DEPARTMENT OF
ECOLOGY
State of Washington

Technical Support Document for Third Tier Review

Yahoo! Data Center
Phase 5 Expansion Project
Quincy, Washington

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1. EXECUTIVE SUMMARY

1.1. Proposal Summary

Yahoo!, Inc. (Yahoo!) proposes to expand their data center located in Quincy, Grant County, Washington. The expansion project, or the Phase 5 development, will consist of five buildings to house server equipment and 10 diesel-powered backup engine-generator sets each rated at 2,280 mechanical kilowatts (kWm). The engines will be housed in separate enclosures.

Potential emissions of diesel engine exhaust particulate matter (DEEP) and nitrogen dioxide (NO_2) from the proposed backup engines exceeded regulatory trigger levels called Acceptable Source Impact Levels (ASILs). Under typical situations, Yahoo! would be required to submit a second tier petition per Chapter 173-460 Washington Administrative Code (WAC). However, in the case of Yahoo!'s Phase 5 project, the Washington State Department of Ecology (Ecology) required Yahoo! to submit a third tier review petition under WAC 173-460-100. A third tier review involves a more rigorous health impacts evaluation than a second tier review.

Additionally, Ecology determined that a community-wide approach to permitting data centers was warranted for the Quincy urban growth area (UGA) because of the relatively close geographic proximity of existing and planned large data centers in Quincy. As part of the community-wide approach, Ecology considers the cumulative impacts of DEEP and NO_2 from existing permitted data centers and other nearby sources of diesel engine emissions.

1.2. Health Impacts Evaluation

Yahoo! retained Landau Associates (Landau) to prepare a Health Impact Assessment (HIA) to evaluate the potential health risks attributable to operation of the diesel-powered generators from the Phase 5 expansion project. The HIA demonstrated that emissions of DEEP from the proposed Phase 5 expansion alone could result in an increased cancer risk of up to 4 in one million (4×10^{-6}) at the maximally impacted residential location, which is an undeveloped residentially zoned property located to the west of Yahoo!. Because the increase in cancer risks attributable to the expansion alone is less than 10 in one million, the project could be approvable under WAC 173-460-090.

The HIA also demonstrated that power outage emissions of NO_2 from the 10 proposed engines (Phase 5) could infrequently result in hazard quotients greater than one at a few non-residential off-site locations near Yahoo!'s southeast boundary. A hazard quotient greater than one means that the estimated short-term (one-hour average) NO_2 levels exceed a reference exposure level (REL) of 470 micrograms per cubic meter ($\mu g/m^3$). At or above this level, some sensitive asthmatics could experience symptoms.

1.3. Health Risks Attributable to Nearby Sources

Landau and Ecology also evaluated emissions from other nearby emission sources to determine the cumulative long-term and short-term health impacts associated with DEEP and NO_2. Ecology evaluated cumulative acute exposure to NO_2 assuming simultaneous power outage

emissions from all existing and proposed data centers in Quincy. Ecology found that acute hazard quotients could infrequently exceed one at some locations in Quincy if worst-case meteorological conditions occurred coincidentally with unplanned power outages. As mentioned above, a hazard quotient equal to or greater than one could cause some sensitive asthmatics to experience symptoms. The concentrations responsible for these hazards are not expected to occur frequently or be sustained for long periods of time. Therefore, Ecology determined that the potential acute hazard due to the project is acceptable.

After the expansion, Ecology estimates the potential cumulative cancer risk posed by DEEP emitted from Yahoo! and other nearby sources to be 25 in one million at an existing residence to the north of the Yahoo! facility, and 21 in one million at an undeveloped residential parcel to the west of Yahoo!. The existing residence is more impacted by allowable emissions from the existing Intuit data center than by emissions from Yahoo!. While there are other residential locations in Quincy that may experience higher DEEP related risks, we found that Yahoo!'s individual contribution to cancer risk at those locations is typically less than one in one million.

Ecology determines that this potential post-expansion cumulative cancer risk is acceptable because it falls within available risk management guidelines.

1.4. Environmental Benefits

In order to assure that the expansion will result in a greater environmental benefit to the state of Washington, as required by WAC 173-460-100(3)(c), Yahoo! has volunteered to extend exhaust stacks and reduce annual fuel usage limits and allowable hours of operation for their existing data center engines in Quincy. The existing data center currently has 13 engines each rated at 2,280 kWe.

Yahoo!'s proposal will result in an overall 37% reduction in potential DEEP emissions and enhanced pollutant dispersion. Potential cancer risk from cumulative exposure to DEEP decreases from a pre-expansion risk of 52 in one million to a post-expansion risk of 21 in one million at the maximally impacted residential parcel located to the west of Yahoo!. Therefore, Ecology concludes that the proposed reduction in maximum annual facility-wide fuel usage will result in a greater environmental benefit to the state of Washington.

1.5. Recommendation

Ecology recommends approval of the proposed project. However, because acute exposure to cumulative NO_2 emissions could infrequently reach levels of concern for some sensitive individuals, Ecology recommends that Yahoo! be required to:

- Communicate health risks posed by Yahoo!'s emissions to potential new homeowners at undeveloped parcels adjacent to Yahoo! or to the local regulatory agency responsible for zoning and development in the affected area;

- Routinely report to Ecology all unplanned power failures occurring at their facility; and

- Immediately report situations where combined duration of power outages exceeds eight hours in any given year. This notification would allow Ecology to reconsider additional measures designed to protect sensitive individuals.

Under a third tier petition, Yahoo! must hold a public hearing in which Yahoo! and Ecology will present the results of the HIA, the proposed emission controls, pollution prevention methods, additional proposed measures, and any remaining risks posed by the project. Yahoo! must participate in discussions and answer the public's questions at the public hearing.

The rest of this document describes the technical review performed by Ecology.

2. YAHOO! QUINCY DATA CENTER

2.1. Yahoo!'s Existing Data Center (Phases 1 through 3)

Yahoo! submitted a Notice of Construction (NOC) application on January 24, 2007, for the installation of the Yahoo! Data Center (Phases 1 through 3) at 1115 Industrial Loop Road, Quincy, in Grant County. Ecology approved the NOC application through Order No. 07AQ-E241 issued on November 13, 2007 (Ecology, 2010a). Construction of Phases 1-3 on a 45+-acre parcel located in the northeastern portion of the Quincy UGA (Figure 1) was completed in 2007-2008.

Yahoo! requires uninterrupted electrical power supply for computer servers inside the data center buildings. While the main power supply to the facility is generally reliable, other sources of electrical power, such as backup diesel engines, are needed in the event of a power interruption.

Phases 1-3 consist of thirteen (13) MTU Detroit Diesel, Inc. Model 16V4000 G83 B3 diesel engines that power Newage AvK Model DSG 86 L1-4s generators with a combined 100% standby rating of 32.5 electric megawatts (MWe). Each engine is permitted to operate for up to 400 hours per year on average, and the total facility diesel fuel usage is limited to 821,600 gallons per year and 49,296 gallons per day of ultra-low sulfur diesel fuel. The data center also uses six Evapco Model AT 212-636 two cell evaporative cooling units (Ecology, 2010a). The Yahoo! Data Center is supported by associated equipment such as fuel tanks, cooling water storage and treatment, and electrical systems.

2.2. Yahoo! Data Center Proposed Expansion Project (Phase 5)

Yahoo! proposes to expand their existing data center complex in Quincy, Washington. The proposed Phase 5 expansion project is located adjacent to the south end of the existing building in Quincy, WA (Figure 2). Phase 5 will include five buildings to house server equipment and ten (10) 2.280 megawatt (MWm) MTU Detroit Diesel, Inc. Model 16V4000 G83 diesel engines to power emergency generators (Landau, 2010).

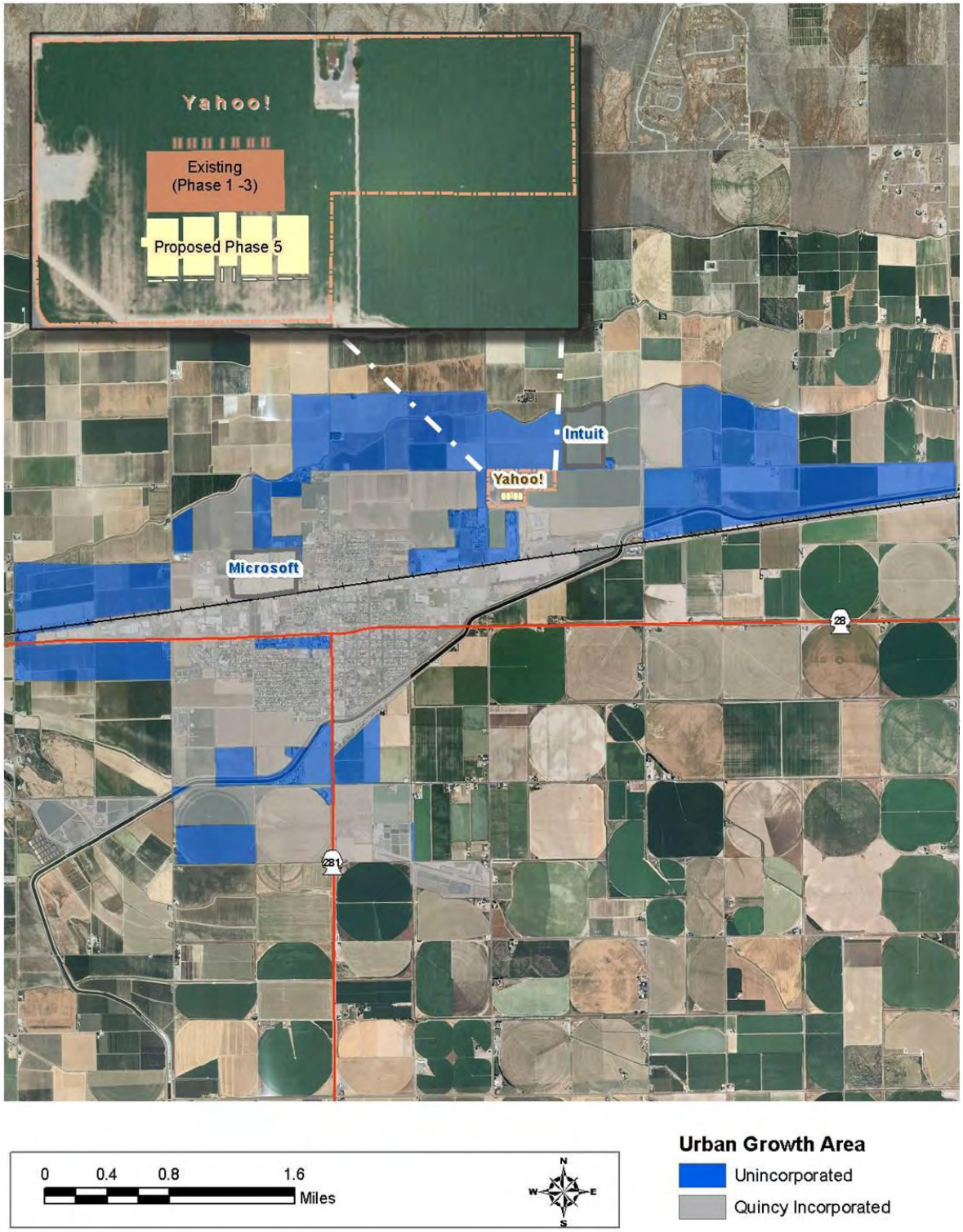

Figure 1. Yahoo! Data Center location within Quincy, WA's Urban Growth Area

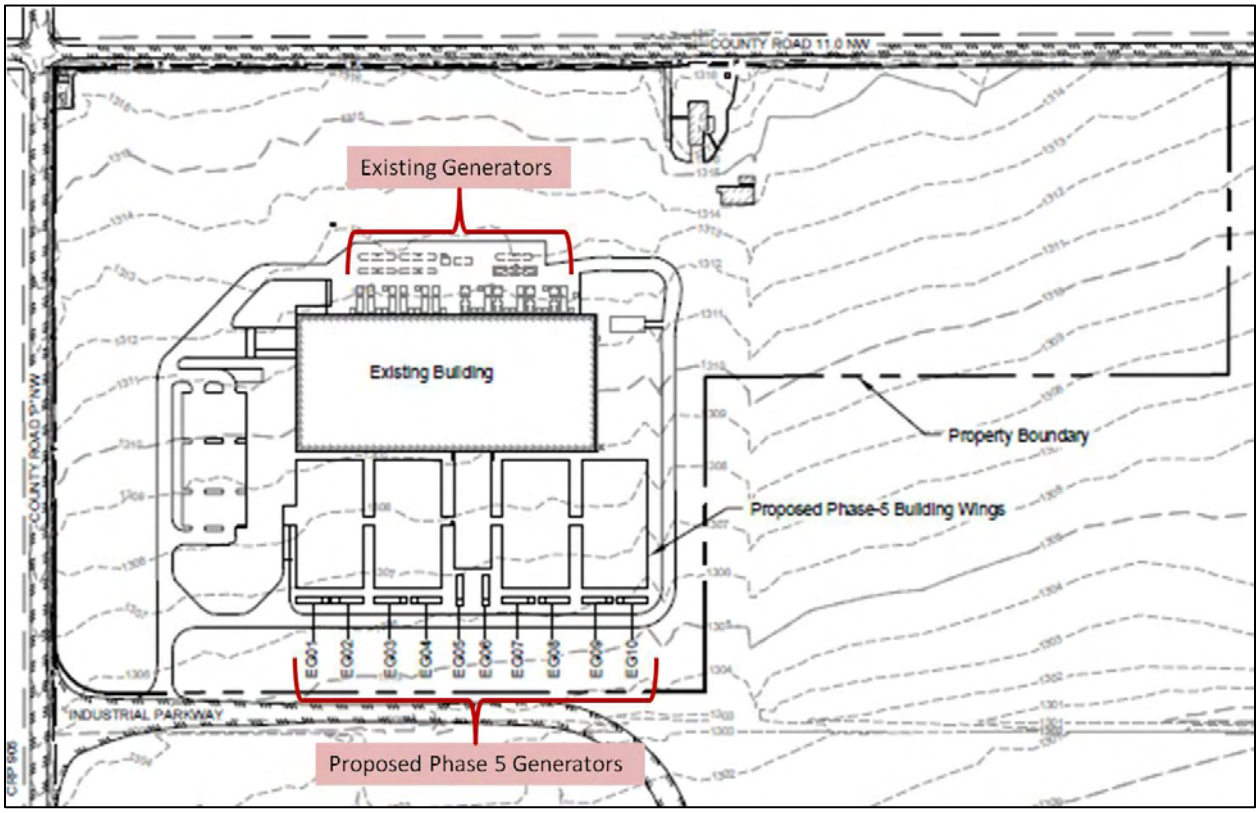

Figure 2. Site plan drawing showing general location of air emission units (Adapted from Landau, 2010)

Yahoo! plans to install four of the 10 engines in 2011. The final six engines will be installed at an undetermined date. The engines will be located in separate generator enclosures to the south of the proposed facility (Figure 2). Exhaust from each engine will be routed through a vertical exhaust stack that extends through the roof of the generator enclosure 30 feet above grade.

