DEPARTMENT OF ECOLOGY
State of Washington

Health Impact Assessment Recommendation Document for

CyrusOne Data Center Quincy, Washington

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Executive Summary

This health impact assessment review evaluates and summarizes the health risks from air pollutants emitted by forty-two (42) new diesel engines at CyrusOne Data Center in Quincy. In general, toxic air pollutant impacts in the area near CyrusOne will not result in excessive risk or cause serious short- or long- term health effects. Ecology concludes that the health risk is acceptable and recommends approval of the project.

CyrusOne proposes to build a new data center in Quincy, Washington. To ensure uninterrupted electrical power, CyrusOne will use:

- Forty 2.25 megawatt diesel-powered emergency generators to provide backup power to server buildings,
- Two 750 kilowatt diesel-powered emergency generators to provide backup power to office and support functions of the data center complex.

While the proposed engines will only operate intermittently (facility average of up to 38 hours per year per engine), the engines may emit two toxic air pollutants – diesel engine exhaust particles and nitrogen dioxide – at rates triggering a requirement to prepare a health impact assessment. A health impact assessment describes the increased health risks from exposure to toxic air pollutants.

CyrusOne hired Landau Associates to prepare a health impact assessment. Landau Associates estimated increased health risks associated with CyrusOne's diesel particles and other toxic air pollutant emissions. Because several data centers with many large diesel engines are located in Quincy, Landau Associates also evaluated emissions from other nearby sources to determine the short- and long-term health risks associated with cumulative exposure to diesel engine emissions.

Conclusions

- Short-term impacts:
    - Nitrogen dioxide emitted from CyrusOne and other west Quincy data center diesel-powered engines that operate during a power outage could rise to levels of short-term concern for people with respiratory problems.
    - The highest short-term nitrogen dioxide impacts occur on-site within data center boundaries, but offsite locations can also be impacted at levels of concern.
        - NO_2 concentrations could potentially exceed an Acute Exposure Guidance Level at locations on or directly adjacent to CyrusOne's property. Exposure to concentrations above this level may result in effects such as headaches, burning eyes, and chest tightness or difficulty breathing. The effects are considered "not disabling" and reversible upon cessation of exposure.

  - The wind and weather conditions conducive to producing higher NO_2 impacts would need to coincide with high emissions during power outages to result in high concentrations. Power outages affecting data centers are not expected to occur frequently, therefore concentrations responsible for these hazards are not expected to occur frequently or be sustained for long periods.

- Long-term impacts:
  - CyrusOne diesel particle emissions result in an increased lifetime cancer risk of up to 9.6 in one million**.** The maximum risk was estimated for workers or tenants on-site at CyrusOne. In assessing cancer risk to on-site tenants, Ecology assumes that workers are exposed to CyrusOne's emissions eight hours per day, five days per week, for 40 years.
  - The maximum risk for a resident is 7.1 in one million and occurs at a home located north of CyrusOne. Ecology assumes continuous lifetime exposure in assessing cancer risks from residents' exposure to project-related diesel engine exhaust particulate.
    - Cancer risk can be expressed either as an increase in an individual's risk of disease, or as the number of cancers that might occur in addition to those normally expected in a population of one million people. The reported diesel engine exhaust particulate-related cancer risk estimates represent increases above a baseline lifetime cancer risk of about 40 percent in the United States.
  - The maximum cumulative cancer risk to people who live near CyrusOne is about 50 in one million. Much of the exposure to diesel particles at this location comes from locomotives.
  - Exposure to diesel particles in the area is not likely to result in long-term non-cancer health effects.

Ecology's recommendation

Ecology recommends approval of the project because:

- Ecology determined that the emission controls for the new and modified emission units represent best available control technology for toxics.
- The applicant demonstrated that the increase in emissions of toxic air pollutants is not likely to result in an increased cancer risk of more than one in one hundred thousand (10 in one million) which is the maximum risk allowed by a second tier review.
- The applicant demonstrated that the cumulative risks to residents living near CyrusOne are below the cumulative risk threshold established by Ecology for permitting data centers in Quincy (100 per million or 100 x 10-6),
- Ecology determined that the non-cancer hazard is acceptable.

- The likelihood of power outage occurrences is low based on the reported reliability of the Grant County PUD power system.

Second Tier Review Processing and Approval Criteria

The health impacts assessment (HIA) for CyrusOne submitted by Landau Associates is part of the second tier toxics review process under WAC 173-460 (Landau Associates, 2018a). Ecology is responsible for processing and reviewing second tier review petitions statewide.

Second tier review processing requirements

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

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

(b) Emission controls contained in the preliminary NOC approval order represent at least best available control technology for toxics (tBACT).

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

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

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

Acting as the "permitting authority" for this project, Ecology's project permit engineer satisfied item (a) and verified item (b) above on February 27, 2019.[1] Ecology approved an HIA protocol (item (c)), and the final HIA (item (e)) was received by Ecology on December 26, 2018. Ecology's modeler confirmed that refined modeling (item (d)) was conducted appropriately.[2]

All five processing requirements above are satisfied.

Second tier review approval criteria

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

(a) Determines that the emission controls for the new and modified emission units represent tBACT.

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[1] Gary Huitsing, "Memo with Recommendations for proposed CyrusOne data center," e-mail message with attachments, addressed to Gary Palcisko and Karin Baldwin, February 27, 2019.
[2] Ranil Dhammapala, "HIA_Modeling Review Checklist_CyrusOne_Dec2018.docx," email attachment, January 18, 2019.

(b) 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.

(c) Ecology determines that the non-cancer hazard is acceptable.

tBACT determination

Ecology's permit engineer determined that CyrusOne's proposed pollution control equipment satisfies the BACT and tBACT requirement for diesel engines powering backup generators (Ecology 2019a). BACT and tBACT for nitrogen oxides (NO_X) and diesel particulate was determined to be met through restricted operation of EPA Tier-2 certified engines operated as emergency engines as defined in 40 CFR §60.4219, and compliance with the operation and maintenance restrictions of 40 CFR Part 60, Subpart IIII. In addition, the source must have written verification from the engine manufacturer that each engine of the same make, model, and rated capacity installed at the facility uses the same electronic Programmable System Parameters, i.e., configuration parameters, in the electronic engine control unit. CyrusOne must install engines consistent with this BACT/tBACT determination.

Health Impact Assessment Review

As described above, the applicant is responsible for preparing the HIA under WAC 173-460-090. Ecology's project team consisting of an engineer, a toxicologist, and a modeler review the HIA to determine if the methods and assumptions are appropriate for assessing and quantifying risks to the surrounding community from a new project.

For the CyrusOne project, the HIA focused on health risks attributable to diesel engine exhaust particulate (DEEP) and nitrogen dioxide (NO_2) exposure because the modeled ambient air concentrations exceeded respective ASILs. Landau briefly described emissions and exposure to other TAPs (carbon monoxide (CO), benzene, 1-3 butadiene, acrolein, and naphthalene) because these pollutants exceeded a small quantity emission rate (SQER), and Ecology requested that health hazards from exposure to these pollutants be quantified.

Health effects summary

The HIA prepared by Landau Associates quantifies the non-cancer hazards and increased cancer risks attributable to CyrusOne's TAP emissions. The HIA focused on potential exposure to diesel particles and NO_2 as these were the two TAPs with emissions causing an exceedance of an ASIL.

DEEP health effects summary

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 or contribute to numerous adverse health effects.

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

Nitrogen dioxide health effects summary

NO_2 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 (National Research Council, 2012). 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 µg/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, 1,446 µg/m^3, 1-hour average, occurs within the CyrusOne property boundary during a power outage scenario that last for at least one hour.

Power outage emissions present the greatest potential for producing high enough short-term concentrations of NO_2 to be of concern for respiratory health effects. Landau Associates and Ecology calculated numerical estimates of exposure and hazard reported later in this document. The likelihood and recurrence of exposure is also discussed.

