Roxul USA, Inc. d/b/a ROCKWOOL

665 Northport Avenue Kearneysville, WV 25430

Human Health Risk Assessment

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THE SCIENCE OF READY℠

Executive Summary

ROCKWOOL asked CTEH to evaluate the potential health risks to students at nearby schools associated with emissions from a mineral wool insulation manufacturing facility currently being constructed by Roxul USA, Inc. d/b/a ROCKWOOL (ROCKWOOL) in Ranson, West Virginia. Given that the facility still is under construction, CTEH has relied upon modeled emissions results as source data for the human health risk assessment.

Constituents of concern were identified based on a review of manufacturing facility processes and potential emissions associated with these processes, and inhalation of impacted air was considered as the sole route of exposure. Criteria pollutant (particulate matter, nitrogen dioxide, and sulfur dioxide) and hazardous air pollutant (formaldehyde, phenol, and methanol) concentrations in air were estimated at five nearby schools, including one childcare facility, using air dispersion modeling software. The air concentrations were modeled at the permitted emission values. Lifetime cancer risk estimates as well as noncancer hazard quotients were developed following standard risk assessment methodology.

From the results of this human health risk assessment we conclude that there is no significantly increased risk of adverse health effects associated with the air concentrations evaluated for the students at the five specified school locations. All cancer risks were below one in one million excess lifetime cancer risk, which is the lower end of the US Environmental Protection Agency's risk management range. In one case, the cancer risk was as low as 1 in 100,000,000 (1E-08), or 100-fold lower than the 1 in 1,000,000 minimum risk level for cancer. Hazard indices, the sum of all hazard quotients representing noncancer health hazards, were all below 1.0, a threshold signifying potential for adverse effects.

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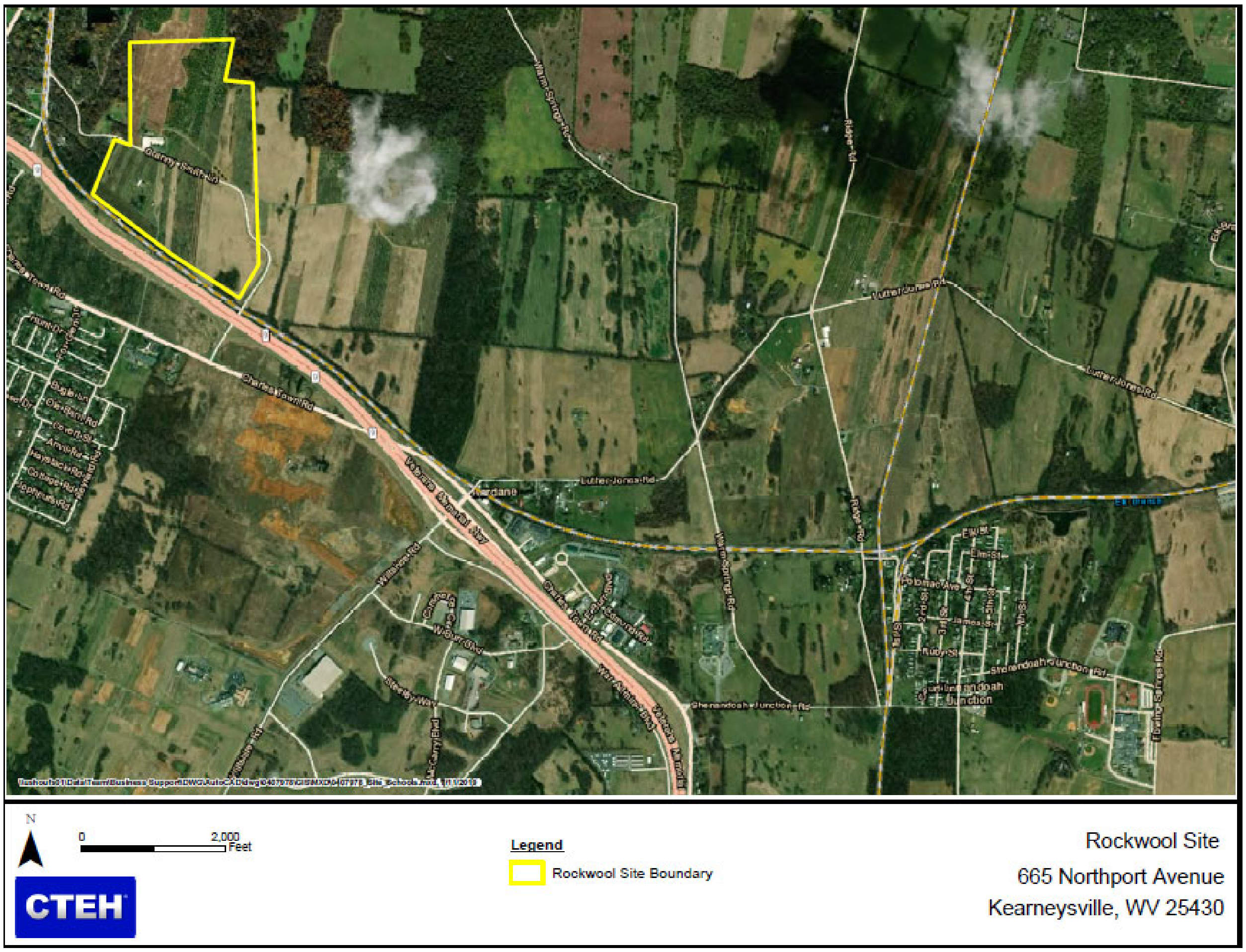
1.0 Project and Site Description

ROCKWOOL asked CTEH to prepare a human health risk assessment for a ROCKWOOL facility in Ranson, West Virginia, for the purposes of better understanding and communicating potential impacts to stakeholders regarding the local air quality. ROCKWOOL is constructing a manufacturing facility that will produce mineral wool insulation, located within approximately 460,000 square feet of industrial space located in 130 acres of land in Ranson, West Virginia. Construction is currently underway. A site location map is provided as **Figure 1**.

