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April 14, 2016

VIA U. S. AND ELECTRONIC MAIL

Mr. Darrell Nitschke, Executive Secretary
North Dakota Public Service Commission
State Capitol Building – 12th Floor
Bismarck, North Dakota 58505

RE: QUARTERLY UPDATE OF INVESTIGATION AND REMEDIATION OF FORMER FARGO MANUFACTURED GAS PLANT SITE (CASE NO. PU-15-514)

Dear Mr. Nitschke:

Northern States Power Company, doing business as Xcel Energy ("Xcel Energy", or "the Company"), submits this 1st quarter 2016 update of progress made in the investigation and clean-up of areas potentially impacted by a former manufactured gas plant (MGP) (the " Project Site") that was previously operated by the Company or prior companies in the city of Fargo, North Dakota. This project was approved for deferred accounting, pursuant to the Commission's motion on December 18, 2015. We provide further information below as to the status of project activities.

Investigation Results and Anticipated Next Steps

The focus of our investigation activities to date has been on evaluating any potential exposure by the public to MGP-related materials. As previously indicated, we have no information that indicates the general public has contact with impacted soils.[1] Most of the former MGP plant and adjacent areas are sealed by paved parking lots and/or streets. In addition, area ground water does not supply local drinking water. With respect to the potential for MGP materials to become airborne, we have conducted further investigation at three properties within the Project Site as follows:

[1] We are evaluating with the City and ND Dept. of Health whether certain precautions should be undertaken in the future by construction workers who may come into contact with potentially impacted soils located beneath the subsurface when working in the vicinity of the historic MGP.

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Compliance filing – Quarterly Update of Investigation and Remediation of Former Fargo Manufactured Gas Plant Site
Northern States Power Company
David Sederquist

11 12th Street (Heartland Apartments)

In the first quarter of 2016, we negotiated access and lease agreements to allow for further investigation activities at 11 12th Street and we performed sampling for sub-slab vapor conditions. The initial data we collected indicates that the current conditions in the area are also considered safe and acceptable according to EPA standards.

However, under EPA's standard procedures, there are two possible paths forward following this initial collection of data. First, we can continue to perform ongoing quarterly sampling within every garden level apartment within the building for the next year. Second, and in the alternative, we can proactively install a subsurface ventilation system (similar to a radon mitigation system) to ensure ongoing protection of human health. We have evaluated both options and believe the least disruptive, most protective, and most cost effective approach would be to install a ventilation system in the building. The cost to install a subsurface ventilation system is on the order of $400,000 (based on conceptual cost estimates) and would require less intrusive access to the building and tenant spaces then further sampling would require. By comparison, it would cost at least the same amount to perform additional sampling in the apartment building, and potentially much more, if we later determined that a ventilation system should be installed at the end of the sampling program.

Further information about the data results and comparison of alternatives is attached (See the enclosed report, *Preliminary Evaluation of Vapor Intrusion Pathway and Comparative Analysis of Alternatives*). We have met with the North Dakota Department of Public Health and the City to discuss our preferred path forward and they have indicated that they generally concur with our proposed next steps. In order to proceed with installation of the subsurface ventilation system, we must first obtain access from the property owner. We currently anticipate that work to install the system will commence in May or June of this year. We intend to provide updates to the public through our website and we are planning to host another public forum prior to installation of the system.

1026 NP Avenue (Historic Union), 12 12th Street (United Refrigeration)

In the first quarter of 2016, we also performed a second round of sub-slab soil gas sampling at 1026 NP Avenue and 12 12th Street. In the next quarter, we intend to complete one final round of sub-slab vapor sampling at these locations. Once we receive the results of this third round of sampling, we will make determinations about whether any additional sampling or action is necessary with regard to vapor, if any. To date, the initial data we collected indicates that the current conditions in the area are considered safe and acceptable according to EPA standards.

While the focus of our investigation activities to date has been on evaluating any potential exposure by the public to MGP related materials, we are at the point in the investigation that we are now turning our attention towards delineating the source and extent of any MGP-related impacts and any impacts from other potential sources in the area. This investigation will allow us to assess potential remediation options, if any, which may be appropriate. We anticipate performing additional soil, groundwater, and vapor investigations at the Project Site in May or June of 2016, subject to our ability to gain access from several property owners and subject to oversight by the North Dakota Department of Public Health (NDDH). On April 1, 2016, we submitted a proposed work plan to the NDDH and City of Fargo for their review. We anticipate that the results of this investigation will be available by the end of summer, at which time we will evaluate potential remediation options, and associated costs and timing for implementation.

Ownership and Operational History

We have also continued to investigate the history of ownership and operation of the Fargo MGP plant, which we believe operated from approximately 1885 to 1960. It should be noted that some of the historical records that we have reviewed to date provide a good indication of the history of the ownership and operation of the MGP, but are contained in meeting minutes or other secondary sources, rather than primary sources such as executed contracts. Based on our current review of historical documents, it appears that Xcel Energy was an owner and operator of the MGP and, at present, it does not appear that there are any other solvent potential owners or operators still in existence today. The following summarizes our current understanding of the MGP corporate history:

- *1881* A franchise was first granted for the MGP.
- *1885-1889* Anecdotal records indicate that the Fargo MGP first became operational in 1885. It appears that the first corporate entity to own the MGP was known as the Fargo Gas Light and Fuel Co. In Brown's Directory in 1886 and 1888, reference is instead made to the Fargo Gas Light and Coke Company. It is unclear, but these may have been the same companies, or the MGP plant was transferred to the Fargo Gas Light and Coke Company from the Fargo Gas Light and Fuel Co. sometime by 1886.
- *1889-1902* In 1889, it appears there was an asset purchase by Fargo Gas and Electric Company ("FGE") of assets of the Fargo Gas Light and Coke Company. Records suggest that the Fargo Gas Light and Coke Company may have been dissolved sometime in 1903.
- *1902-1910* The Union Light, Heat, and Power Company ("ULC") was incorporated on June 3, 1902. It appears ULC then obtained all of the assets and liabilities of, and purchased the properties of FGE, in a stock-for stock transaction. Records suggest that FGE may have been dissolved in 1909. From 1902 to 1910, ULC continued to operate the MGP.
- *1910-1937* Consumers Power Company ("CPC") was incorporated in Minnesota by Henry Byllesby in 1909. It was authorized to do business in North Dakota in August 1910. In 1910, it appears that CPC agreed to purchase certain assets from ULC. Records further indicate CPC may have leased its electric, gas, and steam plants in the City of Fargo back to ULC. In 1916, CPC changed its name to Northern States Power Company ("NSP"). It may be that during this time period CPC/NSP was the owner of the MGP while ULC was the operator. However, during this time, it also appears that a separate company, the Byllesby Engineering and Management Co. may have entered into a contract in 1921 with NSP to provide

some management and operation services to NSP. It is unclear whether this extended to operations of the Fargo plant. Regardless of whether it ever operated the plant, however, it appears that the Byllesby Engineering and Management Co. dissolved in 1956.

- *1937- 1960* In 1937, records indicate that ULC transferred all of the steam, electric and gas franchises, and all certificates of convenience and necessity to NSP. NSP at that time appears to have contractually assumed all indebtedness and liability of ULC for the entire period of 1910-1937. On May 15, 1937, ULC was dissolved. It is our current understanding that NSP owned and operated the plant from 1937 until 1960.
- *1960-1969* Records indicate that operations of the MGP ceased in 1960 and the plant was demolished in 1962. Part of the MGP plant property was sold in 1966 to Refrigeration Supply, Co., Inc. and the remainder of the plant property was sold in 1969 to Wayne Candor.

We are continuing to investigate whether there may be other primary sources relevant to this evaluation. We are also continuing to investigate whether there may be other potentially responsible parties that may have played an important role at the Project Site.

Cost Summary

With respect to actual costs incurred, as of March 31, 2016, $719,885 has been spent on soil and pipeline removal work in the streets and $1,849,404 has been incurred on Project Site investigation activities. In addition, $ 171,536 has been spent on insurance recovery efforts. At this time we have also accrued $2,155,000 for future investigation, mitigation, and limited excavation and restoration costs, which we anticipate will be incurred primarily in 2016 based on currently known information. These estimates could increase, however, as they are fully dependent on the results of our additional Project Site investigation efforts and further discussions with other stakeholders, including the North Dakota Department of Health, the City of Fargo, and property owners in the area.

At this point, we are not able to develop a longer-term forecast of the total project cost because there are still many unknowns that cannot be quantified until more information is available and a remediation plan has been finalized. We would note that the costs of the project could also potentially be offset by any insurance recoveries, as discussed further below.

Insurance Recovery

While we continue to investigate other potential sources of contamination in the area and other potentially responsible parties, we are also seeking insurance recovery for our investigation and remediation costs. In October of 2015, the Company initiated insurance recovery litigation in state court in North Dakota against Associated Electric and Gas Insurance Service, Ltd. (AEGIS). AEGIS subsequently removed the litigation to federal court, in the United States District Court, District of North Dakota and also cross-claimed against 10 additional insurance companies. In February the United States District Court agreed to stay the litigation until July 1, 2016, to allow for further investigation activities to occur at the Project Site this spring and early summer before establishing a scheduling order for the case. The information from the next round of investigation will assist the parties in better understanding the scope and magnitude of potential remediation costs that may ultimately be incurred for this project.

Conclusion and Next Update

We hope this letter has been informative. As previously indicated, we intend to keep the Commission informed of the project status on a quarterly basis. If any material and significant events occur before the end of the quarter, we will provide additional updates as necessary. If the Commission would like any further information about the project, please let me know. Thank you.

Sincerely,

David H Sederquist

David H. Sederquist
Sr. Regulatory Consultant
Xcel Energy

Cc: Mike Diller
Patrick Fahn
Sara Cardwell

Preliminary Evaluation of the Vapor Intrusion Pathway and Comparative Analysis of Alternatives

Heartland Apartments Property, Fargo Former MGP Site

Fargo, Cass County, North Dakota

Prepared for
Northern States Power Co.
Minneapolis, MN

April 1, 2016

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Abbreviations

bgs	Below Ground Surface
BTEX	Benzene, Toluene, Ethylbenzene, and Xylene
COPC	Chemical of Potential Concern
EE/CA	Engineering Evaluation/Cost Analysis
EPC	Exposure Point Concentration
FS	Feasibility Study
HQ	Hazard Quotient
HI	Hazard Index
MAH	Monocyclic Aromatic Hydrocarbon
MGP	Manufactured Gas Plant
NCP	National Contingency Plan
NDDH	North Dakota Department of Health
NP	Northern Pacific
NSP	Northern States Power Co.
O&M	Operations and Maintenance
RfC	Reference Concentration
RfD	Reference Dose
RI	Remedial Investigation
RSL	Regional Screening Level
SSD	Sub-slab Depressurization
tMAH	Total Monocyclic Aromatic Hydrocarbons
UCL	Upper Confidence Limit
UCLM	Upper Confidence Limit on the Mean
US EPA	United States Environmental Protection Agency
VISL	Vapor Intrusion Screening Level
VFE	Vacuum Field Extension
VOC	Volatile Organic Compound

Executive Summary

Between July 2015 and February 2016, Northern States Power Co. (NSP) conducted the preliminary investigation of a former Manufactured Gas Plant (MGP) in Fargo, North Dakota (Site) and its vicinity.[1] The former MGP operated on the north side of Northern Pacific (NP) Avenue between 11th Street North and North University Drive. Investigations were performed on multiple properties, including the Heartland Apartments Property (hereafter, "Heartland Apartments"), which comprises a portion of the former MGP Site.

The site investigation was conducted in accordance with work plans submitted to the North Dakota Department of Health (NDDH) with the following primary objectives:

1. Improve the understanding of current and historical Site conditions;
2. Assess the potential for current human health risks at the Site; and
3. Begin to characterize the potential for off-Site migration of MGP Site constituents.

As part of this investigation and because Heartland Apartments includes occupied apartment buildings, NSP conducted an evaluation of the potential for vapors to intrude upward into the building structures. This evaluation of the vapor intrusion pathway at Heartland Apartments included the following work:

1. Collected 20 soil vapor samples[2] from 20 locations to characterize soil vapor quality beneath and near the apartment building and near the former coal shed;
2. Conducted a vapor mitigation pilot test;
3. Performed a quantitative human health risk assessment of the vapor intrusion pathway, based on the currently available data and on US EPA risk assessment guidance and procedures, to determine whether there are unacceptable risks posed by current conditions; and
4. Performed a comparative analysis of vapor intrusion alternatives, including no action, further vapor sampling with contingent mitigation, or "preemptive mitigation."[3] Factors considered in this analysis include effectiveness, implementability, cost, and community acceptance.[4]

The main conclusions from this work are as follows:

- There are no unacceptable risks to human health from vapor intrusion into the Heartland Apartment buildings based on current conditions as determined by the current data set. Soil gas data were used to evaluate relevant exposures for a current Resident in each of the Heartland

[1] The Fargo MGP Site was located at 1150 Northern Pacific Avenue, Fargo, Cass County, North Dakota and encompassed two parcels (01-2382-04070-000 and 01-2382-04120-000), which are separated by 12th Street North.

[2] And two field duplicate samples.

[3] The terms "preemptive mitigation," "presumptive mitigation," and "early action" are used to describe situations where it may be prudent to implement mitigation early, rather than perform a prolonged sampling effort. (See, *e.g.*, US EPA, 2015a.)

[4] The first three factors are based on US EPA Engineering Evaluation/Cost Analysis (EE/CA) guidance.

Apartment buildings. Cancer risk and non-cancer hazards for a Resident in each of the Heartland Apartment buildings[5] are all within US EPA's target risk range.

- Potential MGP constituents and non-MGP constituents were detected in soil gas, some at concentrations exceeding conservative US EPA residential screening levels. If a measured concentration is below applicable screening levels, there is negligible risk of adverse health effects; exceedance of a relevant screening level indicates that more analysis or investigation may be warranted, not that there is an unacceptable risk. The highest chemical concentrations were detected along the southern perimeter of Building A.

- Consistent with US EPA guidance, based on the perimeter soil gas sampling results for Building A, sub-slab soil gas samples were collected from directly beneath the building structure. Sub-slab soil gas sampling results for Building A showed significantly lower concentrations than soil gas locations from the building perimeter. These sub-slab soil gas samples better represent the vapor intrusion pathway.

- This risk evaluation is preliminary because it is based on a limited data set consisting of 16 samples from 14 locations.[6] Completing the vapor intrusion evaluation in accordance with US EPA guidance would require the collection of additional soil gas samples (spatially and temporally). For example, US EPA (2015a) generally recommends multiple rounds of sub-slab soil gas sampling to develop a comprehensive understanding of vapor intrusion, including to account for heterogeneity and seasonal variation. However, US EPA (2015a) also acknowledges that, in some situations, preemptive mitigation may be both protective of human health and less disruptive to building occupants than multiple rounds of sampling.

- Preemptive mitigation is the preferred alternative to address the vapor intrusion pathway at Heartland Apartments because it: provides the highest level of certainty in human health protection; is readily implementable using existing technology; is less disruptive and faster to implement than repeated vapor sampling in multiple tenant units; provides the most certain outcome, and is similar in cost to the further vapor sampling with contingent mitigation alternative. NSP's ongoing public outreach activities, including hosting a tenant meeting, outreach to affected property owners and interested members of the public, and hosting an informational website, will help develop community understanding and support of this alternative. We anticipate public preference for this alternative given its less disruptive nature and other factors listed above.

[5] Heartland Apartments West (Building A), South (Building B), and North (Building C) Buildings.

[6] Sub-slab soil gas samples, rather than exterior soil gas samples, were used in the risk evaluation for Building A since US EPA guidance states that sub-slab samples are preferable to exterior soil gas samples for assessing vapor intrusion into building structures.

1 Introduction

This report was prepared on behalf of Northern States Power Co. (NSP) to provide an evaluation of the vapor intrusion pathway at Heartland Apartments and to recommend next steps for further vapor sampling and/or mitigation. The vapor intrusion pathway was evaluated as part of the environmental investigation that NSP is performing at and in the vicinity of the Fargo Manufactured Gas Plant (MGP). The Fargo MGP operated on the north side of Northern Pacific (NP) Avenue between 11th Street North and North University Drive in Fargo, North Dakota (MGP Site). This report summarizes the vapor sampling and pilot testing work that was performed (Section 2), analyzes the results, including the analysis of the nature and extent of potential MGP constituents in soil vapor and an evaluation of human health risks (Section 3), and provides a comparative analysis of further investigation and/or mitigation alternatives (Section 4).

These investigations were undertaken at Heartland Apartments in accordance with a work plan and addendum submitted to the North Dakota Department of Health (NDDH) (Gradient, 2015a; Barr, 2016a) and in accordance with access agreements with the Heartland Apartments property owner. The data collected during the Site investigations were provided to NDDH in a series of technical memoranda (Barr, 2015, 2016b).