Toxicity reference values

Agencies develop toxicity reference values for use in evaluating and characterizing exposures to chemicals in the environment. As part of the HIA, Landau Associates identified appropriate toxicity values for DEEP and NO_2.

DEEP toxicity values

Landau identified toxicity values for DEEP from two agencies: the U.S. Environmental Protection Agency (EPA) (EPA, 2002; EPA, 2003), and California EPA's Office of Environmental Health Hazard Assessment (OEHHA) (CalEPA, 1998). These toxicity values are derived from studies of animals that were exposed to a known amount (concentration) of DEEP, or from epidemiological studies of exposed humans. They 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 1 shows the appropriate DEEP non-cancer and cancer toxicity values identified by Landau Associates.

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 µg/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- 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. In these studies, DEEP exposure was estimated from measurements of elemental carbon and respirable particulate representing fresh diesel exhaust.

Therefore, DEEP is defined as the filterable fraction of particulate emitted by diesel engines.[3] The URF is 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 per $\mu g/m^3$ meaning that a lifetime of exposure to 1 $\mu g/m^3$ of DEEP results in an increased individual cancer risk of 0.03 percent or a population cancer risk of 300 excess cancer cases per million people exposed.

Nitrogen dioxide toxicity values

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 exposed 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 less likely to experience effects at NO_2 levels at or below the REL. OEHHA intended for acute RELs to be "for infrequent one hour exposures that occur no more than once every two weeks in a given year" (CalEPA, 2015).

Acute Exposure Guidance Levels (AEGLs) developed by the National Research Council (NRC) are also relevant to acute NO_2 exposures. AEGLs are intended for use by emergency planners and responders as guidance in dealing with rare releases of chemicals into the air. AEGLs are expressed as specific concentrations of airborne chemicals at which health effects, ranging from non-disabling to severe, may occur. The varying AEGL levels (1, 2, or 3) are dictated by the severity of the toxic effects caused by the exposure, with Level 1 being the least and Level 3 being the most severe. They are designed to protect the elderly and children, and other individuals who may be susceptible. The AEGL1 (non-disabling effects) for NO_2 is 940 $\mu g/m^3$. Potential effects include slight burning of the eyes, headache, and chest tightness or labored breathing with exercise in people with asthma.

Although not intended for protection of the public, the Washington State Department of Labor and Industries has established a permissible exposure level – short-term exposure level for NO_2 of 1 ppm or 1880 $\mu g/m^3$.

EPA developed an annual and 1-hour NAAQS for NO_2. Compliance with these NAAQS was demonstrated as part of the NOC application process (Ecology, 2019b).

[3] Condensable particulate is not considered to represent DEEP for the purposes assessing health risks from DEEP exposure, however, both the filterable and condensable fractions of PM are considered when determining compliance with NAAQS for the purposes of the NOC application.

Table 1: Toxicity Values or Comparison Values Considered in Assessing and Quantifying Non-cancer Hazard and Cancer Risk

Pollutant	Agency	Non-cancer	Cancer
DEEP	U.S. Environmental Protection Agency	RfC = 5 $\mu g/m^3$	NA[1]
	California EPA–Office of Environmental Health Hazard Assessment	Chronic REL = 5 $\mu g/m^3$	URF = 0.0003 per $\mu g/m^3$
Nitrogen dioxide	California EPA–Office of Environmental Health Hazard Assessment	Acute REL = 470 $\mu g/m^3$	NA
	National Research Council – Committee on Acute Exposure Guideline Levels.	AEGL – 1 = 940 $\mu g/m^3$	NA
	Washington State Department of Labor and Industries (L&I)	PEL-STEL = 1,880 $\mu g/m^3$	NA

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

[2] RfC – Reference Concentration

[3] REL – Reference Exposure Level

[4] URF – Unit Risk Factor

[5] AEGL – Acute Exposure Guidance Level

[6] PEL – STEL – Permissible Exposure Level – Short-term exposure limit

Community/receptors

While CyrusOne is proposed to be built in an industrially zoned area surrounded largely by agricultural land uses and other data centers, air dispersion modeling indicated that proposed DEEP emissions could result in long-term concentrations in excess of the ASIL at about 1200 parcels with residential land use codes (Figure 1) [Ecology, 2017]. U.S. Census data show that approximately 3,500 people live in the Census Blocks intersected by the area in which DEEP concentrations are estimated to exceed the ASIL (U.S. Census Bureau, 2010). Relevant to short-term impacts, levels of NO_2 could exceed the ASIL at 71 residential parcels (Figure 2) affecting approximately 200 residents (U.S. Census Bureau, 2010).

For the purposes of assessing increased cancer risk and non-cancer hazards, Landau Associates identified receptor locations where the highest exposure to project-related air pollutants could occur: at the project boundary, nearby residences, and on-site and nearby commercial locations (Figures 3 and 5). Landau Associates also evaluated exposures that occur at Mountain View School, Monument Elementary School, and Quincy Valley Medical Center.

Ecology's review of the HIA found that Landau identified appropriate receptors to capture the highest CyrusOne attributable exposures for residential, commercial, school, and hospital receptors.

Increased cancer risk

Landau Associates assessed the increased risk of cancer from lifetime exposure to DEEP emitted from CyrusOne's engines. Cumulative risks posed by other sources of DEEP in the area were also evaluated. Cancer risk was characterized in a manner consistent with EPA guidance for inhalation risk assessment (EPA, 2009). Risks were quantified using the following equations:

Risk = IUR x EC

Where:

IUR $(\mu g/m^3)^{-1}$ = inhalation unit risk (i.e., unit risk factor); and

EC $(\mu g/m^3)$ = exposure concentration

EC = (CA x ET x EF x ED)/AT

Where:

EC (EC $(\mu g/m^3)$ = exposure concentration;

CA $(\mu g/m^3)$ = contaminant concentration in air;

ET (hours/day) = exposure time;

EF (days/year) = exposure frequency;

ED (years) = exposure duration; and

AT (ED in years x 365 days/year x 24 hours/day) = averaging time

Cancer risk attributable to CyrusOne DEEP and other TAP emissions

Table 2, adapted from the HIA, shows the estimated CyrusOne-specific cancer risk per million for residential, commercial, and school receptors. Figure 3 shows the location of these receptors relative to CyrusOne. The highest increase in risks attributable to CyrusOne's emissions is 9.6 per million[4] for workers or tenants on-site at CyrusOne. Landau Associates also calculated risks posed by other carcinogenic TAPs (i.e., acetaldehyde, benzene, formaldehyde, 1,3-butadiene, and carcinogenic polycyclic aromatic hydrocarbons). They estimated a negligible increased risk attributable to these other TAPs of < 0.1 per million.

For residential exposure scenarios, the maximally impacted residential receptor (MIRR) may have increased risks of about 7.1 per million. This receptor is located adjacent to the east boundary of NTT data center on a parcel that is currently used for agriculture (Figure 3).

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[4] Number per million represents an upper-bound theoretical estimate of the number of excess cancers that might result in an exposed population of one million people compared to an unexposed population of one million people. Alternatively, an individual's increase in risk of one in one million means a person's chance of getting cancer in their lifetime increases by one in one-million or 0.0001 percent.

Table 2: Estimated Increased Cancer Risk for Residential, Commercial, and School Receptors Attributable to CyrusOne's DEEP Emissions

Attributable to:	Risk Per Million from DEEP Exposure at Various Receptor Locations			
	On-site tenant (MICR)[1]	East Residence - Property (MIRR)[2]	School - Student[3]	School - Teacher[4]
CyrusOne	9.6	7.1	0.1	0.4

[1] Workplace scenario assumes exposure occurs 250 days per year, eight hours per day for 40 years.
[2] Residential scenarios assume continuous lifetime exposure.
[3] Student scenario assumes exposure occurs 180 days per year, eight hours per day for 13 years.
[4] Teacher scenario assumes exposure occurs 200 days per year, eight hours per day for 40 years.

