DRAFT
FINAL

Woodard & Curran

Human Health and Ecological Risk Assessment Addendum

Caneel Bay Resort Site

Virgin Island National Park
Caneel Bay Resort Site
St. John Island, U.S. Virgin Islands

EDL Number: 5SER3346

0230405.01
VHB
July 2022

woodardcurran.com

Table of Contents

Tables

Figures

Attachments

List of Abbreviations and Acronyms

ABSgi	Gastrointestinal absorption fraction
ACM	Asbestos-containing material
ADAF	Age-dependent adjustment factor
AST	Above ground storage tank
COPC	Contaminant of potential concern
COPEC	Contaminant of potential ecological concern
CSF	Cancer slope factor
DAevent	Dermal absorption factor
DDT	Dichlorodiphenyltrichloroethane
EE/CA	Engineering Evaluation/Cost Analysis
EPC	Exposure point concentration
ESV	Ecological Screening Value
Ft-bgs	Feet below ground surface
HHRA	Human health risk assessment
HI	Hazard index
HQ	Hazard Quotient
IRIS	Integrated Risk Information System
IUR	Inhalation unit risk
µg/l	Micrograms per liter
mg/kg	Milligrams per kilogram
mg/l	Milligrams per liter
NCP	National Oil and Hazardous Substances Pollution Contingency Plan (aka, National Contingency Plan)
NPS	National Park Service
ORNL	Oak Ridge National Laboratory
PAH	Polycyclic aromatic hydrocarbon
PAL	Project action level
PCB	Polychlorinated biphenyls
PCOPEC	Preliminary contaminant of potential ecological concern
PLM	Polarized light microscopy

PPRTV	Provisional Peer-Reviewed Toxicity Value
RME	Reasonable maximum exposure
RSL	Regional Screening Level
SLERA	Screening Level Ecological Risk Assessment
SVOC	Semi-volatile organic compound
TEM	Transmission electron microscopy
USEPA	United States Environmental Protection Agency
UST	Underground Storage Tank
VHB	Vanasse Hangen Brustlin, Inc.
VISL	Vapor Intrusion Screening Level
VOC	Volatile organic compound

1 Introduction

This Human Health Risk Assessment (HHRA) and Screening Level Ecological Risk Assessment (SLERA) Addendum ("Addendum") was prepared subsequent to the September 2021 Engineering Evaluation/Cost Analysis (EE/CA) Report and the May 2021 Human Health Risk Assessment and Ecological Risk Refinement Report (Woodard & Curran, 2021) for the Caneel Bay Resort Site ("Resort") located within the National Park Service (NPS) Virgin Islands National Park (VIIS) on the northwest side of the island of St. John, U.S. Virgin Islands (the location of the Resort is presented on **Figure 1 of the EE/CA Report**). The September 2021 EE/CA Report identified several data gaps that required supplemental investigation in multiple areas of the Resort, including some not previously investigated under the EE/CA. The objective of this Addendum was to evaluate the analytical results and information generated from the EE/CA Addendum field investigation conducted in November 2021 and January 2022 and summarized in Appendix B of the EE/CA Addendum report. This risk assessment Addendum is Appendix C of the EE/CA Addendum report.

Readers should refer to the May 2021 Human Health Risk Assessment and Ecological Risk Refinement report for the original risk assessment upon which this Addendum expands. Additional detail about the risk assessment approach and guidance are provided in the May 2021 report, in Section 2 (2021 HHRA) and Section 3 (2021 SLERA).

Risk assessment provides risk managers the information needed to understand existing or potential threats by identifying the pertinent exposure pathways of contamination, and the human and/or ecological receptors that may be exposed to the contamination. The results of this Addendum will thus be used to inform the basis for future management of identified risks.

The HHRA and SLERA Refinement follows applicable risk assessment policies and guidance published by both NPS and the United States Environmental Protection Agency (USEPA), as provided in the May 2021 HHRA and SLERA.

Section 1 of this Addendum provides a brief discussion of the Resort background and EE/CA Addendum findings that are the subject of these supplemental risk evaluations, as well as a summary of the analytical results for samples collected from the areas of the Resort relevant to this Addendum, herein referred to as the "Site" (see **Section 1.1**). **Sections 2 and 3** present the HHRA and SLERA with Refinement, respectively. **Section 4** presents the overall conclusions of this Addendum, and **Section 5** presents a list of references cited in this report.

1.1 Background

With the exception of a restaurant, the Resort is currently closed to visitors, following the 2017 hurricane season that caused extensive damage to multiple Resort buildings. NPS is considering how the area will be operated after the expiration of the Retained Use Estate on September 30, 2023. Per NPS' direction, it is assumed that Resort operations will eventually resume, and that the Resort may also potentially be redeveloped for residential use.

The 2021 EE/CA Investigation and Risk Assessments focused on three portions of the Resort, designated as:

- Area 1: a storage area on a gravel pad near the wastewater treatment plant
- Area 2: a support area for the Resort, encompassing the engineering, maintenance, landscaping, generator, and fuel facilities, located southwest of Area 1
- Area 3: an un-permitted landfill immediately east of Honeymoon Beach

The Site boundaries were expanded since the initial EE/CA investigation, as described in the EE/CA Addendum. The areas added to the Site included those with building materials and debris located around the Resort that potentially contain asbestos and lead-based paint, buried asbestos pipes, aboveground and underground storage tanks (AST, UST), waste storage areas, and a reported storage/disposal area near the surface water Catchment Basin on the hillside above the Resort buildings.

Subsequent to this supplemental field investigation, some of these areas were eliminated as potential risk drivers due to absence of verified contaminant sources or lack of detected constituents. Readers should refer to Appendix B of the EE/CA Addendum for a detailed discussion of the field investigation findings. Those areas of the Resort that were retained and evaluated in this Addendum[1] are summarized below:

a. **Asbestos-containing material (ACM)**. NPS identified ACM in buildings, pipe insulation, buried pipes, and hurricane debris scattered throughout various parts of the Resort property.
b. **Cottage 7 Borings.** While no contamination in this area below UST piping was observed, analytical results from one sample indicated detected concentrations of polycyclic aromatic hydrocarbons (PAHs).
c. **Area 2 ASTs and Fuel Dispenser Pump.** Several soil and groundwater samples from this area contained PAHs.
d. **Water supply wells.** The EE/CA Addendum investigation found and sampled two shallow (10-12 feet deep) wells (Dug Wells 1 and 2) that appear to date back to the plantation era. Both of these wells are open to air and are not currently used as a source of potable water. Two monitoring wells (MW-2-21 and MW-2-22) were installed between these wells.

These areas are referred to collectively as “Investigation Areas”.

The Risk Addendum evaluates the potential human health and ecological risks associated with each of the above areas.

[1] Per correspondence with VHB, this Addendum does not address the Catchment Basin (no contaminants detected above project action levels [PALs]), lead in building materials, potential emergency water supply deep wells (no viable wells found), Area 1 soil samples (no evidence of contamination), Area 3 groundwater migration (well in this area was dry); or arsenic background samples collected to evaluate cleanup goals.

1.2 Analytical Results

The EE/CA addendum investigation included the collection of surface and subsurface soil, and groundwater samples from the Site. Target analytes in all media included volatile organic compounds (VOCs), PAHs, and pesticides. Soil samples were also analyzed for polychlorinated biphenyls (PCBs) and lead.

Analytical results for detected constituents in soil and groundwater samples for those areas that are the focus of this Addendum, as described in **Section 1.1**, are provided in **Table C-1.1** and **Table C-1.2**, respectively. Refer to **Tables B-1 through B-6D in the Investigation Report (EE/CA Addendum Appendix B)** for the complete set of analytical results, including undetected constituents.

All analytical data generated from the EE/CA field effort that were not rejected as a result of the data validation process, including results qualified as estimated ("J"-flagged[2]), were considered usable in the HHRA and SLERA Refinement addendum. Refer to **Attachment C of the Investigation Report (EE/CA Addendum Appendix B)** for a discussion of data validation.

The following subsections summarize analytical results for soil and groundwater samples.

1.2.1 Soil

Soil samples used in these risk assessments were collected using discrete sampling techniques. **Figures B-3, B-4, and B-5 of the Investigation Report (EE/CA Addendum Appendix B)** present the soil samples collected from the Cottage 7, Area 1, and Area 2 Investigation Areas, respectively. Each Investigation Area mentioned above consists of the following samples:

- Four subsurface soil samples were collected in the Cottage 7 Investigation Area (SC-C7-01 through SC-C7-03), including one duplicate sample. Sample depths range from 5 feet below ground surface (ft-bgs) to 6.6 ft-bgs.
- Seven soil samples were collected in Area 1 (in borings SC-1-01 through SC-1-03), including one duplicate sample. Surface samples (0-0.5 ft-bgs) were collected at each location, as well as subsurface samples, ranging from 4 ft-bgs to 17 ft-bgs.
- Twenty-three soil samples were collected in Area 2 (from borings SC-2-06 through SC-2-22), including two duplicate samples. One to two subsurface samples were collected from each sampling location at depths ranging from 2.4 ft-bgs to 20 ft-bgs. No surface soil samples were collected from Area 2 because surface samples were collected in the previous EE/CA investigation.

Table C-1.1 presents the analytical results and a statistical summary, which includes frequency of detection, minimum detected concentration, and maximum detected concentration for all detected

[2] In the data tables, some results are noted with letters, also known as validation "flags." The flag indicates that something in the sampling or analytical process, or in the sample itself, may have affected the result. These flagged results are usable and valid.

constituents in the samples described above. Also presented in the table are the USEPA soil Residential Regional Screening Levels (RSL; USEPA, 2021) for comparison, which will be used for the selection of constituents of potential concern (COPCs; discussed further below) for the HHRA.

As shown in the table, detected constituents consist of lead, DDT (dichlorodiphenyltrichloroethane) and metabolites, multiple PAHs, and several VOCs. All samples were analyzed for PAHs and VOCs, while lead was only analyzed for in some Area 2 samples, and pesticides were only analyzed for in Area 1.

Lead and acetone are the two constituents detected at the highest frequency. Lead was detected in every sample for which it was analyzed in Area 2 (17 out of 17). Acetone was detected in 17 out of 30 samples across all Investigation Areas. All other VOCs were detected only in Area 2 soil samples at frequencies less than 25%.

In Area 1, DDT and metabolites were detected in one sample collected from surface soil (0.5 ft-bgs). PAHs were detected in Area 2 and Cottage 7 Investigation Areas. Phenanthrene, pyrene, and fluorene were detected at the highest frequencies ranging from 20% to 26% at the Site.

1.2.2 Groundwater

Groundwater samples used in this Addendum were collected from Area 2 in November 2021 and January 2022. November 2021 samples included monitoring wells MW-2-06, MW-2-07, and MW-2-09 installed at soil boring locations SC-2-06, SC-2-07, and SC-2-09. Additionally, two dug wells in Area 2 (Dug Well 1 and Dug Well 2) indicated potential year-round groundwater, prompting the installation of two additional monitoring wells (MW-2-21 and MW-2-22) near the dug wells, for a total of seven sample locations. A duplicate sample was collected at MW-2-22. The results for all sampling events are included in **Table C-1.2**. Also presented in the table are the USEPA tap water Regional Screening Levels (RSLs) (USEPA, 2021) and Vapor Intrusion Screening Levels (VISLs; USEPA 2022a) for comparison, which will be used for the selection of COPCs for the HHRA, and NPS Ecological Screening Values (ESVs), which will be used for the selection of preliminary contaminants of potential ecological concern (PCOPECs) for the SLERA.

As shown in **Table C-1.2,** constituents detected in groundwater included arsenic, barium, and several PAHs and VOCs. For metals, arsenic was detected in two (Dug Wells 1 and 2) out of four samples and barium was detected in all four samples. All PAHs were detected in one or two samples except for naphthalene, which was detected or estimated in five out of ten samples. Most VOCs were detected in three or fewer samples, except for acetone, which was detected in six out of ten samples.

1.2.3 Asbestos-Containing Materials

Samples of various building materials that potentially contained asbestos and were exposed to the environment were analyzed for asbestos by polarized light microscopy (PLM) or transmission electron microscopy (TEM). These sample results are presented on **Table B-1a of the Investigation Report (EE/CA Addendum Appendix B)** and indicated the positive presence of asbestos in roofing materials,

window caulking and glazing, ceiling adhesive, and piping. Most asbestos was identified as either chrysotile or crocidolite, with asbestos composition ranging from 1% to 56%; roofing materials generally had the highest percentages of asbestos.

2 Human Health Risk Assessment

As explained in the May 2021 HHRA, the purpose of the HHRA is to understand potential health risks associated with exposure to constituents at or migrating from a site, in order to evaluate the need for a removal action.

2.1 Hazard Identification

The objective of the Hazard Identification is to present the relevant sampling data, evaluate its usability, and select the COPCs for each medium. Data used in the risk assessment were discussed in **Section 1.2**. Soil and groundwater were both considered media of concern and carried through the HHRA. As previously mentioned, statistical summaries (frequency of detection, minimum detected, and maximum detected) are provided in **Table C-1.1** for soil and **Table C-1.2** for groundwater. The asbestos bulk analysis data are not suitable for inclusion in a quantitative HHRA. Instead, a qualitative evaluation of the potential health risk from asbestos is provided in **Section 2.5.**

COPCs are those constituents detected at the Site that are carried through the quantitative risk assessment process. Criteria considered in the COPC screening process included:

- ***Frequency of Detection:*** Per USEPA guidance (1989), constituents that were not detected at least once in a medium were not retained as COPCs. Consideration of reporting limits with respect to project action levels, and exclusion of these non-detect constituents in estimation of total risk, are discussed in the Uncertainty Analysis (**Section 2.6**).
- ***Comparison to Risk-Based Screening Levels:*** A comparison of constituent concentrations to medium-specific risk-based screening levels was used to focus on the constituents that are most likely to contribute significantly to risks: the COPCs. The screening levels selected in the HHRA are the USEPA residential RSLs for soil and the tap water RSLs for groundwater (USEPA, 2021) and the USEPA residential VISL for groundwater. RSLs and VISLs are based on a target cancer risk of one in one million (1E-06) and target hazard quotient of 0.1.

For contaminants lacking screening values, the screening value for a surrogate compound of similar chemical structure was used where appropriate. There are no USEPA residential soil RSLs available for phenanthrene, benzo(g,h,i)perylene, acenaphthylene, and methylcyclohexane. Therefore, the following surrogates were used:

- Pyrene was used as a surrogate for phenanthrene, benzo(g,h,i)perylene, and acenaphthylene; and,
- Cyclohexane was used as a surrogate for methylcyclohexane.

Uncertainties and biases in the HHRA as a result of the exclusion of constituents as COPCs are addressed further in the Uncertainty Analysis (**Section 2.6**).

Table C-1.1 presents a comparison of the soil analytical data to the USEPA residential soil RSLs. As shown on **Table C-1.1**, benzo(a)pyrene and dibenz(a,h)anthracene were the only constituents with

concentrations that exceeded an RSL and were retained as soil COPCs. All RSL exceedances were located in the Cottage 7 area, depicted on **Figure B-3 of the Investigation Report (EE/CA Addendum Appendix B)**.

Table C-1.2 presents a comparison of the groundwater analytical data to the USEPA tap water RSLs and VISLs. Arsenic, barium, naphthalene, and chloroform concentrations exceeded their tap water RSLs. Arsenic and barium exceeded their RSLs at Dug Well 2, whereas only arsenic exceeded the RSL at Dug Well 1. Naphthalene exceeded its RSL at three locations (MW-2-07, MW-2-09, and Dug Well 2); chloroform exceeded its RSL at only MW-2-09. Refer to **Figure B-5 of the Investigation Report (EE/CA Addendum Appendix B)** for sample locations.

No constituent concentration exceeded its VISL and, therefore, the vapor intrusion pathway (migration of VOCs from the subsurface into indoor air of a building) is considered to be incomplete.

In summary, the COPCs identified for this Addendum include benzo(a)pyrene and dibenz(a,h)anthracene in soil, and arsenic, barium, naphthalene, and chloroform in groundwater.

2.2 Exposure Assessment

The exposure assessment identifies the human receptors who may be present at a site, and the relevant exposure media and routes by which a receptor may be exposed. The objective of the exposure assessment is to estimate the type and magnitude of potential exposure of a receptor to COPCs present at or migrating from a site. The following sections discuss the human receptors and relevant exposure routes and the estimation of COPC intake for each receptor scenario. These routes and pathways are illustrated in the Pathway-Receptor Diagram shown on **Figure C-1**.

2.2.1 Potential Human Receptors and Exposure Pathways

The HHRA Addendum evaluated both current and future potential health risks to human receptors in the supplemental investigation area, as described below and summarized in **Table C-2.1.** The Human Health and Ecological Pathway-Receptor Diagram for the entire Site, which summarizes the source media, migration pathways, exposure media and pathways, and human and ecological receptors, is depicted on **Figure C-1**.

The 2021 HHRA quantitatively evaluated health risks for three human receptor categories[3]: 1) a current or future NPS Park Worker, 2) a future Construction Worker, and 3) a future Resident. These three receptors were evaluated in this HHRA Addendum with respect to the new data and findings generated from the EE/CA Addendum Investigation. Because these recent data were generally collected from areas previously uncharacterized, or from new environmental media (i.e., groundwater), and as such represent

[3] The HHRA included a qualitative evaluation of risk for a Resort visitor, under the assumption that any of the other three scenarios would be adequately protective of a visitor, who is expected to have a lower exposure potential than an NPS Park/Resort Worker or Resident.

new, unique exposures, the HHRA evaluated receptor risks for only these new data; these scenarios did not include the older EE/CA Investigation results.

The receptors and exposure pathways evaluated in the HHRA Addendum ("exposure scenarios") are summarized in **Table C-2.1** and include:

Park/Resort Worker, who is expected to encounter COPCs in surface soil[4] at the Resort. However, because there were no COPCs retained in surface soil samples from the November 2021 investigation, there are no complete soil exposure pathways for this receptor.

There is also the potential for a Park/Resort Worker to be exposed to groundwater that could be used as a potable water supply in the future. Currently, the Resort water is supplied via a desalinization plant. The initial EE/CA investigation was unable to obtain samples of groundwater, and groundwater was not included as a medium of concern in the 2021 HHRA. The 2021 EE/CA Addendum investigation found and sampled two shallow, open-air wells and installed and sampled several monitoring wells in Area 2. Because COPCs were retained in groundwater data from these wells, the HHRA Addendum conservatively assumed that there was potential for groundwater to be used as a potable water supply in the future. Groundwater exposure pathways for the NPS Park/Resort Worker include ingestion, dermal contact, and inhalation of VOCs from washing-related activities (showering, hand washing, dish washing etc.). As described in **Section 2.1**, vapor intrusion of VOCs to indoor air was ruled out as a complete exposure pathway, since all groundwater concentrations were below VISLs.

Construction Worker. This receptor is an adult individual who is expected to be involved in excavation-related activities at the Site and is assumed to be exposed to COPCs in subsurface soil (since no COPCs were retained in surface soil). Exposure pathways for this receptor include incidental ingestion of and dermal contact with soil, and inhalation of fugitive dust and volatiles. In addition, this receptor may come into contact with shallow groundwater (less than 10 ft-bgs) during excavation activities. Potential exposure pathways include dermal contact with groundwater and inhalation of VOCs in ambient air of an excavation pit or trench ("trench air"). Incidental ingestion of groundwater during typical excavation activities is not expected for this receptor and thus considered an incomplete pathway.

Hypothetical Resident. The Site was historically used for agricultural and residential purposes, but in the last century has been used for commercial/recreational purposes; however, it was assumed for purposes of this Addendum that the property could eventually be redeveloped for residential use. The scenario assumes that a Resident lives on the Site property for the entirety of a 26-year residential tenure. Similar to the Park/Resort Worker scenario, only groundwater is considered to be a relevant exposure medium for the Hypothetical Resident receptor. Exposure pathways are thus the same as those for a Park/Resort Worker.

[4] Per NPS/VHB communications, the EE/CA focus is primarily on surface soils, assuming that excavation/digging of Areas 1 and 2 is not likely to occur. It is assumed that any excavation into the subsurface would be on a very limited, occasional basis and relevant to only a construction worker involved in excavation; extensive relocation of subsurface soils is not expected to occur under a redevelopment scenario.

2.2.2 Estimation of Intake

An explanation of how human intakes and reasonable maximum exposures (RMEs) are calculated is in Section 2.2.2 of the 2021 HHRA.

The intake and exposure equations are presented in **Tables C-2.2a** (ingestion and dermal contact) **and C-2.2b** (inhalation) for the current/future Park/Resort Worker, **Tables C-2.3a** (ingestion and dermal contact) **and C-2.3b** (inhalation) for the future Resident, and **Tables C-2.4a** (soil exposure pathways) **and C-2.4b** (groundwater exposure pathways) the future Construction Worker scenarios. These tables also present the exposure parameters and assumptions used in estimation of intake and the basis of each exposure assumption. Physiological/anatomical parameters such as body weight and skin surface area were obtained from USEPA guidance (e.g., USEPA, 2014), as noted on these tables. Summaries of additional values used in the calculation of the intake and exposure equations are presented on **Table C-2.5** (dermal absorption fraction from soil) and **Table C-2.6** (volatilization and particulate emission factors). The following subsections discuss the calculation of exposure point concentrations, selection of exposure parameters, and other information relevant to calculation of intake.

Exposure Points and Calculation of Exposure Point Concentrations

Exposure points are the locations where a receptor is exposed to a COPC. Exposure point concentrations (EPCs) are estimates of the chemical concentrations to which a potential receptor is likely to be exposed; thus, EPCs are both receptor- and time-specific and dependent upon the exposure period and pathway.

Soil: As previously mentioned, soil COPCs were retained in two subsurface soil samples collected at 5 ft-bgs from the Cottage 7 Area. Due to the small number of samples collected, the maximum detected concentration was conservatively used as the EPC for each COPC. The following soil EPCs were used:

- Benzo(a)pyrene - 0.651 milligrams per kilogram (mg/kg)
- Dibenz(a,h)anthracene - 0.118 mg/kg

Groundwater: As previously mentioned, groundwater COPCs were identified in Area 2. While concentrations of arsenic, barium, and/or naphthalene were detected above RSLs in the shallow hand dug wells, the results from these wells were not used to evaluate future groundwater exposures. These wells are open-air wells currently subject to precipitation and runoff, and likely do not conform with current USVI well regulations. Assuming potable wells are installed in the future, data from only the monitoring wells were considered representative of future potable water.

The maximum detected concentration of each COPC was conservatively used as the EPC for groundwater, assuming that each wellhead could be utilized as its own water supply. The following groundwater EPCs were used:

- Naphthalene - 0.001 milligrams per liter (mg/l)
- Chloroform – 0.00055 mg/l

Receptor-Specific Exposure Parameters

Receptor-specific exposure parameters are values that describe various attributes of a receptor group. Such attributes include anatomical and physiological parameters, such as skin surface area, body weight, inhalation rate and ingestion rates, as well as exposure frequency, time, and duration over which a receptor comes into contact with a COPC. Exposure assumptions unique to each exposure scenario are discussed in the following paragraphs. Exposure assumptions used in this HHRA are discussed below.

Park /Resort Worker

The Park/Resort Worker is an adult individual who performs routine maintenance, surveillance, and cleanup. This receptor is assumed to be at the Site five days per week, eight hours per day, for 50 weeks (i.e., 250 days/year), which is the USEPA default value (USEPA, 2014), for a 10-year occupational tenure at the Resort (based on communications with NPS). See **Table C-2.2a** (ingestion of and dermal contact with groundwater) and **C-2.2b** (inhalation of VOCs in air) for a summary of exposure parameters for the Park/Resort Worker scenario.