In order to minimize air quality impacts from the proposed project, Yahoo! agrees to limit the duration of engine testing, maintenance and other usage. Operation of each of the ten (10) MTU Detroit Diesel engines will be limited to 100 hours per year. Each engine will undergo monthly testing for one hour per test and annual load testing for four hours. Yahoo! also requests 36 hours of electrical bypass and 48 hours of outage operation for each engine. In total, Yahoo! estimates that a fuel usage limit of up to 103,551 gallons per year of ultra-low sulfur (less than 0.0015 wt %), EPA on-road specification No. 2 distillate diesel oil will provide enough fuel for operating durations shown in Table 1.

Table 1. Operating Time Limits for Yahoo!'s Proposed Phase 5 Data Center Expansion Diesel Engines

Event	Frequency	# Engines Concurrently Operating	Hours/Event	Engine Load (%)	Total Maximum Hours/Year
Monthly testing	Each engine 1 x per month	1	1	Idle [a]	12
Annual load testing	Each engine 1 x per year	1	4		4
Electrical bypass/maintenance	As needed	1 or 2	b	1 engine @ 80% or 2 engines @ 40%	36
Outage	As needed	10	c	8 engines @ 90% 2 engines @ 10%	48
Combined testing, maintenance + outage					100

a. Engines are not place under load during monthly testing, but Yahoo! assumed 10% load for the purpose of estimating emissions.
b. Yahoo! reports that electrical bypass events generally require fewer than four hours of engine operation in any single day.
c. Outages are not expected to occur for the full allotment of time during any given year.

2.3. Land Use

Although Yahoo!'s property is located among relatively undeveloped land, several nearby parcels are zoned residential, and several others contain commercial/industrial land uses. Table 2 describes general land uses in properties surrounding the Yahoo! facility (Ecology, 2010b; Grant County, 2011). Figure 3 shows general land use designations for parcels near Yahoo!.

Table 2. Land Use Designations Near Yahoo! Data Center in Quincy, WA

Direction From Yahoo!	Land Use	Notable Development
North	Agriculture	Farm buildings/home approximately 1/2 mile
Northeast	Agriculture Communications, transportation, utilities	Intuit Data Center
East Southeast	Communications, transportation, utilities	Industrial park buildings
South	Commercial/industrial Wholesale, retail, trade	Property owned by Quincy Foods LLC
Southwest	Mobile home park Residential Manufacturing	Mobile homes Celite Corporation
West	Residential	Not currently developed
Northwest	Agriculture	None

Figure 3. Land use in parcels near Yahoo!

2.4. Reductions of Emissions From the Existing Yahoo! Data Center Phases 1–3 Emission Units

During the NOC permit review process for Yahoo!'s Phase 5 expansion project, Yahoo! offered to reduce the allowable emissions from Phases 1-3's thirteen (13) MTU Detroit Diesel, Inc. Model 16V4000 G83 B3 diesel engines. These diesel engines were originally permitted to operate at full standby for up to 400 hours per year per engine on average, and a facility-wide diesel fuel consumption limit of 821,600 gallons per year (Table 3). As part of the Phase 5 expansion project proposal, Yahoo! proposes to reduce their existing data center's (Phases 1-3) maximum annual diesel fuel consumption from 821,600 gallons per year to 410,800 gallons per year. Yahoo! also proposed to extend the permitted height of each exhaust stack by five feet.

Table 3 shows that with the 10 additional engines in the proposed Phase 5 expansion, Yahoo!'s net allowable facility-wide fuel consumption will decrease from 821,600 gallons per year to 514,351 gallons per year. This reduction in allowable fuel consumption roughly translates into a 37% net decrease in the amount of DEEP emissions allowed from the facility.

Table 3. Yahoo!'s Maximum Annual Fuel Usage

Project	Historical Allowed Fuel Usage (gallons per year)	Proposed Allowed Fuel Usage (gallons per year)	Percent Reduction (total)
Phases 1-3	821,600	410,800	50%
Phase 5	-	103,551	
Total	821,600	514,351	37.4%

3. 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 toxic air pollutant (TAP) emissions for all new or modified stationary sources in the state of Washington. Sources subject to review under this rule must apply best available control technology for toxics (tBACT) to control emissions of all TAPs subject to review.

There are three levels of review when processing a Notice of Construction application for a new or modified emissions unit emitting TAPs in excess of the de minimis levels: (1) first tier (toxic

[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.

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 acceptable source impact levels (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 health impact assessment (HIA). The objective of a 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 one 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 one million (equivalent to one in one hundred thousand), then an applicant may request Ecology perform a third tier review. For non-carcinogens, a similar path exists, but there is no bright line associated with when a third tier review is triggered.

A third tier review 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.

Yahoo!'s proposed Phase 5 data center expansion required a third tier petition to Ecology because the cumulative health impact from the proposed data center and other existing sources of DEEP necessitated a third tier risk management decision in accordance with WAC 173-460-100.

3.2. tBACT for the Yahoo! Phase 5 Data Center Expansion Project

Table 4 shows Ecology's preliminary tBACT determination for TAPs emitted by Yahoo!'s engines.

Table 4. tBACT for Air Toxics Emitted by Yahoo!'s Diesel Engines

Toxic Air Pollutant(s)	tBACT Determination
Acetaldehyde, acrolein, benzene, benzo(a)pyrene, 1,3-butadiene, carbon monoxide, diesel engine exhaust particulate, formaldehyde, naphthalene, propylene, toluene, total PAHs, xylenes	Restricted operation of EPA Tier-2 certified engines, and compliance with the operation and maintenance restrictions of 40 CFR Part 60, Subpart IIII.
Nitrogen dioxide	Good combustion practices; an engine design that incorporates fuel injection timing retard, turbocharger, and a low-temperature after-cooler; EPA Tier-2 certified engines; and compliance with the operation and maintenance restrictions of 40 CFR Part 60, Subpart IIII.
Sulfur dioxide	Use of ultra-low sulfur diesel fuel containing no more than 15 parts per million by weight of sulfur.

Ecology has also proposed the following emission limits:

- The total amount of PM emissions from operating all 10 expansion project engines during each year shall not exceed 0.35 tons/yr, based on load specific emission factors supplied by the engine manufacturer.

- Nitrogen dioxide (NO_2) emissions from the 10 expansion project engines shall not exceed the following emission rates based on emission factors derived from source testing:
    - 3.5 lb/hr during annual load testing (one engine at a time)
    - 2.5 lb/hr during start-up testing (one engine at a time)
    - 2.3 lb/hr during electrical bypass (one engine @ 80% or two engines @ 40%)
    - 0.34 lb/hr during monthly maintenance (one engine at a time)
    - 23.9 lb/hr during power outages (eight engines @ 90% load and two @ 10% load)

The project review team for the third tier review concurs with this tBACT determination.

3.3. First Tier Review Toxics Screening for the Yahoo! Phase 5 Data Center Expansion Project

Yahoo!'s consultant, Landau, used a combination of EPA emission factors, and EPA Tier-2 engine emission limits to estimate emission rates of TAPs from Yahoo!'s diesel-powered generators (Landau, 2010). Table 5 shows each TAP's proposed emissions compared to its respective small quantity emission rate (SQER).[2] DEEP, nitrogen dioxide, carbon monoxide, benzene, and acrolein emission rates exceed their respective SQER.

[2] An SQER is an emission rate that is not expected to result in an off-site concentration that exceeds an ASIL.

Table 5. Comparison of Emission Rates to SQER

Pollutant	Averaging Period	Total Emissions	SQER	Emissions Above SQER
		See Averaging Period for Units	See Averaging Period for Units	Yes or No
Acetaldehyde	lb/yr	0.36	71	No
Acrolein	lb/24-hr	0.029	0.00789	**Yes**
Benzene	lb/yr	11	6.62	**Yes**
Benzo(a)pyrene (TEQ)	lb/yr	0.013	0.174	No
Benz(a)anthracene	lb/yr	0.009	1.74	No
Benzo(a)pyrene	lb/yr	0.004	0.174	No
Benzo(b)fluoranthene	lb/yr	0.016	1.74	No
Benzo(k)fluoranthene	lb/yr	0.003	1.74	No
Chrysene	lb/yr	0.022	17.4	No
Dibenz(a,h)anthracene	lb/yr	0.005	0.16	No
Indeno(1,2,3-cd)pyrene	lb/yr	0.006	1.74	No
1,3-Butadiene	lb/yr	0.56	1.13	No
Carbon Monoxide	lb/hr	130	50.4	**Yes**
DEEP	lb/yr	699	0.639	**Yes**
Formaldehyde	lb/yr	1.1	32	No
Naphthalene	lb/yr	1.8	5.64	No
Nitrogen Dioxide	lb/hr	23.4	1.03	**Yes**
Propylene	lb/24-hr	10.1	394	No
Sulfur dioxide	lb/hr	0.23	1.45	No
Toluene	lb/24-hr	1.0	657	No
Xylenes	lb/24-hr	0.70	29	No

TEQ – toxic equivalent (sum of relative toxicity of several polycyclic aromatic hydrocarbons similar to benzo(a)pyrene)

Landau used refined dispersion modeling (briefly described in Section 4.2.2) to model ambient concentrations of those TAPs that exceed their SQER. Table 6 shows a comparison of the modeled concentrations of pollutants that exceeded SQERs to their respective ASILs. DEEP and NO_2 exceeded ASILs, therefore, Yahoo! was required to prepare a HIA.

3.4. Third Tier Review of Yahoo!'s Phase 5 Data Center Expansion Project

As stated above, potential DEEP and NO_2 impacts from the proposed expansion exceeded their respective ASILs. As a result, Yahoo! prepared and submitted to Ecology a HIA. Under typical situations, Ecology would evaluate the HIA under second tier review, but Ecology required a higher level of review for Yahoo!'s proposed Phase 5 project. Section 3.5 below explains Ecology's rationale for evaluating Yahoo!'s HIA under third tier review in accordance with WAC 173-460-100. A third tier review petition involves a detailed assessment of proposed emissions controls and environmental benefits of the project, as well as disclosure of expected health risks from the project at a public hearing.

Table 6. Comparison of Modeled Off-Site TAP Concentrations to ASILs

Pollutant	CAS#	Averaging Time	Highest Modeled Off-Site Concentration (µg/m^3)	ASIL (µg/m^3)	Exceeds ASIL
Acrolein	107-02-8	24-hr	0.005	0.06	No
Benzene	71-43-2	Annual	0.001	0.0345	No
Carbon monoxide	630-08-0	1-hr	1,403	23,000	No
DEEP	--	Annual	0.07	0.00333	**Yes**
Nitrogen dioxide	10102-44-0	1-hr	755	470	**Yes**

Note: Applicant also provided maximum 1-hr acrolein concentration at Ecology's request. The resulting value, 0.013 µg/m3, is much lower than the acute reference exposure level (2.5 µg/m^3), so Ecology did not require an evaluation of short-term acrolein impacts.

3.5. The Third Tier Review and the Community-Wide Approach

Between 2006 and 2008, Ecology permitted the construction of three data centers in Quincy, WA. Each data center installed multiple large backup diesel-powered generators to be used during power failures. In total, the three existing data centers currently operate a total of 46 diesel-powered generators each rated at 2.0 MW electrical generating capacity or higher. Microsoft's recent permit to expand will increase total permitted diesel-powered emergency engines at Quincy area data centers to 59.

When Ecology permitted these facilities in 2006-2007, DEEP was not regulated as a TAP under Chapter 173-460 WAC, Controls for Toxic Air Pollutants. In June 2009, Ecology revised Chapter 173-460 WAC, and began regulating DEEP as a TAP along with a number of other new pollutants. The revised rule established an ambient trigger level or ASIL for DEEP of 0.00333 µg/m^3, annual average, above which predicted ambient concentrations of DEEP are subject to second tier review. Primarily because DEEP was not previously regulated, the existing data center permits allowed more hours of operation and fuel use than would likely be permitted under this revised rule.

On March 25, 2010, the governor signed into law a bill (ESSB 6789)[3] passed by the Washington legislature to promote the development of additional data centers in rural Washington. The final law gives anyone who starts constructing a data center between April 1, 2010 and July 1, 2011, an exemption from the sales tax for server equipment and power infrastructure. Among other requirements, eligible data centers have to be located in a rural county, cover at least 20,000 square feet dedicated to servers, and completed by April 1, 2018.

