APENDICE K

Evaluación de Riesgo a la Salud Humana

Noviembre 2010

Declaración de Impacto Ambiental – Preliminar

Planta de Generación de Energía Renovable y Recuperación de Recursos

BARRIO CAMBALACHE DE ARECIBO

EnergyAnswers Arecibo

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Energy Answers International, Inc.

Arecibo, Puerto Rico Renewable Energy Project

Human Health Risk Assessment for the Renewable Energy Power Plant Located in Arecibo

October 2010

ARCADIS

Human Health Risk Assessment

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amsl	above mean sea level
ATSDR	Agency for Toxic Substances and Disease Control
BCF	bioconcentration factor
BAF	bioaccumulation factor
BSAF	biota-sediment accumulation factor
cm/sec	centimeters per second
CIA	Central Intelligence Agency
COC	constituent of concern
COPC	constituent of potential concern
CSF	cancer slope factor
CSM	conceptual site model
EA	Energy Answers International
EC	exposure concentration
ELCR	excess lifetime cancer risk
EPC	exposure point concentration
HHRA	human health risk assessment
HI	hazard index
HQ	hazard quotient
IRIS	Integrated Risk Information System
MCL	Maximum Contaminant Level
mg/m^3	Milligrams per cubic meter of air
mg/kg	milligrams per kilogram
mg/L	milligrams per liter
MRL	Minimal Risk Level
NAS	National Academy of Science
NCEA	National Center for Environmental Assessment
PAH	Polynuclear aromatic hydrocarbons
PCB	polychlorinated biphenyl
PCDD	Polychlorinated dibenzodioxins
PCDF	Polychlorinated dibenzofurans
RRF	Resource Recovery Facility

RME	reasonable maximum exposure
RfD	reference dose
RfC	reference concentration
TCDD	2,3,7,8-tetrachlorodibenzodioxin, dioxin
TEF	Toxic Equivalency Factor
TEQ	Toxic Equivalency
SVOC	semi-volatile organic compound
UCL	upper confidence limit
USEPA	United States Environmental Protection Agency
µg/dL	micrograms per deciliter
µg/L	micrograms per liter
VOC	volatile organic compound
WTE	waste-to-energy

Executive Summary

ARCADIS prepared this *Human Health Risk Assessment (HHRA)* on behalf of Energy Answers International (EA) for the proposed Renewable Energy Power Plant (Facility) to be located in the Municipality of Arecibo in the area of Barrio Cambalache along the north coast of Puerto Rico. The proposed Resource Recovery Facility (RRF) will combust municipal waste, and the heat generated will be used to produce electricity for the nearby population. The HHRA evaluates the potential for exposure to emissions from the two proposed combustion units at the Facility to cause adverse health effects. The HHRA is a comprehensive assessment of the potential for human health risks, as it considers both direct (i.e., inhalation) and indirect (i.e., ingestion) exposure pathways.

An overview of the risk assessment approach and summaries of the HHRA results and conclusions follow.

Approach

The HHRA was completed using approaches and methodologies that are consistent with the United States Environmental Protection Agency (USEPA) risk assessment guidance and policies. The available federal guidance for evaluating emissions from both municipal waste and hazardous waste combustion sources was consulted. However, the USEPA's final combustion guidance, *Human Health Risk Assessment Protocol for Hazardous Waste Combustion Facilities (HHRAP)* was the primary source of approaches, assumptions, and parameters used in the assessment. The HHRAP describes in detail the recommended approach for assessing human health risks associated with hazardous waste combustion facilities, but the methodology is applicable to municipal waste combustion risk assessments as well.

The evaluation of risks and hazards associated with constituents emitted from a combustion source requires the following:

- Identification of constituents of potential concern (COPCs) that may be emitted from the source.
- Estimation of the amount of COPCs that may be emitted from combustion units (i.e., emission rates).
- Estimation of the concentration of COPCs in ambient air based on predictive dispersion and deposition modeling.

- Estimation of concentrations of COPCs in other environmental media (e.g., soil, surface water, and sediment) and food items (e.g., produce, beef) through which humans may be indirectly exposed.

- Identification of human receptor populations and potentially complete direct and indirect pathways through which exposure may occur.

- Quantification of potential exposure in the form of doses.

- Evaluation of potential excess lifetime cancer risks (ELCRs) and noncancer hazards associated with combustion emissions.

Chemical Fate and Transport Modeling

Constituents evaluated in the HHRA were identified based on recommendations provided in USEPA guidance and stack test data generated from the SEMASS RRF, which is located in Massachusetts and has a similar design to the proposed Facility. Chemical dispersion in air and deposition onto the land or surface water bodies were modeled using American Meteorological Society – Environmental Protection Agency Regulatory Model (AERMOD). AERMOD is the recommended model for air quality analysis in the USEPA's *Guideline on Air Quality Models* (40 Code of Federal Regulations Part 51, Appendix W). The modeling was performed with a commercial version of AERMOD (Lakes Environmental's version 6.7.1). Five years of surface and upper air meteorological data from San Juan International Airport were used in the assessment of both chronic (i.e., long-term) and acute (i.e., short-term) health hazards. In addition, one year of meteorological data from a station in Cambalache, located closer to the proposed Facility site, was also used to evaluate the potential for acute health hazards.

AERMOD combined source information (e.g., location, building profile, and operating parameters) with physical data from the area surrounding the proposed Facility site (i.e., meteorology, terrain, and land use information) to estimate unitized ambient air concentrations and deposition fluxes. It was assumed the COPCs emitted from the combustion unit flues are dispersed and deposited as either vapors or particulates (i.e., particles or particle bound). AERMOD therefore generated estimates of air concentrations and deposition fluxes for vapor phase, particle phase, and particle bound COPCs.

Chemical concentrations in air were calculated by multiplying the modeled air concentrations by estimated COPC-specific emission rates. Chemical concentrations in soil, surface water, and other exposure media were calculated by combining the COPC-specific emission rates, the modeled air concentrations and deposition fluxes, and chemical-specific physicochemical data in equations that simulate chemical fate and transport through the environment. Fate and transport models recommended in HHRAP were used to estimate COPC concentrations in environmental media (e.g., soil, surface water) and other components of the environment that may contribute to exposure.

An emission rate for each COPC was derived using stack test data, where available, from “SEMASS Unit 3”. Annual average emission rates representative of typical conditions were used to assess risks from chronic exposure. Because the SEMASS Unit 3 data were collected over years of operation, they not only represent an actual baseline for emissions but should capture variations in emissions, including times when controls and combustion conditions are not optimal. For COPCs for which SEMASS stack test data were not available (i.e., hydrogen fluoride), emission rates were based on manufacturing specifications.

Receptors and Potentially Complete Exposure Pathways

USEPA guidance indicates the most significant atmospheric deposition of emissions from waste combustion units generally occurs within 10 kilometers (km) of a combustion source. The air modeling conducted for this HHRA also predicted the highest air concentrations and deposition fluxes would occur within 10 km of the proposed Facility. Therefore, the potential for exposure and associated health risk was evaluated for exposure scenarios and receptor locations identified within a 10-km radius of the proposed Facility.

Land near the proposed Facility includes the city of Arecibo to the northwest, surrounding suburban areas, and rural areas that include large areas of croplands and dairy and cattle farms. Rural areas also include small residential areas and some industrial facilities. In addition, there are large wetlands northeast of the facility and several surface water bodies.

Based on an evaluation of local conditions and consideration of the general receptor populations recommended in HHRAP, the following receptors and exposure scenarios (i.e., combination of pathways through which a receptor population could potentially be exposed to COPCs) were evaluated in this HHRA:

- Urban Residents (Adults and Children) who live in Arecibo and may be exposed to COPCs in air, soil, drinking water from surface water sources, milk from local dairies, and fish from local surface water bodies.

- Suburban Residents (Adults and Children) who live in suburban areas surrounding Arecibo and may be exposed to COPCs in air, soil, drinking water from surface water sources, home-grown produce, milk from local dairies, and fish from local surface water bodies.

- Local Farmers (Adults and Children) who may be exposed to COPCs in air, soil, drinking water from surface water sources, home-grown produce, and locally-raised animal products (e.g., milk from dairy cows, beef, poultry, pork, and eggs).

- Fishers (Adults and Children) who, under this exposure assessment scenario, rely on fish as the main source of protein in the diet. These receptors may be exposed to COPCs in air, soil, drinking water from surface water sources, home-grown produce, milk from local dairies, and locally-caught fish.

- Nursing infants (i.e., Urban Resident Infant, Suburban Resident Infant, Farmer Infant, and Fisher Infant) who are exposed to PCDDs/PCDFs that may bioaccumulate in human breast milk.

USEPA guidance and equations presented in HHRAP were used to estimate exposure in the form of chemical intakes. The combination of receptor-specific exposure parameters used to approximate the magnitude, frequency, and duration of exposure were intended to result in an estimate of reasonable maximum exposure. The intent is to overestimate the potential for exposure and associated health hazards to provide a conservative (i.e., health-protective) evaluation. Estimated doses were then combined with chemical-specific toxicity information to estimate ELCR or noncancer hazard. The ELCRs and noncancer hazards were then evaluated by comparison to benchmarks identified by federal and state government as acceptable.

Risk Characterization and Conclusions

The total ELCRs and noncancer hazards estimated for each receptor population, for combined COPCs and over all exposure pathways, are presented below.

Excess Lifetime Cancer Risks (across all pathways)							
Urban Resident		**Suburban Resident**		**Farmer**		**Fisher**	
Adult	Child	Adult	Child	Adult	Child	Adult	Child
9E-08	1E-07	1E-07	2E-07	3E-07	4E-07	2E-06	2E-06

Noncancer Hazard Indices (across all pathways)							
Urban Resident		**Suburban Resident**		**Farmer**		**Fisher**	
Adult	Child	Adult	Child	Adult	Child	Adult	Child
0.01	0.01	0.01	0.02	0.02	0.05	0.2	0.5

USEPA generally finds ELCRs between one-in-ten thousand (1E-04) and one-in-a-million (1E-06) (or less) and noncancer hazard indices of less than 1 acceptable.

Based on the assumptions and scenarios used to evaluate potential risks and hazards associated with emissions from the proposed RRF, risks and hazards fall within or are less than the acceptable range. Based on the analysis completed in this HHRA, the proposed RRF does not pose a concern for human health.

1. Introduction

ARCADIS prepared this *Human Health Risk Assessment (HHRA)* on behalf of Energy Answers International (EA) for the proposed Renewable Energy Power Plant (Facility) to be located in the Municipality of Arecibo in the area of Barrio Cambalache along the north coast of Puerto Rico (see Figure 1). The proposed Resource Recovery Facility (RRF) will combust municipal waste, and the heat generated will be used to produce electricity for the nearby population. The HHRA evaluates the potential for exposure to emissions from the two proposed combustion units at the Facility to cause adverse health effects.

The HHRA is organized into the following sections:

- **Section 1**: Introduction – describes the project background and approach used to evaluate the potential for human health risks.
- **Section 2**: Environmental Setting and Physical Conditions – describes the proposed Facility site and surrounding area, including information on terrain, climate, surface water bodies, and land use.
- **Section 3**: Estimated Impacts to Environmental Media – identifies constituents of potential concern (COPCs), the basis for estimated emissions from the proposed Facility's combustion unit stacks, and the predictive air modeling used to estimate COPC dispersion and deposition.
- **Section 4**: Exposure Assessment – identifies the human exposure scenarios evaluated in this HHRA and describes how potential exposure to COPCs is estimated.
- **Section 5**: Toxicity Assessment – presents information on the nature and severity of adverse health effects that may result from COPC exposure.
- **Section 6**: Quantification of Cancer Risk and Noncancer Hazard – describes the equations used to generate cancer risks and noncancer hazard quotients.
- **Section 7**: Risk Characterization – presents the results of the quantitative risk assessment and characterizes the potential for adverse human health effects in terms of cancer risk and noncancer hazard.

- **Section 8**: Uncertainty Analysis – evaluates the uncertainty associated with various assumptions used to generate quantitative risk estimates and determines the degree to which risks and hazards may be underestimated or overestimated.

- **Section 9**: Summary and Conclusions.

1.1 Background

Puerto Rico is an island located between the Caribbean Sea and North Atlantic Ocean (see Figure 1). It has a land mass of approximately 8,870 square miles and is divided into 78 municipalities (Central Intelligence Agency [CIA] 2010). Historically, municipal wastes have been disposed in landfills in Puerto Rico. Currently, there are approximately 32 active landfills in Puerto Rico. However, space for landfills is limited, and the cost to comply with landfill regulations continues to increase because of ongoing maintenance and repair of existing facilities and updates needed to comply with new requirements. RRF provide a good alternative to land-filling wastes. RRF facilities produce energy from waste, recover valuable recyclable materials that benefit the local community while significantly reducing the volume of solid waste (approximately 90 percent reduction) that ultimately needs to be disposed of.

The proposed Facility will be located in Barrio Cambalache in the Municipality of Arecibo, which is west of the capital, San Juan, and within the coastal plains in the northern part of the commonwealth. A topographic map that shows the Site location is provided as Figure 2. Aerial photographs of the area surrounding the proposed Facility are included as Figures 3 (10-kilometer [km] radius) and 4 (3-km radius). Municipalities near Arecibo and the surrounding area evaluated in this risk assessment include Hatillo, Barceloneta, and Florida.

The Facility will be constructed on approximately 42 acres of the 81-acre property. A former paper mill occupies an additional 13 acres of the property. The proposed Facility layout is depicted on Figure 5. The proposed Facility is designed to operate continuously for 30 years and to process approximately 2,100 tons of municipal solid waste per day. It will produce approximately 80 megawatts of electricity per day. Waste-derived fuel will constitute 100 percent of operating fuel. In addition, the fuel preparation system is designed to recover 23.8 percent by weight for the municipal solid waste in the form of recyclable materials. Air pollution control systems for the types of combustors that will be used in this facility have been characterized by the United States Environmental Protection Agency (USEPA) and several state air-permitting agencies as best achievable control technology (BACT) based on demonstrated actual performance levels at similar facilities.

1.2 Human Health Risk Assessment Approach

The HHRA was completed using approaches and methodologies that are consistent with USEPA risk assessment guidance and policy. Information and recommendations from guidance for evaluating emissions from both municipal waste and hazardous waste combustion sources were consulted (USEPA 2005b, USEPA 1990). However, the USEPA's most recent final combustion risk assessment guidance, *Human Health Risk Assessment Protocol for Hazardous Waste Combustion Facilities (HHRAP)* (2005b) was the primary source of default approaches, assumptions, and parameters. The HHRAP describes in detail the recommended approach for assessing human health risks associated with hazardous waste combustion facilities, but the methodology is applicable to municipal waste combustion risk assessments as well.

Evaluation of the potential for adverse health effects from exposure to constituents emitted from a combustion source requires the following:

- Identification of COPCs that may be emitted from the source.
- Estimation of the amount of COPCs that may be emitted (i.e., emission rates).
- Estimation of the concentration of COPCs in ambient air based on predictive dispersion and deposition modeling.
- Estimation of concentrations of COPCs in other environmental media (e.g., soil, surface water, and sediment), including food items (e.g., produce, beef) through which humans may be indirectly exposed.
- Identification of human receptor populations and potentially complete direct and indirect pathways through which human exposure may occur.
- Quantification of potential exposure, in the form of COPC air concentrations and doses, and estimation of excess lifetime cancer risk (ELCR) and noncancer hazard.

The focus of the HHRA is on the combined emissions from the two proposed combustion units. Emissions from ancillary equipment (i.e., emergency generator engines, silos, and cooling towers) and fugitive truck traffic emissions were not included because of the negligible emissions of COPCs from those sources. Those additional emissions sources are addressed through the air quality plan approval permitting process.

COPCs are the chemicals potentially associated with RRF emissions that have the potential to cause adverse health effects through direct (i.e., inhalation) or indirect (e.g., through soil, water, or food sources) exposure pathways. With the exception of lead, the risk assessment does not address emissions of the criteria pollutants (i.e., sulfur dioxide, Particulate Matter (PM) less than 10 microns in size, nitrogen dioxide, ozone, lead, and carbon monoxide). National Ambient Air Quality Standards (NAAQS) protective of human health and the environment have been promulgated for the criteria pollutants. Demonstration of compliance with both the primary and secondary NAAQS precludes the need for additional analysis. However, lead was included in this risk assessment. The NAAQS for lead is based on inhalation exposure only, and applicable guidance documents suggest that indirect exposure pathways for lead (e.g., ingestion of lead in soil) should be considered as well.

Actual expected emissions from the proposed Facility were evaluated in this assessment. Emission rates for each COPC were derived using stack test data, where available, from the SEMASS Resource Recovery Facility (SEMASS) in West Wareham, Massachusetts, which is a RRF with a similar design to the proposed Facility. Specifically, emissions estimates were based on stack test data collected from the "SEMASS Unit 3". Average emission rates representative of typical conditions were used to assess risks from chronic exposure. Because the SEMASS Unit 3 data were collected over years of operations, it not only represents an actual baseline for emissions but should capture variations in emissions, including times when controls and combustion conditions are not optimal.

Source information was combined with physical data (e.g., meteorological, building profile, and land use information) from the area surrounding the proposed Facility to estimate unitized[1] air concentrations and deposition fluxes using the American

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[1] Emission rates were unitized to 1 gram COPC per second for the purpose of air dispersion and deposition modeling. This convention eliminates the need to model each COPC separately and allows for the ambient air concentrations and deposition fluxes to be scaled according to the emission rate derived for each COPC.

Meteorological Society – Environmental Protection Agency Regulatory Model (AERMOD, version 6.7.1). The unitized ambient air concentrations and deposition fluxes were multiplied by the COPC-specific emission rates to yield COPC-specific ambient air concentrations and deposition fluxes.

The COPC-specific ambient air concentrations were used to evaluate the potential for additional (i.e., incremental) cancer risk, termed "excess lifetime cancer risk" (ELCR) and the potential for noncancer hazards from direct exposure (i.e., inhalation) for all human receptor populations considered in the HHRA. The COPC-specific ambient air concentrations, deposition fluxes, and chemical-specific physicochemical data were used to estimate COPC concentrations in various exposure media (e.g., soil, surface water, and food sources). These medium-specific COPC concentrations were then used to evaluate the potential for increased cancer risk and noncancer hazards from exposure through indirect exposure pathways and to evaluate the potential for ecological risk. The exposure media calculations were facilitated with the use of commercially available software, Industrial Risk Assessment Program-Health (IRAP-h View, or IRAP, version 4.0) developed by Lakes Environmental. IRAP was developed to compute human health risk assessments in direct conformance with USEPA's Final 2005 HHRAP.

Annual average ambient air concentrations predicted using AERMOD were used to evaluate the potential for chronic risks from long-term, direct exposure. To evaluate the potential for risk of chronic health effects through indirect exposure pathways, equations and receptor-specific exposure parameter values were used to model human exposure to the predicted COPC concentrations in various exposure media. Potentially exposed human populations (i.e., receptors), exposure scenarios, and exposure parameters were based on area-specific information, where available, and conservative default assumptions recommended in HHRAP were used where local information was lacking. Chemical-specific toxicity information was then applied to provide an estimate of the potential for ELCR and noncancer hazards from the modeled human exposures. The human exposure assessment calculations were performed using IRAP.

Maximum 1-hour air concentrations predicted using AERMOD were used to evaluate the potential for human health effects from short-term exposures. The air concentrations were compared to acute inhalation exposure criteria (AIEC) used to evaluate short-term exposure through the inhalation pathway.

2. Environmental Setting

The proposed Facility will be located in Barrio Cambalache in the Municipality of Arecibo, which is west of the capital, San Juan, and within the coastal plains in the northern part of the commonwealth. The proposed Facility will be located immediately west of highway PR-2, north of the inactive Central Cambalache Sugar Mill, which is presently owned by the Land Development Authority of Puerto Rico (see Figures 2 and 4). It is bounded by Rio Grande de Arecibo (“the Arecibo River”) on the west and on the north by approximately 71 acres of property also owned by the Land Development Authority.

The USEPA guidance indicates that most significant atmospheric deposition of emissions from waste combustion units occurs within 10 km of the source (USEPA 2005b). Consistent with this guidance, air modeling conducted for this risk assessment predicts the highest air concentrations and greatest deposition fluxes will occur within the 10-km radius. Therefore, the HHRA focuses on human exposure scenarios within 10 km of the proposed Facility.

The following section provides a brief description of conditions in the area of interest surrounding the proposed Facility.

2.1 Physical Conditions

2.1.1 Terrain

Puerto Rico is mostly mountainous with a coastal plain belt in the north, mountains that abut the sea on the west coast, and sandy beaches along most coastal areas. Elevations range from sea level at the Caribbean Sea to a high of 1,339 meters at Cerro de Punta.

The entire Cambalache region is shown on the 1999 Federal Emergency Management Agency (FEMA) Flood Zone Map as being within a special food hazard area of Zone AE (1999). Zone AE is within the floodway area of a 100-year coastal flood. The base flood elevation for the 100-year storm event in the area near the proposed Facility is between 4 and 5 meters above mean sea level.

2.1.2 Surface Water

Puerto Rico's high central mountains and many small rivers provide fresh water to much of the island. The northern portion of the island is a fertile coastal plain belt. Wetlands range from the interior montane wetlands of the rain forest to intertidal mangrove swamps along the coast (United States Geological Survey [USGS] 1997a).

The Rio Grande de Arecibo flows north along the western boundary of the proposed Facility site. Its headwaters are in the mountainous terrain of volcanic origin to the south. It drains more than 200 square miles as it flows through the north coast limestone and empties into the Atlantic Ocean at Puerto Arecibo, approximately 2 km downstream of the proposed Facility site. The average width of the Rio Grande de Arecibo near the proposed RRF is 80 feet, and the current velocity is 0.57 meters per second (m/s) (USGS stream gauge at Central Cambalache, data from 1996-2010). Upstream of the proposed Facility site, the Rio Grande de Arecibo flows through Dos Bocas Reservoir, a source of hydroelectric power, and the Superacueducto, a source of local drinking water.

Cienaga Tiburones is Puerto Rico's largest wetland and is located northeast of the proposed Facility site. It encompasses approximately 6,000 acres along the Atlantic Coast, between Rio Grande de Arecibo and Rio Grande de Manati to the east. The wetland was historically a shallow coastal lagoon that drained freshwater from the surrounding river valleys to the ocean through subterranean conduits (Zack and Class-Cacho 1984). In the mid-nineteenth century, the Puerto Rico Department of Agriculture installed a series of ditches and canals (e.g., Caño Tiburones, Caño Norte) to drain the swamp for rice production. Dewatering resulted in subsidence and reversed the hydraulic gradient. By 1980, the previously freshwater wetland was inundated with saltwater, making the area unsuitable for agriculture and freshwater wetland flora and fauna. The USGS and Puerto Rico Department of Agriculture instituted a number of measures in the mid-1980s, including building earthen dams and plugging the subterranean conduits, to restore the wetland to its freshwater status. These measures were largely successful and today, Cienaga Tiburones is a protected wildlife conservation area.

2.1.3 Climate

Puerto Rico has a mild tropical marine climate with little seasonal temperature variation (CIA 2010). The average annual precipitation in Puerto Rico is 60 to 80 inches per year (USGS 1997b). Natural climactic hazards include periodic droughts and hurricanes.

2.1.4 Geology and Hydrogeology

The area of interest is of a flat relief with elevations commonly between 2 to 6 meters. Rio Grande de Arecibo and its tributaries abut to the west, and Cano Tiburones is approximately 1 km to the north-northeast. The Atlantic Ocean is approximately 1 km to the north-northwest. It should be noted that the area of interest is prone to flooding especially during the hurricane season. The amount of water flowing in the river is controlled by a hydroelectric power reservoir farther south from the proposed Facility.

The geology of the area can be described as floodplain alluvium deposits consisting mainly of sands, gravels, silts, and clays. These soils are underlain by karstic Aymamon limestone (Miocene). The soils commonly contain limestone fragments.

The water level is usually found 6 to 10 feet below ground surface (bgs). The groundwater levels vary according to seasons (dry versus wet), tides, and rates of pumping (Cano Tiburones is often pumped, which might reverse the hydraulic gradient) among others. The groundwater flow is generally toward the Atlantic Ocean. There are two more aquifers i.e., intermediate (approximately 150 to 200 feet bgs) and deep (approximately 800 to 2,000 ft bgs) beneath the area.

2.1.5 Drinking Water

Drinking water in Puerto Rico is supplied by the Puerto Rico Aqueduct and Sewer Authority (PRASA), which owns the public water and wastewater systems in Puerto Rico. PRASA is divided into five operational regions with Arecibo and adjacent municipalities (Camuy, Florida, and Hatillo) located in the northern region (“Region Norte”) (http://www.acueductospr.com).

Drinking water in Arecibo is supplied both from groundwater sources and surface water. The main water system in the region is known as the North Coast Aqueduct System (also known as the “Superacueducto”). The Superacueducto system includes a raw water storage reservoir, located approximately 3 km south of the proposed Facility site. Water from this reservoir is treated at the Antonio Santiago Vazquez Water Treatment Plant before distribution to the system. Publicly owned water supplies are regulated under the Safe Drinking Water Act.

2.2 Land – Condition and Use

Land in Puerto Rico is composed of 3.69 percent arable land, 5.59 percent permanent crops, and 90.72 percent other (CIA 2010). Land near the proposed Facility includes the city of Arecibo (approximately 2 km) to the northwest, surrounding suburban residential development, and rural areas that include large areas of croplands and dairy and cattle farms (see aerial photographs, Figure 3 and 4). Rural areas also include small residential areas and some industrial facilities.

Figure 6 depicts land uses within 10 km of the proposed Facility. As shown, a significant portion of the land area within 10 km of the proposed Facility is residential or cropland and pasture. Figure 7 depicts land uses within 3 km of the proposed Facility. Approximately 25 percent of the area within 3 km is commercial, industrial/urban, or residential. Croplands and pasture constitute approximately 50 percent of the total land area. An additional 10% of the total land area is herbaceous or shrub/brush rangeland.

The area of Barrio Cambalache is located in the Rio Grande de Arecibo flood plain. Land use in Barrio Cambalache has been mostly agricultural for the past few decades. Between 1982 and 1983, sugar cane cultivation occupied approximately 55 percent of the valley, rice plantations about 30 percent, and livestock pastures approximately 15 percent.

The closest agricultural land to the Facility is immediately east of highway PR-2 and across from the Facility. The closest home to the proposed RRF is located approximately 100 meters to the east, east of highway PR-2. Five other homes are located approximately 400 meters east of the proposed RRF, east of PR-2. Four other residences are located at Santa Barbara, approximately 569 meters to the north of the proposed RRF, west of PR-2.

2.3 Demographics

2.3.1 Population

Puerto Rico is a territory of the United States with commonwealth status, and its residents are U.S. citizens. Its population is estimated to be 3,971,020 and growing at a rate of 0.279 percent (CIA 2010). The population of Arecibo was estimated to be 100,131 in 2000 U.S. Census (Puerto Rican population then 3,808,610).

The life expectancy in Puerto Rico is 78.57 years, with a life expectancy of 74.91 years for males and 82.41 years for females (CIA 2010). Ninety-eight percent (98.6 percent) of the Puerto Rican population is Hispanic Latino; 76.0 percent of the population is white; 7.3 percent African-American/black; 0.2 percent American Indian and Alaska Native; 0.3 percent Asian; and 11.7percent Other according to data from the U.S. Census Bureau (2006-2008).

The urban population of Puerto Rico makes up 98 percent of the total population, with a 0.8 percent annual rate of change (CIA 2010). The CIA estimates that 19.4 percent of the population is 0 to14 years; 66.1 percent is 15 to 64 years; and 14.5 percent is 65 years and over (CIA 2010).

2.3.2 Economy

Puerto Rico has a diverse industrial sector that has surpassed agriculture as the primary economic activity. Major industries in Puerto Rico include pharmaceuticals, electronics, apparel, and food products. In the past, dairy products and other livestock products were the main source of income in the agricultural sector. Now, sugar surpasses dairy and livestock production as the primary agricultural product. Other agricultural products include coffee, pineapples, plantains, bananas and chickens.

Tourism has traditionally been an important source of income; however, growth in the tourism sector has slowed because of economic conditions in the U.S. (CIA 2010).

The U.S. Census Bureau data indicate that the median family income for Puerto Ricans in 2008 was $21,639 (estimated), with approximately 41.4 percent of families below the poverty level. Data from the 2006 Census finds that 33.9 percent of residents had not completed high school.

Approximately 47.1 percent of the population 16 years and older is part of the labor force (U.S. Census Bureau 2006-2008), with a 12 percent unemployment rate in 2002. According to the CIA, 2.1 percent of the labor force is in agriculture; 19 percent is in industry; and 79 percent is in services (2010).

3. Estimated Impacts to Environmental Media

This section provides the rationale for identifying COPCs evaluated in the assessment, presents the basis for estimated emissions from the proposed Facility's combustion units, and briefly describes the predictive air modeling used to estimate impacts to ambient air and environmental media.

3.1 Identification of Constituents of Concern

Constituents evaluated in the HHRA were identified based on recommendations provided in the USEPA guidance (2005a) and stack test data generated from the "SEMASS Unit 3", a RRF located in Massachusetts with a similar design to the proposed facility.

Chemicals that tend to be persistent and bioaccumulative are of the most interest for potential long term (i.e., chronic) effects. These include certain semi-volatile organic compounds (SVOCs) and certain metals. Select volatile constituents are more of a concern for shorter term (e.g., acute) exposures. The following constituents and constituent classes were evaluated in the HHRA:

- SVOCs
  - Polynuclear aromatic hydrocarbons (PAH)
  - Polychlorinated dibenzodioxins (PCDD)
  - Polychlorinated dibenzofurans (PCDF)
- Metals
  - Antimony
  - Arsenic
  - Beryllium
  - Cadmium
  - Chromium (as Cr VI)
  - Cobalt
  - Copper
  - Lead
  - Manganese

- Mercury (inorganic and organic forms, as elemental mercury, mercuric chloride, and methyl mercury)
- Molybdenum
- Nickel
- Selenium
- Tin
- Vanadium
- Zinc

In addition, select acid gases (i.e., hydrochloric acid and hydrofluoric acid) were included in the evaluation of the potential for adverse health effects from short-term exposure.

3.2 Characterization of Facility Emissions

With a single exception, stack test data collected at the SEMASS Unit 3 were tabulated and used as the basis for the COPC-specific emission rates. Due to the absence of SEMASS stack test data for hydrogen fluoride, the emission rate was based on manufacturing specifications.

For most constituents, over 10 years of SEMASS Unit 3 stack test data were available. The COPC-specific emission rates used in this assessment represent the average of the available data. If a constituent was detected in some tests and not others, then one-half the detection limit was used to represent the non-detect results when calculating the arithmetic average. A summary of the annual average emissions from SEMASS Unit 3 is included in Appendix A. The annual average emissions, measured in micrograms per dry standard cubic meter (µg/dscm), were converted to emission rates in grams per second (g/s), as shown in Appendix A.

Table 1 presents the COPC-specific emission rates used in this assessment. The proposed Facility will consist of two combustion units. Emissions from the two combustion unit flues were modeled in AERMOD as two separate sources. Because the SEMASS Unit 3 emission rates represent emissions from a single combustion unit, the emission rates in Table 1 were applied to each of the two sources in IRAP.

Emission rates for chemicals emitted as particles were adjusted by a factor of 0.38 to account for recent improvements in particulate control technology. The SEMASS facility is capturing particulate emissions using bagfilter technology, which is the same type of technology that Energy Answers proposes to use for controlling particulate emissions from the Arecibo facility. Very recent advancements in filter technologies, however, have proven to be considerably more effective at capturing particulate emissions than traditional filter materials evidenced in the SEMASS stack tests. According to the USEPA's Environmental Technology Verification (ETV) Program, several manufacturers of fabric filters have demonstrated the capability of achieving outlet concentrations of less than 0.0000073 grains per dry standard cubic foot. Standard Verification Testing was conducted and reported as recently as April 2010 on new fabric materials.

To account for the expected improved filter performance that will be achieved by the bagfilters that will be installed at the Arecibo plant, the reported performance level for the new filter materials of 0.0000073 was taken and, as a conservative measure, adjusted upward using a safety factor of 100. This yields an expected outlet concentration of 0.00073 grains per dry standard cubic foot. This value was subsequently compared to the measured average SEMASS stack test value of 0.0019 grams per dry standard cubic foot. By this comparison, the new filters can reasonably be expected to collect particulate at least (1 - 0.00073/0.0019) x 100 = 62 percent better than traditional filter technology. This reduction in particulate emissions, therefore, was taken into account by multiplying the average SEMASS stack test emission rates for chemicals emitted as particles by 0.38. This adjustment to the SEMASS Unit 3 emission rates, where applicable, is also presented in Table 1.

3.2.1 Constituents of Special Interest

3.2.1.1 Dioxins and Furans

Emissions from waste combustion facilities often include mixtures of PCDDs and PCDFs at trace levels. PCDDs and PCDFs are by-products of incomplete combustion and are often referred to as dioxins and furans. They have a molecular structure consisting of two benzene rings with one to eight chlorine atoms attached to the rings in a number of different combinations. There are 210 individual compounds, or congeners, of dioxins/furans. Congeners with chlorine substitutions in the 2, 3, 7, and 8 positions are believed to have greater toxic potency than those without this substitution pattern, with 2,3,7,8-tetrachlorodibenzo-p-dioxin (termed 2,3,7,8-TCDD) having the greatest carcinogenic potency.

Often, the potential for health risk from exposure to dioxin/furan mixtures is evaluated in terms of toxic equivalents (TEQ) of 2,3,7,8-TCDD. Seventeen congeners have been assigned 2,3,7,8-TCDD toxic equivalency factors (TEF) according to the 2005 World

Health Organization (WHO) TEQ weighting scheme (van den Berg. 2006). However, because the chemical-physical characteristics of the congeners may differ, exposure media concentrations were estimated in this HHRA for each of the 17 congeners using the corresponding congener-specific emission rates and fate and transport parameters. Appendix A presents three years of congener-specific SEMASS dioxin/furan data used to estimate potential dioxin and furan emission rates.

3.2.1.2 Mercury

Mercury is present in the environment in one of three forms: elemental, divalent, or methylated. Total mercury in stack emissions is assumed to consist entirely of elemental and divalent species, with no direct emissions of methyl mercury (USEPA 2005b). Exposure to elemental mercury is evaluated for the inhalation pathway only. Exposure to divalent mercury is evaluated for both the direct (i.e., inhalation) and indirect (following dry and wet deposition) exposure pathways. Methyl mercury is the most toxic form of mercury and is bioaccumulative. Methyl mercury is formed through metabolic processes in soil, sediment, and biota. Therefore, exposure to methyl mercury is only evaluated through indirect exposure pathways.

According to the Mercury Study Report to Congress (USEPA 1997), mercury is present as a trace contaminant in the feedstock of municipal waste combustion facilities. Because of its relatively low boiling point, mercury is volatilized during high temperature combustion and is discharged to the atmosphere with the exhaust gas (USEPA 1997). As part of the air pollution control system for the proposed Facility, activated carbon injection systems will be installed and operated to control mercury emissions from the two proposed combustion units.

SEMASS stack test data are reported as total mercury. The following assumptions regarding mercury speciation in the proposed Facility emissions were incorporated into this risk assessment and are based on assumptions that were used to model mercury emissions from a municipal waste combustion facility, in a hypothetical assessment presented in the Mercury Study Report to Congress (USEPA 1997): elemental vapor phase (60 percent), divalent vapor phase (30 percent) and divalent particle-bound (10 percent). These assumptions regarding mercury speciation are considered more appropriate than those presented in HHRAP, because the nature of municipal solid waste differs from that of hazardous waste.

USEPA guidance indicates that 99 percent of the elemental vapor phase mercury emitted from a combustion unit stack is not deposited locally but becomes part of the global mercury cycle (2005b). Thirty-six percent (36 percent) of the particle bound divalent mercury deposits locally. A greater percentage (68 percent) of vapor phase divalent mercury deposits locally because of its reactivity and water solubility (2005b).

Accounting for the global mercury cycle, it was assumed that total mercury locally deposited will be 24.2 percent of the total mercury emitted from the stack (20.4 percent as divalent vapor phase, 3.6 percent as divalent particle bound, and 0.6 percent as elemental vapor phase). This breakdown is shown below:

	Percent of All Hg Emitted	Percent of Hg Type Deposited Locally	Percent of Hg Emitted that is Deposited Locally
Elemental Vapor Phase Mercury	60 %	1 %	0.6 %
Divalent Vapor Phase Mercury	30 %	68 %	20.4 %
Divalent Particle Bound Mercury	10 %	36 %	3.6 %
Total	100 %		24.6 %

It is estimated that approximately 2 percent of the divalent mercury deposited on non-wetland soils becomes methylated, with a higher rate of methylation in wetland soils. Methyl mercury binds to organic matter in water and may be transported to surface water bodies via overland flow (Agency for Toxic Substances and Disease Registry [ATSDR] 1999). Consequentially, water bodies surrounded by forest or agricultural land tend to have higher methylation fractions than those surrounded by developed areas (USEPA 2005b). To calculate water body mercury loading, a dissolved concentration in water was calculated for total mercury using the fate and transport parameters for mercuric chloride. The dissolved concentration was then apportioned based on an 85 percent divalent: 15 percent methylated mercury speciation ratio in the water body (USEPA 2005b).

3.3 Air Dispersion and Deposition Modeling

Air dispersion and deposition modeling combines source emission rates and facility information (e.g., source parameters and building profile) with physical data from the area surrounding the proposed Facility (i.e., meteorology, terrain, and land use information) to estimate unitized ambient air concentrations and deposition fluxes.

3.3.1 Meteorological Data

Careful consideration was given to selecting a location from which to obtain meteorological data that are representative of conditions at the proposed RRF. Five consecutive years' (2005 to 2009) of surface and upper air meteorological (MET) data collected at the San Juan International Airport were used in the evaluation of the potential for chronic health effects from long-term exposure and the potential for acute adverse health effects from short-term exposures. In addition, one year of historical data (August 1992 to August 1993) was available from the Puerto Rico Energy Power Authority (PREPA) meteorological station located in Cambalache, approximately one mile from the proposed Facility site. PREPA data were also used, in conjunction with the San Juan data from the 1992-1993 timeframe, to evaluate the potential for acute adverse health effects from short-term exposures. The PREPA Cambalache data includes wind direction, wind speed, temperature, and solar radiation. To complete the PREPA Cambalache meteorological data set so that it can be used by AERMOD, it was necessary to add parameters representing cloud cover, ceiling height, pressure, and relative humidity. These parameters were extracted from the 1992-1993 meteorological data set collected in San Juan.

Surface and upper air input files for AERMOD were prepared using the AERMET processor programs. The inputs to AERMET for surface characteristics (surface roughness, Albedo and Bowen ratio) were determined as based on land use in the area surrounding the airport anemometer site.

3.3.2 Modeling

Emissions from the proposed Facility were modeled for risk assessment purposes using AERMOD, version 6.7.1 (EPA AERMOD 09292). AERMOD is the recommended model for air quality analysis in USEPA's *Guideline on Air Quality Models* (40 Code of Federal Regulations Part 51, Appendix W).

The modeling was performed with a commercial version of AERMOD, developed by Lakes Environmental, and designed to be compatible with the HHRA software, IRAP. AERMOD includes a pre- and post-processor utility called "Risk Mode," in which input and output files utilized within AERMOD are processed to carry over into IRAP. AERMOD also includes pre-processor programs (AERMAP [09040], AERMET [06341], and AERSURFACE [updated January 2008]) to create the required input files for meteorology and receptor terrain elevations. Appendix B contains the input and output files (i.e., plot files and output files) generated for this HHRA using AERMOD.

The COPCs potentially emitted from the municipal waste combustion unit flues are dispersed and deposited as either vapors or particulates (i.e., particles or particle bound). AERMOD was run to generate estimates of air concentrations and deposition fluxes for vapor phase COPCs, particle phase COPCs, and particle bound COPCs. In general, the following assumptions were applied (USEPA 2005b):

- Most metals and organic COPCs with very low volatility occur only in the particle phase.
- Highly volatile organic COPCs occur only in the vapor phase.
- The remaining organic COPCs occur with a portion of the vapor condensed onto the surface of particulates (i.e., particle bound).

The emissions phase was determined from the fraction of the COPC air concentration in the vapor phase (F_v) consistent with HHRAP. Values for F_v were obtained from the HHRAP Appendix A-2: Chemical-Specific Parameter Values (i.e., HHRAP companion database). Table 2 presents the F_v and assumption regarding the emissions phase of each COPC.

Consistent with the discussion of mercury speciation in Section 3.2.1.2, total mercury in stack emissions was assumed to consist entirely of elemental and divalent species, with no direct emissions of methyl mercury (USEPA 2005b). It was generally assumed that total mercury stack emissions consist of elemental vapor phase (60 percent), divalent vapor phase (30 percent), or divalent particle bound phase (10 percent). Accounting for the global mercury cycle, it was determined following HHRAP guidance that 0.6 percent of the elemental vapor phase mercury, 20.4 percent of the divalent vapor phase mercury, and 3.6 percent of the divalent particle bound mercury were potentially deposited in the vicinity of the stacks.

AERMOD was run in four basic modes:

1. Mercury vapor phase mode to determine the air concentration, dry vapor deposition, and wet vapor deposition.
2. Vapor phase mode to determine the vapor phase air concentration, dry vapor deposition, and wet vapor deposition.

3. Particle phase (or mass weighting) mode to determine the dry and wet deposition fluxes of particles.

4. Particle bound (or surface area weighting) mode to determine the dry and wet deposition fluxes of COPCs that condense on the surfaces of particles leaving the stack.

3.3.3 AERMOD Model – Risk Mode Inputs

To generate the necessary output files for use in IRAP, "Risk Mode" was selected prior to running AERMOD. The primary inputs to AERMOD are the source parameters and receptor locations. Additional inputs include meteorological data and model options (e.g., land use/land cover; building wake information, regulatory control option, averaging time, etc.).

3.3.4 AERMOD Model – Source Parameter Inputs

The focus of the HHRA is on combined emissions from the two proposed combustion units (i.e., boilers). The two combustion unit flues were modeled in AERMOD as separate sources, with unique X, Y coordinates, as shown in the table below. The following source input parameter values were developed as part of the *Revised Air Quality Modeling Protoco*l, Energy Answers International, Puerto Rico Resource Recovery Power Plant Project, prepared by ARCADIS, Inc., dated April 27, 2010 (ARCADIS 2010), and were entered into AERMOD:

	Boiler 1	Boiler 2
Source Location		
X Coordinate (m)	742603.26	742606.42
Y Coordinate (m)	2042533.44	2042535.16
Base Elevation (m)	3	3
Release Height (m)	95.4	95.4
Source Release Parameters		
Emission Rate (g/s)	1	1
Gas Exit Temperature (K)	439.82	439.82
Stack Inside Diameter (m)	2.13	2.13
Gas Exit Velocity (m/s)	28.54	28.54
Gas Exit Flow Rate (m^3/s)	101.7	101.7

Notes:
g/s – grams per second
K- degrees Kelvin
m – meters
m/s – meters per second
m^3/sec – cubic meters per second

AERMOD also requires gas and particle information to model mercury vapor, vapor, particle, and particle bound COPCs. Both sources were modeled using the same assumptions regarding vapor and particle deposition.

To model vapor dispersion and deposition, chemical-specific values are needed for diffusivity in air, diffusivity in water, leaf cuticular resistance, and Henry's Law Constant. Rather than running AERMOD multiple times in the vapor phase mode (to account for each organic COPC that occurs in stack emissions as a vapor), organic COPCs were grouped according to chemical classes (e.g., PAHs, dioxins/furans) and similarities in their Henry's Law Constants (atm-m^3/mol), and a surrogate chemical was selected to model dispersion and deposition for a single group. Henry's Law Constant was the chemical-specific variable used to group the vapor phase COPCs, because it was observed there is relatively more variability in Henry's Law Constant between COPCs as opposed to diffusivities. In general, chemicals with larger molecular weight and lower Henry's Law Constants are relatively more volatile than others. It was assumed these relative differences in volatility would dictate vapor phase COPC fate and transport.

The following surrogate compounds for four groups of organic COPCs were used:

Surrogate COPC	**Henry's Law Constant**		**Apply AERMOD Vapor Phase Output to:**
	(atm-m³/mol)	AERMOD Input (Pa-m³/mol)	
Dibenzo(a,h)anthracene	1.50E-08	1.52E-03	Mercuric chloride and PAHs with H (atm-m³/mol) < 1E-06
Naphthalene	4.80E-04	4.86E+01	Hydrogen chloride and PAHs with H (atm-m³/mol) > 1E-04
Benzo(a)pyrene	1.10E-06	1.12E-01	Hydrogen fluoride and PAHs with H (atm-m³/mol) ≥ 1E-06 but < 1E-04
2,3,7,8-TCDD	3.29E-05	3.33E+00	Dioxins and Furans

Notes:
atm-m³/mol = atmospheres-cubic meter per mol
Pa-m³/mol = Pascals-cubic meter per mol

The following table presents the chemical-specific parameters entered into AERMOD for mercury vapor and for each surrogate COPC used to model organic COPCs assumed to be emitted as vapors.

Surrogate COPCs for Vapor Phase Modeling	**Diffusivity in Air (cm²/s)**	**Diffusivity in Water (cm²/s)**	**Leaf Cuticular Resistance (a) (s/cm)**	**Henry's Law Constant (Pa-m³/mol)**
Mercury	1.09E-02	3.01E-05	1.00E+05	7.19E+02
Dibenzo(a,h)anthracene	1.00E-03	1.00E-05	2.09E-03	1.52E-03
Naphthalene	5.90E-02	7.50E-06	3.65E+02	4.86E+01
Benzo(a)pyrene	4.30E-02	9.00E-06	4.41E-01	1.12E-01
2,3,7,8-TCDD	1.04E-01	5.60E-06	7.84E+00	3.33E+00

Notes:
cm²/s = square centimeters per second
s/cm = seconds per centimeter
Pa-m³/mol = Pascals-cubic meter per mol
a) Wesley 2002

To model particle and particle-bound dispersion and deposition, AERMOD requires a particle size distribution for particles emitted from a stack. Particle size is the main determinant of the fate of particles emitted from a stack. Intuitively, larger particles deposit closer to the source, while very small particles remain suspended in air for longer time periods. The rate at which dry and wet removal processes deposit particles onto the earth's surface depends on particle size and particle density (USEPA 2005b). AERMOD uses the mass-based particle size distribution to apportion the mass of particle phase COPCs according to particle size (USEPA 2005b). To model dispersion and deposition of particle-bound COPCs, AERMOD calculates the area available for COPCs to condense onto the surface of particles. This surface area-based particle size distribution is used to apportion the mass of particle bound COPCs according to particle size.

Particle size distributions can be determined for existing sources through stack testing. Because this assessment considers emissions from a proposed Facility, the following particle size distribution was input to AERMOD and is based on the projected relative emissions of PM 2.5 and PM 10 that were assumed for the PSD permit modeling:

Particle	**Method**	**Particle Diameter (microns)**	**Mass Fraction (0 to 1)**	**Particle Density (g/cm^3)**
Particle - Dry	Method 1: *10% or more has a diameter ≥ 10 microns*	2.5	0.45	1
		10	0.55	1
Particle Bound - Dry	Method 1: *10% or more has a diameter ≥ 10 microns*	2.5	0.766	1
		10	0.234	1

*Note: Due to Lakes' AERMOD View Software limitations, Risk Mode cannot run necessary calculations using the HHRAP-recommended cuticular resistance value of 1E+07 for mercury vapor. Therefore, the value of 1E+05 was used instead.

3.3.4.1 Receptor Locations

A Cartesian receptor grid, centered on the two sources, was used for the air dispersion and deposition modeling analysis. A grid with 100-meter spacing was positioned out to 3 km from the sources and was extended south to encompass a water body included in this risk assessment (i.e., the Superacueducto) that is located just beyond the 3 km radius of the sources (see Figures 9 and 10). A grid with 500-meter spacing was positioned from 3 to 10 km and was extended east to encompass another water body (i.e., Cienaga Tiburones) included in this risk assessment (see Figures 9 and 12). A few discrete receptor locations were placed along streams and within an estuary also included in this assessment. Air concentrations and deposition fluxes were estimated at a total of 5,418 receptor locations.

The receptor coordinates were in the Universal Transverse Mercator (UTM) coordinate system, North American Datum 1983, Zone 19 and are consistent with the source coordinate system. Terrain elevations at each receptor location were assigned using the USEPA's AERMAP software tool (version09040; 2009), which is designed to extract elevations from USGS National Elevation Dataset (NED) data at 1 degree (approximately 30 meter) resolution in GeoTIFF format (2002). While 7.5-minute Digital Elevation Mapping (DEM) data are preferable because they provide better resolution, they are not available for Puerto Rico. The 1 degree data are acceptable internationally, and they adequately capture changes in elevation such as the mountain southwest of the proposed Facility site.

3.3.4.2 AERSURFACE

Land use data, available through the USGS for Puerto Rico, is not considered representative of the current conditions. Therefore, the AERSURFACE utility was not used for this project. As requested by the USEPA Region II, surface characteristic values (e.g. Bowen Ratio, albedo, and surface roughness) values were calculated per the ADEC Guidance for AERMET Geometric Means (ADEC 2009), which was developed by the State of Alaska. This guidance provides the equations needed to calculate the surface roughness numbers for inclusion in AERMET. This guidance essentially replicates the procedure followed by the AERSURFACE utility program, using weighted geometric mean calculations, but instead of using USGS Land Use Data, with the land use values were determined through review of 2009 satellite images and aerial photographs of the area surrounding both the San Juan International Airport and the Camabalche, Arecibo metrological station location.

3.3.4.3 AERMOD Model – Optional Inputs

AERMOD includes a number of options that allow the model to be tailored to specific sources and sites. The following model control options were included in the air dispersion and deposition modeling for the risk assessment:

- **Building Downwash**: A Good Engineering Practice (GEP) stack height analysis was performed using the Building Profile Input Program (BPIP) (USEPA 1995), and appropriate building downwash parameters were applied in AERMOD to evaluate the potential effects of building downwash on dispersion from the combustion flues.

- **Land use**: Selection of the appropriate dispersion coefficients for air quality modeling is determined using the USEPA-preferred land use classification technique in 40 CFR 51, Appendix W (also known as the “Auer method”). This classification technique involves assessing land use for Auer’s categories within a 3-km radius of the proposed Facility site (Auer 1978). The USEPA recommends using urban dispersion coefficients and mixing heights if greater than 50 percent of the area is urban; otherwise, rural coefficients and mixing heights apply. Based on an evaluation of land use in the vicinity of the proposed Facility site, approximately 20 percent of the area within 3 km is urban while rural land use constitutes approximately 80 percent. Therefore, the dispersion environment was classified as rural.

- **Regulatory Default Option**: The modeling used the regulatory default option that includes the use of stack-tip downwash, buoyancy-induced dispersion, final plume rise, calm wind processing, default wind speed profile exponents, and default vertical temperature gradients consistent with HHRAP guidance. When the vapor phase was enabled, it also included the default toxic option.

- **Plume depletion**: As recommended in the HHRAP, the plume depletion option was used to account for the depletion of the plume due to the wet and dry removal processes.

3.3.5 AERMOD Model – Risk Mode Output

As stated above, AERMOD was run using unitized emission rates for each combustion unit flue. Therefore, the model output was in terms of unitized ambient air concentrations and unitized deposition fluxes.

The model generated the following output:

For vapor phase mercury:

- Unitized mercury vapor phase air concentration (micrograms-second per gram-cubic meter [µg-s/g-m^3])

- Unitized dry vapor deposition (seconds per meter squared per year [s/m^2-year])

- Unitized wet vapor deposition (s/m^2-year)

For all other vapor phase COPCs (organic COPCs divided into three groups based on differences in Henry's Law Constant):

- Unitized vapor phase air concentration ($\mu g\text{-}s/g\text{-}m^3$)
- Unitized dry vapor deposition (s/m^2-year)
- Unitized wet vapor deposition (s/m^2-year)

For particle phase COPCs (inorganic and relatively non-volatile COPCs):

- Unitized air concentration ($\mu g\text{-}s/g\text{-}m^3$)
- Unitized dry deposition (s/m^2-year)
- Unitized wet deposition (s/m^2-year)
- Unitized total deposition (i.e., wet and dry)

For particle-bound COPCs (organic COPCs and mercury condensed on particles):

- Unitized air concentration ($\mu g\text{-}s/g\text{-}m^3$)
- Unitized dry deposition (s/m^2-year)
- Unitized wet deposition (s/m^2-year)
- Unitized total deposition (i.e., wet and dry)

Annual average values were generated to evaluate the potential for adverse health effects from chronic exposure. Maximum 1-hour average values were generated to evaluate the potential for adverse health effects from acute exposure.

4. Exposure Assessment

The objective of the exposure assessment is to identify potentially complete pathways by which human exposure may occur and to estimate the magnitude, frequency, duration, and routes of exposure that can reasonably be anticipated under current and future land uses. This information is then integrated and used to estimate an exposure concentration or dose that may be received under assumed conditions. Estimated doses can then be combined with chemical-specific toxicity information to provide insight into the potential for adverse health effects to occur.

This section identifies receptors and exposure pathways and includes the following:

- Identification of human receptor populations, potentially complete exposure pathways through which human exposure may occur, and the receptor locations selected to evaluate human exposure and the potential for adverse health effects to occur.

- Estimation of concentrations in environmental media (i.e., soil, surface water, and sediment) and other features (e.g., produce, beef) in the environment that humans may be exposed through (indirect exposure pathways).

- Estimation of daily chemical intakes or doses to which humans may be exposed.

4.1.1 Exposure Setting

As described in Section 2, the potential for exposure and associated health risk was evaluated for exposure scenarios and receptor locations identified within a 10-km radius of the proposed Facility.

Figures 6 and 7 depict land uses within 10 km and 3 km, respectively, of the proposed Facility. As shown, a significant portion of the land area within 10 km of the proposed Facility is residential or cropland and pasture. Table 3 summarizes the percent of each land use type within the 10 km and 3 km radii. Approximately 25 percent of the area within 3 km is commercial, industrial/urban, or residential. Croplands and pasture constitute approximately 50 percent of the total land area. An additional 10% of the total land area is herbaceous or shrub/brush rangeland.

Appendix C contains additional information on local conditions, land uses, and human exposure patterns (e.g., fishing locations), obtained through consultation with a local environmental consulting firm, CSA. The combination of available information was used to determine relevant human exposure scenarios evaluated in this HHRA.

4.1.2 Exposure Pathways and Conceptual Site Model

An exposure pathway defines a probable path by which a receptor may come in contact with affected media. For an exposure pathway to be complete and exposure to occur, the following four elements must be present:

- Source and mechanism of chemical release
- Retention and/or transport medium
- Point of contact with the medium
- Route of exposure (e.g., inhalation, ingestion, dermal contact)

For exposure to occur, there must be a complete exposure pathway from the source to human receptors. If any one of the four elements is missing, the exposure pathway is incomplete and exposure will not occur.

Human exposure to COPCs potentially associated with RRF emissions can occur through direct (i.e., inhalation) or indirect (e.g., through soil, water, or food sources) exposure pathways. Direct and indirect exposure pathways considered in this HHRA include:

- Direct exposure pathway – inhalation of COPCs in air.
- Indirect exposure pathways – ingestion of COPCs that have deposited on soil, surface water, and vegetation and/or have been assimilated and bioaccumulated in consumed vegetation (i.e., locally grown produce), locally caught fish, and locally raised animal products (i.e., milk, poultry, and eggs).

4.2 Exposure Scenarios

This section identifies the general human receptor populations, exposure scenarios (i.e., combination of pathways through which a receptor population could potentially be exposed to COPCs), and exposure routes evaluated in this HHRA.

4.2.1 Potentially Exposed Populations and Potentially Complete Pathways

Human receptors are defined in this assessment as off-site populations that may be exposed to COPCs because of their relative location to the Facility and/or behaviors. The general receptor populations and exposure pathways evaluated in this HHRA were based on those recommended in combustion risk assessment guidance (USEPA 2005b) but account for local conditions that may contribute to differences in exposure potential. The exposure scenarios were selected based on an understanding of the current and most likely future land uses of the area surrounding the proposed Facility site.

Table 4 summarizes the following human receptor populations and exposure pathways evaluated in this HHRA:

- Urban Residents (Adults and Children) who live in Arecibo and may be exposed to COPCs in air, soil, drinking water from surface water sources, milk from local dairies, and locally caught fish.

- Suburban Residents (Adults and Children) who live in suburban areas surrounding Arecibo and may be exposed to COPCs in air, soil, drinking water from surface water sources, home-grown produce, milk from local dairies, and locally-caught fish.

- Local Farmers (Adults and Children) who may be exposed to COPCs in air, soil, drinking water from surface water sources, home-grown produce, and farm-raised animal products (e.g., milk from dairy cows, beef, poultry, pork, and eggs). While inclusion of all of these HHRAP-recommended exposure pathways may not reflect the realistic exposure potential of a farmer in the area of Arecibo, the intention is to provide a conservative evaluation that overestimates the potential for exposure and human health risk.

- Fishers (Adults and Children) who, under this exposure scenario, rely on fish as the main source of protein in the diet. These receptors may be exposed to COPCs in air, soil, drinking water from surface water sources, home-grown produce, milk from local dairies, and locally caught fish.

- Nursing Infants (i.e., Urban Resident Infant, Suburban Resident Infant, Farmer Infant, and Fisher Infant) who are exposed to dioxins/furans that may bioaccumulate in human breast milk. These exposure scenarios consider the adult mother's total intake of dioxins/furans and the potential for subsequent maternal transfer through breast milk fat.

For the purposes of modeling human exposure through the food ingestion pathways, it was conservatively assumed that 100% of a particular food type consumed (e.g., home-grown produce or beef) consists of home-grown or local sources. Specifically, it was assumed Suburban Residents, Farmers, and Fishers consume produce grown in their own home gardens. It was assumed Farmers consume milk from their own dairy cows. Farmers may bottle excess milk and sell it to the local population. Therefore, in this assessment, Urban Residents, Suburban Residents, and Fishers also consume milk from the farmers' dairy cows.[2]

Dermal exposure to COPCs in soil and surface water was not evaluated because of the negligible contribution of the dermal exposure route to overall risk (USEPA 2005b). Groundwater ingestion of drinking water was not included consistent with USEPA guidance because it has been demonstrated "an insignificant exposure pathway for combustion emissions" (USEPA 2005b).

Off-site commercial/industrial workers were not identified as a receptor population to be specifically evaluated as their relative exposure would be much less than that of residential receptors, including the farmers. The Resident and Farmer evaluations are, therefore, fully protective of off-site commercial/industrial workers.

On-site workers are not evaluated in this HHRA as it is assumed the potential for the exposure and the potential for adverse health effects in workers is regulated under the federal Occupational Safety and Health Act (OSHA) regulations and guidance (USEPA 2005b).

The potential for acute (i.e., short-term) exposures was evaluated for off-property receptors at the location of maximum impacts within the study area (i.e., within a 10 km radius of the proposed Facility). Determination of this maximum impact location is described below.

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[2] The milk ingestion pathway was modeled in IRAP at the Farmer receptor location, and the pathway cancer risks and noncancer hazards were added to each receptor population evaluated.

4.3 Exposure Scenario Locations

The exposure scenario locations are the actual geographic positions (i.e., grid nodes) at which the individual receptor exposure scenarios were evaluated. Exposure scenario locations were based on land uses within the study area and the air concentrations and deposition fluxes predicted by air modeling (AERMOD).

