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November 30, 2020

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RECEIVED
DEC 04 2020
SITE ASSESSMENT, REMEDIATION, & REVITALIZATION

Reference: Updated Human Health Risk Assessment
Former Joslyn Clark, LLC Facility
2013 W. Meeting Street
Lancaster, South Carolina
VCC 13-5875-RP

Dear Greg:

On behalf of Joslyn Clark Controls, LLC (Joslyn Clark), ERM NC, Inc. (ERM) would like to submit the enclosed Human Health Risk Assessment (HHRA), which updates the 2013 HHRA using additional data obtained from 2013 to 2020. An electronic copy of the report is included on a CD.

If you have any questions, please do not hesitate to contact us at 704-541-8345.

Sincerely,

Rick Tarravechia, P.G.
Partner in Charge

Project Manager

Enclosures

Cc: David Bozaan – Joslyn Clark

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Human Health Risk Assessment

FORTIVE

Fortive Corporation

Former Joslyn Clark Controls Facility
2013 W. Meeting Street, Lancaster, South Carolina

23 November 2020

Project No.:0529667

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23 November 2020

Human Health Risk Assessment

Former Joslyn Clark Controls Facility
2013 W. Meeting Street, Lancaster, South Carolina

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1. INTRODUCTION

On behalf of Joslyn Clark Controls, Inc. (Joslyn Clark), ERM NC, Inc. (ERM) conducted a Human Health Risk Assessment (HHRA) for the Joslyn Clark facility in Lancaster, South Carolina (the subject property). This HHRA characterizes both carcinogenic and non-carcinogenic risks associated with the current and future land use, specifically related to the trichloroethene (TCE) impacted groundwater originating from beneath the footprint of the plant building.

This report presents a brief background of the Joslyn Clark facility and a description of the investigation activities completed. Results of the human health risk assessment using data from past investigations are provided herein. This work is being conducted in accordance with Voluntary Cleanup Contract No. 13-5875-RP between Joslyn Clark and the South Carolina Department of Health and Environmental Control (SCDHEC).

1.1 Property Description and Background

The former Joslyn Clark facility is located at 2013 West Meeting Street in Lancaster, Lancaster County, South Carolina approximately three miles west of downtown Lancaster. The general location of the property and the physiographic features of the surrounding area are shown on **Figure 1**, developed from the United States Geological Survey (USGS) 7.5-minute quadrangle for Lancaster, South Carolina, dated 1974. The approximate coordinates of the Site are: latitude 32.7216 degrees N; longitude 80.82448 degrees W.

The Subject Property consists of 23 acres of land and is developed with two buildings (Lancaster Parcel ID 0066-00-031.00). The manufacturing building was constructed in 1964 and consists of approximately 180,000 square feet of floor space. The warehouse/storage building was constructed in 1967 and consists of approximately 14,400 square feet of floor space. Land use in the vicinity of the former Subject Property is a mix of residential, commercial, and wooded undeveloped property. According to Lancaster County, the Subject Property is zoned for industrial activity.

An employee /visitor parking lot is located on the north side of the manufacturing building and trailer parking is located on the southwest side of the manufacturing building. A railroad spur is located in the southwest corner of the Site, which is connected to a rail line that runs along the southern property boundary. The southeast portions of the Site are wooded and the northwest portions are grass-covered. The property is bounded to the east by an apartment complex. Adjacent properties to the south and west are wooded and/or undeveloped. West Meeting Street bounds the Subject Property to the north and development farther north include a mobile home park, and small businesses.

The Subject Property was used to manufacture electrical control equipment for fire safety purposes from 1964 until 2009 when operations ceased. **Figure 2** illustrates the general property layout.

The property was vacant from 2009 until 2016 when it was purchased by Makrochem, who uses the Site to transfer carbon black from bulk quantities (e.g., railcars and tankers) to smaller quantities (e.g. super sacks) for warehousing and subsequent distribution to off-Site locations.

Potable water and sewer are provided by the Lancaster Water and Sewer District. There are no groundwater wells located within ½ mile downgradient of the site.

1.2 Summary of Previous Investigations

Investigation	Date, Consultant	Description
Phase I Environmental Site Assessment (ESA) Report	January 2009, ERM	A Phase I ESA was conducted on behalf of Joslyn Clark by ERM. The Phase I ESA identified potential environmental concerns related to former off-Site wastewater lagoons (discussed above), a former onsite metal plating operation, and a former onsite degreasing operation that took place near the northwest corner of the plant, which TCE as a solvent.
Phase II Site Assessment Report	December 2009, ERM	Phase II ESA activities conducted in 2009 included the installation of 15 soil borings and seven permanent monitor wells (MW-1 through MW-7) to assess areas of potential environmental concern identified in the Phase I ESA. Results showed TCE was detected in several soil samples at low concentrations. TCE was also detected in groundwater samples collected from four monitor wells at concentrations ranging from 7.7 micrograms per liter (µg/L) to 2,700 µg/L, which is above the established South Carolina Maximum Contaminant Level (MCL) for TCE of 5.0 µg/L
Sensitive Receptor Survey (SRS)	January 2011, ERM	The SRS indicated that the closest water supply well to the Site is located at a trailer park approximately 645 feet upgradient from the Site, and according to the property owner the identified well is not in use. The next closest water well is almost 3,500 feet upgradient from the Joslyn Clark Site.
Phase III Site Assessment	February 2012, ERM	Three additional shallow monitor wells (MW-8, MW-9 and MW-10) were installed to further evaluate the horizontal extent of the VOC plume. Two deep wells (MW-3D and MW-10D) were installed to evaluate the vertical extent of VOC impacted groundwater at the Site. Groundwater samples collected during the Phase III activities showed multiple VOCs, with TCE and PCE being the most prevalent. TCE was detected in each Site well except MW-5, MW-10, and MW-10D. MW-9, located adjacent to one of the former off-site lagoons, contained elevated concentrations of TCE and other VOCs. As stated in Section 1.2, assessment and clean-up of impacts from the former lagoons are the responsibility of others.
Passive Soil Gas Survey	November 2012, ERM	60 soil gas points were installed in the northwest portion of the manufacturing building. Twenty-five (25) VOCs were identified in the soil gas samples. The highest VOC concentrations were found at two locations in the northwest portion of the building, in the vicinity of the former wastewater treatment room, and former paint booth and sump (southwest portion of building).
Human Health Risk Assessment (HHRA)	September 2013, ERM	The HHRA indicated there is limited risk/hazard to human health receptors at the Site, with the exception of vapor intrusion risk for Site/ maintenance workers who may be exposed to organic vapors migrating from groundwater, and to a lesser extent construction workers who may contact impacted subsurface soil affected by thallium during future excavation or trenching activities. It should be noted that subsequent indoor air sampling in 2014 and 2015

Investigation	Date, Consultant	Description
		confirmed that indoor air concentrations were below screening levels,(discussed below) eliminating the vapor intrusion risk. Therefore the only remaining potential risk is direct contact with soil affected by thallium for construction workers. However, thallium is naturally occurring, is not a chemical of concern that was used at the Site, and the HHRA concluded “Potential exposure with thallium is limited, if occurring at all.”
Pre-Remedial Assessment Report	September 2013, ERM	Five soil boings were installed to further investigate areas of elevated soil gas in the building. A temporary shallow well was installed in the building, and a group of shallow, intermediate, and deep wells (MW-11 group) were installed in the former paint booth room.
Feasibility Study (FS) Work Plan	November 2013, ERM	The *FS Work Plan* evaluated various remedial technologies against the EPA criteria for feasibility studies. In-Situ Chemical Oxidization (ISCO) was selected as the technology with the highest potential for success at the Site.
Initial Vapor Intrusion (VI) Assessment	May 2014, ERM	Six sub-slab soil gas samples were collected along with six co-located indoor air samples, plus a seventh stand-alone indoor sample in May 2014. Four soil gas samples exceeded a published Regional Screening Level (RSL). TCE was the most prevalent VOC detected, and was detected in each sub-slab sample at concentrations ranging from 6.4 to 28,000 $\mu g/m^3$. Trace concentrations of TCE were detected in six of the seven indoor air samples, and at concentrations below the laboratory’s reporting limit.
ISCO Pilot Test Work Plan & Addendum	April and May, 2014	A Work Plan and Addendum were prepared to detail an ISCO pilot test inside the building at MW-3, where the highest VOC concentrations were detected in shallow groundwater.
ISCO Injection Pilot Test	July 2014 (Event) September 2015 (Report), ERM	The ISCO injection pilot test was performed during June 3 through July 2, 2014. Approximately 2,000 gallons of 5% sodium permanganate solution were injected across four well near MW-3. Post injection monitoring was performed on a quarterly basis thereafter. TCE concentrations in MW-3 decreased from over 3,000 µg/L to less than 3 µg/L at the 270 day mark before a slight rebound to 13.9 µg/L was noted at the end of the one year study period.
Downgradient Well Pair Installation (On-Site)	April 2015	A shallow and deep well nested pair (MW-12 and MW-12D) were installed along the southern property boundary to further characterize the VOC plume.
Additional VI Assessment	May 2015, ERM	A second VI study was performed at the manufacturing building during February 2015, which was a seasonal “worst case scenario” with sub slab and indoor air sample at the same locations as the May 2014 event. Detected soil gas compounds were similar to those detected in May 2014. TCE continued to be the most prevalent VOC detected with concentrations in soil gas ranging from 1.4 to 15,000 $\mu g/m^3$. However, concentrations of TCE and other VOCs in soil gas showed a 50% reduction since the May 2014 event. TCE was

Investigation	Date, Consultant	Description
		detected in five of the seven indoor air samples at concentrations ranging from 0.672 μg/m^3 to 2.54 μg/m^3. These concentrations were below the industrial RSL for TCE, which is 3.0 μg/m^3. Therefore, there is no unacceptable risk associated with the inhalation of TCE in indoor air.
Monitor Well Installation and Site Sampling	June 2018, ERM	Two intermediate and one shallow well were installed in December 2017 to further characterize the plume. A Site-wide sampling event took place in February 2018.
Monitor Well Installation and Site Sampling	July 2019, ERM	An off-Site well pair were installed (MW-15 and MW-15D) in March 2019 to further characterize the plume. A Site-wide sampling event took place in April 2019.
Groundwater Monitoring Reports	April 2020 and September 2020, ERM	Site-wide groundwater monitoring events were conducted in December 2019 and May 2020.

2. HUMAN HEALTH RISK ASSESSMENT

This HHRA was conducted by ERM in accordance with numerous US EPA guidance documents and was prepared using the US EPA Risk Assessment Guidance for Superfund: Volume I, Human Health Evaluation Manual (Part D, Standardized Planning, Reporting, and Review of Superfund Risk Assessments), dated December 2001. Specific procedures detailed in the US EPA Region 4 Human Health Risk Assessment Bulletins, Supplement to RAGS (US EPA 2000) were also used for preparing the HHRA. As such, this HHRA follows the format developed by the US EPA to standardize reporting of human health risk assessments through the preparation of standard tables and worksheets.

2.1 Hazard Identification

The hazard identification process included the following steps:

1) Evaluation of the nature and extent of constituents reported at the Site; and,

2) Selection of a subset of constituents identified as Constituents of Potential Concern (COPCs).

For the hazard identification, the nature and extent of constituents is described in Section 1.0. From these previous investigations, all available analytical data were compiled for risk assessment purposes. The methodology used for the selection of COPCs is described in the following section.

2.1.1 Selection of Chemicals of Potential Concern

Based on previous environmental investigations and historical operations described in Section 1.0, data collected from soil, groundwater, sub-slab soil gas and indoor air were compiled for analysis. The identification of COPCs was performed by comparing maximum constituent concentration in soil and groundwater to the most recent version of the EPA Regional Screening Levels (RSLs) (EPA, May 2020). Other media, including indoor air and soil gas were compared to other relevant screening levels, as described in the following sections. For each, the target risk level used to derive risk-based screening values were set at 1 x 10^{-6} and the hazard quotient of 0.1 to account for multiple non-carcinogenic constituents. As such, the risk-based RSLs are calculated to be protective of receptors with routine exposures to soil, groundwater, and air, using typical default exposure assumptions. Groundwater data were also compared to Maximum Contaminant Levels (MCLs).

The reported maximum constituent concentrations were compared to the RSLs or other risk-based screening levels as follows:

- Soil data, derived from depths up to 20 feet below ground surface, were compared to the industrial soil RSLs, 20 feet is thought to be representative of the unsaturated zone
- On-Site and Off-Site groundwater data were compared to tap water RSLs,
- Indoor air data were compared to industrial air RSLs,
- Sub-Slab Soil gas data, representative of trench air, were compared to Construction Soil Gas Screening Levels derived from the Virginia Unified Risk Assessment Model (VURAM 3.1),
- On-Site groundwater data at the southern property boundary and Off-Site groundwater data were compared to the EPA Vapor Intrusion Screening Levels (VISL) for estimating vapor intrusion into buildings.
- Groundwater data, as a source of vapors, were also compared to Construction Soil Gas Screening Levels derived from the Virginia Unified Risk Assessment Model (VURAM 3.1) assuming depth to groundwater is greater than 20 feet below ground surface.

It is important to note that the available screening levels do not consider potential exposures resulting from the migration of vapors from subsurface into excavations/trenches. Screening levels developed using the EPA-VISL and VURAM were used to evaluate these potentially complete exposure pathway.

The results of the screening analysis for chemicals of potential concern (COPCs) are summarized below and provided in ***Appendix A, Tables A-1 through A-8***. The constituents with concentrations greater than the applicable screening levels were retained for further analysis.

2.1.1.1 Soil – Direct Contact

Soil to a depth of 20 feet below ground surface (bgs) was compiled for use in comparison to EPA RSLs. This comparison included soil data collected from GP-1, GP-2, GP-3, GP-4, GP-5, GP-6, GP-7, GP-8, GP-10, GP-11, GP-12, GP-13, GP-17, GP-18, GP-19, GP-20, and GP-21. As shown in ***Appendix A, Table A-1***, the soil screening analysis indicated that one metal (thallium) was retained for further evaluation as having a maximum concentration of 3.3 mg/kg that is greater than US EPA's RSLs for industrial soil. It is important to note that thallium was detected in only one sample (GP-3) collected from beneath the building near (but outside of) the former footprint of the plating room at a depth of 4-8 feet below ground surface. Also, thallium is not known to have been used at the Joslyn Clark site.

2.1.1.2 On-Site and Off-Site Groundwater

<u>On-Site Groundwater</u> - As described above, MW-9 is located west of the asphalt parking lot and proximal to the off-site former wastewater lagoons that are not associated with the Site. As such, this well is not included in the groundwater screening analysis, except in the sense that it is understood that vapor intrusion issues will need to be considered if any building structures are planned for the MW-9 area. Groundwater data collected from wells IW-01A, IW-01B, IW-02A, IW-02B, MW-1, MW-2, MW-3, MW-3D, MW-4, MW-5, MW-6, MW-7, MW-8, MW-10, MW-10D, MW-11, MW-11I, MW-11D, MW-12, MW-12D, MW-13, MW-12I, MW-14I, and OW-01 were included in the screening analysis. Only data collected from 2013 to 2020 were included in this analysis. Groundwater analytical results indicate that several VOCs and metals are retained for further evaluation as having reported maximum concentrations greater than US EPA's RSLs for tap water. The VOCs include chloroform, 1,2-dichloroethane, 1,1-dichloroethene, 1,4-

dioxane, tetrachloroethene, 1,1,2-trichloroethene, and trichloroethene. Two metals, iron and manganese, were retained for further evaluation. The groundwater screening analysis is provided in ***Appendix A, Table A-2***. Groundwater data was also compared to MCLs, shown on ***Table A-2***, where four VOCs (1, 1-dichlorothene, tetrachloroethene, 1,1,2-trichloroethene, and trichloroethene had maximum reported concentrations exceeding these levels.

It is important to note that since groundwater is not used for potable purposes in the area and the depth to groundwater is greater than 20 feet at the site; there is no potential direct contact exposure with groundwater, thus, further analysis of groundwater COPCs for direct contact is not warranted.

On-Site Groundwater at Downgradient Property Boundary – To consider potentially complete exposure pathways at the southern, downgradient boundary of the site, groundwater data for MW-12 and MW-12D were evaluated. Chloroform, 1,2-dichlorothane, tetrachloroethene and trichloroethene were retained for further evaluation as having reported maximum concentrations greater than US EPA's RSLs for tap water. This groundwater screening analysis is provided in ***Appendix A, Table A-3***. The maximum concentrations of tetrachloroethene and trichloroethene exceeded the respective MCLs (0.005 mg/L), shown in ***Table A-3***. Reported concentrations of tetrachloroethene exceeded the MCL only in MW-12D in samples, while trichloroethene was reported above the MCL in both MW-12 and MW-12D with concentrations appearing to be stable over the sampled timeframe (2015 through 2020).

Off-Site Groundwater - An off-Site well pair were installed (MW-15 and MW-15D) in March 2019 to further characterize the plume. The well pair were sampled in April 2019, November 2019 and May 2020 reporting low concentrations of acetone, methylene chloride, toluene and trichloroethene. Only trichloroethene was retained for further evaluation as having reported maximum concentrations greater than US EPA's RSLs for tap water. The groundwater screening analysis is provided in ***Appendix A, Table A-4***. None of the detected constituents exceeded its MCL, shown in ***Table A-4***; however, trichloroethene was reported at the MCL concentration (0.005 mg/L) in the April 2019 sampling event; trichloroethene was reported below the MCL in the two subsequent sampling events.

2.1.1.3 Subsurface Vapors

To assess the potential for subsurface vapors to migrate into indoor air, sub-slab soil gas samples were collected from within the former manufacturing building in 2014 and 2015. Sub-slab measurements represent concentrations of VOCs that originate from soil and/or groundwater that have collected under the building. Sub-slab samples were collected from six locations through the building floor (SS-1, SS-2, SS-3, SS-4, SS-5 and SS-6). The sub-slab soil gas sample data were compared to Target Sub-Slab and Near Source Soil Gas Concentrations provided in US EPA's VISL (assessed October 2020). These screening levels were set to equal a target cancer risk of 1 x 10-6 and hazard quotient of 0.1. Numerous constituents were detected in the soil gas analysis as shown in ***Appendix A, Table A-5***; however, only two VOCs, chloroform and trichloroethene, exceeded the VISL. Using the VISL suggests that these VOCs could migrate into indoor air.

2.1.1.4 Indoor Air

Seven indoor air samples (AA-1, AA-2, AA-3, AA-4, AA-5, AA-6, and AA-7) were collected during two sampling events, May 9, 2014 and February 18, 2015, within the former manufacturing building from the same locations as the sub-slab soil gas samples. One ambient air sample, OA-1, was collected outdoors approximately 100 feet from the northeast of the building. The indoor air data were compared to US EPA's RSLs for Industrial Air (EPA, May 2020). Using standard risk assessment protocol, these screening levels were set to equal a target cancer risk of 1 x 10-6 and hazard quotient of 0.1 to account for multiple non-carcinogenic constituents. Similar to the sub-slab soil gas data, numerous constituents were detected as shown in ***Appendix A, Table A-6*;** however, only two constituents (1,2-dichloroethane and trichloroethene) were detected at concentrations that exceeded the Industrial Air RSLs. However, 1,2-DCA was not detected in soil gas beneath the building, therefore it was not retained for further evaluation.

2.1.1.5 Vapors in Excavations/Trenches

Regional Screening Levels for tap water do not consider the potential for inhalation of VOC vapors originating from ground water that may migrate into subsurface excavation/trenches. To evaluate this pathway, sub-slab and groundwater data were screened for the evaluation of inhalation risks associated with a construction worker in a trench. This analysis was conducted to evaluate potential exposures on-site and potential exposures off-site by considering groundwater concentrations at the southern, downgradient property boundary. Both sub-slab and groundwater screening levels were obtained from mathematical models made available by the Virginia Department of Environmental Quality (VADEQ), called the Virginia Unified Risk Assessment Model or VURAM (VADEQ, 2018).

On-Site Excavations and Trenches - The comparison of maximum groundwater and sub-slab soil gas concentrations to the VURAM-derived screening levels are provided in ***Appendix A, Table A-7 and Table A-8***, respectively. Based on the screening results, trichloroethene was retained in both comparisons for the evaluation of inhalation risk for a construction worker in a trench. Using the groundwater data, trench air concentrations were calculated as shown in ***Appendix A, Table A-9***. However, taking a conservative approach, all detected VOCs in groundwater were conservatively retained for further evaluation.

Groundwater data from MW-9 is not included in this analysis because the contaminant source is from an offsite location and is not in close proximity to the Joslyn Clark facility building or developed areas. In addition, groundwater data from MW-4, MW-5 and MW-8 were excluded from this analysis because these monitoring wells are located outside of the groundwater contaminant plume and no VOCs were detected in the wells during previous sampling events.

No VOCs were reported in the monitoring well located upgradient of the contaminant plume (MW-1) at the northern boundary of the Site. However, VOCs were detected in the MW-12/MW-12D well pair at the downgradient property line. As such, VOCs are present in off-site groundwater. However, as described above, offsite wells MW-15/15D were installed about 500 feet farther downgradient.

