value in ppm, converted to pounds per hour using generator outlet air flow at 100 percent load.

4.2 Generator Startup Emissions

In order to account for slightly higher emissions during the first minute of each engine startup, the estimated emission rates of pollutants associated with startup (PM, CO, total VOCs, and volatile TAPs) were scaled up using a "black-puff" emission factor. These "black-puff" factors are based on short-term concentration trends for VOC and CO emissions observed immediately after startup of a large diesel backup generator. These observations were documented by the California Energy Commission's report Air Quality Implications of Backup Generators in California (Lents et al. 2005). Our derivation of startup emission factors is provided in Table 3. Additional details are provided in Appendix B.

The resultant project-only and facility-wide potentials-to-emit are provided in Tables 4 and 5.

4.3 Evaporative Fluid Cooler Emissions

The evaporative fluid coolers will be operated using drift eliminators certified to reduce the drift droplet rate to at most 0.0005 percent of the recirculation water flow rate. It will be assumed that the non-volatile chemical concentrations in the drift droplets will be identical to the non-volatile aqueous concentrations in the recirculation water, and the drift droplets will quickly evaporate to form solid drift particles containing those non-volatile compounds.

The size distribution of the liquid droplets for mechanical draft evaporative fluid coolers with a drift performance of 0.0005 percent will be based on data from SPX/Marley, a major manufacturer of evaporative fluid coolers. The size distribution of the evaporated solid particles will be calculated based on the liquid droplet size distribution and the assumption that the total dissolved solids (TDS) concentration inside the liquid droplets will be the same as the TDS concentration within the cooler recirculation water.

It is assumed that the water supply will be a combination of industrial reuse water from the City of Quincy’s industrial wastewater treatment plant and potable water from the City of Quincy’s municipal water supply treated with reverse osmosis. Because the specific mixture of industrial reuse water and potable water may vary depending on water availability, the worst-case concentration of chemicals from either water source will be used to evaluate the worst-case emissions from the evaporative fluid coolers. Cooler emission rates are provided in Table 1. The resultant project-only and facility-wide potentials-to-emit are provided in Tables 4, 5, and 6.

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5.0 EMISSION STANDARD COMPLIANCE

(Section VII of NOC application form)

The emergency diesel generators are subject to the emission control requirements under NSPS Subpart IIII, "Standards of Performance for Stationary Compression Ignition Internal Combustion Engines." The runtime limits requested for the generators satisfy the definition of "emergency generator" as specified by NSPS Subpart IIII. Based on that definition of "emergency generators," NSPS Subpart IIII indicates that the new generators are subject to EPA Tier 2 emission limits for emergency engines as specified by 40 CFR Part 89.

Microsoft will conduct all notifications, generator maintenance, recordkeeping, and reporting as required by NSPS Subpart IIII.

The generators will also be subject to the NESHAP requirements under Subpart ZZZZ, "National Emission Standards for Hazardous Air Pollutants for Reciprocating Internal Combustion Engines (RICEs)." NESHAP Section 63.6590(c)(1) specifies requirements for emergency RICEs that are also subject to NSPS Subpart IIII. The Microsoft facility will be an "area source" of federal HAPs; accordingly, NESHAP Section 63.6590(c)(1) indicates that the emergency generators will not be required to comply with any portions of Subpart ZZZZ as long as the generators comply with EPA Tier 2 emission standards and Microsoft operates the generators in compliance with NSPS Subpart IIII.

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6.0 BEST AVAILABLE CONTROL TECHNOLOGY ANALYSIS

(Section VIII of NOC application form)

This section describes the process of evaluating Best Available Control Technology (BACT) for emergency generators and evaporative fluid coolers or cooling towers.

6.1 General Approach for Best Available Control Technology Assessment

BACT is an emission limitation based on the maximum degree of reduction that can be feasibly achieved for each air pollutant emitted from any new or modified stationary source. Ecology determines BACT using a "top-down" approach as described in the EPA's draft New Source Review Workshop Manual: Prevention of Significant Deterioration and Non-Attainment Area Permitting (EPA 1990). The following five steps are involved in the top-down process:

1. The first step in the top-down analysis is to identify all available control technologies that can be practicably applied for each emission unit.
2. The second step is to determine the technical feasibility of potential control options and to eliminate options that are demonstrated to be technically infeasible.
3. The third step is to rank all remaining options based on control effectiveness, with the most effective control alternative at the top.
4. The fourth step is to evaluate the remaining control alternatives. If the top-ranked control alternative is considered unacceptable based on disproportionate economic, environmental, and/or energy impacts, it is discarded. Justifications for discarding top-ranked control options must be approved by Ecology.
5. The fifth and final step is to choose the top-ranked alternative from the list of control options remaining after applying Steps 1 through 4. This option becomes the BACT, including the resulting emission rate.

Control options for potential reductions in criteria pollutant and, as practical, TAP emissions were identified for each source. In Washington State, the term BACT refers to the control technology applied to achieve reductions in criteria pollutant emission rates. The term "tBACT" refers to BACT applied to achieve reductions in TAP emission rates. Technologies were identified by considering Ecology's previous environmental permit determinations for diesel generators in Washington State. Available controls that are judged to be technically feasible are further evaluated taking into account energy, environmental, and economic impacts and other costs.

The following sections summarize the findings and recommended BACT determination. Detailed cost estimates and assumptions that support this BACT assessment are provided in Appendix C. Additionally, electronic calculation spreadsheets in Excel® format are provided in Appendix E.

6.2 Steps 1, 2, and 3: Identify Feasible Control Technologies for Diesel Generators

Based on Ecology's prior determinations in permitting diesel generators at computer data centers, the following technologies were considered to be commercially available and technically feasible for use at MWH-03/04/05/06:

- **Tier 4 integrated control package**. This control option consists of an integrated diesel particulate filter (DPF), diesel oxidation catalyst (DOC), and urea-based selective catalytic reduction (SCR). This system is highly efficient for control of NO_x (90 percent), PM_{10}/$PM_{2.5}$/DEEP (85 percent of "front-half"), CO (80 percent), VOCs and gaseous TAPs (80 percent), and meets Tier 4 emission standards as defined by the federal regulations (40 CFR Part 89). Note, when engine or emission control system manufacturers are producing Tier 4-compliant engines, they will typically weld the DOC to the DPF and call it a "catalyzed DPF." While the Tier 4 integrated control package is technically feasible, it does have some operational constraints for emergency generators. For example, SCRs typically do not provide NO_x removal when the engine exhaust temperature is below the target temperature of 575°F.
- **Urea-based SCR**. This control option is highly efficient for control of NO_x (90 percent) and NO_2. While the SCR is technically feasible, it does have some operational constraints for emergency generators as described above.
- **Catalyzed DPF**. This control option is highly efficient for control of PM_{10}/$PM_{2.5}$/DEEP (90 percent of "front-half"), CO (80 percent), VOCs and gaseous TAPs (70 percent). Note, catalyzed DPFs do not remove condensable ("back-half") particulates. Additionally, operation at low loads and exhaust temperatures does not allow for necessary routine regeneration of the DPF; therefore, additional operation at high loads/temperatures can be required.
- **DOC**. This control option is highly efficient for removal of CO (80 percent), VOCs and gaseous TAPs (70 percent). It is marginally effective for removal of PM_{10}/$PM_{2.5}$/DEEP (15 to 25 percent depending on the load). This analysis conservatively assumed 25 percent removal of PM_{10}/$PM_{2.5}$/DEEP ("front-half") for the DOC system.
- **Tier 2-certified**. Tier 2-certified engines rely on combustion controls and the use of ultra-low sulfur diesel fuel (15 ppm sulfur content) to comply with EPA Tier 2 emission standards.

In previous permit applications for data centers, three-way catalysts have also been considered to be technologically feasible for use on diesel generators. However, recent compliance stack tests required at another data center in Grant County, Washington indicated that three-way catalysts were ineffective for removal of NO_x, and that the device actually increased the emission rate for NO_2. Those test results support the conclusion that commercially available three-way catalysts are not technically feasible for emergency generator use; therefore, they were dropped from consideration for this analysis.

6.3 Step 4: Evaluate Technically Feasible Technologies for Diesel Generators

All of the technologies listed above are assumed to be commercially available, reasonably reliable, and safe for use on backup diesel generators. One potential concern with the use of DOCs by themselves is their tendency to increase the emission rate for NO_2. Regardless of that concern, use of DOCs by themselves has not been eliminated from consideration based solely on that tendency since they have been demonstrated to provide effective control for CO and VOCs.

6.3.1 Methodology for Cost-Effectiveness Analyses for Diesel Generators

Detailed calculation spreadsheets for the BACT cost-effectiveness analyses are provided in Appendix C. For the individual pollutants, cost effectiveness was calculated by dividing the total life-cycle annual cost (dollars per year) by the tons of pollutant removed by the control device. The derived cost effectiveness was then compared to the following cost-effectiveness criteria values, which were developed based on Ecology's methodology for previous BACT evaluations for diesel generators in Grant County or were calculated by LAI using the Hanford[1] methodology as recommended by Ecology:

- Criteria air pollutants: Range between $5,000 and $12,000 per ton of removed pollutants (Ecology 2016; Appendix C).
- Toxic air pollutants: Range between $730 and $79,000 per ton of TAP removed based on the Hanford methodology (Haass et al. 2010; Appendix C).

The cost-effectiveness analysis for this NOC application was conducted using generally accepted assumptions that provide a reasonable but conservatively low estimate of the capital and operating costs, and a reasonable but conservatively high estimate of the pollutant removal efficiencies.

The capital cost, operating cost, life-cycle annualized cost, and cost effectiveness (dollars per ton of destroyed pollutant) were calculated using the methodology specified in the EPA Air Pollution Control Cost Manual (EPA 2002).

Cost estimates and pollutant destruction and removal efficiencies were obtained from Cummins Power Systems for each evaluated emission control option (Pafford 2016). Indirect cost factors to derive a conservatively low total installation cost were obtained from the EPA Air Pollution Control Cost Manual (EPA 2002). The annual capital recovery costs were calculated assuming a 25-year system lifetime and a 4 percent annual discount rate. Conservatively low estimates of annual operation and maintenance costs for each control option were derived by assuming that there would be no operating cost for electricity or equipment maintenance. To provide a conservatively low estimate of

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[1] The Hanford method for evaluating the cost effectiveness of control technologies is documented in a report titled, Evaluation of Best Available Control Technology for Toxics (tBACT), Double Shell Tank Farms Primary Ventilation Systems Supporting Waste Transfer Operations (Haass et al. 2010; on DVD in Appendix E).

the annual operating cost, the operational unit costs for each emission control option were set to zero.

6.4 Best Available Control Technology Cost Effectiveness

This section describes the evaluation conducted to determine the cost effectiveness of controlling criteria pollutant emissions using the technologies identified in Section 6.2. As discussed below, the costs of controlling criteria pollutant emissions using the Tier 4 integrated control package, catalyzed DPF, SCR, and DOC are disproportionate to the benefit received.

6.4.1 Cost Effectiveness Analysis for Tier 4 Integrated Control Package

The cost effectiveness (as dollars per ton of pollutant removed) of installing the Tier 4 integrated control package for control of NO_x ($15,353), $PM_{10}/PM_{2.5}$ ($1.03 million), CO ($140,412), VOCs ($749,247), and combined criteria air pollutants ($13,413) is provided in Table 7. As shown in Table 7, the forecast cost effectiveness for control of individual and combined pollutants exceeds Ecology's thresholds for cost effectiveness; therefore, subject to Ecology's review and concurrence, the Tier 4 integrated control package is cost-prohibitive for the purpose of reducing criteria air pollutant emissions.

6.4.2 Cost Effectiveness Analysis for SCR

The cost effectiveness of installing an SCR for control of NO_x is $12,312 per ton (Table 7). As shown in Table 7, the forecast cost effectiveness for control of NO_x exceeds Ecology's cost-effectiveness threshold of $12,000 per ton of NO_x; therefore, subject to Ecology's review and concurrence, an SCR is cost-prohibitive for the purpose of controlling NO_x emissions.

6.4.3 Cost Effectiveness Analysis for Catalyzed DPF

The cost effectiveness of installing a catalyzed DPF for control of $PM_{10}/PM_{2.5}$ ($357,970 per ton), CO ($51,427 per ton), VOCs ($313,619 per ton), and combined pollutants ($39,328 per ton) is provided in Table 7. As shown in Table 7, the forecast cost effectiveness for control of individual and combined pollutants exceeds Ecology's thresholds for cost effectiveness; therefore, subject to Ecology's review and concurrence, the catalyzed DPF is cost-prohibitive for the purpose of controlling criteria air pollutant emissions.

6.4.4 Cost Effectiveness Analysis for DOC

The cost effectiveness of installing a DOC for control of $PM_{10}/PM_{2.5}$ ($620,191 per ton), CO ($24,749 per ton), VOCs ($150,931 per ton), and combined pollutants ($20,558 per ton) is provided in Table 7. As shown in Table 7, the forecast cost effectiveness for control of individual and combined pollutants exceeds Ecology's thresholds for cost effectiveness. Therefore, subject to Ecology's review and concurrence, the DOC is cost-prohibitive for the purpose of reducing individual criteria air pollutant emissions.

6.5 Toxics Best Available Control Technology Cost Effectiveness

This section describes the evaluation conducted to determine the cost effectiveness of controlling TAP emissions using the technologies identified in Section 6.2. As discussed below, the costs of controlling TAP emissions using the Tier 4 integrated control package, catalyzed DPF, SCR, and DOC are disproportionate to the benefit received. Subject to Ecology's review and concurrence, the analysis presented below supports the conclusion that Tier 4 integrated controls are cost-prohibitive for designation as BACT on the basis of control efficiencies for TAPs.

TAPs emitted by Tier 2 emergency generators at rates exceeding the *de minimis* thresholds consist of: DEEP, CO, NO_2, benzene, 1,3-butadiene, acetaldehyde, acrolein, naphthalene, formaldehyde, benzo(a)pyrene, benzo(a)anthracene, chrysene, benzo(k)fluoranthene, benzo(b)fluoranthene, dibenz(a,h)anthracene, indeno(1,2,3-cd)pyrene, xylenes, SO_2, and propylene.

The air pollutant emission control options described in Section 6.2 would be effective at various ranges of efficiencies for control of TAPs. A cost-effectiveness summary for each TAP control option is provided in Appendix C. Table 8 summarizes the calculated TAP cost effectiveness for each control option in comparison to the presumed acceptable thresholds derived using the Hanford methodology. The cost-effectiveness calculations are provided in Excel format in Appendix E.

Emission control technologies and the cost-effectiveness evaluation for control of PM_{10}/$PM_{2.5}$ is the same for control of DEEP, because catalyzed DPFs remove only filterable ("front-half") particulates. The derived cost threshold (i.e., the Hanford "ceiling cost"—or the cost threshold above which controls are considered cost-prohibitive) for removal of DEEP, based on the Hanford method, is $72,544 per ton. As shown in Table 8, the forecast cost effectiveness to control DEEP using a Tier 4 integrated control package ($1.03 million per ton), catalyzed DPF ($357,970 per ton), or a DOC ($620,191 per ton) exceeds Ecology's thresholds for cost effectiveness. Therefore, subject to Ecology's review and concurrence, the control options identified are cost-prohibitive for the purpose of controlling DEEP emissions.

A cost-effectiveness evaluation was completed for CO as a criteria pollutant (see Section 6.4 and Table 7). CO is also evaluated as a TAP in this section. The derived cost threshold for removal of CO, based on the Hanford method, is $731 per ton. As shown in Table 8, the forecast cost effectiveness to control CO using a Tier 4 integrated control package ($140,412 per ton), catalyzed DPF ($51,427 per ton), and DOC ($24,749 per ton) exceeds Ecology's thresholds for cost effectiveness. Therefore, subject to Ecology's review and concurrence, the control options identified are cost-prohibitive for the purpose of controlling CO emissions.

NO_2 is a minor component of NO_x; the in-stack ratio of NO_2 to NO_x is assumed to be 10 percent. Therefore, control technologies evaluated for NO_x (Section 6.4) are applicable to NO_2 and costs are proportionately applicable. The derived cost threshold for removal of NO_2, based on the Hanford method, is $18,472 per ton. As shown in Table 8, the forecast cost effectiveness to control NO_2 using a

Tier 4 integrated control package ($144,319 per ton) and SCR ($115,732 per ton) exceeds Ecology's thresholds for cost effectiveness. Therefore, subject to Ecology's review and concurrence, the control options identified are cost-prohibitive for the purpose of controlling NO_2 emissions.

Emissions of benzene, 1,3-butadiene, acetaldehyde, acrolein, naphthalene, formaldehyde, benzo(a)pyrene, benzo(a)anthracene, chrysene, benzo(k)fluoranthene, benzo(b)fluoranthene, dibenz(a,h)anthracene, indeno(1,2,3-cd)pyrene, xylenes, and propylene are treatable using the same control options applicable to control VOCs. The derived cost thresholds for removal of these VOCs, based on the Hanford method, are:

- $59,359 per ton of removed acrolein
- $61,882 per ton of removed benzene
- $69,951 per ton of removed 1,3-butadiene
- $51,063 per ton of removed acetaldehyde
- $67,964 per ton of removed benzo(a)anthracene
- $78,464 per ton of removed benzo(a)pyrene
- $67,964 per ton of removed benzo(b)fluoranthene
- $67,964 per ton of removed benzo(k)fluoranthene
- $57,464 per ton of removed chrysene
- $78,863 per ton of removed dibenz(a,h)anthracene
- $67,964 per ton of removed indeno(1,2,3-cd)pyrene
- $54,691 per ton of removed formaldehyde
- $62,612 per ton of removed naphthalene
- $10,020 per ton of removed propylene
- $21,913 per ton of removed xylenes.

As shown in Table 8, the forecast costs to control these individual VOCs each exceed Ecology's thresholds for cost effectiveness for all applicable control options; therefore, subject to Ecology's review and concurrence, the control options identified are cost-prohibitive for the purpose of controlling individual VOC emissions.

Table 8 also provides the combined cost effectiveness for controlling all TAPs for each emission control option. As shown in Table 8, the combined cost effectiveness for TAPs exceeds Ecology's threshold for cost effectiveness for each control option.

6.6 Step 5: Recommended Best Available Control Technology for Diesel Generators

Although all of the add-on control technology options associated with Tier 4 diesel engine controls (Tier 4 integrated control package, SCR, catalyzed DPF, or DOC) are technically feasible, each of them failed the BACT and tBACT cost-effectiveness evaluations. Therefore, none of the add-on controls are BACT or tBACT because the costs of emission control are disproportionate to the benefit received. Instead, emission limitations consistent with the EPA's Tier 2 emission standards—achieved with combustion controls and the use of ultra-low sulfur diesel fuel—are the recommended BACT and tBACT determination. The proposed BACT recommendation is based on compliance with the EPA's Tier 2 emission standards for a non-road diesel engine: 0.20 grams per mechanical kilowatt-hour (g/kWm-hr) for PM, 3.5 g/kWm-hr for CO, and 6.4 g/kWm-hr for combined NO_x plus VOCs. However, please note that while the recommendation for the BACT and tBACT emission limitations is consistency with the EPA's Tier 2 emission standards, Microsoft will voluntarily equip the generators with a selective catalytic reduction (SCR) and catalyzed diesel particulate filter (DPF) controls to meet EPA Tier 4 emission standards.

6.7 Best Available Control Technology for Cooler Drift

Evaporative fluid coolers or cooling towers are used to cool non-contact process water to a temperature that is useful for the process. The direct contact between the cooling water and air results in entrainment of some of the liquid water into the air. The resulting drift droplets contain total dissolved solids (TDS), which form solid particles after the drift droplets evaporate downwind of the towers or evaporative fluid coolers.

Evaporative fluid coolers or cooling towers will be equipped with high-efficiency drift eliminators certified to reduce the drift droplet rate to at most 0.0005 percent of the recirculation water flow rate within each cooling unit. EVAPCO and Baltimore Air Coil have stated that this reduction is the greatest reduction in drift emissions the manufacturer is able to certify (Baltimore Air Coil 2017; Shank 2017). Therefore, the high-efficiency drift eliminators (0.0005 percent) are proposed as BACT.

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7.0 AMBIENT AIR QUALITY IMPACT ANALYSIS

(Section IX of NOC application form)

This section discusses the air dispersion modeling results and provides a comparison of the results to the NAAQS and Washington Ambient Air Quality Standards (WAAQS) for criteria pollutants and the Washington State small-quantity emission rates (SQERs) and ASILs for TAPs. Air dispersion modeling input values are provided in Appendix D. Copies of the electronic modeling files and inputs are provided in Appendix E.

As discussed in the following sections, the modeled ambient impacts expected from project emissions are less than the NAAQS and WAAQS, even after summing with modeled local background impacts and regional background concentrations. With the exception of two TAPs (DEEP and NO_2), all predicted ambient TAP impacts are less than the ASILs. Therefore, a second-tier health impact assessment will be conducted for DEEP and NO_2.

7.1 First-Tier Screening of Toxic Air Pollutant Impacts

A first-tier TAP assessment compares the forecast emission rates to the SQERs and compares the maximum ambient impacts to ASILs. Table 6 shows the estimated project emission rates for each TAP expected to be released in the Microsoft emergency generator exhaust, and compares those emission rates to the corresponding SQER. Each SQER is an emission rate threshold, below which Ecology does not require an air quality impact assessment for the corresponding TAP. As shown in Table 6, estimated project-only emissions of DEEP, benzene, CO, NO_2, 1,3-butadiene, formaldehyde, acrolein, dibenz(a,h)anthracene, naphthalene, chromium, and ammonia are greater than their respective SQERs, so an ambient impact analysis was completed for those TAPs.

Ecology requires facilities to conduct a first-tier screening analysis for each TAP whose emissions exceed its SQER by modeling the 1st-highest 1-hour, 1st-highest 24-hour, and annual ambient impacts (depending on the TAP of interest), then comparing the modeled values to the ASILs (WAC 173-460-080).

7.2 Air Dispersion Modeling – Model and Assumptions

Air dispersion modeling was conducted in general accordance with the EPA's Revision to the Guideline on Air Quality Models: Adoption of a Preferred General Purpose (Flat and Complex Terrain) Dispersion Model and Other Revisions; Final Rule (EPA 2005). The AERMOD[2] modeling system was used in accordance with the EPA's Revision to the Guideline on Air Quality Models (EPA 2005) to estimate ambient pollutant concentrations beyond the site property boundary.

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[2] American Meteorological Society (AMS)/US Environmental Protection Agency (EPA) Regulatory Model.

AERMOD was used to calculate maximum ambient impact concentrations of criteria pollutants and TAPs that would be emitted from the project. To do this, AERMOD requires input from several models in order to process meteorological parameters, downwash parameters, and terrain heights. The following sections describe these input models, as provided in guidance documents by the EPA, Electric Power Research Institute, and Lakes Environmental.

Ambient air impacts were modeled for all criteria pollutants and TAPs for which compliance is not demonstrated via emissions threshold screening. The Industrial Source Complex (ISC)-AERMOD View Version 9.5.0 interface provided by Lakes Environmental was used for all air dispersion modeling.

The AERMOD interface provided by Lakes Environmental was used for all MWH-03/04/05/06 ambient air dispersion modeling. This version of the Lakes Environmental software incorporated the most recent version of AERMOD (Version 16216r) at the time the modeling was completed. AERMOD incorporates the data from the pre-processors described below with emission estimates and physical emission point characteristics to model ambient impacts. The model was used to estimate ambient concentrations based on various averaging times (e.g., 1 hour, 24 hours, annual, etc.) to demonstrate compliance with air quality standards for a network of receptors.

The AERMOD model was used to estimate the short-term impacts (i.e., 24-hour average or less) of PM_{10}, $PM_{2.5}$, CO, NO_2, SO_2, ammonia, and acrolein emissions and long-term impacts (i.e., annual average) of DEEP, PM_{10}, $PM_{2.5}$, NO_2, benzene, formaldehyde, dibenz(a,h)anthracene, naphthalene, 1,3-butadiene, and chromium emissions.

Each AERMOD setup was arranged to simulate the generator configuration that corresponds to the modeled operating scenario. The modeling setup for short-term impacts at full-variable load included load-specific stack parameters (i.e., flow rate and exhaust exit temperature), which correspond to the characteristic worst-case emission load of each pollutant. For example, since the worst-case emission rate for CO is at 100 percent load, then the input stack parameters for all CO modeling was set up for the corresponding flow rate and temperature reported for 100 percent load conditions. The stack parameters setup for long-term impacts conservatively used the vendor-reported load-specific exhaust flow rate and temperature that would result in the worst-case dispersion conditions (i.e., the load condition with the lowest reported exhaust temperature and velocity).

7.2.1 Stack Heights and Building Downwash Input Parameter Modeling

Generator stack heights and diameters were modeled as follows:

- Stack height for all generators = 72 feet
- Stack diameter of 1.5-MW generators = 24 inches; 3.0-MW generators = 30 inches
- Stacks will discharge vertically with no obstructions.

Building downwash occurs when the aerodynamic turbulence induced by nearby buildings causes a pollutant emitted from an elevated source to be mixed rapidly toward the ground (downwash), resulting in higher ground-level pollutant concentrations. The software program Building Profile Input Program-Plume Rise Model Enhancements was used to determine if exhaust from emission units would be affected by nearby building structures. In general, these determinations are made if a stack's height is less than the height defined by the EPA's Good Engineering Practice (GEP) stack height.

GEP stack height is defined as the height of the nearby structure(s) measured from the ground-level elevation at the base of the stack plus 1.5 times the lesser dimension, height, or projected width of the nearby structure(s). Microsoft's generator exhaust stacks will be lower than GEP height. Building heights are 24 feet for MWH-03 and 46 feet for MWH-04/05/06. The generator stacks are approximately 20 feet from the data hall buildings.

7.2.2 Receptor Grid Spacing and Terrain Height Input Modeling

To model complex terrain, AERMOD requires information about the surrounding terrain. This information includes a height scale and a base elevation for each receptor. The AMS/EPA Regulatory Model Terrain Pre-processor (AERMAP) was used to obtain a height scale and the base elevation for a receptor, and to develop receptor grids with terrain effects.

A receptor grid was extended from beyond the facility boundary consisting of Cartesian flagpole receptor grids placed at a height of 1.5 meters (m) above ground to approximate the human breathing zone. The grid spacing varied with distance from the facility, as listed below:

- 12.5-m spacing from the property boundary to 150 m from the nearest emission source
- 25-m spacing from 150 m to 400 m
- 50-m spacing from 400 m to 900 m
- 100-m spacing from 900 m to 2,000 m
- 300-m spacing between 2,000 m and 4,500 m
- 600-m spacing beyond 4,500 m.

The project generator stack located closest to the property line is a 3.0-MWe generator, located approximately 117 m from the south property boundary.

AERMAP requires the use of topographic data to estimate surface elevations above mean sea level. Digital topographic data (in the form of Shuttle Radar Topography Mission files) for the analysis region were obtained from the Web GIS website (http://www.webgis.com) and processed for use in AERMOD. The Shuttle Radar Topography Mission data used for this project have a resolution of approximately 30 m (1 arc-second).

AERMAP produces a Receptor Output File (*.rou) containing the calculated terrain elevations and scale height for each receptor. The *.rou file was used as an input runstream file (AERMOD Input File) for the Receptor Pathway in the Terrain Options page of the Control Pathway. AERMAP also produces a Source Output File (*.sou). This file contains the calculated base elevations for all sources.

7.2.3 Meteorological Input Parameter Modeling

The AERMOD Meteorological Pre-Processor (AERMET; Version 16216) is the meteorological pre-processor model that estimates boundary-layer parameters for use in AERMOD. AERMET processes three types of meteorological input data in three stages, and from this process it generates two input files for the AERMOD model. The two AERMOD input files produced by AERMET are: the Surface File with hourly boundary-layer parameter estimates; and the Profile File with multi-level observations of wind speed, wind direction, temperature, and standard deviations of fluctuating wind components. The three types of meteorological data used by AERMET for this project are described below.

- National Weather Service (NWS) hourly surface observations from Grant County International Airport in Moses Lake, Washington located approximately 24 miles from the MWH site. Five years (January 1, 2012 through December 31, 2016) of hourly surface data were processed in AERMET.
- NWS twice-daily upper air soundings from Spokane, Washington. Five years (January 1, 2012 through December 31, 2016) of upper air data were processed in AERMET.
- The site-specific data required for AERMET are Albedo, Bowen ratio, and surface roughness. Albedo is a measure of the solar radiation reflected back from earth into space. The Bowen ratio is an evaporation-related measurement and is defined as the ratio of sensible heat to latent heat. The surface roughness length is the theoretical height above ground where the wind speed becomes zero. The MWH site does not have an instrumentation tower to record these site-specific parameters for use in AERMET; therefore, site-specific data were approximated based on surface data from the meteorological tower at Grant County International Airport. AERSURFACE was used to approximate the Albedo, Bowen ratio, and surface roughness within 12 equal sectors of a circle that has a 1-kilometer radius and is centered on the surface station tower. Looking at each sector individually, AERSURFACE determines the percentage of land-use type within each sector. Land cover data from the US Geological Survey (USGS) National Land Cover Data 1992 archives were used as an input to AERSURFACE (USGS 1992). Default seasonal categories are used in AERSURFACE to represent the four seasonal categories as follows: 1) midsummer with lush vegetation; 2) autumn with unharvested cropland; 3) late autumn after frost and harvest, or winter with no continuous snow; and 4) transitional spring with partial green coverage or short annuals.

7.2.4 Demonstration of Compliance with Standards that are Based on an Annual Averaging Period

Annual emission rates were established based on the annual runtime limit of 86 hours of operation per generator with a total of 19 startup events per generator.

To demonstrate compliance for the “theoretical maximum year” during which Microsoft would operate the emergency generators 3 times the annual allotment (86 hours per generator in a 12-month period), emission rates for input to AERMOD were calculated by multiplying the average annual runtime by 3. The total theoretical maximum year emission rate is divided by the number of hours in a year (8,760 hours) to establish the pounds per hour emission rate input into AERMOD. This unlikely but possible scenario was considered for the following AERMOD compliance demonstrations:

- $PM_{2.5}$ annual average NAAQS
- NO_2 annual average NAAQS
- TAPs with an annual averaging period (e.g., DEEP ASIL).

The ambient NO_2 annual average concentrations were modeled using the Plume Volume Molar Ratio Method (PVMRM) option, which was approved by the EPA for use in this model (McAlpine 2017). This AERMOD option calculates ambient NO_2 concentrations surrounding the site by applying a default NO_2/NO_x equilibrium ratio of 0.90 and a NO_2/NO_x in-stack ratio of 0.1. The estimated ambient ozone concentration was assumed to be 49 parts per billion (WSU; accessed October 30, 2017).

The results of the criteria pollutant modeling are provided in Table 9. The results of the TAP modeling are discussed in Section 7.3. Emission rate estimates and stack parameters for these scenarios are provided in Appendix D. The modeled annual average ambient impacts for NO_2, PM_{10}, and $PM_{2.5}$ are less than the NAAQS.

7.2.5 Demonstration of Compliance with Standards that are Based on a 1-Hour Averaging Period (Worst-Case 1-Hour)

To determine the worst-case ambient impacts for CO and SO_2, each with a 1-hour averaging period, the modeling setup assumed the worst-case scenario of all generators facility-wide operating concurrently. The model assumed 72 generators operating under full-variable load for 24 hours per day, 365 days per year, for 5 years. These assumptions are to address the conservative consideration that a power outage could occur at any time of day or night on any day of the year. To account for a worst-case scenario, the hour of activation for the power outage scenario was assumed (i.e., startup emissions of all 72 engines are accounted for in this single-hour scenario). These modeling assumptions are used in the setups for:

- CO 2nd-highest, 1-hour average NAAQS
- SO_2 1st-highest, 1-hour average NAAQS
- Any applicable TAP with a 1-hour averaging period (i.e., NO_2 and SO_2 ASIL).

The results of this scenario are provided in Table 9. The results of the TAP modeling are discussed in Section 7.3. The modeled 1-hour average ambient impacts for CO and SO_2 are less than the NAAQS.

7.2.6 Demonstration of Compliance with Standards that are Based on 3-Hour, 8-Hour, or 24-Hour Averaging Periods (Worst-Case 1-Hour)

To estimate worst-case ambient impacts for pollutants regulated on other short-term averages (i.e., 3-hour, 8-hour, or 24-hour), the modeling setup assumed a worst-case scenario of all generators facility-wide operating concurrently. The air dispersion models were set up for all 72 generators to operate 24 hours per day, 365 days per year, for 5 years. A single startup for each engine was assumed to occur once during each simulation. This modeling setup included:

- CO 2nd-highest, 8-hour average NAAQS
- SO_2 1st-highest, 3-hour average NAAQS
- Any applicable TAP with a 24-hour averaging period (e.g., acrolein).

The results of this scenario are provided in Table 9. The results of the TAP modeling are discussed in Section 7.3. The modeled 8-hour ambient impacts for CO and 3-hour ambient impacts for SO_2 are less than the NAAQS.

7.2.7 Demonstration of Compliance with the NO_2 1-hour Average NAAQS

7.2.7.1 Stochastic Monte Carlo Analysis

Project generator operations will be intermittent and on any given day, the operating scenarios and arrangement of activated engines will vary, as will the meteorological conditions that affect the pollutant dispersion. Due to the random unpredictability of weather patterns and variable timing of operation for intermittent emission sources, a statistical approach has been developed by Ecology using a stochastic Monte Carlo analysis to demonstrate compliance with air quality standards that are based on a percentile of the daily maximum ambient impacts, such as the $PM_{2.5}$ 24-hour average, NO_2 1-hour average, and SO_2 1-hour SO_2 NAAQS.

Ecology has generated a Monte Carlo script, for the statistical freeware "R," that was designed specifically to evaluate compliance of intermittent emissions, such as from emergency generators at data centers (Dhammapala 2016), and it has been previously used to demonstrate compliance with the NO_2 1-hour and $PM_{2.5}$ 24-hour average NAAQS for emergency generators at other data centers located in Grant County, Washington. This script processes output files from several AERMOD runs that are representative of each engine operating scenario. The script iteratively tests a thousand combinations of results from all the generator runtime scenarios, wind directions, and wind speeds to estimate the probability, at any given receptor location, that the NAAQS standard will be violated. For the 1-hour NO_2 NAAQS analysis, the script estimates the 98th-percentile concentration at each individual receptor location within the modeling domain.

7.2.7.2 NO_2 1-Hour Average Modeling and Statistical Analysis

For demonstration of project compliance with the NO_2 1-hour average NAAQS, each project-specific engine runtime scenario has been characterized and ranked, based on worst-case potential project emissions, as shown in Table 10. The 1st- through 6th-highest emitting days are assumed to occur when all 72 generators activate concurrently at full-variable load during an unplanned outage. The 7th-through 14th-highest ranked emitting days are assumed to be days during which electrical bypass operations will occur when up to four or five generators are run at a time. The 15th-through 63rd-highest ranked emitting days and beyond are assumed to be days during which scheduled operations, such as monthly maintenance or load bank testing will occur when up to one or two generators are run at a time.

Each of the above-noted engine runtime scenarios were modeled using the PVMRM option within AERMOD on 5 years of meteorological data. Model input information is provided in Appendix F. The NO_2/NO_x equilibrium ratio, NO_2/NO_x in-stack ratio, and ambient ozone concentration were set equal to the values used for modeling NO_2 annual average impacts, as described in Section 7.2.4. The resultant 1st-highest impact of the above listed AERMOD runs were post-processed using Ecology's Monte Carlo script in "R." This script was used to establish the 98th-percentile impact value at every receptor location within the modeling domain.