Figure 1: ROCKWOOL Facility Map



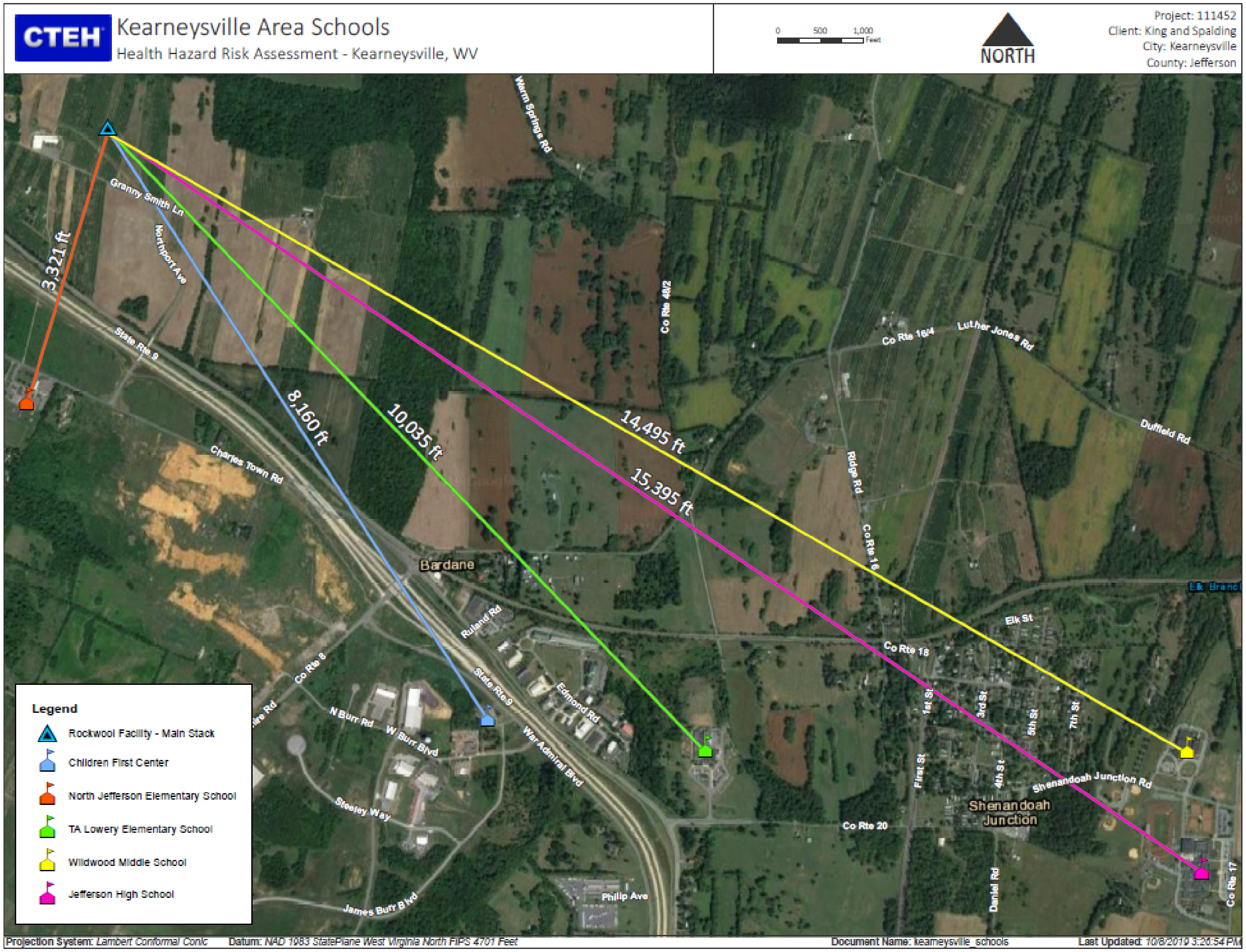
A human health risk assessment analyzes and enumerates potential human health risks associated with exposures to specified chemicals of potential concern (COPCs) and provides useful information to concerned parties regarding potential health impacts that may warrant additional scrutiny. While other methods of evaluation are available, the standardized human health risk assessment provides additional information in the face of uncertainty to decision makers and to the community that may be otherwise unavailable. This information includes, but is not limited to, segregated cancer and noncancer risk evaluation, site-specific exposure assumptions, and a discussion of uncertainties associated with, and necessitated by, the risk assessment process.

The human health risk assessment presented in this report was conducted for five schools located in the vicinity of the future ROCKWOOL manufacturing facility in Ranson. A map of the schools evaluated in this risk assessment is provided as **Figure 2**. The schools assessed, and their respective addresses, are:

School	Address
North Jefferson Elementary School	6996 Charles Town Rd Kearneysville, WV 25430
Children First Center	95 Childrens Way Kearneysville, WV 25430
TA Lowery Elementary School	103 Shenandoah Junction Rd Shenandoah Jct, WV 25442
Wildwood Middle School	1209 Shenandoah Junction Rd Shenandoah Jct, WV 25442
Jefferson High School	4141 Flowing Springs Rd Shenandoah Jct, WV 25442

This HHRA focuses on concentrations in air. The focus on air emissions is due to the physico-chemical properties of the criteria pollutants and the hazardous air pollutants, which represent primarily gaseous emissions. All emissions are anticipated to be below the National Ambient Air Quality Standards (NAAQS) and other health-based thresholds, as described in further detail in Section 2.1. The primary exposure pathway is inhalation and therefore other pathways are not considered in this report.