Resident

A residential scenario is based on the USEPA default total residential tenure of 26 years (USEPA, 2014). This age range encompasses both a child (0-6 years) and an adult (6-26 years). Both adult and child Residents are assumed to reside at the Site for 24-hours per day for 350 day/year (year-round), which are the recommended USEPA default values for a residential scenario (USEPA, 2014). Physiological and behavioral parameters unique to each age group were used to estimate exposure to the adult and child receptors, since adults and children each have different attributes (for example, adults weigh more and have a larger surface area than children). See **Table C-2.3a** (ingestion of and dermal contact with groundwater) and **C-2.3b** (inhalation of VOCs in air) for a summary of exposure parameters for the future residential scenario.

Construction Worker

The Construction Worker is an adult involved in future construction activities for 250 days/year (five days per week for 50 weeks year), eight hours per day, over a one-year period, which reflects default USEPA assumptions. See **Table C-2.4a** (soil exposure pathways) and **Table C-2.4b** (groundwater exposure pathways) for a summary of exposure parameters for soil for the Construction Worker scenario.

For groundwater exposures, it was assumed that a Construction Worker would only come into contact with groundwater while setting up or dismantling dewatering equipment. These activities were assumed to occur for one-half hour at the beginning and ending of a workweek (2 days a week) over a one-year period. Inhalation exposures within the excavation pit or trench were assumed to occur over an eight-hour period (typical length of a workday). See **Table C-2.4b** for a summary of exposure parameters for groundwater for the Construction Worker Scenario.

Calculation of Dermal Absorption Factor

Dermal absorption of water is a function of the concentration of the COPC, the chemical/physical properties of a COPC, and the receptor's exposure time. For evaluating the dermal exposure route for groundwater (for the construction/utility worker scenario), USEPA-recommended equations (USEPA, 2004) were used in conjunction with chemical-specific properties to estimate dermal absorption of COPCs. An intermediate "dermal absorption factor" (DAevent) for water exposures was first calculated; this factor was then used in calculation of dermal dose estimates for groundwater. DAevent calculations are presented on **Table C-2. 7** for the Construction Worker scenario and **Tables C-2.8** (child) and **C-2.9** (adult) for the residential scenario.

Calculation of Ambient Trench Air Concentrations

VOCs (naphthalene and chloroform) were retained as COPCs in groundwater and the potential exists for these constituents to volatilize from standing groundwater within a trench to ambient air (i.e., trench air). Trench air EPCs were estimated from groundwater EPCs using an USEPA air emission model (USEPA, 1990). This model conservatively assumes that VOCs emanate from the subsurface in a trench throughout the workday. A description of the model and ambient air EPC calculations for the current/future construction/utility worker is presented on **Table CA-1** in **Attachment A**.

2.3 Dose-Response Assessment

As explained in Section 2.3 of the 2021 HHRA, the toxicity (or dose-response) assessment describes the relationship between the level of exposure and the likelihood and/or severity of an adverse effect. In other words, the dose-response assessment quantifies the toxicity of each COPC using information obtained from published literature describing epidemiologic or toxicological studies. The products of the dose-response assessment are the toxicity values used to predict the likelihood of adverse health effects in identified receptors at Site-specific exposure levels.

Toxicity information for chemical COPCs was obtained using the USEPA's recommended hierarchy of toxicity values (USEPA, 2003):

- Tier 1: USEPA Integrated Risk Information System (IRIS) database (USEPA, 2022b)
- Tier 2: USEPA Provisional Peer Reviewed Toxicity Values (PPRTVs), as provided on the Oak Ridge National Laboratory (ORNL) PPRTV website (ORNL, 2022)
- Tier 3: Other sources, including the USEPA Health Effects Assessment Summary Tables (USEPA, 1997), California Environmental Protection Agency, Agency for Toxic Substance Disease Registry, and other sources.

Sources of toxicological information for each COPC are documented in the toxicity summary tables (**Tables C-2.10 through C-2.13**).

Dose-response information is divided into three major categories: (1) toxicity data associated with threshold (non-carcinogenic) effects; (2) toxicity data concerning carcinogenicity; and (3) the absorption

adjustment factors used to relate toxicity information identified from the literature to the exposure pathways evaluated for the Site. These categories are described in the following sections.

2.3.1 Dose-Response Criteria for Non-Carcinogenic Effects

The methods for evaluating non-carcinogenic effects and using toxicity values are presented in Section 2.3.1 of the 2021 HHRA. **Table C-2.10** provides a summary of the oral and dermal reference doses (RfDs) for each COPC at the Site. Inhalation reference concentrations (RfCs) are provided in **Table C-2.11**. Gastrointestinal absorption fraction (ABSgi) values, equations for the adjustment of oral RfDs, and resultant dermal RfDs are presented on **Table C-2.10**.

2.3.2 Dose-Response Criteria for Carcinogenic Effects

The methods for evaluating carcinogenic effects and using cancer slope factors (CSFs) and inhalation unit risks (IURs) are presented in Section 2.3.2 of the 2021 HHRA. CSFs and IURs are summarized in **Table C-2.12** and **Table C-2.13**.

2.3.3 Evaluation of Mutagenic COPCs

USEPA's guidance on cancer risks (2005) indicate that carcinogens that act via a mutagenic mode of action may have a greater toxicity during early versus later life stages. Because of this, USEPA specifies the use of age-dependent adjustment factors (ADAFs) for mutagenic constituents when estimating cancer risk (USEPA, 2005) in receptor populations aged under 16 years. Of the COPCs, benzo(a)pyrene was the only COPC identified as a carcinogen with a mutagenic mode of action (USEPA, 2005). However, this COPC occurs in soil, which is a medium of concern for only the Construction Worker, an adult receptor. Therefore, ADAF adjustments were not required.

2.4 Risk Characterization

Risk characterization is the process of quantifying the significance of residual chemicals in the environment in terms of their potential to cause adverse health effects. The quantitative estimates are expressed in terms of a probability statement for the potential theoretical incremental cancer risks and as a hazard index (HI) for the likelihood of adverse non-cancer health effects. The general methodologies used for estimating risk for carcinogens and non-carcinogens are presented below.

2.4.1 Methodology Used to Calculate Cancer Risk

The methods for calculating cancer risk are presented in Section 2.4.1 of the 2021 HHRA.

Table C-2.14 presents the intake and cancer risk estimates for the Park/Resort Worker, **Table C-2.15** for the Resident, and **Table C-2.16** for the Construction Worker.

2.4.2 Methodology Used to Calculate Hazard Indices

The methods for estimating chronic non-cancer HIs are presented in Section 2.4.2 of the 2021 HHRA.

The estimation of intake and non-cancer hazard are presented in **Table C-2.17** for the Park/Resort Worker, **Table C-2.18** for the Resident, and **Table C-2.19** for the Construction Worker.

2.4.3 Points of Departure for Hazard and Cancer Risk

The National Oil and Hazardous Substances Pollution Contingency Plan (NCP) is commonly cited as the basis for target risk and hazard levels. According to the NCP, total cancer risks posed by a site should not exceed one in one million (1E-06) to one in ten thousand (1E-04), and non-carcinogenic chemicals should not be present at levels expected to cause adverse health effects (i.e., HI greater than 1). As a risk management policy, the NPS considers a total cancer risk of 1E-06 and a total non-cancer HI of 1 to be the risk thresholds used to make risk management decisions.

2.4.4 Risk Characterization Results

This section presents the results of the risk characterization for each receptor scenario quantitatively evaluated in the HHRA. **Tables C-2.14 through C-2.16** present calculation of intake, cancer risk, and non-cancer hazard for each COPC and exposure pathway. **Tables C-2.17 through C-2.19** present a summary of non-cancer hazard/cancer risk by COPC and exposure pathway. **Table C-2.20** presents a detailed summary of total cancer risks, hazards, and risk drivers (i.e., COPCs with total cancer risk greater than 1E-06 and non-cancer HI greater than 1) for all receptor scenarios. Results for individual exposure scenarios are summarized below.

The total cancer risk and HI associated with exposure to COPCs identified in Cottage 7 Area (soil) and Investigation Area 2 (groundwater) are shown in Charts 1 and 2 below. The horizontal red line on Charts 1 and 2 identifies the NPS risk threshold for each risk type, cancer (risk=1E-06) or non-cancer (hazard index = 1). Calculated risks below these thresholds indicate that COPCs are not present at levels expected to cause adverse health effects to receptors.

Chart 1 summarizes total cancer risks for all receptors. As shown in this chart, the total cancer risk for potable use exposure pathways for the Resident in Investigation Area 2 is above the NPS risk limit of 1E-06. The total risk of 3E-06 for the Resident is due to naphthalene. The total risk for the Park/Resort Worker and Construction Worker are below the NPS risk threshold of 1E-06.

Chart 1 Total Cancer Risk for All Receptors

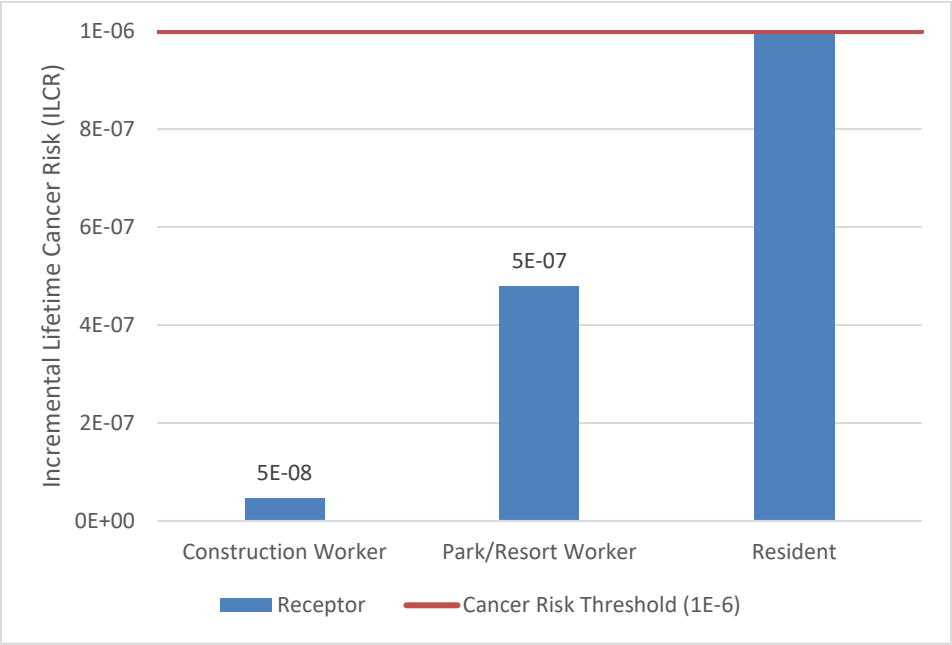
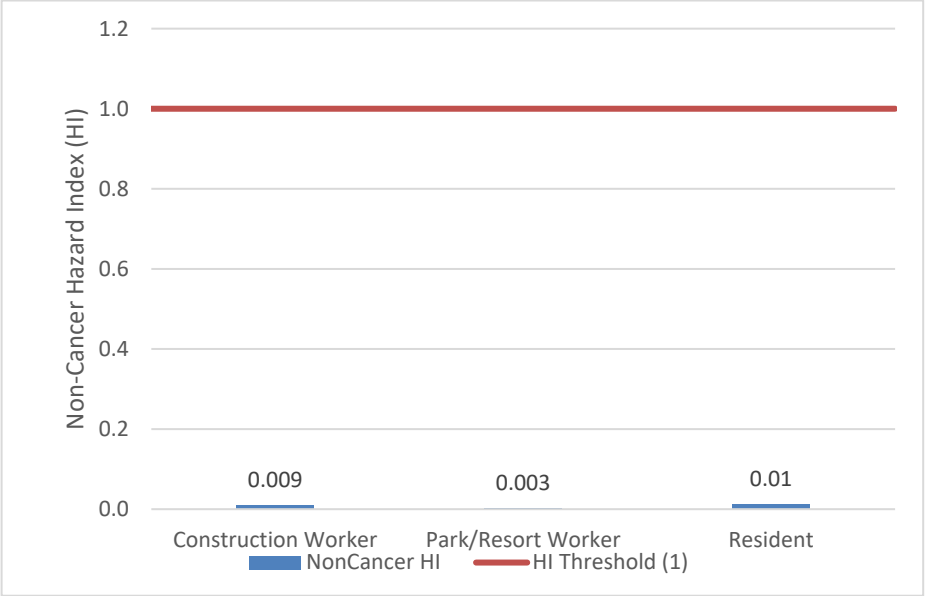


Chart 2 presents the total HI for all receptors; all noncancer HI values are below the NPS threshold of one (1).

Chart 2: Total Non-Cancer HI for All Receptors



2.5 Asbestos Risk Evaluation

VHB conducted an asbestos assessment, summarized in the NPS EE/CA Field Activities Report (VHB, 2021). This assessment included use of ground penetrating radar, visual observations, and collection of samples of possible asbestos-containing materials (ACM) to determine the presence or absence of asbestos and, if observed, the types and percentages of fibers. Sample analysis was conducted using either PLM or TEM. Results were discussed in the EE/CA Addendum and presented in **EE/CA Add Table 1**. VHB confirmed ACM in exposed building materials (such as roofing materials and window caulk and glazing) and buried piping. These materials contained both chrysotile and amphibole asbestos types at levels ranging from approximately 2% to 56%, with roofing material containing the highest percentage levels.

Asbestos generally does not present a health hazard unless asbestos fibers are released from a source material into air, where they can then be inhaled. Inhaling asbestos fibers increases one's risk of developing lung cancer and mesothelioma. Inhaling asbestos fibers can also result in lung fibrosis. Because of these health effects, it is important to understand the potential for a person's exposure to asbestos to occur when ACM is present.

The PLM and TEM asbestos results indicate the percentage of asbestos, if present, in a sampled material. This information does not, however, indicate the level of health risk associated with ACM.

For asbestos in ACM to become airborne, the source material must easily crumbled by hand (friable) such that fibers can be released into the environment and emit fibers. The ACM observed at the Site, based on

VHB's assessment, was considered currently non-friable. Piping, window caulking, glazing, and other building materials were observed to be in competent condition, intact, and for some materials such as piping, buried underground. Hurricane debris was found to have ACM in tar paper, but the paper was still attached to wood and other roof material. Under current conditions, these ACM are unlikely to generate airborne fibers and therefore pose little health risk to human receptors who could potentially encounter ACM on the Site.

However, these ACM have the potential to become friable in the future. Many of the ACM are exposed to outdoor elements such as wind, rain and ultraviolet light, which will eventually cause the ACM to deteriorate with time. Should the ACM not be properly managed and deteriorate, asbestos fibers could be released into the air. Those who are untrained and/or unaware of the presence of ACM (such as visitors, trespassers, local residents, construction workers, or NPS workers) have the potential to inadvertently crumble these materials, allowing asbestos fibers to be emitted and inhaled, and thereby increasing risk of cancer and other adverse lung effects.

2.6 HHRA Uncertainty Analysis

Uncertainty analysis is an important component of all risk assessments. The uncertainty analysis identifies and evaluates the uncertainties typically associated with key parameters in the risk characterization, including the environmental concentrations, screening criteria, toxicity values, and exposure assumptions used to estimate the magnitude of exposure and to quantify health risks. The May 2021 HHRA discussed many of the general uncertainties related to characterization of exposure and effects. This section discusses uncertainties specific to the data that is the subject of this Addendum.

Analytical Data

Soil analytical data used in this HHRA were collected during the November 2021 investigation activities and represent current Site conditions. These discrete soil samples were collected to fill data gaps identified in the May 2021 risk assessment and were used to evaluate the vertical and horizontal extent of impacts in the investigation areas. Little visual evidence of impact was observed, and generally low levels of contaminants were detected in soils, indicating that data gaps have been addressed. Data suggest there is limited or negligible risk associated with soils in these additional investigation areas.

Groundwater samples used in these risk assessments were collected from Area 2 in November 2021 and January 2022. November 2021 samples included monitoring wells MW-2-06, MW-2-07, and MW-2-09. Additionally, two dug wells in Area 2 (Dug Well 1 and Dug Well 2) indicated potential year-round groundwater, prompting the installation of two additional monitoring wells (MW-2-21 and MW-2-22) near the dug wells, for a total of seven sample locations. Only one or two samples were collected from each location. Due to the limited number of groundwater samples, there is some uncertainty on whether these data adequately represent temporal and spatial changes in groundwater concentrations. The wet season may be the only time water is present in some of the installed wells, and temporal sampling may not be possible. Again, however, no specific sources of contamination were identified, and groundwater

contaminant concentrations were relatively low; this lack of additional rounds is not expected to significantly affect the conclusions of the risk assessment.

Additionally, concentrations of arsenic, barium, and/or naphthalene were detected above RSLs in the shallow hand dug wells. Data collected from the hand dug wells were not used to evaluate future groundwater exposures because these wells are open-air wells currently subject to precipitation and runoff, and likely do not provide a viable potable water supply in their current condition. The concentrations of COPCs were similar to those in monitoring wells, and it is expected that, should these wells actually be put into use in the future, the magnitude of risk would be similar to that of the risk calculated for monitoring wells.

Selection of COPCs

Soil and groundwater analytical data were compared to residential RSLs to select COPCs. These criteria are typically designed to be conservative, such that the HHRA focus on the constituents that are most likely to present risk, while not significantly underestimating risk by excluding chemicals from quantitative assessment. Exclusion of contaminants that are present below the RSL will underestimate the total risk for a receptor; however, this underestimation is not expected to be significant relative to risk from identified COPCs.

As previously mentioned, constituents that were never detected in any samples were eliminated as COPCs from the risk assessment.

Overall, most of the analytical results met project action levels (PALs), which are generally based on conservative risk-based screening levels (such as RSLs), so there is a high degree of confidence that any risk from the exclusion of these non-detect results would be negligible. Note that all samples except for the November sampling of MW-2-09 have a PAH reporting limit of 1 microgram per liter (µg/l). This elevated reporting limit adds uncertainty as to whether the actual concentrations are above or below PALs that are less than 1 µg/l, which is the case for anthracene, naphthalene, phenanthrene, and pyrene. For constituents that do not meet PALs, if these constituents are truly present at the Site but at undetectable levels above PALs, their exclusion may underestimate cumulative risks. Concentrations of these PAHs were not detected above soil PALs near the fuel release area, however.

There were three semi-volatile organic compounds (SVOCs) and one VOC detected in soil that did not have residential soil RSLs available. Therefore, screening criteria for other constituents that were structurally similar to these constituents were used as surrogate benchmarks. While this approach allows evaluation of constituents that might otherwise be excluded from the COPC selection process (due to a lack of screening criteria), there is some uncertainty in whether the toxicity of the surrogate compound is equivalent to the toxicity of these other constituents lacking criteria, which could potentially either over- or under- estimate the risk.

Exposure Assessment

In general, estimation of EPCs, characterization of current and reasonably foreseeable Site activities and uses, and calculation of average daily doses contribute most to the uncertainty in the exposure assessment

component of the risk characterization. To counter this uncertainty, conservative exposure assumptions, based on either Site-specific information or conservative default values provided in USEPA and other guidance were used to quantitatively evaluate potential risks at the Site. This risk analysis includes evaluation of the RME for each receptor. The RME exposure assumptions generally are designed to reflect upper-bound values and thus intentionally overestimate risk to the general population. The maximum detected concentration in soil and groundwater was used as the EPC. While this is generally considered to be a conservative approach, since it is expected that contaminant concentrations may vary (and for organic compounds, decrease) over time, there is some uncertainty associated with the full range of detected concentrations in datasets with small sample sizes.

For this HHRA, it was assumed a Construction Worker would come into contact with COPCs in both soil and groundwater during excavation activities. COPCs in soil were retained in the Cottage 7 Area and COPCs in groundwater were retained in Investigation Area 2. Due to COPCs being retained in different areas within the Site, it is unlikely that a Construction Worker would come into contact with COPCs in both soil and groundwater in these two areas at the same time. However, the cumulative risk for the Construction Worker scenario conservatively includes exposure to both media, and intentionally overestimates the risk for this receptor.

During the collection of groundwater samples from MW-2-21 in November 2021, VHB noted that the well ran dry after less than 1 gallon of water was removed. Based on this observation, it is unlikely that groundwater in the overburden would be a viable source of tap water for a Resident or Park/Resort Worker. The assumption that overburden groundwater may be used for drinking water in the future is therefore conservative and likely overestimates health risks for both the Resident and Park/Resort Worker receptor scenarios.

Toxicity

The primary sources of uncertainty in the dose-response assessment are associated with the toxicity values used to quantify risks. These general uncertainties were discussed in the May 2021 HHRA. With regard to the COPCs identified in this Addendum, the CSFs and IURs used to estimate cancer risk are considered conservative values that provide high confidence that the actual cancer risk is not likely to exceed the estimated cancer risk (in other words, the HHRA intentionally overestimates risk). The noncancer RfDs and RfCs are more likely to overestimate rather than underestimate potential health hazards, particularly because many of the values incorporate uncertainty/modification factors spanning up to several orders of magnitude (ranging from 300 to 1,000).

There is some uncertainty in characterizing risks from the dermal route of exposure. Of the COPCs, only barium had an adjustment factor to convert the oral toxicity value to a dermal toxicity value. For the other remaining COPCs, the HHRA Addendum used the oral toxicity values to estimate dermal risks. Use of oral values may potentially over- or underestimate potential risks via dermal exposure routes.

Risk Characterization

Total risk and hazard were calculated as the sum of risk from individual COPCs and exposure routes. This assumption of simple additivity may not necessarily take into account synergistic or antagonistic effects of chemical mixtures and consequently may potentially over- or under-estimate total risk. Additionally, total cancer risk and HI calculated in this HHRA do not include risk related to chemicals excluded from the COPC selection process, thus potentially underestimating total risks. However, these constituents (either not detected or detected at concentrations below conservative RSLs) are assumed to pose negligible risk in general, such that this underestimation is not expected to appreciably affect the conclusions of the HHRA.

Uncertainty Analysis Summary

In summary, each section of the risk characterization is based on a number of assumptions intended to be protective of human health. Uncertainties in this risk characterization may bias the risk result to either overestimate or underestimate risk. Many assumptions incorporated into this risk characterization are inherently conservative (i.e., protective), however, and therefore, the risk estimates presented in this report are typically more likely to overestimate rather than underestimate the potential risk for the Site.

Lastly, it is important to emphasize that the risks calculated in this HHRA are *estimated* risks; and are hypothetical and should not be construed to represent actual cancer risk or non-cancer hazard to an individual. Consequently, these estimates should be used to target areas of the Site that may require additional information, sampling and/or response action, and to provide practical risk management information to Site managers.

2.7 HHRA Summary

The purpose of this HHRA was to characterize the nature and magnitude of total non-cancer hazards and cancer risks associated with exposure to COPCs in soil and groundwater at the Site, to determine the need for removal in support of the EE/CA Addendum Report. The HHRA used the soil and groundwater data collected in November 2021 and January 2022 at the Site to estimate exposure and total cancer risk and hazard for a Park/Resort Worker, Construction Worker, and Resident who may be exposed to COPCs in soil and/or groundwater. The results of the HHRA indicate the following estimated risks associated with exposure to COPCs identified in soil and groundwater.

Park/Resort Worker:

- Total cancer for groundwater (tap water use) for the Park/Resort Worker scenario (5E-07) is below the NPS threshold.
- Non-cancer hazard for the Park/Resort Worker (0.003) is below the NPS threshold of 1.
- No risk drivers were identified for the Park/Resort Worker scenario.

Construction Worker:

- Total cancer for soil and groundwater exposures for the Construction Worker scenario (5E-08) is below the NPS threshold.
- Non-cancer hazard for the Construction Worker (0.009) is below the NPS threshold of 1.
- No risk drivers were identified for the Construction Worker scenario.

Resident:

- Total cancer risk for groundwater (tap water use) for the Resident scenario (3E-06) exceeded the NPS threshold of 1E-06.
- The total non-cancer hazard for the Resident scenario (0.01) is below the NPS threshold of 1.
- The primary risk driver identified for this receptor is naphthalene in groundwater.