7.2.7.3 Background Modeling

This evaluation assumed a "regional background" concentration of 16 micrograms per cubic meter ($\mu g/m^3$), which was obtained from the Washington State University (WSU) NW Airquest website (WSU; accessed October 30, 2017) and accounts for local highway and railroad emission impacts.

Local background estimates were modeled in a manner consistent with Monte Carlo simulations required for other recent data center permit applications in Quincy, Washington. The local background impacts were modeled from neighboring source operations that are assumed to occur during each operating scenario. The modeling assumptions of local background sources are described in Section 7.2.10.

The output files from the AERMOD runs, which included the impacts from local background and project, were used in the Monte Carlo simulation and the resultant Monte Carlo-predicted maximum 98th-percentile impact from all sources was summed with the "regional background" value.

7.2.7.4 Project Compliance with the NO_2 1-hour Average NAAQS

Table F-1 in Appendix F summarizes these Monte Carlo analysis results and inputs to the "R" script. Electronic copies of the AERMOD and Monte Carlo simulation output files are provided in Appendix E.

Based on the assumptions outlined above for the stochastic Monte Carlo analysis, the 3-year rolling average of the 98th-percentile of the project maximum daily 1-hour average concentration of NO_2 is predicted to be 96 µg/m^3 and to occur adjacent to the southern property boundary (as shown on Figure 3). As shown in Table 9, the estimated cumulative concentration at this maximum project impact location is 112 µg/m^3, which is less than the NO_2 1-hour average NAAQS of 188 µg/m^3.

7.2.8 Demonstration of Compliance with the $PM_{2.5}$ 24-hour Average NAAQS

The $PM_{2.5}$ 24-hour average NAAQS is also a probabilistic standard based on the 98th percentile (averaged over 3 years) of the 24-hour average concentration. Ecology allows compliance to be demonstrated with this standard by modeling the 8th-highest daily impact. Therefore, this demonstration compares the 1st-highest 24-hour average $PM_{2.5}$ concentration for the modeled 8th-highest emitting day.

As shown in Table 10, the 8th-highest emitting day is expected to be the scenario for monthly operations. Thirty-six single startup events were assumed to occur during each simulation. The hourly emission rate input to AERMOD assumed operation in this scenario will be restricted to 12 hours per day during daylight hours (7:00 a.m. to 7:00 p.m.).

The results of this scenario are provided in Table 9. The modeled 24-hour average ambient impact for $PM_{2.5}$ is less than the NAAQS.

7.2.9 Demonstration of Compliance with the PM_{10} 24-hour Average NAAQS

The PM_{10} 24-hour average NAAQS is not to be exceeded more than once per year on average over 3 years; therefore, compliance with this standard was modeled based on the 2nd-highest emitting day, which is a scenario that assumes all generators are operating concurrently facility-wide. Note, because Microsoft is requesting a 18-hour operational limit on the 2nd through 7th days of concurrent generator operation in a calendar year, this modeling scenario assumed an 18-hour utility outage and the 1st-highest concentration in AERMOD was compared to the PM_{10} 24-hour average NAAQS. Seventy-two single startup events were assumed to occur during the simulation (one per generator). The 18-hour emissions total for this event was divided by 24 hours to develop the hourly emission rate input into AERMOD.

The results of this scenario are provided in Table 9. The modeled 24-hour average ambient impact for PM_{10} is less than the NAAQS.

7.2.10 Assumed Background Impacts

This evaluation included regional background values contributed by existing regional emission sources in the project vicinity (e.g., permitted sources, highway vehicles, area sources) and local background values contributed by the other nearby data centers and the Con Agra facility. Project coordinate-specific regional background values were obtained from the WSU NW Airquest website (WSU; accessed October 30, 2017).

Local background values for $PM_{2.5}$, PM_{10}, and NO_2 consisted of the ambient impacts, at the project's maximum impact location, caused by emissions from the industrial emission sources at the neighboring NTT DATA Data Center, Microsoft Columbia Data Center, the existing MWH-01/02 Data Center, and the Con Agra industrial facility. Emissions from each of these facilities were assumed to be equal to their respective permit limits. The locations of the maximum project-related impacts were determined, and AERMOD was used to model the local background ambient impacts at that location caused by simultaneous activity of the local background sources. The modeling assumptions for local background sources were as follows:

- **Compliance with PM_{10} 24-hour average NAAQS**. This evaluation assumes that the permitted sources at the NTT DATA Data Center (emergency generators), Microsoft Columbia Data Center (emergency generators and cooling towers), MWH-01/02 Data Center (emergency generators and cooling towers), CyrusOne Data Center (emergency generators) and the boilers at Con Agra would operate at their maximum emission rates.
- **Compliance with $PM_{2.5}$ 24-hour average NAAQS**. This evaluation assumes that the permitted cooling towers at the Microsoft Columbia Data Center and MWH-01/02 Data Center and the boilers at Con Agra would operate at their respective maximum emission rates. This evaluation also assumes that the emergency generators at the NTT DATA Data Center, Microsoft Columbia Data Center, and CyrusOne Data Center are operating in a maintenance scenario.
- **Compliance with NO_2 1-hour average NAAQS**. This evaluation assumes that the Con Agra industrial facility, NTT DATA Data Center, Microsoft Columbia Data Center, MWH-01/02 Data Center, and CyrusOne Data Center would operate at its maximum emission rates. Refer to Section 7.2.7.3 for additional details on local background modeling for this scenario.

7.3 Toxic Air Pollutant Ambient Impacts Compared to Acceptable Source Impact Levels

The first-tier ambient concentration screening analysis is summarized in Table 11. This screening analysis was conducted on all TAPs with expected emission rates that exceed the SQER (as presented in Table 6). The project-only emission rates listed in Table 11 represent full-buildout operations. As shown in Table 11, the maximum modeled ambient concentrations for benzene, 1,3-butadiene, naphthalene, formaldehyde, dibenz(a,h)anthracene, chromium, CO, ammonia, and acrolein are less than their respective ASILs.

7.3.1 Annual Average DEEP Impacts

The DEEP modeling analysis was conducted by assuming all generators at the facility would operate for the theoretical maximum annual runtime hours, under full-variable load conditions. Modeling assumptions are discussed in Section 7.2. Further details on the modeling input parameters are provided in Appendix D. The maximum modeled annual average ambient DEEP concentration was 0.18 $\mu g/m^3$ (Table 11), which exceeds the ASIL of 0.00333 $\mu g/m^3$. The location of the modeled maximum ambient impact is shown on Figure 3.

Since the maximum modeled ambient DEEP concentration (attributable to project-related sources) was modeled to be greater than the ASIL, a second-tier health impact assessment will be conducted for DEEP (to be provided to Ecology under separate cover).

7.3.2 1-Hour NO_2 Impacts During Facility-Wide Concurrent Generator Operation

The maximum ambient 1-hour average NO_2 concentrations were modeled using the PVMRM option within AERMOD. The NO_2/NO_x equilibrium ratio, NO_2/NO_x in-stack ratio, and ambient ozone concentration were set equal to the values used for modeling NO_2 annual average impacts, as described in Section 7.2.4. The AERMOD model for this scenario was set up to assume that Microsoft would operate 72 generators for 24 hours per day, 365 days per year, for 5 years. The maximum modeled 1st-highest 1-hour average ambient NO_2 concentration was 877 $\mu g/m^3$ (Table 11), which exceeds the ASIL of 470 $\mu g/m^3$. The location of the modeled maximum ambient impact is shown on Figure 3.

Since the maximum modeled ambient NO_2 concentration (attributable to project-related sources) was modeled to be greater than the ASIL, a second-tier health impact assessment will be conducted for NO_2 (to be provided to Ecology under separate cover).

8.0 REFERENCES

AMTEST. 2012. Source Evaluation Report: ICF International @ Microsoft Columbia Data Center, Quincy, Washington - Generator CO3.3 Genset #3 Particulate Matter, Nitrogen Oxides, and Carbon Monoxide Emissions. AMTEST Air Quality. January 6.

Baltimore Air Coil. 2017. "Reduction of Drift Droplet Rate." December 22.

Dhammapala, R. 2016. "Re: Vantage Data Center NOC Application - Air Modeling Protocol." Ranil Dhammapala, Washington State Department of Ecology. March 17.

Ecology. 2016. Memorandum: BACT and tBACT Cost-Effectiveness Thresholds. From Robert Koster, Washington State Department of Ecology, to File, Washington State Department of Ecology. August 2.

EPA. 1990. New Source Review Workshop Manual: Prevention of Significant Deterioration and Nonattainment Area Permitting. Office of Air Quality Planning and Standards, US Environmental Protection Agency. October.

EPA. 1995. Compilation of Air Pollutant Emission Factors, Volume 1: Stationary Point and Area Sources. AP-42. 5th ed. Office of Air Quality Planning and Standards, US Environmental Protection Agency. January.

EPA. 2002. EPA Air Pollution Control Cost Manual. EPA/452/B-02-001. 6th ed. Office of Air Quality Planning and Standards, US Environmental Protection Agency. January.

EPA. 2005. Revision to the Guideline on Air Quality Models: Adoption of a Preferred General Purpose (Flat and Complex Terrain) Dispersion Model and Other Revisions: Final Rule. US Environmental Protection Agency. 40 CFR Part 51. November 9.

Haass, C.C., J.L. Kovach, S.E. Kelly, and D.A. Turner. 2010. Evaluation of Best Available Control Technology for Toxics (tBACT), Double Shell Tank Farms Primary Ventilation Systems Supporting Waste Transfer Operations. US Department of Energy. June 3.

Lents, J.M., L. Arth, M. Boretz, M. Chitjian, K. Cocker, N. Davis, K Johnson, Y Long, J.W. Miller, U. Mondragon, R.M. Nikkila, M. Omary, D. Pacocha, Y. Quin, S. Shah, and G. Tonnesen. 2005. Air Quality Implications of Backup Generators in California - Volume One: Generation Scenarios, Emissions and Atmospheric Modeling, and Health Risk Analysis. Publication No. CEC-500-2005-048. California Energy Commission, PIER Energy-Related Environmental Research. March.

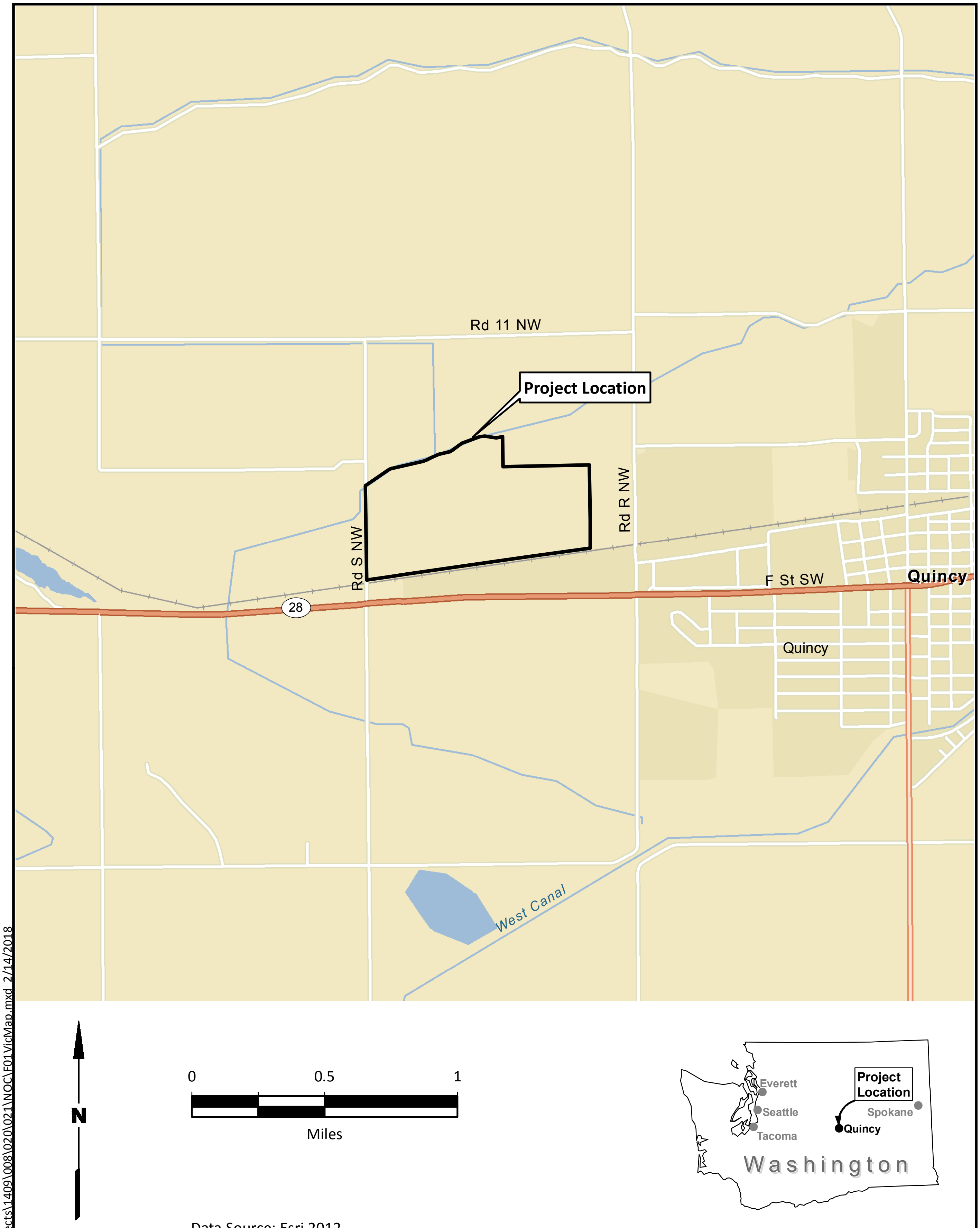
McAlpine, J. 2017. "Re: Microsoft MWH Data Center in Quincy, WA, Air Dispersion Modeling Protocol Review Process." Jay McAlpine, Office of Air and Waste, US Environmental Protection Agency. December 12.

Pafford, B. 2016. "Re: Tier 4 Emission Reductions." Bill Pafford, Engine & Compressor Accessories, Johnson Matthey Stationary Emissions Control, LLC. December 12.

Shank, M. 2017. "Re: Cooling Tower Drift Rate." Matthew Shank, Product Application Manager - Industrial Process Market, Evapco. September 27.

USGS. 1992. National Land Cover Data 1992. US Geological Survey. https://www.mrlc.gov/nlcd1992.php.

WSU. "NW Airquest: Lookup 2009-2011 Design Values of Criteria Pollutants." Northwest International Air Quality Environmental Science and Technology Consortium, Washington State University. http://lar.wsu.edu/nw-airquest/lookup.html.



Data Source: Esri 2012.

Microsoft MWH Data Center Quincy, Washington	**Vicinity Map**	Figure 1

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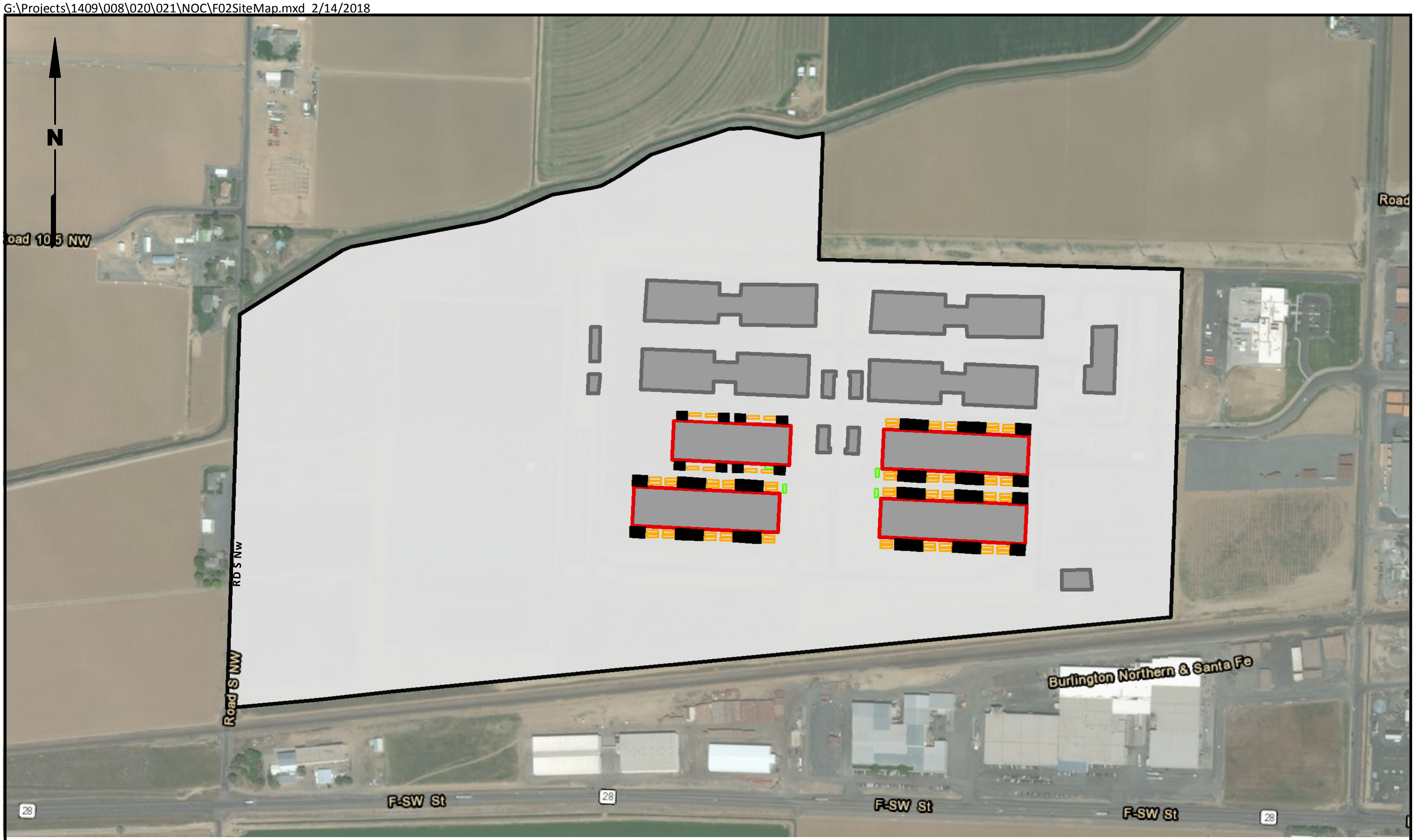

Legend

■ Cooling Towers

▭ 3,000 kW Generator

▭ 1,500 kW Generator

▭ Subject Property

🟥 Proposed Buildings

▨ Existing Buildings

0 670 1,340

Scale in Feet

Data Sources: Grant County GIS; Google Earth Imagery.

Note

1. Black and white reproduction of this color original may reduce its effectiveness and lead to incorrect interpretation.

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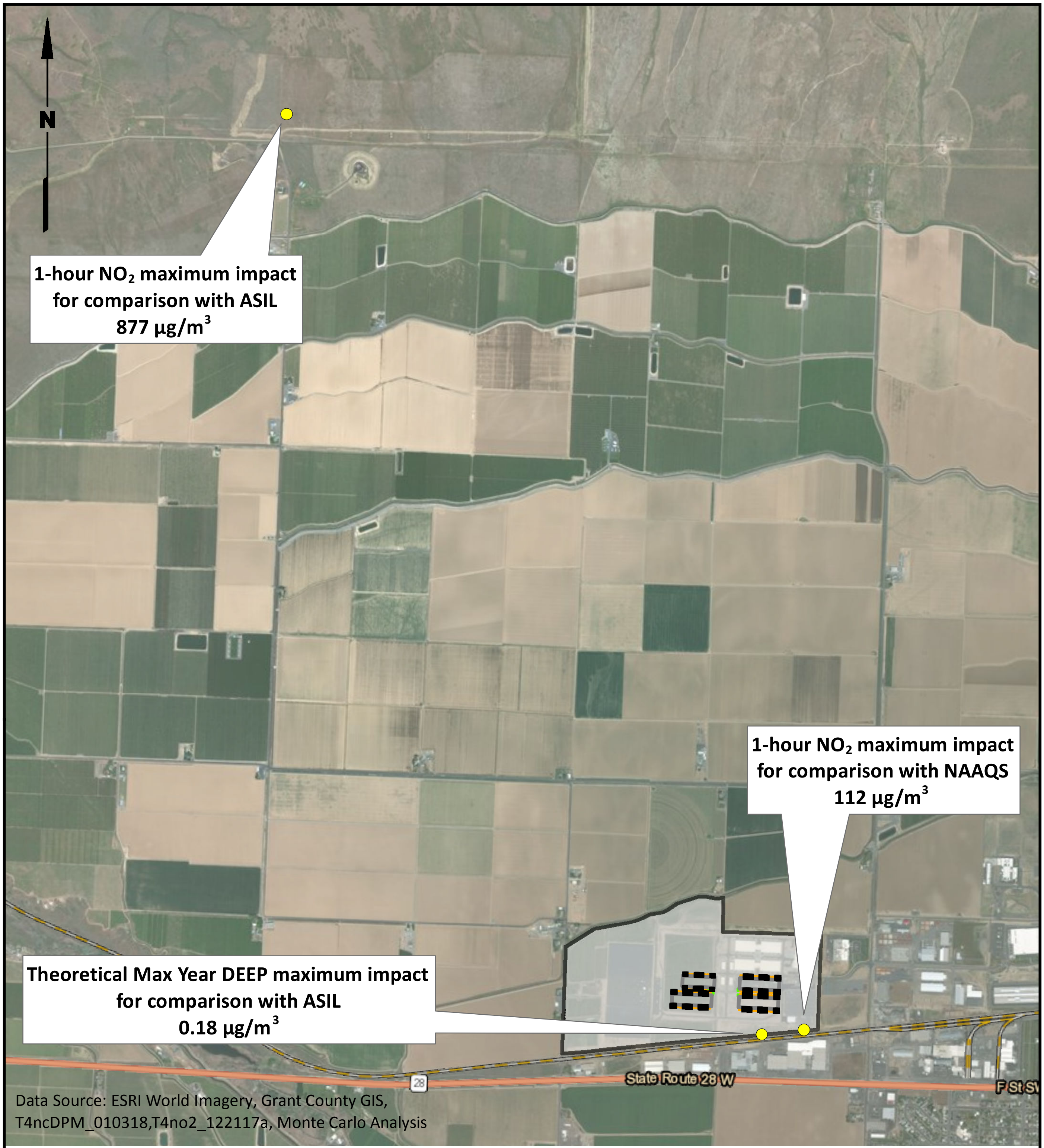
Microsoft MWH Data Center
Quincy, Washington

Site Map

Figure
2



1-hour NO_2 maximum impact for comparison with ASIL 877 µg/m^3

1-hour NO_2 maximum impact for comparison with NAAQS 112 µg/m^3

Theoretical Max Year DEEP maximum impact for comparison with ASIL 0.18 µg/m^3

Data Source: ESRI World Imagery, Grant County GIS, T4ncDPM_010318,T4no2_122117a, Monte Carlo Analysis

Legend

●	Receptors selection
☐	Proposed Buildings
▪	Cooling Towers

Abbreviations

ASIL = Acceptable Source Impact Level
DEEP = Diesel Engine Exhaust Particulates
NAAQS = National Ambient Air Quality Standards
NO_2 = Nitrogen Dioxide
µg/m^3 = Micrograms per cubic meter

Note

1. Black and white reproduction of this color original may reduce its effectiveness and lead to incorrect interpretation.

0 2,250 4,500

Scale in Feet

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Microsoft MWH Data Center
Quincy, Washington

Project Impacts

Figure
3

Table 1
Vendor-Reported Air Pollutant Emission Rates
MWH-03/04/05/06 Data Center
Quincy, Washington

	1.5-MW Generators Full-variable (≤ 100%) Load Emission Parameters[a]			3.0-MW Generators Full-variable (≤ 100%) Load Emission Parameters[a]		
Pollutant	**Worst-case Emissions (lb/hr)**	**Load-specific Exhaust Temp. (°F)**	**Load-specific Exhaust Flow (cfm)**	**Worst-case Emissions (lb/hr)**	**Load-specific Exhaust Temp. (°F)**	**Load-specific Exhaust Flow (cfm)**
Nitrogen oxides (NO_x)	6.24	369	3,339	8.34	468	10,028
Carbon monoxide	1.47	577	4,714	1.71	773	23,365
Hydrocarbons	0.95	369	3,339	1.51	581	16,018
DEEP[b]	0.09	577	4,714	0.15	468	10,028
PM (FH+BH)[c]	0.47	577	4,714	0.84	468	10,028
Ammonia	0.50	880	11,734	0.95	838	24,561
Min Flow/Temp	--	369	3,339	--	468	7,713
Max Flow/Temp	--	880	11,734	--	838	24,561
Fuel usage per genset (gph)	108			213		

Notes:

[a] "Full-variable load" is the pollutant-specific worst-case emission rate at any load ≤100 percent load.

[b] DEEP (diesel engine exhaust particulate matter) is assumed equal to front-half NTE particulate emissions, as reported by the vendors.

[c] FH+BH (Front-half and back-half emissions) was calculated using a FH+BH scaling-factor based on acutal worst-case stack test results.

Cooling Tower Non-Volatile Particulate Matter and TAP Emissions As Evaporated Solid Drift Droplets							
Toxic Air Polutant in Industrial Wastewater	**Conc. In CT Feedwater (mg/L)**	**Hourly Emissions per cooler (lbs/hr)**	**Hourly Emissions all 136 (lbs/hr)**	**Daily Emissions (136 coolers) (lbs/day)**	**Annual Emissions (136 coolers)(lb/yr)**	**SQER**	
Arsenic (As)	0.002	3.25E-08	4.42E-06	1.06E-04	0.0388	0.0581	year
Beryllium (Be)	0.002	3.25E-08	4.42E-06	1.06E-04	0.0388	0.0800	year
Cadmium (Cd)	0.001	1.63E-08	2.21E-06	5.31E-05	0.0194	0.0457	year
Chromium (Cr)	0.002	3.25E-08	4.42E-06	1.06E-04	0.0388	0.0013	year
Copper (Cu)	0.250	4.07E-06	5.53E-04	1.33E-02	4.8438	0.2190	1-hr
Lead (Pb)	0.002	3.25E-08	4.42E-06	1.06E-04	0.0388	16.0000	year
Manganese (Mn)	**0.030**	**4.88E-07**	**6.64E-05**	**1.59E-03**	**0.5813**	0.0053	24-hr
Mercury (Hg)	0.200	3.25E-06	4.42E-04	1.06E-02	3.8750	0.0118	24-hr
Selenium (Se)	0.002	3.25E-08	4.42E-06	1.06E-04	0.0388	2.6300	24-hr
Vanadium (V)	**0.034**	**5.53E-07**	**7.52E-05**	**1.80E-03**	**0.6588**	0.0263	24-hr
Total Cyanide	0.010	1.63E-07	2.21E-05	5.31E-04	0.1938	1.1800	24-hr
Ammonia	0.122	1.98E-06	2.69E-04	6.45E-03	2.3552	9.3100	24-hr
Total Phosphorus	**3.530**	**5.74E-05**	**7.81E-03**	**0.187381**	**68.3941**	2.6300	24-hr
Total Suspended Particulates	1,338	0.0218	2.96	71.0	25,918.05	TSP fraction =	100%
PM_{10} based on droplet size distributi	1,338	0.0218	2.96	71.01	25,918.05	PM10 fraction =	100%
$PM_{2.5}$ based on droplet size distribut	744	0.0121	1.645	39.481	14,410.44	PM2.5 fraction =	56%

Notes:

Detected analytes

detection limit (not detected above)

Table 2
Fuel-Based Emissions Estimation Summary
MWH-03/04/05/06 Data Center
Quincy, Washington

Parameter	Units	Value	
Generator Size	kW	1,500	3,000
No. of Generators	--	4	68
Fuel Usage (per genset)	gph	108	213
Hourly Heat Input	MMBtu /hr	14.80	29.21
Fuel Type	--	Ultra-low Sulfur Diesel	
Fuel Sulfur Content	ppm weight	15	
Fuel Density	lbs /gallon	7.1	
Fuel Heat Content	Btu /gallon	137,000	

Annual Hours of Operation	
Average	86
Max	258
Max with Comm	308

Duration	Units	Peak Hourly	Peak Daily	Annual Average	Project Theoretical Maximum	Theoretical Maximum (Incl. Commissioning)
Fuel Usage (per period)	Gallons	14,930	358,310	1,283,946	3,851,837	4,598,317
Heat Input (per period)	MMBtu	2,045	49,089	175,901	527,702	629,969

			Peak Emission Rate[b]				Annual Emission Rate (TPY)		
Pollutant	CAS Number	Emission factor (lb/MMBtu)[a]	1.5 MWe (lb/hr per genset)	3.0 MWe (lb/hr per genset)	Project Total (lb/hr)	Project Total (lb/dy)	Project Annual Average	Project Theoretical Maximum	Theoretical Maximum (Incl. commissioning)
Nitrogen dioxide (NO_2)	10102-44-0	10% of primary NO_x	0.624	0.834	-	-	-	-	-
Sulfur dioxide (SO_2)	7446-09-5	0.0015% Sulfur (wt)	0.0230	0.045	3.173	76.16	-	-	-
Ammonia	7664-41-7	40 ppm[c]	0.503	0.946	66.36	1592.53	-	-	-
Benzene	71-43-2	7.8E-04	0.0121	0.024	1.67	38.18	0.069	0.207	0.247
Toluene	108-88-3	2.8E-04	0.0044	0.0087	0.61	1.38E+01	2.50E-02	0.075	0.090
Xylenes	95-47-6	1.9E-04	0.0030	0.0059	0.42	9.50E+00	1.72E-02	0.052	0.062
1,3-Butadiene	106-99-0	3.9E-05	6.1E-04	1.2E-03	0.084	1.92E+00	3.48E-03	1.04E-02	1.25E-02
Formaldehyde	50-00-0	7.9E-05	1.2E-03	0.0024	0.170	3.88E+00	7.02E-03	2.11E-02	2.52E-02
Acetaldehyde	75-07-0	2.5E-05	3.9E-04	7.8E-04	0.054	1.24E+00	2.24E-03	6.73E-03	8.03E-03
Acrolein	107-02-8	7.9E-06	1.2E-04	2.4E-04	0.0170	3.88E-01	7.01E-04	2.10E-03	2.51E-03
Benzo(a)pyrene	50-32-8	2.6E-07	4.0E-06	7.9E-06	5.5E-04	1.26E-02	2.29E-05	6.86E-05	8.19E-05
Benzo(a)anthracene	56-55-3	6.2E-07	9.7E-06	1.9E-05	1.3E-03	3.06E-02	5.54E-05	1.66E-04	1.98E-04
Chrysene	218-01-9	1.5E-06	2.4E-05	4.7E-05	0.0033	7.53E-02	1.36E-04	4.09E-04	4.88E-04
Benzo(b)fluoranthene	205-99-2	1.1E-06	1.7E-05	3.4E-05	2.4E-03	5.46E-02	9.88E-05	2.96E-04	3.54E-04
Benzo(k)fluoranthene	207-08-9	2.2E-07	3.4E-06	6.7E-06	4.7E-04	1.07E-02	1.94E-05	5.82E-05	6.95E-05
Dibenz(a,h)anthracene	53-70-3	3.5E-07	5.4E-06	1.1E-05	7.5E-04	1.70E-02	3.08E-05	9.24E-05	1.10E-04
Indeno(1,2,3-cd)pyrene	193-39-5	4.1E-07	6.5E-06	1.3E-05	8.9E-04	2.04E-02	3.68E-05	1.11E-04	1.32E-04
Naphthalene	91-20-3	1.3E-04	2.0E-03	0.0040	0.280	6.40E+00	1.16E-02	3.47E-02	4.14E-02
Propylene	115-07-1	2.8E-03	0.044	0.086	6.0	1.37E+02	2.48E-01	0.75	0.889

Notes:

[a] Source: AP-42 Sec 23.4 (EPA 1995).

[b] Emission rate accounts for one startup event.

[c] Based on a vendor-reported NTE ammonia slip concentration at 100% load

Abbreviations and Acronyms:

Btu = British thermal unit
gph = Gallons per hour
lbs = Pounds
lbs/hr = Pounds per hour
MMBtu = Million metric British thermal units
MW = Megawatts
MWe = Megawatts electrical
NO_x = Nitrogen oxides
ppm = Parts per million
TPY = Tons per year
Sec = Section

Table 3

Startup Emissions Summary
MWH-03/04/05/06 Data Center
Quincy, Washington

"Black-Puff" Emissions Test Data (see Appendix B)

Pollutant	Spike Duration (seconds)	Measured Concentration (ppm) Cold-Start Emission Spike	Measured Concentration (ppm) Steady-State (Warm) Emissions	Cold-Start Emission Factor
PM+HC	14	900	30	4.3
Nitrogen oxides (NO_x)	8.0	40	38	0.94
Carbon monoxide	20	750	30	9.0

	Worst-case Emission Rate (lbs/hr)			
	1.5-MW Generators		3.0-MW Generators	
Pollutant	Cold-start[a]	Warm	Cold-start[a]	Warm
HC	4.0	0.95	6.4	1.51
Nitrogen oxides (NO_x)[c]	6.2	6.2	8.3	8.3
Carbon monoxide	13	1.5	15.4	2
DEEP[b]	0.4	0.09	0.7	0.15
PM (FH+BH)	2.0	0.5	3.6	0.8

Startup emission rate applied to one hour (full-variable Load (≤100% Load) emissions)

Pollutant	1.5 MW - Single Hour Emissions (lb/hr)			3.0 MW Single Hour Emissions (lb/hr)		
	Startup (1 min)	Warm (59 min)	Total (1 hr)	Startup (1 min)	Warm (59 min)	Total (1 hr)
HC	0.07	0.93	1.00	0.11	1.48	1.59
Nitrogen oxides (NO_x)	0.10	6.14	6.24	0.14	8.21	8.34
Carbon monoxide	0.22	1.44	1.66	0.26	1.68	1.94
DEEP[b]	0.01	0.08	0.09	0.01	0.15	0.16
PM (FH+BH)	0.03	0.46	0.50	0.06	0.83	0.89

Notes:

[a] Startup emission factor applies to the first 60 seconds of emissions after engine startup.

[b] DEEP (diesel engine exhaust particulate matter) is assumed equal to front-half NTE particulate emissions, as reported by the vendors.

[c] Although the startup emission factor derived for NO_x is less than 1 (i.e., decreased emissions), this evaluation will conservatively assume a factor of 1.0.