Cancer risk attributable to cumulative DEEP emissions

As part of the health impact assessment, Landau Associates conducted an analysis of cumulative exposure to DEEP in Quincy.[5] In total, the cumulative analysis includes allowable emissions estimates from:

- Microsoft Columbia Data Center
- Microsoft MWH Data Center
- NTT Data Center (formerly Dell)
- CyrusOne Data Center

The cumulative analysis also includes annual DEEP emissions estimates from:

- State Route 28
- State Route 281
- Locomotives on the rail line

The cumulative cancer risk from all known sources of DEEP emissions near[6] CyrusOne (Table 3) is highest for a residential location near the rail line and the southeast corner of Microsoft Columbia Data Center. This parcel is about ½ mile southeast of the CyrusOne Data Center property boundary (Figure 4). The cumulative DEEP risk at this location is about 50 per million,

[5] Landau Associates reported the concentrations obtained from the model, which used five years of meteorological data, and reported cumulative risks associated with DEEP exposure in the area near CyrusOne.
[6] For the purposes of this analysis, the "vicinity" of CyrusOne encompasses the area in which CyrusOne's estimated impact exceeds the DEEP ASIL.

and the majority (~67 percent) of estimated exposure to DEEP is attributable to emissions from locomotives.

Table 3: Estimated Cumulative Increased Cancer Risk for Residential Receptors' Exposure to DEEP Emissions

Source	Residence Maximally Impacted by CyrusOne (MIRR)	Maximum Cumulatively Impacted Residence Identified by Landau	Maximum Cumulatively Impacted Residence Identified by Ecology
CyrusOne[1]	7.1	1.9	1.8
NTT Data (formerly Dell)[1]	1.2	0.2	0.2
Microsoft Columbia[1]	5.6	6.5	6.1
Microsoft MWH[1,6]	6.0	2.6	2.7
SR 28[2]	1.9	5.5	4.6
Rail[3]	4.6	28.9	33.4
SR 281[2]	0.4	1.2	1.1
Cumulative	26.7[4]	46.7[5]	49.9[5]

1 Estimates of ambient impact and risk are based on allowable emissions.

2 Estimates of ambient impact and risk are based on EPA's MOVES model and 2015 highway-specific vehicle mile traveled data from WSDOT.

3 Estimates of ambient impact and risk are based on emissions of Grant County locomotive emissions scaled by the ratio of railroad track feet in Quincy to overall track feet in Grant County.

4 Maximum impact and risk based on 2011 meteorology.

5 Maximum impact and risk based on 2012 meteorology.

6 Impacts and risk from MWH are based on emission rates for MWH 01 and 02 engines that are nearly three times higher than currently allowed. Therefore, these impacts are overestimated.

Non-cancer hazard

Landau Associates assessed the acute and chronic non-cancer hazards from exposure to NO_2 and DEEP emissions from CyrusOne and other local sources. Non-cancer hazard was characterized consistent with EPA guidance for inhalation risk assessment (EPA, 2009). Hazards were quantified using the following equations:

HQ = EC/Toxicity Value

Where:

HQ (unitless) = hazard quotient;

EC ($\mu g/m^3$) = exposure concentration;

Toxicity Value (µg/m^3) = inhalation toxicity value (e.g., RfC, REL) that is appropriate for the exposure scenario (acute, subchronic, or chronic).

EC = CA

Where:

EC (µg/m^3) = exposure concentration;

CA (µg/m^3) = containment concentration in air.

Landau Associates evaluated short-term (acute) exposures to NO_2 emitted during power outage scenarios from CyrusOne and nearby data center engines and determined hazard quotients could exceed unity at several locations (Table 4, Figures 5 and 6). This indicates that there is potential for short-term respiratory hazards from exposure to NO_2. The frequency of these potential occurrences is further discussed in Section 4.2.

Landau Associates also evaluated chronic non-cancer hazards associated with long-term exposure to DEEP emitted from CyrusOne and other local sources. Table 4 shows that hazard quotients associated with all receptors' exposure to CyrusOne-related and cumulative DEEP are much lower than unity (one). This indicates that chronic non-cancer hazards are not likely to occur because of exposure to DEEP near CyrusOne.

Table 4: Estimated Short-term NO_2 and Long-term DEEP Non-cancer Hazards Attributable to CyrusOne and [Cumulative] Emissions at Locations near West Quincy Data Centers

Receptors	Acute (Short-term)			Chronic (Long-term)		
	Max 1-hr NO_2 (µg/m^3)	NO_2 Acute REL (µg/m^3)	HQ	Annual Avg. DEEP (µg/m^3)	DEEP Chronic REL (µg/m^3)	HQ
MIBR/MICR	1446 [1959]		3.1 [4.2]	0.66 [0.74]		0.1 [0.1]
MIRR	851 [974]	470	1.8 [2.1]	0.063 [0.13]	5	<0.1 [<0.1]
School	391 [691]		0.8 [1.5]	0.04 [0.09]		<0.1 [<0.1]

Other Considerations

Short-term exposures to DEEP

Exposure to DEEP can cause both acute and chronic health effects. However, as discussed previously, reference toxicity values specifically for DEEP exposure at short-term or intermediate intervals do not currently exist. Therefore, Landau Associates did not quantify short-term risks or hazards from DEEP exposure. Generally, Ecology assumes that compliance with the 24-hour $PM_{2.5}$ NAAQS is an indicator of acceptable short-term health effects from DEEP exposure. Ecology's Technical Support Document (TSD) for the draft preliminary NOC approval concludes that CyrusOne's emissions are not expected to cause or contribute to an exceedance of any NAAQS (Ecology, 2019b). DEEP exposure during power outages may contribute somewhat to potential respiratory effects experienced during power outage scenarios discussed below.

Frequency of short-term NO_2 hazards

CyrusOne and other Quincy data center emergency engines could emit a high rate of NO_X if they need to be used to supply power during a line power interruption. Generally, line power is reliable in Quincy as Grant County PUD reports a system average interruption duration index (SAIDI) of 139 minutes from 2006 through 2016 (Grant County PUD, 2017).

As previously described, Landau Associates evaluated short-term CyrusOne and cumulative NO_X emissions as part of the second tier review. This analysis incorporated potential NO_X emission rates from each of the engines at all west Quincy data centers during a power outage.[7] The analysis showed that while NO_2 levels could indeed rise to levels of concern[8] during a system-wide outage, the outage would have to occur at a time when the dispersion conditions were optimal for concentrating NO_2 at a given location.

Landau Associates and Ecology estimated the combined probability of a CyrusOne and other west Quincy data centers experiencing a power outage that coincides with unfavorable meteorology. Table 5 shows the recurrence interval of concentrations exceeding either the ASIL (470 $\mu g/m^3$) at each key receptor location resulting from CyrusOne (Figure 7) and simultaneous west Quincy data center power outage NOx emissions (Figure 8). The most frequent NO_2 impacts reaching levels of concern occur within the boundary of CyrusOne data center where eight hours per year of outage emissions could result in levels above the ASIL at least one hour per year. Residential locations are less likely to be affected with impacts greater than the ASIL

[7] According to Grant County PUD, power is served to Quincy by separate feeder lines making it far less likely for both sides of Quincy to be without power at the same time. West Quincy data centers include Microsoft Columbia, Microsoft MWH, NTT, and CyrusOne.

[8] The level of concern in this case is 454 $\mu g/m^3$. This represents California OEHHA's acute reference exposure level of 470 $\mu g/m^3$ minus an estimated regional background concentration of 16 $\mu g/m^3$.

occurring at the most frequently impacted residential receptor once every 10 (assuming eight hours of simultaneous outages at all West Quincy data centers) to 32 years (assuming eight hours of outage at CyrusOne every year).

If outages were to occur more frequently than assumed, then the potential for exposure to NO_2 levels of concern could occur more frequently. Table 5 shows that if west Quincy data centers experience 38 hours of simultaneous outage (equivalent to the CyrusOne requested annual limit on total hours of engine operation), then occurrences above the ASIL at the most frequently impacted residence could occur every three years. Exposures at levels above the ASIL are of most concern for people with existing respiratory problems.

