Final Report
Second-Tier Risk Analysis
Technical Support Document
Four New Generators at VMware Pods 1 and 3
VMware Data Center
East Wenatchee, Washington

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Prepared for

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LIST OF ABBREVIATIONS AND ACRONYMS

$\mu g/m^3$	Microgram per Cubic Meter
µm	Micrometer
AERMOD	American Meteorological Society/EPA Regulatory Model
ASIL	Acceptable Source Impact Level
BACT	Best Available Control Technology
CFR	Code of Federal Regulations
CO	Carbon Monoxide
DEEP	Diesel Engine Exhaust Particulate
Ecology	Washington State Department of Ecology
EPA	U.S. Environmental Protection Agency
HI	Hazard Index
HIA	Health Impact Assessment
HQ	Hazard Quotient
kWe	Kilowatts Electrical Output
m	Meter
MIBR	Maximally Impacted Boundary Receptor
MICR	Maximally Impacted Commercial Receptor
MIRR	Maximally Impacted Residential Receptor
NAAQS	National Ambient Air Quality Standards
NATA	National Air Toxics Assessment
NO_2	Nitrogen Dioxide
NO_x	Nitrogen Oxides
NOC	Notice of Construction
OEHHA	California Office of Environmental Health Hazard Assessment
PAH	Polycyclic Aromatic Hydrocarbon
$PM_{2.5}$	Particulate Matter Less Than or Equal to 2.5 Microns in Size
PRIME	Plume Rise Model Enhancements
PVMRM	Plume Volume Molar Reaction Model
RBC	Risk-Based Concentration
REL	Reference Exposure Level
RfC	Reference Concentration
SQER	Small-Quantity Emission Rate
TAP	Toxic Air Pollutant
tBACT	Toxics Best Available Control Technology
TPY	Tons per Year
TWA	Time-Weighted Average
UGA	Urban Growth Area
URF	Unit Risk Factor
VMware	VMware, Inc.
WAC	Washington Administrative Code

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1.0 EXECUTIVE SUMMARY

1.1 PROPOSED PROJECT

VMware, Inc. (VMware) operates a computer data center, as a tenant within the Intergate-Columbia Data Center complex near East Wenatchee, Washington. VMware currently operates six diesel-powered emergency generators at the facility, which are permitted under Washington State Department of Ecology (Ecology) Approval Order 08AQ-C078 dated July 9, 2010. That permit allowed a total of 10 generators, but VMware installed only the existing six units. VMware proposes to expand its data center to its design capacity described in the existing air quality permit, and proposes to install the final four new Cummins Model 2000-DQKAB diesel generators [each rated at 2,000 kilowatts electrical output (kWe)], which are identical to the original six generators.

The existing 2010 permit was issued based on criteria air pollutant regulations and toxic air pollutant (TAP) regulations that were later revised after the permit was issued. Ecology has indicated that the final four new generators must be permitted as an expansion of the existing six-generator facility, according to current air quality regulations. Therefore, for this application the existing VMware Data Center is treated as an existing facility with six generators, and the four new generators are treated as a proposed expansion. This document has been prepared for VMware to support the submission of a Notice of Construction (NOC) air permit application for the addition of the four new generators.

Potential emissions of diesel engine exhaust particulate (DEEP) from the proposed backup engines exceed regulatory trigger levels called Acceptable Source Impact Levels (ASILs). Therefore, VMware is required to submit a second-tier petition per Chapter 173-460 of the Washington Administrative Code (WAC).

Ecology determined that a cumulative approach to permitting data centers was warranted for the East Wenatchee area because of the relatively close geographic proximity of existing data centers. As part of the cumulative approach, this risk assessment report considers the cumulative impacts of DEEP from existing permitted data centers and other nearby sources of diesel engine emissions.

1.2 HEALTH IMPACTS EVALUATION

The Health Impact Assessment (HIA) demonstrates that the ambient cancer risks and non-cancer risks caused by emissions of DEEP from the proposed project are less than Ecology's approval limits. The four new generators could cause an increased cancer risk of up to 6 in one million (6×10^{-6}) at the maximally impacted residential location, specifically at the closest existing house on agriculturally zoned property bordering the southeastern property line of the Intergate-Columbia Data Center complex. Because the increase in cancer risk attributable to the new data center alone is less than the maximum risk

allowed by a second-tier review, which is 10 in one million, the project is approvable under WAC 173-460-090.

1.3 CUMULATIVE HEALTH RISKS

The modeled cumulative long-term health impacts associated with DEEP emissions from VMware's generators and all other regional emission sources are less than Ecology's approval limits. Based on the cumulative maximum DEEP concentration at a residential location near the VMware Data Center, the estimated maximum potential cumulative cancer risk posed by DEEP emitted from all sources within the area is approximately 45 in one million (45×10^{-6}) at an existing house on agriculturally zoned southeast of the data center. VMware's emissions from its proposed new generators account for only approximately⅛ of this cumulative risk.

1.4 CONCLUSIONS

Project-related health risks are less than the limits permissible under WAC 173-460-090. Therefore, the project is approvable under WAC 173-460-090.

2.0 VMWARE DATA CENTER PROJECT

2.1 DESCRIPTION OF VMWARE DATA CENTER EXPANSION

VMware operates a computer data center, as a tenant within the Intergate-Columbia Data Center complex near East Wenatchee, Washington. Figure 2-1 shows the project vicinity, and Figure 2-2 shows details of the various tenants in the Intergate-Columbia Data Center complex. Figure 2-2 shows details on the proposed locations of VMware's existing six generators and its four proposed new generators. Each new generator will be housed indoors within the main data center building. Each generator will have its own 44-foot-tall vertical exhaust stack, with a diameter of 16 inches, similar to VMware's existing generators.

Figure 2-2 also shows the configuration of the other existing data centers in the Intergate-Columbia Data Center complex. VMware shares a building with two other tenant data centers (Blackrock Data Center, and Costco Data Center). Each of those neighboring tenants operates three diesel generators, each rated at 2,500 kWe. The T-Mobile Data Center occupies a separate building. T-Mobile is permitted to operate 20 2,000-kWe diesel generators.

The emission estimates presented in this permit application are based on the following operating modes for the four new generators, which are defined in this permit application as the "baseline operations" (summarized in Table 1):

- **Monthly Testing**. VMware tests its generators one at a time, for 37 minutes per test, at 60 percent load. For this application, it was assumed that the average monthly test would last for 1 hour. It was assumed that all four new generators would be tested on the same calendar day.
- **Corrective Testing**. If the monthly testing indicates a problem with any generator, then VMware may be required to conduct additional diagnostic testing on that generator. For this permit, it was assumed that each generator may require up to 12 hours per year of corrective testing at 100 percent load, with one generator running at a time. As a worst-case scenario, it was assumed each engine would be run for 12 hours in a single day.
- **Unplanned Power Outages**. In the event of a power outage, three of the four new generators would activate at 100 percent load for the duration of the outage. The fourth generator would serve only as a reserve unit, and would activate only if one of the three primary generators experienced difficulties. For this application, it was assumed that the facility could experience up to 44 hours per year of power outages (the same value that is allowed by the current permit for the six existing generators).
- **3-Year Recurring Electrical Bypass for Full-Building Switchgear and Transformer Maintenance**. Every 3 years, the entire building undergoes scheduled maintenance of its main electrical switchgear and transformer. The entire building is taken off-line, which requires all of VMware's generators to activate at their power outage loads. For this application, it was assumed that the 3-year recurring maintenance requires 2 calendar days of generator usage, totaling 24 hours of runtime.

In addition to the "baseline operations" listed in Table 1, this permit application also accounts for possible emissions from the following occasional, one-time-only operating modes or occasional recurring operating modes:

- **Startup Commissioning (One Time Only)**. Each generator will undergo up to 24 hours of onsite commissioning testing before it is released by the supplier for use at the data center. The commissioning tests will be spread over approximately 12 calendar days. For this permit application, it was assumed that all of the commissioning runtime will be done at 100 percent load. For this application, it was assumed that VMware could commission its three final new generators (out of the four new generators to be installed) in a single calendar year.
- **Recurring Compliance Stack Testing**. Ecology has required some data centers to conduct periodic stack emission testing for their diesel generators. At this time, it is uncertain whether Ecology will require such testing at VMware. As a conservative assumption for this permit application, the emission estimates and ambient air quality analyses account for stack testing of the four new generators every 5 years. It was assumed that each stack test would require up to 24 hours of runtime per generator at an average generator load of 60 percent.

2.2 FORECAST EMISSION RATES

Air pollutant emission rates were calculated for the sources identified in Section 2.1 per the requirements of WAC 173-400-103 and WAC 173-460-050. Emission rates were quantified for criteria pollutants and TAPs. Detailed emission calculation spreadsheets are provided in the NOC Application Supporting Documentation report (Landau Associates 2013).

For this permit application we have defined "baseline emissions" to include all activity listed in Table 1, including schedule generator testing, corrective testing, 3-year recurring switchgear maintenance, and unplanned power outages. The first-tier DEEP risk analysis and second-tier analyses accounted for three categories of theoretical-maximum annual-average DEEP emission rates:

- **"Baseline" Annual DEEP = 0.143 tons per year (TPY)**. This is the presumed limit that will likely be specified as the Potential-to-Emit in the Approval Order. It includes the runtime items listed in Table 1: Unplanned power outages, monthly testing, electrical bypass maintenance, and corrective testing. This baseline value was not used for any purposes other than as the starting point to calculate the "70-year average" and "Maximum theoretical annual" emission rates described below, which were used for the risk calculations.
- **Maximum-Theoretical Annual DEEP = 0.209 TPY**. This is the maximum annual emission rate used for the first-tier ASIL assessments and the non-cancer chronic risk assessment. This value assumes that the maximum theoretical activities in any single calendar year include the "baseline activities" in Table 1 (unplanned power outages, monthly testing, electrical bypass, and corrective testing), but also include commissioning testing of the three final generators plus one round of 5-year recurring stack testing of four generators, all conducted in a 12-month period.
- **70-Year Average DEEP = 0.150 TPY**. This is the weighted average emission rate consisting of 70 years of "baseline activity" listed in Table 1 (unplanned power outages, monthly testing, electrical bypass, and corrective testing), commissioning of VMware's four new generators, and 14 rounds of recurring stack testing of four generators, all averaged over

70 years. This is the value used to model DEEP cancer risks associated with exposure to 70 years of emissions from the four new generators.

2.2.1 BASELINE EMISSIONS (SCHEDULED TESTING AND UNPLANNED POWER OUTAGES)

The allowable baseline emissions from the four new generators were calculated based on the generator runtime values listed in Table 1 and conservatively high emission factors. Table 2 summarizes the calculated emission rates for the baseline activities.

2.2.2 THEORETICAL MAXIMUM ANNUAL EMISSION RATES TO ACCOUNT FOR COMMISSIONING TESTS AND COMPLIANCE STACK TESTS

For the purposes of demonstrating compliance with the annual-average National Ambient Air Quality Standards (NAAQS) and the annual-average ASILs, the theoretical maximum annual emission rates from the four new generators should include emissions from baseline activity (Table 2) and commissioning of VMware's final new generator and 5-year recurring compliance stack testing, all occurring in the same year. These theoretical maximum annual emission rates are presented in Table 3. These theoretical maximum emission rates were used in this permit application to model compliance with the annual-average NAAQS, annual-average ASILs, and to evaluate maximum-year non-cancer health risks.

2.3 LAND USE AND ZONING

Figures 2-2 and 2-3 show land use as well as the locations of other data center facilities near the VMware Data Center site. The project site is level and zoned for industrial use. It is surrounded by agricultural land (apple orchards), industrial-zoned land, commercial businesses, and individual farm house residences.

Detailed zoning information for the greater East Wenatchee area is shown on Figure 2-4 (Douglas County website 2013). From a health impacts standpoint, several existing farm houses located on agricultural land south of the data center (see Figure 2-3) are of primary interest. Table 2-4 describes current and planned land use for properties surrounding the Intergate-Columbia Data Center complex.

2.4 SENSITIVE RECEPTORS

The following sensitive receptors are near the VMware Data Center:

- The nearest school is Rock Island Elementary School, approximately 2.6 miles southeast of the data center.
- The closest daycare or pre-school is the Special Education Pre-School, approximately 3 miles west of the data center.

- The nearest church is Holy Apostles Catholic Church, approximately 3.7 miles northwest of the data center.
- The nearest medical facility is Alpine Valley Wellness Center, approximately 4.1 miles west of the data center.
- The nearest convalescent home is Cherry Lane Country Haven, approximately 1.6 miles southwest of the data center.

3.0 PERMITTING REQUIREMENTS FOR NEW SOURCES OF TOXIC AIR POLLUTANTS

3.1 OVERVIEW OF THE REGULATORY PROCESS

The requirements for performing a toxics screening are established in Chapter 173-460 WAC. This rule requires a review of any non-*de minimis*[1] increase in TAP emissions for all new or modified stationary sources in Washington State. Sources subject to review under this rule must apply best available control technology (BACT) for toxics (tBACT) to control emissions of all TAPs subject to review.