Abbreviations and Acronyms:

BH = "Back-half" condensable emissions
FH = "Front-half" filterable emissions
HC = Hydrocarbons
lbs/hr = Pounds per hour
NA = Not applicable
NTE = Not to exceed
PM = Particulate matter
ppm = Parts per million

Table 4
Project Potential-to-Emit Emissions Summary
MWH-03/04/05/06 Data Center
Quincy, Washington

Pollutant[a]	PTE Project-only Rates			
	Hourly (lbs/hr)	Annual (TPY)	Theoretical Maximum Year (TPY)	Theoretical Maximum Year with Commis. (TPY)
Criteria Pollutants				
Nitrogen oxides (NO_x)	592	25.47	76	91.23
Carbon monoxide (CO)	138	5.4	16.2	19.58
Sulfur dioxide (SO_2)[b]	3.17	0.14	0.41	0.49
$PM_{2.5}$ / PM_{10} (FH+BH)[c] (Gens Only)	62	2.6	7.7	9.24
$PM_{2.5}$ / PM_{10} (FH+BH)[c] (with Cooling Towers)	65	15.5	20.7	22.2
VOCs	112	4.62	13.9	16.64
Toxic Air Pollutants (TAPs)				
Primary NO_2[d]	59	2.55	7.64	9.12
DEEP[e]	11	0.47	1.4	1.68
CO	138	5.4	16.2	19.58
SO_2[b]	3.17	0.136	0.41	0.49
Ammonia (Gens Only)	66	2.85	8.56	10.22
Ammonia (with Cooling Towers)	66	2.85	8.56	10.22
Carbon-based TAPs				
Acrolein	1.70E-02	7.01E-04	2.10E-03	2.51E-03
Benzene	1.67E+00	6.91E-02	2.07E-01	2.47E-01
Propylene	6.02E+00	2.48E-01	7.45E-01	8.89E-01
Toluene	6.06E-01	2.50E-02	7.50E-02	8.96E-02
Xylenes	4.16E-01	1.72E-02	5.15E-02	6.15E-02
Formaldehyde	1.70E-01	7.02E-03	2.11E-02	2.52E-02
Acetaldehyde	5.43E-02	2.24E-03	6.73E-03	8.03E-03
1,3-Butadiene	8.43E-02	3.48E-03	1.04E-02	1.25E-02
Polycyclic Aromatic Hydrocarbons				
Naphthalene	0.28	1.16E-02	3.47E-02	4.14E-02
Benz(a)anthracene	1.3E-03	5.54E-05	1.66E-04	1.98E-04
Chrysene	0.0033	1.36E-04	4.09E-04	4.88E-04
Benzo(b)fluoranthene	0.0024	9.88E-05	2.96E-04	3.54E-04
Benzo(k)fluoranthene	4.7E-04	1.94E-05	5.82E-05	6.95E-05
Benzo(a)pyrene	5.5E-04	2.29E-05	6.86E-05	8.19E-05
Indeno(1,2,3-cd)pyrene	8.9E-04	3.68E-05	1.11E-04	1.32E-04
Dibenz(a,h)anthracene	7.5E-04	3.08E-05	9.24E-05	1.10E-04
Cooler Emissions				
Arsenic (As)	4.42E-06	1.94E-05	NA - coolers conservatively assumed to operate at 100% loading 8,760 hours/year.	
Beryllium (Be)	4.42E-06	1.94E-05		
Cadmium (Cd)	2.21E-06	9.69E-06		
Chromium (Cr)	4.42E-06	1.94E-05		
Copper (Cu)	5.53E-04	2.42E-03		
Lead (Pb)	4.42E-06	1.94E-05		
Manganese (Mn)	6.64E-05	2.91E-04		
Mercury (Hg)	4.42E-04	1.94E-03		
Selenium (Se)	4.42E-06	1.94E-05		
Vanadium (V)	7.52E-05	3.29E-04		
Total Cyanide	2.21E-05	9.69E-05		
Total Phosphorus	7.81E-03	3.42E-02		
Total Suspended Particulate	2.96	12.96		
PM_{10} based on droplet size distribution	2.96	12.96		
$PM_{2.5}$ based on droplet size distribution	1.65	7.21		

Notes:

[a] Startup emissions are accounted for in the project emissions.

[b] SO_2 emissions are based on emission factor for sulfur oxides from AP-42 Section 3.4 (EPA 1995) with an assumed fuel sulfur content of 15 ppm.

[c] FH+BH (Front-half and back-half emissions) was calculated using a FH+BH scaling-factor based on acutal

[d] NO_2 is assumed to be 10% of the NO_x.

[e] Value assumed to be equal the front-half NTE particulate emissions, as reported by the vendors.

Abbreviations and Acronyms:

CO = Carbon monoxide
FH = "Front-half" filterable emissions
lbs/hr = Pounds per hour
NO_x = Nitrogen oxides
PM = Particulate matter
SO_2 = Sulfur dioxide
TPY = Tons per year
NA = Not applicable

Table 5
Facility Potential-to-Emit Emissions Summary
MWH-03/04/05/06 Data Center
Quincy, Washington

	PTE Facility-wide Rates		
Pollutant[a]	**Annual (TPY)**	**Theoretical Maximum Year (TPY)**	**Theoretical Maximum Year with Commis. (TPY)**
Criteria Pollutants			
Nitrogen oxides (NO_x)	58.47	175	190.23
Carbon monoxide (CO)	12.7	38	41.48
Sulfur dioxide (SO_2)[b]	0.21	0.62	0.70
$PM_{2.5}$ / PM_{10} (FH+BH)[c] (Gens Only)	3.4	10.1	11.68
$PM_{2.5}$ / PM_{10} (FH+BH)[c] (with Cooling Towers)	39.3	46.1	47.6
VOCs	5.66	17.0	19.74
Toxic Air Pollutants (TAPs)			
Primary NO_2[d]	5.85	17.5	19.0
DEEP[e]	1.28	3.8	4.12
CO	12.7	38.1	41.48
SO_2[b]	0.205	0.6	0.70
Ammonia (Gens Only)	3.99	12.0	13.6
Ammonia (with Cooling Towers)	3.99	12.0	13.6
Carbon-based TAPs			
Acrolein	7.36E-04	2.21E-03	2.62E-03
Benzene	7.26E-02	2.18E-01	2.58E-01
Propylene	2.61E-01	7.84E-01	9.28E-01
Toluene	2.63E-02	7.89E-02	9.35E-02
Xylenes	1.80E-02	5.41E-02	6.41E-02
Formaldehyde	7.37E-03	2.21E-02	2.62E-02
Acetaldehyde	2.35E-03	7.06E-03	8.36E-03
1,3-Butadiene	3.66E-03	1.10E-02	1.30E-02
Polycyclic Aromatic Hydrocarbons			
Naphthalene	1.22E-02	3.65E-02	4.32E-02
Benz(a)anthracene	5.82E-05	1.74E-04	2.07E-04
Chrysene	1.43E-04	4.29E-04	5.08E-04
Benzo(b)fluoranthene	1.04E-04	3.11E-04	3.69E-04
Benzo(k)fluoranthene	2.04E-05	6.12E-05	7.24E-05
Benzo(a)pyrene	2.41E-05	7.22E-05	8.55E-05
Indeno(1,2,3-cd)pyrene	3.87E-05	1.16E-04	1.38E-04
Dibenz(a,h)anthracene	3.24E-05	9.72E-05	1.15E-04
Cooler Emissions			
Arsenic (As)	1.94E-05	NA - coolers conservatively assumed to operate at 100% loading 8,760 hours/year.	
Beryllium (Be)	1.94E-05		
Cadmium (Cd)	9.69E-06		
Chromium (Cr)	1.94E-05		
Copper (Cu)	2.58E-03		
Lead (Pb)	1.94E-05		
Manganese (Mn)	7.51E-04		
Mercury (Hg)	1.94E-03		
Selenium (Se)	1.94E-05		
Vanadium (V)	3.29E-04		
Total Cyanide	9.69E-05		
Total Phosphorus	3.42E-02		
Chloroform (MWH01/02 only)	2.60E-04		
Bromodichloromethane (MWH01/02 only)	2.60E-04		
Bromoform (MWH01/02 only)	6.90E-03		
Fluoride (MWH01/02 only)	4.80E-03		
Total Suspended Particulates	35.96		
PM_{10} based on droplet size distribution	25.76		
$PM_{2.5}$ based on droplet size distribution	10.20		

Notes:

[a] Startup emissions are accounted for in the project emissions.

[b] SO_2 emissions are based on emission factor for sulfur oxides from AP-42 Section 3.4 (EPA 1995) with an assumed

[c] FH+BH (Front-half and back-half emissions) was calculated using a FH+BH scaling-factor based on actual worst-

[d] NO_2 is assumed to be 10% of the NO_x.

[e] Value assumed to be equal the front-half NTE particulate emissions, as reported by the vendors.

BH = "Back-half" condensable emissions
DEEP = Diesel engine exhaust particulate matter
FH = "Front-half" filterable emissions
NA = Not applicable
NO_2 = Nitrogen dioxide
NO_x = Nitrogen oxides

NTE = Not to exceed
SO_2 = Sulfur dioxide
TAPs = Toxic air pollutants
TPY = Tons per year

Table 6
Project Emissions Compared to Small-Quantity Emission Rates
MWH-03/04/05/06 Data Center
Quincy, Washington

Pollutant	CAS Number	Averaging Period	Project-only Emission Rate	*De Minimis*	SQER	Required Action
			(pounds per averaging period)			
Diesel Engine Generator Emissions						
NO_2	10102-44-0	1-hr	59	0.457	1.03	Model
DEEP	--	year	3,359	0.032	0.639	Model
SO_2	7446-09-5	1-hr	3.2	0.457	1.45	Model
Carbon monoxide (CO)	630-08-0	1-hr	138	1.14	50.4	Model
Benzene	71-43-2	year	495	0.331	6.62	Model
Toluene	108-88-3	24-hr	14	32.9	657	
Xylenes	95-47-6	24-hr	9.5	1.45	29	Report
1,3-Butadiene	106-99-0	year	25	0.0564	1.13	Model
Formaldehyde	50-00-0	year	50	1.6	32	Model
Acetaldehyde	75-07-0	year	16	3.55	71	Report
Acrolein	107-02-8	24-hr	0.39	3.94E-04	0.00789	Model
Benzo(a)pyrene	50-32-8	year	0.16	0.00872	0.174	Report
Benzo(a)anthracene	56-55-3	year	0.40	0.0872	1.74	Report
Chrysene	218-01-9	year	0.98	0.872	17.4	Report
Benzo(b)fluoranthene	205-99-2	year	0.71	0.0872	1.74	Report
Benzo(k)fluoranthene	207-08-9	year	0.14	0.0872	1.74	Report
Dibenz(a,h)anthracene	53-70-3	year	0.22	0.00799	0.16	Model
Indeno(1,2,3-cd)pyrene	193-39-5	year	0.26	0.0872	1.74	Report
Naphthalene	91-20-3	year	83	0.282	5.64	Model
Propylene	115-07-1	24-hr	137	19.7	394	Report
Cooling Unit Emissions						
Arsenic (As)	--	year	*3.88E-02*	0.00291	0.058	Report
Beryllium (Be)	--	year	*3.88E-02*	0.004	0.080	Report
Cadmium (Cd)	7440-43-9	year	*1.94E-02*	0.00228	0.046	Report
Chromium (Cr)	--	year	*3.88E-02*	6.40E-05	1.28E-03	Model
Copper (Cu)	--	1-hr	*5.53E-04*	0.011	0.22	
Lead (Pb)	--	year	*3.88E-02*	10	16	
Manganese (Mn)	--	24-hr	**1.59E-03**	2.63E-04	5.26E-03	Report
Mercury (Hg)	7439-97-6	24-hr	*1.06E-02*	5.91E-04	0.0118	Report
Selenium (Se)	--	24-hr	*1.06E-04*	0.131	2.63	
Vanadium (V)	7440-62-2	24-hr	**0.00180**	0.00131	0.026	Report
Total Cyanide	74-90-8	24-hr	*5.31E-04*	0.0591	1.18	
Total Phosphorus	7723-14-0	24-hr	**0.187**	0.131	2.63	Report
Combined (Diesel Engine Generator + Cooling Unit) Emissions						
Ammonia	7664-41-7	24-hr	*1593*	0.465	9.310	Model

Notes:

Highlighted cells indicate pollutants that require ambient air dispersion model analysis

Italic = not detected above reporting limit; emissions reflect reporting limit

Bold and shaded = detected; emissions reflect actual detected concentrations

Abbreviations and Acronyms:

DEEP = Diesel engine exhaust particulate matter
CAS = Chemical abstract service number
hr = Hour
NO_2 = Nitrogen dioxide
SO_2 = Sulfur dioxide
SQER = Small-quantity emission rate
$\mu g/m^3$ = Micrograms per cubic meter

Table 7
Summary of Cost Effectiveness for Removal of Criteria Pollutants
MWH-03/04/05/06 Data Center
Quincy, Washington

	$PM_{10}/PM_{2.5}$	CO	Total VOCs	NO_x	Actual Cost for Combined Criteria Pollutants
Acceptable Unit Cost (dollars per ton)	$12,000	$5,000	$12,000	$12,000	
Control Option	**Actual Cost to Control (dollars per ton)**				
Tier 4 Integrated Control Package[a]	$1,034,867	$140,412	$749,247	$15,353	$13,413
SCR[b]	--	--	--	$12,312	$12,312
Catalyzed DPF[c]	$357,970	$51,427	$313,619	--	$39,328
DOC[d]	$620,191	$24,749	$150,931	--	$20,558
	not acceptable	not acceptable	not acceptable	not acceptable	not acceptable

Notes:

[a] The expected control efficiency for a Tier 4 integrated control package to reduce emission is 90% for NO_x, 85% for PM (front half), 80% for CO, and 80% for VOCs.

[b] The expected control efficiency for an SCR is 90% for NO_x.

[c] The expected control efficiency for a catalyzed DPF is 90% for PM (front half), 80% for CO, and 70% for VOCs.

[d] The expected control efficiency for a DOC is 80% for CO, 70% for VOCs, and 25% for filterable $PM_{10}/PM_{2.5}$.

Abbreviations and Acronyms:

-- = Ineffective control technology
CO = Carbon monoxide
DEEP = Diesel engine exhaust particulate matter is assumed equal to front-half NTE particulate emissions, as reported by the vendor.
DOC = Diesel oxidation catalyst
DPF = Diesel particulate filter
NO_x = Nitrogen oxides
$PM_{2.5}/PM_{10}$ = Particulate matter attributable to front-half and back-half emissions is assumed equal to the sum of vendor NTE values for PM and hydrocarbons.
SCR = Selective catalytic reduction
VOC = Volatile organic compound

Table 8
Summary of Cost Effectiveness for Removal of Toxic Air Pollutants
MWH-03/04/05/06 Data Center
Quincy, Washington

Toxic Air Pollutant	ASIL ($\mu g/m^3$)	Hanford Method Cost Factor	Hanford Method Ceiling Cost (dollar per ton)	Emission Control Option - Actual Cost to Control (dollars per ton)			
				Tier 4 Integrated Control Package[a]	SCR[b]	Catalyzed DPF[c]	DOC[d]
DEEP	0.0033	6.9	$72,544	$1,034,867	--	$357,970	$620,191
CO	23,000	0.1	$731	$140,412	--	$51,427	$24,749
NO_2 (10% of NO_x)	470	1.8	$18,472	$144,319	$115,732	--	--
Benzene	0.035	5.9	$61,882	$16,717,496	--	$6,997,601	$3,367,634
1,3-Butadiene	0.0059	6.7	$69,951	$331,784,567	--	$138,878,213	$66,835,904
Acetaldehyde	0.37	4.9	$51,063	$514,792,722	--	$215,481,672	$103,701,740
Acrolein	0.06	5.7	$59,359	$1,646,291,445	--	$689,103,824	$331,635,006
Naphthalene	0.029	6.0	$62,612	$99,790,589	--	$41,770,293	$20,102,183
Formaldehyde	0.17	5.2	$54,691	$164,420,489	--	$68,823,043	$33,121,468
Benzo(a)pyrene	0.00091	7.5	$78,464	$50,477,729,904	--	$21,128,942,144	$10,168,419,626
Benzo(a)anthracene	0.00909	6.5	$67,964	$50,477,729,904	--	$21,128,942,144	$10,168,419,626
Benzo(k)fluoranthene	0.00909	6.5	$67,964	$59,508,149,474	--	$24,908,890,510	$11,987,540,569
Benzo(b)fluoranthene	0.0091	6.5	$67,964	$11,687,186,113	--	$4,892,016,334	$4,514,458,591
Chrysene	0.0909	5.5	$57,464	$8,478,938,945	--	$3,549,109,890	$1,708,028,656
Dibenz(a,h)anthracene	0.00083	7.5	$78,863	$37,493,573,946	--	$15,694,040,841	$7,552,843,480
Indeno(1,2,3-cd)pyrene	0.00909	6.5	$67,964	$31,335,209,143	--	$13,116,275,679	$6,312,279,816
Xylenes	221	2.1	$21,913	$67,216,459	--	$28,135,431	$13,540,331
SO_2	660	1.6	$16,924	--	--	--	--
Propylene	3,000	1.0	$10,020	$4,649,741	--	$1,946,286	$936,661
Carcinogenic VOCs	NA	NA	NA	$12,613,334	--	$5,279,683	$2,540,876
Non-Carcinogenic VOCs	NA	NA	NA	$3,964,930	--	$1,659,639	$798,710
Combined TAPs Cost-effectiveness				$65,235	$115,732	$43,510	$22,954
Presumed Acceptable Annual Cost for Combined TAP Control (based on the Hanford Method)				$13,886	$18,472	$10,430	$4,453

Notes:

[a] The expected control efficiency of a Tier 4 integrated control package to reduce emission of VOCs and gaseous TAPs is 70%.

[b] There is no expected control of VOCs and gaseous TAPs using SCR.

[c] The expected control efficiency to reduce emission of VOCs and gaseous TAPs using the catalyzed DPF is 70%.

[d] The expected control efficiency to reduce emission of VOCs and gaseous TAPs using the DOC is 70%.

Abbreviations and Acronyms:

-- = Ineffective control technology
$\mu g/m^3$ = Micrograms per cubic meter
ASIL = Acceptable source impact level
CO = Carbon monoxide
DEEP = Diesel engine exhaust particulate matter is assumed equal to front-half "not-to-exceed" vendor particulate emissions
DOC = Diesel oxidation catalyst
DPF = Diesel particulate filter
NA = Not applicable
NO_2 = Nitrogen dioxide
SCR = Selective catalytic reduction
SO_2 = Sulfur dioxide
TAP = Toxic air pollutant
VOC = Volatile organic compound

Table 9
Estimated Project and Background Impacts Compared to National Ambient Air Quality Standards
MWH-03/04/05/06 Data Center
Quincy, Washington

Criteria Pollutant/ Hazardous Air Pollutant	National Standards Primary (µg/m^3)	National Standards Secondary (µg/m^3)	Washington State Standards (µg/m^3)	Modeled Operating Scenario	AERMOD Filename	Modeled Project	Modeled Project + Local Background[a]	Regional Background[b]	Estimated Cumulative Concentration
						Impact (µg/m^3)			
Carbon Monoxide (CO)									
8-hour average	10,000	--	10,000	Unplanned power outage	T4co_122117	154 [c]	--	3,308	3,462
1-hour average	40,000	--	40,000	Unplanned power outage		467 [c]	--	5,776	6,243
Sulfur Dioxide (SO_2)									
3-hour average	--	1,310	1,310	Unplanned power outage	T4so2_122117	5.1 [d]	--	2.1	7.2
1-hour average	200	--	200	Unplanned power outage		10 [d]	--	2.6	12.7
Particulate Matter (PM_{10})									
24-hour average	150	150	150	Unplanned power outage	T4pm10_011617	67 [d, e]	88	62	149.9
Particulate Matter ($PM_{2.5}$)									
Annual average	12	15	12	Theoretical Max. Year	T4pm25_122117	2.7 [e]	3.3	6.5	9.8
24-hour average	35	35	35	Non-emergency monthly operations (Ranked Day 8)	T4pm25_011718(a-e)	6.4 [f, g]	6.5	21	27.5
Nitrogen Oxides (NO_x)									
Annual average	100	100	100	Theoretical Max. Year	T4nox_122117	8.6 [e]	12	2.8	14.8
1-hour average	188	--	--	Concurrent generator operation	Refer to Monte Carlo Evaluation (Appendix F)	--	96 [h]	16	112

Notes:

[a] Modeled impact, including local background sources, at the project-related maximum impact location.

[b] Regional background level obtained from Ecology's Air Monitoring Network website (WSU; accessed October 30, 2017).

[c] Reported values represent the 2nd-highest modeled impacts.

[d] Reported values represent the 1st-highest modeled impacts.

[e] It was assumed that local data centers were concurrently operating in facility-wide power outage mode. The Con Agra-facility was modeled as continuously operating at PTE rates. All cooling towers were modeled as continuously operating at PTE rates.

[f] Monthly maintenance operations are expected to occur on each engine for 20 minutes per engine per month. In the event that complications arise during testing, this duration may be greater. Multiple sequential tests may occur within the same day for up to 12 hours per day.

[g] This model conservatively assumes that two engines may be running at a time and that operations may occur any time during daytime hours (7 a.m. to 7 p.m.). In order to capture the worst-case emission impacts for this scenario, a test model was run with all project generators operating at full-variable load. The resultant emission impacts for each individual generator was ranked. The generator with the highest ranked impact was simulated to operate concurrently with a randomly chosen adjacent generator for this modeling demonstration. Local background modeling for this scenario assumed nearby data centers were operating generators in a maintenance run scenario.

[h] Reported value is based on the Monte Carlo assessment for NO_2. See the Monte Carlo Analysis (Appendix F) for further details.

Abbreviations and Acronyms:

µg/m^3 = Micrograms per cubic meter
NO_2 = Nitrogen dioxide
PTE = Potential-to-emit
$PM_{2.5}$ = Particulate matter with aerodynamic diameter less than or equal to 2.5 microns.
PM_{10} = Particulate matter with aerodynamic diameter less than or equal to 10 microns.

Table 10
Summary of Ranked Generator Runtime Scenarios
MWH-03/04/05/06 Data Center
Quincy, Washington

Ranked Generator Runtime Scenarios - $PM_{2.5}$

Ranked Day	Activity	Activity Duration (hours/generator)	Max. No. Generators to Operate Concurrently	Max. Daily Operating Hours	Max. Annual Operating Days	Max. Daily Project-$PM_{2.5}$ Emissions (lbs/day)
1-6	Emergency operations	24	72	24	6	1,458
7-30	Non-emergency monthly operations	0.34	2	12	24	63
31-54	Non-emergency semiannual operations	3	2	12	24	60
55-62	Non-emergency triennial operations	2	4-5	12	8	51
63+	Additional non-emergency monthly or semiannual operations	1	1	12	1+	51

Ranked Generator Runtime Scenarios - NO_x

Ranked Day	Activity	Max. No. Generators to Operate Concurrently	Max. Annual Operating Days	Max. Hourly Project-NO_x Emissions (lbs/hour)
1-6	Emergency operations	72	6	592
7-14	Non-emergency triennial operations	4-5	8	40
15-38	Non-emergency monthly operations	2	24	17
39-62	Non-emergency semiannual operations	2	24	17
63+	Additional non-emergency monthly or semiannual operations	1	1+	8.3

Note:

Operating conditions and assumed number of days for each modeling scenario may be subject to change.

Table 11
Estimated Project Impacts Compared to Acceptable Source Impact Levels
MWH-03/04/05/06 Data Center
Quincy, Washington

Pollutant	CAS Number	Averaging Period	AERMOD Filename	Facility-wide Emission Rate (lbs/avg. period)	Modeled Max. Project-Impact (µg/m^3)	ASIL (µg/m^3)
1,3-Butadiene	106-99-0	year	[a,b]	25	0.00132	0.00588
Acrolein		24-hr	T4acrolein_122117	0.39	0.015	0.06
Benzene	71-43-2	year	T4benzene_020218[b]	495	0.0263	0.0345
Carbon monoxide (CO)	630-08-0	1-hr	T4co_122117	138	473	23,000
Chromium	--	year	T4cr_011218[b]	3.9E-02	4.5E-06	6.67E-06
DEEP	--	year	T4ncDPM_010318[b]	3,359	0.18	0.00333
Dibenz(a,h)anthracene	53-70-3	year	T4dbz_011318[b]	50	1.2E-05	8.33E-04
Formaldehyde	50-00-0	year	[a,b]	0.22	1.2E-05	1.67E-01
Naphthalene	91-20-3	year	[a,b]	83	0.0044	0.029
Nitrogen dioxide (NO_2)	10102-44-0	1-hr	T4no2_122117a	59	877	470
Sulfur Dioxide (SO_2)	7446-09-5	1-hr	T4so2_122117	3	10	660
Ammonia	7664-41-7	24-hr	[c]	1,593	61	70.8

Notes:

[a] Predicted impacts were approximated using a dispersion factor derived from the T4benzene_020218 model.

[b] Predicted maximum impacts are based on emissions for the theoretical maximum year.

[c] Predicted impacts were approximated using a dispersion factor derived from the T4acrolein_122117 model.

Highlighted cells indicate pollutants that require a human health impact assessment

Abbreviations and Acronyms:

ASIL = Acceptable source impact level
avg = Averaging
CAS = Chemical abstract service number
CO = Carbon monoxide
DEEP = Diesel engine exhaust particulate matter
hr = hour
lbs = pounds
NO_2 = Nitrogen dioxide
µg/m^3 = micrograms per cubic meter

APPENDIX A

Vendor Specification Sheets

PERFORMANCE DATA [C32DR70]

DECEMBER 18, 2017

For Help Desk Phone Numbers Click here

Perf No: EM0449 **Change Level:** 00

General Heat Rejection Emissions Regulatory Altitude Derate Cross Reference Perf Param Ref

View PDF

SALES MODEL:	C32	**COMBUSTION:**	DI
BRAND:	CAT	**ENGINE SPEED (RPM):**	1,800
ENGINE POWER (BHP):	1,474	**HERTZ:**	60
GEN POWER WITH FAN (EKW):	1,000.0	**FAN POWER (HP):**	56.3
COMPRESSION RATIO:	15.0	**ADDITIONAL PARASITICS (HP):**	1.3
RATING LEVEL:	MISSION CRITICAL STANDBY	**ASPIRATION:**	TA
PUMP QUANTITY:	1	**AFTERCOOLER TYPE:**	ATAAC
FUEL TYPE:	DIESEL	**AFTERCOOLER CIRCUIT TYPE:**	JW+OC, ATAAC
MANIFOLD TYPE:	DRY	**INLET MANIFOLD AIR TEMP (F):**	120
ELECTRONICS TYPE:	ADEM4	**JACKET WATER TEMP (F):**	210.2
IGNITION TYPE:	CI	**TURBO CONFIGURATION:**	PARALLEL
INJECTOR TYPE:	EUI	**TURBO QUANTITY:**	2
REF EXH STACK DIAMETER (IN):	8	**TURBOCHARGER MODEL:**	GTB45518BS-52T-1.37
MAX OPERATING ALTITUDE (FT):	997	**CERTIFICATION YEAR:**	2007
		PISTON SPD @ RATED ENG SPD (FT/MIN):	1,913.4

INDUSTRY	SUB INDUSTRY	APPLICATION
OIL AND GAS	LAND PRODUCTION	PACKAGED GENSET
ELECTRIC POWER	STANDARD	PACKAGED GENSET

General Performance Data Top

GENSET POWER WITH FAN	PERCENT LOAD	ENGINE POWER	BRAKE MEAN EFF PRES (BMEP)	BRAKE SPEC FUEL CONSUMPTN (BSFC)	VOL FUEL CONSUMPTN (VFC)	INLET MFLD PRES	INLET MFLD TEMP	EXH MFLD TEMP	EXH MFLD PRES	ENGINE OUTLET TEMP
EKW	%	BHP	PSI	LB/BHP-HR	GAL/HR	IN-HG	DEG F	DEG F	IN-HG	DEG F
1,000.0	100	1,474	331	0.342	71.9	70.3	118.2	1,209.3	58.1	889.5
900.0	90	1,330	299	0.341	64.7	64.0	111.0	1,150.9	51.9	855.4
800.0	80	1,187	267	0.349	59.2	60.4	106.5	1,116.3	48.6	832.2
750.0	75	1,116	251	0.354	56.4	57.9	103.8	1,100.0	46.6	821.0
700.0	70	1,046	235	0.354	52.9	53.7	99.5	1,077.6	43.2	810.0
600.0	60	905	203	0.353	45.7	43.7	90.1	1,025.8	35.3	788.8
500.0	50	765	172	0.350	38.2	32.9	80.8	964.8	27.0	768.5
400.0	40	628	141	0.351	31.5	23.9	74.7	895.9	20.5	731.2
300.0	30	490	110	0.357	25.0	15.7	70.4	812.1	15.1	676.7
250.0	25	420	94	0.363	21.8	12.0	68.9	764.0	12.7	643.0
200.0	20	350	79	0.374	18.7	8.7	67.9	708.9	10.6	601.8
100.0	10	206	46	0.425	12.5	4.5	67.5	569.8	7.8	489.0

GENSET POWER WITH FAN	PERCENT LOAD	ENGINE POWER	COMPRESSOR OUTLET PRES	COMPRESSOR OUTLET TEMP	WET INLET AIR VOL FLOW RATE	ENGINE OUTLET WET EXH GAS VOL FLOW RATE	WET INLET AIR MASS FLOW RATE	WET EXH GAS MASS FLOW RATE	WET EXH VOL FLOW RATE (32 DEG F AND 29.98 IN HG)	DRY EXH VOL FLOW RATE (32 DEG F AND 29.98 IN HG)
EKW	%	BHP	IN-HG	DEG F	CFM	CFM	LB/HR	LB/HR	FT3/MIN	FT3/MIN
1,000.0	100	1,474	76	422.1	3,094.1	8,065.3	13,465.4	13,968.9	2,939.2	2,688.4

GENSET POWER WITH FAN	PERCENT LOAD	ENGINE POWER	COMPRESSOR OUTLET PRES	COMPRESSOR OUTLET TEMP	WET INLET AIR VOL FLOW RATE	ENGINE OUTLET WET EXH GAS VOL FLOW RATE	WET INLET AIR MASS FLOW RATE	WET EXH GAS MASS FLOW RATE	WET EXH VOL FLOW RATE (32 DEG F AND 29.98 IN HG)	DRY EXH VOL FLOW RATE (32 DEG F AND 29.98 IN HG)
900.0	90	1,330	69	391.5	2,939.0	7,417.0	12,749.0	13,202.3	2,773.0	2,544.8
800.0	80	1,187	65	375.1	2,856.2	7,051.1	12,358.8	12,773.3	2,683.6	2,472.3
750.0	75	1,116	63	363.9	2,783.7	6,813.1	12,021.7	12,415.6	2,615.7	2,413.9
700.0	70	1,046	58	343.3	2,639.5	6,395.9	11,355.9	11,723.5	2,476.8	2,288.3
600.0	60	905	48	302.6	2,355.5	5,576.9	10,061.2	10,377.6	2,196.4	2,033.1
500.0	50	765	37	262.3	2,076.5	4,775.6	8,810.4	9,077.6	1,911.9	1,773.0
400.0	40	628	27	223.0	1,805.8	4,001.6	7,595.0	7,814.6	1,652.1	1,535.9
300.0	30	490	18	183.7	1,537.6	3,237.7	6,435.6	6,610.0	1,400.8	1,306.8
250.0	25	420	14	163.9	1,403.3	2,856.8	5,874.1	6,026.7	1,273.8	1,190.9
200.0	20	350	11	146.2	1,286.2	2,507.0	5,386.7	5,517.7	1,161.2	1,089.1
100.0	10	206	6	122.6	1,147.6	1,981.6	4,797.2	4,885.1	1,027.0	974.3

Heat Rejection Data Top

GENSET POWER WITH FAN	PERCENT LOAD	ENGINE POWER	REJECTION TO JACKET WATER	REJECTION TO ATMOSPHERE	REJECTION TO EXH	EXHAUST RECOVERY TO 350F	FROM OIL COOLER	FROM AFTERCOOLER	WORK ENERGY	LOW HEAT VALUE ENERGY	HIGH HEAT VALUE ENERGY
EKW	%	BHP	BTU/MIN	BTU/MIN	BTU/MIN	BTU/MIN	BTU/MIN	BTU/MIN	BTU/MIN	BTU/MIN	BTU/MIN
1,000.0	100	1,474	20,033	7,238	58,206	31,961	8,218	16,385	62,497	154,292	164,360
900.0	90	1,330	18,378	6,464	52,445	28,178	7,400	14,318	56,390	138,929	147,994
800.0	80	1,187	16,891	5,941	48,853	25,916	6,766	13,293	50,345	127,034	135,323
750.0	75	1,116	16,127	6,236	46,672	24,565	6,445	12,521	47,342	121,002	128,897
700.0	70	1,046	15,231	6,920	43,437	22,625	6,051	11,086	44,338	113,600	121,012
600.0	60	905	13,439	6,738	37,282	19,058	5,220	8,561	38,371	97,997	104,392
500.0	50	765	11,741	5,267	31,535	15,862	4,369	6,404	32,440	82,034	87,386
400.0	40	628	10,827	4,384	25,642	12,387	3,599	4,511	26,618	67,572	71,982
300.0	30	490	9,885	3,711	19,869	8,929	2,858	2,920	20,779	53,663	57,165
250.0	25	420	9,298	3,442	17,092	7,276	2,495	2,235	17,832	46,843	49,899
200.0	20	350	8,559	3,149	14,473	5,698	2,136	1,689	14,848	40,103	42,719
100.0	10	206	6,645	2,319	9,873	2,744	1,432	1,058	8,742	26,884	28,638

Emissions Data Top

Units Filter All Units

RATED SPEED POTENTIAL SITE VARIATION: 1800 RPM

GENSET POWER WITH FAN		EKW	1,000.0	750.0	500.0	250.0	100.0
ENGINE POWER		BHP	1,474	1,116	765	420	206
PERCENT LOAD		%	100	75	50	25	10
TOTAL NOX (AS NO2)		G/HR	8,726	5,093	3,335	2,252	1,328
TOTAL CO		G/HR	356	235	501	819	1,263
TOTAL HC		G/HR	37	104	99	75	153
PART MATTER		G/HR	51.8	39.2	67.6	105.5	83.2
TOTAL NOX (AS NO2)	(CORR 5% O2)	MG/NM3	2,841.8	2,105.6	2,041.6	2,429.4	2,417.2
TOTAL CO	(CORR 5% O2)	MG/NM3	116.1	93.7	305.5	894.8	2,570.4
TOTAL HC	(CORR 5% O2)	MG/NM3	10.3	37.8	52.6	69.6	283.1
PART MATTER	(CORR 5% O2)	MG/NM3	14.1	13.5	35.5	106.1	135.6
TOTAL NOX (AS NO2)	(CORR 5% O2)	PPM	1,384	1,026	994	1,183	1,177
TOTAL CO	(CORR 5% O2)	PPM	93	75	244	716	2,056
TOTAL HC	(CORR 5% O2)	PPM	19	71	98	130	528
TOTAL NOX (AS NO2)		G/HP-HR	5.97	4.59	4.38	5.37	6.45
TOTAL CO		G/HP-HR	0.24	0.21	0.66	1.95	6.14
TOTAL HC		G/HP-HR	0.03	0.09	0.13	0.18	0.74
PART MATTER		G/HP-HR	0.04	0.04	0.09	0.25	0.40
TOTAL NOX (AS NO2)		LB/HR	19.24	11.23	7.35	4.96	2.93
TOTAL CO		LB/HR	0.79	0.52	1.10	1.81	2.78
TOTAL HC		LB/HR	0.08	0.23	0.22	0.17	0.34
PART MATTER		LB/HR	0.11	0.09	0.15	0.23	0.18

RATED SPEED NOMINAL DATA: 1800 RPM

GENSET POWER WITH FAN **ENGINE POWER**		**EKW** **BHP**	**1,000.0** **1,474**	**750.0** **1,116**	**500.0** **765**	**250.0** **420**	**100.0** **206**
PERCENT LOAD		**%**	**100**	**75**	**50**	**25**	**10**
TOTAL NOX (AS NO2)		G/HR	7,212	4,209	2,756	1,861	1,097
TOTAL CO		G/HR	191	126	268	438	676
TOTAL HC		G/HR	19	55	52	40	81
TOTAL CO2		KG/HR	721	564	380	217	124
PART MATTER		G/HR	26.6	20.1	34.7	54.1	42.7
TOTAL NOX (AS NO2)	(CORR 5% O2)	MG/NM3	2,348.6	1,740.1	1,687.3	2,007.8	1,997.7
TOTAL CO	(CORR 5% O2)	MG/NM3	62.1	50.1	163.4	478.5	1,374.6
TOTAL HC	(CORR 5% O2)	MG/NM3	5.5	20.0	27.8	36.8	149.8
PART MATTER	(CORR 5% O2)	MG/NM3	7.2	6.9	18.2	54.4	69.5
TOTAL NOX (AS NO2)	(CORR 5% O2)	PPM	1,144	848	822	978	973
TOTAL CO	(CORR 5% O2)	PPM	50	40	131	383	1,100
TOTAL HC	(CORR 5% O2)	PPM	10	37	52	69	280
TOTAL NOX (AS NO2)		G/HP-HR	4.93	3.79	3.62	4.43	5.33
TOTAL CO		G/HP-HR	0.13	0.11	0.35	1.04	3.28
TOTAL HC		G/HP-HR	0.01	0.05	0.07	0.09	0.39
PART MATTER		G/HP-HR	0.02	0.02	0.05	0.13	0.21
TOTAL NOX (AS NO2)		LB/HR	15.90	9.28	6.08	4.10	2.42
TOTAL CO		LB/HR	0.42	0.28	0.59	0.97	1.49
TOTAL HC		LB/HR	0.04	0.12	0.12	0.09	0.18
TOTAL CO2		LB/HR	1,589	1,244	839	478	273
PART MATTER		LB/HR	0.06	0.04	0.08	0.12	0.09
OXYGEN IN EXH		%	10.1	11.5	12.2	13.5	15.7
DRY SMOKE OPACITY		%	0.7	0.7	1.4	3.0	2.2
BOSCH SMOKE NUMBER			0.18	0.16	0.58	1.31	0.99

Regulatory Information

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EPA TIER 2 **2006 - 2010**

GASEOUS EMISSIONS DATA MEASUREMENTS PROVIDED TO THE EPA ARE CONSISTENT WITH THOSE DESCRIBED IN EPA 40 CFR PART 89 SUBPART D AND ISO 8178 FOR MEASURING HC, CO, PM, AND NOX. THE "MAX LIMITS" SHOWN BELOW ARE WEIGHTED CYCLE AVERAGES AND ARE IN COMPLIANCE WITH THE NON-ROAD REGULATIONS.