Although possible, NO_2 impacts of concern are less likely to occur at school or hospital locations on the west side of Quincy. Generally, recurrence of impacts of concern becomes much less frequent with distance from the data centers.

Higher impacts above the AEGL are possible but less likely to occur (Table 5). The areas most likely to be impacted above the AEGL are those that are on or directly adjacent to CyrusOne. Residences are not likely to be impacted by NO_2 at levels exceeding the AEGL. At levels above the AEGL, people may experience effects such as slight burning of the eyes, headache, and chest tightness or labored breathing with exercise in people with asthma. These effects are reversible once cleaner air returns.

Table 5: Estimated Years between Occurrence of NO_2 Levels > ASIL and > AEGL Depending on Frequency of Power Outage: CyrusOne and Simultaneous West Quincy Data Center Outage Scenarios

Recurrences Due to CyrusOne Outages								
Hr/Yr	Recurrence (Yr) at Most Frequently Impacted Residence		Recurrence (Yr) at Most Frequently Impacted On-site Residence		Recurrence (Yr) at Mt. View Elementary School		Recurrence (Yr) at Quincy Valley Medical Center	
	>ASIL	>AEGL	>ASIL	>AEGL	>ASIL	>AEGL	>ASIL	>AEGL
2.3 (139 mn)	110	Never	3	22	Never	Never	Never	Never
8	32	Never	~1	7	Never	Never	Never	Never
24	11	Never	~1	3	Never	Never	Never	Never
38	7	Never	~1	2	Never	Never	Never	Never
Recurrences Due to Simultaneous West Quincy Data Center Outages								
2.3 (139 mn)	34	6300	3	12	135	Never	Never	Never
8	10	1800	~1	4	40	Never	Never	Never
24	4	610	~1	2	14	Never	Never	Never
38	3	380	~1	1	9	Never	Never	Never

Uncertainty

Many factors of the HIA are prone to uncertainty. Uncertainty relates to the lack of exact knowledge regarding many of the assumptions used to estimate the human health impacts of CyrusOne's emissions. The assumptions used in the face of uncertainty may tend to over- or underestimate the health risks estimated in the HIA. Key aspects of uncertainty in the HIA for CyrusOne's proposed data center are exposure assumptions, emissions estimates, air dispersion modeling, and toxicity of DEEP.

Table 6: Qualitative Summary of How Uncertainty Affects the Quantitative Estimate of Risks or Hazards Attributable to CyrusOne Emissions

Source of Uncertainty	How Does it Affect Estimated Risk from this Project?
Exposure assumptions	Continuous lifetime exposure is likely an overestimate of DEEP exposure.
Emissions estimates	Possible overestimate of emissions because Landau used worst-case emission rate to estimate DEEP and NO_2 emissions.
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.

Exposure uncertainty

It is difficult to characterize the amount of time that people can be exposed to CyrusOne's DEEP emissions. For simplicity and to ensure public health protection, Landau Associates 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 an individual's exposure and risk.

Emissions uncertainty

The exact amount of DEEP emitted from CyrusOne's diesel-powered generators is uncertain. Landau Associates estimated emissions assuming engines would operate at loads that produce the most DEEP, and that engines would operate for the full extent of hours allowed in the draft permit. In reality, the engines will operate at a variety of loads in which emissions may be lower than assumed, and they may be used less frequently than allowed in the draft permit. Landau Associates also attempted to account for higher emissions that would occur during initial start-up. The resulting values are considered an appropriate estimate of DEEP emissions.

Landau Associates also assessed short-term NO_X impacts assuming that each of the 42 proposed engines operate at 100 percent load during a power outage. Engine loads during an outage are likely to be much lower than assumed because it is not likely that CyrusOne would design their facility to require emergency engines to be operated at the highest possible loads. If engines operate at around 75 percent load instead, NO_X emissions would be expected to be about 65 percent of those at 100 percent load (Landau Associates, 2018b). Therefore, estimated NO_X emissions are likely overestimated.

Forecasting the amount of time CyrusOne and other Quincy data center engines are used under emergency conditions is also uncertain. Furthermore, forecasting events that might affect each of the data centers simultaneously is difficult. While future outages cannot be predicted, past outages affecting data centers in Quincy appear to be infrequent as information reported to Landau Associates for the years 2006 through 2016 by Grant County PUD shows that the average time customers were without power was about 139 minutes per year.[9]

Air dispersion 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 CyrusOne project analysis may slightly overestimate the short-term (1-hour average) impacts and somewhat underestimate the annual concentrations.

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. Agencies apply these uncertainty factors so that they derive a toxicity value that is considered protective of humans including susceptible populations. In the case of DEEP exposure, the non-cancer reference values used in this assessment were generally derived from animal studies. These reference values are probably protective of the majority of the population including sensitive individuals, but 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."*

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[9] Based on the average SAIDI from 2006 through 2016. SAIDI is the system average interruption duration index = total duration of interruptions for a group of customers divided by the total number of customers.

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 $1x10^{-5}$ 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.

Conclusions and Recommendation

The project review team has reviewed the HIA and determined that:

(a) The TAP emissions estimates presented by Landau Associates represent a reasonable estimate of the project's future emissions.

(b) Emission controls for the new and modified emission units meet the tBACT requirement.

(c) The ambient impact of the emissions increase of each TAP that exceeds ASILs has been quantified using appropriate refined air dispersion modeling techniques.

(d) The HIA submitted by Landau Associates on behalf of CyrusOne adequately assesses project-related increased health risk attributable to TAP emissions.

In the HIA, Landau Associates estimated lifetime increased cancer risks attributable to CyrusOne DEEP and other toxic air pollutant emissions. DEEP emissions resulted in an increase cancer risk of about 9.6 in one million at the maximally impacted commercial receptor, and 7.1 in one million at the maximally impacted residential receptor.

Landau Associates also assessed chronic and acute non-cancer hazards attributable to the project's emissions and those from other nearby sources and determined that long-term adverse non-cancer health effects from exposure to DEEP are not likely to occur. Acute respiratory hazards, however, are possible from exposure to NO_2 during power outage scenarios that occur during periods of unfavorable pollutant dispersion. If they do happen, these impacts could occur for short periods at commercial and residential locations near CyrusOne and other data centers. These impacts may affect sensitive individuals with existing respiratory conditions such as asthma resulting in chest tightness or labored breathing with exercise. In some cases, healthy people may also experience adverse effects such as headaches and stinging eyes. Symptoms related to these high exposure episodes would be expected to improve once cleaner air conditions resume. Because power outages affecting Quincy data centers are not expected to occur frequently, the concentrations responsible for these hazards are not expected to occur frequently or be sustained for long periods.

Finally, Landau Associates and Ecology assessed the cumulative health risk by adding estimated concentrations attributable to CyrusOne emissions to an estimated background DEEP concentration. The maximum cumulative cancer risk from resident's exposure to DEEP near CyrusOne is approximately **50 in one million**. Locomotives contribute the most to diesel particulate at this location.

Because the increase in cancer risk attributable to the new data center alone is less than the maximum risk allowed by a second tier review, which is 10 in one million, and the non-cancer hazard is acceptable, the project could be approvable under WAC 173-460-090. Furthermore, the cumulative risks to residents living near CyrusOne are below the cumulative risk threshold established by Ecology for permitting data centers in Quincy (100 per million or 100 x 10-6).

The project review team concludes that the HIA represents an appropriate estimate of potential increased health risks posed by CyrusOne TAP emissions. The risk manager may recommend approval of the permit because:

- The cancer risk from CyrusOne's TAP emissions is less than the maximum risk (10 in one million) allowed by a second tier review.
- The cumulative risks to residents living near CyrusOne are below the cumulative risk threshold established by Ecology for permitting data centers in Quincy (100 per million or 100×10^{-6}).
- Ecology determined that the non-cancer hazard is acceptable.
- The likelihood of frequent or sustained power outages is low based on the reported reliability of the Grant County PUD power system.

