Health Impact Assessment Recommendation Document for

Hanford Site Water Systems Upgrades
Hanford area, Washington

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For the

Air Quality Program

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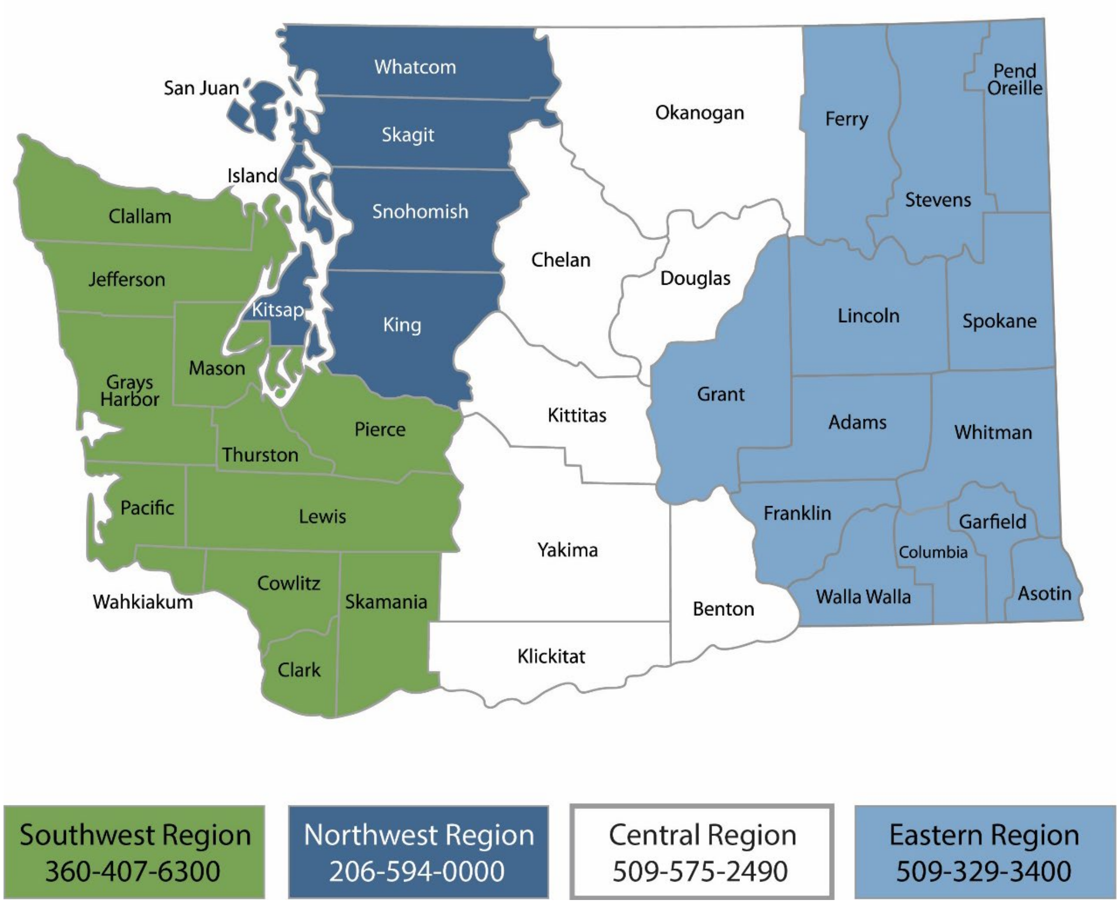

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DEPARTMENT OF
ECOLOGY
State of Washington

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Executive Summary

This Health Impact Assessment (HIA) review evaluates and summarizes the health risks from air pollutants emitted by proposed Hanford Site Water Systems upgrades. In general, the toxic air pollutant impacts in the area will not result in excessive risks of short- or long- term health effects. Ecology concludes that the health risk is acceptable and recommends approval of the project.

The U.S. Department of Energy, Richland Operations Office (RL) is planning various infrastructure upgrades to the Hanford Site Export Water, Raw Water, and Sanitary Water Systems (i.e., Hanford Site Water Systems). These will support ongoing and planned operations on the Hanford Site. Among the proposed new emission units are six diesel engine powered emergency generators, two potable water storage tanks, and one set of wastewater sludge lagoons (from water system backwash). The potable water and wastewater sludge will emit small amounts of chloroform. The diesel engines (Table 1) will emit other toxic air pollutants (TAPs) including two: diesel particulate matter (DPM) and nitrogen dioxide (NO2) that pose higher health risks than the other TAPs they will emit.

Table 1: Water systems upgrade projects proposed installations and operations

Project ID	Description	Rated Capacity (kWe)	Approx. Engine Power (bhp)
L895	Standby Generator	1,250	1,829
L897	Standby Generator	750	1,112
L781 Feed Pump	Feed Pump Building Standby Generator	400	617
L781 Pump House	181 D Pump House	2,500	3,352
L826 Pump House	181 B Pump House	2,500	3,352
L849	282EC Standby Generator	1,250	1,881

Kilowatt hours (kWe) Brake horse power (bhp)

The proposed engines are not expected to operate frequently. Planned operation for routine testing, maintenance, and inspection purposes of the engines powering the emergency generators is not expected to exceed to 55 hours per year, and annual emission calculations in this analysis are based on that interval [DOE/RL-2020-33 Rev. 0]. The engines may emit DPM and NO2 at rates requiring a HIA. The HIA submitted by RL describes the increased health risks from exposure to TAPs from these new sources.

RL hired Ramboll US Consulting, Inc. (Ramboll) to prepare a HIA of emissions of the Hanford Site Water Systems TAPs.

Conclusions

- Potential for effects from brief exposures:
    - Diesel engine exhaust contains chemicals in the gas phase, one of which is NO2. Short-term exposures to it can produce irritation of the airways, which can exacerbate respiratory diseases such as asthma and increase symptoms such as coughing, wheezing, and difficulty breathing.
    - The weather conditions conducive to poor dispersion may coincide with operation of the diesel engines sometimes causing higher concentrations of NO2. Meteorological data collected in the Hanford area indicate that poor dispersion conditions occur only infrequently. Engine operations are expected to be infrequent, as well. Therefore, hazardous concentrations are not likely to occur often or to be sustained for long periods. The highest model-estimated NO2 concentration - if all six engines had run continuously beginning in 2015 and through 2019 - was 670-µg/m3 averaged over a 1-hour period for a single hour during the modeled 5-year period (hazard quotient = 1.4). Modeling showed this to be at a point inside an ~1800-m2 area where concentrations would be >470-µg/m3 (its Acceptable Source Impact Level (ASIL)), averaged over a 1-hour period for at least 1-hour during the modeled 5-year period.
    - Aside from the NO2, the other chemical constituents of diesel engines exhausts are unlikely to result in concentrations high enough to pose respiratory system or other health risks.
- Potential for effects from long-term exposures:
    - Diesel engine exhaust contains particles composed of complex mixtures of solid and liquid phase chemicals. The particles from the proposed engines could increase lifetime cancer risk in the worst-case by up to 7-in-one-million at a location near one of the engines (Project L-826) next to the 181-B Pump House. Worst-case increases lifetime cancer risks in residential areas and workplaces adjacent to the Hanford site are much less than 1-in-one-million.
    - In contrast, the worst-case lifetime cancer risk increase due to exposure to diesel particles from mobile engine sources in the Hanford not part of this permit application may be up to 31.2 per million . The Washington Tracking Network reports the diesel pollution burden in the area is low.[2]

Ecology's recommendation

Ecology recommends approval of the Hanford Site Water Systems upgrades because:

- Ecology determined that the emission controls proposed for the new emission units are the *best available control technology for toxics* (tBACT).

