DEPARTMENT OF
ECOLOGY
State of Washington

Health Impact Assessment Recommendation Document for

Sierra Pacific Industries
Frederickson, Washington

Prepared by

Air Quality Program
Washington State Department of Ecology
Olympia, Washington

October 27, 2014

1. Summary and Purpose

Sierra Pacific Industries (SPI) proposes to build a new lumber facility in Pierce County near Frederickson, Washington (Figure 1). SPI determined that their emissions may cause acetaldehyde, formaldehyde, and acrolein levels to exceed an acceptable source impact level (ASIL). As a result, SPI was required to submit a second tier petition under WAC 173-460-090. A second tier petition requires a health impact assessment (HIA) that describes the health risks posed by SPI's emissions of these toxic air pollutants (TAPs).

SPI hired ENVIRON International Corporation (ENVIRON) to prepare an HIA (ENVIRON, 2014). In this assessment, ENVIRON estimated long-term cancer risk and acute and chronic noncancer hazards to people potentially exposed to SPI's TAP emissions.

The highest increased cancer risk, ranging from about **5 to 6 in one million**, occurs at a home near the proposed SPI facility. Much of this increased risk is due to SPI's emissions of acetaldehyde. This risk assumes that someone is exposed to SPI's emissions continuously for their entire lifetime. The state of Washington allows an increased risk of up to10 in one million from new sources of air pollutants. This risk can also be expressed as the number of cancers that might occur in addition to those normally expected in a population of one million people. The cancer risk estimates reported here are for increases in risk above a baseline lifetime risk of cancer of about 1 in 3 in the United States.

During a few short periods, SPI's emissions may cause levels of acrolein high enough to be of temporary concern at some nearby locations. Most people may not experience any adverse effects during these infrequent occurrences. If sensitive people are affected, the effects will most likely be limited to minor eye and upper respiratory tract irritation.

Over longer periods, SPI's emissions will add to existing air pollutant exposures. This increase in emissions is not likely to contribute to long-term respiratory health hazards near SPI.

Because the increase in cancer risk from SPI's TAP emissions alone is less than the maximum risk allowed by a second tier review, which is 10 in one million, and the noncancer hazard is acceptable, the project may be approved. Although there appears to be a very low likelihood of adverse impacts from SPI's TAP emissions, Ecology recommends that SPI and Puget Sound Clean Air Agency (PSCAA) provide appropriate facility and agency contact information to the residents at the home closest to the proposed facility.

This summary document presents Ecology's review of SPI's HIA and other requirements under WAC 173-460.

2. Second Tier Review Processing and Approval Criteria

2.1. Second Tier Review Processing Requirements

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

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

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

Ecology accepted ENVIRON's HIA protocol (item (c)) on July 24, 2014. Ecology found that the HIA protocol contained sufficient information and requested a final HIA. The final HIA (item (e)) was received by Ecology on September 10, 2014. Ecology's air dispersion modeler found the refined modeling conducted by ENVIRON to be acceptable (item (d)).[1]

Acting as the "permitting authority" for this project, PSCAA satisfied items (a) above on July 14, 2014,[2] and Ecology's second tier review engineer verified item (b).[3] The applicant has satisfied all five requirements above.

2.2. 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.

(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.

---

[1] Ranil Dhammapala, "Modeling Review Checklist_SPI_Frederickson_HIA.docx," submitted to Gary Palcisko, October 13, 2014.
[2] Puget Sound Clean Air Agency Notice of Construction Worksheet, Sierra Pacific Industries, received July 14, 2014.
[3] Marc Crooks, "RE: SPI-Frederickson Health Impact Assessment," e-mail message, addressed to Gary Palcisko, October 13, 2014.

(c) Ecology determines that the noncancer hazard is acceptable.

2.2.1. tBACT Determination

The bulk of TAPs subject to Second Tier Review that are emitted from SPI's proposed project will come from the lumber kiln. Ecology's second tier review engineer concurred with PSCAA's determination that SPI's proposed tBACT will be met through use of a computerized kiln management system. PSCAA determined that lumber kilns do not require add-on control as it is unclear if these types of controls for lumber drying are currently technologically and economically feasible.

3. HIA 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 the surrounding community's risk from a new project.

The HIA focused mainly on health risks attributable to acetaldehyde, formaldehyde, and acrolein exposure as these were the TAPs with modeled concentrations in ambient air that exceeded respective ASILs. ENVIRON also estimated health risks from other TAPs (arsenic, cadmium, hexavalent chromium, 7,12-dimethylbenz(a)anthracene, and nitrogen dioxide) that exceeded the small quantity emission rates (SQERs) and may potentially contribute to similar noncancer effects or increased cancer risk.

3.1. Health Effects Summary

Depending on exposure levels, the three TAPs that exceed ASILs (i.e., acetaldehyde, formaldehyde, and acrolein) can adversely affect the nose and throat (nasopharyx), the eyes, and the entire respiratory tract, including the bronchi. Additionally, acetaldehyde and formaldehyde exposure may cause an increase in the risk of nasal and laryngeal cancer.

The primary acute effects of human exposure to acetaldehyde in air consist of irritation to the eyes, skin, and respiratory tract. Asthmatics exposed to acetaldehyde may experience a decrease in lung function due to bronchoconstriction.

There is little information regarding health outcomes in humans related to long-term exposure to acetaldehyde. In animals, chronic inhalation exposure to acetaldehyde has produced changes in the mucus membranes of the nose and trachea, growth retardation, slight anemia, and increased kidney weight. The United States Environmental Protection Agency (EPA) derived a reference concentration (RfC) based on the degeneration of a layer of cells lining the tissue responsible for smell in the noses (olfactory epithelium) of rats (EPA, 1991). There is currently insufficient human data regarding the carcinogenic effects of acetaldehyde. Animal studies involving inhalation of acetaldehyde have shown an increased rate of nasal tumors in rats and laryngeal

tumors in hamsters. EPA has classified acetaldehyde as a Group B2, probable human carcinogen, and the United States Department of Health and Human Services (DHHS) considers it reasonably anticipated to be a human carcinogen (DHHS, 2014).

Low levels of formaldehyde can cause irritation of the eyes, nose, throat, and skin. It is possible that people with asthma exposed to formaldehyde can experience respiratory symptoms such as wheezing, shortness of breath, and reduced pulmonary function consistent with bronchoconstriction (CalEPA, 2008). At concentrations that typically occur in ambient air, effects occur in tissues where formaldehyde enters the body (i.e., nose or mouth). At higher levels, coughing, wheezing, bronchitis, nasal obstruction, pulmonary edema, choking, dyspnea, and chest tightness may occur.

People chronically exposed to formaldehyde by inhalation have experienced respiratory symptoms and eye, nose, and throat irritation. Animal studies have reported effects on the nasal respiratory epithelium and lesions in the respiratory system from chronic inhalation exposure to formaldehyde. In animal studies, rats exposed to high levels of formaldehyde in air developed cancer in a type of epithelial cell in the nose (nasal squamous cell carcinoma). Some studies of people exposed to formaldehyde in workplace air found more cases of cancer of the nose and throat than expected. DHHS has determined that formaldehyde is a known human carcinogen based on human and animal inhalation studies (DHHS, 2014). EPA has classified formaldehyde as a Group B1, probable human carcinogen.

Acrolein is an irritant to skin and mucous membranes. Effects of acrolein typically occur at the point of exposure (i.e., nasal passages, eyes) and upper respiratory tract. Short-term exposure to acrolein can cause eye and nasal irritation at relatively low concentrations (< 0.25 ppm [≤ 0.6 mg/m^3]) in air (CalEPA, 2008). Higher concentrations may also irritate the entire respiratory tract. Water soluble fine particulates may potentiate the irritancy of acrolein. Accidental exposures to extremely high levels of acrolein result in high fever, dyspnea, coughing, foam expectoration, cyanosis, pulmonary edema, and death (ATSDR, 2007). Animals exposed to higher acrolein concentrations showed signs of lesions in the respiratory tract and respiratory distress. These effects became more severe with increasing concentrations. At higher levels, respiratory distress resulted in death.