As discussed in **Section 2.6**, while there are some uncertainties associated with analytical data, exposure assumptions, and toxicity values used to quantify human health risks, many of the assumptions and parameters used in this HHRA are conservative and therefore intended to overestimate potential human health risk. Based on the slow recharge observed in the MW-2-21 monitoring well and the observations that groundwater is not present in many parts of the resort, it is unlikely that the overburden groundwater could provide adequate water to be used as a tap water supply for either a Resident or Park/Resort Worker.

3 Ecological Risk Assessment

3.1 Introduction

This section presents a screening level ecological risk assessment (SLERA) and Refinement of groundwater data collected during the November 2021 and January 2022 sampling events at Site. The initial EE/CA investigation did not generate groundwater data, due to lack of presence of groundwater in the monitoring wells, and so groundwater was not evaluated in the 2021 SLERA. The subsequent 2021-2022 investigation included installation of monitoring wells and collection of groundwater samples from both monitoring wells and two shallow dug wells (see **Section 1.2.2**). This Addendum thus applies the approach and methodology of the May 2021 SLERA to the assessment of groundwater, which is evaluated as a surrogate for surface water that may be present at the Site in the future or which may discharge to the surface water of Caneel Bay. Further information about the details of the 2021-2022 sampling event and results in other media are provided in the EE/CA.

The May 2021 SLERA established that St. John has a unique set of potential ecological receptors. The birds, bats, amphibians, reptiles, and plants likely to be at the Resort are exposed to surface soil, not subsurface soil. As a result, there is no complete exposure pathway from deep soil to ecological receptors, and the subsurface soil results were not considered in the risk assessment. Because no surface soil decision unit sample results exceeded risk-based screening levels or Removal Goals, no assessment of soil was performed for this Addendum.

The primary purpose of a SLERA is to eliminate from further consideration Site contaminants considered to present negligible risk to ecological receptors. Site contaminants retained in the screening process may have the potential to present a risk to ecological receptors but require further study to confirm whether adverse effects are in fact occurring. For this reason, this study also includes a "Refinement" step, in which additional exposure and evaluation measures are used to more completely characterize the origin and potential effect of Site contaminants identified by the SLERA screening.

This Addendum is based on the same Site understanding and follows the same methodology as presented in the May 2021 SLERA, to which the reader is referred for more detail. For convenience, key components of the May 2021 SLERA are summarized in the sections below, augmented as appropriate to reflect the assessment of groundwater.

3.2 Problem Formulation

The Problem Formulation step identifies the pertinent exposure characteristics of the Site and describes the study objectives. In this Addendum, the Problem Formulation addresses the use of groundwater as a surrogate medium for surface water. The key components of the Problem Formulation for this Addendum are presented below.

Selection of Study Constituents: Consistent with the May 2021 SLERA, all detected compounds are considered Study Constituents and subject to evaluation.

Exposure Pathways and Potential Receptors: As described in the May 2021 SLERA, exposure pathways are the linkage between the contaminant source and the receptor. Receptors are those organisms which, based on the characteristics and distribution of each constituent, are likely to be exposed to study constituents at a site.

As noted, this Addendum evaluates groundwater, which may contain Site constituents as the result of releases to surface or subsurface soils during Resort operations. While groundwater is typically not an exposure medium for ecological receptors, it can become one at this Site if it discharges to surface water either in the Dug Wells, Caneel Bay, or at any future low-lying areas saturated during times of high water levels. location. In these instances, however, concentrations would be subject to substantial reduction through dilution, beginning in the sediment and increasing many-fold as groundwater enters the water column, particularly in Caneel Bay. Nonetheless, in this Addendum groundwater from all locations will be evaluated directly as a conservative surrogate for surface water regardless of proximity to areas of potential discharge as means of assessing all potential future conditions at the Site.

The two Dug Wells at the Site are unique in that the water they contain is open to the air, although Dug Well 1 is currently covered with a pallet and debris. Dug Wells 1 and 2 are about 8 ft wide and 12.5 ft and 10 ft deep, respectively, and are rock-lined, potentially dating from the plantation era. The water surface is about 4.8 ft. below the top of the rock walls around each one, effectively preventing use by wildlife but allowing access by flying insects, which may deposit eggs on the water surface. While the extent to which these wells contain groundwater rather than accumulated surface precipitation (in the manner of a cistern) is unknown, they are evaluated in this report along with other the results from groundwater wells as potential habitat for aquatic organisms.

Assessment Endpoints: Assessment endpoints are the ultimate focus of the risk assessment and are evaluated by the measures of effects to develop a final risk characterization of the Site. An assessment endpoint most commonly consists of an ecological receptor and a characteristic of that receptor (e.g., survival and reproduction). For this Addendum, which focuses exclusively on groundwater, the assessment endpoints are aquatic species, which are considered to have the highest potential for exposure. These are as follows:

- Survival, growth, and reproduction of benthic (bottom-dwelling) and aquatic invertebrates
- Survival, growth, and reproduction of benthic fish (Caneel Bay only)

No fish are expected in any potential future on-site discharge locations.

Measures of Exposure: Measures of exposure quantify or reflect the extent to which receptors are exposed to a site stressor, in this case Study Constituents. As described previously, exposure of organisms to constituents in potential surface waters will be represented by concentrations in Site groundwater and Dug Wells. In accordance with the conservative approach of a SLERA, the maximum detected concentration of each Study Constituent in groundwater is used as the estimate of exposure.

Measures of Effect: Measures of effect are values used to estimate whether or to what degree a stressor may adversely affect a receptor. For this screening-level assessment, measures of effect are ecological screening values (ESVs) for surface water, which are generic, conservative, and chemical-specific screening concentrations associated with no or minimal adverse effects. Consistent with the May 2021 SLERA, ESVs for aquatic life are obtained when available from the following NPS guidance:

- National Park Service (NPS), 2018. NPS protocol for the selection and use of ecological screening values for non-radiological analytes. Rev. 3 NPS Contaminated Sites Program, Washington DC

No aquatic life ESVs were available in this guidance for chloromethane or isopropyl benzene. ESVs for these constituents were thus obtained from the following sources:

- Chloromethane: USEPA Region 3, 2006. Biological Technical Assistance Group (BTAG) Screening Values.
- Isopropylbenzene: Texas Commission on Environmental Quality, 2021. Update to Guidance for Conducting Ecological Risk Assessments at Remediation Sites in Texas RG-263 (Revised). Remediation Division. August.

Pathway-Receptor Diagram: The tenets of the Problem Formulation described above are represented visually in a pathway-receptor diagram. For this Addendum, the pathway-receptor diagram from the May 2021 SLERA has been expanded to include the groundwater-surface water pathway and is shown in **Figure C-1**.

Study Constituent concentrations in groundwater are compared to NPS ESVs in the following section.

3.3 Risk Calculation

In this section, maximum detected concentrations of Study Constituents in groundwater are compared to ESVs to obtain a preliminary assessment of the potential for ecological risk for aquatic receptors. Groundwater concentrations relative to an ESV are presented as a hazard quotient (HQ), expressed as the following:

$$HQ = \frac{\text{Groundwater concentration}}{\text{Chemical-specific ESV}}$$

A maximum HQ of less than 1.0 indicates that all concentrations are below the threshold levels for potential toxic effects and that risks are likely to be negligible. These Study Constituents are not retained for further evaluation. An HQ equal to or greater than 1.0 in at least one sample suggests that exposures may be associated with toxic effects and that further evaluation of these constituents is thus warranted. Study Constituents with a maximum HQ equal to or greater than 1.0 are designated as preliminary contaminants of potential ecological concern (PCOPECs) and are retained for evaluation in **Section 3.5**, Refinement of COPECs.

Groundwater was analyzed for VOCs, PAHs, metals, and pesticides. The risk calculation for Site groundwater is presented by chemical class in the sections below. No pesticides were detected in groundwater at any location, so these are not discussed.

3.3.1 Volatile Organic Compounds Risk Calculation

Groundwater results compared to ESVs and other criteria are shown in **Table C-1.2**. As shown, eight VOCs were detected at trace concentrations in different wells, and none exceeded ESVs. One constituent,

carbon disulfide, was detected in a dug well in January 2021 at a concentration equal to the ESV of 0.92 µg/l, and so was retained for further evaluation in the Refinement of **Section 3.5**.

3.3.2 Polycyclic Aromatic Hydrocarbons Risk Calculation

Table C-1.2 shows groundwater results compared to ESVs and other criteria. As shown in this table, six PAHs were detected in groundwater and trace concentrations of two of them, anthracene (0.028 µg/l) and pyrene (0.065 µg/l), exceeded ESVs, producing HQs of 2.3 and 2.6, respectively. In addition, naphthalene was reported at one location at a concentration of 1.1 µg/l, which is equal to the ESV. These three constituents – anthracene, pyrene, and naphthalene - were thus retained as PCOPECs for further evaluation in the Refinement of **Section 3.5**.

However, the reporting limits for some PAHs exceeded their ESVs. For the January 2022 PAH samples, this resulted from the use of a different extraction technique rather than from sample characteristics. With reporting limits higher than ESVs, some concentrations that exceed the ESV would not be detectable by the analytical method, adding uncertainty to the determination of potential for risk. However, while the reporting limit is the lowest concentration at which a constituent can be accurately measured, analytical techniques can still detect concentrations below this level, and in this instance such detections are reported and qualified by a "J" qualifier, indicating a detection below the reporting limit. With the exception of naphthalene, no J-qualified data were reported for the samples and analytes that had reporting limits higher than the ESVs. The lack of J-qualified data indicating a detection below the reporting limit suggests that these constituents are truly absent in groundwater, so none of these constituents were retained as PCOPECs.

3.3.3 Metals Risk Calculation

Table C-1.2 shows groundwater analytical results for arsenic and barium. Lead was not detected in any of the seven samples for which it was analyzed and is therefore not included in **Table C-1.2.** While lead has a relatively low ESV (0.92 µg/l), reporting limits for all samples were below this value, ranging from 0.37 µg/l to 0.74 µg/l. For barium, all four detected concentrations exceeded the ESV of 3.9 µg/l. Detected concentrations ranged from 220 µg/l at MW-2-21 to 400 µg/l at Dug Well 2, resulting in HQs of 56.4 to 102.6. Arsenic was detected in both Dug Well 1 and Dug Well 2, and concentrations in only Dug Well 1 exceeded the ESV of 3.1 µg/l. The HQ for arsenic at this location is 2.0. Barium and arsenic were thus retained as PCOPECs for further evaluation in the Refinement of **Section 3.5**.

3.4 Summary of Screening Level Risk Assessment

In this section, study constituents in groundwater were compared to ESVs to separate those constituents associated with negligible potential for risk from constituents for which further study is required. Those with maximum concentrations below the ESV were eliminated from further consideration, while those with concentrations equal to or exceeding benchmarks in at least one sample were designated as PCOPECs and retained for further evaluation.

Groundwater constituents designated as PCOPECs and retained for further evaluation consist of the following:

PCOPEC	Maximum Concentration, µg/l	ESV, µg/l	Maximum HQ	No. Exceedances	Location of Maximum Exceedance
Carbon disulfide	0.92	0.92	1.0	1	Dug Well 2
Anthracene	0.028	0.012	2.3	1	MW-2-07
Pyrene	0.065	0.025	2.6	1	MW-2-07
Naphthalene	1.1	1.1	1.0	1	Dug Well 2
Arsenic	6.2	3.1	2.0	1	Dug Well 1
Barium	400	3.9	102.6	4	Dug Well 2

These constituents are evaluated further in **Section 3.5**, below.

3.5 Refinement of Contaminants of Potential Concern

In this analysis, each constituent that exceeded ESVs in **Section 3.4** and was designated as a PCOPEC is evaluated further by considering additional toxicity data and Site-specific information. The goal of this analysis is to reduce the uncertainty associated with the use of the most conservative screening-level toxicity assumptions so that the final risk conclusions are still conservative, but more relevant to Site-specific conditions and actual levels of effect. The results of this analysis provide a more accurate understanding of potential Site-related risk than the screening analysis and are used to inform subsequent investigation or risk management decisions.

For groundwater effects on aquatic organisms, additional information used in the assessment of PCOPECs consists of the following, as appropriate:

- Updated toxicity values
- Consideration of groundwater fraction

Six PCOPECs – carbon disulfide, anthracene, pyrene, naphthalene, arsenic, and barium – were identified in the SLERA. These are evaluated individually below for potential effects on aquatic organisms, the receptors with the highest potential exposure to groundwater constituents.

Carbon Disulfide: Carbon disulfide is used in the manufacturing of industrial chemicals and is also produced naturally in aquatic settings by some algae and degradation processes (Environment Canada, 2000). It is also occasionally detected as a laboratory contaminant from the use of nitrile gloves. It was detected at the ESV of 0.92 µg/l in a single sample from Dug Well 2, and the result was flagged as an estimated quantity.

The carbon disulfide ESV consists of an ecological benchmark developed by Oak Ridge National Laboratory (ORNL) using USEPA Tier II methodology, which is a technique used by USEPA to obtain screening values for constituents for which insufficient data are available to develop defensible water quality criteria (Suter and Tsao, 1996). Under this method, uncertainty factors, some as high as 242, are used to in place of missing data, an approach that introduces a high level of uncertainty to the final calculated values, which in consequence are often below detectable concentrations. An uncertainty factor of 242 was in fact used in the estimation of the 1996 carbon disulfide benchmark. A review of associated data presented with the 1996 Tier II value indicates that the actual estimated lowest chronic effect levels for carbon disulfide range from 244 µg/l to 9,538 µg/l (Suter and Tsao, 1996), well above the 0.92 µg/l detected in Dug Well 2.

In addition, updated Tier II values derived from more recent research were developed by USEPA in 2013 and incorporated into USEPA Region 4 ecological screening values (USEPA Region 4, 2018). The updated screening value for carbon disulfide is 15 µg/l, well above the 0.92 µg/l detected at the Site.

Because the detected concentration falls well below USEPA 2018 screening values and the lowest chronic values associated with the 1996 ESVs, little or no potential for risk to aquatic receptors is expected from reported concentrations of carbon disulfide.

Anthracene, Pyrene, and Naphthalene: These three constituents are components of oil and (for pyrene) soot and residuals from combustion engines and furnaces. They are common constituents in stormwater runoff from roadways, parking lots, and asphalt surfaces, and are ubiquitous in surface waters and sediments in developed areas and urban settings. They tend to bind to organic carbon in sediments and soil, but may be detected in surface water bound to fine particulates or at trace levels in dissolved form, which reflects their relatively low level of solubility.

Anthracene and pyrene were detected at trace levels (0.028 and 0.065 µg/l, respectively) in a single sample obtained from MW-2-07, located near the Dug Wells. Naphthalene was detected at 1.1 µg/l in Dug Well 2. Associated HQs ranged from 1.0 (naphthalene) to 2.6 (pyrene).

NPS ESVs for all three PCOPECs consist of Canadian water quality guidelines. To further assess the detected concentrations of these PAHs, NPS guidance also presents values from other sources for use in Refinement assessments. Where available, these additional values are the Oak Ridge National Laboratory (ORNL) Tier II values from 1996 (Suter and Tsao, 1996) discussed previously, and detected concentrations were compared to these values. For pyrene, however, no additional Refined ESV is provided in NPS guidance (since no ORNL value is available), so detected concentrations were compared to USEPA Region 4 ecological screening values (USEPA Region 4, 2018). These USEPA Region 4 screening values are updated versions of the 1996 Tier II estimates, reflecting new data available after 1996. Detected concentrations relative to these screening numbers are provided below:

PCOPEC	Concentration, µg/l	ESV, µg/l	NPS Refined ESV, µg/l	EPA Region 4 Screening Value, µg/l
anthracene	0.028	0.012	0.73	---
pyrene	0.065	0.025	0.025	4.6
naphthalene	1.1	1.1	12	---

As shown by this table, all detected concentrations of anthracene, pyrene, and naphthalene fell below NPS Refined ESVs or the updated Tier II values cited by USEPA Region 4. All of these screening values are still conservative benchmarks, below which the potential for effect is negligible. Because anthracene, pyrene and naphthalene were detected in only one location at trace concentrations well below these conservative screening values, little or no potential for risk to aquatic receptors is expected in surface waters derived from Site groundwater.

Arsenic: Arsenic was detected in Dug Well 1 and Dug Well 2, at concentrations of 6.2 µg/l and 2.3 µg/l, respectively. Only the concentration in Dug Well 1 exceeds the ESV of 3.1 µg/l, which is a Tier II value generated from limited data (Suter and Tsao, 1996).

However, the NPS Refined ESV for arsenic is 150 µg/l and is the federal chronic water quality criterion, a legally-enforceable national standard protective of aquatic life. The maximum detected concentration of 6.2 µg/l is well below this value. Because maximum arsenic concentrations are below EPA water quality criteria for arsenic, no adverse effect to aquatic organisms exposed to discharging groundwater in the Dug Wells or elsewhere is expected.

Arsenic is found in the environment from both natural sources (in rock, which can erode into water or soil) and anthropogenic sources (in rat and ant poisons and herbicides). The two Dug Wells at the Site are open to the air and cased with stone and are therefore subject to surface runoff and atmospheric deposition. The lack of detected concentrations of arsenic in the two nearby groundwater monitoring wells (MW-2-21 and MW-2-22) suggests that runoff may be a contributor to the arsenic in the Dug Wells.

Barium: Barium is a natural constituent in groundwater and was detected in all four samples at concentrations ranging from 220 µg/l to 400 µg/l. All detected concentrations exceeded the ESV of 3.9 µg/l, producing HQs ranging from 56.4 to 102.6.

The NPS Refined ESV for barium is 4.0 µg/l and is a 1996 Tier II value developed by ORNL using the USEPA the Tier II methodology described previously. The updated 2018 EPA Tier II value for barium is 220 µg/l (USEPA Region 4, 2018) and is derived from an expanded dataset that includes the results of new research conducted since 1996. It is thus a more accurate estimate of a level below which the potential for risk is negligible. Three of the four detected concentrations exceeded this updated screening value of 220 µg/l by less than a factor of two, producing HQs from 1.4 to 1.8.

The elevated concentration of barium may result from characteristics the analysis of groundwater samples. As described previously, the water sample results for metals consists of a "total" metal result,

which includes both dissolved metals and those bound to fine particulates suspended in the water column (visible as turbidity) or stirred up from bottom sediment. ESVs and promulgated water quality criteria for most metals are based on and applicable to the dissolved fraction only, since this is the form that is absorbed by organisms. A total metals result is typically higher than the dissolved fraction, often by a significant margin in turbid or murky samples. Comparison of a total -metals results to dissolved-fraction ESVs will thus significantly overestimate the true potential for risk, since only the dissolved fraction is bioavailable and hence potentially toxic.

Barium is naturally occurring earth metal that was detected at dissolved concentrations up to 400 µg/l in nearby Puerto Rico (Graves, 1991). While little information is available about natural levels in St. John groundwater, detected concentrations are relatively close (within a factor of two) to the latest conservative screening value of 220 µg/l. Levels of significant toxic effect to aquatic organisms are substantially higher, ranging from 1,000 µg/l to over 3,000 µg/l depending on water hardness (Borgmann et al., 2005). Because of the conservatism inherent in screening level development, concentrations close to screening levels are unlikely to be associated with adverse effects and the magnitude of difference between the screening level and concentrations associated with toxicity for barium support this conclusion.

Most important for all groundwater constituents, however, is the substantial dilution that occurs when groundwater discharges to surface waters of Caneel Bay, a phenomenon that can reduce the concentration of any constituent by orders of magnitude depending on natural levels in the Bay itself. Barium entering the Bay from groundwater sources would also tend to precipitate upon contact with natural sulfates during discharge and mixing with ocean water, which would affect final water concentrations as well.

Thus, because maximum concentrations of barium are close (within a factor of two) to conservative screening levels representative of negligible risk and because of the precipitation and substantial dilution that would occur when barium discharges to Caneel Bay, little potential for adverse effects to aquatic organisms from exposure to barium in groundwater discharging to surface water is expected.

Based on this Refined Analysis, the detected concentrations of carbon disulfide, anthracene, pyrene, naphthalene, arsenic and barium in groundwater and dug wells are not expected to present a potential risk to aquatic receptors who may contact groundwater expressing as surface water in the future or in the benthic areas of Caneel Bay. No further study is recommended.

3.6 Uncertainty Analysis

Ecological risk assessments are subject to a wide variety of uncertainties as the result of both the assumptions used to describe Site conditions, receptor exposure, and the natural variability in receptor behavior and toxicological response. Ecological risk assessments must estimate or infer information about receptors, exposures, and effects to reach a conclusion about potential effects at both the individual and population level. While such assumptions do not negate the conclusions of the assessment, they influence how the conclusions are used when making risk management decisions.

This ecological risk assessment was conducted in accordance with USEPA and NPS guidance and standard practice regarding the use of ESVs and food chain models. However, numerous assumptions underlie data collection, data evaluation, risk analysis, and risk characterization. Most assumptions associated with study were documented in the May 2021 SLERA and apply to this report as well. However, two points of uncertainty apply specifically to this report. These are as follows:

1. Use of Groundwater as a surrogate for surface water: This report evaluates groundwater under the assumption that groundwater would be compositionally similar to surface water, either in the sediment porewater and benthic waters in the discharge zone of Caneel Bay or in any future discharge setting. However, this assumption does not account for the substantial diluting and chemical effects of overlying surface water (particularly in Caneel Bay) or the biodegradation of organic constituents that typically occurs in bottom sediments as groundwater flows upwards through the substrate, resulting in the reduction of constituent concentrations. All of these factors can play a significant role in reducing constituent concentrations in surface water of the receiving water body. The evaluation of groundwater as a representative of surface water thus over-estimates potential future surface water concentrations and the resulting potential for risk by a very large margin. This conservatism, combined with the fact that groundwater concentrations are generally lower than toxicity-based concentrations for surface water supports the conclusion that groundwater study constituents present negligible risk to ecological receptors.

2. Use of ‘total metals” results for comparison to ESVs: As described previously, analysis for total metals measures both dissolved metals and metals bound to particulates, whereas most ESVs and water quality criteria are derived from and hence applicable to only the dissolved, bioavailable fraction. Since the total metals results are typically higher than the dissolved fraction alone, comparing total-metal results from this Site to dissolved-fraction ESVs will overestimate the potential for risk.

Both individually and in combination, these considerations further support the conclusion that the potential for risk to aquatic receptors exposed to discharging Site constituents is negligible.

3.7 Summary of the Ecological Risk Assessment

This SLERA and Refinement evaluated groundwater as a surrogate medium for surface water and compared detected concentrations of constituents to ESVs and USEPA values protective of aquatic receptors. Based on this analysis, none of the constituents detected in groundwater were determined to present a potential risk to aquatic receptors, since concentrations either did not exceed Refined ESVs or updated USEPA ecological screening values or, for barium, exceeded screening values by a small margin and were well below levels associated with significant adverse effects. This evaluation did not factor in the substantial additional concentration and associated risk reduction that would occur from the substantial dilution and attenuation of discharging groundwater in overlying surface water. The risk to aquatic receptors in surface water that consists of discharging groundwater is expected to be negligible, and no further study is recommended.

4 Conclusions

The HHRA and SLERA Refinement for the EE/CA Addendum Report used the analytical data collected in November 2021 and January 2022 to evaluate the potential for human health and ecological risk based on the data gaps identified in the September 2021 EE/CA Report.

The HHRA indicated that all total HI values were at or below the NCP Point of Departure of one (1), when rounded to one significant figure, for all receptors. However, the HHRA identified total cancer risks that exceeded the NCP Point of Departure of 1E-06 for the residential tap water use scenario. The total cancer risks for the future Resident (child and adult) in Investigation Area 2 was driven by the incidental ingestion of naphthalene in groundwater (potable use). Based on the slow recharge of groundwater in monitoring wells, however, it is unlikely that the overburden groundwater could be used as a tap water supply for a residence.