Figure 2: Kearneysville Area Schools



2.0 Data Summary and Evaluation

The human health risk assessment methodology used in this report is consistent with current guidance put forth by the EPA in the series of documents titled, "*Risk Assessment Guidance for Superfund, Volume I, Human Health Evaluation Manual.*" The framework for risk assessments is continually supplemented with exposure and toxicity factor information, the most recently updated versions of which are incorporated into this assessment (USEPA, 1989b; USEPA, 2003; USEPA, 2014a). A human health risk assessment (HHRA) is a predictive tool used to estimate potential health risk to human receptors based on measured or modeled emissions data.

To make the relevant comparison, the source data for this risk assessment is drawn from air quality modeling analysis performed by the environmental consulting firm, ERM, in support of permit applications for the ROCKWOOL facility. This human health risk assessment uses the nearest "sensitive receptor" locations which are local area schools in Kearneysville. In brief, an air quality modeling report was prepared on behalf of ROCKWOOL and submitted in support of the pre-construction air permit application to the West Virginia Department of Environmental Protection (WVDEP). Specific information relating to the modeling process can be found in the ERM report (ERM, 2017).

The air permit comprises a mineral wool line, acoustic insulation (Rockfon) line, and coal milling. Other operations which may impact surrounding air quality include natural gas heating, paved haul roads, and fire pump engines, to name a few, and are also accounted for in the permit. Outputs from these additional sources, as well as background sources, are included in the modeling report. The latest versions of several modeling software programs (AERMOD (version 16216r), AERMET (version 16216), AERMINUTE (version 15272), AERMAP (version 11103), AERSURFACE (version 13016), and BPIPRM (version 04274)) have been used to estimate concentrations of COPCs in air at several locations in the vicinity of the ROCKWOOL site (ERM, 2017). These school locations have been selected because they represent opportunities for exposure to COPCs from ROCKWOOL operations by students. Additional locations such as residential homes and commercial or industrial properties are beyond the scope of the present report.

2.1 Chemicals of Potential Concern in Air

This report focuses on a select subset of potential emissions components from the ROCKWOOL facility that were chosen based on permitted constituents: particulate matter ($PM_{2.5}$ and PM_{10}), nitrogen dioxide (NO_2), and sulfur dioxide (SO_2). These emissions components represent those modeled with the highest potential to negatively impact local air quality, though results of the modeling analysis indicate that these and other criteria air pollutants are not expected to cause an exceedance of National Ambient Air Quality Standards (NAAQS) (ERM, 2017).

In addition, emission limits for additional hazardous air pollutants (HAPs) formaldehyde, phenol, and methanol are regulated by an EPA rule during the production of mineral wool insulation, also known as the Maximum Achievable Control Technology (MACT) standards (40 CFR Part 63, 2015). Therefore, the following emissions components are evaluated in the health risk assessment:

- Particulate matter ($PM_{2.5}$ and PM_{10})
- Nitrogen dioxide (NO_2) (CAS# 10102-44-0)
- Sulfur dioxide (SO_2) (CAS# 7446-09-5)
- Formaldehyde (CAS# 50-00-0)
- Phenol (CAS# 108-95-2)
- Methanol (CAS# 67-56-1)

Formaldehyde is the only COPC that has been identified as a carcinogen. EPA has classified formaldehyde as a probable human carcinogen (B1) under conditions of unusually high or prolonged exposure in the most recent completed toxicological review (NCI, 2011; USEPA, 1989a).

While all of the COPCs are regulated under the Clean Air Act, only a subset have established federal air quality standards (particulate matter, NO_2, and SO_2). The remaining components do not have federal air quality standards but may be regulated as hazardous chemicals under various occupational or industrial laws and rules (e.g., OSHA formaldehyde regulations). Regardless of the authority, the regulation of all these components includes the eventual establishment of standards designed to protect human health which are based on the best available science at the time of review and which are designed to protect the health of sensitive populations within communities. In the absence of air quality standards, the concentrations are compared against available health-based criteria.

The EPA is required to establish NAAQS as part of the Clean Air Act. The standards are divided into primary (health-protective) and secondary (welfare-protective) standards that undergo periodic review and update. Primary standards are meant to protect the health of "sensitive" populations such as asthmatics, children, and the elderly, while secondary standards provide protection against decreased visibility and damage to animals, crops, vegetation, and buildings.

Six pollutants are included in the current NAAQS standards: particulate matter, NO_2, SO_2, carbon monoxide (CO), ozone (O_3), and lead (Pb). These are commonly referred to as "criteria air pollutants." The particulate matter pollution category is further divided into inhalable particulate matter (PM_{10}, generally 10 micrometers and smaller) and fine inhalable particles ($PM_{2.5}$, generally 2.5 micrometers and smaller).

Reviewing and updating the NAAQS involves several steps; Integrated Science Assessment (ISA), Risk/Exposure Assessment (REA), Policy Assessment (PA), and Rulemaking. According to the most recently completed review and update:

> *"…protection from both long and short-term $PM_{2.5}$ exposures can most effectively and efficiently be provided by relying primarily on the annual standard, with the 24-hour standard providing supplemental protection for days with high peak concentrations."* (USEPA, 2011)

Reviews of other criteria pollutants focus on differing exposure scenarios, such as the 3-hour average for SO_2. We note that SO_2 does not have an annual standard, and that the shorter duration value is averaged over 3 years. In each evaluation, EPA selects the appropriate monitoring period which provides the highest level of protection for sensitive populations, and these periods may differ among the criteria pollutants and may change with additional evaluation. For the purposes of comparison in this report, the criteria pollutant's primary standard is compared with the most appropriate matched modeled output.