There are no available studies of humans exposed to acrolein over long periods, however, a recent analysis of estimated environmental acrolein exposure in the range of 0.05 to 0.46 $\mu g/m^3$ among U.S. adults was associated with "marginally significant 8% increase in asthma attack prevalence-odds among adults (de Castro 2014)." The overall contribution of acrolein exposure to increased asthma was unclear as the existence of other ambient pollutants was not addressed in this analysis. Longer-term studies in laboratory animals at higher concentrations have demonstrated severe nasal lesions as well as pronounced adverse effects on lung function leading to lethality. Studies indicated that rats were the most sensitive species. The potential carcinogenicity of acrolein cannot be determined because the existing data are inadequate for an assessment of human carcinogenic potential for either the oral or the inhalation route of exposure.

ENVIRON also considered exposure to other TAPs emitted by SPI that did not exceed respective ASILs, but may cause effects like those potentially caused by acetaldehyde, formaldehyde, and acrolein in the same organs. These TAPs are arsenic, cadmium, hexavalent chromium, 7,12-dimethylbenz(a)anthracene, and nitrogen dioxide.

3.1.1. Toxicological Values

Several agencies, EPA, California Environmental Protection Agency's Office of Environmental Health Hazard Assessment (OEHHA), and the Agency for Toxic Substances and Disease Registry (ATSDR), developed toxicological values for assessing noncancer hazards and cancer risk from exposure to TAPs evaluated in the HIA. These values were derived largely from studies of animals that were exposed to a known chemical concentration. Table 1 shows toxicity values considered by Ecology for quantifying potential health hazards and cancer risks from exposure to SPI related TAPs.

To derive noncancer reference values for the TAPs evaluated in the HIA, the agencies applied various uncertainty factors to toxic effect levels that were observed in toxicity studies. The resulting values (i.e., RfC[4], reference exposure level [REL][5], or minimal risk level [MRL][6]), defined in detail in the footnotes, are concentrations in air at or below which noncancer health effects are not expected from exposure to these pollutants. For assessing cancer risk from exposure to most potentially carcinogenic chemicals, there is theoretically no level of exposure for such a chemical that does not pose a small, but finite, probability of generating a carcinogenic response. To develop values for assessing cancer risk, agencies often extrapolate from high exposure concentrations that were used in animal experiments to the origin (where there are zero doses and zero responses). The slope of the line is used to estimate risk at exposure levels that are much lower than those used in the animal experiments. This resulting slope is used to derive a unit risk factor (URF)[7] for assessing cancer risk from exposure to very low levels that might be experienced in the environment.

---

[4] The RfC is an estimate (with uncertainty spanning perhaps an order of magnitude) of a continuous inhalation exposure to the human population (including sensitive subgroups) that is likely to be without appreciable risk of deleterious noncancer effects during a lifetime. It is not a direct estimator of risk but rather a reference point to gauge the potential effects. At exposures increasingly greater than the RfC, the potential for adverse health effects increases. Lifetime exposure above the RfC does not imply that an adverse health effect would necessarily occur.

[5] The concentration level at or below which no adverse health effects are anticipated for a specified exposure duration is termed the reference exposure level (REL). RELs are based on the most sensitive, relevant, adverse health effect reported in the medical and toxicological literature. RELs are designed to protect the most sensitive individuals in the population by the inclusion of margins of safety. Since margins of safety are incorporated to address data gaps and uncertainties, exceeding the REL does not automatically indicate an adverse health impact.

[6] An MRL is an estimate of the daily human exposure to a hazardous substance that is likely to be without appreciable risk of adverse noncancer health effects over a specified duration of exposure. These substance specific estimates, which are intended to serve as screening levels, are used to identify contaminants and potential exposures that may be of concern at a given location.

[7] The unit risk factor (URF) is the upper-bound excess lifetime cancer to result from continuous exposure to an agent at a concentration of 1 $\mu g/m^3$ in air. The interpretation of unit risk would be as follows: if unit risk = 2×10^{-6} per $\mu g/m^3$, 2 excess cancer cases (upper bound estimate) might develop per 1,000,000 people if exposed daily for a lifetime to 1 $\mu g/m^3$ concentration of the chemical in air.

Table 1. Toxicity Values Used to Assess and Quantify Noncancer Hazard from TAP Exposure

Chemical	Agency	Noncancer				Cancer URF
		Chronic	Organ System/ Endpoint	Acute	Organ System/ Endpoint	
Acetaldehyde	EPA	RfC = 9 µg/m^3	Resp.	N/A	N/A	2.2 E-6 per µg/m^3 Nasal and laryngeal tumors in animal studies
	OEHHA	REL = 140 µg/m^3	Resp.	8-hr REL = 300 µg/m^3	Resp.	2.7 E-6 per µg/m^3 Nasal tumors in animal studies
				Acute REL = 470 µg/m^3	Eyes, resp. (sensory irritation)	
Formaldehyde	EPA	N/A	Resp.	N/A	N/A	1.3 E-5 per µg/m^3 Nasal squamous cell carcinoma
	OEHHA	REL = 9 µg/m^3	Resp.	8-hr REL = 9 µg/m^3	Resp.	6.6E-6 per µg/m^3 Nasal squamous cell carcinoma or adenocarcinoma
				Acute REL = 55 µg/m^3	Eyes (sensory irritation)	
	ATSDR	MRL = 10 µg/m^3	Resp.	Intermediate MRL = 37 µg/m^3 Acute MRL = 50 µg/m^3	Resp.	N/A
Acrolein	EPA	RfC = 0.02 µg/m^3	Resp.	N/A	N/A	N/A
	OEHHA	REL = 0.35 µg/m^3	Resp.	8-hr REL = 0.7 µg/m^3	Resp.	N/A
				Acute REL = 2.5 µg/m^3	Eyes, resp. (sensory irritation)	
	ATSDR	N/A	Resp.	Intermediate = 0.09 µg/m^3 Acute = 7 µg/m^3	Resp.	N/A

Toxicity value references: ATSDR, 1999; ATSDR, 2007; CalEPA, 2008; CalEPA, 2011; EPA, 1989; EPA, 1991; and EPA, 2003

Note: ENVIRON also identified appropriate toxicity values for other TAPs (arsenic, cadmium, hexavalent chromium, 7,12-dimethylbenz(a)anthracene, and nitrogen dioxide) that exceeded SQERs and may potentially contribute to similar noncancer effects or increased cancer risk.

3.2. Ambient Air Quality Analysis

ENVIRON modeled emissions of TAPs from vents in the lumber kilns and the boiler stack. ENVIRON presented several maps showing estimated concentrations of TAPs in the area that are attributable to SPI's TAP emissions. Ecology reviewed the modeling files and found them to represent an adequate ambient air quality analysis.

3.3. Land Use – Exposed Receptors

SPI is a new facility proposed to be built on a currently undeveloped parcel. This parcel is located in an area that is broadly designated as "employment center." The Employment Center (EC) designation provides land for industrial, manufacturing, and office jobs. Uses in the EC range from land intensive heavy industrial (e.g., manufacturing, product assembly, fabrication and processing, and heavy trucking uses) to light manufacturing, assembly, wholesale activities, and corporate office and office park development. Other land uses nearby consist of moderate density single-family residential properties to the east and west, and low density rural reserve to the south. The nearest residence, situated in an area zoned as Employment Center, is located only about 200 feet south of the facility's fenceline.

While SPI is proposed to be built in an industrially zoned area, air dispersion modeling indicated that proposed acetaldehyde emissions could result in concentrations in excess of the ASIL at roughly 1,200 parcels with residential land use codes (Figure 2) [Ecology, 2013]. U.S. Census data show that approximately 4,565 people live in the Census Blocks intersected by the area in which acetaldehyde concentrations are estimated to exceed the ASIL (U.S. Census Bureau, 2010). Formaldehyde and acrolein emissions result in annual average concentrations above respective ASILs or relevant toxicity values over a smaller area.

To determine if the impacts of SPI's emissions are acceptable, Ecology requires that sources estimate exposures and health risks for those that are most likely to receive the highest exposures. ENVIRON identified maximally impacted boundary, commercial, and residential receptors (MIBR, MICR, and MIRR, respectively) for evaluating acute and chronic exposure to TAPs emitted from their facility (Figure 3).

ENVIRON also identified areas where sensitive individuals could be exposed to SPI's TAP emissions. These locations included schools and daycares (shown in Figure 2), and medical facilities and convalescent homes. These sensitive receptors were generally impacted less by SPI's emissions than the MIBR, MICR, or MIRR. Evaluation of exposures at the maximally impacted locations adequately addresses lower exposures that might occur at sensitive receptor locations.