The SLERA and Refinement evaluated groundwater as a surrogate for surface water and compared detected concentrations of constituents to ESVs and USEPA values protective of aquatic receptors. Based on this analysis, none of the constituents detected in groundwater were determined to present a potential risk to aquatic receptors, since concentrations either did not exceed Refined ESVs or updated USEPA ecological screening values or, for barium, exceeded screening values by a small margin and were well below levels of significant effect. This evaluation did not factor in the significant additional concentration and risk reduction that would occur from the substantial dilution of discharging groundwater by overlying surface water. The risk to aquatic receptors in surface water that consists of discharging groundwater is expected to be negligible, and no further ecological study is recommended.

5 References

Borgmann, U., Y. Couillard, P. Doyle, and D.G. Dixon, 2005. Toxicity of sixty-three metals and metalloids to *Hyalella azteca* at two levels of water hardness. Environ.Toxicol.Chem. 24(3):641-652

Environment Canada, 2000. Priority Substances List Assessment Report: Carbon Disulfide.

Graves, R.P., 1991. Ground-water resources in LaJas Valley, Puerto Rico. USGS Water Resources Investigation Report 89-4182.

National Park Service (NPS), 2018. NPS protocol for the selection and use of ecological screening values for non-radiological analytes. Rev. 3 NPS Contaminated Sites Program, Washington DC.

Oak Ridge National Laboratory (ORNL), 2022. Energy and Environmental Sciences. Professional Peer-Reviewed Toxicity Values (PPRTV) Assessment Electronic Library.

Suter, G.W. and C.L. Tsao, 1996. Toxicological Benchmarks for Screening Potential Contaminants of Concern for Effects on Aquatic Biota: 1996 Revision. Oak Ridge National Laboratory (ORNL), Tennessee.

Texas Commission on Environmental Quality, 2021. Update to Guidance for Conducting Ecological Risk Assessments at Remediation Sites In Texas RG-263 (Revised). Remediation Division. August.

USEPA Region 3, 2006. Biological Technical Assistance Group (BTAG) Screening Values. Available at https://www.epa.gov/risk/biological-technical-assistance-group-btag-screening-values.

USEPA Region 4, 2018, Surface Water Screening Values for Hazardous Waste Sites in Ecological Risk Assessment Supplemental Guidance March 2018 Update.

USEPA, 2022a. Vapor Intrusion Screening Levels (VISLs) Calculator. Vapor Intrusion Screening Level Home (ornl.gov). Retrieved January 2022

USEPA, 2022b. Integrated Risk Information System (IRIS). On-line database. Office of Emergency and Remedial Response: Washington, D.C., February.

USEPA, 2021. Regional Screening Levels. November 2021. https://www.epa.gov/risk/regional-screening-levels-rsls-generic-tables

USEPA, 2014. Memorandum: Human Health Evaluation Manual, Supplemental Guidance: Update of Standard Default Exposure Factors. February 6, 2014. Office of Solid Waste and Emergency Response. OSWER Directive 9200.1-120. USEPA. 2009a. National Primary Drinking Water Standards. EPA 816-F-09-004. May.

USEPA, 2009. Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part F, Supplemental Guidance for Inhalation Risk Assessment), EPA-540-R-070-002, OSWER 9285.7-82. January.

USEPA, 2005. Supplemental Guidance for Assessing Susceptibility from Early-Life Exposure to Carcinogens, Risk Assessment Forum, EPA/630/R-03/003F. March.

USEPA, 2004. Risk Assessment Guidance for Superfund, Part E. Supplemental Guidance for Dermal Risk Assessment. EPA/540/R/99/05, July.

USEPA, 2003. Human Health Toxicity Values in Superfund Risk Assessments. OSWER Directive 9285.7-53.

USEPA, 1997. Health Effects Assessment Summary Tables (HEAST). EPA 540/R-97-036. July.

USEPA, 1990. Estimation of Baseline Air Emissions at Superfund Sites. Report ASF 2a. Office of Air Quality. August.

USEPA, 1989. Risk Assessment Guidance for Superfund/ Volume I/ Human Health Evaluation Manual (Part A), EPA/540/1-89-002. December.

VHB, 2021. NPS Engineering Evaluation/Cost Analysis Field Activities Report. Virgin Island National Park. EDL # 5SER3346. Prepared by VHB. December 13, 2021.

Woodard & Curran, 2021. Human Health Risk Assessment and Ecological Risk Refinement. Virgin Island National Park, May 2021

DRAFT
FINAL

Woodard & Curran

Human Health and Ecological Risk Assessment Addendum

Tables, Figures & Attachments

Caneel Bay Resort Site

Virgin Island National Park
Caneel Bay Resort Site
St. John Island, U.S. Virgin Islands

EDL Number: 5SER3346

0230405.01
VHB
July 2022

woodardcurran.com

Tables

TABLE C-1.1
DISCRETE SOIL ANALYTICAL RESULTS AND SUMMARY STATISTICS
Caneel Bay Resort; St. John Island, U.S. Virgin Island

Sample Location:		Soil RSL	Discrete Soil Dataset															
			Area 1						Area 2									
Sample Date:			SC-1-01-0.5	SC-1-01-17	SC-1-02-0.5	SC-1-02-4.3 [2]	SC-1-03-0.5	SC-1-03-4	SC-2-06-7	SC-2-06-8	SC-2-07-8.5	SC-2-07-12.5	SC-2-08-15 [2]	SC-2-09-5	SC-2-09-13.5	SC-2-10-13	SC-2-11-8 [2]	SC-2-12-8
Sample Depth (Feet bgs):			11/15/2021	11/15/2021	11/15/2021	11/15/2021	11/15/2021	11/15/2021	11/9/2021	11/9/2021	11/10/2021	11/10/2021	11/10/2021	11/10/2021	11/10/2021	11/10/2021	11/10/2021	11/10/2021
Constituent [1] (mg/kg)	CASN		0.5'	17'	0.5'	4.3'	0.5'	4'	7'	8'	8.5'	12.5'	15'	5'	13.5'	13'	8'	8'
Lead	7439-92-1	400	--	--	--	--	--	--	1.8	5.3	1.9	1.7	2.3	1.3	2.8	2.9	2.1	1.6
Pesticide																		
COCs (Soil Removal Goal shown)																		
4,4-DDD	72-54-8	0.17	0.0026	U <0.0012	U <0.0013	U <0.0011	U <0.0015	U <0.0011	--	--	--	--	--	--	--	--	--	--
4,4-DDE	72-55-9	0.17	0.0278	U <0.0006	U <0.00067	U <0.00056	U <0.00077	U <0.00056	--	--	--	--	--	--	--	--	--	--
4,4-DDT	50-29-3	0.17	0.0431	U <0.00054	U <0.0006	U <0.0005	U <0.00068	U <0.0005	--	--	--	--	--	--	--	--	--	--
Polycyclic aromatic hydrocarbon (PAHs)																		
Acenaphthene	83-32-9	360	U <0.0204	U <0.0186	U <0.021	U <0.0176	U <0.0239	U <0.0175	U <0.0206	U <0.0199	U <0.0792	U <0.0228	U <0.0198	U <0.0187	U <0.0196	U <0.0213	U <0.0199	0.288
Acenaphthylene [3]	208-96-8	180	U <0.0204	U <0.0186	U <0.021	U <0.0176	U <0.0239	U <0.0175	U <0.0206	U <0.0199	U <0.0255	U <0.0228	U <0.0198	U <0.0187	U <0.0196	U <0.0213	U <0.0199	0.148
Anthracene	120-12-7	1800	U <0.0204	U <0.0186	U <0.021	U <0.0176	U <0.0239	U <0.0175	U <0.0206	U <0.0199	U <0.0255	U <0.0228	U <0.0198	U <0.0187	U <0.0196	U <0.0213	U <0.0199	0.0823
Benz(a)anthracene	56-55-3	1.1	U <0.0204	U <0.0186	U <0.021	U <0.0176	U <0.0239	U <0.0175	U <0.0206	U <0.0199	U <0.0255	U <0.0228	U <0.0198	U <0.0187	U <0.0196	U <0.0213	U <0.0199	U <0.0192
Benzo(a)pyrene	50-32-8	0.11	U <0.0204	U <0.0186	U <0.021	U <0.0176	U <0.0239	U <0.0175	U <0.0206	U <0.0199	U <0.0255	U <0.0228	U <0.0198	U <0.0187	U <0.0196	U <0.0213	U <0.0199	U <0.0192
Benz(b)fluoranthene	205-99-2	1.1	U <0.0204	U <0.0186	U <0.021	U <0.0176	U <0.0239	U <0.0175	U <0.0206	U <0.0199	U <0.0255	U <0.0228	U <0.0198	U <0.0187	U <0.0196	U <0.0213	U <0.0199	U <0.0192
Benz(g,h,I,)perylene [3]	191-24-2	180	U <0.0204	U <0.0186	U <0.021	U <0.0176	U <0.0239	U <0.0175	U <0.0206	U <0.0199	U <0.0255	U <0.0228	U <0.0198	U <0.0187	U <0.0196	U <0.0213	U <0.0199	U <0.0192
Benz(k)fluoranthene	207-08-9	11	U <0.0204	U <0.0186	U <0.021	U <0.0176	U <0.0239	U <0.0175	U <0.0206	U <0.0199	U <0.0255	U <0.0228	U <0.0198	U <0.0187	U <0.0196	U <0.0213	U <0.0199	U <0.0192
Chrysene	218-01-9	110	U <0.0204	U <0.0186	U <0.021	U <0.0176	U <0.0239	U <0.0175	J 0.0413	U <0.0199	U <0.0255	U <0.0228	U <0.0198	U <0.0187	U <0.0196	U <0.0213	U <0.0199	U <0.0192
Dibenz(a,h)anthracene	53-70-3	0.11	U <0.0204	U <0.0186	U <0.021	U <0.0176	U <0.0239	U <0.0175	U <0.0206	U <0.0199	U <0.0255	U <0.0228	U <0.0198	U <0.0187	U <0.0196	U <0.0213	U <0.0199	U <0.0192
Fluoranthene (Idryl)	206-44-0	240	U <0.0204	U <0.0186	U <0.021	U <0.0176	U <0.0239	U <0.0175	U <0.0206	U <0.0199	U <0.0255	U <0.0228	U <0.0198	U <0.0187	U <0.0196	U <0.0213	U <0.0199	J 0.0219
Fluorene	86-73-7	240	U <0.0204	U <0.0186	U <0.021	U <0.0176	U <0.0239	U <0.0175	U <0.0206	U <0.0199	U <0.0255	U <0.0228	U <0.0198	U <0.0187	U <0.0196	0.0611	J 0.22	0.732
Indeno(1,2,3-cd)pyrene	193-39-5	1.1	U <0.0204	U <0.0186	U <0.021	U <0.0176	U <0.0239	U <0.0175	U <0.0206	U <0.0199	U <0.0255	U <0.0228	U <0.0198	U <0.0187	U <0.0196	U <0.0213	U <0.0199	U <0.0192
Naphthalene	91-20-3	2	U <0.0204	U <0.0186	U <0.021	U <0.0176	U <0.0239	U <0.0175	U <0.0206	U <0.0199	U <0.0255	U <0.0228	U <0.0198	U <0.0187	U <0.0196	U <0.0213	U <0.0199	J 0.0356
Phenanthrene [3]	85-01-8	180	U <0.0204	U <0.0186	U <0.021	U <0.0176	U <0.0239	U <0.0175	U <0.0206	U <0.0199	0.228	U <0.0228	U <0.0198	U <0.0187	U <0.0196	0.222	0.396	1.09
Pyrene	129-00-0	180	U <0.0204	U <0.0186	U <0.021	U <0.0176	U <0.0239	U <0.0175	U <0.268	U <0.0199	0.135	U <0.0228	U <0.0198	0.0721	U <0.0196	U <0.0213	J 0.046	0.0594
Volatile Organic Compound (VOCs)																		
Acetone	67-64-1	7,000	U <0.0065	U <0.0049	U <0.0055	U <0.0046	J 0.0065	U <0.0038	0.0132	0.0092	0.0167	J 0.0064	J 0.0067	J 0.0055	J 0.0052	0.0219	0.0206	0.0455
Carbon disulfide	75-15-0	77	U <0.00089	U <0.00067	U <0.00076	U <0.00063	U <0.00072	U <0.00052	0.0028	U <0.00057	0.0049	U <0.00062	U <0.00064	J 0.0011	U <0.0007	U <0.00065	U <0.00058	J 0.00071
Cyclohexane	110-82-7	650	U <0.00072	U <0.00054	U <0.00061	U <0.00051	U <0.00058	U <0.00042	U <0.00047	U <0.00046	0.0112	U <0.0005	U <0.00052	U <0.00046	U <0.00057	0.0245	0.0248	0.0329
Ethylbenzene	100-41-4	5.8	U <0.00096	U <0.00073	U <0.00082	U <0.00068	U <0.00078	U <0.00056	U <0.00063	U <0.00061	U <0.00067	U <0.00067	U <0.00069	U <0.00061	U <0.00076	0.0064	U <0.00063	J 0.0018
Isopropylbenzene	98-82-8	190	U <0.00086	U <0.00065	U <0.00073	U <0.00061	U <0.0007	U <0.0005	U <0.00057	U <0.00055	J 0.0106	U <0.0006	U <0.00062	J 0.0012	U <0.00068	0.0496	0.0118	0.048
Methyl ethyl ketone	78-93-3	2700	U <0.0045	U <0.0034	U <0.0039	U <0.0032	U <0.0037	U <0.0026	U <0.003	U <0.0029	U <0.0032	U <0.0032	U <0.0032	U <0.0029	U <0.0036	U <0.0033	J 0.0062	J 0.0092
Methylcyclohexane [1]	108-87-2	650	U <0.00079	U <0.0006	U <0.00067	U <0.00056	U <0.00064	U <0.00046	U <0.00052	U <0.00051	U <0.0144	U <0.00055	U <0.00057	0.0028	U <0.00062	0.369	0.269	0.185

Notes
All units are in mg/kg = milligram per kilogram
[1] This table only presents constituents that were detected in at least one groundwater sample at the Site.
[2] Field duplicate was collected. Results presented are the highest detected value, or the lowest reporting limit for non-detects.
[3] There are no USEPA residential soil RSLs available for phenanthrene, benzo(g,h,i)perylene, acenaphthylene, and methylcyclohexane.
Therefore, a surrogate compound of similar chemical structure was used to the screening the analytical data for these constituents.
The residential soil RSL for pyrene was used as a surrogate for phenanthrene, benzo(g,h,i)perylene, and acenaphthylene.
The residential soil RSL for cyclohexane was used as a surrogate for methylcyclohexane.
RSL = Regional Screening Level for residential soil, based on Carcinogenic Risk of 1E-6, Non-Cancer risk of 0.1 (November 2021)
PAL = Project Action Limit
CASN = Chemical Abstracts Service
J = Value is estimated greater than Laboratory method detection limit (MDL), but less than Laboratory limit of quantitation
U = Value is below the Laboratory MDL (Limit Shown)
feet bgs = Feet below ground surface
-- = not analyzed for or no screening level
indicates concentration exceeds the residential soil RSL

TABLE C-1.1
DISCRETE SOIL ANALYTICAL RESULTS AND SUMMARY STATISTICS
Caneel Bay Resort; St. John Island, U.S. Virgin Island

Sample Location:		Soil RSL	Discrete Soil Dataset														Summary Statistics		
			Area 2											Cottage 7					
Sample Date:			SC-2-13-6	SC-2-14-7.3	SC-2-15-2.8	SC-2-16-2.4	SC-2-17-9.5	SC-2-17-20	SC-2-18-6.7	SC-2-19-20	SC-2-20-15	SC-2-21-15	SC-2-22-18	SC-C7-01-5	SC-C7-02-5	SC-C7-03-6.6 [2]	Frequency of Detection	Minimum Detected Concentration	Maximum Detected Concentration
Sample Depth (Feet bgs):			11/10/2021	11/11/2021	11/11/2021	11/11/2021	11/11/2021	11/11/2021	11/11/2021	11/12/2021	11/12/2021	11/16/2021	11/16/2021	11/12/2021	11/12/2021	11/12/2021			
Constituent [1] (mg/kg)	CASN		6'	7.3'	2.8'	2.4'	9.5'	20'	6.7'	20'	15'	15'	18'	5'	5'	6.6'			
Lead	7439-92-1	400	J 0.69	1.5	J 0.51	J 0.54	1.5	1.6	11	--	--	--	--	--	--	--	17 / 17	0.51	11
Pesticide																			
COCs (Soil Removal Goal shown)																			
4,4-DDD	72-54-8	0.17	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1 / 6	0.0026	0.0026
4,4-DDE	72-55-9	0.17	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1 / 6	0.0278	0.0278
4,4-DDT	50-29-3	0.17	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1 / 6	0.0431	0.0431
Polycyclic aromatic hydrocarbon (PAHs)																			
Acenaphthene	83-32-9	360	U <0.0205	U <0.0209	U <0.0174	U <0.0173	U <0.0208	U <0.0215	U <0.0195	U <0.0217	U <0.0216	U <0.0214	U <0.0221	J 0.0497	0.196	U <0.0194	3 / 30	0.0497	0.288
Acenaphthylene [3]	208-96-8	180	U <0.0205	U <0.0209	U <0.0174	U <0.0173	U <0.0208	U <0.0215	U <0.0195	U <0.0217	U <0.0216	U <0.0214	U <0.0221	U <0.0207	U <0.0221	U <0.0194	1 / 30	0.148	0.148
Anthracene	120-12-7	1800	U <0.0205	U <0.0209	U <0.0174	U <0.0173	U <0.0208	U <0.0215	U <0.0195	U <0.0217	U <0.0216	U <0.0214	U <0.0221	0.114	0.441	U <0.0194	3 / 30	0.0823	0.441
Benz(a)anthracene	56-55-3	1.1	U <0.0205	U <0.0209	U <0.0174	U <0.0173	U <0.0208	U <0.0215	U <0.0195	U <0.0217	U <0.0216	U <0.0214	U <0.0221	0.291	0.952	U <0.0194	2 / 30	0.291	0.952
Benzo(a)pyrene	50-32-8	0.11	U <0.0205	U <0.0209	U <0.0174	U <0.0173	U <0.0208	U <0.0215	U <0.0195	U <0.0217	U <0.0216	U <0.0214	U <0.0221	0.2	0.651	U <0.0194	2 / 30	0.2	0.651
Benz(b)fluoranthene	205-99-2	1.1	U <0.0205	U <0.0209	U <0.0174	U <0.0173	U <0.0208	U <0.0215	U <0.0195	U <0.0217	U <0.0216	U <0.0214	U <0.0221	0.218	0.678	U <0.0194	2 / 30	0.218	0.678
Benz(g,h,I,)perylene [3]	191-24-2	180	U <0.0205	U <0.0209	U <0.0174	U <0.0173	U <0.0208	U <0.0215	U <0.0195	U <0.0217	U <0.0216	U <0.0214	U <0.0221	0.126	0.406	U <0.0194	2 / 30	0.126	0.406
Benz(k)fluoranthene	207-08-9	11	U <0.0205	U <0.0209	U <0.0174	U <0.0173	U <0.0208	U <0.0215	U <0.0195	U <0.0217	U <0.0216	U <0.0214	U <0.0221	0.214	0.742	U <0.0194	2 / 30	0.214	0.742
Chrysene	218-01-9	110	U <0.0205	U <0.0209	U <0.0174	U <0.0173	U <0.0208	U <0.0215	U <0.0195	U <0.0217	U <0.0216	U <0.0214	U <0.0221	0.252	0.836	U <0.0194	3 / 30	0.0413	0.836
Dibenz(a,h)anthracene	53-70-3	0.11	U <0.0205	U <0.0209	U <0.0174	U <0.0173	U <0.0208	U <0.0215	U <0.0195	U <0.0217	U <0.0216	U <0.0214	U <0.0221	J 0.0341	0.118	U <0.0194	2 / 30	0.0341	0.118
Fluoranthene (Idryl)	206-44-0	240	U <0.0205	U <0.0209	U <0.0174	U <0.0173	U <0.0208	U <0.0215	U <0.0195	U <0.0217	U <0.0216	U <0.0214	U <0.0221	0.651	2.29	U <0.0194	3 / 30	0.0219	2.29
Fluorene	86-73-7	240	U <0.0205	U <0.0209	U <0.0174	U <0.0173	0.0797	U <0.0215	U <0.0195	U <0.0217	U <0.0216	U <0.0214	U <0.0221	J 0.0381	0.14	U <0.0194	6 / 30	0.0381	0.732
Indeno(1,2,3-cd)pyrene	193-39-5	1.1	U <0.0205	U <0.0209	U <0.0174	U <0.0173	U <0.0208	U <0.0215	U <0.0195	U <0.0217	U <0.0216	U <0.0214	U <0.0221	0.147	0.491	U <0.0194	2 / 30	0.147	0.491
Naphthalene	91-20-3	2	U <0.0205	U <0.0209	U <0.0174	U <0.0173	U <0.0208	U <0.0215	U <0.0195	U <0.0217	U <0.0216	U <0.0214	U <0.0221	U <0.0207	U <0.073	U <0.0194	1 / 30	0.0356	0.073
Phenanthrene [3]	85-01-8	180	U <0.0205	0.205	U <0.0174	U <0.0173	J 0.0548	U <0.0215	U <0.0195	U <0.0217	U <0.0216	U <0.0214	U <0.0221	0.442	1.68	U <0.0194	8 / 30	0.0548	1.68
Pyrene	129-00-0	180	U <0.0205	U <0.0209	U <0.0174	U <0.0173	U <0.0208	U <0.0215	U <0.0195	U <0.0217	U <0.0216	U <0.0214	U <0.0221	0.468	1.64	U <0.0194	6 / 30	0.046	1.64
Volatile Organic Compound (VOCs)																			
Acetone	67-64-1	7,000	U <0.0062	0.0173	U <0.0055	0.0211	U <0.0048	J 0.0077	U <0.0054	J 0.0083	U <0.0054	J 0.0077	U <0.0049	J 0.0053	U <0.0053	U <0.0046	17 / 30	0.0052	0.0455
Carbon disulfide	75-15-0	77	U <0.00085	J 0.00098	U <0.00075	U <0.00053	U <0.00066	U <0.001	U <0.00073	U <0.00081	U <0.00075	U <0.00059	U <0.00067	U <0.00071	U <0.00073	U <0.00063	5 / 30	0.00071	0.0049
Cyclohexane	110-82-7	650	U <0.00069	0.0169	U <0.00061	U <0.00043	0.0089	U <0.00082	U <0.00059	U <0.00066	U <0.0006	U <0.00047	U <0.00054	U <0.00057	U <0.00059	U <0.00051	6 / 30	0.0089	0.0329
Ethylbenzene	100-41-4	5.8	U <0.00092	J 0.0025	U <0.00081	U <0.00057	U <0.00071	U <0.0011	U <0.00079	U <0.00088	U <0.00081	U <0.00063	U <0.00072	U <0.00076	U <0.00079	U <0.00068	3 / 30	0.0018	0.0064
Isopropylbenzene	98-82-8	190	U <0.00082	0.0145	U <0.00073	U <0.00051	J 0.00077	U <0.00098	U <0.00071	U <0.00079	U <0.00072	U <0.00057	U <0.00065	U <0.00068	U <0.0007	U <0.00061	7 / 30	0.00077	0.0496
Methyl ethyl ketone	78-93-3	2700	U <0.0043	U <0.0041	U <0.0038	U <0.0027	U <0.0034	U <0.0052	U <0.0037	U <0.0041	U <0.0038	U <0.003	U <0.0034	U <0.0036	U <0.0037	U <0.0032	2 / 30	0.0062	0.0092
Methylcyclohexane [1]	108-87-2	650	U <0.00075	0.108	U <0.00067	U <0.00047	0.067	U <0.0009	U <0.00065	U <0.00072	U <0.00066	U <0.00052	U <0.0006	U <0.00063	U <0.00065	U <0.00056	6 / 30	0.0028	0.369

