



TETRA TECH

Environmental Hazard Evaluation

**Hickam Communities Remedial Action Site
Joint Base Pearl Harbor-Hickam
O'ahu, Hawai'i**

June 7, 2012

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Environmental Hazard Evaluation

**Hickam Communities Remedial Action Site
Joint Base Pearl Harbor-Hickam
O'ahu, Hawai'i**

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ACRONYMS AND ABBREVIATIONS

$\mu\text{g}/\text{m}^3$	microgram per cubic meter
AFB	Air Force Base
$\text{atm}\cdot\text{m}^3/\text{mole}$	atmospheres-cubic meter per mole
ATSDR	Agency for Toxic Substances Disease Registry
BASH	Bird-Aircraft Strike Hazard
BHC	benzene hexachloride
$^{\circ}\text{C}$	Degrees Celsius
Cal/EPA	California Environmental Protection Agency
CIH	Certified Industrial Hygienist
cm^2	square centimeter
cm^3/g	cubic centimeter per gram
COC	Contaminants of concern
COPC	Chemical of potential concern
CPSC	Consumer Products Safety Commission
CSF	Cancer slope factor
CSM	conceptual site model
DDD	Dichlorodiphenyldichloroethane
DDE	Dichlorodiphenyldichloroethylene
DDT	Dichlorodiphenyltrichloroethane
DoD	Department of Defense
DU	decision unit
EAL	Environmental Action Level
ECR	excess cancer risk
EHE	Environmental Hazard Evaluation
EHMP	Environmental Hazard Management Plan
EPA	US Environmental Protection Agency
EPC	exposure point concentration
ESA	Environmental site assessment
$^{\circ}\text{F}$	Degrees Fahrenheit
g/mole	grams per mole
HAFB	Hickam Air Force Base
HASP	Health and Safety Plan
HC	Hickam Communities LLC
HDOH	Hawai'i Department of Health
HEAST	Health Effects Assessment Tables
HEER	Hazard Evaluation and Emergency Response
HHRE	human health risk evaluation
HI	Hazard index
HQ	Hazard quotient

ACRONYMS AND ABBREVIATIONS (continued)

IARC	International Agency for Research on Cancer
IRIS	Integrated Risk Information System
IRP	Installation Restoration Program
JBPHH	Joint Base Pearl Harbor-Hickam
Kd	Soil-water partition coefficient
kg	kilogram
KJC	Kennedy, Jenks, Chilton
Koc	Soil organic carbon-water partitioning coefficient (
Lend Lease	Lend Lease Americas LLC
LOAEL	lowest observed adverse effect level
m ³ /hr	cubic meter per hour
m ³ /kg	cubic meter per kilogram
MAC	maximum acceptable concentration
MDL	method detection limit
ME	Ministry for the Environment
mg/cm	milligrams per square centimeter
mg/day	milligrams per day
mg/kg	milligrams per kilogram
mg/L	milligrams per liter
MI	Multi-incremental
MRL	minimal risk level
MS/MSD	matrix spike/matrix spike duplicate
NFA	no further action
NOAEL	no observed adverse effect level
OEHHA	Office of Environmental Health Hazard Assessment
PCB	Polychlorinated biphenyl
PEF	Particulate emission factor
PI	pesticide-impacted
PPE	personal protective equipment
PPRTV	Provisional Peer Reviewed Toxicity Value
PQL	practical quantitation limit
RAA	Remedial Alternatives Analysis
RAM	Response Action Memorandum
RAR	Removal Action Report
RCI	Residential Communities Initiative
REC	recognized environmental condition
REL	Reference exposure level
RfD	Reference dose
RO	Removal Action
RPD	relative percentage difference

ACRONYMS AND ABBREVIATIONS (continued)

RSD	relative standard deviation
SAP	Sampling and Analysis Plan
SMP	Soil Management Plan
sq ft	square feet
TGM	Technical Guidance Manual
USACE	United States Army Corps of Engineers
USAF	US Air Force
USFWS	United States Fish and Wildlife Service
<i>Voluntary Agreement</i>	Voluntary Agreement for Environmental Response Actions
WHO	World Health Organization

1.0 INTRODUCTION

Tetra Tech has prepared this Environmental Hazard Evaluation (EHE) on behalf of Hickam Communities LLC (HC) to evaluate potential environmental hazards associated with chemicals sampled in shallow soil within the HC Remedial Action site at Joint Base Pearl Harbor-Hickam (JBPHH), O'ahu, Hawai'i. The Remedial Action site consists of four neighborhoods that include the Earhart Village I-2, the Earhart Village I-3 neighborhood, the Onizuka Village II-1 neighborhood, and the Hale Na Koa I-1 neighborhood. Figure 1-1 shows the locations of the Remedial Action site (hereinafter the "Site"). In addition to the neighborhoods, the EHE also considers soil located within long-term management units (e.g., burial pits and soil berms), within utility trenches, and under buildings and hardscapes.

This EHE report is being submitted as part of the requirements of *Voluntary Agreement for Environmental Response Actions (Voluntary Agreement)* between the Hawai'i Department of Health (HDOH) and HC.¹ The *Voluntary Agreement* provides a means of allowing Tetra Tech (on behalf of HC) to conduct environmental investigation and remediation activities under the oversight of the HDOH Hazard Evaluation and Emergency Response (HEER) Office pursuant to Hawai'i Revised Statutes Chapter 128D Part I². Once the activities listed in the *Voluntary Agreement* have been completed in accordance with HDOH requirements, HC will request a no further action (NFA) letter, which will state that no further environmental investigation or remediation is required for the Site.

The *Voluntary Agreement* consists of numerous tasks and deliverables, some of which have already been completed to date. This report documents the work conducted to complete the EHE component of the *Voluntary Agreement*. Primary tasks completed to date are summarized briefly below.

Task 1: Develop Sampling and Analysis Plans (SAPs)

Two Sampling and Analysis Plans (SAPs) were prepared to present the scope of work for a comprehensive soil investigation to characterize the current soil conditions at the Site. The purpose of this investigation was to provide sufficient data to evaluate potential environmental hazards to human and ecological receptors posed by contaminants present in soils at the Site.

Task 2: Implement SAPs

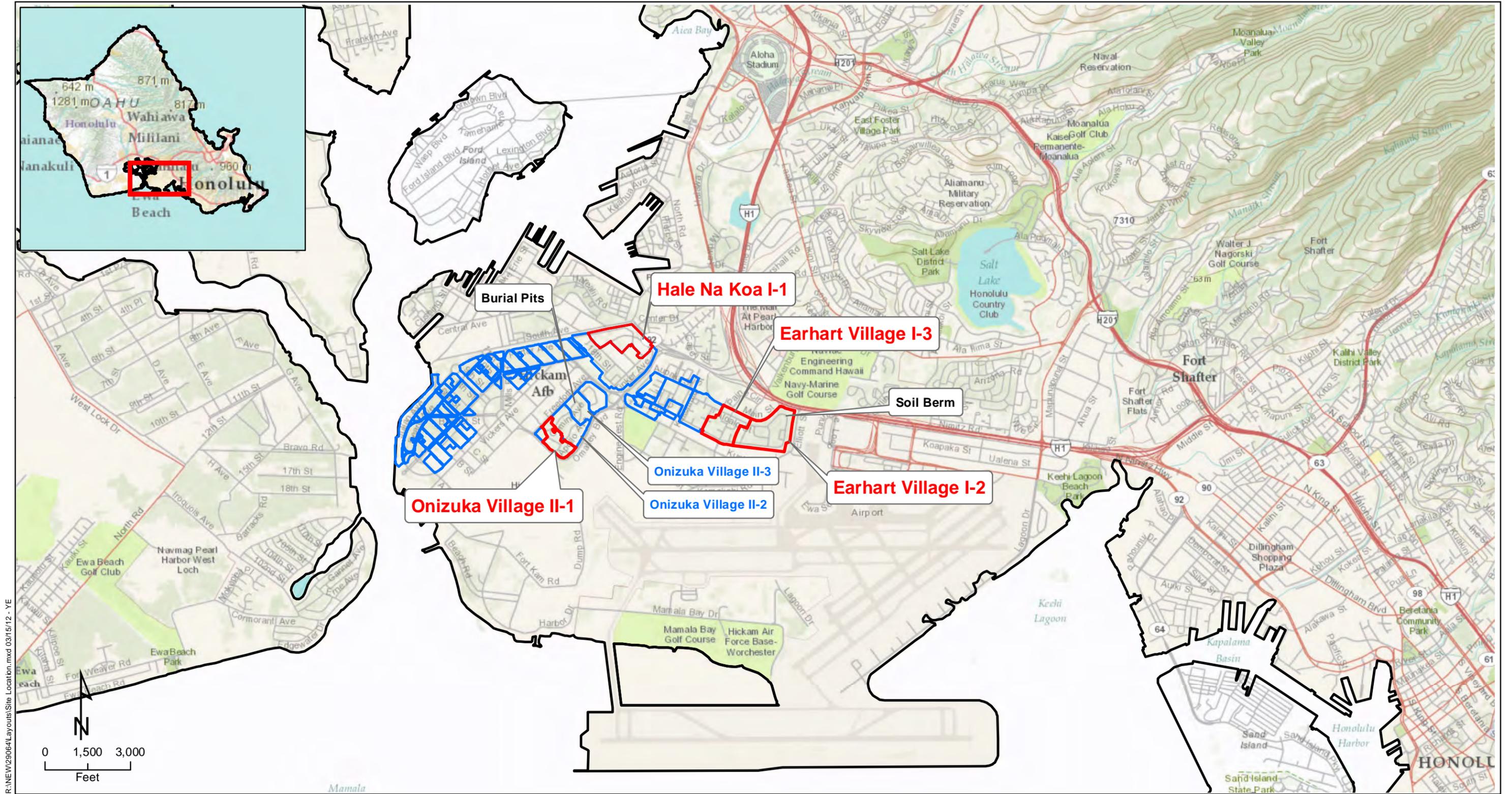
Tetra Tech followed the SAPs during the comprehensive soil investigation that was conducted at the Site from August 12 to October 12, 2010. During site activities, Tetra Tech was in regular contact with HDOH to discuss site conditions and operations. Throughout the investigation, Tetra Tech did not deviate from the SAP methodology unless required to do so based on Site conditions. If required, deviations were only made using an alternate method that had been agreed upon with HDOH. The analytical results associated with this investigation were shared with HDOH soon after they were received from the laboratory and are summarized in the Remedial Investigation report.

¹ (HC 2011)

² *Hawai'i Revised Statutes (HRS) Hawai'i Environmental Response Law, Chapter 128D, Part I: Environmental Response Law*. As Amended 1990.

Task 3: Removal Actions (ROs)

Three Removal Actions (ROs) have been conducted at the Site. The first two ROs conducted at the Site were implemented to address potential short-term health risks. The third RO conducted at the Site was implemented to address long-term health risks. Brief summaries of the three ROs are listed below.



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**Site Location
Hickam Communities Neighborhoods-March 2012**

- Site Boundary
- Hickam Communities Project Boundary

Joint Base Pearl Harbor-Hickam, O'ahu, Hawai'i

1. **Removal Action No. 1 (RO# 1) – Oct-Dec 2010.** RO# 1 addressed pesticide-impacted soils ("PI soil") at the ground surface which posed the most urgent short-term public health risks. RO #1 was implemented using criteria in the 9/2010 *HC Immediate Action Plan*, which was presented in *RO# 1 Work Plan*.³ HDOH approved the *RO #1 Work Plan* in a 9/24/2010 email.⁴
2. **Removal Action No. 2 (RO# 2) – Jan-Apr 2011.** RO# 2 addressed PI surface soils not addressed under RO #1 which posed lesser but still significant short-term public health risks. Following submittal of the Work Plan (Tetra Tech 2010n), RO #2 was implemented using criteria in the 11/10/2010 *Revised Analysis of Potential Removal Alternatives* memorandum ("*APRA Memo*").⁵ HDOH approved the *APRA Memo* on 11/23/2010⁶.
3. **Removal Action No. 3 (RO# 3) – Jun-August 2011.** RO# 3 addressed PI surface soils not addressed under RO# 1 or RO# 2 which could pose long-term public health risks. RO #3 was implemented using criteria in the 5/13/2010 *Draft Preliminary Human Health Risk Evaluation Work Plan for Hickam Communities* ("*HHRE Work Plan*").⁷ HDOH approved the *HHRE Work Plan* on 6/7/2011.⁸

Task 4: Resident Involvement Plan(s)

The goal of the Resident Involvement Plan is to effectively disseminate important information to residents in a timely manner to help ensure their safety and understanding of pesticide-impacted (PI) soil in HC neighborhoods in JBPHH. As per the Resident Involvement Plan,⁹ resident involvement reporting is conducted on an ongoing basis to serve as a progress update memo on how site activities are being implemented. At a minimum, communication with affected residents takes place on a monthly basis to provide residents with a general update on soil removal activities and emphasize safety surrounding PI soil in their area.

Task 5: Environmental Hazard Evaluation

The EHE is the link between the discovery of contaminated soil or groundwater during site investigation and response actions taken (if warranted) to address contamination. The purpose of the EHE is to identify and evaluate potential hazards to human health and sensitive ecological receptors posed by contaminants of concern identified at a site under current and potential future site conditions and provide the basis for evaluating if remedial actions or the implementation of engineering/institutional controls is warranted. The potential hazards evaluated as part of the EHE are as follows:

- Direct exposure threats to human health (this includes reasonably expected future exposure scenarios such as potential for residential and industrial worker exposure to previously buried PI soil due to excavation or erosion);
- Intrusion of subsurface vapors in buildings;
- Leaching;

³ (Tetra Tech 2010L)

⁴ (HDOH 2010a)

⁵ Tetra Tech 2010m)

⁶ (HDOH 2010b)

⁷ (Tetra Tech 2011b)

⁸ (HDOH 2011b)

⁹ (Tetra Tech 2011c)

- Impacts to terrestrial habitats;
- Gross contamination and general resource degradation; and
- Impact to drinking water supplies.

This EHE has been prepared in accordance with HDOH guidelines summarized in the HDOH guidance document titled, *Screening for Environmental Hazards as Sites with Contaminated Soil and Groundwater*¹⁰.

Remaining tasks to be completed as part of the *Voluntary Agreement* include a final Removal Action Report (RAR), a Remedial Alternatives Analysis (RAA), an Environmental Hazard Management Plan (EHMP), a Response Action Memorandum (RAM), and a NFA letter.

¹⁰ (HDOH 2008a)

2.0 BACKGROUND

This Chapter describes the environmental setting of the Site, as well as past and current land uses.

2.1 Site History

Hickam Field was established in 1934.¹¹ Prior to 1930, the area that now contains Hickam Air Force Base (HAFB) was used for agriculture and fish ponds.¹²

The Earhart Villages I-2 and I-3 housing areas were constructed in the 1960s and 1970s on land that was previously part of the airfield and originally contained 89 residential buildings. Onizuka Village II-1 was constructed in 1975 on land that was also previously part of the airfield and originally consisted of 18 multi-family dwellings.¹³

Starting in 2005, Lend Lease Americas LLC (Lend Lease; legacy Actus Lend Lease, LLC), was contracted by the US Air Force (USAF) to develop, design and construct 1,182 new homes, and to renovate 1,260 existing homes at JBPHH as part of the Department of Defense (DoD) Residential Communities Initiative (RCI). Construction Phase I of this contract, which included the Earhart I-2 and Earhart I-3 neighborhoods, was awarded in 2005, and Construction Phase II, which included the Onizuka II-1 neighborhood, was awarded in 2007. Earhart I-2, which was developed in the second stage of construction in the Construction Phase I project, is on the eastern end of the former Earhart Village Housing Area. In Earhart I-2, 46 existing housing structures were demolished beginning in 2008, and were replaced with 69 new multi-family structures. In the Earhart I-3 neighborhood, 40 existing housing structures were demolished and replaced with 61 new multi-family structures. In the Onizuka II-1 neighborhood, eighteen original structures were demolished beginning in 2009, and 27 new multi-family structures were constructed, along with two administrative buildings for the housing management offices. The locations of the three neighborhoods are shown in Figure 1-1.

Prior to the 1980s, organochlorine pesticides were used to control subterranean termites under and around the foundations of buildings at JBPHH. The pesticides used for this purpose included aldrin, chlordane, and dieldrin. Because of their persistence in the environment, these chemicals were gradually taken out of production, and licensing for most uses was discontinued in the mid-1980s, as alternative treatments were developed. However, due to their persistence, pesticide impacted soil was still present under the building foundation slabs when the buildings at the Site were demolished in 2008/2009.

In August 2009, pesticide concentrations significantly above the action levels that had been established for the Program Area¹⁴ were discovered in surface soil within open areas at the nearly-completed Earhart I-4 neighborhood.¹⁵ The concentrations of pesticides in surface soil indicated improper implementation of the PI Soil Management Program.

¹¹ (HAFB 2006)

¹² (KJC 1991)

¹³ (USAF 2005)

¹⁴ Tetra Tech 2009a

¹⁵ (Tetra Tech 2009b, 2009d)

HC's response at Earhart I-4 itself has been addressed separately and is not covered in the Remedial Investigation Report;¹⁶ however, the improper management of PI soil during construction at Earhart I-4 raised concerns that previously-completed neighborhoods such as Hale Na Koa I-1, Earhart I-2, Earhart I-3, and Onizuka II-1, could have similar conditions. Unlike at Earhart I-4, residents had already moved into the new housing in these neighborhoods. At the time of the discovery of the problem at Earhart I-4, Hale Na Koa I-1 had been occupied for more than two years, Earhart I-2 for about 13 months, Earhart I-3 for about two months, and Onizuka II-1 had just begun to be occupied.

In a preliminary investigation in June 2010, HC found evidence of pesticide concentrations at concentrations significantly above the screening levels established for the Program Area in surface soils in the Earhart I-2, Earhart I-3, and concentrations slightly above the screening levels in parts of the Onizuka II-1 neighborhood.¹⁷ Confirmation soil sampling was also conducted by HC in the Hale Na Koa I-1 neighborhood in June 2010.¹⁸ The results of that investigation indicated concentrations generally below the screening levels. The results of these investigations are summarized more fully in Section 2.0, below.

HDOH considered the observed pesticide levels in the Earhart I-2 and Earhart I-3 neighborhoods to be a significant potential human health risk, and directed HC to conduct a thorough and detailed Remedial Investigation to collect information for reliable cleanup action decision-making at all three of the newly-occupied neighborhoods: Earhart I-2, Earhart I-3, and Onizuka II-1 (together, the *Remedial Investigation Study Area*). HC conducted the field portion of the Remedial Investigation in August-October 2010.¹⁹

2.2 Site Description

Joint Base Pearl Harbor-Hickam is situated on approximately 2,700 acres of the Pearl Harbor coastal plain on the southern coast of O'ahu. The topographic relief of the area is generally flat with elevations ranging from 0 to 20 feet above mean sea level.²⁰ Most of the soils on the Base are mapped as fill land. The fill consists of dredge material from Pearl Harbor and other sources. Placement of the fill changed the topography of the Base from an uneven series of low lying coastal ridges and swales to a level plateau. Excess surface drainage flows to local drainage swales which flow to major storm drainage channels.

The Earhart Village I-2 and I-3 housing areas are located on the northern portion of JBPHH. The overall Earhart I-2 and I-3 area is bounded by the inter-island terminal of the Honolulu International Airport to the east, the Nimitz Highway to the north, Kuntz Avenue to the south, and residential housing the west. The Earhart I-2 area comprises approximately 47 acres and the Earhart I-3 area comprises approximately 32 acres. The Onizuka Village II-1 housing area is located approximately one mile to the west of the Earhart neighborhoods and covers approximately 16.5 acres.

¹⁶ (Tetra Tech 2010a, 2010c, 2010f, 2010i)

¹⁷ (Tetra Tech 2010d, 2010e, 2010b)

¹⁸ (Tetra Tech 2010j, 2010k)

¹⁹ (Tetra Tech 2010g, 2010h)

²⁰ (USAF 2002a)

Current Land Use

All three neighborhoods are currently developed for residential multi-family use and are managed under a 50-year lease by Hickam Communities LLC, which has responsibility for maintaining the buildings and grounds. As described above, there are currently 69 newly constructed multi-family housing structures in the Earhart I-2 area, 61 multi-family structures in the Earhart I-3 area, and 27 multi-family structures in the Onizuka II-1 area. In addition to residential lots, the residential areas include children's playgrounds, hiking and biking paths, and large common areas (i.e., open spaces), most of which are covered by Bermuda grass. Due to the fact that the neighborhoods associated with the Site were constructed on land that was previously part of the Hickam airfield, which may be associated with residual concentrations of chemicals used as part of routine airfield operations, the residential lease agreements between HC and current residents stipulate that residents are prohibited from digging, excavating or gardening in an effort to minimize any potential exposures.^{21,22} Landscaping and landscaping maintenance is provided by the property manager (i.e., HC).

2.3 Climate

The climate in the Honolulu area is mild to very warm, with dry to moderate humidity and northeasterly trade winds approximately 90 percent of the summer months, and 50 percent of the winter months. There is very little diurnal or seasonal variation in temperature on O'ahu because of its tropical latitude, marine influence, and the prevailing northeasterly trade winds. The average daytime temperatures range between 22 to 27 degrees Celsius (°C) [72 and 81 degrees Fahrenheit (°F)], and humidity varies between 58 and 90 percent.²³

The average annual precipitation at HAFB is approximately 56 cm (22 in). December is typically the wettest month of the year, and the June is the driest.²⁴

2.4 Soils/Geology

Joint Base Pearl Harbor-Hickam lies on the coastal plain on the leeward side of the Ko'olau Range, immediately east of Pearl Harbor. The Pearl Harbor coastal plain is underlain by a succession of terrestrial alluvial and marine sedimentary layers. As the island subsided over thousands of years, alluvial sediments interspersed with volcanic flows and volcanic ash were deposited on the margin of the island, building a reef platform. During periods of lower sea levels, the reef was exposed. This so-called caprock (because it caps the underlying volcanic rock, which contains the basal aquifer), contains strata of alluvium, lagoonal mud, beach sands, volcanic tuff, and corals. At depth, these strata overlay volcanic bedrock of the Honolulu volcanic series.

²¹ (HC 2010)

²² Beginning in 2007, with the lease of new housing units in the Hale Na Koa neighborhood, HC has included notification to residents of the potential presence of pesticides in soils. Section 5.13 of the *Resident Guide*, which is Appendix A of the standard tenant lease agreement, specifies that tenants may not dig into the ground for any reason without first obtaining approval to do so from HC. Following HC approval of any digging requests, tenants must then obtain a WCR form (647th CES, JBPPH: Form 103) from the CES office at JBPHH.

²³ (USACE 1997)

²⁴ (HAFB 2006)

Most of JBPHH soils are mapped as fill, comprising material dredged from the ocean or hauled in from elsewhere. In addition to the fill, there are five naturally occurring soil types present (Māmala stony silt clay loam, Makalapa clay, Kea’au stony clay, Jaucus sand, and coral outcrop) that are associated with the coastal plain and coral reef substratum over which JBPHH lies. The fill and naturally occurring soil types are considered poor for vegetation growth, and high-maintenance landscaping areas usually contain topsoil fill from off-base sources. The erosion potential for the JBPHH soils is generally slight to moderate, with the exception of Jaucus sand, which is highly erodible.²⁵

2.5 Surface Water

There are no natural lakes, rivers, or streams on the Onizuka or Earhart Village housing areas; however, Manuwai Canal, which provides storm drainage for the eastern third of JBPHH, flows adjacent to the southern boundary of the Earhart Village housing area. The Manuwai Canal empties into Māmala Bay to the south.

The housing areas being evaluated are not within the area on JBPHH designated as a potential flood inundation zone. The housing areas utilize a storm drainage system that collects surface water and sends it to a series of canals that eventually empty into Māmala Bay.

No natural wetlands are present on the Onizuka or Earhart Village housing area properties. The Manuwai Canal, which flows adjacent to the southern boundary of the Earhart Village area, has been classified by the National Wetland Inventory as an estuarine, open water, subtidal inundation, and excavated wetland.²⁶

2.6 Groundwater

There are two groundwater aquifers below HAFB. Most of the installation is underlain by a brackish aquifer that is not suitable for commercial, residential, or recreational use. General groundwater flow in the area is towards the Pacific Ocean to the south. A small portion of the base is underlain by a protected freshwater aquifer that has stringent requirements for water quality protection. Potable water is supplied to HAFB from Navy storage tanks outside the base.²⁷

²⁵ (USAF 2002a)

²⁶ (USAF 2002a)

²⁷ (USAF 1998)

3.0 SUMMARY OF INVESTIGATION HISTORY

3.1 Hickam Air Force Base (HAFB) Investigations

Sources of contaminants from past operations at HAFB have been identified under the DoD Installation Restoration Program (IRP). A number of contaminant source sites have been identified in the vicinity of the Site, and have undergone investigation and remediation. Data from the IRP site investigations provide an important source of information about the environmental conditions in the Site.

A review by of the Preliminary Assessment/Site Inspection submitted by HAFB to the US Environmental Protection Agency (EPA) in 1991 summarized the investigations performed up to that date. As described in the review, 24 source areas were initially identified in a Phase I Records Search.²⁸ Eleven of these sites involved fuel leaks from underground fuel distribution lines and were investigated in a Phase II, Stage 1 Confirmation/Quantification study.²⁹

Additional investigation led to identification of other sites. By 1996, 37 of 41 identified source sites had been evaluated, and an additional 72 areas of concern were identified.³⁰ Among the IRP sites nearest to the Site was a large fuel spill site designated as SS-01, with a floating product plume that extended beneath a residential area east of Onizuka Village. Product removal activities were initiated in 1986 and continued until 2007. A Record of Decision for the SS-01 was prepared in 2007, which identified Monitored Natural Attenuation and institution of Land Use Controls as the long-term remedy for the residual fuel in soils and groundwater at the site.³¹

A Management Action Plan prepared in May 2007 summarized the status of the IRP sites.³² No IRP sites were identified within the Site. In addition to the SS-01 site west of Onizuka Village, several IRP sites were listed that lie adjacent to and south of Earhart Village. These include site MY158 (a former motor pool site with petroleum hydrocarbons, solvents and metals), and SS-25 (the Hickam Village Shoppette site, with petroleum hydrocarbons). Both of these sites have been investigated and Records of Decision have been signed indicating that NFA is required at these sites.

3.2 Previous Investigations of the Site

From 2004 through 2006, pre-construction sampling was conducted at the Site as part of Phase I and Phase II Environmental Site Assessment (ESA) investigations. In late 2006 and 2007, additional pre-construction sampling was conducted to evaluate pesticide levels in areas of the Site where new construction was planned and under homes that had been vacated prior to demolition. In 2010, post-construction sampling was conducted to evaluate pesticide levels in soil beyond the footprints of former buildings that had been demolished prior to the construction of new residential buildings.

²⁸ (USAF 1991)

²⁹ (Dames and Moore, 1986)

³⁰ (Tetra Tech 2007a)

³¹ (Parsons 2007)

³² (HAFB 2007)

3.2.1 Pre-Construction Sampling (2004 – 2007)

In 2004, Tetra Tech was contracted by Lend Lease to prepare a Phase I ESA for the Construction Phase I project sites, including the Earhart Village Housing Area.³³ The Phase I ESA identified several recognized environmental conditions (RECs), including suspected former underground storage tanks, former underground fuel pipelines, IRP sites in the vicinity of the housing areas, polychlorinated biphenyl (PCB) sites, and past applications of pesticides to soils beneath housing foundations. Tetra Tech recommended that sampling be performed to evaluate pesticide concentrations after the building foundations were removed.

Later in 2004, Tetra Tech performed a Phase II ESA of the Site to investigate the RECs identified in the Phase I ESA.³⁴ The Phase II ESA included sampling at three locations next to building foundations, and 16 locations abutting transformers, where discrete shallow soil samples were collected prior to demolition of the existing buildings for analysis of metals, PCBs, and pesticides. These sampling locations, where no evidence of pesticide application is known, typically have significantly lower pesticide levels compared to those from under foundations where pesticides were specifically applied. Dieldrin was detected in three samples at concentrations slightly above the HDOH Tier 1 Environmental Action Level of 0.03 milligrams per kilogram (mg/kg). Tetra Tech recommended performing additional sampling beneath and immediately adjacent to building foundations to further characterize the pesticides, and recommended developing a management plan to protect workers and future residents. The Management Plan for Pesticide-Impacted Soil (MPPIS) was prepared in 2006, as a guide to the D/B contractor during demolition and earth-moving activities that might disturb the soil beneath building foundations.³⁵

In April 2006, Tetra Tech performed additional shallow soil sampling to characterize pesticide occurrence in the Earhart Housing Area.³⁶ Discrete soil samples were collected from selected points and multi-incremental (MI)³⁷ soil samples were collected from common areas in the Earhart I-2 and I-3. One of the objectives of this MI sampling was to evaluate whether concentrations in the surface soil in the common areas between residential housing units posed a potential health risk to residents. It was generally expected that pesticides were applied specifically to subfoundation soils, rather than over broad areas, and it was generally assumed that concentrations of pesticides would be elevated in the subfoundation soils because the organochlorine pesticides are persistent and immobile, so would remain within the localized area where treatments had occurred. The MI soil sampling results of the common areas in Earhart I-2 and I-3, were very similar. Aldrin, dieldrin, and chlordane were not detected in the MI samples from Earhart I-3. Dieldrin was detected at the HDOH Tier I EAL (0.03 mg/kg) in the MI sample from Earhart I-2. These results provided an indication of the baseline conditions within the common areas of the Earhart Village Housing Area prior to demolition of the old buildings and construction of new buildings.

In June 2006, after discussion with HDOH, Tetra Tech prepared a memorandum documenting the basis for and the assumptions used in defining site-specific EALs (referred to as “2006 HHRA Standard”) for the HC Housing Area³⁸, which were approved by HDOH. A copy of the

³³ (Tetra Tech 2004a

³⁴ (Tetra Tech 2004b)

³⁵ (Tetra Tech 2006e)

³⁶ (Tetra Tech 2006b)

³⁷ Multi-incremental samples are composite samples consisting of 30 to 50 sample increments collected at randomly distributed points throughout an area of interest called a decision unit (DU). MI sampling is recommended by HDOH for characterizing DUs.

³⁸ (Tetra Tech 2006c)

memorandum is included in Appendix B. The primary pesticides of concern at the site, based on sampling results up to that time, were chlordane, dieldrin, and aldrin. The use of the Site-specific EALs was contingent on the concurrent, continuing application of specific land-use controls which included stringent residential activity prohibitions (e.g., prohibitions on excavation) as well as limitations on residential exposure periods based on the assumption of military housing as the ongoing land-use.

In September 2006, in order to characterize the distribution of pesticides in the target areas of the Site where new construction was to be located, the Earhart I-2 and I-3 neighborhoods were divided into DUs containing an average of two residential buildings measuring approximately 1 acre (43,560 square feet [sq ft]). Decision units were designed to distinguish a 10-foot zone of soil around each building that was most likely to be pesticide-impacted. Prior. Multi-incremental samples consisting of a minimum of 40 sample increments, were collected from each of the sub-areas within the upper 6 inches of soil. The results of this investigation were generally consistent with the previous sampling of the common areas. Concentrations of all of the pesticides were low, and dieldrin and aldrin concentrations were nearly all below the method detection limit (MDL) or the practical quantitation limit (PQL). Chlordane concentrations were generally below the HDOH Tier 1 EAL of 1.6 mg/kg.³⁹

In February 2007, as some of the buildings were vacated in anticipation of demolition, Tetra Tech sampled beneath the slabs of eight vacated buildings in the Earhart I-2 area and one building in the Earhart I-3 area.⁴⁰ The purpose of this sampling was to evaluate the presence of pesticides at elevated concentrations relative to the Tier 2 Screening Levels. The samples consisted of composite samples from five points under each building. At each of the sample locations 6-inch core samples representing the depth intervals from 0 to 6 inches, 6 to 12 inches, and 12 to 18 inches were collected and combined to produce a 5-point composite sample representing that depth interval. The results of this sampling showed a high degree of heterogeneity, with concentrations ranging from below the 2006 HHRA Standard to many times higher than the 2006 HHRA Standard. The primary constituents encountered were aldrin and dieldrin.

In April 2007, in order to further investigate the depth of pesticide occurrence beneath the foundation slabs of the vacated buildings, Tetra Tech collected additional core samples from depths of 18 to 24 inches and 24 to 30 inches in three of the buildings previously sampled in February 2007.⁴¹ The results were consistent with the results from the shallower samples, suggesting that pesticides were present beneath the foundation slabs to depths greater than 30 inches. Based on these results, it was concluded that soil beneath the foundation slabs would be assumed to contain pesticides and would be managed as such.

3.2.2 Post-Construction Sampling (2006 and 2010)

Hale Na Koa I-1

In 2006, a comprehensive Phase II soil investigation was conducted within the Hale Na Koa I-1 neighborhood from February to April. At the time of the sampling, the former buildings and foundations were demolished and the new buildings constructed. The area was not yet at final

³⁹ (Tetra Tech 2006d)

⁴⁰ (Tetra Tech 2007a)

⁴¹ (Tetra Tech 2007b)

grade and was awaiting import of soil for landscaping. MI soil sampling was conducted within a 10-foot zone surrounding each building footprint which was considered to be the area most likely to be impacted by organochlorine pesticides. Analytical results indicated that organochlorine pesticides were present at concentrations exceeding the 2006 HHRA Standard and were designated as PI soil.⁴² In February 2007, areas identified as having PI soil during the 2006 Phase II investigation were excavated to 1-foot below final grade and were backfilled with stockpiled soil from the area that had been tested and identified as not being PI soil.

Preliminary Investigation (June 2010) – Earhart I-2, Earhart I-3, and Onizuka II-1

During pre-construction preparation activities, PI soil was to be excavated from building footprints to a depth of 1-foot below the final grade. The excavated soil was to be staged on the site pending final disposition of the soil. During construction, the soil was to be placed beneath new hardscapes, including roads, parking lots, sidewalks, and buildings. In addition, PI soil was used to backfill utility trenches. As per the soil management plan⁴³, in all areas not covered by hardscapes, including the footprints of former buildings and utility trenches, 1 foot of clean soil was to be placed over the PI soil as a barrier to prevent exposure.

Upon completion of construction activities, it was suspected that PI soil was inadvertently spread to exposed areas of the site. However, the areas affected by this cross-contamination could not be accurately delineated without sampling. For this reason, a preliminary investigation of the Earhart I-2, Earhart I-3, and Onizuka II-1 areas was undertaken in June 2010, to determine if PI soil had been spread beyond the former building footprints. The results of the preliminary investigation revealed that pesticide concentrations exceeded the 2006 HHRA Standard in common areas of the Earhart I-2 and Earhart I-3 areas. The results for soil in common areas of the Onizuka II-1 neighborhood indicated that pesticide concentrations were generally below the 2006 HHRA Standard, except in two subareas of the site where the concentrations were slightly above the 2006 HHRA Standard. Based on the results of the preliminary investigations, HDOH requested that HC conduct a more detailed investigation to evaluate potential environmental hazards. Based on the HDOH request, a Site-wide, post-construction soil investigation was conducted from August 12 through October 12, 2010 within the three Hickam neighborhoods. This investigation is described below in Section 3.3.

3.3 Analytical Data to Support the Environmental Hazard Evaluation

As described above, numerous soil investigations have been conducted at the Site. In order to evaluate current post-construction conditions, only analytical results associated with the Site-wide, post-construction soil investigation conducted from June 3rd through October 12, 2010 have been included in the EHE because this data is the representative of current soil conditions. Additionally, the soil sampling conducted as part of this investigation was designed to fully characterize exposure areas (referred to as “decision units”) that were delineated in accordance with HDOH guidelines⁴⁴ and with HDOH oversight following the preliminary investigation conducted in June 2010. Field sampling activities associated with this investigation were conducted in accordance with three HDOH-approved SAPs that were prepared following the guidelines presented in the HDOH HEER *Technical Guidance Manual (TGM)*⁴⁵, previous

⁴² (Tetra Tech 2006c)

⁴³ (Tetra Tech 2009)

⁴⁴ (HDOH 2008a)

⁴⁵ (HDOH 2009a)

sampling protocols provided in SAPs from other HC sites, and the Program Manual⁴⁶. The three SAPs prepared for this sampling effort are entitled: 1) *Sampling and Analysis Plan, Earhart I-2 and Earhart I-3 Neighborhoods, Hickam Air Force Base, O'ahu, Hawai'i* (Tetra Tech 2010L); 2) *Sampling and Analysis Plan, Onizuka II-1 Neighborhood, Hickam Air Force Base, O'ahu, Hawai'i* (Tetra Tech 2010m); and 3) *Sampling and Analysis Plan, Soil Investigation, Hale Na Koa I-1, Earhart I-2, Earhart I-3, and Onizuka II-1 Neighborhoods, Hickam Air Force Base, O'ahu, Hawai'i* (Tetra Tech 2010j).

Earhart I-2, Earhart I-3, and Onizuka II-1 Neighborhoods

For the Site-wide post-construction soil investigation, Tetra Tech collected a total of 1,156 samples; 712 samples from the Earhart I-2 neighborhood, 398 samples from the Earhart I-3 neighborhood, and 46 samples from the Onizuka II-1 neighborhood from August 12 through October 12, 2010. For this investigation, multi-increment (MI) soil samples were collected using the method recommended by the HEER TGM.⁴⁷ For each area evaluated, one MI sample was collected from the 0 to 6-inch depth interval and one MI sample was collected from the 6 to 12-inch depth interval. The MI soil sampling results associated with this investigation were used to evaluate potential environmental hazards at the Site and are summarized in Appendices C and E.

Hale Na Koa I-1 Neighborhood

For the Hale Na Koa I-1 neighborhood, Tetra Tech collected a total of 20 samples from 11 DUs. For this investigation, MI soil samples were collected using the method recommended by the HEER TGM⁴⁸. In five DUs associated with areas where PI soil was previously identified and removed, two MI soil samples were collected, one from the 0 to 6 inch depth interval and one from the 6 to 12 inch depth interval. In the six remaining DUs that are associated with areas where PI soil was not identified during previous investigations, one MI soil sample was collected from the 0 to 6-inch depth interval. The MI soil sampling results associated with this investigation were used to evaluate potential environmental hazards at the Site and are summarized in Appendices C and E.

⁴⁶ (Tetra Tech 2009a)

⁴⁷ (HDOH 2009a)

⁴⁸ (HDOH 2009a)

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4.0 CONTAMINANTS OF CONCERN

4.1 Contaminants of Potential Concern

Chemicals of potential concern (COPCs) are chemicals that have been detected in the environment that may adversely impact human or ecological receptors. Based on historical activities described in Section 2 and Site investigations conducted from 2004 through 2010 described in Section 3, organochlorine pesticides in soil were identified as COPCs at the Site.

4.2 Contaminants of Concern

Contaminants of concern (COCs) were identified based on the most recent soil sampling data collected from August 12 through October 12, 2010 to characterize the decision units identified in accordance with HDOH guidelines within the Earhart I-2, Earhart I-3, Onizuka II-1, and Hale Na Koa I-1 neighborhoods (refer to Section 5 for discussion of decision units [DUs]). All soil samples were analyzed by EPA Method 8081 for organochlorine pesticides. For this evaluation, all pesticides detected in at least one soil sample were identified as COCs and evaluated further in the EHE. Chemicals detected at the Site are summarized in Table 4-1 and include aldrin, chlordane, dieldrin, dichlorodiphenyldichloroethane (DDD), dichlorodiphenyldichloroethylene (DDE), and dichlorodiphenyltrichloroethane (DDT), endrin, endrin ketone, endosulfan sulfate, delta-BHC, and methoxychlor. The primary chemicals of concern are aldrin, chlordane, dieldrin, DDD, DDE, and DDT. The other organochlorine pesticides listed in Tale 4-1 have been detected sporadically at concentrations close to their detection limits. As indicated in Table 4-1, endosulfan sulfate, delta-BHC, and methoxychlor were each detected once at low levels.

Table 4-1. Contaminants of Potential Concern

Chemical ^(a)
Aldrin
Chlordane ^(b)
Dieldrin
DDD
DDE
DDT
Endrin
Endrin Ketone
Endosulfan Sulfate ^(c)
Delta-BHC ^c
Methoxychlor ^c

Notes:

^(a) All organochlorine pesticides detected in soil as part of past site investigation activities conducted at the Site in 2010 are included in this table.

^(b) Chlordane is representative of technical chlordane which consists of chlordane isomers, heptachlor, and heptachlor epoxide. For this reason, other chlordane isomers, heptachlor, and heptachlor epoxide are evaluated as chlordane and are not listed individually in this table.

^(c) Listed chemical detected at low levels in one sample.

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5.0 POTENTIAL ENVIRONMENTAL HAZARDS

As indicated in HDOH guidance,⁴⁹ a basic understanding of environmental hazards associated with contaminated soil and groundwater is a critical component in the overall environmental response process. Common environmental hazards that should be evaluated at release sites include:

Table 5-1. Potential Environmental Hazard

Medium	Potential Environmental Hazard	Potentially Significant?
Soil	Direct exposure threats to human health	Yes
	Intrusion of subsurface vapors in buildings	No
	Leaching and subsequent impacts to groundwater	No
	Impacts to terrestrial habitats	No
	Gross contamination and general resource degradation	No
Groundwater	Impacts to drinking water sources	No
	Impacts to aquatic habitats	No
	Intrusion of subsurface vapors into buildings	No
	Gross contamination and general resource degradation	No

Potential environmental hazards were evaluated for their applicability to the Site. Potential environmental hazards that are considered to be insignificant at the Site based on available information were eliminated from further consideration and are not evaluated further. Potential environmental hazards identified as posing a potential threat to human health and/or the environment are evaluated further in the EHE.

5.1 Direct Exposure

Direct exposure hazards to human health and the environment involved direct contact with contaminated soil. Direct contact can be made via incidental ingestion of soil, dermal contact with soil, and inhalation of soil particulates by human and ecological receptors.

In the absence of institutional and/or engineering controls (e.g., lease restrictions prohibiting tenants from digging, and requirement for maintaining groundcover, as documented in the EHMP⁵⁰ and LUCID⁵¹), current and future human and ecological populations at the Site could be exposed to contaminated soil and dust, therefore, the direct exposure hazard is evaluated in the EHE.

⁴⁹ (HDOH 2011a)

⁵⁰ (Tetra Tech 2012a)

⁵¹ (Tetra Tech 2012b)

5.2 Vapor Intrusion from Soil

Volatile chemicals detected in groundwater, soil, or soil gas can potentially migrate in a vapor phase through the unsaturated zone to indoor or ambient air where human populations could potentially be exposed.

As indicated in Table 5-2, none of the chemicals being evaluated in the EHE are classified as volatile compounds by HDOH or EPA. A chemical is classified as volatile if it has a Henry's constant greater than 1×10^{-5} atmospheres-cubic meter per mole ($\text{atm}\cdot\text{m}^3/\text{mole}$) and a molecular weight less than 200 grams per mole (g/mole)⁵². For this reason, the potential for vapor intrusion exposures for these chemicals is insignificant. Therefore, the vapor intrusion hazard is not considered to be a concern and will not be evaluated further in the EHE.

Table 5-2. Physio-Chemical Properties ^(a)

Chemical	Physical State ^(b)		Molecular Weight (g/mol)	Henry's Law Constant H ($\text{atm}\cdot\text{m}^3/\text{mol}$)	Henry's Law Constant H' (unitless)	Organic Carbon Partition Coefficient K_{oc} (cm^3/gram)	Solubility (mg/L)	Soil-Water Partition Coefficient K_d ($F_{oc} = 0.1\%$) ^(c)	Soil-Water Partition Coefficient K_d ($F_{oc} = 0.6\%$) ^(c)
	NV	S							
Aldrin	NV	S	365	4.39E-05	1.80E-03	1.06E+05	1.7E-02	1.06E+02	6.36E+02
Chlordane ^(d)	NV	S	410	4.88E-05	2.00E-03	8.67E+04	5.6E-02	8.67E+01	5.20E+02
Dieldrin	NV	S	381	1.00E-05	4.10E-04	1.06E+04	2.5E-01	1.06E+01	6.36E+01
DDD	NV	S	320	6.59E-06	2.70E-04	1.53E+05	9.0E-02	1.53E+02	9.18E+02
DDE	NV	S	318	4.15E-05	1.70E-03	1.53E+05	4.0E-02	1.53E+02	9.18E+02
DDT	NV	S	354	8.29E-06	3.40E-04	2.20E+05	5.5E-03	2.20E+02	1.32E+03
Endrin	NV	S	381	6.34E-06	2.60E-04	1.06E+04	2.5E-01	1.06E+01	6.36E+01
Endrin Ketone ^(e)	NV	S	381	2.01E-08	8.26E-07	9.72E+03	7.55E-02	9.72E+00	5.83E+01
Endosulfan sulfate ^(e)	NV	S	423	3.24E-07	1.33E-05	9.85E+03	4.80E-01	9.85E+00	5.91E+01
delta-BHC ^(e)	NV	S	291	5.12E-06	2.10E-04	2.81E+03	3.14E+01	2.81E+00	1.69E+01
Methoxychlor	NV	S	346	2.02E-07	8.30E-06	4.26E+04	1.00E-01	4.26E+01	2.56E+02

Notes:

$\text{atm}\cdot\text{m}^3/\text{mol}$ = atmosphere-cubic meter per mole

cm^3/g = cubic centimeter/gram

F_{oc} = fraction of organic carbon

^(a) Listed values are recommended by HDOH (2008) unless noted otherwise.

^(b) Chemical is considered to be volatile if it has a Henry's constant is greater than $1.0\text{E}-05$ and the molecular weight is less than 200 (HDOH 2011a).

^(c) Listed K_d values calculated by multiplying corresponding organic carbon partition coefficients (K_{oc}) by listed HDOH default for fraction organic carbon (F_{oc})

^(d) Chlordane is representative of technical chlordane which consists of chlordane isomers, heptachlor, and heptachlor epoxide. For this reason, other chlordane isomers, heptachlor, and heptachlor epoxide are evaluated as chlordane and are not listed individually in this table.

^(e) Listed values for these compounds taken from Risk Assessment Information System (USDOE 2011).

⁵² (HDOH 2011a)

5.3 Leaching

Leaching refers to the movement of contaminants dissolved in water percolating through soil in the vadose zone and potentially into underlying groundwater. Leaching potential is governed by chemical-specific properties and soil characteristics. Chemicals that are highly soluble in water and do not sorb tightly to soils have the highest leaching potential (i.e., are considered “mobile”) and chemicals with low water solubilities that bind tightly to soils have low leaching potential. (i.e., low mobility).

As shown in Table 5-1, the chlorinated pesticides detected at the Site have low solubilities (range from milligrams per liter (mg/L) 0.0055 for DDT to 31.4 mg/L for delta-BHC) compared to other common organic contaminants such as acetone and trichloroethylene, which have solubilities of 1×10^{-6} mg/L and 1.28×10^{-3} mg/L, respectively. The pesticides listed in Table 5-1 also bind tightly to soil. The organic carbon partition coefficients (Koc) values included in the table indicate how much a chemical will bind to soil. The higher the number, the tighter the chemical will bind to soil. Chemicals with a Koc greater than 300 ($3 \times 10^{+2}$) are generally considered to be relatively immobile. As indicated in Table 5-1, the Koc values range from $2.81 \times 10^{+3}$ cubic centimeters per gram (cm^3/g)(delta BHC) to $2.20 \times 10^{+5}$ cm^3/g (DDT), which are all well above 300, indicating the they will bind tightly to soil and be relatively immobile .

Similar to the evaluation of Koc values, HDOH evaluates the potential mobility of chemicals in soil leachate using a soil-water partition coefficient (Kd). Large Kd values indicate lower mobility in soil. HDOH considers chemicals with a Kd value less than 1 to be highly mobile in soil. HDOH considers chemicals with a Kd values greater than 20 to be essentially immobile.⁵³ As indicated in Table 5-1, generic Kd values calculated for detected pesticides range from $3 \text{ cm}^3/\text{g}$ (delta BHC) to $220 \text{ cm}^3/\text{g}$ (DDT) assuming a total organic carbon content in soil of 0.1 percent (%) (HDOH default assumption for generic Kd calculations) and range from $17 \text{ cm}^3/\text{g}$ (delta BHC) to $1,320 \text{ cm}^3/\text{g}$ (DDT) assuming a total organic carbon content in soil of 0.6% (default listed in HDOH Tier 1 EAL spreadsheets⁵⁴). Based on the Kd values calculated using the HDOH default organic carbon content of 0.6%, only delta-BHC has a Kd value slightly lower than the HDOH threshold of 20. All other Kd values are at least 3-fold higher than the HDOH default. Lastly, although the generic Kd value for delta-BHC (based on organic carbon content of 0.6%) was slightly below the HDOH threshold, it should be noted that delta-BHC was only detected in one sample (refer to Table 4-1).

Based on the results of a site-specific leachate study, the generic Kd values based on an organic carbon content of 0.6% may be more representative of actual Site conditions than the generic Kd values calculated based on an organic carbon content of 0.1%. This observation is based on the results of a 2009 leachability evaluation⁵⁵ conducted in accordance with HDOH guidance⁵⁶ on soil from the Earhart I-4 neighborhood, which is located adjacent to Earhart I-3 (to the west). Due to its close proximity, the soils present within the Earhart I-4 neighborhood are likely similar soil within the neighborhoods being evaluated. Although aldrin, chlordane, and dieldrin were the only pesticides evaluated as part of this study, the results for these three chemicals suggest that Kd values associated with actual Site conditions are likely higher than the generic Kd values calculated based on an organic carbon content of 0.6%. As indicated in the 2009 leachate study, the site-specific Kd values for Aldrin ranged from $5,800 \text{ cm}^3/\text{g}$ to $6,600 \text{ cm}^3/\text{g}$, the Kd value for chlordane was $3,100 \text{ cm}^3/\text{g}$, and the Kd values for dieldrin ranged from

⁵³ (HDOH 2007)

⁵⁴ (HDOH 2011a)

⁵⁵ (Tetra Tech 2009c)

⁵⁶ (HDOH 2008b)

650 cm³/g to 690 cm³/g (leachate study is included as Appendix A). These site-specific Kd values are roughly 9-fold higher for aldrin, 6-fold higher for chlordane, and 10-fold higher for dieldrin than the corresponding generic Kd values calculated based on the assumption of an organic carbon content of 0.6%, which suggests that the detected pesticides are likely far less mobile under actual Site conditions.

Based on the information presented above, the pesticides detected at the Site are considered to have limited mobility and are not considered to pose a significant soil leaching hazard in regard to contamination of groundwater. For this reason, the leaching hazard will not be evaluated further in the EHE.

5.4 Ecotoxicity

Ecotoxicity is the degree to which a contaminant released into the environment from human activities affects the organisms in that environment. The potential ecotoxicity of a contaminant is based on its persistence in the environment, the potential to bioaccumulate, and toxicity to potentially exposed species. For this evaluation, potential impacts to flora and fauna in terrestrial habitats and aquatic (i.e., surface water) habitats are considered.

5.4.1 Impacts to Terrestrial Habitats

As indicated in HDOH guidance,⁵⁷ impacts to terrestrial flora and fauna can occur via exposure to contaminated soil. In general, contaminants associated with potential ecological impacts are relatively immobile, non-volatile, and toxic to ecological receptors. HDOH EAL guidance (Section 4.3.5) indicates that the need for a detailed evaluation of terrestrial ecotoxicity hazards should be based on an inspection of the site by a qualified individual and the identification of potentially threatened habitats and endangered or threatened species. The ecological assessment was performed as part of the Environmental Impact Statement (EIS) for Phase II of the Hickam AFB/Bellows Housing Privatization project, which contains the credentials of the primary preparers.⁵⁸

Vegetation

Vegetation at JBPHH has been disturbed or removed throughout the installation and there are no significant naturally occurring, native plant communities in the vicinity of the JBPHH.⁵⁹ Much of JBPHH was constructed on a filled area that previously had been coral reef, so the lower elevation areas of JBPHH had no historic vegetation. Since JBPHH is largely developed, there is relatively little unmanaged vegetation. Most of the vegetative cover is in landscaped areas, including extensive turf that is mowed regularly. The managed landscaped areas occur mostly around buildings, main roads and recreational areas.⁶⁰ Unmanaged vegetation is mostly found in the southern portion of the Base near the coastline, which is a mile or more away from the Site.

⁵⁷ (HDOH 2011a)

⁵⁸ (USAF 2006)

⁵⁹ (USAF 2002b, 2003, and 2006)

⁶⁰ (USAF 2002b)

Sensitive Habitats/Wildlife

Due to past disturbance, there are no naturally occurring vegetative plant communities or optimum wildlife habitats at JBPHH. However, there is sufficient habitat for a variety of fish and wildlife species within particular areas that tend to fall within hydrological zones such as wetlands that are located in flat or depressional areas along the coastline and edges of channels, which are not located within the three neighborhoods associated with the Site.⁶¹

Rare, Threatened, or Endangered Species

The United States Fish and Wildlife Service (USFWS) maintains a list of threatened or endangered species determined to be potentially occurring on or in the vicinity of JBPHH. The list of threatened or endangered species consists of three marine animals and six terrestrial animals. No known occurrences of threatened or endangered invertebrate species have been recorded at JBPHH⁶². Endangered land snails are not expected to occur on JBPHH because the native forest habitat that supports the snails is not found on the installation.⁶³ The listed marine animals are discussed below in Section 5.4.2 (Impacts to Aquatic Habitats).