4. Noncancer Hazard

In order to evaluate the potential for noncancer adverse health effects that may result from exposure to air pollutants, exposure concentrations at each receptor location are compared to

relevant noncancer toxicity values (i.e., RfC, REL, and MRL). If a concentration exceeds the toxicity value, this indicates only the potential for adverse health effects. The magnitude of this potential can be inferred from the degree to which this value is exceeded. This comparison is known as a hazard quotient (HQ) and is given by the equation below:

$$\text{HQ} = \frac{\text{time weighted average concentration of pollutant in air } (\mu g/m^3)}{\text{time interval specific RfC, MRL, or REL } (\mu g/m^3)}$$

An HQ of one or less indicates that the exposure to a substance is not likely to result in adverse noncancer health effects. As the HQ increases above one, the likelihood of human health effects increases by an undefined amount.

To assess the overall potential for noncarcinogenic effects posed by more than one chemical, EPA developed a hazard index (HI) approach (EPA, 1986). The HI is equal to the sum of the HQs pertaining to the same health endpoint or impacted organ system. When the HI exceeds unity, there may be concern for potential health effects, but health effects may not actually occur. The level of concern rises the more an HQ or HI exceeds unity.

$$\text{HI} = \text{HQ}_{(\text{acetaldehyde})} + \text{HQ}_{(\text{formaldehyde})} + \text{HQ}_{(\text{acrolein})} + \text{HQ}_{(\text{etc.})}$$

4.1. Hazard Quotients and Hazard Indices

ENVIRON evaluated chronic and acute hazards associated with exposure to formaldehyde, acetaldehyde, and acrolein emitted from the lumber kilns and boiler. Table 2 and Figure 4 show the chronic and acute HQs and HIs for the MIBR, MICR, and MIRR exposure to these TAPs near SPI.

Generally, HQs associated with acute and chronic exposure to acetaldehyde and formaldehyde are lower than unity for all receptors. This indicates adverse noncancer effects are not likely to result from chronic exposure to these pollutants emitted by SPI.

When compared to the lowest available reference value (i.e., RfC, REL, or MRL), hazards attributable to acute and chronic exposure to arolein exceed unity meaning that these potential exposures require additional scrutiny. HQs and HIs greater than one do not necessarily indicate adverse effects will occur, just that they become more likely the more it exceeds unity.

Acute Hazards (1-hour exposures)

Acute exposure to TAPs (both 1-hour and 8-hour durations) at the MICR is not likely to result in adverse health effects as lower and higher acute HIs are less than one. The maximum 1-hour exposure estimate at the MIBR results in lower and higher acute HIs of 1.3 and 2.4, respectively, and maximum estimated 1-hour exposure at the MIRR results in lower and higher acute HIs of 1.0 and 1.9, respectively. Acrolein is the pollutant most responsible for HIs that exceed unity.

The maximum 8-hour exposure estimates at the MIBR and MIRR result in an acute HIs of 2.5 and 1.6, respectively, mostly due to acrolein.

As mentioned previously, HIs that exceed unity do not necessarily mean that adverse health effects will occur. While TAP levels may exist at potential levels of concern for some individuals, these exposures are expected to occur infrequently. For example, 1-hour acrolein levels are estimated to exceed the acute REL three times per year at the MIBR and about once per year at the MIRR. During these infrequent occurrences, sensitive individuals may experience acute eye and upper respiratory tract irritation. It is important to note that all short-term acrolein levels are less than ATSDR's MRL and an acute RfC previously proposed by EPA's Office of Prevention, Pesticides, and Toxic Substances (EPA, 2007).

Chronic Hazards

Chronic HQs associated with acrolein at the MIBR, MICR, and MIRR are higher than one of the two chronic toxicity values considered. Consequently, HIs also exceed unity for these same receptors. Acrolein is the pollutant that most influences these hazards because HQs related to long-term exposure to acetaldehyde and formaldehyde are lower than unity.

The HI at the MIBR ranges from a low of 0.4 to a high of 6.3, mostly due to acrolein. Long-term concentration estimates at the MICR result in lower and higher chronic HIs of 0.1 and 2.2, respectively. The HIs at the MIRR ranges from 0.1 to 1.6. The large difference in the lower and higher HIs indicates a lack of consensus on the concentration exposure threshold for chronic effects, mainly concerning acrolein.

Long-term HIs mentioned above will be added to existing background HIs ranging from a low of 0.4 to a high of 4.0. It is also important to note that chronic exposure to background acrolein concentrations results in a higher HQs than that caused solely by SPI's emissions. Figure 5 shows that the background acrolein concentration at the census tract near SPI ranks around the 50th percentile of all census tracts in Washington. The concentration increase at the MIRR resulting from SPI's emissions would rank around the 70th percentile of all census tracts in WA.

Considering the wide range of chronic toxicity values available for acrolein, and that estimated background exposures to acrolein are typically much higher than impacts from SPI, serious long-term adverse health effects attributable to SPI's TAP emissions are unlikely.

Hazard Summary

To summarize, acute eye and upper respiratory tract irritation hazards may exist infrequently at the MIBR and MIRR, but not the MICR, mostly due to short-term exposures to acrolein. Although long-term exposures to TAPs at the MIRR result in an HI greater than unity, there is not strong consensus regarding the long-term toxicity of acrolein at low concentrations. Depending on which reference value is used, hazards can be characterized as not likely to result in adverse noncancer health effects or HIs exceed unity, meaning that exposures should be

carefully considered. Given that estimated levels of acrolein are far below OEHHA's more recently developed REL, and SPI's emission contribute a relatively small increase in acrolein exposure compared to estimated background exposure, the increased hazard posed by SPI's emissions are not likely to appreciably contribute to increased serious long-term respiratory hazards for residents near SPI.

Table 2. Acute and Chronic Hazards Attributable to SPI's Emissions and Background Levels.

	Pollutant	Concentration	Lower Reference Value	Higher Reference Value	Higher HQ	Lower HQ
1 Hr Duration						
MIRR	Acetaldehyde	227	470	470	0.48	0.48
	Formaldehyde	5.82	50	55	0.12	0.11
	Acrolein	3.21	2.5	7	**1.3**	0.46
				Hazard Index	**1.9**	**1.0**
MIBR	Acetaldehyde	284	470	470	0.60	0.60
	Formaldehyde	7.3	50	55	0.15	0.13
	Acrolein	4.03	2.5	7	**1.6**	0.58
				Hazard Index	**2.4**	**1.3**
MICR	Acetaldehyde	107	470	470	0.23	0.23
	Formaldehyde	2.8	50	55	0.06	0.05
	Acrolein	1.52	2.5	7	0.61	0.22
				Hazard Index	0.89	0.50
8-hr Duration						
MIRR	Acetaldehyde	59.8	300		0.20	N/A
	Formaldehyde	1.5	9		0.17	N/A
	Acrolein	0.85	0.7		**1.2**	N/A
				Hazard Index	**1.6**	N/A
MIBR	Acetaldehyde	95.5	300		0.32	N/A
	Formaldehyde	2.5	9		0.27	N/A
	Acrolein	1.3	0.7		**1.9**	N/A
				Hazard Index	**2.5**	N/A
MICR	Acetaldehyde	32.1	300		0.11	N/A
	Formaldehyde	0.84	9		0.094	N/A
	Acrolein	0.45	0.7		0.65	N/A
				Hazard Index	0.85	N/A
Chronic Duration		Concentration	Reference	Reference	HQ	HQ
MIRR	Acetaldehyde	2.0	9	140	0.22	0.014
	Formaldehyde	0.053	9	10	0.0058	0.0053
	Acrolein	0.028	0.02	0.35	**1.4**	0.080
				Hazard Index	**1.6**	0.10
MIBR	Acetaldehyde	7.7	9	140	0.86	0.055
	Formaldehyde	0.2	9	10	0.022	0.02
	Acrolein	0.11	0.02	0.35	**5.5**	0.31
				Hazard Index	**6.3**	0.39
MICR	Acetaldehyde	2.7	9	140	0.30	0.019
	Formaldehyde	0.071	9	10	0.0079	0.0071
	Acrolein	0.038	0.02	0.35	**1.9**	0.11

Table 2. Acute and Chronic Hazards Attributable to SPI's Emissions and Background Levels.						
	Pollutant	**Concentration**	**Lower Reference Value**	**Higher Reference Value**	**Higher HQ**	**Lower HQ**
	Hazard Index				**2.2**	0.13
Background Exposure (NATA)	Acetaldehyde	1.35	9	140	0.15	0.0096
	Formaldehyde	1.52	9	10	0.17	0.15
	Acrolein	0.0742	0.02	0.35	**3.7**	0.21
	Hazard Index				**4.0**	0.37
Note: ENVIRON also included noncancer hazard estimates for other TAPs (arsenic, cadmium, hexavalent chromium, and nitrogen dioxide). These chemicals did not add significantly to overall noncancer HIs.						