There are three levels of review when processing an NOC application for a new or modified emissions unit emitting TAPs in excess of the *de minimis* levels: 1) first tier (toxic screening); 2) second tier (health impacts assessment); and 3) third tier (risk management decision).

All projects with emissions exceeding the *de minimis* levels are required to undergo a toxics screening (first-tier review) as required by WAC 173-460-080. The objective of the toxics screening is to establish the systematic control of new sources emitting TAPs in order to prevent air pollution, reduce emissions to the extent reasonably possible, and maintain such levels of air quality to protect human health and safety. If modeled emissions exceed the trigger levels called ASILs, a second-tier review is required.

As part of a second-tier petition, described in WAC 173-460-090, the applicant submits a site-specific HIA. The objective of an HIA is to quantify the increase in lifetime cancer risk for persons exposed to the increased concentration of any carcinogen, and to quantify the increased health hazard from any non-carcinogen that would result from the proposed project. Once quantified, the cancer risk is compared to the maximum risk allowed by a second-tier review, which is 10 in 1 million, and the concentration of any non-carcinogen that would result from the proposed project is compared to its effect threshold concentration.

In evaluating a second-tier petition, background concentrations of the applicable pollutants must be considered. If the emissions of a TAP result in an increased cancer risk of greater than 10 in 1 million (equivalent to 1 in 100,000), then an applicant may request that Ecology conduct a third-tier review. For non-carcinogens, a similar path exists, but there is no specified numerical criterion to indicate when a third-tier review is triggered.

If an applicant is unable to demonstrate compliance with the second-tier conditions, then approval can be requested under a third-tier review. A third-tier review (which is not required for the VMware

[1] If the estimated increase of emissions of a TAP or TAPs from a new or modified project is below the *de minimis* emissions threshold(s) found in WAC 173-460-150, the project is exempt from review under Chapter 173-460 WAC.

Data Center) is a risk management decision in which Ecology makes a decision that the risk of the project is acceptable based on a determination that emissions will be maximally reduced through available preventive measures, assessment of environmental benefit, disclosure of risk at a public hearing, and related factors associated with the facility and the surrounding community.

3.2 BACT AND TBACT FOR THE VMWARE DATA CENTER PROJECT

Ecology is responsible for establishing BACT and tBACT for controlling criteria pollutants and TAPs emitted from the new diesel generators. The proposed generators will use U.S. Environmental Protection Agency (EPA) Tier 2 combustion controls to reduce emissions of particulate matter, oxides of nitrogen (NO_x), including nitrogen dioxide (NO_2), unburned hydrocarbons, and other pollutants. The proposed BACT and tBACT determinations are summarized in Tables 5 and 6, respectively.

Additional restrictions proposed in the NOC application include:

- Limits on the total number of hours that engines operate
- Limits on the total number of hours the generators are allowed to operate during each category of testing and maintenance
- Use of ultra-low sulfur diesel fuel (15 parts per million sulfur content)
- Compliance with the operation and maintenance restrictions of 40 CFR Part 60, Subpart IIII.

3.3 FIRST-TIER TOXICS SCREENING REVIEW FOR VMWARE'S FOUR NEW GENERATORS

The first-tier TAP assessment compares the forecast emission rates to the Small-Quantity Emission Rates (SQERs) and compares the maximum ambient impacts at any sensitive receptor to the ASILs.

Table 7 shows the calculated emission rates for each TAP emitted from VMware's four new generators, and compares the emission rates to the SQERs. The SQERs are emission thresholds, below which Ecology does not require an air quality impact assessment for the listed TAP. The table lists the "SQER Ratio" of the VMware emission rate compared to the SQER. The maximum emission rates for DEEP, NO_2, and acrolein exceed their respective SQERs, so an ambient impact assessment is required for those pollutants.

Ecology requires facilities to conduct a first-tier screening analysis for each TAP whose emission exceeds its SQER by modeling the 1st-highest 1-hour, 1st-highest 24-hour, and annual impacts at or beyond the project boundary, then comparing the modeled values to the ASILs (WAC 173-460-080). The 1-hour and 24-hour impacts were modeled for the worst-case screening scenario of a facility-wide power outage lasting 24 hours per day for 365 days per year for 5 years, with the American Meteorological

Society/EPA Regulatory Model (AERMOD) automatically selecting the highest 1-hour and 24-hour impacts for each of the 5 modeling years.

Table 8 shows the first-tier ambient concentration screening analysis for each TAP whose emission rate exceeds its SQER. Details on the methodologies for the modeling are provided in the Notice of Construction Application Supporting Documentation report (Landau Associates 2013). All of the modeled maximum impacts occur at the unoccupied facility boundary. The theoretical maximum annual-average DEEP impact at the unoccupied facility boundary far exceeds its ASIL, while the impacts for all TAPs other than DEEP are less than their respective ASILs. Therefore, DEEP is the only TAP for which a second-tier risk assessment is required. The annual-average impacts listed in Table 3-4 are the theoretical maximum-annual values that account for full-buildout operations, initial commissioning testing, and compliance stack testing during the same year of operation.

3.4 SECOND-TIER REVIEW PROCESSING REQUIREMENTS

In order for Ecology to review the second-tier petition, each of the following regulatory requirements under Chapter 173-460-090 must be satisfied:

(a) The permitting authority has determined that other conditions for processing the NOC Order of Approval have been met, and has issued a preliminary approval order.

(b) Emission controls contained in the preliminary NOC approval order represent at least tBACT.

(c) The applicant has developed an HIA protocol that has been approved by Ecology.

(d) The ambient impact of the emissions increase of each TAP that exceeds ASILs has been quantified using refined air dispersion modeling techniques as approved in the HIA protocol.

(e) The second-tier review petition contains an HIA conducted in accordance with the approved HIA protocol.

Ecology provided comments to Landau Associates' HIA protocol [item (c) above]. Ecology's comments were addressed as part of this HIA.

3.5 SECOND-TIER REVIEW APPROVAL CRITERIA

As specified in WAC 173-460-090(7), Ecology may recommend approval of a project that is likely to cause an exceedance of ASILs for one or more TAPs only if:

- Ecology determines that the emission controls for the new and modified emission units represent tBACT
- The applicant demonstrates that the increase in emissions of TAPs is not likely to result in an increased cancer risk of more than 1 in 100,000
- Ecology determines that the non-cancer hazard is acceptable.

The remainder of this document discusses the HIA conducted by Landau Associates.

4.0 HEALTH IMPACT ASSESSMENT

The HIA was conducted according to the requirements of WAC 173-460-090 and guidance provided by Ecology. The HIA addresses the public health risk associated with exposure to DEEP from VMware's proposed diesel-powered emergency generators and existing sources of DEEP in East Wenatchee, Washington. While the HIA is not a complete risk assessment, it generally follows the four steps of the standard health risk assessment approach proposed by the National Academy of Sciences (NAS 1983, 1994). These four steps are: 1) hazard identification; 2) exposure assessment; 3) dose-response assessment; and 4) risk characterization. As described later in this document, the HIA did not consider exposure pathways other than inhalation.

4.1 HAZARD IDENTIFICATION

Hazard identification involves gathering and evaluating toxicity data on the types of health injury or disease that may be produced by a chemical, and on the conditions of exposure under which injury or disease is produced. It may also involve characterization of the behavior of a chemical within the body and the interactions it undergoes with organs, cells, or even parts of cells. This information may be of value in determining whether the forms of toxicity known to be produced by a chemical agent in one population group or in experimental settings are also likely to be produced in human population groups of interest. Note that risk is not assessed at this stage. Hazard identification is conducted to determine whether and to what degree it is scientifically correct to infer that toxic effects observed in one setting will occur in other settings (e.g., are chemicals found to be carcinogenic or teratogenic in experimental animals also likely to be so in adequately exposed humans?).

4.1.1 OVERVIEW OF DEEP TOXICITY

Diesel engines emit very small fine [<2.5 micrometers (μm)] and ultrafine (<0.1 μm) particles. These particles can easily enter deep into the lungs when inhaled. Mounting evidence indicates that inhaling fine particles can cause numerous adverse health effects.

Studies of humans and animals specifically exposed to DEEP show that diesel particles can cause both acute and chronic health effects including cancer. Ecology has summarized these health effects in Concerns about Adverse Health Effects of Diesel Engine Emissions (Ecology 2008).

The following health effects have been associated with exposure to diesel particles:

- Inflammation and irritation of the respiratory tract
- Eye, nose, and throat irritation along with coughing, labored breathing, chest tightness, and wheezing

- Decreased lung function
- Worsening of allergic reactions to inhaled allergens
- Asthma attacks and worsening of asthma symptoms
- Heart attack and stroke in people with existing heart disease
- Lung cancer and other forms of cancer
- Increased likelihood of respiratory infections
- Male infertility
- Birth defects
- Impaired lung growth in children.

It is important to note that the estimated levels of DEEP emissions from the VMware Data Center that will potentially impact people will be much lower than levels associated with many of the health effects listed above. For the purpose of determining whether VMware's project-related and community-wide DEEP impacts are acceptable, non-cancer hazards and cancer risks are quantified and presented in the remaining sections of this document.

4.2 EXPOSURE ASSESSMENT

Exposure assessment involves estimating the extent that the public is exposed to a chemical substance emitted from a facility. This includes:

- Identifying routes of exposure
- Estimating long- and/or short-term offsite pollutant concentrations
- Identifying exposed receptors.
- Estimating the duration and frequency of receptors' exposure.

4.2.1 IDENTIFYING ROUTES OF POTENTIAL EXPOSURE

Humans can be exposed to chemicals in the environment through inhalation, ingestion, or dermal contact. The primary route of exposure to most air pollutants is inhalation; however, some air pollutants may also be absorbed through ingestion or dermal contact. Ecology uses guidance provided in California's *Air Toxics Hot Spots Program Guidance Manual for Preparation of Health Risk Assessments* (CalEPA 2003) to determine which routes and pathways of exposure to assess for chemicals emitted from a facility. Table 4-1 shows a table of chemicals for which Ecology assesses multiple routes and pathways of exposure.

DEEP consists of ultra-fine particles (approximately 0.1 to 1 micron in size) that behave like a gas and do not settle out of the downwind plume by gravity. DEEP particles will eventually be removed

from the atmosphere and be deposited onto the ground surface by either molecular diffusion or by being incorporated into rain droplets, but that deposition process is slow and will likely occur many miles downwind of the data center. At those far downwind distances, the resulting DEEP concentrations in the surface soil will likely be indistinguishable from regional background values.

It is possible that very low levels of polycyclic aromatic hydrocarbons (PAHs) and the few other persistent chemicals in DEEP will build up in food crops, soil, and drinking water sources downwind of the proposed VMware Data Center. However, given the very low levels of PAHs and other multi-exposure route-type TAPs that will be emitted from the data center, quantifying exposures via pathways other than inhalation is very unlikely to yield significant concerns. Further, inhalation is the only route of exposure to DEEP that has received sufficient scientific study to be useful in human health risk assessment. Therefore, in the case of VMware's backup engine emissions, only inhalation exposure to DEEP is evaluated.

4.2.2 ESTIMATING POLLUTANT CONCENTRATIONS

DEEP emissions may be carried by the wind and may impact people living and working in the immediate area. The level of these pollutants in offsite air depends in part on how much is emitted, wind direction, and other weather-related variables at the time the pollutants are emitted. To estimate where pollutants will disperse after they are emitted from the VMware Data Center, Landau Associates conducted air dispersion modeling, which incorporates emissions, meteorological, geographical, and terrain information to estimate pollutant concentrations downwind from a source.

Each of VMware's backup engines was modeled as individual discharge points. Landau Associates used the following model inputs to estimate ambient impacts:

- AERMOD with Plume Rise Model Enhancements (PRIME) algorithm for building downwash.
- Five years of sequential hourly meteorological data from Pangborn Memorial Airport, Wenatchee airport (2001 to 2005).
- Twice-daily upper air data from Spokane (2001 to 2005) to define mixing heights.
- East Wenatchee area shuttle radar topography mission files (which describe local topography and terrain).
- East Wenatchee area digital land classification files (which describe surface characteristics).
- Each engine's emissions were modeled with a stack height of 44 feet above local ground level and a stack inside diameter of 16 inches. Engine-specific exhaust gas temperature and velocity were used.
- The data center building dimensions were included to account for building downwash.
- Two sets of receptors were considered in the AERMOD modeling:

- The receptor grid for the AERMOD modeling domain at or beyond the facility boundary was established using a variable Cartesian grid:
  - 12.5-meter (m) spacing from emission source to 250 m
  - 25-m spacing from 250 m to 500 m
  - 50-m spacing from 500 m to 1,000 m
  - 100 m spacing from 1,000 m to 2,100 m
  - 300 m spacing from 2,100 m to 4,600 m
  - 600 m spacing beyond 4,600 m.
- Additional modeling receptors were placed on the rooftops of each building within the Intergate-Columbia Data Center complex that is expected to be leased by tenants. These receptors are considered to be "ambient air" receptors and were placed at the air intake systems that feed outside air into occupied office space.