The six listed terrestrial animals include: the endangered black-necked stilt; endangered Hawaiian hoary bat; endangered Hawaiian coot; endangered Hawaiian duck; endangered common moorhen; and Hawaiian short-eared owl (Pueo). The Hawaiian Stilt was observed on JBPHH during field surveys in January 1996 in the Reef Runway Lagoon area in the vicinity of the mouth of the Manuwai Canal approximately a mile to the south of the Site. Habitat for the Hawaiian coot and the common moorhen exists at the Manuwai Canal, but these species have not been recorded at this location. The common moorhen has been recorded in the tidal flats near Fort Kamehameha on the southwest coastline of JBPHH approximately a mile from the Site and both species have been observed on Waipio Peninsula in Pearl Harbor, two to 3 miles away from JBPHH. The Hawaiian duck has also been recorded on Waipio Peninsula. The Hawaiian short-eared owl was captured at the base commissary prior to 2002. The current number and distribution of these owls on O'ahu is unknown, but it is unlikely to nest on the installation due to the abundance of ground predators. Additionally, vegetation management in the vicinity of the airfield for the Bird-Aircraft Strike Hazard (BASH) program has directly resulted in reduction of available bird habitat and elimination of food sources and bird roosting sites in the airfield area of JBPHH. The northern boundary of the managed BASH zone borders the southern border of the Onizuka II-1 neighborhood and is approximately 1,400 feet south of the Earhart I-2 and Earhart I-3 neighborhoods associated with the Site. Although not observed at the Site, a few scattered occurrences of the Hawaiian hoary bat have been reported on O'ahu. It is possible that this bat species would utilize portions of JBPHH, but such use is thought to be infrequent since this animal is normally found on Kauai and the Big Island.⁶⁴

As described above, there is little unmanaged vegetation and no naturally occurring vegetative plant communities or optimum wildlife habitat at JBPHH. Additionally, the neighborhoods evaluated in this report have been developed for residential land-use and will likely remain so for the foreseeable future. Due to the developed nature of JBPHH and the residential areas being evaluated, the only ecological receptors likely to be exposed to soil at the Site are common, abundant species that are routinely observed in residential areas or agricultural lands. None of the threatened or endangered species described above are known to nest or otherwise

⁶¹ (USAF 2005),

⁶² (USAF 2002b)

⁶³ (USAF 2006)

⁶⁴ (USAF 2002b, 2006)

utilize the housing areas on Hickam AFB as habitat.⁶⁵ For this reason, the potential for adverse impacts to terrestrial habitats and receptors is not considered to be a significant concern and will not be evaluated further in the EHE.

5.4.2 Impacts to Aquatic Habitats

Joint Base Pearl Harbor-Hickam is a flat area that drains impervious surfaces. Groundwater does not discharge to the surface at the Site and no permanent surface water bodies exist within the three neighborhoods. Therefore, uptake by aquatic receptors within the Site is considered to be an incomplete pathway. Beyond the Site boundary, there is a canal (Manuwai Canal) that provides storm drainage for the eastern portion of JBPHH that flows adjacent to the southern boundary of Earhart Villages I-2 and I-3 and empties into Māmala Bay to the south near the eastern boundary of the Māmala Bay golf course. As indicated in Section 5.4.1, the list of endangered species identified three marine animals that could potentially occur in waters off JBPHH. The listed marine animals include the green sea turtle, Hawaiian monk seal, and humpback whale. The green sea turtle was observed on JBPHH during field surveys in January 1996 along the southwestern coast of JBPHH near Fort Kamehameha. None of these species are associated with areas that are on or near the Site.⁶⁶

As described above in Section 5.3, the COCs detected at the Site have low solubilities and bind tightly to soil and, therefore, are considered to be essentially immobile. Based on these properties, it is unlikely that the COCs detected at the Site would be present in stormwater runoff. If present at all, it is much more likely that the COCs would be associated with suspended sediments rather than dissolved in the runoff. However, the erosion potential for soil within the Site is generally slight to moderate.⁶⁷ Additionally, as described above, most areas not covered with pavement or buildings are landscaped and maintained by HC such that the portion of the Site comprised of bare soil is very limited, which significantly limits the potential for sediments to be present in runoff and transported to Māmala Bay. Lastly, the wetland habitat within the canals at JBPHH is generally disturbed by human activities and of low value for wildlife.⁶⁸ For these reasons, the potential for adverse impacts to aquatic habitats is not considered to be a significant concern and will not be evaluated further.

5.5 Contamination of Drinking Water Supplies

In the event contamination of drinking water supplies occurs, human receptors could potentially be exposed to chemicals that are present in the drinking water aquifer. Depending on the site, contamination of drinking water supplies can occur directly (chemicals enter directly into an aquifer when released) or indirectly (e.g., impacted groundwater at shallow depths migrates into deeper aquifers). As described in HDOH guidance⁶⁹, chemicals that tend to pose a threat to drinking water are typically soluble chemicals that do not sorb tightly to soils and have the potential to migrate within the vadose zone (i.e., are “mobile”).

As described above (Section 5.3 - Leaching), the chlorinated pesticides detected within the Site have low solubilities and tend to bind tightly to soils and, therefore, are generally considered to

⁶⁵ (USAF 2006)

⁶⁶ (USAF 2002b, 2006)

⁶⁷ (USAF 2002a)

⁶⁸ (USAF 2002b and 2003)

⁶⁹ (HDOH 2011a)

be essentially immobile. Thus, it is considered unlikely that the pesticides detected in soil would migrate into groundwater beneath the Site. Additionally, most of the Hickam installation is underlain by a brackish aquifer that is not suitable for commercial, residential, or recreational use. Potable water is supplied to HAFB from Navy storage tanks outside the base. For these reasons, contamination of drinking water supplies is not considered to be a significant concern at the Site and will not be evaluated in the EHE.

5.6 Gross Contamination

Gross contamination of soil and groundwater encompasses the presence of potentially mobile free product, offensive odors and objectionable taste (i.e. in drinking water), unaesthetic appearance, generation of explosive vapors or other safety hazards, and general resource degradation. As described in HDOH guidance, it can be possible for soil to be contaminated at such high levels with some chemicals (e.g. xylenes and gasoline) that the soil could be flammable, but would not be considered toxic in the toxicological sense.

Based on the soil data collected at the Site, organochlorine pesticides are present at levels that are significantly below levels identified by HDOH as indicative of gross contamination. The maximum detected soil concentration of any pesticide is 46 mg/kg (aldrin) and the HDOH screening level for gross contamination for any of the detected pesticides range from 500 mg/kg (DDD, DDE, endrin, endrin ketone, endosulfan sulfate, and methoxychlor) to 1,000 mg/kg (all other detected pesticides)⁷⁰. Since the maximum detected levels of all detected pesticides are well below gross contamination screening levels, gross contamination of soil is not considered to be a concern and will not be evaluated further.

5.7 Retained Potential Environmental Hazards

A conceptual site model (CSM) summarizing the potential and retained environmental hazards for organochlorine pesticides at the Site is presented in Table 5-2. As described in the preceding sections, one of the common potential environmental hazards identified by HDOH (i.e., direct exposure to soil) was retained for further evaluation in the EHE. Vapor intrusion was eliminated as a potential environmental hazard because none of the COCs are classified as volatile compounds by EPA or HDOH. Gross contamination was eliminated because the maximum detected levels of pesticides within the Site are well below the corresponding HDOH screening levels for gross contamination. The chlorinated pesticides detected at the Site have low solubilities and bind tightly soil (i.e., have very limited mobility) and therefore, are not considered to pose a significant soil leaching hazard in regard to contamination of groundwater. Contamination of drinking water supplies was eliminated due to the following: the limited mobility of the COCs, groundwater beneath the Site is brackish and is not suitable for commercial, residential, or recreational use, and because potable water is supplied to HAFB from Navy storage tanks outside HAFB. Terrestrial and aquatic ecotoxicity was eliminated from consideration due to the low mobility of the COCs and due to a lack of sensitive habitat within the Site and immediately adjacent to the Site.

⁷⁰ Endrin used as a surrogate for endrin ketone; endosulfan used as a surrogate for endosulfan sulfate; and gamma-BHC (Lindane) used as a surrogate for delta-BHC.

Table 5-3. Conceptual Site Model for Organochlorine Pesticides^(a)

Primary Sources	Primary Release Mechanism	Secondary Sources	Potential Environmental Hazards		Hazards Present Under Current or Future Conditions?			
					Current Residents	Construction/Maintenance Workers	Future Residents	Construction/Maintenance Workers
Historical Maintenance Activities for Residential Units (Application of pesticides under and around building foundations for termite control)	Soil moving activities associated with recent construction work	Soil	Risk to Human Health	Direct Exposure ^(b) - ingestion - dermal contact - dust inhalation	No ⁽ⁱ⁾	No ⁽ⁱ⁾	Yes	Yes
				Vapor Intrusion into Buildings	----	----	----	----
			Risk to Terrestrial Ecological Habitats ^(c)		No		No	
			Leaching ^(d)		No		No	
			Gross Contamination ^(e)		No		No	
			Groundwater	Risk to Human Health ^(f)	Direct Exposure	----	----	----
		Vapor Intrusion into Buildings			----	----	----	
		Risk to Aquatic Ecological Habitats ^(g)		----		----		
		Gross Contamination ^(h)		----		----		

Notes:

- ^(a) Conceptual Site Model (CSM) is based on EAL Surfer Summary Reports for organochlorine pesticides (HDOH 2011a). It is assumed that the Site is not located within 150 meters of a surface water body or sensitive aquatic habitat, and groundwater is not a current drinking water resource.
- ^(b) Human health hazards include direct exposure to contaminated soil or inhalation of airborne dust.
- ^(c) Assumes significant terrestrial ecological habitat is impacted due to contamination with resulting toxicity to flora/fauna.
- ^(d) Assumes potential leaching of soil contaminants resulting in impacts to underlying groundwater.
- ^(e) Gross contamination hazards for soil include potential explosive hazards, odors and general nuisance concerns, and general resource degradation.
- ^(f) Human health hazards include ingestion of contaminated groundwater and potential dermal and inhalation exposures during showering.
- ^(g) Assumes contaminated groundwater discharges/migrates to an aquatic habitat. Contaminants in groundwater screened using chronic aquatic toxicity action levels for sites < 150 meters from a surface water body.
- ^(h) Gross contamination hazards for groundwater include taste and odor concerns for drinking water, presence of free product, odors, and general resource degradation.
- ⁽ⁱ⁾ Due to remediation activities completed at the Site, current hazards are not likely to exist for current residents. Similarly, for landscape/maintenance and construction workers who may engage in intrusive soil activities, institutional controls are currently in place to ensure that Occupational Safety and Health Administration safe practices are followed by maintenance and construction workers in areas of the Site associated with remaining PI soil.

6.0 EXPOSED POPULATIONS AND EXPOSURE PATHWAYS

The identification of potentially exposed populations and exposure pathways is a critical component of developing health protective EALs. An exposure pathway describes the course a chemical takes from a source to an exposed individual. Based on current and anticipated future conditions at the Site, the chemical exposures that could potentially be associated with the three neighborhoods were identified considering the following four factors:

- Sources of COCs;
- Environmental media in which COCs have been detected (i.e., soil);
- Exposure of contact points with the environmental media (e.g., direct contact with soil); and
- Exposure routes for chemical intake by a receptor (e.g., soil ingestion).

The exposure pathways identified for the Site are based on evaluations of the likelihood of receptors directly contacting COCs and the mechanisms governing the fate and transport of the COCs.

6.1 Potentially Affected Human Populations

Potentially exposed human populations (receptors) were identified for current and expected future land-use scenarios. As described above, the Site is currently developed for residential land use and it is anticipated that it will remain this way for the foreseeable future. Human populations that could potentially be exposed to PI soil within the Site under current and expected future conditions, include residential receptors (adults and children), landscaping/maintenance workers, and construction workers.

6.2 Retained Potentially Affected Human Populations

Within the Site, all work performed by landscaping/maintenance workers and construction workers is conducted in accordance with the HDOH approved site-specific Soil Management Plan (SMP)⁷¹ and the *Pesticide-Impacted Soil Investigation and Management Program Manual* (the "Program Manual")⁷². As described in the *Program Manual*, landscaping/maintenance workers and construction workers must be provided with adequate training so they are familiar with the potential health hazards posed by PI soil. This training consists of a hazard communication briefing conducted by the employer's Certified Industrial Hygienist (CIH) and a PI soil awareness briefing conducted by Tetra Tech. Site workers are also familiarized and provided with the required personal protective equipment (PPE) to eliminate or minimize any potential exposures. Lastly, in addition to the training and use of PPE, all activities performed by Site workers are conducted following required safeguards in accordance with the HDOH approved HC Project Health and Safety Plan (HASP).⁷³ Although potential exposures to maintenance/landscaping workers and construction workers are covered under the HDOH approved documents described above, a reasonably anticipated future exposure scenario for these worker populations includes exposure to previously buried PI soil due to excavation or

⁷¹ (Tetra Tech 2006e)

⁷² (Tetra Tech 2009a and 2011c)

⁷³ (Tetra Tech Date 2011c)

erosion. Therefore, these worker populations were retained for further evaluation in the EHE. Similarly, if PI soil remaining at the Site is brought to the surface in the future, residents could also be potentially exposed.

In summary, the following potentially affected human populations were retained for further evaluation:

- Residential receptors (adults and children);
- Landscaping/Maintenance Workers; and
- Construction Workers.

6.3 Exposure Media and Exposure Pathways

The potentially contaminated exposure media within the Site that will be the focus of the EHE is soil. The complete exposure pathways evaluated for potentially exposed residential receptors are identified in the following sections.

For this evaluation, it is assumed that potential receptors may ingest soil inadvertently (e.g., transfer soil from fingers to mouth) while at home or work. It is also assumed that potential receptors may be exposed to soil through dermal contact with soil and windblown particulates. Based on these considerations, the complete exposure pathways evaluated in the EHE include: 1) incidental ingestion of soil; 2) dermal contact with soil; and 3) inhalation of airborne particulates. Each potentially complete exposure pathway is summarized below.

Table 6-1. Potential Receptors and Exposure Pathways

Receptor	Medium	Exposure Pathway
On-Site Resident (Adult and Child)	Soil	Incidental Ingestion
		Dermal Contact
		Dust Inhalation
Landscaping/Maintenance Worker	Soil	Incidental Ingestion
		Dermal Contact
		Dust Inhalation
Construction Worker	Soil	Incidental Ingestion
		Dermal Contact
		Dust Inhalation

6.4 Identification of Exposure Areas

In order to evaluate potential exposures to all soil not covered by hardscapes, the Earhart I-2, Earhart I-3, and Onizuka II-1 neighborhoods were subdivided into DUs. The maximum size of the DUs was set to 5,500 sq ft of ground not covered by buildings or pavement. The 5,500 sq ft constraint was based on HDOH guidance⁷⁴ recommending that residential exposure areas should be limited to approximately 5,000 sq ft. Since the HDOH guidance is based on a typical single-family residential lot, and because all of the residences within the Site are multi-family buildings, the criterion was increased somewhat to allow for site-specific conditions.

⁷⁴ (HDOH 2009a)

The factors used to delineate DU boundaries were based on anticipated location-specific patterns of land use by residents. Four DU types were identified for the Site.

Playground DUs. The playground areas are covered with either impact matting or tan-bark over plastic. Playground DUs are defined such that they contain an area at least 30 feet beyond the perimeter of the matting/tan bark-covered playground area. Some of the Playground DU boundaries were extended beyond these minimum boundaries to incorporate similar adjacent areas, to facilitate the field delineation of the DUs, and to facilitate implementation of the any corrective action that may be applied to the DU. Playground DUs do not include the area inside the perimeter of the playground area, as the matting/tan bark-cover eliminates potential exposure to surface soil within the playground.

Backyard DUs. The Backyard DUs include the area from the rear walls of the housing units out to a minimum of 30 feet behind each housing unit. HC permits residents to install backyard fencing up to 24 feet from the rear wall of the housing structure. The 30-foot distance selected for backyard DU boundaries includes additional distance to account for attached lanais which can protrude up to 5-feet from the rear walls. Backyard DU boundaries extend beyond these minimum distances in some cases to incorporate similar adjacent areas, to facilitate the field delineation of the DUs, and to facilitate implementation of corrective actions that may be applied to the DU. Every residential building includes one or more Backyard DUs.

Front Yard DUs. The Front Yard DUs include the area measured from the rear walls of the housing units forward to the curb in front of the housing units. Side-yards between buildings are included in the Front Yard DUs. Each residential building is covered by one or more Front Yard DUs.

Common Area DUs. The Common Area DUs include areas that are not included in the Backyard and Playground Area DUs. The Common Area DUs include areas such as ball fields, dog parks, and large grassy areas between groups of housing units. Common Areas are expected to have generally less intensive use by any specific individual and less use by children. Use is more broadly dispersed among the larger community.

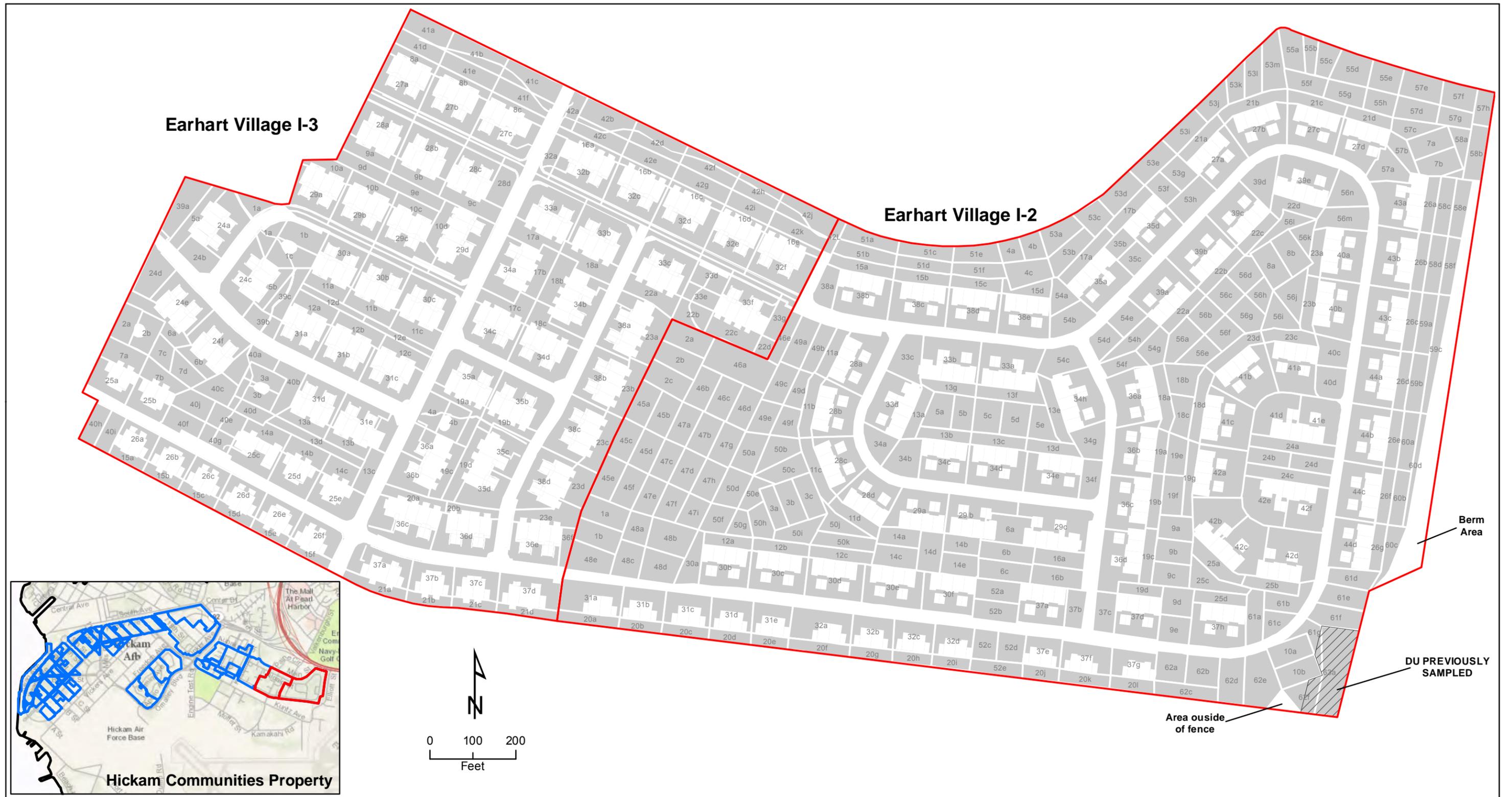
The decision units identified for Earhart I-2, Earhart I-3, Onizuka II-1, and Hale Na Koa I-1 are presented in Figures 6-1 through 6-3.

6.5 Exposure Concentrations

In accordance with HDOH guidance⁷⁵, MI soil samples were collected from each DU to determine the representative exposure concentrations for COCs present in soil. This sampling approach is recommended by HDOH because it reduces the variability and improves the reliability of decision unit data in comparison to conventional discrete sampling strategies. For each DU within the Site, one MI sample was collected from the 0 to 6-inch depth interval and one MI sample was collected from the 6 to 12-inch depth interval. For each depth-specific MI sample, a total of 30 soil increments were collected from stratified-random sub-sampling locations across the entire DU (e.g., grid format) and then physically combined into one sample.

⁷⁵ (HDOH 2009a)

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Earhart Village I-2/I-3
 10b Decision Unit Numbers
 Hardscapes

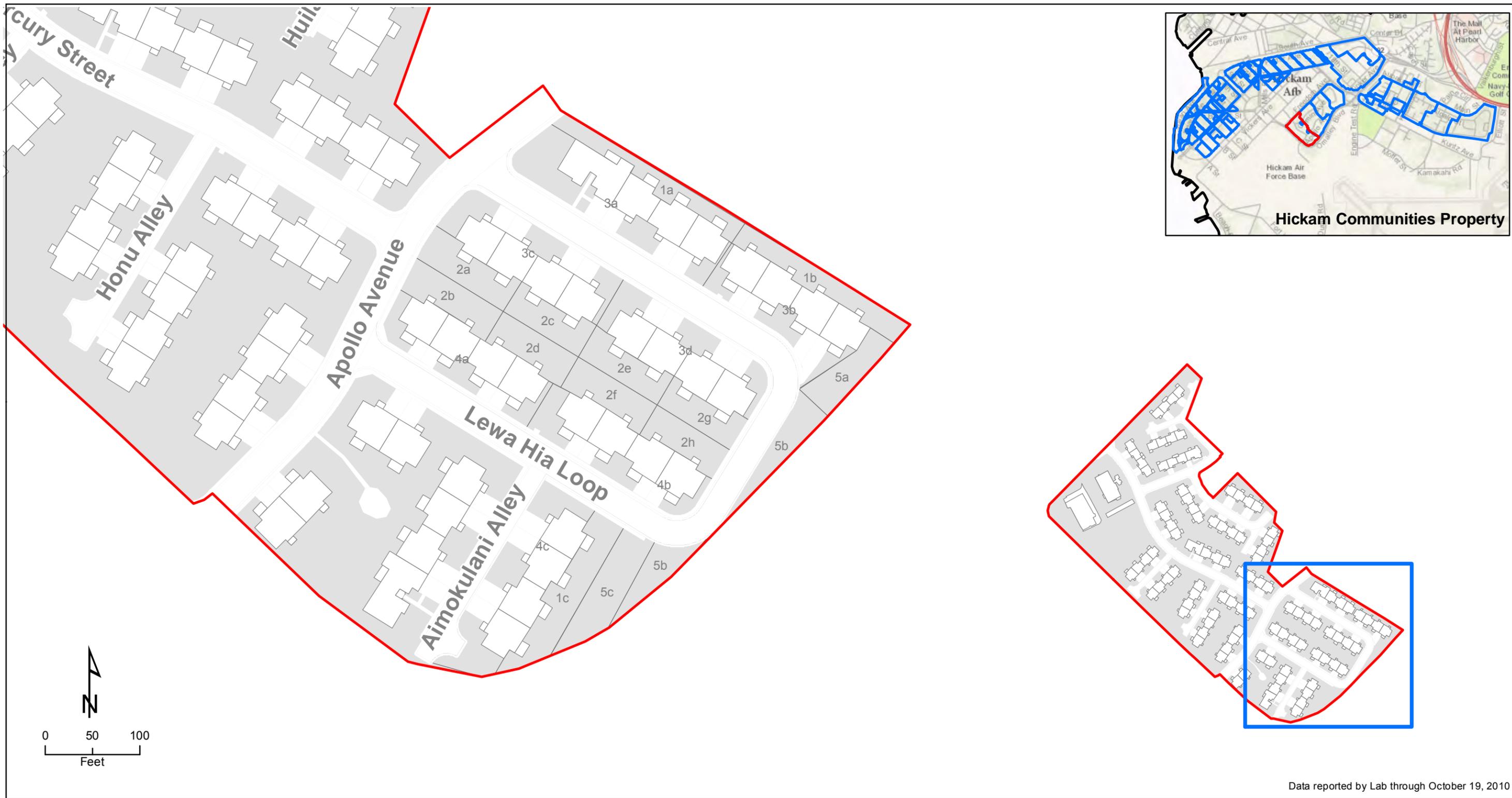
Notes:

- Inset map shows Hickam Communities Property Boundary Line.

**Decision Unit Boundaries
Earhart I-2 and I-3**

Hickam Communities
Joint Base Pearl Harbor-Hickam, Hawai'i

Figure 6-1



Data reported by Lab through October 19, 2010

Decision Unit Boundaries Onizuka II-1

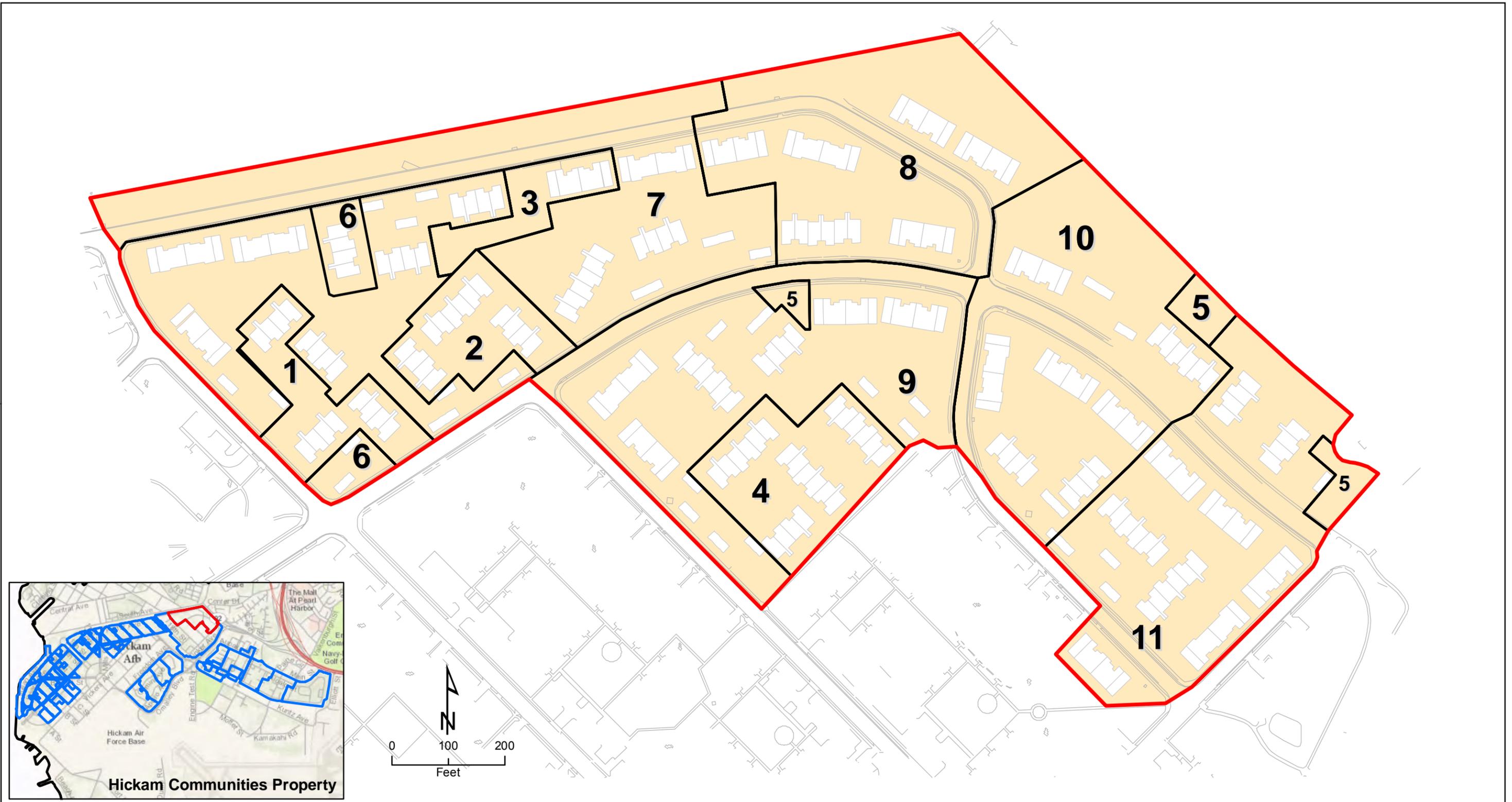
Hickam Communities
Joint Base Pearl Harbor-Hickam, Hawai'i

- 4 b Decision Unit Numbers
- Earhart Village I-3
- Hardscapes

- Notes:**
- Inset map shows Hickam Communities Property Boundary Line.

Figure 6-2

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-  Hardscapes
-  Hale Na Koa I-1
- 1** Decision Unit Number

Notes:

- Inset map shows Hickam Communities Property Boundary Line.

**Decision Units at Hale Na Koa
Hickam Communities**

Joint Base Pearl Harbor-Hickam, O'ahu, Hawai'i

The combined sample was then analyzed to obtain the representative chemical concentration for the entire DU. As described in HDOH guidance, multi-increment sampling data typically have low variability and high reproducibility, which results in a high level of confidence for decision making. The multi-increment soil sampling results for all of the identified DUs are presented in Appendices C and E.

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7.0 PREVIOUS ENVIRONMENTAL ACTION LEVELS

The HDOH has derived conservative screening values for contaminants called environmental action levels (EALs) (HDOH 2011a). The EALs are concentrations of contaminants in soil, soil gas and groundwater above which the contaminants could pose a potential adverse impact to human health and the environment. Individual EALs have been developed for each of the potential environmental hazards discussed in Section 5 (e.g., gross contamination, direct exposure, vapor intrusion, leaching, ecotoxicity, etc.). As described in the HDOH TGM (Section 13.1), “the environmental hazard that drives the potential need for remedial action at a contaminated site depends on the toxicity and mobility of the targeted contaminants.”⁷⁶ Soil containing chemicals that are toxic to humans and relatively immobile (e.g., organochlorine pesticides detected at the Site) primarily pose a potential direct exposure hazard. As indicated in Section 5, direct exposure to humans is the potential environmental hazard retained for evaluation in the EHE. Therefore, EALs protective of direct exposure are used to identify areas the Site that could pose a potential human health risk.

The remainder of this section describes the applicability of site-specific EALs, summarizes previous EALs developed for the Site in 2006 (referred to as the “2006 HHRA Standard”), and presents a comparison of the 2006 HHRA EALs to Site soil data.

7.1 Applicable Site-Specific Environmental Action Levels

As described in HDOH guidance⁷⁷, the most important use of HDOH Tier 1 EALs (the most conservative screening levels) is the rapid identification of potential environmental hazards associated with contaminated soil or groundwater at a site. The guidance also notes that, exceeding the HDOH Tier 1 EALs does not necessarily indicate that contamination at a site poses an environmental hazard; however, it is an indication that additional evaluation is warranted. When measured concentrations of contaminants at a site do exceed Tier I EALs, a more advanced evaluation of potential environmental hazard may be done in which site-specific EALs are derived by incorporating site-specific considerations into the equations used to derive the default Tier 1 EALs. As indicated in Section 3, after discussions with HDOH, Tetra Tech conducted a site-specific evaluation and prepared a memorandum documenting the basis for and the assumptions used to derive the site-specific EALs under the 2006 HHRA Standard for the HC Housing Area for aldrin, chlordane, and dieldrin, which were approved by HDOH. A copy of the 2006 memorandum, which includes a summary of the equations and parameters used to derive the site-specific EALs (under 2006 HHRA Standard) for aldrin, chlordane, and dieldrin is included in Appendix B.

7.2 2006 Site-Specific Environmental Action Levels

The 2006 HHRA Standard for aldrin, chlordane, and dieldrin were derived based on two site-specific adjustments to the default HDOH Tier 1 EALs associated with the assumed residential exposure duration and target risk levels. Specifically, a 6 year residential exposure duration (HDOH Tier 1 default is 30 years) and target risk level of 1×10^{-5} were used (HDOH Tier 1 default is 1×10^{-6}). For the noncancer endpoint, a target hazard quotient (HQ) of 1 was used (HDOH Tier 1 default is 0.2). For other detected pesticides, HDOH Tier 1 EALs were used to

⁷⁶ (HDOH 2009a)

⁷⁷ (HDOH 2009a)

evaluate cumulative risks and hazards assuming a target cumulative risk of 1×10^{-5} and a target hazard index (HI) of 1. A summary of the parameters used to derive the EALs under 2006 HHRA Standard for aldrin, chlordane, and dieldrin is presented in Appendix B.

7.3 Comparison of 2006 HHRA Standard to Site Data

This section presents an evaluation of the retained potential environmental hazards identified in Section 5. Potentially exposed residential receptors were evaluated based on current and expected future conditions at the Site (i.e., residential use).

Direct Exposure Evaluation

The 2006 HHRA Standard for the contaminants of concern in soil for the direct exposure hazard are summarized in Table 7-1 for child and adult residents. As described in Section 6,

Table 7-1. 2006 Environmental Action Levels (EALs) for Soil – Child and Adult Residents^{(a),(b)}

Chemical	HC Site-Specific Soil Screening Levels (mg/kg)				Final EAL
	Child		Adult		
	Cancer-based	Noncancer-based	Cancer-based	Noncancer-based	
	Target Risk ^(c)	Target HQ = 1 ^(d)	Target Risk ^(c)	Target HQ = 1 ^(d)	
Aldrin	0.42	1.8	3.6	15.7	0.42
Chlordane ^e	23.4	35.2	209.8	314.7	23.4
Dieldrin	0.45	3.1	3.8	26.1	0.45
DDD	2	-	2	-	2
DDE	1.4	-	1.4	-	1.4
DDT	1.7	36	1.7	36	1.7
Endrin	-	18	-	18	18
Endrin ketone	-	18	-	18	18
Endosulfan sulfate	-	370	-	370	370
delta-BHC	-	21	-	21	21
Methoxychlor	-	310	-	310	310

Notes:

HC = Hickam Communities

mg/kg = milligram per kilogram

HQ = Hazard quotient

- identifies Tier 1 EALs

^(a) EALs for aldrin, chlordane, and dieldrin listed in this table were derived based on the EAL equations listed in HDOH Guidance (HDOH 2011a) using the 2006 Site-Specific EAL adult and child exposure parameters and toxicity criteria listed in Table 8-1 (refer to "2006 Hickam EAL" section of the table). Equations used to calculate 2006 EALs are presented in Appendix B.

^(b) Listed EALs for chemicals other than aldrin, chlordane, and dieldrin (i.e., shaded compounds) are the HDOH Tier 1 EALs for direct contact with soil (refer to Table I-1 HDOH 2011a).

^(c) The target risk of 1E-05 applies only to aldrin, chlordane, and dieldrin. Target risk of 1E-06 applies to all other chemicals.

^(d) For chemicals other than aldrin, chlordane, and dieldrin, the listed noncancer Tier 1 EALs are based on a target HQ of 1 for purpose of estimating cumulative hazard.

^(e) Chlordane is representative of technical chlordane which consists of chlordane isomers, heptachlor, and heptachlor epoxide. For this reason, other chlordane isomers, heptachlor, and heptachlor epoxide are evaluated as chlordane and are not listed individually in this table.

the direct exposure EALs for residential receptors were developed based on the following exposure pathways:

- Incidental ingestion of soil;
- Dermal contact with soil; and
- Inhalation of airborne particulates.

Of these direct exposure pathways, the majority of the estimated risk and hazard is associated with soil ingestion with only minor contributions from dermal contact and inhalation. The results of the direct exposure evaluation are presented below for each neighborhood. The lowest EALs under the 2006 HHRA Standard are associated with the child resident and, therefore, are protective of other potential receptors (i.e., adult residents). For this reason, only the evaluation results for the child resident are discussed below.

Risk Characterization

The estimated risks and hazards were calculated using ratio of each pesticide's representative soil concentration and its corresponding cancer and noncancer 2006 HHRA Standard EALs. The risk and hazard ratios for each chemical were summed to determine the cumulative multi-pathway carcinogenic risk estimates and noncarcinogenic HI for potentially exposed receptors. For this evaluation, a target cumulative risk of 1×10^{-5} and target HI of one were used to evaluate if pesticides in soils presented a potential health risk. The cumulative risk is estimated using the following equation:

$$\text{Risk} = \left[\left(\frac{A}{\text{HHRA EAL}_{\text{carc}}} + \frac{C}{\text{HHRA EAL}_{\text{carc}}} + \frac{D}{\text{HHRA EAL}_{\text{carc}}} \right) \times 1E-05 \right] + \left[\frac{O}{\text{HDOH Tier 1 EAL}_{\text{carc}}} \times 1E-06 \right]$$

where A, C, D, and O are the detected concentrations for aldrin, chlordane, dieldrin, and other pesticides divided by the corresponding carcinogenic EALs (the 2006 HHRA EALs or HDOH Tier 1 EALs).

The HI is estimated using the following equation:

$$\text{HI} = \left(\frac{A}{\text{HHRA EAL}_{\text{noncarc}}} + \frac{C}{\text{HHRA EAL}_{\text{noncarc}}} + \frac{D}{\text{HHRA EAL}_{\text{noncarc}}} + \frac{O}{\text{HDOH Tier1 EAL}_{\text{noncarc}}} \right)$$

where A, C, D, and O are the detected concentrations for aldrin, chlordane, dieldrin, and other pesticides divided by the corresponding noncarcinogenic EALs (the 2006 HHRA EALs or HDOH Tier 1 EALs).

The estimated risks and hazards associated with potential residential child and adult exposures within all neighborhoods and DUs are summarized in Appendix C.

7.3.1 Earhart I-2 Neighborhood

Child Resident

Figure 7-1 identifies DUs within the Earhart I-2 neighborhood associated with cumulative risks for the child resident exceeding the target risk level of 1×10^{-5} based on the soil sampling results collected within the 0 to 12-inch depth interval and the site-specific child resident 2006 HHRA Standard EALs. A total of 280 DUs are associated with estimated cumulative risks greater than 1×10^{-5} . A histogram summarizing the distribution of the residential child cumulative risk estimates for all of the DUs located within the Earhart I-2 neighborhood is presented in Figure 7-2. As indicated in the histogram, the vast majority of DUs are associated with cumulative risk estimates ranging from 1×10^{-5} to 5×10^{-4} .

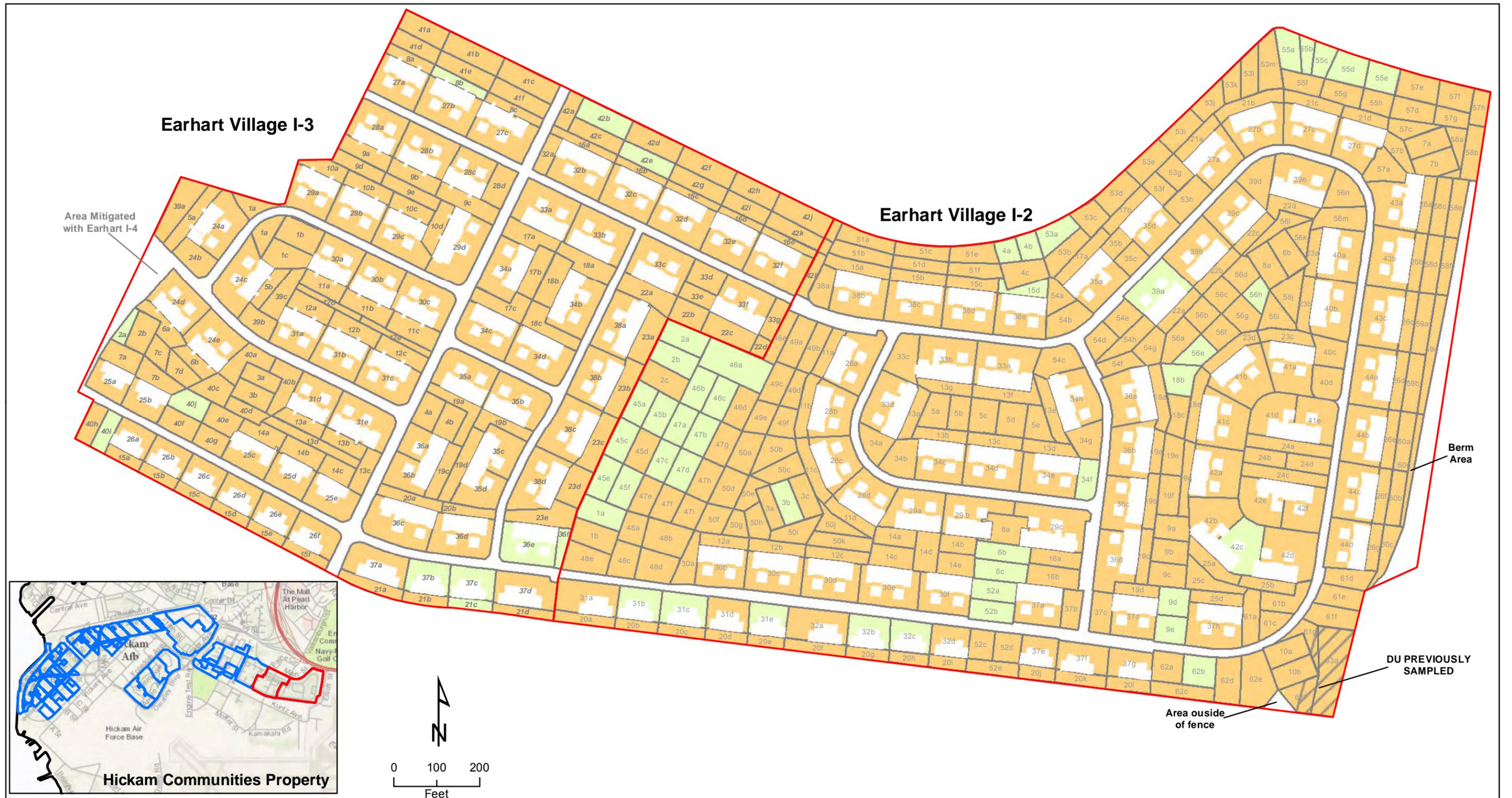
Figure 7-4 identifies DUs within the Earhart I-2 neighborhood associated with an estimated HI for the residential child exceeding the target hazard level of 1. A total of 160 DUs are associated with an estimated HI for the residential child exceeding the target hazard level of 1. A histogram summarizing the distribution of the estimated HIs for the residential child for all of the DUs located within the Earhart I-2 neighborhood is presented in Figure 7-5. As indicated in the histogram, most of the estimated HIs exceeding the target level of 1 are less than 6 with most being between 1 and 4.

7.3.2 Earhart I-3 Neighborhood

Child Resident

Figure 7-1 identifies the DUs within the Earhart I-3 neighborhood with cumulative risks for the child resident exceeding the target risk level of 1×10^{-5} based on the soil sampling results collected within the 0-12 inch depth interval and the 2006 site-specific child resident EALs. A total of 170 DUs are associated with estimated risks for the residential child exceeding the target risk level of 1×10^{-5} . A histogram summarizing the distribution of the residential child cumulative risk estimates based on the 2006 HHRA Standard for all of the DUs located within the Earhart I-3 neighborhood is presented in Figure 7-3. As indicated in the histogram, the vast majority of DUs are associated with cumulative risk estimates ranging from 1×10^{-5} to 5×10^{-4} .

Figure 7-4 identifies DUs within the Earhart I-3 neighborhood associated with an estimated HI for the residential child exceeding the target hazard level of 1. A total of 65 DUs are associated with an estimated HI for the residential child exceeding the target hazard level of 1. A histogram summarizing the distribution of the estimated HIs for the residential child for all of the DUs located within the Earhart I-3 neighborhood is presented in Figure 7-6. As indicated in the histogram, all of the estimated HIs exceeding the target level of 1 are less than 4 with most being between 1 and 3.



Preliminary Risk Estimate (Based on 2006 Tier 2 EALs)

- $\le 10^{-5}$ Carc. Risk
- $> 10^{-5}$ Carc. Risk

- Earhart Village I-2/I-3
- Hardscapes

10 b Decision Unit Numbers

Notes:

- Inset map shows Hickam Communities Property Boundary Line.

**DUs with Cumulative Risks Exceeding Target Risk (0-12 inches) - 2006 EALs
Earhart I-2 and Earhart I-3**

Hickam Communities
Joint Base Pearl Harbor-Hickam, Hawai'i

Figure 7-1

Figure 7-2. Earhart I-2: Distribution of Estimated Cumulative Risks for DUs (0-12 inches) – 2006 EALs

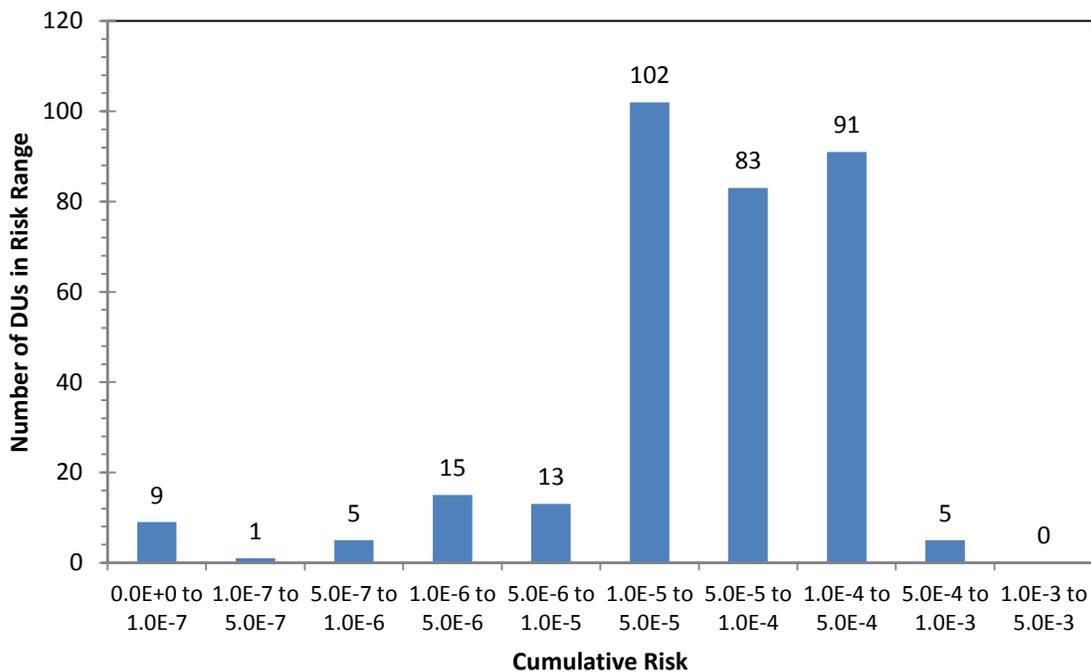
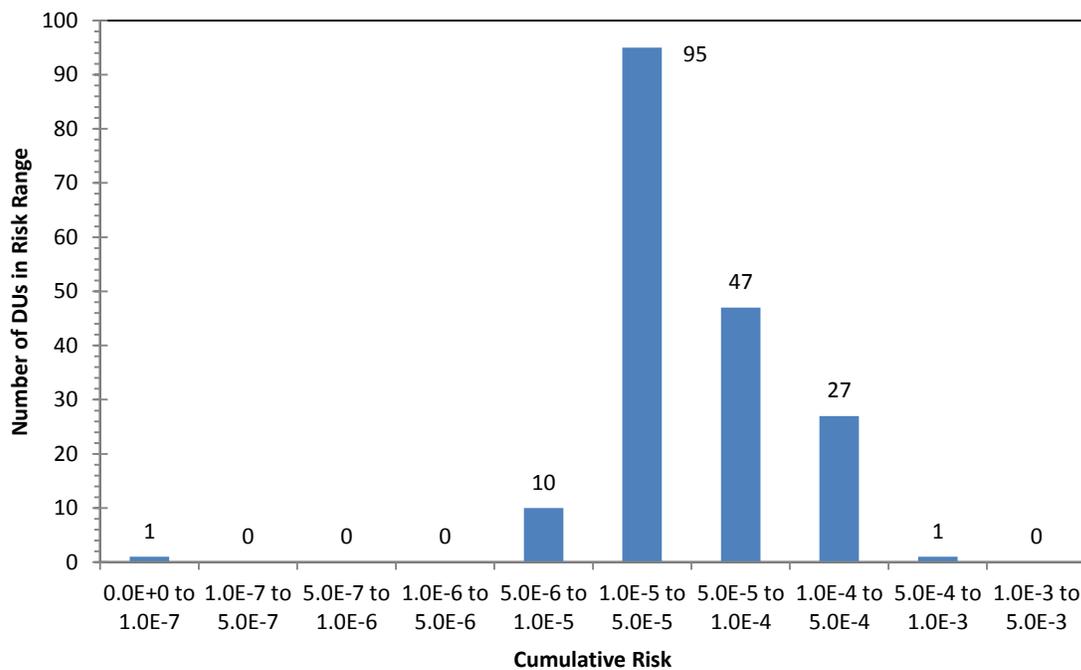
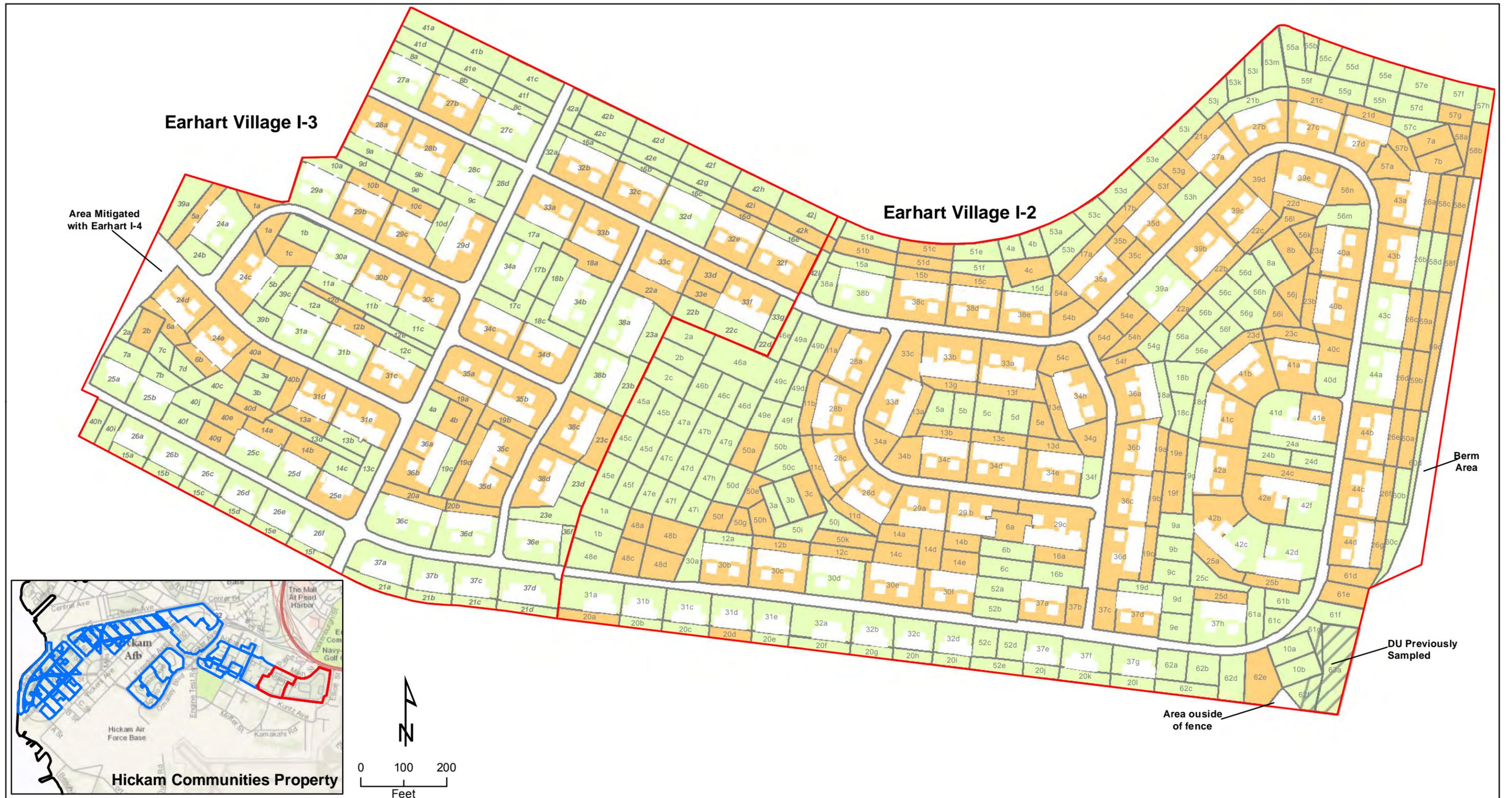


Figure 7-3. Earhart I-3: Distribution of Estimated Cumulative Risks for DUs (0-12 inches) – 2006 EALs



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**DUs with Hazard Index Exceeding Target Hazard (0-12 inches) - 2006 EALs
Earhart I-2 and Earhart I-3**

Preliminary Risk Estimate (Based on 2006 Tier 2 EALs)

- HI 0-1
- HI >1
- Earhart Village I-2/I-3
- Hardscapes
- 10 b Decision Units

Notes:

- Inset map shows Hickam Communities Property Boundary Line.