Potential Off-Site Excavations and Trenches - The comparison of maximum off-Site groundwater concentrations to the VURAM-derived screening levels are provided in ***Appendix A, Table A-10.*** Based on the screening results, trichloroethene was retained in both comparisons for the evaluation of inhalation risk for a construction worker in a trench. Using the groundwater data, trench air concentrations were calculated as shown in ***Appendix A, Table A-11***. However, taking a conservative approach, all detected VOCs in groundwater were conservatively retained for further evaluation.

2.1.1.6 Off-Site Vapors to Indoor Air

To evaluate the potential for the vapor intrusion pathway for off-Site exposures, downgradient groundwater data collected from two locations were considered.

Groundwater Collected at Downgradient Property Boundary – An on-Site well pair (MW-12, which is 55 feet deep, and MW-12D, which is 110 feet deep) located near the southern, downgradient property boundary was used to evaluate the potential for the vapor intrusion pathway should a building be constructed near that location in the future. To evaluate the potential vapor intrusion pathway, US EPA’s VISL (accessed October 2020) was used to estimate indoor air concentrations from groundwater data from MW-12/MW-12D. The estimated indoor air concentrations were then compared to Target Indoor Air Concentrations set to equal a target cancer risk of 1 x 10-6 and hazard quotient of 0.1. As shown in

Appendix A, Table A-12; only trichloroethene, based on the maximum groundwater concentration collected in April 2019, exceeded the indoor air VISL.

Off-Site Groundwater - As described above, an off-Site well pair were installed (MW-15 and MW-15D) in March 2019 to further characterize the plume. The well pair were sampled in April 2019, November 2019 and May 2020 reporting low concentrations of acetone, methylene chloride, toluene and trichloroethene. To evaluate the potential vapor intrusion pathway, US EPA's VISL (assessed October 2020) was used to estimate indoor air concentrations from groundwater data from the MW-15/MW-15D well pair. MW-15 is a shallow, 45-foot deep well, and MW-15D is a 105-foot deep well. The estimated indoor air concentrations were then compared to Target Indoor Air Concentrations set to equal a target cancer risk of 1 x 10-6 and hazard quotient of 0.1. As shown in ***Appendix A, Table A-13***; only trichloroethene, based on the maximum groundwater concentration collected in April 2019, marginally exceeded the indoor air VISL. It is important to note that groundwater samples collected in November 2019 and May 2020 reported lower concentrations of trichloroethene.

2.1.1.7 Surface Water and Sediment

There are no surface water bodies near the subject property. As such, no surface water or sediment samples were collected.

2.2 Exposure Assessment

The exposure assessment evaluates the likelihood, magnitude and frequency of exposure to the COPCs, and identifies pathways and routes by which human receptors may be exposed to these constituents. The specific steps involved in the exposure assessment include the following:

- Characterization of Exposure Setting;
- Identification of Exposure Pathways;
- Development of Exposure Scenarios; and,
- Estimation of Exposure Point Concentrations.

The physical characteristics of the Site were examined to identify pathways by which human receptors may be exposed to constituents at the Site. Exposure scenarios were developed based on demographics, land use, and general human behavior patterns. Intake factors were developed for the identified receptor populations under the defined conditions of exposure. Following the development of exposure scenarios and calculation of intakes, exposure point concentrations were estimated. The intake factors and exposure point concentrations are used in the succeeding steps of the risk assessment to characterize quantitatively the potential risks associated with the defined exposure scenarios

2.2.1 Site Conceptual Model

Table 1 identifies the plausible receptors and exposure pathways evaluated by the risk assessment. The following site-specific factors influence potential exposure:

- Current site conditions are detailed in Section 1.1. The site is currently an active industrial manufacturing site. Future land use will be designated as non-residential;
- Potable water to the subject site and the surrounding neighborhoods is provided by the Lancaster Water and Sewer District;

- No VOCs were detected in MW-1 located upgradient of the contaminant plume, thus no further assessment of off-site receptors in that direction is warranted;
- VOCs were detected in the shallow and deep groundwater near the downgradient property boundary (MW-12/MW-12D);
- No VOCs were detected in the shallow offsite groundwater downgradient of the subject site. However, trichloroethene was detected in the deep offsite well (MW-15D) located approximately 500 feet downgradient of the property line;
- Ground water was not encountered within 20 feet of the ground surface at the Site;
- Disturbance due to the commercial/industrial setting of the site and the surrounding properties preclude the establishment of suitable ecological habitat at the Site. As such, no further assessment of risk to ecological receptors is warranted;
- Land use in the vicinity of the subject property is residential, commercial, and wooded undeveloped property. No ecological concerns were noted for the area.

Human receptor populations under current conditions are detailed in the following sections.

2.2.2 Potentially Complete Exposure Pathways

The identification of potential human receptors is based on several factors, including local land use and groundwater use. This information provides the basis to identify individuals working or engaging in activities on the site, both currently and potentially in the future.

While considering the site conditions described above, the potentially complete pathways of exposure include: contact (i.e., incidental ingestion and dermal contact) with exposed surface soil, or subsurface soil while conducting subsurface activities (e.g., soil excavation); and inhalation of either vapors from soil that may migrate into indoor air or an open excavation, or particulates (i.e., dust) from soil. Vapors originating from groundwater may migrate into the building or into construction excavation/trenches. Potential inhalation of the vapors could occur while working in the building or participating in construction activities.

Overall, the potential for human exposure with impacted environmental media at the site is minimal, if occurring at all. Nonetheless, the risk assessment is considering all potential human receptor populations who may visit the site and the anticipated exposure pathways by which they could contact environmental media. The plausible receptors and exposure pathways considered by the risk assessment under current and future conditions are described below.

2.2.2.1 Current Conditions

Plausible receptor and exposure pathways include the following scenarios:

- Site Worker Scenario – Site workers could be exposed to constituents in exposed surface soil via incidental ingestion, dermal contact and inhalation of vapors and released particulates while conducting limited outdoor maintenance activities. Such worker exposures may occur under long-term commercial exposure scenarios. Site workers could also be exposed to vapors originating from groundwater into the indoor air of the existing building.

- Trespasser/Visitor Scenario. Trespassers/visitors could be exposed to constituents via incidental ingestion, dermal contact and inhalation of vapors and particulates released from surface soils. Although exposures would be limited, visitors could be exposed to vapors originating from groundwater into indoor air of the existing building.

2.2.2.2 Future Conditions

Plausible receptor and exposure pathways include the following scenarios:

- Site Worker Scenario – Future site workers could be exposed to constituents in exposed surface soil via incidental ingestion, dermal contact and inhalation of vapors and released particulates while conducting limited outdoor maintenance activities. Site workers could also be exposed to vapors originating from groundwater into the indoor air of the existing building.

- Construction Worker Scenario - Construction/utility workers may contact impacted media while conducting construction/utility maintenance activities, specifically those requiring subsurface disturbance. Construction/utility workers may contact exposed surface soils and subsurface soils via incidental ingestion, dermal contact, and inhalation of vapor or particulate emissions in outdoor air. Contact with ground water while conducting subsurface activities is not likely because depth to groundwater is greater than 20 feet below ground surface; however, there is potential for exposure of vapors that may be present in utility trenches or construction excavations.

- Trespasser/Visitor Scenario. Trespassers/visitors could be exposed to constituents via incidental ingestion, dermal contact and inhalation of vapors and particulates released from surface soils. Although exposures would be limited, visitors could be exposed to vapors originating from groundwater into indoor air of the existing building

- Hypothetical Off-Site Worker Scenario – This scenario could occur if buildings are constructed on the parcel downgradient and in close proximity to the Joslyn Clark site. While no groundwater use for potable purposes is anticipated, off-site workers could be exposed to vapors originating from groundwater into indoor air of future buildings.

The subject site will remain as non-residential land use with the current structures to be used for industrial/commercial activities. Utilities will be provided by the municipality and the regional electrical power supplier, Duke Energy. There will be no ground water use on site.

2.2.3 Exposure Point Concentrations (EPC)

EPCs can be projected by using either monitoring data alone or a combination of monitoring data and fate and transport modeling. Use of monitoring data alone is most often applicable where exposure involves direct contact with the monitored medium. However, where exposure points are spatially separate from the monitoring points (i.e., the source), fate and transport modeling may be necessary to predict EPCs (USEPA, 1989). A combination of both methods was used in the HHRA.

The EPC was calculated as the Upper Confidence Limit (UCL) on the mean of the analytical data, as recommended and calculated by the US EPA software program ProUCL (Version 5.1.02) (US EPA, 2019). The US EPA ProUCL provides rigorous parametric and nonparametric statistical methods that can be used on full data sets without or without non-detects. Based on appropriate data distribution and the associated skewness, ProUCL provides recommendations about an appropriate UCL computation method that may be used to estimate the mean concentration of a COPC.

Exposure point concentrations (EPCs) were developed for use in estimating potential risks and hazards for all potentially exposed receptor populations at the site. Determination of EPCs typically relies on the use of various approved statistical methodologies aimed at calculating the 95% upper confidence level on the mean.

Soil EPCs are provided in ***Appendix A, Tables A-14 through A-16***. Soil data collected from the ground surface to a depth of 20 feet below ground surface were compiled and used to evaluate the soil pathways of exposure.

Indoor air EPCs are provided in ***Appendix A, Table A-17***.

On-Site Groundwater, On-Site Groundwater at the downgradient property boundary and Off-Site Groundwater EPCs are provided in ***Appendix A, Table A-18, Table A-19 and Table A-20***. While direct contact with groundwater is not anticipated, the concentrations of VOCs in groundwater are used to estimate potential hazard/risk for vapors that could migrate into subsurface excavation/trenches and into off-site buildings that may be constructed in the future. Procedures used to estimate vapor concentrations are described below. For that pathway, the methodology used to estimate VOC concentrations are based on mathematical models that could over or under estimate the actual conditions.

Vapors in an Excavation or Trench. For this inhalation pathway, there are no well-established models available for estimating migration of volatiles from groundwater into the breathing zone within a trench. The US EPA does not provide guidance for evaluating hazards or risks of air inside a trench. To evaluate this pathway, ERM used a box model approach to estimate dispersion of the VOCs measured in soil gas samples within the air in the trench (Virginia DEQ, 2018). For on-Site groundwater, the air concentration in the trench was estimated using the equation and parameter definitions as presented in ***Appendix A, Table A-9*** All other parameters were conservative values used to assess this pathway. This analysis was also used to assess groundwater at the downgradient property boundary, as presented in **Appendix A, Table A-11**.

Summary statistics for all COPCs retained for each receptor population evaluated quantitatively within this assessment are presented in ***Appendix A, Tables A-14 through A-20***. These tables list the COPCs, the arithmetic mean of the data, the ProUCL-recommended UCL, the EPC value, statistic, and rationale for the reasonable maximum exposure (RME) evaluation. The EPC was defined as the lower of the ProUCL-recommended UCL or the maximum-detected concentration for each COPC. .

2.2.4 Exposure Parameters

Appropriate intake parameters were identified for each of the exposure scenarios discussed above. Values for the exposure parameters used generally reflect reasonable maximum exposure (RME) assumptions. Where USEPA guidance (USEPA, 1989) has specified intake parameters for the above-mentioned receptors, these values were used. In some cases, USEPA guidance and other sources were utilized to develop reasonable exposure assumptions. This guidance included the Exposure Factors Handbook (USEPA 2011; 2014) and RAGS Part E Guidance (USEPA, 2004).

The exposure parameters used for each exposure scenario are summarized in ***Appendix A, Tables A-21 through A-27*** for each receptor population in the various media.

To estimate the potential risk to human health that may be posed by the presence of COPCs, it is first necessary to estimate the potential exposure dose of each COPC. The exposure dose was estimated for each constituent via each exposure pathway by which the receptor is assumed to be exposed. Exposure dose equations combine the estimates of constituent concentrations in the environmental medium of interest with assumptions regarding the type and magnitude of each receptor potential exposure to provide a numerical estimate of the exposure dose. The exposure dose is defined as the amount of COPC acquired by the receptor and is expressed in units of milligrams of COPC per kilogram of body weight per day (mg/kg-day).

Exposure doses are defined differently for potential carcinogenic and non-carcinogenic effects. The chronic average daily dose is used to estimate a receptor potential intake from exposure to a COPC with non-carcinogenic effects. According to US EPA (1989), the chronic average daily dose should be calculated by averaging the dose over the period of time for which the receptor is assumed to be exposed. Therefore, the averaging period is the same as the exposure duration.

For COPCs with potential carcinogenic effects, however, the lifetime average daily dose is employed to project potential exposures. In accordance with US EPA (1989) guidance, the lifetime average daily dose is calculated by averaging exposure over a receptor assumed lifetime of 70 years. Therefore, the averaging period is the same as the receptor assumed lifetime.

The standardized equations presented by US EPA (1989) were used to estimate a receptor average daily dose, both lifetime and chronic.

2.2.5 Quantification of Exposure Doses

The following standard US EPA equation (US EPA, 1989) was used to estimate exposure doses received by the receptor populations for all scenarios:

$$I = \frac{C \ x \ CR \ x \ AF \ x \ EF \ x \ ED}{BW \ x \ AT}$$

Where:

I	=	Chronic daily intake [dose] (mg/kg-day);
C	=	Concentration (mg/kg, mg/l or mg/m^3);
CR	=	Contact rate (kg per day or liters per day);
AF	=	Absorption factor (unitless);
EF	=	Exposure frequency (days per year);
ED	=	Exposure duration (years);
BW	=	Body weight (kg); and
AT	=	Averaging time (days).

Appendix A, Tables A-21 through A-27, provide the intake equations and exposure parameters as defined by receptor population for each exposure medium, route and pathway to quantify hazards and risks.

2.3 Toxicity Assessment and Chemical-Specific Parameters

This section presents toxicity criteria and information that relates COPC exposure (dose) to anticipated health effects (response) for each COPC retained for quantitative evaluation in the HHRA. Toxicity criteria derived from dose-response data were used in this report in the Risk Characterization to estimate the non-carcinogenic hazards and carcinogenic risks (i.e., excess lifetime cancer risk or ELCR) associated with exposure to these COPCs.

Current toxicological criteria (e.g., carcinogenic slope factors (CSFs) and reference doses (RfDs)) were identified for each COPC based on the Regional Screening Levels for Chemical Contaminants at Superfund Sites table (US EPA, 2012). As noted in the US EPA Risk Assessment Users Guide (US EPA, 2012b), toxicity values from the following sources were used as defaults for the development of RSLs in ***Appendix A, Tables A-29 through A-32***.

- USEPA IRIS, an on-line toxicity data base updated monthly by USEPA;
- USEPA Provisional Toxicity Values, as provided in the USEPA RSL Table; and,
- Other Sources; e.g., the Health Effects Assessment Summary Tables, HEAST (USEPA) and other toxicological information sources, such as the California EPA and ATSDR.

A slope factor is used to estimate an upper-bound lifetime probability of an individual developing cancer as a result of exposure to a particular level of a potential carcinogen. To derive the carcinogenic slope factors (CSF), data from animal studies (or occasionally from human epidemiological studies) are fit to the linearized multistage model, and the upper 95th percent confidence limit on the slope of the resulting dose-response curve is calculated. This slope factor, therefore, reflects an upper-bound estimate of the probability of carcinogenic response per unit dose of a chemical. The CSF is expressed in units of reciprocal dose (mg/kg-day)-1. CSFs are derived separately for oral and inhalation exposure, as appropriate.

The potential for non-carcinogenic health effects from long duration or chronic exposures (i.e., greater than 7 years) is evaluated by comparing the estimated daily intake with a chronic oral RfD or inhalation RfC. These toxicity values represent average daily exposure levels at which no adverse effects are expected to occur with chronic exposures. Sub-chronic RfDs are applied when exposures are less than 7 years, as is the case with construction workers (i.e., less than 1 year). RfDs reflect the underlying assumption that systemic toxicity occurs as a result of processes that have a threshold (i.e., that a safe level of exposure exists and that toxic effects will not be observed until this level has been exceeded).

Dose-response values are available for oral exposures and these are used to evaluate dermal exposures by applying gastrointestinal absorption factors (GIABS) to the oral RfD. GIABS values used in the adjustment of oral RfDs are presented on the *Regional Screening Levels for Chemical Contaminants at Superfund Sites* table (US EPA, 2020).

For inhalation pathways (carcinogenic and non-carcinogenic COPCs), recommendations presented in *RAGS Part F Guidance* were utilized (US EPA, 2009a). The US EPA (2009) recommends that the inhalation toxicity values no longer be generated using simple route-to-route extrapolation. Rather, reference concentrations (RfCs) in units of mg/m^3 are used for non-carcinogens and inhalation unit risks (IURs) in units of $(ug/m^3)^{-1}$ are used for carcinogens. IURs and RfCs used in the equations are based on continuous exposure (24 hours per day), and are also presented on the *Regional Screening Levels for Chemical Contaminants at Superfund Sites* table (US EPA, 2020).

Appendix A, Table A-29 presents the available oral chronic RfDs used to evaluate non-carcinogenic hazards via the oral exposure route. Dermal RfDs were derived as shown on ***Table A-29*** to evaluate non-carcinogenic hazards via the dermal exposure route. ***Appendix A, Table A-30*** presents the available inhalation chronic RfCs.

Appendix A, Table A-31 presents the available CSFs used to evaluate carcinogenic risks in the HHRA via the oral exposure route. Dermal CSFs were derived as shown on ***Table A-31*** to evaluate carcinogenic risks via the dermal exposure route. ***Appendix A, Table A-32*** presents the available IURs.

2.4 Risk Characterization

The Risk Characterization integrates data developed from the Exposure Assessment and Toxicity Assessment to derive numerical estimates of potential current and future non-carcinogenic hazards and carcinogenic risks attributable to the site COPCs. Hazard and Estimated Lifetime Cancer Risk (ELCR) attributable to site COPCs were assessed for each potential exposure medium (e.g., soil, sediment, surface water, air) under the RME conditions described previously, in accordance with RAGS Part D and US EPA guidance. The US EPA and SCDHEC recognize the acceptable cancer risk range of 1×10^{-6} to 1×10^{-4} and a Hazard Index of 1.0, as defined by the US EPA in the National Oil and Hazardous Substances Pollution Contingency Plan (NCP) (1990). These risks are cumulative of the individual risks posed by each COPC.

Potential non-carcinogenic effects were evaluated based on a comparison of COPC-specific chronic exposure doses with corresponding protective doses derived from health criteria. The result of this comparison is expressed as the hazard quotient (HQ):

$$Hazard\,Quotient = \frac{Dose}{RfD}$$

A HQ that exceeds unity (1) suggests a greater likelihood of developing an adverse sub-chronic or chronic toxic effect. However, the uncertainty factors built into the protective doses result in conservative RfD values. Therefore, the RfD is likely well below the level at which adverse effects may reasonably be anticipated to be observed.

HQs were calculated for each COPC for which health criteria are currently available. The HQs for each COPC were summed to produce a rough estimate of the pathway-specific risk, the Hazard Index (HI). In estimating total non-carcinogenic hazard, potential responses were conservatively assumed to be additive. However, all COPCs do not have the same or similar toxic endpoints and responses may not be additive. Consistent with US EPA (1989) guidance for non-carcinogens, HI values can be calculated for each applicable target organ. The cumulative HI is defined as the sum of the HQs associated with exposure media, COPCs, and pathways of exposure that are applicable for each receptor population. As such, when appropriate, target-organ-specific HIs were used to evaluate potential non-carcinogenic effects. A cumulative target-organ-specific HI greater than 1.0 indicates the potential for adverse health effects.

The ELCR associated with exposure to constituents detected at the site was calculated according to the following equation (US EPA, 1989a):

Incremental Carcinogenic Risk = Cancer Slope Factor x Dose where the incremental carcinogenic risk represents the probability of developing cancer over a lifetime from exposure to the COPCs associated with the site. Carcinogenic risk (CR) is expressed here in scientific notation. For example, a risk of 1 x 10^{-6} indicates that an individual has one in 1,000,000 chance of developing cancer as a result of exposure to site COPCs during a lifetime.

The CSF represents the carcinogenic potency of a constituent. The dose, or intake, represents the amount of constituent to which a receptor is exposed. When evaluating ELCRs, the dose is the estimated daily intake of each constituent during the specified period of exposure, and averaged over a lifetime.

The US EPA has not established a specific value that represents a significant incremental cancer risk. However, the US EPA's NCPs acceptable risk range for Superfund sites has been set at approximately 1 x 10^{-6} to 1 x 10^{-4} per environmental medium (NCP, 1990). In other words, the goal of the NCP is to reduce the cancer risk associated with site COPCs in a given medium to within or below a range of one in 1,000,000 to one in 10,000.

The ELCR was calculated for each COPC having a designated CSF/IUR for all applicable exposure pathways. Risk values for all COPCs assessed were summed by exposure pathway to provide total pathway-specific risks. Results for each receptor population are discussed in the following subsections.

2.4.1 Current Land Use

As previously described, the subject site is currently occupied by Makrochem, who uses the Site to transfer carbon black from bulk quantities (e.g., railcars and tankers) to smaller quantities (e.g. super sacks) for warehousing and subsequent distribution to off-Site locations. Under current conditions, only site workers could be exposed to COPCs in exposed surface soil. There is no potable use of groundwater in the area. As such, estimated hazard indices and incremental ELCRs for each of these receptor populations under current land use conditions are summarized in ***Table 2*** and detailed below.