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[2] https://fortress.wa.gov/doh/wtn/WTNIBL/ accessed Feb.11, 2021

- The applicant demonstrated 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 (10 in one million).
- Ecology determined that non-cancer hazards are acceptable.

Second Tier Review Processing and Approval Criteria

RL and Ramboll completed and submitted the documents and related information required for Ecology to conduct a Second Tier Review process and to confirm approval criteria under WAC 173-460. Ecology is responsible for reviewing Second Tier Review petitions.

Second Tier Review processing requirements

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

(a) The permitting authority has determined that other conditions for processing the NOC Order of Approval (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 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 July 14, 2021.[3] Ecology approved an HIA protocol (item (c)),[4] Ecology confirmed that refined modeling (item (d)) was conducted appropriately,[5] and Ecology received an acceptable HIA (item (e)) on February 3, 2021.[6]

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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[3] Approval Order No. DE19NWP-001

[4] From Matthew Kadlec, to Tanya Williams, Subject: RE: MSA Water Systems HIA Protocol - for review [received by Ecology December 2, 2020], Sent: December 15, 2020

[5] From: Ranil Dhammapala, , to: Matthew Kadlec, and Matt Williams, Subject: Notice of Construction Application and Second Tier Review for Hanford Site Water Systems Upgrade, Sent: February 22, 2021

[6] Attachment 3, 21-ESQ-000366, Second Tier Review Supporting DOE/RL-2020-33, Water Systems Upgrade Notice of Construction Application Technical Information

(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 Hanford's proposed pollution control equipment satisfies the BACT and tBACT requirement for diesel engines powering backup generators (Ecology 2021). Generally tBACT was determined to be met through restricted operation of U.S. Environmental Protection Agency (US EPA) Tier-2 (for the 20 – 2.75 MW diesel engine-powered emergency generator sets) and Tier-3 (for the 2 - 300 kW diesel engine-powered emergency generator sets) 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.

And by restriction of Maximum Non-Emergency Operation times to 55 Hours/Calendar Year for each engine.

The HIA itself proposed pollution control equipment noted as follows:

> *"Best Available Control Technology for Toxics per WAC 173-460-060, "Control technology requirements," new or modified sources that increase TAP emission rates must employ Best Available Control Technology for toxics (tBACT). Table 1. Water systems upgrade projects proposed installations and operations:*
>
> *In the NOC application submitted to Ecology, DOE proposed that tBACT for the diesel engines that would power the proposed emergency generators is:*
>
> - *Tier 2 engine certification for engines with a rated power output greater than 751 bhp*
> - *Tier 3 engine certification for engines with rated power outputs of between 100 and 751 bhp*
> - *Exclusive combustion of ultra-low sulfur diesel (ULSD), and use of proper operation and maintenance procedures recommended by the engine manufacturer."*

Table 2: Water systems upgrade projects proposed tBACT

Project ID	Description	Approx. Engine Power (bhp)	Proposed tBACT
L895	Standby Generator	1,829	Tier 2 engine certification
L897	Standby Generator	1,112	Tier 2 engine certification
L781 Feed Pump	Feed Pump Building Standby Generator	617	Tier 3 engine certification, ultra-low sulfur diesel only, and operation and maintenance procedures as recommended by the engine manufacturer
L781 Pump House	181-D Pump house	3,352	Tier 2 engine certification
L826 Pump House	181 B Pump House	2,500	3,352
L849	282EC Standby Generator	1,250	1,881

Health Impact Assessment Review

WAC 173-460-090 requires permit applicants to prepare a HIA. Then an Ecology engineer, toxicologist, and modeler review it to determine if the methods and assumptions are appropriate for assessing and quantifying risks to the surrounding community from a new project.

The Water Systems upgrades may emit 22 of the TAPs in listed WAC 173-460-150. Of these, 13 may be emitted at rates at or below their respective de minimis levels, therefore they are exempt from further First Tier review under WAC 173-460-080. Emission rates of the others (Benzene, Benzo[a]pyrene, Benzo[b]fluoranthene, Chloroform, Dibenz[a,h]anthracene, DPM, Formaldehyde, Naphthalene, NO2) may exceed their de minimis levels, therefore a t-BACT analysis was conducted. Based on the tBACT accepted by Ecology, the emission rates were re-quantified and then compared to their SQER values. For those that could still be emitted at rates greater than their SQERs (Benzene, Chloroform, DPM, Naphthalene, and NO2), the maximum modeled off-site concentrations were estimated by air dispersion modeling. This modeling suggested concentrations of NO2 and DPM could exceed their ASILs. Therefore a Second Tier Analysis Health Impact Assessment to assess potential health hazards and limit public health risks was required under WAC 173-460-090.

Ramboll also quantified emissions and exposure to naphthalene and benzene to evaluate their potentials to increase the health risks of DPM and NO2.

The potable water to be handled in the upgraded systems has multiple uses at Hanford, including fire suppression. Chloroform, a probable human carcinogen, is a contaminant of potable water that may be emitted by the potable water tank vents, pipelines, and hydrants that are components of the Water Systems upgrades. The NOC included chloroform as a regulated pollutant from the water tanks but chloroform from the water tanks was excluded from the HIA as a result of the large distance (> 13-Km) separating the water tanks from the engines: The highest modeled concentration of chloroform at the ambient air boundary was 7.00E-5 µg/m3 – more than 600 times less than its ASIL so it was not necessary to quantify its risk. Further, the portion of the water for fire suppression is exempt from New Source Review under WAC 173-400-110(4)(h)(xxii).

Health effects summary

The HIA prepared by Ramboll mainly quantifies the non-cancer hazards and increased cancer risks attributable to Hanford's DPM and NO2 emissions.