We note that the current NAAQS are under review and may be subject to change. For example, the 1-hour NAAQS standards for NO_2 and SO_2, set in 2010, were reviewed and retained in 2012, while the Primary $PM_{2.5}$-annual concentration was reviewed and decreased in 2012 from 15 µg/m^3 to 12 µg/m^3. The MACT standards also were also recently reviewed, revised, and finalized in 2015. No changes were made to the HAPs (formaldehyde, phenol, and methanol) from the 2014 proposal based on data collected by the USEPA from operational cupolas (40 CFR Part 63, 2015).

Other chemicals included in this risk assessment (formaldehyde, phenol, and methanol) were evaluated by comparison to health-based criteria established by the EPA's Integrated Risk Information System (IRIS). The IRIS program performs regularly updated toxicological review and summary to identify hazards associated with exposure to a given chemical and set health-based criteria that can be relied upon by risk managers and assessors.

2.2 Modeling Scenarios

Modeling of emissions from the ROCKWOOL facility using the programs described above has focused on the permitted emission values. Evaluation of these permitted values should be considered a "worst case" scenario, with all emissions components emitted at the highest rates possible given the potential output of the facility. The permitted mass emissions are not likely to be reached under normal or typical use scenarios.

Modeled air concentrations of COPCs from permitted emissions are presented in **Table 1** (ERM, 2017). The data evaluated reflect emissions from ROCKWOOL operations only. There are currently no measurements of COPCs in the immediate vicinity of the ROCKWOOL facility nor the school locations to be evaluated.

Table 1: Modeled concentrations of annual permitted COPCs from ROCKWOOL in air at school locations in µg/m^3

Exposures	North Jefferson Elementary School	Children First Center	TA Lowery Elementary School	Wildwood Middle School	Jefferson High School
$PM_{2.5}$	0.400	0.120	0.110	0.080	0.070
PM_{10}	0.650	0.190	0.160	0.110	0.100
NO_2	0.610	0.210	0.190	0.150	0.140
SO_2	0.240	0.110	0.100	0.090	0.080
Formaldehyde	0.230	0.080	0.070	0.050	0.040

Exposures	North Jefferson Elementary School	Children First Center	TA Lowery Elementary School	Wildwood Middle School	Jefferson High School
Phenol	0.290	0.110	0.090	0.060	0.060
Methanol	0.140	0.060	0.060	0.040	0.040

3.0 Exposure Assessment

The objectives of the exposure assessment are to evaluate potential pathways of human exposure to COPCs identified in air in school locations near the ROCKWOOL facility. As discussed in Section 2, $PM_{2.5}$, PM_{10}, NO_2, SO_2, formaldehyde, phenol, and methanol were identified as COPCs in air for the HHRA.

The exposure assessment calculates chemical intakes for potentially exposed populations that could be considered representative of a "reasonable maximum exposure" (RME). The RME is defined by the EPA as the highest exposure that is reasonably expected to occur at a site, and also as the maximum exposure reasonably expected to occur in a population. (USEPA, 1989b; USEPA, 2014b). The intent of the RME scenario is to calculate chemical intakes that do not underestimate exposure under conservative exposure conditions.

3.1 Characterization of the Exposure Setting

The exposure setting evaluated utilizes default assumptions regarding frequency and duration of exposure supported by EPA rather than site-specific information to provide a conservative estimate. For example, an average exposure time of 8 hours per day is recommended by EPA for evaluation of workplace exposure settings, while schools typically do not host classes for this amount of time. In addition, most schools are in session approximately 180 days per year, while the exposure frequency recommended by EPA reflects 250 days in the workplace (USEPA, 2014a). Finally, an assumed exposure duration (ED) of 6 years was used for students, as this reflects the longest period of attendance at any one school (from kindergarten through 5^{th} grade at an elementary school, for example). An additional consideration of a student attending all schools in sequence was included. We note that middle and high schools, as well as childcare facilities, will have shorter durations of attendance. Equations for the averaging time for carcinogens (AT-C) and noncarcinogenic hazards (AT-N) are included below. The assumptions included in the present evaluation exceed any expected actual time on campus and are consistent with EPA guidance. Information relating to the exposure parameters included in this evaluation are presented in **Table 2**.

Table 2: Exposure parameters and intake equation

Exposure Route	Parameter Code	Parameter Definition	Units	RME Value	RME Reference	Model Name/ Intake Equation
Inhalation	CA	Chemical Concentration in Air	μg/m³	NA	NA	
	ET	Exposure Time	hrs/day	8	EPA, 2014	Exposure Concentration (EC) (mg/m³) = CA x CF x ET x EF x ED x 1/AT
	EF	Exposure Frequency	days/year	250	EPA, 2014	
	ED	Exposure Duration	years	6	EPA, 2014	
	AT-C	Averaging Time (Cancer)	hrs	613,200	EPA, 2009	
	AT-N	Averaging Time (Non-Cancer)	hrs	219,000	EPA, 2009	
	CF	Conversion Factor	mg/μg	0.001	NA	

AT-C = 365 days / year * 70 years * 24 hrs/day
AT-N = 365 days / year * ED years * 24 hrs/day

3.2 Exposure Pathway Analysis

According to EPA, an exposure pathway describes the course a chemical or physical agent takes from the source to an exposed individual. An exposure pathway analysis links the sources, locations and types of environmental releases with population locations and activity patterns to determine the significant pathways of human exposure (USEPA, 1989b; USEPA, 2014b).