Site Workers. ***Table 2*** provides the HQs/HIs and cancer risks calculated for the site worker for the potential direct contact with exposed soil and inhalation exposure occurring from airborne volatiles and particulates originating from soil. HIs are detailed in ***Appendix A, Tables A-33 and A-35***, respectively. The total HI across all potential exposure routes for contact with thallium in soil are estimated to be 0.03 for the site worker, which is well below the target HI of 1. Thallium is not considered a carcinogen, thus, no ELCR for the site worker is reported (see ***Tables A-34 and A-36***).

Table 2 also provides the HQs/HIs and cancer risks calculated for the site worker for the potential inhalation exposure of constituents in indoor air collected at the Site in 2014/2015. As shown on ***Table A-37***, the HI for inhalation of 1,2-dichloroethane and trichloroethene in indoor are estimated to be 0.25 for the site worker, which is well below the target HI of 1. The estimated cancer risk for these constituents in indoor are estimated to be 2 x 10-6, which is within the acceptable cancer risk of 1 x 10-6 to 1 x 10-4; thus, no unacceptable cancer risk is observed (see ***Tables A-38).***

Trespassers/Visitors. ***Table 2*** provides the HQs/HIs and cancer risks calculated for the trespasser/visitor for the potential direct contact with exposed soil. HIs are detailed in ***Appendix A, Tables A-39 and A-41*** and cancer risks are detailed in ***Appendix A, Tables A-40 and A-42***. The total HI across all potential exposure routes for contact with thallium in soil are estimated to be 0.2 for the trespasser/visitor, which is well below the target HI of 1. Thallium is not considered a carcinogen, thus, no ELCRs for the site worker are reported. Visitors of the existing site building are expected to be exposed to constituents in indoor air at a much lower frequency and duration than the site worker default assumptions that assume exposures of 8 hours/ day for 250 days/year over a work-life of 25 years. As such, the anticipated HQs/HIs and cancer risks for visitors inhalation of indoor air would be well below the acceptable targets.

2.4.2 Future Land Use

Future land use of the Site will be limited to commercial and/or industrial activities. As such, potential exposures are limited to receptors who may participate in building construction activities or receptors that may visit or work in the building(s). In addition, possible future exposures that may occur at locations downgradient of the Site are also evaluated. Estimated HIs and ELCRs for each of these receptor populations under future land use conditions are summarized in **Table 2** and detailed below.

Future On-Site Site Workers. ***Table 2*** provides the HQs/HIs and cancer risks calculated for the potential direct contact with exposed soil and inhalation exposure occurring from airborne volatiles and particulates originating from soil. The HIs and cancer risks for these pathways of exposure are the same as reported under future land use and are detailed in ***Appendix A, Tables A-33 and A-36***. As described above, potential exposure routes for contact with thallium in soil are estimated to be 0.03 for the site worker, which is well below the target HI of 1. Thallium is not considered a carcinogen, thus, no ELCRs for the site worker are reported.

Likewise, ***Table 2*** also provides the HQs/HIs and cancer risks calculated for the site worker for the potential inhalation exposure of constituents in indoor air collected at the Site in 2014/2015. As shown on ***Table A-37***, the HI for inhalation of 1,2-dichloroethane and trichloroethene in indoor are estimated to be 0.25 for the site worker, which is well below the target HI of 1. The estimated cancer risk for these constituents in indoor are estimated to be 2 x 10-6, which within the acceptable cancer risk of 1 x 10-6 to 1 x 10-4; thus, no unacceptable cancer risk is observed (see ***Table A-38***).

Future On-Site Trespasser/Visitors. As described above, ***Table 2*** provides the HQs/HIs and cancer risks calculated for the trespasser/visitor for the potential direct contact with exposed soil and potential inhalation exposure of constituents in indoor air. HIs are detailed in ***Appendix A, Tables A-39 and A-41*** and cancer risks are detailed in ***Appendix A, Tables A-40 and A-42.*** The total HI across all potential exposure routes for contact with thallium in soil are estimated to be 0.02 for the trespasser/visitor, which is well below the target HI of 1. Thallium is not considered a carcinogen, thus, no ELCR for the site worker is reported. Consistent with current conditions, visitors of the existing site building are expected to be exposed to constituents in indoor air at a much lower frequency and duration than the site worker default assumptions that assume exposures of 8 hours/ day for 250 days/year over a work-life of 25 years. As such, the anticipated HQs/HIs and cancer risks for visitors inhalation of indoor air would be well below the acceptable targets.

Future On-Site Construction/Utility Workers. ***Table*** 2 provides the HQs/HIs and cancer risks calculated for the future construction workers conducting subsurface activities. HIs and cancer risks for direct contact with soil are detailed in ***Appendix A, Tables A-43 through A-46***. The total HI for potential exposure with thallium in soil is estimated to be 0.9, which is below the target HI of 1. It is important to note that thallium was detected in only one sample (GP-3) located beneath the building at a depth of 4-8 feet below ground surface. Thallium is not known to have been used at the subject site. Thallium is not considered a carcinogen, thus, no cancer risk for the construction worker is calculated.

Appendix A, Tables A-47 and A-48 provide the risk and hazard estimates for a construction worker exposed to vapors in a trench. The total HI is estimated at 7 x 10^{-5}, well below the target HI of 1.0 and the total cancer risk for potential inhalation of VOCs in trench air is estimated to be 3 x 10^{-10}.

Future Hypothetical Off-Site Workers. Future exposures for off-Site workers were assessed using on-site groundwater (MW-12/MW-12D) collected near the downgradient property boundary and off-Site groundwater collected at MW-15/MW-15D.

Appendix A, Tables A-49 and A-50 provide the inhalation HQs/HIs and cancer risks calculated for the future construction workers conducting subsurface activities. The HI for inhalation of VOCs in trench indoor air are estimated to be 8.6 x 10^{-6} for an off-site construction worker, which is well below the target HI of 1. The estimated cancer risk is estimated to be 2.3 x 10^{-10}, which is below the acceptable cancer risk of 1 x 10^{-6} to 1 x 10^{-4}. Should a building be constructed in the future near the southern property boundary, the potential for vapor intrusion into indoor air was also assessed. Indoor air concentrations were estimated from groundwater concentrations using the VISL calculator (see ***Table A-12***). As shown on ***Table A-51***, the HI for inhalation of trichloroethene in indoor air is estimated to be 0.14 for the site worker, which is well below the target HI of 1. The estimated cancer risk for TCE in indoor air is estimated to be 4 x 10-7, which is below the acceptable cancer risk of 1 x 10-6 to 1 x 10-4; thus, no unacceptable cancer risk is observed (see ***Table A-52***) based on groundwater data collected from MW-12/MW-12D from 2015-2020.

Using off-Site groundwater data collected from MW-15/MW-15D, the HI and cancer risk for the inhalation of trichloroethene in indoor air of future buildings is shown in ***Appendix A, Tables A-53 and A-54***. The HI is estimated to be 0.18 for an off-the site worker, which is well below the target HI of 1. The estimated cancer risk for trichloroethene in indoor air is estimated to be 5 x 10-7, which is below the acceptable cancer risk of 1 x 10-6 to 1 x 10-4; thus, no unacceptable cancer risk is observed based on groundwater data collected from MW-15/MW-15D during the 2019 and 2020 sampling events.

2.5 Uncertainty Analysis

The carcinogenic risk and non-carcinogenic hazard estimates presented in this HHRA are not intended to be calculations of absolute risk or hazard to individuals who may use the site currently or in the future. Uncertainties in underlying data prevent exact determination of risk to receptor populations. The goal of the HHRA was to provide reasonable, conservative risk estimates to guide decision-making. Using standardized methodology guidelines, in particular RAGS Part D (US EPA 2001), and standardized default exposure factors provided in US EPA (1997a) risk assessments for Superfund sites, provides a basis for evaluating whether remediation should be considered.

US EPA (1991b) states that, "Where the cumulative carcinogenic site risk to an individual based on reasonable maximum exposure for both current and future land use is less than 10^{-4}, and the non-carcinogenic hazard quotient is less than 1, action generally is not warranted unless there are adverse environmental impacts." Moreover, US EPA guidance (US EPA 1989, 2001) acknowledges that uncertainty in a risk assessment can cause differences in the numerical results of more than an order of magnitude. Therefore, it is important to document and discuss the types of uncertainties that may affect the risk estimates calculated in the previous section.

Risk is broadly a function of exposure and toxicity. Therefore, uncertainties in characterizing either of these cause inaccuracy in risk estimates. Specific sources of uncertainty can be divided into two groups: methodological and site-specific. These types of uncertainties are described in the following subsections. Their effect on final risk estimates is discussed, where possible.

2.5.1 General Methodology Uncertainties

2.5.1.1 Site Characterization

It is sometimes impossible to completely characterize heterogeneous environmental media from a statistical standpoint. Soil constituent concentrations may vary by orders of magnitude over intervals of an inch or less and indoor air constituent concentrations may vary over space and time. In some cases, only a few samples are available to evaluate a particular medium or potential source area. Risk estimates based on a limited sample database may not be representative of actual conditions. At this site, samples were concentrated in those areas suspected to have come in contact with site-related constituents and, therefore, are considered a conservative representation of the impacts of former site activities.

2.5.1.2 Toxicological Information

Toxicity data used in human health risk assessments can be limited. Much of the data used to generate health criteria are derived from animal studies. Uncertainties result, given that:

- both endpoints of toxicity (effect or target organ) and the doses at which effects are observed are extrapolated from animals to humans;
- results of short-term exposure studies are used to predict the effects of long-term exposures;
- results of studies using high doses are used to predict effects from exposures to low doses usually expected at hazardous waste sites; and
- effects exhibited by homogeneous populations of animals (or humans) are used to predict effects in heterogeneous populations with variable sensitivities (e.g., the young, elderly, or infirm).

In addition, thorough toxicity data are not available for all constituents detected at many sites. Often, the toxicity value for the most potent constituent in a group is used as a surrogate for structurally similar compounds. This may result in the overestimation of risk.

US EPA and other regulatory agencies attempt to account for these sources of uncertainty by including uncertainty factors that ensure that health criteria such as RfDs are overly protective.

2.5.1.3 Exposure Assessments

Accurately and realistically evaluating exposure to environmental constituents requires a number of different inputs and assumptions. These include the types of exposed populations, including their ages and health conditions; average lifespans; activity patterns such as time spent indoors versus outdoors; time spent at different locations; time spent working or residing in the area of the site; contact rates for contaminated media; skin surface area for dermal contact; and absorption rates via the skin and digestive tract. There are significant uncertainties regarding the extent to which a constituent is absorbed from soil through the skin.

Current US EPA guidance for conducting risk assessments at Superfund sites recommends default values to be used for many of these parameters. This serves to reduce unwarranted variability in exposure assumptions used to perform baseline risk assessments across different sites. Because values specified in guidance documents are often conservative, upper-bound figures, they would rarely lead to underestimating risks. .

Baseline risk assessments also estimate current and future exposure scenarios based on constituent concentrations detected at the site during the site investigation. In general, no attenuation or degradation of constituents over space or time is assumed. This also typically results in a conservative estimate of risk, especially for organic constituents that are typically subjected to natural degradation processes such as biodegradation, volatilization, and oxidation/reduction. In some cases, though, natural degradation processes do result in daughter products more toxic than the parent compound, which could result in greater future human health risk.

2.5.1.4 Risk Characterization

Constituent-specific risks are generally assumed to be additive. This oversimplifies the fact that some constituents are thought to act synergistically (1 + 1 > 3) while others act antagonistically (1 + 1 < 3). The overall effect of these mechanisms on multi-constituent, multi-media risk estimates is difficult to determine but the effects are usually assumed to balance.

3. CONCLUSIONS

A risk assessment has been conducted to evaluate potential health impacts for current and future occupants of the former Joslyn Clark facility. Both carcinogenic and non-carcinogenic hazards were evaluated as part of the risk assessment. Cumulative risks and hazards for each receptor population are shown in ***Table*** 2. The results of the risk assessment described in this HHRA indicate that there is no unacceptable risk/hazard to human health receptors at the site including both current and future site worker and future construction workers. Further, using data collected in 2019 and 2020 from off-site downgradient monitoring wells, there is no unacceptable vapor intrusion risk for hypothetical site workers who may conduct subsurface excavation/trenching activities or work in buildings constructed offsite under future conditions.

4. REFERENCES

US EPA, 1989. Risk Assessment Guidance for Superfund, Volume I, Human Health Evaluation Manual (Part A), Interim Final. US EPA 540/1-89/003. December.

US EPA, 1991. Human Health Evaluation Manual Supplemental Guidance: "Standard Default Exposure Factors." OSWER Directive 9385.6-03. March 35.

US EPA, 1993a. Selecting Exposure Routes and Contaminants of Concern by Risk-Based Screening. US EPA/903/R-93-001. Region 3, Hazardous Waste Management Division. January.

US EPA, 1993b. Supplemental Guidance to RAGS: Calculating the Concentration Term. Office of Solid Waste and Emergency Response. May.

US EPA, 1994, Guidance for Planning for Data Collection in Support of Environmental Decision Making Using the Data Quality Objectives Process, EPA Q/G 4. September 1994.

US EPA, 1997a. Exposure Factors Handbook: Update to Exposure Factors Handbook EPA/600/8-89/043. Office of Research and Development, National Center for Environmental Assessment..

US EPA, 1997b. Health Effects Assessment Summary Tables, FY-1997 Update. US EPA 540/R-97/036. July.

US EPA, 2000. Region 4, Human Health Assessment Bulletins, Supplement to RAGS. http://www.epa.gov/region4/superfund/programs/riskassess/healtbul.html.

US EPA, 2001. Risk Assessment Guidance for Superfund: Volume I, Human Health Evaluation Manual (Part D, Standardized Planning, Reporting, and Review of Superfund Risk Assessments). Final. Publication No. 9385.7-47. Office of Emergency and Remedial Response. Washington, D.C. December.

US EPA, 2002. Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites.

US EPA, 2003a. Updated Dermal Exposure Assessment Guidance. Region 3, Hazardous Waste Management Division. June.

US EPA, 2004b. Risk Assessment Guidance for Superfund: Volume I, Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment). Final. EPA/540/R/99/005. Office of Superfund Remediation and Technology Innovation, Washington, DC. July.

US EPA, 2005a. Guidelines for Carcinogen Risk Assessment. EPA630-P-03/001F. Washington, DC. March.

US EPA, 2005b. Supplemental Guidance for Assessing Susceptibility from Early-Life Exposure to Carcinogens. EPA630-R-03/003F. Washington, DC. March.

US EPA, 2009a. Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part F, Supplemental Guidance for Inhalation Risk Assessment). Final. OSWER 9285.7-82. January 2009.

USEPA, 2011. Exposure Factors Handbook 2011 Edition EPA/600/R-09/052F, amended in 2014 and 2017.

USEPA. 2014. Human Health Evaluation Manual, Supplemental Guidance: Update of Standard Default Exposure Factors. OSWER Directive 9200.1-120. February 6.

USEPA, 2016. Statistical Software ProUCL 5.1.00 for Environmental Applications for Data Sets with and without Nondetect Observations. June.

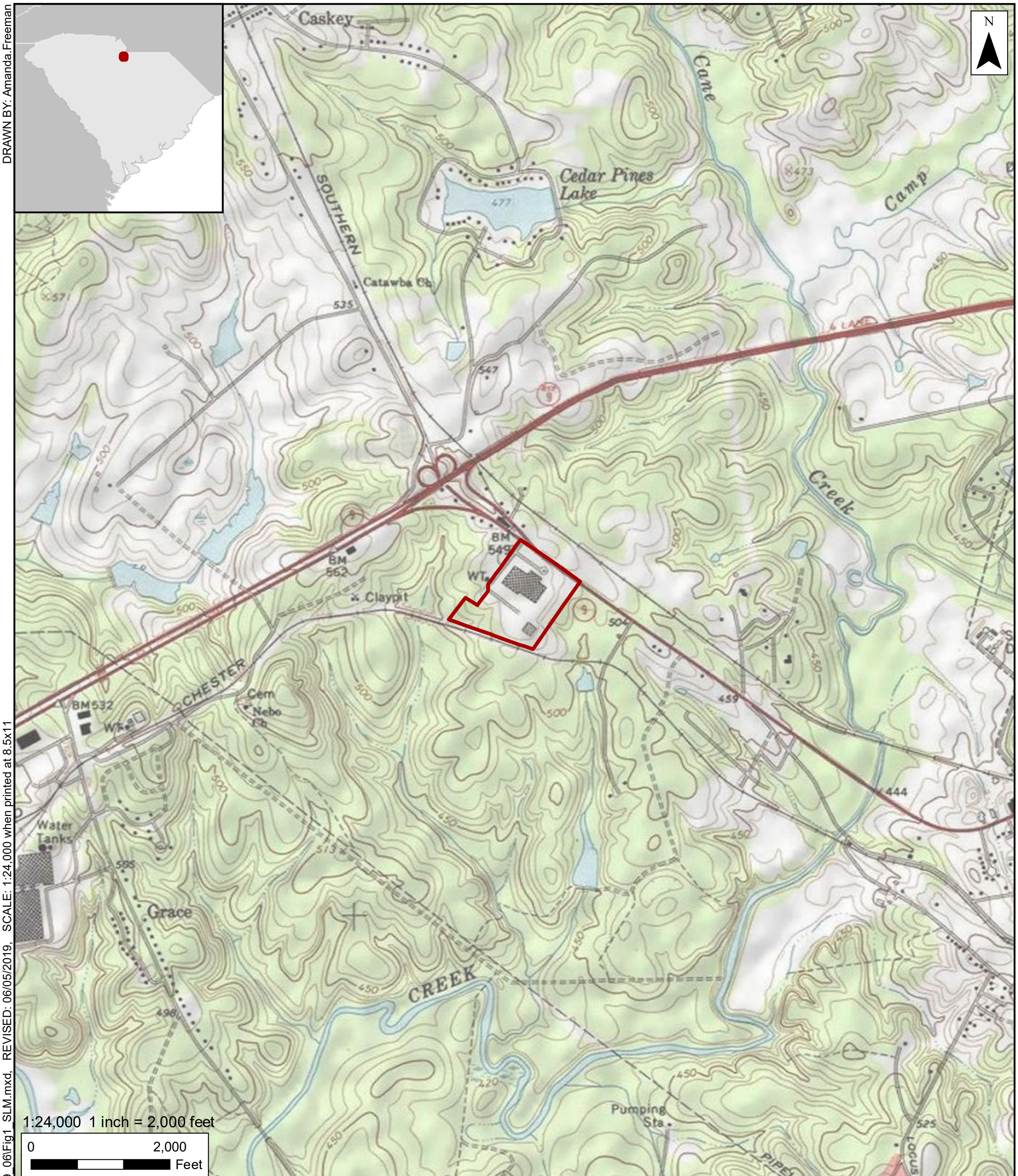
USEPA, 2018. Regional Screening Level Tables and User's Manual. May.

USEPA, 2020. Vapor Intrusion Screening Level (VISL) calculator. Accessed October 2020.

USEPA, 2020. EPA Regional Screening Level Tables. http://www.epa.gov/reg3hwmd/risk/human/rb-concentration_table/index.htm. Revised May 2020.

VADEQ, 2020. Virginia Unified Risk Assessment Model (VURAM) User Guide, version 3.1. http://www.deq.virginia.gov/Programs/LandProtectionRevitalization/RemediationProgram/VoluntaryRemediationProgram/VRPRiskAssessmentGuidance.aspx

FIGURES



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Legend

Site

Environmental Resources Management
www.erm.com
ERM

Figure 1
Site Location Map
Former Joslyn Clark Facility
2013 W, Meeting Street
Lancaster, Lancaster County, SC

Source: Copyright:© 2013 National Geographic Society, i-cubed

Coordinate System: NAD 1983 StatePlane South Carolina FIPS 3900 Feet

Figure 2
Site Map
Former Joslyn Clark Facility
2013 W, Meeting Street
Lancaster County
Lancaster, South Carolina

Environmental Resources Management
www.erm.com
ERM

Source: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Coordinate System: NAD 1983 StatePlane South Carolina FIPS 3900 Feet

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TABLES

Table 1
Selection of Exposure Pathways
Joslyn Clark Facility, Lancaster, South Carolina

Medium	Exposure Medium	Receptor Population	Receptor Age	Exposure Route	Rationale for Selection or Exclusion of Exposure Pathway
Groundwater	Groundwater	On-Site and Off-Site Construction Worker	Adult	Dermal	**Incomplete Pathway** - Depth to water greater than 20 feet below ground surface
				Ingestion	**Incomplete Pathway** - Depth to water greater than 20 feet below ground surface
	Air			Inhalation	**Potentially Complete Pathway** - Inhalation of vapors may occur during excavation/trenching activities.
	Groundwater	Site Workers	Adult	Dermal	**Incomplete Pathway** - Site will remain as industrial use; no groundwater use within 1/2 mile downgradient of site; potable water supplied by lancaster Water and Sewer District.
				Ingestion	**Incomplete Pathway** - Site will remain as industrial use; no groundwater use within 1/2 mile downgradient of site; potable water supplied by Lancaster Water and Sewer District.
	Building Air	On-Site and Off-Site Workers		Inhalation	**Complete Pathway** - Inhalation of vapors that have migrated from groundwater into indoor air.
Surface Water/Sediment	Surface Water/Sediment	Trespasser/Visitor	Adolescent	Dermal	**Incomplete Pathway** - There are no surface water bodies near the site. As such, there is no potential contact with surface water and/or sediment.
				Ingestion	**Incomplete Pathway** - There are no surface water bodies near the site. As such, there is no potential contact with surface water and/or sediment.
Soil	Soil	Construction Worker	Adult	Dermal	**Potentially Complete Pathway** - Receptors could contact surface and subsurface soil.
				Ingestion	**Potentially Complete Pathway** - Receptors could contact surface and subsurface soil.
	Air			Inhalation	**Potentially Complete Pathway** - Receptors could contact surface and subsurface soil.
	Soil	Site Workers	Adult	Dermal	**Potentially Complete Pathway** - Receptors could contact surface soil while conducting limited maintenance outdoor activities.
				Ingestion	**Potentially Complete Pathway** - Receptors could contact surface soil while conducting limited maintenance outdoor activities.
	Air			Inhalation	**Potentially Complete Pathway** - Receptors could contact surface soil while conducting limited maintenance outdoor activities.
	Soil	Trespasser/Visitor	Adolescent	Dermal	**Potentially Complete Pathway** - Receptors could contact surface soil.
				Ingestion	**Potentially Complete Pathway** - Receptors could contact surface soil.
	Air			Inhalation	**Potentially Complete Pathway** - Receptors could contact surface soil.