Diesel Particulate Matter health effects summary

Diesel engines emit particles <2.5 micrometers (µm) in diameter, which easily enter deep into the lung when inhaled. A range of mild to life-threatening effects has been associated with exposure of various durations and concentrations of DPM.[7] Exposure to DPM in controlled laboratory animal studies has demonstrated its carcinogenicity. Epidemiological evidence among occupationally exposed people, although lacking in well-quantified exposure levels, suggests diesel exhaust may cause lung and bladder cancer. The International Agency for Research on Cancer (IARC) designated DPM as a probable (Group 2A) carcinogen in humans based on sufficient evidence in experimental animals and limited evidence in humans[8]. In the Health Assessment Document for Diesel Engine Exhaust, US EPA Office of Research and Development states that diesel exhaust is a probable human carcinogen[9]. At exposure levels significantly higher than those that may cause cancer, DPM can cause a range of other toxic effects including respiratory illnesses, reproductive, developmental, and immune system impairments. Specifically:

- eye, nose, and throat irritation along with coughing, labored breathing, chest tightness, and wheezing associated with inflammation and irritation
- worsening of allergic reactions to inhaled allergens
- increased likelihood of respiratory infections
- asthma attacks and worsening of asthma symptoms
- decreased lung function
- impaired lung growth in children
- heart attack and stroke in people with existing heart disease
- male infertility

[7] Washington Dept. of Ecology. 2008. *Concerns about Adverse Health Effects of Diesel Engine Emissions.* https://apps.ecology.wa.gov/publications/documents/0802032.pdf, accessed on February 23, 2021

[8] International Agency for Research on Cancer. 1989. *Diesel and Gasoline Engine Exhausts and some Nitroarenes*, IARC Monographs on the Evaluation of Carcinogenic Risks to Humans: Vol 46, World Health Organization, Lyon, France

[9] U.S. Environmental Protection Agency Office of Research and Development. 2002. *Health Assessment Document for Diesel Engine Exhaust.* National Center for Environmental Assessment, Washington, D.C., EPA/600/8- 90/057F, 2002, http://cfpub.epa.gov/ncea/cfm/recordisplay.cfm?deid=29060, accessed on February 23, 2021

- birth defects

Nitrogen dioxide health effects summary

NO2 is present in diesel exhaust. It forms when nitrogen, in diesel fuel and air, combines with oxygen. Exposure to NO2 can cause both long-term (chronic) and short-term (acute) health effects.

Long-term exposure to NO2 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 µg/m3) of NO2 may result in serious effects including death (National Research Council, 2012)[10]. Moderate levels (~ 30,000 µg/m3) may severely irritate the eyes, nose, throat, and respiratory tract, and cause shortness of breath and extreme discomfort. Lower level NO2 exposure (< 1,000 µg/m3), such as that experienced near major roadways, or perhaps downwind from stationary sources of NO2, may cause increased bronchial reactivity in some people with asthma, decreased lung function in patients with chronic obstructive pulmonary disease, and increased risk of respiratory infections, especially in young children.

Toxicity reference values

Agencies develop toxicity values for evaluating exposures and characterizing risks from chemicals in the environment. As part of the HIA, Ramboll identified appropriate toxicity values for DPM and NO_2.

DPM toxicity values

Toxicity values for DPM are available from the US EPA,[11] and from the California EPA Office of Environmental Health Hazard Assessment (OEHHA).[12]

These toxicity values were derived from studies of animals exposed to known amounts of DPM, and epidemiological studies of occupationally exposed humans. They are estimates of exposure levels at or below which adverse non-cancer health effects are not expected, and of a

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[10] National Research Council: Committee on Acute Exposure Guideline Levels; Committee on Toxicology; Board on Environmental Studies and Toxicology; Division on Earth and Life Studies (2012), The National Advisory Committee for the Development of Acute Exposure Guideline Levels for Hazardous Substances (AEGL Committee), Acute Exposure Guideline Levels for Selected Airborne Chemicals: Volume 11 <http://www.epa.gov/sites/production/files/2015-09/documents/nitrogen_oxides_volume_11_1.pdf>

[11] United States Environmental Protection Agency, Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part F, Supplemental Guidance for Inhalation Risk Assessment), January 2009 <https://www.epa.gov/sites/production/files/2015-09/documents/partf_200901_final.pdf>

United States Environmental Protection Agency, 2014 National Air Toxics Assessment, Released to the Public on August 22, 2018 < https://www.epa.gov/national-air-toxics-assessment >

[12] California Environmental Protection Agency, Office of Environmental Health Hazard Assessment, Air Toxicology and Epidemiology Section. For the "Proposed Identification of Diesel Exhaust as a Toxic Air Contaminant" Part B: Health Risk Assessment for Diesel Exhaust. May, 1998 <https://oehha.ca.gov/media/downloads/air/document/partb.pdf >

metric by which to quantify increased risk from exposure to a carcinogen. Table 1 shows the appropriate DPM non-cancer and cancer toxicity values used by Ramboll.

EPA's reference concentration (RfC) and OEHHA's reference exposure level (REL) for diesel engine exhaust (measured as DPM) 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 DPM in air at which long-term exposure is not expected to cause adverse non-cancer health effects.

OEHHA derived a unit risk factor (URF) for estimating cancer risk from exposure to DPM. The URF is based on a meta-analysis of several epidemiological studies of humans occupationally exposed to DPM. In these studies, DPM exposure was estimated from measurements of filterable fractions of elemental carbon and respirable particulate in diesel exhaust. Therefore, some condensable particulate matter may have been excluded when assessing health risks; however, the OEHHA URF is based on the most commonly used measure of the atmospheric concentration of particles: The mass of particles collected on a filter per volume of the air that flowed through the filter. This exhaust fraction contains filterable solid and condensed liquids. Concentrations DPM defined this way was considered when determining the Hanford Site Water Systems Upgrade application NOC's compliance with the National Ambient Air Quality Standards and in the HIA.

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 DPM is 0.0003 per $\mu g/m^3$ meaning that a lifetime of exposure to 1 $\mu g/m^3$ of DPM could increase an average person's risk of developing cancer by 0.03 percent, or cause 300 cancer cases per million people exposed.

NO_2 toxicity values

OEHHA developed an acute REL for NO2 based on studies its effects on humans.[13] These studies found that some people with asthma experienced increased airway reactivity following inhalation of about 0.25 ppm of NO_2 (470 $\mu g/m^3$, 24-hour average, the ASIL).

The US EPA has promulgated annual and 1-hour National Ambient Air Quality Standards (NAAQS) for NO_2. Compliance with these NAAQS was demonstrated as part of the NOC application process for the water systems upgrades (Ecology 2021).

The Washington State Department of Labor and Industries has established a Permissible Exposure Level - Short-term exposure limit for workers of 1-ppm or 1880-µg/m3 NO_2 for fifteen-minute exposure periods (WAC 296-841-20025). This is noteworthy herein but not intended for protection of the general public.