The passage of this *Computer Data Centers – Sales and Use Tax Exemption* Act of 2010 prompted much interest from companies wanting to build new data centers in Quincy and other parts of central and eastern Washington. To date, four companies have submitted proposals to Ecology to build or expand their Quincy data centers, including Microsoft Corporation, Sabey Corporation, Dell Marketing, LP, and Yahoo!, Inc.

Given the interest in building several more data centers clustered within the Quincy UGA, and the potential for overlapping DEEP plumes, Ecology's Air Quality Program (AQP) recognized the need to consider the cumulative impacts of new and existing data centers on a community-wide basis (Ecology, 2010c). Therefore, a third tier review will be used by Ecology to consider the approval of Yahoo! and each subsequent company's proposal to construct data centers in the Quincy UGA.

Under the community-wide risk evaluation approach, Ecology estimated background DEEP concentrations by modeling contributions from:

- The existing data centers assuming each of the data centers was operating at their allowed maximum rate; and

- Other known sources of DEEP in the Quincy area.

For the Yahoo! project, Ecology also considered cumulative short-term impacts of NO_2 assuming a system-wide outage in Quincy. Section 4 of this document summarizes Ecology's review of Yahoo!'s HIA and present results of our evaluation of cumulative DEEP and NO_2 concentrations in Quincy.

3.6. Third Tier Review Processing Requirements

In order for Ecology to review the third tier petition, each of the following regulatory requirements under Chapter 173-460-090 and Chapter 173-460-100 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.

[3] http://apps.leg.wa.gov/documents/WSLdocs/2009-10/Pdf/Bills/Session%20Law%202010/6789-S.SL.pdf

(c) The applicant has developed a health impact assessment protocol that has been approved by Ecology.

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

(e) The third tier review petition contains a health impact assessment conducted in accordance with the approved health impact assessment protocol.

Ecology approved the HIA protocol (item (c)) on October 21, 2010, and Ecology received the HIA (item (e)) on December 22, 2010. The project review team found the refined modeling conducted by Yahoo! acceptable.

Acting as the "permitting authority" for this project, Ecology's Eastern Regional Office (ERO) satisfied items (a) and (b) above on February 1, 2011. The applicant has therefore satisfied all of the five requirements above.

3.6.1. Third Tier Review Approval Criteria

Ecology's director approves all third tier petitions. As specified in WAC 173-460-100(3), Ecology's director must find that the following conditions are met before approving a third tier petition:

(a) Proposed emission controls represent at least tBACT.

(b) A health impact assessment (HIA) has been completed as described in WAC 173-460-090(3).

(c) Approval of the project will result in a greater environmental benefit to the state of Washington.

The remainder of this document discusses the HIA review performed by Ecology.

4. HEALTH IMPACT ASSESSMENT

The HIA reviewed by Ecology was conducted according to the requirements of WAC 173-460-100. It addressed the public health risk associated with exposure to DEEP and NO_2 emissions from Yahoo!'s proposed diesel-powered emergency generators and existing sources of DEEP and NO_2 in Quincy, WA. Yahoo!'s consultant (Landau) prepared the HIA.

While the HIA is not a complete risk assessment, it loosely 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.

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 lung 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” available at http://www.ecy.wa.gov/pubs/0802032.pdf.

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 Yahoo!-related DEEP emissions 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 or not Yahoo!'s project-related and community-wide DEEP impacts are acceptable, Ecology quantifies and presents non-cancer hazards and cancer risks in the remaining sections of this document.

4.1.2. Overview of NO_2 Toxicity

NO_2 is a red-brown gas that is present in diesel exhaust. It forms when nitrogen, present in diesel fuel and as a major component of air, combines with oxygen to produce oxides of nitrogen.

NO_2 and other oxides of nitrogen are of concern for ambient air quality because they are part of a complex chain of reactions responsible for the formation of ground-level ozone. Additionally, exposure to NO_2 can cause both long-term (chronic) and short-term (acute) health effects.

Long-term exposure to NO_2 can lead to chronic respiratory illness such as bronchitis and increase the frequency of respiratory illness due to respiratory infections.

Short-term exposure to extremely high concentrations (> 180,000 $\mu g/m^3$) of NO_2 may result in serious effects including death (NAC AEGL Committee, 2008). Moderate levels (~ 30,000 $\mu g/m^3$) may severely irritate the eyes, nose, throat, and respiratory tract, and cause shortness of breath and extreme discomfort. Lower level NO_2 exposure (< 1,000 $\mu g/m^3$), such as that experienced near major roadways, or perhaps downwind from stationary sources of NO_2, may cause increased bronchial reactivity in some asthmatics, decreased lung function in patients with chronic obstructive pulmonary disease, and increased risk of respiratory infections, especially in young children (CalEPA, 2008). For this project, the maximum short-term ambient NO_2 concentration has been estimated to be 755 $\mu g/m^3$, 1-hour average.

Power outage emissions present the greatest potential for producing high enough short-term concentrations of NO_2 to be of concern for susceptible individuals, such as people with asthma. Ecology calculates and presents numerical estimates of exposure and hazard later in 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-term and/or short-term off-site 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 to determine which routes and pathways of exposure to assess for chemicals emitted from a facility (CalEPA, 2003). Table 7 shows a table of chemicals for which Ecology assesses multiple routes and pathway of exposure. It is possible that 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 near Yahoo!. However, given the very low amounts of PAHs and other multi-exposure route type TAPs that will be emitted from Yahoo, 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. In the case of Yahoo!'s emergency generators, Ecology will evaluate only inhalation exposure to DEEP and NO_2.

Table 7. California's Air Toxics Hotspots Risk Assessment Guidance on Specific Pathways to be Analyzed for Each Multi-Pathway Substance

Substance	Ingestion Pathway									
	Soil	Dermal	Meat, Milk & Egg	Fish	Exposed Vegetable	Leafy Vegetable	Protected Vegetable	Root Vegetable	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

4.2.2. Estimating Pollutant Concentrations

Yahoo!'s DEEP and NO_2 emissions will be carried by the wind and possibly impact people living and working in the immediate area. The level of these pollutants in off-site air depends in part on how much is emitted, and the 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 Yahoo!'s generators, Landau conducted air dispersion modeling. Air dispersion modeling incorporates emissions, meteorological, geographical, and terrain information to estimate pollutant concentrations downwind from a source.

Each of Yahoo!'s Phase 5 generators were modeled as individual discharge points. Landau used the following model inputs to estimate ambient impacts:

- American Meteorological Society/Environmental Protection Agency Regulatory Model (AERMOD, Version 09292) with Plume Rise Model Enhancements (PRIME) algorithm for building downwash.
- Five years sequential hourly meteorological data from Moses Lake Airport (2001-2005).
- Twice-daily upper air data from Spokane (2001-2005) to define mixing heights.
- Quincy area digital elevation model (DEM) files (which describe local topography and terrain).
- Quincy area digital land classification files (which describe surface characteristics).
- Each engine's emissions were modeled with a stack height of 30 feet above local ground level and a stack inside diameter of 18 inches (0.457 meters). Engine-specific exhaust gas temperature and velocity were used.
- The data center building dimensions were included to account for building downwash.
- The receptor grid for the AERMOD modeling domain was established using a 10-meter grid spacing along the facility boundary extending to a distance of 300 meters from each facility boundary. A grid spacing of 25 to 50 meters was used for distances more than 300 meters from the boundary.
- Plume Volume Molar Ratio Method (PVMRM) option, which is used to model the conversion of nitrogen oxides (NO_X) to NO_2. One-hour NO_2 concentrations were modeled using PVMRM module, with default concentrations of 40 parts per billion (ppb) 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% NO_2 and 90% nitric oxide (NO) by mass.

Landau modeled both short-term and long-term impacts to demonstrate compliance with NAAQS and derive NO_2 and DEEP concentrations for the HIA. Because Yahoo!'s emissions are intermittent, several operating scenarios were assumed when estimating ambient impacts (Table 8).

Table 8. Operating Scenarios Used for Estimating Ambient Impacts

Operating Scenario Modeled	# Engines	Load	Modeled to Determine	Rationale
Full-time scenario[4]	10	8 @ 90% 2 @ 10%	All short-term NAAQS except 24-hr $PM_{2.5}$ and 1-hr NO_2	Conservative estimate of maximum short-term impact
Electrical bypass	1	80%	Three-year average of eighth highest $PM_{2.5}$ for 24-hr NAAQS Three-year average of eighth highest maximum daily 1-hr NO_2 for NAAQS	First and second highest would occur under power outage scenarios. Third through seventh would occur during annual load testing.
Power outage	10	8 @ 90% 2 @ 10%	NO_2 maximum 1-hr concentrations for HIA	Worst-case acute exposures would occur during power outage scenarios
Sum of all allowable operating scenarios and operating hours	10	Various loads for total operating time of 100 hr/yr	Annual average DPM concentration for HIA	Chronic exposures are averaged over a long period of time.

4.2.3. Identifying Potentially Exposed Receptors

As described in Section 2.3, the proposed Yahoo! facility is located among commercial/industrial-zoned properties, but several different land uses are located within the vicinity of Yahoo!'s property. Landau identified locations where people could be exposed to project-related emissions. Typically, Ecology considers exposures occurring at maximally exposed boundary, residential, and commercial areas to capture worst-case exposure scenarios. In this case, Landau identified these locations and the most impacted schools.[5] The most impacted schools are Quincy High and Quincy Junior High schools located to the southwest of Yahoo!.

4.2.3.1. Receptors Maximally Exposed to DEEP

Table 9 shows maximally exposed receptors of different types and the direction and distance from Yahoo!'s proposed expansion. These receptors represent locations of various land uses that are most impacted by Yahoo! Phase 5 DEEP emissions. This table also shows the estimated average exposure concentration at each maximally exposed receptor.

[4] According to Yahoo!, this modeling scenario assumes that all engines are running 24 hours per day, 7 days per week.

[5] Exposure concentrations for these receptors reported in this document may differ slightly from those reported in the HIA. This is because Ecology relied on modeled concentration values at the nearest grid point instead of interpolating between points. The difference in reported values is minimal.

Table 9. Maximally Exposed Receptors–Annual Average DEEP

Receptor Type	Direction From Nearest Project-Specific DEEP Emission Source	Estimated Distance From Nearest Project-Specific DEEP Emission Source		Estimated Project-Related Increase in Average Annual DEEP Concentration ($\mu g/m^3$) at Receptor Location
		Feet	Meters	
Point of Maximum Impact [a]	NE	250	76	0.074
Maximum Impacted Residence (existing)	NNE	3,400	1,036	0.0030
Maximum Impacted Residential Land Use (currently undeveloped)	NW	850	259	0.014
Maximum Impacted Business/Office	S	550	168	0.016
Maximum Impacted School [b]	SW	3,800	1,158	0.0006

a. Occurs at property fence line.
b. Location identified by Ecology as the maximum impacted school differs slightly from that identified by in the HIA. Landau chose a receptor location at the school property boundary near an open field. Ecology identified the receptor location at a building. For long-term exposure to DEEP, people are more likely to be in or near the building than at the property line.

Figure 4 shows a color-coded map of estimated average DEEP concentrations attributable to Yahoo!'s Phase 5 DEEP emissions. This figure represents the ambient impacts of Yahoo!'s Phase 5 expansion project and each of the maximally exposed receptors representing different land uses. Areas outside the shaded area in Figure 4 are those with an estimated impact below the ASIL. Ecology estimates that Yahoo!'s Phase 5 DEEP emissions impact one residentially zoned parcel at a level exceeding the ASIL. This 10-acre parcel is zoned residential but is currently undeveloped.

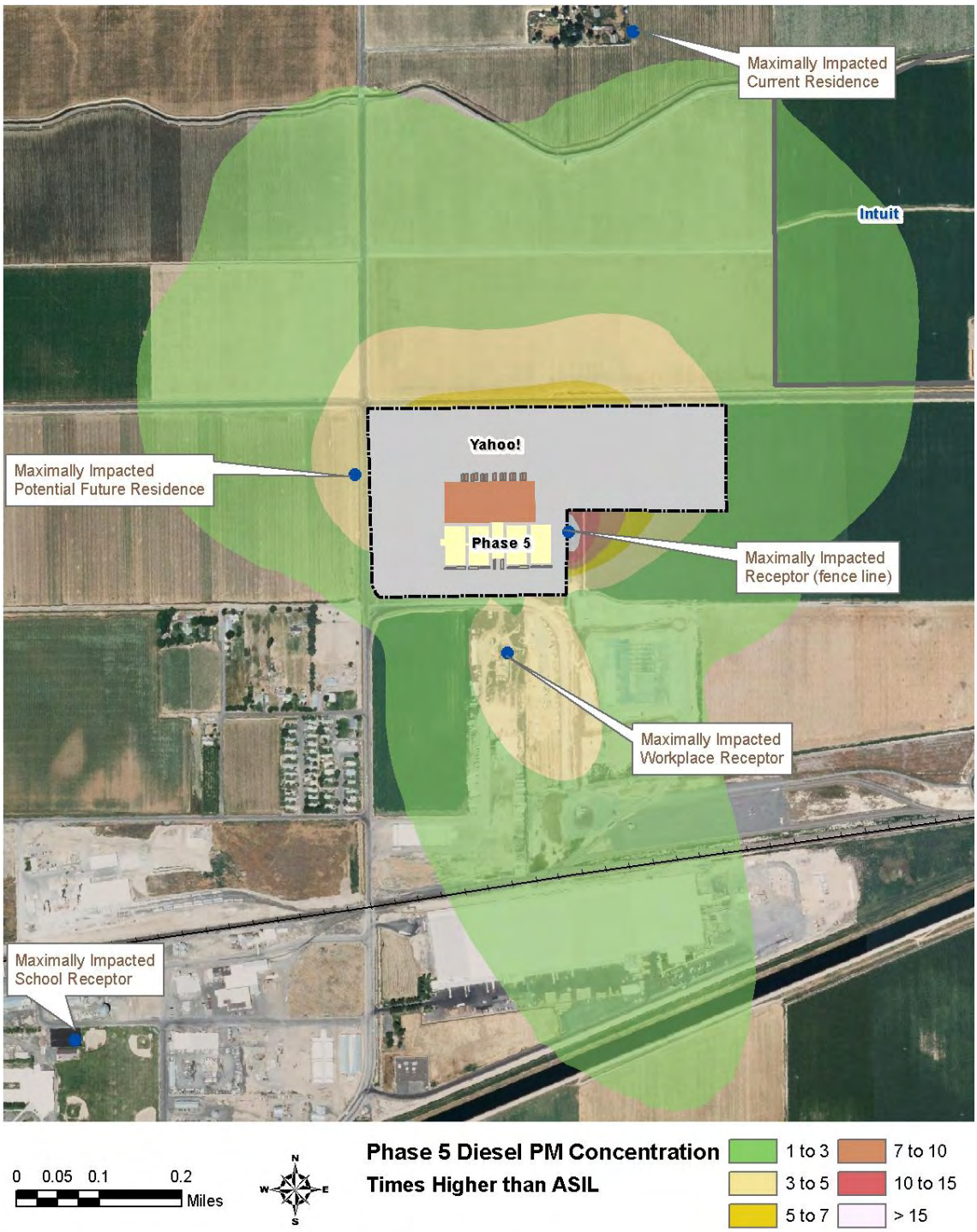

Figure 4. Estimated annual average off-site DEEP concentrations attributable to proposed Yahoo! emissions (Phase 5 expansion project only)