Table 2
Total Carcinogenic and Noncarcinogenic Risk for All Receptors
Joslyn Clark Facility, Lancaster, South Carolina

Potential Receptor Populations and Media of Concern	Current/Future Site Worker		Current/Future Trespasser/Visitor - Adolescent		Future Construction Worker	
	Cancer Risk	Noncancer Risk	Cancer Risk	Noncancer Risk	Cancer Risk	Noncancer Risk
On-Site Current/Future Scenarios						
Site Soil (direct contact and inhalation)	0E+00	2.8E-01	0E+00	1.7E-01	0E+00	9.3E-01
On-Site Indoor Air	7E-07	2.4E-01	- -	- -	- -	- -
On-Site Vapors in trench/excavation	- -	- -	- -	- -	4E-10	6.8E-05
Hypothetical Future Scenarios						
At Downgradient Property Boundary (MW-12/MW-						
Hypothetical Off-Site Worker Inhalation - Indoor Air	4E-07	1.4E-01	- -	- -		
Vapors in trench/excavation	- -	- -	- -	- -	2E-10	8.6E-06
Hypothetical Future Scenario - Off-Site						
Off-Site Groundwater (MW-15/MW-15D)						
Hypothetical Off-Site Worker Inhalation - Indoor Air	5E-07	1.8E-01	- -	- -	- -	- -

- - pathway not quantified. See Table 1 for pathway analysis.

South Carolina recognizes US EPA's acceptable cancer risk range of 1 x 10-6 to 1 x 10-4 and Hazard Index of 1.0; constituents with cancer risks greater than 1 x 10-6 are retained as Chemicals of Concern.

APPENDIX A – *SUPPORTING INFORMATION FOR RISK ASSESSMENT*

APPENDIX A

TABLE A-1

OCCURRENCE, DISTRIBUTION, AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN IN SOIL

Joslyn Clark Facility, Lancaster, South Carolina

Scenario Timeframe:	Current/Future
Medium:	Soil
Exposure Medium:	Soil (0-20')
Exposure Point:	Soil

Chemical Class	CAS Number	Chemical (1)	Minimum Concentration (Qualifier)	Maximum Concentration (Qualifier)	Units	Location of Maximum Concentration	Detection Frequency	Concentration Used for Screening (2)	Background Value (3)	Screening Toxicity Value (N/C) (4)	COPC Flag (Y/N)	Rationale for Selection or Deletion
VOCs	67-64-1	Acetone	0.00131	0.00763	mg/kg	GP-18	4/10	0.00763	--	67000	N	BSL
	156-59-2	cis-1,2-Dichloroethene	0.086	10	mg/kg	GP-9 (10-12')	2/20	10	--	230	N	BSL
	123-91-1	1,4-Dioxane	0.404	0.992	mg/kg	GP-21 (3-5')	5/10	0.992		24	N	BSL
	79-01-6	Trichloroethene	0.0038 J	0.2	mg/kg	GP-9 (10-12')	1/17	0.2	--	1.9	N	BSL
Inorganics	7429-90-5	Aluminum	10,000	17,000	mg/kg	GP-15	3/21	17000	--	110000	N	BSL
	7440-36-0	Antimony	0.62	0.62	mg/kg	GP-1 (0-4')	1/21	0.62	--	47	N	BSL
	7440-38-2	Arsenic	0.65 J	1.6	mg/kg	GP-10 (6-8')	7/21	1.6	4.5	3	N	BSL
	7440-39-3	Barium	9.5	14	mg/kg	GP-16 (10-12')	3/21	14	--	22000	N	BSL
	7440-41-7	Beryllium	0.3	1.9	mg/kg	GP-9 (10-12)	18/21	1.9	0.54	230	N	BSL
	7440-43-9	Cadmium	0.11	1.1	mg/kg	GP-9 (10-12)	13/21	1.1	0.19	98	N	BSL
	7440-473	Chromium	0.79	170	mg/kg	GP-9 (10-12')	22/29	170	13	180000	N	BSL
	7440-48-4	Cobalt	1.2 J	1.5 J	mg/kg	GP-14	3/21	1.5 J	--	35	N	BSL
	7440-50-8	Copper	1.2	120	mg/kg	GP-1 (0-4')	18/29	120	8.1	4700	N	BSL
	7439-89-6	Iron	22,000	35,000	mg/kg	GP-15	3/21	35000	--	82000	N	BSL
	7439-92-1	Lead	1.1	66.6	mg/kg	GP-21 (13-15')	24/29	66.6	13	800	N	BSL
	7439-95-4	Magnesiun	310 J	570	mg/kg	GP-16 (10-12')	3/21	570	--	NE	N	BSL
	7439-96-5	Manganese	39	140	mg/kg	GP-16 (10-12')	3/21	140	--	2600	N	BSL
	7439-97-6	Mercury	0.031	0.031	mg/kg	GP-18 (3-5')	1/12	0.031	--	4.6	N	BSL
	7440-02-0	Nickel	1 J	48	mg/kg	GP-9 (10-12)	16/21	48	4.4	2200	N	BSL
	9/7/7440	Potassium	240 J	500	mg/kg	GP-16 (10-12')	3/21	500	--	NE	N	BSL
	7782-49-2	Selenium	4.2 J	4.2 J	mg/kg	GP-16 (26-28'- DUP-1)	3/3	4.2 J	--	580	N	BSL
	7440-22-4	Silver	0.072 J	8.8	mg/kg	GP-1 (0-4')	13/21	8.8	1.2	580	N	BSL
	7440-28-0	Thallium	3.3	3.3	mg/kg	GP-3 (4-8')	1/21	3.3	--	1.2	Y	ASL
	7440-62-2	Vanadium	9.9	21	mg/kg	GP-15	3/21	21	--	580	N	BSL
	7440-66-6	Zinc	9.9	200	mg/kg	GP-1 (0-4)	27/29	200	29	35000	N	BSL

(1) Constituents with at least one positive detection were included in the screening analysis; soil sample locations include GP-1, GP-2, GP-3, GP-4, GP-5, GP-6, GP-7, GP-8, GP-10, GP-11, GP-12, GP-13, GP-17, GP-18, GP-19, GP-20, and GP-21.

(2) Maximum constituent concentration used for screening analysis.

(3) Soil background concentrations.

(4) EPA Regional Screening Level (RSL) Master Table, Industrial Soil, May 2020. COPC Flag Y represents constituents with concentrations greater than the RSLs.

J Analyte present, reported value should be considered a quantitative estimate

NA Screening level not available; Background value not available

Rationale codes:

ASL Above Screening Level

BSL Below Screening Level

EN Essential nutrient

APPENDIX A

TABLE A-2

OCCURRENCE, DISTRIBUTION, AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN IN GROUNDWATER

Joslyn Clark Facility, Lancaster, South Carolina

Scenario Timeframe:	Current/Future
Medium:	Groundwater
Exposure Medium:	Groundwater
Exposure Point:	On-site Groundwater

Exposure Point	CAS Number	Chemical (1)	Minimum Concentration (Qualifier)	Maximum Concentration (Qualifier)	Units	Location of Maximum Concentration	Detection Frequency	Concentration Used for Screening (2)	Maximum Contaminant Level (MCL) (3)	Screening Toxicity Value (N/C) (TAP) (4)	COPC Flag (Y/N)	Rationale for Selection or Deletion
VOCs	67-66-3	Chloroform	0.00103	0.00276	mg/L	MW-7_WG_20180301	12/114	0.00276	0.08	0.00022	Y	ASL
	107-06-2	1,2-Dichloroethane	0.00302	0.00395	mg/L	MW-13I-WG-20190422	2/114	0.00395	0.005	0.00017	Y	ASL
	75-35-4	1,1-Dichloroethene	0.00112	0.155	mg/L	MW-11_WG_20130502	26/114	0.155	0.007	0.028	Y	ASL
	123-91-1	1,4-Dioxane	0.000787	0.000787	mg/L	MW-11_WG_20130502	1/14	0.000787	NA	0.00046	Y	ASL
	127-18-4	Tetrachloroethene	0.00111	0.054	mg/L	MW-3_WG_20130502	41/114	0.054	0.005	0.0041	Y	ASL
	79-00-5	1,1,2-Trichloroethane	0.000931	0.00644	mg/L	MW-3_WG_20180301	8/114	0.00644	0.005	0.000041	Y	ASL
	79-01-6	Trichloroethene	0.001	3.12	mg/L	MW-3_WG_20130502	78/114	3.12	0.005	0.00028	Y	ASL
Metals	7439-89-6	Iron	2.02	2.02	mg/L	MW-11I_WG_20130502	1/3	2.02	NA	1.4	Y	ASL
	7439-96-5	Manganese	0.00535	43.3	mg/L	MW-3_WG_20141229	36/36	43.3	NA	0.043	Y	ASL

(1) Constituents with at least one positive detection in IW-01A, IW-01B, IW-02A, IW-02B, MW-1, MW-2, MW-3, MW-3D, MW-6, MW-7, MW-10, MW-10D, MW-11, MW-11I, MW-11D, MW-12, MW-12D, MW-13, MW-12I, MW-14I, MW-15, MW-15D and OW-01 were included in the screening analysis for groundwater. MW-9 is associated with an off-site source and is not included in this analysis. Groundwater data from MW-4, MW-5, and MW-8 were also excluded because these wells are located outside of the contaminant plume. MW-9 is associated with an off-site source and is not included in this analysis.

(2) Maximum constituent concentration used for screening analysis.

(3) Available Maximum Contaminant Levels.

(4) EPA Regional Screening Level (RSL) Master Table, May 2020. COPC Flag Y represents constituents with concentrations greater than the RSLs.

Rationale codes:

ASL	Above Screening Level	J	Analyte present, reported value should be considered a quantitative estimate
BSL	Below Screening Level	NA	Screening level not available; Background value not available
EN	Essential nutrient		

APPENDIX A

TABLE A-3

OCCURRENCE, DISTRIBUTION, AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN IN GROUNDWATER

Joslyn Clark Facility, Lancaster, South Carolina

Scenario Timeframe:	Current/Future
Medium:	Groundwater
Exposure Medium:	Groundwater
Exposure Point:	On-site Groundwater at Downgradient Property Border

Exposure Point	CAS Number	Chemical (1)	Minimum Concentration (Qualifier)	Maximum Concentration (Qualifier)	Units	Location of Maximum Concentration	Detection Frequency	Concentration Used for Screening (2)	Maximum Contaminant Level (MCL) (3)	Screening Toxicity Value (N/C) (TAP) (4)	COPC Flag (Y/N)	Rationale for Selection or Deletion
VOCs	67-66-3	Chloroform	0.0005	0.0005	mg/L	MW-12D-WG-20200526	1/13	0.0005	0.08	0.00022	Y	ASL
	107-06-2	1,2-Dichloroethane	0.00077	0.00077	mg/L	MW-12D-WG-20200526	1/13	0.00077	0.005	0.00017	Y	ASL
	75-35-4	1,1-Dichloroethene	0.00112	0.0123	mg/L	MW-12D_WG_20150706	8/13	0.0123	0.007	0.028	N	BSL
	127-18-4	Tetrachloroethene	0.00069	0.0162	mg/L	MW-12D_WG_20150706	11/13	0.0162	0.005	0.0041	Y	ASL
	79-01-6	Trichloroethene	0.0039	0.149	mg/L	MW-12D_WG_20180228	13/13	0.149	0.005	0.00028	Y	ASL

(1) Constituents with at least one positive detection in MW-12 and MW-12D.

(2) Maximum constituent concentration used for screening analysis.

(3) Available Maximum Contaminant Levels.

(4) EPA Regional Screening Level (RSL) Master Table, May 2020. COPC Flag Y represents constituents with concentrations greater than the RSLs.

Rationale codes:

ASL	Above Screening Level	J	Analyte present, reported value should be considered a quantitative estimate
BSL	Below Screening Level	NA	Screening level not available; Background value not available
EN	Essential nutrient		

APPENDIX A

TABLE A-4

OCCURRENCE, DISTRIBUTION, AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN IN GROUNDWATER

Joslyn Clark Facility, Lancaster, South Carolina

Scenario Timeframe:	Current/Future
Medium:	Groundwater
Exposure Medium:	Groundwater
Exposure Point:	Off-site Groundwater - MW15 and MW-15D

Exposure Point	CAS Number	Chemical (1)	Minimum Concentration (Qualifier)	Maximum Concentration (Qualifier)	Units	Location of Maximum Concentration	Detection Frequency	Concentration Used for Screening (2)	Maximum Contaminant Level (MCL) (3)	Screening Toxicity Value (N/C) (TAP) (4)	COPC Flag (Y/N)	Rationale for Selection or Deletion
VOCs	67-64-1	Acetone	0.00148	0.00321	mg/L	MW-15D_WG_20191125	2/6	0.00321	NA	1.4	N	BSL
	75-09-2	Methylene chloride	0.00169	0.00205	mg/L	MW-15_WG_20191125	2/6	0.00205	0.005	0.011	N	BSL
	108-88-3	Toluene	0.00111	0.00111	mg/L	MW-15_WG_20191125	1/6	0.00111	1	0.11	N	BSL
	79-01-6	Trichloroethene	0.00233	0.00503	mg/L	MW-15D_WG_20190423	3/6	0.00503	0.005	0.00028	Y	ASL

(1) Constituents with at least one positive detection in MW-15 and MW-15D were included in the screening analysis for groundwater. These monitoring wells are located on the adjacent downgradient parcel.

(2) Maximum constituent concentration used for screening analysis.

(3) Available Maximum Contaminant Levels.

(4) EPA Regional Screening Level (RSL) Master Table, May 2020. COPC Flag Y represents constituents with concentrations greater than the RSLs.

Rationale codes:

ASL	Above Screening Level	J	Analyte present, reported value should be considered a quantitative estimate
BSL	Below Screening Level	NA	Screening level not available; MCL not available
EN	Essential nutrient		

APPENDIX A

TABLE A-5

OCCURRENCE, DISTRIBUTION, AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN IN SOIL GAS

Joslyn Clark Facility, Lancaster, South Carolina

Scenario Timeframe:	Current/Future
Medium:	Soil Gas
Exposure Medium:	Sub-Slab Soil Gas
Exposure Point:	Indoor Air

Exposure Point	CAS Number	Chemical (1)	Minimum Concentration (Qualifier)	Maximum Concentration (Qualifier)	Units	Location of Maximum Concentration	Detection Frequency	Concentration Used for Screening (2)	Screening Toxicity Value (N/C) (3)	COPC Flag (Y/N)	Rationale for Selection or Deletion
VOCs	67-64-1	Acetone	18 J	940 J	ug/m3	SS-2 (2/19/2015)	10/12	940	45100	N	BSL
	71-43-2	Benzene	0.51 J	1.6 J	ug/m3	SS-5 (2/19/2015)	3/12	1.6	52	N	BSL
	78-93-3	2-Butanone	5.2 J	22	ug/m3	SS-5 (2/19/2015)	4/12	22	73000	N	BSL
	75-15-0	Carbon disulfide	1.6	620 J	ug/m3	SS-2 (2/19/2015)	2/12	620	10200	N	BSL
	67-66-3	Chloroform	1.8 J	240	ug/m3	SS-3 (5/9/2014)	6/12	240	18	Y	ASL
	74-87-3	Chloromethane	1.1 J	1.1 J	ug/m3	SS-5 (2/19/2015)	1/12	1.1	1310	N	BSL
	75-71-8	Dibromodifluoromethane	2.7 J	2.7 J	ug/m3	SS-5 (2/19/2015); SS-6 (2/19/2015)	2/12	2.7	1460	N	BSL
	75-34-3	1,1-Dichloroethane	3.1 J	97	ug/m3	SS-3 (5/9/2014)	5/12	97	256	N	BSL
	156-59-2	cis-1,2-Dichloroethene	0.8 J	170	ug/m3	SS-2 (5/9/2014)	2/12	170	NA	N	BSL
	75-35-4	1,1-Dichloroethene	24 J	660	ug/m3	SS-2 (5/9/2014)	7/12	660	2920	N	BSL
	64-17-5	Ethanol	6.0 J	1,100	ug/m3	SS-2 (2/19/2015)	9/12	1100	NA	N	BSL
	100-41-4	Ethylbenzene	0.88 J	4.9	ug/m3	SS-6 (2/19/2015)	2/12	4.9	164	N	BSL
	622-96-8	4-Ethyltoluene	62	62	ug/m3	SS-3 (5/9/2014)	1/12	62	NA	N	BSL
	71-23-8	2-Propanol	6.8 J	91	ug/m3	SS-4 (5/9/2014)	6/12	91	NA	N	BSL
	110-54-3	Hexane	1,400	1,400	ug/m3	SS-2 (2/19/2015)	1/12	1400	10200	N	BSL
	75-09-2	Methylene chloride	450 J	450 J	ug/m3	SS-2 (2/19/2015)	1/12	450	8760	N	BSL
	127-18-4	Tetrachloroethene	2.4 J	490	ug/m3	SS-2 (2/19/2015)	12/12	490	584	N	BSL
	71-55-6	1,1,1-Trichloroethane	130	250	ug/m3	SS-3 (5/9/2014)	2/12	250	73000	N	BSL
	79-01-6	Trichloroethene	1.4 J	28,000	ug/m3	SS-2 (5/9/2014)	12/12	28000	29	Y	ASL
	75-69-4	Trichlorofluoromethane	1.3 J	1.3 J	ug/m3	SS-5 (2/19/2015); SS-6 (2/19/2015)	2/12	1.3	NA	N	BSL
	95-63-6	1,2,4-Trimethylbenzene	0.75 J	100	ug/m3	SS-3 (5/9/2014)	4/12	100	876	N	BSL
	108-67-8	1,3,5-Trimethylbenzene	1.4 J	32	ug/m3	SS-3 (5/9/2014)	2/12	32	876	N	BSL
	108-38-3	m,p-Xylenes	1.4 J	25	ug/m3	SS-3 (5/9/2014)	5/12	25	1460	N	BSL
	95-47-6	o-Xylenes	2.6 J	340	ug/m3	SS-3 (5/9/2014)	4/12	340	1460	N	BSL

(1) Constituents with at least one positive detection in SS-1, SS-2, SS-3, SS-4, SS-5, and SS-6.

(2) Maximum constituent concentration used for screening analysis.

(3) US EPA Vapor Intrusion Screening Level calculator, Target Sub-Slab and Near Source Soil Gas Concentrations (target cancer risk=1x10 $^{-6}$; target hazard = 0.1), accessed October 2020.
COPC Flag Y represents constituents with concentrations greater than the RSLs.