[13] California Environmental Protection Agency, Office of Environmental Health Hazard Assessment, "Technical Support Document for Noncancer RELs Appendix D2: Acute RELs and toxicity summaries using the previous version of the Hot Spots Risk Assessment guidelines," December 2008, <https://oehha.ca.gov/media/downloads/crnr/appendixd2final.pdf>

Benzene and naphthalene toxicity values

As noted before, dispersion modeling of the TAP emissions that exceeded their SQERs indicated benzene, chloroform, and naphthalene would not exceed their ASILs. The chloroform that could be emitted from the potable water used in the water systems upgrades would be far less than its ASIL and the portion for fire suppression is exempt from review. The benzene and naphthalene in the diesel engine exhausts volatilize then separate from the solid phase exhaust particles over time at rates dependent on temperature. The ASIL-level risk impact areas extend less than 5000-feet in any direction from the engines (Figures 1 and 2), therefore the extent of benzene and naphthalene volatilization from DPM is not likely to be significant in these areas.

Ramboll evaluated increased cancer risks from benzene and naphthalene as separate from DPM using URFs promulgated by the California EPA OEHHA and the US EPA: For benzene an OEHHA URF of 2.90E-05 $(\mu g/m^3)^{-1}$, and the EPA-recommended URF range of 2.20E-06 to 7.8E-06 $(\mu g/m^3)^{-1}$; and for naphthalene the OEHHA URF of 3.4E-05 $(\mu g/m^3)^{-1}$.

Ramboll evaluated the non-cancer health hazards of benzene and naphthalene separately from DPM using risk-based concentrations promulgated by the OEHHA, the US EPA, and the US Department of Health and Human Services Agency for Toxic Substances and Disease Registry (ATSDR). For benzene the EPA reference concentration (RfC) 30-$\mu g/m^3$, the OEHHA Acute reference exposure level (REL) 27-$\mu g/m^3$, the 8-Hour REL 3-$\mu g/m^3$, and the Chronic REL 3-$\mu g/m^3$; the ATSDR Acute minimum risk level (MRL) 29.2-$\mu g/m^3$, the 8-Hour MRL 19.5-$\mu g/m^3$ and the Chronic MRL 9.74-$\mu g/m^3$. For naphthalene, the OEHHA Chronic REL 3-$\mu g/m^3$, and the ATSDR Chronic MRL 3.73-$\mu g/m^3$.

Community/receptors

Ramboll assessed appropriate receptors and locations where the highest exposures to water systems upgrade-emitted air pollutants could occur.

Aside from DOE-operated facilities, no commercial buildings are within the modeled ASIL exceedance areas. Likewise, no existing residential buildings or residential land-use zones are within the modeled ASIL exceedance areas. Benton and Grant county land-use zoning and comprehensive plan maps indicate the entire area within 5-Km of L781PH and L826PH is designated as Hanford Federal Reserve.

Typically, HIAs evaluate maximally-impacted boundary receptor (MIBR) locations where the highest concentration of TAPs of interest could occur near an ambient air perimeter boundary to publicly-accessible land. In this case, the proposed L781PH and L826PH generator sets will be outside of the ambient air boundary so Ramboll evaluated short-duration periodic exposures at the maximally-impacted receptor (MIR). DOE employees or contractors are more likely than members of the public to be present periodically at the MIR.

Ramboll also evaluated the maximally-impacted angler receptors (MIAR) to account for potential exposures to people fishing in the Columbia River. Specifically those participating in the Pikeminnow Sport Reward Fishery Program, which is funded by the Bonneville Power Administration and administered by the Pacific States Marine Fisheries Commission. The Program pays anglers for each Northern Pikeminnow caught.

Ramboll also evaluated project-attributable exposures that could occur at places children or elderly people or people with respiratory illnesses are likely to be. No daycares, preschools, K-12 schools, convalescent homes, or hospitals are located less than 13-miles from the water systems upgrade generator sets in any direction.

Exposure assessment

Ramboll evaluated prolonged and frequent project-attributable pollutant exposure times. The durations (Table 3.) they used to evaluate cancer risks are sufficient for estimating the most extreme residential, commercial, angler, and MIR exposure scenarios.

Table 3: Exposure durations used to evaluate cancer risks

Exposure parameter	Resident	Commercial/industrial worker	Angler	Maximum receptor
Exposure time (hours per day)	24	8	4	2
Exposure frequency (days/year)	350	250	180	250
Exposure duration (years)	70	40	30	30
Averaging time (hours) (70 years x 365 days/year x 24 hrs/day)	613,200	613,200	613,200	613,200
Fraction of 70-year continuous exposure	0.959	0.130	0.0352	0.0245

