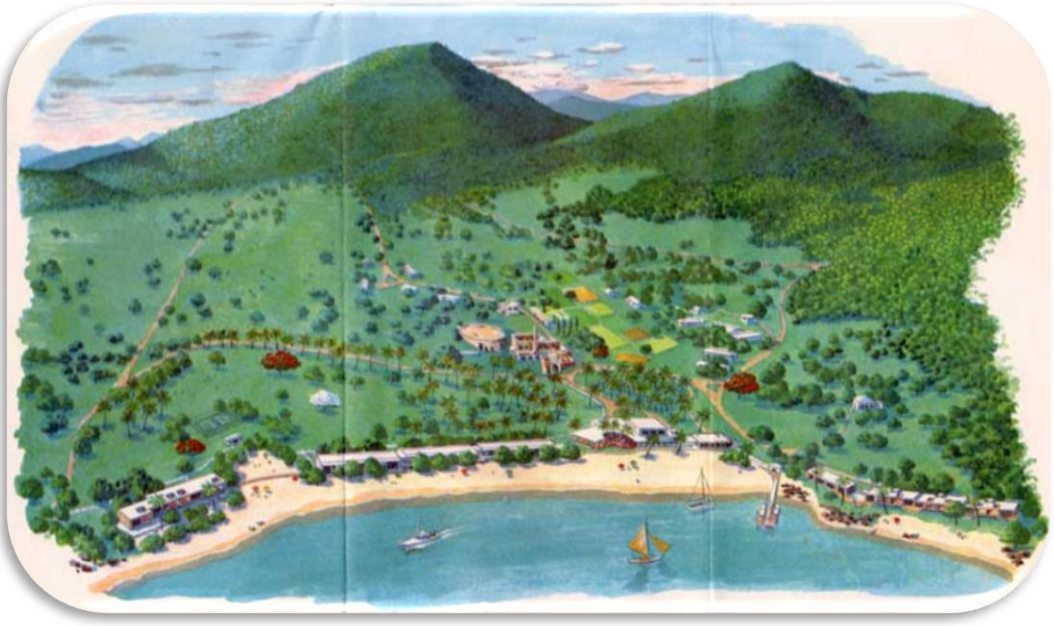

1956 Caneel Bay Resort brochure illustration (Source: Electro's Spark 2009)

DRAFT
Engineering Evaluation/Cost Analysis Risk Assessment Work Plan

Virgin Islands National Park

Caneel Bay Resort Site

Prepared by

WOODARD & CURRAN, INC.

November 18, 2016

Table of Contents

List of Tables

List of Figures

List of Abbreviations and Acronyms

ADAF	Age-dependent adjustment factor
ALM	Adult Lead Model
BERA	Baseline ecological risk assessment
CBR	Caneel Bay Resort
CDC	Centers for Disease Control and Prevention
COPC	Contaminant of potential concern

COPEC	Contaminant of potential ecological concern
CSF	Cancer slope factor
CSM	Conceptual site model
CT	Central Tendency
EE/CA	Engineering Evaluation/Cost Analysis
EPC	Exposure point concentration
ESV	Ecological Screening Value
HHRA	Human Health Risk Assessment
HI	Hazard Index
HQ	Hazard Quotient
IEUBK	Integrated Exposure Uptake Biokinetic
ISM	Incremental Sampling Methodology
ITRC	Interstate Technology Regulatory Council
IUR	Inhalation unit risk
LOEL	Lowest observed effects level
µg/dL	Micrograms per deciliter
NCP	National Oil and Hazardous Substances Pollution Contingency Plan (aka, National Contingency Plan)
NOAEL	No-Observable-Adverse Effect Level
NPS	National Park Service
PAH	Polycyclic aromatic hydrocarbon
RfC	Reference concentration
RfD	Reference dose
RME	Reasonable maximum exposure
RSL	Regional Screening Level
SAP	Sampling and Analysis Plan
SLERA	Screening Level Ecological Risk Assessment
SSL	Soil Screening Level
UCL	Upper confidence limit
USEPA	United States Environmental Protection Agency
VIIS	Virgin Islands National Park
VISL	Vapor Intrusion Screening Level
VOC	Volatile Organic Compound
WWTP	Wastewater treatment plant

1 Introduction

This document serves as the risk assessment Work Plan for the Engineering Evaluation/Cost Analysis (EE/CA) at the Caneel Bay Resort (CBR) within the Virgin Islands National Park (VIIS, or the Park) on the northwest side of the island of St. John, U.S. Virgin Islands. This Work Plan references the Caneel Bay Resort Site EE/CA Sampling and Analysis Plan (SAP), which provides additional information regarding the EE/CA purpose and planned investigation (The Johnson Company 2016). The purpose of this Work Plan is to define:

- The purpose of the risk assessments;
- The use for the data generated; and
- The methods that will be used in risk assessment.

This Work Plan includes four sections: 1) introduction; 2) the human health risk assessment plan; 3) the ecological risk assessment plan; and 4) references.

1.1 Purpose of the Risk Assessments

A baseline Human Health Risk Assessment (HHRA) and Screening Level Ecological Risk Assessment (SLERA) will be performed as part of the EE/CA to evaluate potential risks to both human and ecological receptors associated with exposure to contamination at the Site under existing and potential future use scenarios. Risk assessment provides risk managers the information needed to understand existing or potential threats by identifying the nature, extent, and location of the release, the pertinent exposure pathways of contamination migration, and the human and/or ecological receptors that may be exposed to the contamination. The HHRA and SLERA are expected to evaluate existing and potential risks to human health and ecological receptors in the absence of a response to the releases at the Site, and evaluate if such risks must be addressed by additional response actions.

The HHRA and SLERA will be based on analytical results from the EE/CA investigation.