5. Increased Cancer Risk

Tables 3, 4, and 5, adapted from the HIA (ENVIRON, 2014), shows the estimated SPI project-specific and cumulative increased cancer risk at each of the receptors evaluated. The highest increase in risk attributable to project-related emissions of acetaldehyde and formaldehyde is a lower estimate of **4.8 per million** and a higher estimate of **6.1 per million** for the MIRR located directly to the south of SPI. Most of the risk is attributable to acetaldehyde exposure.

For commercial exposure scenarios, the MICR may have increased risks of about 0.8 per million to 1.1 per million. The MIBR may have increased risks of about 0.8 to 1.2 per million.

Using background concentrations estimated in NATA, the cumulative risk of acetaldehyde and formaldehyde exposure in the vicinity of SPI is highest for the MIRR. The cumulative risk at this location is about 18 to 30 per million.[8] Much of the risk is due to background formaldehyde exposure.

On a population basis, risks can be characterized by estimating increased cancer risks by multiplying the individual cancer risk at various locations, such as census block centroids, by the size of the population. Ecology performed this analysis and determined that about 0.01 excess cancer cases could potentially result over a 70-year period (Figure 6). It is important to note that the theoretical results of this analysis are not predictive of actual cancer cases that may occur.

[8] Note that residential receptors tend to be the most exposed (e.g., longest exposure duration and exposure frequency). Therefore, their risks tend to be higher than other types of receptors. For regulatory decision making purposes, Ecology assumes that a resident is continuously exposed at their residence for their entire lifetime.

Table 3. Ranges of Estimated Worst-Case Boundary Receptor Cancer Risks from Exposure to Acetaldehyde and Formaldehyde Near SPI

	Attributable to:	C_{AIR} (µg/m^3)	Fraction of a 70-year Continuous Exposure	Lower URF	Higher URF	Additional Cancer Risk Range (per million)		
Acetaldehyde	SPI	7.72	0.0245	2.20E-06	2.70E-06	0.4	to	0.5
	Background (NATA 2005)	1.35				0.07	to	0.1
Formaldehyde	SPI	0.2		6.60E-06	1.30E-05	0.03	to	0.06
	Background (NATA 2005)	1.52				0.2	to	0.5
MIBR	Sum of cancer risk from SPI alone					0.5	to	0.6
	Sum of cancer risk from census tract background (NATA) alone					0.3	to	0.6
	Combined cancer risks of SPI and background					0.8	to	1.2

Note: Risks shown above differ from those reported in the HIA. Ecology used alternative exposure scenarios at the MIBR that accounted for repeated exposures of 2 hr/day for 250 days/yr for 30 years.

Table 4. Ranges of Estimated Worst-Case Commercial Receptor Cancer Risks from Exposure to Acetaldehyde and Formaldehyde Near SPI

	Location	C_{AIR} (µg/m^3)	Fraction of a 70-year Continuous Exposure	Lower URF	Higher URF	Additional Cancer Risk Range (per million)		
Acetaldehyde	SPI	2.68	0.1308	2.20E-06	2.70E-06	**0.8**	**to**	**0.9**
	Background (NATA 2005)	1.35				0.4	to	0.5
Formaldehyde	SPI	0.0713		6.60E-06	1.30E-05	**0.06**	**to**	**0.1**
	Background (NATA 2005)	1.52				1.3	to	2.6
MICR	Sum of cancer risk from SPI alone					**0.8**	**to**	**1.1**
	Sum of cancer risk from census tract background (NATA) alone					1.7	to	3.1
	Combined cancer risks of SPI and background					2.5	to	4.2

Note: Risks shown above differ from those reported in the HIA. Ecology used alternative exposure scenarios at the MICR that accounted for repeated exposures of 8 hr/day for 250 days/yr for 40 years.

Table 5. Ranges of Estimated Worst-Case Residential Cancer Risks from Exposure to Acetaldehyde and Formaldehyde Near SPI

	Location	C_{AIR} (µg/m^3)	Fraction of a 70-year Continuous Exposure	Lower URF	Higher URF	Additional Cancer Risk Range (per million)		
Acetaldehyde	SPI	1.99	1	2.20E-06	2.70E-06	**4.4**	**to**	**5.4**
	Background (NATA 2005)	1.35				3.0	to	3.6

Table 5. Ranges of Estimated Worst-Case Residential Cancer Risks from Exposure to Acetaldehyde and Formaldehyde Near SPI								
	Location	**C_{AIR} (μg/m^3)**	**Fraction of a 70-year Continuous Exposure**	**Lower URF**	**Higher URF**	**Additional Cancer Risk Range (per million)**		
Formaldehyde	SPI	0.0525		6.60E-06	1.30E-05	**0.3**	**to**	**0.7**
	Background (NATA 2005)	1.52				10.0	to	19.8
MIRR	Sum of cancer risk from SPI alone					**4.8**	**to**	**6.1**
	Sum of cancer risk from census tract background (NATA) alone					13.0	to	23.4
	Combined cancer risk of SPI and background					17.8	to	29.5
A continuous exposure 24 hr/day for 365 days/yr for 70 years is assumed for the MIRR.								
Note: ENVIRON also included increased cancer risk estimates for other TAPs (arsenic, cadmium, hexavalent chromium, and 7,12-Dimethylbenz(a)anthracene). These chemicals did not add significantly to overall cancer risk at the MIRR (~0.1 to 0.3 per million).								

6. Uncertainty

Uncertainty may be defined as our inability to know for sure. In risk assessments that are intended to inform regulatory decisions, many uncertainties are encountered. Knowledge of these uncertainties allows us to assess the robustness of decisions.

Evaluating the impacts from the SPI project involves several key elements, including emissions rate assumptions, air dispersion and fate modeling, estimates of resulting environmental concentrations, exposure modeling to estimate received doses, and exposure-response relationships to estimate the possibilities of different types of health impacts. Each of these elements contain uncertain science and measurement variability that prevents absolute confidence in predictions about adverse health impacts of this project.

The largest sources of uncertainty and variability are:

6.1. Emissions

The exact amount of pollutants emitted by SPI is uncertain. ENVIRON relied on emission factors for a variety of wood types and operating limits and conditions specified in their draft permit to estimate emissions of TAPs. Generally, ENVIRON chose the highest available emission factor to avoid underestimating emissions.

ENVIRON assumed that the facility would operate continuously for an entire year, but they acknowledge that the process is a batch process meaning that there may be periods of relatively low emissions and relatively high emissions. This could mean that there are short-term periods of emissions that are higher than what they assumed for the purposes of evaluating short-term acute ambient impacts. The use of higher-end emission rates may offset some of the chance that short-term impacts may be occasionally underestimated.

6.2. Air Modeling

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. With regard to the ambient impact analysis, Ecology's air dispersion modeler determined that ENVIRON appropriately modeled emissions of TAPs from SPI so as not to underestimate exposure.

6.3. Exposure Assumptions

It is difficult to characterize the amount of time that people can be exposed to SPI's TAP emissions. For simplicity and to ensure protection of public health, Ecology assumes a residential receptor is at one location for 24 hours per day, 365 days per year, for 70 years. Ecology also assumes that commercial receptors can be exposed 8 hours per day, 250 days per year, for 40 years. These assumptions tend to overestimate potential long-term exposure to SPI-related TAP emissions.

6.4. Toxicity

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. Many risk-based concentrations are based on animal studies at high levels of exposure. To account for uncertainty when developing toxicity values (e.g., RfCs, RELs, MRLs), agencies apply "uncertainty" factors to doses or concentrations that were observed to cause adverse noncancer 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.

Acetaldehyde is a probable human carcinogen based on increased incidence of nasal tumors in male and female rats and laryngeal tumors in male and female hamsters after inhalation exposure. Formaldehyde is a probable human carcinogen based on limited evidence in humans, and sufficient evidence in animals. The URFs for these chemicals may be inaccurate. EPA and OEHHA base most of the URFs they have published upon upper confidence limits of response data or of fitted curves, to avoid underestimating the true cancer potency. In this way, they attempt to ensure that uncertainty and variability are addressed, and to avoid underestimating actual risks.