4.2.3.2. Receptors Maximally Exposed to NO_2

Figure 5 shows the areas near Yahoo! where Phase 5 related emissions result in concentrations greater than the ASIL. The areas within the small area of shaded contours exceed the NO_2 ASIL. Phase 5 NO_2 impacts are below the ASIL for most of the modeling domain except for a small area along the southeast corner of Yahoo!'s property. Table 10 shows 1-hr NO_2 concentrations attributable to Phase 5 emergency outage emissions at each maximally impacted receptor type.

Table 10. Maximally Exposed Receptors–Maximum 1-Hour NO_2

Receptor Type	Direction From Nearest Project-Specific NO_2 Emission Source	Estimated Distance From Nearest Project-Specific NO_2 Emission Source		Estimated 1-Hour Project-Related Increase in Maximum NO_2 Concentration at Receptor Location
		Feet	Meters	
Point of Maximum Impact	SE	190	58	755
Maximum Impacted Residence (existing)	SW	920	280	200
Maximum Impacted Residential Land Use (currently undeveloped)	WNW	600	183	353
Maximum Impacted Business/ Office	SE	330	101	521
Maximum Impacted School	SW	4,800	1,463	130

4.2.4. Exposure Frequency and Duration

The likelihood that someone is exposed to DEEP and NO_2 from Yahoo!'s backup diesel engines depends on local wind patterns (meteorology), how frequently engines operate, and how much time people spend in the immediate area. As discussed previously, the air dispersion model uses emissions and meteorology information (and other assumptions) to determine ambient DEEP and NO_2 concentrations in the vicinity of the proposed Yahoo! expansion.

Ecology considers the land use surrounding the Yahoo! 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 only exposed to Yahoo!-related emissions during the hours that they spend working near the facility.

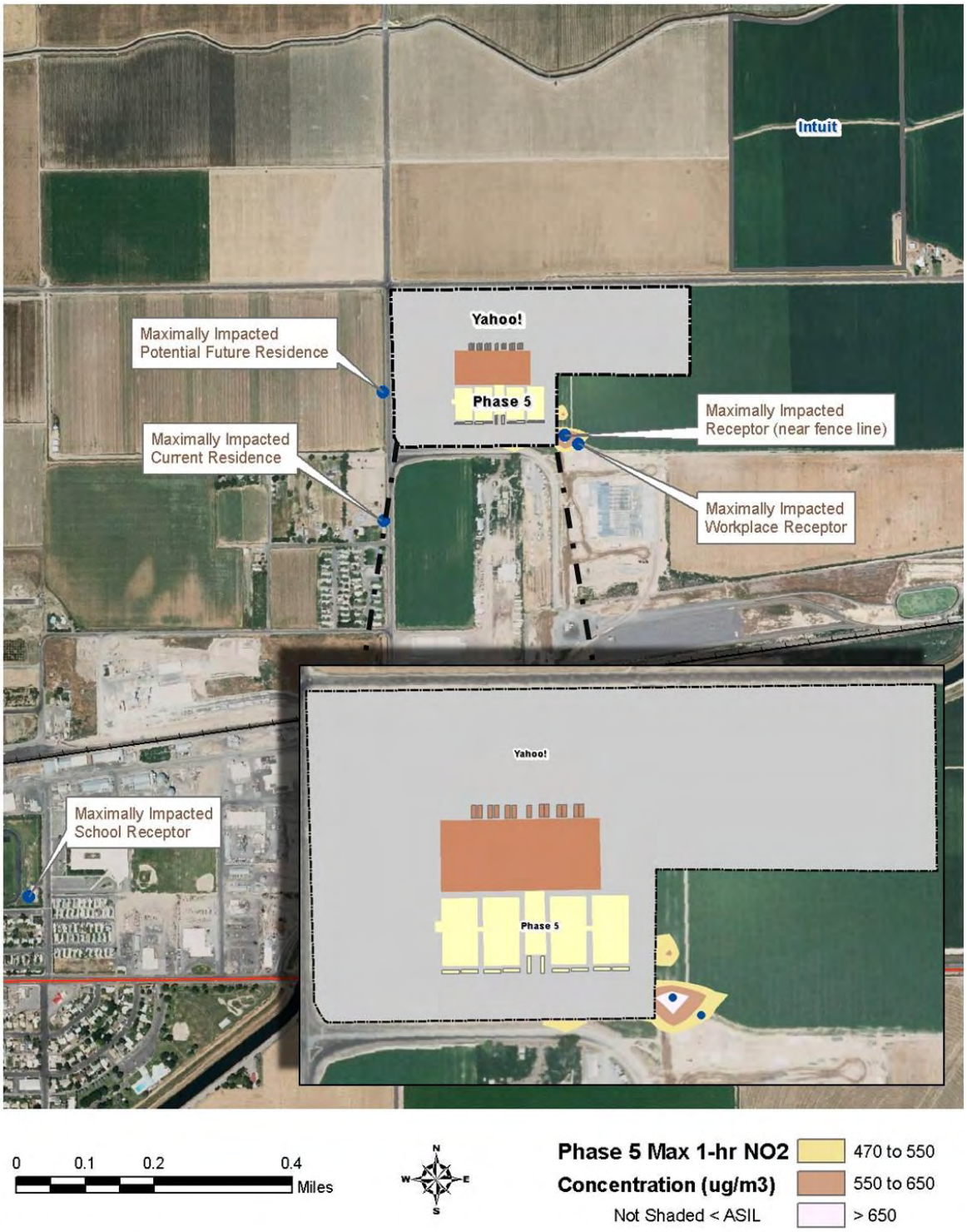

Figure 5. Estimated maximum 1-hr off-site NO_2 concentrations attributable to proposed Yahoo! emissions during a sustained power outage (Phase 5 expansion project only)

Ecology typically makes simplified assumptions about receptors' exposure frequency and duration. Ecology assumes people located at residential receptors are potentially continuously exposed, meaning they never leave their property. Ecology recognizes that 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 that people could spend at their homes. These adjustments are presented in Section 4.4.2 of this document when quantifying cancer risk from intermittent exposure to DEEP.

4.2.5. Background Exposure to Pollutants of Concern

Chapter 173-460-090 WAC states, "background concentrations of TAPs will be considered as part of a second tier review."[6] 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 high interest in building data centers within the Quincy UGA, Ecology determined that the cumulative risk of all sources of diesel engine exhaust (including existing and proposed data centers' emissions) should be considered during the permitting process.

4.2.5.1. Cumulative Exposure to DEEP in Quincy

Ecology used an EPA-recommended dispersion model, AERMOD, to estimate concentrations of DEEP in Quincy emitted from locomotives traveling on the Burlington Northern – Santa FE (BNSF) rail line, trucks on State Route 281 and State Route 28, and the permitted emissions from existing data centers: Yahoo! Phases 1-3, Microsoft, and Intuit. Data center emissions and descriptions were obtained from input files provided by Landau as part of their analysis accompanying the current Yahoo! application. Data center emissions were derived from existing permits from Microsoft (2010), Yahoo! (2007), and Intuit (2007). We also included allowable emissions proposed by Dell Marketing, LP (Dell) and Sabey Corporation (Sabey) for their planned data centers in Quincy. The rail and highway emissions were taken from 2005 emissions inventories.

Ecology's analysis estimated prevailing DEEP concentrations to be about 100 times the DEEP ASIL (0.00333 $\mu g/m^3$) near Yahoo! and Intuit. 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 Ecology assumed, but Ecology calculated worst-case emissions to avoid underestimating prevailing DEEP exposure concentrations.

Ecology also modeled allowable DEEP emissions from Yahoo! after the Phase 5 expansion, extension of Yahoo! Phases 1-3 exhaust stacks, and reduction in allowable fuel use from Phases

[6] http://apps.leg.wa.gov/WAC/default.aspx?cite=173-460-090

1-3 engines. The modeled pre- and post- project DEEP concentrations (μg/m^3) at maximally exposed receptors near Yahoo! are shown in Table 11.

Table 11. Maximally Exposed Receptors–Cumulative Annual DEEP

Attributable to:	Annual DEEP Concentration (μg/m^3) at Various Receptor Locations				
	Fence line Receptor [a, c]	Current Residence [b]	Possible Future Residence [b]	Workplace [b]	Students–Quincy Jr. High [b]
Prevailing (pre-project)	0.81589	0.086	0.17451	0.524	0.0534
Yahoo! Phases 1-3	0.78247	0.01818	0.15389	0.5079	0.00395
Intuit	0.01051	0.05684	0.00393	0.01039	0.0017
Microsoft	0.00219	0.00198	0.00272	0.00212	0.00328
BNSF	0.02059	0.00704	0.01383	0.02327	0.04425
Highways	0.00013	0.00011	0.00014	0.00013	0.00022
Cumulative (post-project)	0.10094	0.082	0.06902	0.0897	0.05196
Yahoo! Phases 1-3	0.06014	0.01181	0.03442	0.04079	0.00193
Yahoo! Phase 5	0.00738	0.003	0.014	0.016	0.00058
Intuit	0.01051	0.05684	0.00393	0.01039	0.0017
Microsoft	0.00219	0.00198	0.00272	0.00212	0.00328
BNSF	0.02059	0.00704	0.01383	0.02327	0.04425
Highways	0.00013	0.00011	0.00014	0.00013	0.00022

a. The maximally impacted fence line receptor exposed to prevailing (pre-project) DEEP occurs at a different location than that most impacted by Phase 5 emissions (Table 9).
b. Locations of maximally exposed receptors are roughly the same for both pre- and post-project scenarios.
c. This is also the point of maximum impact.

Figure 6 shows the calculated prevailing concentrations (presented as the number of times greater than the ASIL of 0.0033 μg/m^3) near Yahoo! based on allowable emissions from all existing permits, rail and highway emissions (panel a), and estimated prevailing concentrations after installation of the proposed project, extension of Yahoo! Phases 1-3 exhaust stacks, and reduction in allowable fuel use from Phases 1-3 engines (panel b). Maximum cumulative DEEP concentrations near the Yahoo! property decrease considerably after accounting for fuel usage reduction and exhaust stack extension. Estimated impacts near the northern and southern boundaries of Yahoo!'s property show the largest decline of more than 50% in some places.