Locality	**Agency**	**Regulation**	**Tier/Stage**	**Max Limits - G/BKW - HR**
U.S. (INCL CALIF)	EPA	NON-ROAD	TIER 2	CO: 3.5 NOx + HC: 6.4 PM: 0.20

EPA EMERGENCY STATIONARY **2011 - ----**

GASEOUS EMISSIONS DATA MEASUREMENTS PROVIDED TO THE EPA ARE CONSISTENT WITH THOSE DESCRIBED IN EPA 40 CFR PART 60 SUBPART IIII AND ISO 8178 FOR MEASURING HC, CO, PM, AND NOX. THE "MAX LIMITS" SHOWN BELOW ARE WEIGHTED CYCLE AVERAGES AND ARE IN COMPLIANCE WITH THE EMERGENCY STATIONARY REGULATIONS.

Locality	**Agency**	**Regulation**	**Tier/Stage**	**Max Limits - G/BKW - HR**
U.S. (INCL CALIF)	EPA	STATIONARY	EMERGENCY STATIONARY	CO: 3.5 NOx + HC: 6.4 PM: 0.20

Altitude Derate Data

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ALTITUDE CORRECTED POWER CAPABILITY (BHP)

AMBIENT OPERATING TEMP (F)	**30**	**40**	**50**	**60**	**70**	**80**	**90**	**100**	**110**	**120**	**130**	**140**	**NORMAL**
ALTITUDE (FT)													
0	1,474	1,474	1,474	1,474	1,474	1,474	1,474	1,468	1,442	1,417	1,393	1,370	1,474
1,000	1,474	1,474	1,474	1,474	1,474	1,466	1,439	1,413	1,388	1,365	1,341	1,319	1,474
2,000	1,474	1,474	1,474	1,465	1,437	1,411	1,385	1,360	1,337	1,313	1,291	1,270	1,434
3,000	1,474	1,466	1,438	1,410	1,383	1,358	1,333	1,309	1,286	1,264	1,242	1,222	1,389
4,000	1,439	1,410	1,383	1,356	1,331	1,306	1,282	1,259	1,237	1,216	1,195	1,175	1,345
5,000	1,384	1,356	1,330	1,304	1,280	1,256	1,233	1,211	1,190	1,169	1,149	1,130	1,302
6,000	1,330	1,304	1,278	1,254	1,230	1,207	1,185	1,164	1,144	1,124	1,105	1,086	1,260
7,000	1,278	1,253	1,228	1,205	1,182	1,160	1,139	1,119	1,099	1,080	1,062	1,044	1,220
8,000	1,228	1,203	1,180	1,157	1,135	1,114	1,094	1,074	1,056	1,037	1,020	1,003	1,180
9,000	1,179	1,156	1,133	1,111	1,090	1,070	1,050	1,032	1,014	996	979	963	1,141
10,000	1,132	1,109	1,087	1,066	1,046	1,027	1,008	990	973	956	940	924	1,103
11,000	1,086	1,064	1,043	1,023	1,004	985	967	950	933	917	902	887	1,066
12,000	1,041	1,021	1,001	981	963	945	928	911	895	880	865	850	1,029
13,000	998	978	959	941	923	906	889	873	858	843	829	815	994
14,000	957	937	919	901	884	868	852	837	822	808	794	781	959

AMBIENT OPERATING TEMP (F)	30	40	50	60	70	80	90	100	110	120	130	140	NORMAL
15,000	916	898	880	863	847	831	816	802	788	774	761	748	926

Cross Reference Top

Test Spec	Setting	Engine Arrangement	Engineering Model	Engineering Model Version	Start Effective Serial Number	End Effective Serial Number
0K4311	GG0776	3801431	GS471	-	PRH00001	
0K4311	GG0776	4259340	GS471	-	PRH00001	
0K4311	GG0776	4447558	GS471	-	PRH00001	
0K4311	GG0776	4447562	GS471	-	PRH00001	
0K4311	GG0776	5233431	GS471	-	PRH00001	

Performance Parameter Reference Top

Parameters Reference: DM9600 - 10

PERFORMANCE DEFINITIONS

PERFORMANCE DEFINITIONS DM9600

APPLICATION: Engine performance tolerance values below are representative of a typical production engine tested in a calibrated dynamometer test cell at SAE J1995 standard reference conditions. Caterpillar maintains ISO9001:2000 certified quality management systems for engine test Facilities to assure accurate calibration of test equipment. Engine test data is corrected in accordance with SAE J1995. Additional reference material SAE J1228, J1349, ISO 8665, 3046-1:2002E, 3046-3:1989, 1585, 2534, 2288, and 9249 may apply in part or are similar to SAE J1995. Special engine rating request (SERR) test data shall be noted.

PERFORMANCE PARAMETER TOLERANCE FACTORS: Power +/- 3% Torque +/- 3% Exhaust stack temperature +/- 8% Inlet airflow +/- 5% Intake manifold pressure-gage +/- 10% Exhaust flow +/- 6% Specific fuel consumption +/- 3% Fuel rate +/- 5% Specific DEF consumption +/- 3% DEF rate +/- 5% Heat rejection +/- 5% Heat rejection exhaust only +/- 10% Heat rejection CEM only +/- 10%
Heat Rejection values based on using treated water.
Torque is included for truck and industrial applications, do not use for Gen Set or steady state applications.
On C7 - C18 engines, at speeds of 1100 RPM and under these values are provided for reference only, and may not meet the tolerance listed.
These values do not apply to C280/3600. For these models, see the tolerances listed below.

C280/3600 HEAT REJECTION TOLERANCE FACTORS: Heat rejection +/- 10% Heat rejection to Atmosphere +/- 50% Heat rejection to Lube Oil +/- 20% Heat rejection to Aftercooler +/- 5%

TEST CELL TRANSDUCER TOLERANCE FACTORS: Torque +/- 0.5% Speed +/- 0.2% Fuel flow +/- 1.0% Temperature +/- 2.0 C degrees Intake manifold pressure +/- 0.1 kPa
OBSERVED ENGINE PERFORMANCE IS CORRECTED TO SAE J1995 REFERENCE AIR AND FUEL CONDITIONS.

REFERENCE ATMOSPHERIC INLET AIR FOR 3500 ENGINES AND SMALLER SAE J1228 AUG2002 for marine engines, and J1995 JAN2014 for other engines, reference atmospheric pressure is 100 KPA (29.61 in hg), and standard temperature is 25deg C (77 deg F) at 30% relative humidity at the stated aftercooler water temp, or inlet manifold temp.
FOR 3600 ENGINES Engine rating obtained and presented in accordance with ISO 3046/1 and SAE J1995 JANJAN2014 reference atmospheric pressure is 100 KPA (29.61 in hg), and standard temperature is 25deg C (77 deg F) at 30% relative humidity and 150M altitude at the stated aftercooler water temperature.

MEASUREMENT LOCATION FOR INLET AIR TEMPERATURE Location for air temperature measurement air cleaner inlet at stabilized operating conditions.

REFERENCE EXHAUST STACK DIAMETER The Reference Exhaust Stack Diameter published with this dataset is only used for the calculation of Smoke Opacity values displayed in this dataset. This value does not necessarily represent the actual stack diameter of the engine due to the variety of exhaust stack adapter options available. Consult the price list, engine order or general dimension drawings for the actual stack diameter size ordered or options available.

REFERENCE FUEL DIESEL Reference fuel is #2 distillate diesel with a 35API gravity; A lower heating value is 42,780 KJ/KG (18,390 BTU/LB) when used at 29 deg C (84.2 deg F), where the density is 838.9 G/Liter (7.001 Lbs/Gal).
GAS Reference natural gas fuel has a lower heating value of 33.74 KJ/L (905 BTU/CU Ft). Low BTU ratings are based on 18.64 KJ/L (500 BTU/CU FT) lower heating value gas. Propane ratings are based on 87.56 KJ/L (2350 BTU/CU Ft) lower heating value gas.

ENGINE POWER (NET) IS THE CORRECTED FLYWHEEL POWER (GROSS) LESS EXTERNAL AUXILIARY LOAD Engine corrected gross output includes the power required to drive standard equipment; lube oil, scavenge lube oil, fuel transfer, common rail fuel, separate circuit aftercooler and jacket water pumps. Engine net power available for the external (flywheel) load is calculated by subtracting the sum of auxiliary load from the corrected gross flywheel out put power. Typical auxiliary loads are radiator cooling fans, hydraulic pumps, air compressors and battery charging alternators. For Tier 4 ratings additional Parasitic losses would also include Intake, and Exhaust Restrictions.

ALTITUDE CAPABILITY Altitude capability is the maximum altitude above sea level at standard temperature and standard pressure at which the engine could develop full rated output power on the current performance data set.

Standard temperature values versus altitude could be seen on TM2001.
When viewing the altitude capability chart the ambient temperature is the inlet air temp at the compressor inlet.
Engines with ADEM MEUI and HEUI fuel systems operating at conditions above the defined altitude capability derate for atmospheric pressure and temperature conditions outside the values defined, see TM2001.
Mechanical governor controlled unit injector engines require a setting change for operation at conditions above the altitude defined on the engine performance sheet. See your Caterpillar technical representative for non standard ratings.

REGULATIONS AND PRODUCT COMPLIANCE TMI Emissions information is presented at 'nominal' and 'Potential Site Variation' values for standard ratings. No tolerances are applied to the emissions data. These values are subject to change at any time. The controlling federal and local emission requirements need to be verified by your Caterpillar technical representative.
Customer's may have special emission site requirements that need to be verified by the Caterpillar Product Group engineer.

EMISSIONS DEFINITIONS: Emissions : DM1176

HEAT REJECTION DEFINITIONS: Diesel Circuit Type and HHV Balance : DM9500

HIGH DISPLACEMENT (HD) DEFINITIONS: 3500: EM1500

RATING DEFINITIONS: Agriculture : TM6008
Fire Pump : TM6009
Generator Set : TM6035
Generator (Gas) : TM6041
Industrial Diesel : TM6010
Industrial (Gas) : TM6040
Irrigation : TM5749
Locomotive : TM6037
Marine Auxiliary : TM6036
Marine Prop (Except 3600) : TM5747
Marine Prop (3600 only) : TM5748
MSHA : TM6042
Oil Field (Petroleum) : TM6011
Off-Highway Truck : TM6039
On-Highway Truck : TM6038

SOUND DEFINITIONS: Sound Power : DM8702
Sound Pressure : TM7080

Date Released : 7/7/15

C32 (DM9933)
Rated speed PSV: 1800 rpm

Genset Power (w/ fan)	ekW	1000	750	500	250	100
Engine Power	bhp	1474	1116	765	420	206
% Load	%	100	75	50	25	10
Exhaust Temperature	deg C	476	438	409	339	254
Total NOx (as NO2)	lb/hr	19.24	11.23	7.35	4.96	2.93
% Reduction	%	90	90	90	90	0
Post Catalyst NOx (as NO2)	lb/hr	1.92	1.12	0.74	0.50	2.93
Total CO	lb/hr	0.79	0.52	1.1	1.81	2.78
% Reduction	%	80	80	80	80	80
Post Catalyst CO	lb/hr	0.16	0.10	0.22	0.36	0.56
Total HC	lb/hr	0.08	0.23	0.22	0.17	0.34
% Reduction	%	80	80	80	80	80
Post Catalyst HC	lb/hr	0.02	0.05	0.04	0.03	0.07
Total PM	lb/hr	0.11	0.09	0.15	0.23	0.18
% Reduction	%	85	85	85	85	85
Post Catalyst PM	lb/hr	0.02	0.01	0.02	0.03	0.03

Performance Number: EM1899 **Change Level: 00**

SALES MODEL:	3512C	**COMBUSTION:**	DI
BRAND:	CAT	**ENGINE SPEED (RPM):**	1,800
ENGINE POWER (BHP):	2,206	**HERTZ:**	60
GEN POWER WITH FAN (EKW):	1,500.0	**FAN POWER (HP):**	88.5
COMPRESSION RATIO:	14.7	**ASPIRATION:**	TA
RATING LEVEL:	MISSION CRITICAL STANDBY	**AFTERCOOLER TYPE:**	ATAAC
PUMP QUANTITY:	1	**AFTERCOOLER CIRCUIT TYPE:**	JW+OC, ATAAC
FUEL TYPE:	DIESEL	**INLET MANIFOLD AIR TEMP (F):**	122
MANIFOLD TYPE:	DRY	**JACKET WATER TEMP (F):**	210.2
GOVERNOR TYPE:	ADEM3	**TURBO CONFIGURATION:**	PARALLEL
ELECTRONICS TYPE:	ADEM3	**TURBO QUANTITY:**	4
CAMSHAFT TYPE:	STANDARD	**TURBOCHARGER MODEL:**	GTB4708BN-52T-0.96
IGNITION TYPE:	CI	**CERTIFICATION YEAR:**	2006
INJECTOR TYPE:	EUI	**CRANKCASE BLOWBY RATE (FT3/HR):**	2,203.4
FUEL INJECTOR:	3920220	**FUEL RATE (RATED RPM) NO LOAD (GAL/HR):**	9.9
UNIT INJECTOR TIMING (IN):	64.34	**PISTON SPD @ RATED ENG SPD (FT/MIN):**	2,244.1
REF EXH STACK DIAMETER (IN):	10		
MAX OPERATING ALTITUDE (FT):	3,937		

INDUSTRY	SUBINDUSTRY	APPLICATION
OIL AND GAS	LAND PRODUCTION	PACKAGED GENSET
ELECTRIC POWER	STANDARD	PACKAGED GENSET

General Performance Data

THIS STANDBY RATING IS FOR A STANDBY ONLY ENGINE ARRANGEMENT. RERATING THE ENGINE TO A PRIME OR CONTINUOUS RATING IS NOT PERMITTED.

GENSET POWER WITH FAN	PERCENT LOAD	ENGINE POWER	BRAKE MEAN EFF PRES (BMEP)	BRAKE SPEC FUEL CONSUMPTN (BSFC)	VOL FUEL CONSUMPTN (VFC)	INLET MFLD PRES	INLET MFLD TEMP	EXH MFLD TEMP	EXH MFLD PRES	ENGINE OUTLET TEMP
EKW	%	BHP	PSI	LB/BHP-HR	GAL/HR	IN-HG	DEG F	DEG F	IN-HG	DEG F
1,500.0	100	2,206	307	0.332	104.6	77.5	120.9	1,145.6	74.6	756.6
1,350.0	90	1,983	276	0.336	95.2	72.2	116.1	1,102.7	68.8	727.5
1,200.0	80	1,768	246	0.343	86.6	66.9	113.2	1,069.1	63.0	713.4
1,125.0	75	1,662	232	0.346	82.0	63.4	111.5	1,052.3	59.5	706.7
1,050.0	70	1,556	217	0.348	77.4	59.7	109.8	1,035.2	55.8	700.0
900.0	60	1,349	188	0.352	67.9	51.1	107.1	1,000.5	47.6	687.3
750.0	50	1,144	159	0.355	58.0	40.6	107.5	963.6	38.4	696.7
600.0	40	940	131	0.359	48.2	30.0	108.4	921.9	29.4	702.2
450.0	30	736	103	0.368	38.6	20.9	107.1	856.0	21.9	685.3
375.0	25	632	88	0.376	33.9	16.9	106.2	809.5	18.8	664.9
300.0	20	527	73	0.388	29.2	13.3	105.2	754.5	16.0	636.4
150.0	10	312	43	0.443	19.7	7.3	103.2	609.7	11.4	540.6

GENSET POWER WITH FAN	PERCENT LOAD	ENGINE POWER	COMPRESSOR OUTLET PRES	COMPRESSOR OUTLET TEMP	WET INLET AIR VOL FLOW RATE	ENGINE OUTLET WET EXH GAS VOL FLOW RATE	WET INLET AIR MASS FLOW RATE	WET EXH GAS MASS FLOW RATE	WET EXH VOL FLOW RATE (32 DEG F AND 29.98 IN HG)	DRY EXH VOL FLOW RATE (32 DEG F AND 29.98 IN HG)
EKW	%	BHP	IN-HG	DEG F	CFM	CFM	LB/HR	LB/HR	FT3/MIN	FT3/MIN
1,500.0	100	2,206	82	449.8	4,937.2	11,734.1	21,796.5	22,529.1	4,743.3	4,317.6
1,350.0	90	1,983	77	428.8	4,734.5	10,945.3	20,885.8	21,551.9	4,532.9	4,136.4
1,200.0	80	1,768	71	409.0	4,506.7	10,265.9	19,853.4	20,459.8	4,302.7	3,938.4
1,125.0	75	1,662	68	396.6	4,371.2	9,868.8	19,223.0	19,797.6	4,160.2	3,812.8
1,050.0	70	1,556	64	382.6	4,218.1	9,442.4	18,511.1	19,053.3	4,003.2	3,672.9
900.0	60	1,349	55	350.3	3,862.4	8,508.3	16,857.2	17,332.4	3,647.3	3,352.3
750.0	50	1,144	44	309.9	3,375.7	7,435.0	14,666.1	15,072.5	3,161.3	2,907.1
600.0	40	940	33	266.6	2,868.4	6,329.0	12,406.6	12,744.3	2,678.2	2,465.5
450.0	30	736	23	224.6	2,431.9	5,278.8	10,481.3	10,752.0	2,266.9	2,093.3
375.0	25	632	19	204.3	2,243.0	4,776.5	9,654.1	9,891.7	2,088.3	1,933.3
300.0	20	527	15	184.2	2,069.9	4,283.3	8,899.4	9,103.9	1,921.3	1,784.5
150.0	10	312	9	148.8	1,782.1	3,338.5	7,648.3	7,786.4	1,641.0	1,539.0

Heat Rejection Data

PERFORMANCE DATA[EM1899]

GENSET POWER WITH FAN	PERCENT LOAD	ENGINE POWER	REJECTION TO JACKET WATER	REJECTION TO ATMOSPHERE	REJECTION TO EXH	EXHUAST RECOVERY TO 350F	FROM OIL COOLER	FROM AFTERCOOLER	WORK ENERGY	LOW HEAT VALUE ENERGY	HIGH HEAT VALUE ENERGY
EKW	%	BHP	BTU/MIN	BTU/MIN	BTU/MIN	BTU/MIN	BTU/MIN	BTU/MIN	BTU/MIN	BTU/MIN	BTU/MIN
1,500.0	100	2,206	28,541	7,072	79,477	38,355	11,956	29,539	93,547	224,476	239,123
1,350.0	90	1,983	26,761	6,706	72,346	33,940	10,882	26,874	84,110	204,315	217,647
1,200.0	80	1,768	25,085	6,393	66,713	30,942	9,897	24,071	74,958	185,825	197,950
1,125.0	75	1,662	24,176	6,249	63,549	29,350	9,376	22,404	70,466	176,039	187,526
1,050.0	70	1,556	23,227	6,110	60,309	27,693	8,845	20,631	66,004	166,069	176,905
900.0	60	1,349	21,222	5,841	53,634	24,225	7,759	16,788	57,205	145,683	155,189
750.0	50	1,144	19,059	5,564	46,826	21,662	6,636	12,311	48,509	124,586	132,716
600.0	40	940	16,790	5,286	39,874	18,604	5,512	8,066	39,882	103,489	110,241
450.0	30	736	14,427	4,840	32,601	14,897	4,416	4,955	31,201	82,917	88,327
375.0	25	632	13,189	4,570	28,900	12,838	3,876	3,774	26,809	72,772	77,520
300.0	20	527	11,900	4,299	25,149	10,707	3,336	2,793	22,353	62,628	66,715
150.0	10	312	9,090	3,818	17,468	6,020	2,253	1,375	13,214	42,301	45,061

Sound Data

SOUND PRESSURE DATA FOR THIS RATING CAN BE FOUND IN PERFORMANCE NUMBER - DM8779.

Emissions Data

RATED SPEED POTENTIAL SITE VARIATION: 1800 RPM

GENSET POWER WITH FAN		EKW	1,500.0	1,125.0	750.0	375.0	150.0
PERCENT LOAD		**%**	**100**	**75**	**50**	**25**	**10**
ENGINE POWER		**BHP**	**2,206**	**1,662**	**1,144**	**632**	**312**
TOTAL NOX (AS NO2)		G/HR	14,366	7,266	4,835	3,673	2,831
TOTAL CO		G/HR	1,890	1,176	1,665	1,965	1,898
TOTAL HC		G/HR	351	381	358	283	329
PART MATTER		G/HR	97.6	99.1	150.9	184.0	112.2
TOTAL NOX (AS NO2)	(CORR 5% O2)	MG/NM3	2,848.7	1,803.1	1,671.1	2,214.1	2,967.2
TOTAL CO	(CORR 5% O2)	MG/NM3	427.2	336.3	712.5	1,486.6	2,381.4
TOTAL HC	(CORR 5% O2)	MG/NM3	68.8	95.6	123.3	175.3	360.2
PART MATTER	(CORR 5% O2)	MG/NM3	18.2	23.5	54.8	110.0	115.7
TOTAL NOX (AS NO2)	(CORR 5% O2)	PPM	1,388	878	814	1,078	1,445
TOTAL CO	(CORR 5% O2)	PPM	342	269	570	1,189	1,905
TOTAL HC	(CORR 5% O2)	PPM	128	178	230	327	672
TOTAL NOX (AS NO2)		G/HP-HR	6.58	4.41	4.26	5.85	9.14
TOTAL CO		G/HP-HR	0.87	0.71	1.47	3.13	6.13
TOTAL HC		G/HP-HR	0.16	0.23	0.32	0.45	1.06
PART MATTER		G/HP-HR	0.04	0.06	0.13	0.29	0.36
TOTAL NOX (AS NO2)		LB/HR	31.67	16.02	10.66	8.10	6.24
TOTAL CO		LB/HR	4.17	2.59	3.67	4.33	4.18
TOTAL HC		LB/HR	0.77	0.84	0.79	0.62	0.73
PART MATTER		LB/HR	0.22	0.22	0.33	0.41	0.25

RATED SPEED NOMINAL DATA: 1800 RPM

GENSET POWER WITH FAN		EKW	1,500.0	1,125.0	750.0	375.0	150.0
PERCENT LOAD		**%**	**100**	**75**	**50**	**25**	**10**
ENGINE POWER		**BHP**	**2,206**	**1,662**	**1,144**	**632**	**312**
TOTAL NOX (AS NO2)		G/HR	11,972	6,055	4,029	3,061	2,359
TOTAL CO		G/HR	1,050	653	925	1,092	1,055
TOTAL HC		G/HR	264	286	269	213	248
TOTAL CO2		KG/HR	1,096	853	602	352	204
PART MATTER		G/HR	69.7	70.8	107.8	131.4	80.1
TOTAL NOX (AS NO2)	(CORR 5% O2)	MG/NM3	2,373.9	1,502.6	1,392.6	1,845.1	2,472.7
TOTAL CO	(CORR 5% O2)	MG/NM3	237.3	186.8	395.9	825.9	1,323.0
TOTAL HC	(CORR 5% O2)	MG/NM3	51.7	71.9	92.7	131.8	270.9
PART MATTER	(CORR 5% O2)	MG/NM3	13.0	16.8	39.1	78.6	82.6
TOTAL NOX (AS NO2)	(CORR 5% O2)	PPM	1,156	732	678	899	1,204
TOTAL CO	(CORR 5% O2)	PPM	190	149	317	661	1,058
TOTAL HC	(CORR 5% O2)	PPM	97	134	173	246	506
TOTAL NOX (AS NO2)		G/HP-HR	5.48	3.68	3.55	4.87	7.62

TOTAL CO	G/HP-HR	0.48	0.40	0.81	1.74	3.40
TOTAL HC	G/HP-HR	0.12	0.17	0.24	0.34	0.80
PART MATTER	G/HP-HR	0.03	0.04	0.09	0.21	0.26
TOTAL NOX (AS NO2)	LB/HR	26.39	13.35	8.88	6.75	5.20
TOTAL CO	LB/HR	2.32	1.44	2.04	2.41	2.32
TOTAL HC	LB/HR	0.58	0.63	0.59	0.47	0.55
TOTAL CO2	LB/HR	2,417	1,881	1,327	776	449
PART MATTER	LB/HR	0.15	0.16	0.24	0.29	0.18
OXYGEN IN EXH	%	11.2	12.3	12.9	13.9	15.8
DRY SMOKE OPACITY	%	1.0	1.3	2.9	5.0	3.0
BOSCH SMOKE NUMBER		0.37	0.45	1.06	1.60	1.11

Regulatory Information

EPA EMERGENCY STATIONARY		2011 - ----		
Locality	**Agency**	**Regulation**	**Tier/Stage**	**Max Limits - G/BKW - HR**
U.S. (INCL CALIF)	EPA	STATIONARY	EMERGENCY STATIONARY	CO: 3.5 NOx + HC: 6.4 PM: 0.20

Altitude Derate Data

ALTITUDE CORRECTED POWER CAPABILITY (BHP)

AMBIENT OPERATING TEMP (F)	30	40	50	60	70	80	90	100	110	120	130	140	NORMAL
ALTITUDE (FT)													
0	2,206	2,206	2,206	2,206	2,206	2,206	2,206	2,206	2,206	2,206	2,206	2,096	2,206
1,000	2,206	2,206	2,206	2,206	2,206	2,206	2,206	2,206	2,206	2,206	2,162	2,074	2,206
2,000	2,206	2,206	2,206	2,206	2,206	2,206	2,206	2,206	2,206	2,176	2,118	2,007	2,206
3,000	2,206	2,206	2,206	2,206	2,206	2,206	2,206	2,173	2,135	2,098	2,052	1,919	2,206
4,000	2,201	2,201	2,201	2,201	2,201	2,171	2,132	2,094	2,057	2,021	1,963	1,831	2,201
5,000	2,129	2,129	2,129	2,129	2,129	2,092	2,054	2,017	1,982	1,947	1,875	1,743	2,129
6,000	2,059	2,059	2,059	2,059	2,053	2,015	1,978	1,943	1,909	1,876	1,765	1,677	2,059
7,000	1,992	1,992	1,992	1,992	1,976	1,940	1,904	1,870	1,838	1,787	1,677	1,588	1,992
8,000	1,927	1,927	1,927	1,927	1,902	1,867	1,833	1,800	1,769	1,699	1,610	1,522	1,927
9,000	1,865	1,865	1,865	1,865	1,831	1,797	1,764	1,733	1,699	1,610	1,522	1,412	1,865
10,000	1,805	1,805	1,805	1,795	1,761	1,729	1,697	1,667	1,610	1,522	1,368	1,279	1,805
11,000	1,522	1,522	1,522	1,522	1,522	1,522	1,522	1,522	1,434	1,324	1,213	1,125	1,522
12,000	1,478	1,478	1,478	1,478	1,478	1,478	1,478	1,390	1,279	1,169	1,081	993	1,478
13,000	1,434	1,434	1,434	1,434	1,434	1,434	1,346	1,235	1,147	1,037	971	882	1,434
14,000	1,390	1,390	1,390	1,390	1,390	1,279	1,191	1,103	1,015	927	860	794	1,390
15,000	1,346	1,346	1,346	1,346	1,235	1,147	1,059	971	882	816	772	728	1,346

Cross Reference

Test Spec	Setting	Engine Arrangement	Engineering Model	Engineering Model Version	Start Effective Serial Number	End Effective Serial Number
4577180	LL1862	5084278	GS656	LS	CT200463	
4577180	LL1862	5157729	PG242	-	LYH00001	

Supplementary Data

Type	Classification	Performance Number
SOUND	SOUND PRESSURE	DM8779

Performance Parameter Reference

Parameters Reference:DM9600-09

PERFORMANCE DEFINITIONS

PERFORMANCE DATA[EM1899]

PERFORMANCE DEFINITIONS DM9600

APPLICATION:

Engine performance tolerance values below are representative of a typical production engine tested in a calibrated dynamometer test cell at SAE J1995 standard reference conditions. Caterpillar maintains ISO9001:2000 certified quality management systems for engine test Facilities to assure accurate calibration of test equipment. Engine test data is corrected in accordance with SAE J1995. Additional reference material SAE J1228, J1349, ISO 8665, 3046-1:2002E, 3046-3:1989, 1585, 2534, 2288, and 9249 may apply in part or are similar to SAE J1995. Special engine rating request (SERR) test data shall be noted.

PERFORMANCE PARAMETER TOLERANCE FACTORS (PLUS/MINUS):

Power 3%
Torque 3%
Exhaust stack temperature 8%
Inlet airflow 5%
Intake manifold pressure-gage 10%
Exhaust flow 6%
Specific fuel consumption 3%
Fuel rate 5%
Specific DEF consumption 3%
DEF rate 5%
Heat rejection 5%
Heat rejection exhaust only 10%
Heat rejection CEM only 10%

Heat Rejection values based on using treated water.

Torque is included for truck and industrial applications, do not use for Gen Set or steady state applications.

On C7 - C18 engines, at speeds of 1100 RPM and under these values are provided for reference only, and may not meet the tolerance listed.

These values do not apply to C280/3600. For these models, see the tolerances listed below.

C280/3600 HEAT REJECTION TOLERANCE FACTORS (PLUS/MINUS):

Heat rejection 10%
Heat rejection to Atmosphere 50%
Heat rejection to Lube Oil 20%
Heat rejection to Aftercooler 5%

TEST CELL TRANSDUCER TOLERANCE FACTORS (PLUS/MINUS):

Torque 0.5%
Speed 0.2%
Fuel flow 1.0%
Temperature 2.0 C degrees
Intake manifold pressure 0.1 kPa

OBSERVED ENGINE PERFORMANCE IS CORRECTED TO SAE J1995 REFERENCE AIR AND FUEL CONDITIONS.

REFERENCE ATMOSPHERIC INLET AIR

FOR 3500 ENGINES AND SMALLER

SAE J1228 AUG2002 for marine engines, and J1995 JAN2014 for other engines, reference atmospheric pressure is 100 KPA (29.61 in hg), and standard temperature is 25deg C (77 deg F) at 30% relative humidity at the stated aftercooler water temp, or inlet manifold temp.

FOR 3600 ENGINES

Engine rating obtained and presented in accordance with ISO 3046/1 and SAE J1995 JANJAN2014 reference atmospheric pressure is 100 KPA (29.61 in hg), and standard temperature is 25deg C (77 deg F) at 30% relative humidity and 150M altitude at the stated aftercooler water temperature.

MEASUREMENT LOCATION FOR INLET AIR TEMPERATURE

Location for air temperature measurement air cleaner inlet at stabilized operating conditions.

REFERENCE EXHAUST STACK DIAMETER

The Reference Exhaust Stack Diameter published with this dataset is only used for the calculation of Smoke Opacity values displayed in this dataset. This value does not necessarily represent the actual stack diameter of the engine due to the variety of exhaust stack adapter options available. Consult the price list, engine order or general dimension drawings for the actual stack diameter size ordered or options available.

REFERENCE FUEL

DIESEL

Reference fuel is #2 distillate diesel with a 35API gravity; A lower heating value is 42,780 KJ/KG (18,390 BTU/LB) when used at 29 deg C (84.2 deg F), where the density is 838.9 G/Liter (7.001 Lbs/Gal).

GAS

Reference natural gas fuel has a lower heating value of 33.74 KJ/L (905 BTU/CU Ft). Low BTU ratings are based on 18.64 KJ/L (500 BTU/CU FT) lower heating value gas. Propane ratings are based on 87.56 KJ/L (2350 BTU/CU Ft) lower heating value gas.

ENGINE POWER (NET) IS THE CORRECTED FLYWHEEL POWER (GROSS) LESS EXTERNAL AUXILIARY LOAD

Engine corrected gross output includes the power required to drive standard equipment; lube oil, scavenge lube oil, fuel transfer, common rail fuel, separate circuit aftercooler and jacket water pumps. Engine net power available for the external (flywheel) load is calculated by subtracting the sum of auxiliary load from the corrected gross flywheel out put power. Typical auxiliary loads are radiator cooling fans, hydraulic pumps, air compressors and battery charging alternators. For Tier 4 ratings additional Parasitic losses would also include Intake, and Exhaust Restrictions.

ALTITUDE CAPABILITY

Altitude capability is the maximum altitude above sea level at standard temperature and standard pressure at which the engine could develop full rated output power on the current performance data set.

Standard temperature values versus altitude could be seen on TM2001.

When viewing the altitude capability chart the ambient temperature is the inlet air temp at the compressor inlet.

Engines with ADEM MEUI and HEUI fuel systems operating at conditions above the defined altitude capability derate for atmospheric pressure and temperature conditions outside the values defined, see TM2001.