The nasopharyngeal cancer risks quantified in this technical analysis are upper-bound theoretical estimates. Actual risks are likely to be lower. Both acetaldehyde and formaldehyde have quantitatively different URFs from EPA and OEHHA. One may be more realistic than the other, but information required in order to determine which are more accurate than others is not

available. The estimates of increased cancer risks are the best possible estimates of the upper extremes.

Calculation of noncancer adverse health effects risks is based on comparisons of possible exposure concentrations and durations to appropriate RELs, RfCs, and MRLs. These toxicity values are estimates of inhalation exposures for humans (including sensitive subgroups) likely to be without appreciable risks of adverse effects for defined durations. A range of toxicity values were considered when assessing noncancer effects from exposure to SPI's TAPs. This range represents different methodologies and/or use of critical studies by various agencies in developing toxicity values. Ecology presented ranges of HQs and HIs at each receptor to demonstrate the range of available toxicity values for each chemical. Depending on which toxicity values are used, HQs and HIs characterizing exposure to SPI's TAPs span a range that is less than to slightly above unity.

6.5. Summary of Uncertainty

To the extent that people may be exposed to emissions of acetaldehyde, formaldehyde, acrolein, and other TAPs from the proposed SPI project, and despite the uncertainties in concentration estimates, exposure estimates, cancer potency estimates, and irritation hazards, potential health risks appear to be acceptable. Quantitative assessments of the effects of SPI's air toxic emissions impacts on human health cannot be made with greater confidence. As in any risk assessment, SPI's HIA involves circumstances of incomplete scientific information.

7. Conclusions and Recommendation

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

a) The TAP emissions estimates presented by ENVIRON 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 refined air dispersion modeling techniques as approved in the HIA protocol.
d) The HIA submitted by ENVIRON on behalf of SPI adequately assesses project-related increased health risk attributable to TAP emissions.

The project review team concludes that the HIA presents an appropriate estimate of potential increased health risks posed by SPI's TAP emissions. SPIs increased acetaldehyde and formaldehyde emissions could result in an increased cancer risk of up to **6.1 per million** for the MIRR located due south of SPI. Increased cancer risk to nearby commercial and boundary receptors is lower (1.1 and 0.6, respectively). These risks fall below Ecology's threshold of maximum acceptable risk (i.e., one per one hundred thousand or 10 per million) as defined in Chapter 173-460 WAC.

Acute eye and upper respiratory tract irritation hazards may exist infrequently at the maximally impacted boundary and residential locations, but not at the maximally impacted commercial location, mostly due to short-term elevations of acrolein concentrations resulting from SPI's emissions. These occurrences are estimated to occur about one hour per year at the MIRR, and perhaps three hours per year at the MIBR. Should exposure actually occur, most people may not experience any adverse effects during these occurrences, but if sensitive people happen to experience effects from these short-term elevations of TAP concentrations, the effects will most likely be limited to minor eye and upper respiratory tract irritation. Though sufficient exposures are unlikely, we cannot completely rule out the possibility people with asthma who might be exposed to the aldehydes from SPI in maximally affected boundary and residential locations may experience respiratory symptoms such as wheezing, shortness of breath, and reduced pulmonary function with bronchoconstriction.

Although estimated acrolein levels slightly exceed EPA's RfC at the MIRR location, chronic long-term exposure to TAPs emitted by SPI are not likely to cause or appreciably contribute to adverse health effects. Acrolein levels, even after considering background exposure, are expected to be lower than OEHHA's REL.

In summary, SPI's emissions are unlikely to result in excessive cancer risk or in any significant adverse noncancer health problems to people at nearby residences or commercial locations. The increased risks from the proposed project appear to be permissible because they fall within the limits defined in WAC 173-460-090(7). Based on our analysis, the Washington State Department of Ecology finds that the applicant, SPI, has satisfied all requirements for approval of the Second Tier petition. The risk manager may recommend approval of the proposed project because project-related health risks are permissible under WAC 173-460-090(7). Ecology also recommends that SPI and PSCAA provide appropriate facility and agency contact information to the residents at the maximally impacted residence should future air quality concerns arise.

8. References

Agency for Toxic Substances and Disease Registry (ATSDR), "Toxicological Profile for Formaldehyde," July 1999. Available at: <http://www.atsdr.cdc.gov/ToxProfiles/tp.asp?id=220&tid=39>

-----, "Toxicological Profile for Acrolein," August 2007. Available at: <http://www.atsdr.cdc.gov/toxprofiles/tp.asp?id=557&tid=102>

California Environmental Protection Agency (CalEPA): Office of Environmental Health Hazard Assessment, "Technical Support Document for Noncancer RELs," December 2008. <http://www.oehha.ca.gov/air/hot_spots/2008/AppendixD1_final.pdf>

-----, Office of Environmental Health Hazard Assessment, "Adoption of the Revised Air Toxic Hot Spots Program Technical Support Document for Cancer Potency Factors: Appendix A – Lookup Table Containing Unit Risk and Cancer Potency Values," updated 2011. Available at: <http://www.oehha.ca.gov/air/hot_spots/tsd052909.html>

De Castro, Rey, Acrolein and Asthma Attack Prevalence in a Representative Sample of the United States Adult Population 2000-2009, Research PLOSone, May 19, 2014. Available at: <http://www.plosone.org/article/info%3Adoi%2F10.1371%2Fjournal.pone.0096926>

ENVIRON International Corporation (ENVIRON), "Health Impact Assessment for a Lumber Manufacturing Facility- Frederickson, WA," prepared for the Sierra Pacific Industries, Redding, CA, September 2014.

United States Department of Health and Human Services: National Toxicology Program, Report on Carcinogens, Thirteenth Edition: Formaldehyde, October 2, 2014. Available at: <http://ntp.niehs.nih.gov/pubhealth/roc/roc13/index.html#F >

United States Environmental Protection Agency (EPA), "Guidelines for the Health Risk Assessment of Chemical Mixtures," September 1986. Available at: <http://www.epa.gov/raf/publications/pdfs/CHEMMIX_1986.PDF>

-----, "Integrated Risk Information System Record for Formaldehyde," Last Significant Revision October 1, 1989. Available at: <http://www.epa.gov/iris/subst/0419.htm>

-----, "Integrated Risk Information System Record for Acetaldehyde," Last Significant Revision 1991. Available at: <http://www.epa.gov/ncea/iris/subst/0290.htm>

-----, "Integrated Risk Information System Record for Acrolein," Last Revised June 3, 2003. Available at: <http://www.epa.gov/iris/subst/0364.htm>

-----, Office of Prevention, Pesticides, and Toxic Substances, "Memorandum Regarding Human Studies Review Board: Weight of Evidence Discussion For Acrolein," May 25, 2007. Available at: <http://www.epa.gov/hsrb/files/meeting-materials/jun-27-29-2007-public-meeting/epa-woe-document-acrolein.pdf>

Figure 1. The SPI proposed facility, located near Frederickson in Pierce County, WA.