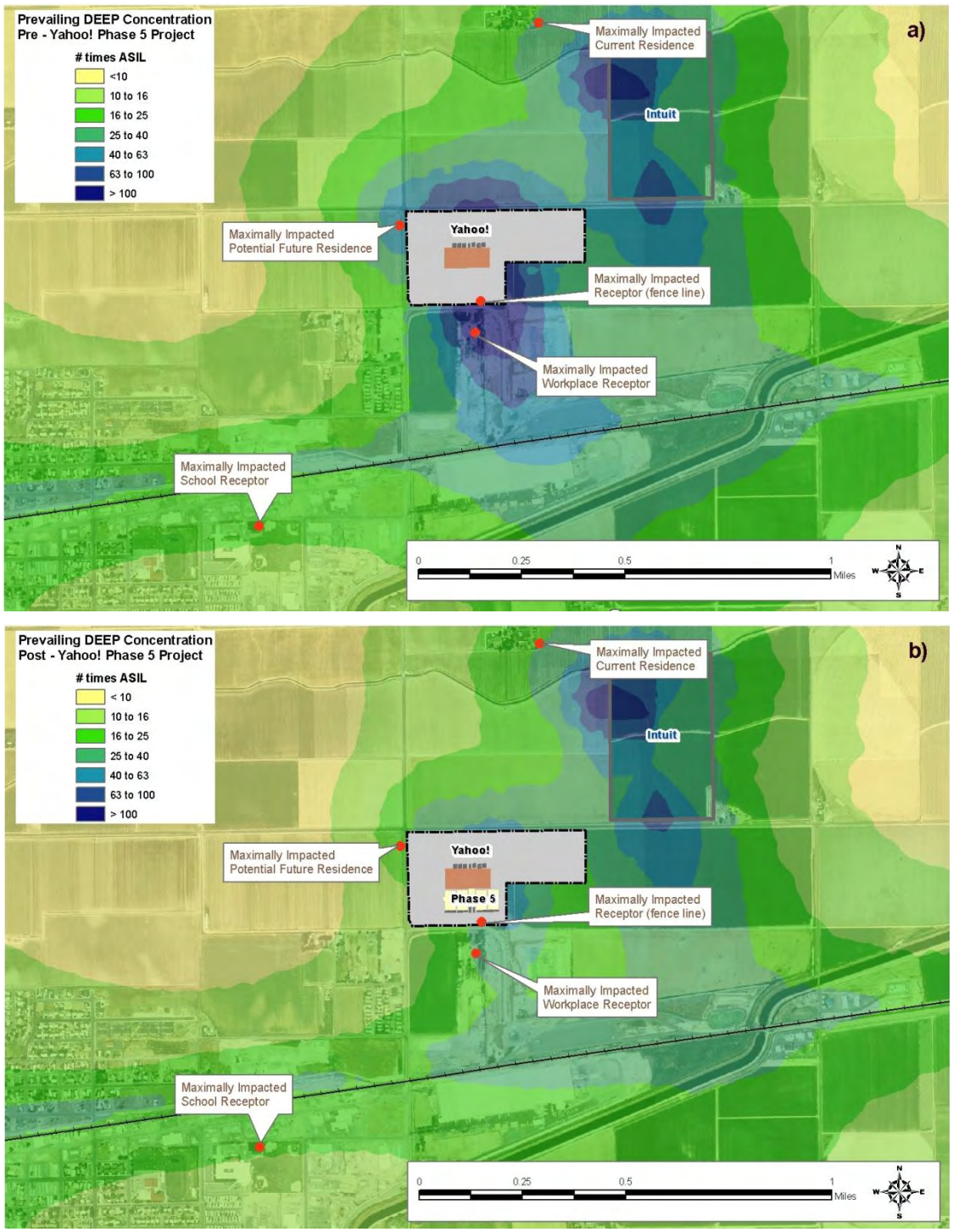

Figure 6. a) Prevailing allowable DEEP concentrations near Yahoo! prior to Yahoo! Phase 5 expansion. b) Prevailing allowable DEEP concentrations near Yahoo! after Phase 5 expansion, reducing allowable fuel use for the existing engines and raising exhaust stacks.

4.2.5.2. Cumulative Exposure to NO_2 in Quincy

Ecology used a similar methodology as described in Section 4.2.5.1 above to estimate the cumulative short-term NO_2 impact assuming a system-wide power outage. The purpose of this effort was to identify worst-case exposure scenarios in the event of system-wide power outage in Quincy.

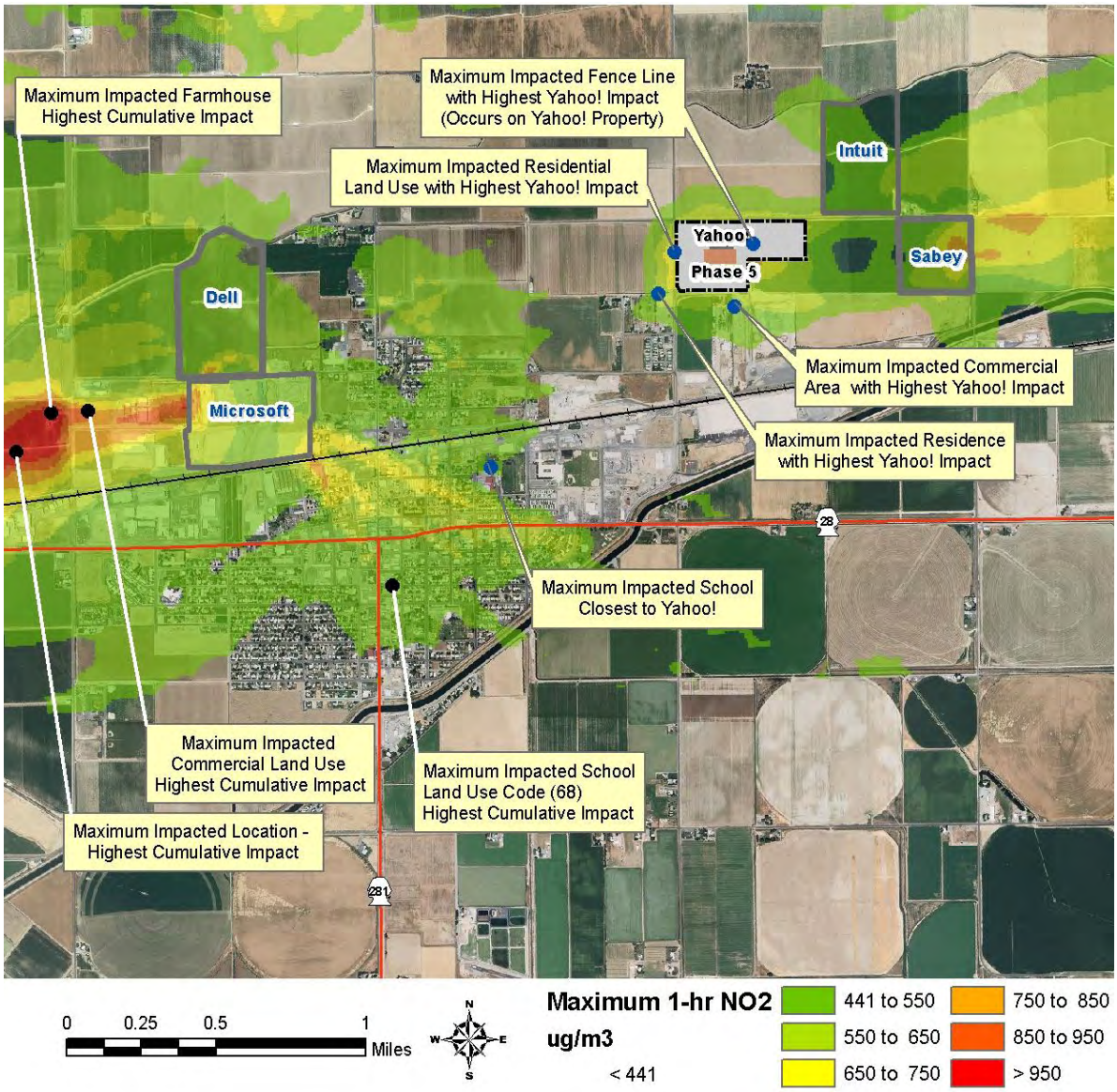

Figure 7. Cumulative 1-hour maximum NO_2 concentrations in Quincy, assuming power outage emissions from all existing and proposed Quincy data centers and emissions from Celite Corporation

Ecology modeled NO_2 emissions during simultaneous power outage from nearby existing data centers (i.e., Microsoft and Intuit) and proposed data centers (i.e., Yahoo! Phase 5 and proposed changes to Phases 1-3, Dell, and Sabey). This model assumed:

- Continuous simultaneous outage emissions for all data center engines for all of 2005.
- Each engine operates at loads specified in permits (for existing data centers) or permit applications (for those data centers not yet permitted).

The model also included potential emissions from nearby Celite Corporation.

Table 12. Maximally Exposed Receptors–Cumulative Annual NO_2

Attributable to:	Maximum 1-Hour NO_2 Concentration ($\mu g/m^3$) at Various Receptor Locations				
	Fence Line Receptor	**Current Residence**	**Possible Future Residence**	**Workplace**	**Students–Quincy Jr. High**
Phase 5 Only	755	200	353	521	130
Cumulative– [c] Highest Yahoo! Impacts	1,006	632	826	610	498 [a]
Attributable to:	**Point of Maximum Impact**	**Apparent Farmhouse [b]**		**Commercial (Land Use Code 20 to 70, not 68)**	**School District Properties (Land Use Code 68)**
Cumulative– [c] Highest Overall Impact	1,174	1,059		1,034	521

Note: Assumed background of 29 $\mu g/m^3$ not added.

a. Although this school is the most impacted by Yahoo!'s emissions, Yahoo! contributes only a negligible amount of NO_2 to the maximum 1-hr concentration.

b. Appears to be farm buildings from aerial image. According to parcel information, the property is owned by Port District #1.

c. "Cumulative" includes simultaneous power outage emissions from Microsoft, Intuit, Yahoo!, proposed Sabey, and proposed Dell. Emissions from Celite Corporation are also included.

Figure 7 and Table 12 show the maximum 1-hour NO_2 concentrations that could occur in Quincy if all data centers operated simultaneously under emergency conditions. Although the NO_2 level of interest is 470 $\mu g/m^3$, the figure shows only those concentrations that exceed 441 $\mu g/m^3$ because Ecology assumes that a prevailing NO_2 concentration of 29 $\mu g/m^3$ exists in Quincy at any given time. It is important to note that the maximum 1-hour concentrations shown in this figure do not all occur at the same time. The figure displays the worst-case concentration at each location in Quincy.

The highest maximum 1-hour concentration (1,174 $\mu g/m^3$) appears to occur at a location to the west of Microsoft's property. At the time of this maximum occurrence, this area appears to be

impacted by primary emissions from Microsoft (55%), and secondary[7] emissions from Sabey (22%), Yahoo! (19%), and Intuit (4%).
Table 12 shows the maximum 1-hour NO_2 concentrations at various receptors attributable to Phase 5 emissions and cumulative emissions from all sources. Worst-case scenarios could result in concentrations above the NO_2 ASIL at locations near Yahoo! and other data centers in Quincy. The frequency with which these impacts could occur is further discussed in Section 4.4.1.4.

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–DEEP

The U.S. Environmental Protection Agency (EPA) and California Office of Environmental Health Hazard Assessment (OEHHA) developed toxicological values for DEEP evaluated in this project (EPA, 2002; EPA, 2003; 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 13 shows DEEP non-cancer and cancer toxicity values.

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.

National Ambient Air Quality Standards (NAAQS) and other regulatory toxicological values for short-term 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 one microgram per cubic meter (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% or a population cancer risk of 300 excess cancer cases per million people exposed.

[7] Secondary emissions refer to the conversion of nitric oxide to nitrogen dioxide over time.

4.3.2. Dose Response Assessment–NO_2

OEHHA developed an acute reference exposure level for NO_2 based on inhalation studies of asthmatics exposed to NO_2. These studies found that some asthmatics exposed to about 0.25 ppm (i.e., 470 $\mu g/m^3$) experienced increased airway reactivity following inhalation exposure to NO_2 (CalEPA, 2008). Not all asthmatic subjects experienced an effect.

The acute REL derived for NO_2 does not contain any uncertainty factor adjustment, and therefore does not provide any additional buffer between the derived value and the exposure concentration at which effects have been observed in sensitive populations. This implies that exposure to NO_2 at levels equivalent to the acute REL (which is also the same as Ecology's ASIL) could result in increased airway reactivity in a subset of asthmatics. People without asthma or other respiratory disease are not likely to experience effects at NO_2 levels at or below the REL.

Table 13. Toxicity Values Used to Assess and Quantify Non-Cancer Hazard and Cancer Risk

Pollutant	Agency	Non-Cancer	Cancer
DEEP	U.S. Environmental Protection Agency	RfC = 5 µg/m3	NA [a]
	California EPA – Office of Environmental Health Hazard Assessment	Chronic REL = 5 µg/m3	URF = 0.0003 per µg/m3
NO_2	California EPA – Office of Environmental Health Hazard Assessment	Acute (1-hr) REL = 470 µg/m3	N/A

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

4.4. Risk Characterization

Risk characterization involves the integration of data analyses from each step of the health impact assessment to determine the likelihood that the human population in question will experience any of the various forms of toxicity 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:

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

A HQ of one 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 one, the probability of human health effects increases by an undefined amount. However, it should be noted that a HQ above one 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:

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

Hazard quotients 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 eight hours per day, five days per week. While EPA risk assessment guidance recommends adjusting to account for periodic instead of continuous exposure, CA OEHHA does not employ this practice. For the purpose of this evaluation, Ecology determined the RfC or REL (5 $\mu g/m^3$) will be used as the chronic risk-based concentration for all scenarios where receptors could be exposed frequently (e.g., residences, work places, or schools).

Table 14 shows chronic HQs at the maximally exposed receptors near Yahoo! attributable to DEEP exposure from all sources. HQs are much lower than one for all receptors' cumulative exposure to DEEP indicating adverse non-cancer effects are not likely to result from chronic exposure to DEEP emitted from Yahoo! and other local sources.

Table 14. Chronic Non-Cancer Hazards for Residential and Occupational Scenarios

Attributable to:	Chronic Hazard Quotient at Various Receptor Locations–DEEP Exposure				
	Fence Line Receptor	Current Residence	Possible Future Residence	Workplace	Students–Quincy Jr. High
Phase 5 only	0.0148	0.001	0.003	0.003	<0.001
Prevailing (pre-project)	0.163	0.017	0.035	0.105	0.011
Yahoo! Phases 1-3	0.156	0.004	0.031	0.102	0.001
Intuit	0.002	0.011	0.001	0.002	<0.001
Microsoft	<0.001	<0.001	0.001	<0.001	0.001
BNSF	0.004	0.001	0.003	0.005	0.009
Highways	<0.001	<0.001	<0.001	<0.001	<0.001
Cumulative (post-project)	0.020	0.016	0.014	0.018	0.010

Attributable to:	Chronic Hazard Quotient at Various Receptor Locations–DEEP Exposure				
	Fence Line Receptor	Current Residence	Possible Future Residence	Workplace	Students–Quincy Jr. High
Yahoo! Phases 1-3	0.012	0.002	0.007	0.008	<0.001
Yahoo! Phase 5	0.001	0.001	0.003	0.003	<0.001
Intuit	0.002	0.011	0.001	0.002	<0.001
Microsoft	<0.001	<0.001	0.001	<0.001	0.001
BNSF	0.004	0.001	0.003	0.005	0.009
Highways	<0.001	<0.001	<0.001	<0.001	<0.001

4.4.1.2. Hazard Quotient–NO_2

To evaluate possible non-cancer effects from exposure to NO_2, modeled concentrations at receptor locations were compared to its respective non-cancer toxicological values. In this case, maximum-modeled 1-hour NO_2 concentrations are compared to the acute REL (470 $\mu g/m^3$). The acute HQ for NO_2 exposure is calculated using the following equation:

$$\text{Acute HQ} = \frac{\text{maximum 1-hr } NO_2 \text{ concentration}}{470\ \mu g/m^3}$$

Table 15 shows acute hazard quotients at the maximally exposed receptors most impacted by Yahoo!'s Phase 5 NO_2 emissions. Hazard quotients exceed one at the fence line and workplace receptors.

