TECHNICAL SUPPORT DOCUMENT
NOTICE OF CONSTRUCTION APPROVAL ORDER NO. 11AQ-E4XX
DELL MARKETING, LP
DELL DATA CENTER
JUNE 9, 2011

1. BACKGROUND

Starting in 2006, internet technology companies became interested in the City of Quincy in Grant County as a good place to build data centers. Data centers house the servers that provide e-mail, manage instant messages, and run software applications for our computers. Grant County has a low-cost, dependable power supply and an area wide fiber optic system. During 2007 and 2008, the Ecology Air Quality Program (AQP) issued approval orders to Microsoft Corporation, Yahoo! Inc., and Intuit Inc. that allowed them to construct and operate data centers.

In 2010, the Washington State Legislature approved a temporary sales tax exemption for data centers building in Grant County and other rural areas. To qualify for the tax exemption, the data center must have at least 20,000 square feet dedicated to servers and start construction before July 1, 2011. The AQP has received permit applications from Microsoft Corporation and Yahoo! Inc. for expansion of their existing data centers in Quincy. Dell Marketing, LP and Sabey Intergate Quincy, LLC have also submitted applications for new data centers in Quincy.

To build or expand, a data center company must first apply to the Washington Department of Ecology (Ecology) for a permit called a notice of construction (NOC) approval order. Its purpose is to protect air quality. The NOC approval order is needed because data centers use large, diesel-powered backup generators to supply electricity to the servers during power failures. Diesel engine exhaust contains both criteria and toxic air pollutants. As part of the permit review process, Ecology carefully evaluates whether the diesel exhaust from a data center's backup generators could cause health problems.

2. EXECUTIVE SUMMARY

Dell Marketing, LP (Dell) submitted a Notice of Construction (NOC) application on January 24, 2011, for the installation of the Dell Data Center in Quincy, Grant County. The Dell Data Center is located directly north of the Microsoft Columbia Data Center, and will be utilized by Dell to store data and run software applications. The primary air contaminant sources at the facility consist of twenty-eight (28) electric generators powered by diesel engines. The generators will have a power capacity of up to 84 MWe at full buildout, and will provide emergency backup power to the facility during infrequent disruption of Grant County PUD electrical power service. The project will be phased in over several years depending on demand.

Review of the January 24, 2011 NOC application began on February 1, 2011, and a completeness determination was issued to Dell on February 14, 2011 by the permit team (Flibbert, Ogulei) under the supervision of the Science and Engineering Section Manager (Johnston) and the Eastern Regional Office Section Manager (Wood). A revised NOC application was submitted by Dell on April 28, 2011. The NOC application was considered complete as of April 28, 2011. The final draft Preliminary Determination (i.e., Proposed Decision) was submitted to HQ on May 3, 2011, for review and to complete the third tier review.

The Preliminary Determination was issued on June 10, 2011, and public review ended on July 18, 2011.

3. PROJECT DESCRIPTION

The Ecology Air Quality Program (AQP) received a Notice of Construction (NOC) application for the Dell Data Center on January 24, 2011. The Dell Data Center consists of phased construction of 3 buildings, i.e., Phase 1, Phase 2, and Phase 3. Phase 1 construction of 100,866 square feet will commence during 2011, and includes fourteen (14) 3.0 Megawatts (MWe) electric generators powered by 4423 brake horse power Caterpillar C175-16 engines. Phase 2 and 3 construction will be 56,659 ft^2 and 57,508 ft^2 of space each, respectively, and each Phase will include seven (7) 3.0 Megawatts (MWe) electric generators powered by 4423 brake horse power Caterpillar C175-16 engines. The Dell Data Center generators will have a total capacity of approximately 84 MWe upon final build out of the three Phases.

Dell Marketing, LP, hereafter referred to as Dell, has requested operational limitations on the facility to reduce emissions below major source thresholds and to minimize air contaminant impacts to the community. Dell has asked to restrict diesel fuel usage at the data center to 175,031 gallons of road specification diesel fuel. Average engine operations of between 50.75 and 54.75 hours per year is commensurate with the diesel fuel limit.

Air contaminant emissions from the Dell Data Center project have been based entirely on operation of the emergency generators. Table 1a contains criteria pollutant potential to emit for the Dell Data Center expansion project. Table 1b contains toxic air pollutant potential to emit for the Dell Data Center expansion project.

Table 1a: Criteria Pollutant Potential to Emit for Dell Data Center

Pollutant	Emission Factor (EF) Reference	Emission Factors	Facility Emissions
Criteria Pollutant		g/kWm-hr	tons/yr
2.1.1 NOx Total			19.87
2.1.1a NOx 10% load-idle	EPA Tier 2	6.12	na
2.1.1b NOx 70% load	Caterpillar	7.16	na
2.1.1c NOx 95% load	Caterpillar	8.23	na
2.1.2 CO	EPA Tier 2	3.50	10.46
2.1.3 SO_2	Mass Balance	na	0.0185
2.1.4 $PM_{2.5}$/DEEP			0.71
2.1.4a DEEP 10% load-idle	Caterpillar	0.590	na
2.1.4b DEEP 70%	EPA Tier 2	0.20	na
2.1.4c DEEP 95%	EPA Tier 2	0.20	na
2.1.5 VOC	EPA Tier 2	0.282	1.47