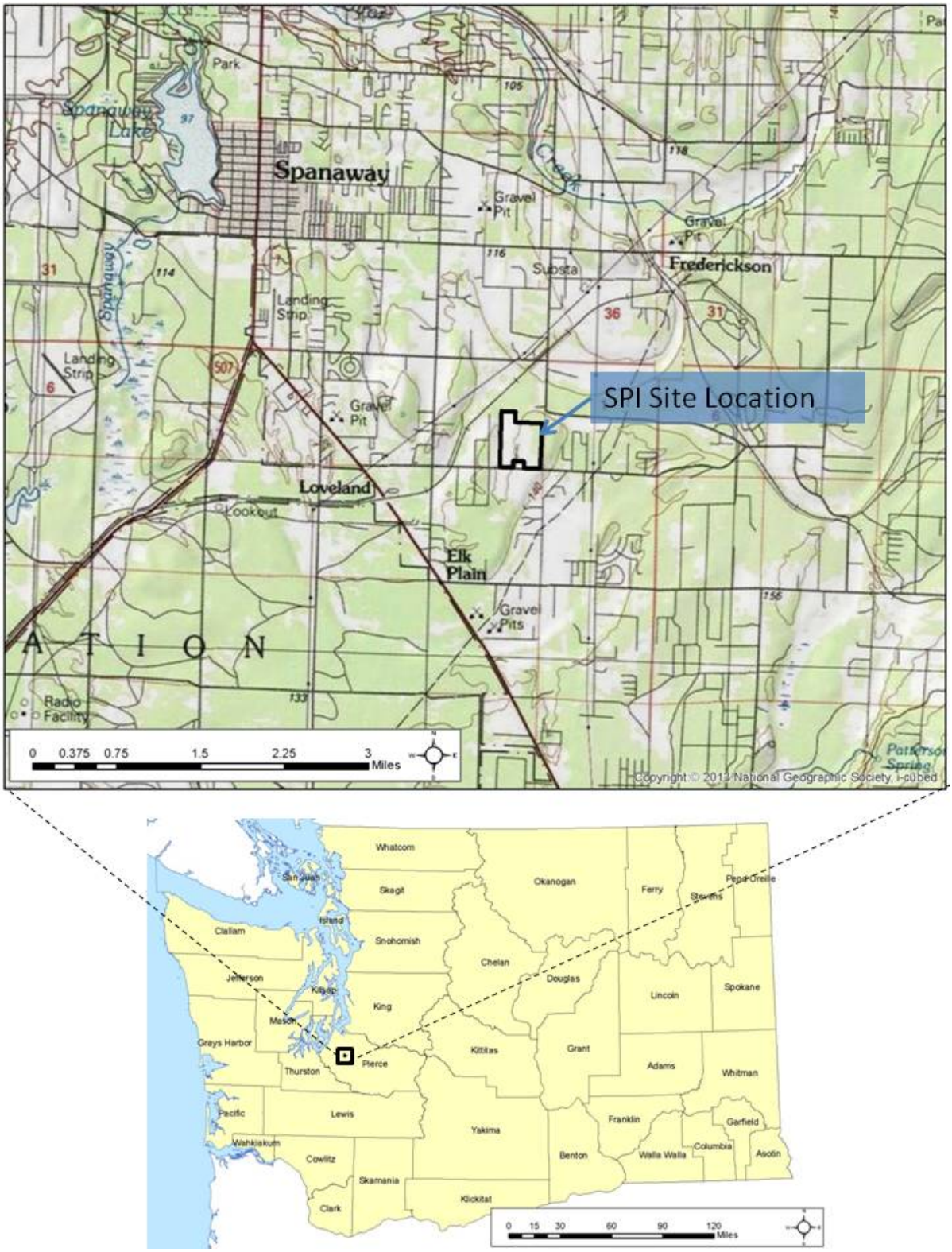


Figure 2. Residential parcels, schools and daycares located in the area impacted by acetaldehyde at concentrations above the ASIL (0.37 µg/m^3).

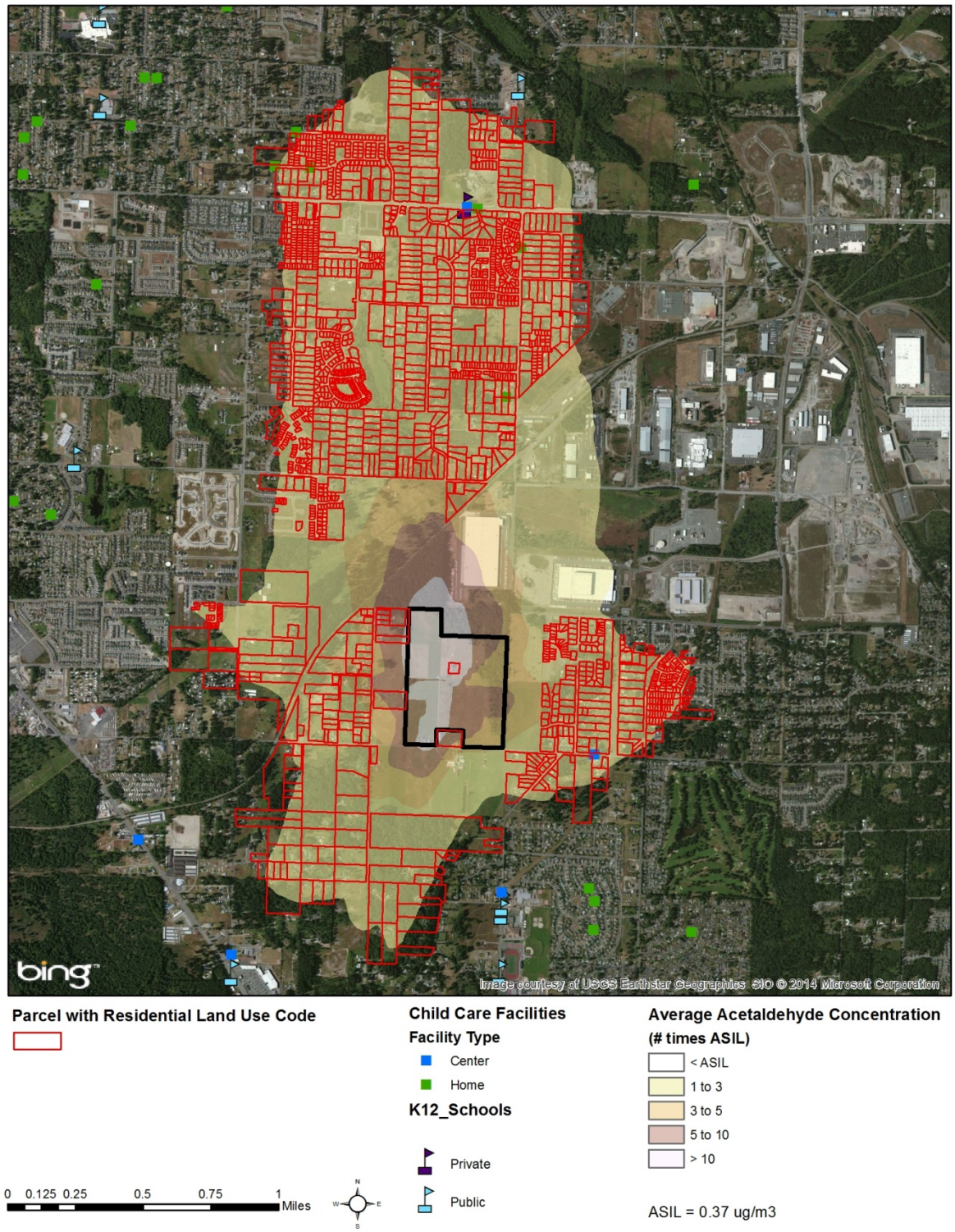


Figure 3. Receptor locations evaluated in the HIA (copied from ENVIRON 2014).