As described in Section 3, AERMOD was used to estimate COPC concentrations in the air above and deposition fluxes onto receptor locations within a 3-km radius[3] of the proposed Facility, according to a Cartesian grid array with 100-meter spacing. From 3 to 10 km, the grid spacing was 500 meters.

4.3.1 Discrete Receptor Locations

Discrete receptor locations were used to evaluate chronic exposure for the Urban Resident, and Suburban Resident, and Farmer exposure scenarios and to evaluate acute exposure at the off-site location where the maximum impacts occurred. These receptor locations were determined using the "receptor identification" tool in IRAP.

4.3.1.1 Chronic Exposure Evaluation

To identify the Urban Resident, Suburban Resident, and Farmer receptor locations using this tool, the air modeling receptor grids were geographically referenced with the land use data (i.e., residential and agricultural land uses) imported into IRAP as base maps. Receptor polygons were drawn around each land use area (i.e., urban, suburban, or residential) of interest within the study area. The IRAP receptor identification tool was used to determine the grid nodes within each polygon where each of the unitized air concentrations and deposition fluxes were maximized.

The chronic exposure evaluation was based on annual average unitized air concentrations and deposition fluxes predicted using AERMOD. The receptor grid nodes that corresponded to the highest predicted annual average unitized value for each air parameter (i.e., air concentration, dry deposition, wet deposition) and phase (i.e., vapor phase mercury and vapor phase, particle phase, and particle bound for

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[3] Initially, air modeling was completed based on a 20 km radius, then reduced to a 10 km radius based on model results.

other COPCs) were chosen as the receptor locations to estimate chronic exposure. While some of the values maximized at a single grid node, there were 12 possible receptor locations within each polygon, as follows:

Phases	Air concentration	Dry deposition	Wet deposition
Vapor phase mercury	x	x	x
Vapor phase	x	x	x
Particle	x	x	x
Particle-bound	x	x	x

For the residential exposure evaluation, receptor identification polygons were drawn around each residential land use polygon within a 10-km radius of the proposed RRF. Distinctions between urban and suburban residential land uses were based on observations of development density on an aerial photograph. The receptor identification tool in IRAP determined the grid nodes within each resident receptor polygon where the unitized air concentrations and deposition fluxes were maximized. To determine the single grid node where the combined unitized air concentrations and deposition fluxes were maximized, COPC-specific emission rates were entered into IRAP, and cancer risks and noncancer hazards were calculated at all of the grid nodes identified by IRAP.

- For the Urban Resident exposure scenario, the single location where the predicted risks and hazards were greatest, and therefore the combination of unitized air concentrations and deposition fluxes was maximized, was at the following grid node (North American Datum [NAD] 1983, UTM Zone 19N coordinates (m)]: x = 740402.13, y = 2042351. This grid node was chosen as the Urban Resident receptor location for this HHRA and is depicted on Figure 8.

- For the Suburban Resident exposure scenario, the single location where the predicted risks and hazards were greatest, and therefore the combination of unitized air concentrations and deposition fluxes was maximized, was at the following grid node [NAD 1983, UTM Zone 19N coordinates (m)]: x = 740302.13, y = 2041551. This grid node was chosen as the Suburban Resident receptor location for this HHRA and is also depicted on Figure 8.

A prior risk assessment, conducted in 1999, identified two farmsteads within 2 km of the proposed Facility. Observations revealed no produce cultivation but did reveal the presence of poultry and dairy animals. The agricultural area directly surrounding the proposed Facility is dominated by grazing lands. However, for the Farmer exposure evaluation included in this HHRA, all HHRAP-recommended exposure pathways were included. To ensure a health-protective assessment, it was assumed any agricultural area within a 10-km radius of the proposed RRF may support the full range of agricultural products under the current or a hypothetical, future exposure scenario.

To evaluate the Farmer exposure scenario, receptor polygons were drawn around agricultural land use areas within 10 km of the proposed RRF. Similar to the approach described above, cancer risks and noncancer hazards were calculated for all grid nodes identified using the IRAP receptor identification tool to determine the single location where the combination of unitized air concentrations and deposition fluxes was maximized. The single location where the predicted risks and hazards were greatest, and therefore the combination of unitized air concentration and deposition fluxes was maximized, was at the following grid node: [NAD 1983, UTM Zone 19N coordinates (m)]: x = 741702.13, y = 2042151. This grid node was chosen as the Farmer receptor location in this HHRA and is depicted on Figure 8.

4.3.1.2 Acute Exposure Evaluation

For the acute exposure evaluation, a receptor identification polygon was drawn in IRAP over the entire area within a 10 km radius of the proposed Facility. The receptor identification tool in IRAP identified the off-site receptor grid node(s) where the maximum 1-hour vapor phase mercury, vapor phase, particle phase, and particle bound air concentrations occurred. It was possible that four receptor locations (i.e., grid nodes) would be identified within the assessment area, and because four separate IRAP runs were required to model differences in the deposition of vapor phase COPCs, there were 16 possible receptor locations within the assessment area. However, the values for each of the four IRAP runs prepared using the meteorological data from San Juan International Airport all maximized at the following grid node: [NAD 1983, UTM Zone 19N coordinates (m)]: x = 745602.13, y = 2037051. This grid node was chosen to model acute exposure and is depicted on Figure 8.

In addition, the potential for adverse health effects from acute exposure was also evaluated using the combination of San Juan and Cambalache meteorological data. Using the same approach described above, two grid nodes were identified where the maximum 1-hour vapor phase mercury, vapor phase, particle phase, and particle bound air concentrations occurred. Hourly air concentrations of each COPC were estimated for both potential acute receptor locations. An acute noncancer hazard index was calculated for each, and the grid node with the greater hazard index was selected to evaluate acute exposures. The single location where the predicted hazard was greatest, and therefore the combination of unitized hourly air concentrations was maximized, was at the following grid node: [NAD 1983, UTM Zone 19N coordinates (m)]: x = 742602.13, y = 2036051. Figure 8 depicts this acute receptor location as well.

4.3.2 Water Bodies and Watersheds

The following sections describe the approach used to model the fish ingestion and drinking water pathways. Table 5 provides a brief summary of the water bodies and watersheds selected to evaluate each exposure pathway. Unlike the approach used to model the resident and farmer exposure scenarios, no single grid node was selected as a receptor location. Instead, the water body and watershed areas selected for evaluation were demarcated in IRAP by drawing receptor polygons around the corresponding water body GIS shapefiles imported into IRAP as base maps, and average unitized air concentrations and deposition fluxes over all of the grid nodes within the water body and watershed areas were used to calculate COPC concentrations in surface water and sediment.

The HHRAP equations assume deposition onto the water body and consider contributions to COPC concentrations in surface water and sediment from deposition onto and surface runoff over the watershed. In this risk assessment, the potential for dilution of surface water concentrations from groundwater recharge to the surface water body was excluded.

Because of the large aerial extent of the entire watershed for each evaluated water body, or portion thereof, there can be considerable uncertainty associated with the use of single values for parameters (e.g., erodibility) to represent an entire watershed in the HHRAP equations. Therefore, an “effective watershed” was defined for each water body. An effective watershed is one that is smaller than the entire watershed and is more accurate for modeling COPC contributions from surface runoff, thereby resulting in representative surface water and sediment concentrations for modeling human exposure. The effective watershed area for each water body was delineated by identifying local topographic highs (e.g., roads, abandoned railroad tracks) that result in downslope drainage directly into the water body (USEPA 2005b).

4.3.2.1 Drinking Water Ingestion Pathway

The drinking water ingestion pathway considers exposure to COPCs potentially associated with combustion emissions from the proposed RRF that are deposited onto a surface water body used as a drinking water source (e.g., a reservoir). The HHRAP equations used to calculate COPC concentrations in surface water consider contributions from deposition onto and surface runoff over the watershed. This evaluation conservatively assumes that potable water from the surface water supply is untreated (USEPA 2005b). However, like any other drinking water utility, Puerto Rico Water Supply is required to meet all federal requirements regarding safe drinking water.

The drinking water ingestion pathway was modeled using the Superacueducto as a water body receptor. Figure 10 depicts the water body and watershed polygons drawn in the IRAP to model the Superacueducto.

Superacueducto is located along the Rio Grande de Arecibo, approximately 3 km south of the proposed Facility site. It is kidney-shaped with dimensions of approximately 1,240 meters north to south and 725 meters east to west. The reservoir has a capacity of 1.14 million cubic meters (300,000,000 gallons). The maximum depth of the Superacueducto is 6 meters; the minimum depth is 2 meters, and the optimal depth is 5 meters. The useable capacity is 150,000,000 gallons, or 1.5 days storage.

4.3.2.2 Fish Ingestion Pathway

The fish ingestion pathway was modeled by considering deposition onto fishable water bodies located near the proposed Facility, and the cancer risks and noncancer hazards from the fish ingestion pathway were added to those estimated for the Urban and Suburban Residents. Three fishable water bodies were selected for modeling the fish ingestion pathway: the estuary where the Rio Grande de Arecibo meets Puerto Arecibo, Cienaga Tiburones, and Puerto Arecibo. These water bodies were selected based on a review of information on local fishing patterns provided by CSA (see Appendix C), which is summarized herein.

It was assumed for this HHRA that half of the total fish intake of Urban and Suburban Residents consisted of fish caught in the Rio Grande de Arecibo estuary, and the other half consisted of fish caught in Puerto Arecibo. For the Fisher exposure scenario, it was assumed the total fish intake consisted of fish caught in Cienaga Tiburones. The receptor location for the Fisher exposure scenario was co-located with the Suburban

Resident exposure scenario for all exposure pathways except fish ingestion. The cancer risks and noncancer hazards from the fish ingestion pathway, calculated by considering deposition onto Cienaga Tiburones, were added to those of the Suburban Resident for all other pathways except fish ingestion and the total cancer risks and noncancer hazards were attributed to the “Fisher.”

Figure 11 depicts the water body and watershed polygons drawn in IRAP to model the Rio Grande de Arecibo estuary. The Rio Grande de Arecibo estuary has three extensions including the Rio Grande de Arecibo and two other courses that may represent past flows of the river. People fish these extensions by small boat, from the water's edge, or from small abandoned bridges. Sirajo goby larvae are caught with nets at the river’s mouth. Other fish species commonly caught for food are snook and schoolmaster. Although the estuary is tidally influenced, the effect of tides on the water body COPC concentrations was not accounted for. This is a conservative approach, in that tidal flushing would serve to decrease the water body COPC concentrations.

Figure 12 depicts the water body and watershed polygons drawn in IRAP to model Cienaga Tiburones. As described in Section 2, Cienaga Tiburones was historically a shallow coastal lagoon that was drained in the 1950s for agricultural production and then was restored to freshwater wetland status in the 1980s. The wetland encompasses approximately 6,000 acres along the Atlantic Coast, north of the proposed Facility site, between Rio Grande de Arecibo and Rio Grande de Manati to the east (Zack and Class-Cacho, 1984). A series of drainage ditches and canals (e.g., Caño Tiburones and Caño Norte) intersect the wetland. Information obtained from CSA indicates people fish from small boats or from the water’s edge throughout the entire wetland area.

Mutton, snapper, bar jack, palometa, permit, and yellowfin snapper were identified by CSA as fish species commonly caught in the coastal waters of the Atlantic Ocean. However, because of the complexity and high degree of uncertainty associated with modeling the ocean as a water body receptor, Puerto Arecibo, and not the Atlantic Ocean, was selected to model COPC concentrations in fish. Figure 13 depicts the water body polygon drawn in the IRAP to model Puerto Arecibo. Puerto Arecibo is a relatively very small port that is located north of the proposed Facility site. It is crescent-shaped and has a single pier. The average channel depth is 6.4 to 7.6 meters. The port receives discharge from the Rio Grande de Arecibo and Cienaga Tiburones. The port is tidally influenced as it is directly connected to the Atlantic Ocean. However, the effect of tides on the water body COPC concentrations was not accounted for. This is a conservative approach in that tidal flushing would serve to decrease the water body COPC concentrations. A corresponding watershed area was not identified; therefore, contributions from overland flow were not included in the water body COPC calculations.

4.4 Estimating Media Concentrations

This section provides a detailed discussion on how COPC concentrations are estimated in environmental exposure media (e.g., air, soil, surface water, locally grown produce) so their potential contribution to exposure can be quantitatively evaluated.

The equations and parameters used to estimate COPC concentrations are those presented in Chapter 5 and Appendices B and C of HHRAP. The equations in HHRAP estimate COPC concentrations based on COPC-specific emission rates and the unitized ambient air concentrations and deposition fluxes predicted using AERMOD. The HHRA calculations were facilitated with the use of IRAP (version 4.0). IRAP was developed to compute HHRAs in direct conformance with the USEPA's Final 2005 HHRAP.

Chemical-specific fate and transport parameters included in the equations were obtained from the HHRAP companion database. The IRAP contains this HHRAP database, and all but a few (i.e., benzo(e)pyrene, benzo(g,h,i)perylene, cobalt, copper, hydrogen fluoride, molybdenum, perylene, tin, 2-methylnaphthalene, and vanadium) of the COPCs evaluated in this risk assessment are included in the database. For the other COPCs, chemical-specific fate and transport parameters were obtained from readily available sources (e.g., USEPA's Superfund Chemical Data Matrix and Syracuse Research Corporation's ChemFate and PhysProp Databases).

Appendix D presents the chemical-specific fate and transport parameters used in the HHRA. The table was exported from IRAP and includes COPCs copied over from the HHRAP database as well as the additional, user-defined COPCs and associated parameter values.

4.4.1 Overview

Migration pathways are processes by which constituents in an affected medium (i.e., air, soil, or groundwater) are transported within that medium and/or between media to locations where exposure may occur. The pertinent migration pathways for this HHRA are briefly discussed below.

The following sections describe the general approach and equations used to calculate COPC concentrations in various environmental exposure media. Table 6 contains the site-specific exposure parameters, in the order they are entered into the IRAP. The basis of each of these parameter values is discussed, where applicable, below.

4.4.2 Constituents of Potential Concern Concentrations in Air

COPC concentrations in air were calculated by summing the vapor phase and particle phase air concentrations according to the equations in Table B-5-1 and Table B-6-1 in HHRAP Appendix B. Unitized annual average air concentrations were used to calculate COPC concentrations in air to evaluate the potential for chronic human health risks. Unitized hourly air concentrations were used to calculate COPC concentrations in air to evaluate the potential for acute human health effects.

For mercury, a value of 0.002 was used to represent the fraction of elemental vapor phase mercury that deposits locally. A value of 0.24 was used to represent the fraction of divalent vapor and particle-bound mercury that deposits locally. These fractions are consistent with the assumptions regarding mercury speciation outlined in Section 3.2.1.2.

4.4.3 Constituents of Potential Concern Concentrations in Soil

COPC concentrations in soil were estimated by summing the vapor phase and particle phase deposition, both wet and dry, to the soil and accounting for loss of COPCs from the soil by several mechanisms, including leaching, erosion, runoff, degradation (biotic and abiotic), and volatilization. Because soil concentrations take years to reach steady-state, the equations recommended in the HHRAP integrate the instantaneous soil concentration over the period of deposition (i.e., the period of facility operation, which by default is 30 years). Equations 5-1C and 5-1D in the HHRAP were used to calculate the cumulative soil concentrations averaged over the receptor-specific exposure duration for carcinogenic COPCs. Equation 5-1E in the HHRAP was used to calculate the highest annual average soil concentration occurring over the exposure duration for noncarcinogenic COPCs. COPC deposition and losses were estimated using the equations and parameters presented in Tables B-1-1 through B-1-6 in the HHRAP Appendix B.

Soil conditions such as pH, structure, organic matter content, and moisture content affect the distribution and mobility of COPCs. Default parameter values were used for soil bulk density, soil mixing zone depth, and soil volumetric water content. A default value of 1.5 grams per cubic centimeter (g/cm^3) for soil bulk density is based on a mean value for loam soil (USEPA 2005b) and is consistent with the range of soil bulk densities given for the various soil types at the discrete receptor locations selected for this HHRA (See Table 6 and Acevido 1982). A default soil mixing zone depth of 2 cm is based on data from untilled soil and was used to model COPC concentrations in soil at the Urban Resident and Suburban Resident receptor locations, while a default value of 20 cm, representing tilled soil, was used to model COPC concentrations in soil at the Farmer receptor location (USEPA 2005b). A default value of 0.2 milliliters of water per cubic centimeter (mL water/$cm^{3)}$ soil represents the midpoint of the range from very sandy soils to heavy loam/clay soils and is the USEPA-recommended value presented in the HHRAP.

For mercury, a value of 0.24 was used to represent the fraction of divalent vapor and particle-bound mercury that deposits locally. This parameter is used in the equation to calculate the soil concentration due to deposition. The value is consistent with the assumptions regarding mercury speciation outlined in Section 3.2.1.2.

Site-specific parameters included in the equations used to calculate COPC concentrations in soil are as follows:

- **Average annual surface runoff from pervious areas (cm/year)**: This variable is used to estimate COPC losses from soil as a result of leaching and runoff. Runoff is a function of land cover type, hydrologic condition, and the runoff potential of the soil. Runoff varies seasonally and spatially in response to changes in precipitation (Hanson 1991). A site-specific value of 76 cm/year was used and is equivalent to an annual average estimate of 30 inches/year for the area near Arecibo (Figure 70 in Hanson 1991).

- **Average annual precipitation (cm/year)**: This variable is used to calculate COPC losses from soil as a result of leaching. A site-specific value of 80 cm/year was calculated using the five years of hourly surface data from San Juan International Airport.

- **Average annual evapotranspiration (cm/year)**: This variable is used to calculate COPC losses from soil as a result of leaching. A site-specific annual average value of 163 cm/year was obtained from Hanson (1991) and is an annual average based on pan evaporation data from coastal areas of Puerto Rico.

- **Average annual irrigation (cm/year)**: This variable is used to calculate COPC losses from soil as a result of leaching. A range of values from zero to 100 cm/year is presented in Table B-5-1 in the HHRAP Appendix B. For the purposes of this HHRA, a default value of zero (0) cm/year was used because site-specific data are not available, and it is conservative to underestimate COPC losses from soil as a result of leaching.

- **Ambient air temperature (Kelvin)**: This variable is used to calculate COPC losses from soil as a result of volatilization. A site-specific annual average value of 301 K was calculated using the five years of hourly surface data from Lancaster Airport.

4.4.4 Constituents of Potential Concern Concentrations in Produce

Indirect exposure resulting from ingestion of produce depends on the total concentration of COPCs in the leafy, fruit, and tuber portions of the plant. Chemical concentrations in locally grown produce were calculated by considering three possible mechanisms of contamination:

- Direct deposition of particle phase (i.e., particle and particle bound) COPCs onto exposed plant surfaces.

- Uptake of vapor phase COPCs through plant foliage.

- Root uptake of COPCs in soil and transfer to aboveground and belowground portions of the plant.

For the purposes of this risk assessment, it was assumed that a portion of the receptor diet is composed of produce that is either aboveground, protected; aboveground, unprotected; or below ground. COPC concentrations in aboveground, unprotected (e.g., lettuce) produce were calculated as the sum of the contamination that results from all three mechanisms. The primary mechanism through which aboveground, protected (e.g., corn, peas) and below ground produce assimilate COPCs is through root uptake of COPCs in soil.

Equation 5-14 in the HHRAP (Table B-2-7 in HHRAP Appendix B) was used to calculate COPC concentrations in aboveground produce due to direct deposition. Equation 5-18 in the HHRAP (Table B-2-8 in the HHRAP Appendix B) was used to calculate chemical concentrations in aboveground produce as a result of air-to-plant transfer. A site-specific value of 0.24 was used to represent the fraction of divalent vapor and particle-bound mercury that deposits locally. A site-specific value of 1.21E-03 g/m^3 was used for air density and corresponds to an annual average air temperature of 301 K.

Equations 5-20A (Table B-2-9 in the HHRAP Appendix B) and 5-20B (Table B-2-10 in the HHRAP Appendix B) in the HHRAP were used to calculate chemical concentrations in aboveground and below ground produce as a result of root uptake. COPC concentrations in soil, which are needed to calculate COPC concentrations in below ground produce, were calculated using the equations and parameters referenced in Section 4.4.3.

4.4.5 Constituents of Potential Concern Concentrations in Beef and Milk from Dairy Cows

COPC concentrations in beef and milk were estimated based on the amount of COPCs cattle are assumed to consume through their diet and through incidental ingestion of soil. It was assumed the cattle's diet consists of the following:

- Forage (primarily pasture grass and hay)
- Grain
- Silage (forage or grain that has been stored and fermented)

Equation 5-22 in the HHRAP (Table B-3-10 in the HHRAP Appendix B) was used to calculate COPC concentrations in beef. Equation 5-24 in the HHRAP (Table B-3-11 in the HHRAP Appendix B) was used to calculate COPC concentrations in cows' milk. It was conservatively assumed that 100 percent of the animal's diet is grown locally on soil that receives COPC deposition, COPCs in soil are 100 percent bioavailable, and metabolism does not decrease the COPC concentration in fat and muscle tissue. COPC concentrations in ingested soil were calculated using the equations referenced in Section 4.4.3.

COPC concentrations in feed were calculated using an approach consistent with that described above for locally grown produce. The total COPC concentration in feed items (e.g., forage, silage, and grain) was estimated as the sum of contamination occurring through the following mechanisms:

- Direct deposition of particles (wet and dry) onto forage and silage.

- Vapor transfer of vapor phase COPCs by forage and silage through foliage.
- Root uptake from the soil and their transfer to the aboveground portions of forage, silage and grain.

The assumptions regarding which mechanisms to include are based on whether the plant is protected by an outer covering. In accordance with HHRAP guidance, grain (e.g., corn) is classified as protected feed. It was assumed that potential contamination of grain occurs only through root uptake of COPCs in soil. COPC concentrations in forage (e.g., alfalfa or grass hay) were calculated as the sum of all three mechanisms. It was assumed that silage consists of hay that is stored and fermented (USEPA 2005b). Default parameter values specific to forage and silage were used, where applicable (see Tables B-3-7 through B-3-9 in the HHRAP Appendix B).

The quantities of feed types consumed by beef cows were changed from default values, which reflect subsistence farmer beef cattle, to those that reflect typical farmer beef cattle. The quantities of forage, grain, and silage consumed were changed to, respectively, 3.8 kg dry weight (DW)/day, 3.8 kg DW/day, and 1.0 kg DW/day (USEPA 2005b). Likewise, the quantities of feed types consumed by dairy cows were changed from default values, which reflect subsistence farmer dairy cows, to those that reflect typical farmer dairy cows. The quantities of forage, grain, and silage consumed were changed to, respectively, 6.2 kg DW/day, 12.2 kg DW/day, and 1.9 kg DW/day (USEPA 2005b).

4.4.6 Constituents of Potential Concern Concentrations in Pork

COPC concentrations in pork tissue were estimated based on the amount of COPCs swine consume through a diet consisting of silage and grain and through incidental ingestion of soil. It was conservatively assumed that 100 percent of the animal's diet is grown locally on soil that receives COPC deposition, COPCs in soil are 100 percent bioavailable, and metabolism does not decrease the COPC concentration in fat and muscle tissue.

Equation 5-25 in the HHRAP (Table B-3-12 in the HHRAP Appendix B) was used to calculate COPC concentrations in pork. COPC concentrations in silage and grain were estimated using the approach presented in Section 4.4.4. COPC concentrations in soil were calculated using the equations referenced in Section 4.4.3.

4.4.7 Constituents of Potential Concern Concentrations in Chicken and Eggs

Chemical concentrations in locally raised chicken and eggs were calculated by considering the amount of COPCs that the chickens consume through their diet (i.e., grain) and through incidental ingestion of soil. In accordance with HHRAP guidance, it was assumed that chickens consume 10 percent of their diet as soil, COPCs in soil are 100 percent bioavailable, and 100 percent of the grain consumed is grown locally on soil that receives COPC deposition (USEPA 2005b).

Equation 5-26 in the HHRAP (Tables B-3-13 and B-3-14 in the HHRAP Appendix B) was used to calculate COPC concentrations in chicken and eggs. The biotransfer factor (i.e., the ratio of the COPC in animal tissue to the daily intake of the COPC) is the distinguishing variable used to calculate COPC concentrations in chicken or eggs. COPC concentrations in grain were estimated using the approach presented in Section 4.4.4. COPC concentrations in soil were calculated using the equations referenced in Section 4.4.3.

4.4.8 Constituents of Potential Concern Concentrations in Surface Water

COPC concentrations in surface water were calculated for water bodies selected to evaluate the drinking water and fish ingestion exposure pathways. Mechanisms considered in determining COPC loading of the water column include the following:

- Direct deposition
- Runoff from impervious surfaces within the watershed
- Runoff from pervious surfaces within the watershed
- Soil erosion over the total watershed
- Internal transformation of compounds chemically or biologically

It was assumed that contributions from other potential mechanisms were negligible compared to these.

The equations used for modeling COPC loading to a water body represent a simple steady-state model to solve for a water column in equilibrium with the upper sediment layer. The equations that were used for estimating surface water concentrations include a sediment mass balance, in which the amount of sediment assumed to be buried and lost from the water body is equal to the difference between the amount of soil introduced to the water body by erosion and the amount of suspended solids lost in downstream flow. As a result, it was assumed that sediments do not accumulate in the water body over time, and equilibrium is maintained between the surficial layer of sediments and the water column.

Table 7 through Table 10 present site-specific parameter values for each of the water bodies and corresponding watersheds evaluated in this risk assessment. The site-specific parameters included in the equations used to calculate COPC concentrations in surface water are as follows:

- **Water Body Surface Area (m^2)**: The surface area of each water body was calculated by IRAP by delineating water body polygons in the IRAP using an aerial photograph as a base map.

- **Depth of Water Column (m)**: The water column depth of 3.79 meters for the Superacuedeucto was calculated by dividing the water body surface area (299,430 m^2) by the total volume of the reservoir (1,135,500 m^3) given by Thames Water, Puerto Rico (see Appendix C). The depth of the Rio Grande de Arecibo estuary (1.3 meters) was estimated by averaging height measurements from a stream gauge installed along the Rio Grande de Arecibo, approximately 2 km upstream of the estuary (USGS stream gauge 50029000, Rio Grande de Arecibo at Central Cambalache; USGS 2006). The depth of Cienaga Tiburones (1 meter) was estimated based on review of USGS topographic maps showing very little relief in the wetland area and information on depths of the canals and ditches from Zack and Class-Cacho (1984). There is some uncertainty associated with this value, because some areas of the wetland are influenced by freshwater springs that may be 40 feet deep. In addition, the canals are up to 6 feet deep, while other wetland areas are shallower. The depth of Puerto Arecibo (3 m) was estimated as the average of 6.4-7.6 meters, which is the channel depth provided as port detail on a readily available website (http://www.searates.com/port/arecibo_pr.htm).

- **Current Velocity (m/s)**: A current velocity of 0.577 m/s for the Rio Grande de Arecibo estuary was estimated by averaging existing mean velocity measurements collected at the USGS stream gauge (50029000) referenced above. Current velocities were not required inputs for the Superacueducto, Cienaga Tiburones, or

Puerto Arecibo, because they were modeled in the IRAP as lacustrine environments and not streams.

- **Average Volumetric Flow Rate (m^3/year)***:* The average volumetric flow rate of 1.38E+08 m^3/year for the Superacueducto was determined by converting the plant output of 100 million gallons daily, given by Thames Water, Puerto Rico (see Appendix C). The flow rate of the estuary (4.23E+08 m^3/year) was estimated based on the average annual discharge of the Rio Grande de Arecibo, measured at the USGS stream gauge (50029000) referenced above. The flow rate of Cienaga Tiburones (1.44E+03 m^3/year) was determined by converting the total discharge of 139.2 million gallons daily, which was reported in a water budget prepared for the Department of Natural & Environmental Resources (GLM & Associates, 2001). The flow rate of Puerto Arecibo (4.23E+08 m^3/year) was estimated by summing the flow rates of the Rio Grande de Arecibo and Cienaga Tiburones, the two main contributors to the port. The influence of tides was not accounted for in determination of the flow rates for the estuary or port, because over the course of a year, the net water flow caused by the tides is zero. This is a conservative approach, in that the tides would act to flush the water column, thereby decreasing the water body COPC concentrations.

- **Fraction of organic carbon in bottom sediment (unitless)***:* The fraction of organic carbon in the bottom sediment is used in the HHRAP equation that relates sediment COPC concentrations to fish tissue concentrations. The greater the organic carbon content of the sediment, the more COPCs are sorbed to the bed sediment and less is available for bioaccumulation in fish. The USEPA default value is 0.4; a fraction organic carbon between 0.3 and 0.5 is reasonable for water bodies where the organic carbon content of surface soils within the surrounding watershed is approximately equivalent to 0.01 (USEPA 2005b). Table 11 estimates the fraction organic carbon for each of the watershed areas based on the percent soil types within each watershed and the percent organic matter for each soil type as determined using the *Soil Survey of Arecibo Area, Northern Puerto Rico* (Acevido 1982). As shown, the estimated fractions of organic carbon in surface soils of the Superacueducto, estuary, and Cienaga Tiburones watersheds are, respectively, 0.013, 0.018, and 0.137. Therefore, the USEPA default value of 0.04 was used for the fraction organic carbon in bed sediment of Superacueducto and estuary.[4] For Cienaga Tiburones, the fraction organic carbon in bottom sediment was entered as 0.137, because there is little topographic relief in the surrounding watershed, and a wetland environment is expected to have a relatively greater fraction organic carbon in bottom sediment than a lake or stream.

No watershed was delineated for Puerto Arecibo. Sediments in the near-shore environment near Puerto Arecibo have been identified as coarse to medium sand (Diaz 2007), which one would expect to have a relatively low (<0.01) organic carbon content (Pait, et al. 2007). The fraction organic carbon in the bottom sediment of Puerto Arecibo is likely greater than 0.01, because fine materials with greater organic carbon content are transported to the port through the Rio Grande de Arecibo and Cienaga Tiburones. However, the fraction of 0.01 was used as an estimate of the organic carbon content because it is a conservative approach that likely overestimates fish tissue concentrations.

- **Total Suspended Solids Concentration (mg/L)**: Total suspended sediment/solids[5] concentrations for the Rio Grande de Arecibo were not available from the USGS stream gauge (50029000) referenced above. However, CSA provided TSS data from a water quality study on the Rio Grande de Arecibo. An average TSS concentration of 36 mg/L was obtained from a monitoring station located in the estuary. This concentration was used for the estuary and for Puerto Arecibo as no TSS data were available from the NOAA tide gauge located near the port. TSS data were not available from upstream reaches of the Rio Grande de Arecibo closer to the Superacueducto. Therefore, the USEPA default value of 10 mg/L was used. This is a reasonable assumption considering the Superacueducto was used to model the drinking water ingestion pathway only, and the potable

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[4] In addition, National Coastal Conditions Report II (USEPA 2005c) indicates 44 percent of Puerto Rico's estuarine sediments contained total organic carbon (TOC) greater than 5 percent. Although higher (2 to3 percent) TOC would be expected in sediments of tropical regions, TOC levels greater than 5 percent are associated with organic loading from untreated wastewaters and agricultural runoff from livestock areas.

[5] Total suspended sediment and total suspended solids concentrations are sometimes used interchangeably.

water supply would be subjected to treatment to remove suspended sediments from the water column. The default value of 10 mg/L was also used for Cienaga Tiburones because of a lack of site-specific TSS data.

- **Watershed Area Receiving COPC Deposition (m^2)***:* The total area of each watershed was calculated by the IRAP and reflects the effective watershed polygon delineated in the IRAP. Watershed boundaries were determined by tracing local topographic highs based on interpretation of a USGS topographic map and aerial photograph of the area surrounding the proposed Facility site. The watershed area receiving COPC deposition was calculated by subtracting the water body surface area from the total area of the effective watershed.

- **Impervious Watershed Area Receiving COPC Deposition (m^2)***:* The impervious watershed area receiving COPC deposition was calculated by multiplying the total watershed area by the percent impervious cover within each effective watershed area. The percent impervious cover was estimated based on aerial photograph interpretation.

- **USLE Cover and Management Factor (unitless)***:* This variable is used in the USLE, which calculates the soil loss rate from the watershed. The cover and management factor is a ratio of the expected soil loss from land under a specific combination of cover type and management scheme to the soil loss from a clean-tilled, fallow field (Wischmeier and Smith 1978). The HHRAP default value of 0.1 reflects dense vegetative cover, such as pasture grass, and is recommended for both grass and agricultural crops (USEPA 2005b). Based on review of an aerial photograph and land cover types within each watershed, the HHRAP default value of 0.01 was used for the Superacueducto, Rio Grande de Arecibo estuary, and Cienaga Tiburones watersheds.

- **USLE Erodibility Factor (ton/acre)**: This variable is used in the USLE and is a measure of the susceptibility of soil to erosion by water. Estimates are dependent on the percentage of silt, sand, and organic matter and on soil structure and permeability (Acevido1982). Erodibility factors are specific to soil types and are available in the Arecibo soil survey (Acevido 1982). Site-specific erodibility factors were estimated for each effective watershed area by determining all of the soil types present within the watershed and multiplying the soil type-specific erodibility factors by the percent each soil type comprises of the total watershed area, as shown in Table 12. A single erodibility factor for each watershed was then calculated by summing the weighted erodibility factors. The percent cover of each soil type was determined by overlapping each effective watershed polygon (exported from IRAP as shapefiles) over the Arecibo soils data (obtained as a GIS shapefile from the USDA NRCS website) in ArcView. The following USLE erodibility factors were used for the Superacueducto, Rio Grande de Arecibo estuary, and Cienage Tiburones watersheds, respectively: 0.17, 0.17, and 0.12.

- **USLE Length-Slope (LS) Factor (unitless)**: This variable is used in the USLE and represents the effect of slope and slope length on soil erosion. Generally, the potential for erosion is greater where slope is steeper and longer. An LS factor for each effective watershed area was estimated according to methods described in Wischmeier and Smith 1978. Flow directions were estimated from an elevation contour map. The slope length was estimated as the distance from the highest point within the watershed to the point where the slope gradient levels out. GIS tools were applied to estimate the slope from a USGS DEM. Figure 4 in Wischmeier and Smith 1978 was used to interpolate an LS factor based on the site-specific length and slope values. Using this approach, LS factors of 4.25, 0, and 0.3 were derived for the Superacueducto, Rio Grande de Arecibo estuary, and Cienage Tiburones watersheds, respectively.

- **USLE Rainfall Factor (year^{-1})**: The rainfall factor is a function of storm activity. A range of values from 50 to 300 year^{-1} is presented in Table B-4-13 in the HHRAP Appendix B. A site-specific modified R factor of 53.13 year^{-1} was calculated using an approach described in Rojas-Gonzalez (2008) and was applied to all of the watershed areas. The modified R factor is based on average monthly precipitation (p) and average annual precipitation (P), according to the following formula:

  - $R = 1.735 \times 10(\log \sum {p^2}/{P} - 0.8188)$

  Monthly precipitation values and annual average precipitation (80.13 cm/year) were obtained from the five years of hourly surface data from San Juan International Airport.

- **Mercury methylation fraction (unitless)**: The HHRAP default mercury methylation fraction of 0.15 was used to represent the portion of total mercury that speciates to methyl mercury in the water column. In accordance with HHRAP, a dissolved phase water concentration for total mercury was calculated using the fate and transport parameters for mercuric chloride (USEPA 2005b). Dissolved phase water concentrations for mercuric chloride and methyl mercury were then calculated by partitioning the total mercury concentration based on a 0.85 divalent mercury and 0.15 methyl mercury speciation split in the water body. The default 15 percent methylation fraction is based on the percentage methyl mercury present in surface water of lake environments and is not necessarily representative of methylation in well-mixed surface waters, such as the Rio Grande de Arecibo estuary and Puerto Arecibo.

- **Average annual wind speed (m/s)**: A site-specific value of 7.5 m/s was calculated using the five years of hourly surface data from San Juan International Airport.

4.4.8.1 Constituents of Potential Concern Concentrations in Fish

In accordance with HHRAP guidance, COPC concentrations in fish were estimated using a bioconcentration factor (BCF), a bioaccumulation factor (BAF), or a biota-sediment accumulation factor (BSAF).

For COPCs with a log octanol-water partitioning coeffieient (K_{ow}) > 4 (except for dioxins/furans and PCBs), COPC concentrations in fish were calculated by multiplying the dissolved phase water concentration, estimated as described in Section 4.4.7, by a chemical-specific BAF (see Table B-4-27 in the HHRAP Appendix B). For COPCs with a log $K_{ow} \leq 4$, COPC concentrations in fish were calculated by multiplying the dissolved phase water concentration by a chemical-specific BCF (see Table B-4-26 in HHRAP Appendix B).

It is assumed that strongly hydrophobic compounds (i.e., dioxins/furans and PCBs) are sorbed to sediments and are less likely to be associated with the water phase. Therefore, COPC concentrations in fish were calculated by multiplying the COPC concentration sorbed to bed sediment (C_{sb}), estimated using Equation 5-47 in the HHRAP (Table B-4-25 in the HHRAP Appendix B), by a chemical-specific BSAF (see Table B-4-28 in the HHRAP Appendix B) and dividing by the fraction of organic carbon in the bottom sediment.

4.5 Quantification of Exposure

This section provides a description of how exposure is estimated through relevant exposure routes (i.e., inhalation and ingestion). The potential for human exposure was evaluated by combining the COPC concentrations in environmental exposure media with human receptor-specific exposure parameter values, such as consumption rate, body weight, exposure duration, and exposure frequency. The human exposure equations used in the IRAP are those presented in the HHRAP Appendix C. Table 13 presents the receptor-specific exposure parameter values used to estimate COPC exposure. The following sections describe the approaches for modeling human exposure via direct (i.e., inhalation) and indirect (i.e., ingestion) exposure pathways.

4.5.1 Inhalation Exposure Pathways

The potential for risk of adverse human health effects from chronic exposure through direct inhalation of vapor and particulate COPCs was considered for all receptor populations identified in Section 4.2.1. Chemical-specific toxicity values were used as indicators of the potential for individual cancer risk and noncancer hazard as a direct consequence of COPC concentrations in air. This methodology is a conservative approach because it does not account for time spent away from the point of maximum unitized air concentrations or for time spent indoors where particulates are more likely to settle out and not be inhaled (USEPA 2005b).

The potential for noncancer hazards from acute exposure to COPCs through inhalation was evaluated by comparing the maximum 1-hour predicted concentrations in air to AIEC. The potential for acute noncancer hazard from exposure to COPCs through indirect exposure pathways was not evaluated because short-term air concentrations and deposition fluxes typically do not significantly contribute to the risk estimates through indirect exposure pathways (USEPA 2005b).

4.5.2 Ingestion Exposure Pathways

Ingestion exposure, or intake, was calculated as an average exposure per unit of time, expressed in terms of body weight (units of milligrams per kilogram of body weight per day [mg/kd-day]). The generic equation used to calculate chemical intakes through ingestion is the following:

$$I = \frac{C \times IR \times EF \times ED}{BW \times AT}$$

Where:

I = Intake (mg/kg-day)
C = COPC concentration in medium of concern (dependent on exposure medium)
IR = Ingestion rate (dependent on exposure medium)
EF = Exposure frequency (days/year)

ED = Exposure duration (years)
BW = Body weight (kg)
AT = Averaging time (days)

The exposures calculated in this risk assessment are intended to represent reasonable maximum exposure (RME) conditions. Studies of the compounding of conservatism in probabilistic risk assessments show that setting as few as two factors at RME levels or high end while setting the remaining variables at "central tendency" or average values results in output insignificantly different from output generated using all RME input variables. In this HHRA, high end (e.g., 90^{th} percentile) values were used for exposure frequency and duration. All other exposure parameters represent average exposure levels.

4.5.2.1 Food Ingestion Exposure Pathways

Plants and animals within the area that may be affected by combustion emissions may take up (i.e., bioaccumulate) COPCs in the air or deposited onto the earth's surface. The food ingestion pathway considers the potential for human exposure to COPCs that have bioaccumulated in locally grown produce, locally raised beef, chicken, eggs, pork, milk from dairy cows, and locally caught fish and are subsequently consumed. Factors that influence human exposure through food ingestion are diet, food consumption rate, the percentage of the diet that is affected by COPC emissions from the proposed Facility's stack, and the COPC media concentrations.

The food consumption rates used in this HHRA were calculated based on information presented in *Food Consumption and Dietary Levels of Households in Puerto Rico, Summer and Fall 1977* (USDA1982). These consumption rates are comparable to the mean food consumption rates presented in Table 6-1 of HHRAP but do not account for COPC losses as a result of food preparation and cooking. Table 14 presents the calculations and assumptions used to estimate food consumption rates specific to central city ("urban"), suburban ("suburban"), and farmer ("non-metro") populations in Puerto Rico. The food consumption rates used in this HHRA reflect only the portion of the diet that consists of home-grown produce, locally raised animal products, or locally caught fish. However, it was conservatively assumed that 100 percent of that portion of the diet is affected by COPC emissions from the proposed Facility.

4.5.2.2 Soil Ingestion Exposure Pathways

Based on air dispersion modeling and deposition of COPCs, COPC concentrations in soil will vary with distance from the source. The soil ingestion pathway considers the potential for human exposure to COPCs from incidental ingestion of soil, primarily from hand-to-mouth behavior. Factors that influence human exposure through soil ingestion are soil COPC concentrations, the rate of soil ingestion over the time of exposure, and the exposure frequency and duration.

4.5.2.3 Water Ingestion Exposure Pathways

The drinking water ingestion pathway considers the potential for human exposure to COPCs from ingestion of drinking water from a surface water body that may receive emissions deposition. Factors that influence human exposure via surface water ingestion are the estimated COPC concentrations in surface water, the water consumption rate, and the exposure frequency and duration. It was conservatively assumed that treatment processes for drinking water do not alter dissolved COPC concentrations.

Exposure from groundwater sources used as drinking water was not evaluated because it is generally an insignificant pathway (USEPA 2005b).

4.5.2.4 Exposure Frequency

This risk assessment assumes that the receptors in each exposure scenario are exposed to all of the scenario-specific exposure pathways 350 days per year (i.e., the exposure frequency is 350 days/year). This assumption is based on the protective estimate that all receptors spend a maximum of 2 weeks away from the exposure scenario location.

4.5.2.5 Exposure Duration

Exposure duration is the length of time that a receptor is exposed through a specific exposure pathway. A receptor is no longer exposed to COPCs through the direct inhalation exposure pathway after an emission source ceases operation. However, a receptor could be exposed through the indirect exposure pathways for as long as they remain in the assessment area. This risk assessment assumes that receptors are exposed to the long-term average COPC soil or water concentrations (and the subsequent COPC plant or animal concentrations) present in the environment or

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media following a period of time during which there were continuous hazardous waste combustor emissions.

An exposure duration of 6 years was used for the resident child, fisher child, and farmer child exposure scenarios. The adult receptor exposure duration depends on the exposure scenario evaluated. An exposure duration of 30 years was used for the urban resident, suburban resident, and fisher, while an exposure duration of 40 years was assumed for the farmer.

4.5.2.6 Body Weight

An average adult body weight of 70 kg and an average child body weight of 15 kg were used.

4.5.2.7 Averaging Time

The averaging time (AT) depends on the type of toxic effect being assessed. When evaluating exposures for potential noncancer health effects, intakes are calculated by averaging over the period of exposure (equivalent to the receptor-specific exposure duration multiplied by 365 days/year), and the intake is termed average daily dose (ADD). When evaluating the potential for cancer risk, intakes are calculated by prorating the total cumulative intake over a lifetime of 70 years (i.e., 25,550 days), and intake is termed lifetime average daily dose (LADD). This distinction is consistent with the hypothesis that the mechanism of action for each of these health effects endpoints is different. The approach for carcinogens is based on the assumption that a high dose received over a short period of time is equivalent to a corresponding low dose spread over a lifetime.

5. Toxicity Assessment

The toxicity assessment evaluates the relationship between the magnitude of exposure to a constituent and the nature and magnitude of adverse health effects that may result from such exposure. Toxicity studies with laboratory animals or epidemiological studies of human populations provide the data used to develop toxicity values. Toxicity values are used in quantitative risk assessment to relate exposure and the potential for toxic effect to occur.

In general, for constituents regulated as carcinogens, the results of the risk assessment are expressed as the unitless probability cancer will occur (e.g., an increased risk of one-in-a-hundred thousand of cancer occurring over a lifetime because of exposure to that constituent). Toxicity values for assessing carcinogenic potential include cancer slope factors (CSFs) and unit risks (URs). Typically for noncancer effects, the likelihood of adverse effects occurring is expressed in terms of a hazard quotient, which relates the estimated exposure to a threshold dose. Toxicity values for evaluating the potential for noncancer health effects include reference doses (RfDs) and reference concentrations (RfCs). There are a few exceptions to these approaches.

In this risk assessment, toxicity values were chosen from sources following the USEPA-approved hierarchy (2003) as listed below:

- Tier 1: USEPA Integrated Risk Information System (IRIS) (2010b);

- Tier 2: USEPA's Provisional Peer Reviewed Toxicity Values (PPRTVs) developed by the Office of Research and Development (ORD), National Center for Environmental Assessment (NCEA), Superfund Health Risk Technical Support Center (STSC).

- Tier 3: Other USEPA and non USEPA sources of toxicity values. Priority is given to the most current sources of information where the basis is transparent, publically available, and which have been peer reviewed.

Toxicity values used in this assessment are summarized in Table 15.

5.1 Chronic Toxicity Values

For risk assessment purposes, toxic effects are typically classified into two broad categories: non-carcinogenic and carcinogenic. The two general approaches are briefly described in the following sections.

5.1.1 Carcinogenic

Certain chemicals are suspected or known to cause cancer in humans. For most of these chemicals, the USEPA (1989) assumes that a relatively small number of events can elicit changes in a cell, ultimately resulting in uncontrolled cell proliferation and cancer. This is referred to as the non-threshold theory of chemical carcinogenesis, a method used by the USEPA that assumes any exposure poses a risk and there is no threshold. Based on this theory, the USEPA uses a two-part process to evaluate the carcinogenic potency of chemicals: (1) assigning a weight of evidence classification and (2) calculating a CSF.

Each USEPA CSF is accompanied by a weight-of-evidence cancer classification. This classification describes the likelihood, based on the weight of the evidence, that a chemical will cause cancer in humans. Many of the USEPA classifications were developed using the approach detailed in the *Guidelines for Carcinogen Risk Assessment* [51 FR 33992]. These classifications were updated in the USEPA's 2005 Cancer Guidelines (2005a) and now are expressed as a narrative. IRIS assessment may include the older classification and, if recently updated may include both. These are summarized below.

- USEPA 1986 Cancer Classifications
  - Group A - Human Carcinogen.
  - Group B - Probable Human Carcinogen.
  - Group C - Possible Human Carcinogen.
  - Group D - Not Classifiable as to Human Carcinogenicity.
  - Group E - Evidence of Non-carcinogenicity in Humans.
- USEPA 2005 Cancer Classifications

- Carcinogenic to humans
- Likely to be carcinogenic to humans.
- Suggestive evidence of carcinogenic potential.
- Inadequate information to assess carcinogenic potential
- Not likely to be carcinogenic to humans

Those chemicals classified as A and B carcinogens or “Carcinogenic to humans or likely to be carcinogenic to humans” are generally evaluated as carcinogens. Typically, chemicals classified as “C” or “suggestive evidence” are evaluated on a case by case basis.

CSFs are toxicity values that are used to relate dose to ELCR. The CSF is defined as a plausible upper-bound estimate of the probability of a response per unit intake of a chemical over a lifetime. It is based on a linear, continuous exposure, and non-threshold extrapolation model, usually the linearized multistage model (LMS), and is expressed in risk per mg/kg-day ($[mg/kg\text{-}day]^{-1}$). The CSF is then multiplied by the estimated dose to estimate an upper-bound lifetime probability of an individual developing cancer as a result of exposure to a particular carcinogenic agent.

5.1.1.1 Early-life Exposure

Early-life exposure to carcinogenic chemicals with a mutagenic mode of action may result in a greater contribution to cancers appearing later in life (USEPA 2005a). To account for this, the USEPA developed age-dependent adjustment factors (ADAF) that can be applied to the oral and inhalation slope factors for carcinogenic COPCs with a mutagenic mode of action evaluated over a lifetime exposure. The USEPA (2005a) recommends the use of a ten-fold adjustment for exposure during 0 and 2 years of age, a three-fold adjustment for exposures between 2 and 16 years of age, and no adjustment for exposures after turning 16 years of age.

The COPCs in this HHRA for which ADAFs were applied are those identified as mutagenic by the USEPA in the Regional Screening Levels tables (USEPA 2010). These are benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, chrysene, dibenzo(a,h)anthracene, indeno(1,2,30cd)pyrene, and chromium VI.

Chronic toxicity values for carcinogenic COPCs are presented in Table 15.

5.1.2 Noncancer

All chemicals can cause harm at high enough exposure levels. Generally, effects other than cancer (such as neurotoxicity, liver toxicity, damage to the lung, effects on the blood, etc.) are grouped together and are regulated based on the assumption that there is a threshold under which these effects will not occur. Toxicity values protective of noncancer effects almost always are based on a threshold level that, if not exceeded, it is not likely adverse effects will occur.

The toxicity value is based on experimental data. Historically, an experimentally defined dose (no observed effect levels [NOAEL] or the lowest observed effect level [LOAEL]) is the basis for the value. The toxicity is derived by reducing the value to account for uncertainty. If data are sufficient, a benchmark dose is derived using a statistical analysis of the dose response relationship, and the upper confidence limit on that dose is used as the basis for the toxicity value. Again, it is reduced by factors to address uncertainty.

Generally, RfDs and airborne RfCs are toxicity values used to evaluate for non-carcinogenic effects in quantitative risk assessment. Oral RfDs are expressed as acceptable daily doses in mg/kg-day. RfCs are typically expressed as mg of compound per cubic meter of air. In general, RfDs and RfCs are estimates (with uncertainty spanning perhaps one order of magnitude) of a daily exposure to the human population (including sensitive subgroups) that is likely to be without an appreciable risk of deleterious effects during a lifetime of exposure (USEPA 1989).

ATSDR develops minimal risk levels (MRLs) protective of noncancer effects for shorter exposure durations as well as chronic MRLs. These include acute (exposure duration less than 2 weeks) and intermediate (exposure duration greater than 2 weeks but less than a year). MRLs were also used in the HHRA.

Chronic toxicity values used to evaluate noncancer effects are presented on Table 15.

5.2 Acute Toxicity Benchmarks

AIECs are intended to protect against a variety of acute effects ranging from discomfort or mild adverse health effects to serious, debilitating, and potentially life-threatening effects. The toxicity values upon which the AIECs are based are designed to protect a variety of exposure groups including occupational workers, military personnel, and the general public. In general, the criteria are based on 1-hour exposure durations, although in some cases the durations may be up to 24 hours in length.

USEPA guidance (2005a) recommends using the Acute Reference Exposure Levels (Acute RELs) developed by the California EPA as the first choice for AIECs. In the absence of Cal/EPA RELs, acute values from other sources are recommended by the HHRAP. The hierarchy of acute values, in order of preference, is presented below:

1. Cal/EPA Acute RELs – an acute REL represents the concentration in air at or below which no adverse health effects are anticipated in the general population, including sensitive individuals, for a specified exposure period (1999).

2. Acute Inhalation Exposure Guidelines (AEGL-1) – an AEGL-1 value is "the airborne concentration of a substance above which it is predicted that the general population, including susceptible individuals, could experience notable discomfort, irritation, or certain asymptomatic nonsensory effects. However, the effects are not disabling and are transient and reversible upon cessation of exposure" (U.S. Department of Energy [DOE] 2009a). AEGLs are developed by the USEPA, Office of Pollution Prevention and Toxics.

3. Level 1 Emergency Planning guidelines (ERPG-1) – an ERPG-1 value is "the maximum concentration in air below which it is believed nearly all individuals could be exposed for up to one hour without experiencing other than mild transient adverse health effects or perceiving a clearly defined objectionable odor" (DOE 2009a). The ERPGs are developed by the American Industrial Hygiene Association (AIHA).

4. Temporary Emergency Exposure Limits (TEEL-1) – a TEEL-1 value represents "the concentration in air of a substance "above which it is predicted that the general population, including susceptible individuals, could experience discomfort, irritation, or certain asymptomatic, nonsensory effects. However, these effects are not disabling and are transient and reversible upon cessation of exposure" (DOE 2009a). TEELs are developed by the U.S. DOE, Subcommittee on Consequence Assessment and Protective Actions (SCAPA).

The most recent available RELs (CalEPA 2008), AEGLs (USEPA 2008), ERPGs

(AIHA 2009) and TEELs (DOE 2009b) were used for this risk assessment. The AIECs, with their sources, are listed in Table 15.

5.3 Chemicals of Special Interest

5.3.1 Lead

Because of the nature of lead and its effects on developing fetuses and children, lead is evaluated differently than most constituents. Lead is classified as a B2 carcinogen. However, neurotoxicity, a noncancer end point, has been identified as the most sensitive. No threshold has been identified for neurotoxicity, and the USEPA does not provide toxicity values such as RfDs or RfCs that can be used in quantitative risk assessment.

Rather, exposure to lead is typically evaluated in terms of the increase in blood lead (PbB) levels following exposure. The US Department of Health and Human Services' Centers for Disease Control and Prevention and the ATSDR have designated, and the USEPA has adopted, 10 micrograms per deciliter (µg/dL) as a PbB level of concern to protect sensitive populations (e.g., neonates, infants, and children). The USEPA's stated goal for lead is that children have no more than a 5 percent probability of exceeding a PbB level of 10 µg/dL. As such, this level is assumed to also provide protection for adults.

The USEPA guidance (USEPA 2005b) recommends that predicted soil lead concentrations be compared to the USEPA's risk-based screening level for lead in residential soil (400 mg/kg) (1994a, 1994b), and depending on the results, consideration should be given to evaluating lead exposure in child receptors using the USEPA's Integrated Exposure Uptake Biokinetic Model for Lead in Children (IEUBK model) (USEPA 2002). The focus of the IEUBK model is the prediction of PbB levels in young children exposed to lead from several sources and by several routes. The model utilizes four interrelated modules (exposure, uptake, biokinetic, and probability distribution) to mathematically and statistically link environmental lead exposure to PbB levels for a population of young children (0 to 84 months of age). A plausible distribution of PbB levels, centered on a geometric mean PbB level, is predicted and used to estimate the probability that a child's or a population of children's PbB levels will exceed the target PbB level. The USEPA's risk-based screening level for lead in residential soil was, in fact, derived from the IEUBK model and represents a soil lead concentration that would be health protective of young children (ages 0 to 7 years) if also exposed to lead in air, water, and the diet at typical concentrations in these other media in the United States (USEPA 1994a, 1994b).

For this HHRA, the estimated soil lead concentrations at the discrete receptor locations (i.e., urban resident, suburban resident, and farmer) were compared to the USEPA's risk-based screening level for lead in soil. In addition, the estimated air concentration, drinking water concentration, and dietary intake for lead were compared to the typical concentrations used as default values in the IEUBK model.

5.3.2 Polychlorinated Dibenzo-P-Dioxins (PCDDS; Dioxins) and Polychlorinated Dibenzofurans (PCDFs; Furans)

Emissions from waste combustion facilities often contain mixtures of polychlorinated PCDDs and PCDFs. Over 210 isomers of PCDDs and PCDF have been identified, each also having between one and eight positions substituted with chlorine. Few of them, except 2,3,7,8-tetrachloro-dibenzo-p-dioxin (2,3,7,8-TCDD) (Cas. No. 1746-01-6) have received appreciable toxicity testing (see select structures below).

The USEPA has classified the carcinogenicity of PCDDs mixture as "B2" ("probable human carcinogen - based on sufficient evidence of carcinogenicity in animals"). The USEPA IRIS historically provided toxicological assessments and recommended toxicity values for 2,3,7,8-TCDD and hexachlorodibenzo-p-dioxin (HxCDD), mixture of 1,2,3,6,7,8-HxCDD and 1,2,3,7,8,9-HxCDD ; (CASRN 57653-85-7 and 19408-74-3) (USEPA 1991).

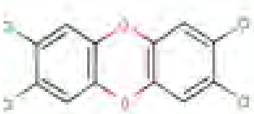
Based on animal study data, the most potent PCDD isomer is 2,3,7,8-TCDD). Cancer risk associated with exposure to other isomers is generally evaluated against the 2,3,7,8-TCDD isomer using toxic equivalency factors (TEFs). Current knowledge of the structure-activity relationships between different PCDDs and PCDFs allows these compounds to be ranked in terms of 2,3,7,8-TCDD.

Each PCDD and PCDF congener (or some cases, group) is assigned a TEF that expresses its potency in terms of 2,3,7,8-TCDD. Thus, while CSF for specific congeners have not been published in IRIS, they may be estimated by multiplying the known, published route-specific slope factor for 2,3,7,8-TCDD by the TEF for the congener.

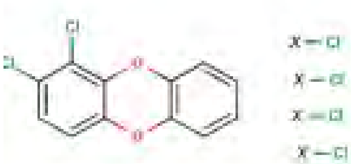
The USEPA generally recommends using the TEFs developed by the World Health Organization (WHO) in 2005 (USEPA 2007, van den Berg et al 2006).

Compound	WHO 2005 TEF	Compound	WHO 2005 TEF
Chlorinated dibenzo-p-dioxins		Chlorinated dibenzofurans	
2,3,7,8-TCDD	1	2,3,7,8-TCDF	0.1
1,2,3,7,8-PeCDD	1	1,2,3,7,8-PeCDF	0.03
1,2,3,4,7,8-HxCDD	0.1	2,3,4,7,8-PeCDF	0.3
1,2,3,6,7,8-HxCDD	0.1	1,2,3,4,7,8-HxCDF	0.1
1,2,3,7,8,9-HxCDD	0.1	1,2,3,6,7,8-HxCDF	0.1
1,2,3,4,6,7,8-HpCDD	0.01	1,2,3,7,8,9-HxCDF	0.1
OCDD	0.0003	2,3,4,6,7,8-HxCDF	0.1
		1,2,3,4,6,7,8-HpCDF	0.01
		1,2,3,4,7,8,9-HpCDF	0.01
		OCDF	0.0003

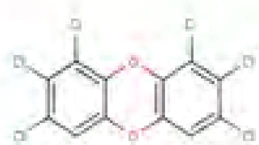
WHO- World Health Organization
TEF-Toxic Equivalency Factor



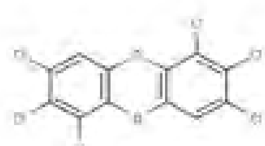
2,3,7,8-Tetrachlorodibenzo-p-dioxin



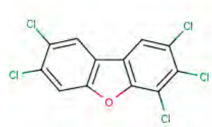
Hexachlorodibenzo-p-dioxin



1,2,3,7,8,9-Hexachloro-dibenzo-p-dioxin



1,2,3,7,8,9-Hexachloro-dibenzo-p-dioxin



2,3,4,7,8-Pentachlorodibenzofuran

The USEPA has not developed health-based RfDs or RfCs to evaluate noncancer health hazards from exposure to the PCDD/PCDF congeners or for 2,3,7,8,-TCDD

TEQ concentrations or intakes. Instead, the HHRAP recommends comparing oral exposure estimates for 2,3,7,8-TCDD TEQ for the PCDD/PCDF congeners to national average background exposure levels. The national average background exposure levels, as 2,3,7,8-TCDD TEQ, are 1 picogram per kilogram per day (pg/kg-day) for adults and 60 pg/kg-day for nursing infants (USEPA 2005b). As noted previously, infant exposure to the PCDD/PCDF congeners through ingestion of their mother's breast milk was evaluated as an additional exposure pathway, separately from the other receptors.