Hickam Communities
Joint Base Pearl Harbor-Hickam, Hawai'i

Figure 7-4

Figure 7-5. Earhart I-2: Distribution of Hazard Indices for DUs (0-12 inches) – 2006 EALs

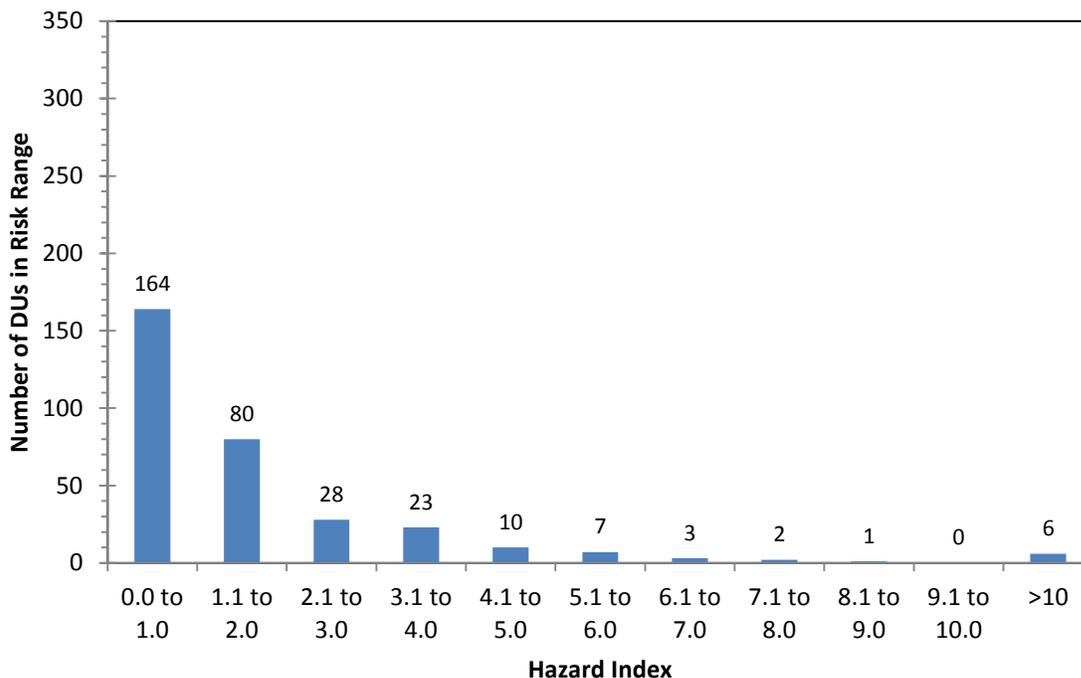
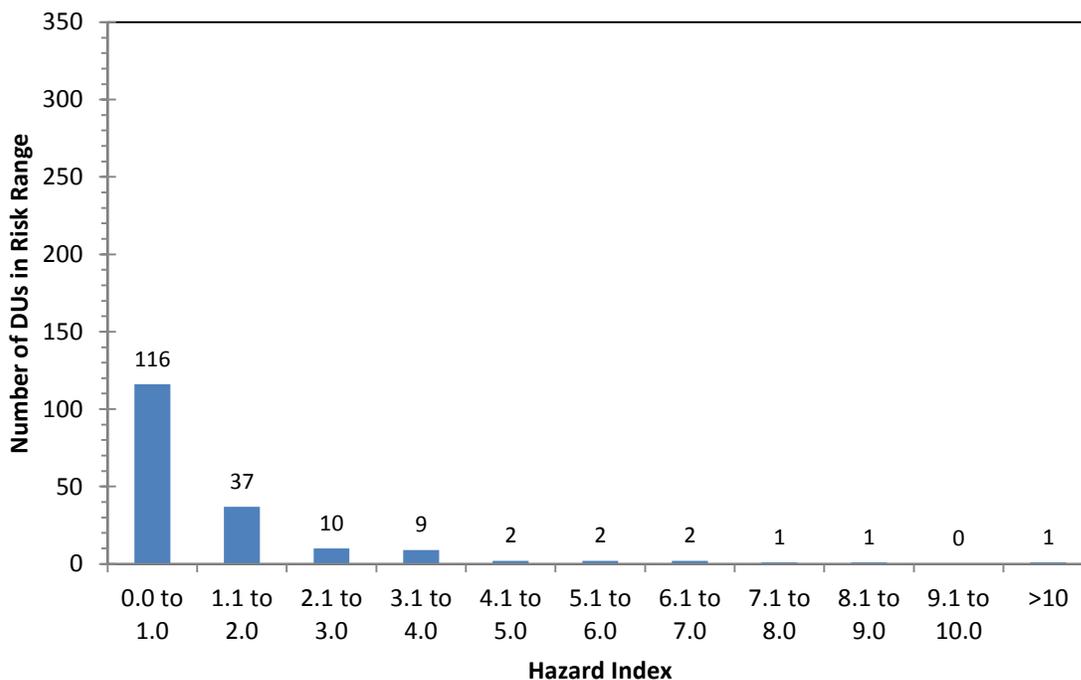


Figure 7-6. Earhart I-3: Distribution of Hazard Indices for DUs (0-12 inches) – 2006 EALs



7.3.3 Onizuka II-1 Neighborhood

Child Resident

Figure 7-7 identifies DUs within the Onizuka II-1 neighborhood with cumulative risks for the child resident exceeding the target risk level of 1×10^{-5} based on the soil sampling results collected within the 0 to 12-inch depth interval and the site-specific child resident 2006 HHRA Standard EALs. As indicated in the figure, nine DUs are associated with estimated risks for the residential child exceeding the target risk level of 1×10^{-5} . A histogram summarizing the distribution of the residential child cumulative risk estimates for all of the DUs located within the Onizuka II-1 neighborhood is presented in Figure 7-8.

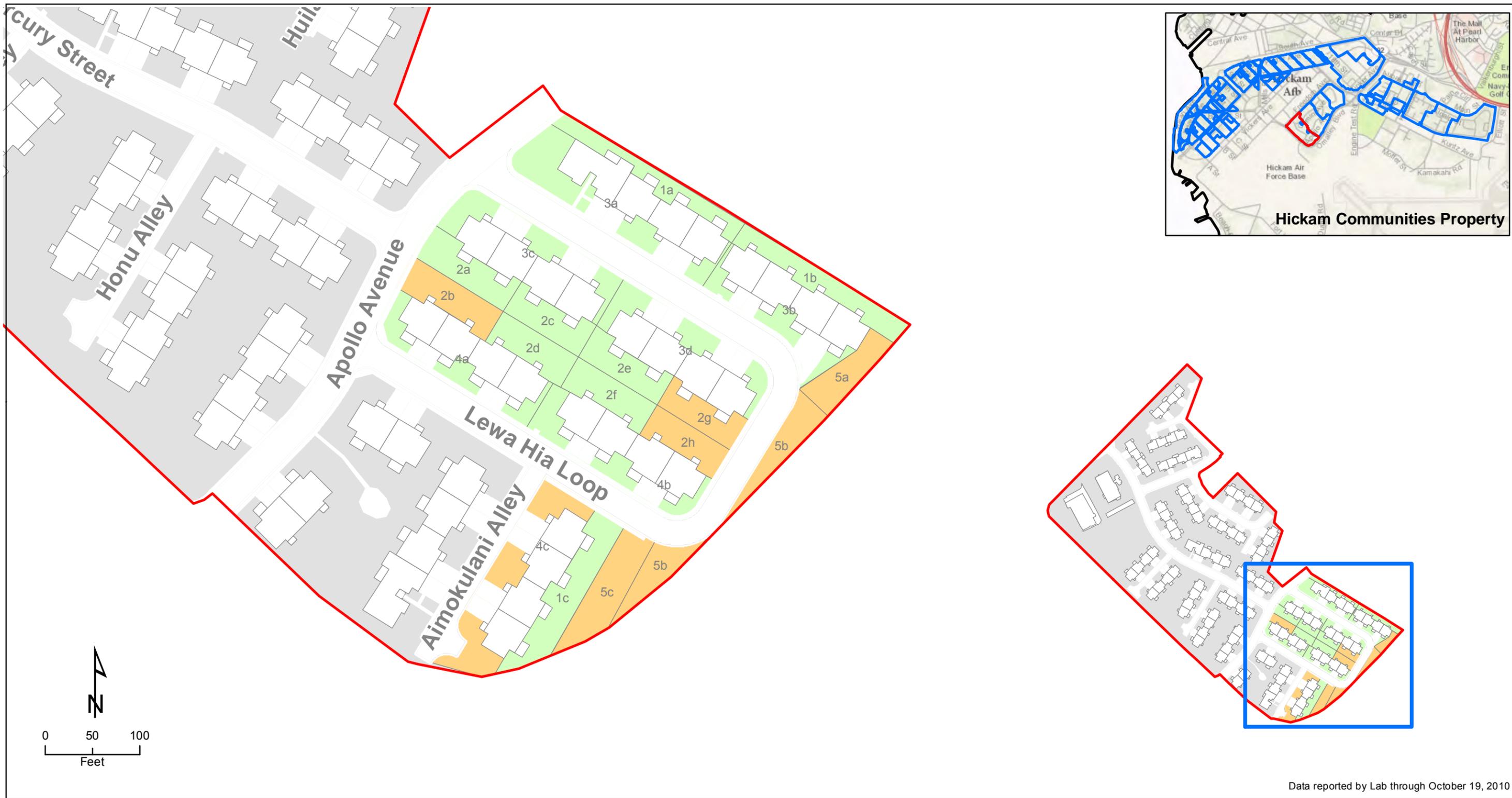
Within the Onizuka II-1 neighborhood, no DUs (21 total) are associated with an estimated HI for the residential child exceeding the target hazard level of 1.

7.3.4 Hale Na Koa I-1 Neighborhood

Child Resident

Within the Hale Na Koa I-1 neighborhood, no DUs (11 total) are associated with a cumulative risk exceeding the target risk level of 1×10^{-5} based on the soil sampling results collected within the 0 to 12-inch depth interval and the site-specific child resident 2006 HHRA Standard EALs (Figure 7-9).

Within the Hale Na Koa I-1 neighborhood, no DUs (11 total) are associated with an estimated HI for the residential child exceeding the target hazard level of 1 (Figure 7-10).



Data reported by Lab through October 19, 2010

**DUs with Cumulative Risks Exceeding Target Risk (0-12 inches) - 2006 EALs
Onizuka II-1**

Hickam Air Force Base, O'ahu, Hawai'i

- 4 b** Decision Unit Numbers
- Earhart Village I-3
- Hardscapes

Preliminary Risk Estimate (Based on 2006 Tier 2 EALs)

- ≤10-5 Carc. Risk
- >10-5 Carc. Risk

Notes:

- Inset map shows Hickam Communities Property Boundary Line.

Figure 7-7

Figure 7-8. Onizuka II-1: Distribution of Estimated Cumulative Risks for DUs (0-12 inches) – 2006 EALs

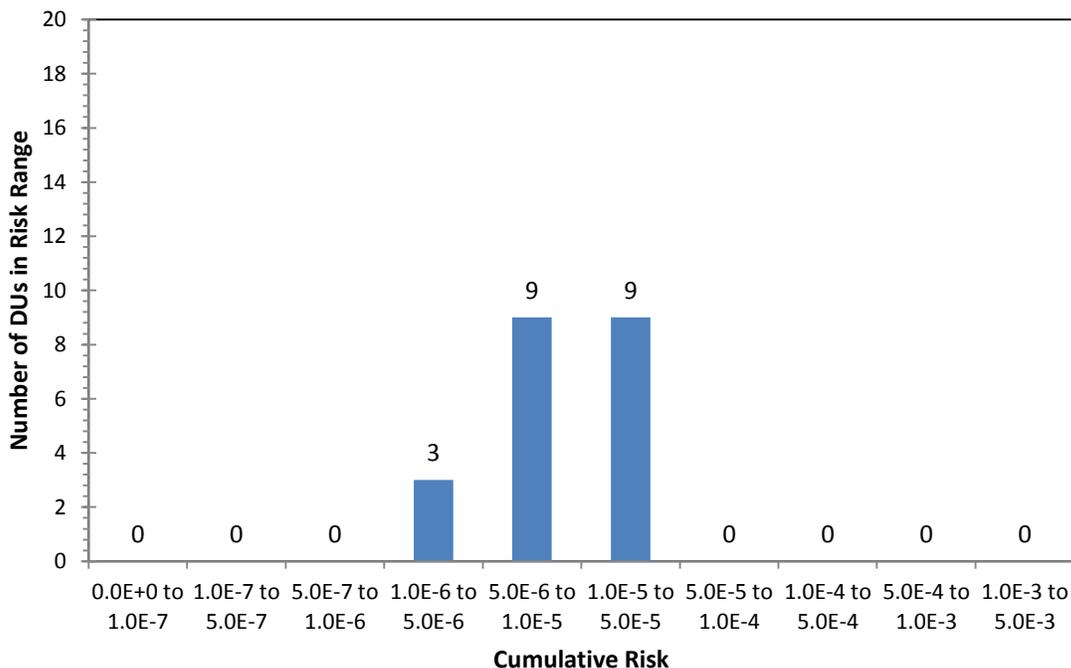
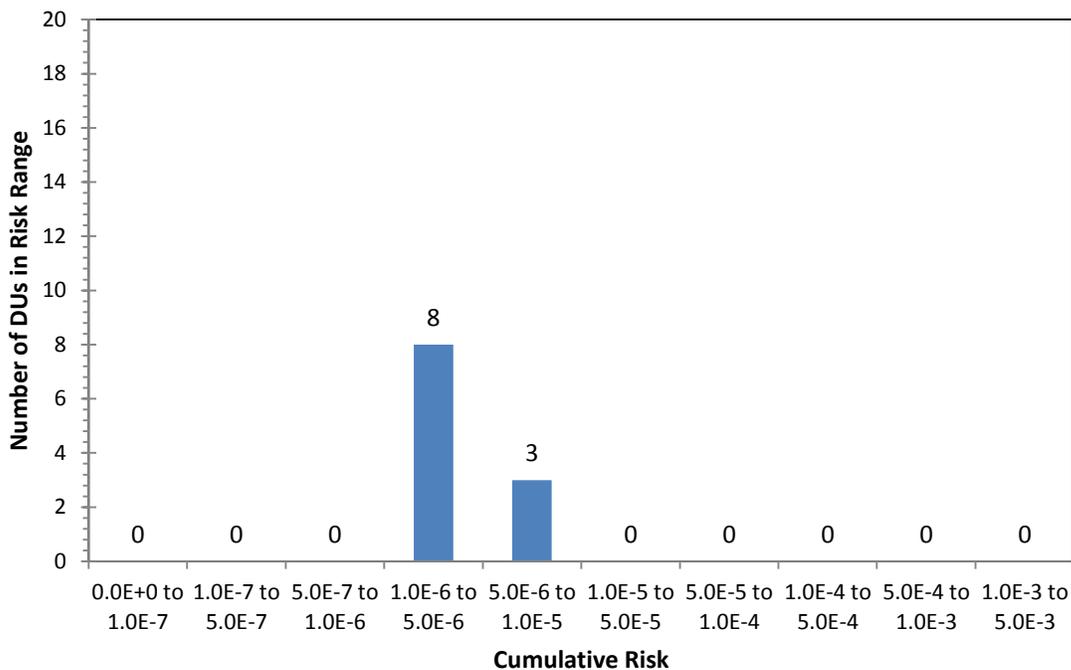
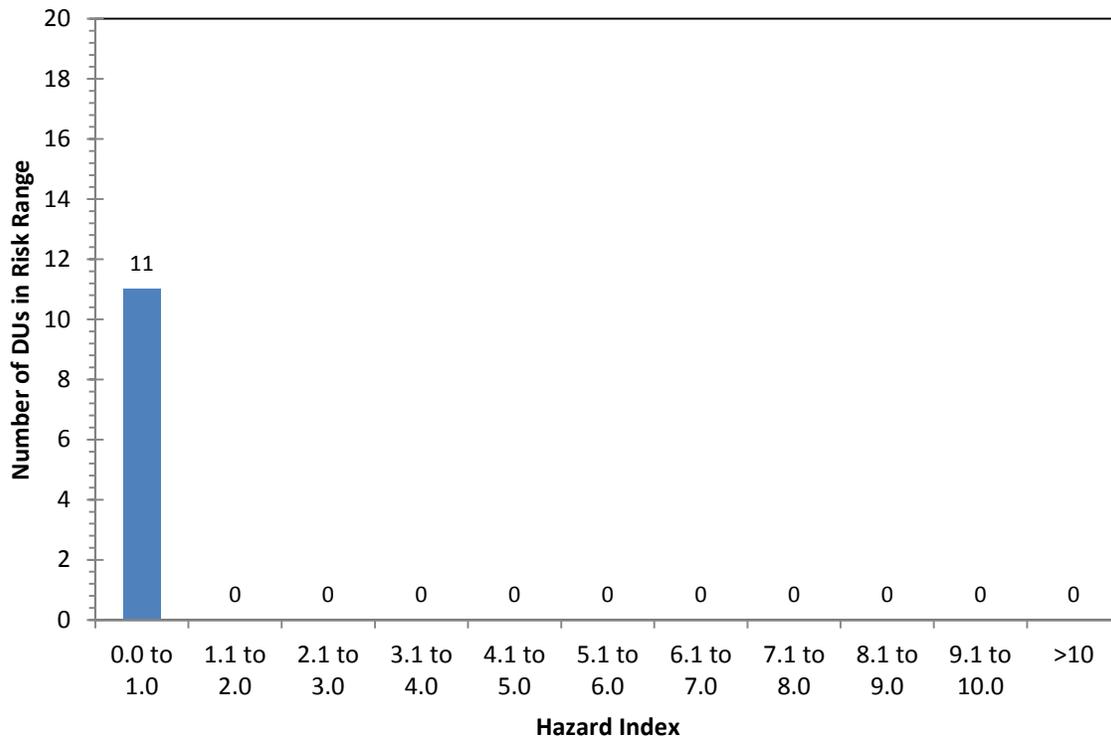


Figure 7-9. Hale Na Koa: Distribution of Cumulative Risks for DUs (0-12 inches)- 2006 EALs



**Figure 7-10. Hale Na Koa: Distribution of Hazard Indices for DUs
(0-12 inches)- 2006 EALs**



8.0 2011 AND 2012 REVISED ENVIRONMENTAL ACTION LEVELS

As described in Section 7, when measured concentrations of contaminants at a site exceed EALs, a more advanced evaluation of environmental hazard may be done in which EALs are refined to better reflect actual site conditions by incorporating site-specific considerations into the HDOH equations used to derive the default HDOH Tier 1 EALs. Based on discussions with HDOH, refined site-specific EALs protective of direct exposure (referred to as “2011 HC HHRE Standard”) were developed based on the following five adjustments to the 2006 HHRA Standard EALs:

- Cancer slope factors for aldrin and dieldrin;
- Target risk levels;
- Noncancer toxicity criteria for aldrin and dieldrin;
- Child soil ingestion rate; and
- Dermal absorption factors for aldrin and dieldrin.

In 2012, HDOH approved revisions to the EALs for chlordane proposed by HC. These combined revisions have been incorporated into the “2012 EHE Standard.” The exposure parameters, toxicity criteria, and methodology used to derive these revised EALs are described below.

8.1 Quantitative Exposure Analysis

Quantitative exposure analysis consists of estimates of the type, timing, and magnitude of exposures that potential human receptors may experience at the Site. In order to calculate the 2012 EHE Standard EALs protective of potential receptors, exposure parameters were determined for residential receptors based on HDOH guidance⁷⁸, EPA guidance⁷⁹, and site-specific information when available. Exposure parameters were estimated for current and future on-site receptors potentially exposed to COCs in soil at the Site via the complete exposure pathways identified in Section 6.1.3 (i.e., soil ingestion, dermal contact with soil, and inhalation of particulates). As described in more detail in Section 8.4, the lowest Site-specific EALs are associated with the residential scenario, and therefore, residential EALs are protective of other potential receptor populations (i.e., landscape/maintenance workers and construction workers). For this reason, only the exposure parameters for the residential receptors are described below and are also provided in Table 8-1 (refer to parameters listed under 2012 EHE Standard). The exposure parameters used to derive the 2006 HHRA Standard EALs are also presented in Table 8-1 for reference purposes.

⁷⁸ (HDOH 2009a, 2011a)

⁷⁹ (EPA 1989, 1991a, 1997a, 2002, and 2004)

Table 8-1. Summary of Parameters Used to Derive Site-Specific EALs for Hickam Neighborhoods

Parameter	Potentially Exposed Population							
	2006 Hickam EALs				2012 Site-Specific EALs			
	Child Resident		Adult Resident		Child Resident		Adult Resident	
Target Risk	1.0E-05	(a)	1.0E-05	(a)	1.0E-04	(b)	1.0E-04	(b)
Target Hazard Quotient	1	(a)	1	(a)	1	(b)	1	(b)
Inhalation of Particulates								
Inhalation Rate (m ³ /day)	10	(c)	20	(c)	10	(d)	20	(d)
Particulate Emission Factor (mg/kg)/(mg/m ³)	1.32E+09	(c)	1.32E+09	(c)	1.32E+09	(d)	1.32E+09	(d)
Ingestion of Soil								
Ingestion Rate (mg/day)	200	(c)	100	(c)	100	e	100	(d)
Dermal Contact with Soil								
Surface Area (cm ² /day)	2,800	(c)	5,700	(c)	2,800	(d)	5,700	(d)
Adherence Factor (mg/cm ²)	0.2	(c)	0.07	(c)	0.2	(d)	0.07	(d)
Absorption Factor - aldrin and dieldrin (unitless)	0.1	(c)	0.1	(c)	0.05	(e)	0.05	(e)
Population-Specific Assumptions								
Exposure Frequency (days/year)	350	(c)	350	(c)	350	(d)	350	(d)
Exposure Duration (years)	6	(a)	6	(a)	6	(a)	6	(a)
Body Weight (kg)	15	(c)	70	(c)	15	(d)	70	(d)
Averaging Time for Carcinogens (days)	25,550	(c)	25,550	(c)	25,550	(d)	25,550	(d)
Averaging Time for Noncarcinogens (days)	2,190	(c)	2,190	(c)	2,190	(d)	2,190	(d)
Toxicity Criteria								
<u>Cancer Slope Factor (mg/kg-day)⁻¹</u>								
Aldrin	17		(c),(f)		3.4			(e)
Dieldrin	16		(c),(f)		7			(e)
<u>Reference Dose (mg/kg-day)</u>								
Aldrin	3.00E-05		(c),(f)		1.00E-04			(e)
Dieldrin	5.00E-05		(c),(f)		8.00E-05			(e)

Notes:

- variables used to derive Alternative EALs that are different from those used to derive the 2006 Hickam EALs or differ from HDOH default parameters.

(a) Tetra Tech 2006a. HDOH default residential target risk is 1E-06 and the default target hazard quotient for residents is 0.2.

(b) HDOH 2011. Target risk for aldrin and dieldrin = 1 x 10⁻⁴. Target risk for other pesticides is 1 x 10⁻⁵. HDOH default residential target risk is 1E-06 and the default target hazard quotient for residents is 0.2.

(c) HDOH 2005

(d) HDOH 2008

(e) Tetra Tech 2011a - All chemical-specific toxicity criteria and dermal absorption factors used to derive 2012 EALs are summarized in Table 8-2.

(f) EPA 2011b

8.1.1 General Exposure Assumptions

Exposure parameters common to all exposure analyses are the exposure time, exposure frequency, exposure duration, body weight, and averaging time. The receptor-specific values used for these parameters are described below.

Exposure Time, Exposure Frequency, and Exposure Duration

The three parameters – exposure time, exposure frequency and exposure duration – together define the total extent of exposure of a receptor. The exposure time is the number of hours per day (or hours per event) during which a receptor is exposed; it is used to describe the inhalation pathway. The exposure frequency is the number of days per year (or events per year) on which exposure occurs. The exposure duration is the total number of years over which exposure occurs.

HDOH and EPA default values for residential exposure time and exposure frequency⁸⁰ are used for this evaluation. The exposure time is assumed to be 24 hours per day and the exposure frequency is assumed to be 350 days per year for both the adult and child resident. The value for the exposure frequency is based on the assumption that residents are present in their homes seven days a week for 50 weeks a year, with approximately two weeks (or 15 days) away from home.

For this evaluation, a residential exposure duration of 6 years was used for both adults and children rather than the default residential exposure duration of 30 years based on site-specific conditions. Since HAFB is a military base, the average length of stay in the on-base housing is shorter than in the general US population. For example, a study entitled Military-specific Exposure Factors Study by the USAF Research Laboratory⁸¹ determined that the mean number of years that USAF enlisted personnel are at a single base is 5.7 years and the mean for officers is 2.6 years. An additional study found that the duration of residency for personnel at HAFB is 5 years or less for approximately 98% of residents (HC and HAFB Housing Office 2006; refer to Appendix B). Based on these studies, HDOH approved a residential exposure duration of 6 years for the 2006 HHRA Standard EALs developed previously for HAFB for aldrin, chlordane, and dieldrin. The 6 year residential exposure duration has also been used to derive the 2012 EHE Standard EALs.⁸²

Body Weight

A default adult body weight of 70 kg was used for adult residential receptors and a default body weight of 15 kg is used for the child resident.⁸³

Averaging Time

The averaging times for estimating chemical intake depend on the type of effect being assessed. The basis for using different averaging times for carcinogens and noncarcinogens is related to the currently held scientific opinion that the mechanisms of action for the two categories of chemicals are different. In accordance with regulatory guidance (HDOH 2011a; EPA 1989), intakes for carcinogens are calculated by averaging the dose received over a lifetime (i.e., 70 years or 25,550 days). The 70-year averaging time is used for consistency with

⁸⁰ (HDOH 2011a; EPA 1991a)

⁸¹ (USAF RL 1998)

⁸² (HDOH 2011c, 2012)

⁸³ (HDOH 2011a; EPA 1989, 1991a)

the basis of the cancer slope factors ([CSFs] are discussed in Section 8.2.1). For noncarcinogens, the averaging time is equal to the exposure duration (in years) times 365 days per year.⁸⁴

8.1.2 Exposure Parameters for Ingestion of Soil

Individuals may be exposed to COCs by inadvertently ingesting contaminated soil. The intake is estimated as the amount of chemical at the exchange boundary (gastrointestinal tract). The exposure parameter specific to the soil ingestion pathway is the soil ingestion rate.

For potential residential receptors, the HDOH and EPA recommended default soil ingestion rates are 100 milligrams per day (mg/day) for adults and 200 mg/day for children.⁸⁵ For this evaluation, an alternative child soil ingestion rate of 100 mg/day was approved by HDOH⁸⁶ and used to evaluate potential exposure to children. This ingestion rate is the mean soil ingestion rate for children listed in EPA's Exposure Factors Handbook⁸⁷ and is considered to be more representative of site-specific conditions than the default child soil ingestion rate. This is due to the fact that there is a restriction on digging associated with the residential leases at HC and because engineering controls, such as maintaining good lawn cover, will likely be instituted as part to the long-term management of the site.

Additional Support for Use of an Alternative Child Soil Ingestion Rate

As described in the Revised *APRA Memo* submitted to HDOH (Tetra Tech 2010m), the New Zealand Ministry for the Environment (ME) recently conducted an extensive review of available literature regarding child soil ingestion rates and identified a median soil ingestion rate ranging from 20 to 30 mg/day and a mean ingestion rate of 60 mg/day. Based on their review, the New Zealand ME opted to use a child soil ingestion rate representing the midpoint between the median and mean values (i.e., 45 mg/day) for the development of their long-term dieldrin soil action level.

Additionally, Edward Calabrese, one of the leading investigators in the field of soil ingestion, recently reevaluated much of the earlier data from which the EPA default of 200 mg/day was developed and noted that a central tendency value is likely 20 mg/day with an upper bound (95th percentile) rate of 100 mg/day.⁸⁸

Based on the information discussed above, a child soil ingestion rate of 100 mg/day likely represents an upper bound estimate based on site-specific conditions.

8.1.3 Exposure Parameters for Dermal Contact with Soil

Individuals may be exposed to COCs in soil by direct contact with skin. For the dermal pathway, the intake is estimated as an absorbed dose, which is the amount of chemical that crosses the skin and passes into the bloodstream. The exposure parameters specific to the dermal pathway are the skin surface area (the area of skin in contact with soil), the amount of soil adhering to

⁸⁴ (HDOH 2011a; EPA 1989)

⁸⁵ (HDOH 2011a; EPA 1991a)

⁸⁶ (HDOH 2011c, 2012)

⁸⁷ (EPA 1997)

⁸⁸ (Calabrese 2003)

the skin (adherence factor), and the chemical-specific absorption fraction (i.e., the fraction of chemical in contact with the skin that crosses the skin barrier).

The adult resident is assumed to wear a short-sleeved shirt, shorts, and shoes; the exposed skin surfaces are the face, hands, forearms, and lower legs, corresponding to a default surface area of 5,700 square centimeters (cm²). The child resident is assumed to wear a short-sleeved shirt and shorts (no shoes); the exposed skin surfaces are the face, hands, forearms, lower legs, and feet, corresponding to a surface area of 2,800 cm².⁸⁹ For this evaluation, default soil adherence factors of 0.2 milligrams per square centimeter (mg/cm²) for the child resident and 0.07 mg/cm² for the adult resident were used.⁹⁰

The chemical-specific dermal absorption values for soil are presented in Table 8-2. With the exception of aldrin and dieldrin, the listed values correspond to HDOH and EPA recommended default values.⁹¹

For aldrin and dieldrin, the recommended default dermal absorption factor noted in HDOH guidance is 0.1. However, this is the generic default value recommended by EPA for organic compounds for which chemical-specific dermal absorption studies are not available. For chlorinated pesticides such as aldrin and dieldrin, a dermal absorption factor 0.05 is a commonly used as a default value. For example, it is the recommended default value used by the California Environmental Protection Agency (Cal/EPA)⁹² for chlorinated pesticides. Additionally, it is noteworthy that EPA⁹³ and HDOH⁹⁴ recommend a default absorption factor of 0.04 for chlordane, which is a structurally similar pesticide detected at the Site. As noted in EPA guidance⁹⁵, the default value for chlordane was derived based on a chemical-specific dermal absorption study. Based on this information, a dermal absorption factor of 0.05 was approved by HDOH⁹⁶ for both aldrin and dieldrin.

8.1.4 Exposure Parameters for Inhalation of Airborne Particulates

Individuals may be exposed to COCs in soil through inhalation of airborne particles released to air through wind erosion or mechanical disturbance. The exposure parameter specific to this pathway is the particulate emission factor (PEF).

Particulate Emission Factor

For this evaluation, the HDOH recommended PEF of 1.32×10^9 cubic meter per kilogram (m³/kg) is used to estimate airborne concentrations of non-volatile pesticides from corresponding soil concentrations for potentially exposed residents. This default residential PEF value was developed based on EPA screening guidelines⁹⁷ and is equivalent to an airborne dust concentration of approximately 0.76 microgram per cubic meter (µg/m³).

The particulate emission factor for inhalation of windblown soil particulates is presented in Table 8-1.

⁸⁹ (HDOH 2011a; EPA 2004)

⁹⁰ (HDOH 2005; EPA 2004)

⁹¹ (HDOH 2011a; EPA 2004)

⁹² (Cal/EPA 1999 and 2005)

⁹³ (EPA 2004)

⁹⁴ (HDOH 2011a)

⁹⁵ (EPA 2004)

⁹⁶ (HDOH 2011c, 2012)

⁹⁷ (EPA 1996a)

Table 8-2. Toxicity Criteria and Dermal Absorption Factors Used to Derive 2012 Site-Specific EALs

Chemical	Toxicity Criteria						Dermal Criteria	
	Cancer		Source	Noncancer		Source	Dermal Absorption Factor (Unitless)	Source
	Slope Factor (mg/kg-day) ⁻¹	Unit Risk Factor (ug/m ³) ⁻¹		Reference Dose (mg/kg-day)	Reference Concentration (mg/m ³)			
	Oral	Inhalation		Oral	Inhalation			
Aldrin ^(a)	3.4E+00	9.7E-04	Tetra Tech 2011a	1E-04	----	Tetra Tech 2011a	0.05	HDOH 2012
Chlordane ^(b)	3.5E-01	1.0E-04	IRIS; HDOH 2011a	3E-04	7E-04	HDOH 2012	0.04	EPA 2004; HDOH 2011a
Dieldrin ^(c)	7.0E+00	2.0E-03	Tetra Tech 2011b	8E-05	----	Tetra Tech 2011b	0.05	HDOH 2012
DDD	2.4E-01	6.9E-05	EPA 2011a; HDOH 2011a	----	----	IRIS; HDOH 2011a	0.1	EPA 2004; HDOH 2011a
DDE	3.4E-01	9.7E-05	EPA 2011a; HDOH 2011a	----	----	IRIS; HDOH 2011a	0.1	EPA 2004; HDOH 2011a
DDT	3.4E-01	9.7E-05	IRIS; HDOH 2011a	5E-04	----	IRIS; HDOH 2011a	0.03	EPA 2004; HDOH 2011a
Endrin	----	----	IRIS; HDOH 2011a	3E-04	----	IRIS; HDOH 2011a	0.1	EPA 2004; HDOH 2011a
Endrin ketone ^(d)	----	----	IRIS; HDOH 2011a	3E-04	----	d	0.1	d
Endosulfan II ^(e)	----	----	IRIS; HDOH 2011a	6E-03	----	e	0.1	e
Endosulfan sulphate ^(e)	----	----	IRIS; HDOH 2011a	6E-03	----	e	0.1	e
delta-BHC ^(f)	----	----	IRIS; HDOH 2011a	3E-04	----	f	0.04	f
Methoxychlor	----	----	IRIS; HDOH 2011a	5E-03	----	IRIS; HDOH 2011a	0.1	EPA 2004; HDOH 2011a

Notes: ---- = No cancer slope factor or noncancer reference dose available

DDD = Dichlorodiphenyldichloroethane

DDE = Dichlorodiphenyltrichloroethylene

█ - identifies parameters that differ from HDOH default parameters.

^(a) HDOH defaults: cancer slope factor = 17 (mg/kg-day)⁻¹, unit risk factor = 4.9E-03, oral reference dose (RfD) = 3 E-05 (mg/kg-day), and dermal absorption factor = 0.1.

^(b) HDOH default is 5E-04

^(c) HDOH defaults: cancer slope factor = 16 (mg/kg-day)⁻¹, unit risk factor = 4.6E-03, oral reference dose (RfD) = 5E-05 (mg/kg-day), and dermal absorption factor = 0.1.

^(d) Endrin is used as a surrogate for endrin ketone.

^(e) Endosulfan is used as a surrogate for endosulfan II and endosulfan sulfate.

^(f) Gamma-BHC (hexachlorocyclohexane [Lindane]) used as a surrogate for delta-BHC.

DDT = Dichlorodiphenyltrichloroethane

IRIS = Integrated Risk Information System (EPA 2012)

mg/kg = milligram per kilogram

8.2 Evaluation of Toxicity

Toxicity analysis is the process of identifying the relevant and appropriate toxicity values required for deriving environmental action levels. This process considers the characteristics of the potential exposure (e.g., chronic), the route of exposure (e.g., oral, inhalation, dermal), and the chemical-specific toxic response (e.g., carcinogenic and/or non-carcinogenic). All potential exposures of on-site receptors were treated as long-term chronic exposures regardless of exposure duration. Where appropriate, route-specific toxicity values were used.

In accordance with risk assessment guidelines, chemicals are evaluated for their potential health effects in two categories, carcinogens and noncarcinogens, with different methods used to estimate the potential for carcinogenic and noncarcinogenic health effects to occur. All chemicals produce noncarcinogenic effects at sufficiently high doses, however, only some chemicals are associated with carcinogenic effects. Regulatory agencies generally consider carcinogens to pose a cancer risk at all exposure levels (i.e., a “no-threshold” assumption); that is, any increase in dose is associated with an increase in the probability of developing cancer. In contrast, for reasons described below, noncarcinogens generally are thought to produce adverse health effects only when some minimum exposure level is reached (i.e., a threshold dose). As applicable, both carcinogenic and non-carcinogenic effects were considered in deriving environmental action levels.

Carcinogenic Effects

Current risk assessment practice for carcinogens is based on the assumption that there is no threshold dose below which carcinogenic effects do not occur and that carcinogenic processes are the same at high and low doses. This approach has generally been adopted by regulatory agencies as a conservative practice to protect public health. The “no-threshold” assumption was used in this EHE for evaluating carcinogenic effects. Therefore, the magnitude of the risk declines with decreasing exposure, however, the resulting risk is believed to be zero only at zero exposure. If there is in fact a threshold for carcinogenicity, actual risks could be zero at sufficiently low doses.

Noncarcinogenic Effects

For the purpose of assessing risks associated with noncarcinogenic effects, the EPA has adopted a science policy position that protective mechanisms such as repair, detoxification, and compensation must be overcome before an adverse noncarcinogenic health effect is manifested. Therefore, a range of exposures exists from zero to some finite value (i.e., a threshold) that can be tolerated by an organism without appreciable risk of adverse effects.

Sources of Toxicity Values

For this evaluation, HDOH recommended toxicity values⁹⁸ were used for all chemicals with the exception of aldrin and dieldrin. The HDOH recommended toxicity criteria were obtained from five primary sources. The sources are prioritized based on EPA guidance⁹⁹ as follows:

- EPA Integrated Risk Information System (IRIS)¹⁰⁰;

⁹⁸ (HDOH 2011a)

⁹⁹ (2003, 2011a)

¹⁰⁰ (EPA 2011b)

- EPA Provisional Peer Reviewed Toxicity Values (PPRTVs)¹⁰¹;
- The Agency for Toxic Substances and Disease Registry (ATSDR) minimal risk levels (MRLs);
- Cal/EPA Office of Environmental Health Hazard Assessment (OEHHA) cancer potency values and chronic reference exposure levels (RELs); and
- EPA Health Effects Assessment Summary Tables (HEAST)¹⁰².

Table 8-2 lists the toxicity values used in this assessment to derive the cancer and non-cancer EALs used to evaluate potential human health risks. Special issues associated with the assessment of aldrin and dieldrin are discussed in Sections 8.2.1 and 8.2.2.

8.2.1 Cancer Slope Factors for Aldrin and Dieldrin

The EPA released its quantitative risk assessment of the carcinogenicity of aldrin and dieldrin in 1987¹⁰³, which was conducted in accordance with EPA's guidelines for carcinogen risk assessments published in 1986¹⁰⁴. The current cancer (CSFs) for aldrin and dieldrin listed in EPA's Integrated Risk Information System, which were used to derive the 2006 HHRA Standard EALs¹⁰⁵ for these compounds, are still based on the 1987 risk assessment. In 1996, EPA published a draft document of proposed guidelines for carcinogen risk assessment, which incorporated revisions to the 1986 guidelines¹⁰⁶. In 2005, EPA published the final version of the updated guidelines for carcinogen risk assessment¹⁰⁷. The 2005 guidelines for carcinogen risk assessment indicate that the EPA recommended rationale and methods for developing cancer risk assessments have evolved substantially since 1986. EPA's 2005 guidelines provide the most scientifically appropriate options for evaluating the carcinogenic potential of chemicals to reflect what is currently known about the mechanisms by which chemicals cause cancer. This fact is also noted in HDOH's 2009 document, *Rationale for the Proposed Revisions to Department of Health Water Quality Standards*¹⁰⁸, which is a document that was produced to provide support for revisions to water quality standards that were being proposed for various reasons, one of which was "...to incorporate over 20 years of new nationwide scientific research to update standards that have been in effect since 1990 and are based on outdated USEPA recommendations."

Application of EPA's 2005 guidelines would result in CSFs for aldrin and dieldrin that are lower than the current aldrin and dieldrin CSFs listed in IRIS, which were obtained from the 1987 carcinogen risk assessment of these compounds. Thus, the 2006 HHRA Standard EALs calculated based on the current aldrin and dieldrin CSFs obtained from EPA's 1987 carcinogen risk assessment are lower (i.e., more conservative) than those that would be estimated if the 1987 slope factors were updated to be consistent with current EPA guidelines¹⁰⁹. This means that the 2006 HHRA Standard EALs are lower than required to be protective of human health.

¹⁰¹ (as cited in EPA 2011a)

¹⁰² (EPA 1997b)

¹⁰³ (EPA 1987)

¹⁰⁴ (EPA 1986)

¹⁰⁵ (Tetra Tech 2006a)

¹⁰⁶ (EPA 1996b)

¹⁰⁷ (EPA 2005)

¹⁰⁸ (HDOH 2009b, pages 1 and 4)

¹⁰⁹ (EPA 2005)

For this evaluation, the CSFs for aldrin and dieldrin incorporate two modifications/updates that are consistent with EPA's 2005 guidelines for carcinogen risk assessment. One modification entails updating the mathematical approach used by EPA for scaling experimental doses from rodents to humans and the other is the use of a benchmark dose to evaluate the cancer dose response assessment. Each of these modifications is described briefly below. The use of the updated CSFs for aldrin and dieldrin are supported by a toxicity evaluation conducted by Tetra Tech, which is included as Appendix D and provides supporting documentation regarding the derivation of the updated CSFs.

Inter-Species Scaling

Inter-species scaling factors are used to account for differences in body size between laboratory test species (mice in the cases of aldrin and dieldrin) and potential receptor species (e.g., humans) and is common practice in human health risk assessment.¹¹⁰ The current aldrin and dieldrin CSFs used by EPA, which were developed in 1987, are based on human equivalent doses calculated using a body weight ratio (rodent to human) to the 1/3 power¹¹¹. However, in 1992 an updated methodology for calculating inter-species scaling factors was adopted by EPA, the Food and Drug Administration, and the Consumer Products Safety Commission (CPSC) as a consensus approach for risk assessment of carcinogens¹¹². The updated scaling factor is based on a rodent to human body weight ratio to the 1/4 power and is the default approach for inter-species scaling as per EPA's 2005 Guidelines for Carcinogen Risk Assessment¹¹³. Similarly, the updated scaling factor based on a rodent to human body weight ratio to the 1/4 is also the default approach for the derivation of the oral reference dose (refer to Section 8.2.2).¹¹⁴

It is noteworthy that EPA applied this same modification to chlordane, which is another structurally similar pesticide detected at the site, when the CSF for chlordane was re-evaluated in 1997.

Benchmark Dose

The EPA cancer dose response assessment¹¹⁵ for aldrin and dieldrin used a linearized multistage model to estimate risk, which the Agency described as leading to an upper limit on risk. The current EPA approach to a cancer dose response assessment would be to use a benchmark dose.¹¹⁶

Cancer slope factors for aldrin and dieldrin based on a benchmark dose were developed using the same data used by EPA in its 1987 cancer risk estimates. The only exception to this was that only data sets comprised of two or more dose groups were used since the benchmark dose approach requires at least two dose groups and a control. When the benchmark dose approach was combined with the update to the inter-species scaling factor described above, the resulting CSFs for aldrin and dieldrin are 3.4 (mg/kg-day)⁻¹ and 7 (mg/kg-day)⁻¹, respectively.

¹¹⁰ (EPA 1992 and 2005)

¹¹¹ (EPA 1987)

¹¹² (EPA 1992)

¹¹³ (EPA 2005)

¹¹⁴ (EPA 2011c)

¹¹⁵ (EPA 1987)

¹¹⁶ (EPA 2000)

It is important to note that the modifications to the CSFs for aldrin and dieldrin presented in this document do not represent a departure from default procedures; but rather an update to the toxicity criteria for aldrin and dieldrin to reflect current risk assessment guidelines.

8.2.2 Noncancer Toxicity Criteria for Aldrin and Dieldrin

The current EPA oral reference doses (RfDs) for aldrin and dieldrin were derived using a lowest observed adverse effect level (LOAEL) and no observed adverse effect level (NOAEL), respectively. The current EPA approach would be to use a benchmark dose methodology. Tetra Tech derived updated RfDs of 1×10^{-4} mg/kg per day for aldrin and 8×10^{-5} mg/kg per day for dieldrin using the benchmark dose methodology (see Appendix D. The updated toxicity criterion for dieldrin is 1.6-fold higher than the oral RfD for dieldrin (i.e., 5×10^{-5} mg/kg-day) and the updated toxicity criterion for aldrin is roughly 3-fold higher than the oral RfD for aldrin (i.e., 3×10^{-5} mg/kg-day) listed in EPA's IRIS, which were used to develop the 2006 HHRA Standard EALs for aldrin and dieldrin. The use of the updated RfDs for aldrin and dieldrin are supported by a toxicity evaluation conducted by Tetra Tech, which is included as Appendix D, and provides supporting documentation regarding the derivation of the updated RfDs.

The updated RfDs for aldrin and dieldrin are quite similar to the RfD that was selected for these compounds as part of the analysis of potential interim removal alternatives. As indicated in the *APRA Memo* dated November 10, 2010¹¹⁷, an alternative oral reference dose (RfD) of 1×10^{-4} mg/kg per day (mg/kg-day) was used for aldrin and dieldrin. This noncancer toxicity criterion was originally developed by the World Health Organization (WHO) and the New Zealand Ministry for the Environment (ME) recently identified the same dose as its chronic tolerable daily intake. Similarly, Health Canada has also identified this dose as the chronic acceptable daily intake to derive the Canadian maximum acceptable concentration for aldrin and dieldrin in drinking water.

As indicated above, it is important to note that the modifications to the reference doses presented in this document do not represent a departure from default procedures; but rather an update to the toxicity criteria for aldrin and dieldrin to reflect current risk assessment guidelines.

8.2.3 Noncancer Toxicity Criteria for chlordane

The current EPA oral RfD for chlordane is based on hepatic necrosis (NOAEL = 0.15 mg/kg-day; LOAEL = 0.75 mg/kg-day) after chronic dietary exposure in mice. The current EPA approach would be to use a benchmark dose methodology. Tetra Tech derived an updated oral RfD of 3×10^{-4} mg/kg per day using the benchmark dose methodology (see Appendix F), which was approved by HDOH (2012). The updated toxicity criterion for chlordane is 1.6-fold lower than the oral RfD for chlordane (i.e., 5×10^{-4} mg/kg-day) listed in EPA's IRIS website, which were used to develop the noncancer 2006 HHRA Standard EAL for chlordane.

8.3 Target Risk Levels

The 2006 HHRA Standard EALs¹¹⁸ for aldrin, chlordane, and dieldrin were developed based on a target risk level of 1×10^{-5} . As noted in the 2006 EAL document, the target risk level of 1×10^{-5}

¹¹⁷ (Tetra Tech 2010m)

¹¹⁸ (Tetra Tech 2006d)

⁵ is within the EPA (1990) acceptable risk range of 1×10^{-6} to 1×10^{-4} . Additionally, the Hawai'i State Contingency Plan, Chapter 11-451, Hawai'i Administrative Rules (1995) states, "For known or suspected carcinogens acceptable cleanup levels are generally concentration levels that represent an excess upper bound lifetime cancer risk to an individual of between 10^{-4} and 10^{-6} using information on the relationship between dose and response."

As noted in EPA (1991b) guidance, EPA uses the general 10^{-4} to 10^{-6} range as a target range within which the Agency strives to manage risks. It is also noted that the upper boundary of the risk range is not a discrete line at 1×10^{-4} , although EPA generally uses 1×10^{-4} in making risk management decisions. Additionally, it is noted that in certain cases EPA may consider risk estimates slightly greater than 1×10^{-4} to be protective if justified based on site-specific conditions.

In addition to the fact that 1×10^{-4} represents the upper end of the EPA target risk range, there is also uncertainty in regard to whether or not aldrin and dieldrin should even be classified as human carcinogens. For example, EPA¹¹⁹ considered aldrin and dieldrin to be probable human carcinogens based on liver tumors in mice, but the mode of action for liver tumors in mice may not be applicable to humans. Additionally, the National Toxicology Program¹²⁰ does not consider aldrin or dieldrin to be human carcinogens or to be reasonably anticipated to be human carcinogens. The International Agency for Research on Cancer (IARC 1987) concluded that aldrin and dieldrin could not be classified as to their carcinogenicity in humans. Studies published since the EPA (1987) and IARC (1987) reports provide no evidence of a causal association between aldrin and dieldrin and an excess risk of cancer in humans. The WHO (2008) accepted the IARC classification of aldrin and dieldrin and went on to state that, "It is considered that all available information on aldrin and dieldrin taken together, including studies on humans, supports the view that, for practical purposes, these chemicals make very little contribution, if any, to the incidence of cancer in humans."

2012 EHE Standard

For this evaluation, the soils within each DU are evaluated using the 2012 Environmental Health Evaluation (EHE) standard developed by HC and approved by HDOH.¹²¹ As per the HDOH-approved 2012 EHE standard, a DU is not considered to pose a threat to human health and the environment due to organochlorine pesticides if all of the following criteria are met: (1) the cumulative excess cancer risk (ECR) for aldrin plus dieldrin must not exceed 1×10^{-4} ; (2) the cumulative ECR for all other organochlorine pesticides must not exceed 1×10^{-5} ; (3) the cumulative ECR for all COPCs must not exceed 1×10^{-4} ; and (4) the hazard index for all COPCs must not exceed 1. If any of these criteria are not met, then the soil within the DU is considered to pose a threat to human health and the environment and must be treated accordingly.

8.4 Derivation of Site-Specific EALs for Direct Exposure to Soil

This section presents the derivation of the cancer and non-cancer residential EALs for soil. The EALs represent chemical concentrations in soil corresponding to a cancer risk of 1×10^{-4} for aldrin and dieldrin, a cancer risk of 1×10^{-5} for other carcinogenic pesticides, or a hazard

¹¹⁹ (EPA 1987)

¹²⁰ (NTP 2010)

¹²¹ (Tetra Tech 2011b, 2011c, 2011d, 2012)

quotient of one (1) and are derived using the exposure parameters and toxicity values discussed in Sections 8.1 and 8.2. The exposure pathways included in the development of the residential soil EALs are ingestion of soil, dermal contact with soil, and inhalation of particulates released from soil.

The residential soil EALs for individual chemicals are calculated using the following equations:

For carcinogens,

$$EAL_{Carc} = \frac{TR \times AT}{EF \times ED \times \left[\left(\frac{IR \times SF_o}{BW \times 10^6 \text{ mg/kg}} \right) + \left(\frac{SA \times AF \times ABS \times SF_o}{BW \times 10^6 \text{ mg/kg}} \right) + \left(\frac{ET \times (1 \text{ day}/24 \text{ hrs}) \times URF \times 10^3 \text{ ug/mg}}{PEF} \right) \right]}$$

and for noncarcinogens,

$$EAL_{NC} = \frac{THQ \times AT}{EF \times ED \times \left[\left(\frac{IR}{BW \times RfD_o \times 10^6 \text{ mg/kg}} \right) + \left(\frac{SA \times AF \times ABS}{BW \times RfD_o \times 10^6 \text{ mg/kg}} \right) + \left(\frac{ET \times (1 \text{ day}/24 \text{ hrs})}{PEF \times RfC} \right) \right]}$$

where:

EAL_{Carc}	=	EAL concentration for soil, based on the cancer endpoint
TR	=	Target risk level for carcinogens (unitless, set equal to 1×10^{-4} for aldrin & dieldrin and 1×10^{-5} for other carcinogenic pesticides)
AT	=	Averaging time - the period over which exposure is averaged (days)
EF	=	Exposure frequency (days/year)
ED	=	Exposure duration (years)
IR	=	Soil ingestion rate (milligrams [mg] per day)
SF_o	=	Oral cancer slope factor ([mg chemical/kg body weight [bw]-day] ⁻¹)
BW	=	Body weight (kilograms [kg])
SA	=	Surface area of exposed skin (square centimeters [cm ²]/day)
AF	=	Soil-to-skin adherence factor (mg/cm ²)
ABS	=	Absorption fraction (unitless)
ET	=	Exposure time (hours/day)
URF	=	Inhalation unit risk factor ($\mu\text{g}/\text{m}^3$) ⁻¹
PEF	=	Particulate emission factor (kg/m^3)
EAL_{NC}	=	EAL concentration for soil, based on the noncancer endpoint
THQ	=	Target hazard quotient (unitless; set equal to 1)
RfD_o	=	Oral reference dose (mg chemical/kg bw-day)
RfC	=	Reference concentration - inhalation (mg/m^3)

The exposure parameters and toxicity values used in these equations were discussed in Sections 8.1 through 8.2 and are summarized in Tables 8-1 through 8-3. The chemical-specific

cancer and non-cancer soil EALs for the child and adult resident are presented in Table 8-4. As indicated above in Section 8.1, the Site-specific EALs for the residential scenario (i.e., child resident) are the lowest Site-specific EALs, and therefore, are protective of potential worker populations. This is due primarily to children having a higher assumed exposure frequency and a higher assumed soil ingestion rate per unit body weight.

8.5 Risk Characterization – Comparison of Site Concentrations to 2012 EHE Standard

Potential environmental hazards were characterized for residential receptors using the ratio of soil concentrations measured at the Site to the receptor-specific and chemical-specific residential soil 2012 EHE Standard EALs. The risk characterization process consists of three components: (1) estimating exposure point concentrations (EPCs) within each decision unit; (2) specifying the target risk and hazard quotient used to derive the EALs; and (3) comparing the EPCs to the soil EALs to estimate risks and hazards for each receptor. Each of these steps is described below.