Rationale codes:

ASL	Above Screening Level	J	Analyte present, reported value should be considered a quantitative estimate
BSL	Below Screening Level	NA	Screening level not available; Background value not available

APPENDIX A

TABLE A-6

OCCURRENCE, DISTRIBUTION, AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN IN INDOOR AIR

Joslyn Clark Facility, Lancaster, South Carolina

Scenario Timeframe:	Current/Future
Medium:	Air
Exposure Medium:	Air
Exposure Point:	Indoor Air

Exposure Point	CAS Number	Chemical (1)	Minimum Concentration (Qualifier)	Maximum Concentration (Qualifier)	Units	Location of Maximum Concentration	Detection Frequency	Concentration Used for Screening (2)	Screening Toxicity Value (N/C) (3)	COPC Flag (Y/N)	Rationale for Selection or Deletion
VOCs	67-64-1	Acetone	11 J	20 J	ug/m3	AA-1 (5/9/2014)	8/8	20	14000	N	BSL
	71-43-2	Benzene	0.425	1.28	ug/m3	AA-2 (2/18/2015)	7/14	1.28	1.6	N	BSL
	56-23-5	Carbon tetrachloride	0.366	0.409	ug/m3	AA-2 (2/18/2015)	7/14	0.409	2	N	BSL
	95-50-1	1,2-Dichlorobenzene	0.166 J	0.421	ug/m3	AA-2 (2/18/2015)	2/14	0.421	88	N	BSL
	541-73-1	1,3-Dichlorobenzene	0.147 J	0.368	ug/m3	AA-2 (2/18/2015)	2/14	0.368	N/A	N	BSL
	106-46-7	1,4-Dichlorobenzene	0.135 J	0.394	ug/m3	AA-2 (2/18/2015)	5/14	0.394	1.1	N	BSL
	107-06-2	1,2-Dichloroethane	0.207	0.581	ug/m3	AA-2 (2/18/2015)	5/14	0.581	0.47	Y	ASL
	156-60-5	trans-1,2-Dichloroethene	0.356	0.356	ug/m3	AA-6 (2/18/2015)	1/14	0.356	N/A	N	BSL
	64-17-5	Ethanol	3.7 J	6.5 J	ug/m3	AA-1 (5/9/2014)	9/14	6.5	N/A	N	BSL
	100-41-4	Ethylbenzene	0.108 J	2.44	ug/m3	AA-2 (2/18/2015)	7/14	2.44	4.9	N	BSL
	76-13-1	Freon 113	0.469	0.504	ug/m3	AA-7 (2/18/2015)	7/14	0.504	2200	N	BSL
	71-23-8	2-Propanol	2.8 J	2.8 J	ug/m3	AA-6 (5/9/2014)	1/14	2.8	N/A	N	BSL
	110-54-3	Hexane	0.69 J	4.5	ug/m3	AA-5 (5/9/2014)	8/14	4.5	310	N	BSL
	127-18-4	Tetrachloroethene	0.141 J	0.364	ug/m3	AA-2 (2/18/2015)	2/14	0.364	18	N	BSL
	108-88-3	Toluene	0.251	1.43	ug/m3	AA-2 (2/18/2015)	7/14	1.43	2200	N	BSL
	79-01-6	Trichloroethene	0.672	3.5 J	ug/m3	AA-1 (5/9/2014)	12/14	3.5	0.88	Y	ASL
	95-63-6	1,2,4-Trimethylbenzene	0.74 J	0.74 J	ug/m3	AA-1 (5/9/2014)	1/14	0.74	26	N	BSL
	108-38-3	m,p-Xylenes	0.230 J	5.26	ug/m3	AA-2 (2/18/2015)	7/14	5.26	44	N	BSL
	95-47-6	o-Xylenes	0.191 J	3.6	ug/m3	AA-2 (2/18/2015)	7/14	3.6	44	N	BSL

(1) Constituents with at least one positive detection in AA-1, AA-2, AA-3, AA-4, AA-5, AA-6, AA-7; two sampling events collected on 5/9/2014 and 2/18/2015. One ambient air sample (OA-1) taken outdoors was not included in the screening analysis.

(2) Maximum constituent concentration used for screening analysis.

(3) EPA Regional Screening Level (RSL) Master Table, Industrial Air, May 2020. COPC Flag Y represents constituents with concentrations greater than the RSLs.

Rationale codes:

ASL	Above Screening Level	J	Analyte present, reported value should be considered a quantitative estimate
BSL	Below Screening Level	NA	Screening level not available; Background value not available

APPENDIX A

TABLE A-7

OCCURRENCE, DISTRIBUTION, AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN FOR TRENCH AIR

Joslyn Clark Facility, Lancaster, South Carolina

Scenario Timeframe:	Future
Medium:	Groundwater
Exposure Medium:	On-Site Groundwater
Exposure Point:	Air - Excavation/Trenches

Exposure Point	CAS Number	Chemical	Minimum Concentration (Qualifier)	Maximum Concentration (Qualifier)	Units	Location of Maximum Concentration	Detection Frequency	Concentration Used for Screening (2)	Screening Toxicity Value (N/C) (TAP) (3)	COPC Flag (Y/N)	Rationale for Selection or Deletion
VOCs	67-66-3	Chloroform	0.00103	0.00276	mg/L	MW-7_WG_20180301	12/114	0.00276	0.71	N	BSL
	107-06-2	1,2-Dichloroethane	0.00302	0.00395	mg/L	MW-13I-WG-20190422	2/114	0.00395	1.76	N	BSL
	75-35-4	1,1-Dichloroethene	0.00112	0.155	mg/L	MW-11_WG_20130502	26/114	0.155	0.23	N	BSL
	123-91-1	1,4-Dioxane	0.000787	0.000787	mg/L	MW-11_WG_20130502	1/14	0.000787	2212.3	N	BSL
	127-18-4	Tetrachloroethene	0.00111	0.054	mg/L	MW-3_WG_20130502	41/114	0.054	0.29	N	BSL
	79-00-5	1,1,2-Trichloroethane	0.000931	0.00644	mg/L	MW-3_WG_20180301	8/114	0.00644	0.23	N	BSL
	79-01-6	Trichloroethene	0.001	3.12	mg/L	MW-3_WG_20130502	78/114	3.12	0.02	Y	ASL

(1) Constituents with at least one positive detection were included in the screening analysis

(2) Maximum constituent concentration used for screening analysis.

(3) Screening value for construction worker (trench) soil gas screening level calculated using the Virginia Unified Risk Assessment Model (VURAM 3.1), June 2020. Depth to groundwater is greater than 15 feet below ground surface. COPC Flag Y represents constituents with concentrations greater than the RSLs.

Rationale codes:

ASL	Above Screening Level	NA	Screening Level Not Available
BSL	Below Screening Level	ND	Non-detect

APPENDIX A

TABLE A-8

OCCURRENCE, DISTRIBUTION, AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN IN SOIL GAS

Joslyn Clark Facility, Lancaster, South Carolina

Scenario Timeframe:	Current/Future
Medium:	Soil Gas
Exposure Medium:	Sub-Slab Soil Gas
Exposure Point:	Trench Air

Exposure Point	CAS Number	Chemical (1)	Minimum Concentration (Qualifier)	Maximum Concentration (Qualifier)	Units	Location of Maximum Concentration	Detection Frequency	Concentration Used for Screening (2)	Screening Toxicity Value (N/C) (3)	COPC Flag (Y/N)	Rationale for Selection or Deletion
VOCs	67-64-1	Acetone	18 J	940 J	ug/m3	SS-2 (2/19/2015)	10/12	940	2445862	N	BSL
	71-43-2	Benzene	0.51 J	1.6 J	ug/m3	SS-5 (2/19/2015)	3/12	1.6	7496	N	BSL
	78-93-3	2-Butanone	5.2 J	22	ug/m3	SS-5 (2/19/2015)	4/12	22	91740	N	BSL
	75-15-0	Carbon disulfide	1.6	620 J	ug/m3	SS-2 (2/19/2015)	2/12	620	55173	N	BSL
	67-66-3	Chloroform	1.8 J	240	ug/m3	SS-3 (5/9/2014)	6/12	240	26600	N	BSL
	74-87-3	Chloromethane	1.1 J	1.1 J	ug/m3	SS-5 (2/19/2015)	1/12	1.1	203023	N	BSL
	75-71-8	Dibromodifluoromethane	2.7 J	2.7 J	ug/m3	SS-5 (2/19/2015); SS-6 (2/19/2015)	2/12	2.7	110000	N	BSL
	75-34-3	1,1-Dichloroethane	3.1 J	97	ug/m3	SS-3 (5/9/2014)	5/12	97	45760	N	BSL
	156-59-2	cis-1,2-Dichloroethene	0.8 J	170	ug/m3	SS-2 (5/9/2014)	2/12	170	NA	N	BSL
	75-35-4	1,1-Dichloroethene	24 J	660	ug/m3	SS-2 (5/9/2014)	7/12	660	7707	N	BSL
	64-17-5	Ethanol	6.0 J	1,100	ug/m3	SS-2 (2/19/2015)	9/12	1100	NA	N	BSL
	100-41-4	Ethylbenzene	0.88 J	4.9	ug/m3	SS-6 (2/19/2015)	2/12	4.9	35779	N	BSL
	622-96-8	4-Ethyltoluene	62	62	ug/m3	SS-3 (5/9/2014)	1/12	62	NA	N	BSL
	71-23-8	2-Propanol	6.8 J	91	ug/m3	SS-4 (5/9/2014)	6/12	91	NA	N	BSL
	110-54-3	Hexane	1,400	1,400	ug/m3	SS-2 (2/19/2015)	1/12	1400	229504	N	BSL
	75-09-2	Methylene chloride	450 J	450 J	ug/m3	SS-2 (2/19/2015)	1/12	450	87479	N	BSL
	127-18-4	Tetrachloroethene	2.4 J	490	ug/m3	SS-2 (2/19/2015)	12/12	490	6764	N	BSL
	71-55-6	1,1,1-Trichloroethane	130	250	ug/m3	SS-3 (5/9/2014)	2/12	250	647147	N	BSL
	79-01-6	Trichloroethene	1.4 J	28,000	ug/m3	SS-2 (5/9/2014)	12/12	28000	263	Y	ASL
	75-69-4	Trichlorofluoromethane	1.3 J	1.3 J	ug/m3	SS-5 (2/19/2015); SS-6 (2/19/2015)	2/12	1.3	128362	N	BSL
	95-63-6	1,2,4-Trimethylbenzene	0.75 J	100	ug/m3	SS-3 (5/9/2014)	4/12	100	27653	N	BSL
	108-67-8	1,3,5-Trimethylbenzene	1.4 J	32	ug/m3	SS-3 (5/9/2014)	2/12	32	27859	N	BSL
	108-38-3	m,p-Xylenes	1.4 J	25	ug/m3	SS-3 (5/9/2014)	5/12	25	12271	N	BSL
	95-47-6	o-Xylenes	2.6 J	340	ug/m3	SS-3 (5/9/2014)	4/12	340	12172	N	BSL

(1) Constituents with at least one positive detection in SS-1, SS-2, SS-3, SS-4, SS-5, and SS-6.

(2) Maximum constituent concentration used for screening analysis.

(3) Virginia Unified Risk Assessment Model (VURAM 3.1) Construction Soil Gas Screening Levels, accessed October 2020. The screening levels are used to assess acceptable concentrations in trench air.
COPC Flag Y represents constituents with concentrations greater than the RSLs.

Rationale codes:

ASL	Above Screening Level	J	Analyte present, reported value should be considered a quantitative estimate
BSL	Below Screening Level	NA	Screening level not available; Background value not available

APPENDIX A
TABLE A-9
CALCULATION OF TRENCH AIR CONCENTRTIONS ESTIMATED FROM GROUNDWATER CONCENTRATIONS
Joslyn Clark Facility, Lancaster, South Carolina

Scenario Timeframe:	Future
Medium:	On-Site Groundwater
Exposure Medium:	Groundwater vapors
Exposure Point:	Air

	Cs Medium EPC mg/L	MW g/mole	K_{iL} cm/sec	K_{iG} cm/sec	Ideal Gas Law Constant	Temperature	Henry's Law Constant * atm-m3/mole	Ki cm/sec	Area cm2	Emission Rate mg/sec	Air Concentration mg/m3
Chloroform	5.3E-04	1.19E+02	3.16E-03	4.42E-01	0.000082	298	3.67E-03	3.01E-03	8.33E-01	1.32E-06	1.2E-07
1,2-Dichloroethane	6.4E-04	9.90E+01	3.47E-03	4.71E-01	0.000082	298	1.18E-03	3.01E-03	8.33E-01	1.59E-06	1.5E-07
1,1-Dichloroethene	1.4E-02	9.69E+01	3.50E-03	4.74E-01	0.000082	298	2.61E-02	3.48E-03	8.33E-01	4.00E-05	3.7E-06
1,4-Dioxane	9.5E-04	8.81E+01	3.68E-03	4.89E-01	0.000082	298	4.80E-06	9.37E-05	8.33E-01	7.41E-08	6.9E-09
Tetrachloroethene	1.1E-01	1.66E+02	2.68E-03	3.96E-01	0.000082	298	1.77E-02	2.65E-03	8.33E-01	2.39E-04	2.2E-05
1,1,2-Trichloroethane	1.0E-02	1.33E+02	2.99E-03	4.26E-01	0.000082	298	8.24E-04	2.47E-03	8.33E-01	2.06E-05	1.9E-06
Trichloroethene	2.0E-01	1.31E+02	3.01E-03	4.28E-01	0.000082	298	9.85E-03	2.96E-03	8.33E-01	5.03E-04	4.7E-05

* = Regional Screening Level (RSL) chemical-specific parameteres supporting table (USEPA, April 2020).

$C_a = E_i$ / LS x V x MH; where C_a is the Ambient Air Concentration (mg/m^3)
$K_{iG} = (MW_{H2O}/MW_i)$^0.335 x (T/298)^1.005 x (k_{iG}, O_2); where KiG is the Gas Phase Mass Transfer Coefficient (cm/second)
$K_{iL} = (MW_{O2}/MW_i)$^0.5 x (T/298) x (k_L, O_2); where K_{iL} is the Liquid Phase Mass Transfer Coefficient (cm/second)
$K_i^{-1} = K_{iL}^{-1}$ + ((R x T)/(H_i x K_{iG})); where K_i is the Overall Mass Transfer Coefficient (cm/second)
$E_i = K_i$ x C_s x A; where E_i is the Emission Rate (mg/second)

Input Variables:	Value	Units
Contaminant Liquid Phase Concentration, C_s =	Chem Specific	mg/cm^3
Area, A =	2.23E+04	cm^2
Ideal Gas Law Constant, R =	8.20E-05	atm-m3/mole-degK
Temperature, T =	298	degK
Henry's Law Constant for Compound I, H_i =	Chem Specific	atm-m^3/mole
Molecular Weight of Oxygen , MW_{O2} =	32	g/mole
Molecular Weight of Water, MW_{H2O} =	18	g/mole
Molecular Weight of Compound i, MW_i =	Chem Specific	g/mole
Liquid Phase Mass Transfer Coefficient for Oxygen at 25 degC, k_L, O_2 =	0.0061	cm/second
Gas Phase Mass Transfer Coefficient for Water Vapor at 25 degC, k_{iG}, O_2 =	0.833	cm/second
Length of side perpendicular to the wind, LS =	2.4	meters
Average wind speed, V =	2.25	m/second
Mixing Height before being inhaled, MH =	2	meters
Molecular Weight of Oxygen , MW_{O2} =	32	g/mole
Molecular Weight of Water, MW_{H2O} =	18	g/mole
Molecular Weight of Compound i, MW_i =	Chem Specific	g/mole
Liquid Phase Mass Transfer Coefficient for Oxygen at 25 degC, k_L, O_2 =	0.0061	cm/second
Gas Phase Mass Transfer Coefficient for Water Vapor at 25 degC, k_{iG}, O_2 =	0.833	cm/second
Length of side perpendicular to the wind, LS =	2.4	meters
Average wind speed, V =	2.25	m/second
Mixing Height before being inhaled, MH =	2	meters

APPENDIX A

TABLE A-10

OCCURRENCE, DISTRIBUTION, AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN FOR TRENCH AIR

Joslyn Clark Facility, Lancaster, South Carolina

Scenario Timeframe:	Future
Medium:	Groundwater
Exposure Medium:	Downgradient Groundwater at Property Boundary
Exposure Point:	Air - Excavation/Trenches

Exposure Point	CAS Number	Chemical	Minimum Concentration (Qualifier)	Maximum Concentration (Qualifier)	Units	Location of Maximum Concentration	Detection Frequency	Concentration Used for Screening (2)	Screening Toxicity Value (N/C) (TAP) (3)	COPC Flag (Y/N)	Rationale for Selection or Deletion
VOCs	67-66-3	Chloroform	0.0005	0.0005	mg/L	MW-12D-WG-20200526	1/13	0.0005	5.50	N	BSL
	107-06-2	1,2-Dichloroethane	0.00077	0.00077	mg/L	MW-12D-WG-20200526	1/13	0.00077	4.40	N	BSL
	127-18-4	Tetrachloroethene	0.00069	0.0162	mg/L	MW-12D_WG_20150706	11/13	0.0162	0.29	N	BSL
	79-01-6	Trichloroethene	0.0039	0.149	mg/L	MW-12D_WG_20180228	13/13	0.149	0.02	Y	ASL

(1) Constituents with at least one positive detection in MW-12 and MW-12D were included in the screening analysis

(2) Maximum constituent concentration used for screening.

(3) Screening value for construction worker (trench) soil gas screening level calculated using the Virginia Unified Risk Assessment Model (VURAM 3.1), June 2020. Depth to groundwater is greater than 15 feet below ground surface. COPC Flag Y represents constituents with concentrations greater than the RSLs.

Rationale codes:

ASL	Above Screening Level	NA	Screening Level Not Available
BSL	Below Screening Level	ND	Non-detect

APPENDIX A
TABLE A-11
CALCULATION OF TRENCH AIR CONCENTRTIONS ESTIMATED FROM GROUNDWATER CONCENTRATIONS
Joslyn Clark Facility, Lancaster, South Carolina

Scenario Timeframe:	Future
Medium:	Groundwater
Exposure Medium:	Vapors from Downgradient Groundwater at Property Boundary
Exposure Point:	Air

	Cs Medium EPC mg/L	MW g/mole	K_{iL} cm/sec	K_{iG} cm/sec	Ideal Gas Law Constant	Temperature	Henry's Law Constant * atm-m3/mole	Ki cm/sec	Area cm2	Emission Rate mg/sec	Air Concentration mg/m3
Chloroform	7.7E-04	1.19E+02	3.16E-03	4.42E-01	0.000082	298	3.67E-03	3.01E-03	8.33E-01	1.93E-06	1.8E-07
1,2-Dichloroethane	5.0E-04	9.90E+01	3.47E-03	4.71E-01	0.000082	298	1.18E-03	3.01E-03	8.33E-01	1.25E-06	1.2E-07
Tetrachloroethene	1.1E-02	1.66E+02	2.68E-03	3.96E-01	0.000082	298	1.77E-02	2.65E-03	8.33E-01	2.45E-05	2.3E-06
Trichloroethene	1.4E-01	1.31E+02	3.01E-03	4.28E-01	0.000082	298	9.85E-03	2.96E-03	8.33E-01	3.55E-04	3.3E-05

* = Regional Screening Level (RSL) chemical-specific parameteres supporting table (USEPA, April 2020).

$C_a = E_i$ / LS x V x MH; where C_a is the Ambient Air Concentration (mg/m^3)
$K_{iG} = (MW_{H2O}/MW_i)$^0.335 x (T/298)^1.005 x (k_{iG}, O_2); where KiG is the Gas Phase Mass Transfer Coefficient (cm/second)
$K_{iL} = (MW_{O2}/MW_i)$^0.5 x (T/298) x (k_L, O_2); where K_{iL} is the Liquid Phase Mass Transfer Coefficient (cm/second)
$K_i^{-1} = K_{iL}^{-1}$ + ((R x T)/(H_i x K_{iG})); where K_i is the Overall Mass Transfer Coefficient (cm/second)
$E_i = K_i$ x C_s x A; where E_i is the Emission Rate (mg/second)

Input Variables:	**Value**	**Units**
Contaminant Liquid Phase Concentration, C_s =	Chem Specific	mg/cm^3
Area, A =	2.23E+04	cm^2
Ideal Gas Law Constant, R =	8.20E-05	atm-m3/mole-degK
Temperature, T =	298	degK
Henry's Law Constant for Compound I, H_i =	Chem Specific	atm-m^3/mole
Molecular Weight of Oxygen , MW_{O2} =	32	g/mole
Molecular Weight of Water, MW_{H2O} =	18	g/mole
Molecular Weight of Compound i, MW_i =	Chem Specific	g/mole
Liquid Phase Mass Transfer Coefficient for Oxygen at 25 degC, k_L, O_2 =	0.0061	cm/second
Gas Phase Mass Transfer Coefficient for Water Vapor at 25 degC, k_{iG}, O_2 =	0.833	cm/second
Length of side perpendicular to the wind, LS =	2.4	meters
Average wind speed, V =	2.25	m/second
Mixing Height before being inhaled, MH =	2	meters
Molecular Weight of Oxygen , MW_{O2} =	32	g/mole
Molecular Weight of Water, MW_{H2O} =	18	g/mole
Molecular Weight of Compound i, MW_i =	Chem Specific	g/mole
Liquid Phase Mass Transfer Coefficient for Oxygen at 25 degC, k_L, O_2 =	0.0061	cm/second
Gas Phase Mass Transfer Coefficient for Water Vapor at 25 degC, k_{iG}, O_2 =	0.833	cm/second
Length of side perpendicular to the wind, LS =	2.4	meters
Average wind speed, V =	2.25	m/second
Mixing Height before being inhaled, MH =	2	meters

APPENDIX A
TABLE A-12
ESTIMATED INDOOR AIR CONCENTRATIONS FROM GROUNDWATER AND COMPARISON TO INDOOR AIR SCREENING LEVELS
Joslyn Clark Facility, Lancaster, South Carolina

Scenario Timeframe:	Future
Medium:	Groundwater
Exposure Medium:	On-site Groundwater at Downgradient Property Border (MW-12 and MW-12D)
Exposure Point:	Air - Vapor Intrusion into Future Buildings

Calculation taken from USEPA, Vapor Intrusion Screening Level Calculator, October 2020

CAS No.	**Constituent**	Maxmum Groundwater Concentration (ug/L) (1)	Estimated Indoor Air Concentration (ug/m^3) (2)	Target Indoor Air Concentration (ug/m^3) (3)	COPC Flag (Y/N)	Rationale for Selection or Deletion
67-66-3	Chloroform	5.00E-04	6.16E-02	5.33E-01	N	BSL
107-06-2	1,2-Dichloroethane	7.70E-04	2.97E-02	4.72E-01	N	BSL
127-18-4	Tetrachloroethene	1.62E-02	3.87E-01	1.75E+01	N	BSL
79-01-6	Trichloroethene	1.49E-01	1.26E+00	8.76E-01	Y	ASL

(1) Maximum groundwater concentration reported used for screening analysis.
(2) Residential indoor air concentrations estimated using the Vapor Intrusion Screening Level calcalator (VISL), assessed October 2020.
COPC Flag Y represents constituents with concentrations greater than the RSLs.
(3) Target Resdential indoor air concentrations obtained from VISL calculator; set to equal a cancer risk of 1x10-6 and hazard quotient of 0.1.
Average groundwater temperature set at 20 degrees centigrade.