- Plume Volume Molar Ratio Method (PVMRM) option, which is used to model the conversion of NO_x to NO_2. One-hour NO_2 concentrations were modeled using a PVMRM module, with default concentrations of 40 parts per billion of ozone, 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 percent NO_2 and 90 percent nitric oxide by mass.

4.2.3 IDENTIFYING POTENTIALLY EXPOSED RECEPTORS

The VMware facility is located among other commercial/industrial-zoned properties, but several different land uses are located within the vicinity of VMware's property. Locations where people could be exposed to project-related emissions are identified on Figure 2-3. Most importantly, three existing farm houses are on commercial agriculture-zoned land adjacent to the data center. Additionally, neighboring tenants of the VMware facility are potentially at risk for exposure to project-related emissions. The neighboring industrial tenants of VMware are identified on Figure 2-2. Most notably, the rooftop vent of the Blackrock facility is nearest to VMware's generators than all other neighboring building tenants. Typically, Ecology considers exposures occurring at maximally exposed boundary, residential, and commercial areas to capture worst-case exposure scenarios.

4.2.3.1 Receptors Maximally Exposed to DEEP

Table 4-2 shows maximally exposed receptors of different types and the direction and distance from the VMware Data Center. These receptors represent locations of various land uses that are most impacted by DEEP emissions from the facility. This table also shows the estimated 70-year average exposure concentration at each maximally exposed receptor for emissions from VMware's four new generators.

Figure 4-1 shows a color-coded map of estimated 70-year annual average DEEP concentrations attributable solely to VMware's DEEP emissions from the four new generators. This figure represents the

ambient impacts of VMware's project and each of the maximally exposed receptors representing different land uses. The concentrations at the Maximally Impacted Boundary Receptor (MIBR), Maximally Impacted Residential Receptor (MIRR), and Maximally Impacted Commercial Receptor (MICR) are highlighted. The modeling indicates that VMware's emissions impact two existing residences (R-1, southeast of the data center and R-2, east-southeast of the data center) at a level exceeding the ASIL. The blue contour line [0.00333 micrograms per cubic meter ($\mu g/m^3$)] represents the ASIL. Receptors at all locations outside the blue contour are forecast to be exposed to concentrations less than the ASIL.

Figure 4-2 shows a contour map of the 70-year annual average DEEP concentrations attributable to the combined generators within the Intergate-Columbia Data Center complex, including VMware's four new generators.

4.2.4 EXPOSURE FREQUENCY AND DURATION

The likelihood that someone is exposed to DEEP from VMware's backup diesel engines depends on local wind patterns, how frequently engines operate, and how much time people spend in the immediate area. As discussed previously, the air dispersion model uses emissions and meteorological information (and other assumptions) to determine ambient DEEP concentrations in the vicinity of the VMware Data Center.

This analysis considers the land use surrounding the VMware facility to estimate the amount of time a given receptor could be exposed. For example, people are more likely to be exposed frequently and for a longer duration if the source impacts residential locations because people spend much of their time at home. People working in offices or commercial buildings in the area are likely exposed to data center-related emissions only during the hours that they spend working near the facility.

This analysis uses simplified assumptions about receptors' exposure frequency and duration and assumes that people located at residential receptors are potentially continuously exposed, meaning they never leave their property. These behaviors are not typical; however, these assumptions are intended to avoid underestimating exposure so that public health protection is ensured. Workplace and other non-residential exposures are also considered, but adjustments are often made because the amount of time that people spend at these locations is more predictable than time spent at their homes. These adjustments are presented in Section 4.4.2 when quantifying cancer risk from intermittent exposure to DEEP.

4.2.5 BACKGROUND EXPOSURE TO POLLUTANTS OF CONCERN

WAC 173-460-090 states, "Background concentrations of TAPs will be considered as part of a second tier review." The word "background" is often used to describe exposures to chemicals that come from existing sources, or sources other than those being assessed.

Given the renewed interest in building data centers in the East Wenatchee urban growth area (UGA), Ecology has determined that the cumulative risk of all sources of DEEP (including existing and proposed data centers' emissions) should be considered during the permitting process.

To estimate local DEEP background concentrations, ambient impacts from existing emergency engines at the Intergate-Columbia Data Center complex were modeled using a similar methodology as described in Section 4.2.2. Ecology estimated regional DEEP background concentrations based on regional data from the EPA's National Air Toxics Assessment (NATA) database (Palcisko 2013).

4.2.6 CUMULATIVE EXPOSURE TO DEEP

Tables 4-3 and 4-4 show the calculated cumulative DEEP concentrations near the location of the VMware Data Center based on allowable emissions from all existing permits, proposed VMware emissions, local background levels, and regional background levels. As shown on Figure 4-1, VMware's DEEP contribution disperses to negligible values within approximately 1 mile of the data center.

The maximum 70-year cumulative concentration at a residence near the VMware Data Center is estimated at 0.15 $\mu g/m^3$ (approximately 45 times greater than the DEEP ASIL). This is modeled to occur at R-1, which is southeast of the data center. It is important to note that the ambient levels of DEEP estimated by Ecology are based on allowable (permitted) emissions instead of actual emissions. Actual emissions are likely to be much lower than what the facilities are permitted for, but worst-case emissions were used to avoid underestimating cumulative DEEP exposure concentrations.

4.3 DOSE-RESPONSE ASSESSMENT

Dose-response assessment describes the quantitative relationship between the amounts of exposure to a substance (the dose) and the incidence or occurrence of injury (the response). The process often involves establishing a toxicity value or criterion to use in assessing potential health risk.

4.3.1 DOSE-RESPONSE ASSESSMENT FOR DEEP

The EPA and California Office of Environmental Health Hazard Assessment (OEHHA) developed toxicological values for DEEP evaluated in this project (EPA 2002; EPA website 2013; CalEPA 1998). These toxicological values are derived from studies of animals that were exposed to a known amount (concentration) of DEEP, or from epidemiological studies of exposed humans, and are intended to represent a level at or below which adverse non-cancer health effects are not expected, and a metric by which to quantify increased risk from exposure to a carcinogen. Table 4-5 shows DEEP non-cancer and cancer toxicity values.

The EPA's reference concentration (RfC) and OEHHA's reference exposure level (REL) for diesel engine exhaust (measured as DEEP) was derived from dose-response data on inflammation and changes in the lung from rat inhalation studies. Each agency established a level of 5 $\mu g/m^3$ as the concentration of DEEP in air at which long-term exposure is not expected to cause adverse non-cancer health effects.

NAAQS and other regulatory toxicological values for short- and intermediate-term exposure to particulate matter have been promulgated, but values specifically for DEEP exposure at these intervals do not currently exist.

OEHHA derived a unit risk factor (URF) for estimating cancer risk from exposure to DEEP. The URF is based on a meta-analysis of several epidemiological studies of humans occupationally exposed to DEEP. URFs are expressed as the upper-bound probability of developing cancer, assuming continuous lifetime exposure to a substance at a concentration of 1 $\mu g/m^3$, and are expressed in units of inverse concentration [i.e., $(\mu g/m^3)^{-1}$]. OEHHA's URF for DEEP is 0.0003 $(\mu g/m^3)^{-1}$ meaning that a lifetime of exposure to 1 $\mu g/m^3$ of DEEP results in an increased individual cancer risk of 0.03 percent or a population cancer risk of 300 excess cancer cases per million people exposed.

4.4 RISK CHARACTERIZATION

Risk characterization involves the integration of data analyses from each step of the HIA to determine the likelihood that the human population in question will experience any of the various health effects associated with a chemical under its known or anticipated conditions of exposure.

4.4.1 EVALUATING NON-CANCER HAZARDS

In order to evaluate the potential for non-cancer adverse health effects that may result from exposure to air pollutants, exposure concentrations at each receptor location are compared to relevant non-cancer toxicological values (i.e., RfC, REL). If a concentration exceeds the RfC or REL, this indicates only the potential for adverse health effects. The magnitude of this potential can be inferred from the degree to which this value is exceeded. This comparison is known as a hazard quotient (HQ) and is given by the equation below:

$$HQ = \frac{\text{Concentration of pollutant in air } (\mu g/m^3)}{\text{RfC or REL}}$$

An HQ of 1 or less indicates that the exposure to a substance is not likely to result in adverse non-cancer health effects. As the HQ increases above 1, the probability of adverse human health effects increases by an undefined amount. However, it should be noted that an HQ above 1 is not necessarily

indicative of health impacts due to the application of uncertainty factors in deriving toxicological reference values (e.g., RfC and REL).

4.4.1.1 Hazard Quotient – DEEP

The chronic HQ for DEEP exposure is calculated using the following equation:

$$\text{Chronic HQ} = \frac{\text{Annual average DEEP concentration } (\mu g/m^3)}{5\ \mu g/m^3}$$

HQs were calculated for the maximally exposed residential and workplace receptors. Because chronic toxicity values (RfCs and RELs) are based on a continuous exposure, an adjustment is sometimes necessary or appropriate to account for people working at commercial properties who are exposed for only 8 hours per day, 5 days per week. While EPA risk assessment guidance recommends adjusting to account for periodic instead of continuous exposure, OEHHA does not employ this practice. For the purpose of this evaluation, an RfC or REL of 5 $\mu g/m^3$ was used as the chronic risk-based concentration for all scenarios where receptors could be exposed frequently (e.g., residences, work places, or schools).

Table 4-6 shows chronic HQs at the maximally exposed receptors near the VMware Data Center attributable to DEEP exposure from all sources. HQs are several-fold lower than 1.0 for all receptors' cumulative exposure to DEEP. This indicates adverse non-cancer effects are not likely to result from chronic exposure to DEEP emitted from the VMware Data Center and other local sources.

Note, the VMware-only annual DEEP values are the "theoretical maximum-annual" impacts that assume VMware will conduct routine operations, storm avoidance plus outages, generator commissioning, and triennial stack emission testing during the same 12-month period.

4.4.1.2 Combined Hazard Quotient for All Pollutants Whose Emission Rates Exceed SQER

Three TAPs emitted by the VMware Data Center have emission rates exceeding their respective SQERs and, therefore, have the potential to cause ambient concentrations high enough to cause acute or chronic non-cancer inhalation health risks: DEEP, NO_2, and acrolein. The receptor locations of concern are the maximally impacted boundary receptor (MIBR), the onsite tenant rooftop locations or maximally impacted commercial receptors (MICR), and the property line of the adjacent residential location or maximally impacted residential receptor (MIRR). Tables 4-7 through 4-9 show modeled concentrations, risk-based concentrations (RBCs), and HQs for each receptor point. All modeled concentrations and RBCs are in $\mu g/m^3$. The hazard index (HI) for each location is the sum of 1-hour time-weighted average (TWA) HQs for NO_2, carbon monoxide (CO), acrolein, and the chronic HQ of DEEP.

Table 4-7 shows the impacts at the MIBR for DEEP, NO_2, CO, and acrolein during a facility-wide power outage. The acute HI of approximately 0.6 and the chronic HQ of 0.023 are much lower than

1.0. This indicates that the MIBR is not likely to experience either acute or chronic non-cancer adverse health effects attributable to emissions from VMware.

Table 4-8 shows the HIs at the Apple Warehouse, which is the MICR. The acute HI of approximately 0.3 and the chronic HQ of 0.016 are both lower than 1.0. This indicates that the MICR is not likely to experience either acute or chronic non-cancer adverse health effects attributable to emissions from VMware.

Table 4-9 shows the HIs at the maximally-impact residential receptor (MIRR). The acute HI of approximately 0.3 and the chronic HQ of 0.006 are both lower than 1.0. This indicates that the MIRR is not likely to experience either acute or chronic non-cancer adverse health effects attributable to emissions from VMware.

The information in Table 4-7 through 4-9 suggests that both chronic and acute health effects are unlikely to occur even under worst-case conditions at the maximally impacted locations. The primary hazard is from acute exposure to NO_2. At times when unfavorable air dispersion conditions occur coincident with electrical grid transmission failure to VMware, the combined HQs (i.e., the hazard index) from NO_2, CO, and acrolein are modeled to be less than 1. If the HI is less than 1, then the risk is generally considered acceptable.

4.4.2 QUANTIFYING AN INDIVIDUAL'S INCREASED CANCER RISK

4.4.2.1 Cancer Risk from Exposure to DEEP

Cancer risk is estimated by determining the concentration of DEEP at each receptor point and multiplying it by its respective URF. Because URFs are based on a continuous exposure over a 70-year lifetime, exposure duration and exposure frequency are important considerations.

The formula used to determine cancer risk is as follows:

$$\text{Risk} = \frac{C_{Air} \times URF \times EF1 \times EF2 \times ED}{AT}$$

The exposure frequencies for each receptor type are shown below, based on Ecology's judgment from review of published risk evaluation guidelines.