Table 15. Acute Non-Cancer Hazards for Residential and Occupational Scenarios

Attributable to:	Acute Hazard Quotient at Various Receptor Locations–NO_2 Exposure				
	Fence Line Receptor [a]	Current Residence	Possible Future Residence	Workplace	Students–Quincy Jr. High
Phase 5 Only	**1.6**	0.4	0.8	**1.1**	0.3
Cumulative– [c] Highest Yahoo! Impacts	2.1	1.3	1.8	1.3	1.1 [b]
Attributable to:	**Point of Maximum Impact**	**Apparent Farmhouse [d]**		**Commercial (Land Use Code 20 to 70, not 68)**	**Land Use Code 68**
Cumulative– [c] Highest Overall Impact	2.5 [a]	2.3 [a]		2.2 [a]	1.1 [a]

a. Yahoo! contributes less than 20% of the NO_2 hazard at these locations. These locations were not further evaluated in this document.
b. Yahoo! contributes negligible NO_2 to this location during maximum cumulative impact days.
c. "Cumulative" includes simultaneous power outage emissions from Microsoft, Intuit, Yahoo!, proposed Sabey, and proposed Dell. Emissions from Celite Corporation are also included.
d. Appears to be farm buildings from aerial image. According to parcel information, the property is owned by Port District #1.

Ecology also calculated HQs for receptors cumulatively impacted by simultaneous data center emissions in Quincy. HQs for each of the maximally exposed receptors near Yahoo! exceed one.

Given that the acute REL for NO_2 does not provide any additional buffer between the derived value and the exposure concentration at which effects have been observed in sensitive populations, someone with asthma or other respiratory illness present at these locations when both meteorological conditions and engine use during a power outage occurred could experience increased airway reactivity and respiratory symptoms.

4.4.1.3. Discussion of Acute Hazard Quotients Greater Than One

NO_2 HQs may exceed one at certain times when unfavorable air dispersion conditions coincide with electrical grid transmission failure at Yahoo! and other Quincy data centers. If the HQ is less than one, then the risk is generally considered acceptable. The more the HQ increases above one, the more likely it is that adverse health effects will occur by some undefined amount (due in part, to how the risk-based concentration is derived).

As mentioned in Section 4.3.2, OEHHA developed an acute reference exposure level for NO_2 based on inhalation studies of people with asthma. These studies found that some subjects exposed to about 0.25 ppm (470 $\mu g/m^3$) experienced increased airway reactivity following exposure (CalEPA, 2008). Not all subjects experienced apparent effects. Like NO_2, DEEP may interact with airways in the respiratory tract. Simultaneous exposure to NO_2 and DEEP components of Yahoo!'s diesel engine exhausts probably results in a higher risk of adverse respiratory effects than exposure to the NO_2 component alone.

4.4.1.4. Probability Analysis of NO_2 ASIL Exceedances

Ecology also analyzed the frequency (# of hours) meteorological conditions could result in a NO_2 concentration greater than 441 $\mu g/m^3$ across the Quincy modeling domain. Figure 8 displays these results graphically. This figure shows the number of hours per year that a cumulative NO_2 concentration could exceed 441 $\mu g/m^3$ assuming data center engines operate continuously throughout the year. In reality, these data centers are only permitted to operate for up to 48 hours per year under emergency outage conditions. According to Grant County Public Utilities District (PUD), the average total outage time for customers that experience an outage throughout PUD's service area is only about 143 minutes per year.

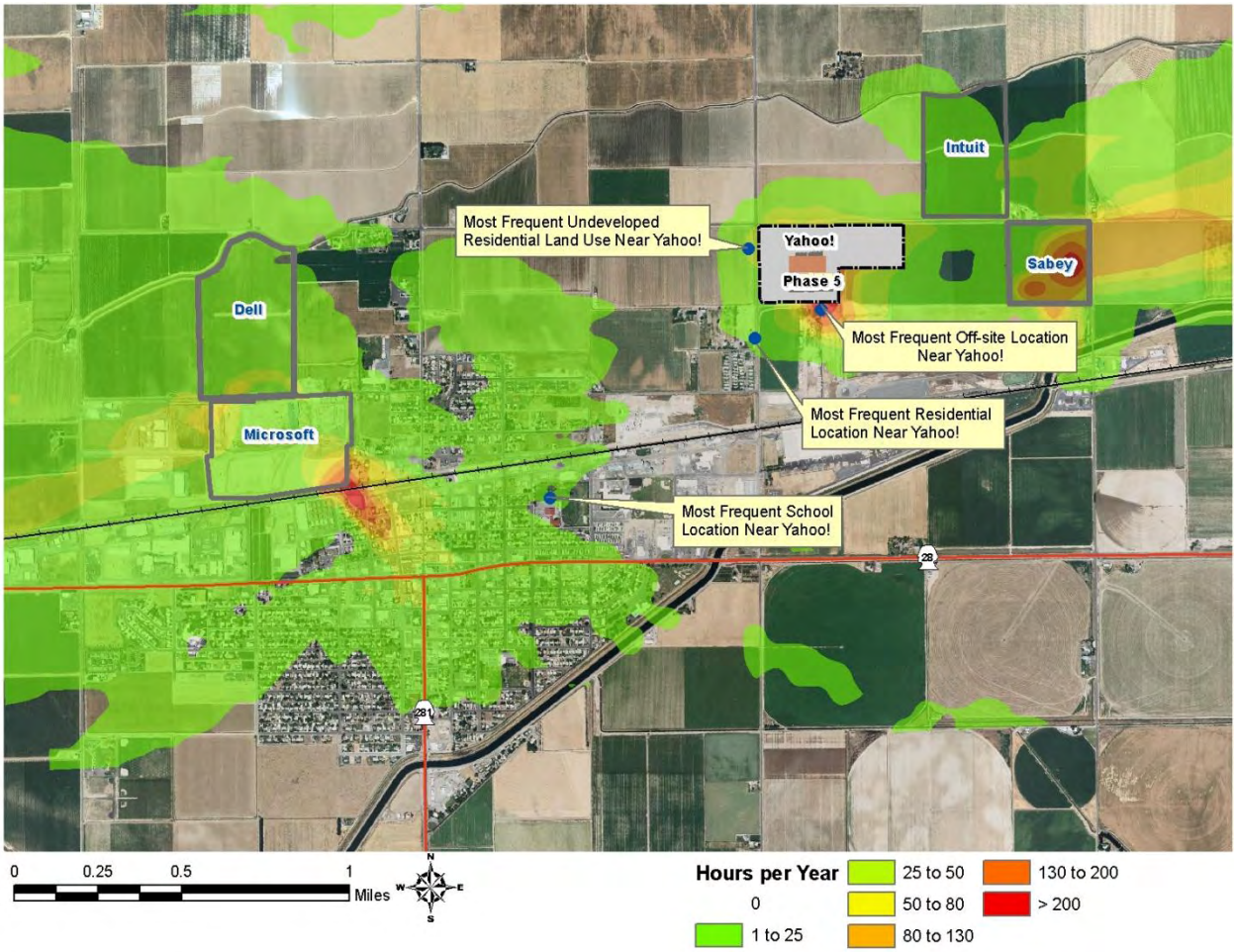

Figure 8. Frequency that cumulative 1-hour NO_2 concentrations could exceed 441 µg/m^3 assuming continuous power outage emissions from all existing and proposed Quincy data centers and emissions from Celite Corporation

To account for infrequent intermittent emergency outages, Ecology further evaluated the modeling data to determine the probability of meteorological conditions necessary to result in ambient NO_2 concentrations in excess of the ASIL, combined with estimates of the probability that a system-wide outage requires simultaneous emergency engine operation. The results of this analysis are summarized in Table 16. Generally, the likelihood that a power outage will coincide with unfavorable meteorological conditions is extremely low. The combined probability of these worst-case scenarios is further described in Section 4.4.1.5.

Table 16. Frequency (hours per year) With Which NO_2 Concentrations Could Exceed 441 µg/m^3 Assuming Continuous Operation of all Data Centers' Engines in Quincy

	Most Frequent Locations That NO_2 Concentrations Could Exceed 441 µg/m^3 (hours per year)				
	Fence Line Receptor	**Current Residence**	**Possible Future Residence**	**Workplace**	**Students– Quincy Jr. High**
Cumulative– Highest Yahoo! Impacts	376	5	36	187	2

4.4.1.5. Joint Probability Analysis

As stated above, Ecology identified conditions that would cause the 1-hour NO_2 concentration to reach or exceed 470 µg/m^3 (441 µg/m^3 from the data center + 29 µg/m^3 from background sources). Ecology has not determined if these times in the 2005 period were at times more (or less) likely to occur simultaneously with power outages. If they occurred at times when outages were no more or less likely than average to take place, the probability of generator operation would be independent of the probability of atmospheric conditions that would lead to high NO_2 concentrations at these locations. A combination of independent probabilities allows evaluation of the joint probability that conditions could occur simultaneously. The joint probability can be estimated as:

$$P(X \cap Y) = P(X) \cdot P(Y)$$

Where:

P(X) = The number of unfavorable atmospheric condition hours that occurred in the 2005 period[8] divided by the total number of hours in the same period, i.e., 8760 hours.

P(Y) = The number of hours during which unplanned outage generator operation takes place divided by the total number of hours considered. Ecology estimated P(Y) by examining possible scenarios under the maximum frequency of outage-caused generator operation to be permitted, i.e., 48 hours per year.

$P(X \cap Y)$ = The hourly probability that the concentration at a given receptor will exceed 441 µg/m^3.

Based on this joint probability, the estimated frequency of times per year that an ambient NO_2 concentration of 441 µg/m^3 would probably occur given full use of the allowance for up to 48 hours of emergency outage operation, is:

Frequency (hours per year) = $P(X \cap Y) \cdot 8760$ hr/yr

[8] The number of times the NO_2 concentration exceeded 441 µg/m^3 in the AERMOD simulation.

The long-term recurrence intervals between hours that an ambient NO_2 concentration of 441 µg/m^3 would probably occur given full use of the allowance for up to 48 hours of emergency outage operation, is:

Recurrence (years) = 1/Frequency (hr/yr)

Table 17 shows combined probability that an ambient NO_2 concentration of 441 µg/m^3 would probably occur given full use of the allowance for up to 48 hours of emergency outage operation for all data centers in Quincy, and recurrence intervals between occurrences at five various receptor types most frequently impacted near Yahoo!. Based on this analysis, the NO_2 levels could reach or exceed 470 µg/m^3 about once every ½ year at Yahoo!'s fence line and once every 91 years at Quincy Junior High School.

Table 17. Combined Probability and Recurrence Intervals With Which NO_2 Concentrations Could Exceed 441 µg/m^3 Assuming 48 Hours Per Year of All Quincy Data Centers' Engines Operating Simultaneously

	Receptors With Highest Yahoo! Impact				
	Fence Line Receptor	**Current Residence**	**Possible Future Residence**	**Workplace**	**Students–Quincy Jr. High**
Frequency (hr/yr)	376	5	36	187	2
P(X)	4.3E-02	5.7E-04	4.1E-03	2.1E-02	2.3E-04
P(Y) 48 hours outage per year	5.5E-03	5.5E-03	5.5E-03	5.5E-03	5.5E-03
P(X ∩ Y)	2.4E-04	3.1E-06	2.3E-05	1.2E-04	1.3E-06
Hours per year	2.1	0.03	0.2	1.0	0.01
Recurrence interval (years)	0.5	36.5	5.1	1.0	91.3

While Yahoo! has requested 48 hours of power outage operation for their permit, the actual frequency and total duration of unplanned operation of the generators is likely to be much less. According to Grant County Public Utilities District (PUD), the average total outage time for customers that experience an outage throughout PUD's service area is only about 143 minutes per year. Some customers experience longer outages and others experience shorter outages. Because data centers may or may not experience similar outages as other Grant County PUD customers, Ecology obtained a report of recent unplanned generator usage at the Ask.com data center in Moses Lake, the Yahoo! Data Center in Quincy,[9] and the Microsoft Columbia Data Center (Quincy).[10]

[9] Lael Allen to Lisa Karstetter, Gerald Allen, Ty Sween, and Mark Johnson, "PUD outages since Dec. 2007," e-mail message, January 03, 2011, 10:17 AM
[10] Jim Wilder to Jack Eaton and David Ogulei, "Unplanned generator usage at MSFT Columbia Data Center," e-mail message, December 08, 2010, 5:04 PM

Since 2007, Yahoo! reported only three instances when emergency engines were operated under emergency outage conditions for a total of three hours. Similarly, Microsoft reported four events, although the durations of these events are not reported. Ask.com in Moses Lake (but part of the Grant County PUD system), experienced three events for a total outage of about 10 minutes and 18 seconds.