Table 8-3. 2012 Site-Specific Environmental Action Levels (EALs) Equations and Parameters

EAL for carcinogens:				
$C_s = \frac{TR \times AT}{EF \times ED \times \left[\left(\frac{IR \times SF_o}{BW \times 10^6 \text{ mg/kg}} \right) + \left(\frac{SA \times AF \times ABS \times SF_o}{BW \times 10^6 \text{ mg/kg}} \right) + \left(\frac{ET \times (1 \text{ day} / 24 \text{ hours}) \times URF \times 10^3 \text{ ug/mg}}{PEF} \right) \right]}$				
EAL for non-carcinogens:				
$C_s = \frac{THQ \times AT}{EF \times ED \times \left[\left(\frac{IR}{BW \times RfD_o \times 10^6 \text{ mg/kg}} \right) + \left(\frac{SA \times AF \times ABS}{BW \times RfD_o \times 10^6 \text{ mg/kg}} \right) + \left(\frac{ET \times (1 \text{ day} / 24 \text{ hours})}{PEF \times RfC} \right) \right]}$				
Variable	Parameter	Value	Units	Source/Rationale
C _s	Concentration in soil		mg/kg	Units for soil
TR	Target Risk			
	Aldrin and Dieldrin	1.00E-04	unitless	HDOH 2011a (HDOH residential default = 1.0E-06)
	Other chemicals	1.00E-05	unitless	HDOH 2011a (HDOH residential default = 1.0E-06)
THQ	Target Hazard Quotient	1	unitless	EPA 1989; HDOH 2011b
BW	Body Weight			
	Adult resident	70	kg	EPA 1989, 1991; HDOH 2011b
	Child resident	15	kg	EPA 1989, 1991; HDOH 2011b
AT	Averaging Time			
	Carcinogens	70 years x 365 days/year		Lifetime (EPA 1989; HDOH 2011b)
	Non-carcinogens	ED x 365 days/year		EPA 1989; HDOH 2011b
EF	Exposure Frequency			
	Adult resident	350	days/year	EPA 1991; HDOH 2011b
	Child resident	350	days/year	EPA 1991; HDOH 2011b
ED	Exposure Duration			
	Adult resident	6	years	Tetra Tech 2006a, HDOH 2011 (HDOH default = 30 years)
	Child resident	6	years	USEPA 1991; HDOH 2011b (HDOH default = 30 years)
IR	Soil Ingestion Rate			
	Adult resident	100	mg/day	USEPA 1991; HDOH 2011b
	Child resident	100	mg/day	Tetra Tech 2011a (HDOH default = 200 mg/day)
SF _o	Oral/dermal carcinogenic slope factor	chemical-specific	(mg/kg-day) ⁻¹	(refer to Table 3)
URF	Unit Risk Factor (inhalation)	chemical-specific	(µg/m ³) ⁻¹	(refer to Table 3)
RfD _o	Oral/dermal reference dose	chemical-specific	mg/kg-day	(refer to Table 3)
RfC	Reference Concentration (inhalation)	chemical-specific	mg/m ³	(refer to Table 3)
SA	Skin Surface Area			
	Adult resident	5,700	cm ²	USEPA 2004; HDOH 2011b
	Child resident	2,800	cm ²	USEPA 2004; HDOH 2011b
AF	Soil Adherence Factor			
	Adult resident	0.07	mg/cm ²	USEPA 2004; HDOH 2011b
	Child resident	0.2	mg/cm ²	USEPA 2004; HDOH 2011b
ABS	Absorption Fraction	chemical-specific	unitless	(refer to Table 3)
PEF	Particulate Emissions Factor	1.32E+09	m ³ /kg	USEPA 1996; HDOH 2011b
ET	Exposure Time (resident)	24	hours/day	USEPA 1991; HDOH 2011b

Notes: [shaded] - variables used to derive site-specific EALs that differ from HDOH default parameters.

Table 8-4. 2012 Site-Specific Environmental Action Levels (EALs) for Soil - Child and Adult Residents^(a)

Chemical ^(b)	HC Site-Specific Soil Screening Levels (mg/kg)				Final EAL
	Child		Adult		
	Cancer-based	Noncancer-based	Cancer-based	Noncancer-based	
	Target Risk ^(c)	Target HQ = 1	Target Risk ^(c)	Target HQ = 1 ^(d)	
Aldrin	42.1	12.2	209.4	60.9	12.2
Chlordane ^(d)	42.6	38.3	219.8	188.8	38.3
Dieldrin	20.4	9.8	101.4	48.7	9.8
DDD	48.7	-	253.6	-	48.7
DDE	34.4	-	179	-	34.4
DDT	46	67	223.7	326	46
Endrin	-	30.1	-	156.5	30.1
Endrin ketone ^(e)	-	30.1	-	156.5	30.1
Endosulfan sulfate ^{(e), (f)}	-	601.6	-	3,130.5	601.6
delta-BHC ^{(e), (f)}	-	38.3	-	188.9	38.3
Methoxychlor ^{(e), (f)}	-	501.4	-	2,609	501.4

Notes:

HC = Hickam Communities mg/kg = milligram per kilogram
 HQ = Hazard quotient HDOH = Hawaii Department of Health

^(a) EALs listed in this table were derived based on the EAL equations listed in HDOH Guidance (HDOH 2011) and presented in Table 8-3 using the child and adult parameters listed in Table 8-1 and the toxicity/dermal criteria summarized in Table 8-2. A summary of modifications to default HDOH parameters is as follows:

Modifications to Chemical-Specific Parameters

- 1) Aldrin - cancer slope factor modified to $3.4 \text{ (mg/kg-day)}^{-1}$, oral reference dose (RfD) modified to $1 \times 10^{-4} \text{ (mg/kg-day)}$, and dermal absorption factor modified to 0.05.
- 2) Dieldrin - cancer slope factor modified to $7 \text{ (mg/kg-day)}^{-1}$, oral reference dose (RfD) modified to $8 \times 10^{-5} \text{ (mg/kg-day)}$, and dermal absorption factor modified to 0.05.

Modifications to Site-Specific Parameters

- 3) Target Risk - target risk for aldrin and dieldrin modified to 1×10^{-4} ; target risk for other pesticides is 1×10^{-5} .
- 4) Target hazard quotient (HQ) - HQ = 1 for all chemicals.
- 5) Exposure duration - assumed to be 6 years for adult and child residents
- 6) Child soil ingestion rate - soil ingestion rate for residential child modified to 100 mg/day based on site-specific considerations.

^(b) All organochlorine pesticides detected in soil as part of site investigation activities conducted at the site in 2010 are included in this table.

^(c) As indicated in Footnote a, the target risk of 1×10^{-4} applies only to aldrin and dieldrin.

^(d) Chlordane is representative of technical chlordane which consists of chlordane isomers, heptachlor, and heptachlor epoxide. For this reason, other chlordane isomers, heptachlor, and heptachlor epoxide are evaluated as chlordane and are not listed individually in this table.

^(e) Endrin used as a surrogate for endrin ketone; endosulfan used as a surrogate for endosulfan II and endosulfan sulfate; and gamma-BHC (Lindane) used as a surrogate for delta-BHC.

^(f) Listed chemical detected at low levels in one sample.

8.5.1 Exposure Point Concentrations

As indicated in Section 6.5, the representative EPCs used in this evaluation were determined in accordance with HDOH guidelines based on multi-increment soil samples collected within each of the identified DUs. As described in HDOH guidance (HDOH 2011a), multi-increment sampling data typically have low variability and high reproducibility, which results in a high level of confidence for decision making.

8.5.2 Risk and Hazard Calculations

The EALs were calculated for a specified target risk of 1×10^{-4} for aldrin and dieldrin, 1×10^{-5} for other carcinogenic pesticides, and a target HQ of 1 for the noncancer endpoint. Therefore, soil concentrations greater than the EALs represent carcinogenic risks or hazards proportionally greater than the corresponding target risk or target hazard. Similarly, concentrations less than the EALs represent carcinogenic risks or hazards proportionally less than the target risk or hazard.

Potential risks are estimated as follows, using the ratio of each COC's representative soil concentration and its corresponding soil EAL:

$$Risk = \frac{\text{Soil Concentration}}{EAL_{\text{Cancer}}} \times (10^{-4} \text{ aldrin dieldrin}, 10^{-5} \text{ other carcinogen s})$$

Potential hazards are estimated in a similar manner as follows:

$$Hazard = \frac{\text{Soil Concentration}}{EAL_{\text{Noncancer}}}$$

In accordance with HDOH and EPA guidance, the risk and hazard ratios for each chemical and potentially complete exposure pathway were summed to determine the multi-pathway carcinogenic risk estimates and noncarcinogenic HI for potentially exposed receptors. The multi-incremental soil sampling results and corresponding estimated risks and hazards (chemical-specific and cumulative) for all of the identified DUs are presented in Appendix E. These results are discussed in more detail in Section 9.

8.5.3 Target Risk and Hazard Levels – 2012 EHE Standard

For this evaluation, the soils within each DU are evaluated using the 2012 EHE standard developed by HC and approved by HDOH.¹²² As per the HDOH-approved 2012 EHE standard, a DU is not considered to pose a threat to human health and the environment due to organochlorine pesticides if all of the following criteria are met: (1) the cumulative ECR for aldrin plus dieldrin must not exceed 1×10^{-4} ; (2) the cumulative ECR for all other organochlorine pesticides must not exceed 1×10^{-5} ; (3) the cumulative ECR for all COPCs must not exceed 1×10^{-4} ; and (4) the hazard index for all COPCs must not exceed 1.0. If any of these criteria are not met, then the soil within the DU is considered to pose a threat to human health and the environment and must be treated accordingly.

¹²² (Tetra Tech 2011b; HDOH 2011b and 2011c)

9.0 SUMMARY OF POTENTIAL ENVIRONMENTAL HAZARDS

This section presents an evaluation of the retained potential environmental hazards identified in Section 5. Potentially exposed receptors are evaluated based on current and expected future conditions at the Site using the site-specific 2012 EHE Standard EALs summarized in Section 8.

9.1 Direct Exposure Evaluation

The residential EALs for the contaminants of concern in soil for the direct exposure hazard are summarized in Table 8-4. As described above, the direct exposure EALs for residential receptors were developed based on the following exposure pathways:

- Incidental ingestion of soil;
- Dermal contact with soil; and
- Inhalation of airborne particulates.

Of these direct exposure pathways, the majority of the estimated risk and hazard is associated with soil ingestion with only minor contributions from dermal contact and inhalation. The results of the direct exposure evaluation are presented below for each neighborhood. As described in Section 8, the lowest site-specific EALs are associated with the child resident and, therefore, are protective of adult residents and potential worker populations. As shown in Table 8-4, the child-specific EALs are roughly 5-fold lower (i.e., more conservative) than the EALs developed for adult residents. For this reason, only the evaluation results for the child resident are discussed/summarized below. The estimated risks and hazards associated with potential residential child and adult exposures for all DUs are summarized in Appendix E.

9.1.1 Earhart I-2 Neighborhood

Child Resident

Table 9-1 summarizes the DUs within the Earhart I-2 neighborhood with cumulative risks for the child resident exceeding at least one of the HDOH cumulative risk criteria associated with the 2012 EHE standard (described in Section 8.5.3) based on the soil sampling results collected within the 0 to 12-inch depth interval and the site-specific 2012 EHE Standard EALs. As indicated in the table, two DUs (DU-37a and DU-15b) are associated with estimated cumulative risks exceeding at least one of the HDOH cumulative risk criteria. The locations of these DUs, where contaminants have the potential to pose a direct exposure risk, are shown in Figure 9-1. A histogram summarizing the distribution of the residential child cumulative risk estimates for all of the DUs located within the Earhart I-2 neighborhood is presented in Figure 9-2. As indicated in the histogram, the vast majority of DUs are associated with cumulative risk estimates less than 5×10^{-5} .

As shown in Table 9-1, a total of 19 DUs are associated with an estimated HI for the residential child exceeding the target hazard level of 1. The locations of these DUs, where contaminants in soil have the potential to pose a direct exposure hazard, are shown in Figure 9-4. A histogram summarizing the distribution of the estimated HIs for the residential child for all of the DUs located within the Earhart I-2 neighborhood is presented in Figure 9-5. As indicated in the histogram, all of the estimated HIs exceeding the target level of 1 are less than 4 with most (i.e., 15 out of 19) being between 1 and 2.

Table 9-1. Evaluation of Decision Units with Cumulative ECRs and Hazard Indices Exceeding Target Levels^{(a),(b)}

Decision Unit ^(c)	Cumulative ECR - Child Resident		HI Screening - Child Resident ^(d)	
	ECR (0-6 inches)	ECR (6-12 inches)	HI (0-6 inches)	HI (6-12 inches)
<u>Earhart I-2</u>				
27d	(e)	(e)	1.46	2.19
38d	(e)	(e)	1.35	0.89
11b	(e)	(e)	1.34	1.28
15b	5.5E-05	1.1E-04	1.34	3.01
42b	(e)	(e)	1.22	2.43
37a	4.5E-05	1.2E-04	1.21	3.44
23b	(e)	(e)	1.14	0.31
29a	(e)	(e)	1.08	0.57
14c	(e)	(e)	1.07	0.48
23a	(e)	(e)	1.06	1.36
42a	(e)	(e)	0.95	2.06
19b	(e)	(e)	0.90	1.80
35b	(e)	(e)	0.89	1.25
27c	(e)	(e)	0.88	1.67
15c	(e)	(e)	0.72	1.15
30f	(e)	(e)	0.70	1.85
28d	(e)	(e)	0.54	1.48
23d	(e)	(e)	0.52	1.06
30e	(e)	(e)	0.35	1.27
<u>Earhart I-3</u>				
12b	(e)	(e)	1.50	2.90
34c	(e)	(e)	1.49	0.39
20a	(e)	(e)	1.21	1.90
33c	(e)	(e)	1.19	0.95
4b	(e)	(e)	0.68	1.62
14b	(e)	(e)	0.27	1.12
12d	(e)	(e)	0.21	1.14
33b	(e)	(e)	0.22	1.40

Notes:

ECR = Excess cancer risk

HI - Hazard index

■ = DUs where the estimated HI for surface soil (i.e., 0-6 inch depth interval) are below target HI of 1.

(a) No other decision units within the Site had cumulative ECRs or HIs exceeding the four HDOH target risk and hazard criteria associated with the HC 2012 EHE standard (HDOH 2011c, 2012), which are as follows:

Criteria #1 - the cumulative ECR for aldrin plus dieldrin must not exceed 1×10^{-4}

Criteria #2 - the cumulative ECR for all other organochlorine pesticides must not exceed 1×10^{-5}

Criteria #3 - the cumulative ECR for all chemicals of potential concern (COPCs) must not exceed 1×10^{-4}

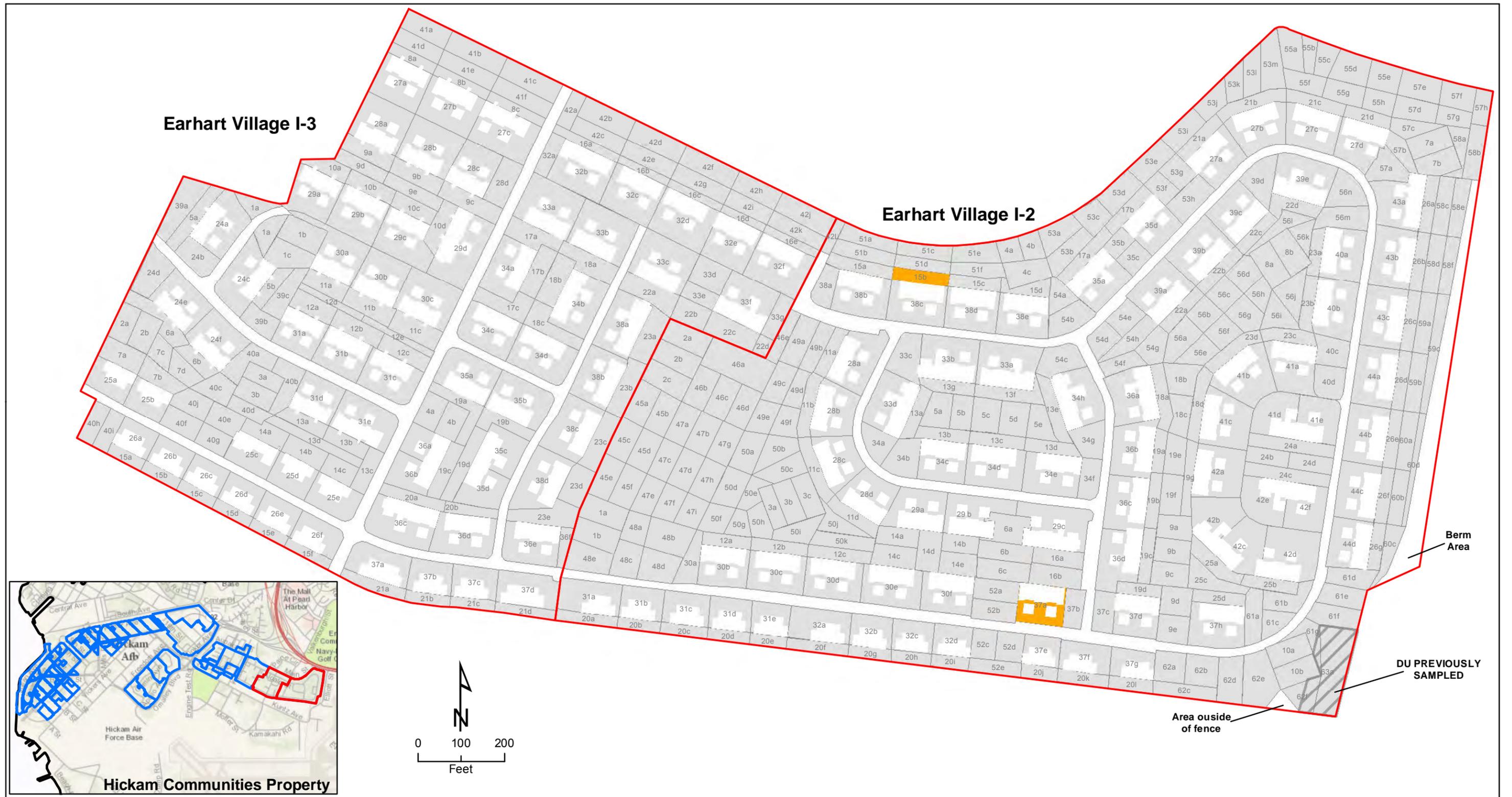
Criteria #4 - the hazard index for all COPCs must not exceed 1.0.

(b) The chemical-specific risks and cumulative ECRs and HIs for all DUs are presented in Appendix E.

(c) No decision units within the Onizuka II-1 or Hale Na Koa neighborhoods were associated with a hazard index exceeding the target HI of one for the child resident.

(d) Target HI is 1 (Criteria #4 in footnote a).

(e) Cumulative ECR does not exceed target risk criteria associated with the HC 2012 EHE standard (see footnote a).



Cumulative Risk

Exceeds HDOH 2011 HHRE Standard target risk criteria

Earhart Village I-2/I-3

Decision Unit Numbers

Hardscapes

Notes:

- Inset map shows Hickam Communities Property Boundary Line.

Earhart I-2 and Earhart I-3: DUs with Cumulative Risks Exceeding Target Risk (0-12 inches) - 2012 EALS

Hickam Communities
Joint Base Pearl Harbor-Hickam, Hawai'i

Figure 9-1

Figure 9-2. Earhart I-2: Distribution of Estimated Cumulative Risks for DUs (0-12 inches) – 2012 EALs

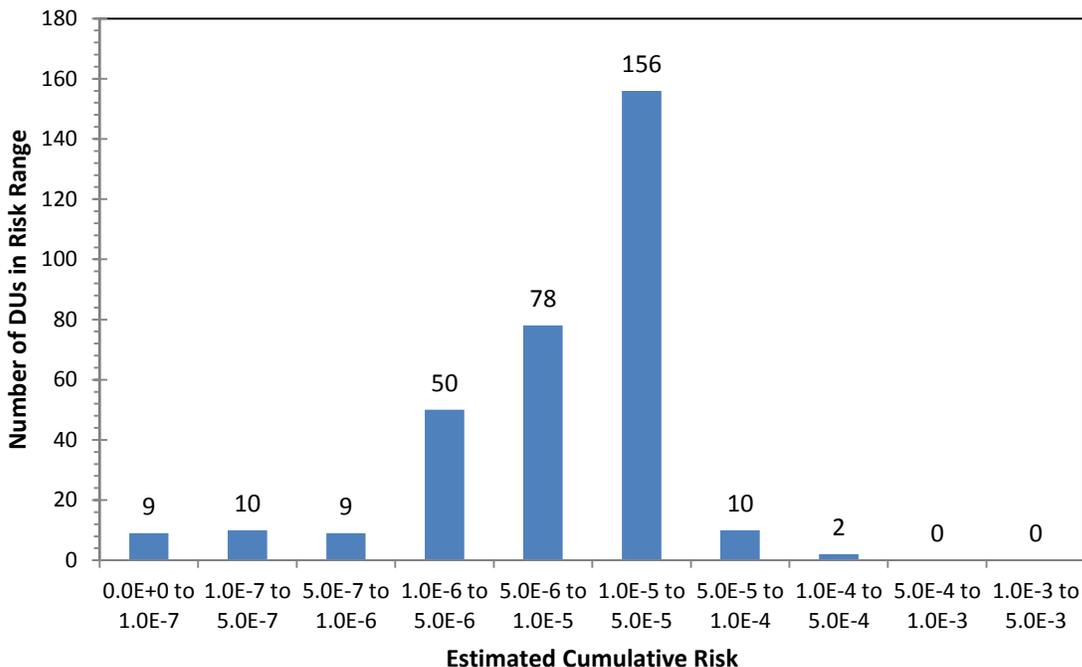
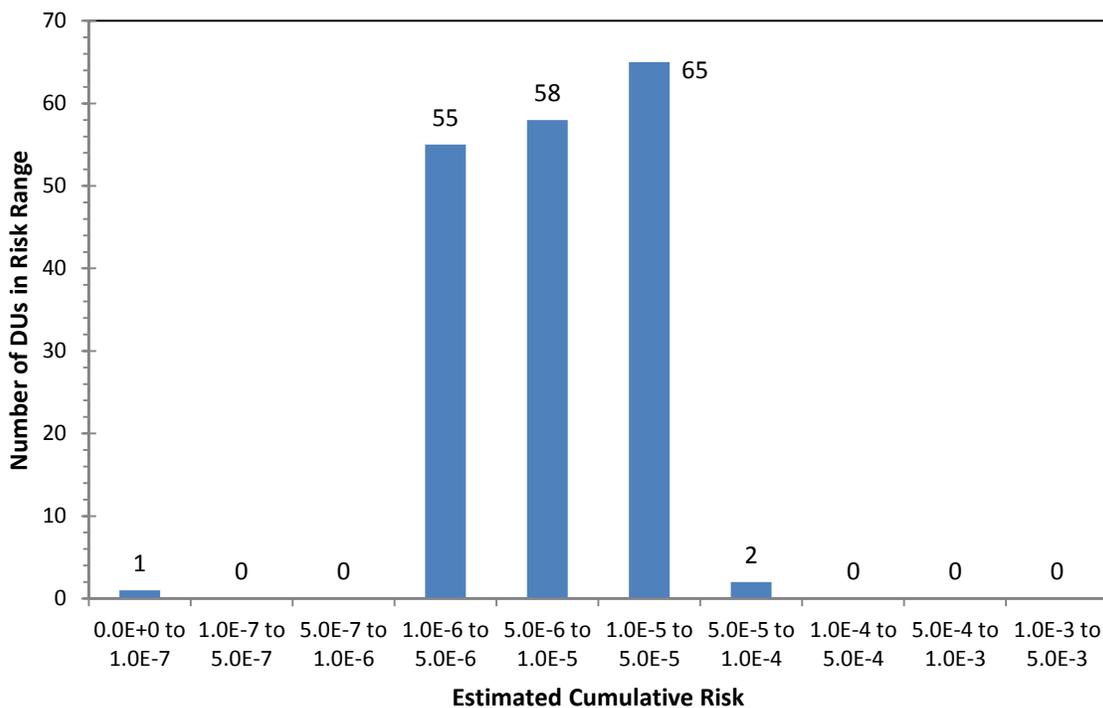


Figure 9-3. Earhart I-3: Distribution of Estimated Cumulative Risks for DUs (0-12 inches) – 2012 EALs



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Cumulative Hazard

- HI > 1
- Earhart Village I-2/I-3
- Hardscapes
- 1 0 b* Decision Unit Numbers

Notes:

- Inset map shows Hickam Communities Property Boundary Line.

Earhart I-2 and Earhart I-3: DUs with Hazard Index Exceeding Target Hazard (0-12 inches) - 2012 EALs

Hickam Communities
Joint Base Pearl Harbor-Hickam, Hawai'i

Figure 9-4

Figure 9-5. Earhart I-2: Distribution of Hazard Indices for DUs (0-12 inches) – 2012 EALs

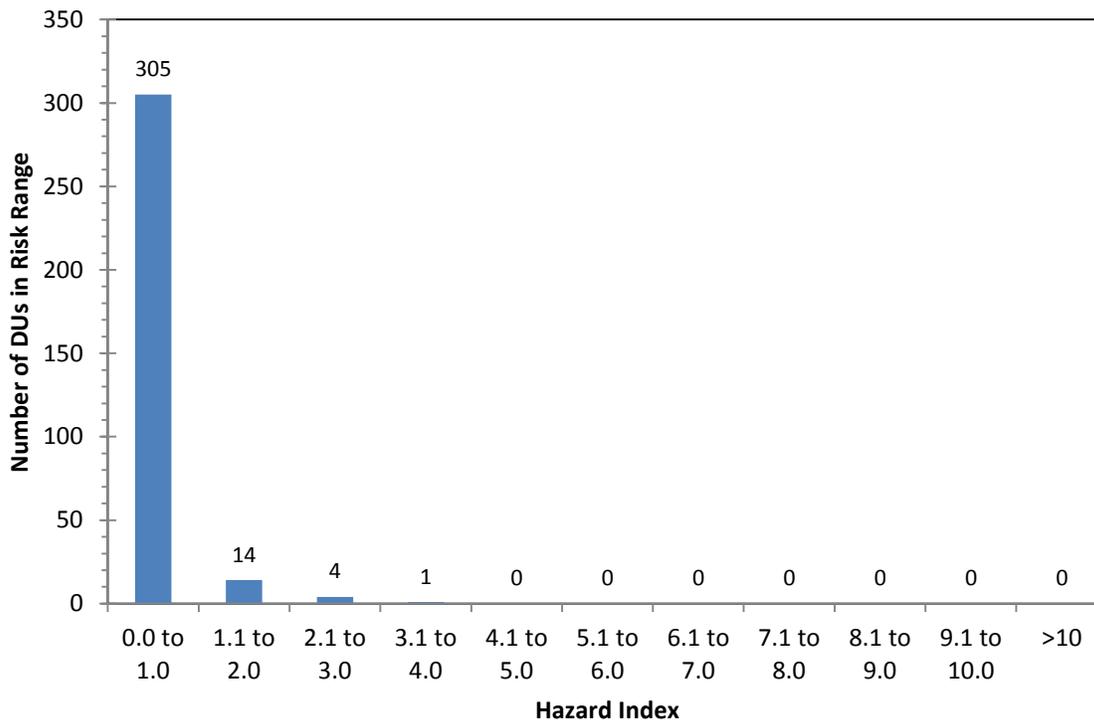
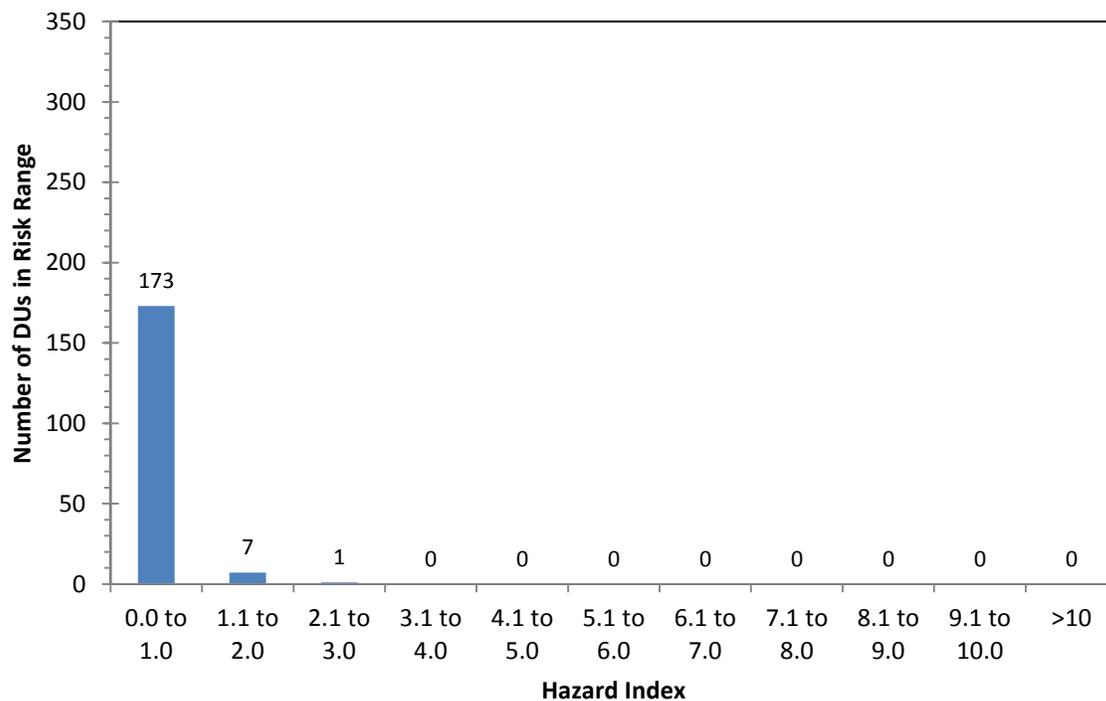


Figure 9-6. Earhart I-3: Distribution of Hazard Indices for DUs (0-12 inches) – 2012 EALs



9.1.2 Earhart I-3 Neighborhood

Child Resident

Within the Earhart I-3 neighborhood, no DUs are associated with estimated risks for the residential child exceeding the HDOH cumulative risk criteria associated with the 2012 EHE Standard based on the soil sampling results collected within the 0 to 12-inch depth interval and the site-specific 2012 EHE Standard EALs. A histogram summarizing the distribution of the residential child cumulative risk estimates for all of the DUs located within the Earhart I-3 neighborhood is presented in Figure 9-3. As indicated in the histogram, the vast majority of DUs are associated with cumulative risk estimates less than 5×10^{-5} .

As shown in Table 9-1, a total of 8 DUs are associated with an estimated HI for the residential child exceeding the target hazard level of 1. The locations of these DUs, where contaminants in soil have the potential to pose a direct exposure hazard, are shown in Figure 9-4. A histogram summarizing the distribution of the estimated HIs for the residential child for all of the DUs located within the Earhart I-3 neighborhood is presented in Figure 9-6. As indicated in the histogram, all of the estimated HIs exceeding the target level of 1 are less than 3 with most (i.e., 5 out of 6) being between 1 and 2.

9.1.3 Onizuka II-1 Neighborhood

Child Resident

Within the Onizuka II-1 neighborhood, no DUs are associated with estimated risks for the residential child exceeding the HDOH cumulative risk criteria associated with the 2012 EHE Standard based on the soil sampling results collected within the 0 to 12-inch depth interval and the site-specific 2012 EHE Standard EALs. A histogram summarizing the distribution of the residential child cumulative risk estimates for all of the DUs located within the Onizuka II-1 neighborhood is presented in Figure 9-7. As indicated in the histogram, no DUs are associated with cumulative risk estimates greater than 1×10^{-5} .

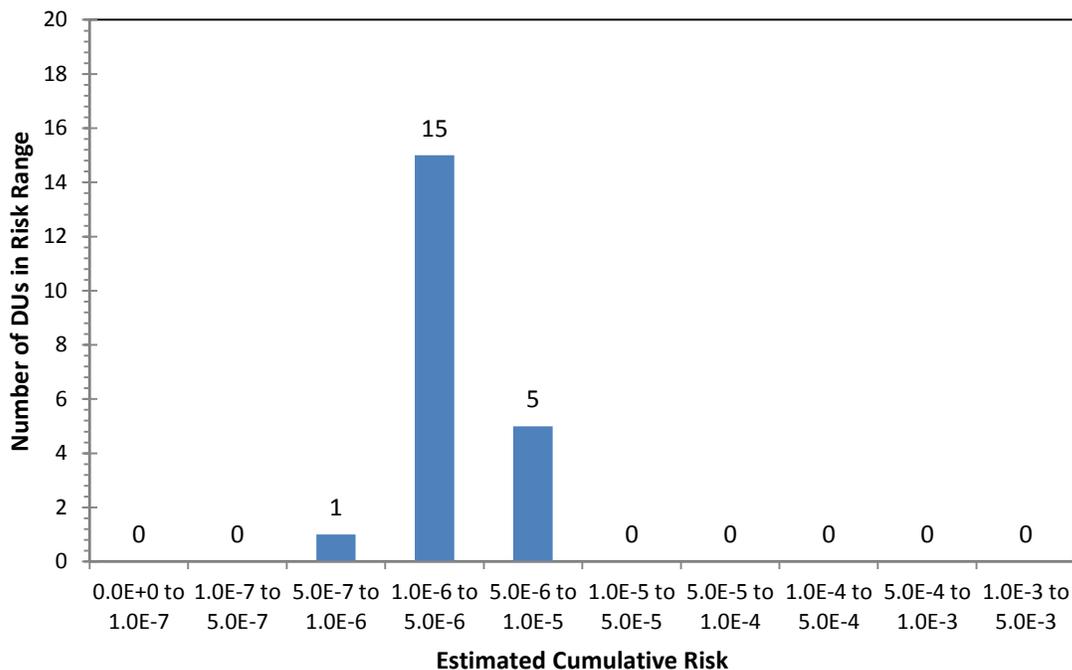
Similar to the cumulative risk estimates described above, no DUs (21 total) are associated with an estimated HI for the residential child exceeding the target hazard level of 1. As shown in Appendix E, the estimated HIs for the child resident range from 0.02 to 0.19, which are well below the target level of 1.

9.1.4 Hale Na Koa I-1 Neighborhood

Child Resident

Within the Hale Na Koa I-1 neighborhood, no DUs are associated with estimated risks for the residential child exceeding the HDOH cumulative risk criteria associated with the 2012 EHE Standard based on the soil sampling results collected within the 0 to 12-inch depth interval and the site-specific 2012 EHE Standard EALs. A histogram summarizing the distribution of the residential child cumulative risk estimates for all of the DUs located within the Hale Na Koa I-1 neighborhood is presented in Figure 9-9. As indicated in the histogram, no DUs are associated with cumulative risk estimates greater than 1×10^{-5} .

Figure 9-7. Onizuka II-1: Distribution of Estimated Cumulative Risks for DUs (0-12 inches) – 2012 EALs



Similar to the cumulative risk estimates described above, no DUs (11 total) are associated with an estimated HI for the residential child exceeding the target hazard level of 1. As shown in Figure 9-10, the estimated HIs for the child resident are well below the target level of 1.

9.2 Summary of Principal Environmental Hazards

Based on the evaluation presented above, a total of 28 DUs were associated with contaminant levels in soil corresponding to a cumulative risk greater than at least one of the HDOH cumulative risk criteria or a cumulative hazard (i.e., HI) greater than the target level of 1. As indicated in Table 8-4, the noncancer EALs for the child resident associated with the primary COCs detected at the Site (i.e., aldrin and dieldrin) are lower than (i.e., more conservative/health protective) the corresponding EALs developed to be protective of carcinogenic effects. Thus, only two DUs were identified with estimated cumulative risks greater than at least one of the HDOH cumulative risk criteria and 28 DUs were identified with estimated HIs greater than the target level of 1 (including the two DUs with estimated cumulative risks exceeding at least one of the 2012 EHE Standard target risk criteria [DU-37a and DU-15b]).

The 28 DUs identified within the Earhart I-2 and Earhart I-3 neighborhoods with contaminants in soil resulting in an estimated HI greater than 1 for the child resident are summarized in Table 9-1. These DUs were screened in a conservative manner in which the maximum HI estimated for either the 0 to 6-inch depth interval or the 6 to 12-inch depth interval was used to identify DUs with an HI greater than 1. In an effort to determine which DUs may require remedial vs.

mitigation efforts, the estimated child resident HIs for both the 0 to 6-inch and 6 to 12-inch depth intervals are summarized in Table 9-1.

Surface Soil (0 to 6-inch Depth Interval)

As shown in Table 9-1, ten DUs in Earhart I-2 and four DUs in Earhart I-3 have contaminant levels in soil that result in an estimated HI greater than 1 for the child resident within the 0 to 6-inch depth interval. Without remediation or the implementation of engineering and/or institutional controls, direct exposure to soil in these DUs could potentially pose threat to residential receptors under current and future conditions. The ten DUs in Earhart I-2 with an HI greater than one within the 0 to 6-inch depth interval include DU-37a, DU-15b, DU-27d, DU-42b, DU-11b, DU-23a, DU-38d, DU-29a, DU-14c, and DU-23b. The four DUs in Earhart I-3 with an HI greater than one within the 0 to 6-inch depth interval include DU-12b, DU-20a, DU-33a and DU-34c. The locations of these DUs are shown in Figures 9-8.

Sub-surface Soil (6 to 12-inch Depth Interval)

As shown in Table 9-1, nine DUs in Earhart I-2 and 4 DUs in Earhart I-3 have contaminant levels in soil within the 6 to 12-inch depth interval that result in an estimated HI greater than 1 for the child resident. However, the estimated HIs for the child resident within surface soil (i.e., 0 to 6-inch depth interval) in these DUs are below the target hazard level of 1 indicating that potential residential exposures to surface soil would not be expected to result in adverse health effects. Thus, for these DUs, as long as institutional and/or engineering controls are in place to control contact with soil within the 6 to 12-inch depth interval, potential residential exposures within these DUs would not be expected to result in adverse health effects. The nine DUs in Earhart I-2 requiring engineering or institutional controls to mitigate potential residential exposures to soil within the 6 to 12-inch depth interval include DU-42a, DU-19b, DU-27c, DU-30f, DU-35b, DU-28d, DU-15c, DU-30e, and DU-23d. The four DUs in Earhart I-3 requiring engineering or institutional controls to mitigate potential residential exposures to soil within the 6 to 12-inch depth interval include DU-4b, DU-14b, DU-12d, and DU-33b. The locations of these DUs are shown in Figure 9-8.



Earhart I-2 and Earhart I-3: Decision Units Requiring Remediation/Mitigation - 2012 EALs

Cumulative Hazard

- HI > 1 in 6-12" only
- HI > 1 in 0-6"
- Earhart Village I-2/I-3
- Hardscapes
- 10b Decision Units

Notes:

- Inset map shows Hickam Communities Property Boundary Line.

Hickam Communities
Joint Base Pearl Harbor-Hickam, Hawai'i

Figure 9-8

Figure 9-9. Hale Na Koa: Distribution of Cumulative Risks for DUs (0-12 inches) – 2012 EALs

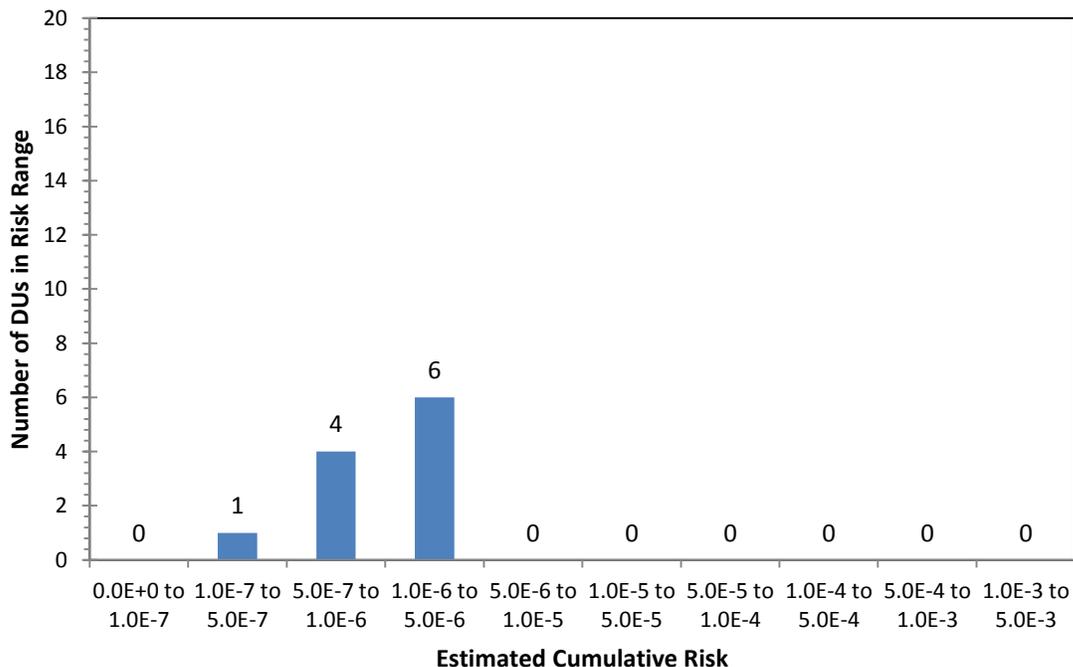
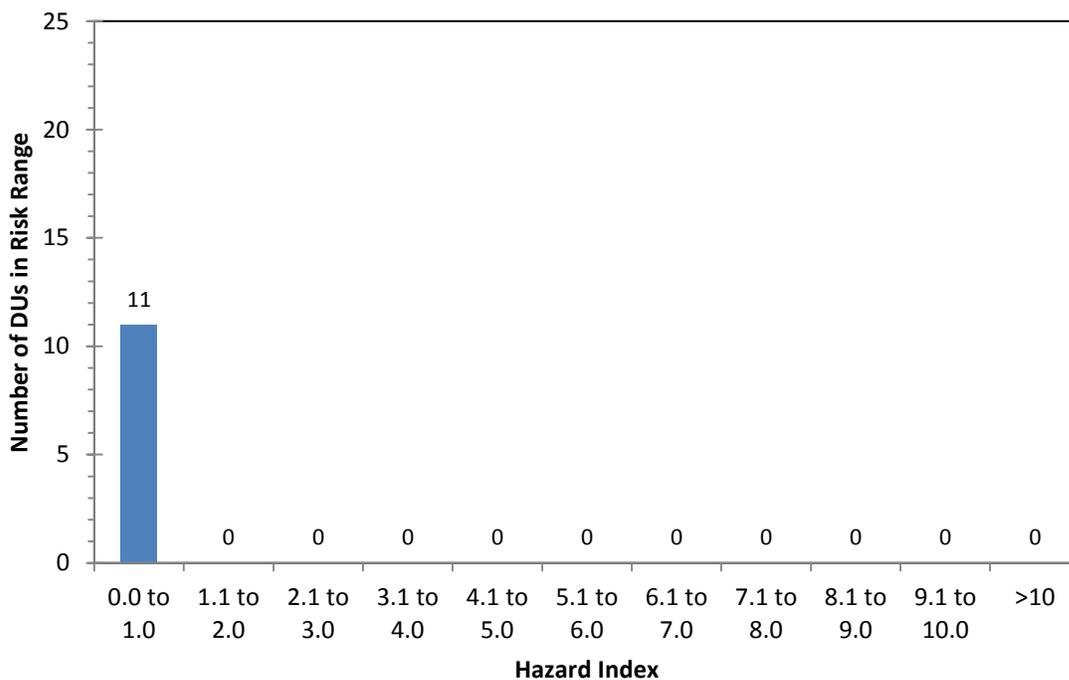


Figure 9-10. Hale Na Koa: Distribution of Hazard Indices for DUs (0-12 inches) – 2012 EALs



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10.0 POST-REMOVAL SITE CONDITIONS

This section summarizes potential risk and hazard levels associated with post-removal site conditions within each neighborhood. As was done in the previous section, only the evaluation results for the child resident are discussed below since the child-specific EALs are lower (i.e., more conservative) than the EALs developed for adult residents. The estimated risks and hazards associated with potential residential child and adult exposures under post-removal Site conditions for all DUs are summarized in Appendix E. In addition to evaluating potential residential exposures to PI soil within the Site DUs, potential risks posed under reasonably anticipated future exposure scenarios are also described.

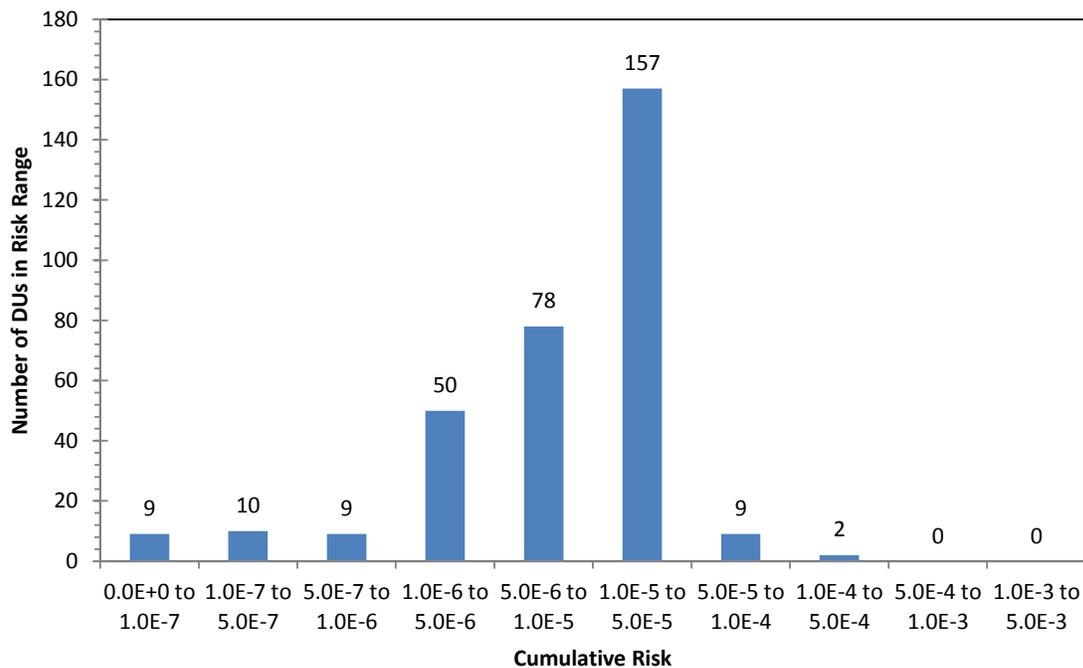
10.1 Earhart I-2 Neighborhood

Child Resident

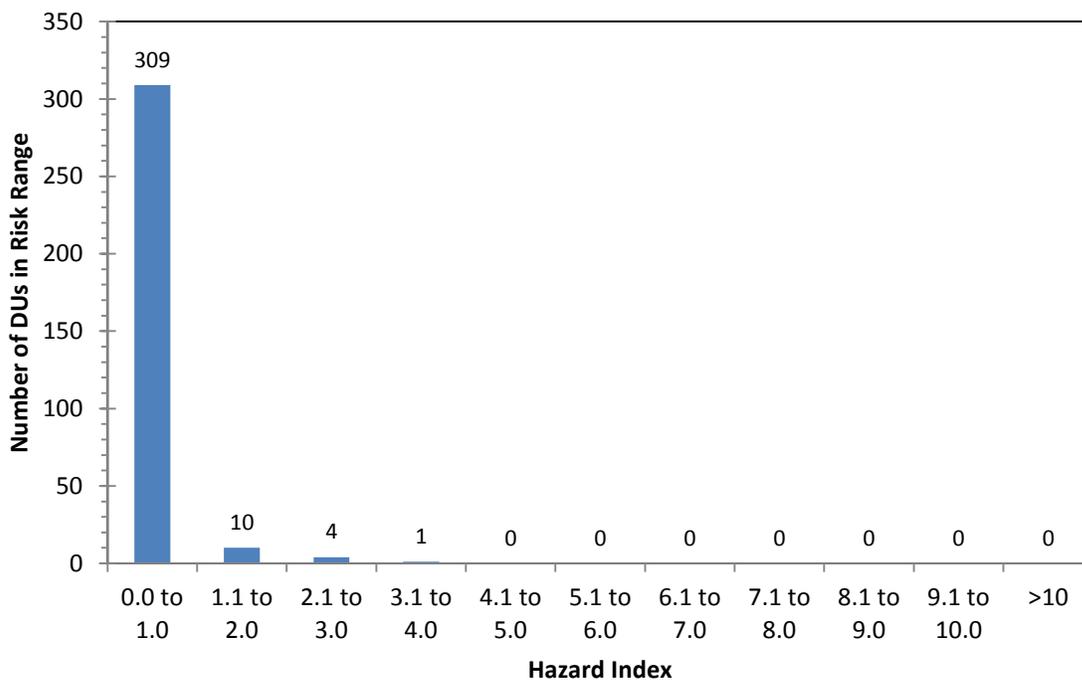
As described in Section 9, two DUs (DU-37a and DU-15b) in Earhart I-2 were associated with estimated cumulative risks exceeding at least one of the HDOH cumulative risk criteria associated with the 2012 EHE standard (described in Section 8.5.3). Both of these DUs were excavated as part of RO #3 conducted at the Site. Thus, under post-removal site conditions, no DUs in Earhart I-2 are associated with levels of organochlorine pesticides in soil that result in estimated risks exceeding the HDOH cumulative risk criteria. For the noncarcinogenic endpoint, nineteen DUs were identified with estimated HIs for the residential child exceeding the target hazard level of 1. Ten of the nineteen DUs were associated with levels of organochlorine pesticides in soil within the 0 to 6-inch depth interval that exceed the target HI of 1 for the child resident and were excavated as part of RO #3. The other nine DUs have levels of organochlorine pesticides in soil within the 6 to 12-inch depth interval that exceed the target HI of 1 for the child resident, but the estimated HIs for the child resident within the 0 to 6 inch depth interval (i.e., surface soil) in these DUs were below the target hazard level of 1. For these 9 DUs, engineering controls (e.g., maintaining good lawn cover) and institutional and controls are in place to mitigate contact with soils within the 6 to 12 inch depth interval. As described in Section 2, residential lease agreements stipulate that residents are prohibited from digging, excavating or gardening in order to control potential exposures. For this reason, potential residential exposures within these DUs would not be expected to result in adverse health effects. The locations of the nine DUs, where institutional controls are in place to control contact with subsurface soil, are shown in Figure 9-8.

A histogram summarizing the post-removal distribution of the residential child cumulative risk estimates for all of the DUs located within the Earhart I-2 neighborhood is presented in Figure 10-1. Under post-removal conditions, the soil within all DUs meets all of the target risk criteria associated with the 2012 EHE standard. As indicated in the histogram, no DUs exceed the target risk level of 1×10^{-4} for aldrin and dieldrin and the vast majority of DUs are associated with cumulative risk estimates less than 5×10^{-5} . A histogram summarizing the post-removal distribution of the estimated HIs for the residential child for all of the DUs located within the Earhart I-2 neighborhood is presented in Figure 10-2. As indicated in the histogram, there are nine DUs remaining with estimated HIs exceeding the target level of 1. However, these are the nine DUs described above (and shown in Figure 9-9) where the estimated HIs for the child resident in surface soil (i.e., 0 to 6 inch depth interval) are below the target level of 1 and institutional controls are in place to control potential contact with sub-surface soils. The

Figure 10-1. Earhart I-2: Distribution of Post-Removal Cumulative Risks for DUs (0-12 inches) – 2012 EALs



Figures 10-2. Earhart I-3: Distribution of Post-Removal Cumulative Risks for DUs (0-12 inches) – 2012 EALs



estimated risks and hazards associated with potential residential child and adult exposures under post-removal Site conditions for all DUs are summarized in Appendix E.

10.2 Earhart I-3 Neighborhood

As described in Section 9, no DUs in Earhart I-3 were associated with estimated cumulative risks exceeding any of the cumulative risk criteria associated with the 2012 EHE Standard. Thus, under post-removal site conditions, no DUs in Earhart I-3 are associated with levels of organochlorine pesticides in soil that result in estimated risks exceeding the HDOH cumulative risk criteria. For the noncarcinogenic endpoint, eight DUs were identified with estimated HIs for the residential child exceeding the target hazard level of 1. Four DUs were associated with levels of organochlorine pesticides in soil within the 0 to 6-inch depth interval that exceed the target HI of 1 for the child resident and were excavated as part of RO #3. Four DUs have levels of organochlorine pesticides in soil within the 6 to 12-inch depth interval that exceed the target HI of 1 for the child resident, but the estimated HIs for the child resident within the 0 to 6-inch depth interval (i.e., surface soil) in these DUs were below the target hazard level of 1. For these four DUs, engineering controls (e.g., maintaining good lawn cover) and institutional and controls are in place to mitigate contact with soils within the 6 to 12-inch depth interval. For this reason, potential residential exposures within these DUs would not be expected to result in adverse health effects. The locations of the four DUs, where institutional controls are in place to control contact with subsurface soil, are shown in Figure 9-8.

A histogram summarizing the post-removal distribution of the residential child cumulative risk estimates for all of the DUs located within the Earhart I-3 neighborhood is presented in Figure 10-3. As indicated in the histogram, no DUs exceed the target risk level of 1×10^{-4} for aldrin and dieldrin and the vast majority of DUs are associated with cumulative risk estimates less than 5×10^{-5} . A histogram summarizing the post-removal distribution of the estimated HIs for the residential child for all of the DUs located within the Earhart I-3 neighborhood is presented in Figure 10-4. As indicated in the histogram, there are four DUs remaining with estimated HIs exceeding the target level of 1. These are the four DUs described above (and shown in Figure 9-8) where the estimated HIs for the child resident in surface soil (i.e., 0 to 6-inch depth interval) are below the target level of 1 and institutional control are in place to control potential contact with sub-surface soil. The estimated risks and hazards associated with potential residential child and adult exposures under post-removal Site conditions for all DUs are summarized in Appendix E.