1.1 Current Site Conditions at Heartland Apartments

The 2.1 acre Heartland Apartments property consists of three residential apartment buildings (Buildings A [West], B [South], and C [North]), a central atrium connecting the three buildings, a storage building connected to the apartment building, and a free-standing storage shed on the northwest corner of the property (Figure 1). Each apartment building consists of three floors. The first floor is at garden level, with the floor located below grade. A laundry room and manager's apartment unit are also on the garden level. The apartment building has a total of 88 units,[7] which have a high occupancy rate. Based on discussions with the property owners, most of the units are occupied by short-term residents (a few years or less), although a handful of units are occupied by longer-term residents. The footprint of each wing is approximately 7,000 square feet. Each building has a 4-inch drain tile and sump system. The remaining spaces on the property are a mix of unpaved areas and paved parking lots. The majority of the former MGP equipment and operations were in areas that are now occupied by the paved parking lots. The apartment building currently occupying the Site was constructed in 1969, in approximately the same configuration as it stands today.

[7] 28 units on the garden level and 30 units each on the second and third floors.

2 Work Performed

2.1 Vapor Sampling

Fifteen soil gas samples (fourteen samples and one field duplicate) were collected around the Heartland Apartment buildings in November 2015 and submitted for laboratory analysis. The samples were collected from approximately 5 feet below ground surface (bgs). In February 2016, seven sub-slab soil gas samples (six samples and one duplicate) were collected from beneath Building A (Figure 2). All of the samples were analyzed for volatile organic compounds (VOCs) plus naphthalene using US EPA Method TO-15.

2.2 Pilot Test

Sub-slab depressurization (SSD) pilot testing was performed in February 2016 in Building A. The testing included depressurizing a building perimeter drain tile system using the existing foundation dewatering sump in the laundry room and suction ports installed in the floors of selected apartments. Vacuum field extension (VFE) testing was conducted to evaluate the response to depressurizing the sub-slab. VFE testing includes measuring the differential pressure across the building slab using a digital micro-manometer *via* vacuum monitoring points drilled through the floor at varying distances from the suction port or drain tile.

The results of the pilot testing indicate that SSD is a viable mitigation alternative. While depressurizing the drain tile system alone did not achieve measurable vacuum extension in the central portion of the building, depressurizing the drain tile system in conjunction with a series of suction ports achieved a vacuum extension of approximately 30 feet from each suction location. The pilot test indicated communication throughout the sub-slab of Building A, suggesting that a relatively permeable base material is present beneath the slab and that the vapor samples collected represent underlying vapor conditions. It also provides measure of confidence that a depressurization system will be effective. Refer to Barr (2016b) for further details of the pilot testing and its results.

3 Results Analysis

3.1 Nature and Extent

Soil gas samples collected from near and beneath the Heartland Apartments buildings detected both potential MGP and non-MGP related constituents. Exterior soil gas and sub-slab soil gas samples contained a wide range of constituents (Table 1). More than half of these constituents have not been detected in soil or groundwater during any of the investigation activities in the Site vicinity,[8] and many are unrelated to former MGP operations (*e.g.*, dichlorodifluoromethane). A number of chemical constituents that may be related to former MGP activities ("potential MGP constituents") were detected, noting that many of these same chemicals (*e.g.*, benzene, toluene, ethylbenzene, and xylene [BTEX]) are not unique to MGPs but are common to many other sources. These potential MGP constituents include monocyclic aromatic hydrocarbons (MAHs[9]) and naphthalene. Total monocyclic aromatic hydrocarbons (tMAH) and naphthalene sampling results[10] are shown on Figure 2.

While higher concentrations of constituents in soil gas samples were observed in samples collected from outside the building, samples taken from below the floor of the building found concentrations of constituents to be much lower. As explained in the next sections, the sample results indicate that current conditions inside the apartment building do not pose an unacceptable risk as defined by US EPA guidance. The sampling results showed the highest detected concentrations of tMAH in building exterior soil gas samples collected around the southwest perimeter of the apartment building (SG-HLA-15 through SG-HLA-18) and around the storage shed on the northwest corner of the property (SG-HLA-05 and SG-HLA-06). Low concentrations of tMAH were detected in soil gas samples from around the northern and eastern apartment building perimeters (tMAH less than 19 $\mu g/m^3$ and no detections of naphthalene).

Sub-slab soil gas samples taken within Building A, with the exception of SS-HLA-01, had tMAH less than 10 $\mu g/m^3$ and no detections of naphthalene. Importantly, this includes SS-HLA-06, which was collected near exterior soil gas sample SG-HLA-18, where the highest exterior soil gas concentration was recorded (tMAH of 13,073 $\mu g/m^3$).

3.2 Risk Evaluation Overview

This section provides an overview of the human health risk evaluation that characterized exposure to soil vapors potentially infiltrating into the Heartland Apartment buildings. This risk evaluation was performed using well-established, conservative (*i.e.*, protective) US EPA guidance and protocols. It should, however, be considered preliminary because it is based on a limited data set; if additional sub-slab soil gas data are collected, these data may be used to update the evaluation. The results of this risk evaluation indicate that there are no unacceptable risks to human health based on current conditions as determined by the current data set. Supporting details, including detailed risk calculation methodologies, are provided in Attachment A.

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[8] Soil and groundwater quality have not yet been characterized at Heartland Apartments, but they have been in its vicinity.
[9] Including BTEX compounds, alkylated MAHs (*e.g.*, trimethylbenzene), and styrene.
[10] The tMAH value was calculated as the sum of BTEX compounds, alkylated MAHs, and styrene.

3.2.1 Methodology

The methodology used to characterize human health risks is based on established US EPA guidance and protocols (*e.g.*, US EPA, 2014a; additional citations to specific and applicable US EPA guidance documents are provided throughout Attachment A).[11] This preliminary vapor intrusion risk evaluation characterizes potential exposures and human health risks associated with any contaminants that exceed the risk-based screening criteria discussed below. It is therefore conservative in that it includes both potential MGP constituents and non-MGP constituents that were detected. The risk evaluation process used in this report is depicted in Figure 3, as shown below.[12]

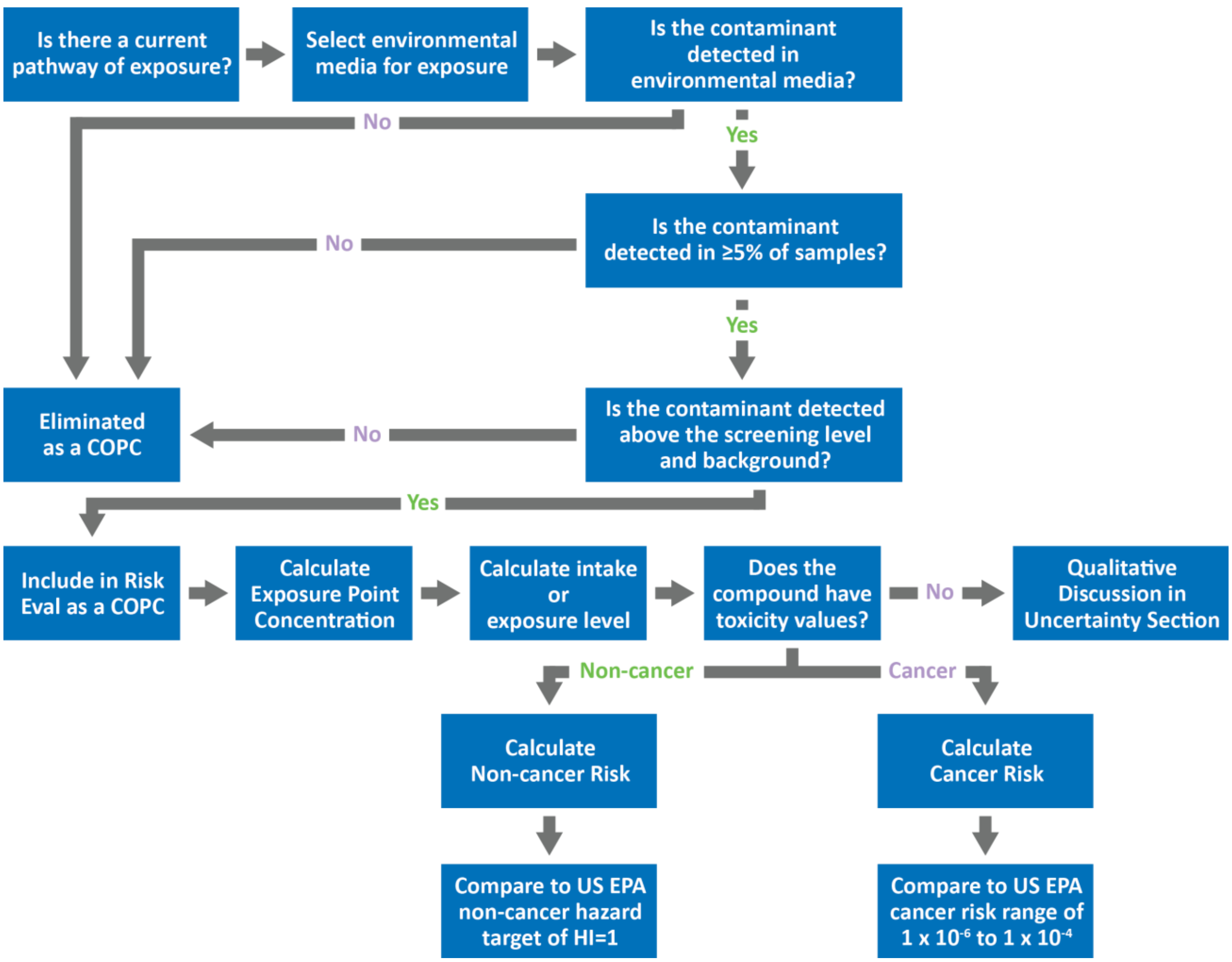

Figure 3 Risk Evaluation Process[13]

[11] It is common practice to use US EPA guidance and regulations absent state-equivalent guidance and regulations.
[12] This figure was developed by Gradient based on US EPA guidance, such as the US EPA (1989) Risk Assessment Guidance for Superfund: Human Health Evaluation Manual and the US EPA (2014b) Regional Screening Table: User's Guide.
[13] COPC = Chemical of Potential Concern; HI = Hazard Index; US EPA = United States Environmental Protection Agency.

Data used in the risk evaluation included 14 sub-slab soil gas or exterior soil gas (where sub-slab soil gas were not available) sampling locations:[14]

- For Building A, data from six sub-slab soil gas sampling locations (including six samples and one field duplicate) were used in the risk evaluation. The soil gas samples collected from outside Building A[15] were excluded from the risk evaluation because US EPA (2015a) guidance states that sub-slab samples are preferable to exterior soil gas samples for assessing vapor intrusion in building structures.
- For Building B, data collected from four exterior soil gas sampling locations adjacent to the building were used in the risk evaluation.
- For Building C, data collected from four exterior soil gas sampling locations (including four samples and one field duplicate sample) were used in the risk evaluation.

For Buildings B and C, sub-slab soil gas samples were not collected (in order to minimize disruption to tenants) and were not considered necessary based on the risk evaluation results (described below).

Soil gas data were compared to risk-based screening levels to identify chemicals of potential concern (COPCs) that required further investigation. For both sub-slab soil gas and exterior soil gas, the maximum detected concentrations were screened against the US EPA Vapor Intrusion Screening Levels (VISLs) for residential sub-slab and exterior soil gas (US EPA, 2015b). Compounds with maximum concentrations above the risk-based screening levels were retained as COPCs for the risk evaluation. However, compounds with a detection frequency less than 5% would not be retained as COPCs (US EPA, 1989). The preliminary data set contains six samples or less for each building, therefore, no compounds were eliminated due to low frequency of detection. If a measured concentration is below applicable screening levels, there is negligible risk of adverse health effects; exceedance of a relevant screening level indicates that more analysis or investigation may be warranted, not that there is necessarily an unacceptable risk.

Exposure to each COPC *via* the vapor intrusion pathway was calculated in a multiple step process. First, consistent with US EPA guidance, exposure point concentrations (EPCs) were calculated for each COPC. These were calculated as either the 95% Upper Confidence Limit on the Mean (UCLM; calculated using US EPA's ProUCL software) or the maximum detected concentration within the exposure area (*i.e.*, each apartment building). Exposure point concentrations (EPCs) were then combined with estimates of exposure frequency, duration, and intensity to calculate human intake levels. Soil gas concentrations were converted to equivalent indoor air concentrations using default attenuation factors per US EPA (2015b,c) guidance. US EPA's default attenuation factor (0.03) has been developed based on the empirical review and analysis of attenuation at over 900 buildings and is used by US EPA to derive health protective vapor intrusion screening levels. The exposure assumptions used to characterize human health risks are consistent with current US EPA guidance. The primary source for the exposure equations used in the risk evaluation is US EPA's Risk Assessment Guidance for Superfund (1989, 2014a). Where appropriate, exposure parameters were based on site-specific considerations and professional judgment.

The human exposure levels were then combined with toxicity values to estimate cancer risk and non-cancer hazard. The toxicity values used were consistent with those used in the derivation of US EPA Regional Screening Levels (RSLs).

[14] For the risk evaluation, the field duplicate samples were averaged with their parent sample to obtain one result per sample.
[15] Soil gas samples: SG-HLA-07, SG-HLA-08, SG-HLA-17, and SG-HLA-18.

- Cancer risks are characterized as the incremental probability that an individual will develop cancer during his or her lifetime due to chemical exposure to contaminants at the site under the specific exposure scenarios evaluated. The risks are calculated with the inputs for the exposure parameters that are described in Attachment A of this report. Cancer risks are expressed as a unitless probability (*e.g.*, 1 in 1 million, 0.000001, or 1 x 10^{-6}) of an individual developing cancer over a lifetime, above background risk, as a result of site-related exposures. US EPA has established a target cancer risk range of 1 x 10^{-6} to 1 x 10^{-4} (*i.e.*, 1 in 1 million to 1 in 10,000); this is often referred to as an acceptable cancer risk range.
- Risks from non-carcinogenic effects are expressed as hazard quotients (HQs) rather than probabilities. An HQ compares the calculated human intakes to toxicity values derived by US EPA. HQs were calculated for each receptor, exposure pathway, and COPC according to US EPA guidance. For each exposure route, HQs were summed across all COPCs to calculate a hazard index (HI). As per US EPA guidance, HIs were rounded to one significant figure, and HIs for the individual exposure pathways were rounded to two significant figures. US EPA considers an HI greater than 1 to exceed the target risk threshold. Because an HQ is simply a ratio of site exposures to reference exposure levels (reference doses [RfDs], reference concentrations [RfCs], *etc.*), HIs do not represent the probability that an adverse health effect will occur. An HI less than 1 suggests that exposures are likely to be without an appreciable risk of non-cancer effects during a lifetime. An HI greater than 1 indicates only that a potential may exist for adverse health effects. Unlike cancer risks, non-cancer HIs are not additive across different age groups for a resident.

3.2.2 Risk Results

The results of this preliminary risk evaluation for the vapor intrusion pathway at Heartland Apartments show that there are no unacceptable risks to human health based on current conditions as determined by the available data set. Cancer risks and non-cancer hazards from inhalation of modeled indoor air concentrations based on sub-slab or exterior soil gas (as described above) were assessed for the adult and child Resident[16] living in each of the three buildings at the Heartland Apartments. Specific results are summarized below, by apartment building.

Heartland Apartments – Building A

Based on currently available data, both the cancer risk and non-cancer hazard for residential vapor intrusion at Building A were within US EPA's acceptable risk range. Cancer risk for the Building A Resident was 1 x 10^{-6}, within US EPA's target risk range of 10^{-6} to 10^{-4}. Non-cancer hazard for the adult Resident was 0.5, which was below US EPA's target HI of 1.

Receptor/Exposure Pathway	Non-cancer Hazard	Cancer Risk	Major Contributors
Inhalation of Indoor Air (Sub-slab Soil Gas)	0.46	1.40E-06	1,2,4-Trimethylbenzene, Naphthalene
Total Hazard or Risk:	**0.5**	**1E-06**	

[16] Receptor populations (*e.g.*, Resident) are capitalized as proper nouns as they refer to the hypothetical receptor evaluated according to US EPA exposure scenarios.

Heartland Apartments – Building B

Based on currently available data, both the cancer risk and non-cancer hazard for residential vapor intrusion at Building B were within US EPA's acceptable risk range. Cancer risk for the Building B Resident was 2 x 10^{-5}, within US EPA's target risk range of 10^{-6} to 10^{-4}. Inhalation of indoor air contributed 100% of the cancer risk, with 1,3-butadiene as the major (100%) contributor. Non-cancer hazard for the adult Resident was 0.9, below the US EPA's target HI of 1.

Receptor/Exposure Pathway	Non-cancer Hazard	Cancer Risk	Major Contributors
Inhalation of Indoor Air (Soil Gas)	0.90	1.70E-05	1,3-Butadiene
Total Hazard or Risk:	**0.9**	**2E-05**	

Heartland Apartments – Building C

Based on currently available data, both the cancer risk and non-cancer hazard for residential vapor intrusion at Building C were within US EPA's acceptable risk range. Cancer risk for the Building C Resident was 1 x 10^{-6}, within US EPA's target risk range of 10^{-6} to 10^{-4}. Non-cancer hazard for the adult Resident was 0.09, below the US EPA's target HI of 1.