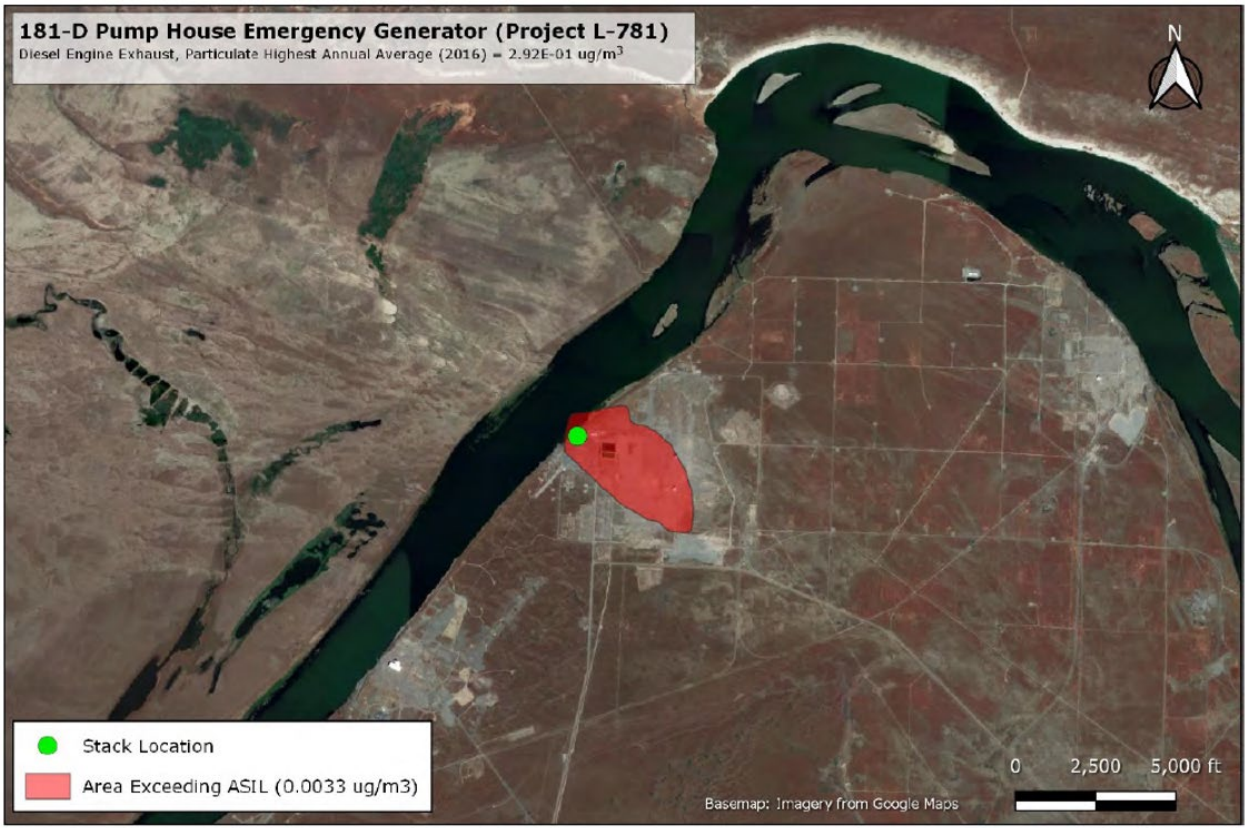

Figure 1: Modeled DPM > ASIL near Pump house 181-D

Highest annual average (2016) 2.92E-01-µg/m^3[14]

[14] Figure 7-3 of 000366_Attachment 2 (DOE-RL-2020-33_FINAL)

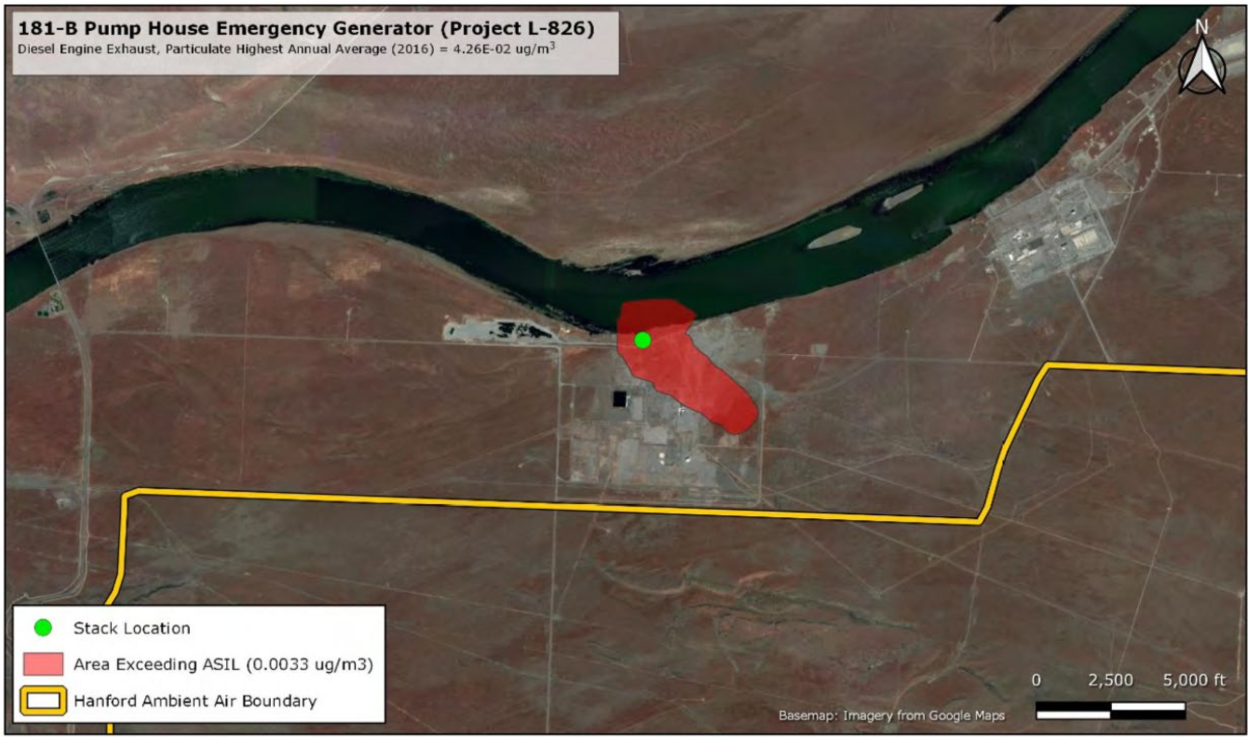

Figure 2: Modeled DPM > ASIL near Pump house 181-B

Highest annual average (2017) 4.26E- µg/m3[15]

[15] Figure 7-4 of 000366_Attachment 2 (DOE-RL-2020-33_FINAL)

Figure 3: Modeled NO2 > ASIL near Pump house 181-D

Highest 1-hour average (in 2019) 670 µg/m^3[16]

Figures 1, 2 and 3 show the greatest DPM and NO2 impact areas adjacent to 181-D and 181-B pump houses that could result from the proposed water systems upgrade diesel engines. The system upgrades did not exceed ASILs anywhere else.

[16] Figure 7-5 of 000366_Attachment 2 (DOE-RL-2020-33_FINAL)