The following subsections present the approach and assumptions for the HHRA and SLERA.

2 Human Health Risk Assessment

2.1.1 Data Evaluation and Selection of the Contaminants of Potential Concern

Data quality objectives for the EE/CA and HHRA are described in the SAP Section 4.6. The screening levels that will be used to identify contaminants of potential concern (COPCs) are the action levels described in SAP Section 4.5.2. COPCs will be identified by comparing maximum detected concentrations of analytes in each medium in each investigation area to United States Environmental Protection Agency (USEPA) residential Regional Screening Levels (RSLs; USEPA 2016a) for soil and tapwater (if water is determined to be potable) and USEPA Vapor Intrusion Screening Levels (VISLs) for groundwater (USEPA 2016b). Carcinogens will be compared to the RSL/VISL representing cancer risk of 1E-06 and noncarcinogenic contaminants will be compared to the RSL/VISL representing hazard quotient (HQ) of 0.1. Contaminants detected above the RSLs will be carried forward as COPCs in the risk

assessment. Contaminants lacking RSLs will not be carried through the quantitative HHRA but will instead be addressed in the uncertainty analysis (see Section 2.1.5).

2.1.2 Exposure Evaluation

As described in SAP Section 2.2.4, the media of concern are surface soil and subsurface soil (including the debris landfill contents) and groundwater.

The three investigation areas that comprise the Site, as described in SAP Section 2.1.1, include:

- Area 1: approximately 1.7 acres in the vicinity of the wastewater treatment plant (WWTP) structures, on the southeastern side of the resort;
- Area 2: approximately 5.4 acres that encompass the engineering, maintenance, landscaping, and fuel buildings and facilities, located to the southwest of the WWTP; and
- Area 3: approximately 1.4 acres of land that will be referred to in this document as the debris landfill to reflect historical usage, located immediately east of Honeymoon Beach.

CBR is open to overnight guests year round, except from the end of August to the beginning of November. Honeymoon Beach, located west of Area 3, is open to the public year-round. Employees live and work at CBR year-round. There are some residences within the resort, including to the northwest of Area 1 and to the southwest of Area 3, but there are no residential neighborhoods near the resort. The only residence near Area 3 is National Park Service (NPS) staff housing at the southern edge of Honeymoon Beach, approximately 1,000 feet southwest of the debris landfill.

The WWTP building in Area 1 includes equipment shelters but there are no offices or other occupied spaces. Occupied offices, garages, maintenance buildings, and a staff canteen are located within Area 2. Immediately west, but outside, of Area 3, there are two small canteens that sell packaged food and drinks, and are occupied during the day. CBR is a gated property with a security office; Areas 1 and 2 are not on the CBR guest map and roads to these areas are marked with “Employees Only” signs. Therefore, access to these areas is limited primarily to employees. The landfill at Area 3 has a gravel surface, is not generally accessible to the public by car, and does not have any buildings other than a small shelter for donkeys. It is assumed that the landfill will be and remain capped and covered, and that there will be no access to subsurface soils in this area of CBR.

The CBR water sources are a desalinization plant operated by CBR and a 1.5-million-gallon catchment basin for rainwater; groundwater is not a drinking water source on St. John. As detailed in Section 2.1.4 of the SAP, there are no groundwater wells in use at CBR.

The risk assessment will estimate current and future potential health risks to the human receptors listed below:

1. A ***trespasser***, who may occasionally visit any of the three areas. This receptor, assumed to be an adolescent age 6-16, could potentially be exposed to contaminants in surface soil

under current conditions in any of the three exposure units and subsurface[1] soils under future conditions in Areas 1 and 2 (it is assumed that no future excavation of soils will occur in Area 3, the landfill). While an adult trespasser may also be present, evaluation of the adolescent trespasser is anticipated to be protective of adult receptors, since children are generally considered to be more sensitive receptors. Exposure pathways to be evaluated include incidental ingestion of and dermal contact with soil and inhalation of fugitive dust and volatiles in soil.

2. An ***adult NPS or CBR employee*** performing routine maintenance, surveillance, and cleanup. This receptor is anticipated to encounter COPCs in surface and subsurface soils in Areas 1 and 2, and to surface soil in Area 3. Exposure pathways to be evaluated include incidental ingestion of and dermal contact with soil and inhalation of fugitive dust and volatiles in soil. Additionally, Area 2 has occupied buildings. If shallow groundwater is found to be contaminated with volatile organic compounds (VOCs), which could migrate into these buildings ("vapor intrusion"), then employees could potentially inhale COPCs in indoor air in this area.

3. An ***adult construction/utility worker/landscaper*** conducting excavation activities in the three exposure units. This receptor is assumed to be exposed to COPCs in surface and subsurface soils, as well as to COPCs in shallow groundwater, in only Areas 1 and 2, since it is assumed that no future construction/excavation will occur in Area 3, the landfill. Exposure pathways to be evaluated for this receptor include incidental ingestion of and dermal contact with soil, inhalation of fugitive dust and volatiles in soil, dermal contact with shallow groundwater and (if VOCs are present), inhalation of VOCs in ambient air of an excavation pit or trench.

None of the potential receptors is expected to be exposed through ingestion of wild or farmed foods or via fishing that may occur in the ocean downgradient of the Site. As the Site is located within CBR and a National Park, the land is not used for hunting or collecting wild foods. Surface water and sediment are not media of concern for this EE/CA.

Figure 1 is a preliminary human health conceptual site model (CSM) that summarizes the sources of contaminated media, release mechanisms, fate and transport, exposure media, and exposure routes to human receptors. The potentially complete exposure pathways include all transport mechanisms and pathways that are considered complete, as well as those for which there are currently insufficient sample data to determine completeness. Complete exposure pathways will be verified by the sample data collected for the EE/CA, and the preliminary CSM will be revised into a final CSM in the HHRA report.