5.3.3 Polynuclear Aromatic Hydrocarbons

PAHs are a group of structurally related compounds. Generally, the critical effect and mechanism of action appears to be similar within the carcinogenic and non-carcinogenic groups. Some are regulated as potential human carcinogens, while others appear to lack carcinogenic potential. Benzo(a)pyrene is the only PAH regulated as a carcinogen that has sufficient data to support the development of a CSF. Thus, the SF for benzo(a)pyrene is generally adjusted using chemical-specific TEFs to estimate potential risk associated with these chemicals. .

Chemicals	**Cancer Classification**		**Relative Potency Factors (TEFs)**
Benzo(a)anthracene	B2	IRIS	0.1
Benzo(b)fluoranthene	B2	IRIS	0.1
Benzo(k)fluoranthene	B2	IRIS	0.01
Benzo[a]pyrene	B2	IRIS	1
Chrysene	B2	IRIS	0.001
Dibenz(a,h)anthracene	B2	IRIS	1
Indeno(1,2,3-cd)pyrene	B2	IRIS	0.1

6. Quantification of Cancer Risk and Noncancer Hazard

This section describes the approach used to combine exposure estimates with toxicity information and generate ELCRs and noncancer hazards. The ELCRs and noncancer hazards for each COPC and exposure scenario evaluated in this HHRA are presented in the Risk Characterization.

6.1 Cancer Risk

The potential for cancer risk from inhalation exposure was estimated by multiplying the annual average air concentration by a chemical-specific unit risk factor (URF). The URF is the increase in the lifetime cancer risk to an individual who is exposed to 1 microgram per cubic meter (µg/m^3) of the COPC in air over a lifetime. The following equation was used to estimate individual ELCR from inhalation exposure:

$$Cancer\ Risk = C_a \times URF$$

Where:

C_a = Annual average COPC concentration in air (g/m^3)

URF = Unit risk factor (g/m^3)$^{-1}$

The potential for cancer risk from indirect (i.e., ingestion) exposure pathways was estimated by multiplying the estimated LADD by the chemical-specific CSF, according to the following equation:

$$Cancer\ Risk = LADD \times CSF$$

Where:

LADD = Lifetime average daily dose (mg/kg-day)

CSF = Cancer slope factor (mg/kg-day)$^{-1}$

For evaluating cancer risk from the mixture of carcinogenic COPCs, the USEPA guidance indicates that, for a given receptor, the individual cancer risk associated with each carcinogenic COPC and exposure pathway/scenario can be summed to arrive at an estimate of the potential for cancer risk from cumulative exposure. This approach assumes independence of action by the COPCs involved (i.e., that there are no synergistic or antagonistic chemical interactions and that all carcinogenic COPCs produce the same effect: cancer).

USEPA generally finds ELCRs between one-in-ten thousand (1x10^{-4}) and one-in-a-million (1E-06) (or less) and noncancer hazard indices of less than 1.0 acceptable. The following compares background risks of developing cancer to an ELCR of 1E-06. The individual cancer risk estimates are expressed as unitless probabilities (e.g., 2E-06 or 2 in 1,000,000) of an individual developing cancer. The unitless probability represents the incremental (or increased) lifetime cancer risk associated with the estimated exposure above the background risk of developing cancer.

In the United States, the background cancer risk, for all cancer sites is approximately 1 in 2 for men and approximately 1 in 3 for women (Altekruse 1975-2007). Therefore, an estimated excess lifetime cancer risk of 1E-05 (2 $x10^{-5}$) represents a 1 in 100,000 increased risk over the background risk of 1 in 2 or 1 in 3. For known or suspected carcinogens, the USEPA (1990) indicates that acceptable exposure levels are generally concentration levels that represent an incremental upper-bound lifetime cancer risk to an individual in the range from 1E-04 (i.e., 1 in 10,000) to 1E-06 (i.e., 1 in 1,000,000) or less.

6.2 Noncancer Hazard

Noncancer hazard expresses the potential for developing noncancer health effects as a result of exposure to COPCs through the scenario-specific exposure pathways and routes. The USEPA indicates that acceptable exposure levels for chemicals with noncancer health effects should represent concentration levels to which the human population, including sensitive subpopulations (e.g., the elderly, young children), may be exposed without adverse health effects during a lifetime or part of a lifetime, incorporating an adequate margin of safety.

The potential for noncancer health effects associated with direct (inhalation) exposure to the COPCs was evaluated in this assessment by comparing the annual average COPC concentration in air to a chronic RfC and by comparing the maximum 1-hour concentration to an AIEC. If the ratio of the air concentration or ADD to the benchmark, termed the hazard quotient, is greater than 1, a potential for adverse noncancer health effects as a result of exposure to that COPC is indicated.

The following equation was used to evaluate the potential for noncancer hazard from inhalation exposures:

$$HQ = \frac{C_a}{RfC \ or \ AIEC}$$

Where:

HQ = Hazard quotient (unitless)
C_a = Annual average or maximum 1-hour COPC concentration in air (mg/m^3)
RfC = Reference concentration (mg/m^3) (for chronic exposure evaluation)
AIEC = Acute inhalation exposure criterion (mg/m^3) (for acute exposure evaluation)

The potential for noncancer health effects associated with indirect exposure to the COPCs was evaluated by comparing the estimated ADD to a reference dose (RfD) derived for a similar exposure period. The following equation was used to calculate individual noncancer hazards from ingestion exposures:

$$HQ = \frac{ADD}{RfD}$$

Where:

HQ = Hazard quotient (unitless)
ADD = Average daily dose (mg/kg-day)
RfD = Reference dose $(mg/kg\text{-}day)^{-1}$

For evaluating noncancer hazard from exposure to the mixture of COPCs, the USEPA guidance assumes that sub-threshold exposures to several chemicals at the same time could result in an adverse health effect. For a given receptor, the sum of the hazard quotients for each COPC and exposure pathway/scenario is the hazard index, assuming that the various noncancer health effects and mechanisms of toxicity of various COPCs are additive. When the hazard index exceeds 1, there may be concern for potential noncancer health effects. Generally, hazard indices are only used in the evaluation of a mixture of chemicals that induce the same effect by the same mechanism of action. However, in this risk assessment, the hazard indices for mixtures of COPCs that can have different effects were used as a screening-level approach, as recommended by the USEPA. Therefore, the HI may overestimate noncancer hazard. For those HIs that exceed 1, cumulative noncancer hazard can also be presented as the sum of the COPC-specific hazard quotients for those chemicals with the same toxic endpoint (e.g., liver toxicity), as determined using the available toxicity information.

7. Risk Characterization

The risk characterization presents the results of the quantitative risk assessment and qualifies the nature of any identified health risks to the corresponding receptor populations.

The following results are contained within this section:

- Estimates of total ELCR and chronic noncancer hazards. The total individual (i.e., COPC-specific) cancer risks and noncancer hazards were summed for each exposure pathway and scenario to arrive at an estimate of the potential for cancer risk and noncancer hazard from cumulative exposure.

- Evaluation of child exposures to lead.

- Evaluation of noncancer hazards of adult exposures to 2,3,7,8-TCDD TEQ and infant exposures via breast milk to 2,3,7,8-TCDD TEQ.

- Evaluation of acute noncancer hazards resulting from direct inhalation of the maximum predicted hourly air concentration of each COPC.

7.1 Chronic Estimated Excess Lifetime Cancer Risks and Noncancer Hazards

The cumulative ELCR and hazard index for each exposure pathway and for the combination of exposure pathways for each receptor population evaluated in the HHRA are summarized in Table 16 and Table 17, respectively. Appendix E presents the COPC-specific cancer risks and hazard quotients by exposure pathway for each receptor population. Application of the USEPA defined age-specific adjustment factors for COPCs identified as having mutagenic potential is shown in Appendix E.

Consistent with USEPA guidance and policy, cancer risks were deemed acceptable if they were within (or less than) the USEPA's acceptable range of 1E-06 to 1E-04. The potential for adverse noncancer health effects was not expected, where the noncancer HI was less than 1.

7.1.1 Excess Lifetime Cancer Risks

The summed ELCRs are summarized below and presented in Table 16.

Excess Lifetime Cancer Risks (across all pathways)							
Urban Resident		**Suburban Resident**		**Farmer**		**Fisher**	
Adult	Child	Adult	Child	Adult	Child	Adult	Child
9E-08	1E-07	1E-07	2E-07	3E-07	4E-07	2E-06	2E-06

The total ELCRs for the Urban Resident, Suburban Resident, and Farmer exposure scenarios are all less than the USEPA acceptable cancer risk range of 1E-06 to 1E-04. The total ELCRs for the Fisher exposure scenario are within the USEPA acceptable cancer risk range of 1E-06 to 1E-04.

The highest ELCRs were estimated for the Fisher Adult and Fisher Child. As described in Section 4.3.2.2, the receptor location for the Fisher exposure scenario was co-located with the Suburban Resident exposure scenario for all exposure pathways except fish ingestion. The fish ingestion pathway was modeled by considering deposition onto Cienaga Tiburones and assuming the Fisher's total dietary intake of fish consists of fish caught in Cienaga Tiburones. Therefore, the cancer risks presented for the Fisher Adult and Fisher Child in Table 16 are equivalent to those estimated for the Suburban Resident Adult and Child for all exposure pathways except fish ingestion. The Urban Resident and Suburban Resident exposure scenarios also considered fish ingestion, but it was assumed that half of the total fish intake of Urban and Suburban Residents consisted of fish caught in the Rio Grande de Arecibo estuary, and the other half consisted of fish caught in Puerto Arecibo.

7.1.2 Noncancer Hazard Indices

The Hazard Indices are summarized below and presented in Table 17.

Hazard Indices (across all pathways)							
Urban Resident		**Suburban Resident**		**Farmer**		**Fisher**	
Adult	Child	Adult	Child	Adult	Child	Adult	Child
0.01	0.01	0.01	0.02	0.02	0.05	0.2	0.5

The hazard indices for all of the receptor populations evaluated in this HHRA are less than the target hazard index of 1. The highest hazard indices were estimated based on the Fisher exposure scenario.

Similar to the cancer risk estimates, the noncancer hazard indices for the Fisher Adult and Fisher Child are equivalent to those estimated for the Suburban Resident Adult and Child for all exposure pathways except fish ingestion (the same exposure scenarios were used to estimate exposure to evaluate ELCR and hazard indices).

7.2 Lead Exposure Evaluation

As described in Section 5.3.1, to evaluate the potential for adverse health effects from exposure to lead, the estimated soil lead concentrations at the discrete receptor locations (i.e., Urban Resident, Suburban Resident, and Farmer) were compared to the USEPA's risk-based screening level for lead in soil. In addition, the estimated air concentration, drinking water concentration, and dietary intake for lead were compared to the typical concentrations used as default values in the IEUBK model. The intent of this comparison is to determine whether exposure to the predicted concentrations and the estimated intakes could result in more than a 5 percent probability of a child's PbB level exceeding 10 µg/dL.

Table 18 presents the predicted soil lead concentrations (which actually reflect the predicted increase in the background soil lead concentrations) at each of the discrete receptor locations, after 30 years of operation of the proposed RRF. The estimated additional soil lead concentrations at the Urban Resident, Suburban Resident, and Farmer receptor locations are, respectively, 0.032 mg/kg, 0.039 mg/kg, and 0.103 mg/kg. These concentrations are a small fraction of the USEPA's risk-based screening level for lead in soil for residential land use of 400 mg/kg (USEPA 1994a, 1994b).

Table 18 also presents the predicted lead concentrations in air at each of the discrete receptor locations, the predicted drinking water concentration in the Superacueducto, and the predicted daily dietary lead intakes for the Urban Resident Child, Suburban Resident Child, Farmer Child, and Fisher Child. These concentrations and intakes are compared in Table 18 to the typical media concentrations and daily dietary intake used as defaults in the IEUBK model (USEPA 1994a, 1994b, 1994c). As shown, the predicted lead concentrations in each medium at each receptor location, and the predicted daily dietary intakes, are just small fractions of the corresponding default values in the IEUBK model. Based on these comparisons, the potential exposure of the child receptor populations to lead emissions from the proposed RRF should not result in increases in PbB levels above the health-protective goal.

7.3 Dioxin/Furan Noncancer Hazard Evaluation

To evaluate the potential for adverse, noncancer health effects from exposure to dioxins/furans, oral exposure estimates for 2,3,7,8-TCDD TEQ were compared to national average background exposure levels. The national average background exposure levels, as 2,3,7,8-TCDD TEQ, are 1 pg/kg-day for adults and 60 pg/kg-day for nursing infants (USEPA 2005b). Infant exposure to the dioxin/furan congeners through ingestion of their mother's breast milk was evaluated as an additional exposure pathway, separately from the other receptors.

Table 19 presents the estimated 2,3,7,8-TCDD TEQ intakes from indirect (i.e., non-inhalation) exposure for each adult and infant receptor, compared to the national average background exposure levels. As indicated, the 2,3,7,8-TCDD TEQ exposure estimates for the Urban Resident Adult, Suburban Resident Adult, Farmer Adult, and Fisher Adult are less than the national average background exposure level. The exposure estimates for all infant receptors are also less than the national average background exposure level.

7.4 Acute Exposure Evaluation

AERMOD was used to predict 1-hour maximum ambient air concentrations, at the acute receptor locations presented on Figure 8, using both the San Juan and Cambalache MET data. These predicted ambient air concentrations (PAIs) were compared to AIECs and noncancer HQs were calculated for each COPC. A hazard index, representing the potential for noncancer adverse health effects from cumulative exposure to the COPCs, was calculated by summing the chemical-specific HQs. As shown in Table 20, the noncancer hazard indices are less than the target hazard index of 1, using either the San Juan or Cambalache MET data. Based on this analysis, acute adverse health effects from exposure to the maximum hourly air concentrations are not expected.

8. Uncertainty Analysis

The HHRA process relies on a set of assumptions and estimates with varying degrees of certainty. Major sources of uncertainty in risk assessment include the following:

- Natural variability (e.g., differences in body weight in a population)
- Assumptions in the models used to estimate key inputs (e.g., dose-response models)
- Assumptions about basic physical, chemical and biological properties and processes (e.g., the affinity of a chemical for soil and its solubility in water)

Perhaps the greatest single source of uncertainty in risk-based assessment is the dose-response relationships, particularly the basis of carcinogenic slope factors. Additional uncertainty may be associated with estimation of dose rate through default exposure assumptions. These and other sources of uncertainty and their anticipated effect in estimated risks associated with the proposed Facility are summarized below:

- Use of the RME scenario includes assumptions regarding the types of exposure that may occur, the frequency and duration of those exposures, and the concentration of chemicals at the point of exposure. As such, it is intended to provide a conservative estimate of intake and is therefore most likely to overestimate rather than underestimate exposure and risk.
- Use of toxicity criteria (e.g., CSFs and RfDs) is intentionally designed to be conservative. For example, the extrapolation of animal carcinogen bioassay results to human risk at much lower levels of exposure involves several assumptions regarding the effect threshold, interspecies extrapolation, high- to low-dose extrapolation and route-to-route extrapolation. The scientific validity of using multiple conservative assumptions is uncertain; each of the individual extrapolations is designed to prevent underestimation of risk. Together, they result in an unquantifiable but potentially significant overestimation of risk. Specifically, the extrapolation of cancer potency from laboratory animals to humans, which forms the basis for the ELCR estimates, may be associated with uncertainties ranging from as much as three to five orders of magnitude (1,000- to 100,000-fold) for selected chemicals. This is likely to contribute to an overestimation of risk.

- Use of toxicity values based on route extrapolations contributes to uncertainty (may overestimate or underestimate risk).

- No emissions data are available for PCBs and there is significant uncertainty associated with whether PCBs would actually be emitted. However since some sources indicate they might be produced and emitted from combustion sources, a separate analysis was completed to address this uncertainty. Total PCBs were modeled in IRAP using the chemical-specific fate and transport parameters and toxicity values specific to Aroclor 1254. The ECLRs for all receptor populations evaluated are well less than the USEPA acceptable range of 1E-06 to 1E-04 (see Table 20). Similarly, the noncancer hazard indices are all less than the target HI of 1 (see Table 21).Therefore, adverse health effects from human exposure to PCBs in combustion emissions from the proposed RRF are not expected.

Overall, assumptions used to complete this assessment were conservative and are expected to overestimate cancer risks and noncancer hazards associated with emissions from the proposed RRF.

9. Summary and Conclusions

Results of the quantitative risk assessment are summarized in the following tables:

Excess Lifetime Cancer Risks (across all pathways)							
Urban Resident		**Suburban Resident**		**Farmer**		**Fisher**	
Adult	Child	Adult	Child	Adult	Child	Adult	Child
9E-08	1E-07	1E-07	2E-07	3E-07	4E-07	2E-06	2E-06

Noncancer Hazard Indices (across all pathways)							
Urban Resident		**Suburban Resident**		**Farmer**		**Fisher**	
Adult	Child	Adult	Child	Adult	Child	Adult	Child
0.01	0.01	0.01	0.02	0.02	0.05	0.2	0.5

USEPA generally finds ELCRs between one-in-ten-thousand (1E-04) and one-in-a-million (1E-06) (or less) and noncancer hazard indices of less than 1 acceptable.

Based on the assumptions and scenarios used to evaluate potential risks and hazards associated with emissions from the proposed RRF, risks and hazards fall within or less than the acceptable range. Based on the analysis completed in this HHRA, the proposed RRF does not pose a concern for human health.

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TABLE 1
Emission Rates for Chemicals of Potential Concern

Chemical of Potential Concern	CAS #	Emission Rate per Flue (g/s)	Emission Rate per Flue Adjusted by 0.38 for Particulates Only	Basis of Emission Rate
Polycyclic Aromatic Hydrocarbons				
Acenapthene	83-32-9	2.44E-08	N/A	Annual average emission rate calculated using stack test data from SEMASS Unit 3
Acenapthylene	208-96-8	1.44E-08	N/A	
Anthracene	120-12-7	1.34E-08	N/A	
Benzo(a)anthracene	56-55-3	1.17E-08	N/A	
Benzo(a)pyrene	50-32-8	1.05E-08	N/A	
Benzo(b)fluoranthene	205-99-2	9.23E-09	N/A	
Benzo(k)fluoranthene	207-08-9	1.01E-08	N/A	
Benzo(e)pyrene	192-97-2	9.84E-09	N/A	
Benzo(g,h,i)perylene	191-24-2	1.28E-08	N/A	
2-Chloronaphthalene	91-58-7	2.51E-08	N/A	
Chrysene	218-01-9	1.25E-08	N/A	
Dibenzo(a)anthracene	53-70-3	1.45E-08	N/A	
Fluoranthene	206-44-0	9.75E-09	N/A	
Indeno(1,2,3-cd)pyrene	193-39-5	1.11E-08	4.22E-09	
2-Methylnaphthalene	91-57-6	2.30E-08	N/A	
Naphthalene	91-20-3	1.56E-07	N/A	
Perylene	198-55-0	1.12E-08	N/A	
Pyrene	129-00-0	8.07E-09	N/A	
Polychlorinated dibenzo-p-dioxins (PCDD) / Polychlorinated dibenzofurans (PCDF)				
2,3,7,8-Tetrachlorodibenzo-p-dioxin (TCDD)	1746-01-6	8.46E-11	N/A	Annual average emission rate calculated using stack test data from SEMASS Unit 3
1,2,3,7,8-Pentachlorodibenzo-p-dioxin (PeCDD)	40321-76-4	1.87E-10	N/A	
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin (HxCDD)	39227-28-6	1.20E-10	4.56E-11	
1,2,3,6,7,8-HxCDD	57653-85-7	2.98E-10	1.13E-10	
1,2,3,7,8,9-HxCDD	19408-74-3	2.99E-10	1.14E-10	
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin (HpCDD)	35822-46-9	1.68E-09	6.38E-10	
1,2,3,4,6,7,8,9-Octachlorodibenzo-p-dioxin (OCDD)	3268-87-9	3.88E-09	N/A	
2,3,7,8-Tetrachlorodibenzofuran (TCDF)	51207-31-9	1.56E-09	N/A	
1,2,3,7,8-Pentachlorodibenzofuran (PeCDF)	57117-41-6	3.73E-10	N/A	
2,3,4,7,8-PeCDF	57117-31-4	5.14E-10	N/A	
1,2,3,4,7,8-Hexachlorodibenzofuran (HxCDF)	70648-26-9	7.03E-10	2.67E-10	
1,2,3,6,7,8-HxCDF	57117-44-9	4.56E-10	N/A	
2,3,4,6,7,8-HxCDF	60851-34-5	4.28E-10	N/A	
1,2,3,7,8,9-HxCDF	72918-21-9	9.61E-11	N/A	
1,2,3,4,6,7,8-Heptachlorodibenzofuran (HpCDF)	67562-39-4	1.23E-09	4.67E-10	
1,2,3,4,7,8,9-HpCDF	55673-89-7	1.27E-10	N/A	
1,2,3,4,6,7,8,9-Octachlorodibenzofuran (OCDF)	39001-02-0	9.33E-10	3.55E-10	

TABLE 1
Emission Rates for Chemicals of Potential Concern

Chemical of Potential Concern	CAS #	Emission Rate per Flue (g/s)	Emission Rate per Flue Adjusted by 0.38 for Particulates Only	Basis of Emission Rate
Metals				
Antimony	7440-36-0	2.76E-04	1.05E-04	Annual average emission rate calculated using stack test data from SEMASS Unit 3
Arsenic	7440-38-2	3.46E-05	1.31E-05	
Beryllium	7440-41-7	3.52E-06	1.34E-06	
Cadmium	7440-43-9	3.97E-05	1.51E-05	
Chromium (as Cr VI)	18540-29-9	1.02E-04	3.88E-05	
Cobalt	7440-48-4	8.84E-06	3.36E-06	
Copper	18540-29-9	1.32E-04	5.02E-05	
Lead	7440-92-1	1.16E-03	4.39E-04	
Manganese	7439-96-5	2.27E-04	8.63E-05	
Mercury, total	--	3.97E-04	N/A	
Mercury, elemental	7439-97-6	1.59E-06	N/A	Calculated using Mercury Wizard in IRAP-h View. Assumed 51.8% lost to global cycle, 48.0% deposited as divalent mercury, and 0.2% deposited as elemental mercury.
Mercury, divalent (as mercuric chloride)	7487-94-7	3.82E-04	N/A	
Molybdenum	7439-98-7	1.46E-04	5.55E-05	Annual average emission rate calculated using stack test data from SEMASS Unit 3
Nickel	7440-02-0	7.84E-05	2.98E-05	
Selenium	7782-49-2	3.56E-05	1.35E-05	
Tin	7440-31-5	5.04E-04	1.92E-04	
Vanadium	7440-62-2	2.64E-05	1.00E-05	
Zinc	7440-66-6	1.32E-02	5.00E-03	
Acid Gases				
Hydrogen chloride	7647-01-0	8.40E-01	N/A	SEMASS stack test data
Hydrogen fluoride	7664-39-3	1.81E-01	N/A	manufacturing specifications

Notes

Except where noted, the emission rates are based on SEMASS Unit 3 stack test data and reflect actual expected emissions of a single combustion unit of the proposed Facility.

The emission rates for elemental mercury and mercuric chloride were estimated using the mercury wizard in IRAP-h View. The mercury wizard apportions the total mercury emissions between the two species, according to assumptions regarding how much elemental mercury is lost to the global cycle and how much elemental and divalent mercury is deposited within the assessment area.

Due to the absence of stack test data for hydrogen fluoride, the emission rate is based on manufacturing specifications.

TCDD TEQ - tetrachlorodibenzo-p-dioxin toxic equivalency

TABLE 2
Assumed Emissions Phase for each COPC

Chemical of Potential Concern (COPC)	CAS #	Fv (unitless)	Assumed emitted as vapor, particle, or vapor with portion particle-bound (V, P, PB)
Polycyclic Aromatic Hydrocarbons			
Acenaphthene	83-32-9	1	V
Acenapthylene	208-96-8	1	V
Anthracene	120-12-7	0.998	99.8% V, 0.2% PB
Benzo(a)anthracene	56-55-3	0.483	48.3% V, 51.7% PB
Benzo(a)pyrene	50-32-8	0.294	29.4% V, 70.6% PB
Benzo(b)fluoranthene	205-99-2	0.966	96.6% V, 3.4% PB
Benzo(k)fluoranthene	207-08-9	0.273	27.3% V, 72.7% PB
Benzo(e)pyrene	192-97-2	N/A	--
Benzo(g,h,i)perylene	191-24-2	N/A	--
2-Chloronaphthalene	91-58-7	N/A	--
Chrysene	218-01-9	0.744	74.4% V, 25.6% PB
Coronene	191-07-1	N/A	--
Dibenzo(a,h)anthracene	53-70-3	0.055	5.5% V, 94.5% PB
Fluoranthene	206-44-0	0.992	99.2% V, 0.8% PB
Indeno(1,2,3-cd)pyrene	193-39-5	0.005	P
2-Methylnaphthalene	91-57-6	1	V
Naphthalene	91-20-3	1	V
Perylene	198-55-0	N/A	--
Pyrene	129-00-0	0.994	99.4% V, 0.6% PB
Polychlorinated dibenzo-p-dioxins (PCDD) / Polychlorinated dibenzofurans (PCDF)			
2,3,7,8-Tetrachlorodibenzo-p-dioxin (TCDD)	1746-01-6	0.664	66.4% V, 33.6% PB
1,2,3,7,8-Pentachlorodibenzo-p-dioxin (PeCDD)	40321-76-4	0.117	11.7 %V, 88.3% PB
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin (HxCDD)	39227-28-6	0.024	P
1,2,3,6,7,8-HxCDD	57653-85-7	0.029	P
1,2,3,7,8,9-HxCDD	19408-74-3	0.016	P
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin (HpCDD)	35822-46-9	0.003	P
1,2,3,4,6,7,8,9-Octachlorodibenzo-p-dioxin (OCDD)	3268-87-9	0.002	P
2,3,7,8-Tetrachlorodibenzofuran (TCDF)	51207-31-9	0.77	77% V, 23% PB
1,2,3,7,8-Pentachlorodibenzofuran (PeCDF)	57117-41-6	0.268	26.8% V, 73.2% PB
2,3,4,7,8-PeCDF	57117-31-4	0.221	22.1% V, 77.9% PB
1,2,3,4,7,8-Hexachlorodibenzofuran (HxCDF)	70648-26-9	0.049	P
1,2,3,6,7,8-HxCDF	57117-44-9	0.052	5.2% V, 94.8% PB
2,3,4,6,7,8-HxCDF	60851-34-5	0.055	5.5% V, 94.5% PB
1,2,3,7,8,9-HxCDF	72918-21-9	0.09	9% V, 91% PB
1,2,3,4,6,7,8-Heptachlorodibenzofuran (HpCDF)	67562-39-4	0.01	P
1,2,3,4,7,8,9-HpCDF	55673-89-7	0.057	5.7% V, 94.3% PB
1,2,3,4,6,7,8,9-Octachlorodibenzofuran (OCDF)	39001-02-0	0.002	P
Other Organic Chemicals			
Polychlorinated biphenyls (Aroclor 1254)	11097-69-1	0.992	99.2% V, 0.8% PB
Metals			
Antimony	7440-36-0	0	P
Arsenic	7440-38-2	0	P
Beryllium	7440-41-7	0	P
Cadmium	7440-43-9	0	P
Chromium (as Cr III)	7440-47-3	0	P
Chromium VI	18540-29-9	0	P
Cobalt	7440-48-4	0	P
Copper	18540-29-9	0	P
Lead	7440-92-1	0	P
Manganese	7439-96-5	0	P
Mercury, elemental	7439-97-6	1	VM
Mercury, divalent (as mercuric chloride)	7487-94-7	0.85	85% V, 15% PB
Molybdenum	7439-98-7	0	P
Nickel	7440-02-0	0	P
Selenium	7782-49-2	0	P
Tin	7440-31-5	0	P
Vanadium	7440-62-2	0	P
Zinc	7440-66-6	0	P
Acid Gases			
Hydrogen chloride	7647-01-0	1	V
Hydrogen fluoride	7664-39-3	1	V

Footnotes:
Fv and H were taken from HHRAP COPC-database.

Assumptions regarding speciation (from HHRAP page 3-8):
1) most metals and organic COPCs with low volatility (Fv<0.05) occur only in the particle phase.
2) highly volatile organic COPCs occur only in the vapor phase (Fv = 1)
3) the remaining organic COPCs occur with a portion of the vapor condensed onto the surface of particulates

TABLE 3
Summary of Land Uses within 10 km and 3 km Radii of Proposed Facility Site

Land Use Description	10 Km Radius		3 Km Radius	
	Total Area (m^2) per Land Use Type	Percent Total Land Area	Total Area (m^2) per Land Use Type	Percent Total Land Area
Bare Exposed Rock	187,478	0.1	16,972	0.1
Beaches	719,244	0.4	208,299	2
Commercial and Services	3,269,535	2	709,132	5
Confined Feeding Operations	24,643	0.01	--	--
Croplands and Pasture	43,999,911	27	7,028,275	53
Deciduous Forest Land	15,164,398	9	17,260	0.1
Evergreen Forest Land	26,632,501	16	77,256	0.6
Herbaceous Rangeland	18,057,887	11	1,066,935	8
Industrial / Urban	3,917,900	2	763,967	6
Orchards, Groves, Vineyards, Nurseries, and Ornamental Horticultural Areas	805,216	0.5	197,614	1
Other agricultural land	789,967	0.5	--	--
Reservoirs / Lakes	298,038	0.2	--	--
Residential	36,355,569	22	1,907,815	14
Shrub and Brush Rangeland	8,152,800	5	299,857	2
Streams and canals	1,114,105	0.7	338,636	3
Strip Mines Quarries, and Gravel Pits	1,042,029	0.6	16,987	0.1
Transitional Area	710,827	0.4	1,243	0.01
Transportation, Communications, and Utilities	3,672,590	2	638,885	5
Forested Wetland	2,114,954	1	782,773	6
Nonforested Wetland	12,935,158	8	3,259,347	25
Total Land Area (m^2) within Designated Radius:	164,914,639		13,289,134	

Notes

Bays and Estuaries (and the Atlantic Ocean) account for approximately 45% of the total area within a 10 km and 3 km radius.

Table 4
Human Exposure Scenarios Evaluated in HHRA

	Urban Resident		Suburban Resident		Farmer		Fisher	
Relevant Exposure Pathways	Adult	Child	Adult	Child	Adult	Child	Adult	Child
Air Inhalation	X	X	X	X	X	X	X	X
Soil Ingestion	X	X	X	X	X	X	X	X
Ingestion of Drinking Water from Surface Water Source	X	X	X	X	X	X	X	X
Ingestion of Home-grown Produce			X	X	X	X	X	X
Ingestion of Beef					X	X		
Ingestion of Milk from Dairy Cows	X [1]	X [1]	X [1]	X [1]	X	X	X [1]	X [1]
Ingestion of Poultry					X	X		
Ingestion of Eggs					X	X		
Ingestion of Pork					X	X		
Ingestion of Locally-caught Fish	X	X	X	X			X	X
Ingestion of Mothers' Milk (infant only)	X [2]		X [2]		X [2]		X [2]	

Notes

HHRA - Human Health Risk Assessment

1 - To evaluate this exposure pathway, it was assumed 100% of milk consumed was produced at local dairies.

2 - The receptor evaluated for this exposure pathway is the infant of an adult mother, who is exposed to COPCs through the pathways that are relevant to each exposure scenario. Infant exposure to only PCDDs/PCDFs in breast milk is evaluated.

Table 5
Summary of Water Bodies and Watersheds Included in HHRA

Exposure Pathway	Waterbody (Type) [1]	Corresponding Watershed	Basis [2]
Drinking Water Ingestion	Superacueducto (Lake)	"Reservoir WS"	Identified as source of drinking water for residents of Arecibo and the surrounding suburban residential areas.
Fish Ingestion	Rio Grande Arecibo de Estuary (Stream)	"Estuary WS"	The Rio Grande Arecibo (RGA) estuary has three extensions including the river and two other courses that may represent past flows of the RGA. People fish these extensions by small boat, from the water's edge, or from small abandoned bridges. Sirajo goby larvae are caught with nets at the RGA mouth. Other fish species commonly caught for food are snook and schoolmaster.
Fish Ingestion	Cienaga Tiburones (Lake)	"Tiburones WS"	Puerto Rico's largest wetland, it is influenced by salt and fresh water and has an open connection with the Atlantic Ocean. People fish from small boats or from the water's edge throughout the entire wetland area. There are approximately 100-120 people who fish this wetland, primarily for blue crab, and are considered subsistence fishermen. A point identified by CSA as "Asociacion de Pescadores de Jarealito" also coincides with this wetland.
Fish Ingestion	Puerto Arecibo (Lake)	None	Atlantic Ocean coastal waters were identified as a source of mutton, snapper, bar jack, palometa, permit, and yellowfin snapper. Points identified as "Arecibo Bay Breakwater" and "Arecibo Outboard Club" also coincide with this waterbody.

Notes
HHRA - Human Health Risk Assessment
1 - Waterbody type is either "lake" or "stream" and is entered into IRAP-h View. Different fate and transport models are used to calculate surface water and sediment concentrations in lakes versus streams.
2 - Based on consultation with CSA.

Table 6
Site-Specific Exposure Parameters

Exposure Parameter	Units	Human Receptor Population							
		Urban Resident		Suburban Resident		Farmer		Fisher	
		Adult	Child	Adult	Child	Adult	Child	Adult	Child
Soil type at modeled receptor location		Ur, urban (mixed types)		RtF: rock outcrop		98.5% To,	1.5% Vm	RtF: rock outcrop	
Soil dry bulk density	g/cm^3	1.5	1.5	1.5	1.5	1.35-1.55	1.35-1.55	1.5	1.5
Forage fraction grown on contaminated soil eaten by Cattle	--	N/A	N/A	N/A	N/A	1	1	N/A	N/A
Grain fraction grown on contaminated soil eaten by Cattle	--	N/A	N/A	N/A	N/A	1	1	N/A	N/A
Silage fraction grown on contaminated soil eaten by Cattle	--	N/A	N/A	N/A	N/A	1	1	N/A	N/A
Qty of forage eaten by Cattle each day	kg DW/day	N/A	N/A	N/A	N/A	3.8	3.8	N/A	N/A
Qty of grain eaten by Cattle each day	kg DW/day	N/A	N/A	N/A	N/A	3.8	3.8	N/A	N/A
Qty of silage eaten by Cattle each day	kg DW/day	N/A	N/A	N/A	N/A	1	1	N/A	N/A
Grain fraction grown on contaminated soil eaten by Chicken	--	N/A	N/A	N/A	N/A	1	1	N/A	N/A
Qty of grain eaten by Chicken each day	kg DW/day	N/A	N/A	N/A	N/A	0.2	0.2	N/A	N/A
Annual average evapotranspiration	cm/year	163	163	163	163	163	163	163	163
Fish lipid content	--	N/A	N/A	N/A	N/A	N/A	N/A	0.03	0.03
Fraction of Chicken's diet that is soil	--	N/A	N/A	N/A	N/A	0.1	0.1	N/A	N/A
Universal gas constant	$atm\text{-}m^3/mol\text{-}K$	8.21E-05	8.21E-05	8.21E-05	8.21E-05	8.21E-05	8.21E-05	8.21E-05	8.21E-05
Annual average irrigation	cm/year	0	0	0	0	0	0	0	0
Plant surface loss coefficient	year^-1	N/A	N/A	18	18	18	18	18	18
Fraction of mercury emissions NOT lost to global cycle	--	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24
Fraction of mercury speciated to MHg in produce	--	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22
Fraction of mercury speciated to MHg in soil	--	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Forage fraction grown on contaminated soil eaten by Dairy Cows	--	N/A	N/A	N/A	N/A	1	1	N/A	N/A
Grain fraction grown on contaminated soil eaten by Dairy Cows	--	N/A	N/A	N/A	N/A	1	1	N/A	N/A
Silage fraction grown on contaminated soil eaten by Dairy Cows	--	N/A	N/A	N/A	N/A	1	1	N/A	N/A
Qty of forage eaten by Dairy Cows each day	kg DW/day	N/A	N/A	N/A	N/A	6.2	6.2	N/A	N/A
Qty of grain eaten by Dairy Cows each day	kg DW/day	N/A	N/A	N/A	N/A	12.2	12.2	N/A	N/A
Qty of silage eaten by Dairy Cows each day	kg DW/day	N/A	N/A	N/A	N/A	1.9	1.9	N/A	N/A
Averaging time	years	1	1	1	1	1	1	1	1
Body weight of an infant	kg	9.4	9.4	9.4	9.4	9.4	9.4	9.4	9.4
Exposure duration of infant to breast milk	years	1	1	1	1	1	1	1	1
Proportion of ingested dioxin that is stored in fat	--	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
Proportion of mother's weight that is fat	--	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Fraction of fat in breast milk	--	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
Fraction of ingested contaminant that is absorbed	--	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
Half-life of dioxin in adults	days	2555	2555	2555	2555	2555	2555	2555	2555
Ingestion rate of breast milk	kg/day	0.688	0.688	0.688	0.688	0.688	0.688	0.688	0.688
Viscosity of air corresponding to air temp.	g/cm-s	1.81E-04	1.81E-04	1.81E-04	1.81E-04	1.81E-04	1.81E-04	1.81E-04	1.81E-04
Average annual precipitation	cm/year	80	80	80	80	80	80	80	80
Grain fraction grown on contaminated soil eaten by Pigs	--	N/A	N/A	N/A	N/A	1	1	N/A	N/A
Silage fraction grown on contaminated soil eaten by Pigs	--	N/A	N/A	N/A	N/A	1	1	N/A	N/A
Qty of grain eaten by Pigs each day	kg DW/day	N/A	N/A	N/A	N/A	3.3	3.3	N/A	N/A
Qty of silage eaten by Pigs each day	kg DW/day	N/A	N/A	N/A	N/A	1.4	1.4	N/A	N/A
Qty of soil eaten by Cattle	kg/day	N/A	N/A	N/A	N/A	0.5	0.5	N/A	N/A
Qty of soil eaten by Chicken	kg/day	N/A	N/A	N/A	N/A	0.022	0.022	N/A	N/A
Qty of soil eaten by Dairy Cows	kg/day	N/A	N/A	N/A	N/A	0.4	0.4	N/A	N/A
Qty of soil eaten by Pigs	kg/day	N/A	N/A	N/A	N/A	0.37	0.37	N/A	N/A

Table 6
Site-Specific Exposure Parameters

Exposure Parameter	Units	Human Receptor Population							
		Urban Resident		Suburban Resident		Farmer		Fisher	
		Adult	Child	Adult	Child	Adult	Child	Adult	Child
Average annual runoff	cm/year	76	76	76	76	76	76	76	76
Density of air	g/cm^3	1.21E-03	1.21E-03	1.21E-03	1.21E-03	1.21E-03	1.21E-03	1.21E-03	1.21E-03
Solids particle density	g/cm^3	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7
Interception fraction - edible portion Aboveground	--	N/A	N/A	0.39	0.39	0.39	0.39	0.39	0.39
Interception fraction - edible portion Forage	--	N/A	N/A	0.5	0.5	0.5	0.5	0.5	0.5
Interception fraction - edible portion Silage	--	N/A	N/A	0.46	0.46	0.46	0.46	0.46	0.46
Ambient air temp.	K	301	301	301	301	301	301	301	301
Temperature correction factor	--	1.026	1.026	1.026	1.026	1.026	1.026	1.026	1.026
Soil volumetric water content	ml/cm^3	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Length of plant exposed to deposition - Aboveground	years	N/A	N/A	0.16	0.16	0.16	0.16	0.16	0.16
Length of plant exposed to deposition - Forage	years	N/A	N/A	0.12	0.12	0.12	0.12	0.12	0.12
Length of plant exposed to deposition - Silage	years	N/A	N/A	0.16	0.16	0.16	0.16	0.16	0.16
Dry deposition velocity	cm/s	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Dry deposition velocity for mercury	cm/s	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9
Wind velocity	m/s	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5
Yield/standing crop biomass - edible portion Aboveground	$kg\ DW/m^2$	N/A	N/A	2.24	2.24	2.24	2.24	2.24	2.24
Yield/standing crop biomass - edible portion Forage	$kg\ DW/m^2$	N/A	N/A	0.24	0.24	0.24	0.24	0.24	0.24
Yield/standing crop biomass - edible portion Silage	$kg\ DW/m^2$	N/A	N/A	0.8	0.8	0.8	0.8	0.8	0.8
Soil mixing zone depth	cm	2	2	2	2	2	2	2	2
Soil mixing zone depth for produce	cm	N/A	N/A	20	20	20	20	20	20

Table 7
Water Body and Watershed Parameters - Superacueducto

Waterbody: Superacueducto
Watershed: "Reservoir WS"
Relevant Exposure Pathway: Drinking Water Ingestion

	Parameter	Value	Units	Source	Notes
WATERBODY PARAMETERS					
Superacueducto	Waterbody surface area (SA)	299,430	m^2	Aerial photograph interpretation	Calculated as area of waterbody drawn in IRAP-h View; waterbody polygon was drawn by tracing aerial photograph
	Depth of water column	3.79	m	Calculated: (V/SA)	Calculation is consistent with information from Thames Water, which indicates maximum (6m) and minimum (2m) depths of raw water lagoon
	Volume (V)	1.14E+06	m^3	Thames Water, Puerto Rico	Equivalent to 300 million gallons
	Average volumetric flow rate through waterbody	1.38E+08	m^3/year	Thames Water, Puerto Rico	Equivalent to plant output of 100 million gallons daily
	Fraction of organic carbon in bottom sediment	0.04	--	HHRAP default (USEPA, 2005b)	A bed sediment fraction organic carbon of 0.03 to 0.05 is reasonable for waterbodies where surface soil organic carbon within the watershed is 0.01 (USEPA, 2005).
	Total suspended solids concentration	10	mg/L	HHRAP default (USEPA, 2005b)	
WATERSHED PARAMETERS					
"Reservoir WS"	Watershed surface area	574,662	m^2	GIS data	Calculated using IRAP-h View
	Watershed area receiving COPC deposition	275,231	m^2	Calculated	Difference between watershed and waterbody areas
	Impervious cover	2	%	Professional judgment	Based on aerial photograph interpretation
	Total impervious area receiving COPC deposition	11,493	m^2	Calculated	Equivalent to watershed surface area x % impervious area
	USLE cover and management factor	0.1	--	HHRAP default (USEPA, 2005b)	Values up to 0.1 reflect dense vegetation cover, such as pasture grass. The HHRAP default value is recommended for both grass and agricultural crops (USEPA, 2005).
	USLE erodibility factor	0.17	ton/acre	USDA NRCS soil survey	Calculated by factoring in % soil type and erodibility factor of each soil type within each watershed area
	USLE length-slope factor	4.25	unitless	Wischmeier and Smith, 1978	Calculated slope (%) using digital elevation data; slope length corresponds to distance from highest point within watershed to the point where the slope gradient levels out
	USLE supporting practice factor	1	--	HHRAP default (USEPA, 2005b)	The HHRAP default value conservatively reflects the absence of any erosion control measures (e.g., terraces or contour cropping) (USEPA, 2005).
	USLE rainfall and runoff factor	53.13	$(year)^{-1}$	Rojas-Gonzalez, 2008	Modified R factor based on monthly and annual precipitation

Notes
IRAP-h View - Industrial Risk Assessment Program, Human Health

Table 8
Water Body and Watershed Parameters - Rio Grande de Arecibo Estuary

Waterbody: Rio Grande de Arecibo Estuary
Watershed: "Estuary WS"
Relevant Exposure Pathway: Fish Ingestion

	Parameter	Value	Units	Source	Notes
WATERBODY PARAMETERS					
Rio Grande de Arecibo Estuary	Waterbody surface area	104,353	m^2	Aerial photograph interpretation	Calculated as area of waterbody drawn in IRAP-h View; waterbody polygon was drawn by tracing aerial photograph
	Depth of water column	1.3	m	USGS stream gage 50029000, Rio Grande de Arecibo at Central Cambalache	Corresponds to average gage height of 4.29 feet from 166 manual measurements collected from 1996-2010
	Current velocity (v)	0.577	m/s		Corresponds to average channel velocity of 1.89 feet per second from 166 manual measurements collected from 1996-2010
	Average volumetric flow rate through waterbody*	4.23E+08	m^3/year		Corresponds to average annual discharge of 473 cubic feet per second from approved daily mean time-series data from 1970-2008
	Fraction of organic carbon in bottom sediment	0.04	--	HHRAP default (USEPA, 2005b)	A bed sediment fraction organic carbon of 0.03 to 0.05 is reasonable for waterbodies where surface soil organic carbon within the watershed is 0.01 (USEPA, 1998).
	Total suspended solids (TSS) concentration	36	mg/L	CSA study	Average TSS concentration from Station 9, corresponding to area of Rio Grande de Arecibo in estuary
WATERSHED PARAMETERS					
"Estuary WS"	Watershed surface area	426,825	m^2	GIS data	Calculated using IRAP-h View
	Watershed area receiving COPC deposition	322,472	m^2	Calculated	Difference between watershed and waterbody areas
	Impervious cover	15	%	Professional judgment	Based on aerial photograph interpretation
	Total impervious area receiving COPC deposition	64,024	m^2	Calculated	Equivalent to watershed surface area x % impervious area
	USLE cover and management factor	0.1	--	HHRAP default (USEPA, 2005b)	Values up to 0.1 reflect dense vegetation cover, such as pasture grass. The HHRAP default value is recommended for both grass and agricultural crops (USEPA, 2005).
	USLE erodibility factor	0.17	ton/acre	USDA NRCS soil survey	Calculated by factoring in % soil type and erodibility factor of each soil type within each watershed area
	USLE length-slope factor	0	unitless	Wischmeier and Smith, 1978	Calculated slope (%) using digital elevation data; slope length corresponds to distance from highest point within watershed to the point where the slope gradient levels out
	USLE supporting practice factor	1	--	HHRAP default	The HHRAP default value conservatively reflects the absence of any erosion control measures (e.g., terraces or contour cropping) (USEPA, 2005).
	USLE rainfall and runoff factor	53.13	$(year)^{-1}$	Rojas-Gonzalez, 2008	Modified R factor based on monthly and annual precipitation

Notes
IRAP-h View - Industrial Risk Assessment Program, Human Health
There is some uncertainty associated with the water column depth, current velocity, and average volumetric flow rate, because the USGS stream gage data represent a stream segment approximately 2 km above the estuary and not the estuary itself.
*This does not account for the effects of tides, which would flush the estuary and effectively reduce COPC waterbody concentrations.

Table 9
Water Body and Watershed Parameters - Cienaga Tiburones

Waterbody: Cienaga Tiburones
Watershed: "Tibuornes WS"
Relevant Exposure Pathway: Fish Ingestion

	Parameter	Value	Units	Source	Notes
WATERBODY PARAMETERS					
Cienaga Tiburones	Waterbody surface area	15,690,087	m^2	Aerial photograph interpretation	Calculated as area of waterbody drawn in IRAP-h View; waterbody polygon was drawn by tracing aerial photograph
	Depth of water column	1	m	Personal communication with wetlands reserve manager, 10/13/2010	The average depth of the canals is 2 meters, while the remainder of the wetland areas are 60 cm (0.6 m).
	Average volumetric flow rate through waterbody	1.44E+03	m^3/year	Personal communication with wetlands reserve manager, 10/13/2010	Based on estimated average flow rate of 139.2 million gallons daily. Water depth and flow are regulated by intermittent pumping of sea water into the wetland system at El Vigia.
	Fraction of organic carbon in bottom sediment	0.137	--	Professional judgment	Estimated from percent organic matter (23.6%) of surface soils within watershed area, where fraction organic carbon is 58% of the fraction of soil organic matter (Lyman, et al., 1982).
	Total suspended solids concentration	10	mg/L	HHRAP default (USEPA, 2005b)	
WATERSHED PARAMETERS					
"Tiburones WS"	Watershed surface area	23,171,187	m^2	GIS data	Calculated using IRAP-h View
	Watershed area receiving COPC deposition	7,481,100	m^2	Calculated	Difference between watershed and waterbody areas
	Impervious cover	5	%	Professional judgment	Based on aerial photograph interpretation
	Total impervious area receiving COPC deposition	1,158,559	m^2	Calculated	Equivalent to watershed surface area x % impervious area
	USLE cover and management factor	0.1	--	HHRAP default (USEPA, 2005b)	Values up to 0.1 reflect dense vegetation cover, such as pasture grass. The HHRAP default value is recommended for both grass and agricultural crops (USEPA, 2005).
	USLE erodibility factor	0.12	ton/acre	USDA NRCS soil survey	Calculated by factoring in % soil type and erodibility factor of each soil type within each watershed area
	USLE length-slope factor	0.3	unitless	Wischmeier and Smith, 1978	Calculated slope (%) using digital elevation data; slope length corresponds to distance from highest point within watershed to the point where the slope gradient levels out
	USLE supporting practice factor	1	--	HHRAP default (USEPA, 2005b)	The HHRAP default value conservatively reflects the absence of any erosion control measures (e.g., terraces or contour cropping) (USEPA, 2005).
	USLE rainfall and runoff factor	53.13	$(year)^{-1}$	Rojas-Gonzalez, 2008	Modified R factor based on monthly and annual precipitation

Notes
IRAP-h View - Industrial Risk Assessment Program, Human Health

Table 10
Water Body and Watershed Parameters - Port Arecibo

Waterbody: Port Arecibo
Watershed: None; waterbody receives water from RGA estuary and Cienaga Tiburones; tidal mixing occurs with ocean
Relevant Exposure Pathway: Fish Ingestion

	Parameter	Value	Units	Source	Notes
WATERBODY PARAMETERS					
Port Arecibo	Waterbody surface area	8.96E+05	m^2	Aerial photograph interpretation	Calculated as area of waterbody drawn in IRAP-h View; waterbody polygon was drawn by tracing aerial photograph
	Depth of water column	3	m		Channel depth of Port Arecibo is 21-25 feet (6.4-7.6 m)
	Average volumetric flow rate through waterbody	4.23E+08	m^3/year	Calculated: (L/t)*A	
	Fraction of organic carbon in bottom sediment	0.01	--	Professional judgment	Sediment in nearshore environment of Puerto Arecibo consists of coarse to medium sand (Diaz, 2007), which one would expect to have relatively low organic carbon content (NOAA, 2007).
	Total suspended solids concentration	36	mg/L	CSA study; Professional judgment	Average TSS concentration from Station 9, corresponding to area of Rio Grande de Arecibo in estuary. No site-specific data were available for Port Arecibo; however, it was considered an underestimate to use the HHRAP default value
WATERSHED PARAMETERS					
None	Watershed surface area	--	m^2		
	Watershed area receiving COPC deposition	--	m^2		
	Impervious cover	--	%		
	Total impervious area receiving COPC deposition	--	m^2		
	USLE cover and management factor	--	--		
	USLE erodibility factor	--	ton/acre		
	USLE length-slope factor	--	unitless		
	USLE supporting practice factor	--	--		
	USLE rainfall and runoff factor	--	$(year)^{-1}$		

Notes
IRAP-h View - Industrial Risk Assessment Program, Human Health

TABLE 11
Calculation of Fraction Organic Carbon in Surface Soils of Watersheds

Soil Type Symbol	Percent (%) Organic Matter [1] (represents average)	Rio Grande de Arecibo Estuary			Reservoir Watershed			Cienaga Tiburones		
		Total Area within Watershed (square meters)	Fraction Watershed Area	Weighted % Organic Matter [2]	Total Area within Watershed (square meters)	Fraction Watershed Area	Weighted % Organic Matter [2]	Total Area within Watershed (square meters)	Fraction Watershed Area	Weighted % Organic Matter [2]
AgC	1.5							11,883	0.001	0.0008
AlB	3							270,847	0.01	0.0368
AlC	3							142,228	0.01	0.0193
AmB	3.5							4,518	0.0002	0.0007
AnB	3.5							761	0.00003	0.0001
Ba	3.5	48,697	0.15	0.52				2,216,765	0.10	0.3514
CcD	3							458,212	0.02	0.0623
Cf	2							58,170	0.003	0.0053
Cg [3]	--	416	0.00	--						
ClD2	7.5							82,739	0.004	0.0281
ClE2	7.5							465	0.00002	0.0002
Cn	3	166,746	0.51	1.53	190,538	0.22	0.65	613,585	0.03	0.0834
CsC	2							33,412	0.002	0.0030
Ga	45							2,225,034	0.10	4.5354
GeC	2.5							1,093,397	0.05	0.1238
HD [3]	--	11,413	0.03	--				57,883	0.003	--
IsC	2.5							360,889	0.02	0.0409
Ja	7							2,719,129	0.12	0.8622
JoC	2.5							1,576,119	0.07	0.1785
Pa	45							1,270,347	0.06	2.5606
Ps [3]	--							38,209	0.002	--
Pt [3]	--	9,425	0.03	--						
Re	3.5				230,400	0.26	0.92			
SaB	4.5							191,356	0.01	0.0390
SgD	3							86,418	0.004	0.0117
SgF	3							38,475	0.002	0.0052
SmF	2.5				217,942	0.25	0.62			
SnC	3							1,205,095	0.05	0.1638
Tb	48							5,521,921	0.25	11.8809
To	2.5	29,438	0.09	0.22						
Ur [3]	--	61,771	0.19	--						
VaB	2.5							1,906	0.0001	0.0002
VaC2	2.5							21,142	0.001	0.0024
VcB	3							101,002	0.005	0.0137
VeB	3.5				118,454	0.14	0.47	440,400	0.02	0.0698
Vg	45							1,234,483	0.06	2.4883
Vm	3				116,758	0.13	0.40			
Total watershed area		**327,907**			**874,092**			**22,076,789**		
			Percent Organic Matter:	2.27		Percent Organic Matter:	3.07		Percent Organic Matter:	23.57
			Fraction Organic Matter:	0.023		Fraction Organic Matter:	0.031		Fraction Organic Matter:	0.236
			Fraction Organic Carbon:	**0.013**		**Fraction Organic Carbon:**	**0.018**		**Fraction Organic Carbon:**	**0.137**

Notes

1 - Values of % organic matter for each soil type were obtained from Table 15 of the Soil Survey of Arecibo Area, Northern Puerto Rico (Acevido, 1982).

2 - Equivalent to "% Organic Matter" x "Fraction Watershed"

3 - No value for % organic matter was available for this unit.

TABLE 12
Calculation of USLE Erodibility Factor

Soil Type Symbol	Erodibility (K_W) [1] (ton/acre)	Rio Grande de Arecibo Estuary: Total Area within Watershed (square meters)	Rio Grande de Arecibo Estuary: Fraction Watershed Area	Rio Grande de Arecibo Estuary: Weighted K_w [2] (ton/acre)	Reservoir Watershed: Total Area within Watershed (square meters)	Reservoir Watershed: Fraction Watershed Area	Reservoir Watershed: Weighted K_w [2] (ton/acre)	Cienaga Tiburones: Total Area within Watershed (square meters)	Cienaga Tiburones: Fraction Watershed Area	Cienaga Tiburones: Weighted K_w [2] (ton/acre)
AgC	0.1							11,883	0.00	5.38E-05
AlB	0.1							270,847	0.01	1.23E-03
AlC	0.1							142,228	0.01	6.44E-04
AmB	0.1							4,518	0.00	2.05E-05
AnB	0.1							761	0.00	3.45E-06
Ba	0.24	48,697	0.15	3.56E-02				2,216,765	0.10	2.41E-02
CcD	0.24							458,212	0.02	4.98E-03
Cf	0.1							58,170	0.00	2.63E-04
Cg [3]	--	416	0.00	--						
ClD2	0.17							82,739	0.00	6.37E-04
ClE2	0.17							465	0.00	3.58E-06
Cn	0.24	166,746	0.51	1.22E-01	190,538	0.22	5.23E-02	613,585	0.03	6.67E-03
CsC	0.02							33,412	0.00	3.03E-05
Ga [3]	--							2,225,034	0.10	--
GeC	0.1							1,093,397	0.05	4.95E-03
HD [3]	--	11,413	0.03	--				57,883	0.00	--
IsC	0.17							360,889	0.02	2.78E-03
Ja	0.24							2,719,129	0.12	2.96E-02
JoC	0.17							1,576,119	0.07	1.21E-02
Pa [3]	--							1,270,347	0.06	--
Ps [3]	--							38,209	0.00	
Pt [3]	--	9,425	0.03	--						
Re	0.1				230,400	0.26	2.64E-02			
SaB	0.17							191,356	0.01	1.47E-03
SgD	0.24							86,418	0.00	9.39E-04
SgF	0.24							38,475	0.00	4.18E-04
SmF	0.17				217,942	0.25	4.24E-02			
SnC	0.17							1,205,095	0.05	9.28E-03
Tb [3]	--							5,521,921	0.25	--
To	0.17	29,438	0.09	1.53E-02						
Ur [3]	--	61,771	0.19	--						
VaB	0.1							1,906	0.00	8.63E-06
VaC2	0.1							21,142	0.00	9.58E-05
VcB	0.1							101,002	0.00	4.58E-04
VeB	0.24				118,454	0.14	3.25E-02	440,400	0.02	4.79E-03
Vg	0.24							1,234,483	0.06	1.34E-02
Vm	0.1				116,758	0.13	1.34E-02			
Total watershed area		**327,907**			**874,092**			**22,076,789**		
		USLE Erodibility Factor:		**0.17**	**USLE Erodibility Factor:**		**0.17**	**USLE Erodibility Factor:**		**0.12**

Notes

1 - Values of K_w for each soil type were obtained from Table 15 of the Soil Survey of Arecibo Area, Northern Puerto Rico (Acevido, 1982).

2 - Equivalent to "Erodibility" x "Fraction Watershed Area"

3 - No K_W value available for this unit.