APPENDIX A
TABLE A-13
ESTIMATED INDOOR AIR CONCENTRATIONS FROM GROUNDWATER AND COMPARISON TO INDOOR AIR SCREENING LEVELS
Joslyn Clark Facility, Lancaster, South Carolina

Scenario Timeframe:	Future
Medium:	Groundwater
Exposure Medium:	Off-site Groundwater - MW15 and MW-15D
Exposure Point:	Air - Vapor Intrusion into Future Buildings

Calculation taken from USEPA, Vapor Intrusion Screening Level Calculator, October 2020

CAS No.	**Constituent**	Maxmum Groundwater Concentration (ug/L) (1)	Estimated Indoor Air Concentration (ug/m^3) (2)	Target Indoor Air Concentration (ug/m^3) (3)	COPC Flag (Y/N)	Rationale for Selection or Deletion
67-64-1	Acetone	3.21E+00	3.77E-03	1.35E+04	N	BSL
75-35-4	Methylene chloride	2.05E+00	2.27E-01	2.63E+02	N	BSL
156-60-5	Toluene	1.11E+00	2.36E-01	2.19E+03	N	BSL
75-09-2	Trichloroethene	5.03E+00	1.62E+00	8.76E-01	Y	ASL

(1) Maximum groundwater concentration reported used for screening analysis.
(2) Residential indoor air concentrations estimated using the Vapor Intrusion Screening Level calcalator (VISL), assessed October 2020.
COPC Flag Y represents constituents with concentrations greater than the RSLs.
(3) Target Resdential indoor air concentrations obtained from VISL calculator; set to equal a cancer risk of 1x10-6 and hazard quotient of 0.1.
Average groundwater temperature set at 20 degrees centigrade.

APPENDIX A
TABLE A-14
MEDIUM-SPECIFIC EXPOSURE POINT CONCENTRATION SUMMARY FOR SOIL
Joslyn Clark Facility, Lancaster, South Carolina

Scenario Timeframe:	Current/Future
Medium:	Soil
Exposure Medium:	Soil
Exposure Point:	Soil (0 - 20 feet)

Chemical of Potential Concern	Units	Arthmetic Mean or Mean of Detected	ProUCL - Recommended (1) UCL on the Mean	Maximum Detected Concentration	Maximum Qualifier	EPC Units	Reasonable Maximum Exposure		
							Medium EPC Value	Medium EPC Statistic	Medium EPC Rationale
Site Soil - (0-20 feet)									
Thallium	mg/kg	--	--	3.3E+00		mg/kg	3.3E+00	maximum	maximum

Statistics: Maximum Detected Value (Maximum); or ProUCL-recommended UCL

APPENDIX A

TABLE A-15

MEDIUM-SPECIFIC EXPOSURE POINT CONCENTRATION SUMMARY FOR SOIL

Joslyn Clark Facility, Lancaster, South Carolina

Scenario Timeframe:	Current/Future
Medium:	Soil
Exposure Medium:	Soil (0-20 feet)
Exposure Point:	Air

Chemical of Potential Concern	Units	Arthmetic Mean or Mean of Detected	ProUCL - Recommended [1] UCL on the Mean	Maximum Detected Concentration	Maximum Qualifier	EPC Units	Reasonable Maximum Exposure		
							Medium EPC Value	Medium EPC Statistic	Medium EPC Rationale
Site Soil - (0-20 feet)									
Thallium	mg/kg	--	--	3.3E+00		mg/kg	3.3E+00	maximum	maximum

Statistics: Maximum Detected Value (Maximum); or ProUCL-recommended UCL

APPENDIX A

TABLE A-16

ROUTE-SPECIFIC CONCENTRATION FOR PARTICULATES AND VAPORS IN OUTDOOR AIR

Joslyn Clark Facility, Lancaster, South Carolina

Scenario Timeframe:	Current/Future
Medium:	Soil
Exposure Medium:	Soil
Exposure Point:	Outdoor Air

Chemical of Potential Concern	Reasonable Maximum Exposure	Reasonable Maximum Exposure	Reasonable Maximum Exposure	Reasonable Maximum Exposure
	Medium EPC Value (mg/kg)	Particulates EPC Value (mg/m^3)	Vapors EPC Value (mg/m^3)	Route EPC Value (mg/m^3)
Volatile Organics				
Thallium	3.30E+00	3.43E-10	--	3.43E-10

Particulate EPC Value = Medium EPC Value / 9.6 x10^9 m^3/kg (based on particulate emission factor for Charleston, SC)

Route EPC Value = Route EPC Values Particulates + Route EPC Value Vapors

APPENDIX A
TABLE A-17
MEDIUM-SPECIFIC EXPOSURE POINT CONCENTRATION SUMMARY
Joslyn Clark Facility, Lancaster, South Carolina

Scenario Timeframe:	Current/Future
Medium:	Indoor Air
Exposure Medium:	Indoor Air
Exposure Point:	Indoor Air

Chemical of Potential Concern	Units	Arithmetic Mean	ProUCL - Recommended [1] UCL on the Mean	Maximum Detected Concentration	Maximum Qualifier	EPC Units	Reasonable Maximum Exposure		
							Medium EPC Value	Medium EPC Statistic	Medium EPC Rationale
Trichloroethene	ug/m3	1.87E+00	2.12E+00	3.50E+00		ug/m3	2.12E+00	95% UCL - NP	KM (t) UCL

Indoor air samples collected from loctations AA-1, AA-2, AA-3, AA-4, AA-5, AA-6, AA-7; two sampling events collected on 5/9/2014 and 2/18/2015.
1,2-Dichloroethane is likely a background contaminant and is not related to site activities; 1,2-Dichloroethane was not retained for further analysis.
Statistics: Maximum Detected Value (Maximum); or ProUCL-recommended UCL
[1] Calculated by ProUCL (Version 4.00.02)
KM = Kaplan Meier
NP = Nonparametric

APPENDIX A
TABLE A-18
MEDIUM-SPECIFIC EXPOSURE POINT CONCENTRATION SUMMARY
Joslyn Clark Facility, Lancaster, South Carolina

Scenario Timeframe:	Future
Medium:	Groundwater
Exposure Medium:	Groundwater
Exposure Point:	On-Site Groundwater

Chemical of Potential Concern	Units	Arithmetic Mean	ProUCL - Recommended [1] UCL on the Mean	Maximum Detected Concentration	Maximum Qualifier	EPC Units	Reasonable Maximum Exposure		
							Medium EPC Value	Medium EPC Statistic	Medium EPC Rationale
Chloroform	mg/L	1.54E-03	5.26E-04	2.76E-03		mg/L	5.26E-04	95% UCL - NP	KM (t)
1,2-Dichloroethane	mg/L	2.74E-03	6.35E-04	3.95E-03		mg/L	6.35E-04	95% UCL - NP	KM (Chebyshev)
1,1-Dichloroethene	mg/L	2.32E-02	1.38E-02	1.55E-01		mg/L	1.38E-02	95% UCL - NP	KM (Chebyshev)
1,4-Dioxane	mg/L	8.68E-04	--	9.50E-04		mg/L	9.50E-04	maximum	maximum
Tetrachloroethene	mg/L	9.79E-03	1.08E-01	5.40E-02		mg/L	1.08E-01	95% UCL - G	GROS Approximate Gamma
1,1,2-Trichloroethane	mg/L	1.83E-03	1.00E-02	6.44E-03		mg/L	1.00E-02	95% UCL - G	GROS Approximate Gamma
Trichloroethene	mg/L	2.17E-01	2.04E-01	3.12E+00		mg/L	2.04E-01	95% UCL - G	Approximate Gamma
Iron	mg/L	--	--	2.02E+00		mg/L	2.02E+00	maximum	maximum
Manganese	mg/L	5.42E+00	1.55E+01	4.33E+01		mg/L	1.55E+01	97.5% UCL - NP	KM (Chebyshev)

Groundwater data from monitoring wells IW-01A, IW-01B, IW-02A, IW-02B, MW-1, MW-2, MW-3, MW-3D, MW-6, MW-7, MW-10, MW-10D, MW-11, MW-11I, MW-11D, MW-12, MW-12D, MW-13, MW-12I, MW-14I, MW-15, MW-15D and OW-01 used in the statistical analysis.

Statistics: Maximum Detected Value (Maximum); or ProUCL-recommended UCL

[1] Calculated by ProUCL (Version 4.00.02)

KM = Kaplan Meier

NP = Nonparametric

G = Gamma

APPENDIX A
TABLE A-19
MEDIUM-SPECIFIC EXPOSURE POINT CONCENTRATION SUMMARY
Joslyn Clark Facility, Lancaster, South Carolina

Scenario Timeframe:	Future
Medium:	Groundwater
Exposure Medium:	Groundwater
Exposure Point:	On-Site Groundwater at Downgradient Property Boundary

Chemical of Potential Concern	Units	Arithmetic Mean	ProUCL - Recommended [1] UCL on the Mean	Maximum Detected Concentration	Maximum Qualifier	EPC Units	Reasonable Maximum Exposure		
							Medium EPC Value	Medium EPC Statistic	Medium EPC Rationale
Chloroform	mg/L	--	--	7.70E-04		mg/L	7.70E-04	maximum	maximum
1,2-Dichloroethane	mg/L	--	--	5.00E-04		mg/L	5.00E-04	maximum	maximum
Tetrachloroethene	mg/L	8.94E-03	1.11E-02	1.62E-02		mg/L	1.11E-02	95% UCL - NP	KM (t)
Trichloroethene	mg/L	6.82E-02	1.44E-01	1.49E-01		mg/L	1.44E-01	95% UCL - G	Adjusted Gamma

Groundwater data from monitoring wells MW-12 and MW-12D used in the statistical analysis.
Statistics: Maximum Detected Value (Maximum); or ProUCL-recommended UCL
[1] Calculated by ProUCL (Version 4.00.02)

KM = Kaplan Meier

NP = Nonparametric

G = Gamma

APPENDIX A
TABLE A-20
MEDIUM-SPECIFIC EXPOSURE POINT CONCENTRATION SUMMARY
Joslyn Clark Facility, Lancaster, South Carolina

Scenario Timeframe:	Future
Medium:	Groundwater
Exposure Medium:	Groundwater
Exposure Point:	Off-Site Groundwater

Chemical of Potential Concern	Units	Arithmetic Mean	ProUCL - Recommended [1] UCL on the Mean	Maximum Detected Concentration	Maximum Qualifier	EPC Units	Reasonable Maximum Exposure		
							Medium EPC Value	Medium EPC Statistic	Medium EPC Rationale
Trichloroethene	mg/L	3.30E-03	--	5.03E-03		mg/L	5.03E-03	maximum	maximum

Groundwater data from monitoring wells MW-15 and MW-15D used in the statistical analysis.
Statistics: Maximum Detected Value (Maximum); or ProUCL-recommended UCL
[1] Calculated by ProUCL (Version 4.00.02)

APPENDIX A
TABLE A-21
VALUES USED FOR DAILY INTAKE CALCULATIONS
Joslyn Clark Facility, Lancaster, South Carolina

Scenario Timeframe:	Current/Future
Medium:	Soil
Exposure Medium:	Soil
Exposure Point:	Soil
Receptor Population:	Site Worker
Receptor Age:	Adult

Exposure Route	Parameter Code	Parameter Definition	Units	RME Value	RME Rationale/ Reference	Intake Equation/ Model Name
Ingestion	CSoil	Chemical Concentration in Soil	mg/kg soil			Chronic Daily Intake (CDI) (mg/kg-day) =
	IR_{soil}	Ingestion Rate of Soil	mg soil/day	100	USEPA 2002, 2014	CSoil x IR_{soil} x CF x FI x EF x ED x 1/BW x 1/AT
	CF	Conversion Factor	kg/mg	0.000001	--	
	FI	Fraction Ingested from Contaminated Source	--	1	Professional Judgment -- assumes 100%	
	EF	Exposure Frequency	days/yr	250	USEPA 1989	
	ED	Exposure Duration	yr	25	USEPA 1991	
	BW	Body Weight	kg	80	USEPA 2014	
	AT_c	Averaging Time for Carcinogens	days	25,550	USEPA 1989	
	AT_{nc}	Averaging Time for Noncarcinogens	days	9,125	USEPA 1989	
Dermal	CSoil	Chemical Concentration in Soil	mg/kg soil			Chronic Daily Intake (CDI) (mg/kg-day) =
	CF	Conversion Factor	kg/mg	0.000001	--	CSoil x CF x SA x SSAF x DABS x EF x
	SA	Skin Surface Area Available for Contact	cm^2/event	3,527	USEPA 2014	ED x 1/BW x 1/AT
	SSAF	Soil-to-Skin Adherence Factor	mg/cm^2/event	0.12	USEPA 2014	
	DABS	Dermal Absorption Factor	--	Chemical-Specific	USEPA 1995 -- Refer to Supporting Documentation	
	EF	Exposure Frequency	days/yr	250	USEPA 1989	
	ED	Exposure Duration	yr	25	USEPA 1991	
	BW	Body Weight	kg	80	USEPA 2014	
	AT_c	Averaging Time for Carcinogens	days	25,550	USEPA 1989	
	AT_{nc}	Averaging Time for Noncarcinogens	days	9,125	USEPA 1989	

APPENDIX A
TABLE A-22
VALUES USED FOR DAILY INTAKE CALCULATIONS
Joslyn Clark Facility, Lancaster, South Carolina

Scenario Timeframe:	Current/Future
Medium:	Soil
Exposure Medium:	Soil
Exposure Point:	Air - Outdoor
Receptor Population:	Site Worker
Receptor Age:	Adult

Exposure Route	Parameter Code	Parameter Definition	Units	RME Value	RME Rationale/ Reference	Intake Equation/ Model Name
Inhalation	CA	Chemical Concentration in Outdoor Air	mg/m^3		Concentration in Soil /Particulate Emission Factor (9.6 $x10^9$ m3/kg)	Exposure Concentration (EC) (mg/m^3) =
	ET	Exposure Time - Outdoor	hr/day	8	Professional Judgment -- assumes 8 hr workday	(CA x ET x EF x ED)/AT
	EF	Exposure Frequency - Outdoor	days/yr	250	USEPA 1989	
	ED	Exposure Duration	yr	25	USEPA 1991 -- recommended maximum exposure for site workers	
	AT_c	Averaging Time for Carcinogens	hours	613,200	USEPA 2009	
	AT_{nc}	Averaging Time for Noncarcinogens	hours	219,000	USEPA 2009	

APPENDIX A
TABLE A-23
VALUES USED FOR DAILY INTAKE CALCULATIONS
Joslyn Clark Facility, Lancaster, South Carolina

Scenario Timeframe:	Future
Medium:	Air
Exposure Medium:	Air
Exposure Point:	Air - Indoor (On-Site and Off-Site)
Receptor Population:	Site Worker
Receptor Age:	Adult

Exposure Route	Parameter Code	Parameter Definition	Units	RME Value	RME Rationale/ Reference	Intake Equation/ Model Name
Inhalation	CA	Chemical Concentration in Indoor Air	mg/m^3			Exposure Concentration (EC) (mg/m^3) = (CA x ET x EF x ED)/AT
	ET	Exposure Time - Indoor	hr/day	8	Professional Judgment -- assumes 8 hr workday	
	EF	Exposure Frequency - Indoor	days/yr	250	USEPA 1989	
	ED	Exposure Duration	yr	25	USEPA 1991 -- recommended maximum exposure for site	
	AT_c	Averaging Time for Carcinogens	hours	613,200	USEPA 2009	
	AT_{nc}	Averaging Time for Noncarcinogens	hours	219,000	USEPA 2009	

APPENDIX A
TABLE A-24
VALUES USED FOR DAILY INTAKE CALCULATIONS
Joslyn Clark Facility, Lancaster, South Carolina

Scenario Timeframe:	Future
Medium:	Soil
Exposure Medium:	Surface Soil
Exposure Point:	Surface Soil
Receptor Population:	Visitor/Trespasser
Receptor Age:	Adolescent

Exposure Route	Parameter Code	Parameter Definition	Units	RME Value	RME Rationale/ Reference	Intake Equation/ Model Name
Ingestion	CSoil	Chemical Concentration in Soil	mg/kg soil			Chronic Daily Intake (CDI) (mg/kg-day) =
	IR_{soil}	Ingestion Rate of Soil	mg soil/day	100	USEPA 2002 - Assume 100 mg/day for adolescents engaged in moderate outdoor activity	CSoil x IR_{soil} x CF x FI x EF x ED x 1/BW x 1/AT
	CF	Conversion Factor	kg/mg	0.000001	--	
	FI	Fraction Ingested from Contaminated Source	--	1	Professional Judgment -- assumes 100%	
	EF	Exposure Frequency	days/yr	50	Assumes adolescent may visit site one day per week for 50 weeks	
	ED	Exposure Duration	yr	10	Professional Judgment -- assumes 6-16 yr old	
	BW	Body Weight	kg	43.3	USEPA 2011, Table 8-10 - mean body weights for male/female age groups 6 -16.	
	AT_c	Averaging Time for Carcinogens	days	25,550	USEPA 1989	
	AT_{nc}	Averaging Time for Noncarcinogens	days	2190	USEPA 1989	
Dermal	CSoil	Chemical Concentration in Soil	mg/kg soil			Chronic Daily Intake (CDI) (mg/kg-day) =
	CF	Conversion Factor	kg/mg	0.000001	--	CSoil x CF x SA x SSAF x DABS x EF x
	SA	Skin Surface Area Available for Contact	cm^2/event	4,175	USEPA 2011, Table 7-2 - average body weights for age groups 6 to 11 and 11-16 for face, lower arms, lower legs, feet, and hands.	ED x 1/BW x 1/AT
	SSAF	Soil-to-Skin Adherence Factor	mg/cm^2/event	0.07	USEPA 2004	
	DABS	Dermal Absorption Factor	--	Chemical-Specific	USEPA 1995 -- Refer to Supporting Documentation	
	EF	Exposure Frequency	days/yr	50	Professional Judgment -- assumes 5 days/week, 50 weeks/year	
	ED	Exposure Duration	yr	10	Professional Judgment -- assumes 6-16 yr old	
	BW	Body Weight	kg	43.3	USEPA 2011, Table 8-10 - mean body weights for male/female age groups 6 -16.	
	AT_c	Averaging Time for Carcinogens	days	25,550	USEPA 1989	
	AT_{nc}	Averaging Time for Noncarcinogens	days	2190	USEPA 1989	

EPC - Exposure Point Concentration, calculated

APPENDIX A
TABLE A-25
VALUES USED FOR DAILY INTAKE CALCULATIONS
Joslyn Clark Facility, Lancaster, South Carolina

Scenario Timeframe:	Current/Future
Medium:	Soil
Exposure Medium:	Surface Soil
Exposure Point:	Air - Outdoor
Receptor Population:	Visitor/Trespasser
Receptor Age:	Adolescent

Exposure Route	Parameter Code	Parameter Definition	Units	RME Value	RME Rationale/ Reference	Intake Equation/ Model Name
Inhalation	CA	Chemical Concentration in Indoor Air	mg/m^3			Exposure Concentration (EC) (mg/m^3) =
	ET	Exposure Time - Indoor	hr/day	2	USEPA 1997 -- recommended value for visitor/trespasser activity	(CA x ET x EF x ED)/AT
	EF	Exposure Frequency - Indoor	days/yr	50	Assumes adolescent may visit site one day per week for 50 weeks	
	ED	Exposure Duration	yr	10	Professional Judgment -- assumes 6-16 yr old	
	AT_c	Averaging Time for Carcinogens	hours	613,200	USEPA 2009	
	AT_{nc}	Averaging Time for Noncarcinogens	hours	87,600	USEPA 2009	

APPENDIX A
TABLE A-26
VALUES USED FOR DAILY INTAKE CALCULATIONS
Joslyn Clark Facility, Lancaster, South Carolina

Scenario Timeframe:	Future
Medium:	Soil
Exposure Medium:	Soil
Exposure Point:	Soil
Receptor Population:	Construction Worker
Receptor Age:	Adult