EXPOSURE FREQUENCIES FOR EACH RECEPTOR TYPE

Parameter	Description	Value Based on Receptor Type					Units
		Residential	Worker	School-Staff	School-Student	Boundary	
CAir	Concentration in air at the receptor	See Table 4-3					$\mu g/m^3$
URF	Unit Risk Factor	0.0003					$(\mu g/m^3)^{-1}$
EF1	Exposure Frequency	365	250	200	180	250	Days/Year
EF2	Exposure Frequency	24	8	8	8	2	Hours/Day
ED	Exposure Duration	70	40	40	7 (Elem) 4 (HS & College)	30	Years
AT	Averaging Time	25,550					Days

Based on the factors listed above, Table 4-10 shows the resulting Unit Risk Factor for each exposure scenario.

Current regulatory practice assumes that a very small dose of a carcinogen will give a very small cancer risk. Cancer risk estimates are, therefore, not yes or no answers but measures of chance (probability). Such measures, however uncertain, are useful in determining the magnitude of a cancer threat because any level of a carcinogenic contaminant carries an associated risk. The validity of this approach for all cancer-causing chemicals is not clear. Some evidence suggests that certain chemicals considered carcinogenic must exceed a threshold of tolerance before initiating cancer. For such chemicals, risk estimates are not appropriate. Guidelines on cancer risk from the EPA reflect the potential that thresholds for some carcinogenesis exist. However, the EPA still assumes no threshold unless sufficient data indicate otherwise.

In this document, cancer risks are reported using scientific notation to quantify the increased cancer risk of an exposed person, or the number of excess cancers that might result in an exposed population. For example, a cancer risk of 1×10^{-6} means that if 1 million people are exposed to a carcinogen, one excess cancer might occur, or a person's chance of getting cancer in their lifetime increases by 1 in 1 million or 0.0001 percent. Note that these estimates are for excess cancers that might result in addition to those normally expected in an unexposed population. Cancer risks quantified in this document are upper-bound theoretical estimates. In other words, each is the estimate of the plausible upper limit, or highest likely true value of the quantity of risk.

Table 4-11 shows ranges of estimated worst-case residential, business, and fence line receptor increased cancer risks attributable to DEEP exposure near the proposed VMware facility. Cancer risks attributable to the data center project are less than 1 in 100,000 (1×10^{-5}). The highest risk occurs at the residential home closest to the VMware property line located to the southeast of VMware (6.0×10^{-6}). Under Chapter 173-460 WAC, Ecology may recommend approval of a project if the applicant

demonstrates that the increase in emissions of TAPs is not likely to result in an increased cancer risk of more than 1 in 100,000 (1×10^{-5}).

As part of the second-tier risk evaluation, Ecology also considers the cumulative impacts of DEEP emissions in the East Wenatchee UGA caused by the relatively large number of computer data centers located near the VMware facility. Note that Chapter 173-460 WAC does not currently contain a numerical limit on allowable cumulative cancer risks.

The results, as shown in Table 4-11, indicate that the cumulative cancer risk for the maximally impacted current residential receptor near the VMware Data Center is approximately **45 in 1 million**. This risk occurs at existing residence to the southeast of the facility. This residence is impacted more by local and regional concentrations of DEEP than the VMware generator emissions only. The maximum cumulative cancer risk at existing commercial businesses near the VMware Data Center, including neighboring building tenants in the Intergate-Columbia Data Center complex, are much lower than 10 in 1 million.

Note that the VMware-only 70-year average DEEP values account for all of VMware's operating modes: Routine testing, power outages, electrical bypass maintenance, generator commissioning annualized over 70 years, and periodic stack emission testing, all annualized over 70 years.

Based on the estimated emissions of all potentially carcinogenic compounds from the proposed data center alone, the emission rates for all of the carcinogenic constituents are less than Ecology's SQERs except for DEEP. The SQERs are Ecology's screening threshold emission rates below which the WAC 173-460 regulation indicates there is negligible potential for ambient air quality impacts. The maximum permitted emission rates for most toxic pollutants emitted at the VMware Data Center are less than their respective SQERs. Regardless of the SQER comparison, the emission rate for every carcinogenic constituent was considered in the cumulative cancer analysis, which is shown in Table 4-12.

As indicated in Table 4-12, the cancer risk associated with DEEP alone at R-1, the SE home, is 5.96 per million. The other recognized carcinogenic compounds contribute negligibly to the overall cancer risk (i.e., less than 0.01 per million). The combined cancer risk caused by all constituents is 5.97 per million.

5.0 UNCERTAINTY CHARACTERIZATION

Many factors of the HIA are prone to uncertainty. Uncertainty relates to the lack of exact knowledge regarding many of the assumptions used to estimate the human health impacts of DEEP emissions from VMware's backup generators and "background" sources of DEEP in East Wenatchee. The assumptions used in the face of uncertainty may tend to overestimate or underestimate the health risks estimated in the HIA.

5.1 EMISSION FACTOR AND EXPOSURE UNCERTAINTY

One of the major uncertainties is the emission factors for TAPs emitted by diesel generators. The forecast emission rates for particulate matter used for this analysis were based on the upper range of vendor estimates for the specific diesel generators to be used. For this analysis, it was conservatively assumed that all of the particulate matter emitted from diesel generators is DEEP, with the highest level of cancer potency. The forecast emission rates for NO_2 were based on the conservatively high assumption that NO_2 comprised 10 percent of the emitted NO_x. The emission rates for the other TAPs were based on published emission factor data from the EPA, which are believed to be conservatively high because they were developed based on historical testing of older-technology engines.

It is difficult to characterize the amount of time that people can be exposed to DEEP emissions from the proposed VMware Data Center. For simplicity, this analysis assumed that a residential receptor is at one location for 24 hours per day, 365 days per year for 70 years. These assumptions tend to overestimate exposure.

The duration and frequency of power outages is also uncertain. For this permit application VMware conservatively estimated that it will use the generators during emergency outages for no more than 44 hours per year. In reality, VMware staff have reported that there have been no unplanned power outages at the facility since it began operations in 2009 (Coleman, 2013, personal communication). While this high level of historical reliability provides some assurance that power service is relatively stable, VMware cannot predict future outages with any degree of certainty. VMware accepted a limit of 44 hours per year for emergency operations, and estimated that this limit should be more than sufficient to meet its emergency demands. It is expected that estimates of cancer risks will be significantly overestimated by assuming generators will operate annually at the maximum permitted level (including 44 hours of power outages every year) for 70 consecutive years.

5.2 AIR DISPERSION MODELING UNCERTAINTY

The transport of pollutants through the air is a complex process. Regulatory air dispersion models have been developed to estimate the transport and dispersion of pollutants as they travel through the air. The models are frequently updated as techniques that are more accurate become known, but are developed to avoid underestimating the modeled impacts. Even if all of the numerous input parameters to an air dispersion model are known, random effects found in the real atmosphere will introduce uncertainty. Typical of the class of modern steady-state Gaussian dispersion models, the AERMOD model used for the VMware Data Center analysis will likely slightly overestimate the short-term (24-hour average) impacts and somewhat underestimate the annual pollutant concentrations. The expected magnitude of the uncertainty is probably similar to the emissions uncertainty and much lower than the toxicity uncertainty.

5.3 TOXICITY UNCERTAINTY

One of the largest sources of uncertainty in any risk evaluation is associated with the scientific community's limited understanding of the toxicity of most chemicals in humans following exposure to the low concentrations generally encountered in the environment. To account for uncertainty when developing toxicity values (e.g., RfCs), the EPA and other agencies apply "uncertainty" factors to doses or concentrations that were observed to cause adverse non-cancer effects in animals or humans. The EPA applies these uncertainty factors so that they derive a toxicity value that is considered protective of humans including susceptible populations. In the case of the EPA's DEEP RfC, EPA acknowledges (EPA 2002):

"… the actual spectrum of the population that may have a greater susceptibility to diesel exhaust (DE) is unknown and cannot be better characterized until more information is available regarding the adverse effects of diesel particulate matter (DPM) in humans."

Quantifying DEEP cancer risk is also uncertain. Although the EPA classifies DEEP as probably carcinogenic to humans, it has not established a URF for quantifying cancer risk. In its health assessment document, the EPA determined that "human exposure-response data are too uncertain to derive a confident quantitative estimate of cancer unit risk based on existing studies." However, the EPA suggested that a URF based on existing DEEP toxicity studies would range from 1×10^{-5} to 1×10^{-3} per $\mu g/m^3$. OEHHA's DEEP URF (3×10^{-4} per $\mu g/m^3$) falls within this range. Regarding the range of URFs, EPA states in its health assessment document for diesel exhaust (EPA 2002):

"Lower risks are possible and one cannot rule out zero risk. The risks could be zero because (a) some individuals within the population may have a high tolerance to exposure from [diesel exhaust] and

therefore not be susceptible to the cancer risk from environmental exposure, and (b) although evidence of this has not been seen, there could be a threshold of exposure below which there is no cancer risk."

Other sources of uncertainty cited in the EPA's health assessment document for diesel exhaust are:

- Lack of knowledge about the underlying mechanisms of DEEP toxicity.
- The question of whether historical toxicity studies of DEEP based on older engines is relevant to current diesel engines. It is likely that the mixture of pollutants emitted by new-technology diesel engines (such as those proposed by VMware) is different from older technology engines.

Table 5-1 presents a summary of how the uncertainty affects the quantitative estimate of risks or hazards.

6.0 OTHER CONSIDERATIONS

6.1 SHORT-TERM EXPOSURE TO DEEP AND $PM_{2.5}$

As discussed previously, exposure to DEEP can cause both acute and chronic health effects. However, as discussed in Section 4.3.1, reference toxicological values specifically for DEEP exposure at short-term or intermediate intervals (e.g., 24-hour values) do not currently exist. Therefore, short-term risks from DEEP exposure are not quantified in this assessment. Regardless, not quantifying short-term health risks in this document does not imply that they have not been considered. Instead, it is assumed that compliance with the 24-hour NAAQS for particulate matter with an aerodynamic diameter less than or equal to 2.5 microns ($PM_{2.5}$) is an indicator of acceptable short-term health effects from DEEP exposure. In our analysis, we assumed all DEEP emissions to be $PM_{2.5}$. The NOC Application Supporting Documentation report (Landau Associates 2013) concludes that emissions from the proposed VMware Data Center are not expected to cause or contribute to an exceedance of any NAAQS.

6.2 SHORT-TERM EXPOSURE TO NO_2

The impacts of higher short-term NO_2 emission rates from the existing unmodified engines at the VMware Data Center have not been evaluated in detail in this document because only DEEP emissions from the project exceeded the ASIL. Because emissions of NO_2 and other TAPs from the project were below the ASIL, no further review was required for those pollutants. Emissions below the ASIL suggest that increased health risks from these project-related pollutants are acceptable. The maximum 1-hour NO_2 concentrations at the nearby receptor locations caused solely by emission from VMware's four new generators are presented in Table 6-1.

7.0 DISCUSSION OF ACCEPTABILITY OF RISK WITH REGARD TO SECOND-TIER REVIEW GUIDELINES

7.1 VMWARE-ONLY CANCER RISKS ARE LOWER THAN 10-PER-MILLION

As noted above, the modeled worst-case TAP concentrations at the facility boundary caused solely by emissions from the proposed new generators at the VMware Data Center are less than the ASIL values established by Ecology for all pollutants, with the exception of DEEP. The worst-case emissions rates are less than the SQERs for most pollutants, with the exception of DEEP, NO_2, acrolein, and CO. The long-term uncontrolled cancer risks at the nearby homes and businesses range from 0.2 to 6 per million for DEEP and are much lower for the other TAPs considered in this analysis. The overall cancer risk at any the maximally exposed home, caused solely by VMware Data Center emissions, is estimated to be less than the 10-per-million threshold that has been established by Ecology under its second-tier review criteria.

7.2 CUMULATIVE CANCER RISK

The total cumulative DEEP cancer risks for the maximally exposed home and business are as follows:

VMware-only cancer risk (R-1 SE home):	6.0 per million
Local + NATA regional background DEEP cancer risk:	39 per million
Cumulative DEEP cancer risk:	45 per million
VMware-only cancer risk (C-2 Apple Warehouse):	2.1 per million
Local + NATA regional background DEEP cancer risk:	7.8 per million
Cumulative DEEP cancer risk:	9.9 per million

7.3 NON-CANCER RISK HAZARD QUOTIENT <1.0

As described previously, the maximum HQ related to VMware-only annual-average DEEP impacts at any maximum impacted receptor is **0.021**. The maximum HQ for cumulative impacts caused by emissions of DEEP, NO_2, CO, and acrolein is only 0.60. This confirms that emissions from VMware's proposed new generators are unlikely to cause non-cancer impacts.