Notes
All units are in mg/kg = milligram per kilogram
[1] This table only presents constituents that were detected in at least one groundwater sample at the Site.
[2] Field duplicate was collected. Results presented are the highest detected value, or the lowest reporting limit for non-detects.
[3] There are no USEPA residential soil RSLs available for phenanthrene, benzo(g,h,i)perylene, acenaphthylene, and methylcyclohexane.
Therefore, a surrogate compound of similar chemical structure was used to the screening the analytical data for these constituents.
The residential soil RSL for pyrene was used as a surrogate for phenanthrene, benzo(g,h,i)perylene, and acenaphthylene.
The residential soil RSL for cyclohexane was used as a surrogate for methylcyclohexane.
RSL = Regional Screening Level for residential soil, based on Carcinogenic Risk of 1E-6, Non-Cancer risk of 0.1 (November 2021)
PAL = Project Action Limit
CASN = Chemical Abstracts Service
J = Value is estimated greater than Laboratory method detection limit (MDL), but less than Laboratory limit of quantitation
U = Value is below the Laboratory MDL (Limit Shown)
feet bgs = Feet below ground surface
-- = not analyzed for or no screening level
indicates concentration exceeds the residential soil RSL

TABLE C-1.2

GROUNDWATER ANALYTICAL RESULTS AND SUMMARY STATISTICS

Caneel Bay Resort; St. John Island, U.S. Virgin Island

Sample Location:		Tapwater RSL	NPS ESV Surface Water	VISL	Groundwater Dataset: Investigation Area 2										Summary Statistics		
					MW-2-06	MW-2-06	MW-2-07	MW-2-07	MW-2-09	MW-2-09	MW-2-21	MW-2-22 [2]	Dug Well 1	Dug Well 2	Frequency of Detection	Minimum Detected Concentration	Maximum Detected Concentration
Sample Date:					11/18/2021	1/13/2022	11/17/2021	1/13/2022	11/17/2021	1/13/2022	1/13/2022	1/13/2022	1/13/2022	1/13/2022			
Constituent [1] (µg/L)	CASN																
Metal																	
Arsenic	7440-38-2	0.052	3.1	--	--	--	--	--	--	--	U <1.1	U <1.1	J **6.2**	J 2.3	2 / 4	2.3	6.2
Barium	7440-39-3	380	3.9	--	--	--	--	--	--	--	**220**	**330**	**310**	**400**	4 / 4	220	400
Polycylic Aromatic Hydrocarbons (PAHs)																	
Acenaphthene	83-32-9	53	5.8	--	J 0.068	U <1	0.15	U <1	U <0.15	U <1	U <1	U <1	U <1	U <1	2 / 10	0.068	0.15
Anthracene	120-12-7	180	0.012	--	U <0.01	U <1	J **0.028**	U <1	U <0.15	U <1	U <1	U <1	U <1	U <1	1 / 10	0.028	0.028
Fluorene	86-73-7	29	3	--	J 0.064	U <1	0.18	U <1	U <0.19	U <1	U <1	U <1	U <1	U <1	2 / 10	0.064	0.18
Naphthalene	91-20-3	0.12	1.1	4.59	J 0.069	U <1	0.13	J 1	U <0.17	J 1	U <1	U <1	U <1	J **1.1**	5 / 10	0.069	1.1
Phenanthrene [3]	85-01-8	180	0.4	--	J 0.03	U <1	0.23	U <1	U <0.13	U <1	U <1	U <1	U <1	U <1	2 / 10	0.03	0.23
Pyrene	129-00-0	12	0.025	--	0.01	U <1	J **0.065**	U <1	U <0.16	U <1	U <1	U <1	U <1	U <1	2 / 10	0.01	0.065
Volatile Organic Compounds (VOCs)																	
Acetone	67-64-1	1800	1500	--	22.5	J 3.8	U <3.1	U <3.1	J 4	J 3.2	U <3.1	U <3.1	J 3.4	J 5	6 / 10	3.2	22.5
Bromomethane	74-83-9	0.75	1300	1.74	U <0.39	U <0.39	U <0.39	J 0.45	U <0.39	U <0.39	J 0.41	J 0.41	U <0.39	U <0.39	3 / 10	0.39	0.45
Carbon disulfide	75-15-0	81	0.92	124	J 0.24	U <0.23	U <0.23	U <0.23	U <0.23	J 0.48	U <0.23	U <0.23	J **0.92**	U <0.23	3 / 10	0.24	0.92
Chloroform	67-66-3	0.22	1.8	0.814	U <0.21	U <0.21	U <0.21	U <0.21	J 0.55	U <0.21	U <0.21	U <0.21	U <0.21	U <0.21	1 / 10	0.55	0.55
Chloromethane [4]	74-87-3	19	28000	26	U <0.31	U <0.31	U <0.31	U <0.31	U <0.31	U <0.31	U <0.31	J 0.39	U <0.31	U <0.31	1 / 10	0.39	0.39
Isopropylbenzene [4]	98-82-8	45	2.6	88.7	U <0.22	U <0.22	J 0.55	U <0.22	U <0.22	U <0.22	U <0.22	U <0.22	U <0.22	U <0.22	1 / 10	0.55	0.55
Methyl Tert-Butyl Ether	1634-04-4	14	10000	450	U <0.67	U <0.67	U <0.33	U <0.67	U <1.5	U <0.67	J 0.47	J 0.67	U <0.67	U <0.67	2 / 10	0.47	0.67
Toluene	108-88-3	110	2	1920	J 0.28	J 0.23	U <0.23	U <0.23	U <0.23	U <0.23	U <0.23	U <0.23	U <0.23	U <0.23	2 / 10	0.23	0.28

Notes

All units are in ug/L = micrograms per liter

[1] This table only presents constituents that were detected in at least one groundwater sample at the Site.

[2] Field duplicate was collected. Results presented are the highest detected value, or the lowest reporting limit for non-detects.

[3] There is no USEPA Tapwater RSL available for phenanthrene. Therefore, the Tapwater RSL for pyrene was used as a surrogate the screen the analytical data.

[4] There is no NPS ESV for chloromethane and isopropylbenzene. The values listed come from the following sources:

Chloromethane: Texas Commission on Environmental Quality (TCEQ), 2021. Update to Guidance for Conducting Ecological Risk Assessments at Remediation Sites In Texas RG-263.

Isopropylbenzene: USEPA Region 3, 2006. Biological Technical Assistance Group (BTAG) Screening Values. (Values are expressed in terms of dissolved analyte in the water column)

Texas Commission on Environmental Quality (TCEQ), 2021. Update to Guidance for Conducting Ecological Risk Assessments at Remediation Sites In Texas RG-263 (Revised). Remediation Division. August.

RSL — Tapwater Regional Screening Level for groundwater, based on Carcinogenic Risk of 1E-6, Non-Cancer risk of 0.1 (November 2021)

NPS ESV — NPS Ecological Screening Value, 2018 values

VISL — Vapor Intrusion Screening Level (residential), based on Carcinogenic Risk of 1E-6, Non-Cancer risk of 0.1 (January 2022).

CASN — Chemical Abstracts Service

J — Value is estimated greater than Laboratory method detection limit, but less than Laboratory limit of quantitation

U — Value is below the Laboratory method detection limit (Limit Shown)

-- = Not analyzed for or no screening level

indicates concentration exceeds a Tapwater RSL

Value indicates a concentration exceeds or is equal to NPS ESV for surface water

indicates a concentration exceeds a residential VISL. There were no exceedances of the residential VISL.

TABLE C-2.1
SELECTION OF EXPOSURE PATHWAYS FOR HUMAN HEALTH RISK ASSESSMENT ADDENDUM

Receptor Population [1]	Receptor Age	Scenario Timeframe	Medium[2]	Exposure Medium	Exposure Point	Exposure Route	Type of Analysis	Rationale for Selection or Exclusion of Exposure Pathway
Park/Resort Worker	Adult	Current/Future	Surface Soil 0-0.5' bgs	Soil	Investigation Area 1	Dermal Contact Incidental Ingestion Inhalation of Fugitive Dust	Not Retained	There were no COPCs retained in surface soil and thus no complete exposure pathways.
			Groundwater	Groundwater	Investigation Area 2	Dermal Contact Incidental Ingestion Inhalation	Quantitative	If groundwater is used for potable purpose in the future, the potential exists for a Park/Resort Worker to be exposed to COPCs in groundwater. Vapor intrusion of volatile COPCs was ruled out as a complete migration pathway.
Construction Worker	Adult	Future	Surface Soil 0-0.5' bgs	Soil	Investigation Area 1	Dermal Contact Incidental Ingestion Inhalation of Fugitive Dust	Not Retained	There were no COPCs retained in surface soil and thus no complete exposure pathways.
			Soil (Subsurface) 0.5-20 ft-bgs	Soil	Investigation Area 1 and 2 Cottage 7	Dermal Contact Incidental Ingestion Inhalation of Fugitive Dust	Quantitative	Construction workers may potentially be exposed to COPCs in subsurface soils while performing excavation-related activities within the Cottage 7 Area.
			Groundwater	Groundwater	Investigation Area 2	Dermal Contact	Quantitative	Construction workers may potentially be exposed to COPCs in shallow groundwater while performing excavation-related activities in Investigation Area 2.
			Groundwater	Trench Air	Investigation Area 2	Inhalation	Quantitative	
Hypothetical Resident	Child and Adult	Future	Surface Soil 0-0.5' bgs	Soil	Investigation Area 1	Dermal Contact Incidental Ingestion Inhalation of Fugitive Dust	Not Retained	There were no COPCs retained in surface soil and thus no complete exposure pathways.
			Groundwater	Groundwater	Investigation Area 2	Dermal Contact Incidental Ingestion Inhalation	Quantitative	While the Site has historically been used for commercial purposes, it is assumed that the property could eventually be redeveloped for residential use. If groundwater is used for potable purpose in the future, the potential exists for a resident to be exposed to COPCs in groundwater. Vapor intrusion of volatile COPCs was ruled out as a complete migration pathway.

Notes:

[1] The HHRA included a qualitative evaluation of risk for a Resort visitor, under the assumption that any of the other scenarios would be adequately protective of a visitor, who is expected to have a lower exposure potential than a Resort worker or resident.

TABLE C-2.2a
VALUES USED FOR DAILY INTAKE CALCULATIONS FOR GROUNDWATER: PARK/RESORT WORKER - INGESTION AND DERMAL CONTACT
REASONABLE MAXIMUM EXPOSURE
Caneel Bay Resort; St. John Island, U.S Virgin Island

Scenario Timeframe:	Current / Future
Medium:	Groundwater
Exposure Medium:	Potable Groundwater

Exposure Route	Receptor Population and Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Reference	
Ingestion of and dermal contact with potable water	Park/Resort Worker Adult	Investigation Area 2	EPC	Exposure Point Concentration	Chemical-specific	mg/L	Calculated	1
			IR_s	Ingestion rate of drinking water	1.4	L/day	USEPA 2019	2
			EF	Exposure Frequency	250	days/year	USEPA 1991	3
			ED	Exposure Duration	10	years	NPS, Professional Judgement	4
			BW	Body weight	80	kg	USEPA 2014	5
			SA	Skin surface area	19652	cm^2	USEPA 2014	6
			DA_e	Absorbed dose per event	Chemical-specific	mg/cm^2-event	Calculated	7
			Kp	Permeability coeffiecient	Chemical-specific	cm/h	USEPA 2004	7
			FA	Fraction Absorbed	Chemical-specific	Dimensionless	USEPA 2004	7
			tau_{event}	Lag time per event	Chemical-specific	hours/event	USEPA 2004	7
			t_e	Event duration	0.71	hours/event	USEPA 2014	8
			B	Ratio of permeability coefficients, stratum corneum to viable epidermis	Chemical-specific	Dimensionless	USEPA 2004	7
			EV	Event Frequency	1	events/day	USEPA 1989	9
			AT_c	Averaging Time-cancer	70	years	USEPA 1989	10
			AT_{nc}	Averaging Time-noncancer	10	years	USEPA 1989	11
			C1	Units Conversion Factor	365	days/year	Constant	
			C2	Units Conversion Factor	0.001	L/cm^3	Constant	

Average Daily Intake (ADI) Equations:

$ADI_{ingestion}$ (mg/kg-d) = EPC * IR * EF * ED * 1/BW * 1/AT * 1/C1

ADI_{dermal} (mg/kg-d) = DA_{event} * EV * EF * ED * SA * 1/BW * 1/AT * 1/C1

Where DA_{event} = Dermal absorbed dose per event:

where for inorganics: DA_{event} (mg/cm^2-event) = EPC (mg/L) * Kp (cm/hr) * t_e (hr/ev) * C2 (L/cm^3)

where for organics: DA_{event} (mg/cm^2-event) = EPC (mg/L) * 2 FA (unitless) * Kp (cm/hr) * C2 * SQRT{(6 * tau-event [hr/ev] * t_e [hr/ev])/pi [unitless])}

(short-duration exposures)

and DA_{event} (mg/cm2-event) = FA (unitless) * Kp (cm/hr) * C2 (L/cm^3) * EPC (mg/L) [(t_e [hr/ev]/1 + B [unitless]) + 2 tau-event (hr/ev) {(1 + 3B + 3 B^2)/(1 + B)^2}]

(long-duration exposures)

Per USEPA 2004, DA_{event} calculations include the multiplication of exposure point concentration (EPC), however for this HHRA the EPC term was extracted from the Daevent calculation to more easily incorporate both terms into the intake calculation tables (RAGS Table 7 series).

TABLE C-2.2a NOTES:

1. EPCs are the maximum detected groundwater concentration in samples collected at the Site.

2. Ingestion rate for the Park/Resort worker is based on 1/2 the 90th percentile of consumer only ingestion of drinking water 21 to <50 years used for a resident scenario (USEPA 2019; Table 3-17). Half of the residential ingestion rate was used because the Park/Resort Worker is only expected to be at the Site for part of their day.

3. The exposure frequency (EF) describes how often the exposure occurs over a given period of time. It was assumed that a park worker would be present at the Site 250 days per year (5 days per week for 50 weeks) in USEPA, 1991. The EF assumes that the worker could be exposed to chemicals in drinking water as well as handwashing, occasional showering, or other activities like dishwashing.

4. The exposure duration (ED) describes the length of time over which the receptor comes into contact with contaminants. The ED assumed an estimated tenure at the park of 10 years; based on communications with NPS.

5. The body weight for the adult is the recommended default body weight in USEPA 2014.

6. SA values are the EPA-recommended SAs for residential water exposures (USEPA 2014).

7. Chemical-specific dermal absorption coefficients/factors are provided in USEPA, 2004.

8. Event durations are the USEPA-recommended values for adult resident water exposure time, as cited in USEPA 2014.

9. Event frequency (EV) describes how many "events" occur for each day of exposure. For all receptors, it was assumed that one event would occur on each day of exposure as recommended by USEPA 1989.

10. The averaging time (AT) for cancer effects (AT_c) for all receptors is set equal to a lifetime (i.e., 70 years), as recommended by USEPA 1989.

11. The averaging time for non-cancer effects (AT_{nc}) for all receptors is set equal to the exposure duration, as recommended by USEPA 1989.

References:

USEPA, 1989. US EPA Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual. (EPA/540/1-89/002).
USEPA, 2004. US EPA Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment) EPA/540/R/99/005, July 2004.
USEPA 2014. Memorandum: Human Health Evaluation Manual, Supplemental Guidance: Update of Standard Default Exposure Factors. February 6, 2014. Office of Solid Waste and Emergency Response. OSWER Directive 9200.1-120.
USEPA 2019. Update for Chapter 3 of the Exposure Factors Handbook: Ingestion of Water and Other Select Liquids. February 2019. EPA/600/R-18/259F

TABLE C-2.2b

VALUES USED FOR DAILY INTAKE CALCULATIONS FOR GROUNDWATER: PARK/RESORT WORKER - INHALATION

CENTRAL TENDENCY EXPOSURE

Caneel Bay Resort, St. John Island, U.S Virgin Island

Scenario Timeframe:	Future
Source Medium:	Groundwater
Exposure Medium:	Air

Exposure Route	Receptor Population and Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Reference	
Inhalation of Volatiles while Showering/Bathing	Park/Resort Worker Adult	Investigation Area 2	EPC	Exposure Point Concentration	Chemical-specific	mg/L	Calculated	1
			EF	Exposure Frequency	250	days/year	USEPA, 2014	2
			ET	Exposure Time adult	8.5	min/day	USEPA 2011	3
			ED	Exposure Duration	10	years	NPS, Professional Judgement	4
			AT_c	Averaging Time-cancer	70	years	USEPA, 1989	5
			AT_{nc}	Averaging Time-noncancer	10	years	USEPA, 1989	6
			K	Andelman Volatilization Factor	0.5	L/m3	USEPA 1991	7
			C1	Units Conversion Factor	365	days/year	Constant	
			C2	Units Conversion Factor	0.017	hours/min	Constant	
			C3	Units Conversion Factor	0.042	days/hour	Constant	

Average Daily Exposure (ADE) Equation:

$ADI_{inhalation\text{-}shower}$ (mg/m^3) = EPC * EF * ED * ET * CF2 *CF3 *K* 1/AT * 1/C1

Notes:

1. EPCs are the the maximum detected groundwater concentration in samples collected at the Site.

2. The exposure frequency (EF) describes how often the exposure occurs over a given period of time. It was assumed that a park worker would be present at the Site 250 days per year (5 days per week for 50 weeks) in USEPA, 1991. The EF assumes that the worker could be exposed to volatiles in indoor air generated from handwashing, occasional showering, or other activities like dishwashing.

3. The exposure time (ET) describes how long each individual exposure event might last. The ET for the adult is based on one-half of the mean showering time for adults 18-65, which was applied to the residential scenario (USEPA, 2011; Table 16-1). One-half of the residential ET was used because the Park/Resort Worker is expected to be at the Site for only part of their day, and exposure via bathing is expected to be mainly associated with hand washing.

4. The exposure duration (ED) describes the length of time over which the receptor comes into contact with contaminants. The ED assumed an estimated tenure at the park of 10 years; based on communications with NPS.

5. The averaging time for carcinogens (AT_c) is set equal to a lifetime (i.e., 70 years) when estimating cancer risk. This is the recommended lifetime in USEPA, 1989.

6. The averaging time for noncancer effects (AT_{nc}) is set equal to the exposure duration (USEPA 1989).

References:

USEPA, 1989. US EPA Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual. (EPA/540/1-89/002).
USEPA 1991. Human Health Evaluation Manual, Supplemental Guidance: Standard Default Exposure Factors. (OSWER Directive 9282.6-03)
USEPA 2011. Exposure Factors Handbook, 2011 Edition. EPA/600/R-090/052F, September 2011. Office of Research and Development, USEPA, Washington, D.C.
USEPA 2014. Memorandum: Human Health Evaluation Manual, Supplemental Guidance: Update of Standard Default Exposure Factors. February 6, 2014. Office of Solid Waste and Emergency Response. OSWER Directive 9200.1-120.

TABLE C-2.3a
VALUES USED FOR DAILY INTAKE CALCULATIONS FOR GROUNDWATER: RESIDENT- INGESTION AND DERMAL CONTACT
REASONABLE MAXIMUM EXPOSURE
Caneel Bay Resort; St. John Island, U.S Virgin Island

Scenario Timeframe:	Current/Future
Medium:	Groundwater
Exposure Medium:	Potable Groundwater

Exposure Route	Receptor Population and Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Reference	
Ingestion of and dermal contact with with potable water	Resident Child (0<6 years)	Investigation Area 2	EPC	Exposure Point Concentration	Chemical-specific	mg/L	Calculated	1
			IR_s	Ingestion rate of drinking water	0.72	L/day	USEPA 2019	2
			EF	Exposure Frequency	350	days/year	USEPA 2014	3
			ED	Exposure Duration	6	years	USEPA 2014	4
			BW	Body weight	15	kg	USEPA 2014	5
			SA	Skin surface area	6365	cm^2	USEPA 2014	6
			DA_e	Absorbed dose per event	Chemical-specific	mg/cm^2-event	Calculated	7
			Kp	Permeability coeffiecient	Chemical-specific	cm/h	USEPA 2004	7
			FA	Fraction Absorbed	Chemical-specific	Dimensionless	USEPA 2004	7
			tau_{event}	Lag time per event	Chemical-specific	hours/event	USEPA 2004	7
			t_e	Event duration	0.54	hours/event	USEPA 2014	8
			B	Ratio of permeability coefficients, stratum corneum to viable epidermis	Chemical-specific	Dimensionless	USEPA 2004	7
			EV	Event Frequency	1	events/day	USEPA 1989	9
			AT_c	Averaging Time-cancer	70	years	USEPA 1989	10
			AT_{nc}	Averaging Time-noncancer	6	years	USEPA 1989	11
			C1	Units Conversion Factor	365	days/year	Constant	
			C2	Units Conversion Factor	0.001	L/cm^3	Constant	

TABLE C-2.3a
VALUES USED FOR DAILY INTAKE CALCULATIONS FOR GROUNDWATER: RESIDENT- INGESTION AND DERMAL CONTACT
REASONABLE MAXIMUM EXPOSURE
Caneel Bay Resort; St. John Island, U.S Virgin Island

Scenario Timeframe:	Current/Future
Medium:	Groundwater
Exposure Medium:	Potable Groundwater

Exposure Route	Receptor Population and Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Reference	
Ingestion of and dermal contact with potable water	Resident Adult	Investigation Area 2	EPC	Exposure Point Concentration	Chemical-specific	mg/L	Calculated	1
			IR_s	Ingestion rate of drinking water	2.7	L/day	USEPA 2019	2
			EF	Exposure Frequency	350	days/year	USEPA 2014	3
			ED	Exposure Duration	20	years	USEPA 2014	4
			BW	Body weight	80	kg	USEPA 2014	5
			SA	Skin surface area	19652	cm^2	USEPA 2014	6
			DA_e	Absorbed dose per event	Chemical-specific	mg/cm^2-event	Calculated	7
			Kp	Permeability coeffiecient	Chemical-specific	cm/h	USEPA 2004	7
			FA	Fraction Absorbed	Chemical-specific	Dimensionless	USEPA 2004	7
			tau_{event}	Lag time per event	Chemical-specific	hours/event	USEPA 2004	7
			t_e	Event duration	0.71	hours/event	USEPA 2014	8
			B	Ratio of permeability coefficients, stratum corneum to viable epidermis	Chemical-specific	Dimensionless	USEPA 2004	7
			EV	Event Frequency	1	events/day	USEPA 1989	9
			AT_c	Averaging Time-cancer	70	years	USEPA 1989	10
			AT_{nc}	Averaging Time-noncancer	20	years	USEPA 1989	11
			C1	Units Conversion Factor	365	days/year	Constant	
			C2	Units Conversion Factor	0.001	L/cm^3	Constant	

Average Daily Intake (ADI) Equations:

$ADI_{ingestion}$ (mg/kg-d) = EPC * IR * EF * ED * 1/BW * 1/AT * 1/C1

ADI_{dermal} (mg/kg-d) = DA_{event} * EV * EF * ED * SA * 1/BW * 1/AT * 1/C1

Where DA_{event} = Dermal absorbed dose per event:

where for inorganics DA_{event} (mg/cm^2-event) = EPC (mg/L) * Kp (cm/hr) * t_e (hr/ev) * C2 (L/cm^3)

where for organics: DA_{event} (mg/cm^2-event) = EPC (mg/L) * 2 FA (unitless) * Kp (cm/hr) * C2 * SQRT{(6 * tau-event [hr/ev] * t_e [hr/ev])/pi [unitless])}

(short-duration exposures)

and DA_{event} (mg/cm2-event) = FA (unitless) * Kp (cm/hr) * C2 (L/cm^3) * EPC (mg/L) [(t_e [hr/ev]/1 + B [unitless]) + 2 tau-event (hr/ev) {(1 + 3B + 3 B^2)/(1 + B)^2}]

(long-duration exposures)

Per USEPA 2004, DA_{event} calculations include the multiplication of exposure point concentration (EPC), however for this HHRA the EPC term was extracted from the Daevent calculation to more easily incorporate both terms into the intake calculation tables (RAGS Table 7 series).