Exposure Route	Parameter Code	Parameter Definition	Units	RME Value	RME Rationale/ Reference	Intake Equation/ Model Name
Ingestion	CSoil	Chemical Concentration in Soil	mg/kg soil			Chronic Daily Intake (CDI) (mg/kg-day) =
	IR_{soil}	Ingestion Rate of Soil	mg soil/day	330	USEPA 2002 -- Recommended value for construction worker.	CSoil x IR_{soil} x CF x FI x EF x ED x 1/BW x 1/AT
	CF	Conversion Factor	kg/mg	0.000001	--	
	FI	Fraction Ingested from Contaminated Source	--	1	Professional Judgment -- assumes 100%	
	EF	Exposure Frequency	days/yr	250	Professional Judgment -- assumes 5 days/week, 50 weeks/year	
	ED	Exposure Duration	yr	1	Professional Judgment -- assumes 1 year construction duration	
	BW	Body Weight	kg	80	USEPA 2014	
	AT_c	Averaging Time for Carcinogens	days	25,550	USEPA 1989	
	AT_{nc}	Averaging Time for Noncarcinogens	days	365	USEPA 1989	
Dermal	CSoil	Chemical Concentration in Soil	mg/kg soil			Chronic Daily Intake (CDI) (mg/kg-day) =
	CF	Conversion Factor	kg/mg	0.000001	--	CSoil x CF x SA x SSAF x DABS x EF x
	SA	Skin Surface Area Available for Contact	cm^2/event	3,527	USEPA 2014	ED x 1/BW x 1/AT
	SSAF	Soil-to-Skin Adherence Factor	mg/cm^2/event	0.12	USEPA 2014	
	DABS	Dermal Absorption Factor	--	Chemical-Specific	USEPA 1995 -- Refer to Supporting Documentation	
	EF	Exposure Frequency	days/yr	250	Professional Judgment -- assumes 5 days/week, 50 weeks/year	
	ED	Exposure Duration	yr	1	Professional Judgment -- assumes 1 year construction duration	
	BW	Body Weight	kg	80	USEPA 2014	
	AT_c	Averaging Time for Carcinogens	days	25,550	USEPA 1989	
	AT_{nc}	Averaging Time for Noncarcinogens	days	365	USEPA 1989	

APPENDIX A
TABLE A-27
VALUES USED FOR DAILY INTAKE CALCULATIONS
Joslyn Clark Facility, Lancaster, South Carolina

Scenario Timeframe:	Future
Medium:	Soil
Exposure Medium:	Soil
Exposure Point:	Air
Receptor Population:	Construction Worker
Receptor Age:	Adult

Exposure Route	Parameter Code	Parameter Definition	Units	RME Value	RME Rationale/ Reference	Intake Equation/ Model Name
Inhalation	CA	Chemical Concentration in Outdoor Air	mg/m^3		Concentration in Soil /Particulate Emission Factor (9.6 x10^9 m3/kg)	Exposure Concentration (EC) (mg/m^3) = (CA x ET x EF x ED)/AT
	ET	Exposure Time - Outdoor	hr/day	8	Professional Judgment -- assumes 8 hr workday	
	EF	Exposure Frequency - Outdoor	days/yr	250	Professional Judgment -- assumes 5 days/week, 50 weeks/year	
	ED	Exposure Duration	yr	1	Professional Judgment -- assumes 1 year construction duration	
	AT_c	Averaging Time for Carcinogens	hours	613,200	USEPA 2009	
	AT_{nc}	Averaging Time for Noncarcinogens	hours	8,760	USEPA 2009	

APPENDIX A

VALUES USED FOR DAILY INTAKE CALCULATIONS
Joslyn Clark Facility, Lancaster, South Carolina

Scenario Timeframe:	Future
Medium:	Groundwater
Exposure Medium:	Groundwater
Exposure Point:	Vapor in Excavation
Receptor Population:	Construction Worker
Receptor Age:	Adult

Exposure Route	Parameter Code	Parameter Definition	Units	RME Value	RME Rationale/ Reference	Intake Equation/ Model Name
Inhalation	CA	Chemical Concentration in Trench Air	mg/m^3			Exposure Concentration (EC) (mg/m^3) = (CA x ET x EF x ED)/AT
	ET	Exposure Time - Outdoor	hr/day	4	Professional Judgment -- assumes 1/2 of the workday may include subsurface activities	
	EF	Exposure Frequency - Outdoor	days/yr	250	Professional Judgment -- assumes 5 days/week, 50 weeks/year	
	ED	Exposure Duration	yr	1	Professional Judgment -- assumes 1 year construction duration	
	AT_c	Averaging Time for Carcinogens	hours	613,200	USEPA 2009	
	AT_{nc}	Averaging Time for Noncarcinogens	hours	8,760	USEPA 2009	

A box model approach will be used to estimate dispersion of the VOCs within the air in the trench using groundwater concentrations.

APPENDIX A
TABLE A-29
NON-CANCER TOXICITY DATA -- ORAL/DERMAL
Joslyn Clark Facility, Lancaster, South Carolina

Chemical of Potential Concern	Chronic/ Subchronic	Oral RfD Value	Oral RfD	Oral to Dermal Adjustment Factor (1)	Adjusted Dermal RfD (2)	Units	Primary Target Organ	Combined Uncertainty/Modifying Factors	Sources of RfD: Target Organ	Dates of RfD: Target Organ (3)
Volatile Organics										
Chloroform	Chronic	1.00E-02	mg/kg-day	100%	1.00E-02	mg/kg-day	Liver	1000	IRIS	10/19/01
1,2-Dichloroethane	Chronic	6.00E-03	mg/kg-day	100%	6.00E-03	mg/kg-day	Not Reported	Not Reported	PPRTV Appendix	N/A
1,1-Dichloroethene	Chronic	5.00E-02	mg/kg-day	100%	5.00E-02	mg/kg-day	Liver	100	IRIS	08/13/02
1,4-Dioxane	Chronic	3.00E-02	mg/kg-day	100%	3.00E-02	mg/kg-day	Liver, Kidney	300	IRIS	08/11/10
Tetrachloroethene	Chronic	6.00E-03	mg/kg-day	100%	6.00E-03	mg/kg-day	Liver	1000	IRIS	02/10/12
1,1,2-Trichloroethane	Chronic	4.00E-03	mg/kg-day	100%	4.00E-03	mg/kg-day	Liver	1000	IRIS	02/01/95
Trichloroethene	Chronic	5.00E-04	mg/kg-day	100%	5.00E-04	mg/kg-day	Kidney, Heart, Thymus	100	IRIS	09/28/11
Inorganics										
Iron	Chronic	7.00E-01	mg/kg-day	100%	7.00E-01	mg/kg-day	Not Reported	Not Reported	PPRTV	N/A
Manganese	Chronic	2.40E-02	mg/kg-day	4%	9.60E-04	mg/kg-day	Nervous system	1	EPA Users Guide	05/01/96
Thallium	Chronic	1.00E-05	mg/kg-day	100%	1.00E-05	mg/kg-day	Nervous system	Not Reported	PPRTV Appendix	09/30/09

(1) Refer to RAGS, Part A
(2) RfD times by the oral to dermal adjustment factor
(3) Toxicity values taken from USEPA Regional Screening Level Table (May 2020).
IRIS = Integrated Risk Information System
PPRTV = Provisional Peer-Reviewed Toxicity Values
N/A = Not Applicable
RfD = Reference Dose

APPENDIX A
TABLE A-30
NON-CANCER TOXICITY DATA -- INHALATION
Joslyn Clark Facility, Lancaster, South Carolina

Chemical of Potential Concern	Chronic/ Subchronic	Value Inhalation RfC	Units	Adjusted Inhalation RfD	Units	Primary Target Organ	Combined Uncertainty/Modifying Factors	Sources of RfC:RfD: Target Organ	Dates (1)
Volatile Organics									
Chloroform	Chronic	9.80E-02	mg/m^3	NA	mg/m^3	Liver	100	ATSDR	09/97
1,2-Dichloroethane	Chronic	7.00E-03	mg/m^3	NA	mg/m^3	Not Reported	Not Reported	PPRTV	N/A
1,1-Dichloroethene	Chronic	2.00E-01	mg/m^3	NA	mg/m^3	Liver	30	IRIS	08/13/02
1,4-Dioxane	Chronic	3.00E-02	mg/m^3	NA	mg/m^3	Nervous, Respiratory System	1000	IRIS	09/30/13
Tetrachloroethene	Chronic	4.00E-02	mg/m^3	NA	mg/m^3	Nervous system	1000	IRIS	02/10/12
1,1,2-Trichloroethane	Chronic	2.00E-04	mg/m^3	NA	mg/m^3	Not reported	Not reported	PPRTV Appendix	Not reported
Trichloroethene	Chronic	2.00E-03	mg/m^3	NA	mg/m^3	Thymus/Heart	100	IRIS	09/28/2011
Inorganics									
Iron	Chronic	NA	mg/m^3	NA	mg/m^3	N/A	N/A	N/A	N/A
Manganese	Chronic	5.00E-05	mg/m^3	NA	mg/m^3	Nervous system	1000	IRIS	12/01/1993
Thallium	Chronic	NA	mg/m^3	NA	mg/m^3	N/A	N/A	N/A	09/30/09

(1) Toxicity values taken from USEPA Regional Screening Level Table (May 2020).
ATSDR = Agency for Toxic Substances and Disease Registry
IRIS = Integrated Risk Information System
PPRTV = Provisional Peer-Reviewed Toxicity Values
NA = Not Applicable
RfC = Reference Concentration
RfD = Reference Dose

APPENDIX A
TABLE A-31
CANCER TOXICITY DATA -- ORAL/DERMAL
Joslyn Clark Facility, Lancaster, South Carolina

Chemical of Potential Concern	Oral Cancer Slope Factor	Oral to Dermal Adjustment Factor	Adjusted Dermal Cancer Slope Factor (1)	Units	Weight of Evidence/ Cancer Guideline Description	Source	Date (2)
Volatile Organics							
Chloroform	3.10E-02	100%	3.10E-02	kg-day/mg	B2	CalEPA	12/18/08
1,2-Dichloroethane	9.10E-02	100%	9.10E-02	kg-day/mg	B2	IRIS	03/31/87
1,1-Dichloroethene	NA	100%	NA	kg-day/mg	C	IRIS	08/13/02
1,4-Dioxane	1.00E-01	100%	1.00E-01	kg-day/mg	N/A	IRIS	08/11/10
Tetrachloroethene	2.10E-03	100%	2.10E-03	kg-day/mg	B2	IRIS	02/10/12
1,1,2-Trichloroethane	5.70E-02	100%	5.70E-02	kg-day/mg	C	IRIS	02/01/94
Trichloroethene	4.60E-02	100%	4.60E-02	kg-day/mg	B2	IRIS	09/28/2011
Inorganics							
Iron	NA	NA	NA	kg-day/mg	C	N/A	N/A
Manganese	NA	4%	NA	kg-day/mg	D	N/A	12/01/96
Thallium	NA	NA	NA	kg-day/mg	C	N/A	09/30/09

(1) Slope factor divided by the oral to dermal adjustment factor
(2) Toxicity values taken from USEPA Regional Screening Level Table (May 2020).

CalEPA = California EPA
IRIS = Integrated Risk Information System
NA = Not Applicable

EPA Group:
A - Human carcinogen
B1 - Probable human carcinogen - indicates that limited human data are available
B2 - Probable human carcinogen - indicates sufficient evidence in animals and inadequate or no evidence in humans
C - Possible human carcinogen
D - Not classifiable as a human carcinogen
E - Evidence of noncarcinogenicity

APPENDIX A
TABLE A-32
CANCER TOXICITY DATA -- INHALATION
Joslyn Clark Facility, Lancaster, South Carolina

Chemical of Potential Concern	Unit Risk	Units	Adjustment	Inhalation Cancer Slope Factor	Units	Weight of Evidence/ Cancer Guideline Description	Source	Date (1)
Volatile Organics								
Chloroform	2.30E-05	m^3/mg	NA	NA	m^3/mg	B2	IRIS	12/18/08
1,2-Dichloroethane	2.60E-05	m^3/mg	NA	NA	m^3/mg	B2	IRIS	01/01/91
1,1-Dichloroethene	NA	m^3/mg	NA	NA	m^3/mg	C	IRIS	08/13/02
1,4-Dioxane	5.00E-06	m^3/mg	NA	NA	m^3/mg	B2	IRIS	09/20/13
Tetrachloroethene	2.60E-07	m^3/mg	NA	NA	m^3/mg	B2	IRIS	02/10/12
1,1,2-Trichloroethane	1.60E-05	m^3/mg	NA	NA	m^3/mg	C	IRIS	02/01/94
Trichloroethene	4.10E-06	m^3/mg	NA	NA	m^3/mg	B2	IRIS	09/28/2011
Inorganics								
Iron	NA	m^3/mg	NA	NA	m^3/mg	C	N/A	N/A
Manganese	NA	m^3/mg	NA	NA	m^3/mg	D	N/A	12/01/96
Thallium	NA	m^3/mg	NA	NA	m^3/mg	C	N/A	09/30/09

(1) Toxicity values taken from USEPA Regional Screening Level Table (May 2020).

CalEPA = California EPA
IRIS = Integrated Risk Information System
NA = Not Applicable

EPA Group:
A - Human carcinogen
B1 - Probable human carcinogen - indicates that limited human data are available
B2 - Probable human carcinogen - indicates sufficient evidence in animals and inadequate or no evidence in humans
C - Possible human carcinogen
D - Not classifiable as a human carcinogen
E - Evidence of noncarcinogenicity

APPENDIX A

TABLE A-33

CALCULATION OF NON-CANCER HAZARDS

Joslyn Clark Facility, Lancaster, South Carolina

Scenario Timeframe:	Current/Future
Medium:	Soil
Exposure Medium:	Soil - 0-20 feet
Exposure Point:	Soil
Receptor Population:	Site Worker
Receptor Age:	Adult

Exposure Route	Chemical of Potential Concern	Medium EPC Value	Medium EPC Units	Route EPC Value	Route EPC Units	EPC Selected for Hazard Calculation (1)	Intake (Non-Cancer)	Intake (Non-Cancer) Units	Reference Dose	Reference Dose Units	Hazard Quotient
Ingestion	Thallium	3.3E+00	mg/kg	3.3E+00	mg/kg	M	2.8E-06	mg/kg-day	1.0E-05	mg/kg-day	3E-01
	(Total)										**3E-01**
Dermal	Thallium	3.3E+00	mg/kg	3.3E+00	mg/kg	M	0.0E+00	mg/kg-day	1.0E-05	mg/kg-day	- -
	(Total)										**0E+00**
						Hazard Index for Ingestion and Dermal Contact Exposure =					**3E-01**

(1) Medium-Specific (M) EPC selected for hazard calculation.

Dermal Absorption Factors: Reference: *USEPA RAGS Part E, July 2004*

Thallium 0%

APPENDIX A
TABLE A-34
CALCULATION OF CANCER RISKS
Joslyn Clark Facility, Lancaster, South Carolina

Scenario Timeframe:	Current/Future
Medium:	Soil
Exposure Medium:	Soil - 0-20 feet
Exposure Point:	Soil
Receptor Population:	Site Worker
Receptor Age:	Adult

Exposure Route	Chemical of Potential Concern	Medium EPC Value	Medium EPC Units	Route EPC Value	Route EPC Units	EPC Selected for Hazard Calculation (1)	Intake (Cancer)	Intake (Cancer) Units	Cancer Slope Factor	Cancer Slope Factor Units	Cancer Risk
Ingestion	Thallium	3.3E+00	mg/kg	3.3E+00	mg/kg	M	1.0E-06	mg/kg-day	NA	mg/kg-day	- -
	(Total)										**0E+00**
Dermal	Thallium	3.3E+00	mg/kg	3.3E+00	mg/kg	M	0.0E+00	mg/kg-day	NA	mg/kg-day	- -
	(Total)										**0E+00**
							Cancer Risk for Ingestion and Dermal Contact Exposure =				**0E+00**

(1) Medium-Specific (M) EPC selected for risk calculation.

NA - Not applicable

Dermal Absorption Factors: Reference: *USEPA RAGS Part E, July 2004*

Thallium 0%

APPENDIX A
TABLE A-35
CALCULATION OF NON-CANCER HAZARDS
Joslyn Clark Facility, Lancaster, South Carolina

Scenario Timeframe:	Current/Future
Medium:	Soil
Exposure Medium:	Soil - 0-20 feet
Exposure Point:	Soil
Receptor Population:	Site Worker
Receptor Age:	Adult

Exposure Route	Chemical of Potential Concern	Medium EPC Value	Medium EPC Units	Route EPC Value	Route EPC Units	EPC Selected for Hazard Calculation (1)	Intake (Non-Cancer)	Intake (Non-Cancer) Units	Reference Concentration	Reference Concentration Units	Hazard Quotient
Inhalation	Thallium	3.3E+00	mg/kg	3.4E-10	mg/m^3	R	7.8E-11	mg/m^3	NA	mg/m^3	--
	(Total)										**0E+00**
							Hazard Index for Inhalation Exposure =				**0E+00**

(1) Route-Specific (R) EPC selected for hazard calculation. See Table A-16 for route-specific EPC.
NA - Not applicable

APPENDIX A
TABLE A-36
CALCULATION OF CANCER RISKS
Joslyn Clark Facility, Lancaster, South Carolina

Scenario Timeframe:	Current/Future
Medium:	Soil
Exposure Medium:	Soil - 0-20 feet
Exposure Point:	Soil
Receptor Population:	Site Worker
Receptor Age:	Adult

Exposure Route	Chemical of Potential Concern	Medium EPC Value	Medium EPC Units	Route EPC Value	Route EPC Units	EPC Selected for Hazard Calculation (1)	Intake (Cancer)	Intake (Cancer) Units	Inhalation Unit Risk (IUR) Concentration	IUR Concentration Units	Cancer Risk
Inhalation	Thallium	3.3E+00	mg/kg	3.4E-10	mg/m^3	R	2.8E-08	mg/m^3	NA	mg/m^3	- -
	(Total)										**0E+00**
							Cancer Risk for Inhalation Exposure =				**0E+00**

(1) Route-Specific (R) EPC selected for risk calculation. See Table A-16 for route-specific EPC.
NA - Not applicable

APPENDIX A
TABLE A-37
CALCULATION OF NON-CANCER HAZARDS
Joslyn Clark Facility, Lancaster, South Carolina

Scenario Timeframe:	Current/Future
Medium:	Air
Exposure Medium:	Air
Exposure Point:	Indoor Air
Receptor Population:	Commercial Worker
Receptor Age:	Adult

Exposure Route	Chemical of Potential Concern	Medium EPC Value (1)	Medium EPC Units	Route EPC Value	Route EPC Units	EPC Selected for Hazard Calculation (2)	Intake (Non-Cancer)	Intake (Non-Cancer) Units	Reference Concentration	Reference Concentration Units	Hazard Quotient
Inhalation	Trichloroethene	2.12E+00	ug/m3	2.12E-03	mg/m^3	M	4.8E-04	mg/m^3	2.0E-03	mg/m^3	2.4E-01
	(Total)										**2.4E-01**
									Hazard Index for Inhalation Exposure	=	**2.4E-01**

(1) Constituents exceeding Industrial Air screening levels (May 2020) retained for evaluation.

(2) Medium-Specific (R) EPC selected for hazard calculation.

APPENDIX A
TABLE A-38
CALCULATION OF CANCER RISKS
Joslyn Clark Facility, Lancaster, South Carolina

Scenario Timeframe:	Current/Future
Medium:	Air
Exposure Medium:	Air
Exposure Point:	Air-Indoor
Receptor Population:	Commercial Worker
Receptor Age:	Adult

Exposure Route	Chemical of Potential Concern	Medium EPC Value (1)	Medium EPC Units	Route EPC Value	Route EPC Units	EPC Selected for Hazard Calculation (2)	Intake (Cancer)	Intake (Cancer) Units	Inhalation Unit Risk (IUR) Concentration	IUR Concentration Units	Cancer Risk
Inhalation	Trichloroethene	2.12E+00	ug/m3	2.12E-03	mg/m^3	M	1.7E-04	mg/m^3	4.10E-06	m^3/mg	7E-07
	(Total)										**7E-07**
										Cancer Risk for Inhalation Exposure =	**7E-07**

(1) Constituents exceeding Industrial Air screening levels (May 2020) retained for evaluation.
(2) Medium-Specific (R) EPC selected for hazard calculation.

APPENDIX A
TABLE A-39
CALCULATION OF NON-CANCER HAZARDS
Joslyn Clark Facility, Lancaster, South Carolina

Scenario Timeframe:	Future
Medium:	Soil
Exposure Medium:	Soil - 0-20 feet
Exposure Point:	Soil
Receptor Population:	Visitor
Receptor Age:	Adolescent

Exposure Route	Chemical of Concern	Medium EPC Value	Medium EPC Units	Route EPC Value	Route EPC Units	EPC Selected for Hazard Calculation (1)	Intake (Non-Cancer)	Intake (Non-Cancer) Units	Reference Dose	Reference Dose Units	Hazard Quotient
Ingestion	Thallium	3.3E+00	mg/kg	3.3E+00	mg/kg	M	1.7E-06	mg/kg	1.0E-05	mg/kg-day	2E-01
	(total)										2E-01
Dermal	Thallium	3.3E+00	mg/kg	3.3E+00	mg/kg	M	0.0E+00	mg/kg	3.0E-04	mg/kg-day	0E+00
	(total)										0E+00
	Hazard Index for Ingestion and Dermal Contact Exposure =										**2E-01**

(1) Medium-Specific (R) EPC selected for hazard calculation. See Table A-14 for route-specific EPC.