Mechanical governor controlled unit injector engines require a setting change for operation at conditions above the altitude defined on the engine performance sheet. See your Caterpillar technical representative for non standard ratings.

REGULATIONS AND PRODUCT COMPLIANCE

TMI Emissions information is presented at 'nominal' and 'Potential Site Variation' values for standard ratings. No tolerances are applied to the emissions data. These values are subject to change at any time. The controlling federal and local emission requirements need to be verified by your Caterpillar technical representative.

Customer's may have special emission site requirements that need to be verified by the Caterpillar Product Group engineer.

EMISSIONS DEFINITIONS:
Emissions : DM1176
HEAT REJECTION DEFINITIONS:
Diesel Circuit Type and HHV Balance : DM9500
HIGH DISPLACEMENT (HD) DEFINITIONS:
3500: EM1500
RATING DEFINITIONS:
Agriculture : TM6008
Fire Pump : TM6009
Generator Set : TM6035
Generator (Gas) : TM6041
Industrial Diesel : TM6010
Industrial (Gas) : TM6040
Irrigation : TM5749
Locomotive : TM6037
Marine Auxiliary : TM6036
Marine Prop (Except 3600) : TM5747
Marine Prop (3600 only) : TM5748
MSHA : TM6042
Oil Field (Petroleum) : TM6011
Off-Highway Truck : TM6039
On-Highway Truck : TM6038
SOUND DEFINITIONS:
Sound Power : DM8702
Sound Pressure : TM7080

3512C (EM1899, Rev 00)
Rated speed PSV: 1800 rpm

Genset Power (w/ fan)	ekW	1500	1125	750	375	150
Engine Power	bhp	2206	1662	1144	632	312
% Load	%	100	75	50	25	10
Exhaust Temperature	deg C	403	375	369	352	283
Total NOx (as NO2)	lb/hr	31.67	16.02	10.66	8.1	6.24
% Reduction	%	90	90	90	90	0
Post Catalyst NOx (as NO2)	lb/hr	3.17	1.60	1.07	0.81	6.24
Total CO	lb/hr	4.17	2.59	3.67	4.33	4.18
% Reduction	%	80	80	80	80	80
Post Catalyst CO	lb/hr	0.83	0.52	0.73	0.87	0.84
Total HC	lb/hr	0.77	0.84	0.79	0.62	0.73
% Reduction	%	80	80	80	80	80
Post Catalyst HC	lb/hr	0.15	0.17	0.16	0.12	0.15
Total PM	lb/hr	0.22	0.22	0.33	0.41	0.25
% Reduction	%	85	85	85	85	85
Post Catalyst PM	lb/hr	0.03	0.03	0.05	0.06	0.04

C175-16 (DM8455, Rev 08)
Rated speed PSV: 1800 rpm

Genset Power (w/o fan)	ekW	3100	2325	1550	775	310
Engine Power	bhp	4376	3282	2188	1094	438
% Load	%	100	75	50	25	10
Exhaust Temperature	deg C	478	457	449	433	338
Total NOx (as NO2)	lb/hr	69.85	45.32	18.54	7.77	7.91
% Reduction	%	90	90	90	90	90
Post Catalyst NOx (as NO2)	lb/hr	6.99	4.53	1.85	0.78	0.79
Total CO	lb/hr	6.05	7.41	3.76	4.02	4.03
% Reduction	%	80	80	80	80	80
Post Catalyst CO	lb/hr	1.21	1.48	0.75	0.80	0.81
Total HC	lb/hr	0.52	0.43	0.82	0.83	0.73
% Reduction	%	80	80	80	80	80
Post Catalyst HC	lb/hr	0.10	0.09	0.16	0.17	0.15
Total PM	lb/hr	0.36	0.37	0.27	0.3	0.28
% Reduction	%	85	85	85	85	85
Post Catalyst PM	lb/hr	0.05	0.06	0.04	0.05	0.04

PERFORMANCE DATA[DM9226]

July 10, 2017

Performance Number: DM9226 **Change Level: 03**

SALES MODEL:	C175-16	**COMBUSTION:**	DI
BRAND:	CAT	**ENGINE SPEED (RPM):**	1,800
ENGINE POWER (BHP):	4,423	**HERTZ:**	60
GEN POWER WITH FAN (EKW):	3,000.0	**FAN POWER (HP):**	187.7
COMPRESSION RATIO:	15.3	**ASPIRATION:**	TA
RATING LEVEL:	MISSION CRITICAL STANDBY	**AFTERCOOLER TYPE:**	SCAC
PUMP QUANTITY:	2	**AFTERCOOLER CIRCUIT TYPE:**	JW+OC+1AC, 2AC
FUEL TYPE:	DIESEL	**AFTERCOOLER TEMP (F):**	115
MANIFOLD TYPE:	DRY	**JACKET WATER TEMP (F):**	210.2
GOVERNOR TYPE:	ADEM4	**TURBO CONFIGURATION:**	PARALLEL
ELECTRONICS TYPE:	ADEM4	**TURBO QUANTITY:**	4
CAMSHAFT TYPE:	STANDARD	**TURBOCHARGER MODEL:**	GTB6251BN-48T-1.38
IGNITION TYPE:	CI	**CERTIFICATION YEAR:**	2008
INJECTOR TYPE:	CR	**CRANKCASE BLOWBY RATE (FT3/HR):**	2,436.4
FUEL INJECTOR:	4439455	**FUEL RATE (RATED RPM) NO LOAD (GAL/HR):**	25.1
REF EXH STACK DIAMETER (IN):	14	**PISTON SPD @ RATED ENG SPD (FT/MIN):**	2,598.4

INDUSTRY	SUBINDUSTRY	APPLICATION
OIL AND GAS	LAND PRODUCTION	PACKAGED GENSET
ELECTRIC POWER	STANDARD	PACKAGED GENSET

General Performance Data

GENSET POWER WITH FAN	PERCENT LOAD	ENGINE POWER	BRAKE MEAN EFF PRES (BMEP)	BRAKE SPEC FUEL CONSUMPTN (BSFC)	VOL FUEL CONSUMPTN (VFC)	INLET MFLD PRES	INLET MFLD TEMP	EXH MFLD TEMP	EXH MFLD PRES	ENGINE OUTLET TEMP
EKW	%	BHP	PSI	LB/BHP-HR	GAL/HR	IN-HG	DEG F	DEG F	IN-HG	DEG F
3,000.0	100	4,423	377	0.338	213.2	91.9	121.6	1,210.6	63.1	894.9
2,700.0	90	3,999	341	0.335	191.1	82.0	121.3	1,161.6	54.8	876.2
2,400.0	80	3,576	305	0.336	171.6	73.8	121.1	1,122.7	48.2	861.4
2,250.0	75	3,364	286	0.339	162.8	70.4	121.1	1,106.9	45.6	855.4
2,100.0	70	3,152	268	0.345	155.5	68.2	121.2	1,096.9	43.9	851.5
1,800.0	60	2,729	232	0.365	142.4	64.4	121.4	1,082.2	41.4	845.8
1,500.0	50	2,305	196	0.392	129.2	59.9	121.6	1,068.3	38.7	841.0
1,200.0	40	1,882	160	0.419	112.6	50.1	121.2	1,043.7	32.5	833.2
900.0	30	1,458	124	0.448	93.3	38.6	120.8	1,011.1	25.6	823.3
750.0	25	1,246	106	0.465	82.9	32.6	120.7	992.4	22.1	817.8
600.0	20	1,035	88	0.486	71.8	26.5	120.7	956.4	18.6	799.8
300.0	10	611	52	0.549	47.9	14.1	121.1	792.3	11.6	696.1

GENSET POWER WITH FAN	PERCENT LOAD	ENGINE POWER	COMPRESSOR OUTLET PRES	COMPRESSOR OUTLET TEMP	WET INLET AIR VOL FLOW RATE	ENGINE OUTLET WET EXH GAS VOL FLOW RATE	WET INLET AIR MASS FLOW RATE	WET EXH GAS MASS FLOW RATE	WET EXH VOL FLOW RATE (32 DEG F AND 29.98 IN HG)	DRY EXH VOL FLOW RATE (32 DEG F AND 29.98 IN HG)
EKW	%	BHP	IN-HG	DEG F	CFM	CFM	LB/HR	LB/HR	FT3/MIN	FT3/MIN
3,000.0	100	4,423	91	449.9	9,354.6	24,561.2	41,178.2	42,670.8	8,914.9	8,125.8
2,700.0	90	3,999	82	413.5	8,669.4	22,333.8	37,919.5	39,258.2	8,219.9	7,506.8
2,400.0	80	3,576	74	383.9	8,104.4	20,515.6	35,241.7	36,443.9	7,635.4	6,989.2
2,250.0	75	3,364	70	371.6	7,867.0	19,759.9	34,120.5	35,261.2	7,387.5	6,771.0
2,100.0	70	3,152	68	364.5	7,728.5	19,298.5	33,455.9	34,545.6	7,236.5	6,643.0
1,800.0	60	2,729	64	353.0	7,492.6	18,546.1	32,341.4	33,337.7	6,984.7	6,432.9
1,500.0	50	2,305	60	338.7	7,182.4	17,661.1	30,929.1	31,831.8	6,676.1	6,168.3
1,200.0	40	1,882	50	308.4	6,446.9	15,853.5	27,583.4	28,376.7	6,029.1	5,577.3
900.0	30	1,458	39	267.3	5,556.6	13,501.7	23,627.7	24,286.8	5,174.3	4,794.1
750.0	25	1,246	33	243.4	5,078.3	12,165.9	21,540.3	22,123.2	4,682.6	4,345.1
600.0	20	1,035	27	217.5	4,586.9	10,746.2	19,412.2	19,914.7	4,195.0	3,902.4
300.0	10	611	14	160.7	3,587.5	7,713.3	15,115.2	15,450.4	3,281.3	3,076.1

Heat Rejection Data

PUMP POWER IS INCLUDED IN HEAT REJECTION BALANCE, BUT IS NOT SHOWN.

GENSET	PERCENT	ENGINE	REJECTION	REJECTION	REJECTION	EXHUAST	FROM OIL	FROM 2ND	WORK	LOW HEAT	HIGH HEAT

POWER WITH FAN	LOAD	POWER	TO JACKET WATER	TO ATMOSPHERE	TO EXH	RECOVERY TO 350F	COOLER	STAGE AFTERCOOLER	ENERGY	VALUE ENERGY	VALUE ENERGY
EKW	%	BHP	BTU/MIN	BTU/MIN	BTU/MIN	BTU/MIN	BTU/MIN	BTU/MIN	BTU/MIN	BTU/MIN	BTU/MIN
3,000.0	100	4,423	78,059	10,340	177,889	98,540	24,373	27,992	187,548	457,607	487,466
2,700.0	90	3,999	69,753	9,728	158,027	87,354	21,844	22,735	169,590	410,123	436,884
2,400.0	80	3,576	62,813	9,257	142,134	78,630	19,611	18,646	151,631	368,192	392,217
2,250.0	75	3,364	59,856	9,074	135,676	75,107	18,605	17,040	142,651	349,309	372,102
2,100.0	70	3,152	57,689	8,964	131,604	72,930	17,781	16,060	133,672	333,838	355,621
1,800.0	60	2,729	54,062	8,823	125,449	69,433	16,278	14,739	115,714	305,626	325,568
1,500.0	50	2,305	50,534	8,716	119,331	65,520	14,768	13,646	97,755	277,263	295,355
1,200.0	40	1,882	45,771	8,538	108,948	57,374	12,870	11,188	79,796	241,627	257,393
900.0	30	1,458	39,630	8,265	94,183	48,019	10,669	8,349	61,838	200,308	213,378
750.0	25	1,246	36,078	8,096	85,285	43,193	9,471	7,028	52,858	177,821	189,424
600.0	20	1,035	31,984	7,842	74,947	37,306	8,207	5,910	43,879	154,087	164,142
300.0	10	611	21,612	6,922	48,843	22,014	5,475	4,318	25,920	102,790	109,497

Sound Data

SOUND DATA REPRESENTATIVE OF NOISE PRODUCED BY THE "ENGINE ONLY"

EXHAUST: Sound Power (1/3 Octave Frequencies)

GENSET POWER WITH FAN	PERCENT LOAD	ENGINE POWER	OVERALL SOUND	100 HZ	125 HZ	160 HZ	200 HZ	250 HZ	315 HZ	400 HZ	500 HZ	630 HZ
EKW	%	BHP	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)
3,000.0	100	4,423	134.5	109.7	115.8	113.7	115.5	116.0	119.0	119.9	121.5	120.4
2,700.0	90	3,999	133.2	110.2	116.1	112.6	114.3	114.5	117.3	118.4	120.1	118.3
2,400.0	80	3,576	132.0	111.6	116.6	111.0	112.7	113.0	115.6	116.9	118.4	116.5
2,250.0	75	3,364	131.4	112.4	116.8	110.2	111.9	112.3	114.8	116.2	117.6	115.6
2,100.0	70	3,152	130.7	113.2	117.1	109.3	111.1	111.6	114.0	115.5	116.8	114.7
1,800.0	60	2,729	129.5	114.8	117.6	107.5	109.4	110.2	112.3	114.1	115.1	113.0
1,500.0	50	2,305	128.2	116.3	118.1	105.8	107.8	108.7	110.6	112.6	113.4	111.2
1,200.0	40	1,882	127.0	117.9	118.6	104.1	106.1	107.3	108.9	111.2	111.8	109.5
900.0	30	1,458	125.7	119.5	119.1	102.3	104.4	105.9	107.3	109.8	110.1	107.7
750.0	25	1,246	125.1	120.2	119.3	101.4	103.6	105.2	106.4	109.1	109.3	106.8
600.0	20	1,035	124.4	121.0	119.6	100.6	102.8	104.5	105.6	108.4	108.4	105.9
300.0	10	611	123.2	122.6	120.0	98.8	101.1	103.0	103.9	106.9	106.8	104.2

EXHAUST: Sound Power (1/3 Octave Frequencies)

GENSET POWER WITH FAN	PERCENT LOAD	ENGINE POWER	1000 HZ	1250 HZ	1600 HZ	2000 HZ	2500 HZ	3150 HZ	4000 HZ	5000 HZ	6300 HZ	8000 HZ
EKW	%	BHP	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)
3,000.0	100	4,423	122.2	122.6	123.5	124.9	124.7	123.1	122.4	121.6	120.1	119.0
2,700.0	90	3,999	120.7	121.0	122.2	123.5	123.2	121.5	120.8	120.0	118.7	117.8
2,400.0	80	3,576	119.4	119.7	120.8	122.5	121.9	120.4	119.8	119.0	117.7	117.1
2,250.0	75	3,364	118.8	119.1	120.1	122.0	121.3	119.9	119.4	118.6	117.2	116.8
2,100.0	70	3,152	118.1	118.5	119.4	121.5	120.6	119.3	119.0	118.2	116.7	116.5
1,800.0	60	2,729	116.9	117.3	118.0	120.4	119.4	118.3	118.1	117.3	115.6	115.9
1,500.0	50	2,305	115.6	116.2	116.6	119.4	118.1	117.3	117.2	116.4	114.6	115.3
1,200.0	40	1,882	114.3	115.0	115.1	118.4	116.8	116.3	116.4	115.6	113.6	114.7
900.0	30	1,458	113.1	113.8	113.7	117.4	115.6	115.3	115.5	114.7	112.6	114.1
750.0	25	1,246	112.4	113.2	113.0	116.9	114.9	114.8	115.1	114.3	112.1	113.8
600.0	20	1,035	111.8	112.6	112.3	116.4	114.3	114.2	114.7	113.9	111.6	113.5
300.0	10	611	110.5	111.4	110.9	115.4	113.0	113.2	113.8	113.0	110.6	112.9

Sound Data (Continued)

MECHANICAL: Sound Power (1/3 Octave Frequencies)

GENSET POWER WITH FAN	PERCENT LOAD	ENGINE POWER	OVERALL SOUND	100 HZ	125 HZ	160 HZ	200 HZ	250 HZ	315 HZ	400 HZ	500 HZ	630 HZ
EKW	%	BHP	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)
3,000.0	100	4,423	125.9	89.8	105.6	98.4	100.6	104.5	108.3	111.6	113.3	112.5
2,700.0	90	3,999	125.8	89.4	105.5	97.9	100.9	103.3	108.7	111.1	112.7	112.2
2,400.0	80	3,576	126.0	89.0	105.0	97.8	99.8	102.4	108.0	111.0	111.8	111.9
2,250.0	75	3,364	126.1	88.8	104.7	97.8	99.1	102.1	107.5	111.0	111.3	111.7

2,100.0	70	3,152	126.2	88.5	104.3	97.8	98.4	101.7	107.0	111.0	110.8	111.6
1,800.0	60	2,729	126.5	88.1	103.7	97.8	96.9	100.9	106.0	111.0	109.8	111.2
1,500.0	50	2,305	126.7	87.7	103.0	97.8	95.4	100.2	105.1	111.0	108.8	110.9
1,200.0	40	1,882	127.0	87.3	102.4	97.7	94.0	99.4	104.1	110.9	107.8	110.6
900.0	30	1,458	127.2	86.9	101.7	97.7	92.5	98.6	103.1	110.9	106.8	110.2
750.0	25	1,246	127.3	86.7	101.4	97.7	91.8	98.2	102.6	110.9	106.3	110.1
600.0	20	1,035	127.4	86.4	101.0	97.7	91.0	97.9	102.1	110.9	105.8	109.9
300.0	10	611	127.7	86.0	100.4	97.7	89.6	97.1	101.2	110.9	104.8	109.6

MECHANICAL: Sound Power (1/3 Octave Frequencies)

GENSET POWER WITH FAN	PERCENT LOAD	ENGINE POWER	1000 HZ	1250 HZ	1600 HZ	2000 HZ	2500 HZ	3150 HZ	4000 HZ	5000 HZ	6300 HZ	8000 HZ
EKW	%	BHP	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)
3,000.0	100	4,423	112.7	113.9	114.6	115.3	115.0	112.7	110.9	111.9	114.3	113.4
2,700.0	90	3,999	112.5	113.7	114.5	115.0	114.5	112.3	110.4	111.1	113.6	112.9
2,400.0	80	3,576	112.2	113.2	113.8	114.4	114.2	111.9	110.0	110.7	113.2	112.6
2,250.0	75	3,364	112.0	112.9	113.4	114.0	114.2	111.7	109.8	110.5	112.9	112.6
2,100.0	70	3,152	111.8	112.6	113.0	113.7	114.1	111.4	109.6	110.3	112.7	112.5
1,800.0	60	2,729	111.3	112.1	112.2	113.1	113.9	111.0	109.3	110.0	112.3	112.3
1,500.0	50	2,305	110.9	111.5	111.4	112.4	113.7	110.6	109.0	109.6	111.9	112.1
1,200.0	40	1,882	110.5	110.9	110.5	111.7	113.5	110.2	108.6	109.3	111.5	111.9
900.0	30	1,458	110.1	110.3	109.7	111.1	113.4	109.8	108.3	109.0	111.0	111.8
750.0	25	1,246	109.9	110.0	109.3	110.7	113.3	109.6	108.1	108.8	110.8	111.7
600.0	20	1,035	109.7	109.7	108.9	110.4	113.2	109.3	107.9	108.6	110.6	111.6
300.0	10	611	109.3	109.2	108.1	109.7	113.0	108.9	107.6	108.3	110.2	111.4

Emissions Data

RATED SPEED POTENTIAL SITE VARIATION: 1800 RPM

GENSET POWER WITH FAN		EKW	3,000.0	2,250.0	1,500.0	750.0	300.0
PERCENT LOAD		**%**	**100**	**75**	**50**	**25**	**10**
ENGINE POWER		**BHP**	**4,423**	**3,364**	**2,305**	**1,246**	**611**
TOTAL NOX (AS NO2)		G/HR	32,120	21,539	9,430	3,810	3,351
TOTAL CO		G/HR	2,658	3,451	1,789	1,814	1,830
TOTAL HC		G/HR	245	185	358	385	347
PART MATTER		G/HR	160.9	170.2	122.6	134.5	129.4
TOTAL NOX (AS NO2)	(CORR 5% O2)	MG/NM3	3,723.8	3,345.5	1,874.3	1,261.1	2,241.5
TOTAL CO	(CORR 5% O2)	MG/NM3	268.6	462.8	302.2	502.2	1,002.8
TOTAL HC	(CORR 5% O2)	MG/NM3	20.9	21.5	53.3	95.7	161.8
PART MATTER	(CORR 5% O2)	MG/NM3	14.0	19.8	18.4	33.9	64.3
TOTAL NOX (AS NO2)	(CORR 5% O2)	PPM	1,814	1,630	913	614	1,092
TOTAL CO	(CORR 5% O2)	PPM	215	370	242	402	802
TOTAL HC	(CORR 5% O2)	PPM	39	40	100	179	302
TOTAL NOX (AS NO2)		G/HP-HR	7.29	6.42	4.09	3.05	5.47
TOTAL CO		G/HP-HR	0.60	1.03	0.78	1.45	2.99
TOTAL HC		G/HP-HR	0.06	0.06	0.16	0.31	0.57
PART MATTER		G/HP-HR	0.04	0.05	0.05	0.11	0.21
TOTAL NOX (AS NO2)		LB/HR	70.81	47.49	20.79	8.40	7.39
TOTAL CO		LB/HR	5.86	7.61	3.94	4.00	4.03
TOTAL HC		LB/HR	0.54	0.41	0.79	0.85	0.76
PART MATTER		LB/HR	0.35	0.38	0.27	0.30	0.29

RATED SPEED NOMINAL DATA: 1800 RPM

GENSET POWER WITH FAN		EKW	3,000.0	2,250.0	1,500.0	750.0	300.0
PERCENT LOAD		**%**	**100**	**75**	**50**	**25**	**10**
ENGINE POWER		**BHP**	**4,423**	**3,364**	**2,305**	**1,246**	**611**
TOTAL NOX (AS NO2)		G/HR	26,766	17,949	7,858	3,175	2,792
TOTAL CO		G/HR	1,477	1,917	994	1,008	1,017
TOTAL HC		G/HR	184	139	269	289	261
TOTAL CO2		KG/HR	2,236	1,651	1,287	779	428
PART MATTER		G/HR	115.0	121.5	87.6	96.1	92.4
TOTAL NOX (AS NO2)	(CORR 5% O2)	MG/NM3	3,103.2	2,787.9	1,561.9	1,050.9	1,867.9
TOTAL CO	(CORR 5% O2)	MG/NM3	149.2	257.1	167.9	279.0	557.1
TOTAL HC	(CORR 5% O2)	MG/NM3	15.7	16.2	40.1	72.0	121.7
PART MATTER	(CORR 5% O2)	MG/NM3	10.0	14.2	13.1	24.2	45.9
TOTAL NOX (AS NO2)	(CORR 5% O2)	PPM	1,512	1,358	761	512	910

TOTAL CO	(CORR 5% O2)	PPM	119	206	134	223	446
TOTAL HC	(CORR 5% O2)	PPM	29	30	75	134	227
TOTAL NOX (AS NO2)		G/HP-HR	6.07	5.35	3.41	2.55	4.56
TOTAL CO		G/HP-HR	0.34	0.57	0.43	0.81	1.66
TOTAL HC		G/HP-HR	0.04	0.04	0.12	0.23	0.43
PART MATTER		G/HP-HR	0.03	0.04	0.04	0.08	0.15
TOTAL NOX (AS NO2)		LB/HR	59.01	39.57	17.32	7.00	6.16
TOTAL CO		LB/HR	3.26	4.23	2.19	2.22	2.24
TOTAL HC		LB/HR	0.41	0.31	0.59	0.64	0.57
TOTAL CO2		LB/HR	4,930	3,639	2,836	1,717	943
PART MATTER		LB/HR	0.25	0.27	0.19	0.21	0.20
OXYGEN IN EXH		%	9.6	10.2	11.6	12.7	14.5
DRY SMOKE OPACITY		%	0.7	1.0	0.3	0.8	1.8
BOSCH SMOKE NUMBER			0.25	0.36	0.13	0.29	0.62

Regulatory Information

EPA TIER 2		**2006 - 2010**		
Locality	**Agency**	**Regulation**	**Tier/Stage**	**Max Limits - G/BKW - HR**
U.S. (INCL CALIF)	EPA	NON-ROAD	TIER 2	CO: 3.5 NOx + HC: 6.4 PM: 0.20

EPA EMERGENCY STATIONARY		**2011 - ----**		
Locality	**Agency**	**Regulation**	**Tier/Stage**	**Max Limits - G/BKW - HR**
U.S. (INCL CALIF)	EPA	STATIONARY	EMERGENCY STATIONARY	CO: 3.5 NOx + HC: 6.4 PM: 0.20

Altitude Derate Data

ALTITUDE DERATE DATA IS BASED ON THE ASSUMPTION OF A 20 DEGREES CELSIUS(36 DEGREES FAHRENHEIT) DIFFERENCE BETWEEN AMBIENT OPERATING TEMPERATURE AND ENGINE INLET MANIFOLD TEMPERATURE (IMAT). AMBIENT OPERATING TEMPERATURE IS DEFINED AS THE AIR TEMPERATURE MEASURED AT THE TURBOCHARGER COMPRESSOR INLET.

ALTITUDE CORRECTED POWER CAPABILITY (BHP)

AMBIENT OPERATING TEMP (F)	**30**	**40**	**50**	**60**	**70**	**80**	**90**	**100**	**110**	**120**	**130**	**140**	**NORMAL**
ALTITUDE (FT)													
0	4,423	4,423	4,423	4,423	4,423	4,423	4,423	4,423	4,423	4,423	4,423	4,423	4,423
1,000	4,423	4,423	4,423	4,423	4,423	4,423	4,423	4,423	4,423	4,423	4,423	4,405	4,423
2,000	4,423	4,423	4,423	4,423	4,423	4,423	4,423	4,423	4,423	4,423	4,423	4,355	4,423
3,000	4,423	4,423	4,423	4,423	4,423	4,423	4,423	4,423	4,423	4,376	4,309	4,216	4,423
4,000	4,345	4,345	4,345	4,345	4,345	4,345	4,344	4,344	4,343	4,280	4,190	4,100	4,345
5,000	4,174	4,174	4,174	4,174	4,174	4,174	4,173	4,172	4,170	4,130	4,073	4,017	4,174
6,000	4,015	4,015	4,015	4,015	4,015	4,015	4,013	4,011	4,008	3,988	3,960	3,933	4,015
7,000	3,868	3,868	3,868	3,868	3,868	3,868	3,866	3,863	3,859	3,853	3,847	3,840	3,868
8,000	3,751	3,751	3,751	3,751	3,751	3,751	3,749	3,745	3,742	3,736	3,729	3,723	3,751
9,000	3,634	3,634	3,634	3,634	3,634	3,634	3,633	3,628	3,624	3,618	3,612	3,606	3,634
10,000	3,523	3,523	3,523	3,523	3,523	3,523	3,521	3,517	3,512	3,506	3,500	3,495	3,523
11,000	3,417	3,417	3,417	3,417	3,417	3,417	3,415	3,411	3,406	3,400	3,394	3,388	3,417
12,000	3,312	3,312	3,312	3,312	3,312	3,312	3,310	3,304	3,299	3,294	3,288	3,282	3,312
13,000	3,206	3,206	3,206	3,206	3,206	3,206	3,204	3,198	3,193	3,188	3,182	3,176	3,206
14,000	3,100	3,100	3,100	3,100	3,100	3,100	3,098	3,093	3,088	3,083	3,079	3,074	3,100
15,000	2,993	2,993	2,993	2,993	2,993	2,993	2,991	2,988	2,984	2,981	2,977	2,974	2,993

Cross Reference

Test Spec	**Setting**	**Engine Arrangement**	**Engineering Model**	**Engineering Model Version**	**Start Effective Serial Number**	**End Effective Serial Number**
3704727	LL6307	3079788	GS265	-	WYB00620	

Performance Parameter Reference

Parameters Reference:DM9600-08

PERFORMANCE DEFINITIONS

PERFORMANCE DEFINITIONS DM9600
APPLICATION:
Engine performance tolerance values below are representative of a typical production engine tested in a calibrated dynamometer test cell at SAE J1995 standard reference conditions. Caterpillar maintains ISO9001:2000 certified quality management systems for engine test Facilities to assure accurate calibration of test equipment. Engine test data is corrected in accordance with SAE J1995. Additional reference material SAE J1228, J1349, ISO 8665, 3046-1:2002E, 3046-3:1989, 1585, 2534, 2288, and 9249 may apply in part or are similar to SAE J1995. Special engine rating request (SERR) test data shall be noted.
PERFORMANCE PARAMETER TOLERANCE FACTORS:
Power +/- 3%
Torque +/- 3%
Exhaust stack temperature +/- 8%
Inlet airflow +/- 5%
Intake manifold pressure-gage +/- 10%
Exhaust flow +/- 6%
Specific fuel consumption +/- 3%
Fuel rate +/- 5%
Specific DEF consumption +/- 3%
DEF rate +/- 5%
Heat rejection +/- 5%
Heat rejection exhaust only +/- 10%
Heat rejection CEM only +/- 10%
Heat Rejection values based on using treated water.
Torque is included for truck and industrial applications, do not use for Gen Set or steady state applications.
On C7 - C18 engines, at speeds of 1100 RPM and under these values are provided for reference only, and may not meet the tolerance listed.
These values do not apply to C280/3600. For these models, see the tolerances listed below.
C280/3600 HEAT REJECTION TOLERANCE FACTORS:
Heat rejection +/- 10%
Heat rejection to Atmosphere +/- 50%
Heat rejection to Lube Oil +/- 20%
Heat rejection to Aftercooler +/- 5%
TEST CELL TRANSDUCER TOLERANCE FACTORS:
Torque +/- 0.5%
Speed +/- 0.2%
Fuel flow +/- 1.0%
Temperature +/- 2.0 C degrees
Intake manifold pressure +/- 0.1 kPa
OBSERVED ENGINE PERFORMANCE IS CORRECTED TO SAE J1995 REFERENCE AIR AND FUEL CONDITIONS.
REFERENCE ATMOSPHERIC INLET AIR
FOR 3500 ENGINES AND SMALLER
SAE J1228 AUG2002 for marine engines, and J1995 JAN2014 for other engines, reference atmospheric pressure is 100 KPA (29.61 in hg), and standard temperature is 25deg C (77 deg F) at 30% relative humidity at the stated aftercooler water temp, or inlet manifold temp.
FOR 3600 ENGINES
Engine rating obtained and presented in accordance with ISO 3046/1 and SAE J1995 JANJAN2014 reference atmospheric pressure is 100 KPA (29.61 in hg), and standard temperature is 25deg C (77 deg F) at 30% relative humidity and 150M altitude at the stated aftercooler water temperature.
MEASUREMENT LOCATION FOR INLET AIR TEMPERATURE
Location for air temperature measurement air cleaner inlet at stabilized operating conditions.
REFERENCE EXHAUST STACK DIAMETER
The Reference Exhaust Stack Diameter published with this dataset is only used for the calculation of Smoke Opacity values displayed in this dataset. This value does not necessarily represent the actual stack diameter of the engine due to the variety of exhaust stack adapter options available. Consult the price list, engine order or general dimension drawings for the actual stack diameter size ordered or options available.
REFERENCE FUEL
DIESEL
Reference fuel is #2 distillate diesel with a 35API gravity;
A lower heating value is 42,780 KJ/KG (18,390 BTU/LB) when used at 29 (84.2), where the density is 838.9 G/Liter (7.001 Lbs/Gal).
GAS
Reference natural gas fuel has a lower heating value of 33.74 KJ/L (905 BTU/CU Ft). Low BTU ratings are based on 18.64 KJ/L (500 BTU/CU FT) lower heating value gas. Propane ratings are based on 87.56 KJ/L (2350 BTU/CU Ft) lower heating value gas.
ENGINE POWER (NET) IS THE CORRECTED FLYWHEEL POWER (GROSS) LESS EXTERNAL AUXILIARY LOAD
Engine corrected gross output includes the power required to drive standard equipment; lube oil, scavenge lube oil, fuel transfer, common rail fuel, separate circuit aftercooler and jacket water

pumps. Engine net power available for the external (flywheel) load is calculated by subtracting the sum of auxiliary load from the corrected gross flywheel out put power. Typical auxiliary loads are radiator cooling fans, hydraulic pumps, air compressors and battery charging alternators. For Tier 4 ratings additional Parasitic losses would also include Intake, and Exhaust Restrictions.

ALTITUDE CAPABILITY

Altitude capability is the maximum altitude above sea level at standard temperature and standard pressure at which the engine could develop full rated output power on the current performance data set.

Standard temperature values versus altitude could be seen on TM2001.

When viewing the altitude capability chart the ambient temperature is the inlet air temp at the compressor inlet.

Engines with ADEM MEUI and HEUI fuel systems operating at conditions above the defined altitude capability derate for atmospheric pressure and temperature conditions outside the values defined, see TM2001.

Mechanical governor controlled unit injector engines require a setting change for operation at conditions above the altitude defined on the engine performance sheet. See your Caterpillar technical representative for non standard ratings.

REGULATIONS AND PRODUCT COMPLIANCE

TMI Emissions information is presented at 'nominal' and 'Potential Site Variation' values for standard ratings. No tolerances are applied to the emissions data. These values are subject to change at any time. The controlling federal and local emission requirements need to be verified by your Caterpillar technical representative.

Customer's may have special emission site requirements that need to be verified by the Caterpillar Product Group engineer.