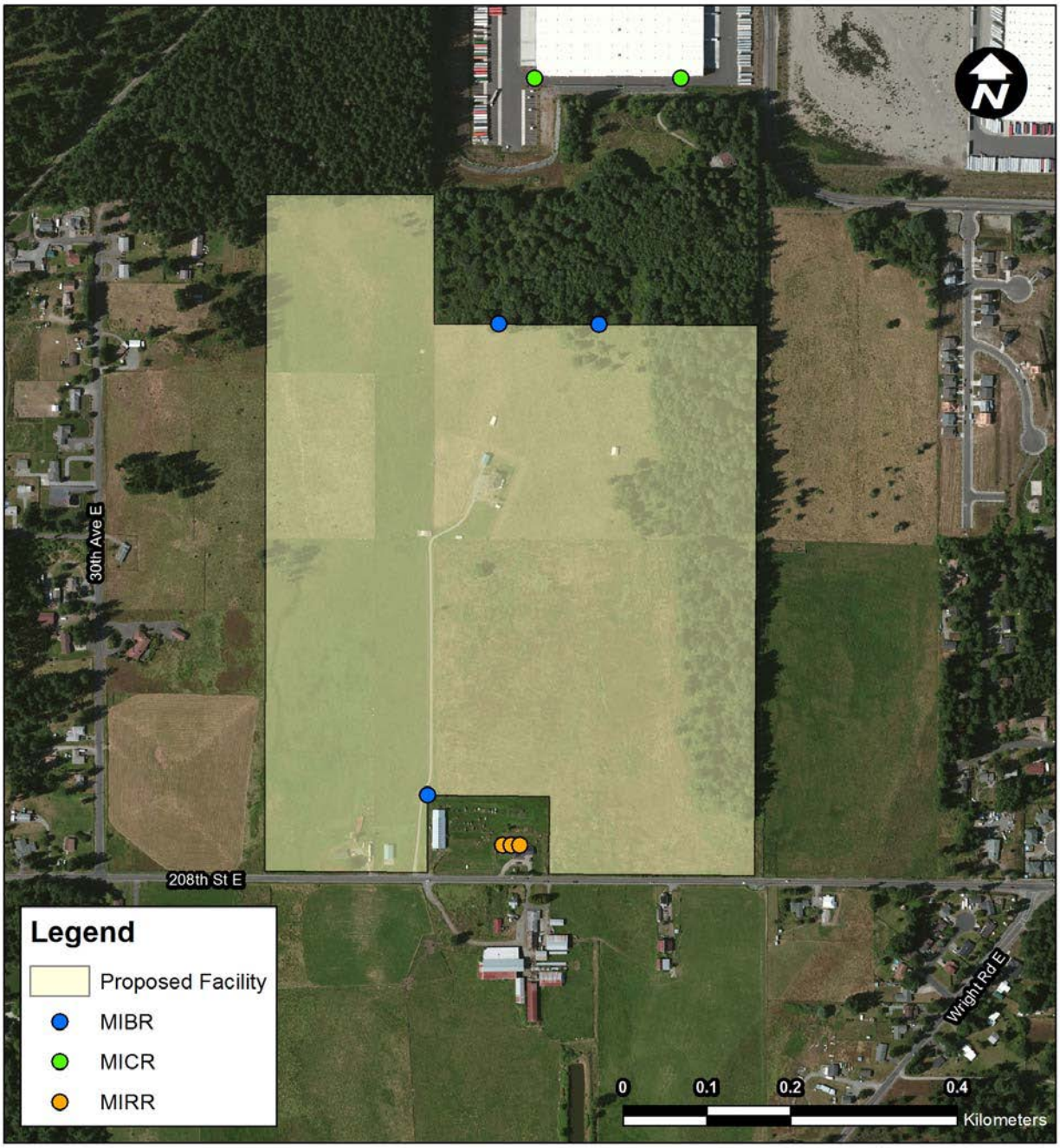
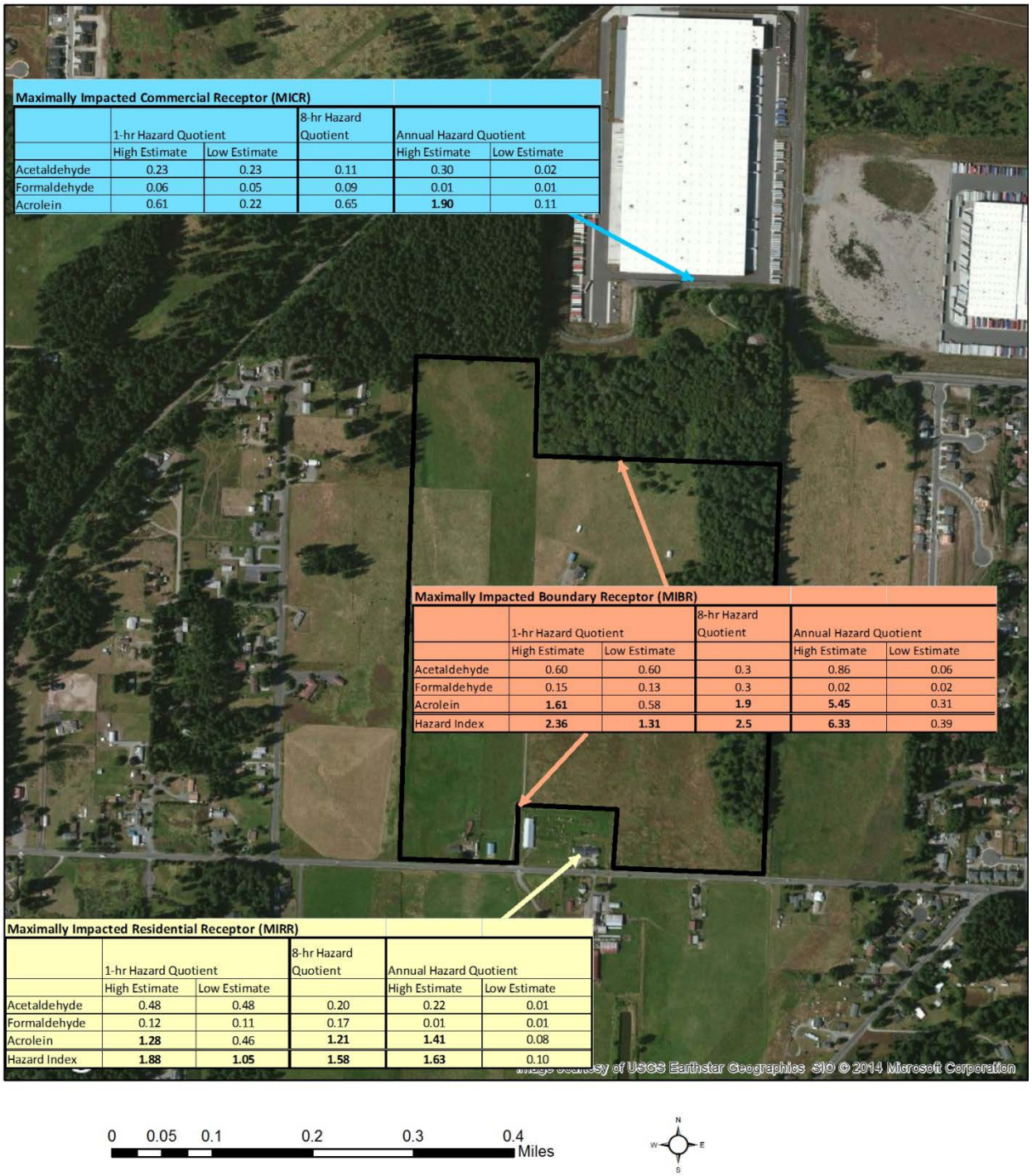


Figure 4. Estimated noncancer HQs and HIs at the MIBR, MICR, and MIRR.



Maximally Impacted Commercial Receptor (MICR)

	1-hr Hazard Quotient		8-hr Hazard Quotient	Annual Hazard Quotient	
	High Estimate	Low Estimate		High Estimate	Low Estimate
Acetaldehyde	0.23	0.23	0.11	0.30	0.02
Formaldehyde	0.06	0.05	0.09	0.01	0.01
Acrolein	0.61	0.22	0.65	**1.90**	0.11

Maximally Impacted Boundary Receptor (MIBR)

	1-hr Hazard Quotient		8-hr Hazard Quotient	Annual Hazard Quotient	
	High Estimate	Low Estimate		High Estimate	Low Estimate
Acetaldehyde	0.60	0.60	0.3	0.86	0.06
Formaldehyde	0.15	0.13	0.3	0.02	0.02
Acrolein	**1.61**	0.58	**1.9**	**5.45**	0.31
Hazard Index	**2.36**	**1.31**	**2.5**	**6.33**	0.39

Maximally Impacted Residential Receptor (MIRR)

	1-hr Hazard Quotient		8-hr Hazard Quotient	Annual Hazard Quotient	
	High Estimate	Low Estimate		High Estimate	Low Estimate
Acetaldehyde	0.48	0.48	0.20	0.22	0.01
Formaldehyde	0.12	0.11	0.17	0.01	0.01
Acrolein	**1.28**	0.46	**1.21**	**1.41**	0.08
Hazard Index	**1.88**	**1.05**	**1.58**	**1.63**	0.10

Figure 5.