Table 1b: Toxic Air Pollutant Potential to Emit for Dell Data Center		
Pollutant	**AP-42 Section 3.4 EF**	**Facility Emissions**
Organic Toxic Air Pollutants	Lbs/MMbtu	tons/yr
2.1.6 Propylene	2.79E-03	3.35E-02
2.1.7 Acrolein	7.88E-06	9.45E-05
2.1.8 Benzene	7.76E-04	9.30E-03
2.1.9 Toluene	2.81E-04	3.37E-03
2.1.10 Xylenes	1.93E-04	2.31E-03
2.1.11 Napthalene	1.30E-04	1.56E-03
2.1.11 1,3 Butadiene	1.96E-05	2.34E-04
2.1.12 Formaldehyde	7.89E-05	9.46E-04
2.1.13 Acetaldehyde	2.52E-05	3.02E-04
Poly Aromatic Hydrocarbons (PAH)		
2.1.14 Benzo(a)Pyrene	1.29E-07	1.54E-06
2.1.15 Benzo(a)anthracene	6.22E-07	7.46E-06
2.1.16 Chrysene	1.53E-06	1.83E-05
2.1.17 Benzo(b)fluoranthene	1.11E-06	1.33E-05
2.1.18 Benzo(k)fluoranthene	1.09E-07	1.31E-06
2.1.19 Dibenz(a,h)anthracene	1.73E-07	2.07E-06
2.1.20 Ideno(1,2,3-cd)pyrene	2.07E-07	2.48E-06
2.1.21 PAH (no TEF)	3.88E-06	4.65E-05
2.1.22 PAH (apply TEF)	4.98E-07	5.97E-06
State Criteria Pollutant Air Toxics		
2.1.23 DEEP/$PM_{2.5}$	EPA Tier 2	0.71
2.1.24 Carbon monoxide	EPA Tier 2	10.46
2.1.25 Sulfur dioxide	EPA Tier 2	0.0185
2.1.26 Primary NO_2*	10% total NOx	1.987

*Assumed to be equal to 10% of the total NOx emitted.

The Dell Data Center relies on cooling systems to dissipate heat from electronic equipment at the facility. It was determined during review of the application that the cooling system has no air contaminant emissions, and does not require approval under state and federal air quality requirements. Additional cooling systems will be added to the facility as necessary to meet the cooling needs of tenants.

4. APPLICABLE REQUIREMENTS

The proposed by Dell Data Center qualifies as a new source of air contaminants as defined in Washington Administrative Code (WAC) 173-400-110 and WAC 173-460-040, and requires

Ecology approval. The installation and operation of the Dell Data Center is regulated by the requirements specified in:

4.1 Chapter 70.94 Revised Code of Washington (RCW), Washington Clean Air Act,
4.2 Chapter 173-400 Washington Administrative Code (WAC), General Regulations for Air Pollution Sources,
4.3 Chapter 173-460 WAC, Controls for New Sources of Toxic Air Pollutants, and
4.4 Title 40 CFR Part 60 Subpart IIII

All state and federal laws, statutes, and regulations cited in this approval shall be the versions that are current on the date the final approval order is signed and issued.

5. BEST AVAILABLE CONTROL TECHNOLOGY

Best Available Control Technology (BACT) is defined[1] as "*an emission limitation based on the maximum degree of reduction for each air pollutant subject to regulation under chapter 70.94 RCW emitted from or which results from any new or modified stationary source, which the permitting authority, on a case-by-case basis, taking into account energy, environmental, and economic impacts and other costs, determines is achievable for such source or modification through application of production processes and available methods, systems, and techniques, including fuel cleaning, clean fuels, or treatment or innovative fuel combustion techniques for control of each such pollutant. In no event shall application of the "best available control technology" result in emissions of any pollutants which will exceed the emissions allowed by any applicable standard under 40 CFR Part 60 and Part 61....*"

For this project, Ecology is implementing the "top-down" approach for determining BACT for the proposed diesel engines. The first step in this approach is to determine, for each proposed emission unit, the most stringent control available for a similar or identical emission unit. If that review can show that this level of control is not technically or economically feasible for the proposed source, then the next most stringent level of control is determined and similarly evaluated. This process continues until the BACT level under consideration cannot be eliminated by any substantial or unique technical, environmental, or economic objections.[2] The "top-down" approach shifts the burden of proof to the applicant to justify why the proposed source is unable to apply the best technology available. The BACT analysis must be conducted for each pollutant that is subject to new source review.

The proposed diesel engines will emit the following regulated pollutants which are subject to BACT review: nitrogen oxides (NOx), carbon monoxide (CO), volatile organic compounds (VOCs), particulate matter (PM, PM_{10} and $PM_{2.5}$) and sulfur dioxide.

[1] RCW 70.94.030(7) and WAC 173-400-030(12)
[2] J. Craig Potter, EPA Assistant Administrator for Air and Radiation memorandum to EPA Regional Administrators, "Improving New Source Review (NSR) Implementation", December 1, 1987.

5.1 BACT ANALYSIS FOR NOx

Dell reviewed EPA's RACT/BACT/LAER Clearinghouse (RBLC) database to look for NOx add-on controls recently installed on internal combustion engines. The RBLC provides a listing of BACT determinations that have been proposed or issued for large facilities within the United States, Canada and Mexico. Dell's review of the RBLC found that urea -based selective catalytic reduction (SCR) was the most stringent add-on control option demonstrated on diesel engines. The application of the SCR technology for NOx control was therefore considered the top-case control technology and evaluated for technical feasibility and cost-effectiveness.

The most common BACT determination identified in the RBLC for NOx control was compliance with EPA Tier 2 standards using engine design, including exhaust gas recirculation (EGR) or fuel injection timing retard with turbochargers. Other NOx control options identified through a literature review include water injection and NOx adsorbers.

5.1.1 ***Selective Catalytic Reduction.*** The SCR system functions by injecting a liquid reducing agent, such as urea, through a catalyst into the exhaust stream of the diesel engine. The urea reacts with the exhaust stream converting nitrogen oxides into nitrogen and water. The use of a lean ultralow sulfur fuel is required to achieve good NOx destruction efficiencies. SCR can reduce NOx emissions by up to 90-95 percent while simultaneously reducing hydrocarbon (HC), CO and PM emissions.

For SCR systems to function effectively, exhaust temperatures must be high enough (about 200 to 500°C) to enable catalyst activation. For this reason, SCR control efficiencies are expected to be relatively low during the first 20 to 30 minutes after engine start up, especially during maintenance, and testing loads. There are also complications of managing and controlling the excess ammonia (ammonia slip) from SCR use. Because backup engines typically experience long idle periods between operations, urea crystallization inside reagent distribution lines could cause damage to the SCR system and to the engine.