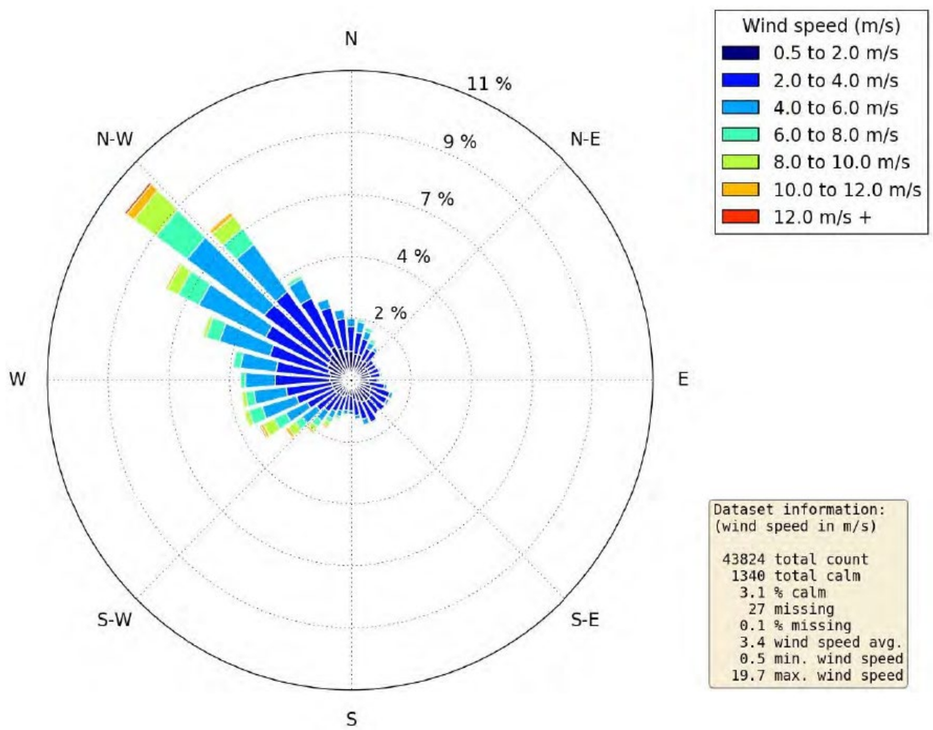

Figure 4: Hanford Meteorological Station wind rose for 2015 through 2019

It is possible that people with heightened sensitivity to NO2 - such as some people with asthma - could suffer short high exposures near one of the proposed engines. However, these engines are in a remote location and they are not expected to operate frequently, which decreases the chance they will be operating the ~1% of the time when wind direction and speed 17(as shown in Figure 4), which does not favor dispersion, therefore creating conditions for high NO2 concentrations.

Health risks

Ramboll assessed the increased lifetime risk of cancer from exposure to DPM, benzene, and naphthalene emitted from the water system upgrades engines, and the cumulative risks posed by them with the existing levels of these TAPs from other sources in the area.

For the risk characterization, the results of the exposure and toxicity assessments were integrated into quantitative estimates of potential health hazards. Cancer risk and non-cancer hazard estimates were quantified for the MIRR, MICR, MIR, and MIAR.

Increased risks of cancer attributable to Water Systems Upgrades emissions and existing diesel engine sources

[17] Figure 4-2 of Attachment 3, 21-ESQ-000366, Second Tier Review Supporting DOE/RL-2020-33, Water Systems Upgrade Notice of Construction Application Technical Information

Cancer risks were estimated in a manner consistent with EPA guidance for inhalation risk assessment [18] using the following equations:

Risk Increase = IUR x EC

Where: IUR = Inhalation Unit Risk (Unit Risk Factor) $(\mu g/m^3)^{-1}$

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

EC = (CA x ET x EF x ED) ⁄ AT

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

ET = exposure time (hours/day)

EF = exposure frequency (days/year)

ED = exposure duration (years)

AT = 70 (average lifetime years)

By applying the available URFs noted in the *Toxicity reference values* section of this review, Ramboll estimated the increases in cancer risks that could result from emissions by the water systems upgrades diesel engines. They also estimated the increased cancer risks from existing diesel engine sources affecting the Hanford area. They evaluated cancer risks attributable the modeled concentrations of emissions from the water systems upgrades diesel engines, and attributable to background concentrations in the appropriate census tracts using data from the latest US EPA *National Ambient Toxics Assessment* (NATA)**.** [19] [20]

Where available, the cancer risk attributable to background concentrations were added to the calculated cumulative cancer risk increases attributable to the project emission increases.[21]

NATA estimates of the annual average concentrations of benzene range from 0.188 to 0.193-$\mu g/m^3$ in census tracts in area of the water systems upgrades diesel engines. Likewise, the annual average concentrations of naphthalene in those tracts range from 0.0243 to 0.0331-$\mu g/m^3$, and the annual average concentrations of DPM range from 0.0799 to 0.104-$\mu g/m^3$. The highest estimated annual average DPM is in the tract covering the Hanford site, itself.

Table 4 shows the estimated increase in lifetime cancer risks to people exposed at locations where modeled DPM concentrations are greater than the ASIL.

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[18] United States Environmental Protection Agency, Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part F, Supplemental Guidance for Inhalation Risk Assessment), January 2009, <https://www.epa.gov/sites/production/files/2015-09/documents/partf_200901_final.pdf>

[19] United States Environmental Protection Agency, 2014 National Air Toxics Assessment. Released to the Public on August 22, 2018. < https://www.epa.gov/national-air-toxics-assessment >

[20] Background Concentration section of Attachment 3, 21-ESQ-000366, Second Tier Review Supporting DOE/RL-2020-33, Water Systems Upgrade Notice lf Construction Application Technical Information

[21] Risk Characterization section of Attachment 3, 21-ESQ-000366, Second Tier Review Supporting DOE/RL-2020-33, Water Systems Upgrade Notice lf Construction Application Technical Information

Table 4: Estimated increase in lifetime cancer risks at locations where modeled DPM concentrations are greater than the ASIL

Receptor	Pollutant	Project: US EPA	Project: OEHHA	Project + background US EPA	Project + background OEHHA
Maximum impact receptor	Benzene	3E-10 to 1E-9	4E-9	1E-8 to 4E-8	1E-7
	DPM	7E-8 to 7E-6	2E-6	1E-7 to 1E-5	3E-6
	naphthalene	--	8E-10	--	2E-8
Cancer risk sum		7E-8 to 7E-6	2E-6	1E-7 to 1E-5	3E-6
Maximum impact angler	Benzene	5E-11 to 2E-10	7E-10	1E-8 to 5E-8	2E-7
	DPM	1E-8 to 1E-6	4E-7	5E-8 to 5E-6	1E-6
	naphthalene	--	1E-10	--	3E-8
Cancer risk sum		1E-8 to 1E-6	4E-7	6E-8 to 5E-6	2E-6

Adapted from table 8-2 of the HIA

Ramboll also calculated risks posed by the carcinogenic TAPs emitted by Water Systems upgrades diesel engines: DPM, benzene, and naphthalene. The increased cancer risk from benzene and naphthalene are at most 0.34% of the separately quantified cancer risk from DPM.

At the MIR, approximately 69% of diesel engine emissions cancer risk will be from the Water Systems upgrades engines, with the remainder from existing diesel engines' emissions. Likewise, at the MIAR, 19% of diesel emissions cancer risk will be from the Water Systems upgrades engines, the remainder from existing engines.

The highest possible increase in cancer risk attributable to the engines' emissions is seven per million at the maximally impacted point receptor (MIR) located next to Pump house 181-D (see Figure 1).

Cancer risk increases attributable to the water systems upgrades at the maximally impacted receptors are all predicted to be less than Ecology's project approval threshold of 1E-05. [22]

Increased risks of non-cancer health impacts attributable to Water Systems upgrades emissions and existing diesel engine sources

[22] 1E-5 is an upper-bound theoretical estimate of the number of excess cancers that might result in an exposed population of one hundred thousand people compared to an unexposed population of the same size. Alternatively, an average person's increase in risk of one in one hundred thousand means their lifetime chance of getting cancer increases by one in one in one hundred thousand (0.001 percent).