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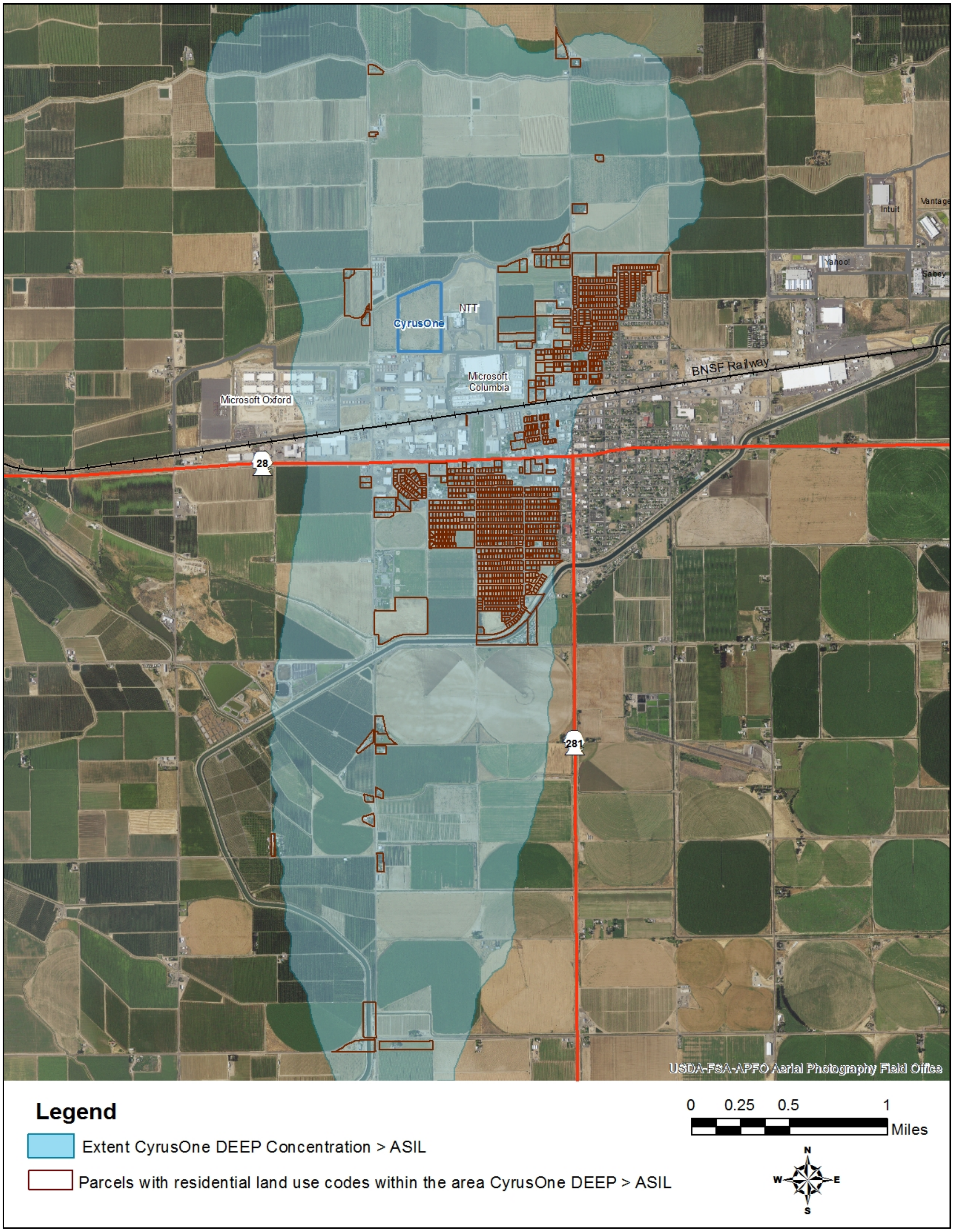

Figure 1: Residential parcels in the area where proposed CyrusOne DEEP emissions may cause impacts that exceed the ASIL

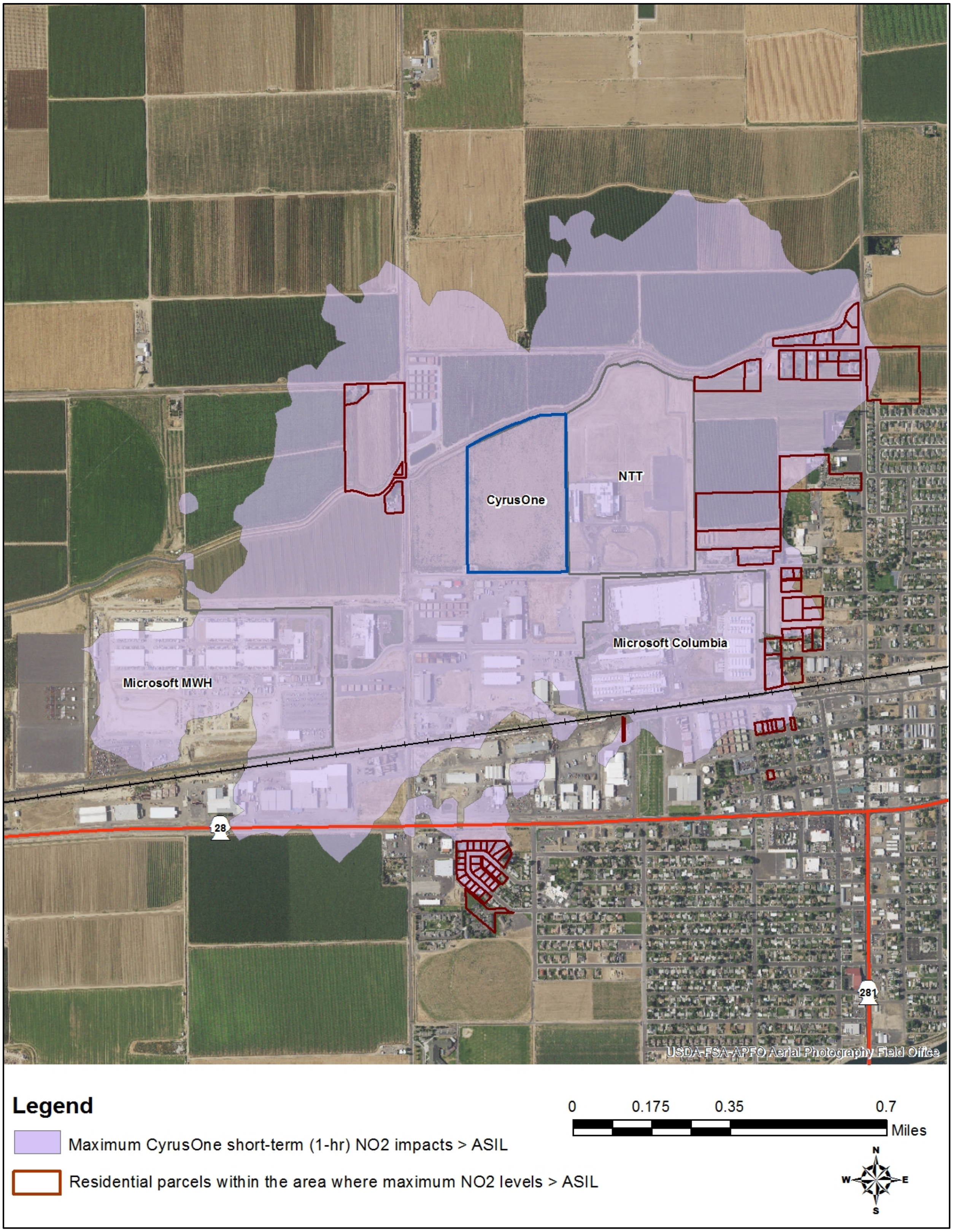

Figure 2: Residential parcels within the area where proposed CyrusOne power outage related NO_2 concentrations could exceed the ASIL