USLE - Universal Soil Loss Equation

Table 13
Human Receptor-Specific Exposure Parameters

Exposure Parameter	Units	Human Receptor Population							
		Urban Resident		Suburban Resident		Farmer		Fisher	
		Adult	Child	Adult	Child	Adult	Child	Adult	Child
Averaging time for carcinogens	years	70	70	70	70	70	70	70	70
Averaging time for noncarcinogens	years	30	6	30	6	40	6	30	6
Consumption rate of beef	kg/kg-day DW	0	0	0	0	2.95E-04	8.47E-04	0	0
Body weight	kg	70	15	70	15	70	15	70	15
Consumption rate of poultry	kg/kg-day FW	0	0	0	0	3.66E-04	1.16E-03	0	0
Consumption rate of aboveground produce	kg/kg-day DW	0	0	5.65E-04	6.35E-03	4.69E-04	5.26E-03	5.65E-04	6.35E-03
Consumption rate of belowground produce	kg/kg-day DW	0	0	1.66E-04	1.28E-03	1.64E-04	1.26E-03	1.66E-04	1.28E-03
Consumption rate of drinking water	L/day	0	0	0	0	1.4	0.67	0	0
Consumption rate of protected aboveground produce	kg/kg-day DW	0	0	3.22E-04	3.70E-03	3.58E-04	4.10E-03	3.22E-04	3.70E-03
Consumption rate of soil	kg/d	0.0001	0.0002	0.0001	0.0002	0.0001	0.0002	0.0001	0.0002
Exposure duration	years	30	6	30	6	40	6	30	6
Exposure frequency	day/yr	350	350	350	350	350	350	350	350
Consumption rate of eggs	kg/kg-day FW	0	0	0	0	1.35E-04	4.52E-04	0	0
Fraction of contaminated aboveground produce	--	1	1	1	1	1	1	1	1
Fraction of contaminated drinking water	--	1	1	1	1	1	1	1	1
Fraction contaminated soil	--	1	1	1	1	1	1	1	1
Consumption rate of fish	kg/kg-day FW	0	0	0	0	0	0	1.33E-04	4.37E-04
Fraction of contaminated fish	--	1	1	1	1	1	1	1	1
Inhalation exposure duration	years	30	6	30	6	40	6	30	6
Inhalation exposure frequency	day/yr	350	350	350	350	350	350	350	350
Inhalation exposure time	hr/day	24	24	24	24	24	24	24	24
Fraction of contaminated beef	--	1	1	1	1	1	1	1	1
Fraction of contaminated poultry	--	1	1	1	1	1	1	1	1
Fraction of contaminated eggs	--	1	1	1	1	1	1	1	1
Fraction of contaminated milk	--	1	1	1	1	1	1	1	1
Fraction of contaminated pork	--	1	1	1	1	1	1	1	1
Inhalation rate	m^3/hr	0.83	0.3	0.83	0.3	0.83	0.3	0.83	0.3
Consumption rate of milk	kg/kg-day FW	0	0	0	0	1.63E-03	1.26E-02	0	0
Consumption rate of pork	kg/kg-day FW	0	0	0	0	2.44E-04	8.70E-04	0	0
Time period at the beginning of combustion	years	0	0	0	0	0	0	0	0
Length of exposure duration	years	30	6	30	6	40	6	30	6

Notes
Exposure parameters are presented in this table, in the order they are entered into IRAP-h View.
FW - fresh weight
DW - dry weight

Table 14
Calculation of Puerto Rico-Specific Food Consumption Rates

Human Receptor Population: Urban Resident									
		HHRAP Default		Central City Resident		Puerto Rico-Specific Food Consumption Rate			
		Adult	Child	Table 6 (USDA, 1982)		portion adult	Adult IR	portion children	Child IR
Exposure Parameter	**Units**			lbs/household-week	kg/household-day	assume 2 adults	kg/kg-day	assume 2 children	kg/kg-day
Consumption rate of milk	kg/kg-day FW	1.37E-02	2.27E-02	9.96	6.45E-01	2.43E-01	1.73E-03	4.03E-01	1.34E-02
fraction of total IR attributed to adult and child		0.38	0.62						
Human Receptor Population: Suburban Resident									
		HHRAP Default		Suburban Resident		Puerto Rico-Specific Food Consumption Rate			
		Adult	Child	Table 6 (USDA, 1982)		portion adult	Adult IR	portion children	Child IR
Exposure Parameter	**Units**			lbs/household-week	kg/household-day	assume 2 adults	kg/kg-day	assume 2 children	kg/kg-day
Consumption rate of aboveground produce	kg/kg-day DW	3.20E-04	7.70E-04	4.2	2.70E-01	7.91E-02	5.65E-04	1.90E-01	6.35E-03
fraction of total IR attributed to adult and child		0.29	0.71						
Consumption rate of belowground produce	kg/kg-day DW	1.40E-04	2.30E-04	0.95	6.16E-02	2.33E-02	1.66E-04	3.83E-02	1.28E-03
fraction of total IR attributed to adult and child		0.38	0.62						
Consumption rate of protected aboveground produce	kg/kg-day DW	6.10E-04	1.50E-03	2.41	1.56E-01	4.51E-02	3.22E-04	1.11E-01	3.70E-03
fraction of total IR attributed to adult and child		0.29	0.71						
Consumption rate of milk	kg/kg-day FW	1.37E-02	2.27E-02	9.35	6.06E-01	2.28E-01	1.63E-03	3.78E-01	1.26E-02
fraction of total IR attributed to adult and child		0.38	0.62						
Human Receptor Population: Farmer									
		HHRAP Default		Non-metro Resident		Puerto Rico-Specific Food Consumption Rate			
		Adult	Child	Table 6 (USDA, 1982)		portion adult	Adult IR	portion children	Child IR
Exposure Parameter	**Units**			lbs/household-week	kg/household-day	assume 2 adults	kg/kg-day	assume 2 children	kg/kg-day
Consumption rate of beef	kg/kg-day DW	1.22E-03	7.50E-04	1.03	0.07	4.13E-02	2.95E-04	2.54E-02	8.47E-04
fraction of total IR attributed to adult and child		0.62	0.38						
Consumption rate of poultry	kg/kg-day FW	6.60E-04	4.50E-04	1.33	0.09	5.12E-02	3.66E-04	3.49E-02	1.16E-03
fraction of total IR attributed to adult and child		0.59	0.41						
Consumption rate of aboveground produce	kg/kg-day DW	4.70E-04	1.13E-03	3.45	0.22	6.57E-02	4.69E-04	1.58E-01	5.26E-03
fraction of total IR attributed to adult and child		0.29	0.71						
Consumption rate of belowground produce	kg/kg-day DW	1.70E-04	2.80E-04	0.94	0.06	2.30E-02	1.64E-04	3.79E-02	1.26E-03
fraction of total IR attributed to adult and child		0.38	0.62						
Consumption rate of protected aboveground produce	kg/kg-day DW	6.40E-04	1.57E-03	2.67	0.17	5.01E-02	3.58E-04	1.23E-01	4.10E-03
fraction of total IR attributed to adult and child		0.29	0.71						
Consumption rate of eggs	kg/kg-day FW	7.50E-04	5.40E-04	0.50	0.03	1.88E-02	1.35E-04	1.36E-02	4.52E-04
fraction of total IR attributed to adult and child		0.58	0.42						
Consumption rate of milk	kg/kg-day FW	1.37E-02	2.27E-02	9.34	0.61	2.28E-01	1.63E-03	3.78E-01	1.26E-02
fraction of total IR attributed to adult and child		0.38	0.62						
Consumption rate of pork	kg/kg-day FW	5.50E-04	4.20E-04	0.93	0.06	3.42E-02	2.44E-04	2.61E-02	8.70E-04
fraction of total IR attributed to adult and child		0.57	0.43						
Human Receptor Population: Fisher									
		HHRAP Default		Suburban Resident		Puerto Rico-Specific Food Consumption Rate			
		Adult	Child	Table 6 (USDA, 1982)		portion adult	Adult IR	portion children	Child IR
Exposure Parameter	**Units**			lbs/household-week	kg/household-day	assume 2 adults	kg/kg-day	assume 2 children	kg/kg-day
Consumption rate of fish	kg/kg-day FW	1.25E-03	8.80E-04	0.49	3.18E-02	1.86E-02	1.33E-04	1.31E-02	4.37E-04
fraction of total IR attributed to adult and child		0.59	0.41						

Notes

Food consumption rates were presented in *Food Consumption and Dietary Levels of Households in Puerto Rico, Summer and Fall 1977* , based on pounds of food per household per week (Table 6; USDA, 1982). These consumption rates were converted to units of kg/household-day by multiplying by 0.45 kg/lb and dividing by 7 days/week. The average surveyed household consisted of four people (USDA, 1982). It was assumed for this HHRA that the four people in the household consisted of two adults and two children. Using the HHRAP default food consumption rates, the expected fractions of adult and child ingestion were calculated ("fraction of total IR attributed to adult and child"). These fractions were then used to apportion the total Puerto Rican household consumption rates between adult and children consumers. The adult ingestion rate (kg food/kg body weight/day), was calculated by dividing the "portion adult" by two and then dividing by an assumed adult body weight of 70 kg. The child ingestion rate (kg food/kg body weight/day) was calculated by dividing the "portion child" by two and then dividing by an assumed child body weight of 15 kg.

FW - fresh weight

DW - dry weight

IR - ingestion rate, used interchangeably with food consumption rate

Table 15
Summary of Chemical-Specific Toxicity Values

Constituent	Oral RfD mg/kg-day		Oral CSF $(mg/kg\text{-}day)^{-1}$		RfC mg/m^3		URF $(ug/m3)^{-1}$		AIEC mg/m^3	
Acenaphthene	6.0E-02	I,R	NA		2.1E-01	HH	NA		1.3E+00	D
Acenaphthylene	NA		NA		NA		NA		2.0E-01	D
Anthracene	3.0E-01	I,R	NA		1.0E+00	HH	NA		4.0E+00	D
Antimony	4.0E-04	I,R	NA		1.4E-03	HH	NA		1.5E+00	D
Aroclor 1254	2.0E-05	I,R	2.0E+00	I,R	7.0E-05	HH	5.7E-04	I,R	1.5E+00	D
Arsenic	3.0E-04	I,R	1.5E+00	I,R	1.5E-05	C,R	4.3E-03	I,R	1.9E-04	C (b)
Benzo(a)anthracene	NA		7.3E-01	E,R	NA		1.1E-04	C,R	6.0E-01	D
Benzo(a)pyrene	NA		7.3E+00	I,R	NA		1.1E-03	C,R	6.0E-01	D
Benzo(b)fluoranthene	NA		7.3E-01	E,R	NA		1.1E-04	C,R	6.0E-01	D
Benzo(k)fluoranthene	NA		7.3E-02	E,R	NA		1.1E-04	C,R	6.0E-01	D
Beryllium	2.0E-03	I,R	NA		2.0E-05	I,R	2.4E-03	I,R	3.5E-03	D
Cadmium	1.0E-03	I,R	NA		1.0E-05	A,R	1.8E-03	I,R	3.0E-02	D
Chromium	1.5E+00	I,R (a)	NA		5.3E+00	HH			1.5E+00	D
Chromium, hexavalent	3.0E-03	I,R	5.0E-01	J,R	1.0E-04	I,R	1.2E-02	I	9.6E-03	D (c)
Chrysene	NA		7.3E-03	E,R	NA		1.1E-05	C,R	6.0E-01	D
Cobalt	3.0E-04	P,R	NA		6.0E-06	P,R	9.0E-03	P,R	3.0E-01	D
Copper	4.0E-02	H,R	NA		NA		NA		3.0E+00	D
Dibenz(a,h)anthracene	NA		7.3E+00	E,R	NA		1.2E-03	C,R	2.5E-03	D
Fluoranthene	4.0E-02	I,R	NA		1.4E-01	HH			2.5E+01	D
Fluorene	4.0E-02	I,R	NA		1.4E-01	HH			5.0E-01	AI
HeptaCDD, 1,2,3,4,6,7,8-	NA		1.3E+03	TEQ	NA		3.8E-01	TEQ	5.0E-01	D
HeptaCDF, 1,2,3,4,6,7,8-	NA		1.3E+03	TEQ	NA		3.8E-01	TEQ	1.5E-01	D
HeptaCDF, 1,2,3,4,7,8,9-	NA		1.3E+03	TEQ	NA		3.8E-01	TEQ	2.5E-01	D
HexaCDD, 1,2,3,4,7,8-	NA		1.3E+04	TEQ	NA		3.8E+00	TEQ	1.3E-03	D
HexaCDD, 1,2,3,6,7,8-	NA		1.3E+04	TEQ	NA		3.8E+00	TEQ	1.5E-02	D
HexaCDD, 1,2,3,7,8,9-	NA		1.3E+04	TEQ	NA		3.8E+00	TEQ	1.5E-02	D
HexaCDF, 1,2,3,4,7,8-	NA		1.3E+04	TEQ	NA		3.8E+00	TEQ	7.5E-03	D
HexaCDF, 1,2,3,6,7,8-	NA		1.3E+04	TEQ	NA		3.8E+00	TEQ	2.5E-03	D
HexaCDF, 1,2,3,7,8,9-	NA		1.3E+04	TEQ	NA		3.8E+00	TEQ	1.3E-01	D
HexaCDF, 2,3,4,6,7,8-	NA		1.3E+04	TEQ	NA		3.8E+00	TEQ	1.5E-03	D
Hydrogen chloride	5.7E-03	HH	NA		2.0E-02	I,R	NA		2.1E+00	C
Hydrogen fluoride	4.0E-02	C,R	NA		1.4E-02	C,R	NA		2.4E-01	C
Indeno(1,2,3-cd) pyrene	NA		7.3E-01	E,R	NA		1.1E-04	C,R	5.0E-01	D
Lead	4.3E-04	HH	8.5E-03	HH	1.5E-03	HH	1.2E-05	HH	1.5E-01	D
Manganese	1.4E-01	I,R	NA		5.0E-05	I,R	NA		3.0E+00	D
Mercuric chloride	3.0E-04	I,R	NA		3.0E-05	C,R	NA		2.0E+00	D
Mercury	1.6E-04	C,R	NA		3.0E-04	I,R	NA		1.8E-03	C
Methyl mercury	1.0E-04	I,R	NA		3.5E-04	HH	NA		3.0E-02	D
Methylnaphthalene, 2-	4.0E-03	I,R	NA		NA		NA		3.0E+00	D
Molybdenum	5.0E-03	I,R	NA		NA		NA		3.0E+01	D
Naphthalene	2.0E-02	I,R	NA		3.0E-03	I,R	3.4E-05	C,R	7.5E+01	D
Nickel	2.0E-02	I,R	NA		9.0E-05	A,R	2.6E-04	C,R	6.0E-03	C
OctaCDD, 1,2,3,4,6,7,8,9-	NA		3.9E+01	TEQ	NA		1.1E-02	TEQ	1.0E-02	D
OctaCDF, 1,2,3,4,6,7,8,9-	NA		3.9E+01	TEQ	NA		1.1E-02	TEQ	7.5E-03	D
PentaCDD, 1,2,3,7,8-	NA		1.3E+05	TEQ	NA		3.8E+01	TEQ	2.5E-03	D
PentaCDF, 1,2,3,7,8-	NA		3.9E+03	TEQ	NA		1.1E+00	TEQ	7.5E-03	D
PentaCDF, 2,3,4,7,8-	NA		3.9E+04	TEQ	NA		1.1E+01	TEQ	7.5E-05	D
Phenanthrene	NA		NA		NA		NA		6.0E+00	D
Pyrene	3.0E-02	I,R	NA		1.1E-01	HH	NA		2.5E+00	D
Selenium	5.0E-03	I,R	NA		2.0E-02	C,R	NA		6.0E-01	D
TetraCDD, 2,3,7,8-	1.0E-09	A,R	1.3E+05	C,R	4.0E-08	C,R	3.8E+01	C,R	1.3E-02	D
TetraCDF, 2,3,7,8-	NA		1.3E+04	TEQ	NA		3.8E+00	TEQ	2.0E-03	D
Tin	6.0E-01	H,R	NA		NA		NA		6.0E+00	D
Vanadium	7.0E-05	P,R	NA		1.0E-04	A	NA		3.0E-02	C (d)
Zinc	3.0E-01	I,R	NA		1.1E+00	HH	NA		6.0E+00	D

See Notes page 2.

Table 15
Summary of Chemical-Specific Toxicity Values

Notes:
(a) = Chromium III
(b) = 4-hour averaging time
(c) = Chromium trioxide
(d) = Vanadium pentoxide

Definitions:
RfD = Reference dose (oral)
CSF = Cancer slope factor (oral)
RfC = Reference concentration (inhalation)
URF = Unit risk factor (inhalation)
AIEC = Acute inhalation exposure criteria
NA = Not applicable
mg/kg-day = milligrams per kilogram per day
mg/m^3 = milligrams per cubic meter

References:
A = ATSDR - Agency for Toxic Substance and Disease Registry
AI = AIHA - American Industrial Hygiene Association
C = Cal EPA - California Environmental Protection Agency
D = Department of Energy
E = Environmental Criteria and Assessment Office
H = HEAST - USEPA Health Effects Summary Tables
HH = Human Health Risk Assessment Protocol. Primary source not specified.
I = IRIS - Integrated Risk Information System
J = New Jersey
P = PPRTV - Provisional Peer Reviewed Toxicity Value
R = From RSL tables - USEPA Regional Screening Levels
TEQ = Based on the 2005 WHO TEQ applied to the RSL toxicity criteria

Full References for Acute Criteria:
U.S. Department of Energy (2009), Subcommittee on Consequence Assessment and Protective Actions (SCAPA) Temporary Emergency Exposure Limits, Protective Action Criteria (PAC) Rev 25 based on applicable 60-minute AEGLs, ERPGs, or TEELs(http://www.eh.doe.gov/chem_safety//teel.html), August, 2009.
California EPA Office of Environmental Health Hazard Assessment (2008), Acute Reference Exposure Levels Summary Table and Table of Hazard Index Target Organs, December, 2008.
U.S. Environmental Protection Agency (2005). Human Health Risk Assessment Protocol for Hazardous Waste Combustion Facilities. Appendix A database. September, 2005.
American Industrial Hygiene Association (2009), Emergency Response Planning Guidelines (ERPGs), 2009.

TABLE 16
Total Excess Lifetime Cancer Risks

	Urban Resident		Suburban Resident		Farmer		Fisher	
Relevant Exposure Pathways	Adult	Child	Adult	Child	Adult	Child	Adult	Child
Air Inhalation	2E-08	2E-08	2E-08	2E-08	7E-08	5E-08	2E-08	2E-08
Soil Ingestion	9E-10	2E-09	1E-09	2E-09	4E-09	6E-09	1E-09	2E-09
Ingestion of Locally-grown Produce	--	--	2E-08	1E-07	6E-08	2E-07	2E-08	1E-07
Ingestion of Drinking Water from Surface Water Source (reservoir)	6E-12	5E-12	6E-12	5E-12	6E-12	5E-12	6E-12	5E-12
Ingestion of Beef	--	--	--	--	4E-08	2E-08	--	--
Ingestion of Milk from Dairy Cows	7E-08	1E-07	7E-08	1E-07	7E-08	1E-07	7E-08	1E-07
Ingestion of Poultry	--	--	--	--	4E-10	2E-10	--	--
Ingestion of Eggs	--	--	--	--	8E-11	4E-11	--	--
Ingestion of Pork	--	--	--	--	1E-08	6E-09	--	--
Ingestion of Fish	2E-10	2E-10	2E-10	2E-10	--	--	2E-06	1E-06
Total Cancer Risk (across all pathways):	9E-08	1E-07	1E-07	2E-07	3E-07	4E-07	2E-06	2E-06

TABLE 17
Total Non-Cancer Hazard Indices

	Urban Resident		Suburban Resident		Farmer		Fisher	
Relevant Exposure Pathways	Adult	Child	Adult	Child	Adult	Child	Adult	Child
Air Inhalation	0.005	0.005	0.005	0.005	0.01	0.01	0.005	0.005
Soil Ingestion	0.0001	0.001	0.0002	0.002	0.0004	0.004	0.0002	0.002
Ingestion of Locally-grown Produce	--	--	0.001	0.014	0.003	0.033	0.001	0.01
Ingestion of Drinking Water from Surface Water Source (reservoir)	0.000001	0.000001	0.000001	0.000001	0.000001	0.000001	0.000001	0.000001
Ingestion of Beef	--	--	--	--	0.0001	0.0004	--	--
Ingestion of Milk from Dairy Cows	0.0003	0.002	0.0003	0.002	0.0003	0.002	0.000282	0.002
Ingestion of Poultry	--	--	--	--	0.000003	0.000010	--	--
Ingestion of Eggs	--	--	--	--	0.000001	0.000003	--	--
Ingestion of Pork	--	--	--	--	0.00002	0.00005	--	--
Ingestion of Fish	0.0001	0.0003	0.0001	0.0003	--	--	0.1	0.5
Hazard Index (across all pathways):	0.01	0.01	0.01	0.02	0.02	0.05	0.2	0.5

TABLE 18
Comparison of Lead Exposure Concentrations for Child Receptors

Exposure Medium	Units	Predicted Lead Concentrations or Intakes				USEPA IEUBK Model Default [1]	
		Urban Resident Child	Suburban Resident Child	Farmer Child	Fisher Child	Value	Note
Air	µg/m³	4E-05	4E-05	1E-04	4E-05	0.1	typical 1993 urban value
Soil	mg/kg	0.032	0.039	0.103	0.039	200	
Drinking Water	µg/L	3E-09	3E-09	3E-09	3E-09	4	typical 1990 urban value
Daily Dietary Intake	µg/day	0.013	0.074	0.161	0.074	6.06 [2]	typical U.S. child in a typical U.S. setting after 1990

Notes

(1) USEPA, 1994 and IEUBK Model (Accessed September 2010 at: www.epa.gov/superfund/lead/products.htm#ieubk).

(2) Average of the individal intakes for ages 0-1, 1-2, 2-3, 3-4, 4-5 and 5-6.

N/A - Not applicable

TABLE 19

Comparison of 2,3,7,8-TCDD TEQ Exposure Estimates to Background Exposure Levels

Receptor Population	**2,3,7,8-TCDD TEQ Exposure Estimate** (pg/kg-day)	**National Average Background 2,3,7,8-TCDD TEQ Exposure Level** (pg/kg-day)
For PCDD/PCDF congeners only		
Urban Resident Adult	0.001	1
Suburban Resident Adult	0.001	1
Farmer Adult	0.002	1
Fisher Adult	0.001	1
Urban Resident Infant	0.03	60
Suburban Resident Infant	0.03	60
Farmer Infant	0.06	60
Fisher Infant	0.03	60

Notes

PCDD/PCDF - polychlorinated dibenzo-p-dioxins / polychlorinated dibenzofurans

TCDD TEQ - tetrachlorodibenzo-p-dioxin toxic equivalents

TABLE 20
Calculation of Acute Non-Cancer Hazard Quotients

Chemical of Potential Concern	CAS #	Acute Inhalation Exposure Criterion (μg/m^3)	Maximum Hourly Air Concentration (μg/m^3)	Non-Cancer Hazard Quotient	Maximum Hourly Air Concentration (μg/m^3)	Non-Cancer Hazard Quotient
Acute Receptor Location:			745602.13 / 2037051.00		742602.13 / 2036051.00	
Meteorological Station Data:			San Juan Int'l Airport		Cambalache Station	
Acenaphthene	83-32-9	1E+03	3E-07	2E-10	3E-07	3E-10
Acenaphthylene	280-96-8	2E+02	2E-07	9E-10	2E-07	1E-09
Anthracene	120-12-7	4E+03	2E-07	4E-11	2E-07	5E-11
Antimony	7440-36-0	2E+03	1E-03	9E-07	1E-03	8E-07
Aroclor 1254	11097-69-1	2E+03	3E-06	2E-09	4E-06	2E-09
Arsenic	7440-38-2	2E-01	2E-04	9E-04	1E-04	8E-04
Benzo(a)anthracene	56-55-3	6E+02	1E-07	2E-10	2E-07	3E-10
Benzo(a)pyrene	50-32-8	6E+02	1E-07	2E-10	1E-07	2E-10
Benzo(b)fluoranthene	205-99-2	6E+02	1E-07	2E-10	1E-07	2E-10
Benzo(k)fluoranthene	207-08-9	6E+02	1E-07	2E-10	1E-07	2E-10
Beryllium	7440-41-7	4E+00	2E-05	5E-06	2E-05	4E-06
Cadmium	7440-43-9	3E+01	2E-04	7E-06	2E-04	6E-06
Chromium, hexavalent	18540-29-9	1E+01	5E-04	5E-05	4E-04	5E-05
Chrysene	218-01-9	6E+02	2E-07	3E-10	2E-07	3E-10
Cobalt	007440-48-4	3E+02	4E-05	1E-07	4E-05	1E-07
Copper	7440-50-8	3E+03	7E-04	2E-07	6E-04	2E-07
Dibenzo(a,h,)anthracene	53-70-3	3E+00	2E-07	7E-08	2E-07	8E-08
Fluoranthene	206-44-0	3E+04	1E-07	5E-12	1E-07	5E-12
HeptaCDD, 1,2,3,4,6,7,8-	35822-46-9	5E+02	8E-09	2E-11	8E-09	2E-11
HeptaCDF, 1,2,3,4,6,7,8-	67562-39-4	2E+02	6E-09	4E-11	6E-09	4E-11
HeptaCDF, 1,2,3,4,7,8,9-	55673-89-7	3E+02	2E-09	7E-12	2E-09	7E-12
HexaCDD, 1,2,3,4,7,8-	39227-28-6	1E+00	6E-10	5E-10	6E-10	5E-10
HexaCDD, 1,2,3,6,7,8-	57653-85-7	2E+01	1E-09	1E-10	1E-09	1E-10
HexaCDD, 1,2,3,7,8,9-	19408-74-3	2E+01	1E-09	1E-10	1E-09	1E-10
HexaCDF, 1,2,3,4,7,8-	70648-26-9	8E+00	3E-09	5E-10	3E-09	5E-10
HexaCDF, 1,2,3,6,7,8-	57117-44-9	3E+00	6E-09	2E-09	6E-09	2E-09
HexaCDF, 1,2,3,7,8,9-	72918-21-9	1E+02	1E-09	1E-11	1E-09	1E-11
HexaCDF, 2,3,4,6,7,8-	60851-34-5	2E+00	6E-09	4E-09	6E-09	4E-09
Hydrogen chloride	7647-01-0	2E+03	1E+01	5E-03	1E+01	6E-03
Hydrogen fluoride	7664-39-3	2E+02	2E+00	9E-03	2E+00	1E-02
Indeno(1,2,3-cd) pyrene	193-39-5	5E+02	6E-08	1E-10	5E-08	1E-10
Lead	7439-92-1	2E+02	6E-03	4E-05	5E-03	3E-05
Manganese	7439-96-5	3E+03	1E-03	4E-07	1E-03	3E-07
Mercuric chloride	7487-94-7	2E+03	1E-03	6E-07	1E-03	7E-07
Mercury	7439-97-6	2E+00	3E-05	2E-05	3E-05	2E-05
Methylnaphthalene, 2-	91-57-6	3E+03	3E-07	1E-10	3E-07	1E-10
Molybdenum	0074939-98-7	3E+04	7E-04	2E-08	6E-04	2E-08
Naphthalene	91-20-3	8E+04	2E-06	3E-11	2E-06	3E-11
Nickel	7440-02-0	6E+00	4E-04	7E-05	3E-04	6E-05
OctaCDD, 1,2,3,4,6,7,8,9-	3268-87-9	1E+01	2E-08	2E-09	2E-08	2E-09
OctaCDF, 1,2,3,4,6,7,8,9-	39001-02-0	8E+00	5E-09	6E-10	5E-09	6E-10
PentaCDD, 1,2,3,7,8-	40321-76-4	3E+00	2E-09	1E-09	2E-09	1E-09
PentaCDF, 1,2,3,7,8-	57117-41-6	8E+00	5E-09	6E-10	5E-09	7E-10
PentaCDF, 2,3,4,7,8-	57117-31-4	8E-02	7E-09	9E-08	7E-09	9E-08
Pyrene	129-00-0	3E+03	1E-07	4E-11	1E-07	4E-11
Selenium	7782-49-2	6E+02	2E-04	3E-07	2E-04	3E-07
TetraCDD, 2,3,7,8-	1746-01-6	1E+01	1E-09	8E-11	1E-09	9E-11
TetraCDF, 2,3,7,8-	51207-31-9	2E+00	2E-08	1E-08	2E-08	1E-08
Tin	007440-31-5	6E+03	3E-03	4E-07	2E-03	4E-07
Vanadium	7440-62-2	3E+01	1E-04	4E-06	1E-04	4E-06
Zinc	7440-66-6	6E+03	7E-02	1E-05	6E-02	9E-06
			Hazard Index:	0.02	**Hazard Index:**	0.02

TABLE 21
Total Excess Lifetime Cancer Risks - PCBs Only

	Urban Resident		Suburban Resident		Farmer		Fisher	
Relevant Exposure Pathways	Adult	Child	Adult	Child	Adult	Child	Adult	Child
Air Inhalation	5E-12	1E-12	5E-12	1E-12	2E-11	3E-12	5E-12	1E-12
Soil Ingestion	7E-14	1E-13	5E-12	1E-12	3E-13	4E-13	5E-12	1E-12
Ingestion of Locally-grown Produce	--	--	5E-12	1E-12	2E-12	3E-12	5E-12	1E-12
Ingestion of Drinking Water from Surface Water Source (reservoir)	5E-16	2E-16	5E-16	2E-16	5E-16	2E-16	5E-16	2E-16
Ingestion of Beef	--	--	--	--	6E-12	2E-12	--	--
Ingestion of Milk from Dairy Cows	1E-11	1E-11	1E-11	1E-11	1E-11	1E-11	1E-11	1E-11
Ingestion of Poultry	--	--	--	--	4E-14	2E-14	--	--
Ingestion of Eggs	--	--	--	--	8E-15	4E-15	--	--
Ingestion of Pork	--	--	--	--	1E-12	7E-13	--	--
Ingestion of Fish	2E-12	1E-12	2E-12	1E-12	--	--	3E-13	2E-13
Total Cancer Risk (across all pathways):	2E-11	1E-11	3E-11	2E-11	4E-11	2E-11	3E-11	1E-11

Notes
PCBs - Polychlorinated biphenyls

TABLE 22
Total Non-Cancer Hazard Indices - PCBs Only

	Urban Resident		Suburban Resident		Farmer		Fisher	
Relevant Exposure Pathways	Adult	Child	Adult	Child	Adult	Child	Adult	Child
Air Inhalation	3E-07	3E-07	3E-07	3E-07	8E-07	8E-07	3E-07	3E-07
Soil Ingestion	7E-09	7E-08	8E-09	7E-08	2E-08	2E-07	8E-09	7E-08
Ingestion of Locally-grown Produce	--	--	4E-08	5E-07	9E-08	1E-06	4E-08	5E-07
Ingestion of Drinking Water from Surface Water Source (reservoir)	2E-11	5E-11	2E-11	5E-11	2E-11	5E-11	2E-11	5E-11
Ingestion of Beef	--	--	--	--	3E-07	8E-07	--	--
Ingestion of Milk from Dairy Cows	5E-07	3E-06	5E-07	3E-06	5E-07	3E-06	5E-07	3E-06
Ingestion of Poultry	--	--	--	--	3E-09	8E-09	--	--
Ingestion of Eggs	--	--	--	--	6E-10	2E-09	--	--
Ingestion of Pork	--	--	--	--	8E-08	3E-07	--	--
Ingestion of Fish	1E-07	3E-07	1E-07	3E-07	--	--	2E-08	6E-08
Hazard Index (across all pathways):	8E-07	4E-06	8E-07	4E-06	2E-06	7E-06	8E-07	4E-06

Notes
PCBs - Polychlorinated biphenyls

TABLE 23

Calculation of Acute Non-Cancer Hazard Quotients - PCBs only

Chemical of Potential Concern	CAS #	Maximum Hourly Air Concentration ($\mu g/m^3$)	Acute Inhalation Exposure Criterion ($\mu g/m^3$)	Non-Cancer Hazard Quotient
Aroclor 1254	11097-69-1	3E-06	2E+03	2E-09

Notes

PCBs - Polychlorinated biphenyls

ENERGY ANSWERS
ARECIBO, PUERTO RICO

PROJECT LOCATION MAP

ARCADIS

FIGURE
1

PROJECT NUMBER:
CITY:NOVI DIV/GROUP:ENV DB: PIC: PM: TM: TR:
G:\GIS\Project Files\EnergyAnswers\Arecibo\Documents\ProjectLocationMap.mxd

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ARECIBO, PUERTO RICO

SITE LOCATION MAP

ARCADIS

FIGURE
2

PROJECT NUMBER:
CITY:NOVI DIV/GROUP:ENV DB: PIC: PM: TM: TR:
G:\GIS\Project Files\EnergyAnswers\Arecibo\Documents\SiteLocationMap.mxd

LEGEND

△ Proposed Facility Site

0 1,400 2,800

Scale in Meters

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AERIAL PHOTO (10 KILOMETER RADIUS)

ARCADIS

FIGURE
3

PROJECT NUMBER: NCENRGY1.0003.0007
CITY:NOVI DIV/GROUP:ENV DB: PIC: PM: TM: TR:
G:\GIS\Project Files\EnergyAnswers\Arecibo\Documents\AerialPhoto_10km_r.mxd

LEGEND

△ Proposed Facility Site

0 420 840

Scale in Meters

ENERGY ANSWERS
ARECIBO, PUERTO RICO

AERIAL PHOTO (3 KILOMETER RADIUS)

ARCADIS

FIGURE 4

PROJECT NUMBER: NCENRGY1.0003.0007
CITY:NOVI DIV/GROUP:ENV DB: PIC: PM: TM: TR:
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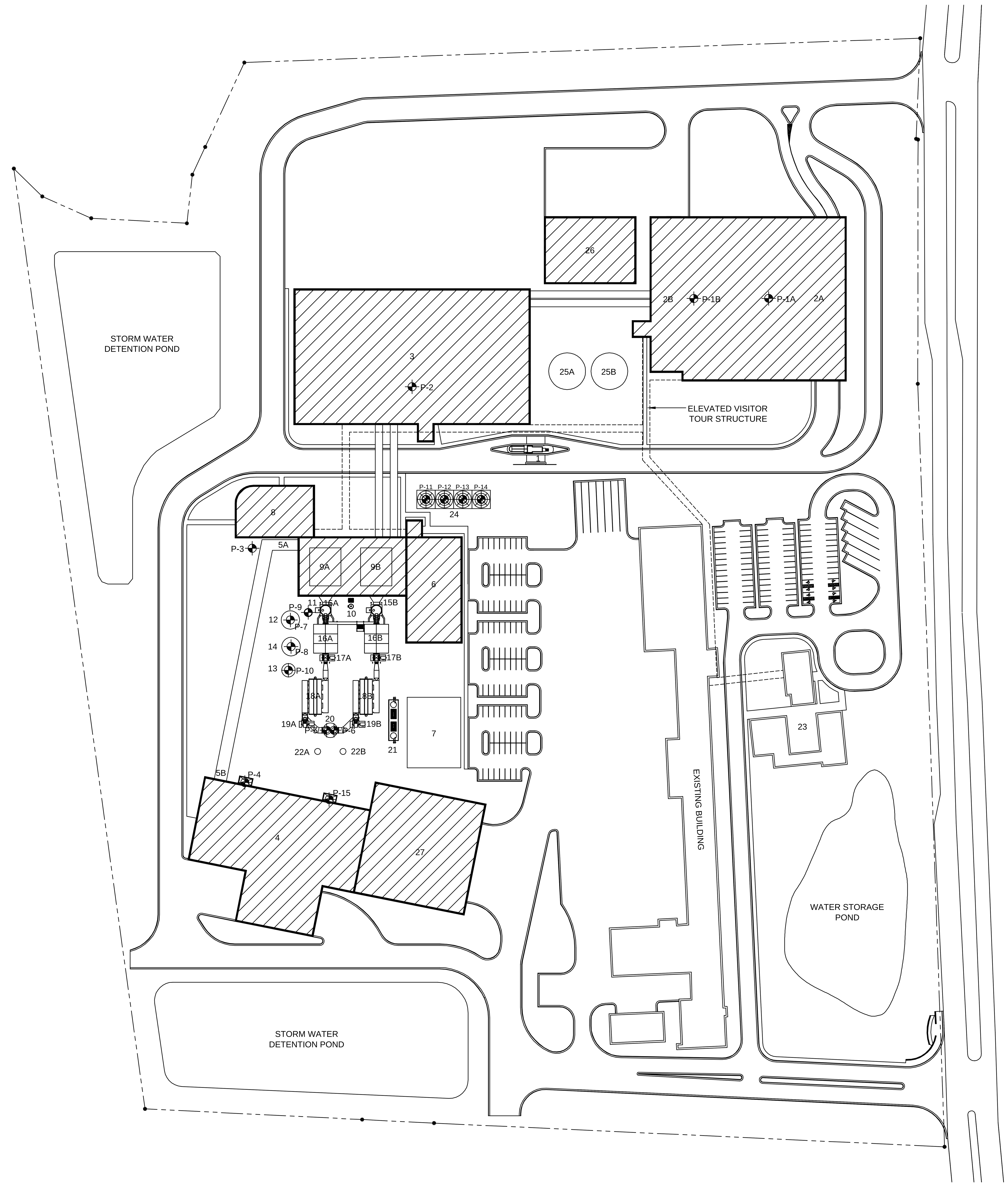

NO.	LEGEND AND LOCATION SCHEDULE	VENT LOCATION SCHEDULE			
	STRUCTURE	VENT NO.	COORDINATES		ELEVATION (METERS)
			METERS*	DEGREES*	
1	WEIGH STATION				
2A	MSW RECEIVING AREA	P-1A	130.9116	71.72	15.2
2B	MSW PROCESSING AREA	P-1B	116.9924	87.74	12.2
3	PRF STORAGE AREA	P-2	132.3847	159.52	30.5
4	ASH PROCESSING AREA	P-15	204.6976	232.72	18.2
5A	BOTTOM ASH TRANSFER AREA	P-3	192.2018	194.47	10.7
5B	BOTTOM ASH TRANSFER AREA	P-4	233.0714	224.33	18.2
6	POWER BLOCK BUILDING				
7	SWITCHYARD				
8	CAFETERIA, TRAINING & LOCKER ROOMS				
9A	BOILER 1				
9B	BOILER 2				
10	WATER TANK				
11	PAC SILO	P-9	169.4434	205.84	13.1
12	LIME SILO	P-7	178.9684	206.28	30.5
13	FLYASH STABILIZATION SILO	P-10	187.833	213.59	14.6
14	FLYASH SILO	P-8	182.5244	210.32	38.1
15A	SDA 1				
15B	SDA 2				
16A	BAGHOUSE 1				
16B	BAGHOUSE 2				
17A	ID FAN 1				
17B	ID FAN 2				
18A	RSCR 1				
18B	RSCR 2				
19A	BOOSTER FAN 1				
19B	BOOSTER FAN 2				
20A	STACK FLUE - BOILER 1	P-5	184.8358	224.44	106.7
20B	STACK FLUE - BOILER 2	P-6	181.7878	225.07	106.7
21	AMMONIA SKID				
22A	RAW WATER STORAGE TANK 1				
22B	RAW WATER STORAGE TANK 2				
23	ADMINISTRATION BUILDING				
24	COOLING TOWER (4 CELLS)	P-11	106.4514	183.88	10.7
24	COOLING TOWER (4 CELLS)	P-12	97.409	183.17	10.7
24	COOLING TOWER (4 CELLS)	P-13	88.3666	182.33	10.7
24	COOLING TOWER (4 CELLS)	P-14	79.3496	181.29	10.7
25A	WATER STORAGE TANK				
25B	WATER STORAGE TANK				
26	STORAGE / WAREHOUSE				
27	CONCRETE PRODUCTS BUILDING				

FOR DISPERSION MODEL PURPOSES COORDINATES ARE GIVEN IN TERMS OF METERS FROM THE NW CORNER OF THE EXISTING PAPERMILL AND DEGREES COUNTERCLOCKWISE FROM TRUE EAST. *

0 100 200
SCALE IN FEET

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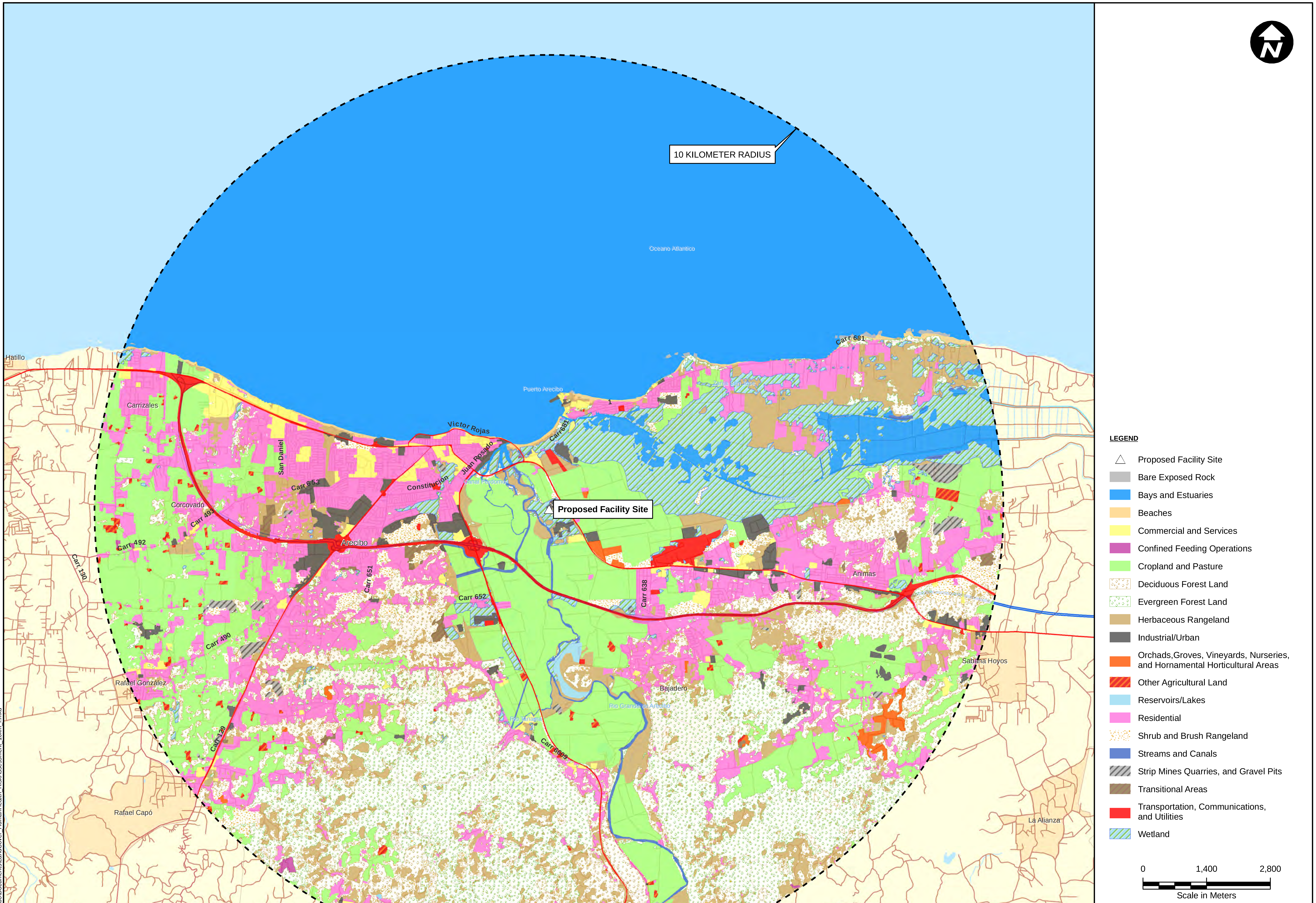
PROPOSED FACILITY LAYOUT

ARCADIS

FIGURE 5



PROJECT NUMBER: NCENRGY1.0003.0007
CITY:NOVI DIV/GROUP:ENV DB: PIC: PM: TM: TR:
G:\GIS\Project Files\EnergyAnswers\Arecibo\Documents\LandCover_HumanHealth_RiskAssessment_10km_r.mxd

ENERGY ANSWERS
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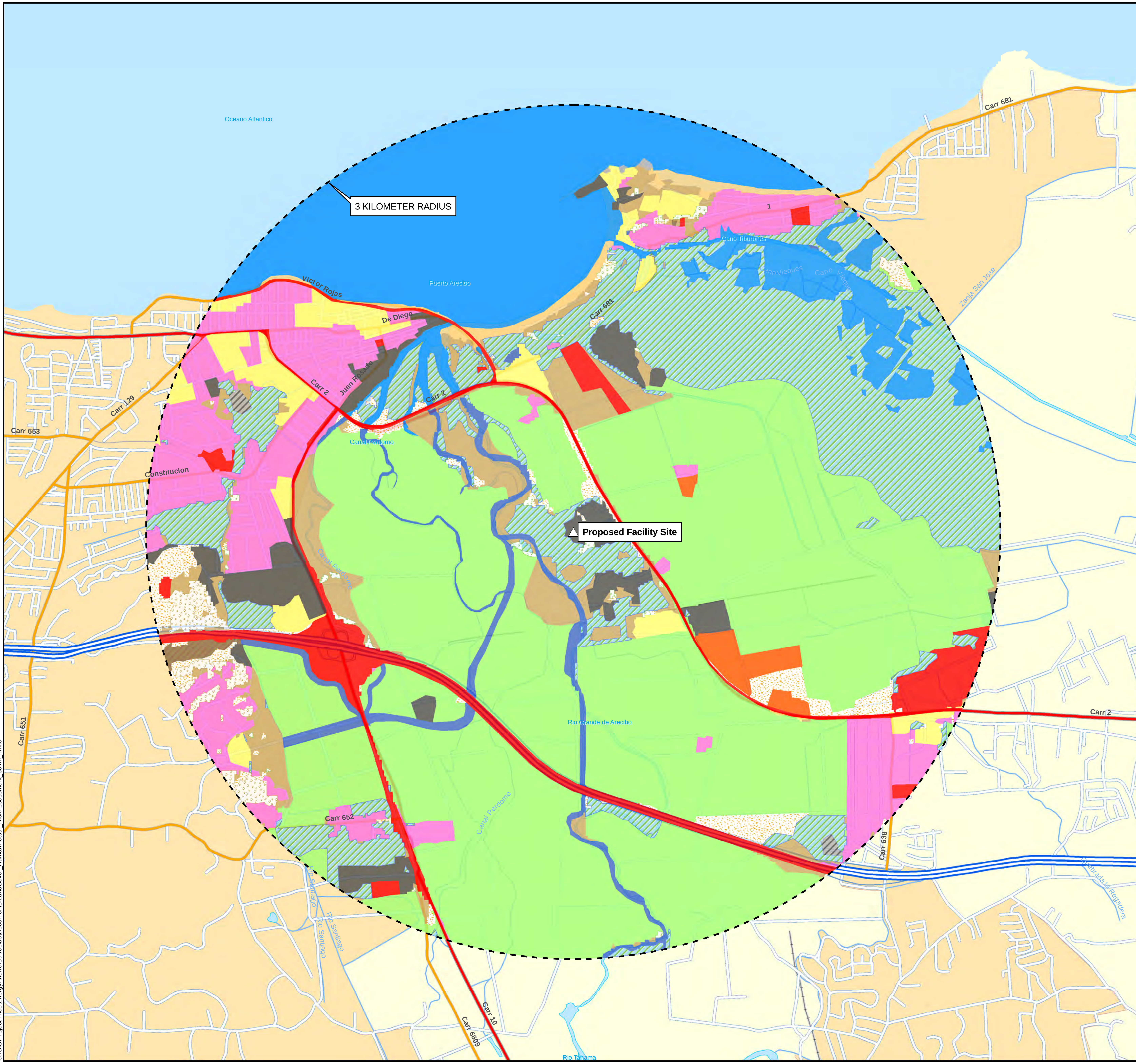
LAND USE (10 KILOMETER RADIUS)

ARCADIS

FIGURE
6



LEGEND

- Proposed Facility Site
- Bare Exposed Rock
- Bays and Estuaries
- Beaches
- Commercial and Services
- Confined Feeding Operations
- Cropland and Pasture
- Deciduous Forest Land
- Evergreen Forest Land
- Herbaceous Rangeland
- Industrial/Urban
- Orchads,Groves, Vineyards, Nurseries, and Hornamental Horticultural Areas
- Other Agricultural Land
- Reservoirs/Lakes
- Residential
- Shrub and Brush Rangeland
- Streams and Canals
- Strip Mines Quarries, and Gravel Pits
- Transitional Areas
- Transportation, Communications, and Utilities
- Wetland

0 450 900

Scale in Meters

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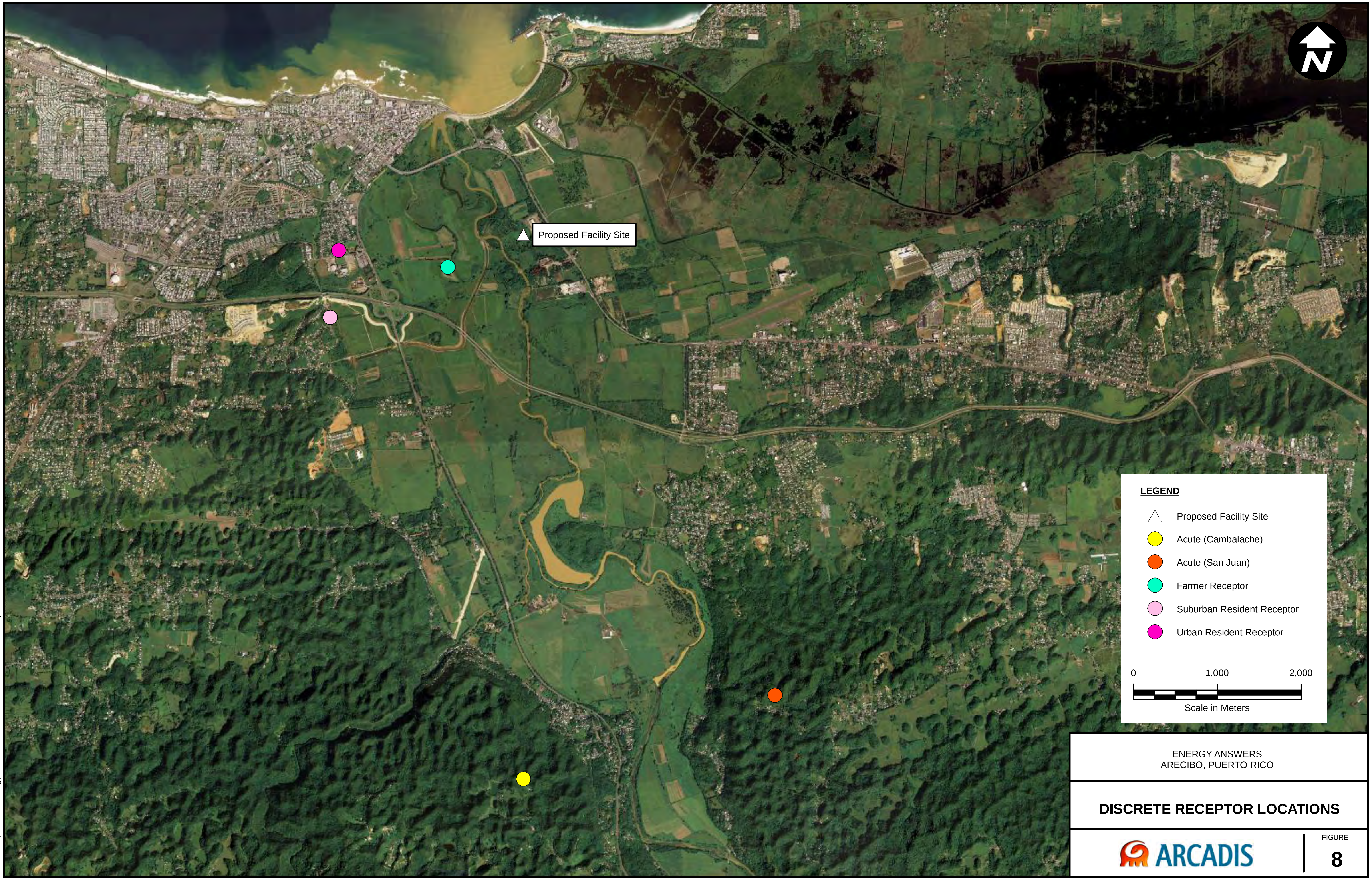
LAND USE (3 KILOMETER RADIUS)

ARCADIS

FIGURE
7

PROJECT NUMBER: NCENRGY1.0003.0007
CITY:NOVI DIV/GROUP:ENV DB: PIC: PM: TM: TR:
G:\GIS\Project Files\EnergyAnswers\Arecibo\Documents\LandCover_HumanHealth_RiskAssessment_03km_r.mxd



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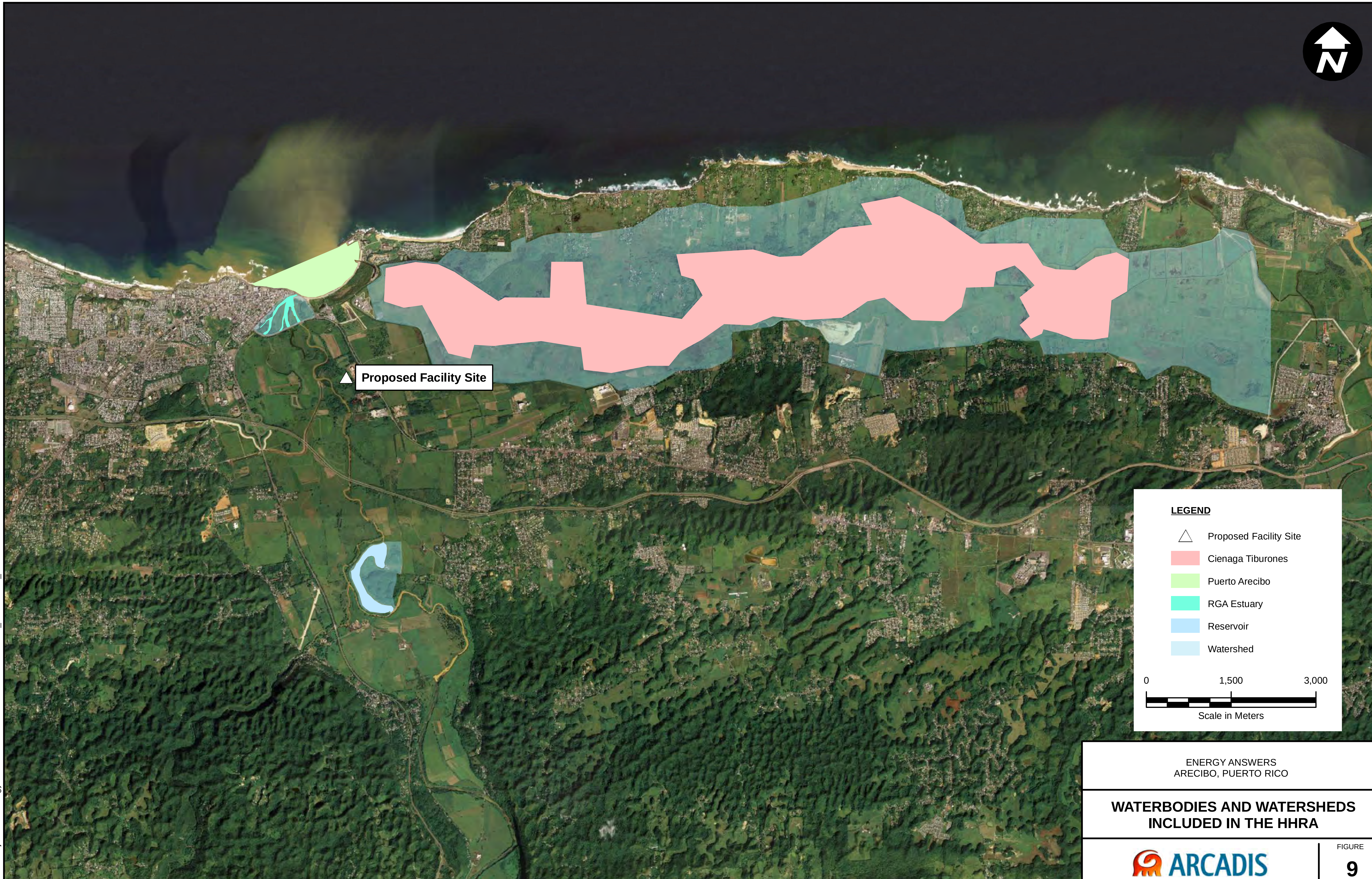
DISCRETE RECEPTOR LOCATIONS

ARCADIS

FIGURE
8

PROJECT NUMBER:
CITY:NOVI DIV/GROUP:ENV DB: PIC: PM: TM: TR:
G:\GIS\Project Files\EnergyAnswers\Arecibo\Documents\DiscreteReceptorLocations.mxd



ENERGY ANSWERS
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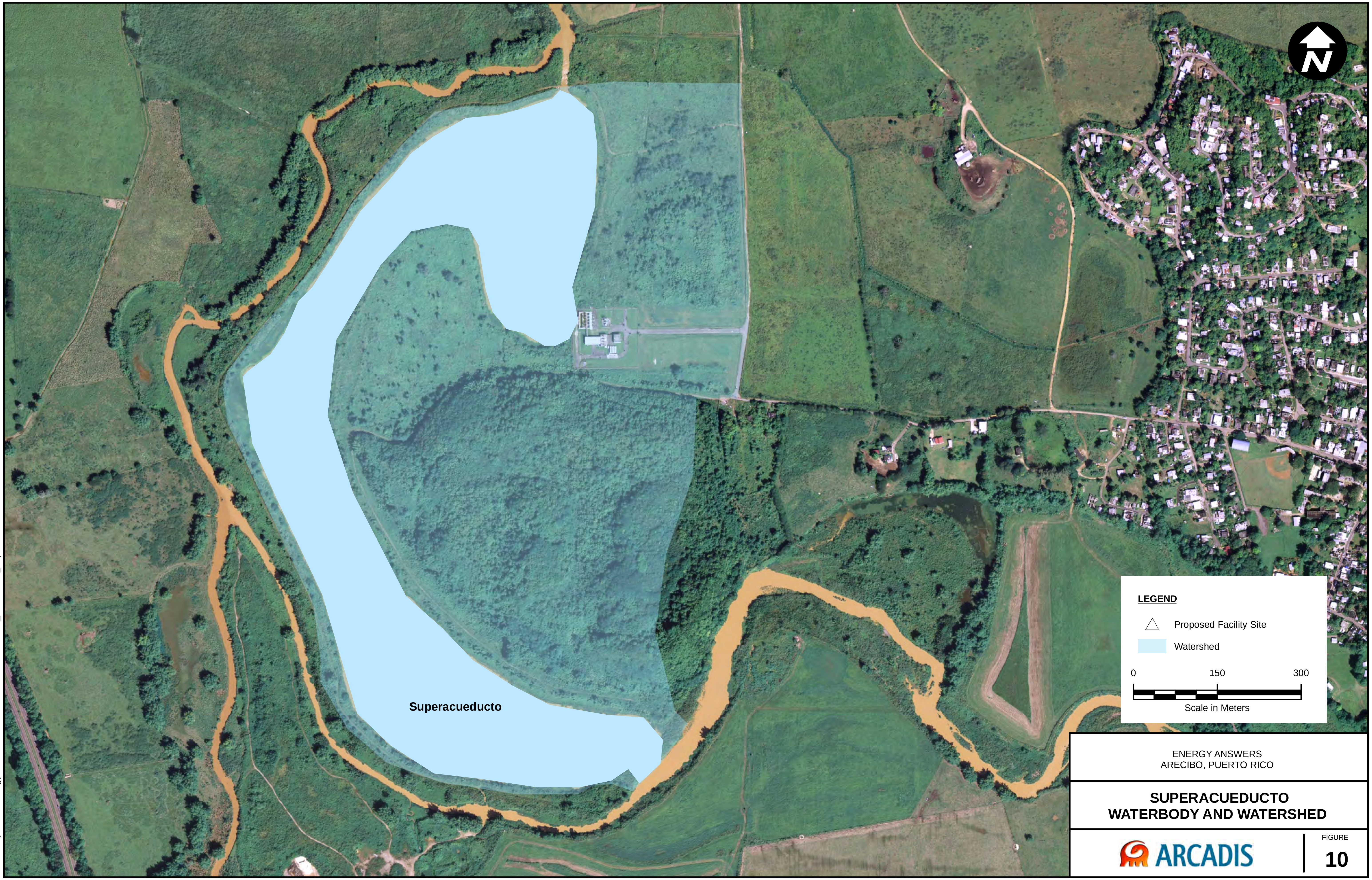
WATERBODIES AND WATERSHEDS INCLUDED IN THE HHRA