TABLE C-2.3a NOTES:

1. EPCs are the maximum detected groundwater concentration in samples collected at the Site.

2. Child Ingestion rate is based on the weighted average of the 90th percentile consumer-only ingestion of drinking water for a child 1-6 years.
   For adults the ingestion rate is based on the 90th percentile of consumer only ingestion of drinking water 21 to <50 years. (USEPA 2019; Table 3-17)

3. Exposure Frequency (EF) describes how often the exposure event occurs over a given period of time. The exposure frequency is the EPA-recommended value for residential scenarios (USEPA, 2014).

4. The exposure duration (ED) describes the length of time over which the receptor comes into contact with contaminants. ED values reflect a 26 year residential tenure, which is the current EPA-recommended value for residence time (USEPA 2014).

5. The body weights for the child and adult resident are the recommended default body weights in Attachment 1 of USEPA 2014.

6. SA values are the EPA-recommended SAs for residential water exposures (USEPA 2014).

7. Chemical-specific dermal absorption coefficients/factors are provided in USEPA, 2004.

8. Event durations are the USEPA-recommended values for adult and child resident water exposure time, as cited in USEPA 2014.

9. Event frequency (EV) describes how many "events" occur for each day of exposure. For all receptors, it was assumed that one event would occur on each day of exposure as recommended by USEPA 1989.

10. The averaging time (AT) for cancer effects (AT_c) for all receptors is set equal to a lifetime (i.e., 70 years), as recommended by USEPA 1989.

11. The averaging time for non-cancer effects (AT_{nc}) for all receptors is set equal to the exposure duration, as recommended by USEPA 1989.

References:

USEPA, 1989. US EPA Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual. (EPA/540/1-89/002).
USEPA, 2004. US EPA Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment) EPA/540/R/99/005, July 2004.
USEPA 2014. Memorandum: Human Health Evaluation Manual, Supplemental Guidance: Update of Standard Default Exposure Factors. February 6, 2014. Office of Solid Waste and Emergency Response. OSWER Directive 9200.1
USEPA 2019. Update for Chapter 3 of the Exposure Factors Handbook: Ingestion of Water and Other Select Liquids. February 2019. EPA/600/R-18/259F

TABLE C-2.3b
VALUES USED FOR DAILY INTAKE CALCULATIONS FOR GROUNDWATER: RESIDENT- INHALATION
REASONABLE MAXIMUM EXPOSURE
Caneel Bay Resort; St. John Island, U.S Virgin Island

Scenario Timeframe:	Current/Future
Source Medium:	Groundwater
Exposure Medium:	Air

Exposure Route	Receptor Population and Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Reference
Inhalation of Volatiles while Showering/Bathing	Resident Child (0<6 years)	Investigation Area 2	EPC	Exposure Point Concentration	Chemical-specific	mg/L	Calculated [1]
			EF	Exposure Frequency	350	days/year	USEPA, 2014 [2]
			ET	Exposure Time	48	min/day	USEPA, 2011 [3]
			ED	Exposure Duration	6	years	USEPA, 2014 [4]
			AT_c	Averaging Time-cancer	70	years	USEPA, 1989 [5]
			AT_{nc}	Averaging Time-noncancer	6	years	USEPA, 1989 [6]
			K	Andelman Volatilization Factor	0.5	L/m3	USEPA 1991 [7]
			C1	Units Conversion Factor	365	days/year	Constant
			C2	Units Conversion Factor	0.017	hours/min	Constant
			C3	Units Conversion Factor	0.042	days/hour	Constant
Inhalation of Volatiles while Showering/Bathing	Resident Adult	Investigation Area 2	EPC	Exposure Point Concentration	Chemical-specific	mg/L	Calculated [1]
			EF	Exposure Frequency	350	days/year	USEPA, 2014 [2]
			ET	Exposure Time	17	min/day	USEPA 2011 [3]
			ED	Exposure Duration	20	years	USEPA, 2014 [3]
			AT_c	Averaging Time-cancer	70	years	USEPA, 1989 [4]
			AT_{nc}	Averaging Time-noncancer	20	years	USEPA, 1989 [5]
			K	Andelman Volatilization Factor	0.5	L/m3	USEPA 1991 [7]
			C1	Units Conversion Factor	365	days/year	Constant
			C2	Units Conversion Factor	0.017	hours/min	Constant
			C3	Units Conversion Factor	0.042	days/hour	Constant

Average Daily Exposure (ADE) Equation:

$ADI_{inhalation\text{-}shower}$ (mg/m^3) = EPC * EF * ED * ET * CF2 *CF3 *K* 1/AT * 1/C1

TABLE C-2.3b NOTES:

1. EPCs are the maximum detected groundwater concentration in samples collected at the Site.

2. Exposure Frequency (EF) describes how often the exposure event occurs over a given period of time. The exposure frequency is the EPA-recommended value for residential scenarios (USEPA, 2014).

3. The exposure time (ET) describes how long each individual exposure event might last. The ET value for bathing for the child is the 95th percentile value indicated in Table 16-1 of USEPA 2011, age-weighted to account for ages 0-6 years. The ET for the adult is the mean showering time for adults 18-65 years.

4. The exposure duration (ED) describes the length of time over which the receptor comes into contact with contaminants. ED values reflect a 26 year residential tenure, which is the current EPA-recommended value for residence time (USEPA 2014).

5. The averaging time for carcinogens (AT_c) is set equal to a lifetime (i.e., 70 years) when estimating cancer risk. This is the recommended lifetime in USEPA, 1989.

6. The averaging time for noncancer effects (AT_{nc}) is set equal to the exposure duration (USEPA 1989).

7. Default volatilization constant that incorporates all uses of household water (e.g., showering, laundering, and dishwashing) (USEPA 1991).

References:

USEPA, 1989. US EPA Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual. (EPA/540/1-89/002).
USEPA 1991. Risk Assessment Guidance for Superfund, Volume I: Human Health Evaluation Manual: Part B, Development of Risk-Based Preliminary Remediation Goals. Office of Emergency and Remedial Response. EPA/540/R-92/003. December
USEPA 2011. Exposure Factors Handbook, 2011 Edition. EPA/600/R-090/052F, September 2011. Office of Research and Development, USEPA, Washington, D.C.
USEPA 2014. Memorandum: Human Health Evaluation Manual, Supplemental Guidance: Update of Standard Default Exposure Factors. February 6, 2014. Office of Solid Waste and Emergency Response. OSWER Directive 9200.1-120.

TABLE C-2.4a
VALUES USED FOR DAILY INTAKE CALCULATIONS FOR SOIL - CONSTRUCTION WORKER
Caneel Bay Resort; St. John Island, U.S. Virgin Island

Scenario Timeframe:	Future
Medium:	Soil (Subsurface): 5 ft-bgs

Exposure Route	Receptor Population and Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Reference	
Incidental ingestion, dermal contact and inhalation of dust	Construction worker Adult	Cottage 7 Area	IR_{soil}	Ingestion rate of soil	330	mg/day	USEPA 2002	1
			AF_{soil}	Soil adherence factor	0.3	mg/cm^2	USEPA 2002	2
			SA_{soil}	Skin surface area	3,527	cm^2 / day	USEPA 2014	3
			EF	Exposure Frequency	250	days/yr	Professional judgment	4
			ED	Exposure Duration	1	years	USEPA 2014	5
			ET_{out}	Exposure time outdoors	8	hours/event	USEPA 2014	6
			FS	Fraction soil contact at Site	1	unitless	Professional judgment	7
			BW	Body Weight	80	kg	USEPA 2014	8
			PEF	Particulate Emission Factor	1.36E+09	m^3/kg	USEPA 2020	9
			VF	Volatilization Factor	Chemical-specific	m^3/kg	USEPA 2020	10
			AT_c	Averaging Time - cancer	70	years	USEPA 1989	11
			AT_{nc}	Averaging Time - noncancer	1	years	USEPA 1989	12
			ABSd	Dermal absorption factor	Chemical-specific	unitless	USEPA 2020	13
			RBA	Relative Bioavailability Factor	Chemical-specific	%	USEPA 2012	14
			EPC	Exposure point concentration	Chemical-specific	mg/kg	Calculated	15

Soil Average Daily Intake (ADI) and Exposure (ADE) Equations:

$ADI_{ingestion}$ (mg/kg-d) = EPCs * IR * RBA * FS * EF * ED * C1 * 1/BW * 1/AT * 1/C2

ADI_{dermal} (mg/kg-d) = EPCs * ABSd * SA * AF * EF * ED * C1* 1/BW * 1/AT * 1/C2

$ADE_{inhalation}$ (mg/m^3) = EPCair* EF * ET * ED * 1/AT * 1/C3 * 1/C2

Where EPC air = EPC soil * (1/VF + 1/PEF)

Unit conversion factors: C1 = 0.000001 kg/mg
C2 = 365 days/yr
C3 = 24 hours/day

TABLE C-2.4a Notes:

1. Soil ingestion rate (IR) is the EPA recommended soil ingestion rate for a construction worker as cited in Exhibit 5-1 of USEPA, 2002.
2. The soil adherence factor (AF) is the EPA recommended default exposure factor for a construction worker as cited in Exhibit 5-1 of USEPA 2002.
3. The skin surface area (SA) is the EPA recommended default exposure factor for an adult worker (USEPA 2014).
4. The exposure frequency (EF) describes how often the exposure occurs over a given period of time. It was assumed that a construction worker would be performing activities for 250 days over a period of a year (5 days per week for 50 weeks), based on professional judgement.
5. The exposure duration (ED) describes the length of time over which the receptor comes into contact with contaminants. It was assumed the construction worker would perform work for one year.
6. The exposure time (ET) is the amount of time spent outdoors. The ET is the USEPA recommended default exposure factor for an outdoor worker of 8 hours (USEPA 2014).
7. Fraction soil contact (FS) is reflective of the daily dose of soil. It was assumed that an adult worker would be exposed to the full daily dose when at the site.
8. The EPA-recommended body weight (BW) for an adult (USEPA 2014).
9. PEF value was obtained from the USEPA Regional Screening Level (RSL) table, November 2021.
10. Volatilization factors were obtained from the USEPA Regional Screening Level (RSL) table, November 2021.
11. The averaging time (AT) for cancer effects (AT_c) for all receptors is set equal to a lifetime (i.e., 70 years), as recommended in USEPA 1989.
12. The averaging time for non-cancer effects (AT_{nc}) for all receptors is set equal to the exposure duration, as recommended in USEPA 1989.
13. The dermal absorption factors (ABSd) are recommended values in Exhibit 3-4 of USEPA 2004, with updates as provided on: https://www.epa.gov/risk/risk-assessment-guidance-superfund-rags-part-e.
14. The EPA recommended default RBA value of 60% is applied to oral arsenic exposures. An RBA of 100% is used for all other constituents (USEPA 2012).
15. Soil EPCs are the maximum detected concentration for each COPC among the November 2021 soil data from Cottage 7.

References:

USEPA. 2020. Regional Screening Levels - Generic Tables. November 2020. https://www.epa.gov/risk/regional-screening-levels-rsls-generic-tables
USEPA 2014. Memorandum: Human Health Evaluation Manual, Supplemental Guidance: Update of Standard Default Exposure Factors. February 6, 2014. Office of Solid Waste and Emergency Response. OSWER Directive 9200.1-120.
USEPA 2012. Recommendations for the Default Value for Relative Bioavailability of Arsenic in Soil. December 2012. OSWER Directive 9200.1-113.
USEPA 2011. Exposure Factors Handbook, 2011 Edition. EPA/600/R-090/052F, September 2011. Office of Research and Development, USEPA, Washington, D.C.
USEPA 2004. Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment) Final, OSWER Directive 9285.7-02EP. EPA/540/R/99/005, USEPA, Washington D.C., July 2004.
USEPA 2002. Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites. Solid Waste and Emergency Response. OSWER 9355.4-24. December.
USEPA 1989. Risk Assessment Guidance for Superfund, Human Health Evaluation Manual, Part A, Interim Final, OSWER Directive 9285.701A. Office of Solid Waste and Emergency Response, USEPA, Washington D.C., December 1989.

TABLE C-2.4b
VALUES USED FOR DAILY INTAKE CALCULATIONS FOR GROUNDWATER - CONSTRUCTION WORKER
Caneel Bay Resort; St. John Island, U.S. Virgin Island

Scenario Timeframe:	Current/Future
Medium:	Groundwater
Exposure Medium:	Groundwater and Ambient Trench Air

Exposure Route	Receptor Population and Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Reference	
Dermal contact, inhalation of volatiles in ambient air	Construction Worker Adult	Investigation Area 2	EPC_{gw}	Exposure Point Concentration - Groundwater	Chemical-specific	mg/L	Calculated	1
			EPC_a	Exposure Point Concentration - Air	Chemical-specific	mg/m^3	Calculated	1
			EF_{gw}	Exposure Frequency - Groundwater	100	days/year	Professional judgment	2
			EF_a	Exposure Frequency - Air	250	days/year	Professional judgment	2
			ET_a	Exposure Time - Air	8	hours/day	USEPA 2014	3
			t_e	Exposure time - Groundwater	0.5	hours/event	USEPA 2014	3
			ED	Exposure Duration	1	years	Professional judgment	4
			BW	Body weight	80	kg	USEPA 2014	5
			SA	Skin surface area	3,527	cm^2	USEPA 2011	6
			DA_e	Absorbed dose per event	Chemical-specific	mg/cm^2-event	Calculated	7
			Kp	Permeability coeffiecient	Chemical-specific	cm/h	USEPA 2004	7
			FA	Fraction Absorbed	Chemical-specific	Dimensionless	USEPA 2004	7
			tau_{event}	Lag time per event	Chemical-specific	hours/event	USEPA 2004	7
			B	Ratio of permeability coefficients, stratum corneum to viable epidermis	Chemical-specific	Dimensionless	USEPA 2004	7
			EV	Event Frequency	1	events/day	USEPA 1989	8
			AT_c	Averaging Time-cancer	70	years	USEPA 1989	9
			AT_{nc}	Averaging Time-noncancer	1	years	USEPA 1989	10

Average Daily Intake (ADI) Equations:

ADI_{dermal} (mg/kg-d) = DA_{event} * EV * EF * ED * SA * 1/BW * 1/AT * 1/C1

$ADI_{inhalation}$ (mg/m^3) = EPC * ET * EF * ED * 1/AT * 1/C1 * 1/C3

Where DA_{event} = Dermal absorbed dose per event:

where for inorganics: DA_{event} (mg/cm^2-event) = EPC (mg/L) * Kp (cm/hr) * t_e (hr/ev) * C2 (L/cm^3)

where for organics: DA_{event} (mg/cm^2-event) = EPC (mg/L) * 2 FA (unitless) * Kp (cm/hr) * C2 * SQRT{(6 * tau-event [hr/ev] * t_e [hr/ev])/pi [unitless])}

(short-duration exposures)

and DA_{event} (mg/cm2-event) = FA (unitless) * Kp (cm/hr) * C2 (L/cm^3) * EPC (mg/L) [(t_e [hr/ev]/1 + B [unitless]) + 2 tau-event (hr/ev) {(1 + 3B + 3 B^2)/(1 + B)^2}]

(long-duration exposures)

Per USEPA 2004, DA_{event} calculations include the multiplication of exposure point concentration (EPC), however for this HHRA the EPC term was extracted from the Daevent calculation to more easily incorporate both terms into the intake calculation tables (RAGS Table 7 series).

Unit Conversion Factors: C1 = 365 days/yr C2 = 0.001 L/cm^3 C3=24 hours/day

TABLE C-2.4b Notes:

1. Groundwater EPCs are based on the maximum detected concentration of the chemical of potential concern in groundwater, based on monitoring well data from 2021 and 2022.
   Ambient air EPCs were estimated from groundwater data using an air emissions model (USEPA, 1990). See Table 2.19 and Appendix B.

2. The exposure frequency (EF) describes how often the exposure occurs over a given period of time. It was assumed that a construction worker would be setting up or dismantling dewatering equipment 2 days a week for one year (2 days per week for 50 weeks).

3. The exposure time (ET) is the amount of time spent outdoors. The ET for inhalation of ambient air is the USEPA recommended default exposure factor for a outdoor worker of 8 hours, from USEPA 2014. The exposure time for groundwater was assume to be 1/2 hour for each event while setting up and dismantling dewatering equipment.

4. The exposure duration (ED) describes the length of time over which the receptor comes into contact with contaminants. It was assumed the construction worker would perform work for one year.

5. The body weight for the adult worker scenario is the EPA recommended default body weight in Attachment 1 of USEPA 2014.

6. The skin surface area (SA) is the EPA recommended default exposure factor for a worker in USEPA 2014.

7. Chemical-specific dermal absorption coefficients/factors are provided in USEPA, 2004.

8. Event frequency (EV) describes how many "events" occur for each day of exposure. For all receptors, it was assumed that one event would occur on each day of exposure as recommended by USEPA 1989.

9. The averaging time (AT) for cancer effects (AT_c) for all receptors is set equal to a lifetime (i.e., 70 years), as recommended by USEPA 1989.

10. The averaging time for non-cancer effects (AT_{nc}) for all receptors is set equal to the exposure duration, as recommended by USEPA 1989.

References:

USEPA, 1989. US EPA Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual. (EPA/540/1-89/002).
U.S. EPA. 1990. Estimation of Baseline Air Emissions at Superfund Sites. Report ASF 2a. Office of Air Quality. August.
USEPA, 2004. US EPA Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment) EPA/540/R/99/005, July 2004.
USEPA 2014. Memorandum: Human Health Evaluation Manual, Supplemental Guidance: Update of Standard Default Exposure Factors. February 6, 2014. Office of Solid Waste and Emergency Response. OSWER Directive 9200.1-120.

TABLE C-2.5
SUMMARY OF VALUES USED FOR DERMAL ABSORPTION FRACTION FROM SOIL
Caneel Bay Resort, St. John Island, U.S. Virgin Island

Contaminant of Potential Concern	CAS Number	Dermal Absorption Fraction from Soil	Source [1]
Polycyclic Aromatic Hydrocarbons (PAHs)			
Benzo(a)pyrene	50-32-8	0.13	USEPA 2004
Dibenz(a,h)anthracene	53-70-3	0.13	USEPA 2004
Naphthalene	91-20-3	0.13	USEPA 2004
Volatile Organic Compounds			
Chloroform	67-66-3	NA	--

NA = Not Available

1. Unless otherwise noted, values are from Exhibit 3-4, USEPA 2004. Risk Assessment Guidance for Superfund Volume 1: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment), Final. EPA/540/R/99/005. For constituents with no available values, risk from those constituents is addressed qualitatively in the uncertainty analysis. in accordance with USEPA 2004.

TABLE C-2.6
SUMMARY OF VOLATILIZATION AND PARTICULATE EMISSION FACTORS
Caneel Bay Resort; St. John Island, U.S. Virgin Island

Contaminant of Potential Concern	CAS Number	VF m^3/kg	PEF m^3/kg
Polycyclic Aromatic Hydrocarbon (PAHs)			
Benzo(a)pyrene	50-32-8	NA	1.36E+09
Dibenz(a,h)anthracene	53-70-3	NA	1.36E+09
Naphthalene	91-20-3	46300.0	1.36E+09
Volatile Organic Compounds			
Chloroform	67-66-3	2.63E+03	1.36E+09

VF = Volatilization Factor, in cubic meters per kilogram
PEF = Particulate Emission Factor, in cubic meters per kilogram
NA = Not available
USEPA. 2021. Regional Screening Levels - Generic Tables. November.
https://www.epa.gov/risk/regional-screening-levels-rsls-generic-tables

TABLE C-2.7
CALCULATON OF THE DERMAL ABSORBED DOSE (AQUEOUS) FACTOR FOR CONSTRUCTION WORKER GROUNDWATER EXPOSURES
REASONABLE MAXIMUM EXPOSURE
Caneel Bay Resort; St. John Island, U.S. Virgin Island

DERMAL ABSORBED DOSE CALCULATION

Organics

If t_{event} <= t*, then: Eq. 1

$DA_{event} = 2FA * Kp * sqrt(6\ tau_{event} * t_{event}/pi) * C1$

If t_{event} > t*, then: Eq. 2

$DA_{event} = FA * Kp\ [t_{event}/(1+B) + 2tau_{event}\ ((1+3B+3B^2) / (1+B)^2)] * C1$

Inorganics Eq. 3

$DA_{event} = Kp * t_{event} * C1$

Parameter		Definition	Units	Value/Source
DA_{event}	=	Dermal absorption factor- aqueous exposures	L/cm^2-event	Calculated
FA	=	Fraction absorbed water	unitless	USEPA 2004
Kp	=	Dermal permeability coefficient in water	cm/hr	USEPA 2004
tau_{event}	=	Lag time per event	hr/event	USEPA 2004
t_{event}	=	Event duration	hr/event	0.5
t*	=	Time to reach steady-state	hr	USEPA 2004
B	=	Kp ratio, stratum corneum : viable epidermis	unitless	USEPA 2004
C1	=	Units conversion factor	L/cm^3	0.001

Chemical of Potential Concern	CAS No.	DERMAL ABSORBED DOSE PER EVENT							
		Outside EPD?	Kp	tau_{event}	B	t*	FA	DA_{event}	Basis
Naphthalene	91-20-3	N	4.7E-02	5.6E-01	2.0E-01	1.3E+00	1.0E+00	6.8E-05	Eq.1
Chloroform	67-66-3	N	6.8E-03	5.0E-01	2.9E-02	1.2E+00	1.0E+00	9.4E-06	Eq.1

Notes:

Equations for the calculation of DAevent as well as values for chemical-specific variables are obtained from USEPA, RAGS Part E, Supplemental Guidance for Dermal Risk Assessment Final, EPA/540/R/99/005, July 2004.

Equations 3.1, 3.2, and 3.3 of the guidance are presented here as Equations 1, 2, and 3, respectively. Values for Kp, tau event, B, t* and FA are obtained from Exhibits 3-1, B-2 and B-3.

NC = Not calculated because COPC is outside of the effective prediction domain of the model used to estimate Kp. Risk from these constituents is addressed qualitatively in the uncertainty analysis.

-- = Not applicable to inorganics. DA_{event} calculated via Equation 3 for inorganics.

Per USEPA 2004, DAevent calculations include the multiplication of exposure point concentration (EPC), however for this HHRA the EPC term was extracted from the Daevent calculation to more easily incorporate both terms into the intake calculation tables (Appendix C, Tables C-4 through C-8; RAGS Table 7 series).