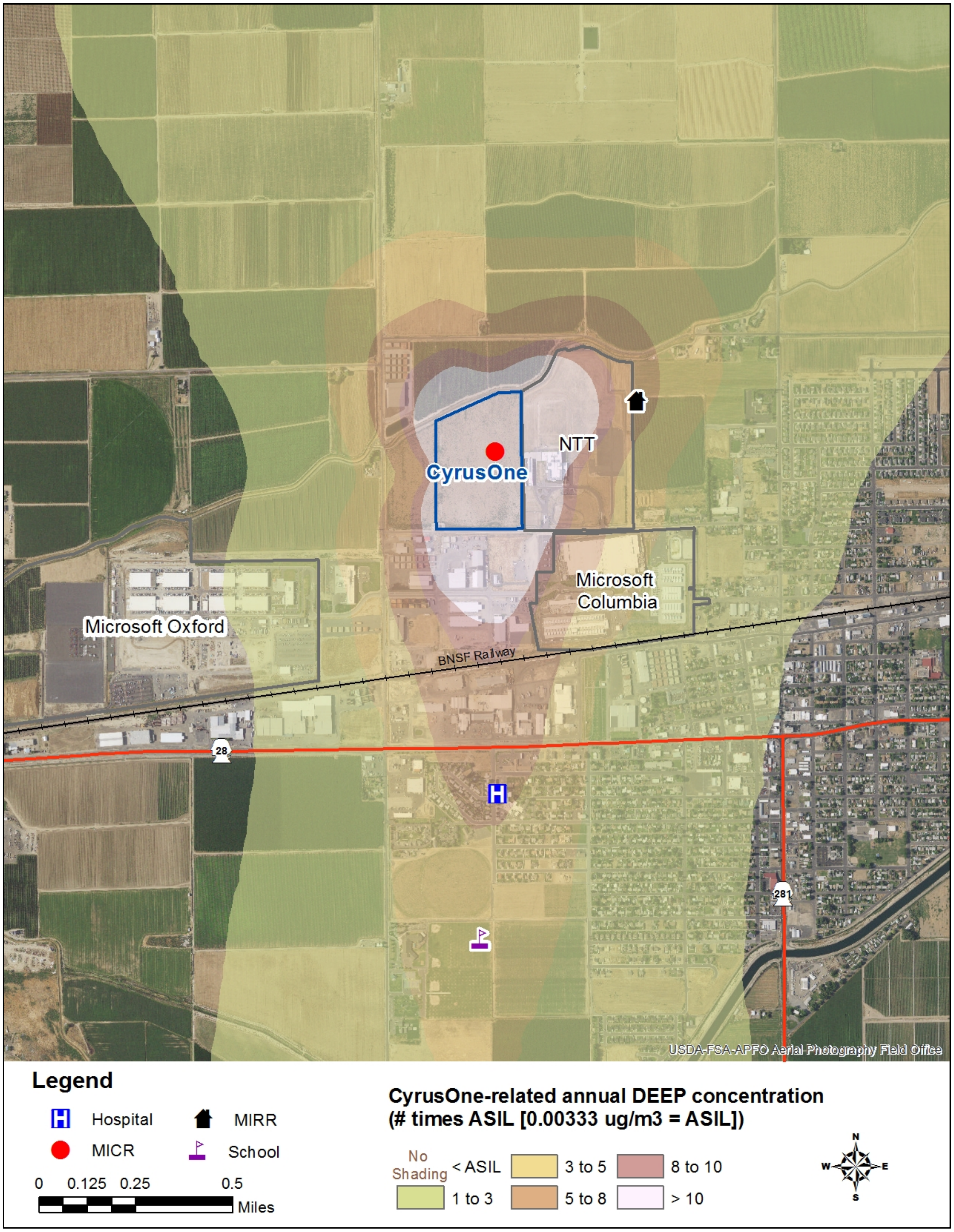

Figure 3: DEEP concentrations attributable to CyrusOne's engines and key receptor locations evaluated in the HIA. Concentrations reported as the number of times greater than the ASIL

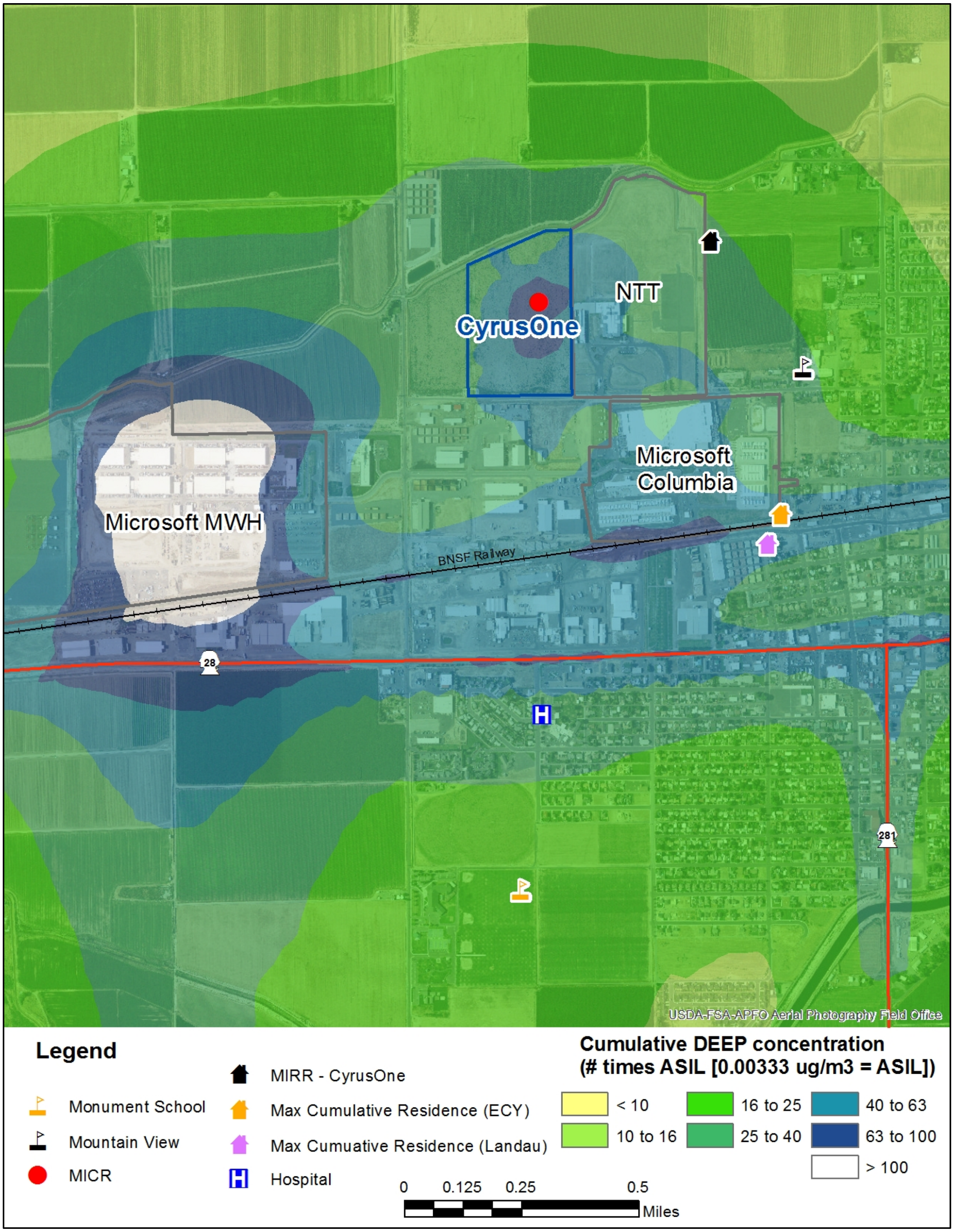

Figure 4: Cumulative DEEP concentrations near CyrusOne. Concentrations reported as the number of times higher than the ASIL