Receptor/Exposure Pathway	Non-cancer Hazard	Cancer Risk	Major Contributors
Inhalation of Indoor Air (Soil Gas)	0.089	1.10E-06	1,3-Butadiene
Total Hazard or Risk:	**0.09**	**1E-06**	

3.2.3 Uncertainties Associated with Risk Evaluation

The risk evaluation process involves multiple steps and assumptions, which contribute uncertainties that affect the final risk estimates, yet following US EPA risk assessment methods promotes a systemic bias towards overestimation of risk in order to be conservative (*i.e.*, protective). Uncertainties may exist in numerous areas, including sample collection, laboratory analysis, derivation of toxicity values, and estimation of potential site exposures. The most important contributors to uncertainty in this risk assessment are discussed below.

Data Selection

The screening evaluation and EPC calculation were based on sample counts of 6 or less samples from each of the three Heartland Apartments buildings. The use of limited datasets may result in uncertainty if they are not representative of the entire exposure area. However, maximum or 95% Upper Confidence Limit (UCL) concentrations were used as EPCs to avoid underestimating risk. Additionally, concentrations from a single round of sampling may not represent temporal variation. However, samples were collected during the winter (home heating) season, which tends to increase the potential for vapor intrusion. If additional sub-slab soil gas samples are collected, these may be used to reduce uncertainty in the risk evaluation.

COPC Selection

Certain chemicals were eliminated as COPCs during the screening evaluation (Attachment A). Maximum detected concentrations were compared against generic health based screening criteria (*e.g.*, RSLs).

Chemicals with concentrations below their respective screening criterion do not warrant further evaluation. US EPA (1989) uses a screening evaluation to reduce the number of COPCs carried through the risk assessment, because in many cases risks are driven by a handful of chemicals. Chemicals that were not identified as COPCs are not expected to be major risk contributors, and the exclusion of these chemicals is not anticipated to change the conclusions of the risk assessment.

Exposure Frequency and Duration

The residential exposure scenario assumes that a resident will live in the Heartland Apartments for 15 years, 350 days per year, 24 hours per day, including 6 years as a child and 9 years as an adult. The use of conservative assumptions to evaluate the vapor intrusion pathway may overestimate risk for a typical resident of Heartland Apartments, that is expected to be more transient with a shorter residential tenure.

Compounds Not Assessed in the Risk Evaluation

Cancer risks and non-cancer hazards were not calculated for ethyl alcohol due to the lack of a published toxicity factor.

4 Comparative Analysis of Alternatives

This section provides a comparative analysis of vapor intrusion alternatives, including no action, further vapor sampling with contingent mitigation, or preemptive mitigation, for Heartland Apartments. These alternatives were compared using factors recommended by US EPA for use in such situations.

4.1 Alternatives Considered

4.1.1 No Action

The no action alternative consists of no further sampling or mitigation activities. It is included as a baseline for comparison to the other alternatives. If no further property access were granted by the Heartland Apartments property owner, this would be the *de facto* alternative. Under this alternative, the vapor intrusion pathway at Heartland Apartments would not be fully characterized (*e.g.*, to account for potential temporal and spatial variability in sampling as recommended by US EPA guidance).

4.1.2 Further Sampling with Contingent Mitigation

This alternative consists of performing additional sub-slab soil gas sampling to complete the characterization of the vapor intrusion pathway. The additional sampling would consist of at least 3 rounds of sampling from each garden level apartment unit (28 total) and the laundry room to account for temporal and spatial variability. Passive measures to reduce vapor intrusion, including sealing cracks and upgrading utility panels, would be performed in each garden level apartment. Upon completion of sampling there would be a decision point: either further sampling, no further action, or contingent mitigation. Thus, even upon completion of additional sampling, the outcome could be mitigation. While an acceptable alternative, this would be challenging to implement, particularly due to access considerations that could significantly delay its implementation. A conceptual layout of this alternative is included in Attachment B.

4.1.3 Preemptive Mitigation

This alternative consists of active mitigation of the vapor intrusion pathway by installing and operating an SSD system. Based on the results of the pilot test (see Barr, 2016b), this mitigation system would consist of the following:

- 4-6 suction ports per apartment building;
- Sump and drain tile depressurization system;
- Header piping in each hallway ceiling leading to vertical piping and a vacuum blower that vents to the roof; and
- Diagnostic ports in each apartment to gauge system performance.

Further details, including a conceptual mitigation system layout, are provided in Attachment B.

The term "preemptive mitigation" (alternately, "presumptive mitigation" or "early action") is used to describe a situation where it may be prudent to move forward with early mitigation rather than perform multiple rounds of sampling (as described in Section 4.1.2). As described by US EPA (2015a, p. 136), "[t]he premise of PEM [preemptive mitigation]…is to protect human health first without necessarily waiting to collect all lines of pertinent evidence of multiple rounds of sampling data." Adequate property access is described by US EPA as one key factor in making such a determination.[17]

4.2 Comparative Analysis

The Section provides a comparative analysis of the three alternatives on the basis of effectiveness, implementability, cost, and community acceptance.

- **Effectiveness**: Whether the alternative is protective of human health and the environment, and whether it is able to meet objectives (in this case ensuring that the vapor intrusion pathway does not pose an unacceptable risk to Heartland Apartment residents).
- **Implementability**: Whether the alternative is implementable, from a technical standpoint (*e.g.*, is the remedy technology proven and available?) and also from an administrative standpoint (*e.g.*, property access, permitting).
- **Cost**: Estimated cost for the alternative, including both capital cost and operations and maintenance (O&M) cost.
- **Community Acceptance**: The degree of community (*i.e.*, Heartland Apartments owners and residents) acceptance of the alternatives.

The first three factors were selected for the comparative analysis because they are used by US EPA in its Engineering Evaluation/Cost Analysis (EE/CA) guidance (US EPA, 1993). An EE/CA is essentially a streamlined Remedial Investigation/Feasibility Study (RI/FS) that is required by the National Contingency Plan (NCP) Section 300.415(b)(4)(i) for non-time-critical removal actions where at least six months of planning are available. This is similar to the situation for the vapor intrusion pathway at Heartland Apartments. The fourth factor (community acceptance) is included to satisfy NCP requirements (Section 300.415) and for practical reasons (the property is owned by a third party and occupied by residents).

4.2.1 Factors Considered

Each of the alternatives is compared for these factors in Table 2, below.

[17] "Depending on individual owners and occupants in the affected community, it may be difficult to obtain adequate data for all buildings within a specified area. Challenges include gaining timely access into each building and other practical considerations…" (US EPA, 2015a, p. 138).

Table 2 Analysis of Alternatives

Evaluation Factor	No Action	Further Sampling with Contingent Mitigation	Preemptive Mitigation
Effectiveness	• No significant human health risk based on current conditions as determined by the available data set. • Data set is limited at this time and does not achieve US EPA requirements for full characterization of the vapor intrusion pathway. • No assurance of long-term protectiveness if future conditions change (*e.g.*, seasonal variations; if exterior source removal work is performed at a future date, it could alter conditions). • May require ongoing controls to ensure that the risk assessment is revisited if conditions change.	• No significant human health risk as determined by the current data set under current conditions (based on current data and risk evaluation). • No significant risk to human health conditions are maintained if sampling captures range of variability for long-term conditions. • Provides a more robust data set that may meet US EPA data requirements for lines of pertinent evidence of multiple rounds of sampling data.	• Highest degree of protectiveness under current and future conditions (vapor intrusion exposure pathway is eliminated).

Evaluation Factor	No Action	Further Sampling with Contingent Mitigation	Preemptive Mitigation
Implementability	• Technically implementable because no work is required.	• Reliable technology with proven track record. • Equipment and contractors are available. • Access to 29 apartment units for multiple rounds of sampling poses a logistical challenge and could greatly delay/impede implementability. • Access frequency and duration in each apartment would be more significant than access needed for preemptive mitigation and perhaps disruptive to tenants. • Schedule – Would require more than a year to implement. Access issues make the schedule highly uncertain. • Some permitting requirements necessary if mitigation is ultimately required.	• Reliable technology with proven track record. • Mitigation system would be implemented in Building A first. More pilot testing data may be needed to expand system to Buildings B and C. • Equipment and contractors are available. • Some permitting requirements to evaluate. • Access to apartment units would be shorter in duration and less intrusive than the further sampling alternative. • Access to fewer apartments required for system installation (all units would be accessed for brief duration for upgrading utility panels and to install diagnostic ports). • Schedule – would require several weeks (much less than a year) to implement. Lower schedule risk because less access is necessary than the further sampling option. Long term O&M duration is possible.

Evaluation Factor	No Action	Further Sampling with Contingent Mitigation		Preemptive Mitigation	
Cost[a]	• Low (none)	• Moderate to high cost. High degree of uncertainty because mitigation could still be necessary after sampling is completed and because access issues may require multiple mobilizations.		• Moderate cost. Moderate uncertainty due to design contingency based on actual field conditions encountered and availability of units for installing suction ports.	
	$0	Construction	$119,000 to $144,000	Construction	$188,000 to $225,000
		Professional Services	$192,000 to $231,000	Professional Services	$60,000 to $72,000
		O&M	$0	O&M NPV[b]	$61,000 to $76,000
		Total Estimated Cost	$311,000 to $375,000 [up to $749,000 if mitigation still required]	Total Estimated Cost	$309,000 to $374,000
Community Acceptance	• Expected to be low. May require public outreach/education to convey why this alternative is acceptable since current data set is limited.	• Expected to be low because access would be more intrusive, longer in duration, and more frequent/recurring. • May require more extensive ongoing public outreach and education to explain.		• Expected to be higher because it offers the greatest level of certainty with regards to protectiveness and is less intrusive than the further sampling with contingent remediation option.	

Notes:
NPV=Net Present Value; O&M = Operations and Maintenance; US EPA = United States Environmental Protection Agency.
(a) Based on AACE International Class 4 cost estimates prepared by Barr Engineering. These costs are considered appropriate for screening or feasibility purposes. They are based on a combination of actual contractor costs from similar activities, cost databases, and professional judgment.
(b) Based on a 1% discount rate for 10-15 years.

4.2.2 Results of Analysis

Although each of the alternatives is viable, preemptive mitigation best addresses the four factors from Section 4.1 and is therefore the preferred alternative to address the vapor intrusion pathway because it:

- Provides the highest level of certainty in human health protection;
- Is readily implementable using existing technology;
- Is less disruptive and faster to implement than repeated vapor sampling in multiple tenant units;
- Provides the most certain outcome; and
- Is similar in cost to the further vapor sampling with contingent mitigation alternative.

NSP's ongoing public outreach activities will help develop community understanding and support for this alternative. Community outreach activities include hosting a tenant meeting, outreach to affected property owners and interested members of the public, and hosting an informational website. We anticipate that the public preference is for the preemptive mitigation alternative given the factors above.

5 Conclusions and Recommendations

The main conclusions are:

- Based on the results of the preliminary risk evaluation for the vapor intrusion pathway at Heartland Apartments, there are no unacceptable risks to human health based on current conditions as determined by the current data set. Calculated cancer risk and non-cancer hazards are all within US EPA's target risk range.
- This risk evaluation is preliminary because it is based on a limited data set. Completing the vapor intrusion evaluation in accordance with US EPA guidance would require the collection of additional soil gas samples (spatially and temporally).
- Soil gas samples collected from near and beneath the Heartland Apartments building detected both potential MGP and non-MGP-related constituents, some at concentrations above US EPA residential screening levels.[18] While soil gas results detected higher concentrations of constituents in outdoor areas around the building, samples taken from below the floor of the building found concentrations of constituents to be much lower.

Preemptive mitigation is therefore the preferred alternative to address the vapor intrusion pathway because it: is a readily understandable concept;[19] provides the highest level of certainty in human health protection; is readily implementable using existing technology; is less disruptive and faster to implement than repeated vapor sampling in multiple tenant units; provides the most certain outcome; and is similar (or lower) in cost than the further vapor sampling with contingent mitigation alternative. Community support for this alternative will be developed through NSP's ongoing public outreach activities, including hosting a tenant meeting, outreach to affected property owners and interested members of the public, and hosting an informational website.

[18] If a measured concentration is below applicable screening levels, there is negligible risk of adverse health effects; exceedance of a relevant screening level indicates that more analysis or investigation may be warranted, not that there is necessarily an unacceptable risk.
[19] Risk determinations are based on highly technical concepts that can increase barriers to public understanding of risks and mitigation; thus, public uncertainty and concern may remain.

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Table 1 Soil Gas Sampling Results, Heartland Apartments