Based on the available records of power failures at data center substations in Grant County, the possibility that Yahoo! will experience the highest permitted duration of power failure of a combined 48 hours per year appears unlikely.

A similar joint probability analysis as described above substituting three hours of power outage per year for the 48 permitted hours per year yields occurrences that are more infrequent. Based on this more likely scenario, the NO_2 levels could reach or exceed 470 µg/m^3 about once every eight years at Yahoo!'s fence line and once every 1,460 years at Quincy Junior High School (Table 18).

Table 18. Combined Probability and Recurrence Intervals With Which NO_2 Concentrations Could Exceed 441 µg/m^3 Assuming 3 Hours Per Year of all Quincy Data Centers' Engines Operating Simultaneously

	Receptors With Highest Yahoo! Impact				
	Fence Line Receptor	**Current Residence**	**Possible Future Residence**	**Workplace**	**Students– Quincy Jr. High**
Frequency (hr/yr)	376	5	36	187	2
P(X)	4.3E-02	5.7E-04	4.1E-03	2.1E-02	2.3E-04
P(Y) 3 hours outage per year	3.4E-04	3.4E-04	3.4E-04	3.4E-04	3.4E-04
P(X ∩ Y)	1.5E-05	2.0E-07	1.4E-06	7.3E-06	7.8E-08
Hours per year	0.129	0.002	0.012	0.064	0.001
Recurrence interval (years)	7.8	584	81.1	15.6	1,460

Ecology's analysis concluded that coincidental worst-case meteorological and power outage conditions are extremely unlikely to occur. Although extremely improbable, we cannot completely rule out the possibility of having such a scenario. If such an event were to occur, people with asthma who might be cumulatively exposed to NO_2 and DEEP from Yahoo! and other sources may experience respiratory symptoms such as wheezing, shortness of breath, and reduced pulmonary function with airway constriction.

4.4.2. Quantifying an Individual's Increased Cancer Risk

Cancer risk is estimated by determining the concentration of DEEP at each receptor point and multiplying it by its respective unit risk factor (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:

$$\text{Risk} = \frac{\text{CAir x URF x EF x ED}}{\text{AT}}$$

Where:

CAir = Concentration in air at the receptor ($\mu g/m^3$)
URF = Unit Risk Factor $(\mu g/m^3)^{-1}$
EF1 = Exposure Frequency (days per year)
EF2 = Exposure Frequency (hours per day)
ED = Exposure Duration (years)
AT = Averaging Time (days)

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/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 EPA reflect the potential that thresholds for some carcinogenesis exist. However, 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 1,000,000 people are exposed to a carcinogen, one excess cancer might occur, or a person's chance of getting cancer in their lifetime increases by one in one million or 0.0001 percent. The reader should 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 19 shows ranges of estimated worst-case residential (current and potential future), off-site worker, school staff, students, and fence line receptor's increased cancer risks attributable to DEEP exposure near the proposed Yahoo! facility. As shown in Table 19, cancer risks attributable to the Phase 5 data center expansion project (rows shaded purple) are less than one in one hundred thousand (1×10^{-5}). The highest risk occurs at residential parcels to the west of the Yahoo! facility (4.2×10^{-6}). This area is currently undeveloped so the estimated risks would apply if this parcel was indeed developed in the future. 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 one in one hundred thousand (1×10^{-5}). Cumulative risk for the maximally exposed residence near Yahoo!'s property, however, exceeds one in one hundred thousand (Table 19).

For the purpose of third tier petitions in the Quincy UGA, Ecology established a cumulative risk management goal of 100 excess cancer cases in one million people exposed (1×10^{-4}). Ecology has defined this goal to represent the cumulative level of concern for Quincy residents (also called an "ample margin of safety")[11] above which a new source of DEEP would not be approved to locate in Quincy, without requiring offsets or other mitigation. It therefore represents a limit on permissible DEEP-associated cancer risk to the community. Note that Chapter 173-460 WAC does not currently contain a numerical limit on allowable cumulative cancer risks.

As shown in Table 19, the maximum cumulative cancer risk for the maximally impacted current residential receptor near Yahoo! after Phase 5 development (rows shaded blue) is 25 in one million. This risk occurs at the existing residence to the north of the Yahoo! facility. This residence is more impacted by allowable emissions from the existing Intuit Data Center than by emissions from Yahoo!. In the event residential parcels to the west of Yahoo! are developed, maximum cumulative risks approach 21 in one million. Occupational, near boundary, and student receptors' cumulative risks from DEEP exposure are much lower than 10 in one million.

Because these cumulative risks are less than 100 in one million, the cumulative risks attributable to Yahoo!'s expansion project are permissible pending public comment. It is important to note that approval of the project and reduction in allowable emissions from the existing data center would result in a decline in the future residential receptor's maximum estimated "prevailing" risk (from 52 per million to 21 per million). A lower risk reduction (from 26 per million to 25 per million) was observed at the existing residence located about ½ mile north of Yahoo!. This residence receives about 80% of its potential DEEP exposure from other nearby sources.

[11] "Ample margin of safety" is the phrase used in the federal clean air act to describe the goal of National Emission Standards for Hazardous Air Pollutants.

Table 19. Estimated Increased Cancer Risk for Residential, Occupational, Student, and Scenarios

Location/ Scenario	Scope	Annual DEEP Concentration ($\mu g/m^3$)	EF1 (days/yr)	EF2 (hr/24 hr)	ED (yr)	AT (days)	Individual Increased Cancer Risk	Risk/Million
Maximally Exposed Current Residence	"Prevailing" pre-project	0.086	365	24/24	70	25550	2.6×10^{-5}	26
	Yahoo! Phases 1-3	0.01818					5.5×10^{-6}	6
	Intuit	0.05684					1.7×10^{-5}	17
	Microsoft	0.00198					6×10^{-7}	~1
	BNSF	0.00704					2.1×10^{-6}	2
	Highways	0.00011					3.3×10^{-8}	<1
	"Prevailing" post-project	0.082					2.5×10^{-5}	25
	Yahoo! Phases 1-3	0.01181					3.5×10^{-6}	4
	Yahoo! Phase 5	**0.003**					**9.0×10^{-7}**	**~1**
	Intuit	0.05684					1.7×10^{-5}	17
	Microsoft	0.00198					6×10^{-7}	~1
	BNSF	0.00704					2.1×10^{-6}	2
	Highways	0.00011					3.3×10^{-8}	<1
Maximally Exposed Potential Future Residence	"Prevailing" pre-project	0.17451	365	24/24	70	25550	5.2×10^{-5}	52
	Yahoo! Phases 1-3	0.15389					$4.6. \times 10^{-5}$	46
	Intuit	0.00393					1.2×10^{-6}	1
	Microsoft	0.00272					8.0×10^{-7}	~1
	BNSF	0.01383					4.1×10^{-6}	4
	Highways	0.00014					4.2×10^{-8}	<1
	"Prevailing" post-project	0.06902					2.1×10^{-5}	21
	Yahoo! Phases 1-3	0.03442					1.0×10^{-5}	10
	Yahoo! Phase 5	**0.014**					**4.2×10^{-6}**	**4**
	Intuit	0.00393					1.2×10^{-6}	1
	Microsoft	0.00272					8.0×10^{-7}	~1
	BNSF	0.01383					4.1×10^{-6}	4
	Highways	0.00014					4.2×10^{-8}	<1

Table 19 (cont'd). Estimated Increased Cancer Risk for Residential, Occupational, Student, and Scenarios

Location/ Scenario	Scope	Annual DEEP Concentration (µg/m^3)	EF1 (days/yr)	EF2 (hr/24 hr)	ED (yr)	AT (days)	Individual Increased Cancer Risk	Risk/ Million
Maximally Impacted Off-Site Workplace	"Prevailing" pre-project	0.524	250	8/24	40	25550	2.1×10^{-5}	21
	Yahoo! Phases 1-3	0.5079					2.0×10^{-5}	20
	Intuit	0.01039					4×10^{-7}	<1
	Microsoft	0.00212					1.0×10^{-7}	<1
	BNSF	0.02327					9×10^{-7}	~1
	Highways	0.00013					5.1×10^{-9}	<1
	"Prevailing" post-project	0.0897					3.5×10^{-6}	4
	Yahoo! Phases 1-3	0.04079					1.6×10^{-6}	2
	Yahoo! Phase 5	**0.016**					**6.0×10^{-7}**	**~1**
	Intuit	0.01039					4×10^{-7}	<1
	Microsoft	0.00212					1.0×10^{-7}	<1
	BNSF	0.02327					9×10^{-7}	~1
	Highways	0.00013					5.1×10^{-9}	<1
Maximally Impacted School–Teacher	"Prevailing" pre-project	0.0534	200	8/24	40	25550	1.7×10^{-6}	2
	Yahoo! Phases 1-3	0.00395					1.2×10^{-7}	<1
	Intuit	0.0017					5.3×10^{-8}	<1
	Microsoft	0.00328					1.0×10^{-7}	<1
	BNSF	0.04425					1.4×10^{-6}	1.4
	Highways	0.00022					6.9×10^{-9}	<1
	"Prevailing" post-project	0.05196					1.6×10^{-6}	2
	Yahoo! Phases 1-3	0.00193					6.0×10^{-8}	<1
	Yahoo! Phase 5	**0.00058**					**1.8×10^{-8}**	<1
	Intuit	0.0017					5.3×10^{-8}	<1
	Microsoft	0.00328					1.0×10^{-7}	<1
	BNSF	0.04425					1.4×10^{-6}	1.4
	Highways	0.00022					6.9×10^{-9}	<1

Table 19 (cont'd). Estimated Increased Cancer Risk for Residential, Occupational, Student, and Scenarios

Location/ Scenario	Scope	Annual DEEP Concentration ($\mu g/m^3$)	EF1 (days/yr)	EF2 (hr/24 hr)	ED (yr)	AT (days)	Individual Increased Cancer Risk	Risk/ Million
Maximally Impacted School–Student	"Prevailing" pre-project	0.0534					1.1×10^{-7}	<1
	Yahoo! Phases 1-3	0.00395					8.3×10^{-9}	<1
	Intuit	0.0017					3.6×10^{-9}	<1
	Microsoft	0.00328					6.9×10^{-9}	<1
	BNSF	0.04425					9.4×10^{-8}	<1
	Highways	0.00022					4.6×10^{-10}	<1
	"Prevailing" post-project	0.05196					1.1×10^{-7}	<1
	Yahoo! Phases 1-3	0.00193					4.1×10^{-9}	<1
	Yahoo! Phase 5	**0.00058**					**1.2×10^{-9}**	<1
	Intuit	0.0017					3.6×10^{-9}	<1
	Microsoft	0.00328					6.9×10^{-9}	<1
	BNSF	0.04425					9.4×10^{-8}	<1
	Highways	0.00022					4.6×10^{-10}	<1
Maximally Impacted Fence Line Receptor	"Prevailing" pre-project	0.81589	250	2/24	40	25550	8.0×10^{-6}	8
	Yahoo! Phases 1-3	0.78247					7.7×10^{-6}	7.7
	Intuit	0.01051					1.0×10^{-7}	<1
	Microsoft	0.00219					2.1×10^{-8}	<1
	BNSF	0.02059					2.0×10^{-7}	<1
	Highways	0.00013					1.3×10^{-9}	<1
	"Prevailing" post-project	0.10094					9.9×10^{-7}	1
	Yahoo! Phases 1-3	0.06014					5.9×10^{-7}	<1
	Yahoo! Phase 5	**0.00738**					**7.2×10^{-8}**	<1
	Intuit	0.01051					1.0×10^{-7}	<1
	Microsoft	0.00219					2.1×10^{-8}	<1
	BNSF	0.02059					2.0×10^{-7}	<1
	Highways	0.00013					1.3×10^{-9}	<1

Note: **Pre-project** refers to Yahoo!'s allowable annual fuel consumption limit from existing (Phases 1 through 3) engines at 821,600 gallons per year. **Post-project** refers to Yahoo!'s voluntary reduction in allowable annual fuel consumption from existing (Phases 1 through 3) engines from 821,600 to 410,800 gallons per year.

5. UNCERTAINTY CHARACTERIZATION

Many factors of the health impact assessment 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 Yahoo!'s backup generators and "background" sources of DEEP in Quincy. The assumptions used in the face of uncertainty may tend to over- or underestimate the health risks estimated in the health impact assessment.

5.1. Exposure Uncertainty

It is difficult to characterize the amount of time that people can be exposed to Yahoo!'s DEEP emissions. For simplicity, Yahoo! and Ecology assumed 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. Yahoo! estimates that they will use the generators during emergency outages for no more than 48 hours per year. Since 2003, the average outage for all Grant County PUD power customers has been about 2.5 hours per year. While this small amount of power outage provides some comfort that power service is relatively stable, Yahoo! cannot predict future outages with any degree of certainty. Yahoo! accepted a limit of emergency operation for 48 hours per year and estimated that this limit should be more than sufficient to meet their emergency demands.

For the purposes of evaluating cumulative exposure to NO_2 during power outages, Ecology assumed that all data centers lose power at the same time. Grant County PUD reports that this circumstance is extremely unlikely because there are two separate feeder lines that supply power to the east and west portions of Quincy (Coe, 2010). Therefore, an outage along either of those lines would only affect Microsoft and Dell (west) or Yahoo!, Intuit, and Sabey (east). A simultaneous outage along both feeder lines is much less likely, and therefore, Ecology's estimate of the cumulative impacts of NO_2 during power outages represents an unlikely worst-case scenario.

5.2. Emissions Uncertainty

The exact amount of DEEP and NO_X emitted from Yahoo!'s diesel-powered generators is uncertain. Yahoo! applied both engine-specific and EPA's Tier-2 emission factors to describe the emission rates from the diesel engines. The most conservative (i.e., highest) emission rate was used in dispersion modeling to ensure that ambient impacts are not underestimated.