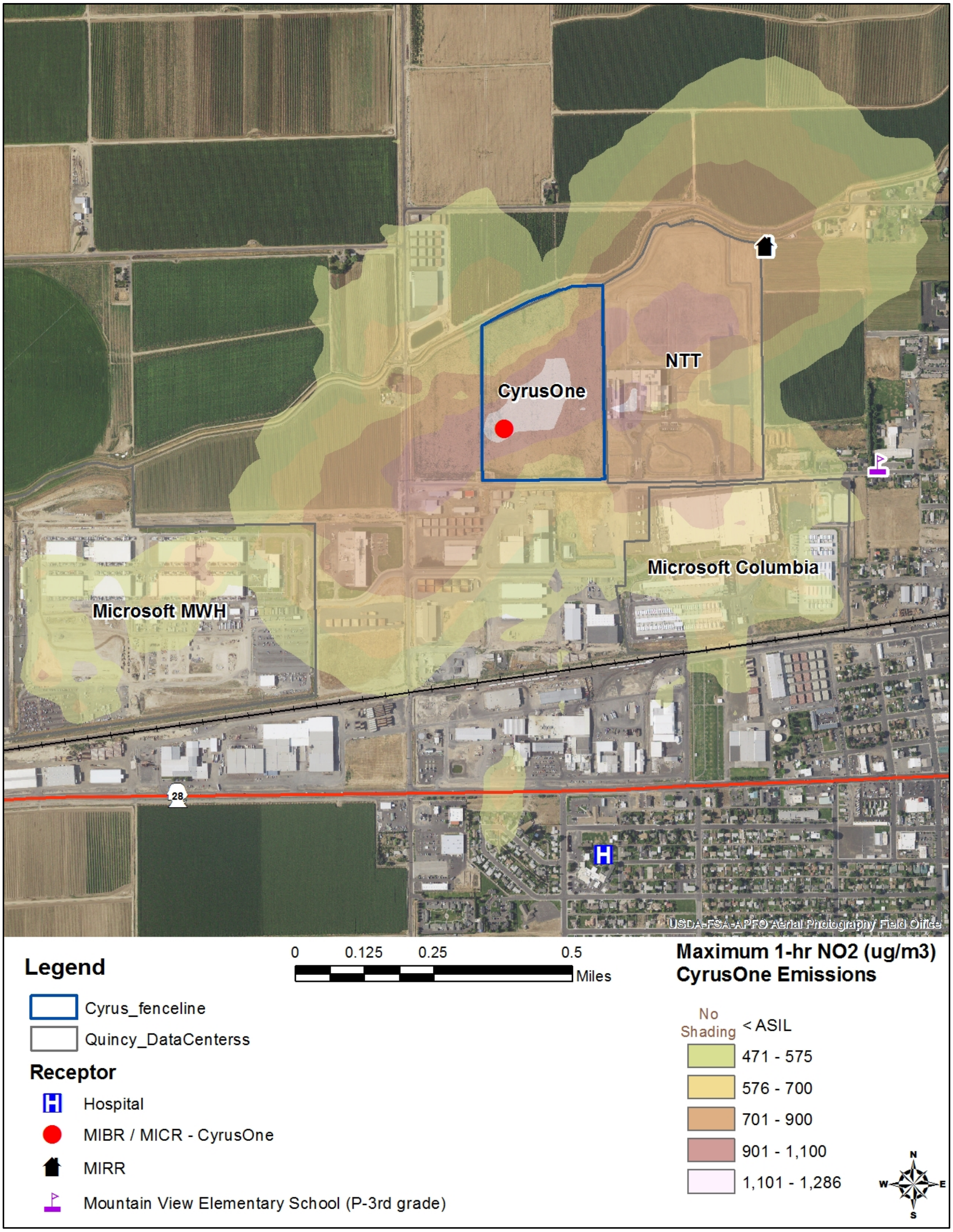

Figure 5: Maximum NO_2 concentrations attributable to CyrusOne outage emissions and key receptor locations evaluated in the HIA

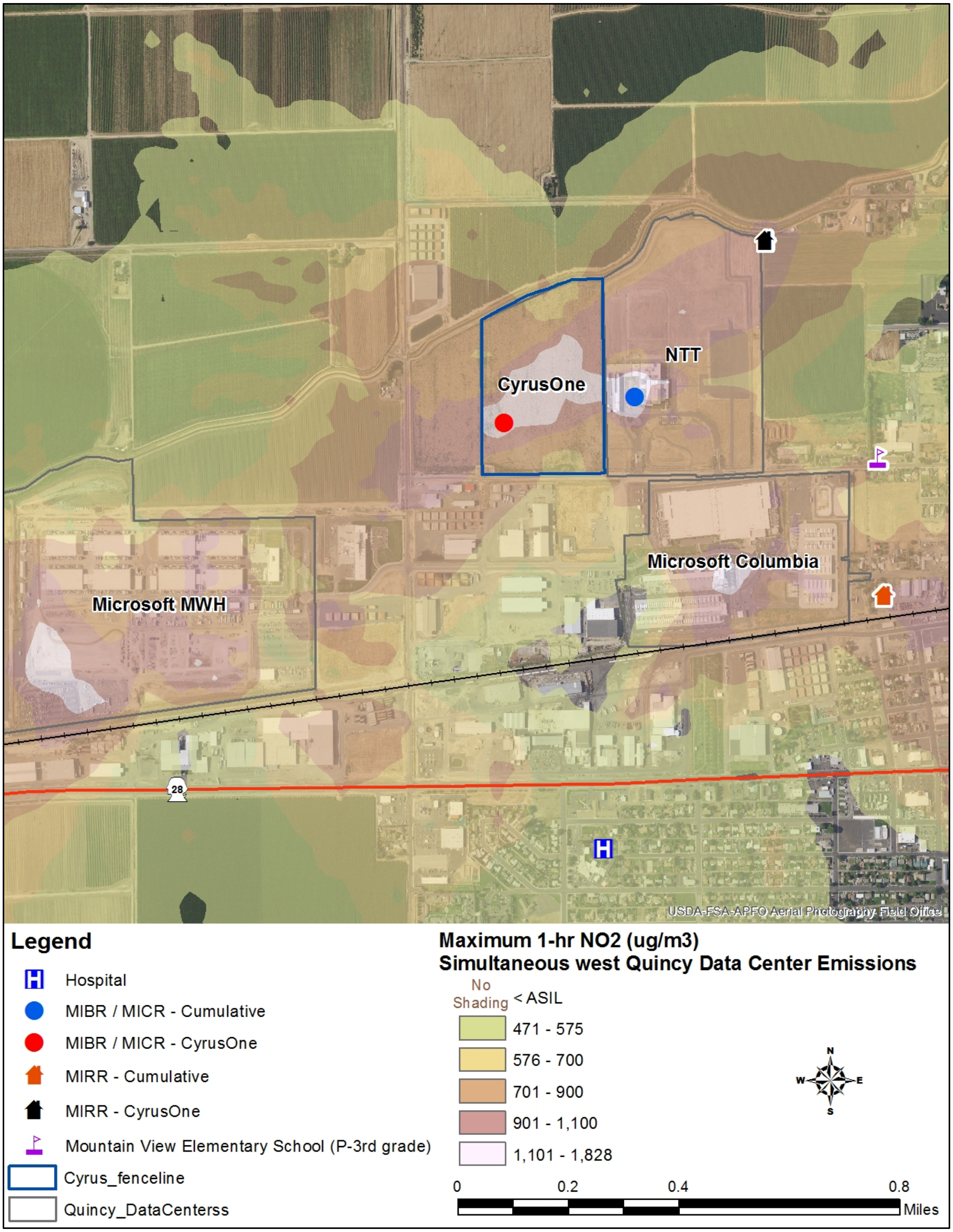

Figure 6: Maximum NO_2 concentrations attributable to simultaneous west side Quincy outage emissions and key receptor locations evaluated in the HIA