Dermal Absorption Factors: Reference: USEPA RAGS Part E, July 2004

Thallium 0%

APPENDIX A
TABLE A-40
CALCULATION OF NON-CANCER HAZARDS
Joslyn Clark Facility, Lancaster, South Carolina

Scenario Timeframe:	Future
Medium:	Soil
Exposure Medium:	Soil - 0-20 feet
Exposure Point:	Air - Outdoor
Receptor Population:	Visitor
Receptor Age:	Adolescent

Exposure Route	Chemical of Concern	Medium EPC Value	Medium EPC Units	Route EPC Value	Route EPC Units	EPC Selected for Hazard Calculation (1)	Intake (Non-Cancer)	Intake (Non-Cancer) Units	Reference Concentration	Reference Concentration Units	Hazard Quotient
Inhalation	Thallium	3.3E+00	mg/kg	3.4E-10	mg/m3	R	3.9E-12	mg/m^3	NA	mg/m^3	--
							Hazard Index for Inhalation Exposure =				**0E+00**

(1) Route-Specific (R) EPC selected for hazard calculation. See Tables A-16 for route-specific EPC.

APPENDIX A
TABLE A-41
CALCULATION OF CANCER RISKS
Joslyn Clark Facility, Lancaster, South Carolina

Scenario Timeframe:	Future
Medium:	Soil
Exposure Medium:	Soil - 0-20 feet
Exposure Point:	Soil
Receptor Population:	Visitor
Receptor Age:	Adolescent

Exposure Route	Chemical of Concern	Medium EPC Value	Medium EPC Units	Route EPC Value	Route EPC Units	EPC Selected for Risk Calculation (1)	Intake (Cancer)	Intake (Cancer) Units	Cancer Slope Factor	IUR Slope Factor Units	Cancer Risk
Ingestion	Thallium	3.3E+00	mg/kg	3.3E+00	mg/kg	M	1.5E-07	mg/kg	NA	mg/kg-day	--
	(total)										0E+00
Dermal	Thallium	3.3E+00	mg/kg	3.3E+00	mg/kg	M	0.0E+00	mg/kg	NA	mg/kg-day	--
	(total)										0E+00
	Cancer Risk for Ingestion and Dermal Contact Exposure =										**0E+00**

(1) Medium-Specific (R) EPC selected for hazard calculation. See Table A-14 for route-specific EPC.

Dermal Absorption Factors: Reference: USEPA RAGS Part E, July 2004

Thallium 0%

APPENDIX A
TABLE A-42
CALCULATION OF CANCER RISKS
Joslyn Clark Facility, Lancaster, South Carolina

Scenario Timeframe:	Future
Medium:	Soil
Exposure Medium:	Soil - AOC 1
Exposure Point:	Air - Outdoor
Receptor Population:	Visitor
Receptor Age:	Adolescent

Exposure Route	Chemical of Concern	Medium EPC Value	Medium EPC Units	Route EPC Value	Route EPC Units	EPC Selected for Risk Calculation (1)	Intake (Cancer)	Intake (Cancer) Units	Inhalation Unit Risk (IUR) Concentration	IUR Concentration Units	Cancer Risk
Inhalation	Thallium	3.3E+00	mg/kg	3.4E-10	mg/m3	R	5.6E-13	mg/m^3	NA	$m^3/\mu g$	--
							Cancer Risk for Inhalation Exposure =				**0E+00**

(1) Route-Specific (R) EPC selected for risk calculation. See Table A-16 for route-specific EPC.

APPENDIX A
TABLE A-43
CALCULATION OF NON-CANCER HAZARDS
Joslyn Clark Facility, Lancaster, South Carolina

Scenario Timeframe:	Future
Medium:	Soil
Exposure Medium:	Soil - 0-20 feet
Exposure Point:	Soil
Receptor Population:	Construction Worker
Receptor Age:	Adult

Exposure Route	Chemical of Potential Concern	Medium EPC Value	Medium EPC Units	Route EPC Value	Route EPC Units	EPC Selected for Hazard Calculation (1)	Intake (Non-Cancer)	Intake (Non-Cancer) Units	Reference Dose	Reference Dose Units	Hazard Quotient
Ingestion	Thallium	3.3E+00	mg/kg	3.3E+00	mg/kg	M	9.3E-06	mg/kg-day	1.0E-05	mg/kg-day	9E-01
	(Total)										**9E-01**
Dermal	Thallium	3.3E+00	mg/kg	3.3E+00	mg/kg	M	0.0E+00	mg/kg-day	1.0E-05	mg/kg-day	- -
	(Total)										**0E+00**
						Hazard Index for Ingestion and Dermal Contact Exposure =					**9E-01**

(1) Medium-Specific (M) EPC selected for hazard calculation.

NA - Not applicable

Dermal Absorption Factors: Reference: *USEPA RAGS Part E, July 2004*

Thallium 0%

APPENDIX A
TABLE A-44
CALCULATION OF NON-CANCER HAZARDS
Joslyn Clark Facility, Lancaster, South Carolina

Scenario Timeframe:	Future
Medium:	Soil
Exposure Medium:	Soil - 0-20 feet
Exposure Point:	Air - Outdoor
Receptor Population:	Construction Worker
Receptor Age:	Adult

Exposure Route	Chemical of Potential Concern	Medium EPC Value	Medium EPC Units	Route EPC Value	Route EPC Units	EPC Selected for Hazard Calculation (1)	Intake (Non-Cancer)	Intake (Non-Cancer) Units	Reference Concentration	Reference Concentration Units	Hazard Quotient
Inhalation	Thallium	3.3E+00	mg/kg	3.4E-10	mg/m^3	R	7.8E-11	mg/m^3	NA	mg/m^3	- -
	(Total)										**0E+00**
							Hazard Index for Inhalation Exposure =				**0E+00**

(1) Route-Specific (R) EPC selected for hazard calculation. See Table A-16 for route-specific EPC.
NA - Not applicable

APPENDIX A
TABLE A-45
CALCULATION OF CANCER RISKS
Joslyn Clark Facility, Lancaster, South Carolina

Scenario Timeframe:	Future
Medium:	Soil
Exposure Medium:	Soil - 0-20 feet
Exposure Point:	Soil
Receptor Population:	Construction Worker
Receptor Age:	Adult

Exposure Route	Chemical of Potential Concern	Medium EPC Value	Medium EPC Units	Route EPC Value	Route EPC Units	EPC Selected for Hazard Calculation (1)	Intake (Cancer)	Intake (Cancer) Units	Cancer Slope Factor	Cancer Slope Factor Units	Cancer Risk
Ingestion	Thallium	3.3E+00	mg/kg	3.3E+00	mg/kg	M	1.3E-07	mg/kg-day	NA	mg/kg-day	- -
	(Total)										**0E+00**
Dermal	Thallium	3.3E+00	mg/kg	3.3E+00	mg/kg	M	0.0E+00	mg/kg-day	NA	mg/kg-day	- -
	(Total)										**0E+00**
							Cancer Risk for Ingestion and Dermal Contact Exposure =				**0E+00**

(1) Medium-Specific (M) EPC selected for risk calculation.

NA - Not applicable

Dermal Absorption Factors: Reference: *USEPA RAGS Part E, July 2004*

Thallium 0%

APPENDIX A
TABLE A-46
CALCULATION OF CANCER RISKS
Joslyn Clark Facility, Lancaster, South Carolina

Scenario Timeframe:	Future
Medium:	Soil
Exposure Medium:	Soil - 0-20 feet
Exposure Point:	Air - Outdoor
Receptor Population:	Construction Worker
Receptor Age:	Adult

Exposure Route	Chemical of Potential Concern	Medium EPC Value	Medium EPC Units	Route EPC Value	Route EPC Units	EPC Selected for Hazard Calculation (1)	Intake (Cancer)	Intake (Cancer) Units	Inhalation Unit Risk (IUR) Concentration	IUR Concentration Units	Cancer Risk
Inhalation	Thallium	3.3E+00	mg/kg	3.4E-10	mg/m^3	R	1.1E-09	mg/m^3	NA	mg/m^3	- -
	(Total)										**0E+00**
							Cancer Risk for Inhalation Exposure =				**0E+00**

(1) Route-Specific (R) EPC selected for hazard calculation. See Table A-16 for route-specific EPC.
NA - Not applicable

APPENDIX A
TABLE A-47
CALCULATION OF NON-CANCER HAZARDS
Joslyn Clark Facility, Lancaster, South Carolina

Scenario Timeframe:	Future
Medium:	Ground Water
Exposure Medium:	Vapor in trench
Exposure Point:	Air-Outdoor
Receptor Population:	Construction Worker
Receptor Age:	Adult

Exposure Route	Chemical of Potential Concern	Medium EPC Value (1)	Medium EPC Units	Route EPC Value (2)	Route EPC Units	EPC Selected for Hazard Calculation (2)	Intake (Non-Cancer)	Intake (Non-Cancer) Units	Reference Concentration	Reference Concentration Units	Hazard Quotient
Inhalation	Chloroform	5.26E-04	mg/L	1.22E-07	mg/m^3	R	1.4E-08	mg/m^3	9.8E-02	mg/m^3	1.4E-07
	1,2-Dichloroethane	6.35E-04	mg/L	1.47E-07	mg/m^3	R	1.7E-08	mg/m^3	7.0E-03	mg/m^3	2.4E-06
	1,1-Dichloroethene	1.38E-02	mg/L	3.70E-06	mg/m^3	R	4.2E-07	mg/m^3	2.0E-01	mg/m^3	2.1E-06
	1,4-Dioxane	9.50E-04	mg/L	6.86E-09	mg/m^3	R	7.8E-10	mg/m^3	3.0E-02	mg/m^3	2.6E-08
	Tetrachloroethene	1.08E-01	mg/L	2.21E-05	mg/m^3	R	2.5E-06	mg/m^3	4.0E-02	mg/m^3	6.3E-05
	1,1,2-Trichloroethane	1.00E-02	mg/L	1.91E-06	mg/m^3	R	2.2E-07	mg/m^3	2.0E-04	mg/m^3	1.1E-03
	Trichloroethene	2.04E-01	mg/L	4.66E-05	mg/m^3	R	5.3E-06	mg/m^3	2.0E-03	mg/m^3	2.7E-03
	(Total)										**6.8E-05**
										Hazard Index for Inhalation Exposure =	**6.8E-05**

(1) Trench Air concentration estimated from groundwater concentrations (Table A-18). All detected volatile organic cosntituents retained for evaluation.

(2) Route-Specific (R) EPC selected for hazard calculation. See Table A-9 for route-specific EPC.

APPENDIX A
TABLE A-48
CALCULATION OF CANCER RISKS
Joslyn Clark Facility, Lancaster, South Carolina

Scenario Timeframe:	Future
Medium:	Ground Water
Exposure Medium:	Vapor in trench
Exposure Point:	Air-Outdoor
Receptor Population:	Construction Worker
Receptor Age:	Adult

Exposure Route	Chemical of Potential Concern	Medium EPC Value (1)	Medium EPC Units	Route EPC Value (2)	Route EPC Units	EPC Selected for Hazard Calculation (2)	Intake (Cancer)	Intake (Cancer) Units	Inhalation Unit Risk (IUR) Concentration	IUR Concentration Units	Cancer Risk
Inhalation	Chloroform	5.26E-04	mg/L	1.22E-07	mg/m^3	R	2.0E-10	mg/m^3	2.30E-05	m^3/mg	5E-12
	1,2-Dichloroethane	6.35E-04	mg/L	1.47E-07	mg/m^3	R	2.4E-10	mg/m^3	2.60E-05	m^3/mg	6E-12
	1,1-Dichloroethene	1.38E-02	mg/L	3.70E-06	mg/m^3	R	6.0E-09	mg/m^3	NA	m^3/mg	--
	1,4-Dioxane	9.50E-04	mg/L	6.86E-09	mg/m^3	R	1.1E-11	mg/m^3	5.00E-06	m^3/mg	6E-14
	Tetrachloroethene	1.08E-01	mg/L	2.21E-05	mg/m^3	R	3.6E-08	mg/m^3	2.60E-07	m^3/mg	9E-12
	1,1,2-Trichloroethane	1.00E-02	mg/L	1.91E-06	mg/m^3	R	3.1E-09	mg/m^3	1.60E-05	m^3/mg	5E-11
	Trichloroethene	2.04E-01	mg/L	4.66E-05	mg/m^3	R	7.6E-08	mg/m^3	4.10E-06	m^3/mg	3E-10
	(Total)										**4E-10**
										Cancer Risk for Inhalation Exposure =	**4E-10**

(1) Trench Air concentration estimated from groundwater concentrations (Table A-18). All detected volatile organic cosntituents retained for evaluation.

(2) Route-Specific (R) EPC selected for hazard calculation. See Table A-9 for route-specific EPC.

APPENDIX A
TABLE A-49
CALCULATION OF NON-CANCER HAZARDS
Joslyn Clark Facility, Lancaster, South Carolina

Exposure Route	Chemical of Potential Concern	Medium EPC Value (1)	Medium EPC Units	Route EPC Value (2)	Route EPC Units	EPC Selected for Hazard Calculation (2)	Intake (Non-Cancer)	Intake (Non-Cancer) Units	Reference Concentration	Reference Concentration Units	Hazard Quotient
Inhalation	Chloroform	7.70E-04	mg/L	1.79E-07	mg/m^3	R	2.0E-08	mg/m^3	9.8E-02	mg/m^3	2.1E-07
	1,2-Dichloroethane	5.00E-04	mg/L	1.16E-07	mg/m^3	R	1.3E-08	mg/m^3	7.0E-03	mg/m^3	1.9E-06
	Tetrachloroethene	1.11E-02	mg/L	2.27E-06	mg/m^3	R	2.6E-07	mg/m^3	4.0E-02	mg/m^3	6.5E-06
	Trichloroethene	1.44E-01	mg/L	3.29E-05	mg/m^3	R	3.8E-06	mg/m^3	2.0E-03	mg/m^3	1.9E-03
	(Total)										**8.6E-06**
									Hazard Index for Inhalation Exposure	**=**	**8.6E-06**

(1) Trench Air concentration estimated from groundwater concentrations (Table A-19). All detected volatile organic constituents retained for evaluation.

(2) Route-Specific (R) EPC selected for hazard calculation. See Table A-11 for route-specific EPC.

APPENDIX A
TABLE A-50
CALCULATION OF CANCER RISKS
Joslyn Clark Facility, Lancaster, South Carolina

Scenario Timeframe:	Future
Medium:	Ground Water at Downgradient Property Boundary
Exposure Medium:	Vapor in trench
Exposure Point:	Air-Outdoor
Receptor Population:	Construction Worker
Receptor Age:	Adult

Exposure Route	Chemical of Potential Concern	Medium EPC Value (1)	Medium EPC Units	Route EPC Value (2)	Route EPC Units	EPC Selected for Hazard Calculation (2)	Intake (Cancer)	Intake (Cancer) Units	Inhalation Unit Risk (IUR) Concentration	IUR Concentration Units	Cancer Risk
Inhalation	Chloroform	7.70E-04	mg/L	1.79E-07	mg/m^3	R	2.9E-10	mg/m^3	2.30E-05	m^3/mg	7E-12
	1,2-Dichloroethane	5.00E-04	mg/L	1.16E-07	mg/m^3	R	1.9E-10	mg/m^3	2.60E-05	m^3/mg	5E-12
	Tetrachloroethene	1.11E-02	mg/L	2.27E-06	mg/m^3	R	3.7E-09	mg/m^3	2.60E-07	m^3/mg	1E-12
	Trichloroethene	1.44E-01	mg/L	3.29E-05	mg/m^3	R	5.4E-08	mg/m^3	4.10E-06	m^3/mg	2E-10
	(Total)										**2E-10**
										Cancer Risk for Inhalation Exposure =	**2E-10**

(1) Trench Air concentration estimated from groundwater concentrations (Table A-19). All detected volatile organic constituents retained for evaluation.

(2) Route-Specific (R) EPC selected for hazard calculation. See Table A-11 for route-specific EPC.

APPENDIX A

TABLE A-51

CALCULATION OF NON-CANCER HAZARDS

Joslyn Clark Facility, Lancaster, South Carolina

Scenario Timeframe:	Current/Future
Medium:	Air - Estimated from MW-12/MW-12D
Exposure Medium:	Indoor Air
Exposure Point:	Hypothetical Off-Site Indoor Air
Receptor Population:	Commercial Worker
Receptor Age:	Adult

Exposure Route	Chemical of Potential Concern	Medium EPC Value (1)	Medium EPC Units	Route EPC Value	Route EPC Units	EPC Selected for Hazard Calculation (2)	Intake (Non-Cancer)	Intake (Non-Cancer) Units	Reference Concentration	Reference Concentration Units	Hazard Quotient
Inhalation	Trichloroethene	1.26E+00	ug/m3	1.26E-03	mg/m^3	M	2.9E-04	mg/m^3	2.0E-03	mg/m^3	1.4E-01
	(Total)										**1.4E-01**
										Hazard Index for Inhalation Exposure l =	**1.4E-01**

(1) Constituents exceeding Industrial Air screening levels (May 2020) retained for evaluation.

(2) Medium-Specific (M) EPC selected for hazard calculation. See Table A-12 for estimated indoor air concentration.

APPENDIX A
TABLE A-52
CALCULATION OF CANCER RISKS
Joslyn Clark Facility, Lancaster, South Carolina

Scenario Timeframe:	Current/Future
Medium:	Air - Estimated from MW-12/MW-12D
Exposure Medium:	Indoor Air
Exposure Point:	Hypothetical Off-Site Indoor Air
Receptor Population:	Commercial Worker
Receptor Age:	Adult

Exposure Route	Chemical of Potential Concern	Medium EPC Value (1)	Medium EPC Units	Route EPC Value	Route EPC Units	EPC Selected for Hazard Calculation (2)	Intake (Cancer)	Intake (Cancer) Units	Inhalation Unit Risk (IUR) Concentration	IUR Concentration Units	Cancer Risk
Inhalation	Trichloroethene	1.26E+00	ug/m3	1.26E-03	mg/m^3	M	1.0E-04	mg/m^3	4.10E-06	m^3/mg	4E-07
	(Total)										**4E-07**
										Cancer Risk for Inhalation Exposure =	**4E-07**

(1) Constituents exceeding Industrial Air screening levels (May 2020) retained for evaluation.

(2) Medium-Specific (M) EPC selected for hazard calculation. See Table A-12 for estimated indoor air concentration.

APPENDIX A
TABLE A-53
CALCULATION OF NON-CANCER HAZARDS
Joslyn Clark Facility, Lancaster, South Carolina

Scenario Timeframe:	Current/Future
Medium:	Air - Estimated from MW-15/MW-15D
Exposure Medium:	Indoor Air
Exposure Point:	Hypothetical Off-Site Indoor Air
Receptor Population:	Commercial Worker
Receptor Age:	Adult

Exposure Route	Chemical of Potential Concern	Medium EPC Value (1)	Medium EPC Units	Route EPC Value	Route EPC Units	EPC Selected for Hazard Calculation (2)	Intake (Non-Cancer)	Intake (Non-Cancer) Units	Reference Concentration	Reference Concentration Units	Hazard Quotient
Inhalation	Trichloroethene	1.62E+00	ug/m3	1.62E-03	mg/m^3	M	3.7E-04	mg/m^3	2.0E-03	mg/m^3	1.8E-01
	(Total)										**1.8E-01**
										Hazard Index for Inhalation Exposure l =	**1.8E-01**

(1) Constituents exceeding Industrial Air screening levels (May 2020) retained for evaluation.

(2) Medium-Specific (M) EPC selected for hazard calculation. See Table A-13 for estimated indoor air concentration.

APPENDIX A
TABLE A-54
CALCULATION OF CANCER RISKS
Joslyn Clark Facility, Lancaster, South Carolina

Scenario Timeframe:	Current/Future
Medium:	Air - Estimated from MW-15/MW-15D
Exposure Medium:	Indoor Air
Exposure Point:	Hypothetical Off-Site Indoor Air
Receptor Population:	Commercial Worker
Receptor Age:	Adult

Exposure Route	Chemical of Potential Concern	Medium EPC Value (1)	Medium EPC Units	Route EPC Value	Route EPC Units	EPC Selected for Hazard Calculation (2)	Intake (Cancer)	Intake (Cancer) Units	Inhalation Unit Risk (IUR) Concentration	IUR Concentration Units	Cancer Risk
Inhalation	Trichloroethene	1.62E+00	ug/m3	1.62E-03	mg/m^3	M	1.3E-04	mg/m^3	4.10E-06	m^3/mg	5E-07
	(Total)										**5E-07**
										Cancer Risk for Inhalation Exposure =	**5E-07**

(1) Constituents exceeding Industrial Air screening levels (May 2020) retained for evaluation.
(2) Medium-Specific (M) EPC selected for hazard calculation. See Table A-13 for estimated indoor air concentration.

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