EMISSIONS DEFINITIONS:
Emissions : DM1176
HEAT REJECTION DEFINITIONS:
Diesel Circuit Type and HHV Balance : DM9500
HIGH DISPLACEMENT (HD) DEFINITIONS:
3500: EM1500
RATING DEFINITIONS:
Agriculture : TM6008
Fire Pump : TM6009
Generator Set : TM6035
Generator (Gas) : TM6041
Industrial Diesel : TM6010
Industrial (Gas) : TM6040
Irrigation : TM5749
Locomotive : TM6037
Marine Auxiliary : TM6036
Marine Prop (Except 3600) : TM5747
Marine Prop (3600 only) : TM5748
MSHA : TM6042
Oil Field (Petroleum) : TM6011
Off-Highway Truck : TM6039
On-Highway Truck : TM6038
SOUND DEFINITIONS:
Sound Power : DM8702
Sound Pressure : TM7080
Date Released : 7/7/15

From: Parker, Steve <SParker@NCPowerSystems.com>
Sent: Monday, May 21, 2018 1:54 PM
To: Mark Brunner
Subject: Fwd: Ammonia Slip

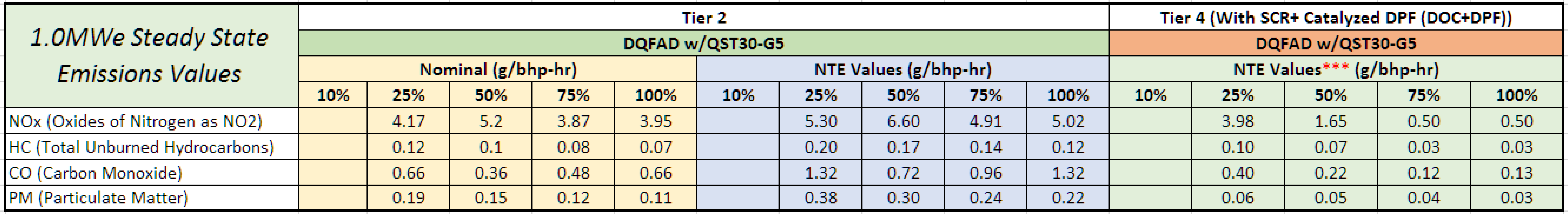
Mark,
See the slip data below.
Thank you

Steve

Sent from my mobile phone

Begin forwarded message:

> **From:** Paul Cook <Cook_Paul@cat.com>
> **Date:** May 21, 2018 at 10:49:33 AM PDT
> **To:** "sparker@ncpowersystems.com" <sparker@ncpowersystems.com>
> **Subject: Ammonia Slip**
>
> Steve,
>
> You can use ammonia slip of not-to-exceed 40 ppm.
>
> If there is a specific requirement let me know and we can dig further into it if needed.
>
> Let me know if you have any questions.
>
> Best regards,
>
> Paul Cook
> Business Development Manager
> Caterpillar Emissions Solutions
> Aftertreatment & Exhaust Systems
> Large Power Systems Division
> Office: 309-494-6977
> Mobile: 309-229-9726
> cook_paul@cat.com
>
>



1.0MWe Steady State Emissions Values	Tier 2										Tier 4 (With SCR+ Catalyzed DPF (DOC+DPF))				
	DQFAD w/QST30-G5										DQFAD w/QST30-G5				
	Nominal (g/bhp-hr)					NTE Values (g/bhp-hr)					NTE Values*** (g/bhp-hr)				
	10%	25%	50%	75%	100%	10%	25%	50%	75%	100%	10%	25%	50%	75%	100%
NOx (Oxides of Nitrogen as NO2)		4.17	5.2	3.87	3.95		5.30	6.60	4.91	5.02		3.98	1.65	0.50	0.50
HC (Total Unburned Hydrocarbons)		0.12	0.1	0.08	0.07		0.20	0.17	0.14	0.12		0.10	0.07	0.03	0.03
CO (Carbon Monoxide)		0.66	0.36	0.48	0.66		1.32	0.72	0.96	1.32		0.40	0.22	0.12	0.13
PM (Particulate Matter)		0.19	0.15	0.12	0.11		0.38	0.30	0.24	0.22		0.06	0.05	0.04	0.03

Exhaust emission data sheet 1000DQFAD

60 Hz Diesel generator set

Engine information:

Model:	Cummins Inc. QST30-G5 NR2	Bore:	5.51 in. (139 mm)
Type:	4 Cycle, 50° V, 12 cylinder diesel	Stroke:	6.5 in. (165 mm)
Aspiration:	Turbocharged and low temperature after-cooled	Displacement:	1860 cu. in. (30.4 liters)
Compression ratio:	14.7:1		
Emission control device:	After-cooled (air-to-air)		

Performance data	1/4 Standby	1/2 Standby	3/4 Standby	Full Standby	Full Prime
BHP @ 1800 RPM (60 Hz)	371	741	1112	1482	1322
Fuel consumption (gal/Hr)	19.1	35.8	54.1	72.2	63.9
Exhaust gas flow (CFM)	2780	4500	6370	7540	6950
Exhaust gas temperature (°F)	620	760	814	890	873
Exhaust emission data					
HC (Total unburned hydrocarbons)	0.12	0.10	0.08	0.07	0.08
NOx (Oxides of nitrogen as NO2)	4.17	5.20	3.87	3.95	4.00
CO (Carbon monoxide)	0.66	0.36	0.48	0.66	0.58
PM (Particular matter)	0.19	0.15	0.12	0.11	0.11
SO2 (Sulfur dioxide)	0.11	0.10	0.10	0.11	0.10
Smoke (Bosch)	0.88	0.80	0.79	0.73	0.75

All values are Grams/HP-Hour, Smoke is Bosch #

Test conditions

Data was recorded during steady-state rated engine speed (± 25 RPM) with full load (± 2%). Pressures, temperatures, and emission rates were stabilized.

Fuel specification:	46.5 Cetane Number, 0.035 Wt.% Sulfur; Reference ISO8178-5, 40CFR86. 1313-98 Type 2-D and ASTM D975 No. 2-D.
Fuel temperature:	99 ± 9 °F (at fuel pump inlet)
Intake air temperature:	77 ± 9 °F
Barometric pressure:	29.6 ± 1 in. Hg
Humidity:	NOx measurement corrected to 75 grains H2O/lb dry air
Reference standard:	ISO 8178

The NOx, HC, CO and PM emission data tabulated here were taken from a single engine under the test conditions shown above. Data for the other components are estimated. These data are subjected to instrumentation and engine-to-engine variability. Field emission test data are not guaranteed to these levels. Actual field test results may vary due to test site conditions, installation, fuel specification, test procedures and instrumentation. Engine operation with excessive air intake or exhaust restriction beyond published maximum limits, or with improper maintenance, may results in elevated emission levels.

NTE Emissions for MWH03 Project

3MWe Steady State Emissions Values	**Tier 2**										**Tier 4 (With SCR+ Catalyzed DPF (DOC+DPF))**				
	C3000D6e w/QSK95-G9										**C3000D6e w/QSK95-G9**				
	Nominal (g/bhp-hr)					**NTE Values (g/bhp-hr)**					**NTE Values*** (g/bhp-hr)**				
	10%	**25%**	**50%**	**75%**	**100%**	**10%**	**25%**	**50%**	**75%**	**100%**	**10%**	**25%**	**50%**	**75%**	**100%**
NOx (Oxides of Nitrogen as NO2)	4.83	3.44	3.26	4.23	5.23	6.13	4.37	4.14	5.37	6.64	6.13*	3.28	0.83	0.50	0.50
HC (Total Unburned Hydrocarbons)	0.63	0.3	0.18	0.1	0.07	1.07	0.51	0.31	0.17	0.12	1.07**	0.51**	0.31**	0.03	0.02
CO (Carbon Monoxide)	1.37	0.46	0.23	0.14	0.21	2.74	0.92	0.46	0.28	0.42	0.82	0.28	0.18	0.14	0.18
PM (Particulate Matter)	0.3	0.207	0.1	0.058	0.045	0.60	0.41	0.20	0.12	0.09	0.09	0.06	0.03	0.02	0.01

1.5MWe Steady State Emissions Values	**Tier 2**										**Tier 4 (With SCR+ Catalyzed DPF (DOC+DPF))**				
	DQGAF w/QSK60-G5										**DQGAF w/QSK60-G5**				
	Nominal (g/bhp-hr)					**NTE Values (g/bhp-hr)**					**NTE Values*** (g/bhp-hr)**				
	10%	**25%**	**50%**	**75%**	**100%**	**10%**	**25%**	**50%**	**75%**	**100%**	**10%**	**25%**	**50%**	**75%**	**100%**
NOx (Oxides of Nitrogen as NO2)	4.22	2.83	3.04	4.3	5.33	5.36	3.59	3.86	5.46	6.77	5.36*	1.80	0.77	0.50	0.50
HC (Total Unburned Hydrocarbons)	0.81	0.42	0.23	0.1	0.06	1.38	0.71	0.39	0.17	0.10	1.38**	0.71**	0.16	0.03	0.02
CO (Carbon Monoxide)	2.31	1.5	0.92	0.78	0.98	4.62	3.00	1.84	1.56	1.96	1.39	1.20	0.55	0.13	0.19
PM (Particulate Matter)	0.22	0.1	0.06	0.05	0.03	0.44	0.20	0.12	0.10	0.06	0.07	0.07	0.02	0.02	0.01

* :

At 10% load, the exhaust gases will pass through the SCR w/o any emissions reduction. Thus, NOx emissions will be same as Genset NOx NTE's at 10% load. Because at 10% load, SCR will not fuction due to very low Exh temp and Exh flow and there will be some percentage reduction for NOx but it will be very minimal. Tier 4 packager (Miratech) is not comfortable guarenting emissions values at 10% load for NOx because there are lot of variations that could impact emissions at this smaller load.

** :

Also, there will not be any reductions of HC until the temperature increases ~ 700F. Below 700F, the HC reductions are not consistent. Although there still may actually be some reductions- due to time, ambient conditions, and other variables, it is too risky to provide them in the form of a guarantee. Thus, HC Emissions, at areas where temp <700 deg F, will be same as Genset HC NTE values

*** :

These are the NTE emissions provided by Miratech with Tier 4 package installed on units 3MWe and 1.5MWe.

Power Generation

Exhaust Emission Data Sheet 1500DQGAF

60 Hz Diesel Generator Set

Engine Information:

Model:	Cummins Inc QSK50-G5 NR2	Bore:	6.25 in. (159 mm)
Type:	4 Cycle, 60°V, 16 Cylinder Diesel	Stroke:	6.25 in. (159 mm)
Aspiration:	Turbocharged and Low Temperature Aftercooled (2 Pump/2 Loop)	Displacement:	3067 cu. In. (50.2 liters)
Compression Ratio:	15.0:1		
Emission Control Device:	Electronic Control		

	1/4 Standby	1/2 Standby	3/4 Standby	Full Standby	Full Prime
PERFORMANCE DATA					
BHP @ 1800 RPM (60 Hz)	555	1110	1665	2220	1971
Fuel Consumption (gal/Hr)	35	62	83	108	96
Exhaust Gas Flow (CFM)	4714	8322	9947	11734	10894
Exhaust Gas Temperature (°F)	739	796	831	937	875
EXHAUST EMISSION DATA					
HC (Total Unburned Hydrocarbons)	0.42	0.23	0.1	0.06	0.08
NOx (Oxides of Nitrogen as NO2)	2.83	3.04	4.3	5.33	4.96
CO (carbon Monoxide)	1.5	0.92	0.78	0.98	0.8
PM (Particular Matter)	0.1	0.06	0.05	0.03	0.03
SO2 (Sulfur Dioxide)	0.01	0.01	0.01	0.01	0.01
Smoke (Bosch)	0.36	0.23	0.25	0.21	0.2

All values are Grams per HP-Hour

TEST CONDITIONS

Data is representative of steady-state engine speed (± 25 RPM) at designated genset loads. Pressures, temperatures, and emission rates were stabilized.

Fuel Specification:	ASTM D975 No. 2-D diesel fuel with ULSD, and 40-48 cetane number.
Fuel Temperature:	99 ± 9 °F (at fuel pump inlet)
Intake Air Temperature:	77 ± 9 °F
Barometric Pressure:	29.6 ± 1 in. Hg
Humidity:	NOx measurement corrected to 75 grains H2O/lb dry air
Reference Standard:	ISO 8178

The NOx, HC, CO and PM emission data tabulated here are representative of test data taken from a single engine under the test conditions shown above. Data for the other components are estimated. These data are subjected to instrumentation and engine-to-engine variability. Field emission test data are not guaranteed to these levels. Actual field test results may vary due to test site conditions, installation, fuel specification, test procedures and instrumentation. Engine operation with excessive air intake or exhaust restriction beyond published maximum limits, or with improper maintenance, may results in elevated emission levels.

NTE Emissions for MWH03 Project

3MWe Steady State Emissions Values	**Tier 2**										**Tier 4 (With SCR+ Catalyzed DPF (DOC+DPF))**				
	C3000D6e w/QSK95-G9										**C3000D6e w/QSK95-G9**				
	Nominal (g/bhp-hr)					**NTE Values (g/bhp-hr)**					**NTE Values*** (g/bhp-hr)**				
	10%	**25%**	**50%**	**75%**	**100%**	**10%**	**25%**	**50%**	**75%**	**100%**	**10%**	**25%**	**50%**	**75%**	**100%**
NOx (Oxides of Nitrogen as NO2)	4.83	3.44	3.26	4.23	5.23	6.13	4.37	4.14	5.37	6.64	6.13*	3.28	0.83	0.50	0.50
HC (Total Unburned Hydrocarbons)	0.63	0.3	0.18	0.1	0.07	1.07	0.51	0.31	0.17	0.12	1.07**	0.51**	0.31**	0.03	0.02
CO (Carbon Monoxide)	1.37	0.46	0.23	0.14	0.21	2.74	0.92	0.46	0.28	0.42	0.82	0.28	0.18	0.14	0.18
PM (Particulate Matter)	0.3	0.207	0.1	0.058	0.045	0.60	0.41	0.20	0.12	0.09	0.09	0.06	0.03	0.02	0.01

1.5MWe Steady State Emissions Values	**Tier 2**										**Tier 4 (With SCR+ Catalyzed DPF (DOC+DPF))**				
	DQGAF w/QSK60-G5										**DQGAF w/QSK60-G5**				
	Nominal (g/bhp-hr)					**NTE Values (g/bhp-hr)**					**NTE Values*** (g/bhp-hr)**				
	10%	**25%**	**50%**	**75%**	**100%**	**10%**	**25%**	**50%**	**75%**	**100%**	**10%**	**25%**	**50%**	**75%**	**100%**
NOx (Oxides of Nitrogen as NO2)	4.22	2.83	3.04	4.3	5.33	5.36	3.59	3.86	5.46	6.77	5.36*	1.80	0.77	0.50	0.50
HC (Total Unburned Hydrocarbons)	0.81	0.42	0.23	0.1	0.06	1.38	0.71	0.39	0.17	0.10	1.38**	0.71**	0.16	0.03	0.02
CO (Carbon Monoxide)	2.31	1.5	0.92	0.78	0.98	4.62	3.00	1.84	1.56	1.96	1.39	1.20	0.55	0.13	0.19
PM (Particulate Matter)	0.22	0.1	0.06	0.05	0.03	0.44	0.20	0.12	0.10	0.06	0.07	0.07	0.02	0.02	0.01

* :

At 10% load, the exhaust gases will pass through the SCR w/o any emissions reduction. Thus, NOx emissions will be same as Genset NOx NTE's at 10% load. Because at 10% load, SCR will not fuction due to very low Exh temp and Exh flow and there will be some percentage reduction for NOx but it will be very minimal. Tier 4 packager (Miratech) is not comfortable guarenting emissions values at 10% load for NOx because there are lot of variations that could impact emissions at this smaller load.

** :

Also, there will not be any reductions of HC until the temperature increases ~ 700F. Below 700F, the HC reductions are not consistent. Although there still may actually be some reductions- due to time, ambient conditions, and other variables, it is too risky to provide them in the form of a guarantee. Thus, HC Emissions, at areas where temp <700 deg F, will be same as Genset HC NTE values

*** :

These are the NTE emissions provided by Miratech with Tier 4 package installed on units 3MWe and 1.5MWe.

Exhaust Emission Data Sheet
C3000 D6e
60 Hz Diesel Generator Set
Tier 2

Engine Information:

Model:	Cummins Inc. QSK95-G9	Bore:	7.48 in. (190 mm)
Type:	4 Cycle, VEE, 16 Cylinder Diesel	Stroke:	8.27 in. (210 mm)
Aspiration:	Turbocharged and Aftercooled	Displacement:	5816 cu. in. (95.3 liters)

Compression Ratio: 15.5:1
Emission Control Device: Turbocharger and Aftercooled.
Emission Level: Stationary Emergency Emission-Nonroad

PERFORMANCE DATA	**1/4 Standby**	**1/2 Standby**	**3/4 Standby**	**Full Standby**	**Full Prime**	**Full Continuous**
BHP @ 1800 RPM (60 Hz)	1155	2206	3256	4307	3918	3572
Fuel Consumption (Gal/Hr)	68	118	160	208	190	174
Exhaust Gas Flow (CFM)	10028	16018	19695	23365	21993	20776
Exhaust Gas Temperature (°F)	630	670	714	830	783	745
EXHAUST EMISSION DATA						
HC (Total Unburned Hydrocarbons)	0.30	0.18	0.10	0.07	0.08	0.09
NOx (Oxides of Nitrogen as NO2)	3.44	3.26	4.23	5.23	4.86	4.54
CO (Carbon Monoxide)	0.46	0.23	0.14	0.21	0.18	0.16
PM (Particulate Matter)	0.207	0.100	0.058	0.045	0.049	0.053
SO2 (Sulfur Dioxide)	0.006	0.005	0.005	0.005	0.005	0.005
Smoke (FSN)	0.92	0.61	0.46	0.44	0.44	0.45

All Values are Grams/HP-Hour

TEST CONDITIONS

Steady-State emissions recorded per ISO8178-1 during operation at rated engine speed (+/-2%) and stated constant load (+/-2%) with engine temperatures, pressures and emission rates stabilized.

Fuel Specification:	40-48 Cetane Number, 0.03 -0.05 Wt.% Sulfur; Reference ISO8178-5, 40CFR86, 1313--98 Type 2-D and ASTM D975 No. 2-D.
Air Inlet Temperature :	25°C (77°F)
Fuel Inlet Temperature:	40°C (104°F)
Barometric Pressure:	100 kPa (29.53 in Hg)
Humidity:	NOx measurement corrected to 10.7 g/kg (75 grains H2O/lb) of dry air
Intake Restriction:	set to maximum allowable limit for clean filter
Exhaust Back Pressure:	Set to maximum allowable limit.

The NOx, HC, CO and PM emission data tabulated here are representative of test data taken from a single engine under the test conditions shown above. Data for the other components are estimated. These data are subjected to instrumentation and engine-to-engine variability. Field emission test data are not guaranteed to these levels. Actual field test results may vary due to test site conditions, installation, fuel specification, test procedures and instrumentation. Engine operation with excessive air intake or exhaust restriction beyond published maximum limits, or with improper maintenance, may results in elevated emission levels.

BALTIMORE
AIRCOIL COMPANY

Submittal Data Form

2-16-2018

Sold To :	**MWH03**	**Project:**	MWH03
		Engineer:	EDS - Chicago
		BAC Order #	U1872469

All Information is per Unit

Quantity: Fourteen (14) Model: Two Cell HXV-1012C-24T-L-2 CLOSED CIRCUIT COOLING TOWER UNITS

Certified Wet Capacity:
600.00 USGPM of Water from 98.00°F to 82.00°F at 74.00°F entering air wet bulb and 6.4 PSIG fluid pressure drop.

Certified Dry Capacity:
600.00 USGPM of Water from 98.00°F to 82.00°F at 46.00°F entering air dry bulb and 6.4 PSIG fluid pressure drop.
500.00 USGPM of Water from 98.00°F to 82.00°F at 55.00°F entering air dry bulb and 4.6 PSIG fluid pressure drop.
450.00 USGPM of Water from 98.00°F to 82.00°F at 58.00°F entering air dry bulb and 3.8 PSIG fluid pressure drop.

Fan Motor(s): Four (4) 7.5 HP fan motor(s): Totally Enclosed, Air Over (TEAO),
1 Speed/1 Winding - Premium Efficiency (Inverter Duty), suitable for 460 volt, 3 phase,
60 hertz electrical service and Space Heater.
NEMA Standard Mg.1 -- Part 31

Spray Pump(s): Two (2) 7.5 HP pump motor(s): 1,300 GPM per unit, 1 Speed/1 Winding - Energy Efficient, suitable for 460 volt, 3 phase, 60 hertz.

Submittal Information	Equipment Summary (All information is per cell)
Mechanical Specifications **Sound Data** **Submittal Drawings/Diagrams** UP-U1872469X Unit Print DC-U1872469X Dry Coil Connections SS-U1872469X Unit Support BA-U1872469X Basin Accessories VL-U1872469X VCOS Location EA-U1872469X External Access IA-U1872469X Internal Access BAC-16894 Combined Enclosure Wiring BAC-16895 Enclosure Diagram	Welded Type 304 Stainless Steel Construction in Cold Water Basin, Galvanized Steel Elsewhere Unit Structure designed in accordance with the 2015 IBC BALTIDRIVE® Power Train Independent Fan Drive Combined Inlet Shield Hail Guard PVC Fill & Drift Eliminators Galvanized Steel, Full Circuit Wet Coil Copper Full Circuit Dry Coil with Aluminum Finning Integral Pumps with End Make-Up (one cell only), Drain and Overflow Connections Brass Mechanical Float Valve Assembly High & Low Water Level Float Switches 12 Kw Electric Immersion Heaters Sized to Maintain +40°F water at a -17°F Ambient with Electrical Requirements Matching Fan Motor(s) Copper Heater Elements Low Water Level Cutout and Thermostat Electronic Vibration Cutout Switch Extended Bearing Lubrication Lines Motor Removal System External Platform with Safety Gate and Ladder with Safety Cage Located on Louver Face(s) of Unit 7' Ladder and Cage Extension for each Ladder Internal Walkway, Ladder with Safety Gate, Service Platform and grating with Galvanized Steel Supports BAC Controls with Single Point Connection Unit will ship in three sections Warranty Per Master Purchase Agreement

THANK YOU FOR YOUR BUSINESS!

Mechanical Specifications

2-16-2018

Project:	**MWH03**
Engineer:	ESD – Chicago
BAC Order #	U1872469

<u>All Information is per Unit</u>

Quantity: Fourteen (14) Model: Two Cell HXV-1012C-24T-L-2 CLOSED CIRCUIT COOLING TOWER UNITS

Materials of Construction:

Structural steel components are constructed from G-235 hot-dip galvanized steel. The edges of the hot-dip galvanized steel components are given a protective coat of zinc-rich compound. The basin is constructed of heavy gauge, weldable Type 304 stainless steel. All factory seams between panels inside the basin are welded water-tight. The basin includes a depressed section with drain/clean-out connection and area under the fill sections is sloped toward the depressed section for easy cleaning. All components that are in contact with the water in the basin and structural supports that extend into the basin will be constructed of Type 304 Stainless Steel. The basin is provided with a five (5) year leak proof guarantee. The casing is constructed entirely from heavy gauge, G-235 hot-dip galvanized steel panels. Hinged access doors are provided on each side wall of the tower for access to eliminators and fan plenum section for all cells. The door(s) is made of a steel frame matching the unit construction. The air inlet louvers are constructed of PVC honeycomb shape louver which also act as an air inlet screen and block sunlight to the basin and the front of the fill.

Unit Structure:

The structure of this product has been designed and analyzed in accordance with the wind load requirements of the 2015 IBC for a basic wind speed of 115 mph in exposure C.

Fan Drive:

Fan(s) are driven by a one-piece multi-groove, neoprene/polyester belt designed specifically for evaporative cooling equipment service. Motor is mounted on an adjustable motor base. Fan and motor sheaves are non-corrosive cast aluminum. The BALTIDRIVE® Power Train independent fan drive system, including fan motors, is warranted against defects in materials and workmanship for five (5) years from date of shipment. Fan(s) and steel fan shaft(s) are supported by heavy-duty, self-aligning, grease-packed, relubricatable ball bearings with special seals for protection against dust and moisture. All bearings are designed for minimum L10 life of 300,000 hours.

CIS Hail Guard:

Corrosion and UV Resistant PVC combined inlet shield hail guards are provided to protect the dry coil from hail damage.

Fill:

The BACross® Fill and integral drift eliminators are formed from self-extinguishing (per ASTM D-568) polyvinyl chloride (PVC), having a flame spread rating of 5 per ASTM Standard E84-77a, and are impervious to rot, decay, and fungus or biological attack. The fill is elevated above the cold water basin floor to facilitate cleaning. This fill is suitable for a maximum entering water temperature of 130°F. The eliminators are designed to limit drift loss to no greater than 0.0005% of the recirculating spray water flow rate and effectively strip entrained moisture from the leaving airstream with a minimum of air resistance.

Wet Coil Type:

The coil is suitable for cooling fluids compatible with carbon steel in a closed system. The coil(s) will be constructed with continuous 1.05" O.D. all prime surface steel tubes continuously formed and bent in a serpentine shape, encased in steel framework. The entire assembly is hot-dip galvanized after fabrication. Coil will be designed for free liquid drainage. Coil has a maximum allowable working pressure of 300 psig and is tested at 375 psig air pressure under water. The system should have a vent placed at the highest point in the installation to facilitate filling and drainage (provided and installed by installing contractor).

Dry Coil Type:

The coil(s) will be constructed with continuous 0.615” full circuit copper tubing with aluminum finning. Coil will have extended surface fins at 10 fins per inch fin density. This extended surface coil is designed to enhance dry operation. Coil has a maximum allowable working pressure of 250 psig and is tested at 320 psig air pressure under water. The system should have a vent placed at the highest point in the installation to facilitate filling and drainage (provided and installed by others). The coils will have a UV coating provided to maximize longevity.

Spray Water Pump Assembly:

Each cold water basin has an integral pump with large area, lift out, stainless steel strainer screens including perforated openings sized smaller than the water distribution nozzle orifices. Strainers include anti-vortexing baffles to prevent air entrainment. A close-coupled, bronze-fitted pump with a mechanical seal is mounted on the basin. The pump motors are energy efficient, totally enclosed, fan cooled (TEFC). A water bleed line with a metering valve to control the bleed rate is installed between the pump discharge and the overflow connection. Electrical requirements match the fan motor.

Basin Water Level Control:

The unit is supplied with a brass make-up valve with unsinkable polystyrene filled plastic float arranged for easy adjustment. The make-up valve is suitable for water supply pressures between 15 psig and 50 psig.

High & Low Water Level Float Switches:

Single-Pole, Double-Throw (SPDT) Liquid Level Float Switches provided in the cold water basin of the unit. When the level in the basin rises above or falls below the required level, the switch will close one circuit and open a second circuit. Field wiring by installing contractor.

Basin Heater(s):

A minimum number of high-watt-density electric immersion heater elements, sized to maintain +40°F basin water at -17°F ambient with a 10 mph wind speed, is provided. Electrical requirements match fan motor. Field wiring by installing contractor.

Heater Element Material of Construction:

The unit is supplied with copper heater elements.

Vibration Cutout Switch:

Fan system is provided with an appropriate number of Metrix Model 440 vibration cutout switches to shut down the unit in the event of excessive vibration. The vibration switch(es) is solid state with a frequency range of 2 to 1,000 Hz (120 to 60,000 RPM), a velocity set point of 0.1 to 1.5 In./Sec., and a time delay adjustable from 2 to 15 seconds. Input power required is 110 V, 50/60 Hz., 3 Watts. Shutdown switch is rated at 5 Amperes, 110 VAC TRIAC. Field wiring is by others.

Extended Lubrication Lines:

Bearing lubrication lines are extended to grease fittings located inside the unit and are accessible from the access door.

Motor Removal System:

Custom internal motor removal system including lifting point with removable grating sections to facilitate lowering of the motor to the internal walkway. Lifting device by to be provided by others.

External Platform at Louver Face:

The unit will be configured with a platform (with FRP grating) with galvanized supports, ladder with safety cage and safety railing on the louver face. The safety rails will be constructed of galvanized steel pipe. A spring loaded safety gate is provided. These access options meet OSHA standards. These components ship loose and are to be assembled and are installed in the field by others.

Ladder and Safety Cage Extension(s):

7' ladder and cage extensions are provided for each ladder.

Internal Access Option:

The unit has access doors on both unit ends, a center stainless steel walkway, and FRP grating between the walkway and the blank off panel of the cold water basin with a cutout for the mechanical make up. Internal walkway will be provided with safety railing on the air inlet side. An internal aluminum ladder and full service platform with galvanized steel supports is supplied to facilitate access to the mechanical equipment. Additional safety is provided by the spring loaded self-closing safety gates. All components meet pertinent OSHA standards.

BAC Controls:

NEMA 4X enclosure
480V 60Hz 3 Phase input power
Panel rating for SCCR of 65kA
Enclosure to include the following components:
(1) 12kW basin heater starter
Spray pump to be interlocked with basin heater to prevent heater from starting while pump is running
(1) 7.5HP pump starter
(2) 7.5HP fan motor ABB ACH-550 VFDs with 3% line reactor
Provide provisions for the connection of (2) Metrix 440 vibration cutout switches
Provide provisions for the connection and control of (2) fan motor space heaters
Enclosure shall be suitable for operation in ambient temperatures of -20°F to 110°F
Enclosure shall be shipped with all pertinent wiring diagrams
Enclosure shall be UL listed
Field wiring of the controls by installing contractor
FLA: 51.69A
MCA: 64.61A
MOP: 70A

APPENDIX B

Startup Emissions Estimation Method

APPENDIX B

Diesel Generator "Cold-Start Spike" Adjustment Factors

Short-term concentration trends for emissions of volatile organic compounds (VOCs), carbon monoxide (CO), and oxides of nitrogen (NO_x) immediately following a cold startup of a large diesel backup generator were measured by the California Energy Commission (CEC) in its document entitled Air Quality Implications of Backup Generators in California (Lents et al. 2005)[1]. CEC used continuous monitors to measure the trends shown in the attached figure (Figure B-1), which are discussed below.

As shown on Figure B-1, during the first 14 seconds after a cold start, the VOC concentration spiked to a maximum value of 900 parts per million (ppm) before dropping back to the steady-state exhaust concentration of 30 ppm. The measured (triangular) area under the 14-second concentration-vs-time curve represents emissions during a "VOC spike," which is 6,300 ppm-seconds.

Unlike VOC emissions, the NO_x exhaust concentration did not "spike" during cold-start. It took 8 seconds for the exhaust concentration of NO_x to rise from the initial value of zero to its steady-state concentration of 38 ppm. The measured area under the concentration-vs-time curve represents the "NO_x deficit" emissions of 160 ppm-seconds.

The CEC was unable to measure the time trend of diesel engine exhaust particulate matter (DEEP) concentrations during the first several seconds after a cold start. Therefore, for the purpose of estimating the DEEP trend, it was assumed that DEEP would exhibit the same concentration-vs-time trend as VOC emissions.

The numerical value of the Cold-start Spike Adjustment Factor was derived by dividing the area under the "cold-start spike" by the area under the steady-state concentration profile for the 1-minute averaging period.

Example: Cold-Start Spike Factor for VOCs, first 1-minute after cold-start at low load.

The "VOC spike" was observed 14 seconds after cold-start and reached a concentration of 6,300 ppm-seconds. The **<u>triangular</u>** area under the curve is $\frac{14\,\text{seconds} \times 900\,ppm}{2} = 6{,}300\;ppm\text{-}seconds$.

The steady-state VOC concentration is 30 *ppm*. For the 1-minute (60-seconds) steady-state period the area under the curve is $(60\;seconds - 14\;seconds) \times 30\;ppm\; = 1{,}380\;ppm\text{-}seconds.$

Therefore, the startup emission factor (to be applied to the warm-emission rate estimate for the first 1-minute after startup) was estimated by $\frac{6{,}300\;ppm{-}seconds\, +\, 1{,}380\;ppm{-}seconds}{30\;ppm \times 60\;seconds}$.

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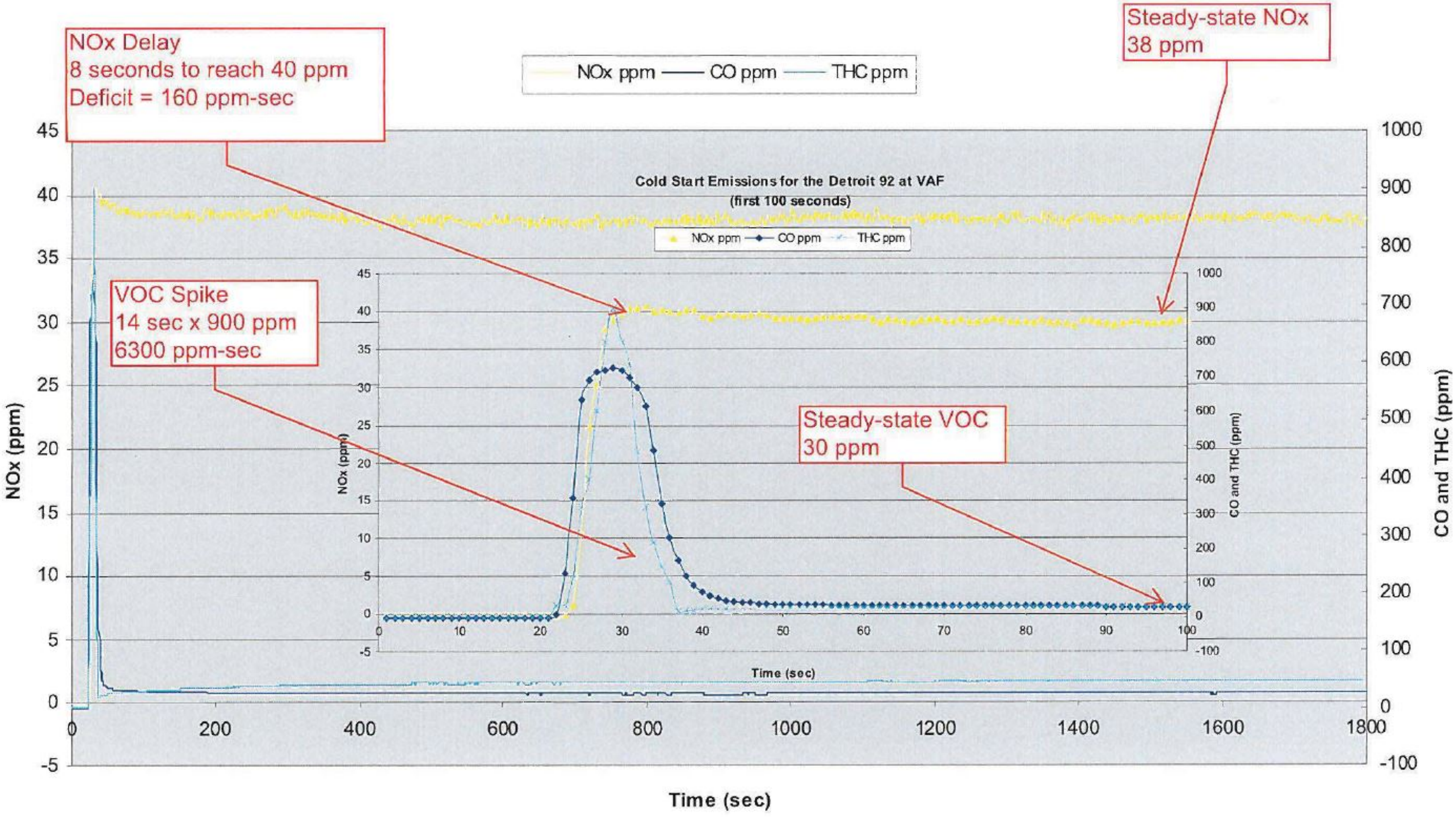
[1] Lents, J.M., L. Arth, M. Boretz, M. Chitjian, K. Cocker, N. Davis, K Johnson, Y Long, J.W. Miller, U. Mondragon, R.M. Nikkila, M. Omary, D. Pacocha, Y. Quin, S. Shah, and G. Tonnesen. 2005. Air Quality Implications of Backup Generators in California - Volume One: Generation Scenarios, Emissions and Atmospheric Modeling, and Health Risk Analysis. Publication No. CEC-500-2005-048. California Energy Commission, PIER Energy-Related Environmental Research. March.



Source: Lents et al. 2005.