While this work plan assumes that the above receptors each could be equally exposed to media in any of the three exposure areas, certain parts of the Site may be considered to be more attractive to or more typically accessed by certain receptors than other areas. Additional information from Park staff will be sought prior to conducting the risk assessment from the Park regarding potential visitation.

2.1.2.1 Estimation of Intake

Intake is estimated using equations and assumptions to develop the intake factors used in the calculation of the risk. An upper-bound estimate (i.e., "reasonable maximum exposure" or RME) of the theoretical

[1] For the HHRA, "surface" soil is defined as the interval located 0-1 foot below ground surface, and "subsurface" is defined as the interval located from 1 to 10 feet below ground surface, in accordance with USEPA guidance.

intake for each of the potentially exposed human populations via each of the exposure routes shown on the CSM will be calculated. RME is defined as the highest exposure that could reasonably be expected to occur for a given exposure pathway at a site, and is intended to account for both uncertainties in the contaminant concentration (exposure point concentration; see following section) and variability in exposure parameters (e.g., exposure frequency, averaging time). While USEPA also recommends evaluating a less-conservative central tendency (CT) estimate of intake, cleanup decisions are often made on the results of the RME scenario, which is the most protective of the two scenarios. Therefore, no CT scenarios are proposed to be conducted for this HHRA.

The USEPA defines exposure as "the contact with a chemical or physical agent," and defines the magnitude of exposure as "the amount of an agent available at [human] exchange boundaries (i.e., lungs, gut, skin) during a specified time period" (USEPA 1989). Exposure assessments are designed to determine the degree of contact a person has with a chemical. Estimates of human intake are a function of exposure parameters such as duration, frequency, and contact rates and are combined with toxicity values to estimate the risk for each population of concern.

The approaches adopted by the USEPA's Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual Part A (USEPA 1989), Part F Supplemental Guidance for Inhalation of Risk Assessment (USEPA 2009) and other relevant risk assessment guidance documents will be used to estimate intakes in this assessment. Specific exposure assumptions for each receptor are provided in the attached Table 1. These usage and exposure assumptions are designed to provide a reasonably conservative estimate of risk, i.e., an RME scenario. The generalized equations used to calculate intake factors in this assessment are provided in Table 2.

2.1.2.2 Calculation of Exposure Point Concentrations

Exposure point concentrations (EPCs) and the basis for choosing the EPC for soil will be provided in tables included in the HHRA. The detection frequency, the range of detected concentrations, number of valid data, and a potential upper confidence limit (UCL) of the arithmetic mean concentration for each chemical will also be provided. Valid data will be determined to be suitable for its intended use through an evaluation of analytical and quality control results for method, procedural, and compliance with the QAPP to determine the analytical quality of a specific data set (USEPA 2002).

Groundwater: EPCs for groundwater will be calculated using the 95% UCL of the mean calculated for discrete groundwater samples, as applicable. Because of the uncertainty associated with estimating the true average concentration at a site, the 95% UCL of the arithmetic mean will be used for the EPC. The 95% UCL provides reasonable confidence that the true site average will not be underestimated (USEPA 1992).

The 95% UCLs for each COPC in groundwater will be calculated using the USEPA's most recent ProUCL software, currently version 5.0 (USEPA 2016c). ProUCL calculates 95% UCLs using multiple alternative methods, including both parametric methods and nonparametric methods. Parametric methods are based on the assumption that the data are consistent with a standard statistical distribution, such as normal, log-normal, or gamma. Nonparametric methods do not require any assumptions about the distribution.

ProUCL will be used to calculate 95% UCLs for chemicals with two or more detected values and more than eight discrete samples. If the 95% UCL is greater than the maximum detected concentration, then the maximum concentration will be used as the EPC. For chemicals with less than two detects or less than eight samples, the maximum sample concentration will be used as the EPC. The ProUCL input data and associated output files will be included in an appendix to the HHRA.

If discrete data indicate the low variability in contaminant concentrations within the investigation area, the 95% UCL calculated using the Student's t-test method will be selected as the EPC. If discrete data or other knowledge suggests that the variability may be high or the variability is unknown, the 95% UCL calculated using the Chebyshev method will be selected as the EPC. The details of the EPC calculations will be included in the HHRA.

Soil: Surface and subsurface soil samples will be collected using incremental sampling methodology (ISM). ProUCL does not currently include the statistical algorithms for handling ISM data (generally, a low number of samples per decision unit) and will not be used for calculating the 95% UCL for samples collected by ISM. Instead, the 95% UCL for soil will be calculated based on three or more ISM samples per investigation area, where more than one replicate is collected in a representative decision unit, using the Interstate Technology & Regulatory Council (ITRC) online calculator (ITRC 2012a). The calculation methods for ISM data sets include Student's t-test (representing the low end of the range) and Chebyshev UCLs (representing the high end of the range) and are expected to "bracket" the range of UCLs that may be calculated from a data set (ITRC 2012b).

2.1.3 Toxicity Assessment

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. This section of the HHRA will describe the relevant toxicity criteria, such as reference doses (RfDs), reference concentrations (RfCs), cancer slope factors (CSFs) and inhalation unit risks (IURs), used in the HHRA to estimate noncancer hazard and cancer risk. Toxicity information will be obtained using the USEPA's recommended hierarchy of toxicity values (USEPA 2003a).