The ratio of NO_2 to NO_X emitted from Yahoo!'s diesel engines is also uncertain. In accordance with guidance from Ecology, Landau assumed that 10% of NO_X emitted from diesel engines is in the form of NO_2. This represents a conservative estimate of primary NO_2 emissions from diesel engines.

5.3. Air Dispersion Modeling Uncertainty

The transport of pollutants through the air is a complex process. Regulatory air dispersion models are 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 written 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 Yahoo! analysis will likely slightly overestimate the short-term (24-hour average) impacts and somewhat underestimate the annual concentrations. The expected magnitude of the uncertainty is probably similar to the emissions uncertainty and much lower than the toxicity uncertainty.

5.4. 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), EPA, and other agencies, apply "uncertainty" factors to doses or concentrations that were observed to cause adverse non-cancer effects in animals or humans. 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 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 EPA classifies DEEP as probably carcinogenic to humans, they have not established a URF for quantifying cancer risk. In their health assessment document, 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, 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 their 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 EPA's health assessment document for diesel exhaust are:

- Lack of knowledge about the underlying mechanisms of DEEP toxicity.
- The question of whether toxicity studies of DEEP based on older engines is relevant to current diesel engines.

Table 20 presents a summary of how the uncertainty affects the quantitative estimate of risks or hazards.

Table 20. Qualitative Summary of how the Uncertainty Affects the Quantitative Estimate of Risks or Hazards

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
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

6. OTHER CONSIDERATIONS

6.1. Short-Term Exposures to DEEP

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 do not currently exist. Therefore, Ecology did not quantify short-term risks from DEEP exposure. By not quantifying short-term health risks in this document, Ecology does not imply that they have not been considered. Instead, we have assumed that compliance with the 24-hour $PM_{2.5}$ NAAQS is an indicator of acceptable short-term health effects from DEEP exposure. In our analysis, we assumed all DEEP emissions to be $PM_{2.5}$.

Relevant to Yahoo!'s DEEP emissions, the 24-hour $PM_{2.5}$ NAAQS was set by EPA to protect people from short-term exposure to small particles (which include DEEP). Ecology determined that Yahoo! adequately demonstrated compliance with the $PM_{2.5}$ NAAQS. Therefore, short-term impacts from DEEP exposure were considered and found to be acceptable.

7. SUMMARY OF HEALTH RISKS, CONCLUSIONS, AND THIRD TIER REVIEW RECOMMENDATIONS

7.1. Project Summary

Yahoo! proposes to expand their data center located in Quincy, Grant County, Washington. The expansion project, or the Phase 5 development, will consist of five buildings to house server equipment and 10 diesel-powered backup engine-generator sets each rated at 2,280 kWm. The engines will be housed in separate enclosures.

Potential emissions of DEEP and NO_2 from the proposed backup engines exceeded regulatory trigger levels called ASILs. The proponent was therefore required to submit a second tier petition per Chapter 173-460 WAC.

Due to the relatively close geographic proximity of existing and planned large data centers in Quincy, Ecology determined that a community-wide approach for permitting data centers is warranted for the Quincy UGA. The community-wide approach considers the cumulative impacts of DEEP, which includes consideration of background emissions from existing permitted data centers and other sources of DEEP. In the case of Yahoo!'s third tier petition, Ecology also considered short-term (acute) NO_2 impacts in the community during outage scenarios.

Because Ecology chose to take a community-wide approach to permitting data centers in Quincy under a third tier review, Ecology is required to make a third tier risk management decision in accordance with WAC 173-460-100. The third tier review process allows Ecology to consider Yahoo!'s request to extend exhaust stacks and reduce allowable DEEP emissions from their existing data center in Quincy, thereby reducing the overall potential risk from exposure to DEEP emitted by Yahoo!'s data center operations in Quincy.

7.2. Potential Health Risks

Yahoo! retained Landau Associates (Landau) to prepare a HIA to evaluate the potential health risks attributable to operation of the diesel-powered generators from the Phase 5 expansion project. The HIA demonstrated that emissions of DEEP from the proposed expansion alone could result in an increased cancer risk of up to 4 in one million (4×10^{-6}) at an undeveloped residentially zoned property located to the west of Yahoo!.

The HIA also demonstrated that power outage emissions of NO_2 from the 10 proposed engines (Phase 5) could infrequently result in hazard quotients greater than one at a few non-residential off-site locations near Yahoo!'s southeast boundary. A hazard quotient greater than one means that the estimated short–term (one-hour average) NO_2 levels exceed a reference exposure level of 470 $\mu g/m^3$. At or above this level, some sensitive asthmatics could experience symptoms.

While Yahoo!'s proposed Phase 5 expansion alone results in increased health risks within the range that Ecology may approve for proposed new sources of TAPs under the second tier review provisions of WAC 173-460-090(7) , Ecology also considered the cumulative impact of:

- Long-term on-road, non-road, and existing data center emissions of DEEP, and

- Short-term NO_2 power outage emissions from all existing and proposed data centers and NO_2 emissions from Celite Corporation added to an assumed background level of 29 $\mu g/m^3$.

The maximum prevailing cumulative cancer risk prior to Yahoo!'s Phase 5 proposal is 26 in one million (2.6×10^{-5}) at an existing residence most impacted by Yahoo!. It is important to note that because Yahoo! is located in a relatively non-residential area, the existing residence maximally exposed to DEEP is located more than ½ mile north of Yahoo!. This particular residence is theoretically more impacted by emissions from the nearby Intuit Data Center than by Yahoo! Data Center. A potentially higher risk of 52 in one million (5.2×10^{-5}) occurs at an undeveloped residential property located to the west of Yahoo!.

Ecology also evaluated the cumulative short-term NO_2 impact assuming all data centers (existing and proposed) lost power at the same time. This cumulative assessment of NO_2 aimed to identify the worst-case short-term impacts in Quincy during emergency outage conditions. Ecology found that NO_2 levels could rise above a level of concern for sensitive individuals during certain meteorological conditions.

Ecology considered the infrequent meteorological conditions required to cause a high NO_2 impact coincident with the infrequent occurrence of emergency outages to determine the probability and frequency with which receptors could be impacted at levels of concern. The worst-case scenario would mean that Yahoo! (and other Quincy data centers) experience a full 48 hours of simultaneous power outage per year as allowed by permit. Short-term NO_2 levels could reach or exceed 470 $\mu g/m^3$ about once every ½ year at Yahoo!'s fence line. Workers at commercial sites directly south of Yahoo! could be impacted once a year, and future residents in the area could be impacted about once every five years (at an undeveloped residentially zoned parcel). Existing residences near Yahoo! could be impacted once every 36 years, and the nearest school could be impacted once every 91 years assuming 48 hours of unplanned simultaneous outage per year in Quincy.

Given that two separate feeder lines are reported to supply power to Quincy, it is unlikely that data centers on the east side (Yahoo!, Intuit, and proposed Sabey) will experience an outage at the same time as those on the west side (Microsoft and proposed Dell). Furthermore, it is also unlikely that Yahoo! or any other data center will use their full permitted limit of emergency outage hours on an annual basis (i.e., 48 hours per year). Ecology evaluated an alternate scenario where data centers experience three hours of unplanned outage per year. This length of time is more in line with average system-wide outage times reported by Grant County PUD. Under this scenario, NO_2 levels could reach or exceed 470 $\mu g/m^3$ about once every eight years at Yahoo!'s fence line. Workers at commercial sites directly south of Yahoo! could be impacted about once

every 16 years, and future residents in the area could be impacted about once every 81 years (at an undeveloped residentially zoned parcel adjacent to Yahoo!). Existing residences near Yahoo! could be impacted about once every 584 years, and the nearest school could be impacted about once every 1,460 years. This analysis demonstrates that individual receptors are not likely to be frequently and repeatedly exposed to short-term NO_2 levels above 470-µg/m^3.

7.3. Third Tier Review Criteria

Section 3.6 lists the minimum approval criteria for a third tier review. The criteria are restated below followed by a brief summary of how Yahoo! satisfied each approval criterion for a third tier review:

(a) Proposed emission controls represent at least BACT.

Ecology's Eastern Regional Office determined that tBACT for DEEP is restricted operation of the EPA Tier-2 certified engines and compliance with the operation and maintenance restrictions of 40 CFR Part 60, Subpart IIII. Ecology verifies that in this case, the technology described represents at least tBACT.

(b) A health impact assessment (HIA) has been completed as described in WAC 173-460-090(3).

Yahoo! submitted a complete HIA to Ecology. Section 4 above summarizes Ecology's review and interpretation of Yahoo!'s HIA.

(c) Approval of the project will result in a greater environmental benefit to the state of Washington.

Section 2.3 describes Yahoo!'s proposal to increase exhaust stack heights to enhance dispersion and to reduce the total facility-wide (existing and proposed data center) allowable fuel consumption from 821,600 gallons per year to 514,351 gallons per year. This enforceable reduction in capacity to use diesel fuel in its diesel engines includes a 50% reduction in fuel use from existing engines, which translates into 37% reduction in Yahoo!'s maximum allowable DEEP emissions. Potential cumulative pre-expansion project risk will decrease from 5.2×10^{-5} (52 in one million) to 2.1×10^{-5} (21 in one million) at a residentially zoned parcel to the west of Yahoo!.

Without this proposed project, such allowable emission reductions would likely not be realized. Ecology views the requested enforceable limit as an environmental benefit to the state of Washington because Yahoo!'s potential long-term facility-wide air quality impact will be reduced.

7.4. Conclusions and Recommendation

Assuming that Yahoo! does not exceed the emission rates relied upon for modeling ambient impacts, the overall increased cancer risk impact from the proposed project and other sources of DEEP are within a range considered by Ecology to reflect an "ample margin of safety."

Although Yahoo!'s emissions are unlikely to result in excessive cancer risk, they may on certain infrequent occasions contribute to adverse airway reaction symptoms among people with NO_2-sensitive asthma. Given the low lifetime risk of severe asthma symptoms from NO_2 emissions and the evidently infrequent recurrence of high NO_2 exposure situations, Ecology concludes that risks from the proposed engines are acceptable under WAC 173-460 provided implementation of the following recommendations.

Ecology concludes that Yahoo! has satisfied the requirements for approval of the third tier review petition, subject to the following recommendations:

1) Yahoo! communicate health risks posed by Yahoo! to potential new homeowners at undeveloped residential parcels adjacent to Yahoo! or to the local regulatory agency responsible for zoning and development in the affected area; and

2) Yahoo! routinely reports to Ecology all unplanned power failures occurring at their facility.

Ecology will use routine reports of unplanned power failures from Yahoo! and other data centers in Quincy to determine the appropriateness of assumptions in this analysis. The reports shall include the date, time, and duration of each power outage and the length of time that each engine operates as a result of the outage. Ecology may also use the power outage records to verify compliance with the 48 hours/year limit on emergency operations.

The project review team recommends that the director approve Yahoo!'s third tier petition subject to implementation of the above recommendations. As required by state rules, Yahoo! must hold a public hearing in which Yahoo! and Ecology will present the results of the health impact analysis, the proposed emission controls, pollution prevention methods, additional proposed measures, and any remaining risks posed by the project. Yahoo! must participate in discussions and answer the public's questions at the public hearing.

8. LIST OF ACRONYMS AND ABBREVIATIONS

AERMOD	American Meteorological Society/Environmental Protection Agency Regulatory Model
AQP	Air Quality Program
ASIL	Acceptable Source Impact Level
AT	Averaging Time (days)
BNSF	Burlington Northern Santa Fe
CAir	Concentration in air
CalEPA	California Environmental Protection Agency
CAS #	Chemical Abstracts Service Number
DEEP	Diesel Engine Exhaust, Particulate
DEM	Digital Elevation Model
Ecology	Washington State Department of Ecology, Headquarters Office
ED	Exposure Duration (years)
EF	Exposure Frequency
EF1	Exposure Frequency (days per year)
EF2	Exposure Frequency (hours per day)
EPA	United States Environmental Protection Agency
ERO	Washington State Department of Ecology, Eastern Regional Office
ESSB 6789	Engrossed Substitute Senate Bill 6789 – Computer Data Centers – Sales and Use Tax Exemption
HIA	Health Impact Analysis
HQ	Hazard Quotient
hr	Hour
ICF	ICF International
kWm	kilowatt, mechanical
Landau	Landau Associates
$\mu g/m^3$	Micrograms per Cubic Meter
μm	Micron or micrometer
MWe	Megawatt, electrical
NAAQS	National Ambient Air Quality Standards
NAC AEGL	The National Advisory Committee for the Development of Acute Exposure Guideline Levels
NAS	National Academies of Science
NO	Nitric Oxide
NO_2	Nitrogen dioxide
NOC	Notice of Construction Order of Approval
NO_X	Oxides of Nitrogen
OEHHA	California Environmental Protection Agency's Office of Environmental Health Hazard Assessment
Phases 1-3	Yahoo! Data Center Phases 1 through 3 (already built)
Phase 5	Yahoo! Data Center Phase 5 (proposed to be built)
$PM_{2.5}$	Particulate Matter less than 2.5 micrometers in diameter
ppb	parts per billion

ppm	parts per million
PRIME	Plume Rise Model Enhancements
PUD	Public Utilities District
PVMRM	Plume Volume Molar Ratio Method
REL	OEHHA Reference Exposure Level
RfC	Reference Concentration
SQER	Small Quaintly Emission Rate
TAP	Toxic Air Pollutant
tBACT	Best Available Control Technology for Toxics
TEQ	Toxic Equivalent
UGA	Urban Growth Area
URF	Unit Risk Factor
WAC	Washington Administrative Code
Yahoo!	Yahoo! Inc.

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