Analyte	Detected in Soil Gas or Sub-slab Soil Gas	Detected in Soil or Groundwater in Vicinity	Location Sample Date Sample Type	SG-HLA-05 11/11/15 Soil Gas		SG-HLA-06 11/11/15 Soil Gas		SG-HLA-07 11/11/15 Soil Gas		SG-HLA-08 11/11/15 Soil Gas		SG-HLA-09 11/11/15 Soil Gas		SG-HLA-10 11/11/15 Soil Gas		SG-HLA-11 11/12/15 Soil Gas		SG-HLA-12 11/12/15 Soil Gas		SG-HLA-13 11/12/15 Soil Gas		SG-HLA-14 11/12/15 Soil Gas		SG-HLA-15 11/13/15 Soil Gas	
1,1,1-Trichloroethane	No	No		6.1	U	1.9	U	1.9	U	1.9	U	1.8	U	1.7	U	1.6	U	1.8	U	1.7	U	1.7	U	1.8	U
1,1,2,2-Tetrachloroethane	No	No		6.1	U	1.9	U	1.9	U	1.9	U	1.8	U	1.7	U	1.6	U	1.8	U	1.7	U	1.7	U	1.8	U
1,1,2-Trichloroethane	No	No		6.1	U	1.9	U	1.9	U	1.9	U	1.8	U	1.7	U	1.6	U	1.8	U	1.7	U	1.7	U	1.8	U
1,1-Dichloroethane	No	No		6.1	U	1.9	U	1.9	U	1.9	U	1.8	U	1.7	U	1.6	U	1.8	U	1.7	U	1.7	U	1.8	U
1,1-Dichloroethylene	No	Yes		6.1	U	1.9	U	1.9	U	1.9	U	1.8	U	1.7	U	1.6	U	1.8	U	1.7	U	1.7	U	1.8	U
1,2,4-Trichlorobenzene	No	No		6.1	U	1.9	U	1.9	U	1.9	U	1.8	U	1.7	U	1.6	U	1.8	U	1.7	U	1.7	U	1.8	U
1,2,4-Trimethylbenzene	Yes	Yes		13		54		1.9	U	1.9	U	1.8	U	1.7	U	1.6	U	1.8	U	1.7	U	1.7	U	3.2	
1,2-Dibromoethane	No	No		6.1	U	1.9	U	1.9	U	1.9	U	1.8	U	1.7	U	1.6	U	1.8	U	1.7	U	1.7	U	1.8	U
1,2-Dichlorobenzene	No	No		6.1	U	1.9	U	1.9	U	1.9	U	1.8	U	1.7	U	1.6	U	1.8	U	1.7	U	1.7	U	1.8	U
1,2-Dichloroethane	No	Yes		6.1	U	1.9	U	1.9	U	1.9	U	1.8	U	1.7	U	1.6	U	1.8	U	1.7	U	1.7	U	1.8	U
1,2-Dichloroethylene, cis	No	No		6.1	U	1.9	U	1.9	U	1.9	U	1.8	U	1.7	U	1.6	U	1.8	U	1.7	U	1.7	U	1.8	U
1,2-Dichloroethylene, trans	No	No		6.1	U	1.9	U	1.9	U	1.9	U	1.8	U	1.7	U	1.6	U	1.8	U	1.7	U	1.7	U	1.8	U
1,2-Dichloropropane	No	No		6.1	U	1.9	U	1.9	U	1.9	U	1.8	U	1.7	U	1.6	U	1.8	U	1.7	U	1.7	U	1.8	U
1,2-Dichlorotetrafluoroethane	No	No		6.1	U	1.9	U	1.9	U	1.9	U	1.8	U	1.7	U	1.6	U	1.8	U	1.7	U	1.7	U	1.8	U
1,3,5-Trimethylbenzene	Yes	Yes		6.1	U	19		1.9	U	1.9	U	1.8	U	1.7	U	1.6	U	1.8	U	1.7	U	1.7	U	1.8	U
1,3-Butadiene	Yes	No		220		100		2.4		3.4		1.8	U	1.7	U	1.8		6.3		1.7	U	3.9		12	
1,3-Dichloro-1-propene, cis	No	No		6.1	U	1.9	U	1.9	U	1.9	U	1.8	U	1.7	U	1.6	U	1.8	U	1.7	U	1.7	U	1.8	U
1,3-Dichloro-1-propene, trans	No	No		6.1	U	1.9	U	1.9	U	1.9	U	1.8	U	1.7	U	1.6	U	1.8	U	1.7	U	1.7	U	1.8	U
1,3-Dichlorobenzene	No	No		6.1	U	1.9	U	1.9	U	1.9	U	1.8	U	1.7	U	1.6	U	1.8	U	1.7	U	1.7	U	1.8	U
1,4-Dichlorobenzene	No	No		6.1	U	1.9	U	1.9	U	1.9	U	1.8	U	1.7	U	1.6	U	1.8	U	1.7	U	1.7	U	1.8	U
2-Hexanone	Yes	No		6.1	U	1.9	U	2.5		1.9	U	1.8	U	1.7	U	1.6	U	1.8	U	1.7	U	1.7	U	3	
4-Ethyltoluene	Yes	No		6.1	U	11		1.9	U	1.9	U	1.8	U	1.7	U	1.6	U	1.8	U	1.7	U	1.7	U	7.2	
Acetone	Yes	Yes		120		240		80		30		30		24		41		60		28		73		54	
Benzene	Yes	Yes		200		77		2.3		3		1.8	U	1.7	U	1.6	U	6		14		12		54	
Benzyl chloride	No	No		6.1	U	1.9	U	1.9	U	1.9	U	1.8	U	1.7	U	1.6	U	1.8	U	1.7	U	1.7	U	1.8	U
Bromodichloromethane	No	Yes		6.1	U	1.9	U	1.9	U	1.9	U	1.8	U	1.7	U	1.6	U	1.8	U	1.7	U	1.7	U	1.8	U
Bromoform	No	No		6.1	U	1.9	U	1.9	U	1.9	U	1.8	U	1.7	U	1.6	U	1.8	U	1.7	U	1.7	U	1.8	U
Bromomethane	No	No		6.1	U	1.9	U	1.9	U	1.9	U	1.8	U	1.7	U	1.6	U	1.8	U	1.7	U	1.7	U	1.8	U
Carbon disulfide	Yes	No		1100		32		19	U	19	U	21		17	U	16	U	18	U	17	U	17	U	18	U
Carbon tetrachloride	No	No		6.1	U	1.9	U	1.9	U	1.9	U	1.8	U	1.7	U	1.6	U	1.8	U	1.7	U	1.7	U	1.8	U
Chlorobenzene	No	No		6.1	U	1.9	U	1.9	U	1.9	U	1.8	U	1.7	U	1.6	U	1.8	U	1.7	U	1.7	U	1.8	U
Chlorodibromomethane	No	No		6.1	U	1.9	U	1.9	U	1.9	U	1.8	U	1.7	U	1.6	U	1.8	U	1.7	U	1.7	U	1.8	U
Chloroethane	Yes	No		6.1	U	3.8		1.9	U	1.9	U	1.8	U	1.7	U	1.6	U	1.8	U	1.7	U	1.7	U	1.8	U
Chloroform	No	Yes		6.1	U	1.9	U	1.9	U	1.9	U	1.8	U	1.7	U	1.6	U	1.8	U	1.7	U	1.7	U	1.8	U
Chloromethane	Yes	No		19		1.9	U	1.9	U	1.9	U	1.8	U	1.7	U	1.6	U	1.8	U	1.7	U	1.7	U	1.8	U
Cyclohexane	Yes	No		61		30		3.9	U	3.7	U	3.6	U	3.5	U	3.3	U	3.6	U	3.5	U	3.9		3.6	U
Dichlorodifluoromethane (CFC-12)	Yes	No		6.1	U	1.9	U	2		1.9		1.9		2.9		2		2		2		2		1.8	
Ethyl acetate	Yes	No		12	U	3.8	U	3.9	U	4.1		3.6	U	3.5	U	3.3	U	3.6	U	3.5	U	3.3	U	3.6	U
Ethyl alcohol	Yes	No		61	U	19	U	19	U	20		18	U	17	U	16	U	18	U	17	U	17	U	18	U
Ethyl benzene	Yes	Yes		24		38		2.5		1.9	U	1.8	U	1.7	U	1.6	U	1.8	U	1.7	U	1.7	U	24	
Heptane	Yes	No		61		160		4.1		1.9	U	1.8	U	1.7	U	1.6	U	3.6		1.7	U	1.9		15	
Hexachlorobutadiene	No	No		6.1	U	1.9	U	1.9	U	1.9	U	1.8	U	1.7	U	1.6	U	1.8	U	1.7	U	1.7	U	1.8	U
Hexane (C6)	Yes	No		66		190		4.3		2.6		1.8	U	6.9		1.7		5.2		1.8		4.7		19	
Isopropyl alcohol	Yes	No		61	U	19	U	19	U	19	U	18	U	17	U	16	U	18	U	17	U	17	U	18	U
Methyl ethyl ketone (2-butanone)	Yes	No		61	U	93		25		19	U	18	U	17	U	16	U	22		17	U	23		18	
Methyl isobutyl ketone (MIBK)	Yes	No		7		7.4		1.9	U	1.9	U	1.8	U	1.7	U	1.6	U	1.8	U	1.7	U	1.7	U	1.8	U
Methyl tertiary butyl ether (MTBE)	No	No		6.1	U	1.9	U	1.9	U	1.9	U	1.8	U	1.7	U	1.6	U	1.8	U	1.7	U	1.7	U	1.8	U
Methylene chloride	Yes	Yes		6.1	U	1.9	U	1.9	U	1.9	U	1.8	U	9.3		1.6	U	1.8	U	1.7	U	1.7	U	1.8	U
Naphthalene	Yes	Yes		6.1	U	160		1.9	U	1.9	U	1.8	U	1.7	U	1.6	U	1.8	U	1.7	U	1.7	U	1.8	U
Propylene	Yes	No		440		1100		32		50		4.1		1.7	U	43		91		25		70		130	
Styrene	Yes	Yes		25		7.8		1.9	U	1.9	U	1.8	U	1.7	U	1.6	U	1.8	U	1.7	U	1.7	U	1.8	U
Tetrachloroethylene	Yes	Yes		6.1	U	1.9	U	1.9	U	1.9	U	1.8	U	1.7	U	1.6	U	1.8	U	1.7	U	1.7	U	1.8	U
Tetrahydrofuran	No	No		6.1	U	1.9	U	1.9	U	1.9	U	1.8	U	1.7	U	1.6	U	1.8	U	1.7	U	1.7	U	1.8	U
Toluene	Yes	Yes		86		110		4.1		5.4		1.8	U	7.9		1.9		4.9		5		6.1		17	
Trichloroethylene	No	Yes		6.1	U	1.9	U	1.9	U	1.9	U	1.8	U	1.7	U	1.6	U	1.8	U	1.7	U	1.7	U	1.8	U
Trichlorofluoromethane	Yes	Yes		6.1	U	1.9	U	1.9	U	1.9	U	1.8	U	1.7	U	1.6	U	1.8	U	1.7	U	1.7	U	1.8	U
Trichlorotrifluoroethane (Freon 113)	No	No		6.1	U	1.9	U	1.9	U	1.9	U	1.8	U	1.7	U	1.6	U	1.8	U	1.7	U	1.7	U	1.8	U
Vinyl acetate	No	No		61	U	19	U	19	U	19	U	18	U	17	U	16	U	18	U	17	U	17	U	18	U
Vinyl chloride	No	No		6.1	U	1.9	U	1.9	U	1.9	U	1.8	U	1.7	U	1.6	U	1.8	U	1.7	U	1.7	U	1.8	U
Xylene, m & p	Yes	Yes		23		62		3.9	U	3.7	U	3.6	U	3.5	U	3.3	U	3.6	U	3.5	U	3.3	U	7.6	
Xylene, o	Yes	Yes		14		35		1.9	U	1.9	U	1.8	U	1.7	U	1.6	U	1.8	U	1.7	U	1.7	U	3.2	
Total MAH, ND = 0	Yes	Yes		385		413.8		8.9		8.4		0	U	7.9		1.9		10.9		19		18.1		116.2	

Table 1 Soil Gas Sampling Results, Heartland Apartments

Analyte	Detected in Soil Gas or Sub-slab Soil Gas	Detected in Soil or Groundwater in Vicinity	Location / Sample Date / Sample Type	SG-HLA-15 11/13/15 Soil Gas		SG-HLA-16 11/13/15 Soil Gas		SG-HLA-17 11/13/15 Soil Gas		SG-HLA-18 11/11/15 Soil Gas		SS-HLA-01 2/8/16 Sub-slab		SS-HLA-02 2/8/16 Sub-slab		SS-HLA-03 2/8/16 Sub-slab		SS-HLA-04 2/8/16 Sub-slab		SS-HLA-05 2/8/16 Sub-slab		SS-HLA-06 2/8/16 Sub-slab		SS-HLA-06 2/8/16 Sub-slab	
1,1,1-Trichloroethane	No	No		1.8	U	1.8	U	1.7	U	73	U	2.1	U	1.9	U	4.2	U	1.9	U	1.9	U	1.9	U	1.9	U
1,1,2,2-Tetrachloroethane	No	No		1.8	U	1.8	U	1.7	U	73	U	2.1	U	1.9	U	4.2	U	1.9	U	1.9	U	1.9	U	1.9	U
1,1,2-Trichloroethane	No	No		1.8	U	1.8	U	1.7	U	73	U	2.1	U	1.9	U	4.2	U	1.9	U	1.9	U	1.9	U	1.9	U
1,1-Dichloroethane	No	No		1.8	U	1.8	U	1.7	U	73	U	2.1	U	1.9	U	4.2	U	1.9	U	1.9	U	1.9	U	1.9	U
1,1-Dichloroethylene	No	Yes		1.8	U	1.8	U	1.7	U	73	U	2.1	U	1.9	U	4.2	U	1.9	U	1.9	U	1.9	U	1.9	U
1,2,4-Trichlorobenzene	No	No		1.8	U	1.8	U	1.7	U	73	U	2.1	U	1.9	U	4.2	U	1.9	U	1.9	U	1.9	U	1.9	U
1,2,4-Trimethylbenzene	Yes	Yes		4.1		17		19		590		80		1.9	U	4.2	U	1.9	U	1.9	U	1.9	U	1.9	U
1,2-Dibromoethane	No	No		1.8	U	1.8	U	1.7	U	73	U	2.1	U	1.9	U	4.2	U	1.9	U	1.9	U	1.9	U	1.9	U
1,2-Dichlorobenzene	No	No		1.8	U	1.8	U	1.7	U	73	U	2.1	U	1.9	U	4.2	U	1.9	U	1.9	U	1.9	U	1.9	U
1,2-Dichloroethane	No	Yes		1.8	U	1.8	U	1.7	U	73	U	2.1	U	1.9	U	4.2	U	1.9	U	1.9	U	1.9	U	1.9	U
1,2-Dichloroethylene, cis	No	No		1.8	U	1.8	U	1.7	U	73	U	2.1	U	1.9	U	4.2	U	1.9	U	1.9	U	1.9	U	1.9	U
1,2-Dichloroethylene, trans	No	No		1.8	U	1.8	U	1.7	U	73	U	2.1	U	1.9	U	4.2	U	1.9	U	1.9	U	1.9	U	1.9	U
1,2-Dichloropropane	No	No		1.8	U	1.8	U	1.7	U	73	U	2.1	U	1.9	U	4.2	U	1.9	U	1.9	U	1.9	U	1.9	U
1,2-Dichlorotetrafluoroethane	No	No		1.8	U	1.8	U	1.7	U	73	U	2.1	U	1.9	U	4.2	U	1.9	U	1.9	U	1.9	U	1.9	U
1,3,5-Trimethylbenzene	Yes	Yes		1.8	U	9.6		3.7		430		19		1.9	U	4.2	U	1.9	U	1.9	U	1.9	U	1.9	U
1,3-Butadiene	Yes	No		13		47		3.2		73	U	2.1	U	3		4.2	U	1.9	U	1.9	U	1.9	U	1.9	U
1,3-Dichloro-1-propene, cis	No	No		1.8	U	1.8	U	1.7	U	73	U	2.1	U	1.9	U	4.2	U	1.9	U	1.9	U	1.9	U	1.9	U
1,3-Dichloro-1-propene, trans	No	No		1.8	U	1.8	U	1.7	U	73	U	2.1	U	1.9	U	4.2	U	1.9	U	1.9	U	1.9	U	1.9	U
1,3-Dichlorobenzene	No	No		1.8	U	1.8	U	1.7	U	73	U	2.1	U	1.9	U	4.2	U	1.9	U	1.9	U	1.9	U	1.9	U
1,4-Dichlorobenzene	No	No		1.8	U	1.8	U	1.7	U	73	U	2.1	U	1.9	U	4.2	U	1.9	U	1.9	U	1.9	U	1.9	U
2-Hexanone	Yes	No		3.7		1.8	U	1.7	U	73	U	2.1	U	1.9	U	4.2	U	1.9	U	1.9	U	2.9		3.8	
4-Ethyltoluene	Yes	No		8.6		3.2		2.3		170		17		1.9	U	4.2	U	1.9	U	1.9	U	1.9	U	1.9	U
Acetone	Yes	Yes		58		71		45		730	U	120		71		130		52		100		33		46	
Benzene	Yes	Yes		59		140		230		10000		2.2		3.9		4.2	U	1.9	U	1.9	U	1.9	U	1.9	U
Benzyl chloride	No	No		1.8	U	1.8	U	1.7	U	73	U	2.1	U	1.9	U	4.2	U	1.9	U	1.9	U	1.9	U	1.9	U
Bromodichloromethane	No	Yes		1.8	U	1.8	U	1.7	U	73	U	2.1	U	1.9	U	4.2	U	1.9	U	1.9	U	1.9	U	1.9	U
Bromoform	No	No		1.8	U	1.8	U	1.7	U	73	U	2.1	U	1.9	U	4.2	U	1.9	U	1.9	U	1.9	U	1.9	U
Bromomethane	No	No		1.8	U	1.8	U	1.7	U	73	U	2.1	U	1.9	U	4.2	U	1.9	U	1.9	U	1.9	U	1.9	U
Carbon disulfide	Yes	No		18	U	40		17	U	730	U	21	U	19	U	42	U	19	U	19	U	19	U	19	U
Carbon tetrachloride	No	No		1.8	U	1.8	U	1.7	U	73	U	2.1	U	1.9	U	4.2	U	1.9	U	1.9	U	1.9	U	1.9	U
Chlorobenzene	No	No		1.8	U	1.8	U	1.7	U	73	U	2.1	U	1.9	U	4.2	U	1.9	U	1.9	U	1.9	U	1.9	U
Chlorodibromomethane	No	No		1.8	U	1.8	U	1.7	U	73	U	2.1	U	1.9	U	4.2	U	1.9	U	1.9	U	1.9	U	1.9	U
Chloroethane	Yes	No		1.8	U	1.8	U	1.7	U	73	U	2.1	U	1.9	U	4.2	U	1.9	U	1.9	U	1.9	U	1.9	U
Chloroform	No	Yes		1.8	U	1.8	U	1.7	U	73	U	2.1	U	1.9	U	4.2	U	1.9	U	1.9	U	1.9	U	1.9	U
Chloromethane	Yes	No		1.8	U	1.8	U	1.7	U	73	U	2.1	U	1.9	U	4.2	U	1.9	U	1.9	U	1.9	U	1.9	U
Cyclohexane	Yes	No		3.7	U	18		8.9		150	U	4.2	U	3.8	U	8.5	U	3.7	U	3.7	U	3.9	U	3.8	U
Dichlorodifluoromethane (CFC-12)	Yes	No		1.9		1.8	U	1.9		73	U	30		23		38		7.1		81		58		60	
Ethyl acetate	Yes	No		3.7	U	5.3		3.5	U	150	U	59		3.8	U	14		3.7	U	9.7		20		8.8	
Ethyl alcohol	Yes	No		19		18	U	17	U	730	U	46		25		150		32		89		56		70	
Ethyl benzene	Yes	Yes		26		22		39		740		6.2		1.9	U	4.2	U	1.9	U	1.9	U	1.9	U	1.9	U
Heptane	Yes	No		15		31		12		120		20		220		300		1.9	U	1.9	U	1.9	U	1.9	U
Hexachlorobutadiene	No	No		1.8	U	1.8	U	1.7	U	73	U	2.1	U	1.9	U	4.2	U	1.9	U	1.9	U	1.9	U	1.9	U
Hexane (C6)	Yes	No		20		49		9.7		130		35		140		700		1.9	U	1.9	U	1.9	U	1.9	U
Isopropyl alcohol	Yes	No		18	U	18	U	17	U	730	U	100		19	U	42	U	19	U	19	U	19	U	19	U
Methyl ethyl ketone (2-butanone)	Yes	No		21		21		17	U	730	U	290		19	U	42	U	19	U	19	U	19	U	19	U
Methyl isobutyl ketone (MIBK)	Yes	No		1.8	U	1.8	U	1.7	U	73	U	6.1		1.9	U	4.2	U	1.9	U	1.9	U	4.4		5.2	
Methyl tertiary butyl ether (MTBE)	No	No		1.8	U	1.8	U	1.7	U	73	U	2.1	U	1.9	U	4.2	U	1.9	U	1.9	U	1.9	U	1.9	U
Methylene chloride	Yes	Yes		1.8	U	1.8	U	1.7	U	73	U	2.1	U	1.9	U	4.2	U	1.9	U	1.9	U	1.9	U	1.9	U
Naphthalene	Yes	Yes		2.2		14		7.3		73	U	6.6		1.9	U	4.2	U	1.9	U	1.9	U	1.9	U	1.9	U
Propylene	Yes	No		130		280		50		160		20		17		10		1.9	U	4		1.9	U	4.1	
Styrene	Yes	Yes		1.8	U	12		1.7	U	73	U	2.1	U	1.9	U	4.2	U	1.9	U	1.9	U	1.9	U	1.9	U
Tetrachloroethylene	Yes	Yes		1.8	U	1.8	U	1.7	U	73	U	2.1	U	1.9	U	4.2	U	2.3		1.9	U	1.9	U	1.9	U
Tetrahydrofuran	No	No		1.8	U	1.8	U	1.7	U	73	U	2.1	U	1.9	U	4.2	U	1.9	U	1.9	U	1.9	U	1.9	U
Toluene	Yes	Yes		18		84		11		81		15		2.7		5.3		1.9	U	3.2		2.3		1.9	U
Trichloroethylene	No	Yes		1.8	U	1.8	U	1.7	U	73	U	2.1	U	1.9	U	4.2	U	1.9	U	1.9	U	1.9	U	1.9	U
Trichlorofluoromethane	Yes	Yes		1.8	U	1.8	U	1.7	U	73	U	2.1	U	2.5		4.2	U	1.9	U	4.4		1.9	U	1.9	U
Trichlorotrifluoroethane (Freon 113)	No	No		1.8	U	1.8	U	1.7	U	73	U	2.1	U	1.9	U	4.2	U	1.9	U	1.9	U	1.9	U	1.9	U
Vinyl acetate	No	No		18	U	18	U	17	U	730	U	21	U	19	U	42	U	19	U	19	U	19	U	19	U
Vinyl chloride	No	No		1.8	U	1.8	U	1.7	U	73	U	2.1	U	1.9	U	4.2	U	1.9	U	1.9	U	1.9	U	1.9	U
Xylene, m & p	Yes	Yes		9.2		40		28		980		27		3.8	U	8.5	U	3.7	U	3.7	U	3.9	U	3.8	U
Xylene, o	Yes	Yes		3.6		21		23		82		11		1.9	U	4.2	U	1.9	U	1.9	U	1.9	U	1.9	U
Total MAH, ND = 0	Yes	Yes		128.5		348.8		356		13073		177.4		6.6		5.3		0	U	3.2		2.3		0	U