8.0 USE OF THIS REPORT

This Second-Tier Risk Analysis Technical Support Document has been prepared for the exclusive use of VMware, Inc. and applicable regulatory agencies for specific application to the VMware Data Center project in East Wenatchee, Washington. No other party is entitled to rely on the information, conclusions, and recommendations included in this document without the express written consent of Landau Associates. Further, the reuse of information, conclusions, and recommendations provided herein for extensions of the project or for any other project, without review and authorization by Landau Associates, shall be at the user's sole risk. Landau Associates warrants that within the limitations of scope, schedule, and budget, our services have been provided in a manner consistent with that level of care and skill ordinarily exercised by members of the profession currently practicing in the same locality under similar conditions as this project. We make no other warranty, either express or implied.

This document has been prepared under the supervision and direction of the following key staff.

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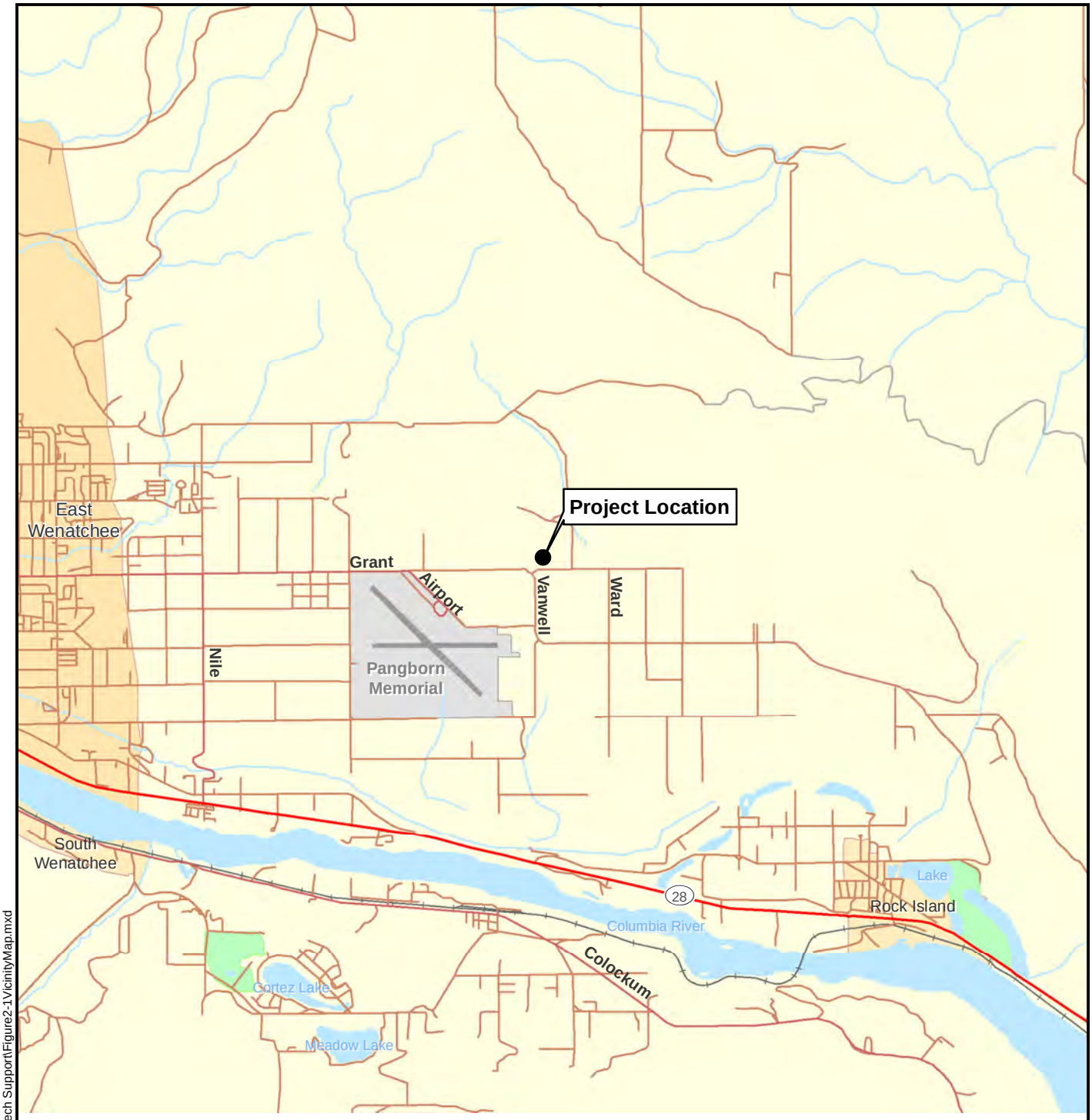

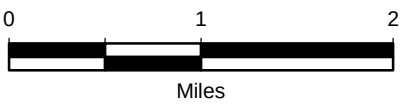

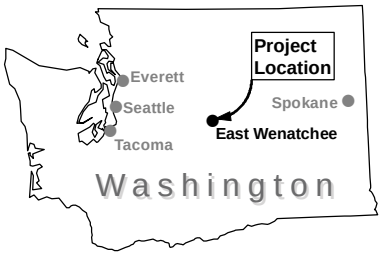

Data Source: ESRI 2008

Y:\Projects\1360001\010\011\Notice of Construction Tech Support\Figure2-1VicinityMap.mxd

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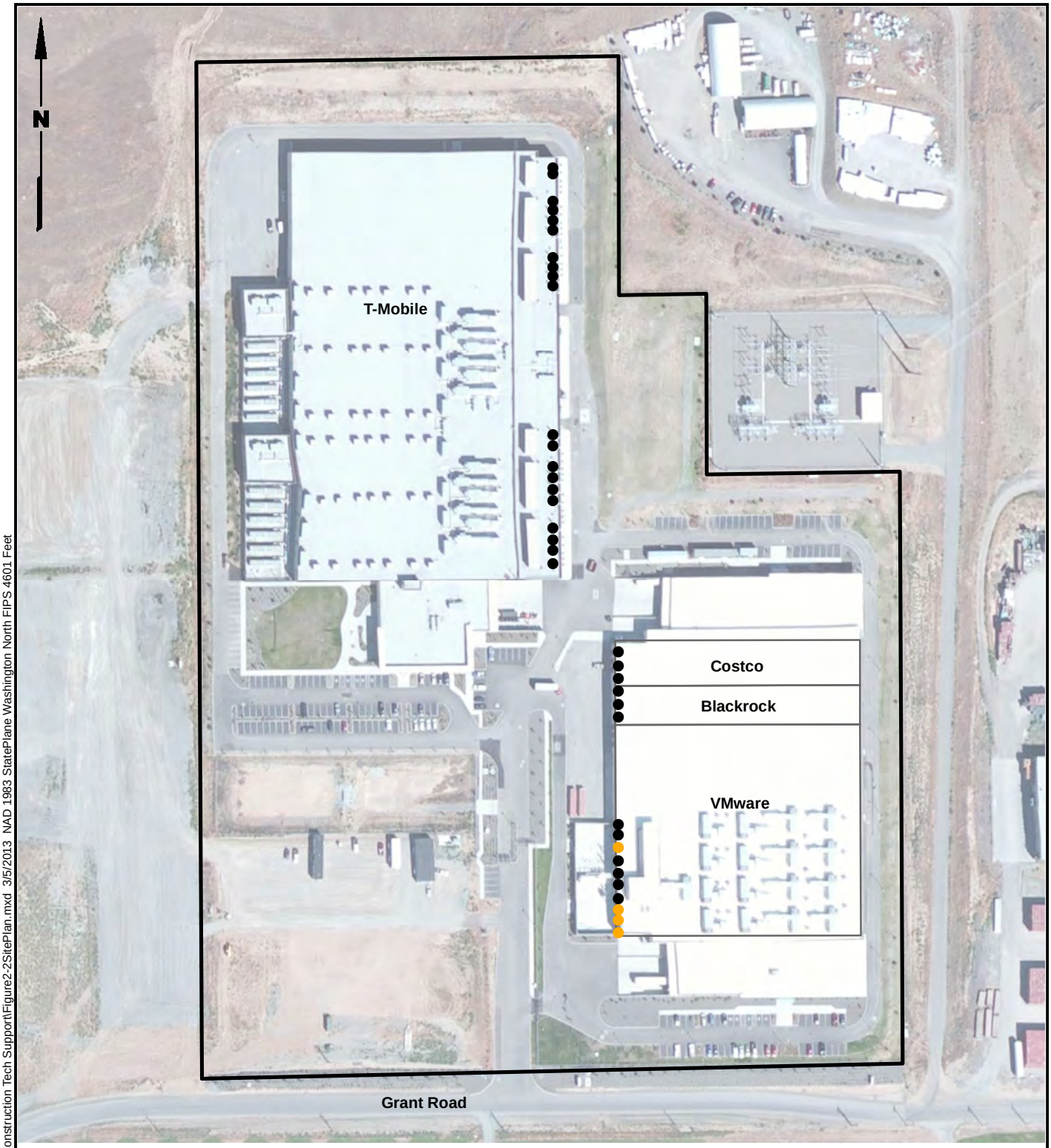
VMware Data Center East Wenatchee, Washington	**Vicinity Map**	Figure 2-1



Legend

- Facility Boundary
- New Generator
- Existing Generator

Note

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

0 200 400

Scale in Feet

Data Source: ESRI World Imagery

Y:\Projects\136000101010011\Notice of Construction Tech Support\Figure2-2SitePlan.mxd 3/5/2013 NAD 1983 StatePlane Washington North FIPS 4601 Feet

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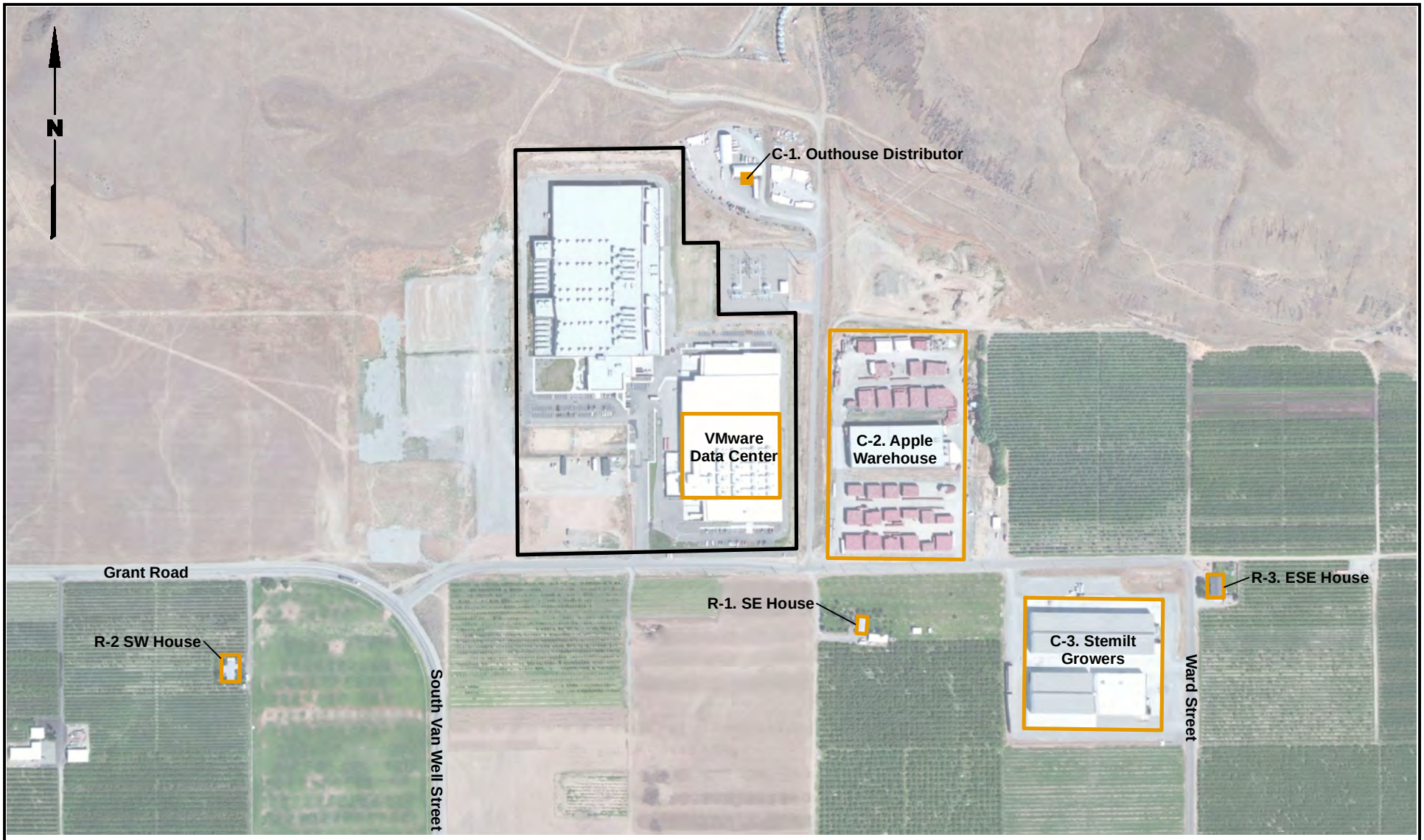
VMware Data Center East Wenatchee, Washington	**Site Plan**	Figure 2-2