10.3 Onizuka II-1 Neighborhood

As described in Section 9, no DUs within the Onizuka II-1 neighborhood are associated with estimated risks for the residential child exceeding the HDOH cumulative risk criteria based on the soil sampling results collected within the 0 to 12-inch depth interval and the site-specific 2012 EHE Standard EALs (see Figure 9-7). Similarly, there are no DUs with estimated HIs for the child resident that exceed the target level of 1.

10.4 Hale Na Koa I-1 Neighborhood

As described in Section 9, no DUs within the Hale Na Koa I-1 neighborhood are associated with estimated risks for the residential child exceeding the HDOH cumulative risk criteria based on

Figure 10-3. Earhart I-3: Distribution of Post-Removal Cumulative Risks for DUs (0-12 inches) – 2012 EALs

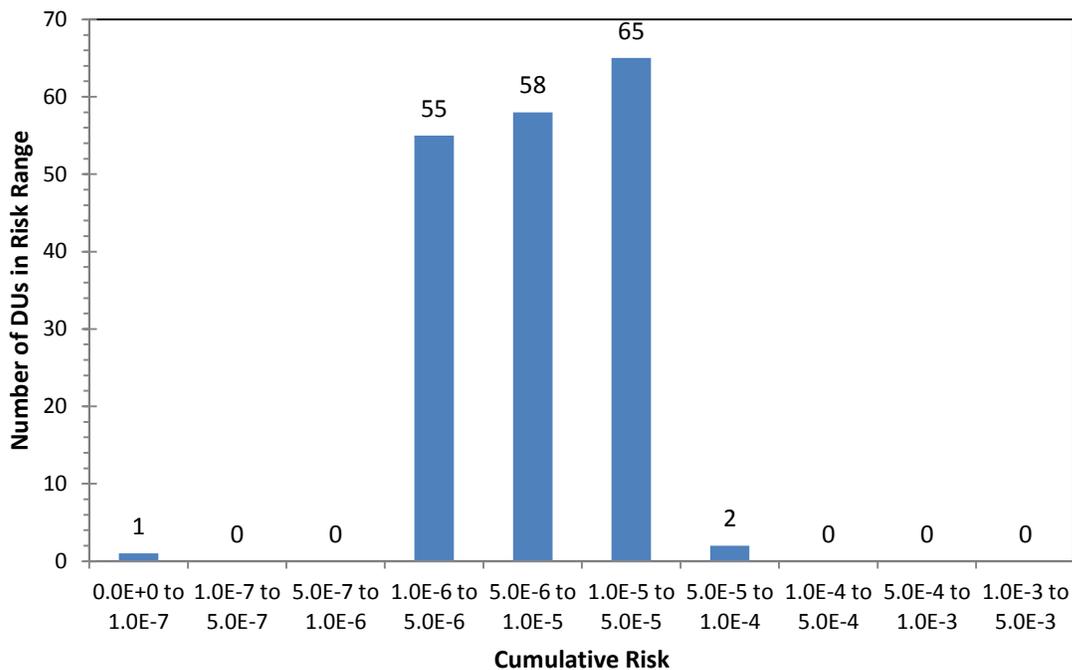
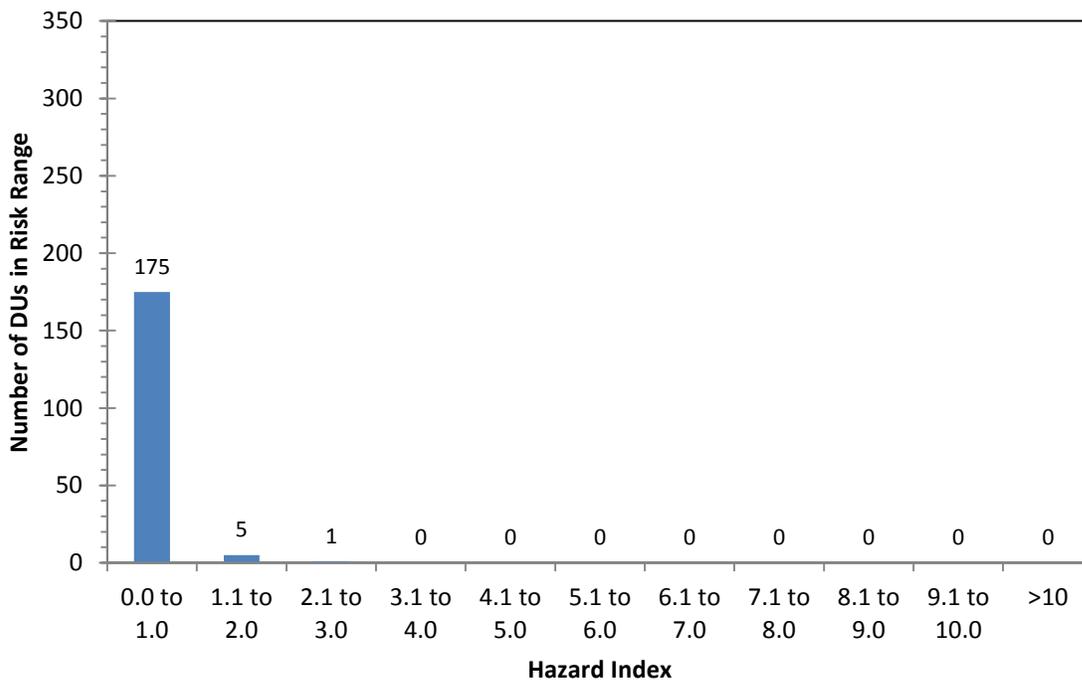


Figure 10-4. Earhart I-3: Distribution of Post-Removal Hazard Indices for DUs (0-12 inches) – 2012 EALs



the soil sampling results collected within the 0 to 12-inch depth interval and the site-specific 2012 EHE Standard EALs (see Figures 9-9 and 9-10). Similarly, there are no DUs with estimated HIs for the child resident that exceed the target level of 1.

10.5 Potential Future Exposures to PI Soil Remaining at the Site

In addition to potential exposures to PI soil remaining with the Site DUs, other reasonably anticipated future exposure scenarios to PI soil remaining at the Site include potential worker and residential exposures to:

- 1) PI soil that has been or will be placed into long-term management units (e.g., burial pits and soil berms);
- 2) PI soil that was placed into utility trenches as backfill;
- 3) PI soil currently beneath buildings and hardscapes; and
- 4) Any other soil at the Site that is presumed to be pesticide-impacted, such as soil deeper than 12 inches below grade located beneath former building footprints.

Landscape/maintenance workers and construction workers could potentially contact PI soil remaining at the Site in areas described above because they may perform intrusive soil activities as part of their jobs. Similarly, if PI soil remaining at the Site is brought to the surface in the future, residents could potentially be exposed. For this reason, institutional controls should be implemented to ensure Occupational Safety and Health Administration safe work practices are followed by landscape/maintenance workers and construction workers in areas of the Site associated with remaining PI soil. Soil management practices should also be implemented to ensure that PI soil is not moved to, and left at the surface, where residents could potentially be exposed.

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11.0 CONCLUSIONS

This environmental hazard evaluation fulfills one of the key requirements associated with the *Voluntary Agreement* between HDOH and HC. Requirements of the *Voluntary Agreement* fulfilled to date and those that will be completed in the future were described in Section 1. As described in this report, the Site has been thoroughly investigated and as part of the EHE, specific portions of the Site have been identified where either remediation or the implementation of engineering and/or institutional controls were required to mitigate direct exposures to contaminants in soil that could pose a potential environmental hazard. Remaining tasks to be completed in fulfillment of the *Voluntary Agreement* include the completion of a RAA, a Final RAM, a remedial implementation plan, an EHMP, and a letter of completion.

Based on current and anticipated future conditions at the Site (i.e., residential use) and the evaluation of potential residential exposure to soil using the site-specific 2012 EHE Standard EALs developed in coordination with HDOH, a total of 27 DUs were identified where organochlorine pesticides are present at levels that could pose a potential environmental hazard to residents via direct exposure to soil without remediation or the implementation of engineering and/or institutional controls. Fourteen of the 27 DUs had levels of organochlorine pesticides within surface soil (i.e., 0 to 6-inch depth interval) that were excavated to mitigate potential residential exposures that could potentially result in adverse health effects (DUs are identified in Figures 9-9 and 9-10). Thirteen of the 27 DUs have levels of organochlorine pesticides in soil within the 6 to 12-inch depth interval that exceed the target HI of 1 for the child resident. However, the estimated HIs for the child resident within the 0 to 6 inch depth interval (i.e., surface soil) in these DUs are below the target hazard level of 1 indicating that potential residential exposures to surface soil would not be expected to result in adverse health effects. For these thirteen DUs, institutional and engineering controls are in place to control contact with soil within the 6 to 12-inch depth interval, therefore, potential residential exposures within these DUs would not be expected to result in adverse health effects (DUs are identified in Figures 9-9 and 9-10).

Based on the results of the EHE, the vast majority of DUs associated with the Site are associated with organochlorine pesticides that are present at levels below site-specific EALs developed to be protective residential receptors. In the near future, Tetra Tech will complete a RAA for all PI soil remaining at the Site that could pose a potential environmental hazard to current or future residents, landscape/maintenance workers, and construction workers. The purpose of the RAA is to select the most efficient, cost-effective, and reliable remedial solution that will mitigate the potential environmental hazard associated with these eleven DUs and any other PI soil remaining at the Site. As described in Section 10.5, reasonably anticipated future exposure scenarios include potential exposures to other PI soil remaining at the Site that was not addressed in the Removal Actions (e.g., PI soil in burial pits, soil berms, utility trenches, and beneath building footprints and hardscapes). These reasonably anticipated future exposure scenarios will be managed using a combination of institutional and engineering controls, exposure management practices, and long-term monitoring to prevent physical contact by potential receptors with any remaining PI soil at the Site. These measures will be described in an EHMP that will be produced by Tetra Tech for all future managers/owners of the Site that will summarize any future land use guidelines and restrictions. Lastly, Tetra Tech will produce a RAM that will provide a detailed discussion of the Site including a description of all ROs, site-specific EALs, and the recommended remedy to mitigate any risks not addressed by the ROs.

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APPENDIX A

**Results of Leachability Testing for Organochlorine Pesticides in Soil –
Earhart I-4**



December 18, 2009

Mr. Robert Lloyd
Development Manager
Actus Lend Lease LLC
200 Kokomalei Street
Honolulu, Hawai`i 96818

via e-mail: Robert.Lloyd@actuslendlease.com

Re: Task Order—31: Results of Leachability Testing for Organochlorine Pesticides in Soil using the Synthetic Precipitation Leaching Procedure, Earhart I-4 Neighborhood, Hickam Air Force Base, Hawai`i

Dear Mr. Lloyd,

Tetra Tech is pleased to present the results of leachability testing for organochlorine pesticides in soil from the Earhart I-4 neighborhood, located Hickam Air Force Base (HAFB), O`ahu, Hawai`i (hereinafter the "Site"). This work was conducted at the request of Hickam Community Housing LLC (HCH).

Three open area multi-incremental (MI) soil samples were selected for analysis using the Synthetic Precipitation Leaching Procedure (SPLP). The MI soil samples were collected at the Site October 2009, and were selected to be representative of pesticide-impacted soil at the Site. Dieldrin and its potential leachability was of particular concern at the Site. Based on results of samples collected by Tetra Tech in October 2009, the average open area dieldrin concentration at Earhart was 1.49 mg/kg. The three samples selected for this leachability study all have dieldrin levels that are higher than the site average.

ANALYTICAL METHODS AND RESULTS

The three MI soil samples were submitted to Torrent Analytical Laboratory of Milpitas, California for the following analyses:

- Organochlorine pesticides by US Environmental Protection Agency (EPA) Method 8081; and
- SPLP by EPA Method 1312.

Due to the selected soil samples being outside the hold time for EPA Method 8081, Tetra Tech reanalyzed the samples for organochlorine pesticides concurrently with the SPLP. The samples were analyzed on a RUSH basis, 1-day turn-around-time (TAT). A copy of the laboratory analytical record is provided in Appendix A.

Organochlorine Pesticides in Soil Results

Organochlorine pesticides were detected at concentrations at or above the reporting limit in all three MI soil samples submitted for analysis by EPA Method 8091. The analytical results were compared to the Hawai'i Department of Health (HDOH) Tier 1 Environmental Action Levels (EALs) (HDOH 2008) and the Tier 2 EALs established for HCH property (Tetra Tech 2009a). The analytical results are presented in Table 1, and results for the organochlorine pesticides dieldrin, aldrin, and chlordane are summarized below.

- Dieldrin was detected in all three soil samples submitted for analysis at concentrations ranging from 2.0 milligrams per kilogram (mg/kg) to 4.5 mg/kg. All three detections exceed the Tier 2 EAL for dieldrin (0.45 mg/kg).
- Aldrin was detected in all three soil samples submitted for analysis at concentrations ranging from 2.1 mg/kg to 8.2 mg/kg. All three detections exceed the Tier 2 EAL for aldrin (0.42 mg/kg).
- Chlordane was detected in all three soil samples submitted for analysis at concentrations ranging from 2.4 mg/kg to 8.8 mg/kg. All three detections were below the Tier 2 EAL value for chlordane (23.4 mg/kg).

Synthetic Precipitation Leaching Procedure Results

Organochlorine pesticides were detected at concentrations at or above the reporting limit in all three MI soil samples submitted for analysis by the SPLP. The analytical results are presented in Table 2, and results for the organochlorine pesticides dieldrin, aldrin, and chlordane are summarized below.

- Dieldrin was detected in all three soil samples submitted for analysis at concentrations ranging from 0.0025 milligrams per liter (mg/L) to 0.0063 mg/L.
- Aldrin was detected in all three soil samples submitted for analysis at concentrations ranging from 0.00034 mg/L to 0.0014 mg/L.
- Chlordane was detected in one of the three soil samples submitted for analysis at a concentration of 0.0028 mg/L.

DISCUSSION

Tetra Tech evaluated the leachability of the organochlorine pesticides aldrin, dieldrin, and chlordane by using the analytical results to calculate a site-specific partitioning coefficient (K_d value) for aldrin, dieldrin, and chlordane. As presented in Tetra Tech's draft memorandum *Leachability of Aldrin, Dieldrin, and Chlordane from Soils Literature Review*, dated December 1, 2009 (Tetra Tech 2009b); the HDOH recommends that the site-specific K_d value be determined for the soil of interest using the SPLP batch test method. If the calculated K_d is lower than the HDOH's recommended threshold of 20 cubic centimeters per gram (cm^3/g), then site-specific conditions should be evaluated. The assumption that the K_d value must be at least $20 \text{ cm}^3/\text{g}$ to be protective under leaching conditions is based on a number of further assumptions regarding environmental conditions at the site, which can be incorporated into standard infiltration and transport models.

The K_d values were only calculated for dieldrin, aldrin, and chlordane concentrations detected by SPLP. The K_d values were calculated using the HDOH Batch Test Leaching Model worksheet (HDOH 2008b). The K_d values calculated from the SPLP analytical results are presented in Table 3, and results for the organochlorine pesticides dieldrin, aldrin, and chlordane are summarized below.

- Dieldrin K_d values were calculated for all three samples where dieldrin was detected by the SPLP. The calculated K_d values ranged from $650 \text{ cm}^3/\text{g}$ to $690 \text{ cm}^3/\text{g}$.
- Aldrin K_d values were calculated for all three samples where aldrin was detected by the SPLP. The calculated K_d values ranged from $5,800 \text{ cm}^3/\text{g}$ to $6,600 \text{ cm}^3/\text{g}$.
- The chlordane K_d value was calculated for the sample where chlordane was detected by the SPLP. The calculated K_d value was $3,100 \text{ cm}^3/\text{g}$.

CONCLUSIONS

The calculated K_d values for dieldrin, aldrin, and chlordane were all significantly greater than the HDOH's recommended threshold of $20 \text{ cm}^3/\text{g}$.

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If you have any questions or comments about this report, please contact me at (415) 490-2930 or Yvonne Parry in our Honolulu office, at (808) 533-3366.

Sincerely,
TETRA TECH

A handwritten signature in blue ink, appearing to read 'Tom Whitehead'.

Tom Whitehead
Principal Hydrologist

Attachments:

Table 1 – Analytical Results for Earhart 1-4 Neighborhood Soil

Table 2 – Synthetic Precipitation Leaching Procedure Analytical Results

Table 3 – Soil-Water Partitioning Coefficient (K_d) Values Calculated for Earhart 1-4 Neighborhood Soil

Appendix A – Laboratory Analytical Report

Appendix B – HDOH Batch Test Leaching Model Calculation Sheets

cc: Gary Floyd, Tetra Tech
Gail Eaton, Tetra Tech

TABLES

Table 1
Analytical Results for Earhart 1-4 Neighborhood Soil
Hickam Air Force Base, Hawai'i

Sample ID →	EAR-FP-E-6-3	EAR-OA-1-6	EAR-FP-D-12	HDOH Tier 1 EAL ¹	HDOH Tier 2 EAL ²
	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)
Sample Date →	10/1/2009	10/2/2009	10/9/2009		
Analyte					
4,4'-DDE	0.34 ^J	0.065	0.12 ^J	1.4	24.8
4,4'-DDT	0.93	0.20	0.43	1.7	24.8
Aldrin	8.2	2.1	2.5	0.029	0.42
alpha-Chlordane	0.69	0.24	0.83	NE	NE
Chlordane	6.3	2.4	8.8	16	23.4
Dieldrin	4.5	2.0	3.0	0.03	0.45
Endrin ketone	0.22 ^J	0.065	0.095 ^J	NE	NE
gamma-Chlordane	0.66	0.26	0.92	NE	NE
Heptachlor	< 0.22	0.021	< 0.11	0.1	NE

Notes:

Exceeds HDOH Tier 2 EAL

Exceeds HDOH Tier 1 EAL

Only detected analytes shown in table.

Samples analyzed for organochlorine pesticides by EPA Method 8081.

HDOH Hawai'i Department of Health

EAL Environmental Action Level

mg/kg milligram per kilogram

< less than the laboratory reporting limit

DDE dichlorodiphenyldichloroethylene

DDT dichlorodiphenyltrichloroethane

J estimated value; analyte detected below the quantitation limit

NE not established

1 HDOH Tier 1 EALs are for soil with an unrestricted land use at a distance greater than 150 meters from surface water, and groundwater is a non drinking water resource (Table B-1).

2 Site-specific HDOH Tier 2 EALs calculated for Hickam Community (Tetra Tech 2009a). Tier 2 EALS for DDD, DDE, and DDT are not established for HCH property at Hickam AFB.

Table 2
Synthetic Precipitation Leaching Procedure Analytical Results
Earhart 1-4 Neighborhood Soil
Hickam Air Force Base, Hawai`i

Sample ID →	EAR-FP-E-6-3	EAR-OA-1-6	EAR-FP-D-12
	(mg/L)	(mg/L)	(mg/L)
Sample Date →	10/1/2009	10/2/2009	10/9/2009
Analyte			
4,4'-DDT	0.00021	< 0.00020	< 0.00020
Aldrin	0.0014	0.00034	0.00038
Chlordane	< 0.0025	< 0.0025	0.0028
Dieldrin	0.0063	0.0025	0.0045
Endrin ketone	0.0014	0.00043	0.00062

Notes: - Only detected analytes shown in table.
 Samples analyzed for organochlorine pesticides by EPA Method 1312.

- mg/L milligram per liter
- < less than the laboratory reporting limit
- DDT dichlorodiphenyltrichloroethane
- J estimated value; analyte detected below the quantitation limit

Table 3
Soil-Water Partitioning Coefficient (K_d) Values
Calculated for Earhart 1-4 Neighborhood Soil
Hickam Air Force Base, Hawai'i

Sample ID →	EAR-FP-E-6-3	EAR-OA-1-6	EAR-FP-D-12
	(cm ³ /g)	(cm ³ /g)	(cm ³ /g)
Sample Date →	10/1/2009	10/2/2009	10/9/2009
K_d Value			
Dieldrin	690	780	650
Aldrin	5,800	6,200	6,600
Chlordane	>2,520 ⁽¹⁾	>960 ⁽¹⁾	3,100

Notes:

Soil-water partitioning coefficient (K_d) values only calculated for dieldrin, aldrin, and chlordane concentrations detected by SPLP. The K_d values were calculated using the Hawai'i Department of Health Batch Test Leaching Model worksheet (HDOH 2008b).

⁽¹⁾ Where chlordane was not detected in leachate, K_d is estimated using the detection limit. Where initial concentration in soil is low, as in sample EAR-OA-1-6, K_d is probably severely underestimated.

cm³/g cubic centimeter per gram
 K_d soil-water partitioning coefficient
 NA not applicable

APPENDIX A
LABORATORY ANALYTICAL REPORTS



December 16, 2009

Yvonne Parry
Tetra Tech, Inc.
737 Bishop St., Ste 3020
Honolulu, HI 96813

TEL: (808) 533-3366
FAX

RE: 100-SFO-T24989/Earhart

Order No.: 0912121

Dear Yvonne Parry:

Torrent Laboratory, Inc. received a request for the analysis of 3 samples on 12/14/2009 for the analyses presented in the following report.

All data for associated QC met EPA or laboratory specification(s) except where noted in the case narrative.

Reported data is applicable for only the samples received as part of the order number referenced above.

Torrent Laboratory, Inc. is certified by the State of California, ELAP #1991. If you have any questions regarding these test results, please feel free to contact the Project Management Team at (408)263-5258; ext: 204.

Sincerely,


Laboratory Director

12/16/09
Date

Torrent Laboratory, Inc.**Date:** 16-Dec-09

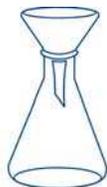
CLIENT: Tetra Tech, Inc.
Project: 100-SFO-T24989/Earhart
Lab Order: 0912121**CASE NARRATIVE**

Analytical Comments, General, For all samples, Note: Samples processed under Incremental Sampling Procedure SOP TCI0109.

Analytical Comments for METHOD 8081S_Tetra Tech, ALL SAMPLE, Note: Per client request, whenever possible (where matrix interference does not preclude it), sample data is reported to the MDL. Results reported between the MDL and PQL are qualified with the appropriate "J" flag and should be considered as estimated values

Note: Extraction of 100 g sample / 500g SPLP Fluid # 2 (pH 5.0 +/-0.05) was performed according to Synthetic Precipitation Leaching Procedure (SPLP) which was rotated in a rotary shaker for 18 hours.

Date Prepared: 12/13/09 at 5:00PM to 012/14/09 at 11:00 AM.



TORRENT LABORATORY, INC.

483 Sinclair Frontage Road • Milpitas, CA • Phone: (408) 263-5258 • Fax: (408) 263-8293

Visit us at www.torrentlab.com email: analysis@torrentlab.com

Report prepared for: Yvonne Parry
Tetra Tech, Inc.

Date Received: 12/14/2009
Date Reported: 12/16/2009

Client Sample ID: EAR-FP-E-6-3
Sample Location: Earhart
Sample Matrix: SOIL (SPLP extraction followed by EPA 8081 analysis)
Date/Time Sampled 10/1/2009

Lab Sample ID: 0912121-001
Date Prepared: 12/15/2009

Parameters	Analysis Method	Date Analyzed	RL	Dilution Factor	MRL	Result	Units	Analytical Batch
4,4'-DDD	SW8081A	12/15/2009	0.0002	1	0.00020	ND	mg/L	R22130
4,4'-DDE	SW8081A	12/15/2009	0.0002	1	0.00020	ND	mg/L	R22130
4,4'-DDT	SW8081A	12/15/2009	0.0002	1	0.00020	0.00021	mg/L	R22130
Aldrin	SW8081A	12/15/2009	0.0002	1	0.00020	0.0014	mg/L	R22130
alpha-BHC	SW8081A	12/15/2009	0.0002	1	0.00020	ND	mg/L	R22130
alpha-Chlordane	SW8081A	12/15/2009	0.0002	1	0.00020	ND	mg/L	R22130
beta-BHC	SW8081A	12/15/2009	0.0002	1	0.00020	ND	mg/L	R22130
Chlordane	SW8081A	12/15/2009	0.0025	1	0.0025	ND	mg/L	R22130
delta-BHC	SW8081A	12/15/2009	0.0002	1	0.00020	ND	mg/L	R22130
Dieldrin	SW8081A	12/16/2009	0.0002	4	0.00080	0.0063	mg/L	R22130
Endosulfan I	SW8081A	12/15/2009	0.0002	1	0.00020	ND	mg/L	R22130
Endosulfan II	SW8081A	12/15/2009	0.0002	1	0.00020	ND	mg/L	R22130
Endosulfan sulfate	SW8081A	12/15/2009	0.0002	1	0.00020	ND	mg/L	R22130
Endrin	SW8081A	12/15/2009	0.0002	1	0.00020	ND	mg/L	R22130
Endrin aldehyde	SW8081A	12/15/2009	0.0002	1	0.00020	ND	mg/L	R22130
Endrin ketone	SW8081A	12/15/2009	0.0002	1	0.00020	0.0014	mg/L	R22130
gamma-BHC	SW8081A	12/15/2009	0.0002	1	0.00020	ND	mg/L	R22130
gamma-Chlordane	SW8081A	12/15/2009	0.0002	1	0.00020	ND	mg/L	R22130
Heptachlor	SW8081A	12/15/2009	0.0002	1	0.00020	ND	mg/L	R22130
Heptachlor epoxide	SW8081A	12/15/2009	0.0002	1	0.00020	ND	mg/L	R22130
Methoxychlor	SW8081A	12/15/2009	0.0005	1	0.00050	ND	mg/L	R22130
Toxaphene	SW8081A	12/15/2009	0.01	1	0.010	ND	mg/L	R22130
Surr: Decachlorobiphenyl	SW8081A	12/15/2009	0	1	52-116	49.4	%REC	R22130
Surr: Tetrachloro-m-xylene	SW8081A	12/15/2009	0	1	40.3-118	69.0	%REC	R22130

Note: Surrogate recovery of DCBP is bias low possibly due to matrix effects; recovery of second surrogate supports data quality.

Report prepared for: Yvonne Parry
Tetra Tech, Inc.

Date Received: 12/14/2009

Date Reported: 12/16/2009

4,4'-DDD	SW8081A	12/15/2009	0.00047	200	0.094	ND	mg/Kg	R22104
4,4'-DDE	SW8081A	12/15/2009	0.00048	200	0.096	0.336 J	mg/Kg	R22104
4,4'-DDT	SW8081A	12/15/2009	0.00081	200	0.16	0.93	mg/Kg	R22104
Aldrin	SW8081A	12/15/2009	0.00044	200	0.088	8.2	mg/Kg	R22104
alpha-BHC	SW8081A	12/15/2009	0.00044	200	0.088	ND	mg/Kg	R22104
alpha-Chlordane	SW8081A	12/15/2009	0.00036	200	0.072	0.69	mg/Kg	R22104
beta-BHC	SW8081A	12/15/2009	0.00036	200	0.072	ND	mg/Kg	R22104
Chlordane	SW8081A	12/15/2009	0.01	200	2.0	6.3	mg/Kg	R22104
delta-BHC	SW8081A	12/15/2009	0.00049	200	0.098	ND	mg/Kg	R22104
Dieldrin	SW8081A	12/15/2009	0.00043	200	0.086	4.5	mg/Kg	R22104
Endosulfan I	SW8081A	12/15/2009	0.00059	200	0.12	ND	mg/Kg	R22104
Endosulfan II	SW8081A	12/15/2009	0.00153	200	0.31	ND	mg/Kg	R22104
Endosulfan sulfate	SW8081A	12/15/2009	0.00048	200	0.096	ND	mg/Kg	R22104
Endrin	SW8081A	12/15/2009	0.00057	200	0.11	ND	mg/Kg	R22104
Endrin aldehyde	SW8081A	12/15/2009	0.001	200	0.20	ND	mg/Kg	R22104
Endrin ketone	SW8081A	12/15/2009	0.0004	200	0.080	0.223 J	mg/Kg	R22104
gamma-BHC	SW8081A	12/15/2009	0.0004	200	0.080	ND	mg/Kg	R22104
gamma-Chlordane	SW8081A	12/15/2009	0.0004	200	0.080	0.66	mg/Kg	R22104
Heptachlor	SW8081A	12/15/2009	0.0011	200	0.22	ND	mg/Kg	R22104
Heptachlor epoxide	SW8081A	12/15/2009	0.0003	200	0.060	ND	mg/Kg	R22104
Methoxychlor	SW8081A	12/15/2009	0.0006	200	0.12	ND	mg/Kg	R22104
Toxaphene	SW8081A	12/15/2009	0.01	200	2.0	ND	mg/Kg	R22104
Surr: Decachlorobiphenyl	SW8081A	12/15/2009		200	52.5-139	D	%REC	R22104
Surr: Tetrachloro-m-xylene	SW8081A	12/15/2009		200	50.2-139	D	%REC	R22104

Note: D - Surrogate diluted out. Reporting limits increased due to dilution necessary for quantitation.

Report prepared for: Yvonne Parry
Tetra Tech, Inc.

Date Received: 12/14/2009
Date Reported: 12/16/2009

Client Sample ID: EAR-OA-1-6
Sample Location: Earhart
Sample Matrix: SOIL (SPLP extraction followed by EPA 8081 analysis)
Date/Time Sampled 10/2/2009

Lab Sample ID: 0912121-002
Date Prepared: 12/15/2009

Parameters	Analysis Method	Date Analyzed	RL	Dilution Factor	MRL	Result	Units	Analytical Batch
4,4'-DDD	SW8081A	12/15/2009	0.0002	1	0.00020	ND	mg/L	R22130
4,4'-DDE	SW8081A	12/15/2009	0.0002	1	0.00020	ND	mg/L	R22130
4,4'-DDT	SW8081A	12/15/2009	0.0002	1	0.00020	ND	mg/L	R22130
Aldrin	SW8081A	12/15/2009	0.0002	1	0.00020	0.00034	mg/L	R22130
alpha-BHC	SW8081A	12/15/2009	0.0002	1	0.00020	ND	mg/L	R22130
alpha-Chlordane	SW8081A	12/15/2009	0.0002	1	0.00020	ND	mg/L	R22130
beta-BHC	SW8081A	12/15/2009	0.0002	1	0.00020	ND	mg/L	R22130
Chlordane	SW8081A	12/15/2009	0.0025	1	0.0025	ND	mg/L	R22130
delta-BHC	SW8081A	12/15/2009	0.0002	1	0.00020	ND	mg/L	R22130
Dieldrin	SW8081A	12/15/2009	0.0002	1	0.00020	0.0025	mg/L	R22130
Endosulfan I	SW8081A	12/15/2009	0.0002	1	0.00020	ND	mg/L	R22130
Endosulfan II	SW8081A	12/15/2009	0.0002	1	0.00020	ND	mg/L	R22130
Endosulfan sulfate	SW8081A	12/15/2009	0.0002	1	0.00020	ND	mg/L	R22130
Endrin	SW8081A	12/15/2009	0.0002	1	0.00020	ND	mg/L	R22130
Endrin aldehyde	SW8081A	12/15/2009	0.0002	1	0.00020	ND	mg/L	R22130
Endrin ketone	SW8081A	12/15/2009	0.0002	1	0.00020	0.00043	mg/L	R22130
gamma-BHC	SW8081A	12/15/2009	0.0002	1	0.00020	ND	mg/L	R22130
gamma-Chlordane	SW8081A	12/15/2009	0.0002	1	0.00020	ND	mg/L	R22130
Heptachlor	SW8081A	12/15/2009	0.0002	1	0.00020	ND	mg/L	R22130
Heptachlor epoxide	SW8081A	12/15/2009	0.0002	1	0.00020	ND	mg/L	R22130
Methoxychlor	SW8081A	12/15/2009	0.0005	1	0.00050	ND	mg/L	R22130
Toxaphene	SW8081A	12/15/2009	0.01	1	0.010	ND	mg/L	R22130
Surr: Decachlorobiphenyl	SW8081A	12/15/2009	0	1	52-116	41.5	%REC	R22130
Surr: Tetrachloro-m-xylene	SW8081A	12/15/2009	0	1	40.3-118	65.8	%REC	R22130

Note: Surrogate recovery of DCBP is bias low possibly due to matrix effects; recovery of second surrogate supports data quality.

Report prepared for: Yvonne Parry
Tetra Tech, Inc.

Date Received: 12/14/2009

Date Reported: 12/16/2009

4,4'-DDD	SW8081A	12/15/2009	0.00047	10	0.0047	ND	mg/Kg	R22104
4,4'-DDE	SW8081A	12/15/2009	0.00048	10	0.0048	0.065	mg/Kg	R22104
4,4'-DDT	SW8081A	12/15/2009	0.00081	10	0.0081	0.20	mg/Kg	R22104
Aldrin	SW8081A	12/15/2009	0.00044	50	0.022	2.1	mg/Kg	R22104
alpha-BHC	SW8081A	12/15/2009	0.00044	10	0.0044	ND	mg/Kg	R22104
alpha-Chlordane	SW8081A	12/15/2009	0.00036	10	0.0036	0.24	mg/Kg	R22104
beta-BHC	SW8081A	12/15/2009	0.00036	10	0.0036	ND	mg/Kg	R22104
Chlordane	SW8081A	12/15/2009	0.01	10	0.10	2.4	mg/Kg	R22104
delta-BHC	SW8081A	12/15/2009	0.00049	10	0.0049	ND	mg/Kg	R22104
Dieldrin	SW8081A	12/15/2009	0.00043	50	0.022	2.0	mg/Kg	R22104
Endosulfan I	SW8081A	12/15/2009	0.00059	10	0.0059	ND	mg/Kg	R22104
Endosulfan II	SW8081A	12/15/2009	0.00153	10	0.015	ND	mg/Kg	R22104
Endosulfan sulfate	SW8081A	12/15/2009	0.00048	10	0.0048	ND	mg/Kg	R22104
Endrin	SW8081A	12/15/2009	0.00057	10	0.0057	ND	mg/Kg	R22104
Endrin aldehyde	SW8081A	12/15/2009	0.001	10	0.010	ND	mg/Kg	R22104
Endrin ketone	SW8081A	12/15/2009	0.0004	10	0.0040	0.065	mg/Kg	R22104
gamma-BHC	SW8081A	12/15/2009	0.0004	10	0.0040	ND	mg/Kg	R22104
gamma-Chlordane	SW8081A	12/15/2009	0.0004	10	0.0040	0.26	mg/Kg	R22104
Heptachlor	SW8081A	12/15/2009	0.0011	10	0.011	0.021	mg/Kg	R22104
Heptachlor epoxide	SW8081A	12/15/2009	0.0003	10	0.0030	ND	mg/Kg	R22104
Methoxychlor	SW8081A	12/15/2009	0.0006	10	0.0060	ND	mg/Kg	R22104
Toxaphene	SW8081A	12/15/2009	0.01	10	0.10	ND	mg/Kg	R22104
Surr: Decachlorobiphenyl	SW8081A	12/15/2009		10	52.5-139	114	%REC	R22104
Surr: Tetrachloro-m-xylene	SW8081A	12/15/2009		10	50.2-139	108	%REC	R22104

Note: Reporting limits increased due to dilution necessary for quantitation.

Report prepared for: Yvonne Parry
Tetra Tech, Inc.

Date Received: 12/14/2009
Date Reported: 12/16/2009

Client Sample ID: EAR-FP-D-12
Sample Location: Earhart
Sample Matrix: SOIL(SPLP extraction followed by EPA 8081 analysis)
Date/Time Sampled 10/9/2009

Lab Sample ID: 0912121-003
Date Prepared: 12/15/2009

Parameters	Analysis Method	Date Analyzed	RL	Dilution Factor	MRL	Result	Units	Analytical Batch
4,4'-DDD	SW8081A	12/15/2009	0.0002	1	0.00020	ND	mg/L	R22130
4,4'-DDE	SW8081A	12/15/2009	0.0002	1	0.00020	ND	mg/L	R22130
4,4'-DDT	SW8081A	12/15/2009	0.0002	1	0.00020	ND	mg/L	R22130
Aldrin	SW8081A	12/15/2009	0.0002	1	0.00020	0.00038	mg/L	R22130
alpha-BHC	SW8081A	12/15/2009	0.0002	1	0.00020	ND	mg/L	R22130
alpha-Chlordane	SW8081A	12/15/2009	0.0002	1	0.00020	0.00026	mg/L	R22130
beta-BHC	SW8081A	12/15/2009	0.0002	1	0.00020	ND	mg/L	R22130
Chlordane	SW8081A	12/15/2009	0.0025	1	0.0025	0.0028	mg/L	R22130
delta-BHC	SW8081A	12/15/2009	0.0002	1	0.00020	ND	mg/L	R22130
Dieldrin	SW8081A	12/16/2009	0.0002	3	0.00060	0.0045	mg/L	R22130
Endosulfan I	SW8081A	12/15/2009	0.0002	1	0.00020	ND	mg/L	R22130
Endosulfan II	SW8081A	12/15/2009	0.0002	1	0.00020	ND	mg/L	R22130
Endosulfan sulfate	SW8081A	12/15/2009	0.0002	1	0.00020	ND	mg/L	R22130
Endrin	SW8081A	12/15/2009	0.0002	1	0.00020	ND	mg/L	R22130
Endrin aldehyde	SW8081A	12/15/2009	0.0002	1	0.00020	ND	mg/L	R22130
Endrin ketone	SW8081A	12/15/2009	0.0002	1	0.00020	0.00062	mg/L	R22130
gamma-BHC	SW8081A	12/15/2009	0.0002	1	0.00020	ND	mg/L	R22130
gamma-Chlordane	SW8081A	12/15/2009	0.0002	1	0.00020	ND	mg/L	R22130
Heptachlor	SW8081A	12/15/2009	0.0002	1	0.00020	ND	mg/L	R22130
Heptachlor epoxide	SW8081A	12/15/2009	0.0002	1	0.00020	ND	mg/L	R22130
Methoxychlor	SW8081A	12/15/2009	0.0005	1	0.00050	ND	mg/L	R22130
Toxaphene	SW8081A	12/15/2009	0.01	1	0.010	ND	mg/L	R22130
Surr: Decachlorobiphenyl	SW8081A	12/15/2009	0	1	52-116	42.1	%REC	R22130
Surr: Tetrachloro-m-xylene	SW8081A	12/15/2009	0	1	40.3-118	71.1	%REC	R22130

Note: Surrogate recovery of DCBP is bias low possibly due to matrix effects; recovery of second surrogate supports data quality.

Report prepared for: Yvonne Parry
Tetra Tech, Inc.

Date Received: 12/14/2009

Date Reported: 12/16/2009

4,4'-DDD	SW8081A	12/15/2009	0.00047	100	0.047	ND	mg/Kg	R22104
4,4'-DDE	SW8081A	12/15/2009	0.00048	100	0.048	0.121 J	mg/Kg	R22104
4,4'-DDT	SW8081A	12/15/2009	0.00081	100	0.081	0.43	mg/Kg	R22104
Aldrin	SW8081A	12/15/2009	0.00044	100	0.044	2.5	mg/Kg	R22104
alpha-BHC	SW8081A	12/15/2009	0.00044	100	0.044	ND	mg/Kg	R22104
alpha-Chlordane	SW8081A	12/15/2009	0.00036	100	0.036	0.83	mg/Kg	R22104
beta-BHC	SW8081A	12/15/2009	0.00036	100	0.036	ND	mg/Kg	R22104
Chlordane	SW8081A	12/15/2009	0.01	100	1.0	8.8	mg/Kg	R22104
delta-BHC	SW8081A	12/15/2009	0.00049	100	0.049	ND	mg/Kg	R22104
Dieldrin	SW8081A	12/15/2009	0.00043	100	0.043	3.0	mg/Kg	R22104
Endosulfan I	SW8081A	12/15/2009	0.00059	100	0.059	ND	mg/Kg	R22104
Endosulfan II	SW8081A	12/15/2009	0.00153	100	0.15	ND	mg/Kg	R22104
Endosulfan sulfate	SW8081A	12/15/2009	0.00048	100	0.048	ND	mg/Kg	R22104
Endrin	SW8081A	12/15/2009	0.00057	100	0.057	ND	mg/Kg	R22104
Endrin aldehyde	SW8081A	12/15/2009	0.001	100	0.10	ND	mg/Kg	R22104
Endrin ketone	SW8081A	12/15/2009	0.0004	100	0.040	0.095 J	mg/Kg	R22104
gamma-BHC	SW8081A	12/15/2009	0.0004	100	0.040	ND	mg/Kg	R22104
gamma-Chlordane	SW8081A	12/15/2009	0.0004	100	0.040	0.92	mg/Kg	R22104
Heptachlor	SW8081A	12/15/2009	0.0011	100	0.11	ND	mg/Kg	R22104
Heptachlor epoxide	SW8081A	12/15/2009	0.0003	100	0.030	ND	mg/Kg	R22104
Methoxychlor	SW8081A	12/15/2009	0.0006	100	0.060	ND	mg/Kg	R22104
Toxaphene	SW8081A	12/15/2009	0.01	100	1.0	ND	mg/Kg	R22104
Surr: Decachlorobiphenyl	SW8081A	12/15/2009		100	52.5-139	D	%REC	R22104
Surr: Tetrachloro-m-xylene	SW8081A	12/15/2009		100	50.2-139	D	%REC	R22104

Note: D - Surrogate diluted out. Reporting limits increased due to dilution necessary for quantitation.

Definitions, legends and Notes

Note	Description
ug/kg	Microgram per kilogram (ppb, part per billion).
ug/L	Microgram per liter (ppb, part per billion).
mg/kg	Milligram per kilogram (ppm, part per million).
mg/L	Milligram per liter (ppm, part per million).
LCS/LCSD	Laboratory control sample/laboratory control sample duplicate.
MDL	Method detection limit.
MRL	Modified reporting limit. When sample is subject to dilution, reporting limit times dilution factor yields MRL.
MS/MSD	Matrix spike/matrix spike duplicate.
N/A	Not applicable.
ND	Not detected at or above detection limit.
NR	Not reported.
QC	Quality Control.
RL	Reporting limit.
% RPD	Percent relative difference.
a	pH was measured immediately upon the receipt of the sample, but it was still done outside the holding time.
sub	Analyzed by subcontracting laboratory, Lab Certificate #

ANALYTICAL QC SUMMARY REPORT

CLIENT: Tetra Tech, Inc.

Work Order: 0912121

Project: 100-SFO-T24989/Earhart

BatchID: R22104

Sample ID: SP091215A-MB	SampType: MBLK	TestCode: 8081S_Tetra	Units: mg/Kg	Prep Date: 12/15/2009	RunNo: 22104						
Client ID: ZZZZ	Batch ID: R22104	TestNo: SW8081A		Analysis Date: 12/15/2009	SeqNo: 316303						
Analyte	Result	PQL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
4,4'-DDD	ND	0.00047									
4,4'-DDE	ND	0.00048									
4,4'-DDT	ND	0.00081									
Aldrin	ND	0.00044									
alpha-BHC	ND	0.00044									
alpha-Chlordane	ND	0.00036									
beta-BHC	ND	0.00036									
Chlordane	ND	0.010									
delta-BHC	ND	0.00049									
Dieldrin	ND	0.00043									
Endosulfan I	ND	0.00059									
Endosulfan II	ND	0.0015									
Endosulfan sulfate	ND	0.00048									
Endrin	ND	0.00057									
Endrin aldehyde	ND	0.0010									
Endrin ketone	ND	0.00040									
gamma-BHC	ND	0.00040									
gamma-Chlordane	ND	0.00040									
Heptachlor	ND	0.0011									
Heptachlor epoxide	ND	0.00030									
Methoxychlor	ND	0.00060									
Toxaphene	ND	0.010									
Surr: Decachlorobiphenyl	0.04551	0	0.05	0	91.0	52.5	139				
Surr: Tetrachloro-m-xylene	0.04614	0	0.05	0	92.3	50.2	139				

Sample ID: SP091215A-LCS	SampType: LCS	TestCode: 8081S_Tetra	Units: mg/Kg	Prep Date: 12/15/2009	RunNo: 22104						
Client ID: ZZZZ	Batch ID: R22104	TestNo: SW8081A		Analysis Date: 12/15/2009	SeqNo: 316304						
Analyte	Result	PQL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
4,4'-DDD	ND	0.00047									
4,4'-DDE	ND	0.00048									
4,4'-DDT	ND	0.00081									
Aldrin	ND	0.00044									
alpha-BHC	ND	0.00044									
alpha-Chlordane	ND	0.00036									
beta-BHC	ND	0.00036									
Chlordane	ND	0.010									
delta-BHC	ND	0.00049									
Dieldrin	ND	0.00043									
Endosulfan I	ND	0.00059									
Endosulfan II	ND	0.0015									
Endosulfan sulfate	ND	0.00048									
Endrin	ND	0.00057									
Endrin aldehyde	ND	0.0010									
Endrin ketone	ND	0.00040									
gamma-BHC	ND	0.00040									
gamma-Chlordane	ND	0.00040									
Heptachlor	ND	0.0011									
Heptachlor epoxide	ND	0.00030									
Methoxychlor	ND	0.00060									
Toxaphene	ND	0.010									
Surr: Decachlorobiphenyl	0.04551	0	0.05	0	91.0	52.5	139				
Surr: Tetrachloro-m-xylene	0.04614	0	0.05	0	92.3	50.2	139				

Qualifiers: E Value above quantitation range H Holding times for preparation or analysis exceeded J Analyte detected below quantitation limits
 ND Not Detected at the Reporting Limit R RPD outside accepted recovery limits S Spike Recovery outside accepted recovery limits

ANALYTICAL QC SUMMARY REPORT

CLIENT: Tetra Tech, Inc.
Work Order: 0912121
Project: 100-SFO-T24989/Earhart

BatchID: R22104

Sample ID: SP091215A-LCS	SampType: LCS	TestCode: 8081S_Tetra	Units: mg/Kg
Client ID: ZZZZ	Batch ID: R22104	Prep Date: 12/15/2009	RunNo: 22104
		Analysis Date: 12/15/2009	SeqNo: 316304

Analyte	Result	PQL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
4,4'-DDD	0.01808	0.00047	0.02	0	90.4	39.6	130				
4,4'-DDE	0.01882	0.00048	0.02	0	94.1	45.3	130				
4,4'-DDT	0.02014	0.00081	0.02	0	101	52.8	134				
Aldrin	0.01874	0.00044	0.02	0	93.7	53	123				
alpha-BHC	0.01963	0.00044	0.02	0	98.1	44.2	130				
alpha-Chlordane	0.01962	0.00036	0.02	0	98.1	42.4	133				
beta-BHC	0.01811	0.00036	0.02	0	90.6	44.2	127				
delta-BHC	0.01902	0.00049	0.02	0	95.1	67.6	117				
Dieldrin	0.01960	0.00043	0.02	0	98.0	44	130				
Endosulfan I	0.01933	0.00059	0.02	0	96.7	65.5	112				
Endosulfan II	0.01867	0.0015	0.02	0	93.3	55.6	93.8				
Endosulfan sulfate	0.01943	0.00048	0.02	0	97.2	68.6	103				
Endrin	0.01902	0.00057	0.02	0	95.1	44.1	121				
Endrin aldehyde	0.01714	0.0010	0.02	0	85.7	32.8	124				
Endrin ketone	0.01846	0.00040	0.02	0	92.3	53.9	120				
gamma-BHC	0.01880	0.00040	0.02	0	94.0	56.9	120				
gamma-Chlordane	0.01992	0.00040	0.02	0	99.6	68.7	112				
Heptachlor	0.01981	0.0011	0.02	0	99.1	63.6	117				
Heptachlor epoxide	0.01949	0.00030	0.02	0	97.4	54.6	137				
Methoxychlor	0.02079	0.00060	0.02	0	104	57	126				
Surr: Decachlorobiphenyl	0.06491	0	0.07	0	92.7	52.5	139				
Surr: Tetrachloro-m-xylene	0.06669	0	0.07	0	95.3	50.2	139				

Sample ID: SP091215A-LCSD	SampType: LCSD	TestCode: 8081S_Tetra	Units: mg/Kg
Client ID: ZZZZ	Batch ID: R22104	Prep Date: 12/15/2009	RunNo: 22104
		Analysis Date: 12/15/2009	SeqNo: 316305

Analyte	Result	PQL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
4,4'-DDD	0.01523	0.00047	0.02	0	76.1	39.6	130	0.01808	17.1	30	
4,4'-DDE	0.01553	0.00048	0.02	0	77.7	45.3	130	0.01882	19.1	30	
4,4'-DDT	0.01698	0.00081	0.02	0	84.9	52.8	134	0.02014	17.0	30	
Aldrin	0.01544	0.00044	0.02	0	77.2	53	123	0.01874	19.3	30	

Qualifiers: E Value above quantitation range H Holding times for preparation or analysis exceeded J Analyte detected below quantitation limits
 ND Not Detected at the Reporting Limit R RPD outside accepted recovery limits S Spike Recovery outside accepted recovery limits

CLIENT: Tetra Tech, Inc.
Work Order: 0912121
Project: 100-SFO-T24989/Earhart

ANALYTICAL QC SUMMARY REPORT

BatchID: R22104

Sample ID: SP091215A-LCSD	SampType: LCSD	TestCode: 8081S_Tetra	Units: mg/Kg	Prep Date: 12/15/2009	RunNo: 22104						
Client ID: ZZZZ	Batch ID: R22104	TestNo: SW8081A		Analysis Date: 12/15/2009	SeqNo: 316305						
Analyte	Result	PQL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
alpha-BHC	0.01589	0.00044	0.02	0	79.4	44.2	130	0.01963	21.1	30	
alpha-Chlordane	0.01625	0.00036	0.02	0	81.2	42.4	133	0.01962	18.8	30	
beta-BHC	0.01475	0.00036	0.02	0	73.8	44.2	127	0.01811	20.4	30	
delta-BHC	0.01548	0.00049	0.02	0	77.4	67.6	117	0.01902	20.5	30	
Dieldrin	0.01643	0.00043	0.02	0	82.2	44	130	0.0196	17.6	30	
Endosulfan I	0.01441	0.00059	0.02	0	72.1	65.5	112	0.01933	29.2	30	
Endosulfan II	0.01392	0.0015	0.02	0	69.6	55.6	93.8	0.01867	29.2	30	
Endosulfan sulfate	0.01620	0.00048	0.02	0	81.0	68.6	103	0.01943	18.1	30	
Endrin	0.01617	0.00057	0.02	0	80.9	44.1	121	0.01902	16.2	30	
Endrin aldehyde	0.01409	0.0010	0.02	0	70.4	32.8	124	0.01714	19.5	30	
Endrin ketone	0.01548	0.00040	0.02	0	77.4	53.9	120	0.01846	17.5	30	
gamma-BHC	0.01535	0.00040	0.02	0	76.7	56.9	120	0.0188	20.2	30	
gamma-Chlordane	0.01652	0.00040	0.02	0	82.6	68.7	112	0.01992	18.6	30	
Heptachlor	0.01632	0.0011	0.02	0	81.6	63.6	117	0.01981	19.4	30	
Heptachlor epoxide	0.01635	0.00030	0.02	0	81.7	54.6	137	0.01949	17.5	30	
Methoxychlor	0.01845	0.00060	0.02	0	92.2	57	126	0.02079	11.9	30	
Surr: Decachlorobiphenyl	0.05414	0	0.07	0	77.3	52.5	139	0	0	0	
Surr: Tetrachloro-m-xylene	0.05432	0	0.07	0	77.6	50.2	139	0	0	0	

Qualifiers: E Value above quantitation range H Holding times for preparation or analysis exceeded J Analyte detected below quantitation limits
 ND Not Detected at the Reporting Limit R RPD outside accepted recovery limits S Spike Recovery outside accepted recovery limits

CLIENT: Tetra Tech, Inc.
Work Order: 0912121
Project: 100-SFO-T24989/Earhart

ANALYTICAL QC SUMMARY REPORT

BatchID: R22130

Sample ID: WP091215A-MB SP	SampType: MBLK	TestCode: 8081_SPLP	Units: mg/L	Prep Date: 12/15/2009	RunNo: 22130						
Client ID: ZZZZZ	Batch ID: R22130	TestNo: SW8081A		Analysis Date: 12/15/2009	SeqNo: 316592						
Analyte	Result	PQL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual

4,4'-DDD	ND	0.00020									
4,4'-DDE	ND	0.00020									
4,4'-DDT	ND	0.00020									
Aldrin	ND	0.00020									
alpha-BHC	ND	0.00020									
alpha-Chlordane	ND	0.00020									
beta-BHC	ND	0.00020									
Chlordane	ND	0.0025									
delta-BHC	ND	0.00020									
Dieldrin	ND	0.00020									
Endosulfan I	ND	0.00020									
Endosulfan II	ND	0.00020									
Endosulfan sulfate	ND	0.00020									
Endrin	ND	0.00020									
Endrin aldehyde	ND	0.00020									
Endrin ketone	ND	0.00020									
gamma-BHC	ND	0.00020									
gamma-Chlordane	ND	0.00020									
Heptachlor	ND	0.00020									
Heptachlor epoxide	ND	0.00020									
Methoxychlor	ND	0.00050									
Toxaphene	ND	0.010									
Surr: Decachlorobiphenyl	0.001847	0	0.0025	0	73.9	52	116				
Surr: Tetrachloro-m-xylene	0.001652	0	0.0025	0	66.1	40.3	118				

Sample ID: WP091215A-LCS SP	SampType: LCS	TestCode: 8081_SPLP	Units: mg/L	Prep Date: 12/15/2009	RunNo: 22130						
Client ID: ZZZZZ	Batch ID: R22130	TestNo: SW8081A		Analysis Date: 12/15/2009	SeqNo: 316593						
Analyte	Result	PQL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual

4,4'-DDT	0.0009110	0.00020	0.001	0	91.1	58.4	126				
Aldrin	0.0007324	0.00020	0.001	0	73.2	55.3	101				

Qualifiers: E Value above quantitation range H Holding times for preparation or analysis exceeded J Analyte detected below quantitation limits
 ND Not Detected at the Reporting Limit R RPD outside accepted recovery limits S Spike Recovery outside accepted recovery limits

CLIENT: Tetra Tech, Inc.
Work Order: 0912121
Project: 100-SFO-T24989/Earhart

ANALYTICAL QC SUMMARY REPORT

BatchID: R22130

Sample ID: WP091215A-LCS SP		SampType: LCS		TestCode: 8081_SPLP		Units: mg/L		Prep Date: 12/15/2009		RunNo: 22130	
Client ID: ZZZZZ		Batch ID: R22130		TestNo: SW8081A				Analysis Date: 12/15/2009		SeqNo: 316593	
Analyte	Result	PQL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Dieldrin	0.0008197	0.00020	0.001	0	82.0	60.3	116				
Endrin	0.0008160	0.00020	0.001	0	81.6	60.4	134				
gamma-BHC	0.0007041	0.00020	0.001	0	70.4	61.6	135				
Heptachlor	0.0006972	0.00020	0.001	0	69.7	60	97.8				
Surr: Decachlorobiphenyl	0.002604	0	0.0035	0	74.4	52	116				
Surr: Tetrachloro-m-xylene	0.002196	0	0.0035	0	62.7	40.3	118				

Sample ID: WP091215A-LCSD S		SampType: LCSD		TestCode: 8081_SPLP		Units: mg/L		Prep Date: 12/15/2009		RunNo: 22130	
Client ID: ZZZZZ		Batch ID: R22130		TestNo: SW8081A				Analysis Date: 12/15/2009		SeqNo: 316594	
Analyte	Result	PQL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
4,4'-DDT	0.0008845	0.00020	0.001	0	88.5	58.4	126	0.000911	2.95	35	
Aldrin	0.0007228	0.00020	0.001	0	72.3	55.3	101	0.0007324	1.32	35	
Dieldrin	0.0007920	0.00020	0.001	0	79.2	60.3	116	0.0008197	3.44	35	
Endrin	0.0007936	0.00020	0.001	0	79.4	60.4	134	0.000816	2.78	35	
gamma-BHC	0.0006995	0.00020	0.001	0	70.0	61.6	135	0.0007041	0.655	35	
Heptachlor	0.0006918	0.00020	0.001	0	69.2	60	97.8	0.0006972	0.778	35	
Surr: Decachlorobiphenyl	0.002384	0	0.0035	0	68.1	52	116	0	0	0	
Surr: Tetrachloro-m-xylene	0.002131	0	0.0035	0	60.9	40.3	118	0	0	0	

Qualifiers: E Value above quantitation range H Holding times for preparation or analysis exceeded J Analyte detected below quantitation limits
 ND Not Detected at the Reporting Limit R RPD outside accepted recovery limits S Spike Recovery outside accepted recovery limits



Change Order Form

Date: <u>12/14/09</u>	Time: <u>14:02</u>
Client: <u>Tetra Tech</u>	Order ID#: <u>0912121</u>
Project Number: <u>100-SFO-T24989</u>	Project Name: <u>Earhart</u>
Order Taken by: <u>P Sandrock via email</u>	Ordered by: <u>Yvonne Parry via email</u>

Laboratory ID	Client ID	Change Requested
<u>0912121-001</u>	<u>EAR-FP-E-6-3</u>	<u>Re run as 8081 MI as well as SPLP</u>
<u>0912121-002</u>	<u>EAR-FP-E-6-3</u>	<u>Re run as 8081 MI as well as SPLP</u>
<u>0912121-003</u>	<u>EAR-FP-D-12</u>	<u>Re run as 8081 MI as well as SPLP</u>
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Remarks:

Please re-run each of the smaples for 8081 MI Tetra Tech. SPLP should also be weighed as MI

2 Day TAT!! Due to client COB 12/16/09!!

Date Test(s) Added: 12/14/09 Test(s) Added by: P Sandrock

Note: Original to be placed in client file (electronic and/or hardcopy).