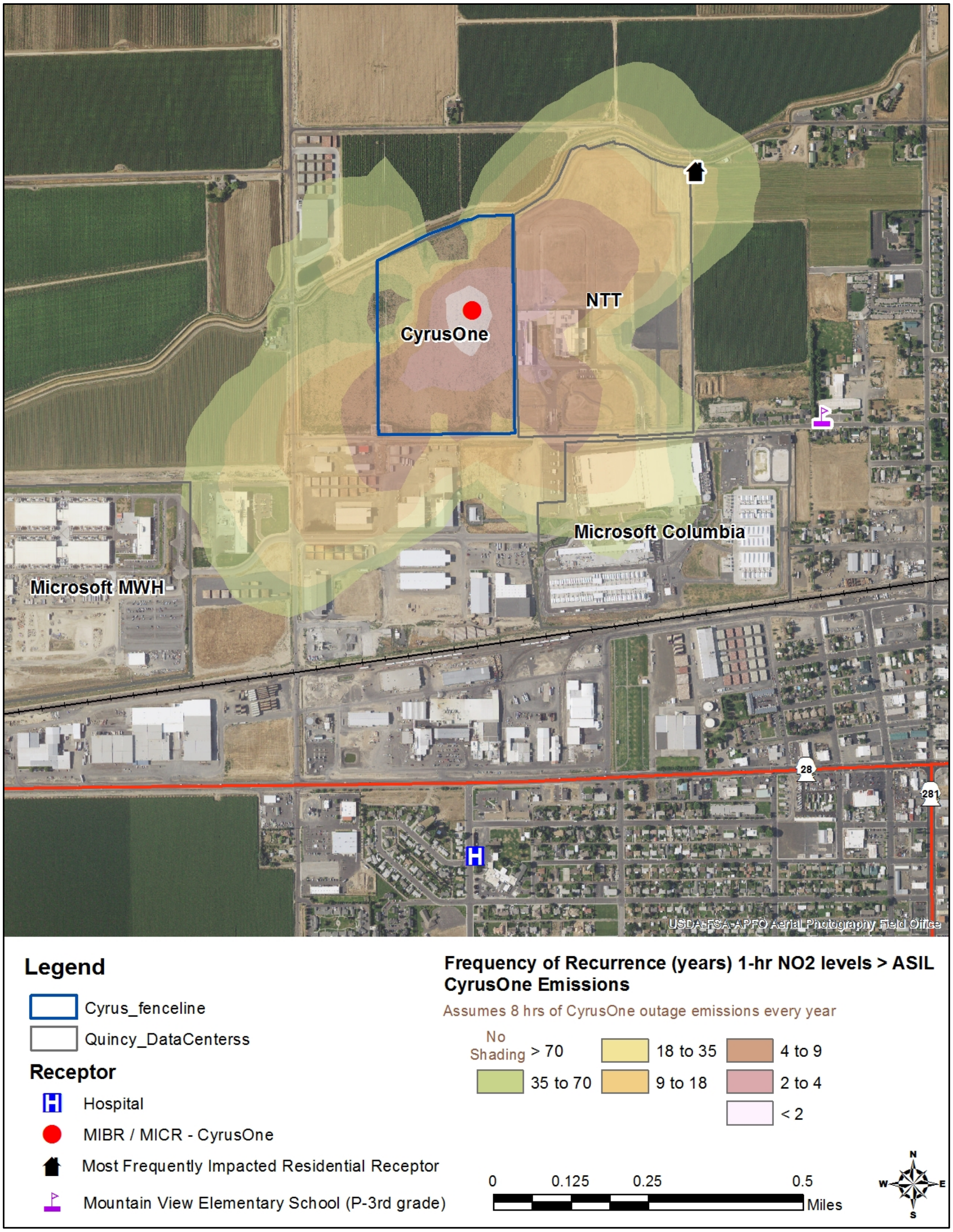

Figure 7: Estimated time interval (years) between occurrences of 1-hr NO_2 concentrations greater than 454 µg/m^3 assuming eight hours of CyrusOne data center emergency engine outage emissions per year

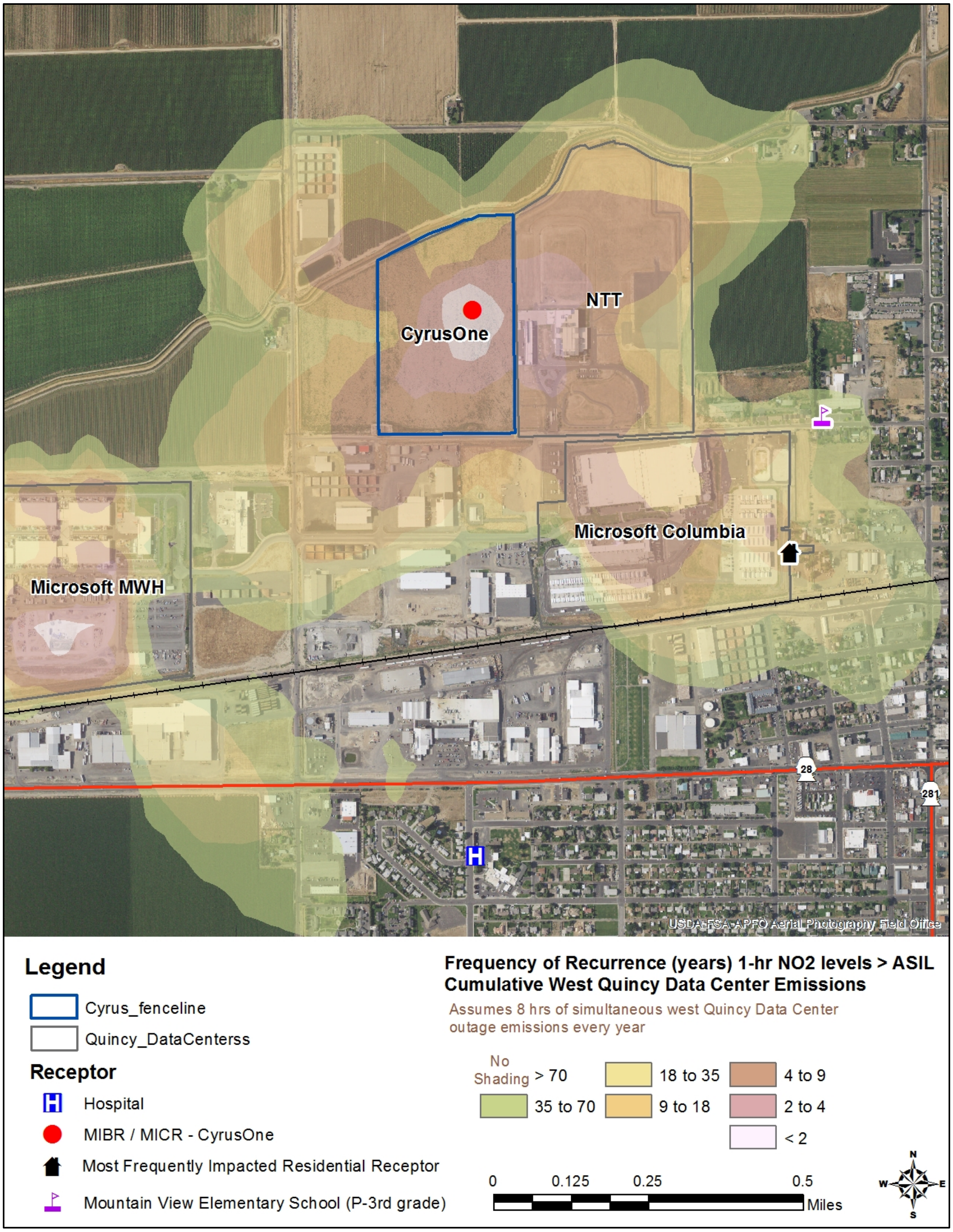

Figure 8: Estimated time interval (years) between occurrences of 1-hr NO_2 concentrations greater than 454 μg/m^3 assuming eight hours of simultaneous west side data center emergency engine outage emissions per year