Y:\Projects\1360001\010\011\Notice of Construction Tech Support\Figure2-3LandUse.mxd 3/5/2013 NAD 1983 StatePlane Washington North FIPS 4601 Feet



Legend

- Outhouse Distributor
- Facility Boundary
- Land Use Areas

0 500 1,000

Scale in Feet

Data Source: ESRI World Imagery

Note

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

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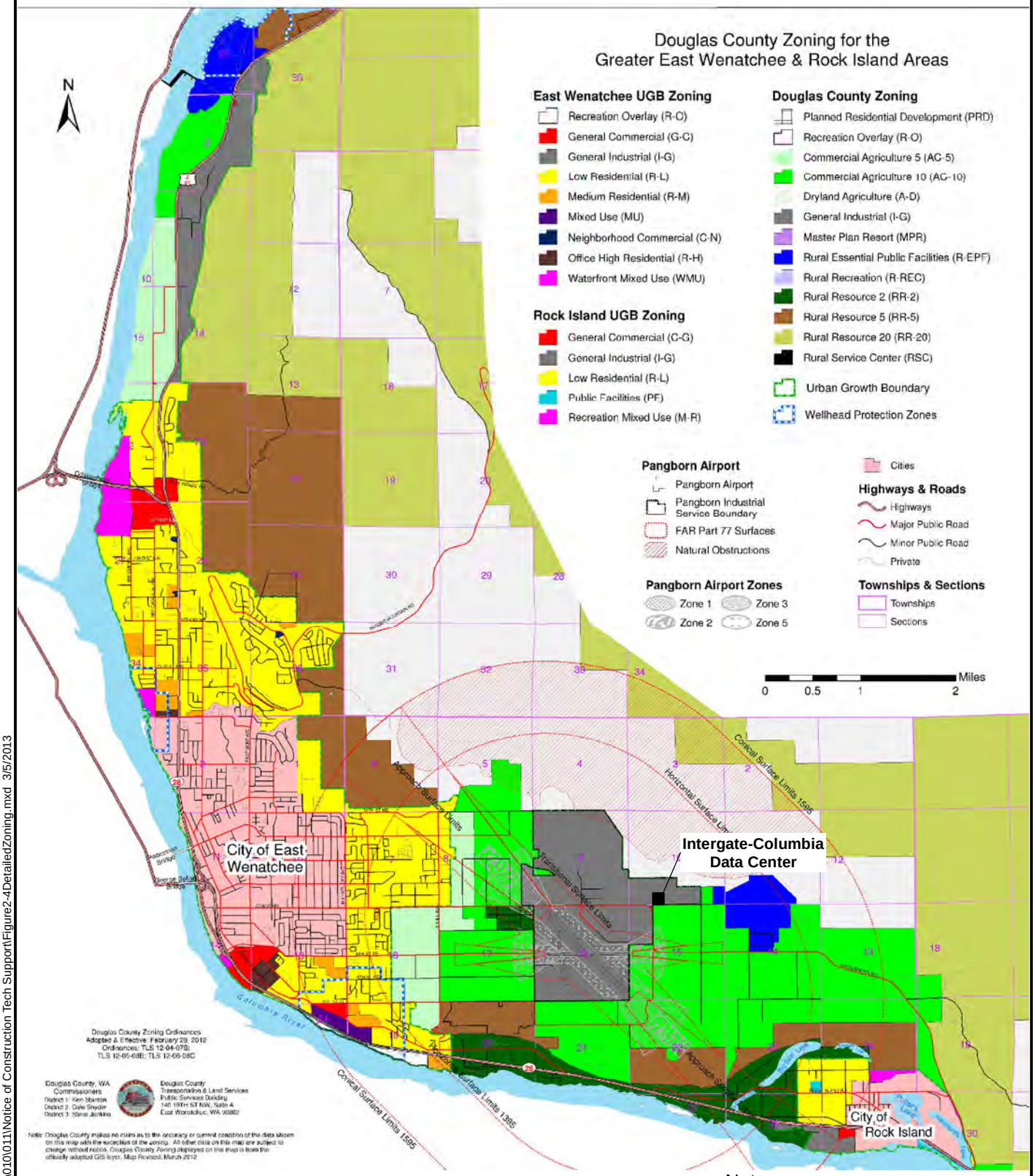
VMware Data Center
East Wenatchee, Washington

Land Use in the Vicinity of the VMware Data Center

Figure 2-3



Note

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

Data Source: Douglas County GIS.

Y:\Projects\136000101010011\Notice of Construction Tech Support\Figure2-4DetailedZoning.mxd 3/5/2013

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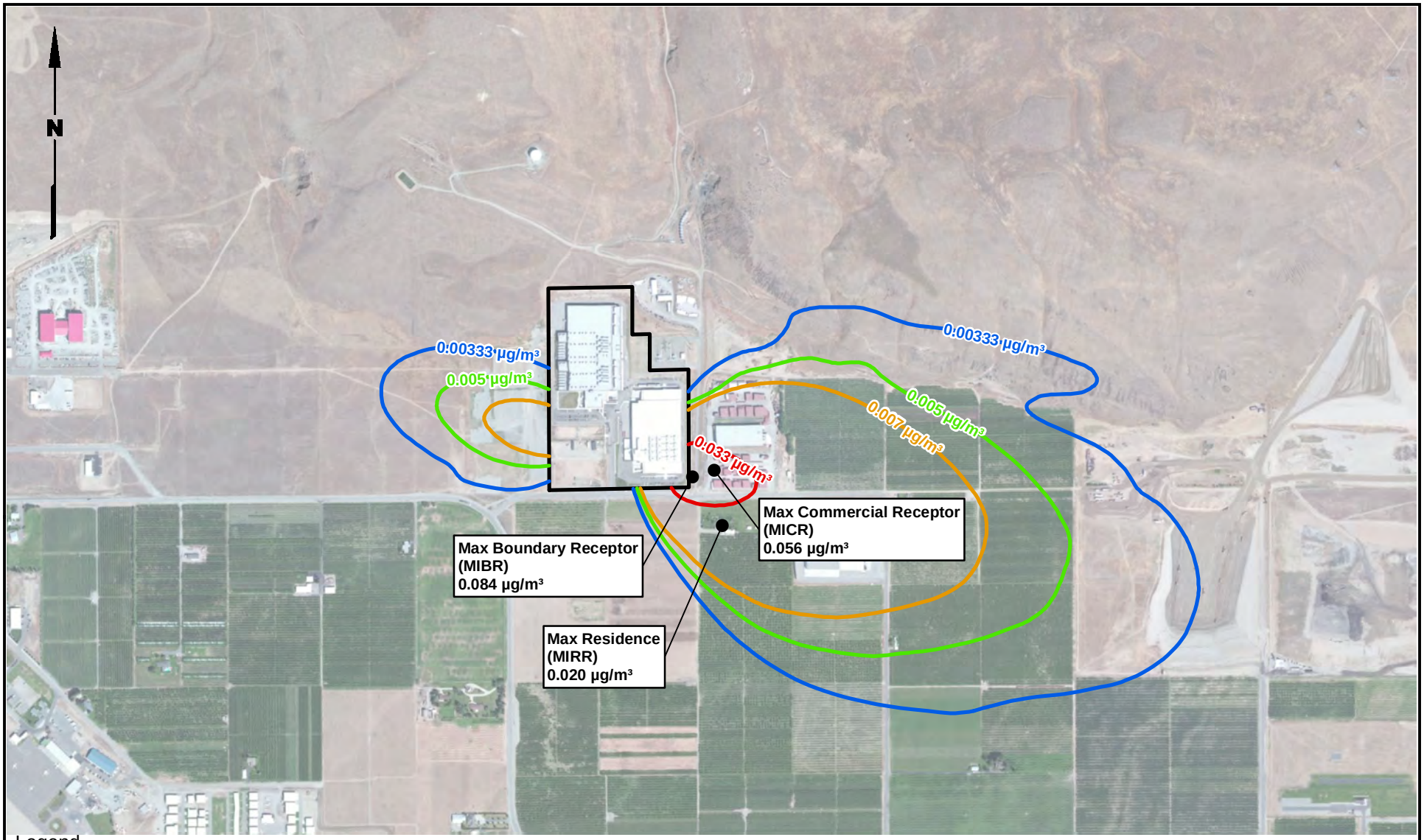
VMware Data Center East Wenatchee, Washington	**Detailed Zoning Map for the Area Near the Intergate-Columbia Data Center Complex**	Figure 2-4

Y:\Projects\1360001\010\011\Notice of Construction Tech Support\Figure4-1DeepContoursVmware.mxd 3/8/2013 NAD 1983 StatePlane Washington North FIPS 4601 Feet



Legend

DEEP Concentrations

- 0.00333 µg/m³
- 0.005 µg/m³
- 0.007 µg/m³
- 0.033 µg/m³

Facility Boundary

0 1,000 2,000

Scale in Feet

Data Source: ESRI World Imagery

Note

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

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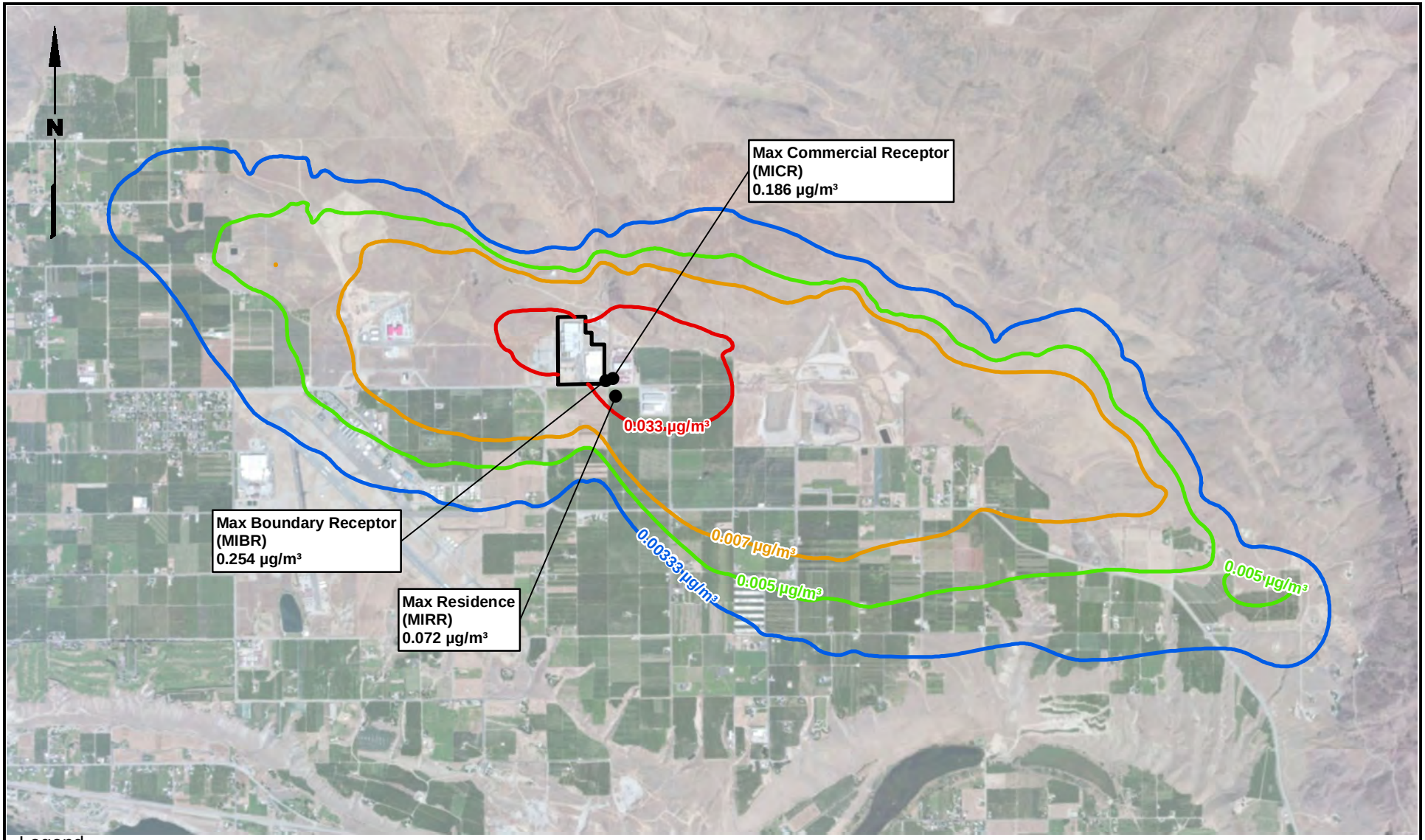
VMware Data Center
East Wenatchee, Washington