APPENDIX B

HDOH BATCH TEST LEACHING MODEL CALCULATION SHEETS

Sample: EAR-OA-1-6

Batch Test Leaching Model

Version: Summer 2008

Hawai'i Department of Health

Hazard Evaluation and Emergency Response Office

- Refer to accompanying technical memorandum for background and use of this spreadsheet (HDOH 2007).
- Spreadsheet calculates Kd desorption coefficient based on input contaminant concentration in soil and Batch Test data.
- Correlative concentration of contaminant in leachate calculated based on estimated Kd value (may differ from batch test data).
- Future impacts to groundwater estimated using simple groundwater/leachate dilution factor.
- Alternative model based on soil gas data provided in accompanying worksheet.
- Possibility of past impacts to groundwater not considered and must be evaluated separately.
- Check to ensure that this is an up-to-date version of the spreadsheet.
- Remove write protection if problems occur in selection of contaminant. Password to unprotect worksheet is "EAL" (under Tools menu).

STEPS:

1. Select chemical from pulldown list (unlisted chemicals - unprotect spreadsheet and input chemical name and chemical constants).
2. Input total contaminant concentration and SPLP (or other applicable batch test) concentration.
3. Input sample properties. Use default values if sample-specific data are not available.
4. Input Batch Test method information. Default SPLP method parameter values noted.
5. Input groundwater:leachate dilution factor (DF of 1.0 = no dilution; USEPA default = 20, USEPA 2002).
6. Input target groundwater action level for comparison to model calculation of groundwater impacts (optional).
7. Input chemical-specific Henry's Law Constant (Kh) and solubility if "Generic (Volatile)" or "Generic (Nonvolatile)" selected from pulldown list. Input "0" if values not available.
8. Spreadsheet calculates sample-specific Kd value and dissolved-phase concentration of contaminant in saturated sample.
9. Spreadsheet calculates concentration of contaminant in groundwater following impact by leachate.

Step 1: ¹⁰Select Contaminant (use pulldown list) DIELDRIN

Step 2: Input Sample Data	DEFAULT	INPUT
¹ Concentration in soil sample (mg/kg)	N/A	2.0E+00
¹ Concentration in Batch Test solution (ug/L)	N/A	2.5E+00
Step 3: Input Sample Properties (⁵ USEPA soil defaults noted)		
Sample density (g/cm ³)	1.50	1.50
Particle density (g/cm ³)	2.65	2.65
Fraction air-filled porosity (assume saturated soil)	0.00	0.00
Step 4: Batch Test Method Data (SPLP defaults noted)		
² Batch Test Solution Volume (ml):	2,000	2,000
² Batch Test Solution Density (g/cm ³):	1.0	1.0
² Batch Test Sample Weight (grams)	100	100

Step 5: Input Groundwater/Leachate Dilution Factor	DEFAULT	INPUT
	20	20
Step 6 (optional): Input Target Groundwater Concentration (ug/L)		
Model Results		
⁵ Kd partition Coefficient (cm ³ /g):	7.8E+02	
⁶ Estimated Concentration in Source Area Leachate (ug/L):	2.6E+00	
⁷ Estimated Concentration in Groundwater (ug/L):	-	

Step 7: ¹⁰Chemical Constants [Generic Chemical only]

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Kd >20. Contaminant not significantly mobile for concentration and soil type tested. Do not place below water table without further evaluation. Address other potential environmental concerns as needed (direct exposure, gross contamination, etc.).

Calculations:	
Sample porosity - total	0.43
Sample porosity - air-filled	0.00
Sample porosity - water-filled	0.43
Batch Test Solution Mass (grams)	2.0E+03
Batch Test Sample Mass (grams)	1.0E+02
Sample Mass:Solution Mass Ratio (gm/gm)	5.0E-02
Total Mass of Contaminant (ug)	2.0E+02
Mass Contaminant in Batch Test Solution (ug)	5.0E+00
Mass Contaminant Sorbed to Soil (ug)	2.0E+02
Concentration Sorbed (ug/kg)	2.0E+03
Batch Test Percent Solid Phase	97.5%
Batch Test Percent Dissolved Phase	2.5%
Batch Test Solid-Phase Contaminant Conc. (mg/kg)	2.0E+00
Batch Test Solution Contaminant Conc. (ug/L)	2.5E+00

Sample: EAR-FP-D-12

Batch Test Leaching Model

Version: Summer 2008

Hawai'i Department of Health

Hazard Evaluation and Emergency Response Office

-Refer to accompanying technical memorandum for background and use of this spreadsheet (HDOH 2007).
 -Spreadsheet calculates Kd desorption coefficient based on input contaminant concentration in soil and Batch Test data.
 -Correlative concentration of contaminant in leachate calculated based on estimated Kd value (may differ from batch test data).
 -Future impacts to groundwater estimated using simple groundwater/leachate dilution factor.
 -Alternative model based on soil gas data provided in accompanying worksheet.
 -Possibility of past impacts to groundwater not considered and must be evaluated separately.
 -Check to ensure that this is an up-to-date version of the spreadsheet.
 -Remove write protection if problems occur in selection of contaminant. Password to unprotect worksheet is "EAL" (under Tools menu).

STEPS:

1. Select chemical from pulldown list (unlisted chemicals - unprotect spreadsheet and input chemical name and chemical constants).
2. Input total contaminant concentration and SPLP (or other applicable batch test) concentration.
3. Input sample properties. Use default values if sample-specific data are not available.
4. Input Batch Test method information. Default SPLP method parameter values noted.
5. Input groundwater:leachate dilution factor (DF of 1.0 = no dilution; USEPA default = 20, USEPA 2002).
6. Input target groundwater action level for comparison to model calculation of groundwater impacts (optional).
7. Input chemical-specific Henry's Law Constant (Kh) and solubility if "Generic (Volatile)" or "Generic (Nonvolatile)" selected from pulldown list. Input "0" if values not available.
8. Spreadsheet calculates sample-specific Kd value and dissolved-phase concentration of contaminant in saturated sample.
9. Spreadsheet calculates concentration of contaminant in groundwater following impact by leachate.

Step 1: ¹⁰Select Contaminant (use pulldown list) DIELDRIN

Step 2: Input Sample Data	DEFAULT	INPUT
¹ Concentration in soil sample (mg/kg)	N/A	3.0E+00
¹ Concentration in Batch Test solution (ug/L)	N/A	4.5E+00
Step 3: Input Sample Properties (⁵ USEPA soil defaults noted)		
Sample density (g/cm ³)	1.50	1.50
Particle density (g/cm ³)	2.65	2.65
Fraction air-filled porosity (assume saturated soil)	0.00	0.00
Step 4: Batch Test Method Data (SPLP defaults noted)		
² Batch Test Solution Volume (ml):	2,000	2,000
² Batch Test Solution Density (g/cm ³):	1.0	1.0
² Batch Test Sample Weight (grams)	100	100

Step 5: Input Groundwater/Leachate Dilution Factor	DEFAULT	INPUT
	20	20
Step 6 (optional): Input Target Groundwater Concentration (ug/L)		
Model Results		
⁵ Kd partition Coefficient (cm ³ /g):	6.5E+02	
⁶ Estimated Concentration in Source Area Leachate (ug/L):	4.6E+00	
⁷ Estimated Concentration in Groundwater (ug/L):	-	

Step 7: ¹⁰Chemical Constants [Generic Chemical only]

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Kd >20. Contaminant not significantly mobile for concentration and soil type tested. Do not place below water table without further evaluation. Address other potential environmental concerns as needed (direct exposure, gross contamination, etc.).

Calculations:	
Sample porosity - total	0.43
Sample porosity - air-filled	0.00
Sample porosity - water-filled	0.43
Batch Test Solution Mass (grams)	2.0E+03
Batch Test Sample Mass (grams)	1.0E+02
Sample Mass:Solution Mass Ratio (gm/gm)	5.0E-02
Total Mass of Contaminant (ug)	3.0E+02
Mass Contaminant in Batch Test Solution (ug)	9.0E+00
Mass Contaminant Sorbed to Soil (ug)	2.9E+02
Concentration Sorbed (ug/kg)	2.9E+03
Batch Test Percent Solid Phase	97.0%
Batch Test Percent Dissolved Phase	3.0%
Batch Test Solid-Phase Contaminant Conc. (mg/kg)	2.9E+00
Batch Test Solution Contaminant Conc. (ug/L)	4.5E+00

Sample: EAR-FP-E-6-3

Batch Test Leaching Model

Version: Summer 2008

Hawai'i Department of Health

Hazard Evaluation and Emergency Response Office

-Refer to accompanying technical memorandum for background and use of this spreadsheet (HDOH 2007).
 -Spreadsheet calculates Kd desorption coefficient based on input contaminant concentration in soil and Batch Test data.
 -Correlative concentration of contaminant in leachate calculated based on estimated Kd value (may differ from batch test data).
 -Future impacts to groundwater estimated using simple groundwater/leachate dilution factor.
 -Alternative model based on soil gas data provided in accompanying worksheet.
 -Possibility of past impacts to groundwater not considered and must be evaluated separately.
 -Check to ensure that this is an up-to-date version of the spreadsheet.
 -Remove write protection if problems occur in selection of contaminant. Password to unprotect worksheet is "EAL" (under Tools menu).

STEPS:

1. Select chemical from pulldown list (unlisted chemicals - unprotect spreadsheet and input chemical name and chemical constants).
2. Input total contaminant concentration and SPLP (or other applicable batch test) concentration.
3. Input sample properties. Use default values if sample-specific data are not available.
4. Input Batch Test method information. Default SPLP method parameter values noted.
5. Input groundwater:leachate dilution factor (DF of 1.0 = no dilution; USEPA default = 20, USEPA 2002).
6. Input target groundwater action level for comparison to model calculation of groundwater impacts (optional).
7. Input chemical-specific Henry's Law Constant (Kh) and solubility if "Generic (Volatile)" or "Generic (Nonvolatile)" selected from pulldown list. Input "0" if values not available.
8. Spreadsheet calculates sample-specific Kd value and dissolved-phase concentration of contaminant in saturated sample.
9. Spreadsheet calculates concentration of contaminant in groundwater following impact by leachate.

Step 1: ¹⁰Select Contaminant (use pulldown list) **DIELDRIN**

Step 2: Input Sample Data	DEFAULT	INPUT
¹ Concentration in soil sample (mg/kg)	N/A	4.5E+00
¹ Concentration in Batch Test solution (ug/L)	N/A	6.3E+00
Step 3: Input Sample Properties (⁵ USEPA soil defaults noted)		
Sample density (g/cm ³)	1.50	1.50
Particle density (g/cm ³)	2.65	2.65
Fraction air-filled porosity (assume saturated soil)	0.00	0.00
Step 4: Batch Test Method Data (SPLP defaults noted)		
² Batch Test Solution Volume (ml):	2,000	2,000
² Batch Test Solution Density (g/cm ³):	1.0	1.0
² Batch Test Sample Weight (grams)	100	100

Step 5: Input Groundwater/Leachate Dilution Factor	DEFAULT	INPUT
	20	20
Step 6 (optional): Input Target Groundwater Concentration (ug/L)		
Model Results		
⁵ Kd partition Coefficient (cm ³ /g):	6.9E+02	
⁶ Estimated Concentration in Source Area Leachate (ug/L):	6.5E+00	
⁷ Estimated Concentration in Groundwater (ug/L):	-	

Step 7: ¹⁰Chemical Constants [Generic Chemical only]

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Kd >20. Contaminant not significantly mobile for concentration and soil type tested. Do not place below water table without further evaluation. Address other potential environmental concerns as needed (direct exposure, gross contamination, etc.).

Calculations:	
Sample porosity - total	0.43
Sample porosity - air-filled	0.00
Sample porosity - water-filled	0.43
Batch Test Solution Mass (grams)	2.0E+03
Batch Test Sample Mass (grams)	1.0E+02
Sample Mass:Solution Mass Ratio (gm/gm)	5.0E-02
Total Mass of Contaminant (ug)	4.5E+02
Mass Contaminant in Batch Test Solution (ug)	1.3E+01
Mass Contaminant Sorbed to Soil (ug)	4.4E+02
Concentration Sorbed (ug/kg)	4.4E+03
Batch Test Percent Solid Phase	97.2%
Batch Test Percent Dissolved Phase	2.8%
Batch Test Solid-Phase Contaminant Conc. (mg/kg)	4.4E+00
Batch Test Solution Contaminant Conc. (ug/L)	6.3E+00

Sample: EAR-FP-E-6-3

Batch Test Leaching Model

Version: Summer 2008

Hawai'i Department of Health

Hazard Evaluation and Emergency Response Office

-Refer to accompanying technical memorandum for background and use of this spreadsheet (HDOH 2007).
 -Spreadsheet calculates Kd desorption coefficient based on input contaminant concentration in soil and Batch Test data.
 -Correlative concentration of contaminant in leachate calculated based on estimated Kd value (may differ from batch test data).
 -Future impacts to groundwater estimated using simple groundwater/leachate dilution factor.
 -Alternative model based on soil gas data provided in accompanying worksheet.
 -Possibility of past impacts to groundwater not considered and must be evaluated separately.
 -Check to ensure that this is an up-to-date version of the spreadsheet.
 -Remove write protection if problems occur in selection of contaminant. Password to unprotect worksheet is "EAL" (under Tools menu).

STEPS:

1. Select chemical from pulldown list (unlisted chemicals - unprotect spreadsheet and input chemical name and chemical constants).
2. Input total contaminant concentration and SPLP (or other applicable batch test) concentration.
3. Input sample properties. Use default values if sample-specific data are not available.
4. Input Batch Test method information. Default SPLP method parameter values noted.
5. Input groundwater:leachate dilution factor (DF of 1.0 = no dilution; USEPA default = 20, USEPA 2002).
6. Input target groundwater action level for comparison to model calculation of groundwater impacts (optional).
7. Input chemical-specific Henry's Law Constant (Kh) and solubility if "Generic (Volatile)" or "Generic (Nonvolatile)" selected from pulldown list. Input "0" if values not available.
8. Spreadsheet calculates sample-specific Kd value and dissolved-phase concentration of contaminant in saturated sample.
9. Spreadsheet calculates concentration of contaminant in groundwater following impact by leachate.

Step 1: ¹⁰Select Contaminant (use pulldown list) **ALDRIN**

Step 2: Input Sample Data	DEFAULT	INPUT
¹ Concentration in soil sample (mg/kg)	N/A	8.2E+00
¹ Concentration in Batch Test solution (ug/L)	N/A	1.4E+00
Step 3: Input Sample Properties (⁵ USEPA soil defaults noted)		
Sample density (g/cm ³)	1.50	1.50
Particle density (g/cm ³)	2.65	2.65
Fraction air-filled porosity (assume saturated soil)	0.00	0.00
Step 4: Batch Test Method Data (SPLP defaults noted)		
² Batch Test Solution Volume (ml):	2,000	2,000
² Batch Test Solution Density (g/cm ³):	1.0	1.0
² Batch Test Sample Weight (grams)	100	100

Step 5: Input Groundwater/Leachate Dilution Factor	DEFAULT	INPUT
	20	20
Step 6 (optional): Input Target Groundwater Concentration (ug/L)		
Model Results		
⁵ Kd partition Coefficient (cm ³ /g):	5.8E+03	
⁶ Estimated Concentration in Source Area Leachate (ug/L):	1.4E+00	
⁷ Estimated Concentration in Groundwater (ug/L):	-	

Step 7: ¹⁰Chemical Constants [Generic Chemical only]

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Kd >20. Contaminant not significantly mobile for concentration and soil type tested. Do not place below water table without further evaluation. Address other potential environmental concerns as needed (direct exposure, gross contamination, etc.).

Calculations:	
Sample porosity - total	0.43
Sample porosity - air-filled	0.00
Sample porosity - water-filled	0.43
Batch Test Solution Mass (grams)	2.0E+03
Batch Test Sample Mass (grams)	1.0E+02
Sample Mass:Solution Mass Ratio (gm/gm)	5.0E-02
Total Mass of Contaminant (ug)	8.2E+02
Mass Contaminant in Batch Test Solution (ug)	2.8E+00
Mass Contaminant Sorbed to Soil (ug)	8.2E+02
Concentration Sorbed (ug/kg)	8.2E+03
Batch Test Percent Solid Phase	99.7%
Batch Test Percent Dissolved Phase	0.3%
Batch Test Solid-Phase Contaminant Conc. (mg/kg)	8.2E+00
Batch Test Solution Contaminant Conc. (ug/L)	1.4E+00

Sample: EAR-OA-1-6

Batch Test Leaching Model

Version: Summer 2008

Hawai'i Department of Health

Hazard Evaluation and Emergency Response Office

-Refer to accompanying technical memorandum for background and use of this spreadsheet (HDOH 2007).
 -Spreadsheet calculates Kd desorption coefficient based on input contaminant concentration in soil and Batch Test data.
 -Correlative concentration of contaminant in leachate calculated based on estimated Kd value (may differ from batch test data).
 -Future impacts to groundwater estimated using simple groundwater/leachate dilution factor.
 -Alternative model based on soil gas data provided in accompanying worksheet.
 -Possibility of past impacts to groundwater not considered and must be evaluated separately.
 -Check to ensure that this is an up-to-date version of the spreadsheet.
 -Remove write protection if problems occur in selection of contaminant. Password to unprotect worksheet is "EAL" (under Tools menu).

STEPS:

1. Select chemical from pulldown list (unlisted chemicals - unprotect spreadsheet and input chemical name and chemical constants).
2. Input total contaminant concentration and SPLP (or other applicable batch test) concentration.
3. Input sample properties. Use default values if sample-specific data are not available.
4. Input Batch Test method information. Default SPLP method parameter values noted.
5. Input groundwater:leachate dilution factor (DF of 1.0 = no dilution; USEPA default = 20, USEPA 2002).
6. Input target groundwater action level for comparison to model calculation of groundwater impacts (optional).
7. Input chemical-specific Henry's Law Constant (Kh) and solubility if "Generic (Volatile)" or "Generic (Nonvolatile)" selected from pulldown list. Input "0" if values not available.
8. Spreadsheet calculates sample-specific Kd value and dissolved-phase concentration of contaminant in saturated sample.
9. Spreadsheet calculates concentration of contaminant in groundwater following impact by leachate.

Step 1: ¹⁰Select Contaminant (use pulldown list) ALDRIN

Step 2: Input Sample Data	DEFAULT	INPUT
¹ Concentration in soil sample (mg/kg)	N/A	2.1E+00
¹ Concentration in Batch Test solution (ug/L)	N/A	3.4E-01
Step 3: Input Sample Properties (⁵ USEPA soil defaults noted)		
Sample density (g/cm ³)	1.50	1.50
Particle density (g/cm ³)	2.65	2.65
Fraction air-filled porosity (assume saturated soil)	0.00	0.00
Step 4: Batch Test Method Data (SPLP defaults noted)		
² Batch Test Solution Volume (ml):	2,000	2,000
² Batch Test Solution Density (g/cm ³):	1.0	1.0
² Batch Test Sample Weight (grams)	100	100

Step 5: Input Groundwater/Leachate Dilution Factor	DEFAULT	INPUT
	20	20
Step 6 (optional): Input Target Groundwater Concentration (ug/L)		
Model Results		
⁵ Kd partition Coefficient (cm ³ /g):	6.2E+03	
⁶ Estimated Concentration in Source Area Leachate (ug/L):	3.4E-01	
⁷ Estimated Concentration in Groundwater (ug/L):	-	

Step 7: ¹⁰Chemical Constants [Generic Chemical only]

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Kd >20. Contaminant not significantly mobile for concentration and soil type tested. Do not place below water table without further evaluation. Address other potential environmental concerns as needed (direct exposure, gross contamination, etc.).

Calculations:	
Sample porosity - total	0.43
Sample porosity - air-filled	0.00
Sample porosity - water-filled	0.43
Batch Test Solution Mass (grams)	2.0E+03
Batch Test Sample Mass (grams)	1.0E+02
Sample Mass:Solution Mass Ratio (gm/gm)	5.0E-02
Total Mass of Contaminant (ug)	2.1E+02
Mass Contaminant in Batch Test Solution (ug)	6.8E-01
Mass Contaminant Sorbed to Soil (ug)	2.1E+02
Concentration Sorbed (ug/kg)	2.1E+03
Batch Test Percent Solid Phase	99.7%
Batch Test Percent Dissolved Phase	0.3%
Batch Test Solid-Phase Contaminant Conc. (mg/kg)	2.1E+00
Batch Test Solution Contaminant Conc. (ug/L)	3.4E-01

Sample: EAR-FP-D-12

Batch Test Leaching Model

Version: Summer 2008

Hawai'i Department of Health

Hazard Evaluation and Emergency Response Office

- Refer to accompanying technical memorandum for background and use of this spreadsheet (HDOH 2007).
- Spreadsheet calculates Kd desorption coefficient based on input contaminant concentration in soil and Batch Test data.
- Correlative concentration of contaminant in leachate calculated based on estimated Kd value (may differ from batch test data).
- Future impacts to groundwater estimated using simple groundwater/leachate dilution factor.
- Alternative model based on soil gas data provided in accompanying worksheet.
- Possibility of past impacts to groundwater not considered and must be evaluated separately.
- Check to ensure that this is an up-to-date version of the spreadsheet.
- Remove write protection if problems occur in selection of contaminant. Password to unprotect worksheet is "EAL" (under Tools menu).

STEPS:

1. Select chemical from pulldown list (unlisted chemicals - unprotect spreadsheet and input chemical name and chemical constants).
2. Input total contaminant concentration and SPLP (or other applicable batch test) concentration.
3. Input sample properties. Use default values if sample-specific data are not available.
4. Input Batch Test method information. Default SPLP method parameter values noted.
5. Input groundwater:leachate dilution factor (DF of 1.0 = no dilution; USEPA default = 20, USEPA 2002).
6. Input target groundwater action level for comparison to model calculation of groundwater impacts (optional).
7. Input chemical-specific Henry's Law Constant (Kh) and solubility if "Generic (Volatile)" or "Generic (Nonvolatile)" selected from pulldown list. Input "0" if values not available.
8. Spreadsheet calculates sample-specific Kd value and dissolved-phase concentration of contaminant in saturated sample.
9. Spreadsheet calculates concentration of contaminant in groundwater following impact by leachate.

Step 1: ¹⁰Select Contaminant (use pulldown list)	ALDRIN
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Step 2: Input Sample Data	DEFAULT	INPUT
¹ Concentration in soil sample (mg/kg)	N/A	2.5E+00
¹ Concentration in Batch Test solution (ug/L)	N/A	3.8E-01
Step 3: Input Sample Properties (⁵USEPA soil defaults noted)		
Sample density (g/cm ³)	1.50	1.50
Particle density (g/cm ³)	2.65	2.65
Fraction air-filled porosity (assume saturated soil)	0.00	0.00
Step 4: Batch Test Method Data (SPLP defaults noted)		
² Batch Test Solution Volume (ml):	2,000	2,000
² Batch Test Solution Density (g/cm ³):	1.0	1.0
² Batch Test Sample Weight (grams)	100	100

Step 5: Input Groundwater/Leachate Dilution Factor	DEFAULT	INPUT
	20	20
Step 6 (optional): Input Target Groundwater Concentration (ug/L)		
Model Results		
⁵ Kd partition Coefficient (cm ³ /g):		6.6E+03
⁶ Estimated Concentration in Source Area Leachate (ug/L):		3.8E-01
⁷ Estimated Concentration in Groundwater (ug/L):		-

Step 7: ¹⁰Chemical Constants [Generic Chemical only]

Kd >20. Contaminant not significantly mobile for concentration and soil type tested. Do not place below water table without further evaluation. Address other potential environmental concerns as needed (direct exposure, gross contamination, etc.).

Calculations:	
Sample porosity - total	0.43
Sample porosity - air-filled	0.00
Sample porosity - water-filled	0.43
Batch Test Solution Mass (grams)	2.0E+03
Batch Test Sample Mass (grams)	1.0E+02
Sample Mass:Solution Mass Ratio (gm/gm)	5.0E-02
Total Mass of Contaminant (ug)	2.5E+02
Mass Contaminant in Batch Test Solution (ug)	7.6E-01
Mass Contaminant Sorbed to Soil (ug)	2.5E+02
Concentration Sorbed (ug/kg)	2.5E+03
Batch Test Percent Solid Phase	99.7%
Batch Test Percent Dissolved Phase	0.3%
Batch Test Solid-Phase Contaminant Conc. (mg/kg)	2.5E+00
Batch Test Solution Contaminant Conc. (ug/L)	3.8E-01

Sample: EAR-FP-D-12

Batch Test Leaching Model

Version: Summer 2008

Hawai'i Department of Health

Hazard Evaluation and Emergency Response Office

- Refer to accompanying technical memorandum for background and use of this spreadsheet (HDOH 2007).
- Spreadsheet calculates Kd desorption coefficient based on input contaminant concentration in soil and Batch Test data.
- Correlative concentration of contaminant in leachate calculated based on estimated Kd value (may differ from batch test data).
- Future impacts to groundwater estimated using simple groundwater/leachate dilution factor.
- Alternative model based on soil gas data provided in accompanying worksheet.
- Possibility of past impacts to groundwater not considered and must be evaluated separately.
- Check to ensure that this is an up-to-date version of the spreadsheet.
- Remove write protection if problems occur in selection of contaminant. Password to unprotect worksheet is "EAL" (under Tools menu).

STEPS:

1. Select chemical from pulldown list (unlisted chemicals - unprotect spreadsheet and input chemical name and chemical constants).
2. Input total contaminant concentration and SPLP (or other applicable batch test) concentration.
3. Input sample properties. Use default values if sample-specific data are not available.
4. Input Batch Test method information. Default SPLP method parameter values noted.
5. Input groundwater:leachate dilution factor (DF of 1.0 = no dilution; USEPA default = 20, USEPA 2002).
6. Input target groundwater action level for comparison to model calculation of groundwater impacts (optional).
7. Input chemical-specific Henry's Law Constant (Kh) and solubility if "Generic (Volatile)" or "Generic (Nonvolatile)" selected from pulldown list. Input "0" if values not available.
8. Spreadsheet calculates sample-specific Kd value and dissolved-phase concentration of contaminant in saturated sample.
9. Spreadsheet calculates concentration of contaminant in groundwater following impact by leachate.

Step 1: ¹⁰Select Contaminant (use pulldown list) CHLORDANE (TECHNICAL)

Step 2: Input Sample Data	DEFAULT	INPUT
¹ Concentration in soil sample (mg/kg)	N/A	8.8E+00
¹ Concentration in Batch Test solution (ug/L)	N/A	2.8E+00
Step 3: Input Sample Properties (⁵ USEPA soil defaults noted)		
Sample density (g/cm ³)	1.50	1.50
Particle density (g/cm ³)	2.65	2.65
Fraction air-filled porosity (assume saturated soil)	0.00	0.00
Step 4: Batch Test Method Data (SPLP defaults noted)		
² Batch Test Solution Volume (ml):	2,000	2,000
² Batch Test Solution Density (g/cm ³):	1.0	1.0
² Batch Test Sample Weight (grams)	100	100

Step 5: Input Groundwater/Leachate Dilution Factor	DEFAULT	INPUT
	20	20
Step 6 (optional): Input Target Groundwater Concentration (ug/L)		
Model Results		
⁵ Kd partition Coefficient (cm ³ /g):		3.1E+03
⁶ Estimated Concentration in Source Area Leachate (ug/L):		2.8E+00
⁷ Estimated Concentration in Groundwater (ug/L):		-

Step 7: ¹⁰Chemical Constants [Generic Chemical only]

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Kd >20. Contaminant not significantly mobile for concentration and soil type tested. Do not place below water table without further evaluation. Address other potential environmental concerns as needed (direct exposure, gross contamination, etc.).

Calculations:	
Sample porosity - total	0.43
Sample porosity - air-filled	0.00
Sample porosity - water-filled	0.43
Batch Test Solution Mass (grams)	2.0E+03
Batch Test Sample Mass (grams)	1.0E+02
Sample Mass:Solution Mass Ratio (gm/gm)	5.0E-02
Total Mass of Contaminant (ug)	8.8E+02
Mass Contaminant in Batch Test Solution (ug)	5.6E+00
Mass Contaminant Sorbed to Soil (ug)	8.7E+02
Concentration Sorbed (ug/kg)	8.7E+03
Batch Test Percent Solid Phase	99.4%
Batch Test Percent Dissolved Phase	0.6%
Batch Test Solid-Phase Contaminant Conc. (mg/kg)	8.7E+00
Batch Test Solution Contaminant Conc. (ug/L)	2.8E+00

Notes (refer also to accompanying memo).

1. Total contaminant concentration measured in soil sample and results of Batch Test analysis (e.g., SPLP).
2. Batch Test: Default SPLP method calls for 100 grams of sample and 2 liters of solution with a density of approximately 1.0
3. Site-specific or default groundwater/leachate dilution factor (default = 20, USEPA 2001).
4. Target groundwater action level. Refer to HDOH EAL document and appropriate groundwater category.
5. Partition Coefficient (Kd) = $\text{Concentration}_{\text{sorbed}} / \text{Concentration}_{\text{solution}}$ (after Roy et al 1992).
Partition Coefficient units in L/Kg [(ug/Kg)/ug/L] or cm^3/g [(ug/g)/ug/cm³]
6. Estimated dissolved-phase concentration of contaminant in saturated sample based on calculated partition coefficient Kd
7. Tier 3 concentration in groundwater calculated as concentration in leachate divided by input dilution factor. Reduction of contaminant solubility and a Kd value will not be generated (refer to "Leaching Evaluation of Heavily Contaminated Soils" in text). Model assumes that free product is present in the batch test solution and a Kd cannot be calculated (see text).
9. Error Message: The batch test data are not valid if the contaminant mass calculated for solute exceeds total mass calculated for sample (based on sample mass and input total contaminant concentration). This may not be uncommon given the potential for lab error at very low concentrations of contaminants.
10. "GENERIC CHEMICAL" can be selected from pulldown menu and used to model of any chemical, including chemicals not listed. Selection requires input of Kh (atm m³/mole) and Solubility constants in Step 7 if available. Note that a chemical's physiochemical constants affect results for VOCs only if input Fraction Air-Filled Porosity is >0% (model considers partitioning into pore space air for VOCs as well as leachate).

References:

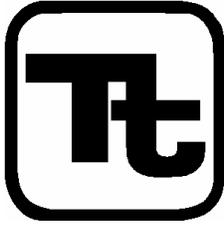
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- USEPA, 2002, Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites: U.S. Environmental Protection Agency, Solid Waste and Emergency Response, OSWER 9355.4-24, December 2002, http://www.epa.gov/superfund/resources/soil/ssg_main.pdf

APPENDIX B

2006 Hickam EAL Development Memorandum

Appendix B

Summary of Human Health Risk Assessment and Tier 2 Environmental Action Level Development



TETRA TECH, INC.

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June 30, 2006

Mr. Jeff Apitz
Vice President Development, Project Director – Hickam Community Housing
7130 Ohana Nui Circle
Hickam Air Force Base, Hawaii 96818-4548

Subject: Summary of Human Health Risk Assessment of Chlordane (Including Heptachlor and Heptachlor Epoxide), Dieldrin and Aldrin in Soil, Hickam Community Housing Areas, Hickam Air Force Base, Hawaii

Dear Mr. Apitz:

Tetra Tech performed a human health risk assessment for three organochlorine pesticides [chlordane (including heptachlor and heptachlor epoxide), dieldrin and aldrin] in soil for Hickam Community Housing (HCH). The purpose of this risk assessment was to develop Tier 2 Environmental Action Levels (EALs) that are sufficiently protective of human health while taking into account site-specific considerations.

Soil sampling and analysis has already occurred at the Capehart and Earhart Housing Areas on Hickam Air Force Base (AFB) in Hawai'i. All three pesticides [chlordane (including heptachlor and heptachlor epoxide), dieldrin and aldrin] were detected at concentrations exceeding the Tier 1 Hawai'i Department of Health (DOH) EALs. Following Hawai'i DOH (2005) guidance, if the Tier 1 EALs are exceeded, "selected components of the models used to develop the Tier 1 EALs are modified with respect to site-specific data or considerations" to calculate site-specific Tier 2 EALs. The Tier 2 EALs presented here could apply to Phase II as well as future HCH residential housing as conditions are sufficiently uniform throughout the site.

This letter 1) presents the calculation of site-specific Tier 2 EALs for aldrin, chlordane, and dieldrin, and 2) compares the soils data from the Capehart and Earhart Housing Areas at Hickam AFB to the site-specific Tier 2 EALs.

Site-specific screening levels

The Hawai'i DOH has calculated conservative screening values for contaminants in soils called Environmental Action Levels (EALs) (Hawai'i DOH 2005). When measured concentrations of contaminants at a site exceed the default, or Tier 1, EALs at a site, new EALs may be calculated for that site incorporating site-specific considerations into the equations used to derive the EALs (Hawai'i DOH 2005).

The Tier 1 EALs initially used for evaluation of soils data at the site are protective of a risk of 1×10^{-6} for residential exposures of 30 years. The Tier 2 EALs developed for Hickam AFB suggest a modification of exposure duration and target risk level based on site-specific conditions.

Exposure Duration

In calculating the Tier 2 EALs, it is recommended that the residency time be modified from 30 years to 6 years based on site-specific conditions. As Hickam AFB is a military base, the average length of stay in the on-base housing is likely to be considerably shorter than in the general U.S. population. For example, a study entitled Military-specific exposure factors study by the U.S. Air Force Research Laboratory determined that the mean number of years that Air Force enlisted personnel are at a single base is 5.7 years and the mean for officers is 2.6 years (1998). Based on these conclusions, the exposure duration proposed for use in the Tier 2 EALs for Hickam AFB is 6 years. An additional study found that the duration of residency at Hickam AFB is 5 years or less for approximately 98% of residents (HCH and HAFB Housing Office 2006; see attachment).

This exposure duration is consistent with the average time on base for enlisted personnel in the Air Force. It is, therefore, recommended that the Air Force enforce a 6-year maximum stay in on-base housing based on the risk assessment parameters used by Tetra Tech in calculating the Tier 2 EALs.

Target Risk Level

In calculating the Tier 2 EALs, it is recommended that the target risk level be modified from 1×10^{-6} to 1×10^{-5} . Both the Hawai'i DOH guidance (2005) and the USEPA (1990) allow modification of the target risk level from 1×10^{-6} to 1×10^{-5} .

Modifying the target risk levels for the calculation of Tier 2 EALs is specifically called out as one of the permitted modifications in the Hawai'i DOH guidance (2005). The Hawai'i DOH Interim Final Rule, Screening For Environmental Concerns At Sites With Contaminated Soil and Groundwater, Section 3.2.2 specifically lists "use of alternative target risk levels" as a common modification for determining Tier 2 soil action levels.

The proposed target risk level of 10^{-5} is also within the USEPA (1990) acceptable risk range of 10^{-6} to 10^{-4} (40 CFR Part 300:55). In addition, the Hawai'i State Contingency Plan, Chapter 11-451, Hawai'i Administrative Rules states, "For known or suspected carcinogens acceptable cleanup levels are generally concentration levels that represent an excess upper bound lifetime cancer risk to an individual of between 10^{-4} and 10^{-6} using information on the relationship between dose and response" (1995).

These two modifications from the parameters used in calculating the Tier 1 EALs represent the only changes proposed for the Tier 2 EALs for Hickam AFB. All of the other parameters used in calculating the Tier 2 EALs are the same as in the Hawai'i DOH (2005) EAL guidance document; however, since the exposure duration has been shortened from 30 years to 6 years for residents, the time-weighted equations that are used to calculate a single Tier 1 EAL for child and adult residents together will not be used. Instead, the non-time-weighted equations will be used to calculate EALs for child and adult residents separately. The equations and parameters used are presented in Table 1.

Using these parameters, the following Tier 2 EALs (mg/kg) were calculated for both the carcinogenic endpoints (Risk = 10^{-5}) and non-carcinogenic endpoint (Hazard Index = 1) for each pesticide:

Pesticide	Resident	Risk = 10⁻⁵	Hazard Index = 1	Tier 2 EAL	Tier 1 EAL
Aldrin				0.42	0.029
	Adult	3.6	15.7		
	Child	0.42	1.8		
Chlordane				23.4	1.6
	Adult	209.8	314.7		
	Child	23.4	35.2		
Dieldrin				0.45	0.0023
	Adult	3.8	26.1		
	Child	0.45	3.1		

The lowest or child risk values (See column labeled Risk = 10⁻⁵) presented in the table above for each pesticide will be selected as the final Tier 2 EAL and used to screen the pesticide concentrations measured in soils at Hickam AFB.

Comparison of measured concentrations in soils to Tier 2 EALs

The concentrations of aldrin, chlordane, and dieldrin measured in soils at Hickam AFB are presented by housing unit in Tables 2 through 4.

Aldrin was detected in only one of 129 soil samples collected from Hickam AFB (Table 2). The one detected concentration exceeded the Tier 1 EAL, but not the Tier 2 EAL as calculated in this memo. It should be noted, however, that the Tier 1 EAL is below the aldrin practical quantitation limit (PQL) for some samples. Due to this single detection, there are no figures displaying aldrin concentrations.

The soil results for chlordane are shown in Table 3. Chlordane was not detected (ND) in soils from the Earhart housing unit as depicted in Figure 1. In soils from the Capehart housing unit, chlordane was detected in 110 of 111 samples. Detected concentrations of chlordane range from 0.311 mg/kg to 36.7 mg/kg. Using the Tier 1 EAL of 1.6 mg/kg (Hawai'i DOH 2005), chlordane exceeded screening levels in 105 samples; however, using the Tier 2 EAL calculated in this memo of 23.4 mg/kg, chlordane only exceeded screening levels in 11 sample locations (see Table 2 and Figure 2).

Dieldrin was detected in 22 of 129 soil samples from Hickam AFB (Table 4). All detected concentrations of dieldrin were greater than the Tier 1 EAL. None of the detected concentrations of dieldrin exceeded the Tier 2 EAL. It should be noted that the Tier 1 EAL for dieldrin is based on protection of potable groundwater, whereas the Tier 2 EAL is based only on direct exposure to soils. Also, it should be noted that the Tier 1 EAL is below the dieldrin PQL for all samples. These results are also shown in Figures 3 and 4.

Conclusions

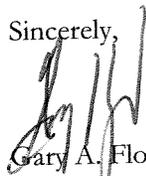
It is Tetra Tech's professional opinion that the Tier 2 EALs calculated for the HCH Areas at Hickam AFB are sufficiently protective of human health given the specific characteristics of the HCH Areas. The site-specific Tier 2 EALs were calculated using a target risk level to 1 x 10⁻⁵ and an exposure duration of 6 years.

Site-specific Tier 2 EALs were calculated following Hawai'i DOH (2005) guidance for aldrin, chlordane, and dieldrin in soils at Hickam AFB of 0.42, 23.4, and 0.45 mg/kg, respectively. Neither aldrin nor

dieldrin was detected in soils exceeding the Tier 2 EALs. Chlordane exceeded the Tier 2 EAL calculated in this memo in only 11 sample locations in the Capehart housing unit. Chlordane did not exceed the Tier 2 EAL at the Earhart housing unit. This indicates that assumed residential exposures of up to 6 years to aldrin and dieldrin will not result in risks greater than 1×10^{-5} at either of the two housing units at Hickam AFB. For chlordane, assumed residential exposures of up to 6 years may result in risks greater than 1×10^{-5} in only 11 of 111 sample locations in the Capehart housing unit and exposures to chlordane at all of the Earhart housing units are expected to result in risks less than 1×10^{-5} .

Please note that the Tier 2 EAL for dieldrin is not protective of potable groundwater use. Since dieldrin in soils exceeded screening levels protective of leaching to groundwater, the groundwater at the site could potentially be impacted by dieldrin leaching from soils to groundwater.

Sincerely,



Gary A. Floyd
Project Manager



Dr. Mark Rigby
Risk Assessor

Hickam Air Force Base
 Length of Resident Stay
 As of April 2006

Years in Unit	Privatized Family Housing		Military Family Housing		Combined	
	# of Families	% of Total	# of Families	% of Total	# of Families	% of Total
0 - 5	1,108	97.71%	1113	98.58%	2,221	98.14%
6 - 8	24	2.12%	13	1.15%	37	1.63%
9 - 11	2	0.18%	2	0.18%	4	0.18%
12 - 16	-	0.00%	1	0.09%	1	0.04%
Total	1,134	100.00%	1129	100.00%	2,263	100.00%

NOTE: Length of stay is based on current residents as of April 2006, accumulated by Hickam Community Housing and HAFB Housing Office, respectively, for privatized and military housing.

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Table 1
Tier 2 Environmental Action Level (EAL)
Equations and Parameters
Hickam Air Force Base, HI

EAL for carcinogens

$$C_s = \frac{TR \times BW \times AT}{EF \times ED \times \left[\left(\frac{IR \times SF_o}{10^6 \text{ mg/kg}} \right) + \left(\frac{SA \times AF \times ABS \times SF_o}{10^6 \text{ mg/kg}} \right) + (INR \times PEF \times ET \times SF_i) \right]}$$

EAL for non-carcinogens

$$C_s = \frac{THQ \times BW \times AT}{EF \times ED \times \left[\left(\frac{IR}{RfD_o \times 10^6 \text{ mg/kg}} \right) + \left(\frac{SA \times AF \times ABS}{RfD_o \times 10^6 \text{ mg/kg}} \right) + \left(\frac{INR \times PEF \times ET}{RfD_i} \right) \right]}$$

Variable	Parameter	Value	Source/Rationale
C _s	Concentration in soil	mg/kg	Units for soil
TR	Target Risk	10 ⁻⁵ (-)	proposed
THQ	Target Hazard Quotient	1 (-)	USEPA 1989; DOH 2005
BW	Body Weight		
	Adult resident	70 kg	USEPA 1989, 1991; DOH 2005
	Child resident	15 kg	USEPA 1989, 1991; DOH 2005
AT	Averaging Time		
	Carcinogens	70 years x 365 days/year	Lifetime (U.S. EPA 1989; DOH 2005)
	Non-carcinogens	ED x 365 days/year	USEPA 1989; DOH 2005
EF	Exposure Frequency		
	Adult resident	350 days/year	USEPA 1991; DOH 2005
	Child resident	350 days/year	USEPA 1991; DOH 2005
ED	Exposure Duration		
	Adult resident	6 years	proposed
	Child resident	6 years	USEPA 1991; DOH 2005
IR	Soil Ingestion Rate		
	Adult resident	100 mg/day	USEPA 1991; DOH 2005
	Child resident	200 mg/day	USEPA 1991; DOH 2005
SF _o	Oral/dermal carcinogenic slope factor		
	aldrin	17 (mg/kg-day) ⁻¹	USEPA 2006; DOH 2005
	chlordane	0.35 (mg/kg-day) ⁻¹	USEPA 2006; DOH 2005
	dieldrin	16 (mg/kg-day) ⁻¹	USEPA 2006; DOH 2005
SF _i	Inhalation carcinogenic slope factor		
	aldrin	17 (mg/kg-day) ⁻¹	USEPA 2006; DOH 2005
	chlordane	0.35 (mg/kg-day) ⁻¹	USEPA 2006; DOH 2005
	dieldrin	16 (mg/kg-day) ⁻¹	USEPA 2006; DOH 2005
RfD _o	Oral/dermal reference dose		
	aldrin	3.00E-05 mg/kg-day	USEPA 2006; DOH 2005
	chlordane	5.00E-04 mg/kg-day	USEPA 2006; DOH 2005
	dieldrin	5.00E-05 mg/kg-day	USEPA 2006; DOH 2005
RfD _i	Inhalation reference dose		
	aldrin	3.00E-05 mg/kg-day	DOH 2005
	chlordane	2.00E-04 mg/kg-day	USEPA 2006; DOH 2005
	dieldrin	5.00E-05 mg/kg-day	DOH 2005
SA	Skin Surface Area		
	Adult resident	5,700 cm ²	USEPA 2004; DOH 2005
	Child resident	2,800 cm ²	USEPA 2004; DOH 2005
AF	Soil Adherence Factor		
	Adult resident	0.07 mg/cm ²	USEPA 2004; DOH 2005
	Child resident	0.2 mg/cm ²	USEPA 2004; DOH 2005
ABS	Absorption Fraction		
	aldrin	0.1 -	USEPA 2004; DOH 2005
	chlordane	0.04 -	USEPA 2004; DOH 2005
	dieldrin	0.1 -	USEPA 2004; DOH 2005
INR	Inhalation rate		
	Adult resident	20 m ³ /day	USEPA 1991; DOH 2005
	Child resident	10 m ³ /day	USEPA 1991; DOH 2005
PEF	Particulate Emissions Factor	7.58E-10 kg/m ³	USEPA 1996; DOH 2005
ET	Exposure Time		
	Industrial Worker	24 hours/day	USEPA 1991; DOH 2005
	Construction Worker	24 hours/day	USEPA 1991; DOH 2005

Table 2
Comparison of Aldrin in Soils at Hickam Community Housing to EALs
Hickam AFB, HI

Housing Area	Sample ID	Sample type	Date	Aldrin (mg/kg)			Exceeds EAL?	
				Result	Qual	PQL	Tier 2	Tier 1
Earhart	I-1a	incremental	4/14/06	0.018	ND	0.018		
Earhart	I-1aD	incremental	4/14/06	0.018	ND	0.018		
Earhart	I-1b	incremental	4/14/06	0.019	ND	0.019		
Earhart	I-2	incremental	4/14/06	0.025	ND	0.025		
Earhart	I-3	incremental	4/14/06	0.020	ND	0.020		
Earhart	I-4	incremental	4/14/06	0.019	ND	0.019		
Earhart	COM	incremental	4/14/06	0.019	ND	0.019		
Earhart	POOL	incremental	5/5/06	0.039	ND	0.039		
Earhart	SHONO	incremental	5/5/06	0.041	ND	0.041		
Earhart	ER1640	discrete	4/13/06	0.017	ND	0.017		
Earhart	ER1647	discrete	4/13/06	0.018	ND	0.018		
Earhart	ER1452	discrete	4/13/06	0.019	ND	0.019		
Earhart	ER1457	discrete	4/13/06	0.017	ND	0.017		
Earhart	ER1461	discrete	4/13/06	0.017	ND	0.017		
Earhart	ER1465	discrete	4/13/06	0.018	ND	0.018		
Earhart	ER1472	discrete	4/13/06	0.019	ND	0.019		
Earhart	ER1490	discrete	4/13/06	0.019	ND	0.019		
Earhart	ER1495	discrete	4/13/06	0.018	ND	0.018		
Capehart	I-1c (occ)	incremental	4/14/06	0.018	ND	0.018		
Capehart	C-01	incremental	4/5/06	0.180	ND	0.180		
Capehart	C-02	incremental	4/4/06	0.180	ND	0.180		
Capehart	C-03	incremental	4/4/06	0.180	ND	0.180		
Capehart	C-04	incremental	4/4/06	0.200	ND	0.200		
Capehart	C-05	incremental	4/4/06	0.190	ND	0.190		
Capehart	C-06	incremental	4/4/06	0.180	ND	0.180		
Capehart	C-07	incremental	4/4/06	0.036	ND	0.036		
Capehart	C-08	incremental	4/4/06	0.180	ND	0.180		
Capehart	C-09	incremental	4/4/06	0.200	ND	0.200		
Capehart	C-10	incremental	4/5/06	0.170	ND	0.170		
Capehart	C-11	incremental	4/5/06	0.170	ND	0.170		
Capehart	C-12	incremental	4/4/06	0.180	ND	0.180		
Capehart	C-12D	incremental	4/4/06	0.180	ND	0.180		
Capehart	C-13	incremental	4/5/06	0.180	ND	0.180		
Capehart	D-01	incremental	4/5/06	0.170	ND	0.170		
Capehart	D-02	incremental	2/21/06	0.180	ND	0.180		
Capehart	D-05	incremental	2/21/06	0.180	ND	0.180		
Capehart	D-06	incremental	2/21/06	0.180	ND	0.180		
Capehart	D-06D	incremental	3/2/06	0.170	ND	0.170		
Capehart	D-07	incremental	2/20/06	0.180	ND	0.180		
Capehart	D-08	incremental	2/20/06	0.018	ND	0.018		
Capehart	D-09	incremental	2/20/06	0.180	ND	0.180		
Capehart	D-10	incremental	2/20/06	0.170	ND	0.170		
Capehart	D-11	incremental	2/20/06	0.200	ND	0.200		
Capehart	D-12	incremental	2/21/06	0.180	ND	0.180		
Capehart	D-13	incremental	2/21/06	0.180	ND	0.180		
Capehart	D-14	incremental	2/21/06	0.170	ND	0.170		
Capehart	D-15	incremental	2/21/06	0.180	ND	0.180		
Capehart	D-16	incremental	2/21/06	0.180	ND	0.180		
Capehart	D-17	incremental	2/21/06	0.190	ND	0.190		
Capehart	D-18	incremental	2/21/06	0.180	ND	0.180		
Capehart	D-P1	incremental	4/5/06	0.170	ND	0.170		
Capehart	D-P2	incremental	4/5/06	0.170	ND	0.170		
Capehart	E-01	incremental	2/24/06	0.010	ND	0.010		
Capehart	E-02	incremental	2/24/06	0.0098	ND	0.0098		
Capehart	E-03	incremental	2/24/06	0.190	ND	0.190		
Capehart	E-04	incremental	2/24/06	0.0095	ND	0.0095		
Capehart	E-05	incremental	2/24/06	0.0098	ND	0.0098		
Capehart	E-06	incremental	2/24/06	0.019	ND	0.019		
Capehart	E-07	incremental	2/24/06	0.149		0.019		X
Capehart	E-08	incremental	2/24/06	0.020	ND	0.020		
Capehart	E-09	incremental	4/5/06	0.180	ND	0.180		
Capehart	E-11	incremental	2/24/06	0.180	ND	0.180		