Dell has evaluated the cost effectiveness of installing and operating SCR systems on each of the proposed diesel engines. The analysis indicates that the use of SCR systems would cost approximately $57,634 per ton of NOx removed from the exhaust stream, based on worst-case power outage of eight (8) hours per year. A previous survey by Ecology found that the permitting agencies surveyed have required installation of NOx controls as BACT with expected operational costs ranging from $143 to $9,473 per ton of NOx removed. Ecology concludes that while SCR is a demonstrated emission control technology for prime diesel engines, it is not economically feasible for this project. Therefore, Ecology rejects this NOx control option as BACT.

5.1.2 ***NOx adsorbers.*** The use of NOx adsorbers (sometimes called lean NOx traps) is a catalytic method being developed and tested by diesel engine manufacturers to reduce NOx emissions, primarily from mobile sources. The NOx adsorber contains a catalyst (e.g., zeolite or platinum) that is used to "trap" NOx (NO and NO_2) molecules found in the exhaust. NOx adsorbers can achieve NOx reductions greater than 90% at typical steady-state exhaust gas temperatures.

However, as of this writing, NOx adsorbers are experimental technology and are, therefore, very expensive. Additionally, a literature search did not reveal any indication that this technology is commercially available for stationary backup generators. Thus, Ecology rejects NOx adsorbers as BACT for the proposed diesel engines.

5.1.3 ***Combustion Controls and Tier 2 compliance.*** Diesel engine manufacturers typically use proprietary combustion control methods to achieve the emission reductions needed to meet applicable EPA tier standards. Common controls include fuel injection timing retard and exhaust gas recirculation. Injection timing retard reduces the peak flame temperature and NOx emissions, but may lead to higher fuel consumption. Dell will install 4423 hp Caterpillar Model C175-16 engines that will use a combination of combustion control methods, including fuel injection timing retard, to comply with EPA Tier-2 emission limits.

5.1.4 ***Two-Stage Oxidation Catalysts for NOx Reduction***

Ecology has learned that 2-stage oxidation catalysts ("3-way" catalysts) can be designed to reduce NOx emissions from emergency generators. Such a system has been proposed by R S Titan Lotus, LLC for the Titan Data Center expansion in Moses Lake, Washington. The system proposed by R S Titan Lotus, LLC and proposed for approval by Ecology is specially designed to remove 35% or more of NOx emissions, as well as considerable quantities of diesel particulate, CO and VOC emissions. The system reviewed by Ecology is a single-pass system that can be installed without retrofitting closed-loop systems such as Exhaust Gas Recirculation. Each catalyst system uses a stainless steel honeycomb mesh catalyst element coated with three catalysts: cerium washcoat; platinum (Pt) and rhodium (Rh) catalyst coatings.

The 2-stage oxidation catalysts first oxidize CO and VOC while removing oxygen from the gas stream, then the remaining rich-burn environment reacts with the Rh catalyst to chemically convert the NO and NO_2 in the exhaust stream to nitrogen. The system achieves the required low-oxygen environment by using a specialized catalyst coating and cell structure to remove oxygen molecules from the diesel exhaust stream. Exhaust temperature must be at least 250°C and not exceed 750°C for the system to be effective.

Although 2-stage oxidation catalyst systems appear to have been commercially deployed for standby diesel engine applications in Europe, Australia and Canada, Ecology is unaware of specific applications within the United Sates. The Titan Data Center (Moses Lake, Washington) has proposed to use two 35" diameter x 3.5" thick 3-way catalysts within one stainless steel housing for their planned expansion. The manufacturer of that catalyst system (Clean Emissions Products, Inc.) will guarantee a NOx reduction of not less than 35% although their website and a company salesman both claim that their 2-stage catalysts are capable of reducing up to 99% of CO, 70% of NOx and 90% of diesel particulate.[3] The catalysts proposed by the Titan Data Center are also expected to reduce at least 90% of VOC. Actual test data have reported about 43% NOx reduction and about 88% diesel particulate reduction.

Ecology evaluated the cost effectiveness of installing and operating specially-designed 2-stage oxidation catalyst systems (3-way catalysts) for NOx reduction from Dell's proposed engines. Based on information supplied by one manufacturer, Ecology estimates that the use of these catalysts would cost Dell more than $11,700 for each ton of NOx removed from the exhaust stream, based on a worst-case power outage scenario of eight (8) hours per year.

As stated above, a previous survey by Ecology found that the surveyed permitting agencies had required installation of NOx controls as BACT with expected operational costs ranging from $143 to $9,473 per ton of NOx removed. In general, Ecology considers operating costs for NOx control equipment that exceed $10,000 per ton of NOx removed to be cost-prohibitive under BACT. This presumption can be defeated if the applicant proposes to install a specific emissions control technology regardless of the associated costs. Ecology concludes that while specially designed 2-stage oxidation catalysts are promising and potentially effective for NOx control, they are not cost effective under general BACT guidelines. Since Dell does not propose the use of 2-stage (3-way) catalysts to control NOx emissions, Ecology cannot force Dell to install 2-stage catalysts as BACT for NOx emissions.

5.1.5 ***Other control options***. Other NOx control options, such as water injection, were rejected because there was no indication that they are commercially available and/or effective in new large diesel engines.

5.1.6 **BACT determination for NOx**

Ecology determines that BACT for NOx is:

a. Use of good combustion practices;
b. Use of an engine design that incorporates fuel injection timing retard, turbocharger and a low-temperature aftercooler;
c. Use of EPA Tier 2 certified engines if the engines are installed and operated as emergency engines, as defined at 40 CFR§60.4219; or applicable emission standards found in 40 CFR Part 89.112 Table 1 and 40 CFR Part 1039.102 Tables 6 and 7 if Model Year 2011 or later engines are installed and operated as non-emergency engines; and
d. Compliance with the operation and maintenance restrictions of 40 CFR Part 60, Subpart IIII.