Microsoft MWH Data Center
Quincy, Washington

Cold-Start Emission Trends

Figure
B-1

APPENDIX C

Best Available Control Technology Cost Summary Tables

Table C-1
Tier 4 Integrated Control Package Capital Cost
MWH-03/04/05/06 Data Center
Quincy, Washington

Cost Category	Cost Factor	Source of Cost Factor	Quant.	Unit Cost	Subtotal Cost
Direct Costs					
Purchased Equipment Costs					
3,000-KWe emission control package	Cost estimate by Cummins		68	$250,000	$17,000,000
3,000-KWe miscellaneous parts	Assumed no cost			$0	$0
1,500-KWe emission control package	Cost estimate by Cummins		4	$250,000	$1,000,000
1,500-KWe miscellaneous parts	Assumed no cost			$0	$0
Combined systems cost					$18,000,000
Instrumentation	Assumed no cost		0	$0	$0
Sales Tax	WA state tax	WA state tax	6.5%	--	$1,170,000
Shipping (3,000-KWe)		Johnson Matthey	68	$ 4,500	$306,000
Shipping (1,500-KWe)		Johnson Matthey	4	$ 4,500	$18,000
Subtotal Purchased Equipment Cost (PEC)					$19,494,000
Direct Installation Costs					
Enclosure structural supports (3,000-KWe)	Cost estimate by Johnson Matthey		68	$3,500	$238,000
Onsite Installation (3,000-KWe)	Cost estimate by Johnson Matthey		68	$22,000	$1,496,000.00
Enclosure structural supports (1,500-KWe)	Cost estimate by Johnson Matthey		4	$3,500	$14,000
Onsite Installation (1,500-KWe)	Cost estimate by Johnson Matthey		4	$22,000	$88,000
Electrical	Included above		0	$0	$0.00
Piping	Included above		0	$0	$0.00
Insulation	Assumed no cost		0	$0	$0.00
Painting	Assumed no cost		0	$0	$0.00
Subtotal Direct Installation Costs (DIC)					$1,836,000
Site Preparation and Buildings (SP)	Assumed no cost		0	$0	$0.00
Total Direct Costs, (DC = PEC + DIC + SP)					$21,330,000
Indirect Costs (Installation)					
Engineering		Johnson Matthey	72	$5,000	$360,000
Construction and field expenses		Johnson Matthey	72	$3,000	$216,000
Contractor Fees	From DIS data center		6.8%	--	$1,319,744
Startup		Johnson Matthey	72	$3,000	$216,000
Performance Test (Tech support)	0.01*PEC	EPA Cost Manual	1.0%	--	$194,940
Contingencies	0.03*PEC	EPA Cost Manual	3.0%	--	$584,820
Subtotal Indirect Costs (IC)					$2,891,504
Total Capital Investment (TCI = DC+IC)					**$24,221,504**

Table C-2
Tier 4 Integrated Control Package Cost Effectiveness
MWH-03/04/05/06 Data Center
Quincy, Washington

Item	Quantity	Units	Unit Cost	Units	Subtotal
Annualized Capital Recovery					
Total Capital Cost					$24,221,504
Capital Recovery Factor:	25	years	4%	discount	0.064
Subtotal Annualized 25-year Capital Recovery Cost					$1,550,466
Direct Annual Cost					
Increased Fuel Consumption	Insignificant				$0
Reagent Consumption (estimated by Pacific Power Group)	62,986	gallons/year	$4.00	per gallon	$251,942
Catalyst Replacement (EPA Manual)	Insignificant				$0
Annual operation/labor/maintenance costs: Upper-bound estimate would assume CARB's value of $1.50/hp/year and would result in $171,985/year. Lower-bound estimate would assume zero annual O&M. Mid-range value would account for fuel for pressure drop, increased inspections, periodic OEM visits, and the costs for Ecology's increased emission testing requirements. <u>For this screening-level analysis, we assumed the lower-bound annual O&M cost of zero.</u>					$0
Subtotal Direct Annual Cost					$251,942
Indirect Annual Costs					
Annual Admin charges (EPA Manual)	2.0%	of Total Capital Investment			$484,430
Annual Property tax (EPA Manual)	1.0%	of Total Capital Investment			$242,215
Annual Insurance (EPA Manual)	1.0%	of Total Capital Investment			$242,215
Subtotal Indirect Annual Costs					$968,860
Total Annual Cost (Capital Recovery + Direct Annual Costs + Indirect Annual Costs)					**$2,771,269**
Uncontrolled Emissions (Combined Pollutants)					246
Annual Tons Removed (Combined Pollutants)					207
Cost Effectiveness ($ per tons combined pollutant destroyed)					**$13,413**

Annual O&M Cost Based on CARB Factors (lowermost CARB estimate)			
$1,556,927	per year per generator	$778,463	per year per generator
3,000	KW-hr	1,500	KW-hr
17544	annual generator hours	1032	annual generator hours
$1.50	per HP_M per year	$1.50	per HP_M per year

MULTI-CRITERIA POLLUTANT COST EFFECTIVENESS (Reasonable vs. Actual Cost to Control)[a]

Pollutant	Ecology Acceptable Unit Cost ($/ton)	Forecast Removal (TPY)[a]	Subtotal Reasonable Annual Cost ($/year)
NO_x	$12,000	181	$2,166,033 per year
CO	$5,000	19.7	$98,684 per year
VOCs	$12,000	3.70	$44,385 per year
PM	$12,000	2.68	$32,135 per year
Total Reasonable Annual Control Cost for Combined Pollutants			$2,341,237 per year
Actual Annual Control Cost			$2,771,269 per year
		Is the Control Device Reasonable?	**NO (Actual >> Acceptable)**

CRITERIA POLLUTANT CONTROL EFFICIENCIES[a]

Pollutant	PM (FH)	CO	VOCs	NO_x
Tier 2 Uncontrolled Emissions (TPY)	3.15	24.7	4.62	213
Controlled Emissions (TPY)	0.473	4.9	0.92	32.9
TPY Removed	2.68	19.7	3.70	181
Combined Uncontrolled Emissions (TPY)	246			
Combined TPY Removed	207			
Expected Removal Efficiency	85%	80%	80%	90%
Annualized Cost ($/year)	$2,771,269			
Individual Pollutant $/Ton Removed	$1,034,867	$140,412	$749,247	$15,353

MULTI-TOXIC AIR POLLUTANT COST EFFECTIVENESS (Reasonable vs. Actual Cost to Control)[a]

Pollutant	ASIL ($\mu g/m^3$)	"Hanford Method" Cost Factor	Ecology Guidance "Ceiling Cost" ($/ton)	Forecast Removal (TPY)[a]	Subtotal Reasonable Annual Cost ($/year)
DEEP	0.00333	6.9	$72,544	2.68	$194,265 per year
CO	23,000	0.070	$731	19.7	$14,431 per year
NO_2 (10% of NO_x)	470	1.8	$18,472	19.2	$354,713 per year
Benzene	0.0345	5.9	$61,882	0.1658	$10,258 per year
1,3-Butadiene	0.00588	6.7	$69,951	8.4E-03	$584 per year
Acetaldehyde	0.37	4.9	$51,063	5.4E-03	$275 per year
Acrolein	0.06	5.7	$59,359	1.7E-03	$100 per year
Naphthalene	0.0294	6.0	$62,612	2.8E-02	$1,739 per year
Formaldehyde	0.167	5.2	$54,691	1.7E-02	$922 per year
Benzo(a)pyrene	9.09E-04	7.5	$78,464	5.5E-05	$4.31 per year
Benzo(a)anthracene	9.09E-03	6.5	$67,964	5.5E-05	$4 per year
Benzo(k)fluoranthene	9.09E-03	6.5	$67,964	4.7E-05	$3 per year
Benzo(b)fluoranthene	9.09E-03	6.5	$67,964	2.4E-04	$16.12 per year
Chrysene	9.09E-02	5.5	$57,464	3.3E-04	$18.78 per year
Dibenz(a,h)anthracene	8.33E-04	7.5	$78,863	7.4E-05	$5.83 per year
Indeno(1,2,3-cd)pyrene	9.09E-03	6.5	$67,964	8.8E-05	$6 per year
Xylenes	221	2.1	$21,913	4.1E-02	$903 per year
SO_2	660	1.6	$16,924	0.0	$0 per year
Propylene	3,000	1.0	$10,020	0.596	$5,972 per year
Carcinogenic VOCs	n.a.	n.a.	$9,999	0.220	$2,197 per year
Non-Carcinogenic VOCs	n.a.	n.a.	$5,000	0.699	$3,495 per year
Total Reasonable Annual Control Cost for Combined Pollutants					$589,911 per year
Actual Annual Control Cost					$2,771,269 per year
				Is the Control Device Reasonable?	**NO (Actual >> Acceptable)**

TOXIC AIR POLLUTANT CONTROL EFFICIENCIES[a]

TAP	Tier 2 Uncontrolled Emissions	Controlled Emissions (TPY)	TPY Removed	Expected Removal Efficiency	Individual Pollutant $/Ton Removed
DEEP	3.15	0.473	2.68	85%	$1,034,867
CO	24.67	4.9	19.7	80%	$140,412
NO_2 (10% of NOx)	21.34	2.13	19.2	90%	$144,319
Benzene	0.207	0.0414	0.1658	80%	$16,717,496
1,3-Butadiene	0.010	2.1E-03	8.35E-03	80%	$331,784,567
Acetaldehyde	0.007	1.3E-03	5.38E-03	80%	$514,792,722
Acrolein	2.10E-03	4.2E-04	1.68E-03	80%	$1,646,291,445
Naphthalene	3.47E-02	6.9E-03	2.78E-02	80%	$99,790,589
Formaldehyde	2.11E-02	4.2E-03	1.69E-02	80%	$164,420,489
Benzo(a)pyrene	6.86E-05	1.4E-05	5.49E-05	80%	$50,477,729,904
Benzo(a)anthracene	6.86E-05	1.4E-05	5.49E-05	80%	$50,477,729,904
Benzo(k)fluoranthene	5.82E-05	1.2E-05	4.66E-05	80%	$59,508,149,474
Benzo(b)fluoranthene	2.96E-04	5.9E-05	2.37E-04	80%	$11,687,186,113
Chrysene	4.09E-04	8.2E-05	3.27E-04	80%	$8,478,938,945
Dibenz(a,h)anthracene	9.24E-05	1.8E-05	7.39E-05	80%	$37,493,573,946
Indeno(1,2,3-cd)pyrene	1.11E-04	2.2E-05	8.84E-05	80%	$31,335,209,143
Xylenes	5.15E-02	0.0103	0.0412	80%	$67,216,459
SO_2	1.36E-01	0.136	0.0	0%	--
Propylene	7.45E-01	0.149	0.596	80%	$4,649,741
Carcinogenic VOCs	2.75E-01	0.0549	0.220	80%	$12,613,334
Non-Carcinogenic VOCs	8.74E-01	0.175	0.699	80%	$3,964,930
Annualized Cost ($/yr)					$2,771,269
Combined Uncontrolled Emissions (TPY)					50.4
Combined TPY Removed					42.5
Combined TAPs $/Ton Removed					$65,235

Notes:

FH ("front-half" filterable emissions)

BH ("back-half" condensable emissions)

PM (particulate matter) attributable to front-half and back-half emissions is assumed equal to the sum of vendor NTE values for PM and hydrocarbons.

DEEP (diesel engine exhaust particulate matter) is assumed equal to front-half NTE particulate emissions, as reported by the vendors.

DEEP (diesel engine exhaust particulate matter) is assumed equal to front-half NTE particulate emissions, as reported by the vendors.

[a] The expected Tier 4 control efficiency to reduce emission is 90% for NO_x, 85% for PM (front half), 80% for CO, and 80% for VOCs.

Table C-3
Selective Catalytic Reduction Capital Cost
MWH-03/04/05/06 Data Center
Quincy, Washington

Cost Category	Cost Factor	Source of Cost Factor	Quant.	Unit Cost	Subtotal Cost
Direct Costs					
Purchased Equipment Costs					
3,000-KWe emission control package	Cost estimate by Cummins		68	$200,000	$13,600,000
3,000-KWe miscellaneous parts	Assumed no cost			$0	$0
1,500-KWe emission control package	Cost estimate by Cummins		4	$200,000	$800,000
1,500--KWe miscellaneous parts	Assumed no cost			$0	$0
Combined systems cost					$14,400,000
Instrumentation	Assumed no cost		0	$0	$0
Sales Tax	WA state tax	WA state tax	6.5%	--	$936,000
Shipping (3,000-KWe)		Johnson Matthey	68	$3,500	$238,000
Shipping (1,500-KWe)		Johnson Matthey	4	$2,200	$8,800
Subtotal Purchased Equipment Cost (PEC)					$15,582,800
Direct Installation Costs					
Enclosure structural supports (3,000-KWe)	Cost estimate by Johnson Matthey		68	$2,500	$170,000
Onsite Installation (3,000-KWe)	Cost estimate by Johnson Matthey		68	$12,000	$816,000
Enclosure structural supports (1,500-KWe)	Cost estimate by Johnson Matthey		4	$2,200	$8,800
Onsite Installation (1,500-KWe)	Cost estimate by Johnson Matthey		4	$10,000	$40,000
Electrical	Included above		0	$0	$0
Piping	Included above		0	$0	$0
Insulation	Assumed no cost		0	$0	$0
Painting	Assumed no cost		0	$0	$0
Subtotal Direct Installation Costs (DIC)					$1,034,800
Site Preparation and Buildings (SP)	Assumed no cost		0	$0	$0
Total Direct Costs, (DC = PEC + DIC + SP)					$16,617,600
Indirect Costs (Installation)					
Engineering		Johnson Matthey	72	$3,000	$216,000
Construction and field expenses		Johnson Matthey	72	$3,000	$216,000
Contractor Fees	From DIS data center		6.8%	--	$1,054,956
Startup		Johnson Matthey	72	$3,000	$216,000
Performance Test (Tech support)	0.01*PEC	EPA Cost Manual	1.0%	--	$155,828
Contingencies	0.03*PEC	EPA Cost Manual	3.0%	--	$467,484
Subtotal Indirect Costs (IC)					$2,326,268
Total Capital Investment (TCI = DC+IC)					**$18,943,868**

Table C-4
Selective Catalytic Reduction Cost Effectiveness
MWH-03/04/05/06 Data Center
Quincy, Washington

Item	Quantity	Units	Unit Cost	Units	Subtotal
Annualized Capital Recovery					
Total Capital Cost					$18,943,868
Capital Recovery Factor:	25	years	4%	discount	0.064
Subtotal Annualized 25-year Capital Recovery Cost					$1,212,634
Direct Annual Cost					
Increased Fuel Consumption	Insignificant				$0
Reagent Consumption (estimated by Pacific Power Group)	62,986	gallons/year	$4.00	per gallon	$251,942
Catalyst Replacement (EPA Manual)	Insignificant				$0
Annual operation/labor/maintenance costs: Upper-bound estimate would assume CARB's value of $1.50/hp/year and would result in $171,986/year. Lower-bound estimate would assume zero annual O&M. Mid-range value would account for fuel for pressure drop, increased inspections, periodic OEM visits, and the costs for Ecology's increased emission testing requirements. For this screening-level analysis, we assumed the lower-bound annual O&M cost of zero.					$0
Subtotal Direct Annual Cost					$251,942
Indirect Annual Costs					
Annual Admin charges (EPA Manual)	2.0%	of Total Capital Investment			$378,877
Annual Property tax (EPA Manual)	1.0%	of Total Capital Investment			$189,439
Annual Insurance (EPA Manual)	1.0%	of Total Capital Investment			$189,439
Subtotal Indirect Annual Costs					$757,755
Total Annual Cost (Capital Recovery + Direct Annual Costs + Indirect Annual Costs)					**$2,222,331**
Uncontrolled Emissions (Combined Pollutants)					246
Annual Tons Removed (Combined Pollutants)					181
Cost Effectiveness ($ per tons combined pollutant destroyed)					**$12,312**

Annual O&M Cost Based on CARB Factors (lowermost CARB estimate)			
$1,556,927	per year per generator	$778,463	per year per generator
3,000	KW-hr	1,500	KW-hr
17544	annual generator hours	1032	annual generator hours
$1.50	per HP_M per year	$1.50	per HP_M per year

MULTI-CRITERIA POLLUTANT COST EFFECTIVENESS (Reasonable vs. Actual Cost to Control)[a]

Pollutant	Ecology Acceptable Unit Cost ($/ton)	Forecast Removal (TPY)[a]	Subtotal Reasonable Annual Cost ($/year)
NO_x	$12,000	181	$2,166,033 per year
CO	$5,000	0	$0 per year
VOCs	$12,000	0	$0 per year
PM	$12,000	0	$0 per year
Total Reasonable Annual Control Cost for Combined Pollutants			$2,166,033 per year
Actual Annual Control Cost			$2,222,331 per year
		Is the Control Device Reasonable?	**NO (Actual >> Acceptable)**

CRITERIA POLLUTANT CONTROL EFFICIENCIES[a]

Pollutant	PM (FH)	CO	VOCs	NO_x
Tier 2 Uncontrolled Emissions (TPY)	3.15	24.7	4.62	213
Controlled Emissions (TPY)	3.15	24.7	4.62	32.9
TPY Removed	0	0	0	181
Combined Uncontrolled Emissions (TPY)	246			
Combined TPY Removed	181			
Expected Removal Efficiency	0%	0%	0%	90%
Annualized Cost ($/year)	$2,222,331			
Individual Pollutant $/Ton Removed	--	--	--	$12,312

MULTI-TOXIC AIR POLLUTANT COST-EFFECTIVENESS (Reasonable vs. Actual Cost to Control)[a]

Pollutant	ASIL (µg/m^3)	"Hanford Method" Cost Factor	Ecology Guidance "Ceiling Cost" ($/ton)	Forecast Removal (TPY)[a]	Subtotal Reasonable Annual Cost ($/year)
DEEP	0.00333	6.9	$72,544	0.0	$0 per year
CO	23,000	0.070	$731	0.0	$0 per year
NO_2 (10% of NO_x)	470	1.8	$18,472	19.2	$354,713 per year
Benzene	0.0345	5.9	$61,882	0.0	$0 per year
1,3-Butadiene	0.00588	6.7	$69,951	0.0	$0 per year
Acetaldehyde	0.37	4.9	$51,063	0.0	$0 per year
Acrolein	0.06	5.7	$59,359	0.0	$0 per year
Naphthalene	0.0294	6.0	$62,612	0.0	$0 per year
Formaldehyde	0.167	5.2	$54,691	0.0	$0 per year
Benzo(a)pyrene	9.09E-04	7.5	$78,464	0.0	$0 per year
Benzo(a)anthracene	9.09E-03	6.5	$67,964	0.0	$0 per year
Benzo(k)fluoranthene	9.09E-03	6.5	$67,964	0.0	$0 per year
Benzo(b)fluoranthene	0.00909	6.5	$67,964	0.0	$0 per year
Chrysene	9.09E-02	5.5	$57,464	0.0	$0 per year
Dibenz(a,h)anthracene	8.33E-04	7.5	$78,863	0.0	$0 per year
Indeno(1,2,3-cd)pyrene	9.09E-03	6.5	$67,964	0.0	$0 per year
Xylenes	221	2.1	$21,913	0.0	$0 per year
SO_2	660	1.6	$16,924	0.0	$0 per year
Propylene	3,000	1.0	$10,020	0.0	$0 per year
Carcinogenic VOCs	n.a.	n.a.	$9,999	0.0	$0 per year
Non-Carcinogenic VOCs	n.a.	n.a.	$5,000	0.0	$0 per year
Total Reasonable Annual Control Cost for Combined Pollutants					$354,713 per year
Actual Annual Control Cost					$2,222,331 per year
				Is the Control Device Reasonable?	**NO (Actual >> Acceptable)**

TOXIC AIR POLLUTANT CONTROL EFFICIENCIES[a]

TAP	Tier 2 Uncontrolled Emissions (TPY)	Controlled Emissions (TPY)	TPY Removed	Expected Removal Efficiency	Individual Pollutant $/Ton Removed
DEEP	3.15	3.15	0.0	0%	--
CO	24.67	24.7	0.0	0%	--
NO_2 (10% of NO_x)	21.34	2.13	19.2	90%	$115,732
Benzene	0.207	0.207	0.0	0%	--
1,3-Butadiene	0.010	1.0E-02	0.0	0%	--
Acetaldehyde	0.0067	6.7E-03	0.0	0%	--
Acrolein	2.10E-03	2.1E-03	0.0	0%	--
Naphthalene	3.47E-02	3.5E-02	0.0	0%	--
Formaldehyde	2.11E-02	2.1E-02	0.0	0%	--
Benzo(a)pyrene	6.86E-05	6.9E-05	0.0	0%	--
Benzo(a)anthracene	6.86E-05	6.9E-05	0.0	0%	--
Benzo(k)fluoranthene	5.82E-05	5.8E-05	0.0	0%	--
Benzo(b)fluoranthene	2.96E-04	3.0E-04	0.0	0%	--
Chrysene	4.09E-04	4.1E-04	0.0	0%	--
Dibenz(a,h)anthracene	9.24E-05	9.2E-05	0.0	0%	--
Indeno(1,2,3-cd)pyrene	1.11E-04	1.1E-04	0.0	0%	--
Xylenes	5.15E-02	5.2E-02	0.0	0%	--
SO_2	1.36E-01	0.136	0.0	0%	--
Propylene	7.45E-01	0.745	0.0	0%	--
Carcinogenic VOCs	2.75E-01	0.275	0.0	0%	--
Non-Carcinogenic VOCs	8.74E-01	0.874	0.0	0%	--
Annualized Cost ($/yr)					$2,222,331
Combined Uncontrolled Emissions (TPY)					50
Combined TPY Removed					19.2
Combined TAPs $/Ton Removed					$115,732

Notes:

FH ("front-half" filterable emissions)

BH ("back-half" condensable emissions)

PM (particulate matter) attributable to front-half and back-half emissions is assumed equal to the sum of vendor NTE values for PM and hydrocarbons.

DEEP (diesel engine exhaust particulate matter) is assumed equal to front-half NTE particulate emissions, as reported by the vendors.

DEEP (diesel engine exhaust particulate matter) is assumed equal to front-half NTE particulate emissions, as reported by the vendors.

[a] The expected control efficiency using the SCR control option is 90% for NO_x, only.

Table C-5
Catalyzed Diesel Particulate Filter Capital Cost
MWH-03/04/05/06 Data Center
Quincy, Washington

Cost Category	Cost Factor	Source of Cost Factor	Quant.	Unit Cost	Subtotal Cost
Direct Costs					
Purchased Equipment Costs					
3,000-KWe emission control package	Cost estimate by Cummins		68	$100,000	$6,800,000
3,000-KWe miscellaneous parts	Assumed no cost			$0	$0
1,500-KWe emission control package	Cost estimate by Cummins		4	$100,000	$400,000
1,500-KWe miscellaneous parts	Assumed no cost			$0	$0
Combined systems cost					$7,200,000
Instrumentation	Assumed no cost		0	$0	$0
Sales Tax	WA state tax	WA state tax	6.5%	--	$468,000
Shipping (3,000-KWe)		Johnson Matthey	68	$3,000	$204,000
Shipping (1,500-KWe)		Johnson Matthey	4	$1,500	$6,000
Subtotal Purchased Equipment Cost (PEC)					$7,878,000
Direct Installation Costs					
Enclosure structural supports (3,000-KWe)	Cost estimate by Johnson Matthey		68	$1,000	$68,000
Onsite Installation (3,000-KWe)	Cost estimate by Johnson Matthey		68	$10,000	$680,000
Enclosure structural supports (1,500-KWe)	Cost estimate by Johnson Matthey		4	$1,000	$4,000
Onsite Installation (1,500-KWe)	Cost estimate by Johnson Matthey		4	$7,000	$28,000
Electrical	Included above		0	$0	$0
Piping	Included above		0	$0	$0
Insulation	Assumed no cost		0	$0	$0
Painting	Assumed no cost		0	$0	$0
Subtotal Direct Installation Costs (DIC)					$780,000
Site Preparation and Buildings (SP)	Assumed no cost		0	$0	$0
Total Direct Costs, (DC = PEC + DIC + SP)					$8,658,000
Indirect Costs (Installation)					
Engineering		Johnson Matthey	72	$2,000	$144,000
Construction and field expenses		Johnson Matthey	72	$0	$0
Contractor Fees	From DIS data center		6.8%	--	$533,341
Startup		Johnson Matthey	72	$1,500	$108,000
Performance Test (Tech support)	0.01*PEC	EPA Cost Manual	1.0%	--	$78,780
Contingencies	0.03*PEC	EPA Cost Manual	3.0%	--	$236,340
Subtotal Indirect Costs (IC)					$1,100,461
Total Capital Investment (TCI = DC+IC)					**$9,758,461**

Table C-6
Catalyzed Diesel Particulate Filter Cost Effectiveness
MWH-03/04/05/06 Data Center
Quincy, Washington

Item	Quantity	Units	Unit Cost	Subtotal
Annualized Capital Recovery				
Total Capital Cost				**$9,758,461**
Capital Recovery Factor, 25 yrs, 4% discount rate				0.064
Subtotal Annualized 25-year Capital Recovery Cost				$624,658
Direct Annual Costs				
Annual Admin charges	2% of TCI (EPA Manual)		0.02	$195,169
Annual Property tax	1% of TCI (EPA Manual)		0.01	$97,585
Annual Insurance	1% of TCI (EPA Manual)		0.01	$97,585
Annual operation/labor/maintenance costs: Upper-bound estimate would assume CARB's value of $1.00/hp/year and would result in $114,657/year. Lower-bound estimate would assume zero annual O&M. Mid-range value would account for fuel for pressure drop, increased inspections, periodic OEM visits, and the costs for Ecology's increased emission testing requirements. For this screening-level analysis we assumed the lower-bound annual O&M cost of zero.				$0
Subtotal Direct Annual Costs				$390,338
Total Annual Cost (Capital Recovery + Direct Annual Costs)				**$1,014,997**
Uncontrolled Emissions (Combined Pollutants)				246
Annual Tons Removed (Combined Pollutants)				25.8
Cost Effectiveness ($ per tons combined pollutant destroyed)				**$39,328**

Annual O&M Cost Based on CARB Factors (lowermost CARB estimate)	
$1,037,951 per year per generator	$518,976 per year per generator
3,000 KW-hr	1,500 KW-hr
17544 annual generator hours	1032 annual generator hours
$1.00 per HP_M per year	$1.00 per HP_M per year

MULTI-CRITERIA POLLUTANT COST EFFECTIVENESS (Reasonable vs. Actual Cost to Control)[a]

Pollutant	Ecology Acceptable Unit Cost ($/ton)	Forecast Removal (TPY)[a]	Subtotal Reasonable Annual Cost ($/year)
NO_x	$12,000	0	$0 per year
CO	$5,000	20	$98,684 per year
VOCs	$12,000	3	$38,837 per year
PM	$12,000	2.8	$34,025 per year
Total Reasonable Annual Control Cost for Combined Pollutants			$171,546 per year
Actual Annual Control Cost			$1,014,997 per year
		Is the Control Device Reasonable?	**NO (Actual >> Acceptable)**

CRITERIA POLLUTANT CONTROL EFFICIENCIES[a]

Pollutant	PM (FH)	CO	VOCs	NO_x
Tier 2 Uncontrolled Emissions (TPY)	3.15	24.7	4.62	213
Controlled Emissions (TPY)	0.315	4.9	1.39	213
TPY Removed	2.84	19.7	3.24	0
Combined Uncontrolled Emissions (TPY)	246			
Combined TPY Removed	25.8			
Expected Removal Efficiency	90%	80%	70%	0%
Annualized Cost ($/year)	$1,014,997			
Individual Pollutant $/Ton Removed	$357,970	$51,427	$313,619	--

MULTI-TOXIC AIR POLLUTANT COST-EFFECTIVENESS (Reasonable vs. Actual Cost to Control)[a]

Pollutant	ASIL (μg/m^3)	"Hanford Method" Cost Factor	Ecology Guidance "Ceiling Cost" ($/ton)	Forecast Removal (TPY)[a]	Subtotal Reasonable Annual Cost ($/year)
DEEP	0.00333	6.9	$72,544	2.84	$205,692 per year
CO	23,000	0.070	$731	19.7	$14,431 per year
NO_2 (10% of NO_x)	470	1.8	$18,472	0.0	$0.0 per year
Benzene	0.0345	5.9	$61,882	0.1450	$8,976 per year
1,3-Butadiene	0.00588	6.7	$69,951	7.3E-03	$511 per year
Acetaldehyde	0.37	4.9	$51,063	4.7E-03	$241 per year
Acrolein	0.06	5.7	$59,359	1.5E-03	$87.4 per year
Naphthalene	0.0294	6.0	$62,612	0.0243	$1,521 per year
Formaldehyde	0.167	5.2	$54,691	0.0147	$807 per year
Benzo(a)pyrene	9.09E-04	7.5	$78,464	4.8E-05	$3.77 per year
Benzo(a)anthracene	9.09E-03	6.5	$67,964	4.8E-05	$3 per year
Benzo(k)fluoranthene	9.09E-03	6.5	$67,964	4.1E-05	$3 per year
Benzo(b)fluoranthene	0.00909	6.5	$67,964	2.1E-04	$14.10 per year
Chrysene	9.09E-02	5.5	$57,464	2.9E-04	$16.43 per year
Dibenz(a,h)anthracene	8.33E-04	7.5	$78,863	6.5E-05	$5.10 per year
Indeno(1,2,3-cd)pyrene	9.09E-03	6.5	$67,964	7.7E-05	$5 per year
Xylenes	221	2.1	$21,913	0.0361	$791 per year
SO_2	660	1.6	$16,924	0.0	$0 per year
Propylene	3,000	1.0	$10,020	0.522	$5,225 per year
Carcinogenic VOCs	n.a.	n.a.	$9,999	0.192	$1,922 per year
Non-Carcinogenic VOCs	n.a.	n.a.	$5,000	0.612	$3,058 per year
Total Reasonable Annual Control Cost for Combined Pollutants					$243,313 per year
Actual Annual Control Cost					$1,014,997 per year
				Is the Control Device Reasonable?	**NO (Actual >> Acceptable)**

TOXIC AIR POLLUTANT CONTROL EFFICIENCIES[a]

TAP	Tier 2 Uncontrolled Emissions (TPY)	Controlled Emissions (TPY)	TPY Removed	Expected Removal Efficiency	Individual Pollutant $/Ton Removed
DEEP	3.15	0.32	2.84	90%	$357,970
CO	24.67	4.9	19.7	80%	$51,427
NO_2 (10% of NO_x)	21.34	21.3	0.0	0%	--
Benzene	0.207	0.0622	0.1450	70%	$6,997,601
1,3-Butadiene	0.010	3.1E-03	7.3E-03	70%	$138,878,213
Acetaldehyde	0.007	2.0E-03	4.71E-03	70%	$215,481,672
Acrolein	2.10E-03	6.3E-04	1.5E-03	70%	$689,103,824
Naphthalene	3.47E-02	1.0E-02	0.0243	70%	$41,770,293
Formaldehyde	2.11E-02	6.3E-03	0.0147	70%	$68,823,043
Benzo(a)pyrene	6.86E-05	2.1E-05	4.8E-05	70%	$21,128,942,144
Benzo(a)anthracene	6.86E-05	2.1E-05	4.80E-05	70%	$21,128,942,144
Benzo(k)fluoranthene	5.82E-05	1.7E-05	4.07E-05	70%	$24,908,890,510
Benzo(b)fluoranthene	2.96E-04	8.9E-05	2.07E-04	70%	$4,892,016,334
Chrysene	4.09E-04	1.2E-04	2.86E-04	70%	$3,549,109,890
Dibenz(a,h)anthracene	9.24E-05	2.8E-05	6.5E-05	70%	$15,694,040,841
Indeno(1,2,3-cd)pyrene	1.11E-04	3.3E-05	7.74E-05	70%	$13,116,275,679
Xylenes	5.15E-02	0.0155	0.0361	70%	$28,135,431
SO_2	1.36E-01	0.136	0.0	0%	--
Propylene	7.45E-01	0.224	0.522	70%	$1,946,286
Carcinogenic VOCs	2.75E-01	0.0824	0.192	70%	$5,279,683
Non-Carcinogenic VOCs	8.74E-01	0.262	0.612	70%	$1,659,639
Annualized Cost ($/yr)					$1,014,997
Combined Uncontrolled Emissions (TPY)					50.4
Combined TPY Removed					23.3
Combined TAPs $/Ton Removed					$43,510

Notes:

FH ("front-half" filterable emissions)

BH ("back-half" condensable emissions)

PM (particulate matter) attributable to front-half and back-half emissions is assumed equal to the sum of vendor NTE values for PM and hydrocarbons.

DEEP (diesel engine exhaust particulate matter) is assumed equal to front-half NTE particulate emissions, as reported by the vendors.

DEEP (diesel engine exhaust particulate matter) is assumed equal to front-half NTE particulate emissions, as reported by the vendors.

[a] The expected control efficiency using the catalyzed DPF is 85% for PM (front half), 80% for CO, and 70% for VOCs. There is no expected control of NO_x emissions using the catalyzed DPF option.