Table 2
Comparison of Aldrin in Soils at Hickam Community Housing to EALs
Hickam AFB, HI

Housing Area	Sample ID	Sample type	Date	Aldrin (mg/kg)			Exceeds EAL?	
				Result	Qual	PQL	Tier 2	Tier 1
Capehart	E-12	incremental	2/24/06	0.180	ND	0.180		
Capehart	E-12D	incremental	3/2/06	0.170	ND	0.170		
Capehart	E-13	incremental	2/23/06	0.180	ND	0.180		
Capehart	E-14	incremental	2/23/06	0.170	ND	0.170		
Capehart	E-15	incremental	2/23/06	0.180	ND	0.180		
Capehart	E-16	incremental	2/23/06	0.180	ND	0.180		
Capehart	E-17	incremental	2/23/06	0.180	ND	0.180		
Capehart	E-18	incremental	2/23/06	0.190	ND	0.190		
Capehart	E-19	incremental	2/23/06	0.180	ND	0.180		
Capehart	E-20	incremental	2/23/06	0.180	ND	0.180		
Capehart	E-21	incremental	2/23/06	0.180	ND	0.180		
Capehart	E-22	incremental	2/23/06	0.180	ND	0.180		
Capehart	E-23	incremental	2/23/06	0.180	ND	0.180		
Capehart	E-24	incremental	2/23/06	0.170	ND	0.170		
Capehart	E-25	incremental	2/23/06	0.180	ND	0.180		
Capehart	E-26	incremental	2/23/06	0.170	ND	0.170		
Capehart	E-P1	incremental	4/5/06	0.170	ND	0.170		
Capehart	F-01	incremental	2/28/06	0.180	ND	0.180		
Capehart	F-02	incremental	2/28/06	0.180	ND	0.180		
Capehart	F-03	incremental	2/28/06	0.180	ND	0.180		
Capehart	F-04	incremental	2/28/06	0.180	ND	0.180		
Capehart	F-05	incremental	2/27/06	0.160	ND	0.160		
Capehart	F-06	incremental	2/27/06	0.190	ND	0.190		
Capehart	F-07	incremental	2/27/06	0.160	ND	0.160		
Capehart	F-08	incremental	2/27/06	0.180	ND	0.180		
Capehart	F-09	incremental	2/27/06	0.170	ND	0.170		
Capehart	F-10	incremental	2/27/06	0.170	ND	0.170		
Capehart	F-10D	incremental	3/2/06	0.160	ND	0.160		
Capehart	F-11	incremental	2/27/06	0.170	ND	0.170		
Capehart	F-12	incremental	2/27/06	0.180	ND	0.180		
Capehart	F-13	incremental	2/27/06	0.160	ND	0.160		
Capehart	F-P1	incremental	4/5/06	0.180	ND	0.180		
Capehart	F-P2	incremental	4/5/06	0.170	ND	0.170		
Capehart	F-P2D	incremental	4/5/06	0.170	ND	0.170		
Capehart	F-P3	incremental	4/5/06	0.170	ND	0.170		
Capehart	G-01	incremental	3/2/06	0.190	ND	0.190		
Capehart	G-01D	incremental	3/2/06	0.190	ND	0.190		
Capehart	G-02	incremental	3/2/06	0.180	ND	0.180		
Capehart	G-03	incremental	3/1/06	0.190	ND	0.190		
Capehart	G-04	incremental	3/2/06	0.200	ND	0.200		
Capehart	G-05	incremental	3/2/06	0.200	ND	0.200		
Capehart	G-06	incremental	3/2/06	0.170	ND	0.170		
Capehart	G-07	incremental	3/2/06	0.160	ND	0.160		
Capehart	G-08	incremental	3/2/06	0.160	ND	0.160		
Capehart	G-09	incremental	3/2/06	0.180	ND	0.180		
Capehart	G-10	incremental	3/2/06	0.180	ND	0.180		
Capehart	G-12	incremental	3/2/06	0.180	ND	0.180		
Capehart	G-13	incremental	3/1/06	0.170	ND	0.170		
Capehart	G-14	incremental	3/1/06	0.180	ND	0.180		
Capehart	G-15	incremental	3/1/06	0.180	ND	0.180		
Capehart	G-16	incremental	3/1/06	0.190	ND	0.190		
Capehart	G-17	incremental	3/1/06	0.180	ND	0.180		
Capehart	G-18	incremental	3/1/06	0.170	ND	0.170		
Capehart	G-19	incremental	3/1/06	0.180	ND	0.180		
Capehart	G-20	incremental	3/1/06	0.180	ND	0.180		
Capehart	G-21	incremental	3/1/06	0.180	ND	0.180		
Capehart	G-22	incremental	3/1/06	0.180	ND	0.180		
Capehart	G-23	incremental	3/1/06	0.180	ND	0.180		
Capehart	G-24	incremental	2/28/06	0.150	ND	0.150		
Capehart	G-25	incremental	3/1/06	0.170	ND	0.170		
Capehart	G-26	incremental	3/2/06	0.180	ND	0.180		
Capehart	G-27	incremental	2/28/06	0.170	ND	0.170		

Table 2
Comparison of Aldrin in Soils at Hickam Community Housing to EALs
Hickam AFB, HI

Housing Area	Sample ID	Sample type	Date	Aldrin (mg/kg)			Exceeds EAL?	
				Result	Qual	PQL	Tier 2	Tier 1
Capehart	G-28	incremental	3/1/06	0.180	ND	0.180		
Capehart	G-29	incremental	3/1/06	0.180	ND	0.180		
Capehart	G-30	incremental	3/1/06	0.160	ND	0.160		
Capehart	G-P1	incremental	4/5/06	0.170	ND	0.170		
Capehart	G-P2	incremental	6/12/06	0.015	ND	0.015		
Capehart	G-P3	incremental	4/5/06	0.170	ND	0.170		
Capehart	G-P4	incremental	6/12/06	0.016	ND	0.016		

Notes:

J = The quantitation is an estimation.

mg/kg = milligrams/kilogram

ND = Indicates the analyte is not detected (above the PQL)

PQL = practical quantitation limit (reporting limit)

D = duplicate

Table 3
Comparison of Chlordane in Soils at Hickam Community Housing to EALs
Hickam AFB, HI

Housing Area	Sample ID	Sample type	Date	Chlordane (mg/kg)			Exceeds EAL?	
				Result	Qual	PQL	Tier 2	Tier 1
Earhart	I-1a	incremental	4/14/06	0.590	ND	0.590		
Earhart	I-1aD	incremental	4/14/06	0.586	ND	0.586		
Earhart	I-1b	incremental	4/14/06	0.621	ND	0.621		
Earhart	I-2	incremental	4/14/06	0.845	ND	0.845		
Earhart	I-3	incremental	4/14/06	0.673	ND	0.673		
Earhart	I-4	incremental	4/14/06	0.619	ND	0.619		
Earhart	COM	incremental	4/14/06	0.623	ND	0.623		
Earhart	POOL	incremental	5/5/06	1.300	ND	1.300		
Earhart	SHONO	incremental	5/5/06	1.350	ND	1.350		
Earhart	ER1640	discrete	4/13/06	0.558	ND	0.558		
Earhart	ER1647	discrete	4/13/06	0.593	ND	0.593		
Earhart	ER1452	discrete	4/13/06	0.640	ND	0.640		
Earhart	ER1457	discrete	4/13/06	0.574	ND	0.574		
Earhart	ER1461	discrete	4/13/06	0.553	ND	0.553		
Earhart	ER1465	discrete	4/13/06	0.585	ND	0.585		
Earhart	ER1472	discrete	4/13/06	0.625	ND	0.625		
Earhart	ER1490	discrete	4/13/06	0.629	ND	0.629		
Earhart	ER1495	discrete	4/13/06	0.585	ND	0.585		
Capehart	I-1c (occ)	incremental	4/14/06	0.605	ND	0.605		
Capehart	C-01	incremental	4/5/06	3.780	J	5.920		X
Capehart	C-02	incremental	4/4/06	18.400		6.150		X
Capehart	C-03	incremental	4/4/06	3.060	J	6.090		X
Capehart	C-04	incremental	4/4/06	16.600		6.640		X
Capehart	C-05	incremental	4/4/06	14.600		6.320		X
Capehart	C-06	incremental	4/4/06	4.900	J	6.120		X
Capehart	C-07	incremental	4/4/06	4.930		1.200		X
Capehart	C-08	incremental	4/4/06	5.640	J	6.020		X
Capehart	C-09	incremental	4/4/06	15.100		6.630		X
Capehart	C-10	incremental	4/5/06	3.590	J	5.720		X
Capehart	C-11	incremental	4/5/06	18.900		5.730		X
Capehart	C-12	incremental	4/4/06	5.710	J	6.130		X
Capehart	C-12D	incremental	4/4/06	4.710	J	6.020		X
Capehart	C-13	incremental	4/5/06	5.860	J	5.900		X
Capehart	D-01	incremental	4/5/06	5.990		5.740		X
Capehart	D-02	incremental	2/21/06	10.100		5.970		X
Capehart	D-05	incremental	2/21/06	9.090		6.070		X
Capehart	D-06	incremental	2/21/06	29.200		5.900	X	X
Capehart	D-06D	incremental	3/2/06	18.500		5.740		X
Capehart	D-07	incremental	2/20/06	8.430		5.98		X
Capehart	D-08	incremental	2/20/06	2.240		6.00		X
Capehart	D-09	incremental	2/20/06	13.900		5.960		X
Capehart	D-10	incremental	2/20/06	11.300		5.550		X
Capehart	D-11	incremental	2/20/06	20.000		6.510		X
Capehart	D-12	incremental	2/21/06	5.340	J	6.100		X
Capehart	D-13	incremental	2/21/06	9.050		5.910		X
Capehart	D-14	incremental	2/21/06	14.100		5.820		X
Capehart	D-15	incremental	2/21/06	15.800		6.060		X
Capehart	D-16	incremental	2/21/06	4.960	J	6.090		X
Capehart	D-17	incremental	2/21/06	6.420		6.360		X
Capehart	D-18	incremental	2/21/06	17.000		6.040		X
Capehart	D-P1	incremental	4/5/06	7.760		5.630		X
Capehart	D-P2	incremental	4/5/06	16.500		5.590		X
Capehart	E-01	incremental	2/24/06	0.340		0.333		
Capehart	E-02	incremental	2/24/06	0.533		0.327		
Capehart	E-03	incremental	2/24/06	3.780	J	6.490		X
Capehart	E-04	incremental	2/24/06	0.51		0.318		
Capehart	E-05	incremental	2/24/06	0.311	J	0.325		
Capehart	E-06	incremental	2/24/06	0.482	J	0.648		
Capehart	E-07	incremental	2/24/06	3.870	J	6.260		X
Capehart	E-08	incremental	2/24/06	1.870		0.654		X
Capehart	E-09	incremental	4/5/06	11.100		6.150		X
Capehart	E-11	incremental	2/24/06	9.430		6.110		X

Table 3
Comparison of Chlordane in Soils at Hickam Community Housing to EALs
Hickam AFB, HI

Housing Area	Sample ID	Sample type	Date	Chlordane (mg/kg)			Exceeds EAL?	
				Result	Qual	PQL	Tier 2	Tier 1
Capehart	E-12	incremental	2/24/06	14.400		6.120		X
Capehart	E-12D	incremental	3/2/06	6.870		5.640		X
Capehart	E-13	incremental	2/23/06	9.050		6.070		X
Capehart	E-14	incremental	2/23/06	8.120		5.810		X
Capehart	E-15	incremental	2/23/06	8.210		5.960		X
Capehart	E-16	incremental	2/23/06	11.000		6.060		X
Capehart	E-17	incremental	2/23/06	11.400		6.090		X
Capehart	E-18	incremental	2/23/06	12.400		6.220		X
Capehart	E-19	incremental	2/23/06	23.600		5.910	X	X
Capehart	E-20	incremental	2/23/06	21.000		6.030		X
Capehart	E-21	incremental	2/23/06	18.200		6.120		X
Capehart	E-22	incremental	2/23/06	14.700		6.030		X
Capehart	E-23	incremental	2/23/06	31.100		5.970	X	X
Capehart	E-24	incremental	2/23/06	8.020		5.700		X
Capehart	E-25	incremental	2/23/06	9.860		5.960		X
Capehart	E-26	incremental	2/23/06	7.190		5.830		X
Capehart	E-P1	incremental	4/5/06	5.740		5.620		X
Capehart	F-01	incremental	2/28/06	16.800		6.140		X
Capehart	F-02	incremental	2/28/06	12.200		6.100		X
Capehart	F-03	incremental	2/28/06	28.500		11.700	X	X
Capehart	F-04	incremental	2/28/06	23.900		6.080	X	X
Capehart	F-05	incremental	2/27/06	24.400		5.470	X	X
Capehart	F-06	incremental	2/27/06	26.700		6.200	X	X
Capehart	F-07	incremental	2/27/06	13.500		10.900		X
Capehart	F-08	incremental	2/27/06	14.700		6.030		X
Capehart	F-09	incremental	2/27/06	12.800		5.710		X
Capehart	F-10	incremental	2/27/06	26.200		11.200	X	X
Capehart	F-10D	incremental	3/2/06	36.700		10.600	X	X
Capehart	F-11	incremental	2/27/06	20.200		5.740		X
Capehart	F-12	incremental	2/27/06	32.200		11.800	X	X
Capehart	F-13	incremental	2/27/06	22.000		5.450		X
Capehart	F-P1	incremental	4/5/06	13.100		5.910		X
Capehart	F-P2	incremental	4/5/06	6.500		5.770		X
Capehart	F-P2D	incremental	4/5/06	5.120	J	5.800		X
Capehart	F-P3	incremental	4/5/06	14.200		5.550		X
Capehart	G-01	incremental	3/2/06	3.440	J	6.230		X
Capehart	G-01D	incremental	3/2/06	3.000	J	6.220		X
Capehart	G-02	incremental	3/2/06	12.200		5.970		X
Capehart	G-03	incremental	3/1/06	12.500		6.200		X
Capehart	G-04	incremental	3/2/06	5.940	J	6.580		X
Capehart	G-05	incremental	3/2/06	5.550	J	6.820		X
Capehart	G-06	incremental	3/2/06	23.2		5.610		X
Capehart	G-07	incremental	3/2/06	22.900		5.370		X
Capehart	G-08	incremental	3/2/06	25.400		5.480	X	X
Capehart	G-09	incremental	3/2/06	11.200		6.080		X
Capehart	G-10	incremental	3/2/06	21.400		5.930		X
Capehart	G-12	incremental	3/2/06	23.900		6.160	X	X
Capehart	G-13	incremental	3/1/06	17.400		5.830		X
Capehart	G-14	incremental	3/1/06	15.500		6.030		X
Capehart	G-15	incremental	3/1/06	16.700		6.100		X
Capehart	G-16	incremental	3/1/06	5.710	J	6.130		X
Capehart	G-17	incremental	3/1/06	22.200		6.130		X
Capehart	G-18	incremental	3/1/06	12.400		5.600		X
Capehart	G-19	incremental	3/1/06	14.000		5.860		X
Capehart	G-20	incremental	3/1/06	7.450		5.860		X
Capehart	G-21	incremental	3/1/06	4.090	J	6.090		X
Capehart	G-22	incremental	3/1/06	6.180		6.010		X
Capehart	G-23	incremental	3/1/06	18.800		5.910		X
Capehart	G-24	incremental	2/28/06	18.900		5.150		X
Capehart	G-25	incremental	3/1/06	10.900		5.530		X
Capehart	G-26	incremental	3/2/06	14.300		5.970		X
Capehart	G-27	incremental	2/28/06	16.500		5.730		X

Table 3
Comparison of Chlordane in Soils at Hickam Community Housing to EALs
Hickam AFB, HI

Housing Area	Sample ID	Sample type	Date	Chlordane (mg/kg)			Exceeds EAL?	
				Result	Qual	PQL	Tier 2	Tier 1
Capehart	G-28	incremental	3/1/06	15.700		5.840		X
Capehart	G-29	incremental	3/1/06	5.030	J	5.830		X
Capehart	G-30	incremental	3/1/06	11.700		5.300		X
Capehart	G-P1	incremental	4/5/06	12.100		5.690		X
Capehart	G-P2	incremental	6/12/06	4.120	J	5.160		X
Capehart	G-P3	incremental	4/5/06	9.790		5.510		X
Capehart	G-P4	incremental	6/12/06	12.400		5.340		X

Notes:

J = The quantitation is an estimation.

mg/kg = milligrams/kilogram

ND = Indicates the analyte is not detected (above the PQL)

PQL = practical quantitation limit (reporting limit)

D = duplicate

Table 4
Comparison of Dieldrin in Soils at Hickam Community Housing to EALs
Hickam AFB, HI

Housing Area	Sample ID	Sample type	Date	Dieldrin (mg/kg)			Exceeds EAL?	
				Result	Qual	PQL	Tier 2	Tier 1
Earhart	I-1a		4/14/06	0.139		0.024		X
Earhart	I-1aD		4/14/06	0.114		0.023		X
Earhart	I-1b		4/14/06	0.0529		0.025		X
Earhart	I-2		4/14/06	0.0310	J	0.034		X
Earhart	I-3		4/14/06	0.0168	J	0.027		X
Earhart	I-4		4/14/06	0.0249		0.025		X
Earhart	COM		4/14/06	0.025	ND	0.025		
Earhart	POOL		5/5/06	0.125		0.052		X
Earhart	SHONO		5/5/06	0.164		0.054		X
Earhart	ER1640		4/13/06	0.0754		0.022		X
Earhart	ER1647		4/13/06	0.0455		0.024		X
Earhart	ER1452		4/13/06	0.0877		0.026		X
Earhart	ER1457		4/13/06	0.0310		0.023		X
Earhart	ER1461		4/13/06	0.0196	J	0.022		X
Earhart	ER1465		4/13/06	0.0315		0.023		X
Earhart	ER1472		4/13/06	0.0531		0.025		X
Earhart	ER1490		4/13/06	0.0745		0.025		X
Earhart	ER1495		4/13/06	0.0136	J	0.023		X
Capehart	I-1c (occ)		4/14/06	0.0361		0.024		X
Capehart	C-01		4/5/06	0.240	ND	0.240		
Capehart	C-02		4/4/06	0.250	ND	0.250		
Capehart	C-03		4/4/06	0.240	ND	0.240		
Capehart	C-04		4/4/06	0.270	ND	0.270		
Capehart	C-05		4/4/06	0.250	ND	0.250		
Capehart	C-06		4/4/06	0.240	ND	0.240		
Capehart	C-07		4/4/06	0.048	ND	0.048		
Capehart	C-08		4/4/06	0.240	ND	0.240		
Capehart	C-09		4/4/06	0.270	ND	0.270		
Capehart	C-10		4/5/06	0.230	ND	0.230		
Capehart	C-11		4/5/06	0.230	ND	0.230		
Capehart	C-12		4/4/06	0.250	ND	0.250		
Capehart	C-12D		4/4/06	0.240	ND	0.240		
Capehart	C-13		4/5/06	0.240	ND	0.240		
Capehart	D-01		4/5/06	0.230	ND	0.230		
Capehart	D-02		2/21/06	0.240	ND	0.240		
Capehart	D-05		2/21/06	0.240	ND	0.240		
Capehart	D-06		2/21/06	0.240	ND	0.240		
Capehart	D-06D		3/2/06	0.230	ND	0.230		
Capehart	D-07		2/20/06	0.240	ND	0.240		
Capehart	D-08		2/20/06	0.0569		0.024		X
Capehart	D-09		2/20/06	0.240	ND	0.240		
Capehart	D-10		2/20/06	0.220	ND	0.220		
Capehart	D-11		2/20/06	0.260	ND	0.260		
Capehart	D-12		2/21/06	0.240	ND	0.240		
Capehart	D-13		2/21/06	0.240	ND	0.240		
Capehart	D-14		2/21/06	0.230	ND	0.230		
Capehart	D-15		2/21/06	0.240	ND	0.240		
Capehart	D-16		2/21/06	0.240	ND	0.240		
Capehart	D-17		2/21/06	0.250	ND	0.250		
Capehart	D-18		2/21/06	0.240	ND	0.240		
Capehart	D-P1		4/5/06	0.230	ND	0.230		
Capehart	D-P2		4/5/06	0.220	ND	0.220		
Capehart	E-01		2/24/06	0.0261		0.013		X
Capehart	E-02		2/24/06	0.0537		0.013		X
Capehart	E-03		2/24/06	0.260	ND	0.260		
Capehart	E-04		2/24/06	0.013	ND	0.013		
Capehart	E-05		2/24/06	0.013	ND	0.013		
Capehart	E-06		2/24/06	0.026	ND	0.026		
Capehart	E-07		2/24/06	0.181		0.025		X
Capehart	E-08		2/24/06	0.026	ND	0.026		
Capehart	E-09		4/5/06	0.250	ND	0.250		
Capehart	E-11		2/24/06	0.240	ND	0.240		

Table 4
Comparison of Dieldrin in Soils at Hickam Community Housing to EALs
Hickam AFB, HI

Housing Area	Sample ID	Sample type	Date	Dieldrin (mg/kg)			Exceeds EAL?	
				Result	Qual	PQL	Tier 2	Tier 1
Capehart	E-12		2/24/06	0.240	ND	0.240		
Capehart	E-12D		3/2/06	0.230	ND	0.230		
Capehart	E-13		2/23/06	0.240	ND	0.240		
Capehart	E-14		2/23/06	0.230	ND	0.230		
Capehart	E-15		2/23/06	0.240	ND	0.240		
Capehart	E-16		2/23/06	0.240	ND	0.240		
Capehart	E-17		2/23/06	0.240	ND	0.240		
Capehart	E-18		2/23/06	0.250	ND	0.250		
Capehart	E-19		2/23/06	0.240	ND	0.240		
Capehart	E-20		2/23/06	0.240	ND	0.240		
Capehart	E-21		2/23/06	0.240	ND	0.240		
Capehart	E-22		2/23/06	0.240	ND	0.240		
Capehart	E-23		2/23/06	0.240	ND	0.240		
Capehart	E-24		2/23/06	0.230	ND	0.230		
Capehart	E-25		2/23/06	0.240	ND	0.240		
Capehart	E-26		2/23/06	0.230	ND	0.230		
Capehart	E-P1		4/5/06	0.220	ND	0.220		
Capehart	F-01		2/28/06	0.250	ND	0.250		
Capehart	F-02		2/28/06	0.240	ND	0.240		
Capehart	F-03		2/28/06	0.230	ND	0.230		
Capehart	F-04		2/28/06	0.240	ND	0.240		
Capehart	F-05		2/27/06	0.220	ND	0.220		
Capehart	F-06		2/27/06	0.250	ND	0.250		
Capehart	F-07		2/27/06	0.220	ND	0.220		
Capehart	F-08		2/27/06	0.240	ND	0.240		
Capehart	F-09		2/27/06	0.230	ND	0.230		
Capehart	F-10		2/27/06	0.220	ND	0.220		
Capehart	F-10D		3/2/06	0.210	ND	0.210		
Capehart	F-11		2/27/06	0.230	ND	0.230		
Capehart	F-12		2/27/06	0.240	ND	0.240		
Capehart	F-13		2/27/06	0.220	ND	0.220		
Capehart	F-P1		4/5/06	0.240	ND	0.240		
Capehart	F-P2		4/5/06	0.230	ND	0.230		
Capehart	F-P2D		4/5/06	0.230	ND	0.230		
Capehart	F-P3		4/5/06	0.220	ND	0.220		
Capehart	G-01		3/2/06	0.250	ND	0.250		
Capehart	G-01D		3/2/06	0.250	ND	0.250		
Capehart	G-02		3/2/06	0.240	ND	0.240		
Capehart	G-03		3/1/06	0.250	ND	0.250		
Capehart	G-04		3/2/06	0.260	ND	0.260		
Capehart	G-05		3/2/06	0.270	ND	0.270		
Capehart	G-06		3/2/06	0.220	ND	0.220		
Capehart	G-07		3/2/06	0.210	ND	0.210		
Capehart	G-08		3/2/06	0.220	ND	0.220		
Capehart	G-09		3/2/06	0.240	ND	0.240		
Capehart	G-10		3/2/06	0.240	ND	0.240		
Capehart	G-12		3/2/06	0.250	ND	0.250		
Capehart	G-13		3/1/06	0.230	ND	0.230		
Capehart	G-14		3/1/06	0.240	ND	0.240		
Capehart	G-15		3/1/06	0.240	ND	0.240		
Capehart	G-16		3/1/06	0.250	ND	0.250		
Capehart	G-17		3/1/06	0.250	ND	0.250		
Capehart	G-18		3/1/06	0.220	ND	0.220		
Capehart	G-19		3/1/06	0.230	ND	0.230		
Capehart	G-20		3/1/06	0.230	ND	0.230		
Capehart	G-21		3/1/06	0.240	ND	0.240		
Capehart	G-22		3/1/06	0.240	ND	0.240		
Capehart	G-23		3/1/06	0.240	ND	0.240		
Capehart	G-24		2/28/06	0.210	ND	0.210		
Capehart	G-25		3/1/06	0.220	ND	0.220		
Capehart	G-26		3/2/06	0.240	ND	0.240		
Capehart	G-27		2/28/06	0.230	ND	0.230		

Table 4
Comparison of Dieldrin in Soils at Hickam Community Housing to EALs
Hickam AFB, HI

Housing Area	Sample ID	Sample type	Date	Dieldrin (mg/kg)			Exceeds EAL?	
				Result	Qual	PQL	Tier 2	Tier 1
Capehart	G-28		3/1/06	0.230	ND	0.230		
Capehart	G-29		3/1/06	0.230	ND	0.230		
Capehart	G-30		3/1/06	0.210	ND	0.210		
Capehart	G-P1		4/5/06	0.230	ND	0.230		
Capehart	G-P2		6/12/06	0.021	ND	0.021		
Capehart	G-P3		4/5/06	0.220	ND	0.220		
Capehart	G-P4		6/12/06	0.021	ND	0.021		

Notes:

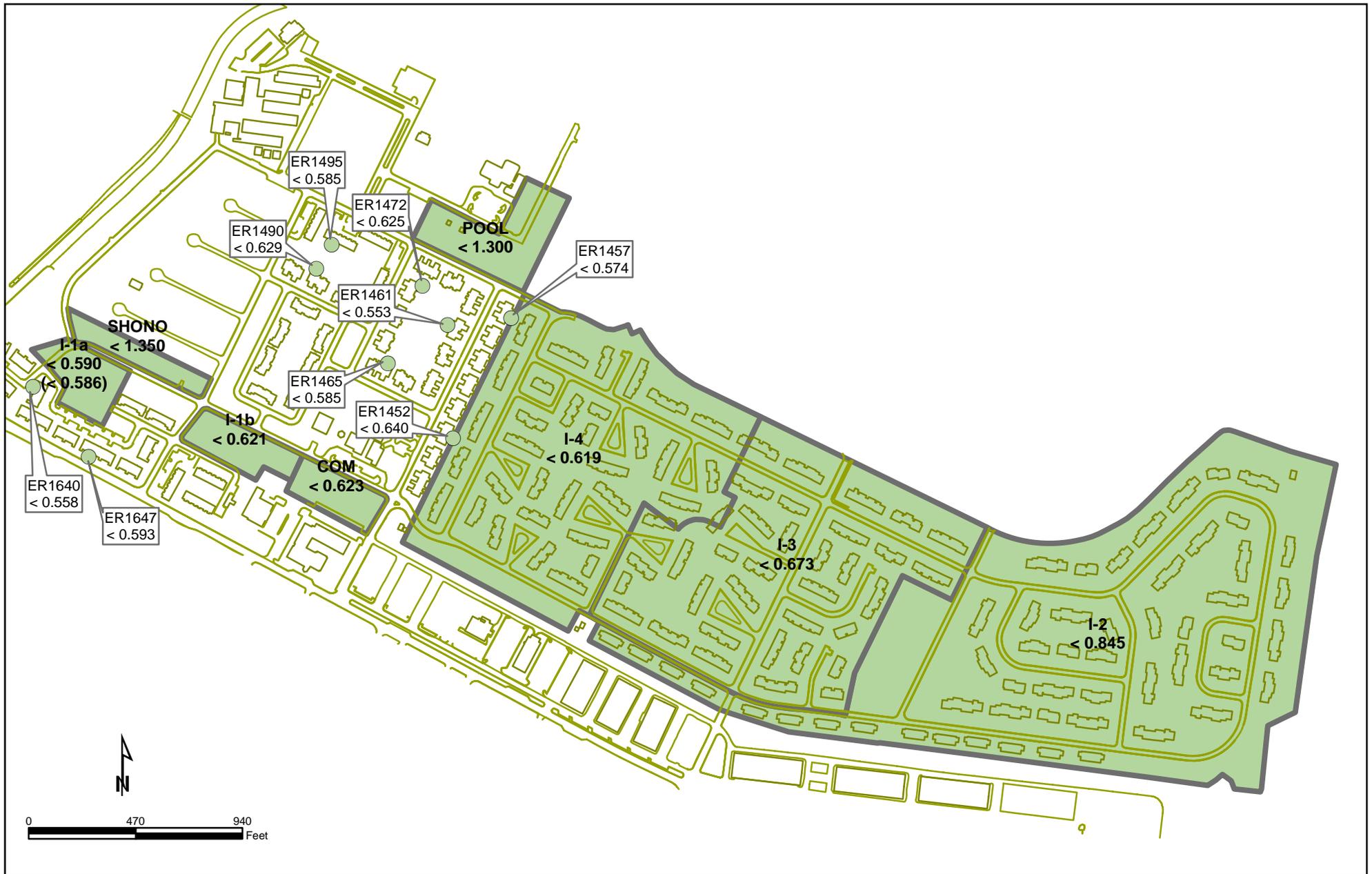
J = The quantitation is an estimation.

mg/kg = milligrams/kilogram

ND = Indicates the analyte is not detected (above the PQL)

PQL = practical quantitation limit (reporting limit)

D = duplicate



Duplicated samples indicated in parentheses.

Technical Chlordane (Including Heptachlor and Heptachlor Epoxide) Test Results - Earhart

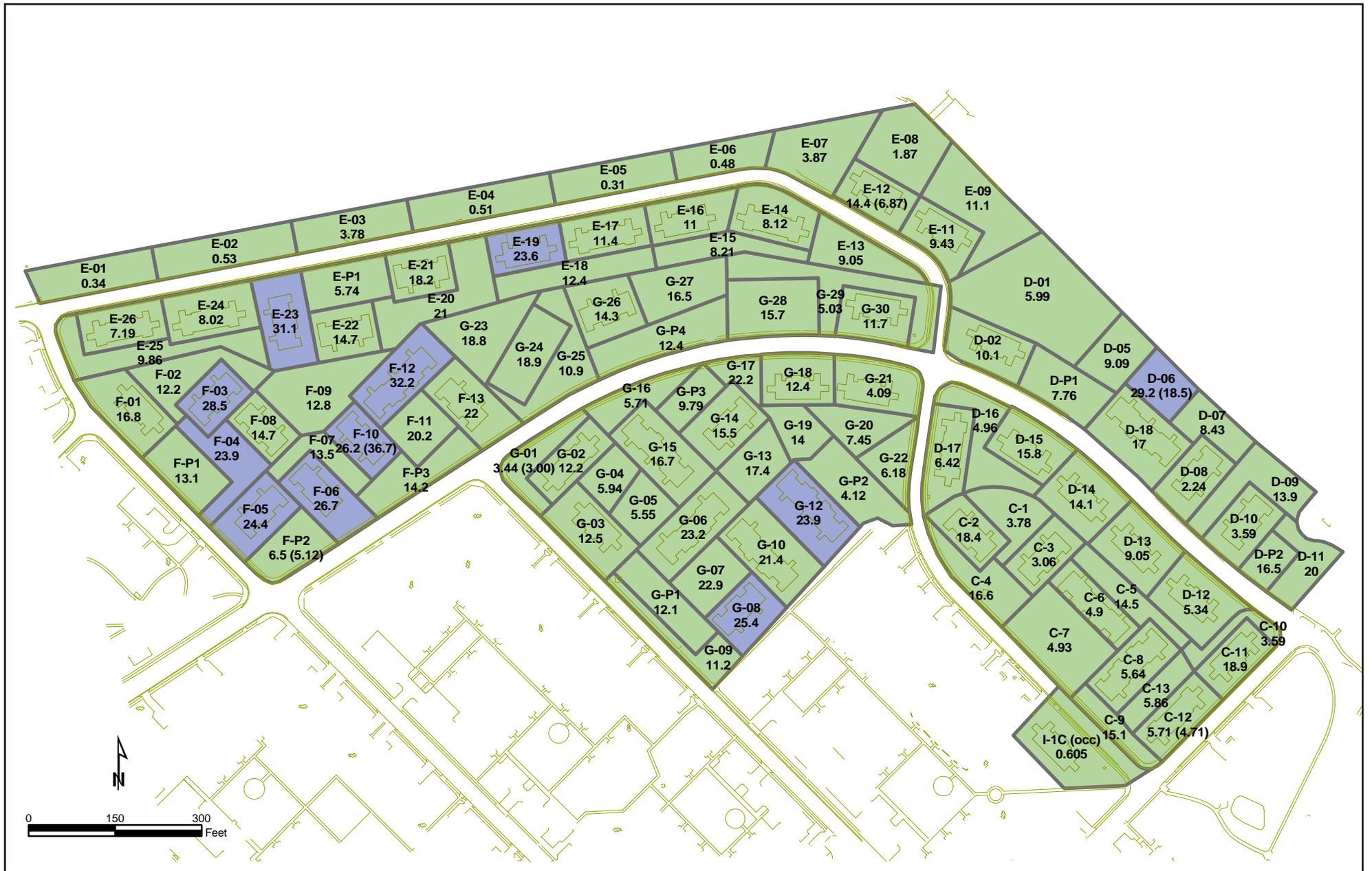
Incremental Samples

- Chlordane <math>< 23.4</math> mg/kg
- Chlordane >math>23.4</math> mg/kg

Discrete Samples

- Chlordane <math>< 23.4</math> mg/kg
- Chlordane >math>23.4</math> mg/kg

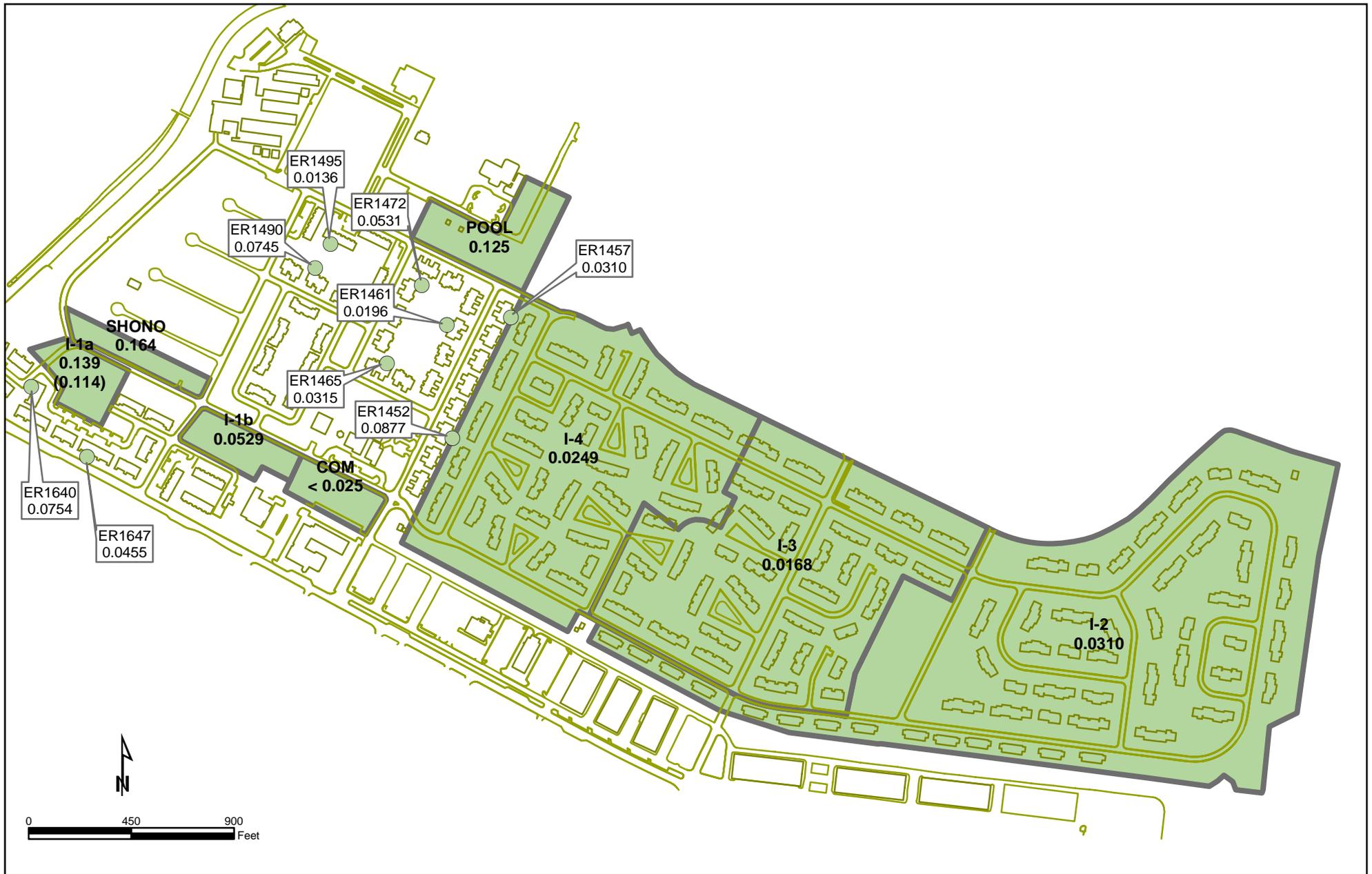
- Road and Curb
- Building



Duplicate samples indicated in parentheses.

Technical Chlordane (Including Heptachlor and Heptachlor Epoxide) Test Results - Capehart

- Chlordane < 23.4 mg/kg
- Chlordane > 23.4 mg/kg
- Road and Curb
- Building



Duplicated samples indicated in parentheses.

Dieldrin Test Results - Earhart

Incremental Samples

- Dieldrin < 0.45 mg/kg
- Dieldrin > 0.45 mg/kg

Discrete Samples

- Dieldrin < 0.45 mg/kg
- Dieldrin > 0.45 mg/kg

- Road and Curb
- Building



Duplicate samples indicated in parentheses.

- Dieldrin < 0.45 mg/kg
- Dieldrin > 0.45 mg/kg
- Paved - Not Sampled
- Road and Curb
- Building

Dieldrin Test Results - Capehart



Duplicated samples indicated in parentheses.

Aldrin Test Results - Earhart

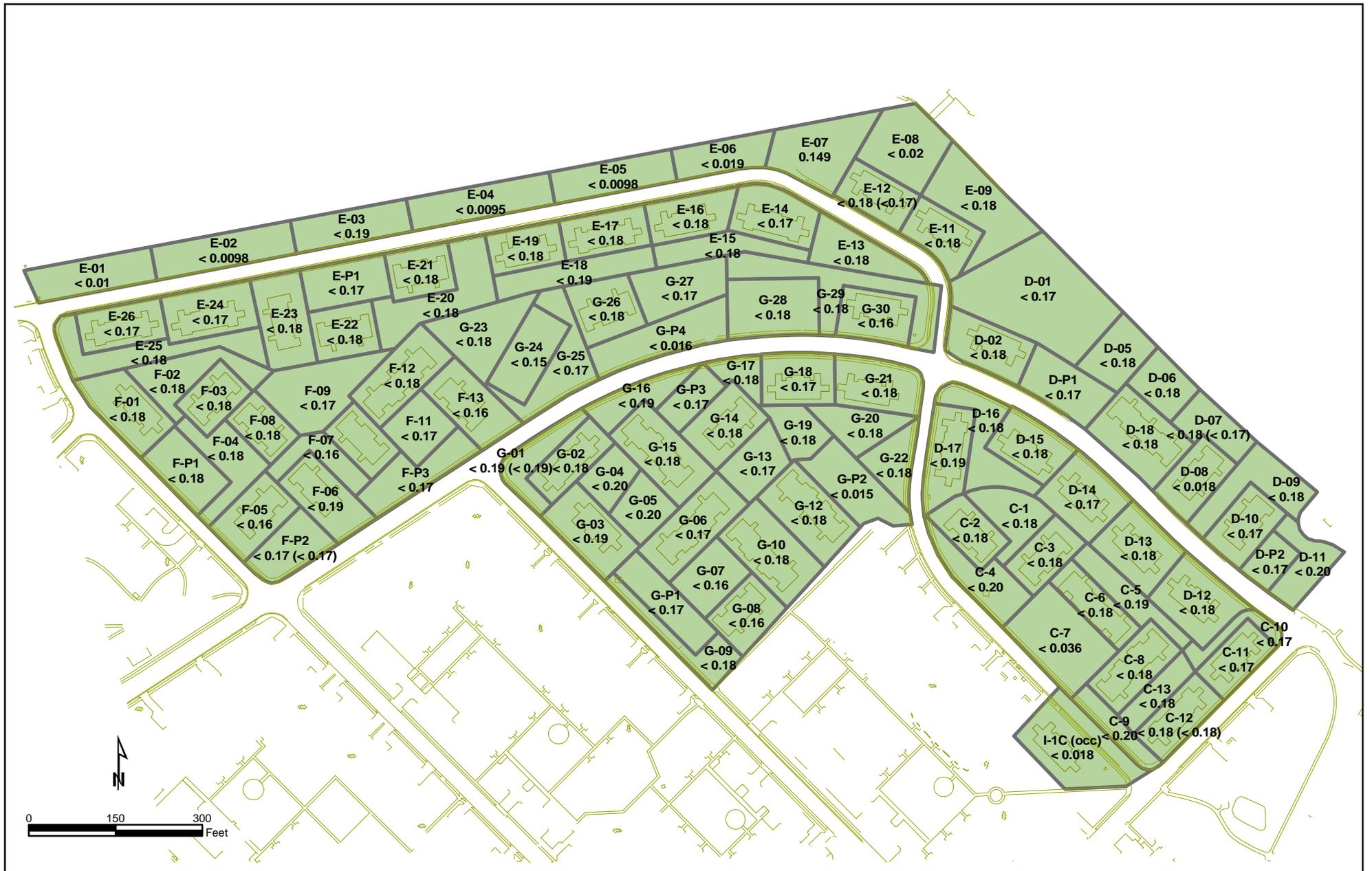
Incremental Samples

- Aldrin < 0.42 mg/kg
- Aldrin > 0.42 mg/kg

Discrete Samples

- Aldrin < 0.42 mg/kg
- Aldrin > 0.42 mg/kg

- Road and Curb
- Building



Duplicate samples indicated in parentheses.

- Aldrin < 0.42 mg/kg
- Aldrin > 0.42 mg/kg
- Road and Curb
- Building

Aldrin Test Results - Capehart

APPENDIX C

**Analytical Results and Risk/Hazard Calculations for Decision Units –
2006 HHRA Standard**

**TABLE C-3
Earhart I-3: Risk and Hazard Calculations - Child Resident**

Decision Unit	Depth (feet)	Analytical Results (mg/kg)									Child Resident																	Exceed HDOH Target Risk or Hazard Criteria? ^b			
											Cancer Risk									Noncancer Hazard											
		Aldrin	Chlordane	Dieldrin	4,4-DDD	4,4-DDE	4,4-DDT	Endosulfan sulfate	Endrin	Endrin Ketone	Aldrin	Chlordane	Dieldrin	4,4-DDD	4,4-DDE	4,4-DDT	Endosulfan sulfate	Endrin	Endrin Ketone	Aldrin	Chlordane	Dieldrin	4,4-DDD	4,4-DDE	4,4-DDT	Endosulfan sulfate	Endrin		Endrin Ketone	Hazard Index ^a	
Resident Child - Cancer EALs (mg/kg)		0.42	23.4	0.45	2.0	1.4	1.7	----	----	----										Cumulative Risk											
Res. Child - Noncancer EALs (mg/kg)		1.8	35.2	3.1	----	----	36	370	18	18																					
EAR3-RA-9c-12	1	0.35	2.1	0.85	0.076	0.58	0.72	<0.024	<0.028	<0.02	8.3E-06	9.0E-07	1.9E-05	3.8E-08	4.1E-07	4.2E-07	ND	ND	ND	2.9E-05	1.9E-01	6.0E-02	2.7E-01	----	----	2.0E-02	ND	ND	ND	0.5	Yes
EAR3-RA-9d-06	0.5	0.21	1.7	0.85	<0.024	0.1	0.12	<0.024	<0.028	<0.02	5.0E-06	7.3E-07	1.9E-05	ND	7.1E-08	7.1E-08	ND	ND	ND	2.5E-05	1.2E-01	4.8E-02	2.7E-01	ND	----	3.3E-03	ND	ND	ND	0.4	Yes
EAR3-RA-9d-12	1	0.19	1.3	0.52	0.03	0.17	0.24	<0.024	<0.028	<0.02	4.5E-06	5.6E-07	1.2E-05	1.5E-08	1.2E-07	1.4E-07	ND	ND	ND	1.7E-05	1.1E-01	3.7E-02	1.7E-01	----	----	6.7E-03	ND	ND	ND	0.3	Yes
EAR3-RA-9e-06	0.5	0.63	2.8	1.8	<0.024	0.26	0.28	<0.024	<0.028	0.029	1.5E-05	1.2E-06	4.0E-05	ND	1.9E-07	1.6E-07	ND	ND	----	5.7E-05	3.5E-01	8.0E-02	5.8E-01	ND	----	7.8E-03	ND	ND	1.6E-03	1.0	Yes
EAR3-RA-9e-12	1	0.16	1.7	0.6	0.048	0.52	0.43	<0.024	<0.028	<0.02	3.8E-06	7.3E-07	1.3E-05	2.4E-08	3.7E-07	2.5E-07	ND	ND	ND	1.9E-05	8.9E-02	4.8E-02	1.9E-01	----	----	1.2E-02	ND	ND	ND	0.3	Yes
EAR3-RA-14b-06	0.5	0.44	3	1.5	<0.024	0.15	0.18	<0.024	<0.028	<0.02	1.0E-05	1.3E-06	3.3E-05	ND	1.1E-07	1.1E-07	ND	ND	ND	4.5E-05	2.4E-01	8.5E-02	4.8E-01	ND	----	5.0E-03	ND	ND	ND	0.8	Yes
EAR3-RA-14b-12	1	2.1	12	6.1	<0.094	0.58	0.56	<0.098	<0.11	0.081	5.0E-05	5.1E-06	1.4E-04	ND	4.1E-07	3.3E-07	ND	ND	----	1.9E-04	1.2E+00	3.4E-01	2.0E+00	ND	----	1.6E-02	ND	ND	4.5E-03	3.5	Yes

Notes:

^a The hazard index represents the sum of all chemical-specific hazard quotients (HQs).

^b Target cumulative risk is 1×10^{-5} and target hazard is one (1).