[3] http://www.cleanemissions.com/pdf/TwoStageCatalyst.pdf

5.2 BACT ANALYSIS FOR PARTICULATE MATTER, CARBON MONOXIDE AND VOLATILE ORGANIC COMPOUNDS

Dell reviewed the available published literature and the RBLC and identified the following demonstrated technologies for the control of diesel engine exhaust particulate, carbon monoxide and volatile organic compounds from the proposed diesel engines:

5.2.1 ***Diesel particulate filters (DPFs)***. These add-on devices include passive and active DPFs, depending on the method used to clean the filters (i.e., regeneration). Passive filters rely on a catalyst while active filters typically use continuous heating with a fuel burner to clean the filters. The use of DPFs to control diesel engine exhaust particulate emissions has been demonstrated in multiple engine installations worldwide. Particulate matter reductions of up to 85% or more have been reported. Therefore, this technology was identified as the top case control option for diesel engine exhaust particulate emissions from the proposed engines.

Dell has evaluated the cost effectiveness of installing and operating DPFs on each of the proposed diesel engines. The analysis indicates that the use of DPFs would cost approximately $1,541,088 per ton of engine exhaust particulate removed from the exhaust stream, assuming eight (8) hours of power outage per year. A previous survey by Ecology found that none of the permitting agencies surveyed had required installation of a particulate matter control device (as BACT) that was expected to cost more than $23,200 per ton of particulate removed.

Since the estimated DPF cost effectiveness value for the proposed Dell project far exceeds the $23,200 per ton upper limit, Ecology concludes that the use of DPFs is not economically feasible for this project. Therefore, Ecology rejects this control option as BACT for particulate matter.

5.2.2 ***Diesel oxidation catalysts***. This method utilizes metal catalysts to oxidize carbon monoxide, particulate matter, and hydrocarbons in the diesel exhaust. Diesel oxidation catalysts (DOCs) are commercially available and reliable for controlling particulate matter, carbon monoxide and hydrocarbon emissions from diesel engines. While the primary pollutant controlled by DOCs is carbon monoxide (approximately 90% reduction), DOCs have also been demonstrated to reduce up to 30% of diesel engine exhaust particulate emissions, and more than 50% of hydrocarbon emissions.

Dell has evaluated the cost effectiveness of installing and operating DOCs on each of the proposed diesel engines. The cost effectiveness of DOC use has not been evaluated using the total amount of particulate matter reduced since control efficiency is only 5% to 10%. The DOC cost effectiveness value for carbon monoxide and volatile organic compounds destruction is approximately $24,709 per ton and $175,824 per ton, respectively.

Diesel Oxidation Catalyst technology is commercially available. A previous survey by Ecology found that the permitting agencies surveyed have required installation of carbon monoxide controls as BACT on other types of emission units, with expected operational costs ranging from $300 to $9,795 per ton of carbon monoxide removed. The upper level of that range is suspect and it is possible that that number actually reflects California BACT which is typically equivalent to a Lowest Achievable Emissions Rate (LAER) limit. In Washington, costs for controlling CO from combined cycle natural gas electric generating facilities are usually in the $3,500 to $5,000 range. The cost effectiveness estimates calculated for the Dell project are outside this range when all pollutants to be controlled are considered, or if only carbon monoxide is considered.

5.2.3 *Two-Stage Oxidation Catalysts*

The theory and design of 2-stage diesel oxidation catalysts (i.e., diesel oxidation catalysts operating in a 3-way catalyst mode) was described in Section 5.1.4. As stated above, one manufacturer of one such commercially-available system claims their systems are capable of reducing up to 99% of CO, 70% of NOx, 90% of VOC, and 90% of diesel particulate.

Ecology has evaluated the cost effectiveness of installing and operating specially-designed 2-stage oxidation catalyst systems (3-way catalysts) for NOx reduction from Dell's proposed engines. Based on information supplied by one manufacturer, and assuming a worst-case power outage scenario of eight (8) hours per year, Ecology estimates that the use of these catalysts would cost Dell **more than**:

- $255,178 for each ton of PM removed from the exhaust stream;
- $15,746 for each ton of CO removed from the exhaust stream; and
- $123,249 for each ton of VOC removed from the exhaust stream.

Ecology considers the above annual control cost estimates to be prohibitive under BACT guidelines. Ecology concludes that while specially designed 2-stage oxidation catalysts are promising and potentially effective for CO, PM and VOC control, they are not cost effective under general BACT guidelines. Since Dell does not propose the use of 2-stage (3-way) catalysts to control CO, PM or VOC emissions, Ecology cannot force Dell to install 2-stage catalysts as BACT for CO, PM or VOC emissions.

5.2.4 <u>BACT Determination for Particulate Matter, Carbon Monoxide and Volatile Organic Compounds</u>

Ecology determines BACT for particulate matter, carbon monoxide and volatile organic compounds is:

a. Use of good combustion practices;
b. Use of EPA Tier 2 certified engines if the engines are installed and operated as emergency engines, as defined at 40 CFR§60.4219; or applicable emission standards found in 40 CFR Part 89.112 Table 1 and 40 CFR Part 1039.102 Tables 6 and 7 if Model Year 2011 or later engines are installed and operated as non-emergency engines; and
c. Compliance with the operation and maintenance restrictions of 40 CFR Part 60, Subpart IIII.

5.3 BACT ANALYSIS FOR SULFUR DIOXIDE

5.3.1 Ecology and Dell did not find any add-on control options commercially available and feasible for controlling sulfur dioxide emissions from diesel engines. Dell's proposed BACT for sulfur dioxide is the use of ultra-low sulfur diesel fuel (15 ppm by weight of sulfur). Using this control measure, sulfur dioxide emissions would be limited to 0.0185 tons per year.

5.3.2 <u>**BACT Determination for Sulfur Dioxide**</u>
Ecology determines that BACT for sulfur dioxide is the use of ultra-low sulfur diesel fuel containing no more than 15 parts per million by weight of sulfur.

5.4 BEST AVAILABLE CONTROL TECHNOLOGY FOR TOXICS

Best Available Control Technology for Toxics (tBACT) means BACT, as applied to toxic air pollutants.[4] The procedure for determining tBACT follows the same procedure used above for determining BACT. Under state rules, tBACT is required for all toxic air pollutants for which the increase in emissions will exceed de minimis emission values as found in WAC 173-460-150.