ARCADIS

FIGURE
9

PROJECT NUMBER:
CITY:NOVI DIV/GROUP:ENV DB: PIC: PM: TM: TR:
G:\GIS\Project Files\EnergyAnswers\Arecibo\Documents\Waterbodies_Watersheds_HHRA.mxd



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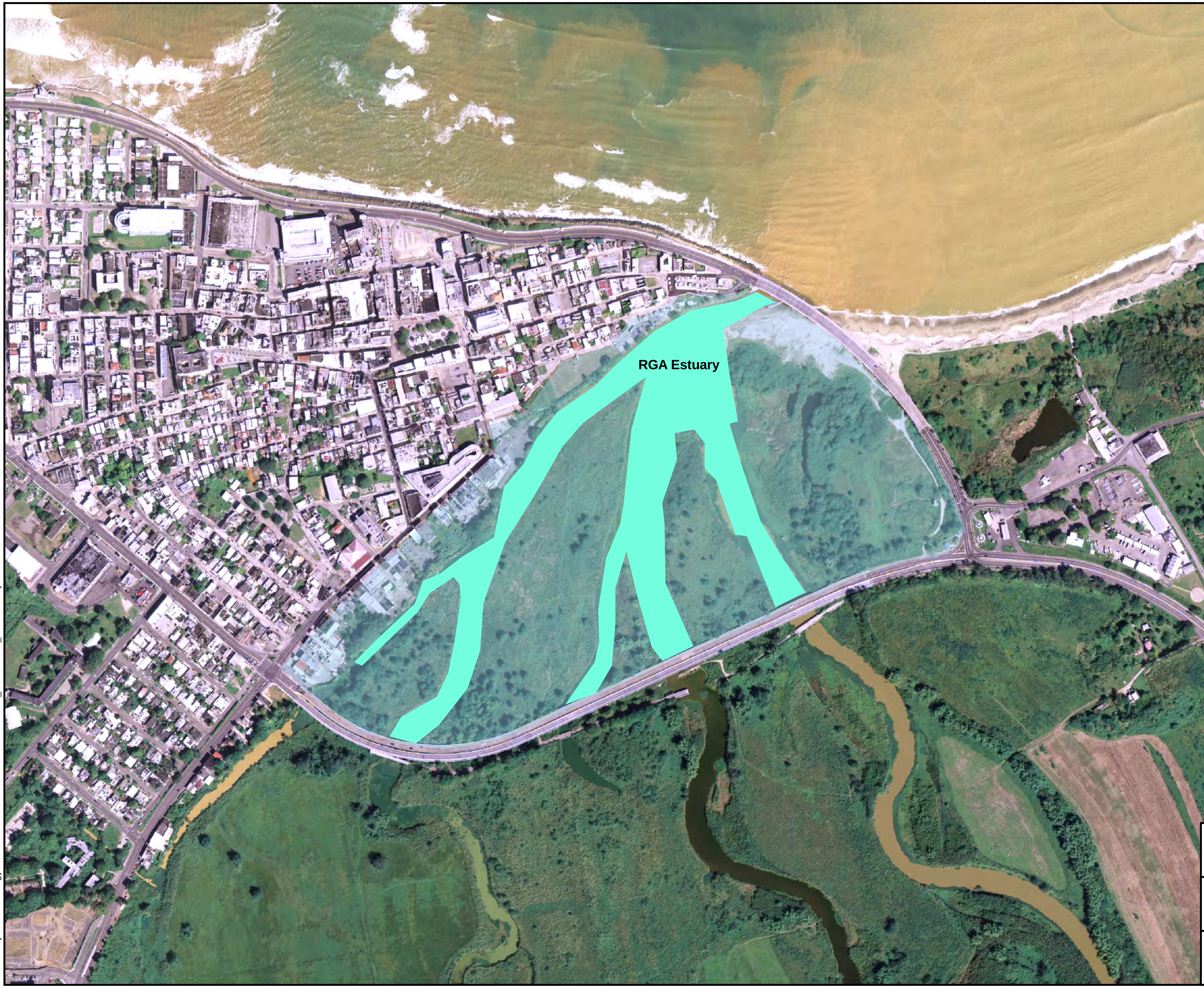
SUPERACUEDUCTO WATERBODY AND WATERSHED

ARCADIS

FIGURE 10

PROJECT NUMBER:
CITY:NOVI DIV/GROUP:ENV DB: PIC: PM: TM: TR:
G:\GIS\Project Files\EnergyAnswers\Arecibo\Documents\Waterbodies_Watersheds_Superacueducto.mxd



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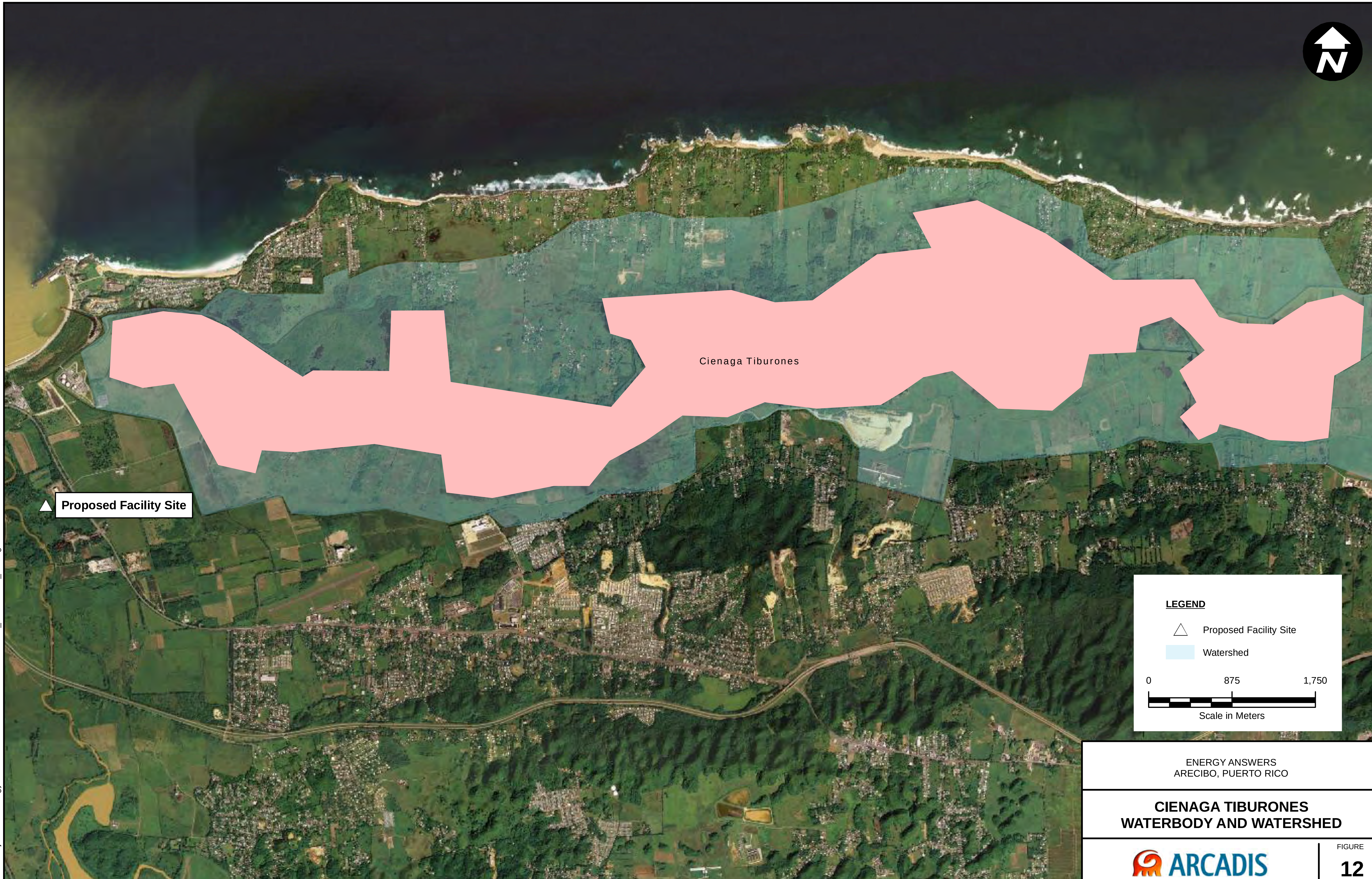
RIO GRANDE de ARECIBO ESTUARY WATERBODY AND WATERSHED

ARCADIS

FIGURE
11

CITY:NOVI DIV/GROUP:ENV DB: PIC: PM: TM: TR:
PROJECT NUMBER:
G:\GIS\Project Files\EnergyAnswers\Arecibo\Documents\Waterbodies_Watersheds_RGA Estuary.mxd



ENERGY ANSWERS
ARECIBO, PUERTO RICO

CIENAGA TIBURONES
WATERBODY AND WATERSHED

ARCADIS

FIGURE
12

PROJECT NUMBER:
CITY:NOVI DIV/GROUP:ENV DB: PIC: PM: TM: TR:
G:\GIS\Project Files\EnergyAnswers\Arecibo\Documents\Waterbodies_Watersheds_Cienaga Tiburones.mxd

ENERGY ANSWERS
ARECIBO, PUERTO RICO

PUERTO ARECIBO
WATERBODY AND WATERSHED

ARCADIS

FIGURE
13

PROJECT NUMBER:
CITY:NOVI DIV/GROUP:ENV DB: PIC: PM: TM: TR:
G:\GIS\Project Files\EnergyAnswers\Arecibo\Documents\Waterbodies_Watersheds_Port Arecibo.mxd

ARCADIS

Appendix A

SEMASS Unit 3 Stack Test Data

Appendix A
ENERGY ANSWERS ARECIBO, PUERTO RICO PROJECT
Emission Calculations
EACH BOILER

Estimated Stack Flow Rate (dscmm) 3806 3460

Emission Rate Calculations	SEMASS Stack Test Data 1993 ng/dscm	1994 ng/dscm	1996 ng/dscm	Average Emission Factor ng/dscm	Emission Rates Maximum g/s	Average g/s
PCDD						
Permit Limit (total mass) - Units conversion				13	8.25E-07	
Permit Limit (TEQ) - Units conversion				0.2	1.27E-08	
2,3,7,8-TCDD**	0.0018	0.0011	ND	0.0015	9.30E-11	8.46E-11
1,2,3,7,8-PeCDD**	0.0038	0.0027	ND	0.0033	2.06E-10	1.87E-10
1,2,3,4,7,8-HxCDD**	0.0023	0.0018	ND	0.0021	1.32E-10	1.20E-10
1,2,3,6,7,8-HxCDD**	0.0037	0.0067	ND	0.0052	3.28E-10	2.98E-10
1,2,3,7,8,9-HxCDD**	0.0037	0.0067	ND	0.0052	3.29E-10	2.99E-10
1,2,3,4,6,7,8-HpCDD	0.0185	0.0398	ND	0.0292	1.85E-09	1.68E-09
1,2,3,4,6,7,8,9-OCDD	0.0442	0.0658	0.0920	0.0673	4.27E-09	3.88E-09
PCDFs						
2,3,7,8-TCDFt**	0.0222	0.0319	ND	0.0271	1.72E-09	1.56E-09
1,2,3,7,8-PeCDF**	0.0055	0.0074	ND	0.0065	4.10E-10	3.73E-10
2,3,4,7,8-PeCDF**	0.0074	0.0104	ND	0.0089	5.66E-10	5.14E-10
1,2,3,4,7,8-HxCDF*	0.0133	0.0111	ND	0.0122	7.73E-10	7.03E-10
1,2,3,6,7,8-HxCDF	0.0047	0.0059	0.0131	0.0079	5.02E-10	4.56E-10
2,3,4,6,7,8-HxCDF*	0.0074	0.0074	ND	0.0074	4.70E-10	4.28E-10
1,2,3,7,8,9-HxCDF**	0.0022	0.0011	ND	0.0017	1.06E-10	9.61E-11
1,2,3,4,6,7,8-HpCDF	0.0178	0.0133	0.0328	0.0213	1.35E-09	1.23E-09
1,2,3,4,7,8,9-HpCDF**	0.0028	0.0016	ND	0.0022	1.40E-10	1.27E-10
OCDF	0.0083	0.0073	0.0329	0.0162	1.03E-09	9.33E-10
PAH						
Naphthalene		2.71		2.714	1.72E-07	1.56E-07
Benz(a)anthracene		*0.203*		*0.203*	1.29E-08	1.17E-08
Benzo(b)fluoranthene		*0.16*		*0.160*	1.01E-08	9.23E-09
Benzo(k)fluoranthene		*0.175*		*0.175*	1.11E-08	1.01E-08
Benzo(a)pyrene		*0.182*		*0.182*	1.15E-08	1.05E-08
Acenapthene		*0.422*		*0.422*	2.68E-08	2.44E-08
2-Chloronapthalene		*0.435*		*0.435*	2.76E-08	2.51E-08
2-Methylnaphthalene		*0.398*		*0.398*	2.52E-08	2.30E-08
Acenapthylene		*0.250*		*0.250*	1.58E-08	1.44E-08
Chrysene		*0.217*		*0.217*	1.38E-08	1.25E-08
Dibenz(a,h)anthracene		*0.251*		*0.251*	1.59E-08	1.45E-08
Benzo(g,h,i)perylene		*0.222*		*0.222*	1.41E-08	1.28E-08
Perylene		*0.195*		*0.195*	1.24E-08	1.12E-08
Benzo(e)pyrene		*0.171*		*0.171*	1.08E-08	9.84E-09
Pyrene		*0.140*		*0.140*	8.88E-09	8.07E-09
Fluoranthene		*0.169*		*0.169*	1.07E-08	9.75E-09
Anthracene		*0.232*		*0.232*	1.47E-08	1.34E-08
Indeno(1,2,3-cd)pyrene		*0.193*		*0.193*	1.23E-08	1.11E-08

Notes:
Stack test measurements for were not taken in 1995.
ND = Non Detected.
Figures reported in italics are equal to the detection limit.
dscmm = dry standard cubic meters per minute

Appendix A

ENERGY ANSWERS ARECIBO, PUERTO RICO PROJECT

OPERATING SCENARIOS AND STACK PARAMETERS

EACH BOILER

Estimated Flow Rate (dscmm) 3460

		SEMASS STACK TEST RESULTS																	Average
Constituent	units	1996	1997	1998	1999	2000	Jan-01	Apr-01	Apr-02	Jan-03	Sep-03	Jun-04	Apr-05	Dec-05	Sep-06	Jul-07	Apr-08	**AVERAGE**	**g/s**
Hydrogen Chloride	ppm @ 7% O_2	3.62	2.78	4.4	6	4.49	9.9	8.49	23.09	19.7	6.21	4.88	15.5	27.3	7.6	5.85	5.9	9.73	0.84
Mercury	mg/dscm @ 7% O_2	3.67	3.46	3.431	6.4	1.38	2.6	23.82	7.1183	24.47	13.24	5.56	2.6	6	1.3	1.8	3.43	6.89	3.97E-04
Zinc	mg/dscm @ 7% O_2	24.8	40.9	33.154	44.2	49.7	24.4	23.47	18.225	52.19	115.64	69.26	30.88	2948.2	29	57.36	91	228.27	1.32E-02
Nickel	mg/dscm @ 7% O_2	6.74	<0.366	0.773	1.37	1.19	0.61	0.88	2.0767	1.37	0.89	0.916	1.63	0.86	0.51	0.28	0.306	1.36	7.84E-05
Arsenic	mg/dscm @ 7% O_2	0.857	0.36	<0.334	0.785	0.71	0.18	0.44	<0.12531	0.35	1.42	0.572	<0.26	<0.17	0.37	0.4	0.751	0.60	3.46E-05
Antimony	mg/dscm @ 7% O_2	7.79	25.6	2.021	2.47	4.76	1.76	1.37	0.72428	3.73	7.67	5.51	1.67	1.2	0.89	5.29	4.15	4.79	2.76E-04
Cadmium	mg/dscm @ 7% O_2	<0.110	0.379	0.426	0.83	0.68	0.447	0.37	0.32764	0.61	1.79	0.935	0.44	0.45	0.72	0.92	1	0.69	3.97E-05
Chromium	mg/dscm @ 7% O_2	12.9	<0.194	<0.243	0.637	0.99	0.44	<0.21	<0.5413	0.41	1.72	0.653	0.44	<1.7	0.14	0.51	0.593	1.77	1.02E-04
Copper	mg/dscm @ 7% O_2	2.83	0.572	1.785	3.04	2.99	1.59	2.19	0.94974	4.32	5.07	2.75	2.29	0.83	1.59	1.92	1.87	2.29	1.32E-04
Cobalt	mg/dscm @ 7% O_2	NA	NA	NA	NA	NA	0.04	0.14	<0.083733	<0.55	0.25	<0.273	<0.26	<0.30	<0.11	<0.11	0.183	0.15	8.84E-06
Lead	mg/dscm @ 7% O_2	6.37	29.1	11.854	23.6	24.3	6.5	5.85	5.7849	13.64	56.56	34.02	9.29	<2.5	17.8	31.1	25	20.05	1.16E-03
Manganese	mg/dscm @ 7% O_2	4.24	7.98	5.226	2.96	3.04	2.26	1.46	7.3208	4.43	7.05	<0.129	3.3	4.6	1.92	2.75	0.458	3.93	2.27E-04
Molybdenum	mg/dscm @ 7% O_2	6.64	<0.248	0.287	<0.282	<0.178	<0.190	<0.27	1.7385	<0.34	5.7	<0.453	<0.13	<0.30	0.4	<0.05	0.458	2.54	1.46E-04
PCDDs/PCDFs	ng/dscm @ 7% O_2 [2]	0.417	0.868	0.022	8.9	1.19	3.31	1.31	1.67	1.32	3.21	1.69	9.91	7.7	3.6	3.9	<2.35	3.27	1.88E-07
Tin	mg/dscm @ 7% O_2	<1.44	7.12	8.563	11	9.3	5.62	9.45	10.258	13.7	16.49	<0.485	<0.13	7.9	4.98	<0.25	0.458	8.74	5.04E-04
Selenium	mg/dscm @ 7% O_2	NA	<0.356	<0.162	<0.303	<0.298	<0.250	0.58	<0.83733	0.66	<0.36	<0.273	<0.26	<0.47	<0.54	<0.11	0.611	0.62	3.56E-05
Vanadium	mg/dscm @ 7% O_2	<0.237	<0.129	<0.115	<0.113	<0.205	<0.106	<0.12	<0.16747	<0.55	<0.27	<0.273	<0.32	<0.21	<0.11	<0.11	0.458	0.46	2.64E-05
Beryllium	mg/dscm @ 7% O_2	<0.110	<0.0221	<0.057	<0.058	<0.054	<0.051	<0.06	<0.083733	<0.13	<0.04	<0.027	<0.03	<0.021	<0.028	<0.027	0.0611	0.06	3.52E-06

Notes:

dscmm = dry standard cubic meters per minute

ARCADIS

Appendix B

AERMOD Input and Output Files

The attached CD has the AERMOD air dispersion modeling input and output files. AERMOD is the recommended model in USEPA's *Guideline on Air Quality Models* (40 CFR Part 51, Appendix W) (USEPA 2005) for predicting ambient air concentrations of emissions from stationary industrial sources like the proposed Energy Answers facility. Software created by *Lakes Environmental* was used for executing USEPA's AERMOD model.

Input and output files for running the USEPA's BPIPPRM utility program for calculating building profile dimensions and Good Engineering Practice Stack Height are included.

ARCADIS

Appendix C

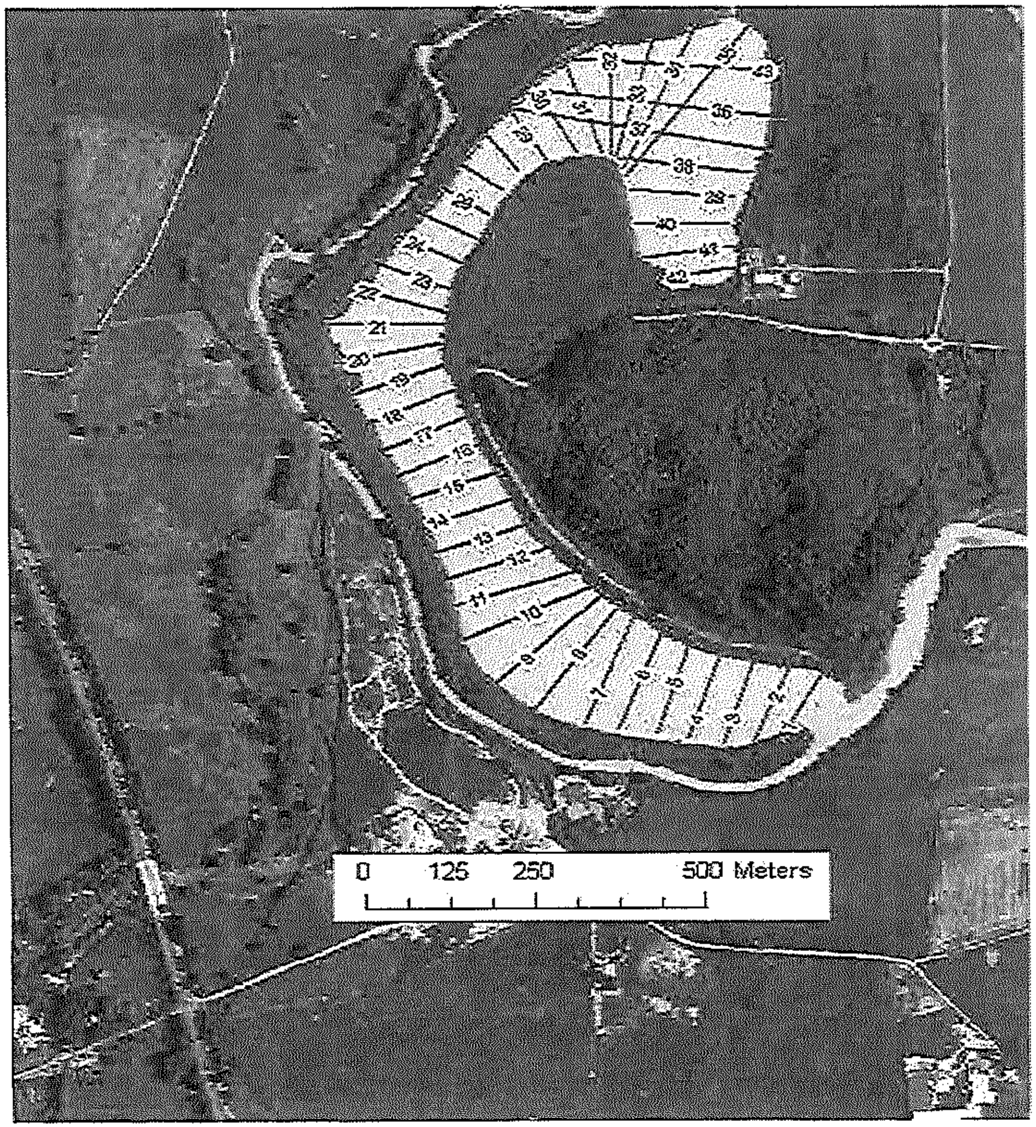
Local Information

Thames Water Puerto Rico

Raw Water Lagoon

Superacueducto

Lagoon Volume:	300.00	MG
Lagoon Depth:	6.00	meters
	19.68	feet



Optimal Depth:	5.00	meters
	16.40	feet
Minuimum Depth:	2.00	meters
	6.56	feet
Specific Capacity	50.00	MG / meter
	15.24	MG / foot
Usable Capacity:	3.00	meters
	150.00	MG
	1.50	Days Storage
Plant Output:	100.00	MGD
	4.17	MG / Hour

Capacity Chart

Meters	MG	Hours of Supply
5.00	150.00	36.00
4.75	137.50	33.00
4.50	125.00	30.00
4.25	112.50	27.00
4.00	100.00	24.00
3.75	87.50	21.00
3.50	75.00	18.00
3.25	62.50	15.00
3.00	50.00	12.00
2.75	37.50	9.00
2.50	25.00	6.00
2.25	12.50	3.00
2.00	0.00	0.00

Water released by PREPA from Caonillas will reach the Raw Water Lagoon in 6 - 8 hours.

TABLE D- IDENTIFY FISHING PATTERNS AND PRACTICES - (area 20 km to west, 20 km south, 10 km east, north to the ocean for the site).

Receptor		UTM coordinates	
Identify areas where people are known to be fishing for food	**Description**	Xutm	Y[1] utm
Name/Location			
Dos Bocas Reservoir	A 256.6 ha impoundment of the Grande de Arecibo River, the Limon River and the Caonillas River between the municipalities of Arecibo and Utuado. People fish from small boats or from the water's edge throughout the day.	746237.13476	2028526.1718
PR-680 Bridge and waterfront near mouth of RGA	Stretch of approximately 900 meters along PR-680 associated to the mouth of the Grande de Arecibo River. People fish with fishing rods or hand held reels from the bridge of from the rock wall during late afternoon or at night.	744753.39461	2032425.27666
RGA Estuary	The RGA estuary has three extensions including the river and two other courses that may represent past flows of the RGA. People fish these extensions by small boat, from the waters edge or from small abandoned bridges during late afternoon and at night. Ceti is caught with nets at the RGA mouth.	741717.17004	2043989.75454
Arecibo Bay Breakwater	This breakwater was constructed to protect a new boat ramp for the Arecibo Outboard Club. People fish with fishing rods on the breakwater late afternoon and at night.	742765.24961	2044615.15580
Caño Tiburones	PR's largest wetland, it covers approximately 7,000 acres between the Grande de Arecibo and Grande de Manati rivers. It is influenced by salt and fresh water and has an open connection with the Atlantic Ocean. People fish from small boats or from the water's edge throughout the entire zone.	748964.56798	2043586.76289
Camuy Coast line	This is an approximately 5.5 kilometer long stretch of coast in the Municipality of Camuy where people fish with fishing rods or with castnets.	728440.75122	2045513.18594
Ramp and dock at El Membrillo in Camuy	New boat ramp and dock build for the Asociación de Pescadores de Membrillo. Fishermen fish in the late afternoon and at night with fishing rods.	725164.05836	2045788.22422
Identify what fish are generally caught and eaten from fresh and salt water bodies within the areas of interest	**Fish species caught**		
Water Body			
Atlantic Ocean-offshore	Dolphin, Little tuna, Silk snapper, King mackerel, Swordfish, Yellowfin tuna, Mutton snapper, Queen snapper, Yellowfin snapper, Bar jack	751283.04463	2078455.18361
Atlantic Ocean coastal waters	Mutton snapper, Bar jack, Palometa, Permit, Yellowfin snapper	741419.01094	2044125.62376
Rio Grande de Arecibo	Snook, Schoolmaster, Sirajo goby (larvae locally called "ceti")	741598.85804	2043852.91997
Caño Tiburones	Snook, Schoolmaster	748964.56798	2043586.76289
Dos Bocas Reservoir	Largemouth bass, Peacock bass, Mozambique Tilapia, Blue tilapia, Redbreast sunfish, Redear sunfish, White catfish, Marbled bullhead, Channel catfish, Redbreast tilapia, Red devil	746527.22306	2028582.79220
		UTM coordinates	
Receptor	**Description**	Xutm	Y[1] utm
Identify what fish sport fishing locations and fisheries within Sport fishing locations and fisheries			
Name/Location			
Arecibo Outboard Club	Private Club	742903.40194	2044598.76583
Club Nautico Arecibo	Private Club	743097.54668	2044311.18369
Asociacion de Pescadores de Jarealito	Local fishermen's Association	743590.17533	2044622.90090
Asociacion de Pescadores El Membrillo	Local fishermen's Association	725240.04906	2045814.03385
Dos Bocas Reservoir-Club Lobiñero Villalbeño	Conduct tournaments in Dos Bocas Reservoir	746237.13476	2028526.17180

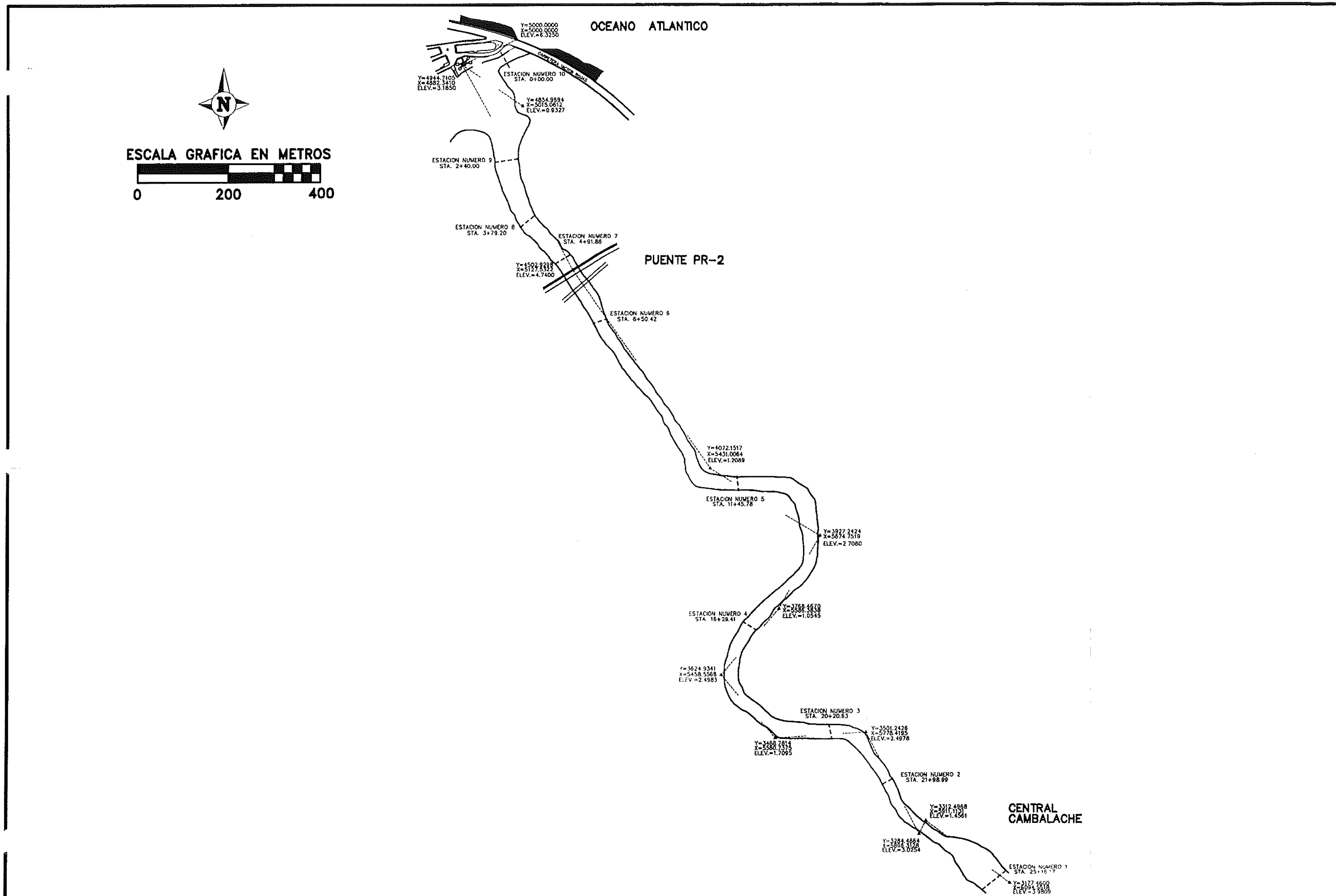


FIGURA 2-1 CONFIGURACION DEL CANAL DEL ESTUARIO DEL RIO GRANDE DE ARECIBO

PROGRAMA DE MONITOREO DEL ESTUARIO DEL RIO GRANDE DE ARECIBO

ARCHITECTS & ENGINEERS

Tabla 4-1. Lista de Parámetros de Calidad de Agua y Métodos Analíticos

Párametros	Métodos (EPA)	Limite Detección
Amonia (mg/L)	350.1	0.10
BOD (mg/L)	405.1	1.0
Bromuro (mg/L)	320.1	0.10
Calcio (mg/L)	200.7	0.01
Cloruro (mg/L)	325.2	3.0
COD (mg/L)	410.4	5.0
Fluoruro (mg/L)	340.2	0.01
Fósforo (mg/L)	365.3	0.01
Fosfato - ortho (mg/L)	365.3	0.01
Magnesio (mg/L)	200.7	0.01
Nitrato (mg/L)	353.2	0.01
Nitrito (mg/L)	353.2	0.01
Nitrogeno Kjeldahl Total (TKN) (mg/L)	351.2	0.2
Nitrogeno Orgánico Total (mg/L)	351.2	0.2
Potasio (mg/L)	200.7	0.01
Sodio (mg/L)	200.7	0.01
Sólidos Suspendidos Totales (TSS) (mg/L)	160.2	5.0
Sulfato (mg/L)	375.4	1.0
TOC (mg/L)	415.1	0.1
Turbiedad (NTU)	180.1	0.05
Metales		
Arsenico (ug/L)	200.9	0.4
Bario (ug/L)	200.7	50
Cadmio (ug/L)	200.7	2
Cromio (ug/L)	200.7	2
Cobre (ug/L)	200.7	10
Hierro (ug/L)	200.7	20
Plomo (ug/L)	200.7	5
Manganeso (ug/L)	200.7	5
Mercurio (ug/L)	245.1	0.2
Selenio (ug/L)	200.9	1
Plata (ug/L)	200.7	2
Zinc (ug/L)	200.7	5

Tabla 4-2. Resumen de Datos de Calidad de Agua en la Estación 2 del Estuario del RGA

Parámetro	Unidades	Periodo	N	Media	Desviación Estandar	Mínimo	Máximo	Estándares de Calidad de Agua[1]
Temperatura	°C	1	22	25.30	1.21	22.41	27.55	32.2
		2	11	25.07	1.82	22.06	27.44	
		3	12	25.38	1.10	23.81	26.93	
		Total	45	25.26	1.33	22.06	27.55	
pH	Unidades	1	22	7.78	0.17	7.52	8.24	6.0 - 9.0
		2	11	7.71	0.16	7.57	8.02	
		3	12	7.74	0.15	7.41	7.91	
		Total	45	7.75	0.16	7.41	8.24	
Oxígeno Disuelto	mg/L	1	22	7.91	0.52	7.24	9.66	5.0
		2	11	8.03	0.29	7.68	8.78	
		3	12	7.86	0.42	7.30	8.58	
		Total	45	7.93	0.44	7.24	9.66	
Conductividad	mS/cm	1	22	0.26	0.05	0.17	0.36	(0.07)
		2	11	0.23	0.04	0.17	0.28	
		3	12	0.26	0.02	0.24	0.31	
		Total	45	0.25	0.04	0.17	0.36	
Salinidad	ppt (‰)	1	22	0.12	0.04	0.08	0.20	
		2	11	0.11	0.02	0.09	0.14	
		3	12	0.13	0.01	0.11	0.15	
		Total	45	0.12	0.03	0.08	0.20	
Sólidos Disueltos Totales (TDS)	g/L	1	22	0.17	0.03	0.11	0.23	0.5
		2	11	0.15	0.02	0.11	0.18	
		3	12	0.17	0.01	0.15	0.20	
		Total	45	0.16	0.03	0.11	0.23	
Amonio	mg/L	1	10	0.11	0.06	0.05	0.23	1.0
		2	11	0.08	0.05	0.05	0.17	
		3	12	0.07	0.04	0.05	0.15	
		Total	33	0.08	0.05	0.05	0.23	
Demanda Bioquímica de Oxígeno (BOD_5)	mg/L	1	22	1.78	0.95	0.50	3.20	(2.0 -15.0)
		2	11	1.39	1.13	0.50	4.40	
		3	12	2.14	1.48	0.50	5.40	
		Total	45	1.78	1.16	0.50	5.40	
Bromuro	mg/L	1	22	4.40	4.91	1.00	14.70	
		2	11	1.00	0.00	1.00	1.00	
		3	12	0.46	0.48	0.05	1.00	
		Total	45	2.52	3.88	0.05	14.70	
Calcio	mg/L	1	22	37.40	12.12	22.40	73.00	(13.0 - 15.0)
		2	11	29.75	3.10	24.00	34.80	
		3	12	35.85	5.28	29.30	46.30	
		Total	45	35.12	9.45	22.40	73.00	
Cloruro	mg/L	1	22	12.06	4.14	7.98	22.97	250.0
		2	11	9.82	1.75	7.31	12.20	
		3	10	9.75	1.09	8.40	11.50	
		Total	43	10.95	3.30	7.31	22.97	
Demanda Química de Oxígeno (COD)	mg/L	1	22	10.70	9.18	2.50	40.23	
		2	11	6.23	6.94	1.50	25.00	
		3	12	9.50	8.21	2.50	24.00	
		Total	45	9.29	8.45	1.50	40.23	
Fluoruro	mg/L	1	22	0.09	0.03	0.01	0.13	0.70
		2	11	0.09	0.05	0.01	0.17	
		3	11	0.09	0.02	0.06	0.14	
		Total	44	0.09	0.03	0.01	0.17	
ortho-Fosfato	mg/L	1	22	0.32	0.65	0.01	2.94	(0.01 - 0.5)
		2	11	0.11	0.09	0.01	0.26	
		3	12	0.09	0.13	0.02	0.48	

Tabla 4-2. Resumen de Datos de Calidad de Agua en la Estación 2 del Estuario del RGA

Parámetro	Unidades	Periodo	N	Media	Desviación Estandar	Mínimo	Máximo	Estándares de Calidad de Agua[1]
		Total	45	0.20	0.47	0.01	2.94	
Fosforo Total	mg/L	1	22	0.32	0.60	0.01	2.92	1.00
		2	10	0.20	0.14	0.08	0.54	
		3	12	0.10	0.06	0.02	0.19	
		Total	44	0.23	0.44	0.01	2.92	
Magnesio	mg/L	1	22	5.89	1.33	1.80	8.90	(4.0)
		2	11	5.22	0.95	3.22	6.81	
		3	9	4.49	1.77	0.01	6.00	
		Total	42	5.41	1.43	0.01	8.90	
Nitrato (NO_3)	mg/L	1	20	0.67	0.22	0.25	1.16	(0.23)
		2	11	0.60	0.24	0.27	0.95	
		3	12	0.65	0.64	0.30	2.64	
		Total	43	0.65	0.38	0.25	2.64	
Nitrito (NO_2)	mg/L	1	20	0.01	0.00	0.01	0.02	(0.01 - 0.50)
		2	11	0.01	0.00	0.01	0.02	
		3	12	0.01	0.00	0.01	0.01	
		Total	43	0.01	0.00	0.01	0.02	
$NO_2 + NO_3$	mg/L	1	22	0.66	0.22	0.25	1.16	10.0
		2	11	0.61	0.24	0.27	0.95	
		3	12	0.66	0.64	0.30	2.65	
		Total	45	0.65	0.37	0.25	2.65	
Nitrógeno Orgánico Total (TON)	mg/L	1	10	0.35	0.20	0.10	0.74	(0.1 - 9.0)
		2	11	0.38	0.20	0.10	0.70	
		3	12	0.45	0.22	0.10	0.75	
		Total	33	0.39	0.21	0.10	0.75	
Nitrógeno Kjedahl Total (TKN)	mg/L	1	10	0.44	0.20	0.21	0.85	
		2	11	0.42	0.18	0.21	0.70	
		3	12	0.49	0.17	0.26	0.75	
		Total	33	0.45	0.18	0.21	0.85	
Potasio	mg/L	1	22	2.40	2.03	1.44	11.36	(1.3 - 2.3)
		2	11	2.45	1.25	1.40	5.78	
		3	12	1.32	0.66	0.34	3.10	
		Total	45	2.13	1.63	0.34	11.36	
Sodio	mg/L	1	22	11.22	9.19	2.90	50.00	(5.1 - 6.3)
		2	11	8.68	1.20	6.71	10.40	
		3	12	7.48	0.97	5.71	8.94	
		Total	45	9.60	6.60	2.90	50.00	
Sólidos Suspendidos Totales (TSS)	mg/L	1	22	40.20	72.37	2.50	282.00	(10 -110)
		2	11	32.86	46.82	2.50	166.00	
		3	12	17.33	14.01	2.50	47.00	
		Total	45	32.31	56.03	2.50	282.00	
Sulfato	mg/L	1	22	12.72	5.57	4.20	31.08	250.0
		2	11	12.88	3.93	4.76	18.70	
		3	12	5.54	3.40	0.50	10.00	
		Total	45	10.85	5.63	0.50	31.08	
Carbono Orgánico Total (TOC)	mg/L	1	22	3.22	2.85	1.30	12.00	(1 - 10)
		2	11	1.74	0.69	1.07	3.06	
		3	11	1.96	0.73	1.08	3.22	
		Total	44	2.54	2.17	1.07	12.00	
Turbiedad	Unidades Nefelométricas	1	20	52.08	112.28	3.60	512.00	50.0
		2	11	42.33	66.31	2.38	230.00	
		3	12	12.27	12.75	2.10	49.60	
		Total	43	38.48	84.15	2.10	512.00	

[1] Estándares de Calidad de Agua (JCA, 1990). Valores en paréntesis son valores típicos (Maidment, 1993).

Tabla 4-3. Resumen de Datos de Calidad de Agua en la Estación 5 del Estuario del RGA

Parámetro	Unidades	Periodo	N	Media	Desviación Estandar	Mínimo	Máximo	Estándares de Calidad de Agua[1]
Temperatura	°C	1	22	25.64	1.19	23.24	27.70	32.2
		2	11	25.40	1.99	22.26	28.13	
		3	12	26.02	1.15	24.60	28.05	
		Total	45	25.69	1.40	22.26	28.13	
pH	Unidades	1	22	7.77	0.14	7.58	8.15	6.0 - 9.0
		2	11	7.64	0.18	7.33	7.98	
		3	12	7.70	0.13	7.37	7.87	
		Total	45	7.72	0.16	7.33	8.15	
Oxígeno Disuelto	mg/L	1	22	7.78	0.47	6.82	8.57	5.0
		2	11	7.84	0.32	7.22	8.37	
		3	12	7.35	0.32	6.78	7.79	
		Total	45	7.68	0.44	6.78	8.57	
Conductividad	mS/cm	1	22	0.28	0.09	0.17	0.55	(0.07)
		2	11	0.24	0.06	0.17	0.41	
		3	12	0.29	0.09	0.24	0.55	
		Total	45	0.27	0.08	0.17	0.55	
Salinidad	ppt (‰)	1	22	0.13	0.06	0.08	0.30	
		2	11	0.12	0.03	0.09	0.20	
		3	12	0.14	0.04	0.11	0.27	
		Total	45	0.13	0.05	0.08	0.30	
Sólidos Disueltos Totales (TDS)	g/L	1	22	0.18	0.05	0.11	0.31	0.5
		2	11	0.15	0.04	0.11	0.26	
		3	12	0.18	0.05	0.15	0.35	
		Total	45	0.17	0.05	0.11	0.35	
Amonio	mg/L	1	10	0.11	0.07	0.05	0.26	1.0
		2	11	0.06	0.02	0.05	0.12	
		3	12	0.10	0.12	0.05	0.47	
		Total	33	0.09	0.08	0.05	0.47	
Demanda Bioquímica de Oxígeno (BOD_5)	mg/L	1	22	1.77	0.97	0.50	3.00	(2.0 -15.0)
		2	11	1.42	1.14	0.50	4.40	
		3	12	2.05	1.15	0.50	5.10	
		Total	45	1.76	1.06	0.50	5.10	
Bromuro	mg/L	1	22	2.88	4.16	1.00	19.40	
		2	11	1.00	0.00	1.00	1.00	
		3	12	0.49	0.46	0.05	1.00	
		Total	45	1.78	3.08	0.05	19.40	
Calcio	mg/L	1	22	36.52	11.09	19.40	58.30	(13.0 - 15.0)
		2	11	30.22	5.29	22.40	39.10	
		3	12	35.11	5.58	29.40	48.10	
		Total	45	34.60	8.92	19.40	58.30	
Cloruro	mg/L	1	22	16.94	14.30	8.25	65.10	250.0
		2	11	12.20	8.09	7.04	36.00	
		3	12	13.61	8.61	8.80	37.60	
		Total	45	14.89	11.63	7.04	65.10	
Demanda Química de Oxígeno (COD)	mg/L	1	22	6.54	5.15	2.50	26.28	
		2	11	8.68	6.76	2.50	22.00	
		3	12	11.00	6.56	2.50	21.00	
		Total	45	8.25	6.12	2.50	26.28	
Fluoruro	mg/L	1	22	0.11	0.07	0.01	0.33	0.70
		2	11	0.08	0.04	0.01	0.17	
		3	11	0.17	0.25	0.06	0.92	
		Total	44	0.12	0.14	0.01	0.92	
ortho-Fosfato	mg/L	1	22	0.20	0.29	0.01	1.30	(0.01 - 0.5)
		2	11	0.08	0.07	0.01	0.24	
		3	12	0.07	0.07	0.02	0.28	

Tabla 4-3. Resumen de Datos de Calidad de Agua en la Estación 5 del Estuario del RGA

Parámetro	Unidades	Periodo	N	Media	Desviación Estandar	Mínimo	Máximo	Estándares de Calidad de Agua[1]
		Total	45	0.13	0.21	0.01	1.30	
Fosforo Total	mg/L	1	22	0.33	0.59	0.01	2.84	1.00
		2	10	0.12	0.08	0.04	0.29	
		3	12	0.11	0.09	0.02	0.31	
		Total	44	0.22	0.43	0.01	2.84	
Magnesio	mg/L	1	22	6.35	1.66	2.40	10.44	(4.0)
		2	11	5.46	0.81	4.18	6.75	
		3	9	4.67	1.95	0.01	7.32	
		Total	42	5.76	1.67	0.01	10.44	
Nitrato (NO_3)	mg/L	1	20	0.65	0.21	0.22	1.09	(0.23)
		2	11	0.59	0.25	0.26	0.94	
		3	12	0.51	0.18	0.28	0.84	
		Total	43	0.60	0.22	0.22	1.09	
Nitrito (NO_2)	mg/L	1	20	0.01	0.01	0.01	0.06	(0.01 - 0.50)
		2	11	0.01	0.00	0.01	0.02	
		3	12	0.01	0.00	0.01	0.01	
		Total	43	0.01	0.01	0.01	0.06	
NO_2 + NO_3	mg/L	1	22	0.64	0.21	0.22	1.10	10.0
		2	11	0.59	0.25	0.26	0.95	
		3	12	0.51	0.18	0.28	0.84	
		Total	45	0.60	0.22	0.22	1.10	
Nitrógeno Orgánico Total (TON)	mg/L	1	10	0.38	0.24	0.10	0.82	(0.1 - 9.0)
		2	11	0.40	0.20	0.10	0.85	
		3	12	0.41	0.18	0.10	0.74	
		Total	33	0.40	0.20	0.10	0.85	
Nitrógeno Kjedahl Total (TKN)	mg/L	1	10	0.46	0.26	0.10	0.94	
		2	11	0.42	0.17	0.22	0.85	
		3	12	0.46	0.21	0.10	0.83	
		Total	33	0.45	0.21	0.10	0.94	
Potasio	mg/L	1	22	2.17	0.50	1.46	3.36	(1.3 - 2.3)
		2	11	2.03	0.53	1.30	2.90	
		3	12	1.85	1.45	0.47	5.98	
		Total	45	2.05	0.85	0.47	5.98	
Sodio	mg/L	1	22	12.91	7.52	5.20	37.75	(5.1 - 6.3)
		2	11	9.95	4.25	6.69	22.10	
		3	12	9.76	4.87	6.57	22.70	
		Total	45	11.35	6.28	5.20	37.75	
Sólidos Suspendidos Totales (TSS)	mg/L	1	22	44.17	74.93	4.80	267.00	(10 -110)
		2	11	34.25	50.85	6.00	183.00	
		3	12	16.16	12.78	2.50	49.00	
		Total	45	34.28	58.71	2.50	267.00	
Sulfato	mg/L	1	22	13.02	5.74	2.81	25.40	250.0
		2	11	13.88	3.03	9.90	18.70	
		3	12	6.08	4.48	0.50	14.30	
		Total	45	11.38	5.78	0.50	25.40	
Carbono Orgánico Total (TOC)	mg/L	1	22	3.34	3.05	1.20	12.30	(1 - 10)
		2	11	1.63	0.59	1.09	2.92	
		3	11	1.74	0.60	1.04	3.07	
		Total	44	2.51	2.32	1.04	12.30	
Turbiedad	Unidades Nefelométricas	1	20	55.89	115.30	3.80	525.00	50.0
		2	11	48.39	74.19	2.35	260.00	
		3	12	12.98	11.80	2.56	47.40	
		Total	43	42.00	87.77	2.35	525.00	

[1] Estándares de Calidad de Agua (JCA, 1990). Valores en paréntesis son valores tipicos (Maidment, 1993).

Tabla 4-4. Resumen de Datos de Calidad de Agua en la Estación 9 del Estuario del RGA

Parámetro	Unidades	Periodo	N	Media	Desviación Estandar	Mínimo	Máximo	Estándares de Calidad de Agua[1]
Temperatura	°C	1	22	26.15	1.24	24.27	28.67	32.2
		2	11	25.74	2.08	22.47	28.51	
		3	12	26.62	1.27	24.43	28.63	
		Total	45	26.18	1.49	22.47	28.67	
pH	Unidades	1	22	7.77	0.15	7.57	8.17	6.0 - 9.0
		2	11	7.62	0.14	7.37	7.81	
		3	12	7.72	0.14	7.40	7.87	
		Total	45	7.72	0.15	7.37	8.17	
Oxígeno Disuelto	mg/L	1	22	7.58	0.63	6.63	9.26	5.0
		2	11	7.73	0.27	7.35	8.19	
		3	12	7.30	0.48	6.21	8.02	
		Total	45	7.54	0.54	6.21	9.26	
Conductividad	mS/cm	1	22	0.43	0.34	0.03	1.55	(0.07)
		2	11	0.40	0.55	0.17	2.06	
		3	12	0.47	0.46	0.25	1.87	
		Total	45	0.43	0.42	0.03	2.06	
Salinidad	ppt (‰)	1	22	0.22	0.19	0.09	0.90	
		2	11	0.20	0.30	0.09	1.10	
		3	12	0.24	0.25	0.12	1.01	
		Total	45	0.22	0.23	0.09	1.10	
Sólidos Disueltos Totales (TDS)	g/L	1	22	0.28	0.21	0.13	1.01	0.5
		2	11	0.25	0.35	0.11	1.31	
		3	12	0.30	0.30	0.16	1.20	
		Total	45	0.28	0.27	0.11	1.31	
Amonio	mg/L	1	10	0.11	0.07	0.05	0.23	1.0
		2	11	0.07	0.03	0.05	0.14	
		3	12	0.08	0.04	0.05	0.15	
		Total	33	0.08	0.05	0.05	0.23	
Demanda Bioquímica de Oxígeno (BOD_5)	mg/L	1	22	2.23	2.36	0.50	12.00	(2.0 -15.0)
		2	11	1.30	1.02	0.50	4.00	
		3	12	2.02	1.48	0.50	6.00	
		Total	45	1.95	1.89	0.50	12.00	
Bromuro	mg/L	1	22	2.85	4.78	1.00	22.30	
		2	11	1.00	0.00	1.00	1.00	
		3	12	0.81	0.34	0.24	1.00	
		Total	45	1.86	3.45	0.24	22.30	
Calcio	mg/L	1	22	36.47	10.50	21.00	53.30	(13.0 - 15.0)
		2	11	30.34	8.74	24.70	55.00	
		3	12	36.18	7.99	28.40	54.40	
		Total	45	34.89	9.63	21.00	55.00	
Cloruro	mg/L	1	22	65.05	94.31	9.37	362.00	250.0
		2	11	16.10	11.78	7.31	48.60	
		3	12	67.46	135.59	11.60	481.90	
		Total	45	53.72	96.66	7.31	481.90	
Demanda Química de Oxígeno (COD)	mg/L	1	22	7.25	6.87	2.50	35.60	
		2	11	11.68	9.03	2.50	29.00	
		3	12	12.17	8.89	2.50	34.00	
		Total	45	9.65	8.15	2.50	35.60	
Fluoruro	mg/L	1	22	0.11	0.06	0.01	0.25	0.70
		2	11	0.08	0.04	0.01	0.15	
		3	11	0.10	0.04	0.06	0.20	
		Total	44	0.10	0.05	0.01	0.25	
ortho-Fosfato	mg/L	1	22	0.32	0.52	0.01	2.10	(0.01 - 0.5)
		2	11	0.12	0.12	0.03	0.37	
		3	12	0.07	0.05	0.02	0.23	

Tabla 4-4. Resumen de Datos de Calidad de Agua en la Estación 9 del Estuario del RGA

Parámetro	Unidades	Periodo	N	Media	Desviación Estandar	Mínimo	Máximo	Estándares de Calidad de Agua[1]
		Total	45	0.20	0.38	0.01	2.10	
Fosforo Total	mg/L	1	22	0.37	0.62	0.01	2.85	1.00
		2	10	0.14	0.10	0.06	0.35	
		3	12	0.11	0.09	0.02	0.28	
		Total	44	0.25	0.45	0.01	2.85	
Magnesio	mg/L	1	22	8.83	4.86	2.20	23.18	(4.0)
		2	11	7.26	6.42	4.20	26.50	
		3	9	8.13	10.28	0.01	35.10	
		Total	42	8.27	6.57	0.01	35.10	
Nitrato (NO_3)	mg/L	1	20	0.66	0.21	0.31	1.13	(0.23)
		2	11	0.58	0.26	0.24	0.94	
		3	12	0.84	1.28	0.24	4.87	
		Total	43	0.69	0.69	0.24	4.87	
Nitrito (NO_2)	mg/L	1	20	0.01	0.00	0.01	0.02	(0.01 - 0.50)
		2	11	0.01	0.00	0.01	0.02	
		3	12	0.01	0.00	0.01	0.01	
		Total	43	0.01	0.00	0.01	0.02	
$NO_2 + NO_3$	mg/L	1	22	0.64	0.21	0.31	1.14	10.0
		2	11	0.58	0.26	0.24	0.95	
		3	12	0.84	1.28	0.24	4.87	
		Total	45	0.68	0.68	0.24	4.87	
Nitrógeno Orgánico Total (TON)	mg/L	1	10	0.41	0.32	0.10	0.85	(0.1 - 9.0)
		2	11	0.45	0.20	0.10	0.79	
		3	12	0.39	0.12	0.20	0.60	
		Total	33	0.41	0.21	0.10	0.85	
Nitrógeno Kjedahl Total (TKN)	mg/L	1	10	0.50	0.31	0.10	1.08	
		2	11	0.48	0.17	0.21	0.79	
		3	12	0.44	0.12	0.23	0.64	
		Total	33	0.47	0.20	0.10	1.08	
Potasio	mg/L	1	22	3.42	2.25	1.44	9.36	(1.3 - 2.3)
		2	11	3.84	5.82	1.20	21.30	
		3	12	3.02	2.91	0.83	11.00	
		Total	45	3.42	3.51	0.83	21.30	
Sodio	mg/L	1	22	43.66	49.81	6.80	167.00	(5.1 - 6.3)
		2	11	11.12	6.16	7.00	28.70	
		3	12	28.85	41.20	7.11	142.00	
		Total	45	31.76	42.39	6.80	167.00	
Sólidos Suspendidos Totales (TSS)	mg/L	1	22	42.12	66.73	4.60	247.00	(10 -110)
		2	11	43.27	50.90	5.00	188.00	
		3	12	23.33	12.39	7.70	45.00	
		Total	45	37.39	53.16	4.60	247.00	
Sulfato	mg/L	1	22	20.40	10.42	9.10	48.20	250.0
		2	11	22.74	24.35	5.76	85.90	
		3	12	17.59	32.49	0.50	120.00	
		Total	45	20.22	21.31	0.50	120.00	
	mg/L	1	22	3.03	2.92	0.66	12.40	(1 - 10)
Carbono Orgánico Total (TOC)		2	11	1.77	0.59	1.15	3.13	
		3	11	1.78	0.63	0.98	3.06	
		Total	44	2.40	2.18	0.66	12.40	
Turbiedad	Unidades Nefelométricas	1	20	53.67	109.89	3.40	500.00	50.0
		2	11	54.93	75.89	5.10	270.00	
		3	12	15.87	11.44	3.52	48.80	
		Total	43	43.44	84.68	3.40	500.00	

[1] Estándares de Calidad de Agua (JCA, 1990). Valores en paréntesis son valores tipicos (Maidment, 1993).