70-Year Average DEEP Concentrations Caused Solely by Emissions from VMware's Four New Generators

Figure
4-1

Y:\Projects\1360001\010\011\Notice of Construction Tech Support\Figure4-2DeepContoursCumulative.mxd 3/5/2013 NAD 1983 StatePlane Washington North FIPS 4601 Feet



Legend

DEEP Concentrations

- 0.00333 µg/m³
- 0.005 µg/m³
- 0.007 µg/m³
- 0.033 µg/m³

Facility Boundary

0 3,000 6,000

Scale in Feet

Data Source: ESRI World Imagery

Note

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

LANDAU ASSOCIATES

VMware Data Center
East Wenatchee, Washington

70-Year Average DEEP Concentrations Caused by Combined Generators at Intergate-Columbia Data Center

Figure
4-2

TABLE 2-1
GENERATOR RUNTIME FORECAST FOR BASELINE OPERATIONS
VMWARE DATA CENTER
EAST WENATCHEE, WASHINGTON

Generator		Power Outages		Monthly Tests			Corrective Tests and Occasional Diagnostic Testing Other Than Monthly		3-Year Recurring Electrical Bypass for Main Switchgear & Transformer Tests (a)		Total Engine Runtime, hrs per year per engine
Gen No.	Generator Size kWe	% Load	Hrs/Yr	% Load	Hrs per Test	Tests/Yr	% Load	Hrs/Yr	% Load	Hrs/Yr	
P3-6	2,000	100	44	60	1	12	100	12	100	24	92
P1-2	2,000	100	44	60	1	12	100	12	100	24	92
P1-3	2,000	100	44	60	1	12	100	12	100	24	92
P1-4 Reserve	2,000	100	0	60	1	12	100	12	100	0	24

(a) Electrical bypass for main switchgear and transformer maintenance is actually conducted once every 3 years, but is assumed to be conducted annually for emission calculations and permitting

TABLE 2-2
EMISSION RATES AND FUEL USAGE FOR BASELINE ACTIVITY FOR FOUR NEW GENERATORS
VMWARE DATA CENTER
EAST WENATCHEE, WASHINGTON

	Four New Generators for Pods 1 & 3				
	Monthly Testing	Unplanned Outage	Electrical Bypass for Main Switchgear and Transformer Testing	Corrective Testing	Total Baseline Emissions
Pollutant	**(Ton/Yr)**	**(Ton/Yr)**	**(Ton/Yr)**	**(Ton/Yr)**	**(Ton/Yr)**
NO_x	0.45	2.93	1.60	1.06	6.04
$PM_{2.5}$ or DEEP	0.0147	0.0671	0.0366	0.0244	0.143
CO	0.0079	0.24	0.13	0.088	0.542
VOCs	0.02	0.09	0.05	0.03	0.20
SO_2	4.64E-04	1.96E-03	1.07E-03	7.12E-04	4.20E-03
Primary NO_2	0.045	0.29	0.16	0.106	0.604
Benzene	2.35E-04	9.91E-04	5.41E-04	3.61E-04	2.13E-03
Toluene	8.51E-05	3.59E-04	1.96E-04	1.31E-04	7.70E-04
Xylenes	5.84E-05	2.47E-04	1.35E-04	8.97E-05	5.29E-04
1,3-Butadiene	5.92E-06	2.50E-05	1.36E-05	9.08E-06	5.36E-05
Formaldehyde	2.39E-05	1.01E-04	5.50E-05	3.67E-05	2.16E-04
Acetaldehyde	7.63E-06	3.22E-05	1.76E-05	1.17E-05	6.91E-05
Acrolein	2.39E-06	1.01E-05	5.49E-06	3.66E-06	2.16E-05
Benzo(a)pyrene	3.89E-08	1.64E-07	8.96E-08	5.97E-08	3.52E-07
Total PAHs (a)	1.51E-07	6.36E-07	3.47E-07	6.78E+03	1.37E-06
Fuel Usage (gallons/year)	4,421	18,652	10,174	6,782	40,028

(a) Applies toxicity equivalency factors.

TABLE 2-3
THEORETICAL MAXIMUM ANNUAL EMISSION RATES FOR FOUR NEW GENERATORS
VMWARE DATA CENTER
EAST WENATCHEE, WASHINGTON

Pollutant	Baseline Emissions (Scheduled Tests Plus Unplanned Outages) (Ton/Yr)	Commissioning Tests on 3 Final Generators (Ton/Yr)	Compliance Stack Testing on 4 New Generators (Ton/Yr)	Theoretical Maximum Annual Emissions (Ton/Yr)
NO_X	6.04	1.60	0.90	8.53
$PM_{2.5}$ or DEEP	0.143	0.037	0.029	0.209
CO	0.54	0.64	0.51	1.69
VOCs	2.01E-01	5.15E-02	4.12E-02	2.93E-01
SO_2	4.20E-03	1.07E-03	9.28E-04	6.20E-03
Primary NO_2	0.604	0.160	0.090	0.853
Benzene	2.13E-03	5.41E-04	4.70E-04	3.14E-03
Toluene	7.70E-04	1.96E-04	1.70E-04	1.14E-03
Xylenes	5.29E-04	1.35E-04	1.17E-04	7.81E-04
1,3-Butadiene	5.36E-05	1.36E-05	1.18E-05	7.91E-05
Formaldehyde	2.16E-04	5.50E-05	4.78E-05	3.19E-04
Acetaldehyde	6.91E-05	1.76E-05	1.53E-05	1.02E-04
Acrolein	2.16E-05	5.49E-06	4.77E-06	3.19E-05
Benzo(a)pyrene	3.52E-07	8.96E-08	7.78E-08	5.20E-07
Benzo(a)anthracene	1.71E-06	4.33E-07	3.77E-07	2.52E-06
Chrysene	4.20E-06	1.07E-06	9.27E-07	6.19E-06
Benzo(b)fluoranthene	3.04E-06	7.74E-07	6.72E-07	4.49E-06
Benzo(k)fluoranthene	2.99E-07	7.60E-08	6.60E-08	4.41E-07
Dibenz(a,h)anthracene	4.74E-07	1.21E-07	1.05E-07	7.00E-07
Ideno(1,2,3-cd)pyrene	5.68E-07	1.44E-07	1.25E-07	8.37E-07
Total PAHs (a)	1.37E-06	3.47E-07	3.02E-07	2.01E-06

(a) Applies toxicity equivalency factors.

TABLE 2-4
GENERAL LAND USE ZONES NEAR THE VMWARE DATA CENTER
VMWARE DATA CENTER
EAST WENATCHEE, WASHINGTON

Direction From VMware Data Center	Zoning (from East Wenatchee Zoning map)	Notable Development
North	Industrial	Receptor C-1, Outhouse Distributor
East	Industrial	Receptor C-1, Apple Warehouses
West	Industrial	Vacant Land
South	Commercial Agriculture	Apple Orchards with Receptors R-1, R-2, and R-3 (isolated farm houses)
Additional data center tenants within the Intergate-Columbia Data Center complex	Industrial	Additional tenants: Blackrock Data Center, Costco Data Center, and T-Mobile Data Center

TABLE 3-1
SUMMARY OF BACT DETERMINATION
VMWARE DATA CENTER
EAST WENATCHEE, WASHINGTON

Pollutant(s)	BACT Determination
Particulate matter (PM)	Use of good combustion practices; Use of EPA Tier 2-certified engines; and Compliance with the operation and maintenance restrictions of 40 CFR Part 60, Subpart IIII
Nitrogen oxides (NO_x)	Use of good combustion practices; Use of EPA Tier 2-certified engines; and Compliance with the operation and maintenance restrictions of 40 CFR Part 60, Subpart IIII
Carbon monoxide (CO) and volatile organic compounds (VOCs)	Use of good combustion practices; Use of EPA Tier 2-certified engines; and Compliance with the operation and maintenance restrictions of 40 CFR Part 60, Subpart IIII
Sulfur dioxide (SO_2)	Use of ultra-low sulfur diesel fuel containing no more than 15 parts per million by weight of sulfur

TABLE 3-2
SUMMARY OF TBACT DETERMINATION FOR AIR TOXICS
VMWARE DATA CENTER
EAST WENATCHEE, WASHINGTON

Toxic Air Pollutant(s)	tBACT Determination
DEEP	Compliance with the PM BACT requirement
Acetaldehyde, carbon monoxide, acrolein, benzene, benzo(a)pyrene, 1,3-butadiene, formaldehyde, propylene, toluene, total PAHs, xylenes	Compliance with the VOC BACT requirement
Nitrogen dioxide	Compliance with the NO_x BACT requirement
Sulfur dioxide	Compliance with the SO_2 BACT requirement

TABLE 3-3
SMALL-QUANTITY EMISSION RATES COMPARISON FOR TOXIC AIR POLLUTANTS
VMWARE DATA CENTER
EAST WENATCHEE, WASHINGTON

Pollutant	SQER	Units	VMware Generator Emission	SQER Ratio
$PM_{2.5}$	0.64	lbs/yr	418	654
CO	50.2	lbs/1-hour	11.0	0.2
SO_2	1.45	lbs/1-hour	0.09	0.06
Primary NO_2	1.03	lbs/1-hour	13.3	12.9
Benzene	6.62	lbs/yr	6.2	0.94
Toluene	657	lbs/24-hr day	0.39	5.96E-04
Xylenes	58	lbs/24-hr day	0.27	4.64E-03
1,3-Butadiene	1.13	lbs/yr	0.157	0.14
Formaldehyde	32	lbs/yr	0.632	1.98E-02
Acetaldehyde	71	lbs/yr	0.202	2.84E-03
Acrolein	0.0079	lbs/24-hr day	0.0110	1.39
Benzo(a)pyrene	0.17	lbs/yr	1.03E-03	5.92E-03
Benzo(a)anthracene	1.74	lbs/yr	4.99E-03	2.87E-03
Chrysene	17.4	lbs/yr	1.23E-02	7.05E-04
Benzo(b)fluoranthene	1.74	lbs/yr	8.90E-03	5.11E-03
Benzo(k)fluoranthene	1.74	lbs/yr	8.74E-04	5.02E-04
Dibenz(a,h)anthracene	0.16	lbs/yr	1.39E-03	8.67E-03
Indeno(1,2,3-cd)pyrene	1.74	lbs/yr	1.66E-03	9.53E-04

Note: Highlighted cells indicate SQER ratios exceeding 1.0.

TABLE 3-4
FIRST-TIER AMBIENT IMPACT ASSESSMENT FOR TOXIC AIR POLLUTANTS
VMWARE DATA CENTER
EAST WENATCHEE, WASHINGTON

Toxic Air Pollutant	ASIL (µg/m^3)	Averaging Period	1st-Highest Ambient Concentration (µg/m^3)
DEEP	0.00333	Annual average	0.117
NO_2	470	1-hour average	280
Acrolein	0.06	24-hour average	0.00328

TABLE 4-1
CALIFORNIA'S AIR TOXICS HOTSPOTS RISK ASSESSMENT GUIDANCE ON SPECIFIC PATHWAYS TO BE ANALYZED FOR EACH MULTI-PATHWAY SUBSTANCE SIL COMPLIANCE AT FACILITY BOUNDARY
VMWARE DATA CENTER
EAST WENATCHEE, WASHINGTON

Substance	Ingestion Pathway									
	Soil	Dermal	Meat, Milk & Egg	Fish	Exposed Veg.	Leafy Veg.	Protected Veg.	Root Veg.	Water	Breast Milk
4,4'-Methylene dianiline	X	X		X	X	X	X	X	X	
Creosotes	X	X	X	X	X	X			X	
Diethylhexylphthalate	X	X		X	X	X	X	X	X	
Hexachlorocyclohexanes	X	X		X	X	X			X	
PAHs	X	X	X	X	X	X			X	
PCBs	X	X	X	X	X	X	X	X	X	X
Cadmium & compounds	X	X	X	X	X	X	X	X	X	
Chromium VI & compounds	X	X	X	X	X	X	X	X	X	
Inorganic arsenic & compounds	X	X	X	X	X	X	X	X	X	
Beryllium & compounds	X	X	X	X	X	X	X	X	X	
Lead & compounds	X	X	X	X	X	X	X	X	X	
Mercury & compounds	X	X		X	X	X	X	X	X	
Nickel	X	X	X		X	X	X	X	X	
Fluorides (including hydrogen fluoride)	To be determined									
Dioxins & furans	X	X	X	X	X	X	X		X	X

Veg. = Vegetable

TABLE 4-10
EXPOSURE ASSUMPTIONS AND UNIT RISK FACTORS FOR DIESEL PARTICULATE MATTER RISK ASSESSMENT
VMWARE DATA CENTER
EAST WENATCHEE, WASHINGTON