For the proposed project, tBACT must be determined for each of the toxic air pollutants listed in Table 1 below. As illustrated by Table 2, Ecology has determined that compliance with BACT, as determined above, satisfies the tBACT requirement.

Table 2. tBACT Determination

Toxic Air Pollutant	tBACT
Acetaldehyde	Compliance with the VOC BACT requirement
Acrolein	Compliance with the VOC BACT requirement
Benzene	Compliance with the VOC BACT requirement
Benzo(a)pyrene	Compliance with the VOC BACT requirement
1,3-Butadiene	Compliance with the VOC BACT requirement
Carbon monoxide	Compliance with the CO BACT requirement
Diesel engine exhaust particulate	Compliance with the PM BACT requirement
Formaldehyde	Compliance with the VOC BACT requirement
Nitrogen dioxide	Compliance with the NOx BACT requirement
Sulfur dioxide	Compliance with the SO_2 BACT requirement
Toluene	Compliance with the VOC BACT requirement
Total PAHs	Compliance with the VOC BACT requirement
Xylenes	Compliance with the VOC BACT requirement

[4] WAC 173-460-020

6. AMBIENT IMPACTS ANALYSIS

ICF conducted air dispersion modeling for Dell Data Center's generators to demonstrate compliance with ambient air quality standards and acceptable source impact levels. The generators were modeled as multiple discharge points. ICF used AERMOD (Version 09292), with EPA's PRIME algorithm for building downwash, to determine worst-case ambient air quality impacts caused by emissions from the proposed generators at the property line and beyond, and at the rooftop of the commonly occupied data center building. The ambient impacts analysis indicates that no ambient air quality standard is expected to be exceeded.

6.1 Ambient Air Quality Compliance Boundary

Ecology directed ICF to assume that for purposes of AERMOD modeling, the air quality compliance boundary consists of all locations beyond the facility boundary, regardless of whether they are occupied.

6.2 AERMOD Dispersion Modeling Methodology

The AERMOD model employed the following data and assumptions[5]:

a) Five years of sequential hourly meteorological data (2004-2008) from Moses Lake were used.

b) Twice-daily upper air data from Spokane were used to define mixing heights.

c) Digital topographical data (in the form of Digital Elevation Model files) for the vicinity were obtained from the Micropath Corporation. 2001 National Land Cover (NLCD2001) land use data.

d) The data center building was included to account for building downwash.

e) The receptor grid for the AERMOD modeling was established using a 10-meter grid spacing along the facility boundary extending to a distance of 300 meters from the north and south sides of the facility boundary, and about 200 meters from the east and west sides of the facility boundary (i.e., within approximately a 350 meter range of all generators).

f) One-hour NO_2 concentrations were modeled using the Plume Volume Molar Ratio Method (PVMRM) module, with default ozone concentrations of 40 parts per billion (ppb), and an equilibrium NO_2/NO_X ambient ratio of 90 percent. For purposes of modeling NO_2 impacts, the primary NO_X emissions were assumed to be 10% NO_2 and 90% nitric oxide (NO) by mass.

g) Compliance with the 1-hour NO_2 and 24-hour $PM_{2.5}$ NAAQS was demonstrated as shown in the following sections. For purposes of demonstrating compliance with the 24 hour NAAQS and the 24 hour ASILs, Dell assumed the forecast 8 hours/year of power outages would occur on a single day. To estimate annual average

[5] See NOC application and second tier petition support documents.

concentrations (for DEEP and other pollutants with annual averages), AERMOD/PVMRM was run using 28 different generator stacks each with its assigned engine size, engine load, stack diameter, stack height, stack temperature, stack velocity, and maximum annualized emission rates[6]. The generators were assumed to operate continuously at their assigned load for 24 hours, 7 days per week, 365 days per year for each of the five years. AERMOD then specified the 1st-highest annual impact location and magnitude. The maximum impact per year and the number of hours for which the ASIL was exceeded during the five-year simulation period were recorded.

h) The 1st-highest 1-hour NO_2 concentrations during a full power outage were modeled to assess compliance with the ASIL. Because a power outage could occur at any time on any day, all 28 new generators were modeled at their assigned loads continuously, for 24 hours per day and 365 days per year for the five years of meteorology used in the analysis. The AERMOD/PVMRM was set to indicate the 1st-highest 1-hour value for each separate modeling year.

i) Scheduled testing was assumed to take place between 7:00 a.m. to 7:00 p.m. Sabey assumed unplanned outages could occur anytime during the day or night.

6.3 Compliance With the 1-Hour NO_2 National Ambient Air Quality Standard (NAAQS)

In 2010, EPA established a new 1-hour NAAQS for NO_2, set at 100 parts per billion (ppb) or approximately 188 $\mu g/m^3$. The new 1-hour standard is intended to protect against short-term exposure to high NO_2 concentrations, particularly near major roadways. The new NO_2 standard establishes a new 1-hour averaging period for the NO_2 NAAQS. To comply with the 1-hour NO_2 NAAQS, the three-year average of the 98th percentile of the annual distribution of daily maximum 1-hour average concentrations at the ambient air receptor must be less than 100 ppb. The 1-hour NAAQS is designed to protect against health effects associated with short-term exposures to NO_2, which are generally highest on and near major roads.

During a full unplanned power outage, most of the generators would activate at design load, while other "redundant units" would initially activate but would run at idle to serve as a standby unit. The active generators are designed to run at loads of 47% to 64% during an outage. For this air quality permit it was assumed that only one generator would serve as the "redundant unit". Depending on specific tenant needs, it is likely that they could require a lower electrical demand and could use more than one "redundant unit". In that case the actual emission rates would be lower than the upper-bound rates assumed for this analysis.

Dell assumed the facility would experience 8 hours per year of unplanned power outages, and for estimating worst-case annual emissions, Dell assumed each tenant would conduct their occasional electrical bypass maintenance in the same worst-case year. For purposes of demonstrating compliance with the 24 hour NAAQS and the 24 hour ASILs, Dell further assumed the forecast 8 hours/year of power outages would occur on a single day. However, for

[6] That is, annual emissions in tons per year divided by 8760 hours.

purposes of the statistical "Monte Carlo" analysis used to demonstrate compliance with the 1-hour NO_2 NAAQS it was assumed there would be power outages lasting at least one hour on 4 days per year.