Notes:

Data obtained from Barr (2015, 2016b).

MAH = Monocyclic Aromatic Hydrocarbon; ND = Not Detected; U = Analyte Not Detected Above Specified Detection Limit.

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NO.	BY	CHK.	APP.	DATE	REVISION DESCRIPTION

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HEARTLAND APARTMENTS
FARGO, ND
FIGURE 1
APARTMENT BUILDING LAYOUT

BARR PROJECT No. 34091030.00
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DWG. No.
REV. No.

SOURCE: Barr, 2016c.

GRADIENT

Heartland Apartments
Building Layout
Fargo, ND

FIGURE
1
Date: 3/4/2016

GRADIENT

Sub-slab and Soil Gas Sampling Results (Total MAH and Naphthalene)

Fargo, ND

FIGURE 2

Date: 4/1/2016

Attachment A

Preliminary Risk Evaluation, Heartland Apartments Vapor Intrusion Pathway

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List of Tables

**Table numbering conforms with US EPA risk assessment table numbering guidelines.*

Abbreviations

ATSDR	Agency for Toxic Substances and Disease Registry
CalEPA	California Environmental Protection Agency
COPC	Chemical of Potential Concern
ELCR	Excess Lifetime Cancer Risk
EPC	Exposure Point Concentration
HEAST	Health Effects Assessment Summary Table
HI	Hazard Index
HQ	Hazard Quotient
IRIS	Integrated Risk Information System
IUR	Inhalation Unit Risk
PPRTV	Provisional Peer Reviewed Toxicity Value
RfC	Reference Concentration
RSL	Regional Screening Level
UCLM	Upper Confidence Limit on the Mean
US EPA	United States Environmental Protection Agency
VISL	Vapor Intrusion Screening Level
VOC	Volatile Organic Compound

A.1 Preliminary Risk Evaluation

A.1.1 Potential Receptors and Pathways

This human health risk evaluation is focused on the vapor intrusion pathway at the Heartland Apartments Property (hereafter, "Heartland Apartments"), which is zoned as residential and expected to remain as such. Accordingly, the following receptors were assessed in the risk evaluation:

- A current/future Resident[1] in each of the three Site buildings (North, South, and West) to account for adult or child Residents of the Site.

An adult or child resident could potentially be exposed to volatile organic compounds (VOC) and naphthalene that may infiltrate from the subsurface into the apartment buildings. This potential exposure was evaluated based on sub-slab soil gas data collected beneath the Heartland Apartments Building A (West) and based on exterior soil gas data collected from locations adjacent to Buildings B (South) the C (North). Sub-slab soil gas data for Buildings B and C were not available at the time of analysis.

The exposure scenario used to evaluate a hypothetical Resident of Heartland Apartments is based on generic United States Environmental Protection Agency (US EPA) assumptions that are intended to be conservative and health-protective. The Resident is assumed to have an exposure frequency of 350 days per year (accounting for 15 days per year spent away from home) and an exposure duration of 6 years as a child and 9 years as an adult for a total exposure of 15 years (US EPA, 2004). In the absence of site specific exposure duration values, the exposure duration is based on the central tendency national statistics for the number of years spent by individuals at one residence (US EPA, 1989, 2004). US EPA's (2011a) most recent recommendation for the mean time spent at 1 residence is 12 years. This estimate is based on US Census Bureau studies and is expected to be representative of the US population (US EPA, 2011a).

A.1.2 Data Selection

Data used in the risk evaluation included sub-slab soil gas and exterior soil gas data collected in 2015 and 2016.

- For Building A, data from six sub-slab soil gas sampling locations (including six samples and one field duplicate[2]) were used in the risk evaluation. The soil gas samples collected from outside Building A[3] were excluded from the risk evaluation because US EPA (2015a) guidance states that sub-slab samples are preferable to exterior soil gas samples for assessing vapor intrusion in building structures.
- For Building B, data collected from four exterior soil gas sampling locations adjacent to the building were used in the risk evaluation.

[1] Receptor populations (*e.g.*, Resident) are capitalized as proper nouns as they refer to the hypothetical receptor evaluated according to US EPA exposure scenarios.
[2] For the risk evaluation, the field duplicate samples were averaged with their parent sample to obtain one result per sample.
[3] Soil gas samples: SG-HLA-07, SG-HLA-08, SG-HLA-17, and SG-HLA-18.

- For Building C, data collected from four exterior soil gas sampling locations (including four samples and one field duplicate sample[4]) were used in the risk evaluation.

For Buildings B and C, sub-slab soil gas samples were not collected (in order to minimize disruption to tenants) and were not considered necessary based on the risk evaluation results (described below).

Table 1 of the main report presents the soil gas data used in this evaluation.

A.1.2.1 Soil Gas and Sub-slab Soil Gas Data Used

Fifteen exterior soil gas samples (fourteen samples and one field duplicate) were collected adjacent to Heartland Apartments in November 2015. The nine soil gas samples (eight samples and one field duplicate) collected adjacent to Buildings B and C were used to assess potential exposure to VOCs and naphthalene in indoor air. Sub-slab soil gas samples collected in February 2016 from six locations (SS-HLA-01 through SS-HLA-06) beneath the Building A were used to assess potential exposure to VOCs and naphthalene in indoor air.

A.1.3 Selection of Chemicals of Potential Concern

A screening level analysis was conducted to identify the chemicals of potential concern (COPCs) to be evaluated in the quantitative risk evaluation. The maximum detected soil gas/sub-slab concentrations were screened against risk-based screening criteria for soil gas. For sub-slab soil gas and exterior soil gas, the maximum detected concentrations were screened against the US EPA Vapor Intrusion Screening Levels (VISLs) for residential sub-slab and exterior soil gas (US EPA, 2015b).

The US EPA (2015c) Regional Screening Level (RSL) guidelines indicate that a target hazard quotient (HQ) of 0.1 should be used for "multiple chemical" risk evaluations; therefore, the US EPA VISLs used for residential screening were those where non-cancer hazard are calculated with a target HQ of 0.1. Similarly, for cancer risks, RSLs and VISLs were calculated with a target risk of 1×10^{-6}.

For several compounds with no published screening criteria, a screening value for a suitable surrogate compound was used. Surrogates were chosen based on compounds with similar structures that were expected to be toxicologically similar.

- For heptanes, hexane was used.
- For m- and p-xylenes, total xylenes was used.

Field duplicate samples were averaged with their parent sample to obtain one result per sample.

A.1.3.1 Screening Results

The results of the screening evaluation and the preliminary identification of COPCs are summarized below. Detailed screening results are presented in Attachment A, Table 2.1. Analytes with maximum concentrations above the risk-based screening criteria were retained as COPCs for the risk evaluation. Compounds without screening criteria were also retained for further evaluation in the risk evaluation.

[4] For the risk evaluation, the field duplicate samples were averaged with their parent sample to obtain one result per sample.

Based on the screening analysis, the following seven compounds were retained as COPCs:

- Sub-slab Soil Gas (Building A):
  - Four VOCs (1,2,4-trimethylbenzene, 1,3,5-trimethylbenzene, 4-ethyltoluene, and ethyl alcohol) and naphthalene.
- Exterior Soil Gas (Building B):
  - Five VOCs (1,3,5-trimethylbenzene, 1,3-butadiene, 4-ethyltoluene, benzene, and ethyl alcohol) and naphthalene.
- Exterior Soil Gas (Building C):
  - One VOC (1,3-butadiene).

A.1.4 Exposure Point Concentrations for COPCs

In a risk evaluation, an exposure point concentration (EPC) represents the concentration of a chemical in an environmental medium to which an individual is potentially exposed. Sub-slab soil gas and exterior soil gas EPCs were calculated as the 95% Upper Confidence Limit on the Mean (UCLM), or the maximum value, whichever is lower. The data set used in the EPC calculations are presented in Table 1 of the main report, and discussed in Section A.1.2.

The 95% UCLM values for sub-slab soil gas and exterior soil gas were calculated using US EPA's ProUCL software Version 5 (US EPA, 2013) using the option that specifies whether a value is a non-detect. If the 95% UCLM was higher than the maximum detected value, the maximum detected concentration within the exposure area was used as the EPC.

Indoor air EPCs were calculated by applying a sub-slab soil gas attenuation factor (0.03) to the sub-slab soil gas and exterior soil gas EPCs. This attenuation factor accounts for dilution from mixing with air inside a building and during migration of soil gas through cracks in the foundation (US EPA, 2015a). EPCs are provided in Attachment A, Table 3.1.

A.1.5 Quantification of Exposure

This section discusses the basis for calculating human intake levels resulting from exposures to COPCs and describes each input parameter. For inhalation, exposure estimates represent the theoretical, calculated daily exposure of a chemical taken into the body, averaged over the appropriate exposure period. Exposure factors (*e.g.*, exposure frequency, exposure duration) are the parameters that are used to calculate a receptor's exposure for a given exposure scenario. The values used for each exposure factor are summarized in Attachment A, Table 4.1 and are discussed below. The exposure factor input values are consistent with current US EPA guidance (US EPA, 2004, 2014). Where appropriate, exposure parameters were based on site-specific considerations and professional judgment.

Cancer risks for the Resident are calculated separately for carcinogens with mutagenic modes of action to account for potentially increased susceptibility to mutagenic carcinogens for early life exposures (US EPA, 2005). None of the COPCs for the vapor intrusion pathway are classified by US EPA as mutagens (US EPA, 2015d).

A.1.5.1 Inhalation of Indoor Air

VOCs and naphthalene in soil and groundwater can volatilize and migrate into indoor air, resulting in potential indoor air exposure to residents. For inhalation of VOCs and naphthalene in indoor air *via* the vapor intrusion pathway, an average daily exposure was calculated using the following equation from US EPA (2009) guidance:

$$EC = \frac{EPC_{air} \times ET \times EF \times ED \times CF1 \times CF2}{AT}$$

where:

EC	=	Exposure Concentration (µg/m^3);
EPC_{air}	=	Exposure Point Concentration of Chemical in Indoor Air (mg/m^3);
ET	=	Exposure Time (hours/day);
EF	=	Exposure Frequency (days/year);
ED	=	Exposure Duration (years);
AT	=	Averaging Time (days);
CF1	=	Conversion Factor (1 day/24 hours); and
CF2	=	Conversion Factor (µg/mg).

Indoor Air Concentrations (EPC_{air}). The lower of either the 95% UCLM or the maximum detected concentration in soil gas was used to model the indoor air EPC using US EPA's default sub-slab and soil gas attenuation factor of 0.03 for residential exposures (US EPA, 2015b) (Attachment A, Table 3.1).

Exposure Time (ET), Exposure Duration (ED), and Exposure Frequency (EF). Residents were assumed to be exposed to indoor air 24 hours a day, 350 days a year, for 15 years (6 years as a child and 9 years as an adult).

Averaging Time (AT): For non-cancer hazards, the averaging time was equal to the exposure duration multiplied by 365 days/year. For cancer risks, exposures were averaged over a 70-year average lifetime (US EPA, 2014).

A.1.6 Toxicity Assessment

A.1.6.1 Overview of Toxicity Values

Potential cancer risk and non-cancer hazard were evaluated using dose-response relationships for carcinogenicity (Inhalation Unit Risk [IUR]) and systemic toxicity (inhalation Reference Concentrations [RfC]s). As per US EPA (2003), toxicity values were obtained from a hierarchy of sources. The primary source of toxicity values was US EPA's Integrated Risk Information System (IRIS). Toxicity values in IRIS undergo a rigorous peer review process and are generally considered to be of high quality. Additional toxicity values were obtained from US EPA's Provisional Peer Reviewed Toxicity Values (PPRTVs), followed by tertiary sources such as the Health Effects Assessment Summary Tables (HEASTs), the Agency for Toxic Substances and Disease Registry (ATSDR), or the California Environmental Protection Agency (CalEPA). The toxicity values used are consistent with those used in the US EPA RSL Table (US EPA, 2015d).

Toxicity factors are summarized in Attachment A, Tables 5.2 and 6.2 which also includes the source of the toxicity values and the form of the compound upon which they are based.

A.1.6.2 Inhalation Reference Concentrations

Inhalation RfCs are used to evaluate systemic toxicity *via* inhalation exposure as per US EPA (2009). An inhalation RfC is "an estimate…of a continuous inhalation exposure to the human population (including sensitive subgroups) that is likely to be without appreciable risk of deleterious effects during a lifetime" (US EPA, 2011b). The RfC values are given in units of mg/m^3 and are presented in Attachment A, Table 5.2.

A.1.6.3 Inhalation Unit Risk

Inhalation Unit Risk (IUR) values are used to evaluate inhalation carcinogenicity as recommended by US EPA (2009). An IUR is the "upper-bound excess lifetime cancer risk estimated to result from continuous exposure to an agent at a concentration of 1 $\mu g/m^3$ in air" (US EPA, 2011b). The IUR values are given in units of $(\mu g/m^3)^{-1}$ and are presented in Attachment A, Table 6.2.

A.1.7 Risk Characterization

This risk evaluation examined the cancer risk and non-cancer hazard for all receptors exposed to the various media in each exposure area. The total risk for each receptor is the sum of the risks over all COPCs and all exposure pathways.

A.1.7.1 Calculation of Cancer Risk

Cancer risks are characterized as the incremental probability that an individual will develop cancer during his or her lifetime due to chemical exposure to contaminants at the site under the specific exposure scenarios evaluated. The risks are calculated with the inputs for the exposure parameters that were described earlier in this report. The term "incremental" implies the risk above the background cancer risk experienced by all individuals in the course of daily life. According to the American Cancer Society, the lifetime probability of developing cancer (*i.e.*, background cancer risk) is slightly less than 1 in 2 (42%) for men and slightly more than 1 in 3 (38%) for women (ACS, 2016). The incremental risk above the background cancer risk is termed the "excess lifetime cancer risk" (ELCR). Cancer risks are expressed as a unitless probability (*e.g.*, 1 in 1 million, or 1×10^{-6}) of an individual developing cancer over a lifetime, above background risk, as a result of site-related exposures. US EPA has established a target cancer risk range of 1×10^{-6} to 1×10^{-4} (1 in 1 million to 1 in 10,000) (US EPA, 1990, 1991a).