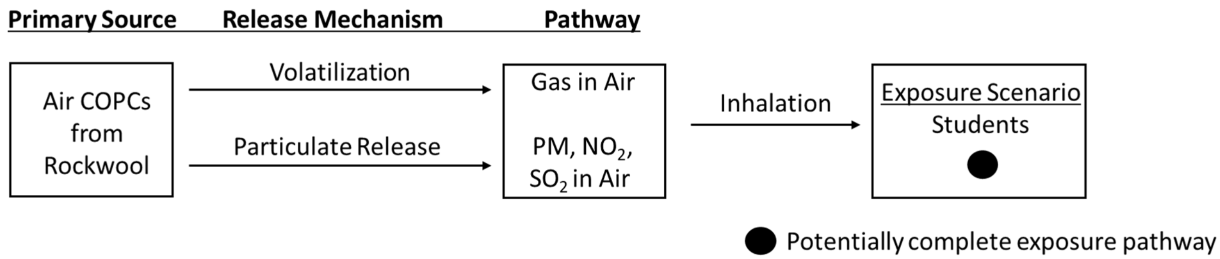
An exposure pathway is made up of four elements. These are:

- A source and mechanism of chemical release;
- A retention or transport medium;
- A point of potential human contact with the contaminated medium; and
- An exposure route at the contact point.

The source evaluated in this report is the ROCKWOOL facility: the mineral wool line (including the recycle plant), tile insulation line, coal milling, natural gas heating, emergency fire pump engine, internal truck traffic, and storage tanks (ERM, 2017). This evaluation is focused on inhalation of impacted air and assumes exposures exclusively to impacted outdoor air. No effort has been made to reduce exposure assumptions to reflect time indoors, where air filters or other processes would likely reduce concentrations of COPCs in air.

An exposure pathway diagram for chemicals in air is described in **Figure 3**.

Figure 3: Exposure pathway diagram



3.3 Determination of Exposure Point Concentrations

Exposure point concentrations reflect potential contact with COPCs in the various media through a particular route (e.g., inhalation of a chemical in air). Exposure point concentrations (EPCs) are determined for each environmental medium of concern at or potentially affected by the ROCKWOOL site. Typically, the EPC is a conservative estimate of the arithmetic average concentration of a COPC in a particular environmental medium (e.g., air). The conservative average is a calculated concentration when sufficient sample results are available. In that case, the 95% upper confidence limit (UCL) of the arithmetic mean is calculated to represent a conservative EPC.

When measured data of sufficient quantity or quality are not available, modeled or estimated values must be used. In this case, modeled air emissions can be used as EPCs given that valid methods are used in generating the output air concentrations. The EPA has identified several preferred and recommended air quality dispersion models for use in permit application and other processes, and one of these (AERMOD) was used to produce the EPC used in this risk assessment (ERM, 2017). AERMOD is a steady-state plume model based on five years of meteorological data from a given area, which can accommodate both surface and elevated sources and both simple and complex terrain.

4.0 Toxicity Assessment

Sources and selection of toxicity values used in the HHRA follows EPA hierarchy and are as follows: Integrated Risk Information System (IRIS) (Tier 1 values), EPA provisional peer-reviewed toxicity values (Tier 2 values), and other EPA and non-EPA derived toxicity values (Tier 3 values).

4.1 Toxicity Assessment for Non-cancer Effects

In the case of the criteria pollutants ($PM_{2.5}$, PM_{10}, NO_2, SO_2) there are no EPA-derived toxicity values available for consideration in a risk assessment context, so EPA guidance regarding the use of NAAQS values is followed. It is recognized that the NAAQS and standard toxicity values undergo differing reviews and are developed with differing methods. However, EPA has recommended the use of NAAQS as toxicity values. Specifically, EPA states:

> *"Since the primary NAAQS and the inhalation RfC [Reference Concentration] serve essentially the same function, and the primary NAAQS have extensive data bases rigorously reviewed, the primary NAAQS with annual averaging times should be used in lieu of an inhalation RfC, except for lead."* (USEPA, 1997)

The non-cancer effects of COPCs were assessed using the EPA hazard quotient approach. Briefly, this approach compares the average daily exposure concentration of each chemical to a published reference concentration (RfC) for chronic or subchronic exposure (i.e., chronic and subchronic RfC). As the constituents considered here are all inhalation toxicants, the RfC values are used. The EPA's RfC definition is presented here (USEPA, 2014b):

Reference Concentration (RfC):

A Reference Concentration, or 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 an appreciable risk of deleterious effects during a lifetime. It can be derived from a no observed adverse effect level (NOAEL), lowest observed adverse effect level (LOAEL), or benchmark concentration, with uncertainty factors generally applied to reflect limitations of the data used. RfCs generally are used in EPA's non-cancer health assessments.

Table 3 presents the RfCs used to assess non-cancer hazards for each of the chemicals of potential concern.

Table 3: Reference concentrations for COPCs

Chemical	Chronic/ Subchronic	Reference Concentration (RfC)	Units	Primary Target Organ	Source of RfC
$PM_{2.5}$	Chronic	12	ug/m^3	Respiratory	NAAQS
PM_{10}	Chronic	150	ug/m^3	Respiratory	NAAQS
NO_2	Chronic	100	ug/m^3	Respiratory	NAAQS
SO_2	Chronic	196	ug/m^3	Respiratory	NAAQS
Formaldehyde	Chronic	9.8	ug/m^3	Respiratory	ATSDR
Phenol	Chronic	6	ug/m^3	No effect value	EPA Provisional
Methanol	Chronic	20,000	ug/m^3	Brain	EPA IRIS

The air concentration/RfC is defined by the EPA to be the hazard quotient (HQ) for a chemical. When the HQ is less than 1, it is unlikely that an adverse health effect will occur. The potential for observing an effect increases as the HQ increasingly exceeds unity. The EPA directs that the HQ for each chemical and each route of exposure be summed to calculate a hazard index (HI). This process conservatively assumes that simultaneous exposure to multiple chemicals at intakes below their respective RfCs may produce an adverse health effect if the HI exceeds 1. When calculated according to EPA methods, the HI assumes that the effects of each chemical are additive. The HI is used as a screening method to determine whether or not the effects of intake of multiple chemicals may be of concern. If the HI is less than one, there is little reason to expect that any adverse effect will result from concurrent exposure to all of the COPCs.