Evaluation of Mutagenic COPCs: USEPA's guidance on cancer risks (2005a; 2005b) specify the use of age-dependent adjustment factors (ADAFs) for carcinogens that act via a mutagenic mode. Carcinogenic polycyclic aromatic hydrocarbons (PAHs), trichloroethylene, and hexavalent chromium are included in the group of chemicals that have been determined to act in this manner. If these compounds are identified as COPCs, USEPA guidance recommends using ADAFs combined with age-specific exposure estimates when assessing cancer risks. In the absence of chemical-specific data, the supplemental guidance recommends the following default adjustments, which reflect the fact that cancer risks are generally higher from early-life exposures than from similar exposures later in life:

- For exposures before 2 years of age (i.e., spanning a 2-year interval from the first day of birth until a child's second birthday), a 10-fold adjustment is made.
- For exposures between 2 and 16 years of age (i.e., spanning a 14-year time interval from a child's second birthday until their sixteenth birthday), a three-fold adjustment is made.
- For exposures after turning 16 years of age, no adjustment is made.

For this risk assessment, ADAFs would apply to only the youth trespasser scenario; since the age range for that receptor is 6-16 years, an ADAF of 3 will be applied to the calculated intake, using the following equation:

$$Intake_{Youth} = Intake\ (ages\ 6\text{-}16\ years) \times 3$$

Evaluation of Lead: The intake equations presented in Table 2 not apply to lead exposures. If lead is identified as a COPC, different procedures will be used to evaluate lead exposures for the trespasser, facility and construction workers, in accordance with USEPA guidance (USEPA 1996, 2003b). The Adult Lead Methodology (ALM) model is used for evaluating adult non-residential lead exposures, and relates lead concentrations in soil to a blood lead level in women of child-bearing age. This model calculates the probability that an estimated blood lead concentration in the fetus of an exposed adult worker will exceed a target blood lead level, assuming a lognormal distribution (USEPA 1996).

While the focus of the ALM model is generally on adults, it will also be used to evaluate the youth trespasser scenario. USEPA currently recommends use of only two models that estimate blood lead concentrations. For children 0-84 months in a residential setting, the Integrated Exposure Uptake Biokinetic (IEUBK) model is typically used; however, the trespasser scenario encompasses an older child/adolescent that is only present at the Site on an intermittent basis and does not reflect the kind of high-intensity, chronic residential soil exposures evaluated for young children in the IEUBK model. Therefore, the ALM is appropriate in evaluating lead risk for older children in a non-residential setting (USEPA 2003b).

Since the toxicokinetics (i.e., the absorption, distribution, metabolism, and excretion of toxicants in the body) of lead are well understood, lead is regulated based on blood lead concentration. USEPA and the Centers for Disease Control and Prevention (CDC) have determined that childhood blood lead concentrations at or above 5 micrograms of lead per deciliter of blood (µg/dL) present risks to children's health (CDC 2012). The USEPA risk reduction goal for contaminated sites is to limit the probability of a child's blood lead concentration exceeding 5 µg/dL (the P05) to 5 percent or less after cleanup.

2.1.4 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 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.

2.1.4.1 Methodology Used to Calculate Cancer Risk

Excess lifetime cancer risks associated with exposure to COPCs classified by the USEPA as carcinogens are characterized as an estimate of the probability (risk) that an individual will develop cancer over a lifetime (USEPA 1989). This estimated theoretical lifetime incremental risk is expressed as a unitless probability. For example, an incremental cancer risk of 1E-06 indicates an individual has a one-in-one million chance of developing cancer during a 70-year lifetime as a result of the assumed exposure conditions. The lifetime incremental risk of cancer resulting from exposure to the COPC will be estimated as discussed below.

To estimate cancer risks associated with the inhalation of vapors migrating into indoor or outdoor air, and the inhalation of particulates from soil, the methods prescribed in USEPA's inhalation risk assessment guidance (2009) are proposed. This estimating process uses the following equation.

Chemical-specific risk (unitless) = Intake factor x EPC x IUR

Where: EPC = exposure point concentration
IUR = inhalation unit risk

Cancer risks associated with direct contact with soil and groundwater, as applicable, will be estimated using the methods prescribed in USEPA's human health risk assessment guidance (1989), in accordance with the following equation:

Chemical-specific cancer risk (unitless) = Intake factor x EPC x CSF

Where: EPC = exposure point concentration
CSF = cancer slope factor

Following these initial calculations, the incremental cancer risk associated with exposure to multiple carcinogens for a single exposure pathway will be calculated by summing the individual chemical-specific incremental cancer risks as follows:

Pathway-specific cancer risk (unitless) = Σ(Chemical-specific cancer risk [unitless])

Multiple pathway-specific risks will then be summed to estimate the total excess lifetime cancer risk for each human receptor evaluated:

Total cancer risk (unitless) = Σ(Pathway-specific cancer risk [unitless])

2.1.4.2 Methodology Used to Calculate Hazard Indices

Estimation of chronic non-cancer HIs will be conducted in a process similar to that used in estimating cancer risks. First, the equation below will be used to estimate the chemical-specific non-cancer hazard quotients for inhalation of vapors migrating into outdoor or indoor air or inhalation of particulates from soil as prescribed in RAGS Part F (USEPA 2009).

Hazard Quotient (unitless) = Intake Factor x EPC / RfC

Where: EPC = exposure point concentration
RFC = reference concentration

The methods prescribed in USEPA (1989) will be used for the estimation of non-cancer risks associated with the direct contact with soil and groundwater using the following equation:

Hazard Quotient (unitless) = Intake Factor x EPC / RfD

Where: EPC = exposure point concentration
RfD = reference dose

In the second step, the HIs associated with exposure to multiple non-carcinogens for a single exposure pathway will be calculated by summing the individual chemical-specific non-cancer hazard as follows:

Pathway-specific HI (unitless) = Σ(Chemical-specific HQs [unitless])

In the third step, any multiple pathway-specific HIs will then be summed across all relevant exposure pathways and media to estimate the total HI for each receptor:

Total HI (unitless) = Σ(Pathway-specific HI [unitless])

2.1.4.3 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, lifetime incremental 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 cumulative cancer risk of 1E-06, and a cumulative non-carcinogenic HI of 1, to be a point of departure for purposes of making risk management decisions.