The NAAQS limits for 24-hour $PM_{2.5}$ and 1-hour NO_2 are both based on the 3-year average of the 98th percentile highest daily impact. This is equivalent to the eighth-highest operating day during each year. It is unlikely that the Moses Lake area would experience 8 major power failures in any given year. Therefore, for purposes of evaluating 24-hour average $PM_{2.5}$ impacts it was assumed the seventh (and eighth)-highest operating days in any year would consist of the routine monthly engine testing, which consists of each generator running one at a time on the same day for short duration at low load (1.5 hours at 50% load).

To demonstrate compliance with the 1-hour NO_2 NAAQs, a "Monte Carlo" statistical analysis was used to estimate the likelihood of an exceedance of the ambient 1-hour NO_2 NAAQS.

6.3.1. Description of the Methodology of the "Monte Carlo" Statistical Analysis

The 1-hour NO_2 NAAQS is based on the 3-year rolling average of the 98th percentile of the daily maximum 1-hour NO_2 impacts. Data centers operate their generators on an intermittent basis under a wide range of engine loads, under a wide range of meteorological conditions. As such it is difficult to determine whether high-emitting generator runtime regimes coincide with meteorological conditions giving rise to poor dispersion, and trigger an exceedance of the 1-hour NO_2 NAAQS at any given location beyond the facility boundary. This issue was recently recognized by EPA when they stated that "[m]odeling of intermittent emission units, such as emergency generators, and/or intermittent emission scenarios, such as startup/shutdown operations, has proven to be one of the main challenges for permit applicants undertaking a demonstration of compliance with the 1-hour NO_2 NAAQS".[7]

To address this problem, Ecology developed a statistical re-sampling technique, that we loosely call the "Monte Carlo analysis". This technique performs a statistical analysis of the AERMOD-derived ambient NO_2 impacts caused by individual generator operating regimes, each of which exhibits its own NOx emission rates at various locations throughout the facility. The randomizing function of the Monte Carlo analysis allows inspection of how the combination of sporadic generator operations, sporadic generator emissions at various locations, and variable meteorology affect the modeled 98th-percentile concentrations at modeling receptors placed within the facility and outside the facility boundary.

The Monte Carlo methodology consists of two steps. The first step is the application of AERMOD for a variety of emissions scenarios, as needed to represent the emissions from each of the expected operating modes. In this step, AERMOD is run for all five years using the worst-case emissions for each operating mode.

[7] http://www.epa.gov/ttn/scram/Additional_Clarifications_AppendixW_Hourly-NO2-NAAQS_FINAL_03-01-2011.pdf

The next step is to statistically analyze the results and estimate the 98th percentile NO_2 concentration for each receptor. This involves randomly selecting concentrations corresponding to each operating mode for the number of days of operation corresponding to that mode. The concentrations for these selected days represent one possible array of concentrations associated with a typical year of operation, from which the 98th percentile value can be calculated. The random selection of days/concentrations is repeated 1000 times and the median of the 98th percentile values of concentrations for each receptor is calculated. This repeated random sampling of the days is also referred to as a Monte Carlo approach. For each year, the highest value (i.e., the highest median 98th percentile value) resulting from this procedure over all receptors is then identified. Finally, the median value of these highest values from each year is obtained. This value is used for comparison with the NAAQS.

Compliance with the 1-hour NO_2 NAAQS was evaluated based on the median of the distribution of 98th percentile values calculated for each of the five years modeled. The analysis showed that the 1-hour NO_2 NAAQS is not likely to be exceeded.

6.3.2. Application Procedures and Results

The Monte Carlo approach was used to examine NAAQS compliance for a worst-case scenario that includes both commissioning testing and routine operations following full build out of the data center. The scenario is only possible if commissioning occurs early in the year and all other routine testing is done during that same year. Thus it is an unlikely but possible one-time only scenario with maximum annual emissions.

Two separate Monte Carlo analyses were conducted. In the first analysis, only the emissions from the Dell facility were considered in the AERMOD runs that provide the basis for the analysis (this is referred to as the Dell-only analysis). In the second analysis, emissions from other, nearby facilities were also considered and additional AERMOD runs were conducted to establish the impacts from these facilities (this is referred to as the multiple-facility analysis). The results for both analyses are presented in the remainder of this section.

6.3.3. Dell-Only Analysis Procedures

The statistical analysis to support the NAAQS compliance demonstration considered two days of power outage, commissioning of the Phase 3 engines, and all routine diagnostic testing. The scenarios, operating modes, and events included in the analysis are listed in Table 3. The number of days per year associated with each event is also listed.

The power outage scenarios include all generators, even those undergoing commissioning. Weekly testing was not included, since the emissions are very small compared to all of the other scenarios and the impacts are expected to be negligible. All scenarios involving running only one engine at a time (such as additional days of annual and semi-annual testing) were also not included since the emissions are very small. Finally, corrective generator maintenance was not included, since it would likely involve one engine at a time at moderate load and a very small amount of emissions.

Table 3. Emissions Scenarios/Events and Number of Days Included in the Monte Carlo Analysis for the Dell Data Center.

Scenario/Event	Number of Days per Year Included in the Monte Carlo Analysis
Full power outage	2
Commissioning of Phase 3	4
Annual testing of Phase 1abc	1
Semi-annual testing of Phase 1abc	1
Monthly testing of Phase 1abc	10
Annual testing of Phase 1t4	1
Semi-annual testing of Phase 1t4	1
Monthly testing of Phase 1t4	10
Annual testing of Phase 2	1
Semi-annual testing of Phase 2	1
Monthly testing of Phase 2	10
Annual testing of Phase 3	1
Semi-annual testing of Phase 3	1
Monthly testing of Phase 3	10

AERMOD was not run specifically for each scenario/operating mode. AERMOD was run for the full power outage scenario and for the commissioning scenarios for each phase or group of engines (1abc, 1t4, 2 and 3). The AERMOD results for the remaining testing scenarios were adjusted (scaled) to reflect the generator runtimes and hourly emissions rates associated with each scenario. Specifically, the annual testing results were estimated by scaling the commissioning testing results by a factor of 0.75 representing a change in runtime from 60 to 45 minutes. The semi-annual testing results were estimated by scaling the commissioning testing results by a factor of 0.5, representing a change from 60 to 30 minutes. In addition, impacts associated with monthly testing were estimated by scaling the commissioning testing results by a factor of 0.25, representing the difference between 60 and 15 minutes. Scaling was only used for cases where the only difference between the scenarios is the engine runtime.