Table C-7
Diesel Oxidation Catalyst Capital Cost
MWH-03/04/05/06 Data Center
Quincy, Washington

Cost Category	Cost Factor	Source of Cost Factor	Quant.	Unit Cost	Subtotal Cost
Direct Costs					
Purchased Equipment Costs					
3,000-KWe emission control package	Cost estimate by Cummins		68	$50,000	$3,400,000
3,000-KWe miscellaneous parts	Assumed no cost			$0	$0
1,500-KWe emission control package	Cost estimate by Cummins		4	$50,000	$200,000
1,500-KWe miscellaneous parts	Assumed no cost			$0	$0
Combined systems ost					$3,600,000
Instrumentation	Assumed no cost		0	$0	$0
Sales Tax	WA state tax	WA state tax	6.5%	--	$234,000
Shipping (3,000-KWe)		Johnson Matthey	68	$500	$34,000
Shipping (1,500-KWe)		Johnson Matthey	4	$300	$1,200
Subtotal Purchased Equipment Cost (PEC)					$3,869,200
Direct Installation Costs					
Enclosure structural supports (3,000-KWe)	Cost estimate by Johnson Matthey		68	$0	$0
Onsite Installation (3,000-KWe)	Cost estimate by Johnson Matthey		68	$3,000	$204,000
Enclosure structural supports (1,500-KWe)	Cost estimate by Johnson Matthey		4	$0	$0
Onsite Installation (1,500-KWe)	Cost estimate by Johnson Matthey		4	$3,000	$12,000
Electrical	Included above		0	$0	$0
Piping	Included above		0	$0	$0
Insulation	Assumed no cost		0	$0	$0
Painting	Assumed no cost		0	$0	$0
Subtotal Direct Installation Costs (DIC)					$216,000
Site Preparation and Buildings (SP)	Assumed no cost		0	$0	$0
Total Direct Costs, (DC = PEC + DIC + SP)					$4,085,200
Indirect Costs (Installation)					
Engineering		Johnson Matthey	72	$1,200	$86,400
Construction and field expenses		Johnson Matthey	72	$0	$0
Contractor Fees	From DIS data center		6.8%	--	$261,945
Startup		Johnson Matthey	72	$1,500	$108,000
Performance Test (Tech support)	0.01*PEC	EPA Cost Manual	1.0%	--	$38,692
Contingencies	0.03*PEC	EPA Cost Manual	3.0%	--	$116,076
Subtotal Indirect Costs (IC)					$611,113
Total Capital Investment (TCI = DC+IC)					**$4,696,313**

Table C-8
Diesel Oxidation Catalyst Cost Effectiveness
MWH-03/04/05/06 Data Center
Quincy, Washington

Item	Quantity	Units	Unit Cost	Subtotal
Annualized Capital Recovery				
Total Capital Cost				**$4,696,313**
Capital Recovery Factor, 25 yrs, 4% discount rate				0.064
Subtotal Annualized 25-year Capital Recovery Cost				$300,620
Direct Annual Costs				
Annual Admin charges	2% of TCI (EPA Manual)		0.02	$93,926
Annual Property tax	1% of TCI (EPA Manual)		0.01	$46,963
Annual Insurance	1% of TCI (EPA Manual)		0.01	$46,963
Catalyst Replacement	Assume cost of zero.		$0	$0
Annual operation/labor/maintenance costs: Upper-bound estimate would assume CARB's value of $0.20/hp/year and would result in $22,931/year. Lower-bound estimate would assume zero annual O&M. Mid-range value would account for fuel for pressure drop, increased inspections, periodic OEM visits, and the costs for Ecology's increased emission testing requirements. For this screening-level analysis, we assumed the lower-bound annual O&M cost of zero.				$0
Subtotal Direct Annual Costs				$187,853
Total Annual Cost (Capital Recovery + Direct Annual Costs)				**$488,473**
Uncontrolled Emissions (Combined Pollutants)				246
Annual Tons Removed (Combined Pollutants)				23.8
Cost Effectiveness ($ per tons combined pollutant destroyed)				**$20,558**

Annual O&M Cost Based on CARB Factors (lowermost CARB estimate)	
$207,590 per year per generator	$103,795 per year per generator
3,000 KW-hr	1,500 KW-hr
17544 annual generator hours	1032 annual generator hours
$0.20 per HP_M per year	$0.20 per HP_M per year

MULTI-CRITERIA POLLUTANT COST EFFECTIVENESS (Reasonable vs. Actual Cost to Control)[a]

Pollutant	Ecology Acceptable Unit Cost ($/ton)	Forecast Removal (TPY)[a]	Subtotal Reasonable Annual Cost ($/year)
NO_x	$12,000	0	$0 per year
CO	$5,000	19.7	$98,684 per year
VOCs	$12,000	3.24	$38,837 per year
PM	$12,000	0.79	$9,451 per year
Total Reasonable Annual Control Cost for Combined Pollutants			$146,972 per year
Actual Annual Control Cost			$488,473 per year
		Is the Control Device Reasonable?	**NO (Actual >> Acceptable)**

CRITERIA POLLUTANT CONTROL EFFICIENCIES[a]

Pollutant	PM (FH)	CO	VOCs	NO_x
Tier 2 Uncontrolled Emissions (TPY)	3.15	24.7	4.62	213
Controlled Emissions (TPY)	2.36	4.93	1.39	213
TPY Removed	0.79	19.7	3.24	0
Combined Uncontrolled Emissions (TPY)	246			
Combined TPY Removed	23.8			
Expected Removal Efficiency	25%	80%	70%	0%
Annualized Cost ($/year)	$488,473			
Individual Pollutant $/Ton Removed	$620,191	$24,749	$150,931	--

MULTI-TOXIC AIR POLLUTANT COST-EFFECTIVENESS (Reasonable vs. Actual Cost to Control)[a]

Pollutant	ASIL (μg/m^3)	"Hanford Method" Cost Factor	Ecology Guidance "Ceiling Cost" ($/ton)	Forecast Removal (TPY)[a]	Subtotal Reasonable Annual Cost ($/year)
DEEP	0.00333	6.9	$72,544	0.79	$57,137 per year
CO	23,000	0.1	$731	19.7	$14,431 per year
NO_2 (10% of NO_x)	470	1.8	$18,472	0.0	$0 per year
Benzene	0.0345	5.9	$61,882	0.1450	$8,976 per year
1,3-Butadiene	0.00588	6.7	$69,951	7.3E-03	$511 per year
Acetaldehyde	0.37	4.9	$51,063	4.7E-03	$241 per year
Acrolein	0.06	5.7	$59,359	1.5E-03	$87.4 per year
Naphthalene	0.0294	6.0	$62,612	0.0243	$1,521 per year
Formaldehyde	0.167	5.2	$54,691	0.0147	$807 per year
Benzo(a)pyrene	9.09E-04	7.5	$78,464	4.8E-05	$4 per year
Benzo(a)anthracene	9.09E-03	6.5	$67,964	4.8E-05	$3 per year
Benzo(k)fluoranthene	9.09E-03	6.5	$67,964	4.1E-05	$3 per year
Benzo(b)fluoranthene	9.09E-03	6.5	$67,964	2.1E-04	$14.10 per year
Chrysene	9.09E-02	5.5	$57,464	2.9E-04	$16.43 per year
Dibenz(a,h)anthracene	8.33E-04	7.5	$78,863	6.5E-05	$5.10 per year
Indeno(1,2,3-cd)pyrene	9.09E-03	6.5	$67,964	7.7E-05	$5 per year
Xylenes	221	2.1	$21,913	0.0361	$791 per year
SO_2	660	1.6	$16,924	0.0	$0 per year
Propylene	3,000	1.0	$10,020	0.522	$5,225 per year
Carcinogenic VOCs	n.a.	n.a.	$9,999	0.192	$1,922 per year
Non-Carcinogenic VOCs	n.a.	n.a.	$5,000	0.612	$3,058 per year
Total Reasonable Annual Control Cost for Combined Pollutants					$94,757 per year
Actual Annual Control Cost					$488,473 per year
				Is the Control Device Reasonable?	**NO (Actual >> Acceptable)**

TOXIC AIR POLLUTANT CONTROL EFFICIENCIES[a]

TAP	Tier 2 Uncontrolled Emissions (TPY)	Controlled Emissions (TPY)	TPY Removed	Expected Removal Efficiency	Individual Pollutant $/Ton Removed
DEEP	3.15	2.36	0.79	25%	$620,191
CO	24.67	4.9	19.7	80%	$24,749
NO_2 (10% of NOx)	21.34	21.3	0.0	0%	--
Benzene	0.207	0.0622	0.1450	70%	$3,367,634
1,3-Butadiene	0.010	3.1E-03	7.3E-03	70%	$66,835,904
Acetaldehyde	0.007	2.0E-03	4.71E-03	70%	$103,701,740
Acrolein	2.10E-03	6.3E-04	1.5E-03	70%	$331,635,006
Naphthalene	3.47E-02	1.0E-02	2.4E-02	70%	$20,102,183
Formaldehyde	2.11E-02	6.3E-03	0.0147	70%	$33,121,468
Benzo(a)pyrene	6.86E-05	2.1E-05	4.8E-05	70%	$10,168,419,626
Benzo(a)anthracene	6.86E-05	2.1E-05	4.80E-05	70%	$10,168,419,626
Benzo(k)fluoranthene	5.82E-05	1.7E-05	4.07E-05	70%	$11,987,540,569
Benzo(b)fluoranthene	2.96E-04	8.9E-05	2.07E-04	70%	$4,514,458,591
Chrysene	4.09E-04	1.2E-04	2.86E-04	70%	$1,708,028,656
Dibenz(a,h)anthracene	9.24E-05	2.8E-05	6.5E-05	70%	$7,552,843,480
Indeno(1,2,3-cd)pyrene	1.11E-04	3.3E-05	7.74E-05	70%	$6,312,279,816
Xylenes	5.15E-02	0.0155	0.0361	70%	$13,540,331
SO_2	1.36E-01	0.136	0.0	0%	--
Propylene	7.45E-01	0.224	0.522	70%	$936,661
Carcinogenic VOCs	2.75E-01	8.2E-02	0.192	70%	$2,540,876
Non-Carcinogenic VOCs	8.74E-01	0.262	0.612	70%	$798,710
Annualized Cost ($/yr)					$488,473
Combined Uncontrolled Emissions (TPY)					50.4
Combined TPY Removed					21.3
Combined TAPs $/Ton Removed					$22,954

Notes:

FH ("front-half" filterable emissions)

BH ("back-half" condensable emissions)

PM (particulate matter) attributable to front-half and back-half emissions is assumed equal to the sum of vendor NTE values for PM and hydrocarbons.

DEEP (diesel engine exhaust particulate matter) is assumed equal to front-half NTE particulate emissions, as reported by the vendors.

DEEP (diesel engine exhaust particulate matter) is assumed equal to front-half NTE particulate emissions, as reported by the vendors.

[a] The expected control efficiency using the DOC is 80% for CO, and 70% for VOCs. DOCs are marginally effective for removal of PM (15% - 25%) depending on the load). There is no expected control of NO_x emissions using the DOC control option.

APPENDIX D

Summary of AERMOD Inputs

Table D-1
AERMOD Parameter Estimation General Compliance Demonstration
MWH-03/04/05/06 Data Center
Quincy, Washington

AERMOD Input - Theoretical Maximum Year

Regulatory Demonstration	AERMOD Input (lb/hr) per Point Source[a,b]		
	1.5-MWe Genset	3.0-MWe Genset	Cooling Tower Cell[c]
NO_x (annual NAAQS)	0.2194	0.2934	NA
DEEP (ASIL / non-cancer risk HQ)	0.0031	0.0055	NA
$PM_{2.5}$ (annual NAAQS)	0.0168	0.0300	0.00605
Dibenz(a,h)anthracene (ASIL)	1.831E-07	3.614E-07	NA
Benzene	4.106E-04	8.106E-04	NA
Chromium (ASIL)	NA	NA	1.63E-08
Worst-case Exhaust Temp. (°F)	369	468	80
Worst-case Exhaust Flow (cfm)	3,339	7,713	63,845
Stack height (ft)	72	72	17.5
Stack diameter (in)	24	30	95.04

AERMOD Input Power Outage Scenario (Worst-case 1-hour & ASIL)

Operating Condition	Assumptions for Cold-start Emissions Calculations			
	Startup	Warm	Startup	Warm
Number of events	1	1	1	1
Duration of each event (hours)	0.017	0.983	0.017	0.983
Hours at each runtime mode	0.017	0.983	0.017	0.983
Maximum Generators Concurrently Operating	4		68	

Regulatory Demonstration	AERMOD Input (lb/hr) per Point Source[a,b]		
	1.5-MWe Genset	3.0-MWe Genset	Cooling Tower Cell[c]
CO (1 & 8-hour NAAQS)	1.6626	1.9353	NA
Load-Specific Exhaust Temp. (°F)	577	773	NA
Load-Specific Exhaust Flow (cfm)	4,714	23,365	NA
SO_2 (1 & 3-hour NAAQS)	0.0230	0.0453	NA
Load-Specific Exhaust Temp. (°F)	880	838	NA
Load-Specific Exhaust Flow (cfm)	11,734	24,561	NA
NO_2 (1-hour ASIL)	6.2400	8.3445	NA
Load-Specific Exhaust Temp. (°F)	369	468	NA
Load-Specific Exhaust Flow (cfm)	3,339	10,028	NA

AERMOD INPUT Power Outage Scenario (Worst-case 24-hour)

Operating Condition	Assumptions for Cold-start Emissions Calculations			
	Startup	Warm	Startup	Warm
Number of events	1	1	1	1
Duration of each event (hours)	0.017	0.983	0.017	0.983
Hours at each runtime mode	0.017	0.983	0.017	0.983

Regulatory Demonstration	AERMOD Input (lb/hr) per Point Source[a,b]		
	1.5 MWe Genset	3.0 MWe Genset	Cooling Tower Cell[c]
Acrolein (ASIL)	1.17E-04	2.31E-04	NA
Load-Specific Exhaust Temp. (°F)	880	838	NA
Load-Specific Exhaust Flow (cfm)	11,734	24,561	NA

Notes:

[a] All generators were modeled under full-variable load conditions (≤100% Load). Startup emissions were included for applicable pollutants.

[b] For modeling local background impacts, neighboring data centers were assumed to emit at the permitted potential-to-emit rates. Cooling towers and the Lamb Weston facility were assumed to operate continuously and emit at permited rates.

[c] Two cooling tower cells per cooling unit. All cooling units were assumed to operate continuously, all year.

Abbreviations and Acronyms:

ASIL = Acceptable source impact level
cfm = Cubic feet per minute
CO = Carbon monoxide
in = inches
ft = feet
HQ = Hazard quotient
lb/hr = Pounds per hour
MWe = Megawatts electrical
NA = Not applicable
NAAQS = National Ambient Air Quality Standards
NO_x = Nitrogen oxides
SO_2 = Sulfur dioxide

Table D-2
AERMOD Parameter Estimation 24-hr PM Compliance Demonstration
MWH-03/04/05/06 Data Center
Quincy, Washington

24-hr PM NAAQS

AERMOD Setup: Emergency operations (power outage)

Operating Condition	**Assumptions for Cold-start Emissions Calculations**			
	Startup	**Warm**	**Startup**	**Warm**
Number of events	1	1	1	1
Duration of each event (hours)	0.017	23.983	0.017	23.983
Hours at each runtime mode	0.017	23.983	0.017	23.983
Maximum Generators Concurrently Operating	4		68	

Regulatory Demonstration	**AERMOD Input (lb/hr) per Point Source[a]**		
	1.5 MWe Genset	**3.0 MWe Genset**	**Cooling Tower Cell[b]**
PM$_{10}$ (24-hour WAAQS)[c] Day 2, Hours = 18	0.3538	0.6311	0.0109
Load-Specific Exhaust Temp. (°F)	577	468	80
Load-Specific Exhaust Flow (cfm)	4,714	10,028	63,845
Background assumptions	It was assumed that local data centers were concurrently operating in facility-wide power outage mode. The Con-Agra facility was modeled as continuously operating at PTE rates. All cooling towers were modeled as continuously operating at PTE rates.		

AERMOD Setup: Non-emergency routine monthly operations (worst-case)

Operating Condition	**Assumptions for Startup Emissions Calculations**			
	Startup	**Warm**	**Startup**	**Warm**
Hours of operation per day	Emissions from maintenance operations on the 1.5-MWe gensets are equal to or less than maintenance operations on the 3.0-Mwe gensets.		12	
Number of events per day			36	36
Duration of each event (hours)			0.017	0.317
Hours at each runtime mode (per day)			0.6	11.4
Maximum gensets to concurrently operate			2 [d]	

Regulatory Demonstration	**AERMOD Input (lb/hr) per Point Source[a]**		
	1.5-MWe Genset	**3.0-MWe Genset**	**Cooling Tower Cell[b]**
PM$_{2.5}$ (24-hour NAAQS)[d, e]	n.a.	0.9767	0.00605
Load-Specific Exhaust Temp. (°F)		468	80
Load-Specific Exhaust Flow (cfm)		10,028	63,845
Background assumptions	This model setup conservatively assumed that local data centers were concurrently operating in maintenance mode. The Con-Agra facility was modeled as continuously operating at PTE rates. All cooling towers were modeld as continuously operating at PTE rates.		

Notes:

[a] All generators were modeled under full-variable load conditions (≤100% Load). Startup emissions were included for all applicable pollutants.

[b] Two cooling tower cells per cooling unit. All cooling units were assumed to operate continuously, all year.

[c] Modeled operating scenario for 2nd-highest ranked PM emitting day for an 18-hr power outage scenario. The evaluated results correspond to the 1st high impact.

[d] Monthly maintencance operations are expected to occur on a single engine for 20 minutes per engine per month. In the event that complications arise during testing, this duration may be greater. Likewise, multiple sequential tests may occur within the same day for up to 12 hr/dy.

[e] This model conservatiely assumes that two engines may be running at a time and that operations may occur anytime, between daylight hours. In order to capture the worst-case emission impacts for this scenario, a test-model was run with all project-generators operating at full-variable load. From the test-model, the resultant emission impacts for each individual genset was ranked. In this model, the highest ranked genset (genset with greatest maximum impact) was simulated to operate concurrently with a randomly chosen neighboring genset, as set up for this demonstration.

APPENDIX E

Electronic Files Archive

(on DVD)

APPENDIX F

Monte Carlo Analysis

Table F-1
AERMOD Parameter Estimation Monte Carlo Assessment
MWH-03/04/05/06 Data Center
Quincy, Washington

1-hr NO_2 NAAQS Monte Carlo Analysis

Regulatory Demonstration	AERMOD Input (lb/hr) per Point Source[a]	
	1.5-MWe Genset	**3.0-MWe Genset**
NO_2 (1-hour NAAQS)	6.2400	8.3445
Load-specific exhaust temp. (°F)	369	468
Load-specific exhaust flow (cfm)	3,339	10,028
Runtime Activity	**Maximum Generators Concurrently Operating**	
	1.5-MWe Genset	**3.0-MWe Genset**
Emergency operation (24-hr power outage)[b, c]	4	68
Non-emergency Triennial operation scenario 2 (worst-case)[d, e, f]	1	4
Non-emergency Triennial operation scenario 1 (worst-case)[d, e, f]	The admin generators are not expected to run during this runtime activity.	4
Non-emergency routine Monthly operations (worst-case) [e, g, h]	Emissions from maintenance operations on the 1.5-MWe gensets are equal to or less than maintenance operations on the 3.0-Mwe gensets.[d]	2
Non-emergency Routine semiannual operations (worst-case)[e, h, i]	Emissions from maintenance operations on the 1.5-MWe gensets are equal to or less than maintenance operations on the 3.0-Mwe gensets.[d]	2
Non-emergency Single generator operations (worst-case)[e,j]	Emissions from maintenance operations on the 1.5-MWe gensets are equal to or less than maintenance operations on the 3.0-Mwe gensets.[d]	1

Notes:

[a] All generators were modeled under full-variable load conditions (≤100% Load).

[b] This application assumes 6 days of power outage operations. In order to account for the permit limitation set on the MWH-01 through MWH-02 generators, which allows up to 4 days of power outage operation, one model was set up to estimate impacts from those 4 days of facility-wide power outage. A second model was set up to simulate the additional 2 days of power outage operations when only the MWH-03/04/05/06 generators will be allowed to operate in that scenario.

[c] This scenario assumed that local data centers were concurrently operating in facility-wide power outage mode. The Con-Agra facility was modeled as continuously operating at PTE rates.

[d] Electrical bypass operations are expected to occur for 2 hours and involve four (scenario 1) or five (scenario 2) concurrently operating generators, within the same colo. Additional single engine operations may continue within the same day for up to 12 hours/day (total operation). These operations are expected to occur triennially for each generator and at any location within the project for up to a total of 8 days per year.

[e] This scenario conservatively assumed that local data centers were concurrently operating in maintenance mode. The Con-Agra facility was modeled as continuously operating at PTE rates.

[f] In order to capture the worst-case emission impacts for this scenario, a test-model was run with all electrical bypass arrangements set up in separate source groups. From the test-model, the resultant emission impacts for each source group was ranked. The highest-rank modeled arrangement for each building was used for this simulation.

[g] Monthly maintenance operations are expected to occur on a single engine for 20 minutes per engine per month. In rare cases, this duration may be greater. Multiple sequential tests may occur within the same day for up to 12 hours/day. This model conservatively assumes that two engines may concurrently operate between daylight hours (assumed 7 a.m. to 7 p.m.).

[h] In order to capture the worst-case emission impacts for this scenario, a test model was run with all project generators operating at full-variable load. From the test model, the resultant emission impacts for each individual generator was ranked. The highest-rank modeled generator (i.e., generator with greatest maximum impact) was used for this simulation and was assumed to operate concurrently with a randomly chosen neighboring generator.

[i] Semiannual operations are expected to occur on each generator for 3 hours every 6 months. Multiple sequential tests may occur within the same day for up to 12 hours/day. This model conservatively assumes that two generators may concurrently operate any time during daylight hours (assumed 7 a.m. to 7 p.m.).

[j] In order to capture the worst-case emission impacts for this scenario, a test model was run with all project generators operating at full-variable load. From the test model, the resultant emission impacts for each individual generator was ranked. The highest-rank modeled generator (i.e., generator with greatest maximum impact) was used for this simulation.

Abbreviations and Acronyms:

cfm = Cubic feet per minute
Mwe = Megawatts electrical
NAAQS = National Ambient Air Quality Standards
NO_2 = Nitrogen dioxide
PTE = Potential-to-emit

Table F-2
Summary of Monte Carlo Analysis
MWH-03/04/05/06 Data Center
Quincy, Washington

UTM = 11	(m East)	(m North)
Monte Carlo Predicted: NO_2 Max. Impact Location	282,048	5,235,338
	98th-percentile Impact (µg/m^3)	
	96	
Regional Background Concentration	16	
Estimated Cumulative Concentration	112	
Regulatory Limit (based on 98th-percentile)	188	

	Generator Runtime Activity[a]	**AERMOD Filename** **Script Input Filename**	**Simulation Days of Operation**
Project Operations	Project-emergency operations [c]	T4NOx_041418f MAXDAILY_aPO2_NO2.DAT aPO2	2
	Triennial operations scenario 1 [b,d,e,f] - Location A (MWH-03)	T4NOx_041418b MAXDAILY_aEB1_NO2.DAT aEB1	1
	Triennial operations scenario 1 [b,d,e,f] - Location B (MWH-04)	T4NOx_041418c MAXDAILY_aEB12_NO2.DAT aEB12	1
	Triennial operations scenario 1 [b,d,e,f] - Location C (MWH-05)	T4NOx_041418d MAXDAILY_aEB4_NO2.DAT aEB4	1
	Triennial operations scenario 1 [b,d,e,f] - Location D (MWH-06)	T4NOx_041418e MAXDAILY_aEB7_NO2.DAT aEB7	1
	Triennial operations scenario 2 [b,d,e,f,g] - Location E (MWH-03)	T4NOx_041418g MAXDAILY_aMWH3_NO2.DAT aMWH3	1
	Triennial operations scenario 2 [b,d,e,f,g] - Location F (MWH-04)	T4NOx_041418h MAXDAILY_aMWH4_NO2.DAT aMWH4	1
	Triennial operations scenario 2 [b,d,e,f,g] - Location G (MWH-05)	T4NOx_041418i MAXDAILY_aMWH5_NO2.DAT aMWH5	1
	Triennial operations scenario 2 [b,d,e,f,g] - Location H (MWH-06)	T4NOx_041418j MAXDAILY_aMWH6_NO2.DAT aMWH6	1
	Maintenance operations - Semiannual maintenance [b,f, h, i]	T4NOx_041418a MAXDAILY_Asemi_NO2.DAT Asemi	24
	Maintenance operations - Monthly maintenance [b,f, h,i,]	T4NOx_041418a MAXDAILY_Amonth_NO2.DAT Amonth	24
	Maintenance operations - Single generator operations [b,e,f,k]	T4NOx_042318k MAXDAILY_aWCSG_NO2.DAT aWCSG	50
	MWH01 & MWH02 Activities	**AERMOD Filename** **Script Input Filename** **Source Group**	**Simulation Days of Operation**
Existing Operations	Facility-wide emergency operations [c]	T4NOx_041418_MC1 MAXDAILY_aPO1_NO2.DAT aPO1	4
	Bypass Scenario 1, represents two AZ buildings at NE quadrant[b, j]	T4NOx_041818_MC2 MAXDAILY_aMC2_NO2.DAT aMC2	4
	Bypass Scenario 2, represents two AZ buildings at NW quadrant [b,j]	T4NOx_041818_MC3 MAXDAILY_aMC3_NO2.DAT aMC3	4
	Bypass Scenario 3, represents two AZ buildings at SW quadrant [b,j]	T4NOx_041818_MC4 MAXDAILY_aMC4_NO2.DAT aMC4	4
	Bypass Scenario 4, represents two AZ buildings at SE quadrant [b,j]	T4NOx_041918_MC5 MAXDAILY_aMC5_NO2.DAT aMC5	4

Table F-2
Summary of Monte Carlo Analysis
MWH-03/04/05/06 Data Center
Quincy, Washington

Notes:

[a] All project generators were modeled under full-variable load conditions (≤100% Load). Cold-start emissions are not applicable to this pollutant (see discussion on cold-start emissions).

[b] These models conservatively assumed that local data centers were concurrently operating in maintenance mode. The Con Agra facility was modeled as continuously operating at PTE rates.

[c] The existing generators (MWH-01/02) are permitted to operate in a power outage mode for up to 4 days in a single calendar year (i.e., ranked days 1 through 4, see Table 10). The proposed generators (MWH-03/04/05/06) are assumed to operate in power outage mode for the 4 days (with MWH-01/02), plus an additional 2 days per year without the existing generators (i.e., ranked days 5 and 6, see Table 10). Therefore, for the Monte Carlo model run the first 4 days of operation in a power outage mode included emissions from the whole facility (as a PO1) in a modified version of the MC1 AERMOD run (LAI 2016). The additional 2 days of project-related operation in a power outage mode were modeled in a separate AERMOD run (as a PO2).

[d] In order to capture the worst-case emission impacts for this scenario, a test model was run with all electrical bypass arrangements set up in separate source groups. The resultant emission impacts for each source group were ranked. For these Monte Carlo models, the setup used the the highest ranked arrangement within the applicable building. That is, one worst-case model per building was set up for simulation of this runtime activity.

[e] Electrical bypass operations are expected to occur for 2 hours and include four (scenario 1) or five (scenario 2) concurrently operating generators within the same colo. Additional single generator operations may continue within the same day for up to 12 hours/day. Simulation of impacts from a single generator operation have been demonstrated not to exceed the NO_2 1-hour NAAQS; however, for completeness of analysis, a single-generator arrangement was included in this Monte Carlo assessment.

[f] This model assumed project operations will occur during daylight hours only (assumed 7 a.m. to 7 p.m.)

[g] For electrical bypass scenario 2, operation of five concurrently operating generators can occur in only one colo per building (i.e., the colo that contains the administration generator). All other colos operating in an electrical bypass scenario 2 would operate with only four concurrently operating generators.

[h] For semiannual and monthly operations, generators are expected to be run one or two at a time for up to 12 hours/day (this modeling conservatively assumed two at a time).

[i] In order to capture the worst-case emission impacts for the maintenance mode scenario, a test model was run. In the test model, each individual project-related generator was placed in a separate source group and the resultant emission impacts for each source group were ranked. For this Monte Carlo model run, the highest ranked generator was simulated to operate concurrently with a randomly chosen adjacent generator.

[j] This model setup is from the 2016 Monte Carlo assessment submitted for the existing MWH-01/02 operations (LAI 2016) modified to include local background operations.

[k] In order to capture the worst case emission impacts for this scenario, a test model was run with all individual generators in separate source groups. The resultant emission impacts for each source group were ranked. For these Monte Carlo models, the setup used the the highest ranked single generator. That is, one worst-case model was set up for simulation of this runtime activity.

Abbreviations and Acronyms:

E = East
m = Meters
N = North
NAAQS = National Ambient Air Quality Standards
NO_2 = Nitrogen dioxide
$PM_{2.5}$ = Particulate matter with aerodynamic diameter less than or equal to 2.5 microns.
PTE = Potential-to-emit
UTM = Universal transverse mercator coordinate system zone
$\mu g/m^3$ = micrograms per cubic meter
NA = not applicable

Notice of Construction Application

A notice of construction permit is required before installing a new source of air pollution or modifying an existing source of air pollution. This application applies to facilities in Ecology's jurisdiction. Submit this application for review of your project. For general information about completing the application, refer to Ecology Forms ECY 070-410a-g, "Instructions for Ecology's Notice of Construction Application."

Ecology offers up to 2 hours of free pre-application help. We encourage you to schedule a pre-application meeting with the contact person specified for the location of your proposal (see below). For more help than the initial 2 free hours, submit Part 1 of the application and the application fee. You may schedule a meeting with us at any point in the process.

Completing the application, enclose it with a check for the initial fee and mail to:

WA Department of Ecology
Cashiering Unit
P.O. Box 47611
Olympia, WA 98504-7611

For Fiscal Office Use Only:
001-NSR-216-0299-000404

Check the box for the location of your proposal. For help, call the contact listed below.		
	Ecology Permitting Office	**Contact**
☐ **CRO**	**Chelan, Douglas, Kittitas, Klickitat, or Okanogan County** Ecology Central Regional Office – Air Quality Program	Lynnette Haller (509) 457-7126 lynnette.haller@ecy.wa.gov
☒ **ERO**	**Adams, Asotin, Columbia, Ferry, Franklin, Garfield, Grant, Lincoln, Pend Oreille, Stevens, Walla Walla, or Whitman County** Ecology Eastern Regional Office – Air Quality Program	Jolaine Johnson (509) 329-3452 jolaine.johnson@ecy.wa.gov
☐ **NWRO**	**San Juan County** Ecology Northwest Regional Office – Air Quality Program	Dave Adler (425) 649-7267 david.adler@ecy.wa.gov
☐ **IND**	**Kraft and Sulfite Paper Mills and Aluminum Smelters** Ecology Industrial Section – Waste 2 Resources Program Permit manager: ______________________	James DeMay (360) 407-6868 james.demay@ecy.wa.gov
☐ **NWP**	**U.S. Department of Energy Hanford Reservation** Ecology Nuclear Waste Program	Phil Gent (509) 372-7983 phil.gent@ecy.wa.gov

To request ADA accommodation, call (360) 407-6800, 711 (relay service), or 877-833-6341 (TTY).

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Check the box for the fee that applies to your application.

New project or equipment

☐	**$1,500: Basic project** initial fee covers up to 16 hours of review
☒	**$10,000: Complex project** initial fee covers up to 106 hours of review

Change to an existing permit or equipment

☐	**$200: Administrative or simple change** initial fee covers up to 3 hours of review Ecology may determine your change is complex during completeness review of your application. If your project is complex, you must pay the additional $675 before we will continue working on your application.
☒	**$875: Complex change** initial fee covers up to 10 hours of review
☐	**$350** flat fee: **Replace or alter control technology equipment** (WAC 173-400-114) Ecology will contact you if we determine your change belongs in another fee category. You must pay the fee associated with that category before we will continue working on your application.

Read each statement, then check the box next to it to acknowledge that you agree.

☒	The initial fee you submitted may not cover the cost of processing your application. Ecology will track the number of hours spent on your project. If the number of hours Ecology spends exceeds the hours included in your initial fee, Ecology will charge you $95 per hour for the extra time.
☒	You must include all information in this application. Ecology may not process your application if it does not include all the information requested.
☒	Submittal of this application allows Ecology staff to inspect your facility.

DEPARTMENT OF ECOLOGY

Notice of Construction Application

Part 1: General Information

I. Project, Facility, and Company Information

1. Project Name
MWH-03/04/05/06 Data Center Expansion

2. Facility Name
MWH Data Center

3. Facility Street Address
1515 Port Industrial Parkway, Quincy, WA 98848

4. Facility Legal Description
PARCEL 'C' OXFORD SP 28-8

5. Company Legal Name (if different than Facility Name)
Microsoft Corporation

6. Company Mailing Address (street, city, state, zip)
1515 Port Industrial Parkway, Quincy, WA 98848

II. Contact Information and Certification

1. Facility Contact Name (who will be on-site)
Jaymes Kirkham

2. Facility Contact Mailing Address (if different than Company Mailing Address)
1515 Port Industrial Parkway, Quincy, WA 98848

3. Facility Contact Phone Number 509-237-3633	4. Facility Contact Email jayki@microsoft.com

5. Billing Contact Name (who should receive billing information)
Mark Brunner, Landau Associates, Inc.

6. Billing Contact Mailing Address (if different than Company Mailing Address)
130 2nd Avenue S, Edmonds, WA, 98020

7. Billing Contact Phone Number (206) 631-8695	8. Billing Contact Email mbrunner@landauinc.com

9. Consultant Name (optional – if 3rd party hired to complete application)
Mark Brunner

10. Consultant Organization/Company
Landau Associates Inc.

11. Consultant Mailing Address (street, city, state, zip)
130 2nd Avenue S, Edmonds, WA, 98020

12. Consultant Phone Number (206) 631-8695	13.Consultant Email mbrunner@landauinc.com

14. Responsible Official Name and Title (person responsible for project policy or decision-making)
Jaymes Kirkham

15. Responsible Official Mailing Address
1515 Port Industrial Parkway, Quincy, WA 98848

16. Responsible Official Phone 509-237-3633	17. Responsible Official Email jayki@microsoft.com

18. Responsible Official Certification and Signature
I certify that the information on this application is accurate and complete.

Signature ______________________ Date 7-3-18

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Part 2: Technical Information

The Technical Information may be sent with this application to the Ecology Cashiering Unit, or may be sent directly to the appropriate Ecology office along with a copy of this application.

For all sections, check the box next to each item as you complete it.

III. Project Description

Attach the following to your application:

☒ Description of your proposed project
☐ Projected construction start and completion dates
☒ Operating schedule and production rates
☒ List of all major process equipment with manufacturer and maximum rated capacity
☒ Process flow diagram with all emission points identified
☒ Plan view site map
☒ Manufacturer specification sheets for major process equipment components
☒ Manufacturer specification sheets for pollution control equipment
☒ Fuel specifications, including type, consumption (per hour and per year), and percent sulfur

IV. State Environmental Policy Act (SEPA) Compliance

Check the appropriate box below.

☐ SEPA review is complete.
Include a copy of the final SEPA checklist and SEPA determination (e.g., DNS, MDNS, EIS) with your application.

☒ SEPA review has not been conducted.

☒ If SEPA review will be conducted by another agency, list the agency. You must provide a copy of the final SEPA checklist and SEPA determination before Ecology will issue your permit.

Agency Reviewing SEPA:
City of Quincy

☐ If SEPA review will be conducted by Ecology, fill out a SEPA checklist and submit it with your application. You can find a SEPA checklist online at http://www.ecy.wa.gov/programs/sea/sepa/forms.htm.

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V. Emissions Estimations of Criteria Pollutants

Does your project generate air pollutant emissions? ☒ Yes ☐ No

If yes, provide the following information about your air pollutant emissions:

☒ Air pollutants emitted, such as carbon monoxide (CO_2), lead (Pb), nitrogen dioxide (NO_2), ozone (O_3), and volatile organic compounds (VOC), particulate matter ($PM_{2.5}$, PM_{10}, TSP), sulfur dioxide (SO_2)

☒ Potential emissions of criteria air pollutants in tons per hour, tons per day, and tons per year (include calculations)

☐ Fugitive air pollutant emissions – pollutant and quantity

VI. Emissions Estimations of Toxic Air Pollutants

Does your project generate toxic air pollutant emissions? ☒ Yes ☐ No

If yes, provide the following information about your toxic air pollutant emissions:

☒ Toxic air pollutants emitted (specified in WAC 173-460-150[1])

☒ Potential emissions of toxic air pollutants in pounds per hour, pounds per day, and pounds per year (include calculations)

☐ Fugitive toxic air pollutant emissions - pollutant and quantity

VII. Emission Standard Compliance

Does your project comply with all applicable standards identified? ☒ Yes ☐ No

☒ Provide a list of all applicable new source performance standards, national emission standards for hazardous air pollutants, national emission standards for hazardous air pollutants for source categories, and emission standards adopted under the Washington Clean Air Act, Chapter 70.94 RCW.

VIII. Best Available Control Technology

☒ Provide a complete evaluation of Best Available Control Technology (BACT) for your proposal.

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[1] http://apps.leg.wa.gov/WAC/default.aspx?cite=173-460-150

IX. Ambient Air Impacts Analyses

Does your project cause or contribute to a violation of any ambient air quality standard or acceptable source impact level? ☒ Yes ☐ No

Provide the following:

☒ Ambient air impacts analyses for criteria air pollutants (including fugitive emissions)

☒ Ambient air impacts analyses for toxic air pollutants (including fugitive emissions)

☒ Discharge point data for each point included in ambient air impacts analyses (include only if modeling is required)

- ☒ Exhaust height
- ☒ Exhaust inside dimensions (diameter or length and width)
- ☒ Exhaust gas velocity or volumetric flow rate
- ☒ Exhaust gas exit temperature
- ☒ Volumetric flow rate
- ☒ Discharge description (i.e., vertically or horizontally) and if there are any obstructions (e.g., raincap)
- ☒ Emission unit(s) discharging from the point
- ☒ Distance from the stack to the nearest property line
- ☒ Emission unit building height, width, and length
- ☒ Height of tallest building on-site or in the vicinity, and the nearest distance of that building to the exhaust
- ☒ Facility location (urban or rural)