2.1.5 Uncertainty

A summary of the uncertainties inherent to each component of the risk assessment process will be included along with a discussion of how they may affect the quantitative risk estimates and conclusions of the risk analysis. Two types of uncertainty will be addressed: measurement uncertainty and informational uncertainty. Measurement uncertainty refers to the usual variance that accompanies scientific measurements such as the uncertainties associated with sampling and measurement variability. Informational uncertainties are those that stem from assumptions related to chemical toxicity for predicting human exposure. For example, to account for uncertainties in the development of exposure assumptions, conservative estimates will be made to ensure that the particular assumptions are protective of sensitive subpopulations or the maximum exposed individuals, resulting in a bias towards over predicting both carcinogenic and non-carcinogenic risks. Thus, the uncertainties will be summarized and the methods and assumptions will be defined to establish that the approach used accurately and appropriately quantifies risks to human health.

2.2 Screening Level Ecological Risk Assessment

As specified by USEPA guidance, the first step in the ecological risk assessment process is a screening level ecological risk assessment (SLERA), which has the objective of focusing the risk assessment effort by identifying constituents and media that do *not* warrant further evaluation in a more comprehensive baseline ecological risk assessment (BERA). The goal is to eliminate constituents that present insignificant hazards while retaining for further study contaminants with concentrations that may have the potential to present a risk to ecological receptors. The SLERA itself follows a simplified methodology that uses concentration data from site media and generic ecological screening values (ESVs) to evaluate constituents, using assumptions and parameters that are consistently biased in the direction of over-estimating risk. In statistical language, the SLERA thus minimizes the chances of concluding that there is no risk when in fact a risk exists, or more specifically, the SLERA assures that the probability of false acceptance is minimized and the probability of a false negative is very low (see SAP Section 4.6.2).

This evaluation will also include an additional step, referred to as the SLERA Refinement, in which the conservative conclusions of the SLERA are re-evaluated in light of a broader array of effects and contaminant distribution data to further define and focus the constituents that warrant further evaluation. No additional sampling will precede this step, unless indicated by the results of the SLERA screening evaluation. The results of both the SLERA and the Refinement will be used to reach a final conclusion about potential risk and the need for risk-specific testing and evaluations at the site, efforts that would be described in a subsequent BERA work plan.

This SLERA will follow both USEPA and NPS ecological risk assessment methodology, as presented in the following guidance documents:

- *Protocol for the Selection and Use of Ecological Screening Values for Non-radiological Analytes. Revision 2* (NPS 2016);
- *Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments* (USEPA 1997)*;* and
- *ECO Update: The Role of Screening-Level Risk Assessments and Refining Contaminants of Concern in Baseline Ecological Risk Assessments* (USEPA 2001).

In accordance with this guidance, the assessment will be comprised of the following sections:

- Problem Formulation
- Exposure and Effects Assessment
- SLERA Risk Calculation
- SLERA Refinement
- Summary and Conclusions
- Uncertainty Analysis

The specific activities associated with each of these sections are described below.

2.2.1 Problem Formulation

The purpose of the problem formulation is to determine the focus and scope of the SLERA by systematically identifying the stressors, the ecosystems potentially at risk, the potential ecological receptors, and the ecological effects to be evaluated. Components of the Problem Formulation thus consist of the selection of constituents that will be included in the study (chemicals of potential ecological concern, or COPECs), a description of exposure pathways and potential receptors, an ecological CSM, and, based on this model, the selection of specific assessment endpoints and measures of effects.

At this site, stressors are expected to be the chemicals detected in shallow surface soil samples. All detected compounds will initially be considered as study constituents that will be screened against ESVs. Undetected compounds may be included as study constituents if reporting limits are elevated and the constituent is a known site contaminant with a migration pathway to soil. Since a detailed data quality evaluation, described in Section 4 of the SAP, will precede the SLERA, all data used in the SLERA are assumed to will be of adequate quality and quantity.

Exposure pathways will be confirmed during the SLERA, but are expected to include shallow soils as an exposure media. Since shallow soils are a growth medium for plants and a potential exposure medium for

animals though ingestion or trophic transfer, potential receptors are expected to be plants, soil invertebrates, birds, and mammals. Thus, the assessment endpoints for the study will be as follows:

- Survival and growth of terrestrial plants
- Survival and growth of soil invertebrates
- Survival, growth, and reproduction of birds
- Survival, growth, and reproduction of mammals

The relationship of potential receptors to contaminant source areas at the site will be illustrated visually through a conceptual site model that depicts sources, exposure pathways, media, and routes, as well as potential receptors. Figure 2 is a preliminary ecological CSM for the Site based on existing information. This CSM illustrates the fate and transport of constituents at each of the three study areas and identifies the potentially complete pathways to ecological receptors, based on current site understanding.

Measures of exposure will be based on the measured concentrations of constituents in shallow soil samples collected via the ISM method. This sampling and collection program was described in the SAP. In accord with the ISM sampling approach, the exposure of ecological receptors to site contaminants will be represented by the 95% UCL of the shallow soil data from within each area. Each sampling area (1, 2, and 3) will be evaluated separately for each receptor; data will not be combined across areas.

Measures of effect for this SLERA will consist of the SLERA COPEC Selection ESVs developed by NPS (NPS 2016). These values are generic, conservative, and chemical-specific screening concentrations associated with no or minimal adverse effects. They are literature values derived from large data sets comprised of data from other sites, and are intended to serve as conservative no-effect values, suitable for distinguishing between constituents with negligible potential for risk and those for which additional evaluation is necessary.

2.2.2 Exposure and Effects Assessment

This section presents the specific data, methods and values by which exposure and effects will be estimated for each receptor.