TABLE C-2.8
CALCULATON OF THE DERMAL ABSORBED DOSE (AQUEOUS) FACTOR FOR CHILD GROUNDWATER EXPOSURES
REASONABLE MAXIMUM EXPOSURE
Caneel Bay Resort; St. John Island, U.S. Virgin Island

DERMAL ABSORBED DOSE CALCULATION

Organics

If t_{event} <= t*, then: Eq. 1

$DA_{event} = 2FA * Kp * sqrt(6\ tau_{event} * t_{event}/pi) * C1$

If t_{event} > t*, then: Eq. 2

$DA_{event} = FA * Kp [t_{event}/(1+B) + 2tau_{event} ((1+3B+3B^2) / (1+B)^2)] * C1$

Inorganics Eq. 3

$DA_{event} = Kp* t_{event} * C1$

Parameter		Definition	Units	Value/Source
DA_{event}	=	Dermal absorption factor- aqueous exposures	L/cm^2-event	Calculated
FA	=	Fraction absorbed water	unitless	USEPA 2004
Kp	=	Dermal permeability coefficient in water	cm/hr	USEPA 2004
tau_{event}	=	Lag time per event	hr/event	USEPA 2004
t_{event}	=	Event duration	hr/event	0.54
t*	=	Time to reach steady-state	hr	USEPA 2004
B	=	Kp ratio, stratum corneum : viable epidermis	unitless	USEPA 2004
C1	=	Units conversion factor	L/cm^3	0.001

Chemical of Potential Concern	CAS No.	DERMAL ABSORBED DOSE PER EVENT							
		Outside EPD?	Kp	tau_{event}	B	t*	FA	DA_{event}	Basis
Naphthalene	91-20-3	N	4.7E-02	5.6E-01	2.0E-01	1.3E+00	1.0E+00	7.1E-05	Eq.1
Chloroform	67-66-3	N	6.8E-03	5.0E-01	2.9E-02	1.2E+00	1.0E+00	9.8E-06	Eq.1

Notes:

Equations for the calculation of DAevent as well as values for chemical-specific variables are obtained from USEPA, RAGS Part E, Supplemental Guidance for Dermal Risk Assessment Final, EPA/540/R/99/005, July 2004. Equations 3.1, 3.2, and 3.3 of the guidance are presented here as Equations 1, 2, and 3, respectively. Values for Kp, tau event, B, t* and FA are obtained from Exhibits 3-1, B-2 and B-3.

-- = Not applicable to inorganics. DA_{event} calculated via Equation 3 for inorganics.

Per USEPA 2004, DAevent calculations include the multiplication of exposure point concentration (EPC), however for this HHRA the EPC term was extracted from the Daevent calculation to more easily incorporate both terms into the intake calculation tables (RAGS Table 7 series).

TABLE C-2.9
CALCULATON OF THE DERMAL ABSORBED DOSE (AQUEOUS) FACTOR FOR ADULT GROUNDWATER EXPOSURES
REASONABLE MAXIMUM EXPOSURE
Caneel Bay Resort; St. John Island, U.S. Virgin Island

DERMAL ABSORBED DOSE CALCULATION

Organics

If t_{event} <= t*, then: Eq. 1

$DA_{event} = 2FA * Kp * sqrt(6\ tau_{event} * t_{event}/pi) * C1$

If t_{event} > t*, then: Eq. 2

$DA_{event} = FA * Kp [t_{event}/(1+B) + 2tau_{event} ((1+3B+3B^2) / (1+B)^2)] * C1$

Inorganics Eq. 3

$DA_{event} = Kp * t_{event} * C1$

Parameter		Definition	Units	Value/Source
DA_{event}	=	Dermal absorption factor- aqueous exposures	L/cm^2-event	Calculated
FA	=	Fraction absorbed water	unitless	USEPA 2004
Kp	=	Dermal permeability coefficient in water	cm/hr	USEPA 2004
tau_{event}	=	Lag time per event	hr/event	USEPA 2004
t_{event}	=	Event duration	hr/event	0.71
t*	=	Time to reach steady-state	hr	USEPA 2004
B	=	Kp ratio, stratum corneum : viable epidermis	unitless	USEPA 2004
C1	=	Units conversion factor	L/cm^3	0.001

Chemical of Potential Concern	CAS No.	DERMAL ABSORBED DOSE PER EVENT						
		Kp	tau_{event}	B	t*	FA	DA_{event}	Basis
Naphthalene	91-20-3	4.7E-02	5.6E-01	2.0E-01	1.3E+00	1.0E+00	8.1E-05	Eq.1
Chloroform	67-66-3	6.8E-03	5.0E-01	2.9E-02	1.2E+00	1.0E+00	1.1E-05	Eq.1

Notes:

Equations for the calculation of DAevent as well as values for chemical-specific variables are obtained from USEPA, RAGS Part E, Supplemental Guidance for Dermal Risk Assessment Final, EPA/540/R/99/005, July 2004. Equations 3.1, 3.2, and 3.3 of the guidance are presented here as Equations 1, 2, and 3, respectively. Values for Kp, tau event, B, t* and FA are obtained from Exhibits 3-1, B-2 and B-3.

-- = Not applicable to inorganics. DA_{event} calculated via Equation 3 for inorganics.

Per USEPA 2004, DAevent calculations include the multiplication of exposure point concentration (EPC), however for this HHRA the EPC term was extracted from the Daevent calculation to more easily incorporate both terms into the intake calculation tables (RAGS Table 7 series).

TABLE C-2.10

NON-CANCER TOXICITY DATA -- ORAL/DERMAL

Caneel Bay Resort; St. John Island, U.S. Virgin Island

Chemical of Potential Concern	Chronic/ Subchronic	Oral Reference Dose (RfD)		Oral Absorption Efficiency for Dermal (1)	Absorbed RfD for Dermal (2)		Primary Target Organ(s)	Combined Uncertainty/Modifying Factors	RfD:Target Organ(s)	
		Value	Units		Value	Units			Source(s) (3)	Date(s)
Volatile Organic Compounds										
Chloroform	Chronic	1.0E-02	(mg/kg-day)	1.0E+00	1.0E-02	(mg/kg-day)	Liver	1000 / 1	IRIS	02/10/22
Semi Volatile Organic Compounds										
Benzo(a)pyrene	Chronic	3.0E-04	(mg/kg-day)	1.0E+00	3.0E-04	(mg/kg-day)	Developmental	300	IRIS	02/10/22
Dibenzo(a,h)anthracene	-	-	-	--	-	-	-	-	-	-
Naphthalene	Chronic	2.0E-02	(mg/kg-day)	1.0E+00	2.0E-02	(mg/kg-day)	Whole Body	-	IRIS	2/10/2022

Notes

mg/kg-day = milligrams per kilogram per day

(1) The oral absorption efficiency for dermal was obtained from USEPA Risk Assessment Guidance for Superfund (RAGS): Part E, Exhibit 4-1. 2004.

(2) The absorbed RfD for dermal is calculated by multiplying the oral RfD by the oral absorption efficiency value (EPA RAGS : Part E, 2004).

(3) IRIS = Integrated Risk Information System. Searched 2022. IRIS Final Assessments Search. https://cfpub.epa.gov/ncea/iris2/atoz.cfm

TABLE C-2.11

NON-CANCER TOXICITY DATA -- INHALATION

Caneel Bay Resort; St. John Island, U.S. Virgin Island

Chemical of Potential Concern	Chronic/ Subchronic	Inhalation Reference Concentration (RfC)		Primary Target Organ(s)	Combined Uncertainty/Modifying Factors	RfC : Target Organ(s)	
		Value	Units			Source(s) (1)	Date(s)
Volatile Organic Compounds							
Chloroform	Chronic	9.8E-02	mg/m^3	Liver	100	ATSDR	2/10/2022
Semi Volatile Organic Compounds							
Benzo(a)pyrene	Chronic	2.0E-06	mg/m^3	Developmental	3000	IRIS	2/10/2022
Dibenzo(a,h)anthracene	-	-	-	-	-	-	-
Naphthalene	Chronic	3.0E-03	mg/m^3	Nose/Respiratory	-	IRIS	2/10/2022

Notes

mg/m^3 = milligrams per meter cubed

mg/kg/day = milligrams per kilogram per day

(1) IRIS = Integrated Risk Information System. Searched 2022. IRIS Final Assessments Search. https://cfpub.epa.gov/ncea/iris2/atoz.cfm

ATSDR = Agency for Toxic Substances & Disease Registry. Minimal Risk Levels (MRLs) for Hazardous Substances. https://www.atsdr.cdc.gov/mrls/mrllist.asp#16tag

CAL EPA = California Environmental Protection Agency. Chronic Reference Exposure Level (REL). OEHAA 2008, Technical Supporting Document for Noncancer RELs Appendix D1.

HEAST = Health Effects Assessment Summaty Tables (HEAST). USEPA, 1997

TABLE C-2.12

CANCER TOXICITY DATA -- ORAL/DERMAL

Caneel Bay Resort; St. John Island, U.S. Virgin Island

Chemical of Potential Concern	Oral Cancer Slope Factor (CSF)		Oral Absorption Efficiency for Dermal (1)	Absorbed CSF for Dermal (2)		Weight of Evidence/ Cancer Guideline Description	Source(s) (3)	Date(s)
	Value	Units		Value	Units			
Volatile Organic Compounds								
Chloroform	3.1E-02	$(mg/kg\text{-}day)^{-1}$	1.0E+00	3.1E-02	$(mg/kg\text{-}day)^{-1}$	Likely	CAL EPA	2/10/2022
Semi Volatile Organic Compounds								
Benzo(a)pyrene	1.0E+00	$(mg/kg\text{-}day)^{-1}$	1.0E+00	1.0E+00	$(mg/kg\text{-}day)^{-1}$	B2***	IRIS	2/10/2022
Dibenzo(a,h)anthracene	1.0E+00	$(mg/kg\text{-}day)^{-1}$	1.0E+00	1.0E+00	$(mg/kg\text{-}day)^{-1}$	B2***	IRIS*	2/10/2022
Naphthalene	1.2E-01	$(mg/kg\text{-}day)^{-1}$	1.0E+00	1.2E-01	(mg/kg-day)-1	C	IRIS	2/10/2022

Notes

mg/kg-day = milligrams per kilogram per day

(1) The oral absorption efficiency for dermal was obtained from USEPA Risk Assessment Guidance for Superfund (RAGS): Part E, Exhibit 4-1. 2004.

(2) Absorbed cancer slope factor for dermal was calculated by dividing the oral cancer slope factor by the oral absorption efficiency value (EPA RAGS- Part E, 2004).

(3) IRIS = Integrated Risk Information System. Searched 2022. IRIS Final Assessments Search. https://cfpub.epa.gov/ncea/iris2/atoz.cfm

CAL EPA = California Environmental Protection Agency. Office of Environmental Health Hazard Assessment (OEHAA) Chemical Database. https://oehha.ca.gov/chemicals

* = Toxic equivalency factors (TEF) applied to the cancer slope factor (CSF) for benzo(a)pyrene to derive CSF for other PAHs. TEFs from USEPA. Provisional Guidance for Quantitative Risk Assessment of PAHs. 1993. EPA/600/R-93/C89.

Cancer Description (USEPA 1986):

A = Human carcinogen

B2 = Probable human carcinogen, sufficient evidence in animals and inadequate or no evidence in humans

C = Possible human carcinogen

D = Not classifiable as to human carcinogenicity

*** Constituent has a mutagenic mode of action (MOA). Cancer risk for constituents identified as having a (MOA) is calculated by applying an age-dependent adjustment factor (ADAF) for childhood exposures from birth through 15 years. These ADAFs are summarized below (EPA 2005).

The ADAFs are as follows:

Year	ADAF
0-2	10
2 < 16	3
≥16	1

TABLE C-2.13

CANCER TOXICITY DATA -- INHALATION

Caneel Bay Resort; St. John Island, U.S. Virgin Island

Chemical of Potential Concern	Unit Risk		Unit Risk		Weight of Evidence/ Cancer Guideline Description	Source(s)	Date(s)
	Value	Units	Value	Units			
Volatile Organic Compounds							
Chloroform	2.30E-05	$(ug/m^3)^{-1}$	2.3E-02	$(mg/m^3)^{-1}$	B2	IRIS:CAL EPA	2/10/2022
Semi Volatile Organic Compounds							
Benzo(a)pyrene	6.00E-04	$(ug/m^3)^{-1}$	6.0E-01	$(mg/m^3)^{-1}$	B2***	IRIS	2/10/2022
Dibenzo(a,h)anthracene	6.00E-04	$(ug/m^3)^{-1}$	6.0E-01	$(mg/m^3)^{-1}$	B2***	IRIS*	2/10/2022
Naphthalene	3.40E-05	$(ug/m^3)^{-1}$	3.4E-02	$(mg/m^3)^{-1}$	C	CAL EPA	2/10/2022

Notes

$(mg/m^3)^{-1}$ = milligrams per cubic meter

$(mg/kg\text{-}day)^{-1}$ = milligrams per kilograms per day

IRIS = Integrated Risk Information System. IRIS Final Assessments Searched 2022. https://cfpub.epa.gov/ncea/iris2/atoz.cfm

CAL EPA = California Environmental Protection Agency. Office of Environmental Health Hazard Assessment (OEHAA) Chemical Database.

* = Toxic equivalency factors (TEF) applied to the cancer slope factor (CSF) for benzo(a)pyrene to derive CSF for other PAHs.

TEFs from USEPA. Provisional Guidance for Quantitative Risk Assessment of PAHs. EPA/600/R-93/C89.

Cancer Description (USEPA 1986):

A = Human carcinogen

B2 = Probably human carcinogen, sufficient evidence in animals and inadequate or no evidence in humans

C = Possible human carcinogen

D = Not Classifiable as to human carcinogenicity

*** Constituent has a mutagenic mode of action (MOA). Cancer risk for constituents identified as having a MOA is calculated by applying an age-dependent adjustment factor (ADAF) for childhood exposures from birth through 15 years. These ADAFs are summarized below.

The ADAFs are as follows:

Year	ADAF
0-2	10
2 < 16	3
≥16	1

TABLE C-2.14

CALCULATION OF CHEMICAL CANCER RISKS AND NON-CANCER HAZARDS FOR POTABLE GROUNDWATER : PARK/RESORT WORKER

REASONABLE MAXIMUM EXPOSURE

Caneel Bay Resort, St. John Island, U.S Virgin Island

Scenario Timeframe:	Current/Future
Receptor Population:	Park/Resort Worker
Receptor Age:	Adult

							Cancer Risk Calculations					Non-Cancer Hazard Calculations				
					Value	Units										
Groundwater	Potable Groundwater	Invetigation Area 2	Ingestion	Naphthalene	1.0E-03	mg/L	1.7E-06	mg/kg-day	1.2E-01	$(mg/kg-day)^{-1}$	2.0E-07	1.2E-05	mg/kg-day	2.0E-02		
				Chloroform	5.5E-04	mg/L	9.1E-07	mg/kg-day	3.1E-02	$(mg/kg-day)^{-1}$	2.8E-08	6.4E-06	mg/kg-day	1.0E-02		
			Exp. Route Total								2.3E-07					
			Dermal Contact	Naphthalene	1.0E-03	mg/L	1.9E-06	mg/kg-day	1.2E-01	$(mg/kg-day)^{-1}$	2.3E-07	1.4E-05	mg/kg-day	2.0E-02		
				Chloroform	5.5E-04	mg/L	1.5E-07	mg/kg-day	3.1E-02	$(mg/kg-day)^{-1}$	4.6E-09	1.0E-06	mg/kg-day	1.0E-02		
			Exp. Route Total								2.4E-07					
			Inhalation	Naphthalene	1.0E-03	mg/L	3.0E-07	mg/m^3	3.4E-02	$(mg/m^3)^{-1}$	1.0E-08	2.1E-06	mg/m^3	3.0E-03	mg/m^3	6.9E-04
				Chloroform	5.5E-04	mg/L	1.6E-07	mg/m^3	2.3E-02	$(mg/m^3)^{-1}$	3.8E-09	1.1E-06	mg/m^3	9.8E-02	mg/m^3	1.2E-05
			Exp. Route Total								1.4E-08					
		Exposure Point Total														
	Exposure Medium Total															
							Total of Receptor Risks Across All Media				4.8E-07					
							Risks from Reference				NA					NA
							Risks from Site				4.8E-07					2.7E-03

(1) EPC = Exposure Point Concentration; CSF = Cancer Slope Factor; RfD = Reference Dose; RfC = Reference Concentration

(2) Cancer risk = Intake/exposure equation * CSF or Unit Risk; Hazard Index = Intake/exposure equation / RfD or RfC.

"-" = Not available

"--"= Not calculated

NA = Not applicable

mg/m^3 = milligrams per cubic meter

mg/kg-day = milligrams per kilogram per day

mg/L = milligrams per liter

TABLE C-2.15

CALCULATION OF CHEMICAL CANCER RISKS AND NON-CANCER HAZARDS FOR POTABLE WATER: RESIDENT

REASONABLE MAXIMUM EXPOSURE

Caneel Bay Resort, St. John Island, U.S Virgin Island

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

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	EPC		Cancer Risk Calculations					Non-Cancer Hazard Calculations				
							Intake/Exposure Concentration		CSF/Unit Risk*		Cancer Risk	Intake/Exposure Concentration		RfD/RfC		Hazard Quotient
					Value	Units	Value	Units	Value	Units		Value	Units	Value	Units	
Groundwater	Potable Groundwater	Investigation Area 2	Ingestion	Naphthalene	1.0E-03	mg/L	1.3E-05	mg/kg-day	1.2E-01	$(mg/kg\text{-}day)^{-1}$	1.6E-06	4.6E-05	mg/kg-day	2.0E-02	mg/kg/day	2.3E-03
				Chloroform	5.5E-04	mg/L	7.3E-06	mg/kg-day	3.1E-02	$(mg/kg\text{-}day)^{-1}$	2.2E-07	2.5E-05	mg/kg-day	1.0E-02	mg/kg/day	2.5E-03
			Exp. Route Total								1.8E-06					4.8E-03
			Dermal Contact	Naphthalene	1.0E-03	mg/L	7.9E-06	mg/kg-day	1.2E-01	$(mg/kg\text{-}day)^{-1}$	9.5E-07	2.9E-05	mg/kg-day	2.0E-02	mg/kg/day	1.4E-03
				Chloroform	5.5E-04	mg/L	6.0E-07	mg/kg-day	3.1E-02	$(mg/kg\text{-}day)^{-1}$	1.9E-08	2.2E-06	mg/kg-day	1.0E-02	mg/kg/day	2.2E-04
			Exp. Route Total								9.7E-07					1.7E-03
			Inhalation	Naphthalene	1.0E-03	mg/L	3.1E-06	mg/m^3	3.4E-02	$(mg/m^3)^{-1}$	1.0E-07	1.6E-05	mg/m^3	3.0E-03	mg/m^3	5.5E-03
				Chloroform	5.5E-04	mg/L	1.7E-06	mg/m^3	2.3E-02	$(mg/m^3)^{-1}$	3.9E-08	9.0E-06	mg/m^3	9.8E-02	mg/m^3	9.2E-05
			Exp. Route Total								1.4E-07					5.6E-03
		Exposure Point Total									2.9E-06					1.2E-02
	Exposure Medium Total										2.9E-06					1.2E-02
							Total of Receptor Risks Across All Media				2.9E-06					1.2E-02
							Risks from Reference				NA					NA
							Risks from Site				2.9E-06					1.2E-02

(1) EPC = Exposure Point Concentration; CSF = Cancer Slope Factor; RfD = Reference Dose; RfC = Reference Concentration

(2) Cancer risk = Intake/exposure equation * CSF or Unit Risk; Hazard Index = Intake/exposure equation / RfD or RfC.

"-" = Not available

"--"= Not calculated

NA = Not applicable

mg/m^3 = milligrams per cubic meter

mg/kg-day = milligrams per kilogram per day

mg/L = milligrams per liter

TABLE C-2.16

CALCULATION OF CHEMICAL CANCER RISKS AND NON-CANCER HAZARDS: CONSTRUCTION WORKER

REASONABLE MAXIMUM EXPOSURE

Caneel Bay Resort; St. John Island, U.S. Virgin Island

Scenario Timeframe:	Future
Receptor Population:	Construction Worker
Receptor Age:	Adult

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	EPC		Cancer Risk Calculations					Non-Cancer Hazard Calculations				
							Intake/Exposure Concentration		CSF/Unit Risk*		Cancer Risk	Intake/Exposure Concentration		RfD/RfC		Hazard Quotient
					Value	Units	Value	Units	Value	Units		Value	Units	Value	Units	
Soil	Subsurface Soil (5')	Cottage 7 Area	Incidental Ingestion	Benzo(a)pyrene	6.5E-01	mg/kg	2.6E-08	mg/kg-day	1.0E+00	$(mg/kg\text{-}day)^{-1}$	2.6E-08	1.8E-06	mg/kg-day	3.0E-04	mg/kg/day	6.1E-03
				Dibenz(a,h)anthracene	1.2E-01	mg/kg	4.8E-09	mg/kg-day	1.0E+00	$(mg/kg\text{-}day)^{-1}$	4.8E-09	3.3E-07	mg/kg-day	-	-	--
			Exp Route Total								3.1E-08					6.1E-03
			Dermal Contact	Benzo(a)pyrene	6.5E-01	mg/kg	1.1E-08	mg/kg-day	1.0E+00	$(mg/kg\text{-}day)^{-1}$	1.1E-08	7.7E-07	mg/kg-day	3.0E-04	mg/kg/day	2.6E-03
				Dibenz(a,h)anthracene	1.2E-01	mg/kg	2.0E-09	mg/kg-day	1.0E+00	$(mg/kg\text{-}day)^{-1}$	2.0E-09	1.4E-07	mg/kg-day	-	mg/kg/day	--
			Exp Route Total								1.3E-08					2.6E-03
			Inhalation (Fugitive Dust)	Benzo(a)pyrene	6.5E-01	mg/kg	1.6E-12	mg/m^3	6.0E-01	$(mg/m^3)^{-1}$	9.4E-13	1.1E-10	mg/m^3	2.0E-06	mg/m^3	5.5E-05
				Dibenz(a,h)anthracene	1.2E-01	mg/kg	2.8E-13	mg/m^3	6.0E-01	$(mg/m^3)^{-1}$	1.7E-13	2.0E-11	mg/m^3	-	-	--
			Exp Route Total								1.1E-12					5.5E-05
		Exposure Point Total									4.4E-08					8.7E-03
	Exposure Medium Total										4.4E-08					8.7E-03
Risk From Reference											NA					NA
Risk from Site											4.4E-08					8.7E-03
Groundwater	Groundwater	Investigation Area 2	Dermal Contact	Naphthalene	1.0E-03	mg/L	1.2E-08	mg/kg-day	1.2E-01	$(mg/kg\text{-}day)^{-1}$	1.4E-09	8.2E-07	mg/kg-day	2.0E-02	mg/kg/day	4.1E-05
				Chloroform	5.5E-04	mg/L	8.9E-10	mg/kg-day	3.1E-02	$(mg/kg\text{-}day)^{-1}$	2.8E-11	6.3E-08	mg/kg-day	1.0E-02	mg/kg/day	6.3E-06
			Exp. Route Total								1.4E-09					4.7E-05
		Exposure Point Total									1.4E-09					4.7E-05
	Exposure Medium Total										1.4E-09					4.7E-05
Groundwater	Groundwater	Investigation Area 2	Ambient (Trench) Air	Naphthalene	5.4E-06	mg/m^3	1.8E-08	mg/m^3	3.4E-02	$(mg/m^3)^{-1}$	6.0E-10	1.2E-06	mg/m^3	3.0E-03	mg/m^3	4.1E-04
				Chloroform	4.5E-06	mg/m^3	1.5E-08	mg/m^3	2.3E-02	$(mg/m^3)^{-1}$	3.4E-10	1.0E-06	mg/m^3	9.8E-02	mg/m^3	1.1E-05
			Exp. Route Total								9.4E-10					4.2E-04
		Exposure Point Total									9.4E-10					4.2E-04
	Exposure Medium Total										9.4E-10					4.2E-04
Risk From Reference											NA					NA
Risk from Site											2.4E-09					4.7E-04
							Total of Receptor Risks Across All Media				4.6E-08					9.2E-03
							Risks from Reference				NA					NA
							Risks from Site				4.6E-08					9.2E-03

(1) EPC = Exposure Point Concentration; CSF = Cancer Slope Factor; RfD = Reference Dose; RfC = Reference Concentration

(2) Cancer risk = Intake/exposure equation * CSF or Unit Risk; Hazard Index = Intake/exposure equation / RfD or RfC.