AERMOD was applied for a radially telescoping receptor grid, with 10-meter spacing along the fenceline, 12.5-meter spacing out to 150 meters, 25-meter spacing out to 500 meters, 50-meter spacing out to 900 meters, and 100-meter spacing out to 2300 meters. All software used for this application was provided by Ecology, and applied according to Ecology's recommended procedures.

6.3.4. Dell-Only Analysis Results

For the Dell-only analysis, the Monte-Carlo-based estimate of the three-year average 98th percentile 1-hour NO2 value (for the receptor location with the maximum value) is 22.3 μg/m^3. After accounting for regional background, the NO2 impact at or beyond the project boundary is 51.3 μg/m^3, and is lower than the NAAQS (Table 4).

Table 4. Dell-Only 1-Hour NO_2 Impact At Or Beyond The Project Boundary

Parameter	Concentration (μg/m^3)
Three-year average 98th percentile 1-hour NO_2 increment (no background)	22.3
Regional background	29.0
NO_2: Increment plus background	51.3
NAAQS Limit	188

The location of the estimated Dell-only maximum 3-year average 98th percentile 1-hour NO_2 concentration is near the mid-point of the Dell western property line. This is the boundary immediately adjacent to Dell's generators.

6.3.5. Multiple-Facility Analysis Procedures

In addition to the Dell-only scenarios, operating modes, and events listed in Table 3, this analysis also considered the impacts from three nearby facilities: Microsoft, Celite, and Con-Agra. To represent the local background, AERMOD results for these facilities were included in the Monte Carlo analysis. For the Microsoft facility, power outages, monthly testing, and electrical bypass maintenance were considered. For Celite and Con-Agra, which run 24 hours per day and 7days per week (24/7), routine plant operations were accounted for. These are listed in Table 5 along with the number of days per year associated with each event.

The two days of power outage are the same days for both the Dell and Microsoft facility. Emissions from the Yahoo and Intuit facilities which are further away were not included. Previous analysis (performed in support of Dell's original application submittal) confirmed that the contributions from these facilities to the area of maximum impact from Dell are very small. All software used for this application was provided by Ecology, and applied according to Ecology's recommended procedures.

Table 5. Microsoft, Celite and Con-Agra Emissions Scenarios/Events and Number of Days Included in the Monte Carlo Analysis for the Dell Data Center.

Scenario/Event	Number of Days per Year Included in the Monte Carlo Analysis
Microsoft full power outage	2
Microsoft monthly testing	24
Microsoft electrical bypass	30
Celite routine operations	365/366
Con-Agra routine operations	365/366

6.3.6. Multiple-Facility Results

For the multiple-facility analysis, the Monte-Carlo-based estimate of the three-year average 98th percentile 1-hour NO_2 value (for the receptor location with the maximum value) is 95.0 μg/m^3. This includes local background (from the Microsoft, Celite, and Con-Agra facilities). After accounting for regional background, the NO_2 impact at or beyond the project boundary is 124.0 μg/m^3, and is lower than the NAAQS (Table 6).

Table 6. Multiple-Facility 1-Hour NO_2 Impact At Or Beyond The Project Boundary

Parameter	Concentration (μg/m^3)
Three-year average 98th percentile 1-hour NO_2 increment (no background)	95.0
Regional background	29.0
NO_2: Increment plus background	124.0
NAAQS Limit	188

The location of the estimated multiple-facility maximum 3-year average 98th percentile 1-hour NO_2 concentration is near the southeast corner of the Dell property, along the eastern end of the southern property line. Because that location is very close to Microsoft's generators but away from Dell's generators, it is concluded Microsoft and/or ConAgra are the dominant contributors.

6.4. Compliance With the 24-Hour PM_{10} and $PM_{2.5}$ NAAQS

6.4.1. PM_{10} Impacts During Full Power Outage

For 24-hour PM_{10}, AERMOD was used to simulate the effects of a full power outage, with a duration of eight hours in one calendar day. This is the scenario with the highest emissions for PM_{10}. The emissions for this scenario were calculated using the assumptions that the 19 primary backup generators would run at 70% load for the full eight hours, and that the three redundant generations and the six additional "+1" backup generators would run at 10% load for the first 4 hours of the power outage. All days were modeled with these worst-case PM_{10} emissions. The PM_{10} NAAQS considers the 2nd highest 24-hour PM_{10} value per year. The 2nd highest modeled PM_{10} concentration for this scenario was examined and compared to the NAAQS. For this application, the simulated 2nd highest 24-hour PM_{10} value for any year is 14.8 $\mu g/m^3$. To account for cold-start emissions, this value was multiplied by a factor of 1.007 with a resulting concentration of 14.9 $\mu g/m^3$. After accounting for regional and local[8] background, the second highest PM_{10} impact at or beyond the project boundary during a full power outage is 77.2 $\mu g/m^3$, and is lower than the NAAQS (Table 7):

Table 7. Modeled Second Highest PM_{10} Impacts During Full Power Outage

Parameter	Concentration ($\mu g/m^3$)
Second highest 24-hour PM_{10} increment (no background)	14.9
Regional background	60.0
Local background	2.3
PM_{10}: Increment plus background	77.2
NAAQS Limit	150

6.4.2. $PM_{2.5}$ Impacts During Diagnostic Testing

For 24-hour $PM_{2.5}$, AERMOD was used to simulate the effects of routine annual testing of the generators. As summarized in Table 8, this scenario has the second highest $PM_{2.5}$ emissions of any diagnostic testing scenario and the third highest $PM_{2.5}$ emissions overall. The annual testing