As described above, the exposure of site receptors to soil constituents is estimated by the use of measured concentrations of constituents in soil. Maximum values among discrete samples are typically used in a SLERA. However, because ISM data will be collected from each investigation area, the 95% UCL will be used as the screening concentration, as described in Section 2.1.2. These data will be presented in this section.

Likewise, the potential for effect will be represented by NPS SLERA COPEC Selection ESVs, which are the lowest screening values from among all soil receptors. In this section, the ESVs for each study constituent will be presented and described. ESVs will be presented in table format.

2.2.3 Risk Calculation

In this section, the exposure data (soil 95% UCLs or maxima) and effects data (ESVs) are compared to produce an estimate of the potential for risk to the receptors designated as assessment endpoints. Media concentrations relative to an ESV are expressed as a hazard quotient (HQ), which is calculated as follows:

$$HQ = \frac{\text{Exposure concentration (95\% UCL)}}{\text{COPEC-selection ESV}}$$

A maximum HQ of less 1.0 indicates that all concentrations are below the threshold levels for potential adverse effects and that risks are likely to be negligible. These constituents will not be retained for further evaluation. An HQ equal to or in excess of 1.0 suggests that exposures may be associated with adverse effects and that further evaluation of these constituents is thus warranted. Constituents with a maximum HQ equal to or greater than 1.0 will be retained for evaluation as part of the SLERA Refinement, described below. This screening evaluation will be conducted separately for each of the three areas at the site.

At the end of this section, a table will be presented explicitly identifying which study constituents exceed ESVs and which are not associated with potential risk for each of the three site areas. Those constituents retained for further identification will be designated as contaminants of potential ecological concern, or COPECs. This will formally conclude the SLERA phase of the assessment, as required by USEPA (1997).

2.2.4 SLERA Refinement

In this analysis, each constituent that exceeded ESVs in the SLERA will be 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 conservative exposure and 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. From a practical standpoint, the goal of the Refinement is to obtain as complete an understanding of site risks as possible without conducting site-specific ecological tests, such as toxicity, food chain or bioaccumulation studies.

Additional factors that may be considered in this section are described below.

Comparison to Refined SLERA ESVs: Refined SLERA ESVs are screening values that are specific to the receptor under consideration. The values themselves still represent low- or no-effect concentrations, but are based on data only for that receptor, in this case plants, invertebrates, birds, and mammals.

Magnitude of Refined SLERA ESV Exceedances: For many constituents, exceedances of the ESV by factors of two or three or more may still not reflect a potential risk, because of the conservatism of the assumptions used to develop the ESV. For soils, the toxicity literature will be reviewed to obtain a more complete understanding of the risk associated with ESV exceedances.

Use of Average Site Data: For this analysis, the arithmetic average site concentration, rather than the 95% UCL, will be compared to Refined SLERA ESVs to obtain a more representative assessment of exposure, particularly for mammals and birds which roam freely across and between the study areas.

Comparison to Other Site Media: Since the goal of corrective measures at this facility is to address contamination resulting from site activities, COPECs will be reviewed for potential associations with source area media or historical operations. Some constituents, such as metals, have multiple potential sources, and may not be present from site operations.

Comparison to Background Area Concentrations: In this step, the concentrations of COPECs will also be compared to reference area data, if available. This evaluation helps put Site data in context

relative to non-Site-related areas, and is particularly useful for naturally occurring or anthropogenic constituents, which are often ubiquitous in the environment.

Comparison to Lowest-Observed-Effect Levels: In this section, an evaluation will be conducted that compares site data to values associated with the actual onset of effects, or a high probability of effects. For soils, these will be lowest observed effect levels (LOELs) as obtained from the USEPA Soil Screening Level (SSL) database, the EcoTox database, or other literature sources. As opposed to the no-effect values used as ESVs, these low-effect values define a level where effects are more likely or, in toxicological tests, where effects were actually detected. The actual onset of effects occurs somewhere between the no-effect ESV and the LOEL, so this comparison provides helps to bound the risk estimate and thus provides important information about the actual potential for effect. USEPA guidance (1997) specifies that cleanup levels should be based on low-effect values, rather than screening values.

To obtain LOELs for birds and mammals, the food-chain exposure models developed by USEPA will be modified to incorporate the LOEL, rather than a no-effect value, as the toxicity reference value. For plants and invertebrates, LOELs will be selected from among the studies used to calculate the SSL, or from literature values if SSL data is lacking. Doses may be calculated using both average and 95% UCL data, and exposure and area use factors may be adjusted to match site conditions.

In the Refinement, a LOEL-HQ of less than 1.0 indicates that the concentration is below that conservatively associated with the onset of adverse effects and will be interpreted to mean that the potential for significant risk, while present, is relatively low. An HQ equal to or in excess of 1.0 will be interpreted to mean that exposures are in the estimated range of potential effects and that further evaluation of these constituents may be warranted.

The results of all of these evaluations will be considered together to reach a final assessment of the potential for ecological risk.

2.2.5 Summary and Conclusions

At the conclusion of the Refinement, a summary of the SLERA and Refinement approach as well as findings and recommendations will be presented. This information will be used to determine which COPECs and pathways need to be further evaluated in a Baseline Ecological Risk Assessment (BERA) and which COPECs and pathways can be eliminated from further consideration. At this scientific decision point, three possible decisions can be reached following the SLERA:

1. Information is sufficient to conclude that ecological risks are low or non-existent and remedial activities are unnecessary.

2. Information is insufficient to make a decision and further investigation or sampling is necessary, or

3. The information indicates a potential for adverse ecological effects, and a BERA is required.

The report will conclude with a succinct statement about which COPECs, if any, have the potential to present an ecological risk. Each area will be considered separately, and separate conclusions will be

drawn for each receptor. Any data gaps and additional sampling needs will be identified in general terms, but with sufficient detail to support the development of a subsequent work plan, if necessary.