Excess (incremental) cancer risks for the inhalation pathway was calculated as the inhalation exposure concentration (in $\mu g/m^3$) multiplied by the IUR:

$$CancerRisk = EC\left(\frac{\mu g}{m^3}\right) \times IUR\left(\frac{\mu g}{m^3}\right)^{-1}$$

Cancer risks were calculated for each exposure pathway and COPC according to US EPA guidance (US EPA, 1989). The total ELCR was the sum of the cancer risks across all COPCs and exposure pathways for each exposure area. Pursuant to US EPA guidance (US EPA, 1989), the total cancer risks were rounded to one significant digit for presentation.[5] Detailed cancer risk calculations are presented in Attachment A, Table 7.1.

A.1.7.2 Calculation of Non-cancer Hazard

Risks from non-carcinogenic effects are expressed as HQs rather than probabilities. An HQ compares the calculated exposures (exposures calculated as part of the exposure assessment in Section A.1.5) to concentrations derived by US EPA (RfCs) (summarized as part of the toxicity assessment in Section A.1.6).

For indoor air inhalation, the HQ was calculated as the inhalation exposure concentration (in mg/m[3]) divided by the inhalation RfC:

$$HazardQuotient = \frac{EC\left(\frac{mg}{m^3}\right)}{RfC\left(\frac{mg}{m^3}\right)}$$

HQs were calculated for each receptor, exposure pathway, and COPC according to US EPA guidance (US EPA, 1989). For each exposure route, HQs were summed across all COPCs to calculate a hazard index (HI). As per US EPA guidance, HIs were rounded to one significant figure, and HIs for the individual exposure pathways were rounded to two significant figures (US EPA, 1989). Detailed non-cancer hazard calculations are presented in Attachment A, Table 7.2.

US EPA considers an HI greater than 1 to exceed the target risk threshold. Because an HQ is simply a ratio of site exposures to reference exposure levels (RfDs, RfCs, *etc.*), HIs do not represent the probability that an adverse health effect will occur. An HI less than 1 suggests that exposures are likely to be without an appreciable risk of non-cancer effects during a lifetime. An HI greater than 1 indicates only that a potential may exist for adverse health effects. Unlike cancer risks, non-cancer HIs are not additive across different age groups for a resident. Typically, because child exposures are higher than adult exposures, the HI for a child resident represents the greatest HI experienced by that receptor during his or her lifetime.

Summing HQs for different COPCs represents a conservative approach that may overestimate actual Site risks, because the RfD or RfC for a COPC is calculated based on a specific toxicological endpoint (*e.g.*, liver or kidney effects). As recognized by US EPA (1989), summations are most valid for chemicals that are associated with similar toxicological endpoints (*i.e.,* they affect the same target organ or operate *via* similar mechanisms of action). Based on US EPA guidance, major effects categories for target organs or systems include neurotoxicity, developmental toxicity, reproductive toxicity, immunotoxicity, and adverse effects by target organ (*i.e.*, hepatic, renal, respiratory, cardiovascular, gastrointestinal, hematological, musculoskeletal, and dermal/ocular effect) (US EPA, 1989). The following target organs or systems were identified: adrenal, developmental, endocrine, gastrointestinal, hematological, hepatic, immunological, nervous system, renal, reproductive, respiratory, and skin. The target system was assigned as "systemic" when the critical effect was identified as decreased body weight, or when the effect was of unclear biological significance (*e.g.*, decreased hair cystine). In order to provide an accurate

[5] The use of significant figures in reporting risk results was presented in US EPA (1989, p. 8-8 for non-cancer hazard and p. 8-12 for cancer risk).

estimate of potential non-cancer health risks, the risk tables in Attachment A present the HIs summed by toxicological endpoint (Attachment A, Table 9.1).

A.1.8 Risk Results

Based on existing data, cancer risks and non-cancer hazards associated with the vapor intrusion pathway were assessed for the adult and child Resident living in each of the three buildings at the Heartland Apartments, as summarized below and in Attachment A, Tables 11 and 12.

As shown in Table 12, the major contributors to the cancer risk and non-cancer hazard for the Resident of the Building A are 1,2,4-trimethylbenzene and naphthalene. For Buildings B and C, the major contributor to the cancer risk and non-cancer hazard was identified as 1,3-butadiene.

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Tables

Table 2.1
Occurrence, Distribution, and Selection of Chemicals of Potential Concern

Scenario Timeframe:	Future
Medium:	Soil Gas
Exposure Medium:	Heartland Apartments - Sub-slab and Exterior Soil Gas

Exposure Point	Chemical Group	CAS Number	Chemical	Minimum Detected Concentration (Qualifier)	Maximum Detected Concentration (Qualifier)	Units	Location of Maximum Concentration	Detection Frequency	Range of Detection Limits	Concentration Used for Screening (1)	Screening Criteria (2)	Criteria Basis (2)	Exceeds Crit	COPC Flag (Y/N)	Rationale for Selection or Deletion (3)
Heartland Apartments A	VOC	100-41-4	Ethyl benzene	6.2	6.2	$\mu g/m^3$	SS-HLA-01	1/6	1.9-4.2	6.2	37	EPA VISL Residential (C)	0	No	BSL
Heartland Apartments A	VOC	106-99-0	1,3-Butadiene	3	3	$\mu g/m^3$	SS-HLA-02	1/6	1.9-4.2	3	3.1	EPA VISL Residential (C)	0	No	BSL
Heartland Apartments A	VOC	108-10-1	Methyl isobutyl ketone (MIBK)	4.4	6.1	$\mu g/m^3$	SS-HLA-01	2/6	1.9-4.2	6.1	10429	EPA VISL Residential (N)	0	No	BSL
Heartland Apartments A	VOC	108-67-8	1,3,5-Trimethylbenzene	19	19	$\mu g/m^3$	SS-HLA-01	1/6	1.9-4.2	19	NC			Yes	NC
Heartland Apartments A	VOC	108-88-3	Toluene	1.9	15	$\mu g/m^3$	SS-HLA-01	5/6	1.9-4.2	15	17381	EPA VISL Residential (N)	0	No	BSL
Heartland Apartments A	VOC	110-54-3	Hexane (C6)	35	700	$\mu g/m^3$	SS-HLA-03	3/6	1.9-4.2	700	2433	EPA VISL Residential (N)	0	No	BSL
Heartland Apartments A	VOC	115-07-1	Propylene	1.9	20	$\mu g/m^3$	SS-HLA-01	5/6	1.9-4.2	20	10429	EPA VISL Residential (N)	0	No	BSL
Heartland Apartments A	VOC	127-18-4	Tetrachloroethylene	2.3	2.3	$\mu g/m^3$	SS-HLA-04	1/6	1.9-4.2	2.3	139	EPA VISL Residential (N)	0	No	BSL
Heartland Apartments A	VOC	141-78-6	Ethyl acetate	8.8	59	$\mu g/m^3$	SS-HLA-01	4/6	3.7-8.5	59	243	EPA VISL Residential (N)	0	No	BSL
Heartland Apartments A	VOC	142-82-5	Heptane	20	300	$\mu g/m^3$	SS-HLA-03	3/6	1.9-4.2	300	2433	EPA VISL Residential (N, n-hexane)	0	No	BSL
Heartland Apartments A	VOC	591-78-6	2-Hexanone	2.9	3.8	$\mu g/m^3$	SS-HLA-06	1/6	1.9-4.2	3.8	104	EPA VISL Residential (N)	0	No	BSL
Heartland Apartments A	VOC	622-96-8	4-Ethyltoluene	17	17	$\mu g/m^3$	SS-HLA-01	1/6	1.9-4.2	17	NC			Yes	NC
Heartland Apartments A	VOC	64-17-5	Ethyl Alcohol	25	150	$\mu g/m^3$	SS-HLA-03	6/6	19-42	150	NC			Yes	NC
Heartland Apartments A	VOC	67-63-0	Isopropyl alcohol	100	100	$\mu g/m^3$	SS-HLA-01	1/6	19-42	100	695	EPA VISL Residential (N)	0	No	BSL
Heartland Apartments A	VOC	67-64-1	Acetone	33	130	$\mu g/m^3$	SS-HLA-03	6/6	19-42	130	107762	EPA VISL Residential (N)	0	No	BSL
Heartland Apartments A	VOC	71-43-2	Benzene	2.2	3.9	$\mu g/m^3$	SS-HLA-02	2/6	1.9-4.2	3.9	12	EPA VISL Residential (C)	0	No	BSL
Heartland Apartments A	VOC	75-69-4	Trichlorofluoromethane	2.5	4.4	$\mu g/m^3$	SS-HLA-05	2/6	1.9-4.2	4.4	2433	EPA VISL Residential (N)	0	No	BSL
Heartland Apartments A	VOC	75-71-8	Dichlorodifluoromethane (CFC-12)	7.1	81	$\mu g/m^3$	SS-HLA-05	6/6	1.9-4.2	81	348	EPA VISL Residential (N)	0	No	BSL
Heartland Apartments A	VOC	78-93-3	Methyl ethyl ketone (2-butanone)	290	290	$\mu g/m^3$	SS-HLA-01	1/6	19-42	290	17381	EPA VISL Residential (N)	0	No	BSL
Heartland Apartments A	VOC	91-20-3	Naphthalene	6.6	6.6	$\mu g/m^3$	SS-HLA-01	1/6	1.9-4.2	6.6	2.8	EPA VISL Residential (C)	1	Yes	ASL
Heartland Apartments A	VOC	95-47-6	Xylene, o	11	11	$\mu g/m^3$	SS-HLA-01	1/6	1.9-4.2	11	348	EPA VISL Residential (N)	0	No	BSL
Heartland Apartments A	VOC	95-63-6	1,2,4-Trimethylbenzene	80	80	$\mu g/m^3$	SS-HLA-01	1/6	1.9-4.2	80	24	EPA VISL Residential (N)	1	Yes	ASL
Heartland Apartments A	VOC	MPXYL	Xylene, m & p	27	27	$\mu g/m^3$	SS-HLA-01	1/6	3.7-8.5	27	348	EPA VISL Residential (N, total xylenes)	0	No	BSL
Heartland Apartments B	VOC	100-41-4	Ethylbenzene	22	26	$\mu g/m^3$	SG-HLA-15	2/4	1.7-1.8	26	37	EPA VISL Residential (C)	0	No	BSL
Heartland Apartments B	VOC	100-42-5	Styrene	12	12	$\mu g/m^3$	SG-HLA-16	1/4	1.7-1.8	12	3476	EPA VISL Residential (N)	0	No	BSL
Heartland Apartments B	VOC	106-99-0	1,3-Butadiene	3.9	47	$\mu g/m^3$	SG-HLA-16	3/4	1.7-1.8	47	3.1	EPA VISL Residential (C)	3	Yes	ASL
Heartland Apartments B	VOC	108-67-8	1,3,5-Trimethylbenzene	9.6	9.6	$\mu g/m^3$	SG-HLA-16	1/4	1.7-1.8	9.6	NC			Yes	NC
Heartland Apartments B	VOC	108-88-3	Toluene	5	84	$\mu g/m^3$	SG-HLA-16	4/4	1.7-1.8	84	17381	EPA VISL Residential (N)	0	No	BSL
Heartland Apartments B	VOC	110-54-3	Hexane (C6)	1.8	49	$\mu g/m^3$	SG-HLA-16	4/4	1.7-1.8	49	2433	EPA VISL Residential (N)	0	No	BSL
Heartland Apartments B	VOC	110-82-7	Cyclohexane	3.9	18	$\mu g/m^3$	SG-HLA-16	2/4	3.3-3.7	18	20857	EPA VISL Residential (N)	0	No	BSL
Heartland Apartments B	VOC	115-07-1	Propylene	25	280	$\mu g/m^3$	SG-HLA-16	4/4	1.7-1.8	280	10429	EPA VISL Residential (N)	0	No	BSL
Heartland Apartments B	VOC	141-78-6	Ethyl acetate	5.3	5.3	$\mu g/m^3$	SG-HLA-16	1/4	3.3-3.7	5.3	243	EPA VISL Residential (N)	0	No	BSL
Heartland Apartments B	VOC	142-82-5	Heptane	1.9	31	$\mu g/m^3$	SG-HLA-16	3/4	1.7-1.8	31	2433	EPA VISL Residential (N, hexane)	0	No	BSL
Heartland Apartments B	VOC	591-78-6	2-Hexanone	3	3.7	$\mu g/m^3$	SG-HLA-15	1/4	1.7-1.8	3.7	104	EPA VISL Residential (N)	0	No	BSL
Heartland Apartments B	VOC	622-96-8	4-Ethyltoluene	3.2	8.6	$\mu g/m^3$	SG-HLA-15	2/4	1.7-1.8	8.6	NC			Yes	NC
Heartland Apartments B	VOC	64-17-5	Ethyl Alcohol	18	19	$\mu g/m^3$	SG-HLA-15	1/4	17-18	19	NC			Yes	NC
Heartland Apartments B	VOC	67-64-1	Acetone	28	73	$\mu g/m^3$	SG-HLA-14	4/4	17-18	73	107762	EPA VISL Residential (N)	0	No	BSL
Heartland Apartments B	VOC	71-43-2	Benzene	12	140	$\mu g/m^3$	SG-HLA-16	4/4	1.7-1.8	140	12	EPA VISL Residential (C)	4	Yes	ASL
Heartland Apartments B	VOC	75-15-0	Carbon disulfide	40	40	$\mu g/m^3$	SG-HLA-16	1/4	17-18	40	2433	EPA VISL Residential (N)	0	No	BSL
Heartland Apartments B	VOC	75-71-8	Dichlorodifluoromethane (CFC-12)	1.8	2	$\mu g/m^3$	SG-HLA-13	3/4	1.7-1.8	2	348	EPA VISL Residential (N)	0	No	BSL
Heartland Apartments B	VOC	75-71-8	Dichlorodifluoromethane (CFC-12)	1.8	2	$\mu g/m^3$	SG-HLA-14	3/4	1.7-1.8	2	348	EPA VISL Residential (N)	0	No	BSL
Heartland Apartments B	VOC	78-93-3	Methyl ethyl ketone (2-butanone)	18	23	$\mu g/m^3$	SG-HLA-14	3/4	17-18	23	17381	EPA VISL Residential (N)	0	No	BSL
Heartland Apartments B	VOC	91-20-3	Naphthalene	1.8	14	$\mu g/m^3$	SG-HLA-16	2/4	1.7-1.8	14	2.8	EPA VISL Residential (C)	1	Yes	ASL
Heartland Apartments B	VOC	95-47-6	Xylene, o	3.2	21	$\mu g/m^3$	SG-HLA-16	2/4	1.7-1.8	21	348	EPA VISL Residential (N)	0	No	BSL
Heartland Apartments B	VOC	95-63-6	1,2,4-Trimethylbenzene	3.2	17	$\mu g/m^3$	SG-HLA-16	2/4	1.7-1.8	17	24	EPA VISL Residential (N)	0	No	BSL
Heartland Apartments B	VOC	MPXYL	Xylenes, m & p	7.6	40	$\mu g/m^3$	SG-HLA-16	2/4	3.3-3.7	40	348	EPA VISL Residential (N, total xylenes)	0	No	BSL

Table 2.1
Occurrence, Distribution, and Selection of Chemicals of Potential Concern

Scenario Timeframe:	Future
Medium:	Soil Gas
Exposure Medium:	Heartland Apartments - Sub-slab and Exterior Soil Gas

Exposure Point	Chemical Group	CAS Number	Chemical	Minimum Detected Concentration (Qualifier)	Maximum Detected Concentration (Qualifier)	Units	Location of Maximum Concentration	Detection Frequency	Range of Detection Limits	Concentration Used for Screening (1)	Screening Criteria (2)	Criteria Basis (2)	Exceeds Crit	COPC Flag (Y/N)	Rationale for Selection or Deletion (3)
Heartland Apartments C	VOC	106-99-0	1,3-Butadiene	1.8	6.3	$\mu g/m^3$	SG-HLA-12	2/4	1.6-1.8	6.3	3.1	EPA VISL Residential (C)	1	Yes	ASL
Heartland Apartments C	VOC	108-88-3	Toluene	1.9	7.9	$\mu g/m^3$	SG-HLA-10	3/4	1.6-1.8	7.9	17381	EPA VISL Residential (N)	0	No	BSL
Heartland Apartments C	VOC	110-54-3	Hexane (C6)	1.7	6.9	$\mu g/m^3$	SG-HLA-10	3/4	1.6-1.8	6.9	2433	EPA VISL Residential (N)	0	No	BSL
Heartland Apartments C	VOC	115-07-1	Propylene	4.1	91	$\mu g/m^3$	SG-HLA-12	3/4	1.6-1.8	91	10429	EPA VISL Residential (N)	0	No	BSL
Heartland Apartments C	VOC	142-82-5	Heptane	3.6	3.6	$\mu g/m^3$	SG-HLA-12	1/4	1.6-1.8	3.6	2433	EPA VISL Residential (N, hexane)	0	No	BSL
Heartland Apartments C	VOC	67-64-1	Acetone	24	60	$\mu g/m^3$	SG-HLA-12	4/4	16-18	60	107762	EPA VISL Residential (N)	0	No	BSL
Heartland Apartments C	VOC	71-43-2	Benzene	6	6	$\mu g/m^3$	SG-HLA-12	1/4	1.6-1.8	6	12	EPA VISL Residential (C)	0	No	BSL
Heartland Apartments C	VOC	75-09-2	Methylene chloride	9.3	9.3	$\mu g/m^3$	SG-HLA-10	1/4	1.6-1.8	9.3	2086	EPA VISL Residential (N)	0	No	BSL
Heartland Apartments C	VOC	75-15-0	Carbon disulfide	21	21	$\mu g/m^3$	SG-HLA-09	1/4	16-18	21	2433	EPA VISL Residential (N)	0	No	BSL
Heartland Apartments C	VOC	75-71-8	Dichlorodifluoromethane (CFC-12)	1.9	2.9	$\mu g/m^3$	SG-HLA-10	4/4	1.6-1.8	2.9	348	EPA VISL Residential (N)	0	No	BSL
Heartland Apartments C	VOC	78-93-3	Methyl ethyl ketone (2-butanone)	22	22	$\mu g/m^3$	SG-HLA-12	1/4	16-18	22	17381	EPA VISL Residential (N)	0	No	BSL

Notes:
Only analytes detected in at least one sample are presented.
VISL = Vapor Intrusion Screening Level.