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Appendix D

Chemical of Potential Concern (COPC) Database

Chemical Abstract Services Number	Chemical of Potential Concern	Molecular Weight	Melting Point	Vapor Pressure	Aqueous Solubility	Henry's Law Constant	Diffusivity in Air	Diffusivity in Water	Log Octanol-Water Partitioning Coefficient	Organic Carbon Normalized Soil Sorption Coefficient	Soil to Water Partition Coefficient	Suspended Sediment to Surface Water Partition Coefficient	Bottom Sediment to Sediment Pore Water Partition Coefficient	Soil Loss Constant due to Degradation
		g/mole	Kelvin	atm	mg/L	atm-m^3/mole	cm^2/s	cm^2/s	unitless	mL/g	cm^3/g	L/kg	cm^3/g	1/yr
CAS_NUMBER	**COPC_NAME**	**param_MW**	**param_T_m**	**param_V_p**	**param_S**	**param_H**	**param_D_a**	**param_Dw**	**param_K_ow**	**param_K_oc**	**param_Kd_s**	**param_Kd_sw**	**param_Kd_bs**	**param_K_sg**
83-32-9	Acenaphthene	154.212	366.15	3.29E-6	3.6	0.00016	0.001	1E-5	7943.28234724282	4900	1100	367.5	196	2.48
280-96-8	Acenaphthylene	152.21	366	1E-6	16	1.1E-4	.0438669	7.53E-6	12589	6123	1500	0	0	0
120-12-7	Anthracene	178.234	493.15	3.55E-9	0.043	6.5E-5	0.001	1E-5	31622.7766016838	23500	4500	1762.5	940	0.55
7440-36-0	Antimony	124.77	903.15	0	0	0	0	0	0	0	45	45	45	0
11097-69-1	Aroclor 1254	326.44	283.1	1.01E-7	0.043	0.000283	0.001	1E-5	3162277.66016838	2453465.75	24534.66	184009.93	98138.63	0.03
7440-38-2	Arsenic	77.95	1093.15	3.3E-12	0	0	0	0	0	0	29	29	29	0
56-55-3	Benzo(a)anthracene	228.294	357.15	1.45E-10	0.0094	3.4E-6	0.051	9E-6	501187.233627273	358000	60000	26850	14320	0.37
50-32-8	Benzo(a)pyrene	252.32	453.15	7.24E-12	0.0016	1.1E-6	0.043	9E-6	1000000	969000	160000	72675	38760	0.48
205-99-2	Benzo(b)fluoranthene	252.32	440.65	6.58E-10	0.0015	0.000111	0.001	1E-5	1330454.41797809	1047543.34	10475.43	78565.75	41901.7335931264	0.41
207-08-9	Benzo(k)fluoranthene	252.32	493.15	2.63E-12	0.0008	8.3E-7	0.001	1E-5	1258925.41179417	992156.08	190000	74411.7	39686.24	0.12
7440-41-7	Beryllium	9.01	1573.15	5.58E-12	0	0	0	0	0	0	790	790	790	0
7440-43-9	Cadmium	112.4	593.15	5.45E-12	0	0	0	0	0	0	75	75	75	0
7440-47-3	Chromium	51.996	2173.15	5.58E-12	0	0	0	0	0	0	19	19	19	0
18540-29-9	Chromium, hexavalent	51.996	2173.15	0	1.69E6	0	0	0	0	0	19	19	19	0
218-01-9	Chrysene	228.294	533.15	8.16E-12	0.0063	9.5E-5	0.001	1E-5	501187.233627273	401217.62	60000	30091.32	16048.7	0.25
007440-48-4	Cobalt	58.9	1773.15	0	0	0	0	0	0	0	45	45	45	0
7440-50-8	Copper	63.55	1356	5.58E-12	0	0	0	0	0	0	35	35	35	0
53-70-3	Dibenz(a,h)anthracene	278.33	543.15	1.32E-13	0.0025	1.5E-8	0.001	1E-5	3162277.66016838	1790000	580000	134250	71600	0.27
206-44-0	Fluoranthene	202.256	383.15	1.03E-8	0.21	1.6E-5	0.001	1E-5	100000	49100	11000	3682.5	1964	0.57
86-73-7	Fluorene	166.223	383.15	8.29E-7	2	6.4E-5	0.001	1E-5	15848.9319246112	7710	2100	578.25	308.4	4.22
35822-46-9	HeptaCDD, 1,2,3,4,6,7,8-	425.31	537.7	7.37E-15	2.4E-6	1.2E-5	0.0904888336173498	8E-6	100000000	61659500.19	616595	4624462.51	2466380	0.03
67562-39-4	HeptaCDF, 1,2,3,4,6,7,8-	409.31	509.7	4.61E-14	1.35E-6	1.41E-5	0.0203183391320296	8E-6	25118864.3150958	15488166.19	154881.66	1161612.46	619526.65	0.03
55673-89-7	HeptaCDF, 1,2,3,4,7,8,9-	409.31	495.2	4.04E-13	1.4E-6	1.4E-5	0.0203183391320296	8E-6	25118864.3150958	15488166.19	154881.66	1161612.46	619526.65	0.03
39227-28-6	HexaCDD, 1,2,3,4,7,8-	390.87	547.2	5E-14	4.42E-6	1.07E-5	0.094391224035758	8E-6	63095734.4480194	38904514.5	389045.14	2917838.59	1556180.58	0.03
57653-85-7	HexaCDD, 1,2,3,6,7,8-	390.87	558.7	4.73E-14	4.4E-6	1.1E-5	0.094391224035758	8E-6	19952623.1496888	12302687.71	123026.88	922701.58	492107.51	0.03
19408-74-3	HexaCDD, 1,2,3,7,8,9-	390.87	516.7	6.45E-14	4.4E-6	1.1E-5	0.094391224035758	8E-6	19952623.1496888	12302687.71	123026.88	922701.58	492107.51	0.03
70648-26-9	HexaCDF, 1,2,3,4,7,8-	374.87	499.2	3.16E-13	8.25E-6	1.43E-5	0.0212311754528064	8E-6	10000000	6165950.02	61659.5	462446.25	246638	0.03
57117-44-9	HexaCDF, 1,2,3,6,7,8-	374.87	505.7	2.89E-13	1.77E-5	7.31E-6	0.0212311754528064	8E-6	10000000	6165950.02	61659.5	462446.25	246638	0.03
72918-21-9	HexaCDF, 1,2,3,7,8,9-	374.87	520.7	3.68E-13	1.3E-5	1.1E-5	0.0212311754528064	8E-6	10000000	6165950.02	61659.5	462446.25	246638	0.03
60851-34-5	HexaCDF, 2,3,4,6,7,8-	374.87	512.7	2.63E-13	1.3E-5	1.1E-5	0.0212311754528064	8E-6	10000000	6165950.02	61659.5	462446.25	246638	0.03
7647-01-0	Hydrogen chloride	36.46	158.98	46.6	720000	0.00235870614035088	0	0	0	0	0	0	0	0
7664-39-3	Hydrogen fluoride	20.01	186.6	1.21	922	1.4E-5	0	0	1.698	150	150	150	150	0
193-39-5	Indeno(1,2,3-cd) pyrene	276.34	433.15	1.32E-13	2.2E-5	1.6E-6	0.001	1E-5	3981071.70553498	3076663.5	530000	230749.76	123066.54	0.35
7439-92-1	Lead	209.21	603.15	3.97E-12	0	0	0	0	0	0	900	900	900	0
7439-96-5	Manganese	54.94	1517	5.58E-12	0	0	0	0	0	0	65	65	65	0
7487-94-7	Mercuric chloride	271.52	550.1	0.00012	69000	7.1E-10	0	0	0.609536897240169	0	58000	100000	50000	0
7439-97-6	Mercury	200.59	234.23	2.63E-6	0.06	0.0071	0.0109	3.01E-5	0	0	1000	1000	3000	0
22967-92-6	Methyl mercury	216	0	0	0	4.7E-7	0	0	0	0	7000	100000	3000	0
91-57-6	Methylnaphthalene, 2-	142.2	308	7.24E-5	24.6	5.18E-4	4.8E-2	7.84E-6	7.24E3	8500	950	950	950	0
0074939-98-7	Molybdenum	95.9	2893.15	0	0	0	0	0	0	0	2.0E+01	2.0E+01	2.0E+01	0
91-20-3	Naphthalene	128.18	353.15	0.000112	31	0.00048	0.059	7.5E-6	1995.26231496888	1190	300	89.25	47.6	5.27
7440-02-0	Nickel	58.71	1773.15	5.58E-12	0	0	0	0	0	0	65	65	65	0
3268-87-9	OctaCDD, 1,2,3,4,6,7,8,9-	460.76	598.7	1.09E-15	7.4E-8	6.75E-6	0.0869381516281836	8E-6	158489319.246111	97723722.1	977237.22	7329279.16	3908948.88	0.03

Chemical Abstract Services Number	Chemical of Potential Concern	Molecular Weight	Melting Point	Vapor Pressure	Aqueous Solubility	Henry's Law Constant	Diffusivity in Air	Diffusivity in Water	Log Octanol-Water Partitioning Coefficient	Organic Carbon Normalized Soil Sorption Coefficient	Soil to Water Partition Coefficient	Suspended Sediment to Surface Water Partition Coefficient	Bottom Sediment to Sediment Pore Water Partition Coefficient	Soil Loss Constant due to Degradation
		g/mole	Kelvin	atm	mg/L	atm-m^3/mole	cm^2/s	cm^2/s	unitless	mL/g	cm^3/g	L/kg	cm^3/g	1/yr
CAS_NUMBER	**COPC_NAME**	**param_MW**	**param_T_m**	**param_V_p**	**param_S**	**param_H**	**param_D_a**	**param_Dw**	**param_K_ow**	**param_K_oc**	**param_Kd_s**	**param_Kd_sw**	**param_Kd_bs**	**param_K_sg**
39001-02-0	OctaCDF, 1,2,3,4,6,7,8,9-	444.76	532.2	4.93E-15	1.16E-6	1.88E-6	0.0194917809291022	8E-6	100000000	61659500.19	616595	4624462.51	2466380	0.03
40321-76-4	PentaCDD, 1,2,3,7,8-	356.42	513.7	5.79E-13	0.000118	2.6E-6	0.0988477422976492	8E-6	4365158.32240167	2691534.8	26915.35	201865.11	107661.39	0.03
57117-41-6	PentaCDF, 1,2,3,7,8-	340.42	499.2	2.23E-12	0.00024	5E-6	0.0222795722631019	8E-6	6165950.01861483	3801893.96	38018.94	285142.05	152075.76	0.03
57117-31-4	PentaCDF, 2,3,4,7,8-	340.42	469.4	3.42E-12	0.000236	4.98E-6	0.0222795722631019	8E-6	3162277.66016838	1949844.6	19498.45	146238.34	77993.78	0.03
85-01-8	Phenanthrene	178.234	372.15	1.45E-7	1.1	2.3E-5	0.001	1E-5	31622.7766016838	26532.61	3700	1989.95	1061.3	1.26
129-00-0	Pyrene	202.256	423.15	6.05E-9	1.4	1.1E-5	0.001	1E-5	79432.8234724283	68000	9500	5100	2720	0.13
7782-49-2	Selenium	78.96	493.15	1.87E-13	0	0	0	0	0	0	5	5	5	0
1746-01-6	TetraCDD, 2,3,7,8-	321.98	578.7	1.97E-12	1.93E-5	3.29E-5	0.104	5.6E-6	6309573.44480193	3890451.45	38904.51	291783.86	155618.06	0.03
51207-31-9	TetraCDF, 2,3,7,8-	305.98	500.7	1.97E-11	0.000419	1.44E-5	0.0235	6.01E-6	1258925.41179417	776247.12	7762.47	58218.53	31049.88	0.03
007440-31-5	Tin	121	286.35	0	0	0	0	0	0	250	250	0	0	0
7440-62-2	Vanadium	50.94	2183	0	0	0	0	0	0	0	1000	1000	1000	0
7440-66-6	Zinc	65.37	693.15	5.09E-12	0	0	0	0	0	0	62	62	62	0

Appendix D. Constituent of Potential Concern (COPC) Database of Chemical and Physical Parameters

Chemical Abstract Services Number	Chemical of Potential Concern	Fraction of COPC air Concentration in Vapor Phase	Root Concentration Factor	Root Vegetable to Soil Bioconcentration Factor	Leafy Vegetable to Soil Bioconcentration Factor	Forage to Soil Bioconcentration Factor	Air to Leafy Vegetable Biotransfer Factor	Air to Forage Biotrasfer Factor	Biotrasfer Factor for Milk	Biotransfer Factor for Beef	Biotransfer Factor for Pork
		unitless	ug/g WW plant / ug/mL Soil water	ug/g DW plant / ug/g soil	ug/g DW plant / ug/g soil	ug/g DW plant / ug/g soil	ug/g DW plant / ug/g air	ug/g DW plant / ug/g air	day/kg	day/kg	day/kg
CAS_NUMBER	**COPC_NAME**	**param_f_v**	**param_RCF**	**param_br_root_veg**	**param_br_leafy_veg**	**param_br_forage**	**param_bv_leafy_veg**	**param_bv_forage**	**param_ba_milk**	**param_ba_beef**	**param_ba_pork**
83-32-9	Acenaphthene	1	234	0.213	0.216	0.216	4.97	4.97	0.00512000035782844	0.0243200016996851	0.0294400020575135
280-96-8	Acenaphthylene	1	0	0	.27	.27	0	0	0	0	0
120-12-7	Anthracene	0.998	678	0.151	0.0971	0.0971	53.3	53.3	0.00711721345857463	0.0338067639282295	0.0409239773868041
7440-36-0	Antimony	0	0	0.03	0.0319	0.2	0	0	0.0001	0.001	0
11097-69-1	Aroclor 1254	0.992	23499	0.958	0.00678	0.00678	1652	1652	0.00652093680331813	0.0309744498157611	0.0374953866190793
7440-38-2	Arsenic	0	0	0.008	0.00633	0.036	0	0	6E-5	0.002	0
56-55-3	Benzo(a)anthracene	0.483	5689	0.0948	0.0197	0.0197	19338	19338	0.00840523753621224	0.0399248782970081	0.0483301158332204
50-32-8	Benzo(a)pyrene	0.294	9684	0.0605	0.0132	0.0132	124742	124742	0.00790787856044744	0.0375624231621253	0.0454703017225728
205-99-2	Benzo(b)fluoranthene	0.966	12065	1.15	0.0112	0.0112	1675	1675	0.00761913673015491	0.0361908994682358	0.0438100361983908
207-08-9	Benzo(k)fluoranthene	0.273	11562	0.0609	0.0115	0.0115	211264	211264	0.00767838689440205	0.0364723377484097	0.0441507246428118
7440-41-7	Beryllium	0	0	0.0015	0.00258	0.01	0	0	9E-7	0.001	0
7440-43-9	Cadmium	0	0	0.064	0.125	0.364	0	0	6.5E-6	0.00012	0.000191489361702128
7440-47-3	Chromium	0	0	0.0045	0.00488	0.0075	0	0	0.0015	0.0055	0
18540-29-9	Chromium, hexavalent	0	0	0.0045	0.00488	0.0075	0	0	0.0015	0.0055	0
218-01-9	Chrysene	0.744	5689	0.0948	0.0197	0.0197	692	692	0.00840523753621224	0.0399248782970081	0.0483301158332204
007440-48-4	Cobalt	0	0	1.3E-03	1.10E-01	2.8E-01	0	0	7E-05	1E-04	0.000121053
7440-50-8	Copper	0	0	.25	0	.4	0	0	1.5E-3	1E-2	0
53-70-3	Dibenz(a,h)anthracene	0.055	23499	0.0405	0.00678	0.00678	31175561	31175561	0.00652093680331813	0.0309744498157611	0.0374953866190793
206-44-0	Fluoranthene	0.992	1644	0.15	0.0499	0.0499	738	738	0.00826152062324212	0.0392422229604001	0.0475037435836422
86-73-7	Fluorene	1	398	0.19	0.145	0.145	26	26	0.00616169207896548	0.029268037375086	0.0354297294540515
35822-46-9	HeptaCDD, 1,2,3,4,6,7,8-	0.003	335781	0.545	0.00092	0.00092	910000	910000	0.00184527029824152	0.00876503391664721	0.0106103042148887
67562-39-4	HeptaCDF, 1,2,3,4,6,7,8-	0.01	115892	0.748	0.00205	0.00205	830000	830000	0.00345796020756315	0.016425310985925	0.0198832711934881
55673-89-7	HeptaCDF, 1,2,3,4,7,8,9-	0.057	115892	0.748	0.00205	0.00205	830000	830000	0.00345796020756315	0.016425310985925	0.0198832711934881
39227-28-6	HexaCDD, 1,2,3,4,7,8-	0.024	235535	0.605	0.0012	0.0012	520000	520000	0.00231686106529583	0.0110050900601552	0.01332195112545 1
57653-85-7	HexaCDD, 1,2,3,6,7,8-	0.029	97063	0.789	0.00234	0.00233	520000	520000	0.00377876593260574	0.0179491381798773	0.021727904112483
19408-74-3	HexaCDD, 1,2,3,7,8,9-	0.016	97063	0.789	0.00234	0.00234	520000	520000	0.00377876593260574	0.0179491381798773	0.021727904112483
70648-26-9	HexaCDF, 1,2,3,4,7,8-	0.049	57023	0.925	0.00348	0.00348	162000	162000	0.00479799721259752	0.0227904867598382	0.0275884839724357
57117-44-9	HexaCDF, 1,2,3,6,7,8-	0.052	57023	0.925	0.00348	0.00348	162000	162000	0.00479799721259752	0.0227904867598382	0.0275884839724357
72918-21-9	HexaCDF, 1,2,3,7,8,9-	0.09	57023	0.925	0.00348	0.00348	162000	162000	0.00479799721259752	0.0227904867598382	0.0275884839724357
60851-34-5	HexaCDF, 2,3,4,6,7,8-	0.055	57023	0.925	0.00348	0.00348	162000	162000	0.00479799721259752	0.0227904867598382	0.0275884839724357
7647-01-0	Hydrogen chloride	1	0	0	0	0	0	0	1.10169148133526E-5	5.23303453634251E-5	6.33472601767777E-5
7664-39-3	Hydrogen fluoride	1	0	0	0	0	0	0	1.92E-5	9.11E-5	.00011
193-39-5	Indeno(1,2,3-cd) pyrene	0.005	28057	0.0529	0.00593	0.00593	373495	373495	0.0061889929977113	0.0293977167391287	0.03558670973684
7439-92-1	Lead	0	0	0.009	0.0136	0.045	0	0	0.00025	0.0003	0
7439-96-5	Manganese	0	0	.5	0	.25	0	0	3.5E-4	4E-4	0
7487-94-7	Mercuric chloride	0.85	0	0.036	0.0145	0	1800	1800	0.002262	0.00522	3.393E-5
7439-97-6	Mercury	1	0	0	0	0	0	0	0	0	0
22967-92-6	Methyl mercury	0	0	0.099	0.0294	0	0	0	0.000338	0.00078	5.07E-6
91-57-6	Methylnaphthalene, 2-	1	218	.229	.227	.227	1.51	1.51	5E-3	3.4E-2	2.86E-2
0074939-98-7	Molybdenum	0	0	3.20E-01	5.10E-01	0	0	0	1.7E-03	1E-03	0.001210526
91-20-3	Naphthalene	1	80.7	0.269	0.479	0.479	0.381	0.381	0.00312571942223865	0.0148471672556336	0.0179728866778722
7440-02-0	Nickel	0	0	0.008	0.00931	0.032	0	0	0.001	0.006	0
3268-87-9	OctaCDD, 1,2,3,4,6,7,8,9-	0.002	478692	0.49	0.000705	0.000705	2360000	2360000	0.00144311184484882	0.00685478126303191	0.00829789310788074

Chemical Abstract Services Number	Chemical of Potential Concern	Fraction of COPC air Concentration in Vapor Phase	Root Concentration Factor	Root Vegetable to Soil Bioconcentration Factor	Leafy Vegetable to Soil Bioconcentration Factor	Forage to Soil Bioconcentration Factor	Air to Leafy Vegetable Biotransfer Factor	Air to Forage Biotrasfer Factor	Biotrasfer Factor for Milk	Biotransfer Factor for Beef	Biotransfer Factor for Pork
		unitless	ug/g WW plant / ug/mL Soil water	ug/g DW plant / ug/g soil	ug/g DW plant / ug/g soil	ug/g DW plant / ug/g soil	ug/g DW plant / ug/g air	ug/g DW plant / ug/g air	day/kg	day/kg	day/kg
CAS_NUMBER	**COPC_NAME**	**param_f_v**	**param_RCF**	**param_br_root_veg**	**param_br_leafy_veg**	**param_br_forage**	**param_bv_leafy_veg**	**param_bv_forage**	**param_ba_milk**	**param_ba_beef**	**param_ba_pork**
39001-02-0	OctaCDF, 1,2,3,4,6,7,8,9-	0.002	478692	0.776	0.00092	0.00092	2280000	2280000	0.00184527029824152	0.00876503391664721	0.0106103042148887
40321-76-4	PentaCDD, 1,2,3,7,8-	0.117	30120	1.12	0.00562	0.00562	239000	239000	0.00605326366811965	0.0287530024235684	0.034806266091688
57117-41-6	PentaCDF, 1,2,3,7,8-	0.268	39296	1.03	0.00461	0.00461	97500	97500	0.00553419033200588	0.0262874040770279	0.0318215944090338
57117-31-4	PentaCDF, 2,3,4,7,8-	0.221	23499	1.21	0.00678	0.00678	97500	97500	0.00652093680331813	0.0309744498157611	0.0374953866190793
85-01-8	Phenanthrene	0.999	678	0.183	0.097	0.0971	151	151	0.00711721345857463	0.0338067639282295	0.0409239773868041
129-00-0	Pyrene	0.994	1377	0.145	0.057	0.057	840	840	0.00809226304381041	0.0384382494580995	0.0465305125019099
7782-49-2	Selenium	0	0	0.022	0.0195	0.016	0	0	0.0058565	0.002265	0.187659574468085
1746-01-6	TetraCDD, 2,3,7,8-	0.664	39999	1.03	0.00455	0.00455	65500	65500	0.00549920603406625	0.0261212286618147	0.031620434695881
51207-31-9	TetraCDF, 2,3,7,8-	0.77	11562	1.49	0.0115	0.0115	45700	45700	0.00767838689440205	0.0364723377484097	0.0441507246428118
007440-31-5	Tin	0	0	0	1	0	0	0	1E-03	1E-02	0.012105263
7440-62-2	Vanadium	0	0	3E-3	0	5.5E-3	0	0	2E-5	2.5E-3	0
7440-66-6	Zinc	0	0	0.9	0.097	0.25	0	0	3.25E-5	9E-5	0.000127659574468085

Chemical Abstract Services Number	Chemical of Potential Concern	Bioconcentration Factor for Poultry Eggs	Bioconcentration Factor for Chicken	Bioconcentration Factor for Fish	Bioaccumulation Factor for Fish	Fish to Biota Sediment Accumulation Factor	Oral Reference Dose	Oral Cancer Slope Factor	Inhalation Reference Concentration	Inhalation Unit Risk Factor	Inhalation Cancer Slope Factor
		unitless	unitless	L/kg	L/kg	unitless	mg/kg-d	$(mg/kg\text{-}d)^{-1}$	mg/m^3	$(ug/m^3)^{-1}$	$(mg/kg\text{-}d)^{-1}$
CAS_NUMBER	**COPC_NAME**	**param_bcf_egg**	**param_bcf_chicken**	**param_BCF_fish**	**param_BAF_fish**	**param_BSAF_fish**	**param_RfD**	**param_Oral_csf**	**param_RfC**	**param_inhalation_urf**	**param_inhalation_csf**
83-32-9	Acenaphthene	0.0731973468298426	0	201	0	0	0.06	0	0.21	0	0
280-96-8	Acenaphthylene	0	0	0	0	0	0	0	0	0	0
120-12-7	Anthracene	0.234461865043566	0	582	1027.99428258336	0	0.3	0	1	0	0
7440-36-0	Antimony	0	0	40	0	0	0.0004	0	0.0014	0	0
11097-69-1	Aroclor 1254	12.7976684313957	0	84100	0	2	2E-5	2	7E-5	5.7E-4	2
7440-38-2	Arsenic	0	0	114	0	0	0.0003	1.5	1.5E-5	0.0043	15
56-55-3	Benzo(a)anthracene	3.78927929749341	0	4886	49886.5193653099	0	0	0.73	0	0.00011	.39
50-32-8	Benzo(a)pyrene	10.6974645787847	0	8317.64	133048.932825583	0	0	7.3	0	0.0011	3.85
205-99-2	Benzo(b)fluoranthene	12.6514246601006	0	10400	206293.629312622	0	0	0.73	0	0.00011	.39
207-08-9	Benzo(k)fluoranthene	12.5892525891687	0	9930	176605.826890695	0	0	0.073	0	0.00011	.39
7440-41-7	Beryllium	0	0	62	0	0	0.002	0	2E-5	0.0024	8.4
7440-43-9	Cadmium	0.0025	0	907	0	0	1E-3	0	1E-5	0.0018	6.3
7440-47-3	Chromium	0	0	19	0	0	1.5	0	5.3	0	0
18540-29-9	Chromium, hexavalent	0	0	3.16	0	0	0.003	0.5	1E-4	1.2E-02	420
218-01-9	Chrysene	4.35480922748771	0	4890	49886.5193653099	0	0	0.0073	0	1.1E-5	.039
007440-48-4	Cobalt	0	0	300	0	0	3E-04	0	6E-06	9E-03	32
7440-50-8	Copper	0	0	0	0	0	4E-2	0	0	0	0
53-70-3	Dibenz(a,h)anthracene	28.0205798290515	0	20183	496598.860120211	0	0	7.3	0	0.0012	4.2
206-44-0	Fluoranthene	0.964997599237141	0	1410	4493.28192944499	0	0.04	0	0.14	0	0
86-73-7	Fluorene	0.116948945998456	0	342	471.931630668919	0	0.04	0	0.14	0	0
35822-46-9	HeptaCDD, 1,2,3,4,6,7,8-	0.02552	0.39	2754	0	0.005	0	1.3E+03	0	.38	1.3E+03
67562-39-4	HeptaCDF, 1,2,3,4,6,7,8-	0.0209	0.32	18281	0	0.005	0	1.3E+03	0	.38	1.3E+03
55673-89-7	HeptaCDF, 1,2,3,4,7,8,9-	0.0242	0.48	18281	0	0.005	0	1.3E+03	0	.38	1.3E+03
39227-28-6	HexaCDD, 1,2,3,4,7,8-	0.04532	1.83	5176	0	0.04	0	1.3E+04	0	3.8	1.3E+04
57653-85-7	HexaCDD, 1,2,3,6,7,8-	0.03696	1.17	25100	0	0.04	0	1.3E+04	0	3.8	1.3E+04
19408-74-3	HexaCDD, 1,2,3,7,8,9-	0.02332	0.63	25100	0	0.04	0	1.3E+04	0	3.8	1.3E+04
70648-26-9	HexaCDF, 1,2,3,4,7,8-	0.0451	1.58	48977	0	0.04	0	1.3E+04	0	3.8	1.3E+04
57117-44-9	HexaCDF, 1,2,3,6,7,8-	0.04532	1.62	48977	0	0.04	0	1.3E+04	0	3.8	1.3E+04
72918-21-9	HexaCDF, 1,2,3,7,8,9-	0	0	48977	0	0.04	0	1.3E+04	0	3.8	1.3E+04
60851-34-5	HexaCDF, 2,3,4,6,7,8-	0.02706	0.79	48977	0	0.04	0	1.3E+04	0	3.8	1.3E+04
7647-01-0	Hydrogen chloride	0	0	3.16	0	0	0.00571	0	0.02	0	0
7664-39-3	Hydrogen fluoride	0	0	0	0	0	4E-02	0	1.4E-2	0	0
193-39-5	Indeno(1,2,3-cd) pyrene	65.3205735856933	0	24100	618020.247186678	0	0	0.73	0	0.00011	.39
7439-92-1	Lead	0	0	0.09	0	0	0.000429	0.0085	0.0015	1.2E-5	4.2E-02
7439-96-5	Manganese	0	0	0	0	0	.14	0	5E-5	0	0
7487-94-7	Mercuric chloride	0.023925	0	0	0	0	0.0003	0	3E-05	0	0
7439-97-6	Mercury	0	0	0	0	0	1.6E-4	0	0.0003	0	0
22967-92-6	Methyl mercury	0.003575	0	0	6800000	0	0.0001	0	0.00035	0	0
91-57-6	Methylnaphthalene, 2-	0	0	97.72	0	0	4E-3	0	0	0	0
0074939-98-7	Molybdenum	0	0	1.00E+01	0	0	5.0E-03	0	0	0	0
91-20-3	Naphthalene	0.0187143732101041	0	69.3	0	0	0.02	0	0.003	3.4E-5	1.2E-1
7440-02-0	Nickel	0	0	78	0	0	0.02	0	9E-5	0.00026	.91
3268-87-9	OctaCDD, 1,2,3,4,6,7,8,9-	0.0099	0.05	1465	0	0.0001	0	39	0	1.14E-2	4E+01

Chemical Abstract Services Number	Chemical of Potential Concern	Bioconcentration Factor for Poultry Eggs	Bioconcentration Factor for Chicken	Bioconcentration Factor for Fish	Bioaccumulation Factor for Fish	Fish to Biota Sediment Accumulation Factor	Oral Reference Dose	Oral Cancer Slope Factor	Inhalation Reference Concentration	Inhalation Unit Risk Factor	Inhalation Cancer Slope Factor
		unitless	unitless	L/kg	L/kg	unitless	mg/kg-d	$(mg/kg\text{-}d)^{-1}$	mg/m^3	$(ug/m^3)^{-1}$	$(mg/kg\text{-}d)^{-1}$
CAS_NUMBER	**COPC_NAME**	**param_bcf_egg**	**param_bcf_chicken**	**param_BCF_fish**	**param_BAF_fish**	**param_BSAF_fish**	**param_RfD**	**param_Oral_csf**	**param_RfC**	**param_inhalation_urf**	**param_inhalation_csf**
39001-02-0	OctaCDF, 1,2,3,4,6,7,8,9-	0.00792	0.02	2754	0	0.0001	0	39	0	1.14E-2	4E+01
40321-76-4	PentaCDD, 1,2,3,7,8-	0.04708	2.5	25870	0	0.09	0	1.3E+05	0	38	1.3E+05
57117-41-6	PentaCDF, 1,2,3,7,8-	0	0	33752	0	0.09	0	3.9E+03	0	1.14	4E+03
57117-31-4	PentaCDF, 2,3,4,7,8-	0.0561	3.28	20183	0	0.09	0	3.9E+04	0	11.4	4E+04
85-01-8	Phenanthrene	0.28198652332712	0	582	1027.99428258336	0	0	0	0	0	0
129-00-0	Pyrene	0.798093350556875	0	1180	3288.85552491596	0	0.03	0	0.11	0	0
7782-49-2	Selenium	1.12625	0	129	0	0	0.005	0	0.02	0	0
1746-01-6	TetraCDD, 2,3,7,8-	0.05962	3.32	34400	0	0.09	1E-9	1.3E+5	4E-8	38	1.3E+5
51207-31-9	TetraCDF, 2,3,7,8-	0.03608	2.56	9931	0	0.09	0	1.3E+04	0	3.8	1.3E+04
007440-31-5	Tin	0	0	3000	0	0	6E-01	0	0	0	0
7440-62-2	Vanadium	0	0	0	0	0	7E-05	0	1E-04	0	0
7440-66-6	Zinc	0.00875	0	2059	0	0	0.3	0	1.05	0	0

Chemical Abstract Services Number	Chemical of Potential Concern	Chemical Type	chemical subtype	Grain to Soil Bioconcentration Factor	Biotransfer Factor for Eggs	Biotransfer Factor for Chicken	Inhalation Reference Dose	Toxic Equivalency Factor
				mg/kg DW plant / g/kg soil	day/kg	day/kg	mg/kg-d	unitless
CAS_NUMBER	**COPC_NAME**	**Chemical_type**	**Chemical_subtype**	**Param_br_grain**	**Param_ba_egg**	**Param_ba_chicken**	**Param_inhalation_rfd**	**Param_tef**
83-32-9	Acenaphthene	O	PAH	0.216	0.0102400007156569	0.0179200012523996	0.06	0
280-96-8	Acenaphthylene	O	PAH	0	0	0	0	0
120-12-7	Anthracene	O	PAH	0.0971	0.0142344269171493	0.0249102471050112	0.286	0
7440-36-0	Antimony	I	Metal	0.03	0	0	0.0004	0
11097-69-1	Aroclor 1254	O	PCB	0.00678	0.0130418736066363	0.0228232788116135	2E-5	0
7440-38-2	Arsenic	I	Metal	0.004	0	0	4.29E-5	0
56-55-3	Benzo(a)anthracene	O	PAH	0.0197	0.0168104750724245	0.0294183313767428	0	0
50-32-8	Benzo(a)pyrene	O	PAH	0.0132	0.0158157571208949	0.027677574961566	0	0
205-99-2	Benzo(b)fluoranthene	O	PAH	0.0112	0.0152382734603098	0.0266669785555422	0	0
207-08-9	Benzo(k)fluoranthene	O	PAH	0.0115	0.0153567737888041	0.0268743541304072	0	0
7440-41-7	Beryllium	I	Metal	0.0015	0	0	5.71E-6	0
7440-43-9	Cadmium	I	Metal	0.062	0.0025	0.10625	2.86E-6	0
7440-47-3	Chromium	I	Metal	0.0045	0	0	1.51	0
18540-29-9	Chromium, hexavalent	I	Metal	0.0045	0	0	2.86E-5	0
218-01-9	Chrysene	O	PAH	0.0197	0.0168104750724245	0.0294183313767428	0	0
007440-48-4	Cobalt	I	Metal	8.50E-03	0	7.89E-05	1.71E-06	0
7440-50-8	Copper	I	Metal	.25	0	0	0	0
53-70-3	Dibenz(a,h)anthracene	O	PAH	0.00678	0.0130418736066363	0.0228232788116135	0	0
206-44-0	Fluoranthene	O	PAH	0.0499	0.0165230412464842	0.0289153221813474	0.04	0
86-73-7	Fluorene	O	PAH	0.145	0.012323384157931	0.0215659222763792	0.04	0
35822-46-9	HeptaCDD, 1,2,3,4,6,7,8-	O	D	0.00092	0.00369054059648304	0.00645844604384531	0	0.01
67562-39-4	HeptaCDF, 1,2,3,4,6,7,8-	O	F	0.00205	0.00691592041512631	0.012102860726471	0	0.01
55673-89-7	HeptaCDF, 1,2,3,4,7,8,9-	O	F	0.00205	0.00691592041512631	0.012102860726471	0	0.01
39227-28-6	HexaCDD, 1,2,3,4,7,8-	O	D	0.0012	0.00463372213059166	0.00810901372853541	0	0.1
57653-85-7	HexaCDD, 1,2,3,6,7,8-	O	D	0.00234	0.00755753186521148	0.0132256807641201	0	0.1
19408-74-3	HexaCDD, 1,2,3,7,8,9-	O	D	0.00234	0.00755753186521148	0.0132256807641201	0	0.1
70648-26-9	HexaCDF, 1,2,3,4,7,8-	O	F	0.00348	0.00959599442519503	0.0167929902440913	0	0.1
57117-44-9	HexaCDF, 1,2,3,6,7,8-	O	F	0.00348	0.00959599442519503	0.0167929902440913	0	0.1
72918-21-9	HexaCDF, 1,2,3,7,8,9-	O	F	0.00348	0.00959599442519503	0.0167929902440913	0	0.1
60851-34-5	HexaCDF, 2,3,4,6,7,8-	O	F	0.00348	0.00959599442519503	0.0167929902440913	0	0.1
7647-01-0	Hydrogen chloride	I		0	2.20338296267053E-5	3.85592018467343E-5	0.00571428571428571	0
7664-39-3	Hydrogen fluoride	I		0	3.837E-5	6.714E-5	4.00E-03	0
193-39-5	Indeno(1,2,3-cd) pyrene	O	PAH	0.00593	0.0123779859954226	0.0216614754919896	0	0
7439-92-1	Lead	I	Metal	0.009	0	0	4.29E-04	0
7439-96-5	Manganese	I	Metal	.5	0	0	1.43E-5	0
7487-94-7	Mercuric chloride	I	Divalent	0.0093	0.023925	0.023925	8.6E-06	0
7439-97-6	Mercury	I	Metal	0	0	0	8.57142857142857E-5	0
22967-92-6	Methyl mercury	O		0.019	0.003575	0.003575	0.0001	0
91-57-6	Methylnaphthalene, 2-	O	PAH	.227	9.96E-3	1.74E-2	0	0
0074939-98-7	Molybdenum	I	Metal	8.00E-01	0	0.000789474	0	0
91-20-3	Naphthalene	O	PAH	0.479	0.00625143884447729	0.0109400179778353	8.57E-4	0
7440-02-0	Nickel	I	Metal	0.006	0	0	2.57E-5	0
3268-87-9	OctaCDD, 1,2,3,4,6,7,8,9-	O	D	0.000705	0.00288622368969765	0.00505089145697088	0	.0003

Chemical Abstract Services Number	Chemical of Potential Concern	Chemical Type	chemical subtype	Grain to Soil Bioconcentration Factor	Biotransfer Factor for Eggs	Biotransfer Factor for Chicken	Inhalation Reference Dose	Toxic Equivalency Factor
				mg/kg DW plant / g/kg soil	day/kg	day/kg	mg/kg-d	unitless
CAS_NUMBER	**COPC_NAME**	**Chemical_type**	**Chemical_subtype**	**Param_br_grain**	**Param_ba_egg**	**Param_ba_chicken**	**Param_inhalation_rfd**	**Param_tef**
39001-02-0	OctaCDF, 1,2,3,4,6,7,8,9-	O	F	0.00092	0.00369054059648304	0.00645844604384531	0	.0003
40321-76-4	PentaCDD, 1,2,3,7,8-	O	D	0.00562	0.0121065273362393	0.0211864228384188	0	1
57117-41-6	PentaCDF, 1,2,3,7,8-	O	F	0.00461	0.0110683806640118	0.0193696661620206	0	.03
57117-31-4	PentaCDF, 2,3,4,7,8-	O	F	0.00678	0.0130418736066363	0.0228232788116135	0	.3
85-01-8	Phenanthrene	O	PAH	0.0971	0.0142344269171493	0.0249102471050112	0	0
129-00-0	Pyrene	O	PAH	0.057	0.0161845260876208	0.0283229206533364	0.0314	0
7782-49-2	Selenium	I	Metal	0.002	1.12625	1.12625	5.71E-3	0
1746-01-6	TetraCDD, 2,3,7,8-	O	D	0.00455	0.0109984120681325	0.0192472211192319	1.1E-8	1
51207-31-9	TetraCDF, 2,3,7,8-	O	F	0.0115	0.0153567737888041	0.0268743541304072	0	0.1
007440-31-5	Tin	I	Metal	0	0	0.007894737	0	0
7440-62-2	Vanadium	I	Metal	3E-3	0	0	2.9E-05	0
7440-66-6	Zinc	I	Metal	0.054	0.00875	0.00875	0.3	0

Notes:
atm - atmosphere
cm - centimeter
d - day
g - gram
kg - kilogram
L - liter
m - meter
mg - milligram
mL - milliliter
s - second
ug - microgram
yr - year
DW - dry weight
WW - wet weight
D - Polychlorinated dibenzo-p-dioxin
F - Polychlorinated dibenzo-p-furan
I - Inorganic
O - Organic
PAH - Polynuclear Aromatic Hydrocarbons
PCB - Polychlorinated biphenyls

ARCADIS

Appendix E

Pathway and COPC-Specific Cancer Risks and Noncancer Hazards

Table E-1. Pathway and Constituent of Potential Concern Cancer Risks and Noncancer Hazards - IRAP Output
Run 1 - 2,3,7,8-Tetrachlorodibenzo-p-dioxin
Farmer

COPC Name	CAS Number	Pathway		Farmer Adult Cancer Risk	Farmer Child Cancer Risk	Farmer Adult Hazard Quotient	Farmer Child Hazard Quotient	IRAP Output
Antimony	7440-36-0	Inhalation		0.00E+00	0.00E+00	1.56E-05	1.56E-05	
Arsenic	7440-38-2	Inhalation		6.69E-09	1.00E-09	1.82E-04	1.82E-04	
Beryllium	7440-41-7	Inhalation		3.82E-10	5.73E-11	1.39E-05	1.39E-05	
Cadmium	7440-43-9	Inhalation		3.23E-09	4.84E-10	3.14E-04	3.14E-04	
Chromium, hexavalent	18540-29-9	Inhalation		5.53E-08	4.42E-08	8.07E-05	8.07E-05	8.30E-09
Cobalt	7440-48-4	Inhalation		3.59E-09	5.39E-10	1.16E-04	1.16E-04	
HeptaCDD, 1,2,3,4,6,7,8-	35822-46-9	Inhalation		2.89E-11	4.33E-12	0.00E+00	0.00E+00	
HeptaCDF, 1,2,3,4,6,7,8-	67562-39-4	Inhalation		2.11E-11	3.17E-12	0.00E+00	0.00E+00	
HeptaCDF, 1,2,3,4,7,8,9-	55673-89-7	Inhalation		5.74E-12	8.62E-13	0.00E+00	0.00E+00	
HexaCDD, 1,2,3,4,7,8-	39227-28-6	Inhalation		2.06E-11	3.09E-12	0.00E+00	0.00E+00	
HexaCDD, 1,2,3,6,7,8-	57653-85-7	Inhalation		5.11E-11	7.67E-12	0.00E+00	0.00E+00	
HexaCDD, 1,2,3,7,8,9-	19408-74-3	Inhalation		5.16E-11	7.73E-12	0.00E+00	0.00E+00	
HexaCDF, 1,2,3,4,7,8-	70648-26-9	Inhalation		1.21E-10	1.82E-11	0.00E+00	0.00E+00	
HexaCDF, 1,2,3,6,7,8-	57117-44-9	Inhalation		2.07E-10	3.10E-11	0.00E+00	0.00E+00	
HexaCDF, 1,2,3,7,8,9-	72918-21-9	Inhalation		4.34E-11	6.51E-12	0.00E+00	0.00E+00	
HexaCDF, 2,3,4,6,7,8-	60851-34-5	Inhalation		1.94E-10	2.90E-11	0.00E+00	0.00E+00	
Indeno(1,2,3-cd) pyrene	193-39-5	Inhalation		5.54E-14	4.43E-14	0.00E+00	0.00E+00	8.31E-15
Lead	7439-92-1	Inhalation		6.26E-10	9.39E-11	6.08E-05	6.08E-05	
Manganese	7439-96-5	Inhalation		0.00E+00	0.00E+00	3.59E-04	3.59E-04	
Mercury	7439-97-6	Inhalation		0.00E+00	0.00E+00	1.66E-06	1.66E-06	
Nickel	7440-02-0	Inhalation		9.20E-10	1.38E-10	6.88E-05	6.88E-05	
OctaCDD, 1,2,3,4,6,7,8,9-	3268-87-9	Inhalation		2.01E-12	3.01E-13	0.00E+00	0.00E+00	
OctaCDF, 1,2,3,4,6,7,8,9-	39001-02-0	Inhalation		4.82E-13	7.23E-14	0.00E+00	0.00E+00	
PentaCDD, 1,2,3,7,8-	40321-76-4	Inhalation		8.50E-10	1.28E-10	0.00E+00	0.00E+00	
PentaCDF, 1,2,3,7,8-	57117-41-6	Inhalation		5.06E-11	7.59E-12	0.00E+00	0.00E+00	
PentaCDF, 2,3,4,7,8-	57117-31-4	Inhalation		6.99E-10	1.05E-10	0.00E+00	0.00E+00	
TetraCDD, 2,3,7,8-	1746-01-6	Inhalation		3.82E-10	5.74E-11	4.40E-07	4.40E-07	
TetraCDF, 2,3,7,8-	51207-31-9	Inhalation		7.06E-10	1.06E-10	0.00E+00	0.00E+00	
Vanadium	7440-62-2	Inhalation		0.00E+00	0.00E+00	2.08E-05	2.08E-05	
Zinc	7440-66-6	Inhalation		0.00E+00	0.00E+00	9.90E-07	9.90E-07	
			Pathway Total:	**7.42E-08**	**4.71E-08**	**1.23E-03**	**1.23E-03**	

Table E-1. Pathway and Constituent of Potential Concern Cancer Risks and Noncancer Hazards - IRAP Output
Run 1 - 2,3,7,8-Tetrachlorodibenzo-p-dioxin
Farmer

COPC Name	CAS Number	Pathway	Farmer Adult Cancer Risk	Farmer Child Cancer Risk	Farmer Adult Hazard Quotient	Farmer Child Hazard Quotient	IRAP Output
Antimony	7440-36-0	Locally-grown Produce	0.00E+00	0.00E+00	4.83E-04	5.36E-03	
Arsenic	7440-38-2	Locally-grown Produce	1.56E-08	2.62E-08	6.18E-05	6.91E-04	
Beryllium	7440-41-7	Locally-grown Produce	0.00E+00	0.00E+00	9.47E-07	1.06E-05	
Cadmium	7440-43-9	Locally-grown Produce	0.00E+00	0.00E+00	5.62E-05	6.22E-04	
Chromium, hexavalent	18540-29-9	Locally-grown Produce	1.51E-08	1.36E-07	1.78E-05	2.00E-04	2.55E-08
Cobalt	7440-48-4	Locally-grown Produce	0.00E+00	0.00E+00	3.14E-05	3.54E-04	
Copper	7440-50-8	Locally-grown Produce	0.00E+00	0.00E+00	2.38E-06	2.42E-05	
HeptaCDD, 1,2,3,4,6,7,8-	35822-46-9	Locally-grown Produce	2.87E-10	4.81E-10	0.00E+00	0.00E+00	
HeptaCDF, 1,2,3,4,6,7,8-	67562-39-4	Locally-grown Produce	2.13E-10	3.56E-10	0.00E+00	0.00E+00	
HeptaCDF, 1,2,3,4,7,8,9-	55673-89-7	Locally-grown Produce	5.82E-11	9.72E-11	0.00E+00	0.00E+00	
HexaCDD, 1,2,3,4,7,8-	39227-28-6	Locally-grown Produce	2.04E-10	3.42E-10	0.00E+00	0.00E+00	
HexaCDD, 1,2,3,6,7,8-	57653-85-7	Locally-grown Produce	5.11E-10	8.54E-10	0.00E+00	0.00E+00	
HexaCDD, 1,2,3,7,8,9-	19408-74-3	Locally-grown Produce	5.18E-10	8.65E-10	0.00E+00	0.00E+00	
HexaCDF, 1,2,3,4,7,8-	70648-26-9	Locally-grown Produce	1.19E-09	1.98E-09	0.00E+00	0.00E+00	
HexaCDF, 1,2,3,6,7,8-	57117-44-9	Locally-grown Produce	2.02E-09	3.38E-09	0.00E+00	0.00E+00	
HexaCDF, 1,2,3,7,8,9-	72918-21-9	Locally-grown Produce	4.12E-10	6.87E-10	0.00E+00	0.00E+00	
HexaCDF, 2,3,4,6,7,8-	60851-34-5	Locally-grown Produce	1.89E-09	3.15E-09	0.00E+00	0.00E+00	
Indeno(1,2,3-cd) pyrene	193-39-5	Locally-grown Produce	2.45E-12	2.21E-11	0.00E+00	0.00E+00	4.14E-12
Lead	7439-92-1	Locally-grown Produce	3.40E-09	5.52E-09	1.78E-03	1.99E-02	
Manganese	7439-96-5	Locally-grown Produce	0.00E+00	0.00E+00	1.82E-06	1.69E-05	
Molybdenum	74939-98-7	Locally-grown Produce	0.00E+00	0.00E+00	6.04E-05	6.63E-04	
Nickel	7440-02-0	Locally-grown Produce	0.00E+00	0.00E+00	2.26E-06	2.52E-05	
OctaCDD, 1,2,3,4,6,7,8,9-	3268-87-9	Locally-grown Produce	2.00E-11	3.35E-11	0.00E+00	0.00E+00	
OctaCDF, 1,2,3,4,6,7,8,9-	39001-02-0	Locally-grown Produce	4.82E-12	8.07E-12	0.00E+00	0.00E+00	
PentaCDD, 1,2,3,7,8-	40321-76-4	Locally-grown Produce	8.15E-09	1.36E-08	0.00E+00	0.00E+00	
PentaCDF, 1,2,3,7,8-	57117-41-6	Locally-grown Produce	4.01E-10	6.67E-10	0.00E+00	0.00E+00	
PentaCDF, 2,3,4,7,8-	57117-31-4	Locally-grown Produce	5.94E-09	9.87E-09	0.00E+00	0.00E+00	
Selenium	7782-49-2	Locally-grown Produce	0.00E+00	0.00E+00	3.73E-06	4.18E-05	
TetraCDD, 2,3,7,8-	1746-01-6	Locally-grown Produce	1.56E-09	2.60E-09	2.16E-05	2.40E-04	
TetraCDF, 2,3,7,8-	51207-31-9	Locally-grown Produce	2.16E-09	3.57E-09	0.00E+00	0.00E+00	
Tin	7440-31-5	Locally-grown Produce	0.00E+00	0.00E+00	8.01E-06	9.07E-05	
Vanadium	7440-62-2	Locally-grown Produce	0.00E+00	0.00E+00	1.93E-04	2.16E-03	
Zinc	7440-66-6	Locally-grown Produce	0.00E+00	0.00E+00	9.51E-05	9.03E-04	
		Pathway Total:	**5.97E-08**	**2.10E-07**	**2.82E-03**	**3.13E-02**	

Table E-1. Pathway and Constituent of Potential Concern Cancer Risks and Noncancer Hazards - IRAP Output
Run 1 - 2,3,7,8-Tetrachlorodibenzo-p-dioxin
Farmer

COPC Name	CAS Number	Pathway	Farmer Adult Cancer Risk	Farmer Child Cancer Risk	Farmer Adult Hazard Quotient	Farmer Child Hazard Quotient	IRAP Output
Antimony	7440-36-0	Beef Ingestion	0.00E+00	0.00E+00	1.22E-05	3.63E-05	
Arsenic	7440-38-2	Beef Ingestion	9.10E-10	4.08E-10	3.60E-06	1.07E-05	
Beryllium	7440-41-7	Beef Ingestion	0.00E+00	0.00E+00	4.73E-08	1.40E-07	
Cadmium	7440-43-9	Beef Ingestion	0.00E+00	0.00E+00	1.01E-07	2.99E-07	
Chromium, hexavalent	18540-29-9	Beef Ingestion	2.42E-09	5.77E-09	2.85E-06	8.43E-06	1.08E-09
Cobalt	7440-48-4	Beef Ingestion	0.00E+00	0.00E+00	5.39E-08	1.60E-07	
Copper	7440-50-8	Beef Ingestion	0.00E+00	0.00E+00	6.58E-07	1.95E-06	
HeptaCDD, 1,2,3,4,6,7,8-	35822-46-9	Beef Ingestion	1.11E-10	4.75E-11	0.00E+00	0.00E+00	
HeptaCDF, 1,2,3,4,6,7,8-	67562-39-4	Beef Ingestion	1.58E-10	6.78E-11	0.00E+00	0.00E+00	
HeptaCDF, 1,2,3,4,7,8,9-	55673-89-7	Beef Ingestion	5.45E-11	2.36E-11	0.00E+00	0.00E+00	
HexaCDD, 1,2,3,4,7,8-	39227-28-6	Beef Ingestion	1.06E-10	4.53E-11	0.00E+00	0.00E+00	
HexaCDD, 1,2,3,6,7,8-	57653-85-7	Beef Ingestion	4.33E-10	1.86E-10	0.00E+00	0.00E+00	
HexaCDD, 1,2,3,7,8,9-	19408-74-3	Beef Ingestion	4.19E-10	1.80E-10	0.00E+00	0.00E+00	
HexaCDF, 1,2,3,4,7,8-	70648-26-9	Beef Ingestion	1.21E-09	5.19E-10	0.00E+00	0.00E+00	
HexaCDF, 1,2,3,6,7,8-	57117-44-9	Beef Ingestion	2.07E-09	8.86E-10	0.00E+00	0.00E+00	
HexaCDF, 1,2,3,7,8,9-	72918-21-9	Beef Ingestion	4.40E-10	1.89E-10	0.00E+00	0.00E+00	
HexaCDF, 2,3,4,6,7,8-	60851-34-5	Beef Ingestion	1.94E-09	8.31E-10	0.00E+00	0.00E+00	
Indeno(1,2,3-cd) pyrene	193-39-5	Beef Ingestion	2.27E-12	5.46E-12	0.00E+00	0.00E+00	1.02E-12
Lead	7439-92-1	Beef Ingestion	3.93E-11	1.67E-11	2.28E-05	6.74E-05	
Manganese	7439-96-5	Beef Ingestion	0.00E+00	0.00E+00	1.50E-08	4.44E-08	
Molybdenum	74939-98-7	Beef Ingestion	0.00E+00	0.00E+00	5.31E-07	1.57E-06	
Nickel	7440-02-0	Beef Ingestion	0.00E+00	0.00E+00	3.92E-07	1.16E-06	
OctaCDD, 1,2,3,4,6,7,8,9-	3268-87-9	Beef Ingestion	6.14E-12	2.63E-12	0.00E+00	0.00E+00	
OctaCDF, 1,2,3,4,6,7,8,9-	39001-02-0	Beef Ingestion	1.88E-12	8.06E-13	0.00E+00	0.00E+00	
PentaCDD, 1,2,3,7,8-	40321-76-4	Beef Ingestion	1.18E-08	5.08E-09	0.00E+00	0.00E+00	
PentaCDF, 1,2,3,7,8-	57117-41-6	Beef Ingestion	5.49E-10	2.37E-10	0.00E+00	0.00E+00	
PentaCDF, 2,3,4,7,8-	57117-31-4	Beef Ingestion	8.98E-09	3.87E-09	0.00E+00	0.00E+00	
Selenium	7782-49-2	Beef Ingestion	0.00E+00	0.00E+00	2.39E-07	7.07E-07	
TetraCDD, 2,3,7,8-	1746-01-6	Beef Ingestion	3.07E-09	1.34E-09	4.52E-05	1.34E-04	
TetraCDF, 2,3,7,8-	51207-31-9	Beef Ingestion	6.02E-09	2.63E-09	0.00E+00	0.00E+00	
Tin	7440-31-5	Beef Ingestion	0.00E+00	0.00E+00	1.73E-07	5.12E-07	
Vanadium	7440-62-2	Beef Ingestion	0.00E+00	0.00E+00	2.62E-05	7.76E-05	
Zinc	7440-66-6	Beef Ingestion	0.00E+00	0.00E+00	7.59E-08	2.25E-07	
		Pathway Total:	**4.07E-08**	**2.23E-08**	**1.15E-04**	**3.41E-04**	

Table E-1. Pathway and Constituent of Potential Concern Cancer Risks and Noncancer Hazards - IRAP Output
Run 1 - 2,3,7,8-Tetrachlorodibenzo-p-dioxin
Farmer

COPC Name	CAS Number	Pathway	Farmer Adult Cancer Risk	Farmer Child Cancer Risk	Farmer Adult Hazard Quotient	Farmer Child Hazard Quotient	IRAP Output
Cadmium	7440-43-9	Chicken Ingestion	0.00E+00	0.00E+00	5.77E-07	1.83E-06	
Cobalt	7440-48-4	Chicken Ingestion	0.00E+00	0.00E+00	1.49E-10	4.73E-10	
HeptaCDD, 1,2,3,4,6,7,8-	35822-46-9	Chicken Ingestion	1.50E-12	6.33E-13	0.00E+00	0.00E+00	
HeptaCDF, 1,2,3,4,6,7,8-	67562-39-4	Chicken Ingestion	2.04E-12	8.63E-13	0.00E+00	0.00E+00	
HeptaCDF, 1,2,3,4,7,8,9-	55673-89-7	Chicken Ingestion	5.31E-13	2.24E-13	0.00E+00	0.00E+00	
HexaCDD, 1,2,3,4,7,8-	39227-28-6	Chicken Ingestion	1.32E-12	5.57E-13	0.00E+00	0.00E+00	
HexaCDD, 1,2,3,6,7,8-	57653-85-7	Chicken Ingestion	5.28E-12	2.23E-12	0.00E+00	0.00E+00	
HexaCDD, 1,2,3,7,8,9-	19408-74-3	Chicken Ingestion	5.39E-12	2.28E-12	0.00E+00	0.00E+00	
HexaCDF, 1,2,3,4,7,8-	70648-26-9	Chicken Ingestion	1.56E-11	6.61E-12	0.00E+00	0.00E+00	
HexaCDF, 1,2,3,6,7,8-	57117-44-9	Chicken Ingestion	2.66E-11	1.12E-11	0.00E+00	0.00E+00	
HexaCDF, 1,2,3,7,8,9-	72918-21-9	Chicken Ingestion	5.38E-12	2.27E-12	0.00E+00	0.00E+00	
HexaCDF, 2,3,4,6,7,8-	60851-34-5	Chicken Ingestion	2.48E-11	1.05E-11	0.00E+00	0.00E+00	
Indeno(1,2,3-cd) pyrene	193-39-5	Chicken Ingestion	7.31E-15	2.24E-14	0.00E+00	0.00E+00	4.20E-15
Molybdenum	74939-98-7	Chicken Ingestion	0.00E+00	0.00E+00	5.05E-09	1.60E-08	
OctaCDD, 1,2,3,4,6,7,8,9-	3268-87-9	Chicken Ingestion	8.17E-14	3.45E-14	0.00E+00	0.00E+00	
OctaCDF, 1,2,3,4,6,7,8,9-	39001-02-0	Chicken Ingestion	2.51E-14	1.06E-14	0.00E+00	0.00E+00	
PentaCDD, 1,2,3,7,8-	40321-76-4	Chicken Ingestion	1.28E-10	5.44E-11	0.00E+00	0.00E+00	
PentaCDF, 1,2,3,7,8-	57117-41-6	Chicken Ingestion	5.93E-12	2.51E-12	0.00E+00	0.00E+00	
PentaCDF, 2,3,4,7,8-	57117-31-4	Chicken Ingestion	1.01E-10	4.30E-11	0.00E+00	0.00E+00	
Selenium	7782-49-2	Chicken Ingestion	0.00E+00	0.00E+00	5.60E-08	1.77E-07	
TetraCDD, 2,3,7,8-	1746-01-6	Chicken Ingestion	2.19E-11	9.40E-12	4.54E-07	1.44E-06	
TetraCDF, 2,3,7,8-	51207-31-9	Chicken Ingestion	4.26E-11	1.83E-11	0.00E+00	0.00E+00	
Tin	7440-31-5	Chicken Ingestion	0.00E+00	0.00E+00	2.12E-09	6.71E-09	
Zinc	7440-66-6	Chicken Ingestion	0.00E+00	0.00E+00	4.30E-08	1.36E-07	
		Pathway Total:	**3.89E-10**	**1.65E-10**	**1.14E-06**	**3.60E-06**	

Table E-1. Pathway and Constituent of Potential Concern Cancer Risks and Noncancer Hazards - IRAP Output
Run 1 - 2,3,7,8-Tetrachlorodibenzo-p-dioxin
Farmer

COPC Name	CAS Number	Pathway	Farmer Adult Cancer Risk	Farmer Child Cancer Risk	Farmer Adult Hazard Quotient	Farmer Child Hazard Quotient	IRAP Output
Antimony	7440-36-0	Drinking Water Ingestion	0.00E+00	0.00E+00	5.30E-08	1.18E-07	
Arsenic	7440-38-2	Drinking Water Ingestion	1.90E-12	7.38E-13	8.78E-09	1.96E-08	
Beryllium	7440-41-7	Drinking Water Ingestion	0.00E+00	0.00E+00	1.18E-10	2.65E-10	
Cadmium	7440-43-9	Drinking Water Ingestion	0.00E+00	0.00E+00	3.07E-09	6.86E-09	
Chromium, hexavalent	18540-29-9	Drinking Water Ingestion	1.88E-12	3.91E-12	2.59E-09	5.79E-09	7.33E-13
Cobalt	7440-48-4	Drinking Water Ingestion	0.00E+00	0.00E+00	2.26E-09	5.05E-09	
Copper	7440-50-8	Drinking Water Ingestion	0.00E+00	0.00E+00	2.53E-10	5.65E-10	
HeptaCDD, 1,2,3,4,6,7,8-	35822-46-9	Drinking Water Ingestion	9.97E-16	3.19E-16	0.00E+00	0.00E+00	
HeptaCDF, 1,2,3,4,6,7,8-	67562-39-4	Drinking Water Ingestion	2.54E-15	8.13E-16	0.00E+00	0.00E+00	
HeptaCDF, 1,2,3,4,7,8,9-	55673-89-7	Drinking Water Ingestion	6.91E-16	2.22E-16	0.00E+00	0.00E+00	
HexaCDD, 1,2,3,4,7,8-	39227-28-6	Drinking Water Ingestion	1.11E-15	3.57E-16	0.00E+00	0.00E+00	
HexaCDD, 1,2,3,6,7,8-	57653-85-7	Drinking Water Ingestion	7.37E-15	2.37E-15	0.00E+00	0.00E+00	
HexaCDD, 1,2,3,7,8,9-	19408-74-3	Drinking Water Ingestion	7.37E-15	2.36E-15	0.00E+00	0.00E+00	
HexaCDF, 1,2,3,4,7,8-	70648-26-9	Drinking Water Ingestion	2.90E-14	9.29E-15	0.00E+00	0.00E+00	
HexaCDF, 1,2,3,6,7,8-	57117-44-9	Drinking Water Ingestion	5.15E-14	1.65E-14	0.00E+00	0.00E+00	
HexaCDF, 1,2,3,7,8,9-	72918-21-9	Drinking Water Ingestion	1.06E-14	3.41E-15	0.00E+00	0.00E+00	
HexaCDF, 2,3,4,6,7,8-	60851-34-5	Drinking Water Ingestion	4.71E-14	1.51E-14	0.00E+00	0.00E+00	
Indeno(1,2,3-cd) pyrene	193-39-5	Drinking Water Ingestion	6.56E-17	1.20E-16	0.00E+00	0.00E+00	2.25E-17
Lead	7439-92-1	Drinking Water Ingestion	2.93E-13	9.31E-14	1.76E-07	3.93E-07	
Manganese	7439-96-5	Drinking Water Ingestion	0.00E+00	0.00E+00	1.25E-10	2.79E-10	
Molybdenum	74939-98-7	Drinking Water Ingestion	0.00E+00	0.00E+00	2.24E-09	4.99E-09	
Nickel	7440-02-0	Drinking Water Ingestion	0.00E+00	0.00E+00	3.02E-10	6.75E-10	
OctaCDD, 1,2,3,4,6,7,8,9-	3268-87-9	Drinking Water Ingestion	4.48E-17	1.44E-17	0.00E+00	0.00E+00	
OctaCDF, 1,2,3,4,6,7,8,9-	39001-02-0	Drinking Water Ingestion	1.69E-17	5.41E-18	0.00E+00	0.00E+00	
PentaCDD, 1,2,3,7,8-	40321-76-4	Drinking Water Ingestion	4.19E-13	1.36E-13	0.00E+00	0.00E+00	
PentaCDF, 1,2,3,7,8-	57117-41-6	Drinking Water Ingestion	1.88E-14	6.10E-15	0.00E+00	0.00E+00	
PentaCDF, 2,3,4,7,8-	57117-31-4	Drinking Water Ingestion	3.54E-13	1.15E-13	0.00E+00	0.00E+00	
Selenium	7782-49-2	Drinking Water Ingestion	0.00E+00	0.00E+00	5.40E-10	1.21E-09	
TetraCDD, 2,3,7,8-	1746-01-6	Drinking Water Ingestion	9.55E-14	3.13E-14	1.44E-09	3.21E-09	
TetraCDF, 2,3,7,8-	51207-31-9	Drinking Water Ingestion	3.94E-13	1.30E-13	0.00E+00	0.00E+00	
Tin	7440-31-5	Drinking Water Ingestion	0.00E+00	0.00E+00	6.59E-11	1.47E-10	
Vanadium	7440-62-2	Drinking Water Ingestion	0.00E+00	0.00E+00	2.40E-08	5.37E-08	
Zinc	7440-66-6	Drinking Water Ingestion	0.00E+00	0.00E+00	3.38E-09	7.55E-09	
		Pathway Total:	**5.51E-12**	**5.21E-12**	**2.78E-07**	**6.22E-07**	