"-" = Not available

NC = Not calculated due to constituent not being classified as a volatile.

mg/kg = milligrams per kilogram

mg/kg-day = milligrams per kilogram per day

mg/m^3 = milligrams per cubic meter

mg/L = milligrams per liter

TABLE C-2.17

SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs: PARK/RESORT WORKER

REASONABLE MAXIMUM EXPOSURE

Caneel Bay Resort; St. John Island, U.S. Virgin Island

Scenario Timeframe: Current/Future
Receptor Population: Park/Resort Worker
Receptor Age: Adult

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Carcinogenic Risk				Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Inhalation	Dermal	Exposure Routes Total
Groundwater	Groundwater (potable)	Investigation Area 2	Naphthalene	2.0E-07	1.0E-08	2.3E-07	4.4E-07	Whole Body, Respiratory, Nose	5.8E-04	6.9E-04	6.8E-04	2.0E-03
			Chloroform	2.8E-08	3.8E-09	4.6E-09	3.7E-08	Liver	6.4E-04	1.2E-05	1.0E-04	7.5E-04
			Chemical Total	2.3E-07	1.4E-08	2.4E-07	4.8E-07		1E-03	7E-04	8E-04	3E-03
		Exposure Point Total					4.8E-07					2.7E-03
	Exposure Medium Total						4.8E-07					2.7E-03
Medium Total							4.8E-07					2.7E-03
Receptor Total						Receptor Risk Total	4.8E-07				Receptor HI Total	2.7E-03

Notes

"--" = Risk not calculated. See calculation of chemical cancer risk and non-cancer hazards In Table C-2.14.

Total Whole Body HI Across All Media=	2.0E-03
Total Liver Across All Media=	7.5E-04
Total Respiratory Across All Media=	2.0E-03

TABLE C-2.18

SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs: RESIDENT

REASONABLE MAXIMUM EXPOSURE

Caneel Bay Resort; St. John Island, U.S. Virgin Island

Scenario Timeframe: Future
Receptor Population: Resident
Receptor Age: Child and Adult

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Carcinogenic Risk				Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Inhalation	Dermal	Exposure Routes Total
Groundwater	Groundwater (potable)	Investigation Area 2	Naphthalene	1.6E-06	1.0E-07	9.5E-07	2.6E-06	Whole Body, Respiratory, Nose	2.3E-03	5.5E-03	1.4E-03	9.2E-03
			Chloroform	2.2E-07	3.9E-08	1.9E-08	2.8E-07	Liver	2.5E-03	9.2E-05	2.2E-04	2.8E-03
			Chemical Total	1.8E-06	1.4E-07	9.7E-07	2.9E-06		5E-03	6E-03	2E-03	1E-02
		Exposure Point Total					2.9E-06					1.2E-02
	Exposure Medium Total						2.9E-06					1.2E-02
Medium Total							2.9E-06					1.2E-02
Receptor Total						Receptor Risk Total	2.9E-06				Receptor HI Total	1.2E-02

Notes

"--" = Risk not calculated. See calculation of chemical cancer risk and non-cancer hazards in Table C-2.15.

Total Whole Body HI Across All Media=	9.2E-03
Total Liver Across All Media=	2.8E-03
Total Respiratory Across All Media=	9.2E-03
Total Kidney Across All Media=	8.1E-02

TABLE C-2.19

SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs: CONSTRUCTION WORKER

REASONABLE MAXIMUM EXPOSURE

Caneel Bay Resort; St. John Island, U.S. Virgin Island

Scenario Timeframe: Future
Receptor Population: Construction Worker
Receptor Age: Adult

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Carcinogenic Risk				Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Inhalation	Dermal	Exposure Routes Total
Subsurface Soil (5 feet bgs)	Soil	Cottage 7 Area	Benzo(a)pyrene	2.6E-08	9.4E-13	1.1E-08	3.7E-08	Developmental	6.1E-03	5.5E-05	2.6E-03	8.7E-03
			Dibenz(a,h)anthracene	4.8E-09	1.7E-13	2.0E-09	6.7E-09	-	--	--	--	--
			Chemical Total	3.1E-08	1.1E-12	1.3E-08	4.4E-08	Chemical Total	6.1E-03	5.5E-05	2.6E-03	8.7E-03
		Exposure Point Total					4.4E-08					8.7E-03
	Exposure Medium Total						4.4E-08					8.7E-03
Medium Total							4.4E-08					8.7E-03
			Naphthalene	--	--	1.4E-09	1.4E-09	Whole Body, Respiratory, Nose	--	--	4.1E-05	4.1E-05
			Chloroform	--	--	2.8E-11	2.8E-11	Liver	--	--	6.3E-06	6.3E-06
			Chemical Total	--	--	1.4E-09	1.4E-09		--	--	4.7E-05	4.7E-05
		Exposure Point Total					1.4E-09					4.7E-05
	Exposure Medium Total						1.4E-09					4.7E-05
	Ambient Air (Trench)	Investigation Area 2	Naphthalene	--	6.0E-10	--	6.0E-10	Whole Body, Respiratory, Nose	--	4.1E-04	--	4.1E-04
			Chloroform	--	3.4E-10	--	3.4E-10	Liver	--	1.1E-05	--	1.1E-05
			Chemical Total	--	9.4E-10	--	9.4E-10		--	4.2E-04	--	4.2E-04
		Exposure Point Total					9.4E-10					4.2E-04
	Exposure Medium Total						9.4E-10					4.2E-04
Medium Total							2.4E-09					4.7E-04
Receptor Total						Receptor Risk Total	4.6E-08				Receptor HI Total	9.2E-03

Notes

"--" = Risk not calculated. See calculation of chemical cancer risk and non-cancer hazards in Table C-2.16.

Total Whole Body HI Across All Media=	4.1E-05
Total Developmental HI Across All Media=	8.7E-03
Total Liver Across All Media=	1.1E-05
Total Respiratory Across All Media=	4.1E-05

TABLE C-2.20

SUMMARY OF RECEPTOR RISKS

Caneel Bay Resort; St. John Island, U.S. Virgin Island

Receptor	Total Cancer Risk		Total Noncancer Hazard	
	Cancer Risk	**Risk Driver**	**Non-Cancer (HI)**	**Risk Driver**
Current/Future Park/Resort Worker				
Groundwater (Investigation Area 2)	*5E-07*		*0.003*	
Ingestion	*2E-07*	None	*0.001*	None
Dermal Contact	*2E-07*	None	*0.0008*	None
Inhalation (Potable Use)	*1E-08*	None	*0.0007*	None
Total Risk	**5E-07**		**0.003**	
Future Construction Worker				
Soil -Subsurface (Cottage Area 7)	4E-08		0.009	
Incidental Ingestion	*3E-08*	None	*0.006*	None
Dermal Contact	*1E-08*	None	*0.003*	None
Inhalation (Fugitive Dust)	*1E-12*	None	*0.00005*	None
Groundwater (Investigation Area 2)	2E-09		0.0005	
Dermal Contact	*1E-09*	None	*0.00005*	None
Inhalation of Ambient (Trench) Air	*9E-10*	None	*0.0004*	None
Total Risk	**5E-08**		**0.009**	
Future Resident				
Groundwater (Investigation Area 2)	*3E-06*		*0.01*	
Ingestion	*2E-06*	Naphthalene	*0.005*	None
Dermal Contact	*1E-06*	None	*0.002*	None
Inhalation (Potable Use)	*1E-07*	None	*0.006*	None
Total Risk	**3E-06**		**0.01**	

Notes:

Risk drivers are provided only for chemicals of potential concern within a medium that have a cumulative Hazard Index greater than one (1), or a cumulative cancer risk greater than one in one million (1E-06).

HI = Hazard Index

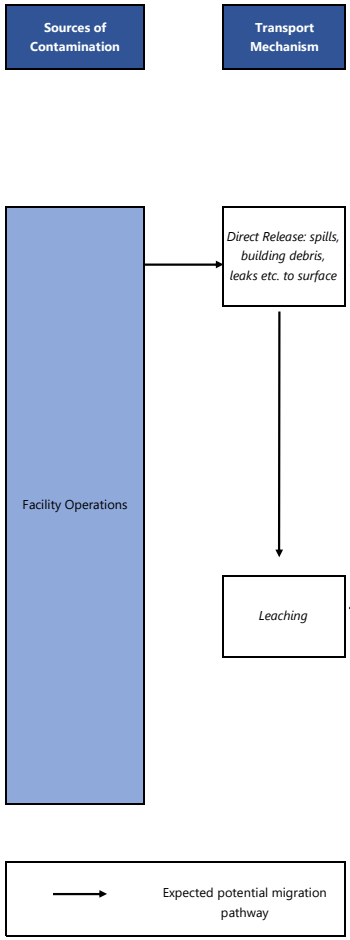
Figures

FIGURE C-1

HUMAN HEALTH AND ECOLOGICAL PATHWAY-RECEPTOR DIAGRAM

Caneel Bay Resort

St. John Island, U.S. Virgin Island



Receptors and Potentially Complete Exposure Pathways

Human Receptors

Exposure Route	Visitor	Park/Resort Worker	Construction Worker	Hypothetical Future Resident
Inhalation of Fugitive Dust	(X) [2]	X	X	X
Dermal contact	(X) [2]	X	X	X
Incidental Ingestion	(X) [2]	X	X	X

Exposure Route [4]	Visitor	Park/Resort Worker	Construction Worker	Hypothetical Future Resident
Inhalation of Fugitive Dust	--	--	--	--
Dermal contact	--	--	--	--
Incidental Ingestion	--	--	--	--

Exposure Route	Visitor	Park/Resort Worker	Construction Worker	Hypothetical Future Resident
Incidental Ingestion	--	--	X	X
Dermal contact	--	--	X	X
Inhalation of Fugitive Dust	--	--	X	X

Exposure Route	Visitor	Park/Resort Worker	Construction Worker	Construction Worker
Incidental Ingestion	--	--	--	X
Dermal contact	--	--	--	X
Inhalation of Fugitive Dust	--	--	--	X

Ecological Receptors

Exposure Route	Plants	Terrestrial Invertebrates	Amphibians/ Reptiles	Birds	Mammals
Ingestion	--	--	(X) [3]	--	--
Dermal contact	--	--	(X) [3]	--	--
Inhalation of Fugitive Dust	--	--	X	X	X
Direct uptake	X	X	--	--	--
Uptake into biota (e.g., fish)	--	--	(X) [3]	X	X

Exposure Route	Benthic and Aquatic Invertebrates	Fish [5]
Ingestion	X	X
Dermal contact	X	X
Direct uptake	--	--

NOTES:

X = Indicates the complete or potentially complete exposure pathway that was retained for quantitative evaluation for this medium and receptor.

(X) = Complete or potentially complete pathway, but risk qualitatively evaluated

-- = Not a relevant exposure pathway for receptor.

[1] Groundwater data are used as a surrogate for surface water for ecological receptors, assuming groundwater could emerge as surface water (seeps etc.) at the Site, or migrate to Caneel Bay.

[2] The visitor is expected to have an exposure potential lower than either the Park/Resort Worker or Hypothetical Future Site Resident receptor scenarios. Therefore, a quantitative evaluation of risk for the visitor was not conducted.

[3] Inadequate toxicological/exposure data available to quantify risk from this pathway.

[4] Due to the significant volume of dilution in Caneel Bay, recreational users of the beach are not expected to have significant chemical exposures in surface water, should Site groundwater migrate and discharge to the bay. (There are no surface water bodies at the Resort itself.)

[5] While no fish are expected in any on-site discharge locations, fish are included to capture potential exposure in Caneel Bay.

DRAFT FINAL

Woodard & Curran

Attachment A: Estimation of Exposure Point Concentrations in Ambient Air in a Trench

ATTACHMENT A

ESTIMATION OF EXPOSURE POINT CONCENTRATIONS IN AMBIENT AIR IN A TRENCH

TABLE OF CONTENTS

TABLES

1. INTRODUCTION

While undertaking excavation activities at the Site, construction workers may inhale volatile organic compounds (VOCs) that accumulate in the air of an excavation pit or trench ("trench air") as a result of shallow groundwater intrusion. Woodard & Curran used a combination of two exposure models to estimate "trench" air concentrations of volatile chemicals of potential concern (COPC) at the Site. These models were used to evaluate risks associated with the inhalation of trench air for a future construction worker scenario. Refer to Section 2.2 of the HHRA text for additional information on this scenario.

Volatile COPCs retained in groundwater from monitoring wells in Investigation Area 2 (MW-2-07 and MW-02-09) include naphthalene and chloroform. Depth at these locations ranged from approximately 5.5 feet bgs at MW-2-07 to 9 feet bgs at MW-2-09. The maximum excavation depth on the construction worker is assumed to be approximately 10 feet bgs or to the top of the water table, whichever is shallower. Therefore, it was assumed that a construction worker could potentially encounter standing water in a trench in Investigation Area 2.

Groundwater data used to support this model were collected at the Site between November 2021 and January 2022, data for which are presented in **Table C-1.2** of the HHRA. The maximum detected concentration in groundwater was used as the exposure point concentrations (EPC) that was used to derive ambient air EPCs. The following groundwater EPCs were used (refer to Section 2.2.2.1 in the HHRA for further discussion):

- Naphthalene - 0.001 mg/L
- Chloroform – 0.00055 mg/L

2. TRENCH MODEL USING GROUNDWATER DATA

A conservative screening level model (RTI Model; USEPA, 1990) describing simple mass transfer of volatile constituents from liquid surfaces to air was used in this analysis. The RTI model was originally developed for assessing volatile emissions from aerated and non-aerated lagoons. The model is also applicable to quiescent and turbulent conditions. The model was selected for this analysis due to the similarities between a quiescent lagoon and standing water in the bottom of a trench. The overall mass transfer coefficient was based on an estimation technique presented in Lyman (1982). The compound specific flux rate was then entered into a simple one box mass balance model which integrates the effects of air movement through the trench. This model estimates the concentration of contaminant in air (in milligrams of compound per cubic meter (mg/m^3) of air). Descriptions of both these models and associated assumptions are provided below.

2.1 MODEL FOR VOLATILE CONSTITUENT MASS EMISSION RATE

The RTI model, which predicts a mass emission rate, is based on the contaminant concentration in the liquid phase (i.e., groundwater seeping into a trench), the area of the liquid surface, the area of the trench, and the overall mass transfer coefficient of each individual volatile constituent.

The RTI Model is summarized as follows:

$$E = K * SA * Cw * CF1 * CF2$$

where,

E = Mass emission rate of contaminant in air phase (g/sec)

K = Overall mass transfer coefficient (m/sec)

SA = Liquid surface area (m^2)

C_w = Concentration of contaminant in liquid phase (mg/L)

CF1 = Units conversion factor, 1000 L/m^3

CF2 = Units conversion factor, 1 g / 1000 mg

For the calculation of E, K is converted from units of m/hr to m/sec with a conversion factor of 1 hour per 3,600 seconds.

The liquid-phase concentration (C_W) was based on all groundwater data available for the Site. The maximum groundwater concentration was used as the concentration of each contaminant in liquid phase for the specified exposure.

The overall mass transfer coefficient, K (m/hr), is related to the liquid phase exchange coefficient, kL (m/hr), and the gas-phase exchange coefficient, kG (m/hr), as follows:

$$\frac{1}{K} = \left(\frac{1}{kL} + \frac{R * T}{H * kG} \right) * CF$$

where,

R = Universal gas constant, 8.206 x 10^{-5} (m^3 atm/mol °K)

T = Temperature (298°K)

H = Henry's Law Constant (m^3-atm/mol)

CF = Units conversion factor (3600 sec per hr)

The overall mass transfer coefficient can be determined from experiment or from knowledge of the liquid and gas phase exchange coefficients. Model calculations may also be performed relating these coefficients to physical properties such as the molecular weight and scaling based upon mass transfer coefficients for other compounds. One set of such relationships, presented in Lyman (1982), is given by:

$$\mathrm{kL} = 20 * \sqrt{\frac{44}{\mathrm{M}}} * \mathrm{CF}$$

where,

kL = Liquid phase exchange coefficient (m/hr)

20 = Liquid phase exchange coefficient for carbon dioxide (CO_2) (cm/hr)

44 = Molecular weight of CO_2 (g/mole)

M = Molecular weight of chemical of interest (g/mole)

CF = Units conversion factor (1 m per 100 cm)

and:

$$\mathrm{kG} = 3000 * \sqrt{\frac{18}{\mathrm{M}}} * \mathrm{CF}$$

where,

kG = Gas phase exchange coefficient (m/hr)

3000 = Gas phase exchange coefficient for H_2O (cm/hr)

18 = Molecular weight of H_20 (g/mole)

M = Molecular weight of chemical of interest (g/mole)

CF = Units conversion factor (1 m per 100 cm)

The overall mass transfer coefficients and mass emission rates are presented on **Table CA-1** for the construction worker scenario.

2.2 MODEL FOR ESTIMATING AIR CONCENTRATIONS

A simple one box mass balance model was used to estimate the concentration of groundwater constituents in the ambient air of an excavation trench. This model assumes that emissions from pooled groundwater in the trench are diluted into air passing through the excavation. The parameters used to calculate the volume

of air flowing through the trench and thus the volume into which the emissions are diluted include the following:

- the wind speed, which was assumed to be 14 miles/hour (6.26 meters per second), which is based on the average wind speed for the windier part of the year (between June and August) in Cruz Bay, U.S. Virgin Islands (Weather Spark, 2022).; and
- the width and depth of the excavation.

For the future construction worker scenario, a trench dimensions of two-meter-wide and 10 meters long were used for all scenarios. The depth of the trench was based on the average depth to groundwater in Investigation Area 2, which is approximately 6 feet bgs.

Concentrations of volatile constituents in trench air were estimated as follows:

$$[\mathrm{OHM}]\mathrm{air} = \frac{\mathrm{E}}{\mathrm{Q}} * \frac{1}{\mathrm{A}} * \mathrm{CF}$$

where,

$[OHM]_{air}$ = Concentration of contaminant in trench air (mg/m^3)

E = Mass emission rate of contaminants (g/s; as estimated in Section 2.1)

Q = Wind speed of air moving through trench (m/s)

A = Cross sectional area of trench (m^2)

CF = Units conversion factor (1000 mg per g)

The results of the mass emission rate modeling including derivation of mass transfer coefficients, chemical specific volatilization rates, and estimated trench air concentrations are presented on **Table CA-1** for the construction worker scenario.

3. REFERENCES

Crank, J. 1975. *The Mathematics of Diffusion*. Second Edition. Oxford Science Publications, Clarendon Press, Oxford.

Gas Research Institute (GRI). 1998. *Management of Manufactured Gas Plant Sites, Volume III (Risk Assessment),* Appendix B. May.

U.S. EPA, 1990. *Estimation of Baseline Air Emissions at Superfund Sites*. Report ASF 2a. Office of Air Quality. August.

Weather Spark, 2022. Climate and Average Weather Year Around in Cruz Bay. U.S Virgin Islands. Accessed February 2022. Cruz Bay Climate, Weather By Month, Average Temperature (U.S. Virgin Islands) - Weather Spark.

ATTACHMENT A: TABLE CA-1
ESTIMATION OF AMBIENT AIR CONCENTRATIONS IN A TRENCH
Caneel Bay Resort; St. John Island, U.S. Virgin Island

Calculation of Mass Emission Rate

$E = K * SA * Cw * CF1 * 1/CF2$

Where:
- E = Mass emission rate of contaminant in air phase (g/s)
- K = Overall mass transfer coefficient (m/s)
- SA = Liquid surface area (m^2)
- Cw = Concentration of contaminant in liquid phase (mg/L) (max wellhead average)
- CF1 = Units conversion factor (1000 L/ m^3)
- CF2 = Units conversion factor (1000 mg/g)

Calculation of Ambient Air Concentration

$EPC_{aa} = E/Q * 1/A * CF2$

Where:
- EPC_{aa} = Ambient air exposure point concentration
- E = Mass emission rate (g/s)
- Q = Windspeed of air moving through trench (m/s)
- A = Cross-sectional area of trench (m^2)
- CF2 = Units conversion factor (1000 mg/g)

Calculation of Mass Transfer Coefficients

$(1/K) = ((1/K_l) + [(R^* T) / (H * K_g)]) * CF3$

$K_l = 20 \sqrt{(44/M)} * CF4$ $K_g = 3000 \sqrt{(18/M)} * CF4$

Where:
- K_l = Liquid-phase mass transfer coefficient (m/hr)
- Kg = Gas-phase mass transfer coefficient (m/hr)
- R = Universal Gas Constant (8.206 x 10^{-5} m^3-atm/mol-ºK)
- T = Temperature (298 ºK)
- H = Henry's Law Constant (m^3-atm/mol)
- 20 = Liquid-phase exchange coefficient of carbon dioxide (cm/hr)
- 3000 = Gas-phase exchange coefficient of water (cm/hr)
- 44 = Molecular weight of carbon dioxide (g/mole)
- 18 = Molecular weight of water (g/mole)
- M = Molecular weight of chemical of potential concern (g/mole)
- CF3 = Conversion factor (3600 sec / hr)
- CF4 = Conversion factor (1 m per 100 cm)

Chemical of Potential Concern	CAS Number	C w	SA	Trench Dimensions			H	M	Kg	Kl	K	E	Q	A	EPC_{aa}
		Groundwater Concentration (mg/L)	Liquid Surface Area (m^2)	(L) Length (m)	(W) Width (m)	(D) Depth (m)	Henry's Law Constant (m^3-atm/mol)	Molecular Weight (g/mole)	Phase Exchange Coefficient - Gas (m/hr)	Phase Exchange Coefficient - Liquid (m/hr)	Overall Mass Transfer Coefficient (m/sec)	Emission Rate (g/s)	Wind Speed (m/s)	Cross-sectional Area of Trench (m^2)	Trench Air Concentration (mg/m^3)
Volatile Organic Compounds (VOCs)															
Naphthalene	91-20-3	1.00E-03	3.00E+00	1.20E+01	1.00E+00	1.83E+00	4.40E-04	1.28E+02	1.12E+01	1.17E-01	2.06E-05	6.18E-08	6.26E+00	1.83E+00	5.40E-06
Chloroform	67-66-3	5.50E-04	3.00E+00	1.20E+01	1.00E+00	1.83E+00	3.67E-03	1.19E+02	1.16E+01	1.21E-01	3.15E-05	5.20E-08	6.26E+00	1.83E+00	4.55E-06

Notes
1. Only constituents identified as potentially volatile (Henry's Law > 1E-05 m^3-atm/mol) are presented on this table.
2. U.S. EPA. 1990. Estimation of Baseline Air Emissions at Superfund Sites. Report ASF 2a. Office of Air Quality. August
3. Groundwater concentration is the maximum detected concentration of monitoring wells screened less than 10 feet below top of casing located Investigation Area 2.
4. Liquid surface area was calculated as the length of the excavation times the width of the excavation. While dewatering of the trench is expected to occur, the model assumes that 25 percent of the trench contained standing water to account for volatilization for two other transport mechanisms (i.e., from groundwater to soil gas to air and from soil to air). Therefore, a factor of 0.25 was applied to the liquid surface area.
5. It was assumed that a trench would be 12 meters long by 1 meter wide, with a depth equivalent to the average depth to groundwater measured at wells in Investigation Area 2 (6 feet).
6. Molecular weights and Henry's Law constants were obtained from USEPA's Regional Screening Level Chemical Specific Parameters Table. November 2021. https://www.epa.gov/risk/regional-screening-levels-rsls-generic-tables
7. Windspeed of air moving through the trench was based on Cruz Bay weather data from weatherspark.com using the average wind speed between June and August, considered the windier part of the year. The mean wind speed of 14 miles/h was used to represent the windspeed of air moving through the trench.
8. The cross-sectional area of the trench is based on the trench dimensions above. Therefore, the cross-sectional area was simply calculated as (D x W).