(1) The maximum detected concentration was used for the screening.
(2) All compounds were screened against the US EPA (2015b) Vapor Intrusion Screening Levels (VISL) for commercial sub-slab and soil gas (THQ = 0.1; Target Cancer Risk = 10^{-6}).
(N) - Non-cancer.
(C) - Cancer.
(NC) - No criterion available.
(Surrogate/form) - Screening values of surrogate/chemical form used in the absence of chemical specific screening value.

(3) Rationale codes:
Selection reason: Above screening level (ASL).
Deletion reason: Below screening level (BSL).
(NC) - No criterion available.

Table 3.1
Exposure Point Concentrations

Scenario Timeframe:	Current/Future
Medium:	Soil Gas
Exposure Medium:	Indoor Air

Exposure Point	Chemical Group		Chemical of Potential Concern	Arithmetic Mean ($\mu g/m^3$)	95% UCLM ($\mu g/m^3$)	Maximum Concentration ($\mu g/m^3$)	Soil Gas Exposure Point Concentration ($\mu g/m^3$)	Statistic/Rationale	Modeled Indoor Air Concentration (EPC_{air}) (mg/m^3)
Heartland Apartments A	VOC	95-63-6	1,2,4-Trimethylbenzene	14	NA	80	80	Maximum Concentration	0.0024
Heartland Apartments A	VOC	108-67-8	1,3,5-Trimethylbenzene	4	NA	19	19	Maximum Concentration	0.0006
Heartland Apartments A	VOC	622-96-8	4-Ethyltoluene	4	NA	17	17	Maximum Concentration	0.001
Heartland Apartments A	VOC	64-17-5	Ethyl Alcohol	68	106	150	106	95% Student's-t UCL	0.0032
Heartland Apartments A	VOC	91-20-3	Naphthalene	2	NA	7	7	Maximum Concentration	0.000
Heartland Apartments B	VOC	108-67-8	1,3,5-Trimethylbenzene	3.1	NA	9.6	9.6	Maximum Concentration	0.00029
Heartland Apartments B	VOC	106-99-0	1,3-Butadiene	16	42	47	42	95% KM (t) UCL	0.0013
Heartland Apartments B	VOC	622-96-8	4-Ethyltoluene	3.2	7.9	8.6	7.9	95% KM (t) UCL	0.00024
Heartland Apartments B	VOC	71-43-2	Benzene	56	126	140	126	95% Student's-t UCL	0.0038
Heartland Apartments B	VOC	64-17-5	Ethyl Alcohol	10	NA	19	19	Maximum Concentration	0.00057
Heartland Apartments B	VOC	91-20-3	Naphthalene	4.3	43	14	14	Maximum Concentration	0.00042
Heartland Apartments C	VOC	106-99-0	1,3-Butadiene	2.5	6.2	6.3	6.2	95% KM (t) UCL	0.00018

Notes:
COPC = Chemical of Potential Concern; EPC = Exposure Point Concentration; KM = Kaplan-Meier; UCL = Upper Confidence Limit; UCLM = Upper Confidence Limit on the Mean.
Only chemicals identified as COPCs at each Heartland Apartment building are presented.
NA - Could not calculate using ProUCL because of a small sample size.
(1) Indoor air concentration modeled from sub-slab using US EPA VISL Attenuation factor

Generic Sub-slab and Soil Gas Attenuation Factor:	0.03

Table 4.1
Values Used for Daily Intake Calculations

Scenario Timeframe:	Current and/or Future
Medium:	Soil Gas
Exposure Medium:	Indoor Air

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Inhalation-Indoor Air	Resident	Adult	Heartland Apartments	C_{air}	Chemical Concentration Modeled from Soil Gas or Sub-slab to Indoor Air	See Table 3.1	mg/L	See Table 3.1	Exposure Concentration (EC) =
				ET	Exposure Time	24	hrs/day	US EPA (2014)	(C_{air} x ET x EF x ED x CF1 x CF2)
				EF	Exposure Frequency	350	days/year	US EPA (1991b, 2014)	AT
				ED	Exposure Duration	9	years	Recommended central tendency for time spent at one residence (US EPA 2004)	
				CF1	Conversion Factor	1,000	µg/mg		*Mutagenic Compounds:*
				CF2	Conversion Factor	0.042	days/hr		Exposure Concentration (EC) =
				AT-C	Averaging Time - Cancer	25,550	days	70 year lifetime * 365 days.	(C_{air} x ET x EF x ED x CF1 x CF2 x TAF)
				AT-N	Averaging Time - Non-cancer	3,285	days	Exposure Duration * 365 days.	AT
Inhalation-Indoor Air	Resident	Child	Heartland Apartments	C_{air}	Chemical Concentration Modeled from Exterior Soil Gas or Sub-slab to Indoor Air	See Table 3.1	mg/L	See Table 3.1	Exposure Concentration (EC) =
				ET	Exposure Time	24	hrs/day	US EPA (2011a, Table 16-29)	(C_{air} x ET x EF x ED x CF1 x CF2)
				EF	Exposure Frequency	350	days/year	US EPA (1991b, 2014)	AT
				ED	Exposure Duration	6	years	Recommended central tendency for time spent at one residence (US EPA 2004)	
				CF1	Conversion Factor	1,000	µg/mg		*Mutagenic Compounds:*
				CF2	Conversion Factor	0.042	days/hr		Exposure Concentration (EC) =
				TAF	Toxicity Adjustment Factor	Age-specific	unitless	For mutagenic compounds only.	(C_{air} x ET x EF x ED x CF1 x CF2 x TAF)
				AT-C	Averaging Time - Cancer	25,550	days	70 year lifetime * 365 days.	AT
				AT-N	Averaging Time - Non-cancer	2,190	days	ED * 365 days.	

Notes:
Sources: US EPA (1991b, 2004, 2011a, 2014).

Table 5.2
Non-cancer Toxicity Data – Inhalation

Chemical of Potential Concern	Chronic/ Subchronic	Inhalation Reference Concentration (RfC)		Primary Target Organ(s)	Combined Uncertainty/ Modifying Factors	RfC: Target Organ(s)	
						Source(s) (1)	Date(s)
NAPHTHALENE	Chronic	3.0E-03	mg/m3	Respiratory	3000	IRIS	9/17/1998
1,3-BUTADIENE	Chronic	2.0E-03	mg/m3	Reproductive	1000	IRIS	11/5/2002
BENZENE	Chronic	3.0E-02	mg/m3	Immunological	300	IRIS	4/17/2003
ETHYL ALCOHOL	Chronic	NA	NA	NA	NA	NA	NA
4-ETHYLTOLUENE	Chronic	7.0E-03	mg/m3	Hematological	3000	PPRTV (1,2,4-Trimethylbenzene)	6/11/2007
1,2,4-TRIMETHYLBENZENE	Chronic	7.0E-03	mg/m3	Hematological	3000	PPRTV	6/11/2007
1,3,5-TRIMETHYLBENZENE	Chronic	NA	NA	NA	NA	NA	NA

Notes:
NA – Not Available.
(1) US EPA (2015d) cites the following sources for toxicity values (Cancer Slope Factor, Reference Dose, Unit Risk and Reference Concentration):
US EPA Integrated Risk Information System (IRIS)
Health Effects Assessment Summary Tables (HEAST)
California Environmental Protection Agency (CalEPA)
Agency for Toxic Substances and Disease Registry (ATSDR)
Provisional Peer Reviewed Toxicity Values (PPRTV)
Provisional Peer Reviewed Toxicity Values- Appendix (PPRTV - Appendix)

Table 6.2
Cancer Toxicity Factors – Inhalation

Chemical of Potential Concern	Inhalation Unit Risk (IUR)		Weight of Evidence/Cancer Guideline Description	Unit Risk		Mutagen (2)
				Source(s) (1)	Date(s)	
NAPHTHALENE	3.4E-05	$(\mu g/m^3)^{-1}$	B2	Cal EPA	1/20/2011	No
1,3-BUTADIENE	3.0E-05	$(\mu g/m^3)^{-1}$	B2	IRIS	11/5/2002	No
BENZENE	7.8E-06	$(\mu g/m^3)^{-1}$	A	IRIS	1/19/2000	No
ETHYL ALCOHOL	NA	NA	NA	NA	NA	NA
4-ETHYLTOLUENE	NA	NA	NA	NA	NA	NA
1,2,4-TRIMETHYLBENZENE	NA	NA	NA	NA	NA	No
1,3,5-TRIMETHYLBENZENE	NA	NA	NA	NA	NA	No

Toxicity factors, absorption factors (Dermal and GI), and mutagen identification from US EPA (2015a).

NA – Not Available.

(1) US EPA (2015d) cites the following sources for toxicity values (Cancer Slope Factor, Reference Dose, Unit Risk and Reference Concentration):

- US EPA Integrated Risk Information System (IRIS)
- Health Effects Assessment Summary Tables (HEAST)
- California Environmental Protection Agency (CalEPA)
- Agency for Toxic Substances and Disease Registry (ATSDR)
- Provisional Peer Reviewed Toxicity Values (PPRTV)
- Provisional Peer Reviewed Toxicity Values - Appendix (PPRTV - Appendix)

(2) Mutagen info obtained from the US EPA RSL table (US EPA, 2015d).

Table 7.1
Calculation of Chemical Cancer Risks for Resident

Scenario Timeframe:	Current/Future
Receptor Population:	Resident
Receptor Age:	Child/Adult

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	EPC		Cancer Risk Calculations				Cancer Risk
							Intake/Exposure		CSF/Unit Risk		
					Value	Units	Value	Units	Value	Units	
Soil Gas	Indoor Air	Heartland Apartments A	Inhalation	**SVOC**							
			Inhalation	NAPHTHALENE	2.0E-04	mg/m3	4.1E-02	µg/m3	3.4E-05	(µg/m3)-1	1.4E-06
			Inhalation	**VOC**							
			Inhalation	ETHYL ALCOHOL	3.2E-03	mg/m3	3.0E+00	µg/m3	NA	(µg/m3)-1	NA
			Inhalation	4-ETHYLTOLUENE	5.1E-04	mg/m3	1.0E-01	µg/m3	NA	(µg/m3)-1	NA
			Inhalation	1,2,4-TRIMETHYLBENZENE	2.4E-03	mg/m3	4.9E-01	µg/m3	NA	(µg/m3)-1	NA
			Inhalation	1,3,5-TRIMETHYLBENZENE	5.7E-04	mg/m3	1.2E-01	µg/m3	NA	(µg/m3)-1	NA
			Exposure Route Total [Indoor Air-Inhalation]								**1.4E-06**
		Heartland Apartments B	Inhalation	**SVOC**							
			Inhalation	NAPHTHALENE	4.2E-04	mg/m3	8.6E-02	µg/m3	3.4E-05	(µg/m3)-1	2.9E-06
Soil Gas			Inhalation	**VOC**							
			Inhalation	1,3-BUTADIENE	1.3E-03	mg/m3	2.6E-01	µg/m3	3.0E-05	(µg/m3)-1	7.9E-06
			Inhalation	BENZENE	3.8E-03	mg/m3	7.8E-01	µg/m3	7.8E-06	(µg/m3)-1	6.1E-06
			Inhalation	ETHYL ALCOHOL	5.7E-04	mg/m3	5.3E-01	µg/m3	NA	(µg/m3)-1	NA
			Inhalation	4-ETHYLTOLUENE	2.4E-04	mg/m3	4.8E-02	µg/m3	NA	(µg/m3)-1	NA
			Inhalation	1,3,5-TRIMETHYLBENZENE	2.9E-04	mg/m3	5.9E-02	µg/m3	NA	(µg/m3)-1	NA
			Exposure Route Total [Indoor Air-Inhalation]								**1.7E-05**
		Heartland Apartments C	Inhalation	**VOC**							
			Inhalation	1,3-BUTADIENE	1.8E-04	mg/m3	3.8E-02	µg/m3	3.0E-05	(µg/m3)-1	1.1E-06
			Exposure Route Total [Indoor Air-Inhalation]								**1.1E-06**
Exposure Point Total (Heartland Apartments A)											**1E-06**
Exposure Point Total (Heartland Apartments B)											**2E-05**
Exposure Point Total (Heartland Apartments C)											**1E-06**

Notes:
NA - Not available. -- Not applicable.
CSF = Cancer Slope Factor; EPC = Exposure Point Concentration; SVOC = Semi-volatile Organic Compound; VOC = Volatile Organic Compound.

Inhalation-Indoor Air (IA)

$$\text{Intake Factor (IF)} = \frac{EF \times ED \times ET \times CF1 \times CF2 \times TAF}{AT} =$$

		Non-Mutagens	
		8.2E+01 (Child)	1.2E+02 (Adult)
EF	Exposure Frequency (days/yr)	350	350
ED	Exposure Duration (yrs)	6	9
ET	Exposure Time (hr/day)	24	24
CF1	Conversion Factor (day/hour)	0.042	0.042
CF2	Conversion Factor (µg/mg)	1000	1000
AT	Averaging Time (days)	25,550	25,550
TAF	Toxicity Adjustment Factor	--	--

Exposure Conc ($\mu g/m^3$) = EPC_{air} x IF

Cancer risk = Exposure Conc. x Inhalation Unit Risk (IUR)

Table 7.2
Calculation of Chemical Non-cancer Hazards

Scenario Timeframe:	Current/Future
Receptor Population:	Resident
Receptor Age:	Child/Adult

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	EPC		Non-cancer Hazard Calculations - Child				Non-cancer Hazards Child	Non-cancer Hazard Calculations - Adult				Non-cancer Hazards Adult
					Value	Units	Intake/Exposure		RfD / RfC			Intake/Exposure		RfD / RfC		
							Value	Units	Value	Units		Value	Units	Value	Units	
Soil Gas	Indoor Air	Heartland Apartments A	Inhalation	**SVOC**												
			Inhalation	NAPHTHALENE	2.0E-04	mg/m3	1.9E-04	mg/m3	3.0E-03	mg/m3	6.3E-02	1.9E-04	mg/m3	3.0E-03	mg/m3	6.3E-02
			Inhalation	**VOC**												
			Inhalation	ETHYL ALCOHOL	3.2E-03	mg/m3	3.0E-03	mg/m3	NA	mg/m3	NA	3.0E-03	mg/m3	NA	mg/m3	NA
			Inhalation	4-ETHYLTOLUENE	5.1E-04	mg/m3	4.9E-04	mg/m3	7.0E-03	mg/m3	7.0E-02	4.9E-04	mg/m3	7.0E-03	mg/m3	7.0E-02
			Inhalation	1,2,4-TRIMETHYLBENZENE	2.4E-03	mg/m3	2.3E-03	mg/m3	7.0E-03	mg/m3	3.3E-01	2.3E-03	mg/m3	7.0E-03	mg/m3	3.3E-01
			Inhalation	1,3,5-TRIMETHYLBENZENE	5.7E-04	mg/m3	5.5E-04	mg/m3	NA	mg/m3	NA	5.5E-04	mg/m3	NA	mg/m3	NA
			Exposure Route Total [Indoor Air-Inhalation]								**4.6E-01**					**4.6E-01**
Soil Gas	Indoor Air	Heartland Apartments B	Inhalation	**SVOC**												
			Inhalation	NAPHTHALENE	4.2E-04	mg/m3	4.0E-04	mg/m3	3.0E-03	mg/m3	1.3E-01	4.0E-04	mg/m3	3.0E-03	mg/m3	1.3E-01
			Inhalation	**VOC**												
			Inhalation	1,3-BUTADIENE	1.3E-03	mg/m3	1.2E-03	mg/m3	2.0E-03	mg/m3	6.1E-01	1.2E-03	mg/m3	2.0E-03	mg/m3	6.1E-01
			Inhalation	BENZENE	3.8E-03	mg/m3	3.6E-03	mg/m3	3.0E-02	mg/m3	1.2E-01	3.6E-03	mg/m3	3.0E-02	mg/m3	1.2E-01
			Inhalation	ETHYL ALCOHOL	5.7E-04	mg/m3	5.5E-04	mg/m3	NA	mg/m3	NA	5.5E-04	mg/m3	NA	mg/m3	NA
			Inhalation	4-ETHYLTOLUENE	2.4E-04	mg/m3	2.3E-04	mg/m3	7.0E-03	mg/m3	3.2E-02	2.3E-04	mg/m3	7.0E-03	mg/m3	3.2E-02
			Inhalation	1,3,5-TRIMETHYLBENZENE	2.9E-04	mg/m3	2.8E-04	mg/m3	NA	mg/m3	NA	2.8E-04	mg/m3	NA	mg/m3	NA
			Exposure Route Total [Indoor Air-Inhalation]								**9.0E-01**					**9.0E-01**
Soil Gas	Indoor Air	Heartland Apartments C	Inhalation	**VOC**												
			Inhalation	1,3-BUTADIENE	1.8E-04	mg/m3	1.8E-04	mg/m3	2.0E-03	mg/m3	8.9E-02	1.8E-04	mg/m3	2.0E-03	mg/m3	8.9E-02
			Exposure Route Total [Indoor Air-Inhalation]								**8.9E-02**					**8.9E-02**
Exposure Point Total (Heartland Apartments A)											**5E-01**					**5E-01**
Exposure Point Total (Heartland Apartments B)											**9E-01**					**9E-01**
Exposure Point Total (Heartland Apartments C)											**9E-02**					**9E-02**

Notes:

NA - Not available.