Table E-1. Pathway and Constituent of Potential Concern Cancer Risks and Noncancer Hazards - IRAP Output
Run 1 - 2,3,7,8-Tetrachlorodibenzo-p-dioxin
Farmer

COPC Name	CAS Number	Pathway	Farmer Adult Cancer Risk	Farmer Child Cancer Risk	Farmer Adult Hazard Quotient	Farmer Child Hazard Quotient	IRAP Output
Cadmium	7440-43-9	Eggs Ingestion	0.00E+00	0.00E+00	5.01E-09	1.68E-08	
HeptaCDD, 1,2,3,4,6,7,8-	35822-46-9	Eggs Ingestion	3.16E-13	1.41E-13	0.00E+00	0.00E+00	
HeptaCDF, 1,2,3,4,6,7,8-	67562-39-4	Eggs Ingestion	4.30E-13	1.92E-13	0.00E+00	0.00E+00	
HeptaCDF, 1,2,3,4,7,8,9-	55673-89-7	Eggs Ingestion	1.12E-13	5.00E-14	0.00E+00	0.00E+00	
HexaCDD, 1,2,3,4,7,8-	39227-28-6	Eggs Ingestion	2.78E-13	1.24E-13	0.00E+00	0.00E+00	
HexaCDD, 1,2,3,6,7,8-	57653-85-7	Eggs Ingestion	1.11E-12	4.97E-13	0.00E+00	0.00E+00	
HexaCDD, 1,2,3,7,8,9-	19408-74-3	Eggs Ingestion	1.14E-12	5.08E-13	0.00E+00	0.00E+00	
HexaCDF, 1,2,3,4,7,8-	70648-26-9	Eggs Ingestion	3.29E-12	1.47E-12	0.00E+00	0.00E+00	
HexaCDF, 1,2,3,6,7,8-	57117-44-9	Eggs Ingestion	5.61E-12	2.50E-12	0.00E+00	0.00E+00	
HexaCDF, 1,2,3,7,8,9-	72918-21-9	Eggs Ingestion	1.13E-12	5.06E-13	0.00E+00	0.00E+00	
HexaCDF, 2,3,4,6,7,8-	60851-34-5	Eggs Ingestion	5.23E-12	2.34E-12	0.00E+00	0.00E+00	
Indeno(1,2,3-cd) pyrene	193-39-5	Eggs Ingestion	1.54E-15	4.99E-15	0.00E+00	0.00E+00	9.36E-16
OctaCDD, 1,2,3,4,6,7,8,9-	3268-87-9	Eggs Ingestion	1.72E-14	7.68E-15	0.00E+00	0.00E+00	
OctaCDF, 1,2,3,4,6,7,8,9-	39001-02-0	Eggs Ingestion	5.28E-15	2.36E-15	0.00E+00	0.00E+00	
PentaCDD, 1,2,3,7,8-	40321-76-4	Eggs Ingestion	2.70E-11	1.21E-11	0.00E+00	0.00E+00	
PentaCDF, 1,2,3,7,8-	57117-41-6	Eggs Ingestion	1.25E-12	5.59E-13	0.00E+00	0.00E+00	
PentaCDF, 2,3,4,7,8-	57117-31-4	Eggs Ingestion	2.14E-11	9.57E-12	0.00E+00	0.00E+00	
Selenium	7782-49-2	Eggs Ingestion	0.00E+00	0.00E+00	2.06E-08	6.91E-08	
TetraCDD, 2,3,7,8-	1746-01-6	Eggs Ingestion	4.62E-12	2.09E-12	9.57E-08	3.20E-07	
TetraCDF, 2,3,7,8-	51207-31-9	Eggs Ingestion	8.98E-12	4.07E-12	0.00E+00	0.00E+00	
Zinc	7440-66-6	Eggs Ingestion	0.00E+00	0.00E+00	1.58E-08	5.31E-08	
		Pathway Total:	**8.19E-11**	**3.67E-11**	**1.37E-07**	**4.59E-07**	

Table E-1. Pathway and Constituent of Potential Concern Cancer Risks and Noncancer Hazards - IRAP Output
Run 1 - 2,3,7,8-Tetrachlorodibenzo-p-dioxin
Farmer

COPC Name	CAS Number	Pathway	Farmer Adult Cancer Risk	Farmer Child Cancer Risk	Farmer Adult Hazard Quotient	Farmer Child Hazard Quotient	IRAP Output
Antimony	7440-36-0	Milk Ingestion	0.00E+00	0.00E+00	1.10E-05	8.47E-05	
Arsenic	7440-38-2	Milk Ingestion	2.45E-10	2.85E-10	9.63E-07	7.44E-06	
Beryllium	7440-41-7	Milk Ingestion	0.00E+00	0.00E+00	3.00E-10	2.32E-09	
Cadmium	7440-43-9	Milk Ingestion	0.00E+00	0.00E+00	4.91E-08	3.80E-07	
Chromium, hexavalent	18540-29-9	Milk Ingestion	5.95E-09	3.69E-08	6.98E-06	5.39E-05	6.92E-09
Cobalt	7440-48-4	Milk Ingestion	0.00E+00	0.00E+00	3.35E-07	2.59E-06	
Copper	7440-50-8	Milk Ingestion	0.00E+00	0.00E+00	9.45E-07	7.31E-06	
HeptaCDD, 1,2,3,4,6,7,8-	35822-46-9	Milk Ingestion	1.76E-10	2.00E-10	0.00E+00	0.00E+00	
HeptaCDF, 1,2,3,4,6,7,8-	67562-39-4	Milk Ingestion	2.54E-10	2.88E-10	0.00E+00	0.00E+00	
HeptaCDF, 1,2,3,4,7,8,9-	55673-89-7	Milk Ingestion	9.19E-11	1.05E-10	0.00E+00	0.00E+00	
HexaCDD, 1,2,3,4,7,8-	39227-28-6	Milk Ingestion	1.71E-10	1.94E-10	0.00E+00	0.00E+00	
HexaCDD, 1,2,3,6,7,8-	57653-85-7	Milk Ingestion	7.03E-10	7.99E-10	0.00E+00	0.00E+00	
HexaCDD, 1,2,3,7,8,9-	19408-74-3	Milk Ingestion	6.73E-10	7.65E-10	0.00E+00	0.00E+00	
HexaCDF, 1,2,3,4,7,8-	70648-26-9	Milk Ingestion	1.94E-09	2.21E-09	0.00E+00	0.00E+00	
HexaCDF, 1,2,3,6,7,8-	57117-44-9	Milk Ingestion	3.32E-09	3.77E-09	0.00E+00	0.00E+00	
HexaCDF, 1,2,3,7,8,9-	72918-21-9	Milk Ingestion	7.15E-10	8.13E-10	0.00E+00	0.00E+00	
HexaCDF, 2,3,4,6,7,8-	60851-34-5	Milk Ingestion	3.12E-09	3.54E-09	0.00E+00	0.00E+00	
Indeno(1,2,3-cd) pyrene	193-39-5	Milk Ingestion	4.18E-12	2.61E-11	0.00E+00	0.00E+00	4.89E-12
Lead	7439-92-1	Milk Ingestion	2.47E-10	2.77E-10	1.34E-04	1.04E-03	
Manganese	7439-96-5	Milk Ingestion	0.00E+00	0.00E+00	1.36E-07	1.05E-06	
Molybdenum	74939-98-7	Milk Ingestion	0.00E+00	0.00E+00	9.38E-06	7.25E-05	
Nickel	7440-02-0	Milk Ingestion	0.00E+00	0.00E+00	5.69E-07	4.40E-06	
OctaCDD, 1,2,3,4,6,7,8,9-	3268-87-9	Milk Ingestion	9.80E-12	1.11E-11	0.00E+00	0.00E+00	
OctaCDF, 1,2,3,4,6,7,8,9-	39001-02-0	Milk Ingestion	3.00E-12	3.40E-12	0.00E+00	0.00E+00	
PentaCDD, 1,2,3,7,8-	40321-76-4	Milk Ingestion	1.95E-08	2.23E-08	0.00E+00	0.00E+00	
PentaCDF, 1,2,3,7,8-	57117-41-6	Milk Ingestion	9.11E-10	1.04E-09	0.00E+00	0.00E+00	
PentaCDF, 2,3,4,7,8-	57117-31-4	Milk Ingestion	1.48E-08	1.69E-08	0.00E+00	0.00E+00	
Selenium	7782-49-2	Milk Ingestion	0.00E+00	0.00E+00	5.61E-06	4.34E-05	
TetraCDD, 2,3,7,8-	1746-01-6	Milk Ingestion	5.38E-09	6.17E-09	7.61E-05	5.88E-04	
TetraCDF, 2,3,7,8-	51207-31-9	Milk Ingestion	1.06E-08	1.22E-08	0.00E+00	0.00E+00	
Tin	7440-31-5	Milk Ingestion	0.00E+00	0.00E+00	1.35E-07	1.04E-06	
Vanadium	7440-62-2	Milk Ingestion	0.00E+00	0.00E+00	1.45E-06	1.12E-05	
Zinc	7440-66-6	Milk Ingestion	0.00E+00	0.00E+00	2.46E-07	1.90E-06	
		Pathway Total:	**6.88E-08**	**1.09E-07**	**2.48E-04**	**1.92E-03**	

Table E-1. Pathway and Constituent of Potential Concern Cancer Risks and Noncancer Hazards - IRAP Output
Run 1 - 2,3,7,8-Tetrachlorodibenzo-p-dioxin
Farmer

COPC Name	CAS Number	Pathway	Farmer Adult Cancer Risk	Farmer Child Cancer Risk	Farmer Adult Hazard Quotient	Farmer Child Hazard Quotient	IRAP Output
Cadmium	7440-43-9	Pork Ingestion	0.00E+00	0.00E+00	2.84E-08	1.01E-07	
Cobalt	7440-48-4	Pork Ingestion	0.00E+00	0.00E+00	9.01E-09	3.21E-08	
HeptaCDD, 1,2,3,4,6,7,8-	35822-46-9	Pork Ingestion	3.52E-11	1.72E-11	0.00E+00	0.00E+00	
HeptaCDF, 1,2,3,4,6,7,8-	67562-39-4	Pork Ingestion	4.91E-11	2.40E-11	0.00E+00	0.00E+00	
HeptaCDF, 1,2,3,4,7,8,9-	55673-89-7	Pork Ingestion	1.50E-11	7.41E-12	0.00E+00	0.00E+00	
HexaCDD, 1,2,3,4,7,8-	39227-28-6	Pork Ingestion	3.23E-11	1.58E-11	0.00E+00	0.00E+00	
HexaCDD, 1,2,3,6,7,8-	57653-85-7	Pork Ingestion	1.31E-10	6.42E-11	0.00E+00	0.00E+00	
HexaCDD, 1,2,3,7,8,9-	19408-74-3	Pork Ingestion	1.30E-10	6.36E-11	0.00E+00	0.00E+00	
HexaCDF, 1,2,3,4,7,8-	70648-26-9	Pork Ingestion	3.76E-10	1.84E-10	0.00E+00	0.00E+00	
HexaCDF, 1,2,3,6,7,8-	57117-44-9	Pork Ingestion	6.41E-10	3.14E-10	0.00E+00	0.00E+00	
HexaCDF, 1,2,3,7,8,9-	72918-21-9	Pork Ingestion	1.33E-10	6.54E-11	0.00E+00	0.00E+00	
HexaCDF, 2,3,4,6,7,8-	60851-34-5	Pork Ingestion	5.99E-10	2.94E-10	0.00E+00	0.00E+00	
Indeno(1,2,3-cd) pyrene	193-39-5	Pork Ingestion	3.46E-13	1.07E-12	0.00E+00	0.00E+00	2.00E-13
Molybdenum	74939-98-7	Pork Ingestion	0.00E+00	0.00E+00	1.29E-07	4.59E-07	
OctaCDD, 1,2,3,4,6,7,8,9-	3268-87-9	Pork Ingestion	1.93E-12	9.45E-13	0.00E+00	0.00E+00	
OctaCDF, 1,2,3,4,6,7,8,9-	39001-02-0	Pork Ingestion	5.93E-13	2.90E-13	0.00E+00	0.00E+00	
PentaCDD, 1,2,3,7,8-	40321-76-4	Pork Ingestion	3.39E-09	1.67E-09	0.00E+00	0.00E+00	
PentaCDF, 1,2,3,7,8-	57117-41-6	Pork Ingestion	1.58E-10	7.79E-11	0.00E+00	0.00E+00	
PentaCDF, 2,3,4,7,8-	57117-31-4	Pork Ingestion	2.63E-09	1.30E-09	0.00E+00	0.00E+00	
Selenium	7782-49-2	Pork Ingestion	0.00E+00	0.00E+00	1.74E-06	6.21E-06	
TetraCDD, 2,3,7,8-	1746-01-6	Pork Ingestion	7.56E-10	3.83E-10	1.31E-05	4.67E-05	
TetraCDF, 2,3,7,8-	51207-31-9	Pork Ingestion	1.49E-09	7.56E-10	0.00E+00	0.00E+00	
Tin	7440-31-5	Pork Ingestion	0.00E+00	0.00E+00	4.89E-08	1.74E-07	
Zinc	7440-66-6	Pork Ingestion	0.00E+00	0.00E+00	1.73E-08	6.18E-08	
		Pathway Total:	**1.06E-08**	**5.24E-09**	**1.51E-05**	**5.38E-05**	

Table E-1. Pathway and Constituent of Potential Concern Cancer Risks and Noncancer Hazards - IRAP Output
Run 1 - 2,3,7,8-Tetrachlorodibenzo-p-dioxin
Farmer

COPC Name	CAS Number	Pathway	Farmer Adult Cancer Risk	Farmer Child Cancer Risk	Farmer Adult Hazard Quotient	Farmer Child Hazard Quotient	IRAP Output
Antimony	7440-36-0	Soil Ingestion	0.00E+00	0.00E+00	7.40E-06	6.91E-05	
Arsenic	7440-38-2	Soil Ingestion	1.53E-10	2.75E-10	7.95E-07	7.42E-06	
Beryllium	7440-41-7	Soil Ingestion	0.00E+00	0.00E+00	2.04E-07	1.91E-06	
Cadmium	7440-43-9	Soil Ingestion	0.00E+00	0.00E+00	7.09E-07	6.62E-06	
Chromium, hexavalent	18540-29-9	Soil Ingestion	9.94E-11	9.65E-10	1.55E-07	1.44E-06	1.81E-10
Cobalt	7440-48-4	Soil Ingestion	0.00E+00	0.00E+00	3.16E-07	2.95E-06	
Copper	7440-50-8	Soil Ingestion	0.00E+00	0.00E+00	2.75E-08	2.57E-07	
HeptaCDD, 1,2,3,4,6,7,8-	35822-46-9	Soil Ingestion	4.11E-11	5.12E-11	0.00E+00	0.00E+00	
HeptaCDF, 1,2,3,4,6,7,8-	67562-39-4	Soil Ingestion	2.99E-11	3.72E-11	0.00E+00	0.00E+00	
HeptaCDF, 1,2,3,4,7,8,9-	55673-89-7	Soil Ingestion	7.77E-12	9.67E-12	0.00E+00	0.00E+00	
HexaCDD, 1,2,3,4,7,8-	39227-28-6	Soil Ingestion	2.88E-11	3.58E-11	0.00E+00	0.00E+00	
HexaCDD, 1,2,3,6,7,8-	57653-85-7	Soil Ingestion	7.07E-11	8.81E-11	0.00E+00	0.00E+00	
HexaCDD, 1,2,3,7,8,9-	19408-74-3	Soil Ingestion	7.22E-11	8.99E-11	0.00E+00	0.00E+00	
HexaCDF, 1,2,3,4,7,8-	70648-26-9	Soil Ingestion	1.64E-10	2.05E-10	0.00E+00	0.00E+00	
HexaCDF, 1,2,3,6,7,8-	57117-44-9	Soil Ingestion	2.80E-10	3.49E-10	0.00E+00	0.00E+00	
HexaCDF, 1,2,3,7,8,9-	72918-21-9	Soil Ingestion	5.66E-11	7.05E-11	0.00E+00	0.00E+00	
HexaCDF, 2,3,4,6,7,8-	60851-34-5	Soil Ingestion	2.61E-10	3.25E-10	0.00E+00	0.00E+00	
Indeno(1,2,3-cd) pyrene	193-39-5	Soil Ingestion	5.95E-14	5.38E-13	0.00E+00	0.00E+00	1.01E-13
Lead	7439-92-1	Soil Ingestion	4.41E-10	5.45E-10	3.28E-04	3.06E-03	
Manganese	7439-96-5	Soil Ingestion	0.00E+00	0.00E+00	2.51E-08	2.34E-07	
Molybdenum	74939-98-7	Soil Ingestion	0.00E+00	0.00E+00	1.40E-07	1.31E-06	
Nickel	7440-02-0	Soil Ingestion	0.00E+00	0.00E+00	6.06E-08	5.66E-07	
OctaCDD, 1,2,3,4,6,7,8,9-	3268-87-9	Soil Ingestion	2.87E-12	3.57E-12	0.00E+00	0.00E+00	
OctaCDF, 1,2,3,4,6,7,8,9-	39001-02-0	Soil Ingestion	6.88E-13	8.55E-13	0.00E+00	0.00E+00	
PentaCDD, 1,2,3,7,8-	40321-76-4	Soil Ingestion	1.07E-09	1.33E-09	0.00E+00	0.00E+00	
PentaCDF, 1,2,3,7,8-	57117-41-6	Soil Ingestion	5.41E-11	6.74E-11	0.00E+00	0.00E+00	
PentaCDF, 2,3,4,7,8-	57117-31-4	Soil Ingestion	7.83E-10	9.78E-10	0.00E+00	0.00E+00	
Selenium	7782-49-2	Soil Ingestion	0.00E+00	0.00E+00	8.66E-09	8.08E-08	
TetraCDD, 2,3,7,8-	1746-01-6	Soil Ingestion	2.01E-10	2.54E-10	4.17E-06	3.89E-05	
TetraCDF, 2,3,7,8-	51207-31-9	Soil Ingestion	2.78E-10	3.51E-10	0.00E+00	0.00E+00	
Tin	7440-31-5	Soil Ingestion	0.00E+00	0.00E+00	4.76E-08	4.44E-07	
Vanadium	7440-62-2	Soil Ingestion	0.00E+00	0.00E+00	4.75E-05	4.43E-04	
Zinc	7440-66-6	Soil Ingestion	0.00E+00	0.00E+00	6.47E-07	6.04E-06	
		Pathway Total:	**4.10E-09**	**6.04E-09**	**3.90E-04**	**3.64E-03**	

Note:
Shading indicates carcinogen is a mutagen and the age-dependent adjsutment factors (ADAFs) have been applied to the cancer risk calculations.

Table E-2. I Pathway and Constituent of Potential Concern Cancer Risks and Noncancer Hazards - IRAP Output.
Run 1 - 2,3,7,8-Tetrachlorodibenzo-p-dioxin
Urban Resident

COPC Name	CAS Number	Pathway	Urban Res Adult Cancer Risk	Urban Res Child Cancer Risk	Urban Res Adult Hazard Quotient	Urban Res Child Hazard Quotient	IRAP Output
Antimony	7440-36-0	Inhalation	0.00E+00	0.00E+00	6.02E-06	6.02E-06	
Arsenic	7440-38-2	Inhalation	1.94E-09	3.87E-10	7.01E-05	7.01E-05	
Beryllium	7440-41-7	Inhalation	1.11E-10	2.21E-11	5.38E-06	5.38E-06	
Cadmium	7440-43-9	Inhalation	9.35E-10	1.87E-10	1.21E-04	1.21E-04	
Chromium, hexavalent	18540-29-9	Inhalation	1.60E-08	1.71E-08	3.11E-05	3.11E-05	3.20E-09
Cobalt	7440-48-4	Inhalation	1.04E-09	2.08E-10	4.49E-05	4.49E-05	
HeptaCDD, 1,2,3,4,6,7,8-	35822-46-9	Inhalation	8.41E-12	1.68E-12	0.00E+00	0.00E+00	
HeptaCDF, 1,2,3,4,6,7,8-	67562-39-4	Inhalation	6.16E-12	1.23E-12	0.00E+00	0.00E+00	
HeptaCDF, 1,2,3,4,7,8,9-	55673-89-7	Inhalation	1.68E-12	3.35E-13	0.00E+00	0.00E+00	
HexaCDD, 1,2,3,4,7,8-	39227-28-6	Inhalation	6.01E-12	1.20E-12	0.00E+00	0.00E+00	
HexaCDD, 1,2,3,6,7,8-	57653-85-7	Inhalation	1.49E-11	2.98E-12	0.00E+00	0.00E+00	
HexaCDD, 1,2,3,7,8,9-	19408-74-3	Inhalation	1.50E-11	3.01E-12	0.00E+00	0.00E+00	
HexaCDF, 1,2,3,4,7,8-	70648-26-9	Inhalation	3.53E-11	7.07E-12	0.00E+00	0.00E+00	
HexaCDF, 1,2,3,6,7,8-	57117-44-9	Inhalation	6.03E-11	1.21E-11	0.00E+00	0.00E+00	
HexaCDF, 1,2,3,7,8,9-	72918-21-9	Inhalation	1.27E-11	2.53E-12	0.00E+00	0.00E+00	
HexaCDF, 2,3,4,6,7,8-	60851-34-5	Inhalation	5.64E-11	1.13E-11	0.00E+00	0.00E+00	
Indeno(1,2,3-cd) pyrene	193-39-5	Inhalation	1.60E-14	1.71E-14	0.00E+00	0.00E+00	3.21E-15
Lead	7439-92-1	Inhalation	1.81E-10	3.62E-11	2.35E-05	2.35E-05	
Manganese	7439-96-5	Inhalation	0.00E+00	0.00E+00	1.39E-04	1.39E-04	
Mercury	7439-97-6	Inhalation	0.00E+00	0.00E+00	6.48E-07	6.48E-07	
Nickel	7440-02-0	Inhalation	2.66E-10	5.33E-11	2.66E-05	2.66E-05	
OctaCDD, 1,2,3,4,6,7,8,9-	3268-87-9	Inhalation	5.85E-13	1.17E-13	0.00E+00	0.00E+00	
OctaCDF, 1,2,3,4,6,7,8,9-	39001-02-0	Inhalation	1.40E-13	2.81E-14	0.00E+00	0.00E+00	
PentaCDD, 1,2,3,7,8-	40321-76-4	Inhalation	2.48E-10	4.96E-11	0.00E+00	0.00E+00	
PentaCDF, 1,2,3,7,8-	57117-41-6	Inhalation	1.48E-11	2.96E-12	0.00E+00	0.00E+00	
PentaCDF, 2,3,4,7,8-	57117-31-4	Inhalation	2.04E-10	4.08E-11	0.00E+00	0.00E+00	
Selenium	7782-49-2	Inhalation	0.00E+00	0.00E+00	5.42E-08	5.42E-08	
TetraCDD, 2,3,7,8-	1746-01-6	Inhalation	1.12E-10	2.24E-11	1.72E-07	1.72E-07	
TetraCDF, 2,3,7,8-	51207-31-9	Inhalation	2.07E-10	4.13E-11	0.00E+00	0.00E+00	
Vanadium	7440-62-2	Inhalation	0.00E+00	0.00E+00	8.03E-06	8.03E-06	
Zinc	7440-66-6	Inhalation	0.00E+00	0.00E+00	3.82E-07	3.82E-07	
		Pathway Total:	**2.15E-08**	**1.82E-08**	**4.77E-04**	**4.77E-04**	

Table E-2. I Pathway and Constituent of Potential Concern Cancer Risks and Noncancer Hazards - IRAP Output.
Run 1 - 2,3,7,8-Tetrachlorodibenzo-p-dioxin
Urban Resident

COPC Name	CAS Number	Pathway	Urban Res Adult Cancer Risk	Urban Res Child Cancer Risk	Urban Res Adult Hazard Quotient	Urban Res Child Hazard Quotient	IRAP Output
Antimony	7440-36-0	Soil Ingestion	0.00E+00	0.00E+00	2.32E-06	2.17E-05	
Arsenic	7440-38-2	Soil Ingestion	4.63E-11	8.64E-11	2.50E-07	2.33E-06	
Beryllium	7440-41-7	Soil Ingestion	0.00E+00	0.00E+00	6.42E-08	5.99E-07	
Cadmium	7440-43-9	Soil Ingestion	0.00E+00	0.00E+00	2.23E-07	2.08E-06	
Chromium, hexavalent	18540-29-9	Soil Ingestion	3.04E-11	3.03E-10	4.86E-08	4.53E-07	5.68E-11
Cobalt	7440-48-4	Soil Ingestion	0.00E+00	0.00E+00	9.92E-08	9.26E-07	
Copper	7440-50-8	Soil Ingestion	0.00E+00	0.00E+00	8.65E-09	8.08E-08	
HeptaCDD, 1,2,3,4,6,7,8-	35822-46-9	Soil Ingestion	8.61E-12	1.61E-11	0.00E+00	0.00E+00	
HeptaCDF, 1,2,3,4,6,7,8-	67562-39-4	Soil Ingestion	6.26E-12	1.17E-11	0.00E+00	0.00E+00	
HeptaCDF, 1,2,3,4,7,8,9-	55673-89-7	Soil Ingestion	1.63E-12	3.04E-12	0.00E+00	0.00E+00	
HexaCDD, 1,2,3,4,7,8-	39227-28-6	Soil Ingestion	6.04E-12	1.13E-11	0.00E+00	0.00E+00	
HexaCDD, 1,2,3,6,7,8-	57653-85-7	Soil Ingestion	1.48E-11	2.77E-11	0.00E+00	0.00E+00	
HexaCDD, 1,2,3,7,8,9-	19408-74-3	Soil Ingestion	1.51E-11	2.83E-11	0.00E+00	0.00E+00	
HexaCDF, 1,2,3,4,7,8-	70648-26-9	Soil Ingestion	3.45E-11	6.44E-11	0.00E+00	0.00E+00	
HexaCDF, 1,2,3,6,7,8-	57117-44-9	Soil Ingestion	5.88E-11	1.10E-10	0.00E+00	0.00E+00	
HexaCDF, 1,2,3,7,8,9-	72918-21-9	Soil Ingestion	1.19E-11	2.22E-11	0.00E+00	0.00E+00	
HexaCDF, 2,3,4,6,7,8-	60851-34-5	Soil Ingestion	5.49E-11	1.02E-10	0.00E+00	0.00E+00	
Indeno(1,2,3-cd) pyrene	193-39-5	Soil Ingestion	1.70E-14	1.69E-13	0.00E+00	0.00E+00	3.17E-14
Lead	7439-92-1	Soil Ingestion	9.17E-11	1.71E-10	1.03E-04	9.62E-04	
Manganese	7439-96-5	Soil Ingestion	0.00E+00	0.00E+00	7.88E-09	7.35E-08	
Molybdenum	74939-98-7	Soil Ingestion	0.00E+00	0.00E+00	4.40E-08	4.11E-07	
Nickel	7440-02-0	Soil Ingestion	0.00E+00	0.00E+00	1.90E-08	1.78E-07	
OctaCDD, 1,2,3,4,6,7,8,9-	3268-87-9	Soil Ingestion	6.00E-13	1.12E-12	0.00E+00	0.00E+00	
OctaCDF, 1,2,3,4,6,7,8,9-	39001-02-0	Soil Ingestion	1.44E-13	2.69E-13	0.00E+00	0.00E+00	
PentaCDD, 1,2,3,7,8-	40321-76-4	Soil Ingestion	2.25E-10	4.20E-10	0.00E+00	0.00E+00	
PentaCDF, 1,2,3,7,8-	57117-41-6	Soil Ingestion	1.14E-11	2.13E-11	0.00E+00	0.00E+00	
PentaCDF, 2,3,4,7,8-	57117-31-4	Soil Ingestion	1.66E-10	3.09E-10	0.00E+00	0.00E+00	
Selenium	7782-49-2	Soil Ingestion	0.00E+00	0.00E+00	2.72E-09	2.54E-08	
TetraCDD, 2,3,7,8-	1746-01-6	Soil Ingestion	4.42E-11	8.26E-11	1.35E-06	1.26E-05	
TetraCDF, 2,3,7,8-	51207-31-9	Soil Ingestion	6.22E-11	1.16E-10	0.00E+00	0.00E+00	
Tin	7440-31-5	Soil Ingestion	0.00E+00	0.00E+00	1.50E-08	1.40E-07	
Vanadium	7440-62-2	Soil Ingestion	0.00E+00	0.00E+00	1.49E-05	1.39E-04	
Zinc	7440-66-6	Soil Ingestion	0.00E+00	0.00E+00	2.03E-07	1.90E-06	
		Pathway Total:	**8.90E-10**	**1.91E-09**	**1.23E-04**	**1.14E-03**	

Note:
Shading indicates carcinogen is a mutagen and the age-dependent adjsutment factors (ADAFs) have been applied to the cancer risk calculations.

Table E-3. Pathway and Constituent of Potential Concern Cancer Risks and Noncancer Hazards - IRAP Output.
Run 1 - 2,3,7,8-Tetrachlorodibenzo-p-dioxin
Suburban Resident

COPC Name	CAS Number	Pathway		Suburban Res Adult Cancer Risk	Suburban Res Child Cancer Risk	Suburban Res Adult Hazard Quotient	Suburban Res Child Hazard Quotient	IRAP Output
Antimony	7440-36-0	Inhalation		0.00E+00	0.00E+00	6.25E-06	6.25E-06	
Arsenic	7440-38-2	Inhalation		2.01E-09	4.02E-10	7.28E-05	7.28E-05	
Beryllium	7440-41-7	Inhalation		1.15E-10	2.30E-11	5.58E-06	5.58E-06	
Cadmium	7440-43-9	Inhalation		9.71E-10	1.94E-10	1.26E-04	1.26E-04	
Chromium, hexavalent	18540-29-9	Inhalation		1.66E-08	1.77E-08	3.23E-05	3.23E-05	3.33E-09
Cobalt	7440-48-4	Inhalation		1.08E-09	2.16E-10	4.67E-05	4.67E-05	
HeptaCDD, 1,2,3,4,6,7,8-	35822-46-9	Inhalation		8.76E-12	1.75E-12	0.00E+00	0.00E+00	
HeptaCDF, 1,2,3,4,6,7,8-	67562-39-4	Inhalation		6.41E-12	1.28E-12	0.00E+00	0.00E+00	
HeptaCDF, 1,2,3,4,7,8,9-	55673-89-7	Inhalation		1.75E-12	3.49E-13	0.00E+00	0.00E+00	
HexaCDD, 1,2,3,4,7,8-	39227-28-6	Inhalation		6.26E-12	1.25E-12	0.00E+00	0.00E+00	
HexaCDD, 1,2,3,6,7,8-	57653-85-7	Inhalation		1.55E-11	3.10E-12	0.00E+00	0.00E+00	
HexaCDD, 1,2,3,7,8,9-	19408-74-3	Inhalation		1.57E-11	3.13E-12	0.00E+00	0.00E+00	
HexaCDF, 1,2,3,4,7,8-	70648-26-9	Inhalation		3.68E-11	7.36E-12	0.00E+00	0.00E+00	
HexaCDF, 1,2,3,6,7,8-	57117-44-9	Inhalation		6.28E-11	1.26E-11	0.00E+00	0.00E+00	
HexaCDF, 1,2,3,7,8,9-	72918-21-9	Inhalation		1.32E-11	2.64E-12	0.00E+00	0.00E+00	
HexaCDF, 2,3,4,6,7,8-	60851-34-5	Inhalation		5.88E-11	1.18E-11	0.00E+00	0.00E+00	
Indeno(1,2,3-cd) pyrene	193-39-5	Inhalation		1.67E-14	1.78E-14	0.00E+00	0.00E+00	3.33E-15
Lead	7439-92-1	Inhalation		1.88E-10	3.76E-11	2.44E-05	2.44E-05	
Manganese	7439-96-5	Inhalation		0.00E+00	0.00E+00	1.44E-04	1.44E-04	
Mercury	7439-97-6	Inhalation		0.00E+00	0.00E+00	6.77E-07	6.77E-07	
Nickel	7440-02-0	Inhalation		2.77E-10	5.54E-11	2.76E-05	2.76E-05	
OctaCDD, 1,2,3,4,6,7,8,9-	3268-87-9	Inhalation		6.10E-13	1.22E-13	0.00E+00	0.00E+00	
OctaCDF, 1,2,3,4,6,7,8,9-	39001-02-0	Inhalation		1.46E-13	2.93E-14	0.00E+00	0.00E+00	
PentaCDD, 1,2,3,7,8-	40321-76-4	Inhalation		2.58E-10	5.17E-11	0.00E+00	0.00E+00	
PentaCDF, 1,2,3,7,8-	57117-41-6	Inhalation		1.54E-11	3.08E-12	0.00E+00	0.00E+00	
PentaCDF, 2,3,4,7,8-	57117-31-4	Inhalation		2.13E-10	4.25E-11	0.00E+00	0.00E+00	
Selenium	7782-49-2	Inhalation		0.00E+00	0.00E+00	5.63E-08	5.63E-08	
TetraCDD, 2,3,7,8-	1746-01-6	Inhalation		1.17E-10	2.33E-11	1.79E-07	1.79E-07	
TetraCDF, 2,3,7,8-	51207-31-9	Inhalation		2.16E-10	4.31E-11	0.00E+00	0.00E+00	
Vanadium	7440-62-2	Inhalation		0.00E+00	0.00E+00	8.33E-06	8.33E-06	
Zinc	7440-66-6	Inhalation		0.00E+00	0.00E+00	3.97E-07	3.97E-07	
			Pathway Total:	**2.23E-08**	**1.89E-08**	**4.95E-04**	**4.95E-04**	

Table E-3. Pathway and Constituent of Potential Concern Cancer Risks and Noncancer Hazards - IRAP Output.
Run 1 - 2,3,7,8-Tetrachlorodibenzo-p-dioxin
Suburban Resident

COPC Name	CAS Number	Pathway	Suburban Res Adult Cancer Risk	Suburban Res Child Cancer Risk	Suburban Res Adult Hazard Quotient	Suburban Res Child Hazard Quotient	IRAP Output
Antimony	7440-36-0	Locally-grown Produce	0.00E+00	0.00E+00	2.13E-04	2.37E-03	
Arsenic	7440-38-2	Locally-grown Produce	5.32E-09	1.19E-08	2.80E-05	3.14E-04	
Beryllium	7440-41-7	Locally-grown Produce	0.00E+00	0.00E+00	4.29E-07	4.82E-06	
Cadmium	7440-43-9	Locally-grown Produce	0.00E+00	0.00E+00	2.36E-05	2.62E-04	
Chromium, hexavalent	18540-29-9	Locally-grown Produce	5.17E-09	6.19E-08	8.09E-06	9.08E-05	1.16E-08
Cobalt	7440-48-4	Locally-grown Produce	0.00E+00	0.00E+00	1.35E-05	1.52E-04	
Copper	7440-50-8	Locally-grown Produce	0.00E+00	0.00E+00	1.03E-06	1.07E-05	
HeptaCDD, 1,2,3,4,6,7,8-	35822-46-9	Locally-grown Produce	9.75E-11	2.19E-10	0.00E+00	0.00E+00	
HeptaCDF, 1,2,3,4,6,7,8-	67562-39-4	Locally-grown Produce	7.22E-11	1.62E-10	0.00E+00	0.00E+00	
HeptaCDF, 1,2,3,4,7,8,9-	55673-89-7	Locally-grown Produce	1.98E-11	4.44E-11	0.00E+00	0.00E+00	
HexaCDD, 1,2,3,4,7,8-	39227-28-6	Locally-grown Produce	6.94E-11	1.56E-10	0.00E+00	0.00E+00	
HexaCDD, 1,2,3,6,7,8-	57653-85-7	Locally-grown Produce	1.73E-10	3.89E-10	0.00E+00	0.00E+00	
HexaCDD, 1,2,3,7,8,9-	19408-74-3	Locally-grown Produce	1.76E-10	3.93E-10	0.00E+00	0.00E+00	
HexaCDF, 1,2,3,4,7,8-	70648-26-9	Locally-grown Produce	4.02E-10	9.01E-10	0.00E+00	0.00E+00	
HexaCDF, 1,2,3,6,7,8-	57117-44-9	Locally-grown Produce	6.84E-10	1.53E-09	0.00E+00	0.00E+00	
HexaCDF, 1,2,3,7,8,9-	72918-21-9	Locally-grown Produce	1.39E-10	3.12E-10	0.00E+00	0.00E+00	
HexaCDF, 2,3,4,6,7,8-	60851-34-5	Locally-grown Produce	6.39E-10	1.43E-09	0.00E+00	0.00E+00	
Indeno(1,2,3-cd) pyrene	193-39-5	Locally-grown Produce	8.37E-13	1.00E-11	0.00E+00	0.00E+00	1.88E-12
Lead	7439-92-1	Locally-grown Produce	1.11E-09	2.48E-09	7.90E-04	8.83E-03	
Manganese	7439-96-5	Locally-grown Produce	0.00E+00	0.00E+00	7.53E-07	7.14E-06	
Molybdenum	74939-98-7	Locally-grown Produce	0.00E+00	0.00E+00	2.50E-05	2.76E-04	
Nickel	7440-02-0	Locally-grown Produce	0.00E+00	0.00E+00	1.01E-06	1.14E-05	
OctaCDD, 1,2,3,4,6,7,8,9-	3268-87-9	Locally-grown Produce	6.80E-12	1.53E-11	0.00E+00	0.00E+00	
OctaCDF, 1,2,3,4,6,7,8,9-	39001-02-0	Locally-grown Produce	1.64E-12	3.67E-12	0.00E+00	0.00E+00	
PentaCDD, 1,2,3,7,8-	40321-76-4	Locally-grown Produce	2.75E-09	6.16E-09	0.00E+00	0.00E+00	
PentaCDF, 1,2,3,7,8-	57117-41-6	Locally-grown Produce	1.36E-10	3.04E-10	0.00E+00	0.00E+00	
PentaCDF, 2,3,4,7,8-	57117-31-4	Locally-grown Produce	2.00E-09	4.48E-09	0.00E+00	0.00E+00	
Selenium	7782-49-2	Locally-grown Produce	0.00E+00	0.00E+00	1.69E-06	1.90E-05	
TetraCDD, 2,3,7,8-	1746-01-6	Locally-grown Produce	5.32E-10	1.19E-09	9.83E-06	1.10E-04	
TetraCDF, 2,3,7,8-	51207-31-9	Locally-grown Produce	7.30E-10	1.63E-09	0.00E+00	0.00E+00	
Tin	7440-31-5	Locally-grown Produce	0.00E+00	0.00E+00	3.25E-06	3.69E-05	
Vanadium	7440-62-2	Locally-grown Produce	0.00E+00	0.00E+00	8.80E-05	9.86E-04	
Zinc	7440-66-6	Locally-grown Produce	0.00E+00	0.00E+00	3.85E-05	3.70E-04	
		Pathway Total:	**2.02E-08**	**9.57E-08**	**1.25E-03**	**1.39E-02**	

Table E-3. Pathway and Constituent of Potential Concern Cancer Risks and Noncancer Hazards - IRAP Output.
Run 1 - 2,3,7,8-Tetrachlorodibenzo-p-dioxin
Suburban Resident

COPC Name	CAS Number	Pathway	Suburban Res Adult Cancer Risk	Suburban Res Child Cancer Risk	Suburban Res Adult Hazard Quotient	Suburban Res Child Hazard Quotient	IRAP Output
Antimony	7440-36-0	Soil Ingestion	0.00E+00	0.00E+00	2.78E-06	2.60E-05	
Arsenic	7440-38-2	Soil Ingestion	5.54E-11	1.03E-10	2.99E-07	2.79E-06	
Beryllium	7440-41-7	Soil Ingestion	0.00E+00	0.00E+00	7.68E-08	7.17E-07	
Cadmium	7440-43-9	Soil Ingestion	0.00E+00	0.00E+00	2.67E-07	2.49E-06	
Chromium, hexavalent	18540-29-9	Soil Ingestion	3.64E-11	3.63E-10	5.81E-08	5.43E-07	6.80E-11
Cobalt	7440-48-4	Soil Ingestion	0.00E+00	0.00E+00	1.19E-07	1.11E-06	
Copper	7440-50-8	Soil Ingestion	0.00E+00	0.00E+00	1.04E-08	9.67E-08	
HeptaCDD, 1,2,3,4,6,7,8-	35822-46-9	Soil Ingestion	1.03E-11	1.93E-11	0.00E+00	0.00E+00	
HeptaCDF, 1,2,3,4,6,7,8-	67562-39-4	Soil Ingestion	7.49E-12	1.40E-11	0.00E+00	0.00E+00	
HeptaCDF, 1,2,3,4,7,8,9-	55673-89-7	Soil Ingestion	1.95E-12	3.64E-12	0.00E+00	0.00E+00	
HexaCDD, 1,2,3,4,7,8-	39227-28-6	Soil Ingestion	7.23E-12	1.35E-11	0.00E+00	0.00E+00	
HexaCDD, 1,2,3,6,7,8-	57653-85-7	Soil Ingestion	1.78E-11	3.31E-11	0.00E+00	0.00E+00	
HexaCDD, 1,2,3,7,8,9-	19408-74-3	Soil Ingestion	1.81E-11	3.38E-11	0.00E+00	0.00E+00	
HexaCDF, 1,2,3,4,7,8-	70648-26-9	Soil Ingestion	4.13E-11	7.71E-11	0.00E+00	0.00E+00	
HexaCDF, 1,2,3,6,7,8-	57117-44-9	Soil Ingestion	7.03E-11	1.31E-10	0.00E+00	0.00E+00	
HexaCDF, 1,2,3,7,8,9-	72918-21-9	Soil Ingestion	1.42E-11	2.66E-11	0.00E+00	0.00E+00	
HexaCDF, 2,3,4,6,7,8-	60851-34-5	Soil Ingestion	6.56E-11	1.23E-10	0.00E+00	0.00E+00	
Indeno(1,2,3-cd) pyrene	193-39-5	Soil Ingestion	2.03E-14	2.02E-13	0.00E+00	0.00E+00	3.79E-14
Lead	7439-92-1	Soil Ingestion	1.10E-10	2.05E-10	1.23E-04	1.15E-03	
Manganese	7439-96-5	Soil Ingestion	0.00E+00	0.00E+00	9.43E-09	8.80E-08	
Molybdenum	74939-98-7	Soil Ingestion	0.00E+00	0.00E+00	5.27E-08	4.92E-07	
Nickel	7440-02-0	Soil Ingestion	0.00E+00	0.00E+00	2.28E-08	2.13E-07	
OctaCDD, 1,2,3,4,6,7,8,9-	3268-87-9	Soil Ingestion	7.19E-13	1.34E-12	0.00E+00	0.00E+00	
OctaCDF, 1,2,3,4,6,7,8,9-	39001-02-0	Soil Ingestion	1.72E-13	3.22E-13	0.00E+00	0.00E+00	
PentaCDD, 1,2,3,7,8-	40321-76-4	Soil Ingestion	2.69E-10	5.03E-10	0.00E+00	0.00E+00	
PentaCDF, 1,2,3,7,8-	57117-41-6	Soil Ingestion	1.36E-11	2.54E-11	0.00E+00	0.00E+00	
PentaCDF, 2,3,4,7,8-	57117-31-4	Soil Ingestion	1.98E-10	3.69E-10	0.00E+00	0.00E+00	
Selenium	7782-49-2	Soil Ingestion	0.00E+00	0.00E+00	3.26E-09	3.04E-08	
TetraCDD, 2,3,7,8-	1746-01-6	Soil Ingestion	5.19E-11	9.68E-11	1.59E-06	1.48E-05	
TetraCDF, 2,3,7,8-	51207-31-9	Soil Ingestion	7.22E-11	1.35E-10	0.00E+00	0.00E+00	
Tin	7440-31-5	Soil Ingestion	0.00E+00	0.00E+00	1.79E-08	1.67E-07	
Vanadium	7440-62-2	Soil Ingestion	0.00E+00	0.00E+00	1.79E-05	1.67E-04	
Zinc	7440-66-6	Soil Ingestion	0.00E+00	0.00E+00	2.43E-07	2.27E-06	
		Pathway Total:	**1.06E-09**	**2.28E-09**	**1.47E-04**	**1.37E-03**	

Note:
Shading indicates carcinogen is a mutagen and the age-dependent adjsutment factors (ADAFs) have been applied to the cancer risk calculations.

Table E-4. Pathway and Constituent of Potential Concern Cancer Risks and Noncancer Hazards - IRAP Output.
Run 1 - 2,3,7,8-Tetrachlorodibenzo-p-dioxin
Fisher at Puerto Arecibo

COPC Name	CAS Number	Pathway	Fisher PA Adult Cancer Risk	Fisher PA Child Cancer Risk	Fisher PA Adult Hazard Quotient	Fisher PA Child Hazard Quotient	IRAP Output
Antimony	7440-36-0	Fish Ingestion	0.00E+00	0.00E+00	4.48E-08	1.47E-07	
Arsenic	7440-38-2	Fish Ingestion	4.10E-12	2.69E-12	2.13E-08	6.99E-08	
Beryllium	7440-41-7	Fish Ingestion	0.00E+00	0.00E+00	1.77E-10	5.83E-10	
Cadmium	7440-43-9	Fish Ingestion	0.00E+00	0.00E+00	5.85E-08	1.92E-07	
Chromium, hexavalent	18540-29-9	Fish Ingestion	1.12E-13	3.93E-13	1.75E-10	5.73E-10	7.37E-14
Cobalt	7440-48-4	Fish Ingestion	0.00E+00	0.00E+00	1.43E-08	4.71E-08	
HeptaCDD, 1,2,3,4,6,7,8-	35822-46-9	Fish Ingestion	3.10E-13	2.04E-13	0.00E+00	0.00E+00	
HeptaCDF, 1,2,3,4,6,7,8-	67562-39-4	Fish Ingestion	2.16E-13	1.42E-13	0.00E+00	0.00E+00	
HeptaCDF, 1,2,3,4,7,8,9-	55673-89-7	Fish Ingestion	5.76E-14	3.79E-14	0.00E+00	0.00E+00	
HexaCDD, 1,2,3,4,7,8-	39227-28-6	Fish Ingestion	1.76E-12	1.15E-12	0.00E+00	0.00E+00	
HexaCDD, 1,2,3,6,7,8-	57653-85-7	Fish Ingestion	4.10E-12	2.69E-12	0.00E+00	0.00E+00	
HexaCDD, 1,2,3,7,8,9-	19408-74-3	Fish Ingestion	4.13E-12	2.71E-12	0.00E+00	0.00E+00	
HexaCDF, 1,2,3,4,7,8-	70648-26-9	Fish Ingestion	8.90E-12	5.85E-12	0.00E+00	0.00E+00	
HexaCDF, 1,2,3,6,7,8-	57117-44-9	Fish Ingestion	1.55E-11	1.02E-11	0.00E+00	0.00E+00	
HexaCDF, 1,2,3,7,8,9-	72918-21-9	Fish Ingestion	3.17E-12	2.09E-12	0.00E+00	0.00E+00	
HexaCDF, 2,3,4,6,7,8-	60851-34-5	Fish Ingestion	1.43E-11	9.40E-12	0.00E+00	0.00E+00	
Indeno(1,2,3-cd) pyrene	193-39-5	Fish Ingestion	7.20E-13	2.52E-12	0.00E+00	0.00E+00	4.73E-13
Molybdenum	74939-98-7	Fish Ingestion	0.00E+00	0.00E+00	4.76E-10	1.56E-09	
Nickel	7440-02-0	Fish Ingestion	0.00E+00	0.00E+00	4.96E-10	1.63E-09	
OctaCDD, 1,2,3,4,6,7,8,9-	3268-87-9	Fish Ingestion	4.35E-16	2.86E-16	0.00E+00	0.00E+00	
OctaCDF, 1,2,3,4,6,7,8,9-	39001-02-0	Fish Ingestion	1.04E-16	6.83E-17	0.00E+00	0.00E+00	
PentaCDD, 1,2,3,7,8-	40321-76-4	Fish Ingestion	1.38E-10	9.05E-11	0.00E+00	0.00E+00	
PentaCDF, 1,2,3,7,8-	57117-41-6	Fish Ingestion	7.73E-12	5.08E-12	0.00E+00	0.00E+00	
PentaCDF, 2,3,4,7,8-	57117-31-4	Fish Ingestion	9.05E-11	5.95E-11	0.00E+00	0.00E+00	
Selenium	7782-49-2	Fish Ingestion	0.00E+00	0.00E+00	1.49E-09	4.89E-09	
TetraCDD, 2,3,7,8-	1746-01-6	Fish Ingestion	3.73E-11	2.45E-11	6.70E-07	2.20E-06	
TetraCDF, 2,3,7,8-	51207-31-9	Fish Ingestion	4.16E-11	2.73E-11	0.00E+00	0.00E+00	
Tin	7440-31-5	Fish Ingestion	0.00E+00	0.00E+00	4.10E-09	1.35E-08	
Zinc	7440-66-6	Fish Ingestion	0.00E+00	0.00E+00	1.47E-07	4.82E-07	
		Pathway Total:	**3.72E-10**	**2.47E-10**	**9.63E-07**	**3.16E-06**	

Note:
Shading indicates carcinogen is a mutagen and the age-dependent adjsutment factors (ADAFs) have been applied to the cancer risk calculations.

Table E-5. I Pathway and Constituent of Potential Concern Cancer Risks and Noncancer Hazards - IRAP Output.
Run 1 - 2,3,7,8-Tetrachlorodibenzo-p-dioxin
Fisher at Cienaga Tiburones

COPC Name	CAS Number	Pathway	Fisher Tib Adult Cancer Risk	Fisher Tib Child Cancer Risk	Fisher Tib Adult Hazard Quotient	Fisher Tib Child Hazard Quotient	IRAP Output
Antimony	7440-36-0	Fish Ingestion	0.00E+00	0.00E+00	1.45E-02	4.78E-02	
Arsenic	7440-38-2	Fish Ingestion	1.85E-06	1.21E-06	9.80E-03	3.22E-02	
Beryllium	7440-41-7	Fish Ingestion	0.00E+00	0.00E+00	3.01E-06	9.89E-06	
Cadmium	7440-43-9	Fish Ingestion	0.00E+00	0.00E+00	1.22E-02	4.01E-02	
Chromium, hexavalent	18540-29-9	Fish Ingestion	6.92E-08	2.42E-07	1.09E-04	3.59E-04	4.55E-08
Cobalt	7440-48-4	Fish Ingestion	0.00E+00	0.00E+00	4.66E-03	1.53E-02	
HeptaCDD, 1,2,3,4,6,7,8-	35822-46-9	Fish Ingestion	5.79E-13	3.80E-13	0.00E+00	0.00E+00	
HeptaCDF, 1,2,3,4,6,7,8-	67562-39-4	Fish Ingestion	1.70E-13	1.12E-13	0.00E+00	0.00E+00	
HeptaCDF, 1,2,3,4,7,8,9-	55673-89-7	Fish Ingestion	4.57E-14	3.00E-14	0.00E+00	0.00E+00	
HexaCDD, 1,2,3,4,7,8-	39227-28-6	Fish Ingestion	2.25E-12	1.48E-12	0.00E+00	0.00E+00	
HexaCDD, 1,2,3,6,7,8-	57653-85-7	Fish Ingestion	1.85E-12	1.22E-12	0.00E+00	0.00E+00	
HexaCDD, 1,2,3,7,8,9-	19408-74-3	Fish Ingestion	1.86E-12	1.22E-12	0.00E+00	0.00E+00	
HexaCDF, 1,2,3,4,7,8-	70648-26-9	Fish Ingestion	3.09E-12	2.03E-12	0.00E+00	0.00E+00	
HexaCDF, 1,2,3,6,7,8-	57117-44-9	Fish Ingestion	8.10E-12	5.32E-12	0.00E+00	0.00E+00	
HexaCDF, 1,2,3,7,8,9-	72918-21-9	Fish Ingestion	1.28E-12	8.41E-13	0.00E+00	0.00E+00	
HexaCDF, 2,3,4,6,7,8-	60851-34-5	Fish Ingestion	5.76E-12	3.79E-12	0.00E+00	0.00E+00	
Indeno(1,2,3-cd) pyrene	193-39-5	Fish Ingestion	5.34E-11	1.87E-10	0.00E+00	0.00E+00	3.51E-11
Molybdenum	74939-98-7	Fish Ingestion	0.00E+00	0.00E+00	2.88E-04	9.45E-04	
Nickel	7440-02-0	Fish Ingestion	0.00E+00	0.00E+00	1.18E-04	3.86E-04	
OctaCDD, 1,2,3,4,6,7,8,9-	3268-87-9	Fish Ingestion	1.49E-15	9.78E-16	0.00E+00	0.00E+00	
OctaCDF, 1,2,3,4,6,7,8,9-	39001-02-0	Fish Ingestion	8.21E-16	5.40E-16	0.00E+00	0.00E+00	
PentaCDD, 1,2,3,7,8-	40321-76-4	Fish Ingestion	3.81E-11	2.50E-11	0.00E+00	0.00E+00	
PentaCDF, 1,2,3,7,8-	57117-41-6	Fish Ingestion	3.54E-12	2.33E-12	0.00E+00	0.00E+00	
PentaCDF, 2,3,4,7,8-	57117-31-4	Fish Ingestion	2.58E-11	1.69E-11	0.00E+00	0.00E+00	
Selenium	7782-49-2	Fish Ingestion	0.00E+00	0.00E+00	1.86E-03	6.12E-03	
TetraCDD, 2,3,7,8-	1746-01-6	Fish Ingestion	6.01E-12	3.95E-12	1.09E-07	3.58E-07	
TetraCDF, 2,3,7,8-	51207-31-9	Fish Ingestion	4.06E-12	2.67E-12	0.00E+00	0.00E+00	
Tin	7440-31-5	Fish Ingestion	0.00E+00	0.00E+00	7.78E-03	2.56E-02	
Zinc	7440-66-6	Fish Ingestion	0.00E+00	0.00E+00	3.62E-02	1.19E-01	
		Pathway Total:	**1.92E-06**	**1.46E-06**	**8.75E-02**	**2.88E-01**	

Note:
Shading indicates carcinogen is a mutagen and the age-dependent adjsutment factors (ADAFs) have been applied to the cancer risk calculations.

Table E-6. Pathway and Constituent of Potential Concern Cancer Risks and Noncancer Hazards - IRAP Output.
Run 1 - 2,3,7,8-Tetrachlorodibenzo-p-dioxin
Fisher at Rio Grande de Arecibo Estuary

COPC Name	CAS Number	Pathway	Fisher RGA Adult Cancer Risk	Fisher RGA Child Cancer Risk	Fisher RGA Adult Hazard Quotient	Fisher RGA Child Hazard Quotient	IRAP Output
Antimony	7440-36-0	Fish Ingestion	0.00E+00	0.00E+00	5.60E-08	1.84E-07	
Arsenic	7440-38-2	Fish Ingestion	4.99E-12	3.28E-12	2.66E-08	8.73E-08	
Beryllium	7440-41-7	Fish Ingestion	0.00E+00	0.00E+00	1.64E-10	5.38E-10	
Cadmium	7440-43-9	Fish Ingestion	0.00E+00	0.00E+00	7.31E-08	2.40E-07	
Chromium, hexavalent	18540-29-9	Fish Ingestion	1.38E-13	4.83E-13	2.18E-10	7.16E-10	9.05E-14
Cobalt	7440-48-4	Fish Ingestion	0.00E+00	0.00E+00	1.79E-08	5.89E-08	
HeptaCDD, 1,2,3,4,6,7,8-	35822-46-9	Fish Ingestion	3.11E-14	2.04E-14	0.00E+00	0.00E+00	
HeptaCDF, 1,2,3,4,6,7,8-	67562-39-4	Fish Ingestion	2.18E-14	1.44E-14	0.00E+00	0.00E+00	
HeptaCDF, 1,2,3,4,7,8,9-	55673-89-7	Fish Ingestion	5.69E-15	3.74E-15	0.00E+00	0.00E+00	
HexaCDD, 1,2,3,4,7,8-	39227-28-6	Fish Ingestion	1.73E-13	1.14E-13	0.00E+00	0.00E+00	
HexaCDD, 1,2,3,6,7,8-	57653-85-7	Fish Ingestion	4.11E-13	2.70E-13	0.00E+00	0.00E+00	
HexaCDD, 1,2,3,7,8,9-	19408-74-3	Fish Ingestion	4.19E-13	2.75E-13	0.00E+00	0.00E+00	
HexaCDF, 1,2,3,4,7,8-	70648-26-9	Fish Ingestion	9.05E-13	5.95E-13	0.00E+00	0.00E+00	
HexaCDF, 1,2,3,6,7,8-	57117-44-9	Fish Ingestion	1.54E-12	1.01E-12	0.00E+00	0.00E+00	
HexaCDF, 1,2,3,7,8,9-	72918-21-9	Fish Ingestion	3.12E-13	2.05E-13	0.00E+00	0.00E+00	
HexaCDF, 2,3,4,6,7,8-	60851-34-5	Fish Ingestion	1.44E-12	9.45E-13	0.00E+00	0.00E+00	
Indeno(1,2,3-cd) pyrene	193-39-5	Fish Ingestion	2.88E-13	1.01E-12	0.00E+00	0.00E+00	1.89E-13
Molybdenum	74939-98-7	Fish Ingestion	0.00E+00	0.00E+00	5.94E-10	1.95E-09	
Nickel	7440-02-0	Fish Ingestion	0.00E+00	0.00E+00	6.20E-10	2.04E-09	
OctaCDD, 1,2,3,4,6,7,8,9-	3268-87-9	Fish Ingestion	4.35E-17	2.86E-17	0.00E+00	0.00E+00	
OctaCDF, 1,2,3,4,6,7,8,9-	39001-02-0	Fish Ingestion	1.04E-17	6.83E-18	0.00E+00	0.00E+00	
PentaCDD, 1,2,3,7,8-	40321-76-4	Fish Ingestion	1.18E-11	7.75E-12	0.00E+00	0.00E+00	
PentaCDF, 1,2,3,7,8-	57117-41-6	Fish Ingestion	6.38E-13	4.19E-13	0.00E+00	0.00E+00	
PentaCDF, 2,3,4,7,8-	57117-31-4	Fish Ingestion	8.07E-12	5.30E-12	0.00E+00	0.00E+00	
Selenium	7782-49-2	Fish Ingestion	0.00E+00	0.00E+00	1.86E-09	6.10E-09	
TetraCDD, 2,3,7,8-	1746-01-6	Fish Ingestion	2.63E-12	1.73E-12	4.77E-08	1.57E-07	
TetraCDF, 2,3,7,8-	51207-31-9	Fish Ingestion	2.36E-12	1.55E-12	0.00E+00	0.00E+00	
Tin	7440-31-5	Fish Ingestion	0.00E+00	0.00E+00	4.95E-09	1.63E-08	
Zinc	7440-66-6	Fish Ingestion	0.00E+00	0.00E+00	1.83E-07	6.02E-07	
		Pathway Total:	**3.62E-11**	**2.50E-11**	**4.13E-07**	**1.36E-06**	

Note:
Shading indicates carcinogen is a mutagen and the age-dependent adjsutment factors (ADAFs) have been applied to the cancer risk calculations.