Receptor Type	Annual Exposure	Exposure Duration	Diesel Particulate Matter Cancer Unit Risk Factor (risk per million, per annual µg/m^3 DEEP)
Unoccupied Land	2 hours/day 250 days/year	30 years	7.3-per-million cancer risk per µg/m^3 DEEP
Residences	24 hours/day 365 days/year	70 years	300-per-million cancer risk per µg/m^3 DEEP
Schools (College Students)	36 hours/week 40 weeks/year	4 years	2.8-per million risk per µg/m^3 DEEP
Schools (High School Students)	36 hours/week 40 weeks/year	4 years	2.8-per-million risk per µg/m^3 DEEP
Schools (Elementary School Students)	36 hours/week 40 weeks/year	7 years	4.9-per-million risk per µg/m^3 DEEP
Schools (All Teachers)	40 hours/week 40 weeks/year	40 years	31-per-million risk per µg/m^3 DEEP
Churches	2 hours/week 52 weeks/year	40 years	2-per-million risk per µg/m^3 DEEP
Business	8 hours/day 250 days/year	40 years	38-per-million risk per µg/m^3 DEEP

TABLE 4-11
ESTIMATED CUMULATIVE INCREASED CANCER RISK
VMWARE DATA CENTER
EAST WENATCHEE, WASHINGTON

Attributable To:	70-Year Average Risk Per Million From DEEP Exposure at Various Receptor Locations							
	Fence Line Receptor (MIBR)	**Blackrock Roof Vent**	**R-1 SE House (MIRR)**	**R-2 SW House**	**R-3 ESE House**	**C-1 Outhouse Distributor**	**C-2 Apple Warehouse (MICR)**	**C-3 Stemilt Growers**
VMware's Four New Generators	0.61	0.24	5.96	0.50	4.1	0.056	2.1	0.95
Local Background	1.2	4.6	16	3.6	16	2.4	4.9	2.8
NATA Regional Background	0.55	2.9	23	23	23	2.9	2.9	2.9
Cumulative (Post-Project)	2.4	7.7	45	27	43	5.3	9.9	6.7

NATA = National-Scale Air Toxics Assessment

TABLE 4-12
CANCER RISK CAUSED BY ALL EMITTED CARCINOGENS
VMWARE DATA CENTER
EAST WENATCHEE, WASHINGTON

Carcinogen	70-Year Average Emission Rate (Tons per Year)	ASIL (µg/m^3)	Cancer Risk at Key Receptors (per Million)		
			MIRR	MIBR	MICR
DPM	0.149	0.00333	5.96	0.61	2.150
Benzene	2.23E-03	3.50E-02	8.45E-03	8.64E-04	3.05E-03
1,3-Butadiene	5.61E-05	5.88E-03	1.27E-03	1.30E-04	4.57E-04
Formaldehyde	2.26E-04	1.67E-01	1.80E-04	1.84E-05	6.49E-05
Acetaldehyde	7.23E-05	3.70E-01	2.59E-05	2.66E-06	9.36E-06
Benzo(a)Pyrene	3.69E-07	9.09E-04	5.38E-05	5.51E-06	1.94E-05
Benzo(a)anthracene	1.78E-06	9.09E-03	2.61E-05	2.67E-06	9.40E-06
Chrysene	4.39E-06	9.09E-02	6.41E-06	6.56E-07	2.31E-06
Benzo(b)fluoranthene	3.18E-06	9.09E-03	4.65E-05	4.76E-06	1.68E-05
Benzo(k)fluoranthene	3.13E-07	9.09E-03	4.57E-06	4.67E-07	1.65E-06
Dibenz(a,h)anthracene	4.96E-07	9.09E-04	7.25E-05	7.42E-06	2.62E-05
Ideno(1,2,3-cd)pyrene	5.94E-07	9.09E-03	8.67E-06	8.88E-07	3.13E-06
Total Risk Per Million	--	--	5.97	0.611	2.154

TABLE 4-2
MAXIMALLY EXPOSED RECEPTORS
70-YEAR AVERAGE DEEP, ATTRIBUTABLE TO VMWARE'S FOUR NEW GENERATORS
VMWARE DATA CENTER
EAST WENATCHEE, WASHINGTON

Receptor Type	Direction From Nearest Project-Specific DEEP Emission Source	Estimated Distance From Nearest Project-Specific DEEP Emission Source		Estimated VMware-Only Increase in 70-Year Average DEEP Concentration at Receptor Location ($\mu g/m^3$)
		Feet	Meters	
Point of Maximum Offsite Impact (a)	East (roadway at eastern facility boundary)	400	122	0.084
Maximum Impacted Residence –(Yard near residential building, R-1)	Southeast	827	252	0.020
Maximum Offsite Impacted Business/Office (Apple Warehouse, C-2)	East	515	157	0.056
Maximum Onsite Tenant Rooftop Impact (Blackrock)	Northeast	259	79	0.0064

(a) East fence line, approximately 46 meters north of the southern property line.

TABLE 4-3
MAXIMALLY EXPOSED RECEPTORS
70-YEAR AVERAGE CUMULATIVE ANNUAL DEEP
VMWARE DATA CENTER
EAST WENATCHEE, WASHINGTON

Attributable To	70-Year Average Annual DEEP Concentration (µg/m^3) at Various Receptor Locations – VMware Receptors							
	Fence Line Receptor (MIBR)	**Blackrock Roof Vent**	**R-1 SE House (MIRR)**	**R-2 SW House**	**R-3 ESE House**	**C-1 Outhouse Distributor**	**C-2 Apple Warehouse (MICR)**	**C-3 Stemilt Growers**
VMware's Four New Generators	0.084	0.0064	0.020	0.0017	0.014	0.0015	0.056	0.025
Local Background	0.17	0.12	0.052	0.012	0.053	0.062	0.13	0.074
NATA Regional Background	0.076	0.076	0.076	0.076	0.076	0.076	0.076	0.076
Cumulative (Post-project)	0.33	0.20	0.15	0.090	0.14	0.14	0.26	0.18

TABLE 4-4
MAXIMALLY EXPOSED RECEPTORS
THEORETICAL ANNUAL DEEP CONCENTRATIONS
VMWARE DATA CENTER
EAST WENATCHEE, WASHINGTON

Attributable To	Theoretical Annual Maximum DEEP Concentration (µg/m^3) at Various Receptor Locations – VMware Receptors							
	Fence Line Receptor (MIBR)	**Blackrock Roof Vent**	**R-1 SE House (MIRR)**	**R-2 SW House**	**R-3 ESE House**	**C-1 Outhouse Distributor**	**C-2 Apple Warehouse (MICR)**	**C-3 Stemilt Growers**
VMware's Four New Generators	0.117	0.0089	0.028	0.0024	0.019	0.0020	0.079	0.035
Local Background	0.17	0.12	0.052	0.012	0.053	0.062	0.13	0.074
NATA Regional Background	0.076	0.076	0.076	0.076	0.076	0.076	0.076	0.076
Cumulative (Post-project)	0.36	0.20	0.16	0.090	0.15	0.14	0.29	0.19

TABLE 4-5
TOXICITY VALUES USED TO ASSESS AND QUANTIFY NON-CANCER HAZARD AND CANCER RISK
VMWARE DATA CENTER
EAST WENATCHEE, WASHINGTON

Pollutant	Agency	Non-Cancer	Cancer
DEEP	U.S. Environmental Protection Agency	RfC = 5 µg/m^3	NA (a)
	California EPA–Office of Environmental Health Hazard Assessment	Chronic REL = 5 µg/m^3	URF = 0.0003 per µg/m^3

(a) The EPA considers DEEP to be a probable human carcinogen, but has not established a cancer slope factor or unit risk factor.

TABLE 4-6
DEEP CHRONIC NON-CANCER HAZARD QUOTIENTS FOR RESIDENTIAL AND OCCUPATIONAL SCENARIOS (THEORETICAL MAXIMUM YEAR)
VMWARE DATA CENTER
EAST WENATCHEE, WASHINGTON

Attributable To:	DEEP Chronic Hazard Quotient at Various Receptor Locations							
	Fence Line Receptor (MIBR)	**Blackrock Roof Vent**	**R-1 SE House (MIRR)**	**R-2 SW House**	**R-3 ESE House**	**C-1 Outhouse Distributor**	**C-2 Apple Warehouse (MICR)**	**C-3 Stemilt Growers**
VMware's Four New Generators	0.023	0.0018	0.0056	0.00048	0.0038	0.00040	0.016	0.0070
Local Background	0.034	0.024	0.010	0.0024	0.011	0.012	0.026	0.015
NATA Regional Background	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015
Cumulative (Post-project)	0.073	0.041	0.031	0.018	0.030	0.028	0.057	0.037

TABLE 4-7
NON-CANCER HAZARDS OF VMWARE EMISSIONS AT THE MAXIMALLY EXPOSED LOCATION AT OR BEYOND THE FACILITY BOUNDARY (MAXIMALLY IMPACTED BOUNDARY RECEPTOR)
VMWARE DATA CENTER
EAST WENATCHEE, WASHINGTON

NO_2			
NO_2 Concentration (µg/m^3)	280		
RBC (µg/m^3)	REL = 470		
HQ	0.60		
DEEP			
DEEP Concentration (µg/m^3)		0.117 (Max annual TWA)	
RBC (µg/m^3)		RfC = 5	REL = 5
HQ		0.023	0.023
Acrolein			
Acrolein Concentration (µg/m^3)	0.00619 (Max 1-hr TWA)		
RBC (µg/m^3)	REL = 2.5		
HQ	0.0025		
Combined Pollutants			
Combined Pollutant Hazard Index	Max 1-hr Acute Hazard	Max Chronic Hazard	
	0.60	0.023	

TABLE 4-8
NON-CANCER HAZARDS OF VMWARE EMISSIONS AT THE APPLE WAREHOUSE
(MAXIMALLY IMPACTED COMMERCIAL RECEPTOR)
VMWARE DATA CENTER
EAST WENATCHEE, WASHINGTON

NO_2			
NO_2 Concentration (µg/m^3)	160 (Max 1-hr TWA)		
RBC (µg/m^3)	REL = 470		
HQ	0.34		
DEEP			
DEEP Concentration (µg/m^3)		0.079 (Max annual TWA)	
RBC (µg/m^3)		RfC = 5	REL = 5
HQ		0.016	0.016
Acrolein			
Acrolein Concentration (µg/m^3)	0.00417 (Max 1-hr TWA)		
RBC (µg/m^3)	REL = 2.5		
HQ	0.00167		
Combined Pollutants			
Combined Pollutant Hazard Index	Max 1-hr Acute Hazard	Max Chronic Hazard	
	0.34	0.016	

TABLE 4-9
NON-CANCER HAZARDS OF VMWARE EMISSIONS AT THE MAXIMALLY EXPOSED RESIDENTIAL RECEPTOR
VMWARE DATA CENTER
EAST WENATCHEE, WASHINGTON

NO_2			
NO_2 Concentration (µg/m^3)	161 (Max 1-hr TWA)		
RBC (µg/m^3)	REL = 470		
HQ	0.34		
DEEP			
DEEP Concentration (µg/m^3)		0.028 (Max annual TWA)	
RBC (µg/m^3)		RfC = 5	REL = 5
HQ		0.0056	0.0056
Acrolein			
Acrolein Concentration (µg/m^3)	0.00147 (Max 1-hr TWA)		
RBC (µg/m^3)	REL = 2.5		
HQ	0.00059		
Combined Pollutants			
Combined Pollutant Hazard Index	Max 1-hr Acute Hazard	Max Chronic Hazard	
	0.34	0.0056	

TABLE 5-1
QUALITATIVE SUMMARY OF THE EFFECTS OF UNCERTAINTY ON QUANTITATIVE ESTIMATES OF RISKS OR HAZARDS
VMWARE DATA CENTER
EAST WENATCHEE, WASHINGTON

Source of Uncertainty	How Does it Affect Estimated Risk From This Project?
Exposure assumptions	Likely overestimate of exposure
Emissions estimates	Possible overestimate of emissions concentrations
AERMOD air modeling methods	Possible underestimate of average long-term ambient concentrations and overestimate of short-term ambient concentration
Toxicity of DEEP at low concentrations	Possible overestimate of cancer risk, possible underestimate of non-cancer hazard for sensitive individuals

TABLE 6-1
MAXIMALLY EXPOSED RECEPTORS – VMWARE ONLY NO_2 CONCENTRATIONS
VMWARE DATA CENTER
EAST WENATCHEE, WASHINGTON

Attributable To:	Maximum 1-Hour NO_2 Concentration ($\mu g/m^3$) at Various Receptor Locations – VMware Receptors							
	Fence Line Receptor (MIBR)	Blackrock Roof Vent	R-1 SE House (MIRR)	R-2 SW House	R-3 ESE House	C-1 Outhouse Distributor	C-2 Apple Warehouse (MICR)	C-3 Stemilt Growers
VMware's Four New Generators	280	125	161	99	140	125	160	169

ASIL = 470 $\mu g/m^3$