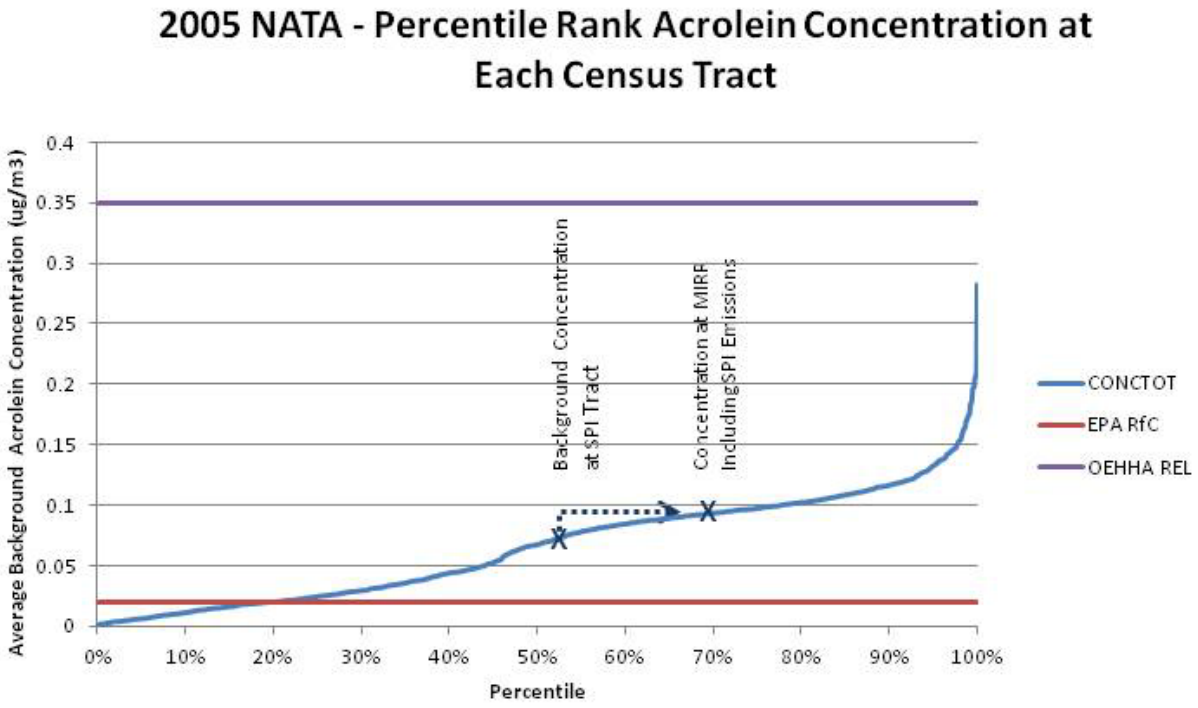
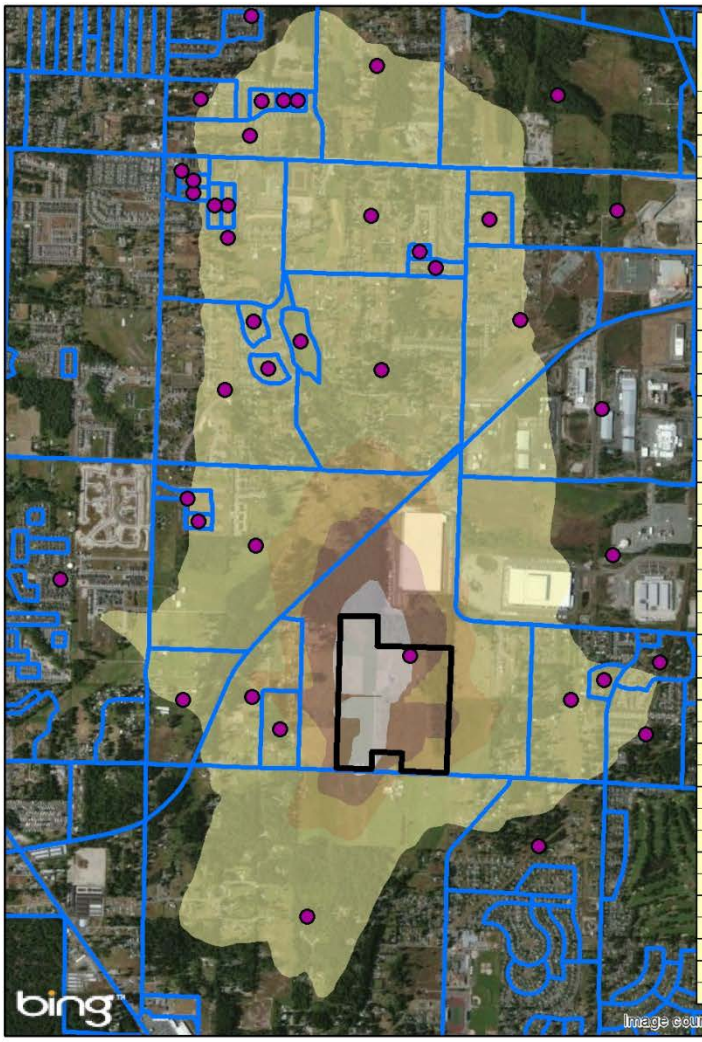
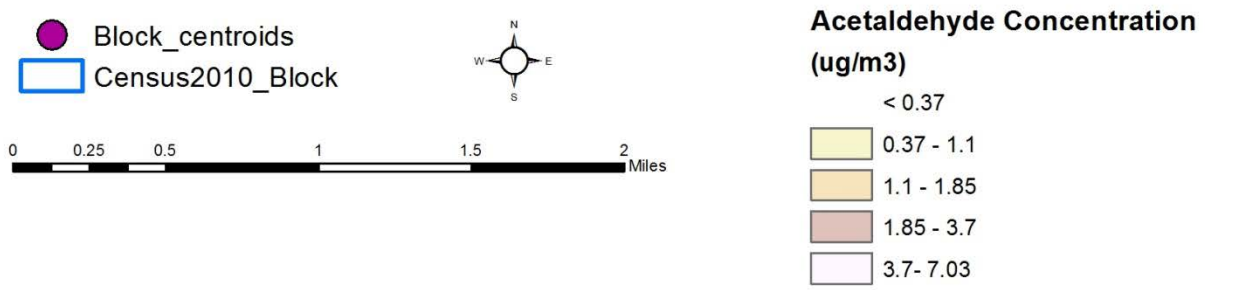

2005 NATA - Percentile Rank Acrolein Concentration at Each Census Tract
Average Background Acrolein Concentration (ug/m3)
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Percentile
Background Concentration at SPI Tract
Concentration at MIRR Including SPI Emissions
CONCTOT
EPA RfC
OEHHA REL

Figure 6. Estimated number of excess cancers that could occur in the population surrounding SPI over a 70-year period. The total number of excess cancers was estimated by multiplying the estimated lifetime risk at each census block centroid by the population at each census block and summing the results. The total of 0.01 excess cancers over a 70-year period represents a low population risk. Note that these are theoretical estimates and not predictive of actual cancer that could occur in a population.



Block ID	2010 Population	Acetaldehyde Conc (ug/m3)	Acetaldehyde Risk	Excess Cancers per 70 years
530530714061000	519	0.56	1.5E-06	0.0008
530530714061001	0	0.55	1.5E-06	0.0000
530530714061002	488	0.44	1.2E-06	0.0006
530530714061003	55	0.43	1.2E-06	0.0001
530530714061004	53	0.36	9.6E-07	0.0001
530530714061005	101	0.40	1.1E-06	0.0001
530530714061006	72	0.33	9.0E-07	0.0001
530530714061007	39	0.36	9.7E-07	0.0000
530530714061008	66	0.53	1.4E-06	0.0001
530530714061009	669	0.44	1.2E-06	0.0008
530530714061010	0	0.67	1.8E-06	0.0000
530530714061011	104	0.59	1.6E-06	0.0002
530530714061012	455	0.85	2.3E-06	0.0010
530530714061013	36	0.56	1.5E-06	0.0001
530530714062000	163	0.98	2.6E-06	0.0004
530530714062001	0	0.43	1.2E-06	0.0000
530530714062002	35	0.37	9.9E-07	0.0000
530530714062003	200	3.63	9.8E-06	0.002
530530714062004	196	0.61	1.6E-06	0.0003
530530714062005	4	0.47	1.3E-06	0.00001
530530714062006	63	0.44	1.2E-06	0.0001
530530714062007	68	0.86	2.3E-06	0.0002
530530714062008	28	0.96	2.6E-06	0.0001
530530714062009	533	0.53	1.4E-06	0.0008
530530714063003	128	0.28	7.5E-07	0.0001
530530714063006	60	0.24	6.4E-07	0.0000
530530714063007	39	0.44	1.2E-06	0.00005
530530714063008	169	0.39	1.0E-06	0.0002
530530714063019	0	0.27	7.3E-07	0
530530714063021	5	0.25	6.6E-07	0.000003
530530714064000	321	0.39	1.1E-06	0.0003
530530714064001	491	0.35	9.4E-07	0.0005
530530714064004	17	0.44	1.2E-06	0.00002
530530714064005	40	0.41	1.1E-06	0.00004
530530714064010	17	0.43	1.2E-06	0.00002
530530714064012	70	0.36	9.9E-07	0.0001
530530714064013	222	0.41	1.1E-06	0.0002
530530714073000	283	0.27	7.2E-07	0.0002
530530714074007	113	0.32	8.5E-07	0.0001
530530714074011	411	0.36	9.7E-07	0.0004
530530714111000	1677	0.27	7.3E-07	0.001
Total				0.011