Table E-7. Pathway and Constituent of Potential Concern Cancer Risks and Noncancer Hazards - IRAP Output.
Run 2 - Benzo(a)pyrene
Farmer

COPC Name	CAS Number	Pathway	Farmer Adult Cancer Risk	Farmer Child Cancer Risk	Farmer Adult Hazard Quotient	Farmer Child Hazard Quotient	IRAP Output
Anthracene	120-12-7	Inhalation	0.00E+00	0.00E+00	2.79E-12	2.79E-12	
Benzo(a)anthracene	56-55-3	Inhalation	1.53E-13	1.23E-13	0.00E+00	0.00E+00	2.30E-14
Benzo(a)pyrene	50-32-8	Inhalation	1.37E-12	1.10E-12	0.00E+00	0.00E+00	2.06E-13
Chrysene	218-01-9	Inhalation	1.65E-14	1.32E-14	0.00E+00	0.00E+00	2.48E-15
Fluoranthene	206-44-0	Inhalation	0.00E+00	0.00E+00	1.45E-11	1.45E-11	
Hydrogen fluoride	7664-39-3	Inhalation	0.00E+00	0.00E+00	2.69E-03	2.69E-03	
Pyrene	129-00-0	Inhalation	0.00E+00	0.00E+00	1.53E-11	1.53E-11	
		Pathway Total:	**1.54E-12**	**1.24E-12**	**2.69E-03**	**2.69E-03**	
Anthracene	120-12-7	Locally-grown Produce	0.00E+00	0.00E+00	7.61E-13	8.60E-12	
Benzo(a)anthracene	56-55-3	Locally-grown Produce	1.59E-12	1.43E-11	0.00E+00	0.00E+00	2.69E-12
Benzo(a)pyrene	50-32-8	Locally-grown Produce	2.00E-11	1.80E-10	0.00E+00	0.00E+00	3.37E-11
Chrysene	218-01-9	Locally-grown Produce	8.54E-15	7.75E-14	0.00E+00	0.00E+00	1.45E-14
Fluoranthene	206-44-0	Locally-grown Produce	0.00E+00	0.00E+00	3.26E-12	3.67E-11	
Pyrene	129-00-0	Locally-grown Produce	0.00E+00	0.00E+00	1.16E-11	1.31E-10	
		Pathway Total:	**2.16E-11**	**1.94E-10**	**1.56E-11**	**1.76E-10**	
Anthracene	120-12-7	Beef Ingestion	0.00E+00	0.00E+00	5.75E-13	1.65E-12	
Benzo(a)anthracene	56-55-3	Beef Ingestion	2.31E-12	5.40E-12	0.00E+00	0.00E+00	1.01E-12
Benzo(a)pyrene	50-32-8	Beef Ingestion	3.47E-11	8.04E-11	0.00E+00	0.00E+00	1.51E-11
Chrysene	218-01-9	Beef Ingestion	1.14E-14	2.69E-14	0.00E+00	0.00E+00	5.04E-15
Fluoranthene	206-44-0	Beef Ingestion	0.00E+00	0.00E+00	5.81E-12	1.67E-11	
Hydrogen fluoride	7664-39-3	Beef Ingestion	0.00E+00	0.00E+00	3.84E-07	1.10E-06	
Pyrene	129-00-0	Beef Ingestion	0.00E+00	0.00E+00	1.65E-11	4.74E-11	
		Pathway Total:	**3.70E-11**	**8.59E-11**	**3.84E-07**	**1.10E-06**	
Anthracene	120-12-7	Chicken Ingestion	0.00E+00	0.00E+00	1.89E-14	6.00E-14	
Benzo(a)anthracene	56-55-3	Chicken Ingestion	7.09E-15	2.19E-14	0.00E+00	0.00E+00	4.10E-15
Benzo(a)pyrene	50-32-8	Chicken Ingestion	5.68E-14	1.79E-13	0.00E+00	0.00E+00	3.35E-14
Chrysene	218-01-9	Chicken Ingestion	7.58E-17	2.25E-16	0.00E+00	0.00E+00	4.21E-17
Fluoranthene	206-44-0	Chicken Ingestion	0.00E+00	0.00E+00	1.14E-13	3.62E-13	
Hydrogen fluoride	7664-39-3	Chicken Ingestion	0.00E+00	0.00E+00	1.54E-08	4.90E-08	
Pyrene	129-00-0	Chicken Ingestion	0.00E+00	0.00E+00	5.21E-13	1.65E-12	
		Pathway Total:	**6.40E-14**	**2.01E-13**	**1.54E-08**	**4.90E-08**	
Anthracene	120-12-7	Drinking Water Ingestion	0.00E+00	0.00E+00	1.04E-15	2.31E-15	
Benzo(a)anthracene	56-55-3	Drinking Water Ingestion	2.97E-16	5.36E-16	0.00E+00	0.00E+00	1.00E-16
Benzo(a)pyrene	50-32-8	Drinking Water Ingestion	1.96E-15	3.53E-15	0.00E+00	0.00E+00	6.63E-16
Chrysene	218-01-9	Drinking Water Ingestion	1.12E-18	2.04E-18	0.00E+00	0.00E+00	3.83E-19
Fluoranthene	206-44-0	Drinking Water Ingestion	0.00E+00	0.00E+00	6.82E-15	1.52E-14	
Hydrogen fluoride	7664-39-3	Drinking Water Ingestion	0.00E+00	0.00E+00	2.49E-07	5.55E-07	
Pyrene	129-00-0	Drinking Water Ingestion	0.00E+00	0.00E+00	9.28E-15	2.07E-14	
		Pathway Total:	**2.26E-15**	**4.07E-15**	**2.49E-07**	**5.55E-07**	

Table E-7. Pathway and Constituent of Potential Concern Cancer Risks and Noncancer Hazards - IRAP Output.
Run 2 - Benzo(a)pyrene
Farmer

COPC Name	CAS Number	Pathway	Farmer Adult Cancer Risk	Farmer Child Cancer Risk	Farmer Adult Hazard Quotient	Farmer Child Hazard Quotient	IRAP Output
Anthracene	120-12-7	Eggs Ingestion	0.00E+00	0.00E+00	3.99E-15	1.34E-14	
Benzo(a)anthracene	56-55-3	Eggs Ingestion	1.50E-15	4.87E-15	0.00E+00	0.00E+00	9.13E-16
Benzo(a)pyrene	50-32-8	Eggs Ingestion	1.20E-14	3.98E-14	0.00E+00	0.00E+00	7.47E-15
Chrysene	218-01-9	Eggs Ingestion	1.60E-17	5.00E-17	0.00E+00	0.00E+00	9.38E-18
Fluoranthene	206-44-0	Eggs Ingestion	0.00E+00	0.00E+00	2.41E-14	8.06E-14	
Hydrogen fluoride	7664-39-3	Eggs Ingestion	0.00E+00	0.00E+00	3.26E-09	1.09E-08	
Pyrene	129-00-0	Eggs Ingestion	0.00E+00	0.00E+00	1.10E-13	3.68E-13	
		Pathway Total:	**1.35E-14**	**4.47E-14**	**3.26E-09**	**1.09E-08**	
Anthracene	120-12-7	Milk Ingestion	0.00E+00	0.00E+00	7.36E-13	5.69E-12	
Benzo(a)anthracene	56-55-3	Milk Ingestion	4.28E-12	2.67E-11	0.00E+00	0.00E+00	5.00E-12
Benzo(a)pyrene	50-32-8	Milk Ingestion	6.54E-11	4.07E-10	0.00E+00	0.00E+00	7.62E-11
Chrysene	218-01-9	Milk Ingestion	2.01E-14	1.26E-13	0.00E+00	0.00E+00	2.37E-14
Fluoranthene	206-44-0	Milk Ingestion	0.00E+00	0.00E+00	8.68E-12	6.71E-11	
Hydrogen fluoride	7664-39-3	Milk Ingestion	0.00E+00	0.00E+00	3.58E-07	2.77E-06	
Pyrene	129-00-0	Milk Ingestion	0.00E+00	0.00E+00	2.05E-11	1.59E-10	
		Pathway Total:	**6.97E-11**	**4.33E-10**	**3.58E-07**	**2.77E-06**	
Anthracene	120-12-7	Pork Ingestion	0.00E+00	0.00E+00	3.68E-13	1.31E-12	
Benzo(a)anthracene	56-55-3	Pork Ingestion	3.71E-13	1.14E-12	0.00E+00	0.00E+00	2.14E-13
Benzo(a)pyrene	50-32-8	Pork Ingestion	5.23E-12	1.56E-11	0.00E+00	0.00E+00	2.93E-12
Chrysene	218-01-9	Pork Ingestion	2.38E-15	7.45E-15	0.00E+00	0.00E+00	1.40E-15
Fluoranthene	206-44-0	Pork Ingestion	0.00E+00	0.00E+00	2.52E-12	9.00E-12	
Hydrogen fluoride	7664-39-3	Pork Ingestion	0.00E+00	0.00E+00	2.84E-07	1.01E-06	
Pyrene	129-00-0	Pork Ingestion	0.00E+00	0.00E+00	1.02E-11	3.64E-11	
		Pathway Total:	**5.60E-12**	**1.68E-11**	**2.84E-07**	**1.01E-06**	
Anthracene	120-12-7	Soil Ingestion	0.00E+00	0.00E+00	1.24E-13	1.16E-12	
Benzo(a)anthracene	56-55-3	Soil Ingestion	4.20E-14	3.82E-13	0.00E+00	0.00E+00	7.16E-14
Benzo(a)pyrene	50-32-8	Soil Ingestion	3.60E-13	3.34E-12	0.00E+00	0.00E+00	6.25E-13
Chrysene	218-01-9	Soil Ingestion	4.49E-16	3.92E-15	0.00E+00	0.00E+00	7.35E-16
Fluoranthene	206-44-0	Soil Ingestion	0.00E+00	0.00E+00	6.70E-13	6.26E-12	
Hydrogen fluoride	7664-39-3	Soil Ingestion	0.00E+00	0.00E+00	4.08E-05	3.81E-04	
Pyrene	129-00-0	Soil Ingestion	0.00E+00	0.00E+00	3.10E-12	2.90E-11	
		Pathway Total:	**4.02E-13**	**3.72E-12**	**4.08E-05**	**3.81E-04**	

Note:
Shading indicates carcinogen is a mutagen and the age-dependent adjsutment factors (ADAFs) have been applied to the cancer risk calculations.

Table E-8. Pathway and Constituent of Potential Concern Cancer Risks and Noncancer Hazards - IRAP Output.
Run 2 - Benzo(a)pyrene
Urban Resident

COPC Name	CAS Number	Pathway	Urban Res Adult Cancer Risk	Urban Res Child Cancer Risk	Urban Res Adult Hazard Quotient	Urban Res Child Hazard Quotient	IRAP Output
Anthracene	120-12-7	Inhalation	0.00E+00	0.00E+00	1.09E-12	1.09E-12	
Benzo(a)anthracene	56-55-3	Inhalation	4.47E-14	4.77E-14	0.00E+00	0.00E+00	8.95E-15
Benzo(a)pyrene	50-32-8	Inhalation	4.01E-13	4.28E-13	0.00E+00	0.00E+00	8.03E-14
Chrysene	218-01-9	Inhalation	4.82E-15	5.15E-15	0.00E+00	0.00E+00	9.65E-16
Fluoranthene	206-44-0	Inhalation	0.00E+00	0.00E+00	5.66E-12	5.66E-12	
Hydrogen fluoride	7664-39-3	Inhalation	0.00E+00	0.00E+00	1.05E-03	1.05E-03	
Pyrene	129-00-0	Inhalation	0.00E+00	0.00E+00	5.95E-12	5.95E-12	
		Pathway Total:	**4.51E-13**	**4.81E-13**	**1.05E-03**	**1.05E-03**	
Anthracene	120-12-7	Soil Ingestion	0.00E+00	0.00E+00	4.84E-14	4.52E-13	
Benzo(a)anthracene	56-55-3	Soil Ingestion	1.26E-14	1.25E-13	0.00E+00	0.00E+00	2.34E-14
Benzo(a)pyrene	50-32-8	Soil Ingestion	1.08E-13	1.07E-12	0.00E+00	0.00E+00	2.01E-13
Chrysene	218-01-9	Soil Ingestion	1.36E-16	1.35E-15	0.00E+00	0.00E+00	2.53E-16
Fluoranthene	206-44-0	Soil Ingestion	0.00E+00	0.00E+00	2.61E-13	2.43E-12	
Hydrogen fluoride	7664-39-3	Soil Ingestion	0.00E+00	0.00E+00	1.60E-05	1.49E-04	
Pyrene	129-00-0	Soil Ingestion	0.00E+00	0.00E+00	1.21E-12	1.13E-11	
		Pathway Total:	**1.20E-13**	**1.20E-12**	**1.60E-05**	**1.49E-04**	

Note:
Shading indicates carcinogen is a mutagen and the age-dependent adjsutment factors (ADAFs) have been applied to the cancer risk calculations.

Table E-9. Pathway and Constituent of Potential Concern Cancer Risks and Noncancer Hazards - IRAP Output.
Run 2 - Benzo(a)pyrene
Suburban Resident

COPC Name	CAS Number	Pathway	Suburban Res Adult Cancer Risk	Suburban Res Child Cancer Risk	Suburban Res Adult Hazard Quotient	Suburban Res Child Hazard Quotient	IRAP Output
Anthracene	120-12-7	Inhalation	0.00E+00	0.00E+00	1.14E-12	1.14E-12	
Benzo(a)anthracene	56-55-3	Inhalation	4.67E-14	4.98E-14	0.00E+00	0.00E+00	9.33E-15
Benzo(a)pyrene	50-32-8	Inhalation	4.18E-13	4.46E-13	0.00E+00	0.00E+00	8.36E-14
Chrysene	218-01-9	Inhalation	5.03E-15	5.37E-15	0.00E+00	0.00E+00	1.01E-15
Fluoranthene	206-44-0	Inhalation	0.00E+00	0.00E+00	5.91E-12	5.91E-12	
Hydrogen fluoride	7664-39-3	Inhalation	0.00E+00	0.00E+00	1.10E-03	1.10E-03	
Pyrene	129-00-0	Inhalation	0.00E+00	0.00E+00	6.21E-12	6.21E-12	
		Pathway Total:	**4.70E-13**	**5.01E-13**	**1.10E-03**	**1.10E-03**	
Anthracene	120-12-7	Locally-grown Produce	0.00E+00	0.00E+00	3.32E-13	3.76E-12	
Benzo(a)anthracene	56-55-3	Locally-grown Produce	5.44E-13	6.52E-12	0.00E+00	0.00E+00	1.22E-12
Benzo(a)pyrene	50-32-8	Locally-grown Produce	6.86E-12	8.22E-11	0.00E+00	0.00E+00	1.54E-11
Chrysene	218-01-9	Locally-grown Produce	2.93E-15	3.51E-14	0.00E+00	0.00E+00	6.58E-15
Fluoranthene	206-44-0	Locally-grown Produce	0.00E+00	0.00E+00	1.45E-12	1.63E-11	
Pyrene	129-00-0	Locally-grown Produce	0.00E+00	0.00E+00	5.08E-12	5.74E-11	
		Pathway Total:	**7.41E-12**	**8.88E-11**	**6.86E-12**	**7.75E-11**	
Anthracene	120-12-7	Soil Ingestion	0.00E+00	0.00E+00	5.03E-14	4.69E-13	
Benzo(a)anthracene	56-55-3	Soil Ingestion	1.46E-14	1.46E-13	0.00E+00	0.00E+00	2.73E-14
Benzo(a)pyrene	50-32-8	Soil Ingestion	1.27E-13	1.26E-12	0.00E+00	0.00E+00	2.37E-13
Chrysene	218-01-9	Soil Ingestion	1.53E-16	1.52E-15	0.00E+00	0.00E+00	2.85E-16
Fluoranthene	206-44-0	Soil Ingestion	0.00E+00	0.00E+00	2.72E-13	2.54E-12	
Hydrogen fluoride	7664-39-3	Soil Ingestion	0.00E+00	0.00E+00	1.66E-05	1.55E-04	
Pyrene	129-00-0	Soil Ingestion	0.00E+00	0.00E+00	1.26E-12	1.17E-11	
		Pathway Total:	**1.42E-13**	**1.41E-12**	**1.66E-05**	**1.55E-04**	

Note:
Shading indicates carcinogen is a mutagen and the age-dependent adjsutment factors (ADAFs) have been applied to the cancer risk calculations.

Table E-10. Pathway and Constituent of Potential Concern Cancer Risks and Noncancer Hazards - IRAP Output.
Run 2 - Benzo(a)pyrene
Fisher at Puerto Arecibo

COPC Name	CAS Number	Pathway	Fisher PA Adult Cancer Risk	Fisher PA Child Cancer Risk	Fisher PA Adult Hazard Quotient	Fisher PA Child Hazard Quotient	IRAP Output
Anthracene	120-12-7	Fish Ingestion	0.00E+00	0.00E+00	2.73E-14	8.97E-14	
Benzo(a)anthracene	56-55-3	Fish Ingestion	2.69E-13	9.42E-13	0.00E+00	0.00E+00	1.77E-13
Benzo(a)pyrene	50-32-8	Fish Ingestion	4.29E-12	1.50E-11	0.00E+00	0.00E+00	2.82E-12
Chrysene	218-01-9	Fish Ingestion	1.11E-15	3.88E-15	0.00E+00	0.00E+00	7.28E-16
Fluoranthene	206-44-0	Fish Ingestion	0.00E+00	0.00E+00	7.72E-13	2.54E-12	
Pyrene	129-00-0	Fish Ingestion	0.00E+00	0.00E+00	6.24E-13	2.05E-12	
		Pathway Total:	**4.56E-12**	**1.60E-11**	**1.42E-12**	**4.68E-12**	

Note:
Shading indicates carcinogen is a mutagen and the age-dependent adjsutment factors (ADAFs) have been applied to the cancer risk calculations.

Table E-11. Pathway and Constituent of Potential Concern Cancer Risks and Noncancer Hazards - IRAP Output.
Run 2 - Benzo(a)pyrene
Fisher at Cienaga Tiburones

COPC Name	CAS Number	Pathway	Fisher Tib Adult Cancer Risk	Fisher Tib Child Cancer Risk	Fisher Tib Adult Hazard Quotient	Fisher Tib Child Hazard Quotient	IRAP Output
Anthracene	120-12-7	Fish Ingestion	0.00E+00	0.00E+00	2.71E-14	8.89E-14	
Benzo(a)anthracene	56-55-3	Fish Ingestion	4.11E-13	1.44E-12	0.00E+00	0.00E+00	2.70E-13
Benzo(a)pyrene	50-32-8	Fish Ingestion	2.58E-11	9.06E-11	0.00E+00	0.00E+00	1.70E-11
Chrysene	218-01-9	Fish Ingestion	1.15E-15	4.04E-15	0.00E+00	0.00E+00	7.57E-16
Fluoranthene	206-44-0	Fish Ingestion	0.00E+00	0.00E+00	2.18E-12	7.16E-12	
Pyrene	129-00-0	Fish Ingestion	0.00E+00	0.00E+00	2.55E-12	8.37E-12	
		Pathway Total:	**2.63E-11**	**9.20E-11**	**4.76E-12**	**1.56E-11**	

Note:
Shading indicates carcinogen is a mutagen and the age-dependent adjsutment factors (ADAFs) have been applied to the cancer risk calculations.

Table E-12. Pathway and Constituent of Potential Concern Cancer Risks and Noncancer Hazards - IRAP Output.
Run 2 - Benzo(a)pyrene
Fisher at Rio Grande de Arecibo Estuary

COPC Name	CAS Number	Pathway	Fisher RGA Adult Cancer Risk	Fisher RGA Child Cancer Risk	Fisher RGA Adult Hazard Quotient	Fisher RGA Child Hazard Quotient	IRAP Output
Anthracene	120-12-7	Fish Ingestion	0.00E+00	0.00E+00	1.02E-14	3.37E-14	
Benzo(a)anthracene	56-55-3	Fish Ingestion	6.20E-14	2.17E-13	0.00E+00	0.00E+00	4.07E-14
Benzo(a)pyrene	50-32-8	Fish Ingestion	1.16E-12	4.07E-12	0.00E+00	0.00E+00	7.63E-13
Chrysene	218-01-9	Fish Ingestion	4.60E-16	1.61E-15	0.00E+00	0.00E+00	3.02E-16
Fluoranthene	206-44-0	Fish Ingestion	0.00E+00	0.00E+00	2.44E-13	8.03E-13	
Pyrene	129-00-0	Fish Ingestion	0.00E+00	0.00E+00	1.98E-13	6.51E-13	
		Pathway Total:	**1.22E-12**	**4.29E-12**	**4.53E-13**	**1.49E-12**	

Note:
Shading indicates carcinogen is a mutagen and the age-dependent adjsutment factors (ADAFs) have been applied to the cancer risk calculations.

Table E-13. Pathway and Constituent of Potential Concern Cancer Risks and Noncancer Hazards - IRAP Output.
Run 3 - Dibenzo(a,h)anthracene
Farmer

COPC Name	CAS Number	Pathway	Farmer Adult Cancer Risk	Farmer Child Cancer Risk	Farmer Adult Hazard Quotient	Farmer Child Hazard Quotient	IRAP Output
Benzo(k)fluoranthene	207-08-9	Inhalation	1.32E-13	1.06E-13	0.00E+00	0.00E+00	1.98E-14
Dibenz(a,h)anthracene	53-70-3	Inhalation	2.07E-12	1.66E-12	0.00E+00	0.00E+00	3.11E-13
Mercuric chloride	7487-94-7	Inhalation	0.00E+00	0.00E+00	6.64E-04	6.64E-04	
		Pathway Total:	**2.20E-12**	**1.76E-12**	**6.64E-04**	**6.64E-04**	
Benzo(k)fluoranthene	207-08-9	Locally-grown Produce	2.10E-13	1.89E-12	0.00E+00	0.00E+00	3.55E-13
Dibenz(a,h)anthracene	53-70-3	Locally-grown Produce	1.19E-10	1.07E-09	0.00E+00	0.00E+00	2.00E-10
Mercuric chloride	7487-94-7	Locally-grown Produce	0.00E+00	0.00E+00	7.29E-05	7.96E-04	
Methyl mercury	22967-92-6	Locally-grown Produce	0.00E+00	0.00E+00	4.77E-05	5.31E-04	
		Pathway Total:	**1.19E-10**	**1.07E-09**	**1.21E-04**	**1.33E-03**	
Benzo(k)fluoranthene	207-08-9	Beef Ingestion	4.35E-13	1.01E-12	0.00E+00	0.00E+00	1.88E-13
Dibenz(a,h)anthracene	53-70-3	Beef Ingestion	7.42E-10	1.71E-09	0.00E+00	0.00E+00	3.20E-10
Mercuric chloride	7487-94-7	Beef Ingestion	0.00E+00	0.00E+00	1.23E-05	3.53E-05	
Methyl mercury	22967-92-6	Beef Ingestion	0.00E+00	0.00E+00	5.52E-07	1.59E-06	
		Pathway Total:	**7.42E-10**	**1.71E-09**	**1.28E-05**	**3.69E-05**	
Benzo(k)fluoranthene	207-08-9	Chicken Ingestion	1.90E-15	5.09E-15	0.00E+00	0.00E+00	9.55E-16
Dibenz(a,h)anthracene	53-70-3	Chicken Ingestion	1.40E-13	4.17E-13	0.00E+00	0.00E+00	7.82E-14
Mercuric chloride	7487-94-7	Chicken Ingestion	0.00E+00	0.00E+00	2.13E-06	6.76E-06	
Methyl mercury	22967-92-6	Chicken Ingestion	0.00E+00	0.00E+00	1.88E-08	5.95E-08	
		Pathway Total:	**1.42E-13**	**4.22E-13**	**2.15E-06**	**6.82E-06**	
Benzo(k)fluoranthene	207-08-9	Drinking Water Ingestion	1.08E-17	1.95E-17	0.00E+00	0.00E+00	3.66E-18
Dibenz(a,h)anthracene	53-70-3	Drinking Water Ingestion	1.29E-15	2.35E-15	0.00E+00	0.00E+00	4.41E-16
Mercuric chloride	7487-94-7	Drinking Water Ingestion	0.00E+00	0.00E+00	3.21E-09	7.17E-09	
Methyl mercury	22967-92-6	Drinking Water Ingestion	0.00E+00	0.00E+00	1.70E-09	3.80E-09	
		Pathway Total:	**1.30E-15**	**2.37E-15**	**4.91E-09**	**1.10E-08**	
Benzo(k)fluoranthene	207-08-9	Eggs Ingestion	4.00E-16	1.13E-15	0.00E+00	0.00E+00	2.13E-16
Dibenz(a,h)anthracene	53-70-3	Eggs Ingestion	2.94E-14	9.29E-14	0.00E+00	0.00E+00	1.74E-14
Mercuric chloride	7487-94-7	Eggs Ingestion	0.00E+00	0.00E+00	7.86E-07	2.63E-06	
Methyl mercury	22967-92-6	Eggs Ingestion	0.00E+00	0.00E+00	6.93E-09	2.32E-08	
		Pathway Total:	**2.98E-14**	**9.41E-14**	**7.93E-07**	**2.66E-06**	
Benzo(k)fluoranthene	207-08-9	Milk Ingestion	7.92E-13	4.92E-12	0.00E+00	0.00E+00	9.22E-13
Dibenz(a,h)anthracene	53-70-3	Milk Ingestion	1.43E-09	8.85E-09	0.00E+00	0.00E+00	1.66E-09
Mercuric chloride	7487-94-7	Milk Ingestion	0.00E+00	0.00E+00	3.16E-05	2.44E-04	
Methyl mercury	22967-92-6	Milk Ingestion	0.00E+00	0.00E+00	2.04E-06	1.58E-05	
		Pathway Total:	**1.43E-09**	**8.86E-09**	**3.36E-05**	**2.60E-04**	

Table E-13. Pathway and Constituent of Potential Concern Cancer Risks and Noncancer Hazards - IRAP Output.
Run 3 - Dibenzo(a,h)anthracene
Farmer

COPC Name	CAS Number	Pathway	Farmer Adult Cancer Risk	Farmer Child Cancer Risk	Farmer Adult Hazard Quotient	Farmer Child Hazard Quotient	IRAP Output
Benzo(k)fluoranthene	207-08-9	Pork Ingestion	8.63E-14	2.52E-13	0.00E+00	0.00E+00	4.72E-14
Dibenz(a,h)anthracene	53-70-3	Pork Ingestion	1.21E-10	3.47E-10	0.00E+00	0.00E+00	6.50E-11
Mercuric chloride	7487-94-7	Pork Ingestion	0.00E+00	0.00E+00	3.61E-08	1.29E-07	
Methyl mercury	22967-92-6	Pork Ingestion	0.00E+00	0.00E+00	5.76E-10	2.05E-09	
		Pathway Total:	**1.21E-10**	**3.47E-10**	**3.67E-08**	**1.31E-07**	
Benzo(k)fluoranthene	207-08-9	Soil Ingestion	1.24E-14	9.80E-14	0.00E+00	0.00E+00	1.84E-14
Dibenz(a,h)anthracene	53-70-3	Soil Ingestion	1.08E-12	9.49E-12	0.00E+00	0.00E+00	1.78E-12
Mercuric chloride	7487-94-7	Soil Ingestion	0.00E+00	0.00E+00	1.57E-05	1.46E-04	
Methyl mercury	22967-92-6	Soil Ingestion	0.00E+00	0.00E+00	9.16E-07	8.55E-06	
		Pathway Total:	**1.09E-12**	**9.59E-12**	**1.66E-05**	**1.55E-04**	

Note:
Shading indicates carcinogen is a mutagen and the age-dependent adjsutment factors (ADAFs) have been applied to the cancer risk calculations.

Table E-14. Pathway and Constituent of Potential Concern Cancer Risks and Noncancer Hazards - IRAP Output.
Run 3 - Dibenzo(a,h)anthracene
Urban Resident

COPC Name	CAS Number	Pathway	Urban Res Adu Cancer Risk	Urban Res Chil Cancer Risk	Urban Res Adult Hazard Quotient	Urban Res Child Hazard Quotient	IRAP Output
Benzo(k)fluoranthene	207-08-9	Inhalation	3.86E-14	4.12E-14	0.00E+00	0.00E+00	7.72E-15
Dibenz(a,h)anthracene	53-70-3	Inhalation	6.04E-13	6.44E-13	0.00E+00	0.00E+00	1.21E-13
Mercuric chloride	7487-94-7	Inhalation	0.00E+00	0.00E+00	2.59E-04	2.59E-04	
		Pathway Total:	**6.43E-13**	**6.85E-13**	**2.59E-04**	**2.59E-04**	
Benzo(k)fluoranthene	207-08-9	Soil Ingestion	3.11E-15	3.09E-14	0.00E+00	0.00E+00	5.80E-15
Dibenz(a,h)anthracene	53-70-3	Soil Ingestion	3.00E-13	2.99E-12	0.00E+00	0.00E+00	5.60E-13
Mercuric chloride	7487-94-7	Soil Ingestion	0.00E+00	0.00E+00	5.27E-06	4.92E-05	
Methyl mercury	22967-92-6	Soil Ingestion	0.00E+00	0.00E+00	3.08E-07	2.87E-06	
		Pathway Total:	**3.03E-13**	**3.02E-12**	**5.58E-06**	**5.21E-05**	

Note:
Shading indicates carcinogen is a mutagen and the age-dependent adjsutment factors (ADAFs) have been applied to the cancer risk calculations.

Table E-15. Pathway and Constituent of Potential Concern Cancer Risks and Noncancer Hazards - IRAP Output.
Run 3 - Dibenzo(a,h)anthracene
Suburban Resident

COPC Name	CAS Number	Pathway	Sub Res Adult Cancer Risk	Sub Res Child Cancer Risk	Sub Res Adult Hazard Quotient	Sub Res Child Hazard Quotient	IRAP Output
Benzo(k)fluoranthene	207-08-9	Inhalation	4.02E-14	4.29E-14	0.00E+00	0.00E+00	8.05E-15
Dibenz(a,h)anthracene	53-70-3	Inhalation	6.29E-13	6.71E-13	0.00E+00	0.00E+00	1.26E-13
Mercuric chloride	7487-94-7	Inhalation	0.00E+00	0.00E+00	2.70E-04	2.70E-04	
		Pathway Total:	**6.69E-13**	**7.14E-13**	**2.70E-04**	**2.70E-04**	
Benzo(k)fluoranthene	207-08-9	Locally-grown Produce	7.21E-14	8.65E-13	0.00E+00	0.00E+00	1.62E-13
Dibenz(a,h)anthracene	53-70-3	Locally-grown Produce	4.29E-11	5.14E-10	0.00E+00	0.00E+00	9.64E-11
Mercuric chloride	7487-94-7	Locally-grown Produce	0.00E+00	0.00E+00	3.33E-05	3.66E-04	
Methyl mercury	22967-92-6	Locally-grown Produce	0.00E+00	0.00E+00	2.25E-05	2.51E-04	
		Pathway Total:	**4.29E-11**	**5.15E-10**	**5.58E-05**	**6.17E-04**	
Benzo(k)fluoranthene	207-08-9	Soil Ingestion	3.71E-15	3.70E-14	0.00E+00	0.00E+00	6.93E-15
Dibenz(a,h)anthracene	53-70-3	Soil Ingestion	3.59E-13	3.58E-12	0.00E+00	0.00E+00	6.70E-13
Mercuric chloride	7487-94-7	Soil Ingestion	0.00E+00	0.00E+00	6.08E-06	5.67E-05	
Methyl mercury	22967-92-6	Soil Ingestion	0.00E+00	0.00E+00	3.55E-07	3.31E-06	
		Pathway Total:	**3.63E-13**	**3.61E-12**	**6.43E-06**	**6.00E-05**	

Note:
Shading indicates carcinogen is a mutagen and the age-dependent adjsutment factors (ADAFs) have been applied to the cancer risk calculations.

Table E-16. Pathway and Constituent of Potential Concern Cancer Risks and Noncancer Hazards - IRAP Output.
Run 3 - Dibenzo(a,h)anthracene
Fisher at Puerto Arecibo

COPC Name	CAS Number	Pathway	Fisher PA Adult Cancer Risk	Fisher PA Child Cancer Risk	Fisher PA Adult Hazard Quotient	Fisher PA Child Hazard Quotient	IRAP Output
Benzo(k)fluoranthene	207-08-9	Fish Ingestion	3.61E-14	1.26E-13	0.00E+00	0.00E+00	2.37E-14
Dibenz(a,h)anthracene	53-70-3	Fish Ingestion	1.23E-11	4.31E-11	0.00E+00	0.00E+00	8.08E-12
Methyl mercury	22967-92-6	Fish Ingestion	0.00E+00	0.00E+00	1.48E-04	4.87E-04	
		Pathway Total:	**1.23E-11**	**4.32E-11**	**1.48E-04**	**4.87E-04**	

Note:
Shading indicates carcinogen is a mutagen and the age-dependent adjsutment factors (ADAFs) have been applied to the cancer risk calculations.

Table E-17. Pathway and Constituent of Potential Concern Cancer Risks and Noncancer Hazards - IRAP Output.
Run 3 - Dibenzo(a,h)anthracene
Fisher at Cienaga Tiburones

COPC Name	CAS Number	Pathway	Fisher Tib Adult Cancer Risk	Fisher Tib Child Cancer Risk	Fisher Tib Adult Hazard Quotient	Fisher Tib Child Hazard Quotient	IRAP Output
Benzo(k)fluoranthene	207-08-9	Fish Ingestion	2.67E-12	9.36E-12	0.00E+00	0.00E+00	1.75E-12
Dibenz(a,h)anthracene	53-70-3	Fish Ingestion	3.77E-09	1.32E-08	0.00E+00	0.00E+00	2.48E-09
Methyl mercury	22967-92-6	Fish Ingestion	0.00E+00	0.00E+00	6.15E-02	2.02E-01	
		Pathway Total:	**3.77E-09**	**1.32E-08**	**6.15E-02**	**2.02E-01**	

Note:
Shading indicates carcinogen is a mutagen and the age-dependent adjsutment factors (ADAFs) have been applied to the cancer risk calculations.

Table E-18. Pathway and Constituent of Potential Concern Cancer Risks and Noncancer Hazards - IRAP Output.
Run 3 - Dibenzo(a,h)anthracene
Fisher at Rio Grande de Arecibo Estuary

COPC Name	CAS Number	Pathway	Fisher RGA Adult Cancer Risk	Fisher RGA Child Cancer Risk	Fisher RGA Adult Hazard Quotient	Fisher RGA Child Hazard Quotient	IRAP Output
Benzo(k)fluoranthene	207-08-9	Fish Ingestion	1.39E-14	4.87E-14	0.00E+00	0.00E+00	9.13E-15
Dibenz(a,h)anthracene	53-70-3	Fish Ingestion	4.87E-12	1.71E-11	0.00E+00	0.00E+00	3.20E-12
Methyl mercury	22967-92-6	Fish Ingestion	0.00E+00	0.00E+00	6.27E-05	2.06E-04	
		Pathway Total:	**4.89E-12**	**1.71E-11**	**6.27E-05**	**2.06E-04**	

Note:
Shading indicates carcinogen is a mutagen and the age-dependent adjsutment factors (ADAFs) have been applied to the cancer risk calculations.

Table E-19. Pathway and Constituent of Potential Concern Cancer Risks and Noncancer Hazards - IRAP Output.
Run 4 - Naphthalene
Farmer

COPC Name	CAS Number	Pathway	Farmer Adult Cancer Risk	Farmer Child Cancer Risk	Farmer Adult Hazard Quotient	Farmer Child Hazard Quotient	IRAP Output
Acenaphthene	83-32-9	Inhalation	0.00E+00	0.00E+00	2.42E-11	2.42E-11	
Benzo(b)fluoranthene	205-99-2	Inhalation	1.21E-13	9.70E-14	0.00E+00	0.00E+00	1.82E-14
Hydrogen chloride	7647-01-0	Inhalation	0.00E+00	0.00E+00	8.71E-03	8.71E-03	
Naphthalene	91-20-3	Inhalation	6.36E-13	9.54E-14	1.09E-08	1.09E-08	
		Pathway Total:	**7.57E-13**	**1.92E-13**	**8.71E-03**	**8.71E-03**	
Acenaphthene	83-32-9	Locally-grown Produce	0.00E+00	0.00E+00	2.03E-13	2.26E-12	
Benzo(b)fluoranthene	205-99-2	Locally-grown Produce	8.45E-14	7.60E-13	0.00E+00	0.00E+00	1.43E-13
Methylnaphthalene, 2-	91-57-6	Locally-grown Produce	0.00E+00	0.00E+00	3.41E-11	3.66E-10	
Naphthalene	91-20-3	Locally-grown Produce	0.00E+00	0.00E+00	9.49E-13	1.05E-11	
		Pathway Total:	**8.45E-14**	**7.60E-13**	**3.53E-11**	**3.79E-10**	
Acenaphthene	83-32-9	Beef Ingestion	0.00E+00	0.00E+00	1.95E-14	5.61E-14	
Benzo(b)fluoranthene	205-99-2	Beef Ingestion	1.38E-13	3.20E-13	0.00E+00	0.00E+00	6.01E-14
Hydrogen chloride	7647-01-0	Beef Ingestion	0.00E+00	0.00E+00	6.46E-11	1.85E-10	
Methylnaphthalene, 2-	91-57-6	Beef Ingestion	0.00E+00	0.00E+00	3.19E-12	9.17E-12	
Naphthalene	91-20-3	Beef Ingestion	0.00E+00	0.00E+00	5.69E-14	1.63E-13	
		Pathway Total:	**1.38E-13**	**3.20E-13**	**6.78E-11**	**1.95E-10**	
Acenaphthene	83-32-9	Chicken Ingestion	0.00E+00	0.00E+00	3.04E-16	9.65E-16	
Benzo(b)fluoranthene	205-99-2	Chicken Ingestion	2.62E-16	8.16E-16	0.00E+00	0.00E+00	1.53E-16
Hydrogen chloride	7647-01-0	Chicken Ingestion	0.00E+00	0.00E+00	2.60E-12	8.23E-12	
Methylnaphthalene, 2-	91-57-6	Chicken Ingestion	0.00E+00	0.00E+00	4.92E-14	1.56E-13	
Naphthalene	91-20-3	Chicken Ingestion	0.00E+00	0.00E+00	1.35E-15	4.27E-15	
		Pathway Total:	**2.62E-16**	**8.16E-16**	**2.65E-12**	**8.39E-12**	
Acenaphthene	83-32-9	Drinking Water Ingestion	0.00E+00	0.00E+00	1.47E-15	3.29E-15	
Benzo(b)fluoranthene	205-99-2	Drinking Water Ingestion	1.55E-17	2.78E-17	0.00E+00	0.00E+00	5.22E-18
Methylnaphthalene, 2-	91-57-6	Drinking Water Ingestion	0.00E+00	0.00E+00	9.09E-15	2.03E-14	
Naphthalene	91-20-3	Drinking Water Ingestion	0.00E+00	0.00E+00	1.32E-14	2.94E-14	
		Pathway Total:	**1.55E-17**	**2.78E-17**	**2.37E-14**	**5.30E-14**	

Table E-19. Pathway and Constituent of Potential Concern Cancer Risks and Noncancer Hazards - IRAP Output.
Run 4 - Naphthalene
Farmer

COPC Name	CAS Number	Pathway	Farmer Adult Cancer Risk	Farmer Child Cancer Risk	Farmer Adult Hazard Quotient	Farmer Child Hazard Quotient	IRAP Output
Acenaphthene	83-32-9	Eggs Ingestion	0.00E+00	0.00E+00	6.42E-17	2.15E-16	
Benzo(b)fluoranthene	205-99-2	Eggs Ingestion	5.53E-17	1.82E-16	0.00E+00	0.00E+00	3.41E-17
Hydrogen chloride	7647-01-0	Eggs Ingestion	0.00E+00	0.00E+00	5.47E-13	1.83E-12	
Methylnaphthalene, 2-	91-57-6	Eggs Ingestion	0.00E+00	0.00E+00	1.04E-14	3.48E-14	
Naphthalene	91-20-3	Eggs Ingestion	0.00E+00	0.00E+00	2.84E-16	9.50E-16	
		Pathway Total:	**5.53E-17**	**1.82E-16**	**5.58E-13**	**1.87E-12**	
Acenaphthene	83-32-9	Milk Ingestion	0.00E+00	0.00E+00	3.33E-14	2.58E-13	
Benzo(b)fluoranthene	205-99-2	Milk Ingestion	2.59E-13	1.61E-12	0.00E+00	0.00E+00	3.02E-13
Hydrogen chloride	7647-01-0	Milk Ingestion	0.00E+00	0.00E+00	6.01E-11	4.64E-10	
Methylnaphthalene, 2-	91-57-6	Milk Ingestion	0.00E+00	0.00E+00	5.80E-12	4.49E-11	
Naphthalene	91-20-3	Milk Ingestion	0.00E+00	0.00E+00	1.15E-13	8.91E-13	
		Pathway Total:	**2.59E-13**	**1.61E-12**	**6.60E-11**	**5.10E-10**	
Acenaphthene	83-32-9	Pork Ingestion	0.00E+00	0.00E+00	7.74E-15	2.76E-14	
Benzo(b)fluoranthene	205-99-2	Pork Ingestion	2.12E-14	6.36E-14	0.00E+00	0.00E+00	1.19E-14
Hydrogen chloride	7647-01-0	Pork Ingestion	0.00E+00	0.00E+00	4.78E-11	1.71E-10	
Methylnaphthalene, 2-	91-57-6	Pork Ingestion	0.00E+00	0.00E+00	1.23E-12	4.38E-12	
Naphthalene	91-20-3	Pork Ingestion	0.00E+00	0.00E+00	3.09E-14	1.10E-13	
		Pathway Total:	**2.12E-14**	**6.36E-14**	**4.91E-11**	**1.75E-10**	
Acenaphthene	83-32-9	Soil Ingestion	0.00E+00	0.00E+00	2.51E-15	2.35E-14	
Benzo(b)fluoranthene	205-99-2	Soil Ingestion	1.73E-15	1.58E-14	0.00E+00	0.00E+00	2.97E-15
Hydrogen chloride	7647-01-0	Soil Ingestion	0.00E+00	0.00E+00	1.19E-08	1.12E-07	
Methylnaphthalene, 2-	91-57-6	Soil Ingestion	0.00E+00	0.00E+00	6.43E-14	6.00E-13	
Naphthalene	91-20-3	Soil Ingestion	0.00E+00	0.00E+00	1.19E-14	1.11E-13	
		Pathway Total:	**1.73E-15**	**1.58E-14**	**1.19E-08**	**1.12E-07**	

Note:
Shading indicates carcinogen is a mutagen and the age-dependent adjsutment factors (ADAFs) have been applied to the cancer risk calculations.

Table E-20. Pathway and Constituent of Potential Concern Cancer Risks and Noncancer Hazards - IRAP Output.
Run 4 - Naphthalene
Urban Resident

COPC Name	CAS Number	Pathway	Urban Res Adult Cancer Risk	Urban Res Child Cancer Risk	Urban Res Adult Hazard Quotient	Urban Res Child Hazard Quotient	IRAP Output
Acenaphthene	83-32-9	Inhalation	0.00E+00	0.00E+00	6.09E-08	6.09E-08	
Benzo(b)fluoranthene	205-99-2	Inhalation	2.29E-10	2.45E-10	0.00E+00	0.00E+00	4.58E-11
Hydrogen chloride	7647-01-0	Inhalation	0.00E+00	0.00E+00	8.31E-03	8.31E-03	
Naphthalene	91-20-3	Inhalation	1.20E-09	2.40E-10	2.74E-05	2.74E-05	
		Pathway Total:	**1.43E-09**	**4.84E-10**	**8.34E-03**	**8.34E-03**	
Acenaphthene	83-32-9	Soil Ingestion	0.00E+00	0.00E+00	6.66E-12	6.22E-11	
Benzo(b)fluoranthene	205-99-2	Soil Ingestion	3.29E-12	3.27E-11	0.00E+00	0.00E+00	6.13E-12
Hydrogen chloride	7647-01-0	Soil Ingestion	0.00E+00	0.00E+00	1.20E-08	1.12E-07	
Methylnaphthalene, 2-	91-57-6	Soil Ingestion	0.00E+00	0.00E+00	1.70E-10	1.59E-09	
Naphthalene	91-20-3	Soil Ingestion	0.00E+00	0.00E+00	3.14E-11	2.94E-10	
		Pathway Total:	**3.29E-12**	**3.27E-11**	**1.22E-08**	**1.14E-07**	

Note:
Shading indicates carcinogen is a mutagen and the age-dependent adjsutment factors (ADAFs) have been applied to the cancer risk calculations.

Table E-21. Pathway and Constituent of Potential Concern Cancer Risks and Noncancer Hazards - IRAP Output.
Run 4 - Naphthalene
Suburban Resident

COPC Name	CAS Number	Pathway	Suburban Res Adult Cancer Risk	Suburban Res Child Cancer Risk	Suburban Res Adult Hazard Quotient	Suburban Res Child Hazard Quotient	IRAP Output
Acenaphthene	83-32-9	Inhalation	0.00E+00	0.00E+00	9.88E-12	9.88E-12	
Benzo(b)fluoranthene	205-99-2	Inhalation	3.71E-14	3.96E-14	0.00E+00	0.00E+00	7.42E-15
Hydrogen chloride	7647-01-0	Inhalation	0.00E+00	0.00E+00	3.55E-03	3.55E-03	
Naphthalene	91-20-3	Inhalation	1.95E-13	3.89E-14	4.45E-09	4.45E-09	
		Pathway Total:	**2.32E-13**	**7.85E-14**	**3.55E-03**	**3.55E-03**	
Acenaphthene	83-32-9	Locally-grown Produce	0.00E+00	0.00E+00	9.76E-14	1.09E-12	
Benzo(b)fluoranthene	205-99-2	Locally-grown Produce	2.90E-14	3.47E-13	0.00E+00	0.00E+00	6.51E-14
Methylnaphthalene, 2-	91-57-6	Locally-grown Produce	0.00E+00	0.00E+00	1.50E-11	1.61E-10	
Naphthalene	91-20-3	Locally-grown Produce	0.00E+00	0.00E+00	4.29E-13	4.75E-12	
		Pathway Total:	**2.90E-14**	**3.47E-13**	**1.55E-11**	**1.67E-10**	
Acenaphthene	83-32-9	Soil Ingestion	0.00E+00	0.00E+00	1.04E-15	9.66E-15	
Benzo(b)fluoranthene	205-99-2	Soil Ingestion	6.02E-16	5.99E-15	0.00E+00	0.00E+00	1.12E-15
Hydrogen chloride	7647-01-0	Soil Ingestion	0.00E+00	0.00E+00	4.92E-09	4.59E-08	
Methylnaphthalene, 2-	91-57-6	Soil Ingestion	0.00E+00	0.00E+00	2.65E-14	2.47E-13	
Naphthalene	91-20-3	Soil Ingestion	0.00E+00	0.00E+00	4.89E-15	4.56E-14	
		Pathway Total:	**6.02E-16**	**5.99E-15**	**4.92E-09**	**4.59E-08**	

Note:
Shading indicates carcinogen is a mutagen and the age-dependent adjsutment factors (ADAFs) have been applied to the cancer risk calculations.

Table E-22. Pathway and Constituent of Potential Concern Cancer Risks and Noncancer Hazards - IRAP Output.
Run 4 - Naphthalene
Fisher at Puerto Arecibo

COPC Name	CAS Number	Pathway	Fisher PA Adult Cancer Risk	Fisher PA Child Cancer Risk	Fisher PA Adult Hazard Quotient	Fisher PA Child Hazard Quotient	IRAP Output
Acenaphthene	83-32-9	Fish Ingestion	0.00E+00	0.00E+00	1.95E-11	6.40E-11	
Benzo(b)fluoranthene	205-99-2	Fish Ingestion	1.12E-10	3.91E-10	0.00E+00	0.00E+00	7.33E-11
Hydrogen chloride	7647-01-0	Fish Ingestion	0.00E+00	0.00E+00	2.36E-09	7.76E-09	
Methylnaphthalene, 2-	91-57-6	Fish Ingestion	0.00E+00	0.00E+00	6.81E-11	2.24E-10	
Naphthalene	91-20-3	Fish Ingestion	0.00E+00	0.00E+00	6.91E-11	2.27E-10	
		Pathway Total:	**1.12E-10**	**3.91E-10**	**2.52E-09**	**8.27E-09**	

Note:
Shading indicates carcinogen is a mutagen and the age-dependent adjsutment factors (ADAFs) have been applied to the cancer risk calculations.

Table E-23. Pathway and Constituent of Potential Concern Cancer Risks and Noncancer Hazards - IRAP Output.
Run 4 - Naphthalene
Fisher at Cienaga Tiburones

COPC Name	CAS Number	Pathway	Fisher Tib Adult Cancer Risk	Fisher Tib Child Cancer Risk	Fisher Tib Adult Hazard Quotient	Fisher Tib Child Hazard Quotient	IRAP Output
Acenaphthene	83-32-9	Fish Ingestion	0.00E+00	0.00E+00	2.54E-11	8.35E-11	
Benzo(b)fluoranthene	205-99-2	Fish Ingestion	3.79E-10	1.33E-09	0.00E+00	0.00E+00	2.49E-10
Hydrogen chloride	7647-01-0	Fish Ingestion	0.00E+00	0.00E+00	1.78E-03	5.85E-03	
Methylnaphthalene, 2-	91-57-6	Fish Ingestion	0.00E+00	0.00E+00	5.40E-11	1.78E-10	
Naphthalene	91-20-3	Fish Ingestion	0.00E+00	0.00E+00	5.64E-11	1.85E-10	
		Pathway Total:	**3.79E-10**	**1.33E-09**	**1.78E-03**	**5.85E-03**	

Note:
Shading indicates carcinogen is a mutagen and the age-dependent adjsutment factors (ADAFs) have been applied to the cancer risk calculations.

Table E-24. Pathway and Constituent of Potential Concern Cancer Risks and Noncancer Hazards - IRAP Output.
Run 4 - Naphthalene
Fisher at Rio Grande de Arecibo Estuary

COPC Name	CAS Number	Pathway	Fisher RGA Adult Cancer Risk	Fisher RGA Child Cancer Risk	Fisher RGA Adult Hazard Quotient	Fisher RGA Child Hazard Quotient	IRAP Output
Acenaphthene	83-32-9	Fish Ingestion	0.00E+00	0.00E+00	1.20E-11	3.93E-11	
Benzo(b)fluoranthene	205-99-2	Fish Ingestion	8.30E-11	2.91E-10	0.00E+00	0.00E+00	5.46E-11
Hydrogen chloride	7647-01-0	Fish Ingestion	0.00E+00	0.00E+00	2.06E-08	6.78E-08	
Methylnaphthalene, 2-	91-57-6	Fish Ingestion	0.00E+00	0.00E+00	4.95E-11	1.63E-10	
Naphthalene	91-20-3	Fish Ingestion	0.00E+00	0.00E+00	4.92E-11	1.62E-10	
		Pathway Total:	**8.30E-11**	**2.91E-10**	**2.07E-08**	**6.82E-08**	

Note:
Shading indicates carcinogen is a mutagen and the age-dependent adjsutment factors (ADAFs) have been applied to the cancer risk calculations.

Table E-25. Pathway and Constituent of Potential Concern Cancer Risks and Noncancer Hazards - IRAP Output.
Run 5 - Aroclor 1254
Farmer

COPC Name	CAS Number	Pathway	Farmer Adult Cancer Risk	Farmer Child Cancer Risk	Farmer Adult Hazard Quotient	Farmer Child Hazard Quotient
Aroclor 1254	11097-69-1	Inhalation	1.77E-11	2.65E-12	7.75E-07	7.75E-07
		Pathway Total:	**1.77E-11**	**2.65E-12**	**7.75E-07**	**7.75E-07**
Aroclor 1254	11097-69-1	Locally-grown Produce	1.97E-12	3.27E-12	8.98E-08	1.00E-06
		Pathway Total:	**1.97E-12**	**3.27E-12**	**8.98E-08**	**1.00E-06**
Aroclor 1254	11097-69-1	Beef Ingestion	5.58E-12	2.36E-12	2.67E-07	7.68E-07
		Pathway Total:	**5.58E-12**	**2.36E-12**	**2.67E-07**	**7.68E-07**
Aroclor 1254	11097-69-1	Chicken Ingestion	3.94E-14	1.67E-14	2.66E-09	8.44E-09
		Pathway Total:	**3.94E-14**	**1.67E-14**	**2.66E-09**	**8.44E-09**
Aroclor 1254	11097-69-1	Drinking Water Ingestion	5.13E-16	1.71E-16	2.30E-11	5.13E-11
		Pathway Total:	**5.13E-16**	**1.71E-16**	**2.30E-11**	**5.13E-11**
Aroclor 1254	11097-69-1	Eggs Ingestion	8.31E-15	3.73E-15	5.62E-10	1.88E-09
		Pathway Total:	**8.31E-15**	**3.73E-15**	**5.62E-10**	**1.88E-09**
Aroclor 1254	11097-69-1	Milk Ingestion	9.80E-12	1.12E-11	4.51E-07	3.49E-06
		Pathway Total:	**9.80E-12**	**1.12E-11**	**4.51E-07**	**3.49E-06**
Aroclor 1254	11097-69-1	Pork Ingestion	1.40E-12	7.06E-13	7.85E-08	2.80E-07
		Pathway Total:	**1.40E-12**	**7.06E-13**	**7.85E-08**	**2.80E-07**
Aroclor 1254	11097-69-1	Soil Ingestion	3.05E-13	3.81E-13	2.06E-08	1.92E-07
		Pathway Total:	**3.05E-13**	**3.81E-13**	**2.06E-08**	**1.92E-07**

Table E-26. Pathway and Constituent of Potential Concern Cancer Risks and Noncancer Hazards - IRAP Output.
Run 5 - Aroclor 1254
Urban Resident

COPC Name	CAS Number	Pathway	Urban Res Adu Cancer Risk	Urban Res Chil Cancer Risk	Urban Res Adult Hazard Quotient	Urban Res Child Hazard Quotient
Aroclor 1254	11097-69-1	Inhalation	5.17E-12	1.03E-12	3.03E-07	3.03E-07
		Pathway Total:	**5.17E-12**	**1.03E-12**	**3.03E-07**	**3.03E-07**
Aroclor 1254	11097-69-1	Soil Ingestion	6.99E-14	1.30E-13	7.06E-09	6.58E-08
		Pathway Total:	**6.99E-14**	**1.30E-13**	**7.06E-09**	**6.58E-08**

Table E-27. Pathway and Constituent of Potential Concern Cancer Risks and Noncancer Hazards - IRAP Output.
Run 5 - Aroclor 1254
Suburban Resident

COPC Name	CAS Number	Pathway	Sub Res Adult Cancer Risk	Sub Res Child Cancer Risk	Sub Res Adult Hazard Quotient	Sub Res Child Hazard Quotient
Aroclor 1254	11097-69-1	Inhalation	5.40E-12	1.08E-12	3.16E-07	3.16E-07
		Pathway Total:	**5.40E-12**	**1.08E-12**	**3.16E-07**	**3.16E-07**
Aroclor 1254	11097-69-1	Locally-grown Produce	6.71E-13	1.50E-12	4.10E-08	4.57E-07
		Pathway Total:	**6.71E-13**	**1.50E-12**	**4.10E-08**	**4.57E-07**
Aroclor 1254	11097-69-1	Soil Ingestion	7.83E-14	1.46E-13	7.91E-09	7.38E-08
		Pathway Total:	**7.83E-14**	**1.46E-13**	**7.91E-09**	**7.38E-08**

Table E-28. Pathway and Constituent of Potential Concern Cancer Risks and Noncancer Hazards - IRAP Output.
Run 5 - Aroclor 1254
Fisher at Puerto Arecibo

COPC Name	CAS Number	Pathway	Fisher PA Adult Cancer Risk	Fisher PA Child Cancer Risk	Fisher PA Adult Hazard Quotient	Fisher PA Child Hazard Quotient
Aroclor 1254	11097-69-1	Fish Ingestion	3.08E-12	2.02E-12	1.80E-07	5.90E-07
		Pathway Total:	**3.08E-12**	**2.02E-12**	**1.80E-07**	**5.90E-07**

Table E-29. Pathway and Constituent of Potential Concern Cancer Risks and Noncancer Hazards - IRAP Output.
Run 5 - Aroclor 1254
Fisher at Cienaga Tiburones

COPC Name	CAS Number	Pathway	Fisher Tib Adult Cancer Risk	Fisher Tib Child Cancer Risk	Fisher Tib Adult Hazard Quotient	Fisher Tib Child Hazard Quotient
Aroclor 1254	11097-69-1	Fish Ingestion	3.18E-13	2.09E-13	1.86E-08	6.12E-08
		Pathway Total:	**3.18E-13**	**2.09E-13**	**1.86E-08**	**6.12E-08**

Table E-30. Pathway and Constituent of Potential Concern Cancer Risks and Noncancer Hazards - IRAP Output.
Run 5 - Aroclor 1254
Fisher at Rio Grande de Arecibo Estuary

COPC Name	CAS Number	Pathway	Fisher RGA Adult Cancer Risk	Fisher RGA Child Cancer Risk	Fisher RGA Adult Hazard Quotient	Fisher RGA Child Hazard Quotient
Aroclor 1254	11097-69-1	Fish Ingestion	2.19E-13	1.44E-13	1.29E-08	4.22E-08
		Pathway Total:	**2.19E-13**	**1.44E-13**	**1.29E-08**	**4.22E-08**