4.2 Toxicity Assessment for Carcinogenic Effects

Formaldehyde is the only carcinogenic COPC included in this risk assessment. The following data were compiled for formaldehyde:

- Current inhalation unit risk (IUR)
- EPA weight-of-evidence classification
- Target organ(s)

The IUR risk values are quantitative estimates defined as the risk per milligram of chemical per cubic meter of air $(mg/m^3)^{-1}$. The weight-of-evidence classification indicates the extent to which available data indicate the substance is a human carcinogen. This information is available from the USEPA in IRIS. We note that formaldehyde is classified by USEPA as a Probable Human Carcinogen (B1), based on limited evidence of carcinogenicity in humans and sufficient evidence in animals (USEPA, 1989a).

The IUR values, EPA weight-of-evidence classification, and target organs for the carcinogenic effects of formaldehyde is presented in **Table 4.**

Table 4: Toxicity information for carcinogenic evaluation

Chemical	Inhalation Unit Risk $(ug/m^3)^{-1}$	Weight of Evidence/ Cancer Guideline Description	Target Organ	Source
Formaldehyde	1.30E-05	B1	Respiratory	EPA

Due to the increased susceptibility of cancer in infants and children to cancer, the EPA indicates that cancer risks for mutagenic carcinogens, such as the carcinogenic polycyclic aromatic hydrocarbons (PAHs), should be adjusted upward by multiplying calculated risks by an age dependent adjustment factor (ADAF). In the most recent final evaluation by USEPA, formaldehyde is not considered to have a mutagenic mode of action, so ADAFs are not necessary (USEPA, 1989a).

5.0 Risk Characterization

The methods described in Chapter 8 of the Human Health Evaluation Manual (USEPA, 1989b) and other appropriate EPA guidance were used to calculate hazard quotients for non-carcinogens and excess theoretical cancer risks for carcinogens. Risk estimates were obtained by calculating the exposure concentration (EC) for non-cancer hazard and cancer risk assessments. Inhalation exposures were calculated according to methods described in EPA *Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part F, Supplemental Guidance for Inhalation Risk Assessment)* (USEPA, 2009).

5.1 Assessment of Non-cancer Hazards

Non-cancer effects are expressed as the ratio of EC divided by the RfC. This ratio is called a Hazard Quotient (HQ) and is calculated as follows:

$$HQ = EC / RfC$$

where:

HQ = hazard quotient

EC = exposure concentration in air (mg/m^3)

RfC = reference concentration (mg/m^3); for periods of exposure less than 7 years, the subchronic RfC is used if available; the chronic RfC is used to evaluated non-cancer hazards for exposure periods of 7 years or longer or when there is no available subchronic RfC.

HQs for each COPC and each exposure pathway are added together to derive the Hazard Index (HI). The HI is the sum of more than one HQ for multiple substances and/or multiple exposure pathways. If the HI is less than 1, the chemicals are unlikely to pose a hazard to human health. If the HI is greater than 1, the chemicals are segregated according to target organ toxicity. Separate hazard indices are calculated for each toxicological effect. Finally, if the HI is still greater than 1, exposure to these chemicals may be a concern for potential non-cancer effects. HQs and HI are presented for each receptor and exposure pathway of concern.

Subchronic RfCs are appropriate for scenarios with exposure durations less than 7 years (i.e. the construction worker). Subchronic RfCs were unavailable for the COPCs at the site, therefore chronic RfCs were used for the exposure scenarios even though the exposures are less than the 7 year to lifetime exposure duration that EPA defines as a chronic exposure period.

5.2 Assessment of Theoretical Carcinogenic Risks

Theoretical cancer risks associated with exposure to COPCs were calculated as follows:

$$Risk = EC \times IUR$$

where:

Risk = a unitless probability (e.g. 2E-5) of an individual developing cancer over a 70-year lifetime.

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

IUR = inhalation unit risk ($(\mu g/m^3)^{-1}$)

The resulting cancer risks are expressed in scientific notation (e.g., 1.0E-04 to 1.0E-06) and refer to additional lifetime cancer risks of one cancer in 10,000 persons to one cancer in 1,000,000 persons. For example, a calculated theoretical lifetime cancer risk of 1.0E-05 (or 1 in 100,000) indicates that if 100,000 people were exposed to a potentially carcinogenic chemical during their 70-year lifetimes, one of the 100,000 individuals would theoretically develop cancer from the exposure. The EPA generally considers total lifetime cancer risks between 1.0E-04 and 1.0E-06 as acceptable for exposures to multiple chemicals with potential carcinogenic effects. This assessment used the EPA-derived cancer slope factors and inhalation unit risk values discussed above to quantitatively assess carcinogenic risks.

5.3 Risks and Hazards from Exposures to COPCs in Air

The sections below describe the risk and hazard results to students at each of the five assessed school locations following exposure to impacted air.