2.2.6 Uncertainty

Ecological risk assessments are subject to a wide variety of uncertainties as the result of both the assumptions used to describe site conditions and receptor exposure, as well as 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 section will consist of a systematic review of the assumptions and uncertainties associated with the methodology and data used to complete the study. Assumptions or limitations that underlie the conclusions of the SLERA and Refinement will be identified and the magnitude and direction of the bias associated with each assumption will be described in a tabular format. While some assumptions made during a typical SLERA may clearly underestimate or overestimate effects, for many assumptions the relationship is unknown, since no data exist for the parameter of interest. This section will both enumerate the various points of uncertainty and provide an overall statement about the level of uncertainty in this assessment relative to other studies of this type.

3 References

Centers for Disease Control and Prevention (CDC). 2012. Low Level Lead Exposure Harms Children: A Renewed Call for Primary Prevention, Report of the Advisory Committee on Childhood Lead Poisoning Prevention of the Centers for Disease Control and Prevention. January 4, 2012. https://www.cdc.gov/nceh/lead/acclpp/final_document_030712.pdf

Electro's Spark. 2009. Caneel Bay Plantation, 1956. April 4. http://electrospark.blogspot.com/2009/04/caneel-bay-plantation-1956.html.

Interstate Technology & Regulatory Council (ITRC) 2012a. Calculate_95UCL_for_ISM (Excel file), http://www.itrcweb.org/ISM-1/4_2_2_UCL_Calculation_Method.html. Accessed April 22, 2016.

ITRC. 2012b. Incremental Sampling Methodology. ISM-1. Washington, D.C.: Interstate Technology & Regulatory Council, Incremental Sampling Methodology Team. www.itrcweb.org.

National Park Service (NPS). 2016. NPS Protocol for the Selection and Use of Ecological Screening Values for Non-Radiological Analytes. Revision 2. February 18.

The Johnson Company, Inc. 2016. DRAFT Engineering Evaluation/Cost Analysis Sampling and Analysis Plan, Virgin Islands National Park, Caneel Bay Resort Site. November.

United States Environmental Protection Agency (USEPA). 2016a. USEPA Region 9, Regional Screening Levels (RSLs). May. http://www.epa.gov/region9/superfund/prg/.

USEPA. 2016b. Vapor Intrusion Screening Levels. May. https://www.epa.gov/vaporintrusion/vapor-intrusion-screening-levels-visls

USEPA. 2016c. Statistical Software ProUCL Version 5.0.00 for Environmental Applications for Data Sets with and without Nondetect Observations, EPA/600/R-07/041, https://www.epa.gov/land-research/proucl-software. Accessed April 22.

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. 2005a. Guidelines for Carcinogen Risk Assessment, Risk Assessment Forum, EPA/630/P-03/001F. March.

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

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

USEPA 2003b. Assessing Intermittent or Variable Exposures at Lead Sites. Office of Solid Waste and Emergency Response. EPA-540-R-03-008 OSWER # 9285.7-76.

USEPA. 2002. Guidance on Environmental Data Verification and Data Validation. EPA/240/R-02/004. November.

USEPA. 2001. ECO Update: The Role of Screening-Level Risk Assessments and Refining Contaminants of Concern in Baseline Ecological Risk Assessments, OSWER Publication 9345.0-14, EPA 540/F-01/014. June.

USEPA. 1997. Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments, EPA 540-R-97-006, OSWER 9285.7-25. June.

USEPA. 1996. Recommendations of the Technical Review Workgroup for Lead for an Approach to Assessing Risks Associated with Adult Exposures to Lead in Soil, EPA-540-R-03-001, OSWER Dir #9285.7-54.

USEPA. 1992. Supplemental Guidance to RAGS: Calculating the Concentration Term, OSWER Publication 9285.7-08I. May.

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

Table 2 Generalized Equations used to Calculate Intake Factors for Humans
Caneel Bay Resort Site

Parameters	**Trespasser Adolescent**		**Park Employee Adult**		**Construction Worker Adult**	
AT – averaging time for carcinogens (days)	25,550 (70 years)	a	25,550 (70 years)	a	25,550 (70 years)	a
AT – averaging time for noncarcinogens (days)	7,300 (10 years)	b	2,920 (8 years)	b	365 (1 year)	b
BW – Body weight (kg)	44	c	80	d	80	d
ED – Exposure duration (years)	10 years (6-16 yrs)	b	8 years estimated tenure at Park	b	1 year project	b
EF – Exposure frequency (days/year)	60 days/year (Visit site once or twice per week) Assume 2 hrs per visit for each exposure area	b	250 days per year (5x per week, 50 weeks) Assume 8-hr work day doing maintenance, cleanup activities	e	250 days per year (5x per week, 50 weeks) Assume 8-hr work day (for groundwater exposures, assume 0.5 hours per exposure event, assuming minimal contact with water)	b
SA – Skin surface area available for contact (cm^2) with soil	3,240 cm^3 (hands, feet, lower legs)	f	3,300 cm^3 (face, forearms, and hands)	d	3,300 cm^3 (face, forearms, and hands)	d
AF – Soil-to-skin adherence factor (mg/cm^2)	0.07	d	0.12	d	0.3	g
$I_{ng}R_{soil}$ – Ingestion rate for soil (mg/day)	100	e	100	e	330	g

References:

a. USEPA. 1999. *Exposure Factors Handbook*. NCEA. EPA/600/C-99/001.
b. Site-specific data (Best Professional Judgment [BPJ] to be verified by National Park Service)
c. USEPA. 2011. *Exposure Factors Handbook*. NCEA. EPA/600/R-090/052F.
    i. Trespasser body weight is the age-weighted mean body weight for males and females 6-16 years.