[8] Contributions of PM_{10} and $PM_{2.5}$ to the "local background" from other nearby data center and manufacturing facilities (the existing Microsoft, Yahoo, and Intuit data centers and the Celite manufacturing plant) were estimated using the AERMOD model and were added to the area-wide background value to assess compliance with the NAAQS. Specifically, the emissions from the nearby Microsoft (with approved expansion), Yahoo, Intuit, and Celite facilities were set at their permit limits and were modeled using the same meteorological conditions (same date and time) that resulted in the maximum Dell-only concentrations applicable for comparison with the NAAQS.

occurs over several days and the emissions for this scenario represent the test day with the highest $PM_{2.5}$ emissions. The emissions were calculated using the assumption that eight of the backup generators will be simultaneously tested at 70% load for 45 minutes. This will be followed by one engine at 100% load for 240 minutes (4 hours). All 365/366 days per year of activity were modeled with these emissions.

Table 8. Hierarchy of Daily $PM_{2.5}$ Emission Rates.

Expected Daily Rank of Ambient Impact at Maximum Receptor Location	Event	Peak Daily $PM_{2.5}$ (g/sec)
1	Full power outage	9.46E-01
2	Semi-annual testing (Phase 1)	7.05E-02
3	Annual testing day 5 (All Phase 1 + one Phase 1t4)	6.62E-02
4-15	Annual testing days 1 – 4 (Phase 1) Annual testing days 6 & 7 (Phase 1t4) Annual testing days 9 – 11 (Phase 2) Annual testing days 13 – 15 (Phase 3)	6.33E-02
16-17	Annual testing day 12 (Phase 2) Annual testing day 16 (Phase 3)	6.19E-02
18-19	Semi-annual testing (Phase 2) Semi-annual (Phase 3)	6.16E-02
20-29	Monthly testing (Phase 1)	5.83-02
30	Annual Testing day 8 (Phase 1t4)	5.76E-02
31-50	Monthly testing (Phase 2) Monthly testing (Phase 3)	5.32E-02
51	Semi-annual (Phase 1t4)	5.28E-02
52-61	Monthly testing (Phase 1t4)	4.56E-02

The $PM_{2.5}$ NAAQS considers the three-year average of the 98^{th} percentile 24-hour $PM_{2.5}$ value per year. Using EPA's standard post-processing software, this is the 8^{th} highest modeled value per year. To account for the possibility of higher concentrations at the maximum receptor location during a power outage (and assuming that power outages occur on two days per year and cause an ambient impact on two days per year) as well as the semi-annual testing scenario with higher emissions (three days total), the 5^{th} highest $PM_{2.5}$ value corresponding to annual testing scenario for each year was extracted and a three year average was calculated for comparison to the NAAQS. For this application, the AERMOD-derived highest three-year average 98th percentile value at any receptor location is 1.7 μg/m^3. Note that this value already accounts for cold-start emissions (they were included in AERMOD). After accounting for regional and local background[9], the $PM_{2.5}$ impact at or beyond the project boundary during monthly testing of all generators, is 23.1 μg/m^3 and is lower than the NAAQS (Table 9). The location of the impact is along the western boundary of the property, approximately midway between the southern and northern ends of the property boundaries.

Table 9. Modeled $PM_{2.5}$ Impacts During Monthly Testing Of All Generators

Parameter	Concentration (μg/m^3)
Three-year average 98th percentile 24-hour $PM_{2.5}$ increment (no background)	1.7
Regional background	21.0
Local background	0.4
$PM_{2.5}$: Increment plus background	23.1
NAAQS Limit	35

To consider the effects of commissioning on up to 4 days during certain years, which could have higher emissions than the highest ranked semi-annual testing day, Dell also examined the 1st highest $PM_{2.5}$ impact for this scenario. The resulting value of 2.5 μg/m^3, when combined with local and regional background, is also in compliance with the NAAQS (Table 10).

Table 10. Modeled $PM_{2.5}$ Impacts During Commissioning

Parameter	Concentration (μg/m^3)
Three-year average 98th percentile 24-hour $PM_{2.5}$ increment (no background)	2.5
Regional background	21.0
Local background	0.6
$PM_{2.5}$: Increment plus background	24.1
NAAQS Limit	35

[9] Id.

7. SECOND TIER REVIEW FOR DIESEL ENGINE EXHAUST PARTICULATE

As discussed above, proposed emissions of diesel engine exhaust particulate (DEEP) from the twenty-eight (28) additional engines exceed the regulatory trigger level for toxic air pollutants (also called an Acceptable Source Impact Level, (ASIL). A second tier review is required for DEEP in accordance with WAC 173-460-090.

The Dell Data Center is in addition to the three data centers operating in the rural town of Quincy, WA. The three data centers utilize dozens of large (>2 MW) diesel engines to supply backup power in support of data center operations. Additionally, due to the April, 2010 enactment of the *Computer Data Centers – Sales and Tax Exemption* law in Washington State, several companies have expressed interest in expanding existing or developing new data centers in Quincy. Thus, more large diesel-powered generators will be needed to supply backup power for the additional data centers.

Large diesel-powered backup engines emit DEEP, which is a high priority toxic air pollutant in the state of Washington. In light of the potential rapid development of other data centers in the Quincy area, and recognizing the potency of DEEP emissions, Ecology decided to evaluate Dell's proposal on a community-wide basis. The community-wide evaluation approach considers the cumulative impacts of DEEP emissions resulting from Dell's project, and includes consideration of prevailing background emissions from existing permitted data centers and other DEEP sources in Quincy. This evaluation was conducted under the second tier review requirements of WAC 173-460-090.

The results of Ecology's evaluation of cumulative risks associated with Dell's project are included in a separate technical support document. Please refer to that technical support document for a discussion and evaluation of the risks associated with diesel engine exhaust particulate emitted by Dell.

8. CONCLUSION

Based on the above analysis, Ecology concludes that operation of the twenty-eight (28) generators will not have an adverse impact on air quality. Ecology finds that Dell has satisfied all requirements for NOC approval.

******END OF DELL TSD ******