Ramboll assessed the increased non-cancer health hazards from exposure to TAPs emitted from the water system upgrades engines, and the cumulative hazards posed by them together with already-existing levels of these TAPs coming from other sources in the area.

For the risk characterization, the results of the exposure and toxicity assessments were integrated into quantitative estimates of potential health hazards. Non-cancer hazard estimates were quantified for the MIRR, MICR, MIR, and MIAR.

Ramboll assessed the non-cancer hazards from acute and chronic exposures to NO_2 and DPM emissions from the water systems upgrades engines and other sources.[23] They quantified the hazards in a way consistent with EPA guidance for inhalation risk assessment [24] using the following equation:

HQ = EC ⁄ Toxicity Value

Where: HQ = hazard quotient (unitless)

EC = exposure concentration (the contaminant concentration in air) (µg/m^3)

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

1-hour average concentration of NO_2 (669.8-µg/m^3) exceeded its ASIL. NO_2 and benzene are the only TAPs emitted that have 1-hour average RBC values.

As shown in Table 5, the hazard quotient of benzene at its maximum estimated 1-hour average concentration at the MIR (1.85-µg/m^3) was less than one. None of the other TAPs concentrations exceeded their ASILs in any modeled location or time average interval.

Annual average background concentrations estimates of benzene, DPM, and naphthalene in census tracts in and around the Hanford area were obtained from the latest US EPA *National Ambient Toxics Assessment* (NATA). [25, 26] NATA provides only annual averages, not other intervals' averages, so Ramboll evaluated the 1-hour average NO_2 concentration at the node closest to the MIR estimated by NW Airquest [27] as the background NO_2 concentration. It is

[23] Risk Characterization section of Attachment 3, 21-ESQ-000366, Second Tier Review Supporting DOE/RL-2020-33, Water Systems Upgrade Notice lf Construction Application Technical Information.

[24] United States Environmental Protection Agency, Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part F, Supplemental Guidance for Inhalation Risk Assessment), January 2009. <https://www.epa.gov/sites/production/files/2015-09/documents/partf_200901_final.pdf>

[25] United States Environmental Protection Agency, 2014 National Air Toxics Assessment. Released to the Public on August 22, 2018. < https://www.epa.gov/national-air-toxics-assessment >

[26] Background Concentration section of Attachment 3, 21-ESQ-000366, Second Tier Review Supporting DOE/RL-2020-33, Water Systems Upgrade Notice lf Construction Application Technical Information

[27] NW Airquest, accessed October 2020 < https://arcg.is/1jXmHH >

22.0-µg/m^3. Given the limited available data, use of these background concentration estimates from NATA and NW Airquest is appropriate.

Table 5 shows the water systems upgrades diesel engines (Project) and the Project plus Background concentrations hazard quotients and quotient sums (hazard indexes) at the only location where these are greater than unity (one). The other receptor locations and intervals are much lower than one, which together indicates that with only one exception, non-cancer health effects from exposure to diesel engine exhaust are very unlikely in the vicinity of the water systems upgrades.

Table 5: Non-cancer hazards quotients of the worst-case 1-hour exposures at the maximum impact receptor

Pollutant	Project: OEHHA	Project: ATSDR	Project + background OEHHA	Project + background ATSDR
Benzene	0.069	0.064	0.076	0.070
NO_2	1.4	-	1.5	-
Hazard Index	**1.5**	**0.064**	**1.5**	**0.070**

The hazard quotients and indexes at the MIR exceed unity, even without exposure to background benzene and NO_2. This indicates a potential respiratory system effect hazard from short-term exposure to the water systems upgrades emissions. NO_2 emissions comprise most of this hazard. The benzene emissions slightly add to it.

There is only a small chance NO_2 concentrations will actually reach high levels. NO_2 is a federal criteria air pollutant, so to assure compliance with its NAAQS, Ramboll modeled concentrations that could result from the proposed L781 and L826 Pump house engines. Assuming a background NO_2 concentration of 48.88-µg/m^3, they showed the probability of exceeding an ambient concentration of 139.12-µg/m^3 would be less than a 10% at any receptor in the modeled area.[28] Thus there is minimal potential for these engines to violate the NAAQS. If people happen to be exposed to concentrations greater than 470-µg/m^3 for an hour or more, those with existing respiratory illnesses may experience temporary chest tightness or labored breathing during physical exertion.

Uncertainty

Uncertainty may be defined as imperfect knowledge concerning the present and future conditions of a system under consideration. In risk assessments undertaken in support of regulatory decisions, there are many uncertainties. Identification of them allows us to assess the dependability of decisions.

Evaluating potential impacts of the water systems upgrades involves elements including pollutant emissions rates, air dispersion modeling, and resulting ambient concentrations and

[28] DOE/RL-2020-33 Rev. 0, Part 7.4.1

exposures, as well as exposure-response relationships to estimate the possibilities of different types of health impacts. Each of these elements is encumbered by uncertain science and measurement variability that prevents absolute confidence in predictions about adverse health impacts of this project.

To the extent that people may be exposed to emissions of TAPs from the proposed water systems upgrades, and despite the uncertainties in concentration estimates, exposure estimates, cancer potency estimates, and respiratory hazards, the potential health risks appear to be acceptable. Quantitative assessments of the effects of the diesel generators' emission impacts on human health cannot be made with greater confidence. The overall risk uncertainties are summarized in Table 6.

Table 6: Qualitative summary of how uncertainties affect the estimated risks and hazards

Source of Uncertainty	Effects on estimated risks and hazards
Emissions estimates	Likely to overestimate risks initially but to underestimate risk in coming decades
Concentration modeling	Possible underestimate of long-term risks and possible overestimate of acute risks
Exposure assumptions	Likely to slightly overestimate risks
Toxicity of emissions	Possible overestimate of cancer risk, and possible underestimate of non-cancer hazards for extremely sensitive people

Emissions uncertainty

Emissions uncertainty includes measurement uncertainty and process variability. The emissions factors used to estimate emission rates from the proposed new diesel engine generators are estimates of central tendency of measured emissions from comparable diesel engines. Ramboll used the EPA Tier 2 average emission limits as emission factors (EFs) for DPM and NO2. EFs for organic compounds and other TAPs emitted from large diesel engines are listed in EPA's AP-42. These EFs are just as likely to underestimate as to overestimate emissions. No quantitative description of uncertainty and variability consistent with available data is available.