After analyzing potential risks and hazards associated with exposure to air concentrations at the maximum permitted emissions of COPCs, we conclude that the cancer risk to students at each site is less than the minimum risk level of 1 in 1,000,000 incidences of cancer. Similarly, the hazard index for students at each site is below 1.0. Risks and hazard indices are presented in **Table 5**, while individual hazard results for each COPC are presented in **Supplementary Tables 1A and 1B.**

We note that additive cancer risks may be appropriate for a student attending the schools in succession, and that in this case the sum of cancer risks for all schools attended should be calculated. In this instance, a student beginning attendance at Children First Center followed by North Jefferson Elementary School, Wildwood Middle School, and Jefferson High School may experience cancer risks of up to 1.02E-07, which is below the 1 in 1,000,000 (1E-06) minimum risk level for cancer risk. In the case of Jefferson High School, the cancer risk was as low as 1 in 100,000,000 (1E-08), or 100-fold lower than the 1 in 1,000,000 minimum risk level for cancer. We also note that such an additive time component would not be appropriate for non-cancer hazards, which are not expected to accumulate over time in the same way as cancer risks.

Table 5: Cancer risks and HI for permitted emission values

Total Cancer Risks and Hazard Indices	Cancer Risk Students	Hazard Index Students
North Jefferson Elementary School	5.9E-08	0.027
Children First Center	2.0E-08	0.009
TA Lowery Elementary School	1.8E-08	0.008
Wildwood Middle School	1.3E-08	0.006
Jefferson High School	1.0E-08	0.005

6.0 Risk Assessment Uncertainties

Uncertainties are inherent to any risk assessment and a discussion of the uncertainties helps put into perspective the risks calculated for a site. Uncertainties may be associated with the environmental data used to assess exposure, the estimate of exposure, or the toxicity of the chemical of concern. Since risk characterization serves as a bridge between risk assessment and risk management, it is important that major assumptions, scientific judgements, and estimates of uncertainties be described in an uncertainty analysis. The EPA has identified several categories of uncertainties associated with risk assessments (USEPA, 1989b). These include analytical-, exposure- and toxicity-related uncertainties.

6.1 Exposure Uncertainties

Use of modeled data for risk assessment purposes involves assumptions relating to exposure that are not present in assessments based on measured data. In this case, we have elected to use the annual average air concentration for all constituents at each receptor location, with the understanding that the modeling process itself adds additional conservatism. These additional uncertainties are considered health protective, as they serve to increase the air concentration of all COPCs considered. For example, HAPs formaldehyde, methanol, and phenol are modeled with no consideration for degradation in air or sunlight. All the HAPs readily biodegrade in air, and none accumulate in the environment; modeling processes provide additional margin of safety by not considering these fate and transport processes.

Another area of uncertainty involves the annual average data used, which includes operation of the facility full-time for the entire year. This is not reflective of reality, and there is no simple method for predicting non-operational time for the furnace or any components of the ROCKWOOL facility. Due to the lack of biodegradation considerations and less emission time during real-world operations, the annual average is expected to include significant margins of exposure that are conservative in nature.

Exposure time and duration add uncertainty as well, and this evaluation was conducted in such a way as to overestimate both factors due to lack of suitable substitute values. The default EPA exposure time of 8 hours per day is not reflective of an actual school day, though some students may spend additional time on campus on some occasions. Similarly, students are likely not outdoors for more than a small portion of the 8-hour period considered in this evaluation; indoor air is likely not impacted to the same degree as outdoor air through the action of filters and air circulation. The frequency of exposure, 250 days per year, is likely a significant overestimation of the time on campus for students as well. This is 70 days more than the legal minimum in West Virginia of a 180-day school year and would account for significant time before and after the school year for additional on-campus activities such as activities outside of the classroom for students. We considered use of exposure time and duration values that could be more reflective of the actual experiences of students, such as inclusion of before and after school activities, but could not identify verifiable sources for such information. Therefore, we have relied upon default assumptions from EPA for workplace exposures in the present analysis with the understanding that these assumptions are likely far higher than those experienced at the school locations.

This report focuses on the potential risks and hazards associated with exposure to a limited number of COPCs associated with the ROCKWOOL facility. These COPCs were chosen based on their relevance to the permitting and regulatory processes, as described in Section 2. Additional COPCs are likely associated with ROCKWOOL operations, though these have been identified and are below threshold assessment in the permitting processes. Risks and hazards from these COPCs are not addressed here.

While risk assessments are capable of estimating health risks associated with contact with multiple media such as air, water, and soil, this report focuses on concentrations in air. The current analysis is limited to air while consideration of impacts to other media are beyond the scope of this report.

This analysis focuses on the contributions from ROCKWOOL to health risks and hazards and does not include background sources present in the immediate vicinity of the schools (such as roads and other facilities) or regional influences on air quality, which may impact the concentrations of COPCs in air and thus risk and hazard. This limitation is due to the lack of air monitoring data for the local area.

In brief, the areas of uncertainty and which add conservatism to the results of this HHRA include:

- Use of modeling to predict airborne concentrations;
- Assumption that the ROCKWOOL facility operates all processes 365 days per year with no downtime for maintenance;
- Use of conservative values for the number of days students are present in school buildings; and
- Use of conservative hours for student presence in school buildings.

6.2 Toxicity Factor Uncertainties

Uncertainties are associated with the toxicity values for COPCs and the manner in which lifetime cancer risks are estimated. Perhaps the greatest uncertainty associated with the risk assessment process is the evaluation of carcinogenic risk due to chemical exposure. The fundamental principles underlying risk assessment for carcinogenic chemicals remain arguable, including the tenet that every potential carcinogen is associated with some degree of carcinogenic risk, no matter how small the dose (i.e., linear no-threshold model) (Calabrese, 2011). In other words, the linear no-threshold model assumes that every exposure leads to a quantifiable increased health risk. This policy is adopted by the EPA to ensure that human health is protected with a margin of safety. However, a policy-based implementation of the linear no-threshold model is not necessarily based on actual or realized increases in human health risk. This is exemplified by our daily exposure to a variety of carcinogens without significant increases in cancer risk.