EPC = Exposure Point Concentration; RfC = Reference Concentration; RfD = Reference Dose; SVOC = Semi-volatile Organic Compound; VOC = Volatile Organic Compound.

Inhalation - Indoor Air (IA)

$$\text{Intake Factor (IF)} = \frac{ET \times EF \times ED \times CF1}{AT} =$$

		Non-cancer	
		9.6E-01	9.6E-01
		(Child)	(Adult)
EF	Exposure Frequency (days/yr)	350	350
ED	Exposure Duration (yrs)	6	9
ET	Exposure Time (hr/day)	24	24
CF1	Conversion Factor (day/hour)	0.042	0.042
AT	Averaging Time (days)	2,190	3,285

Exposure Conc (mg/m^3) = EPCair x IF

Non-cancer Hazard = Exposure/RfC

Table 9.1
Chemical Cancer Risks and Non-cancer Hazards
Resident (Child/Adult)

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Carcinogenic Risk - Child/Adult				Non-Carcinogenic Hazard Quotient - Child				Non-Carcinogenic Hazard Quotient - Adult				Target Organ	
				Ingestion	Dermal	Inhalation	Total	Ingestion	Dermal	Inhalation	Total	Ingestion	Dermal	Inhalation	Total	RfD	RfC
Soil Gas	Indoor Air	Heartland Apartments A	**SVOC**														
			NAPHTHALENE			1.4E-06	**1.4E-06**			6.3E-02	**6.3E-02**			6.3E-02	**6.3E-02**	Systemic	Respiratory
			VOC														
			ETHYL ALCOHOL			NA	**NA**			NA	**NA**			NA	**NA**	NA	NA
			4-ETHYLTOLUENE			NA	**NA**			7.0E-02	**7.0E-02**			7.0E-02	**7.0E-02**	NA	Hematological
			1,2,4-TRIMETHYLBENZENE			NA	**NA**			3.3E-01	**3.3E-01**			3.3E-01	**3.3E-01**	NA	Hematological
			1,3,5-TRIMETHYLBENZENE			NA	**NA**			NA	**NA**			NA	**NA**	Hepatic	NA
Exposure Point Total (Heartland Apartments A)				0.0E+00	0.0E+00	1.4E-06	**1E-06**	0.0E+00	0.0E+00	4.6E-01	**5E-01**	0.0E+00	0.0E+00	4.6E-01	**5E-01**		
								Total Organ HI (Heartland Apartments A)			**Child**				**Adult**		
								Hematological			4.E-01				4.E-01		
								Respiratory			6.E-02				6.E-02		
Soil Gas	Indoor Air	Heartland Apartments B	**SVOC**														
			NAPHTHALENE			2.9E-06	**2.9E-06**			1.3E-01	**1.3E-01**			1.3E-01	**1.3E-01**	Systemic	Respiratory
			VOC														
			1,3-BUTADIENE			7.9E-06	**7.9E-06**			6.1E-01	**6.1E-01**			6.1E-01	**6.1E-01**	NA	Reproductive
			BENZENE			6.1E-06	**6.1E-06**			1.2E-01	**1.2E-01**			1.2E-01	**1.2E-01**	Immunological	Immunological
			ETHYL ALCOHOL			NA	**NA**			NA	**NA**			NA	**NA**	NA	NA
			4-ETHYLTOLUENE			NA	**NA**			3.2E-02	**3.2E-02**			3.2E-02	**3.2E-02**	NA	Hematological
			1,3,5-TRIMETHYLBENZENE			NA	**NA**			NA	**NA**			NA	**NA**	Hepatic	NA
Exposure Point Total (Heartland Apartments B)				0.0E+00	0.0E+00	1.7E-05	**2E-05**	0.0E+00	0.0E+00	9.0E-01	**9E-01**	0.0E+00	0.0E+00	9.0E-01	**9E-01**		
								Total Organ HI (Heartland Apartments B)			**Child**				**Adult**		
								Hematological			3.E-02				3.E-02		
								Immunological			1.E-01				1.E-01		
								Reproductive			6.E-01				6.E-01		
								Respiratory			1.E-01				1.E-01		
Soil Gas	Indoor Air	Heartland Apartments C	**VOC**														
			1,3-BUTADIENE			1.1E-06	**1.1E-06**			8.9E-02	**8.9E-02**			8.9E-02	**8.9E-02**	NA	Reproductive
Exposure Point Total (Heartland Apartments C)				0.0E+00	0.0E+00	1.1E-06	**1E-06**	0.0E+00	0.0E+00	8.9E-02	**9E-02**	0.0E+00	0.0E+00	8.9E-02	**9E-02**		
								Total Organ HI (Heartland Apartments C)			**Child**				**Adult**		
								Reproductive			9.E-02				9.E-02		

Notes:
HI = Hazard Index; NA = Not Available; RfC = Reference Concentration; RfD = Reference Dose; SVOC = Semi-volatile Organic Compound; VOC = Volatile Organic Compound.

Table 11
Summary of Total Cancer Risks and Non-cancer Hazards by Exposure Area

Exposure Area	Resident		
	Total Excess Lifetime Cancer Risk	Non-cancer Hazard Child	Non-cancer Hazard Adult
Heartland Apartments A	1E-06	0.5	0.5
Heartland Apartments B	2E-05	0.9	0.9
Heartland Apartments C	1E-06	0.09	0.09

Note:

BOLD - Cancer Risk > 1×10^{-4} or Hazard Index > 1.

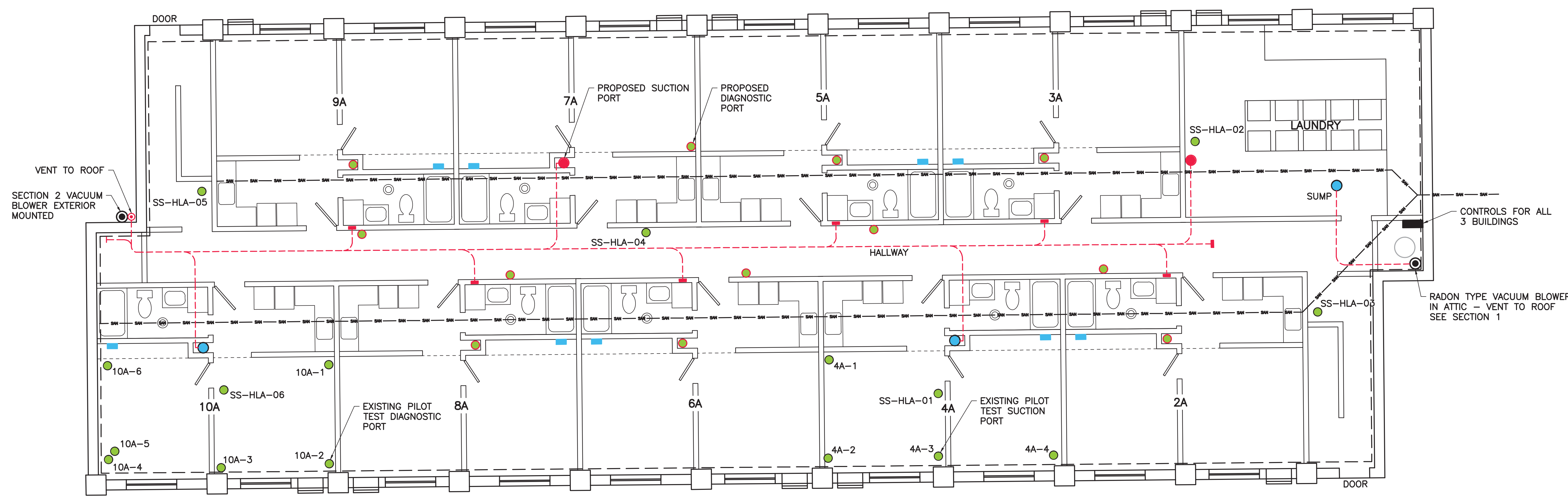
Table 12 Risk Summary Detail

	Heartland Apartments A			Heartland Apartments B			Heartland Apartments C		
Non-cancer Hazard									
Receptor/Exposure Pathway	**Non-cancer Hazard**	**Percent Contribution**	**Major Contributor**	**Non-cancer Hazard**	**Percent Contribution**	**Major Contributor**	**Non-cancer Hazard**	**Percent Contribution**	**Major Contributor**
Adult Resident									
Inhalation of Indoor Air (Soil Gas)	4.6E-01	100%	1,2,4-TRIMETHYLBENZENE (71%)	9.0E-01	100%	1,3-BUTADIENE (68%)	8.9E-02	100%	1,3-BUTADIENE (100%)
Total Hazard:	**5.E-01**			**9.E-01**			**9.E-02**		
Child Resident									
Inhalation of Indoor Air (Soil Gas)	4.6E-01	100%	1,2,4-TRIMETHYLBENZENE (71%)	9.0E-01	100%	1,3-BUTADIENE (68%)	8.9E-02	100%	1,3-BUTADIENE (100%)
Total Hazard:	**5E-01**			**9E-01**			**9E-02**		
Cancer Risk									
Receptor/Exposure Pathway	**Cancer Risk**	**Percent Contribution**	**Major Contributor**	**Cancer Risk**	**Percent Contribution**	**Major Contributor**	**Cancer Risk**	**Percent Contribution**	**Major Contributor**
Adult and Child Resident									
Inhalation of Indoor Air (Soil Gas)	1.4E-06	100%	NAPHTHALENE (100%)	1.7E-05	100%	1,3-BUTADIENE (47%)	1.1E-06	100%	1,3-BUTADIENE (100%)
Total Risk:	**1E-06**			**2E-05**			**1E-06**		

Major contributor: Chemical of Potential Concern Contributing Majority of Risk by Receptor & Pathway (% contribution)

Attachment B

Conceptual Layouts of Alternatives



Vapor Intrusion Preemptive Mitigation Overview (Building A shown - Similar for Buildings B and C)

- Access to all garden level apartments; however, tenants can remain in place during work
- Remove current plumbing access panels adjacent to bathrooms
- Place non-shrinking grout below bathtub drains to seal pipe drain penetrations through concrete floors
- Install new sealed plumbing access panels
- Install diagnostic ports (one per apartment)
- Install sealed covers over the dewatering sumps and connect mitigation piping
- Connect mitigation piping to dewatering sumps In each building
- Install suction ports in closets of four to six apartments in each building
- Install header piping in each hallway ceiling (requires removal and replacement of hallway ceiling sheetrock)
- Connect suction ports to header piping and route header piping to end closets
- Install vertical piping to the roof tops of each building
- Perform installation start up and vacuum extension testing; install additional suction ports if needed
- Install final vacuum blowers and controls
- Monitor operation and performance metrics with remote telemetry
- Perform monthly inspections for the first three months, followed with annual inspections and maintenance
- Operate mitigation systems until it is determined that it is no longer needed

LEGEND:

- PILOT TEST DIAGNOSTIC PORT
- PILOT TEST SUCTION PORT
- SAN — SEWER LINE
- ASSUMED PERIMETER DRAIN
- SEAL ACCESS PANELS IN ALL UNITS
- PROPOSED DIAGNOSTIC PORT
- PROPOSED SUCTION PORT
- PROPOSED PIPING
- BLIND FLANGE
- SWEEP FITTINGS (SWEEP FROM WEST)

1 PLAN: BUILDING A

0 5 10 SCALE IN FEET

N

CADD USER: Rick Gustner FILE: M:\ADEPTWORK\RLG\34091030000_FIGURE 2_CPMS DESIGN BUILDING A.DWG PLOT SCALE: 1:2 PLOT DATE: 3/31/2016 7:46 PM
Xrefs in Drawing – C:\AdeptSupport\AdeptVL\Adept 2014\RLG\3409-0_00.fb6d5eb0-ce79-4958-9445-0fb4d36dd2b3\11.0\34091030000_BASE-EXISTING.dwg
rig M:\AdeptWork\RLG\34091030000_C-02 BUILDING A.dwg Plot at 1 03/22/2016 15:31:44

NO.	BY	CHK.	APP.	DATE	REVISION DESCRIPTION

I HEREBY CERTIFY THAT THIS PLAN, SPECIFICATION, OR REPORT WAS PREPARED BY ME OR UNDER MY DIRECT SUPERVISION AND THAT I AM A DULY LICENSED PROFESSIONAL ENGINEER UNDER THE LAWS OF THE STATE OF MINNESOTA.

PRINTED NAME ____
SIGNATURE ____
DATE ____ LICENSE # ____

RELEASED TO/FOR	A	B	C	0	1	2	3
CLIENT							
BID							
CONSTRUCTION							
	DATE RELEASED						

BARR
Corporate Headquarters: Minneapolis, Minnesota Ph: 1-800-632-2277

Project Office:
BARR ENGINEERING CO.
4300 MARKETPOINTE DRIVE
Suite 200
MINNEAPOLIS, MN 55435
Ph: 1-800-632-2277
Fax: (952) 832-2601
www.barr.com

Scale	AS SHOWN
Date	03-03-16
Drawn	RLG
Checked	
Designed	
Approved	

NORTHERN STATES POWER CO.

HEARTLAND PROPERTY
FARGO, ND

CONCEPTUAL PREEMPTIVE MITIGATION SYSTEM DESIGN – BUILDING A

BARR PROJECT No. 34091030.00
CLIENT PROJECT No.
DWG. No. FIGURE 1
REV. No.

Vapor Intrusion Sampling Overview (All garden level apartments)

- Access all garden level apartments and tenants will need to vacate apartments for a minimum of two weeks
- Remove current plumbing access panels adjacent to bathrooms
- Place non-shrinking grout below bathtub drains to seal pipe drain penetrations through concrete floors
- Install new sealed plumbing access panels
- Install sealed covers over the dewatering sumps;
- Remove floor coverings, inspect concrete integrity, and seal cracks
- Install sub-slab soil vapor pins (one per apartment with two in apartment 2C)
- Collect initial round of sub-slab soil gas samples
- Replace floor coverings in each apartment (retain access to vapor pins)
- Collect sub-slab samples on a quarterly basis for a minimum of three events
- Evaluate data and determine if additional sampling is needed
- Terminate sampling and/or initiate active mitigation if deemed necessary

1 PLAN: HEARTLAND APARTMENTS

0 20 40
SCALE IN FEET

CADD USER: Brian Hughes FILE: M:\ADEPTWORK\BJH\34091030000–FIGURE 1 – APARTMENT BUILDING LAYOUT.DWG PLOT SCALE: 1:2 PLOT DATE: 3/8/2016 4:13 AM
BAR M:\AutoCAD 2011\AutoCAD 2011 Support\enu\Template\Barr_2011_Template.dwt Plot at 1 10/05/2010 14:03:50

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A B C 0 1 2 3
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Scale	AS SHOWN
Date	
Drawn	BJH
Checked	
Designed	
Approved	

XCEL ENERGY

HEARTLAND APARTMENTS
FARGO, ND
FIGURE 2
HEARTLAND APARTMENT VI SAMPLING

BARR PROJECT No. 34091030.00
CLIENT PROJECT No.
DWG. No.
REV. No.