Further uncertainty in the diesel generators emissions estimates comes from the increasing possibility of emergency operation of the diesel generators as increasing regional electricity demand [29,30,31] coincides with increasingly uncertain generation capacity from diminishing stream flows resulting from climate change.[32] Consistent hydroelectric power production over the next century in eastern Washington is uncertain. According to a study [33] by UW scientists:

> ". . . *substantial changes in the amount and seasonality of energy supply and demand in the PNW are likely to occur over the next century in response to warming, precipitation changes, and population growth. For the 2020s, regional hydropower production increases by 0.5-4% in winter, decreases by 9-11% in summer, with annual reductions of 1-4%. Slightly larger increases in winter, and summer decreases, are projected for the 2040s and 2080s*."

In general, it appears that the overall risk of emergency generator operation is low now and that it will increase over time.

Concentration modeling uncertainty

TAP concentration modeling uncertainty results from uncertainties about future meteorology, and the measurement variability and applicability of past meteorological conditions of the air data used for the current analyses. Additionally, TAP concentrations uncertainty arises from uncertainty in the precision and accuracy of the air quality dispersion model used: The US EPA AERMOD and its pre- and post-processors. 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 were known precisely, random fluctuations in the atmosphere would still induce uncertainty.

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[29] In May 2001, the Bonneville Power Administration asked ten aluminum smelters in the Pacific Northwest to close for two years, to reduce electricity consumption in the area. Reported in *The Outlook, WALL ST. J Online*, May 21, 2001.

[30] http://openjurist.org/126/f3d/1158/association-of-public-agency-customers-inc-v-bonneville-poweradministration-and-utility-reform-proj

[31] Effects of projected climate change on energy supply and demand in the Pacific Northwest and Washington State Hamlet, A.F., S.Y. Lee, K.E.B. Mickelson, and M.M. Elsner, 2009, Effects of projected climate change on energy supply and demand in the Pacific Northwest and Washington State, Chapter 4 in *The Washington Climate Change Impacts Assessment: Evaluating Washington's Future in a Changing Climate*. Climate Impacts Group, University of Washington, Seattle, Washington < http://www.cses.washington.edu/db/pdf/wacciach4energy647.pdf >

[32] *Ibid.*

[33] *Ibid.*

AERMOD may slightly overestimate high end 1-hour average impacts and somewhat underestimate the annual concentrations, as is typical of other steady-state Gaussian dispersion models.

Additional uncertainty arises in our estimate of NOx to NO_2 conversion in the atmosphere.[34] Ramboll used an "ambient ratio method" input to AERMOD for estimating NO_2 concentrations. They applied a NOx:NO_2 conversion ratio of 0.2211 based on information appropriate for standby generators from a US EPA database of in-stack testing of NOx speciation results.

Natural variation in meteorological conditions year-to-year will also effect the concentrations of the emitted TAPs. For the cancer risk assessment, a 70-year average concentration estimate would be ideal but its reliability very uncertain. Instead, Ramboll evaluated the highest concentration impact year among the five modeled years: 2015 to 2019.

Exposure uncertainty

Exposure uncertainty results from potential inaccuracies of assumptions about the time people will spend in various locations. The one location that could be affected by project engines emissions at toxicologically relevant concentrations is the MIR. Ramboll evaluated an extremely high exposure scenario for people entering this location. This ensured that uncertainty and variability are accounted for and that maximal exposures are not underestimated, but it is likely to have overestimated the extent of exposures that will actually occur.

Toxicity uncertainty

Toxicity uncertainty results from potential inaccuracies in the RBCs used in a risk assessment. RBCs are based on inherently variable experimental toxicology and observational epidemiological studies.

To avoid underestimating the true cancer potency of DPM, OEHHA based the URF on upper confidence limits of response data. In this way, they attempted to ensure that uncertainty and variability were addressed and to avoid underestimating actual risks. Thus, the cancer risks quantified in this technical analysis are theoretical estimates of the highest possible risks.[35]

Although EPA classifies DPM as probably carcinogenic to humans, they have not established a URF for quantifying cancer risk. In their Health Assessment Document for Diesel Exhaust, US EPA determined that "human exposure-response data are too uncertain to derive a confident

[34] Most of the NO_X emitted from diesel engines is nitric oxide, which is not currently a listed TAP in Chapter 173-460-150 WAC.

[35] A URF is the upper-bound of a confidence interval around, most typically, a mean of expected carcinogenic response at a given concentration. The 95 percent confidence interval for a mean is the range of values that will contain the true population mean 95 percent of the time.

quantitative estimate of cancer unit risk based on existing studies." However, they suggested that a URF based on existing DPM toxicity studies would range from 1E-5 to 1E-3 per $\mu g/m^3$. OEHHA's DPM URF (3×10^{-4} per $\mu g/m^3$) falls within this range.

Other sources of uncertainty cited in the US EPA Health Assessment Document for Diesel Exhaust are the lack of knowledge about the underlying mechanisms of its toxicity, and the question of whether the studies of emissions from engines of older designs are relevant to emissions from current-technology engines.

Lastly, Ramboll added the risks of benzene and naphthalene to DPM, finding they add at most 0.34% to the quantified risk of DPM. Evaluating benzene and naphthalene as separate constituents of DPM potentially double-counts their risk since the OEHHA and US EPA DPM URFs do not discriminate these semi-volatile components for the other constituents of DPM. In this case, this may have led to slight over-estimation of the cancer potency of the emissions.

Conclusions and Recommendation

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

(a) The TAP emissions estimates presented by Ramboll are reasonable estimates of the water system upgrades 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 Ramboll on behalf of Hanford adequately assesses project-related increased health risks attributable to TAP emissions.

In the HIA, Ramboll estimated lifetime increased cancer risks attributable to DPM and other TAP emissions from the water systems upgrades. The engine emissions resulted in a worst-case increase cancer risk of about 7-in-one-million at the MIR.

Ramboll assessed the cumulative health risk by adding estimated concentrations attributable to emissions to an estimated background DPM concentration. The maximum cumulative cancer risk from exposure to DPM in the vicinity of the proposed Pump house diesel engine generators is approximately 10-in-one-million.

Ramboll also assessed chronic and acute non-cancer hazards attributable to the project emissions and determined that long-term adverse non-cancer health effects are not likely to occur. However, acute respiratory hazards, are possible when engines are in use during unfavorable pollutant dispersion conditions. 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. Symptoms related to high exposure episodes would resolve once cleaner air conditions resume. Because poor-dispersion weather conditions are not expected to occur frequently and because the generators will be used mainly during emergencies, the high concentrations that could produce these hazards are expected only rarely and are unlikely to be sustained for long periods. The non-cancer hazard from exposure to project emission together with existing background levels of the TAPs is about 7% greater than the hazard of the project emissions alone.

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

- The cancer risk from toxic air pollutant emissions is less than the maximum risk (10 in one million) allowed by a Second Tier review.
- Long-term non-cancer hazards are very low, and short-term non-cancer hazards, although possible, are not likely to occur frequently, but likely to be mild in terms of illness severity when they do occur.