An additional uncertainty related to toxicity factor selection is due to the lack of RfC values for criteria air pollutants. While specific EPA guidance recommends the use of NAAQS values in lieu of RfCs, differences in the review process and calculations exist between the RfCs and NAAQS values. The NAAQS values are updated on a regular basis, while RfC values are reviewed on a less regular schedule determined subjectively by the EPA and dependent upon receipt of potentially significant new data.

7.0 Summary and Discussion

The human health risks from a variety of COPCs associated with activities at the ROCKWOOL, WV, facility were evaluated for students at five area schools. The COPCs were evaluated for both cancer and noncancer endpoints, which are described herein.

Air concentrations from the ROCKWOOL facility were modeled using permitted emissions values, which represent a worst-case scenario. Students were assessed due to concerns about sensitive receptors at local schools. Risks and hazards for students were lower than the EPA risk management range of one in one million to one in ten thousand increased cancer risks and for noncancer hazards were below the hazard index of 1.0, a threshold signifying potential for adverse effects.

The results of the human health risk assessment indicate that there is no significantly increased risk of adverse health effects for students at nearby schools associated with operations of the ROCKWOOL facility. This conclusion is based on the assumptions described within this report and the duration and frequency of exposure to COPCs assessed in this report.

All of the conclusions in this report are expressed to a reasonable degree of scientific certainty. CTEH reserves the right to amend the conclusions contained within this report should additional information become available.

Respectfully submitted,

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8.0 Supplementary Tables

Supplementary Table 1A and 1B: Hazard Results for Permitted Emissions

1A) Hazardous Air Pollutants

Hazard Quotient for Hazardous Air Pollutants	Formaldehyde	Phenol	Methanol
	Student	Student	Student
North Jefferson Elementary School	5.4E-03	1.1E-02	1.6E-06
Children First Center	1.9E-03	4.2E-03	6.8E-07
TA Lowery Elementary School	1.6E-03	3.4E-03	6.8E-07
Wildwood Middle School	1.2E-03	2.3E-03	4.6E-07
Jefferson High School	9.3E-04	2.3E-03	4.6E-07

1B) Criteria Pollutants

Hazard Quotient for Criteria Air Pollutants	PM2.5	PM10	NO2	SO2
	Student	Student	Student	Student
North Jefferson Elementary School	7.6E-03	9.9E-04	1.4E-03	2.8E-04
Children First Center	2.3E-03	2.9E-04	4.8E-04	1.3E-04
TA Lowery Elementary School	2.1E-03	2.4E-04	4.3E-04	1.2E-04
Wildwood Middle School	1.5E-03	1.7E-04	3.4E-04	1.0E-04
Jefferson High School	1.3E-03	1.5E-04	3.2E-04	9.3E-05

9.0 References

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Appendix A

Qualifications and Biographies

CTEH Overview

CTEH is a scientific consulting firm composed of teams of experts dedicated to being the most trusted and valued resource to the companies, governments and communities we serve in times of need. Our work includes risk and exposure assessment, disaster and emergency response and recovery, industrial hygiene, and occupational health, as well as other areas of expertise. We have more than 20 PhD toxicologists with expertise and experience in human health risk assessment and communication, and teams of health scientists and other professionals committed to protecting human health and the environment.

CTEH is experienced in human health risk assessments in general and has specific experience in the conduct of assessments considering exposure to children as well as exposure to particulate matter. CTEH provides qualitative and quantitative site-specific evaluations of risks posed to human health. Unlike other consulting firms, CTEH toxicologists and health scientists understand the basis of toxicology in the field of human health risk assessment and apply fundamentals of toxicology to protect people and the environments they live in.

Our toxicologists, Dr. Angie Perez and Dr. Patrick Kerzic, have prepared this human health risk assessment. Brief bio sketches are below, and more detailed information can be found on the following pages.

Angie Perez, PhD

Dr. Angie Perez is a senior toxicologist with 15 years of experience in toxicology, exposure and human health risk assessment, and risk communication. Dr. Perez has participated in numerous stakeholder and community meetings related to the Portland Harbor Superfund Site and the Oregon Department of Agriculture. She serves as an expert and director of a broad range of projects including those involving exposure assessment of children's products, dose reconstruction, industrial hygiene, and disease causation. Dr. Perez also participates in the Toxicology Emergency Response Program (TERP), conducting air monitoring and environmental sampling to address worker and public safety following HazMat incidents across North America. She has over 35 published articles and abstracts on the topics of asbestos, triclosan, metals, phthalates, styrene, volatile organic chemicals (VOCs), poly- and perfluoroalkyl substances (PFAS - e.g., PFOA, PFOS), and decision analysis tools for chemical hazard prioritization.

Patrick Kerzic, PhD DABT

Dr. Kerzic is a board-certified toxicologist with more than 12 years of experience in human health risk assessment as well as nearly 20 years of experience studying inhalation toxicology. He has overseen risk assessments for over 100 contaminated sites during his work as a staff toxicologist for the California Environmental Protection Agency and has led and participated in risk communication activities within many of the communities involved. He has experience applying health-based standards for indoor and ambient air for risk assessments including considerations for sensitive receptors such as schools and child day care facilities. Dr. Kerzic has also served as an outside peer reviewer for EPA's Provisional Peer-Reviewed Toxicity Values (PPRTV) program, assigning toxicity criteria to chemicals that have not undergone complete agency review.