Table 2 Generalized Equations used to Calculate Intake Factors for Humans
Caneel Bay Resort Site

d. USEPA. 2014. *Memorandum: Human Health Manual, Supplemental Guidance: Update of Standard Default Exposure Factors*. 2/6/14. OSWER Directive 9200.1-120.
   i. SA and AF for employee and construction worker is the recommended value for an adult outdoor worker. The AF for the trespasser is the recommended value for the adult resident.
   ii. Soil ingestion rate for employee is that for an outdoor worker; for the trespasser, the recommended adult resident soil ingestion rate was used.
   iii. Water ingestion rate for the employee is the EPA recommended drinking water ingestion rate for a resident, adjusted to account for an employee's presence at the site for 1/3 of his/her day (2.5 L/d * 0.3 day).
e. USEPA. 1991. *Human Health Evaluation Manual, Supplemental Guidance: Standard Default Exposure Factors.* OSWER Directive 9285.6-03.
f. USEPA. 2004. Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment) Final. OSWER 9285.7-02EP.
g. USEPA. 2002. *Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites*. OSWER 9355.4-24. December.

Intake Factors for Dermal Contact and Ingestion of Soil

Equations:

$$IF_{ing\text{-}nc} = \frac{IRc \cdot CF \cdot EF \cdot EDc}{BWc \cdot ATnc}$$

$$IF_{ing\text{-}ca} = \frac{[(IRc \cdot EDc / BWc) + (IRa \cdot EDa / BWa)] \cdot EF \cdot CF}{ATca}$$

$$IF_{derm\text{-}nc} = \frac{CF \cdot SAc \cdot AFc \cdot ABS \cdot EF \cdot EDc}{BWc \cdot ATnc}$$

$$IF_{derm\text{-}ca} = \frac{[(SAc \cdot AFc \cdot EDc / BWc) + (SAa \cdot AFa \cdot Eda / BWa)] \cdot ABS \cdot EF \cdot CF}{ATca}$$

Where:

$IF_{ing\text{-}nc}$ (day^{-1}) =	Intake factor for ingestion of soil- noncarcinogenic effects
$IF_{ing\text{-}ca}$ (day^{-1}) =	Intake factor for ingestion of soil- carcinogenic effects
$IF_{derm\text{-}nc}$ (day^{-1}) =	Intake factor for dermal contact with soil- noncarcinogenic effects
$IF_{derm\text{-}ca}$ (day^{-1}) =	Intake factor for dermal contact with soil- carcinogenic effects
ABS =	Dermal Absorption factor
AFa =	Soil to skin adherence factor-adult

Table 2 Generalized Equations used to Calculate Intake Factors for Humans
Caneel Bay Resort Site

AFc =	Soil to skin adherence factor-child
ATca =	Averaging time for carcinogenic effects
ATnc =	Averaging time for noncarcinogenic effects
BWa =	Body weight-adult
BWc =	Body weight-child
CF =	Conversion factor (1E-06 mg/kg)
Eda =	Exposure duration-adult
EDc =	Exposure duration-child
EF =	Exposure frequency
IRa =	Ingestion rate-adult
IRc =	Ingestion rate-child
SAa =	Surface area-adult
Sac =	Surface area-child

Intake Factors for Inhalation of Air

Equations:

$$IF_{inh\text{-}nc} = \frac{ET \bullet EF \bullet EDc}{ATnc \bullet CF}$$

$$IF_{inh\text{-}ca} = \frac{ET \bullet EF \bullet EDc}{ATc \bullet CF}$$

Where:

$IF_{inh\text{-}nc}$ (unitless) =	Intake factor for inhalation from affected media-noncarcinogenic effects
$IF_{inh\text{-}ca}$ (unitless) =	Intake factor for inhalation from affected media-carcinogenic effects
ATca =	Averaging time for carcinogenic effects
ATnc =	Averaging time for noncarcinogenic effects
CF =	Conversion factor (24 hr/day)
ED =	Exposure duration
ET =	Exposure time
EF =	Exposure frequency

Table 2 Generalized Equations used to Calculate Intake Factors for Humans
Caneel Bay Resort Site

Intake Factors for Dermal Contact with Groundwater

Equations:

$$IF_{derm\text{-}nc} = \frac{CF \bullet SAc \bullet PC \bullet CF \bullet ET \bullet EF \bullet ED}{BWc \bullet ATnc}$$

$$IF_{derm\text{-}ca} = \frac{[(SAc \bullet PC \bullet CF \bullet ED / BWc) + (SAa \bullet PC \bullet CF \bullet ED / BWa)] \bullet ABS \bullet EF \bullet CF}{ATca}$$

Where:

$IF_{derm\text{-}nc}$ (day^{-1}) =	Intake factor for dermal contact of water-noncarcinogenic effects
$IF_{derm\text{-}ca}$ (day^{-1}) =	Intake factor for dermal contact of water-carcinogenic effects
ABS =	Absorption factor
PC =	Chemical-specific permeability constant (cm/hr)
ATca =	Averaging time for carcinogenic effects
ATnc =	Averaging time for noncarcinogenic effects
BWa =	Body weight-adult (kg)
CF =	Volumetric conversion factor (1L/1,000cm^3)
EDa =	Exposure duration-adult
EF =	Exposure frequency
SAa =	Surface area-adult

Units and abbreviations for all calculations:

cm^2	=	square centimeter	m^3	=	cubic meter
cm^3	=	cubed centimeter	mg	=	milligram
derm	=	dermal	IF	=	Intake factor
ing	=	ingestion			
inh	=	inhalation			
kg	=	kilogram			
L	=	liter			

Table 2 Generalized Equations used to Calculate Intake Factors for Humans
Caneel Bay Resort Site