**TABLE C-5
Onizuka II-1: Risk and Hazard Calculations - Child Resident**

Decision Unit	Depth (feet)	Analytical Results (mg/kg)						Child Resident														Exceed HDOH Target Risk or Hazard Criteria? ^b			
		Aldrin	Chlordane	Dieldrin	4,4-DDD	4,4-DDE	4,4-DDT	Cancer Risk						Cumulative Risk	Noncancer Hazard						Hazard Index ^a				
								Aldrin	Chlordane	Dieldrin	4,4-DDD	4,4-DDE	4,4-DDT		Aldrin	Chlordane	Dieldrin	4,4-DDD	4,4-DDE	4,4-DDT					
Resident Child - Cancer EALs (mg/kg)		0.42	23.4	0.45	2.0	1.4	1.7																		
Res. Child - Noncancer EALs (mg/kg)		1.8	35.2	3.1	----	----	36																		
ONI-RA-1a-06-1	0.5	0.03	0.95	0.21	0.01	0.053	0.054	7.1E-07	4.1E-07	4.7E-06	5.0E-09	3.8E-08	3.2E-08	5.9E-06	1.7E-02	2.7E-02	6.8E-02	----	----	1.5E-03	0.1	No			
ONI-RA-1a-06-2	0.5	0.041	1.4	0.21	<0.0047	0.032	0.036	9.8E-07	6.0E-07	4.7E-06	ND	2.3E-08	2.1E-08	6.3E-06	2.3E-02	4.0E-02	6.8E-02	ND	----	1.0E-03	0.1	No			
ONI-RA-1a-06-3	0.5	0.034	0.9	0.18	<0.0047	0.032	0.04	8.1E-07	3.8E-07	4.0E-06	ND	2.3E-08	2.4E-08	5.2E-06	1.9E-02	2.6E-02	5.8E-02	ND	----	1.1E-03	0.1	No			
ONI-RA-1a-12	1	0.034	0.77	0.14	<0.0047	0.017	0.03	8.1E-07	3.3E-07	3.1E-06	ND	1.2E-08	1.8E-08	4.3E-06	1.9E-02	2.2E-02	4.5E-02	ND	----	8.3E-04	0.1	No			
ONI-RA-1b-06	0.5	0.053	1.5	0.21	0.014	0.06	0.059	1.3E-06	6.4E-07	4.7E-06	7.0E-09	4.3E-08	3.5E-08	6.7E-06	2.9E-02	4.3E-02	6.8E-02	----	----	1.6E-03	0.1	No			
ONI-RA-1b-12	1	0.027	0.99	0.13	0.023	0.044	0.061	6.4E-07	4.2E-07	2.9E-06	1.2E-08	3.1E-08	3.6E-08	4.0E-06	1.5E-02	2.8E-02	4.2E-02	----	----	1.7E-03	0.1	No			
ONI-RA-1c-06	0.5	0.075	4.1	0.31	<0.024	0.026	0.041	1.8E-06	1.8E-06	6.9E-06	ND	1.9E-08	2.4E-08	1.0E-05	4.2E-02	1.2E-01	1.0E-01	ND	----	1.1E-03	0.3	No			
ONI-RA-1c-12	1	0.035	5.4	0.16	<0.024	<0.024	<0.04	8.3E-07	2.3E-06	3.6E-06	ND	ND	ND	6.7E-06	1.9E-02	1.5E-01	5.2E-02	ND	ND	ND	0.2	No			
ONI-RA-2a-06	0.5	0.041	2.8	0.17	0.0056	0.089	0.099	9.8E-07	1.2E-06	3.8E-06	2.8E-09	6.4E-08	5.8E-08	6.1E-06	2.3E-02	8.0E-02	5.5E-02	----	----	2.8E-03	0.2	No			
ONI-RA-2a-12	1	0.0089	3.2	0.07	<0.0047	0.055	0.062	2.1E-07	1.4E-06	1.6E-06	ND	3.9E-08	3.6E-08	3.2E-06	4.9E-03	9.1E-02	2.3E-02	ND	----	1.7E-03	0.1	No			
ONI-RA-2b-06	0.5	0.13	4.7	0.45	<0.024	<0.024	0.046	3.1E-06	2.0E-06	1.0E-05	ND	ND	2.7E-08	1.5E-05	7.2E-02	1.3E-01	1.5E-01	ND	ND	1.3E-03	0.4	Yes			
ONI-RA-2b-12	1	<0.022	5.5	0.067	<0.024	<0.024	0.064	ND	2.4E-06	1.5E-06	ND	ND	3.8E-08	3.9E-06	ND	1.6E-01	2.2E-02	ND	ND	1.8E-03	0.2	No			
ONI-RA-2c-06	0.5	0.067	4.3	0.29	<0.0094	0.06	0.08	1.6E-06	1.8E-06	6.4E-06	ND	4.3E-08	4.7E-08	1.0E-05	3.7E-02	1.2E-01	9.4E-02	ND	----	2.2E-03	0.3	No			
ONI-RA-2c-12	1	0.034	3.9	0.16	<0.0094	0.045	0.066	8.1E-07	1.7E-06	3.6E-06	ND	3.2E-08	3.9E-08	6.1E-06	1.9E-02	1.1E-01	5.2E-02	ND	----	1.8E-03	0.2	No			
ONI-RA-2d-06	0.5	0.12	3.5	0.34	<0.024	<0.024	0.049	2.9E-06	1.5E-06	7.6E-06	ND	ND	2.9E-08	1.2E-05	6.7E-02	9.9E-02	1.1E-01	ND	ND	1.4E-03	0.3	Yes			
ONI-RA-2d-12	1	0.034	3.4	0.1	<0.024	<0.024	<0.04	8.1E-07	1.5E-06	2.2E-06	ND	ND	ND	4.5E-06	1.9E-02	9.7E-02	3.2E-02	ND	ND	ND	0.1	No			
ONI-RA-2e-06	0.5	0.019	2.3	0.14	<0.0094	0.051	0.056	4.5E-07	9.8E-07	3.1E-06	ND	3.6E-08	3.3E-08	4.6E-06	1.1E-02	6.5E-02	4.5E-02	ND	----	1.6E-03	0.1	No			
ONI-RA-2e-12	1	0.011	0.8	0.076	<0.0047	0.063	0.051	2.6E-07	3.4E-07	1.7E-06	ND	4.5E-08	3.0E-08	2.4E-06	6.1E-03	2.3E-02	2.5E-02	ND	----	1.4E-03	0.1	No			
ONI-RA-2f-06	0.5	0.044	1.7	0.19	<0.0047	0.033	0.034	1.0E-06	7.3E-07	4.2E-06	ND	2.4E-08	2.0E-08	6.0E-06	2.4E-02	4.8E-02	6.1E-02	ND	----	9.4E-04	0.1	No			
ONI-RA-2f-12	1	0.028	1	0.066	<0.0047	0.022	0.023	6.7E-07	4.3E-07	1.5E-06	ND	1.6E-08	1.4E-08	2.6E-06	1.6E-02	2.8E-02	2.1E-02	ND	----	6.4E-04	0.1	No			
ONI-RA-2g-06	0.5	0.32	3.7	0.86	<0.024	0.068	0.08	7.6E-06	1.6E-06	1.9E-05	ND	4.9E-08	4.7E-08	2.8E-05	1.8E-01	1.1E-01	2.8E-01	ND	----	2.2E-03	0.6	Yes			
ONI-RA-2g-12	1	0.083	2.6	0.25	<0.0094	0.077	0.09	2.0E-06	1.1E-06	5.6E-06	ND	5.5E-08	5.3E-08	8.8E-06	4.6E-02	7.4E-02	8.1E-02	ND	----	2.5E-03	0.2	No			
ONI-RA-2h-06	0.5	0.03	2.4	0.16	<0.0094	0.093	0.054	7.1E-07	1.0E-06	3.6E-06	ND	6.6E-08	3.2E-08	5.4E-06	1.7E-02	6.8E-02	5.2E-02	ND	----	1.5E-03	0.1	No			
ONI-RA-2h-12	1	0.3	2.8	0.54	<0.024	0.15	0.063	7.1E-06	1.2E-06	1.2E-05	ND	1.1E-07	3.7E-08	2.0E-05	1.7E-01	8.0E-02	1.7E-01	ND	----	1.8E-03	0.4	Yes			
ONI-RA-3a-06	0.5	0.076	1.1	0.24	<0.0047	0.021	0.033	1.8E-06	4.7E-07	5.3E-06	ND	1.5E-08	1.9E-08	7.6E-06	4.2E-02	3.1E-02	7.7E-02	ND	----	9.2E-04	0.2	No			
ONI-RA-3a-12	1	0.056	2.4	0.14	<0.0047	0.038	0.039	1.3E-06	1.0E-06	3.1E-06	ND	2.7E-08	2.3E-08	5.5E-06	3.1E-02	6.8E-02	4.5E-02	ND	----	1.1E-03	0.1	No			
ONI-RA-3b-06	0.5	0.099	1.3	0.36	0.011	0.064	0.08	2.4E-06	5.6E-07	8.0E-06	5.5E-09	4.6E-08	4.7E-08	1.1E-05	5.5E-02	3.7E-02	1.2E-01	----	----	2.2E-03	0.2	Yes			
ONI-RA-3b-12	1	0.12	1.1	0.35	0.0098	0.064	0.061	2.9E-06	4.7E-07	7.8E-06	4.9E-09	4.6E-08	3.6E-08	1.1E-05	6.7E-02	3.1E-02	1.1E-01	----	----	1.7E-03	0.2	Yes			
ONI-RA-3c-06	0.5	0.028	1.2	0.11	0.0078	0.068	0.095	6.7E-07	5.1E-07	2.4E-06	3.9E-09	4.9E-08	5.6E-08	3.7E-06	1.6E-02	3.4E-02	3.5E-02	----	----	2.6E-03	0.1	No			
ONI-RA-3c-12	1	0.029	0.96	0.087	0.017	0.072	0.11	6.9E-07	4.1E-07	1.9E-06	8.5E-09	5.1E-08	6.5E-08	3.2E-06	1.6E-02	2.7E-02	2.8E-02	----	----	3.1E-03	0.1	No			
ONI-RA-3d-06	0.5	0.027	1.7	0.082	<0.0047	0.022	0.03	6.4E-07	7.3E-07	1.8E-06	ND	1.6E-08	1.8E-08	3.2E-06	1.5E-02	4.8E-02	2.6E-02	ND	----	8.3E-04	0.1	No			
ONI-RA-3d-12	1	0.095	2.7	0.21	<0.0047	0.036	0.055	2.3E-06	1.2E-06	4.7E-06	ND	2.6E-08	3.2E-08	8.1E-06	5.3E-02	7.7E-02	6.8E-02	ND	----	1.5E-03	0.2	No			
ONI-RA-4a-06-1	0.5	0.042	1.1	0.14	<0.0047	0.017	0.029	1.0E-06	4.7E-07	3.1E-06	ND	1.2E-08	1.7E-08	4.6E-06	2.3E-02	3.1E-02	4.5E-02	ND	----	8.1E-04	0.1	No			
ONI-RA-4a-06-2	0.5	0.043	1.2	0.13	<0.0047	0.013	0.029	1.0E-06	5.1E-07	2.9E-06	ND	9.3E-09	1.7E-08	4.5E-06	2.4E-02	3.4E-02	4.2E-02	ND	----	8.1E-04	0.1	No			
ONI-RA-4a-06-3	0.5	0.033	1.3	0.13	<0.0047	0.022	0.03	7.9E-07	5.6E-07	2.9E-06	ND	1.6E-08	1.8E-08	4.3E-06	1.8E-02	3.7E-02	4.2E-02	ND	----	8.3E-04	0.1	No			
ONI-RA-4a-12	1	0.015	0.88	0.062	<0.0047	<0.0048	0.033	3.6E-07	3.8E-07	1.4E-06	ND	ND	1.9E-08	2.1E-06	8.3E-03	2.5E-02	2.0E-02	ND	ND	9.2E-04	0.1	No			
ONI-RA-4b-06	0.5	0.075	1.4	0.21	0.0057	0.04	0.064	1.8E-06	6.0E-07	4.7E-06	2.9E-09	2.9E-08	3.8E-08	7.1E-06	4.2E-02	4.0E-02	6.8E-02	----	----	1.8E-03	0.2	No			
ONI-RA-4b-12	1	0.087	1.7	0.2	<0.0047	0.015	0.041	2.1E-06	7.3E-07	4.4E-06	ND	1.1E-08	2.4E-08	7.3E-06	4.8E-02	4.8E-02	6.5E-02	ND	----	1.1E-03	0.2	No			
ONI-RA-4c-06	0.5	0.35	1.9	0.77	<0.024	<0.024	<0.04	8.3E-06	8.1E-07	1.7E-05	ND	ND	ND	2.6E-05	1.9E-01	5.4E-02	2.5E-01	ND	ND	ND	0.5	Yes			
ONI-RA-4c-12	1	0.27	1.6	0.54	<0.024	<0.024	<0.04	6.4E-06	6.8E-07	1.2E-05	ND	ND	ND	1.9E-05	1.5E-01	4.5E-02	1.7E-01	ND	ND	ND	0.4	Yes			
ONI-RA-5a-06	0.5	0.26	1.9	0.79	<0.024	0.079	0.063	6.2E-06	8.1E-07	1.8E-05	ND	5.6E-08	3.7E-08	2.5E-05	1.4E-01	5.4E-02	2.5E-01	ND	----	1.8E-03	0.5	Yes			
ONI-RA-5a-12	1	0.54	2	0.98	<0.024	0.09	0.076	1.3E-05	8.5E-07	2.2E-05	ND	6.4E-08	4.5E-08	3.6E-05	3.0E-01	5.7E-02	3.2E-01	ND	----	2.1E-03	0.7	Yes			
ONI-RA-5b-06	0.5	0.23	1.7	0.73	<0.024	0.051	0.048	5.5E-06	7.3E-07	1.6E-05	ND	3.6E-08	2.8E-08	2.2E-05	1.3E-01	4.8E-02	2.4E-01	ND	----	1.3E-03	0.4	Yes			
ONI-RA-5b-12	1	0.3	1.9	0.82	<0.024	0.066	0.064	7.1E-06	8.1E-07	1.8E-05	ND	4.7E-08	3.8E-08	2.6E-05	1.7E-01	5.4E-02	2.6E-01	ND	----	1.8E-03	0.5	Yes			
ONI-RA-5c-06	0.5	0.32	1.9	1	<0.024	0.051	0.04	7.6E-06	8.1E-07	2.2E-05	ND	3.6E-08	2.4E-08	3.1E											

TABLE C-6
Onizuka II-1: Risk and Hazard Calculations - Adult Resident

Decision Unit	Depth (feet)	Analytical Results (mg/kg)						Adult Resident														Exceed HDOH Target Risk or Hazard Criteria? ^{a,b}			
		Aldrin	Chlordane	Dieldrin	4,4-DDD	4,4-DDE	4,4-DDT	Cancer Risk						Cumulative Risk	Noncancer Hazard										
								Aldrin	Chlordane	Dieldrin	4,4-DDD	4,4-DDE	4,4-DDT		Aldrin	Chlordane	Dieldrin	4,4-DDD	4,4-DDE	4,4-DDT	Hazard Index ^a				
Resident Adult - Cancer EALs (mg/kg)		3.6	209.8	3.8	2.0	1.4	1.7																		
Res. Adult - Noncancer EALs (mg/kg)		15.7	314.7	26.1	----	----	36																		
ONI-RA-1a-06-1	0.5	0.03	0.95	0.21	0.01	0.053	0.054	8.3E-08	4.5E-08	5.5E-07	5.0E-09	3.8E-08	3.2E-08	7.6E-07	1.9E-03	3.0E-03	8.0E-03	----	----	1.5E-03	0.01	No			
ONI-RA-1a-06-2	0.5	0.041	1.4	0.21	<0.0047	0.032	0.036	1.1E-07	6.7E-08	5.5E-07	ND	2.3E-08	2.1E-08	7.8E-07	2.6E-03	4.4E-03	8.0E-03	ND	----	1.0E-03	0.02	No			
ONI-RA-1a-06-3	0.5	0.034	0.9	0.18	<0.0047	0.032	0.04	9.4E-08	4.3E-08	4.7E-07	ND	2.3E-08	2.4E-08	6.6E-07	2.2E-03	2.9E-03	6.9E-03	ND	----	1.1E-03	0.01	No			
ONI-RA-1a-12	1	0.034	0.77	0.14	<0.0047	0.017	0.03	9.4E-08	3.7E-08	3.7E-07	ND	1.2E-08	1.8E-08	5.3E-07	2.2E-03	2.4E-03	5.4E-03	ND	----	8.3E-04	0.01	No			
ONI-RA-1b-06	0.5	0.053	1.5	0.21	0.014	0.06	0.059	1.5E-07	7.1E-08	5.5E-07	7.0E-09	4.3E-08	3.5E-08	8.6E-07	3.4E-03	4.8E-03	8.0E-03	----	----	1.6E-03	0.02	No			
ONI-RA-1b-12	1	0.027	0.99	0.13	0.023	0.044	0.061	7.5E-08	4.7E-08	3.4E-07	1.2E-08	3.1E-08	3.6E-08	5.4E-07	1.7E-03	3.1E-03	5.0E-03	----	----	1.7E-03	0.01	No			
ONI-RA-1c-06	0.5	0.075	4.1	0.31	<0.024	0.026	0.041	2.1E-07	2.0E-07	8.2E-07	ND	1.9E-08	2.4E-08	1.3E-06	4.8E-03	1.3E-02	1.2E-02	ND	----	1.1E-03	0.03	No			
ONI-RA-1c-12	1	0.035	5.4	0.16	<0.024	<0.024	<0.04	9.7E-08	2.6E-07	4.2E-07	ND	ND	ND	7.8E-07	2.2E-03	1.7E-02	6.1E-03	ND	ND	ND	0.03	No			
ONI-RA-2a-06	0.5	0.041	2.8	0.17	0.0056	0.089	0.099	1.1E-07	1.3E-07	4.5E-07	2.8E-09	6.4E-08	5.8E-08	8.2E-07	2.6E-03	8.9E-03	6.5E-03	----	----	2.8E-03	0.02	No			
ONI-RA-2a-12	1	0.0089	3.2	0.07	<0.0047	0.055	0.062	2.5E-08	1.5E-07	1.8E-07	ND	3.9E-08	3.6E-08	4.4E-07	5.7E-04	1.0E-02	2.7E-03	ND	----	1.7E-03	0.02	No			
ONI-RA-2b-06	0.5	0.13	4.7	0.45	<0.024	<0.024	0.046	3.6E-07	2.2E-07	1.2E-06	ND	ND	2.7E-08	1.8E-06	8.3E-03	1.5E-02	1.7E-02	ND	ND	1.3E-03	0.04	No			
ONI-RA-2b-12	1	<0.022	5.5	0.067	<0.024	<0.024	0.064	ND	2.6E-07	1.8E-07	ND	ND	3.8E-08	4.8E-07	ND	1.7E-02	2.6E-03	ND	ND	1.8E-03	0.02	No			
ONI-RA-2c-06	0.5	0.067	4.3	0.29	<0.0094	0.06	0.08	1.9E-07	2.0E-07	7.6E-07	ND	4.3E-08	4.7E-08	1.2E-06	4.3E-03	1.4E-02	1.1E-02	ND	----	2.2E-03	0.03	No			
ONI-RA-2c-12	1	0.034	3.9	0.16	<0.0094	0.045	0.066	9.4E-08	1.9E-07	4.2E-07	ND	3.2E-08	3.9E-08	7.7E-07	2.2E-03	1.2E-02	6.1E-03	ND	----	1.8E-03	0.02	No			
ONI-RA-2d-06	0.5	0.12	3.5	0.34	<0.024	<0.024	0.049	3.3E-07	1.7E-07	8.9E-07	ND	ND	2.9E-08	1.4E-06	7.6E-03	1.1E-02	1.3E-02	ND	ND	1.4E-03	0.03	No			
ONI-RA-2d-12	1	0.034	3.4	0.1	<0.024	<0.024	<0.04	9.4E-08	1.6E-07	2.6E-07	ND	ND	ND	5.2E-07	2.2E-03	1.1E-02	3.8E-03	ND	ND	ND	0.02	No			
ONI-RA-2e-06	0.5	0.019	2.3	0.14	<0.0094	0.051	0.056	5.3E-08	1.1E-07	3.7E-07	ND	3.6E-08	3.3E-08	6.0E-07	1.2E-03	7.3E-03	5.4E-03	ND	----	1.6E-03	0.02	No			
ONI-RA-2e-12	1	0.011	0.8	0.076	<0.0047	0.063	0.051	3.1E-08	3.8E-08	2.0E-07	ND	4.5E-08	3.0E-08	3.4E-07	7.0E-04	2.5E-03	2.9E-03	ND	----	1.4E-03	0.01	No			
ONI-RA-2f-06	0.5	0.044	1.7	0.19	<0.0047	0.033	0.034	1.2E-07	8.1E-08	5.0E-07	ND	2.4E-08	2.0E-08	7.5E-07	2.8E-03	5.4E-03	7.3E-03	ND	----	9.4E-04	0.02	No			
ONI-RA-2f-12	1	0.028	1	0.066	<0.0047	0.022	0.023	7.8E-08	4.8E-08	1.7E-07	ND	1.6E-08	1.4E-08	3.3E-07	1.8E-03	3.2E-03	2.5E-03	ND	----	6.4E-04	0.01	No			
ONI-RA-2g-06	0.5	0.32	3.7	0.86	<0.024	0.068	0.08	8.9E-07	1.8E-07	2.3E-06	ND	4.9E-08	4.7E-08	3.4E-06	2.0E-02	1.2E-02	3.3E-02	ND	----	2.2E-03	0.07	No			
ONI-RA-2g-12	1	0.083	2.6	0.25	<0.0094	0.077	0.09	2.3E-07	1.2E-07	6.6E-07	ND	5.5E-08	5.3E-08	1.1E-06	5.3E-03	8.3E-03	9.6E-03	ND	----	2.5E-03	0.03	No			
ONI-RA-2h-06	0.5	0.03	2.4	0.16	<0.0094	0.093	0.054	8.3E-08	1.1E-07	4.2E-07	ND	6.6E-08	3.2E-08	7.2E-07	1.9E-03	7.6E-03	6.1E-03	ND	----	1.5E-03	0.02	No			
ONI-RA-2h-12	1	0.3	2.8	0.54	<0.024	0.15	0.063	8.3E-07	1.3E-07	1.4E-06	ND	1.1E-07	3.7E-08	2.5E-06	1.9E-02	8.9E-03	2.1E-02	ND	----	1.8E-03	0.05	No			
ONI-RA-3a-06	0.5	0.076	1.1	0.24	<0.0047	0.021	0.033	2.1E-07	5.2E-08	6.3E-07	ND	1.5E-08	1.9E-08	9.3E-07	4.8E-03	3.5E-03	9.2E-03	ND	----	9.2E-04	0.02	No			
ONI-RA-3a-12	1	0.056	2.4	0.14	<0.0047	0.038	0.039	1.6E-07	1.1E-07	3.7E-07	ND	2.7E-08	2.3E-08	6.9E-07	3.6E-03	7.6E-03	5.4E-03	ND	----	1.1E-03	0.02	No			
ONI-RA-3b-06	0.5	0.099	1.3	0.36	0.011	0.064	0.08	2.8E-07	6.2E-08	9.5E-07	5.5E-09	4.6E-08	4.7E-08	1.4E-06	6.3E-03	4.1E-03	1.4E-02	----	----	2.2E-03	0.03	No			
ONI-RA-3b-12	1	0.12	1.1	0.35	0.0098	0.064	0.061	3.3E-07	5.2E-08	9.2E-07	4.9E-09	4.6E-08	3.6E-08	1.4E-06	7.6E-03	3.5E-03	1.3E-02	----	----	1.7E-03	0.03	No			
ONI-RA-3c-06	0.5	0.028	1.2	0.11	0.0078	0.068	0.095	7.8E-08	5.7E-08	2.9E-07	3.9E-09	4.9E-08	5.6E-08	5.3E-07	1.8E-03	3.8E-03	4.2E-03	----	----	2.6E-03	0.01	No			
ONI-RA-3c-12	1	0.029	0.96	0.087	0.017	0.072	0.11	8.1E-08	4.6E-08	2.3E-07	8.5E-09	5.1E-08	6.5E-08	4.8E-07	1.8E-03	3.1E-03	3.3E-03	----	----	3.1E-03	0.01	No			
ONI-RA-3d-06	0.5	0.027	1.7	0.082	<0.0047	0.022	0.03	7.5E-08	8.1E-08	2.2E-07	ND	1.6E-08	1.8E-08	4.1E-07	1.7E-03	5.4E-03	3.1E-03	ND	----	8.3E-04	0.01	No			
ONI-RA-3d-12	1	0.095	2.7	0.21	<0.0047	0.036	0.055	2.6E-07	1.3E-07	5.5E-07	ND	2.6E-08	3.2E-08	1.0E-06	6.1E-03	8.6E-03	8.0E-03	ND	----	1.5E-03	0.02	No			
ONI-RA-4a-06-1	0.5	0.042	1.1	0.14	<0.0047	0.017	0.029	1.2E-07	5.2E-08	3.7E-07	ND	1.2E-08	1.7E-08	5.7E-07	2.7E-03	3.5E-03	5.4E-03	ND	----	8.1E-04	0.01	No			
ONI-RA-4a-06-2	0.5	0.043	1.2	0.13	<0.0047	0.013	0.029	1.2E-07	5.7E-08	3.4E-07	ND	9.3E-09	1.7E-08	5.5E-07	2.7E-03	3.8E-03	5.0E-03	ND	----	8.1E-04	0.01	No			
ONI-RA-4a-06-3	0.5	0.033	1.3	0.13	<0.0047	0.022	0.03	9.2E-08	6.2E-08	3.4E-07	ND	1.6E-08	1.8E-08	5.3E-07	2.1E-03	4.1E-03	5.0E-03	ND	----	8.3E-04	0.01	No			
ONI-RA-4a-12	1	0.015	0.88	0.062	<0.0047	<0.0048	0.033	4.2E-08	4.2E-08	1.6E-07	ND	ND	1.9E-08	2.7E-07	9.6E-04	2.8E-03	2.4E-03	ND	ND	9.2E-04	0.01	No			
ONI-RA-4b-06	0.5	0.075	1.4	0.21	0.0057	0.04	0.064	2.1E-07	6.7E-08	5.5E-07	2.9E-09	2.9E-08	3.8E-08	9.0E-07	4.8E-03	4.4E-03	8.0E-03	----	----	1.8E-03	0.02	No			
ONI-RA-4b-12	1	0.087	1.7	0.2	<0.0047	0.015	0.041	2.4E-07	8.1E-08	5.3E-07	ND	1.1E-08	2.4E-08	8.8E-07	5.5E-03	5.4E-03	7.7E-03	ND	----	1.1E-03	0.02	No			
ONI-RA-4c-06	0.5	0.35	1.9	0.77	<0.024	<0.024	<0.04	9.7E-07	9.1E-08	2.0E-06	ND	ND	ND	3.1E-06	2.2E-02	6.0E-03	3.0E-02	ND	ND	ND	0.06	No			
ONI-RA-4c-12	1	0.27	1.6	0.54	<0.024	<0.024	<0.04	7.5E-07	7.6E-08	1.4E-06	ND	ND	ND	2.2E-06	1.7E-02	5.1E-03	2.1E-02	ND	ND	ND	0.04	No			
ONI-RA-5a-06	0.5	0.26	1.9	0.79	<0.024	0.079	0.063	7.2E-07	9.1E-08	2.1E-06	ND	5.6E-08	3.7E-08	3.0E-06	1.7E-02	6.0E-03	3.0E-02	ND	----	1.8E-03	0.05	No			
ONI-RA-5a-12	1	0.54	2	0.98	<0.024	0.09	0.076	1.5E-06	9.5E-08	2.6E-06	ND	6.4E-08	4.5E-08	4.3E-06	3.4E-02	6.4E-03	3.8E-02	ND	----	2.1E-03	0.08	No			
ONI-RA-5b-06	0.5	0.23	1.7	0.73	<0.024	0.051	0.048	6.4E-07	8.1E-08	1.9E-06	ND	3.6E-08	2.8E-08	2.7E-06	1.5E-02	5.4E-03	2.8E-02	ND	----	1.3E-03	0.05	No			
ONI-RA-5b-12	1	0.3	1.9	0.82	<0.024	0.066	0.064	8.3E-07	9.1E-08	2.2E-06	ND	4.7E-08	3.8E-08	3.2E-06	1.9E-02	6.0E-03	3.1E-02	ND	----	1.8E-03	0.06	No			
ONI-RA-5c-06	0.5	0.32	1.9	1	<0.024	0.051	0.04	8.9E-07	9.1E-08	2.6E-06	ND	3.6E-08	2.4E-08	3.7E-06	2.0E-02	6.0E-03	3.8E-02	ND	----	1.1E-03	0.07	No			
ONI-RA-5c-12	1	0.42	2	1.2	0.057	0.036	0.044	1.2E-06	9.5E-08	3.2E-06	2.9E-08	2.6E-08	2.6E-08	4.5E-06	2.7E-02	6.4E-03	4.6E-02	----	----	1.2E-03	0.08	No			

Notes:

^a The hazard index represents the sum of all chemical-specific hazard quotients (HQs).

^b Target cumulative risk is 1 x 10⁻⁵ and target hazard is one (1).

**TABLE C-7
Hale Na Koa I-1: Risk and Hazard Calculations - Child Resident**

Decision Unit	Depth (feet)	Analytical Results (mg/kg)					Child Resident													Exceed HDOH Target Risk or Hazard Criteria? ^b				
		Chlordane	Dieldrin	4,4-DDE	4,4-DDT	Endrin	Cancer Risk					Cumulative Risk	Noncancer Hazard					Hazard Index ^a						
							Chlordane	Dieldrin	4,4-DDE	4,4-DDT	Endrin		Chlordane	Dieldrin	4,4-DDE	4,4-DDT	Endrin							
Resident Child - Cancer EALs (mg/kg)		23.4	0.45	1.4	1.7	----																		
Res. Child - Noncancer EALs (mg/kg)		35.2	3.1	----	36	18																		
HNK-OA-1-06	0.5	5.8	0.04	0.045	0.03	<0.0057	2.5E-06	8.9E-07	3.2E-08	1.8E-08	ND	3.4E-06	1.6E-01	1.3E-02	----	8.3E-04	ND	0.18	No					
HNK-OA-1-12	1	6.5	0.043	0.046	0.034	<0.0057	2.8E-06	9.6E-07	3.3E-08	2.0E-08	ND	3.8E-06	1.8E-01	1.4E-02	----	9.4E-04	ND	0.20	No					
HNK-OA-2-06-1	0.5	7.3	0.029	0.034	<0.04	<0.028	3.1E-06	6.4E-07	2.4E-08	ND	ND	3.8E-06	2.1E-01	9.4E-03	----	ND	ND	0.22	No					
HNK-OA-2-06-2	0.5	4	0.016	0.026	0.037	<0.011	1.7E-06	3.6E-07	1.9E-08	2.2E-08	ND	2.1E-06	1.1E-01	5.2E-03	----	1.0E-03	ND	0.12	No					
HNK-OA-2-06-3	0.5	5.9	0.024	0.032	0.032	<0.011	2.5E-06	5.3E-07	2.3E-08	1.9E-08	ND	3.1E-06	1.7E-01	7.7E-03	----	8.9E-04	ND	0.18	No					
HNK-OA-2-12	1	17	0.04	<0.024	0.065	<0.028	7.3E-06	8.9E-07	ND	3.8E-08	ND	8.2E-06	4.8E-01	1.3E-02	ND	1.8E-03	ND	0.50	No					
HNK-OA-3-06	0.5	5.9	0.038	0.037	0.092	<0.011	2.5E-06	8.4E-07	2.6E-08	5.4E-08	ND	3.4E-06	1.7E-01	1.2E-02	----	2.6E-03	ND	0.18	No					
HNK-OA-3-12	1	9.8	0.056	0.069	0.11	<0.011	4.2E-06	1.2E-06	4.9E-08	6.5E-08	ND	5.5E-06	2.8E-01	1.8E-02	----	3.1E-03	ND	0.30	No					
HNK-OA-4-06	0.5	6.1	0.044	0.043	0.042	<0.011	2.6E-06	9.8E-07	3.1E-08	2.5E-08	ND	3.6E-06	1.7E-01	1.4E-02	----	1.2E-03	ND	0.19	No					
HNK-OA-4-12	1	7.4	0.062	0.045	0.039	<0.011	3.2E-06	1.4E-06	3.2E-08	2.3E-08	ND	4.6E-06	2.1E-01	2.0E-02	----	1.1E-03	ND	0.23	No					
HNK-OA-5-06	0.5	2.3	0.019	0.032	<0.016	<0.011	9.8E-07	4.2E-07	2.3E-08	ND	ND	1.4E-06	6.5E-02	6.1E-03	----	ND	ND	0.07	No					
HNK-OA-5-12	1	5.7	0.049	0.065	0.035	<0.011	2.4E-06	1.1E-06	4.6E-08	2.1E-08	ND	3.6E-06	1.6E-01	1.6E-02	----	9.7E-04	ND	0.18	No					
HNK-OA-6-06	0.5	6.8	0.04	0.11	0.071	<0.011	2.9E-06	8.9E-07	7.9E-08	4.2E-08	ND	3.9E-06	1.9E-01	1.3E-02	----	2.0E-03	ND	0.21	No					
HNK-OA-7-06	0.5	3.3	0.02	0.24	0.1	<0.011	1.4E-06	4.4E-07	1.7E-07	5.9E-08	ND	2.1E-06	9.4E-02	6.5E-03	----	2.8E-03	ND	0.10	No					
HNK-OA-8-06	0.5	3.1	0.017	0.051	0.026	<0.011	1.3E-06	3.8E-07	3.6E-08	1.5E-08	ND	1.8E-06	8.8E-02	5.5E-03	----	7.2E-04	ND	0.09	No					
HNK-OA-9-06	0.5	1.8	0.014	0.028	<0.016	0.011	7.7E-07	3.1E-07	2.0E-08	ND	----	1.1E-06	5.1E-02	4.5E-03	----	ND	6.1E-04	0.06	No					
HNK-OA-10-06	0.5	3.8	0.026	0.047	0.07	<0.011	1.6E-06	5.8E-07	3.4E-08	4.1E-08	ND	2.3E-06	1.1E-01	8.4E-03	----	1.9E-03	ND	0.12	No					
HNK-OA-11-06-1	0.5	2.2	0.018	0.017	0.016	<0.011	9.4E-07	4.0E-07	1.2E-08	9.4E-09	ND	1.4E-06	6.3E-02	5.8E-03	----	4.4E-04	ND	0.07	No					
HNK-OA-11-06-2	0.5	1.9	0.016	0.011	<0.016	<0.011	8.1E-07	3.6E-07	7.9E-09	ND	ND	1.2E-06	5.4E-02	5.2E-03	----	ND	ND	0.06	No					
HNK-OA-11-06-3	0.5	1.9	0.012	0.025	<0.016	<0.011	8.1E-07	2.7E-07	1.8E-08	ND	ND	1.1E-06	5.4E-02	3.9E-03	----	ND	ND	0.06	No					

Notes:

^a The hazard index represents the sum of all chemical-specific hazard quotients (HQs).

^b Target cumulative risk is 1×10^{-5} and target hazard is one (1).

**TABLE C-8
Hale Na Koa I-1: Risk and Hazard Calculations - Adult Resident**

Decision Unit	Depth (feet)	Analytical Results (mg/kg)					Adult Resident														Exceed HDOH Target Risk or Hazard Criteria? ^b
		Chlordane	Dieldrin	4,4-DDE	4,4-DDT	Endrin	Cancer Risk					Cumulative Risk	Noncancer Hazard					Hazard Index ^a			
							Chlordane	Dieldrin	4,4-DDE	4,4-DDT	Endrin		Chlordane	Dieldrin	4,4-DDE	4,4-DDT	Endrin				
Res. Adult - Cancer EALs (mg/kg)		209.8	3.8	1.4	1.7	----															
Res. Adult - Noncancer EALs (mg/kg)		314.7	26.1	----	36	18															
HNK-OA-1-06	0.5	5.8	0.04	0.045	0.03	<0.0057	2.8E-07	1.1E-07	3.2E-08	1.8E-08	ND	4.3E-07	1.8E-02	1.5E-03	----	8.3E-04	ND	0.02	No		
HNK-OA-1-12	1	6.5	0.043	0.046	0.034	<0.0057	3.1E-07	1.1E-07	3.3E-08	2.0E-08	ND	4.8E-07	2.1E-02	1.6E-03	----	9.4E-04	ND	0.02	No		
HNK-OA-2-06-1	0.5	7.3	0.029	0.034	<0.04	<0.028	3.5E-07	7.6E-08	2.4E-08	ND	ND	4.5E-07	2.3E-02	1.1E-03	----	ND	ND	0.02	No		
HNK-OA-2-06-2	0.5	4	0.016	0.026	0.037	<0.011	1.9E-07	4.2E-08	1.9E-08	2.2E-08	ND	2.7E-07	1.3E-02	6.1E-04	----	1.0E-03	ND	0.01	No		
HNK-OA-2-06-3	0.5	5.9	0.024	0.032	0.032	<0.011	2.8E-07	6.3E-08	2.3E-08	1.9E-08	ND	3.9E-07	1.9E-02	9.2E-04	----	8.9E-04	ND	0.02	No		
HNK-OA-2-12	1	17	0.04	<0.024	0.065	<0.028	8.1E-07	1.1E-07	ND	3.8E-08	ND	9.5E-07	5.4E-02	1.5E-03	ND	1.8E-03	ND	0.06	No		
HNK-OA-3-06	0.5	5.9	0.038	0.037	0.092	<0.011	2.8E-07	1.0E-07	2.6E-08	5.4E-08	ND	4.6E-07	1.9E-02	1.5E-03	----	2.6E-03	ND	0.02	No		
HNK-OA-3-12	1	9.8	0.056	0.069	0.11	<0.011	4.7E-07	1.5E-07	4.9E-08	6.5E-08	ND	7.3E-07	3.1E-02	2.1E-03	----	3.1E-03	ND	0.04	No		
HNK-OA-4-06	0.5	6.1	0.044	0.043	0.042	<0.011	2.9E-07	1.2E-07	3.1E-08	2.5E-08	ND	4.6E-07	1.9E-02	1.7E-03	----	1.2E-03	ND	0.02	No		
HNK-OA-4-12	1	7.4	0.062	0.045	0.039	<0.011	3.5E-07	1.6E-07	3.2E-08	2.3E-08	ND	5.7E-07	2.4E-02	2.4E-03	----	1.1E-03	ND	0.03	No		
HNK-OA-5-06	0.5	2.3	0.019	0.032	<0.016	<0.011	1.1E-07	5.0E-08	2.3E-08	ND	ND	1.8E-07	7.3E-03	7.3E-04	----	ND	ND	0.01	No		
HNK-OA-5-12	1	5.7	0.049	0.065	0.035	<0.011	2.7E-07	1.3E-07	4.6E-08	2.1E-08	ND	4.7E-07	1.8E-02	1.9E-03	----	9.7E-04	ND	0.02	No		
HNK-OA-6-06	0.5	6.8	0.04	0.11	0.071	<0.011	3.2E-07	1.1E-07	7.9E-08	4.2E-08	ND	5.5E-07	2.2E-02	1.5E-03	----	2.0E-03	ND	0.03	No		
HNK-OA-7-06	0.5	3.3	0.02	0.24	0.1	<0.011	1.6E-07	5.3E-08	1.7E-07	5.9E-08	ND	4.4E-07	1.0E-02	7.7E-04	----	2.8E-03	ND	0.01	No		
HNK-OA-8-06	0.5	3.1	0.017	0.051	0.026	<0.011	1.5E-07	4.5E-08	3.6E-08	1.5E-08	ND	2.4E-07	9.9E-03	6.5E-04	----	7.2E-04	ND	0.01	No		
HNK-OA-9-06	0.5	1.8	0.014	0.028	<0.016	0.011	8.6E-08	3.7E-08	2.0E-08	ND	----	1.4E-07	5.7E-03	5.4E-04	----	ND	6.1E-04	0.01	No		
HNK-OA-10-06	0.5	3.8	0.026	0.047	0.07	<0.011	1.8E-07	6.8E-08	3.4E-08	4.1E-08	ND	3.2E-07	1.2E-02	1.0E-03	----	1.9E-03	ND	0.02	No		
HNK-OA-11-06-1	0.5	2.2	0.018	0.017	0.016	<0.011	1.0E-07	4.7E-08	1.2E-08	9.4E-09	ND	1.7E-07	7.0E-03	6.9E-04	----	4.4E-04	ND	0.01	No		
HNK-OA-11-06-2	0.5	1.9	0.016	0.011	<0.016	<0.011	9.1E-08	4.2E-08	7.9E-09	ND	ND	1.4E-07	6.0E-03	6.1E-04	----	ND	ND	0.01	No		
HNK-OA-11-06-3	0.5	1.9	0.012	0.025	<0.016	<0.011	9.1E-08	3.2E-08	1.8E-08	ND	ND	1.4E-07	6.0E-03	4.6E-04	----	ND	ND	0.01	No		

Notes:

^a The hazard index represents the sum of all chemical-specific hazard quotients (HQs).

^b Target cumulative risk is 1×10^{-5} and target hazard is one (1).

APPENDIX D

Toxicity Evaluation for Aldrin and Dieldrin

**Report for the Hawaii Department of Health
on Aldrin/Dieldrin Concentrations
in Soil at the Hickam Air Force Base**

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EXECUTIVE SUMMARY

U.S. EPA (1987) considered aldrin and dieldrin to be probable human carcinogens based on liver tumors in mice, but the mode of action for liver tumors in mice may not be applicable to humans. The National Toxicology Program (2010) does not consider aldrin or dieldrin to be human carcinogens or to be reasonably anticipated to be human carcinogens. The International Agency for Research on Cancer (1987) concluded that aldrin and dieldrin could not be classified as to their carcinogenicity in humans. Studies published since the U.S. EPA (1987) and IARC (1987) reports provide no evidence of a causal association between aldrin and dieldrin and an excess risk of cancer in humans.

U.S. EPA (1987) estimated Cancer Slope Factors for aldrin and dieldrin of 17 and 16 (mg/kg-day)⁻¹, respectively. The current EPA approach to deriving Cancer Slope Factors is different than it was when the U.S. EPA (1987) document was published. U.S. EPA would currently use a benchmark dose approach to estimate the cancer risk and would derive the human equivalent dose differently than it did in 1987. These differences would cause the cancer slope factors for aldrin and dieldrin to be estimated at 3.4 and 7.0 (mg/kg-day)⁻¹, respectively (i.e., about 5 and 2.3 fold lower risk). From knowledge of the soil concentrations of aldrin and dieldrin, the duration of exposure, and the cancer slope factors, one can estimate the excess cancer risks that one might incur from living at Hickam. To detect a risk of 10⁻⁵ or even 10⁻⁴ would require a larger population than currently exists in Hawaii.

U.S. EPA (1988, 1990) derived Reference Doses (RfDs) for noncancer endpoints (liver lesions) for aldrin and dieldrin of 0.00003 and 0.00005 mg/kg-day. Again, the method that EPA would currently use to derive the RfDs is different than that which was used in 1988 and 1990. The current approach would estimate RfDs of 0.0001 and 0.00008 mg/kg-day for aldrin and dieldrin, respectively. These are higher (i.e., less risk) than the RfDs estimated by EPA (1988, 1990) and close to the Allowable Daily Intake (ADI) of 0.0001 mg/kg-day, developed by the Joint Meeting on Pesticide Residues (JMPR) (1967). The ADI is similar to the RfD as a guidance value for noncancer risk. The JMPR is an international expert scientific group jointly administered by the Food and Agricultural Organization of the United Nations and the World Health Organization. The JMPR ADI for aldrin and dieldrin has been cited by Health Canada (1994), the World Health Organization (WHO) (1989), WHO (2008) and New Zealand (2010). Studies published since 1987 provide no evidence that would change the updated Reference Dose or ADI estimates described above.



INTRODUCTION

This report is organized into two sections – cancer and noncancer. The cancer and noncancer sections include descriptions of hazard evaluations and dose response assessments on aldrin and dieldrin. The sections also include a review of the scientific literature that has been published since 1987 and that was not described in either the U.S. EPA (1987) or the ATSDR (2002b). 1987 was selected as the beginning date of the search since that was the year of the U.S. EPA and IARC assessments on aldrin and dieldrin. Each section concludes with a summary and discussion.

CANCER

HAZARD EVALUATIONS

U.S. EPA (1987)

U.S. EPA concluded that the evidence of a cancer risk in humans from exposure to aldrin and dieldrin was inadequate but that the animal evidence was sufficient leading to the overall evaluation that both aldrin and dieldrin were probable human carcinogens.

IARC (1987)

IARC (1987) concluded that the evidence of carcinogenicity in humans was inadequate and that the evidence of carcinogenicity in animals was limited for both aldrin and dieldrin. Aldrin and dieldrin were thus classified in Group 3 (cannot be classified as to its carcinogenicity in humans).

ATSDR (2002)

ATSDR does not classify substances as to their carcinogenic potential in the manner of U.S. EPA, IARC, or NTP but does state in its ToxFAQs (ATSDR 2002a) that, “There is no conclusive evidence that aldrin or dieldrin cause cancer in humans.”

NTP (2005, 2010)

The NTP 11th Report on Carcinogens does not list aldrin or dieldrin as either “known to be human carcinogens” or “reasonably anticipated to be human carcinogens.” Neither aldrin or dieldrin have been nominated as candidate substances for the 12th Report on Carcinogens.



WHO (2008)

The 3rd edition of the World Health Organization Drinking Water Guidelines stated that while dieldrin produced tumors in mice, it did not produce tumors in rats and does not appear to be genotoxic. The document quoted the IARC (1987) classification of aldrin and dieldrin in Group 3 (cannot be classified as to its carcinogenicity in humans). The document stated, "It is considered that all the available information on aldrin and dieldrin taken together, including studies on humans, supports the view that, for practical purposes, these chemicals make very little contribution, if any, to the incidence of cancer in humans."

DOSE RESPONSE ASSESSMENT

The only cancer dose response assessment is that of the U.S. EPA (1987). The U.S. EPA (1987) assessment used a linearized multistage model to estimate risk which the Agency described as leading to an upper limit on risk. The current U.S. EPA approach to a cancer dose response assessment (assuming that the low dose response is linear) would be to use a benchmark dose (U.S. EPA 2000b). If mode of action data were available, the Agency would consider the effect of mode of action on the dose response.

The benchmark dose approach requires at least two dose groups and a control. The U.S. EPA (1987) dose response for aldrin was a geometric mean of three slope factors. Two slope factors were derived from male and female mice data from Davis (1965); the third slope factor was derived from an NCI study. The study by Davis (1965) had only one dose group. The benchmark dose approach requires at least two dose groups and a control. To arrive at a human equivalent dose from the animal studies, U.S. EPA (1987) multiplied the doses administered to the animals by the ratio of the animal to human weight to the 1/3 power. The current approach by U.S. EPA would be to multiply the doses administered to the animals by the ratio of animal to human weight to the 1/4 power (U.S. EPA 1992, 2005).

Cancer slope factors for aldrin and dieldrin were developed using the same data used by U.S. EPA (1987) in its cancer risk estimates. Exceptions were that only data sets that had two or more dose groups were used and human equivalent doses were derived from animal doses by the ratio of the animal to human weight to the 1/4 power. See Appendices A-1 and A-2 for explanations of how the benchmark dose results were derived. A comparison of the U.S. EPA (1987) cancer risk estimates for aldrin and dieldrin with the estimates for these substances derived from the benchmark dose approach are provided in Tables 1 and 2.



Table 1. Comparison of U.S. EPA 1987 cancer slope factors for Aldrin with the Cancer Slope Factors Derived by Benchmark Dose and Human Equivalent Doses Derived by Scaling to the ¼ power.

Reference for Data Set (Subjects)	Dose levels in Human Equivalent Dose (mg/kg-day)	BMD	BMDL	BMD-Based CSF (mg/kg-day) ⁻¹	U.S. EPA 1987 CSF ^a (mg/kg-day) ⁻¹	U.S. EPA 1987 CSF ^a ¼ power BW scaling ^b (mg/kg-day) ⁻¹
NCI 1978 (male B6C3F1 mice)	0 0.12273 0.24546	0.0426138	0.0294365	3.39715	17	5.54

a. Geometric mean of 3 slope factors

b. Scaling based on ratio of modern (¼ power) and historic Human Equivalent Dose methods

Table 2. Comparison of U.S. EPA 1987 cancer slope factors for Dieldrin with the Cancer Slope Factors Derived by Benchmark Dose and Human Equivalent Doses Derived by Scaling to the ¼ power.

Reference for Data Set (Subjects)	Dose levels in Human Equivalent Dose (mg/kg-day)	BMD	BMDL	BMD-Based CSF (mg/kg-day) ⁻¹	U.S. EPA 1987 CSF ^a (mg/kg-day) ⁻¹	U.S. EPA 1987 CSF ^a ¼ power BW scaling ^b (mg/kg-day) ⁻¹
NCI 1978 (male B6C3F1 mice)	0 0.07674 0.1535	0.027485	0.0188779	5.29719	9.8	3.19
Walker et al. 1972 (male CF1 mice)	0 0.002607 0.02607 0.2607	0.0201651	0.0104576	9.56246	25	8.15
Walker et al. 1972 (male CF1 mice)	0 0.02579 0.065158 0.13032	0.0317161	0.0168577	5.932	15	4.89
Walker et al. 1972 (female CF1 mice)	0 0.03238 0.06476 0.12952	0.0218267	0.0125613	7.96094	26	8.47
Geometric mean of four BMD-based cancer slope factors				6.99351		
Geometric mean of 13 cancer slope factors reported by EPA 1987					16	
Geometric mean of 13 cancer slope factors reported by EPA 1987 with ¼ power BW scaling						5.41

a. Geometric mean of 3 slope factors

b. Scaling based on ratio of modern (¼ power) and historic Human Equivalent Dose methods



DATA PUBLISHED SINCE 1987

The scientific literature since 1987 was searched utilizing PubMed for any articles related to exposure, cancer, mortality and disease and aldrin/dieldrin in humans. The following search terms were used: ((aldrin) OR dieldrin) AND ((epidemiological studies) OR cancer OR neoplasm OR carcinogenic OR tumor OR maternal OR diabetes). Two-hundred twenty five (225) potentially relevant references were identified. These references were further screened to identify studies of carcinogenicity related to exposure to aldrin and/or dieldrin in humans or animals. *In vitro* studies, environmental and wildlife monitoring reports, and studies of mixtures with other compounds in animals were excluded. Studies that have been reviewed by ATSDR (2002b) were also excluded. Of the remaining studies, thirty-seven references considered useful for further evaluation of both carcinogenic and non-cancer evidence for aldrin and dieldrin were identified.

Human Data

Twenty-three of the studies identified in the literature search were epidemiologic studies that assessed various cancer outcomes including any cancer, Non-Hodgkin's Lymphoma, pancreatic cancer, breast cancer, childhood cancers, prostate cancer, and carcinoma of the gallbladder. The cancer epidemiologic studies are described in more detail in Appendix B.

Two studies assessed cancer mortality among a cohort of 570 male employees at aldrin and dieldrin formulation and production plants at Pernis in the Netherlands (Swaen et al. 2002 and van Amelsvoort et al. 2009). Both studies were updates of de Jong et al. (1997) which is described in the ATSDR (2002b) review. Exposure assessment of aldrin and dieldrin among the Pernis workers included air and blood measurements that allowed for the calculation of chemical intake for each individual. These studies provide for the best assessment of exposure among the epidemiologic studies that have been conducted on aldrin and dieldrin. When stratified by job title, "operators" had significantly increased risks of both rectal and skin cancer mortality in the Swaen (2002) update, but only skin cancer mortality was significantly elevated in van Amelsvoort et al. (2009). In both Swaen et al. (2002) and van Amelsvoort et al. (2009), the rectal and skin cancer Standardized Mortality Ratios (SMRs) were based on only 4 and 3 deaths, respectively. When the cohort in both Swaen et al. (2002) and van Amelsvoort et al. (2009) was divided into low, moderate, and high intake, there was no evidence of a dose response for either skin or rectal cancer mortality. Sielken (1999), in an analysis of the de Jong et al. (1997) data, reported that there was no evidence of an increased cancer risk for a dose considerably above the dose for which the U.S. EPA dose response analysis would have predicted a 10^{-4} risk.

Three analyses of the Agricultural Health Study examined cancer outcomes and exposure to a variety of pesticides including aldrin and dieldrin (Engel et al. 2005; Flower et al. 2004; Purdue et al. 2007). Exposures were self reported. Engel et al. (2005) found an increased risk of breast cancer among wives of pesticide applicators who used aldrin and dieldrin, but the results were not consistent when stratified by state (Iowa vs. North Carolina), menopausal status at enrollment, and cumulative dose groups. No increase in breast cancer risk was found among



female pesticide applicators that used aldrin and dieldrin. Flower et al. (2003) studied cancer risk among children of pesticide applicators who applied various pesticides including aldrin and dieldrin. A statistically significant increase in childhood cancer risk was associated with paternal application of aldrin prior to conception based on six cases which varied in site and morphology. Purdue et al. (2007) reported an increased risk of lung cancer following exposure to dieldrin and a decreased relative risk of rectal cancer following exposure to aldrin. The authors concluded that overall there was no clear relationship between organochlorine pesticide use and an increased risk of cancer.

Five case-control studies examined Non-Hodgkin's Lymphoma (NHL) and exposure to various pesticides including aldrin and dieldrin (Cantor et al. 2003; Cocco et al. 2008; McDuffie et al. 2001; Quintana et al. 2004; Schroeder et al. 2001). Exposure data were provided either by questionnaire, adipose or serum/plasma sample. Cantor et al. (2003) found no evidence of an association between NHL and serum levels of any of the chemicals that were evaluated. Cocco et al. (2008) found similar results and reported no increased risk of NHL or its subtypes was associated with any of the compounds examined, including aldrin and dieldrin. McDuffie et al. (2001) found a significant association of aldrin exposure and NHL, but exposure information was based on questionnaires and phone interviews. Quintana et al. (2004) found an association of organochlorine pesticide residue in adipose tissue and NHL. The authors also found that the highest quartile level of dieldrin exposure was significantly associated with NHL, and found a significant dose response trend for dieldrin. The exposure information was collected after diagnosis, however, and there was a lack of information on variables that could affect organochlorine levels in the body such as diet, occupation and BMI. Schroeder et al. (2001) examined t(14,18)-positive NHL and found that aldrin was not associated with this subtype or the negative subtype of NHL. Dieldrin was associated with t(14,18)-positive NHL when compared to controls. Exposure, however, was self-reported. Based on these five studies and their varying outcomes and limitations, there is inadequate evidence of a causal association between Non-Hodgkin's Lymphoma and either aldrin or dieldrin exposure.

Five case-control studies investigated the association between breast cancer and aldrin/dieldrin exposure (Gammon et al. 2002; Høyer et al. 2001; Høyer et al. 2002; Ibarluzea et al. 2004; Ward et al. 2000). Exposure status was ascertained through blood, serum or adipose samples. Gammon et al. (2002), conducted a study on Long Island, NY, and found no significant increased risk in breast cancer in association with the highest quintile of lipid-adjusted serum levels of dieldrin. A dose-response relationship was not apparent either. Regarding their results, the authors stated, "These findings, based on the largest number of samples analyzed to date among primarily white women, do not support the hypothesis that organochlorines increase breast cancer risk among Long Island women." Høyer et al. (2001 and 2002) conducted two studies on women who participated in the Copenhagen City Heart Study. In the first study, Høyer et al. (2001) found an increased breast cancer risk linked to exposure to dieldrin for women who developed estrogen receptor negative (ERN) breast tumors. Women with the highest dieldrin levels in their serum generally had tumors that were larger and more often spread at diagnosis when compared to estrogen receptor positive (ERP) tumors. The study,



however, had limited statistical power and the authors state, “The results do not suggest that exposure to potential estrogenic organochlorines leads to development of an ERP breast cancer.” Høyer et al. (2002) examined exposure to various organochlorine pesticides and breast cancer with respect to p53 mutation. A non-significant but slightly elevated risk was found in the highest level of exposure for dieldrin among women who developed a tumor with mutant p53. A significant dose response relationship was present for dieldrin in ‘wild-type’ p53 tumors. Ibarluzea et al. (2004) found that the geometric mean of aldrin in adipose tissue was higher (but not significantly) in breast cancer cases compared to controls. Ward et al. (2000) found no association between breast cancer and aldrin and dieldrin in serum. The breast cancer case-control studies have mixed results and provide unconvincing evidence of a causal association between breast cancer and aldrin/dieldrin exposure.

Additional studies including an ecologic study of pancreatic cancer, a cross-sectional study of prostate cancer, a study examining risk assessment of daily pesticide intake from drinking water and cancer risk, and a case-control study of carcinoma of the gallbladder did not yield any results indicating significantly increased risks associated with aldrin or dieldrin (Clary & Ritz 2003; Ritchie et al. 2003; Buczyńska & Szadkowska-Stanczyk 2005; Shukla et al. 2001). A cross-sectional study in India found increased blood levels of aldrin (and several other organochlorine pesticides) among breast cancer patients compared to women without breast cancer (Mathur et al. 2002). An ecological study examined the association between pesticide use and concentration in adipose tissue and prostate cancer (Belpomme et al. 2009). Ecological studies, however, are generally used to generate hypotheses and are subject to the ecological fallacy (an incorrect inference based on aggregate data). A cross-sectional study by Xu et al. (2010) examined serum concentrations of dieldrin and self-reported physician diagnosed breast and prostate cancer. The authors found a marginally significant trend in the odds ratios for prostate cancer when compared by tertiles of serum concentration. Due to the nature of the cross-sectional design of this study, causality between OC pesticide exposure and cancer risk cannot be concluded.

Collectively, these studies do not provide evidence of a causal association between aldrin and dieldrin and an increased risk of cancer. The results are inconsistent. There is no evidence of a dose response or specificity of cancer site. The study designs of several of the studies are limited (cross-sectional, ecological). The self-reported exposure and self-reported disease diagnosis of several of the studies limit their interpretation. The study with the best exposure data and the best design (and likely the greatest exposure to the study population) (Swaen et al. 2002; van Amelsvoort 2009) found no evidence of an increased risk of cancer.

Animal Data

One animal study related to the carcinogenicity of dieldrin was identified (Cameron et al. 2009). The authors found that perinatal exposure to dieldrin promotes tumors in genetically predisposed mice (i.e., mice that were genetically modified to be susceptible to the type of tumor expressed). The results are summarized in Table 3. No animal studies examining tumorigenic response to aldrin published since 1987 were identified.

Table 3. Animal studies on Dieldrin published since 1987 that examined tumorigenic response.

Study	Type of study	Results	Comment
Cameron et al. 2009	Oral gavage of dieldrin to FVB-MMTV/neu female mice; 0.45, 2.25, and 4.5 µg/g daily for 5 days prior to mating and once weekly through gestation and lactation; pregnancy outcome with focus on mammary tumors in offspring.	No effect on litter size, birth weight or the number of pups surviving to weaning; significantly increased number and volume of total tumors of thoracic mammary glands at the 4.5 µg/g dose level but not at the lower dose levels; numbers of liver tumors increased dose-dependently in mice treated with 2.25, and 4.5 µg/g.	Dieldrin increased tumor burden in genetically predisposed mice.

DISCUSSION

There is a significant level of uncertainty in regard to whether aldrin and dieldrin should be classified as human carcinogens. IARC (1987) states that the evidence of carcinogenicity for aldrin and dieldrin cannot be classified (Group 3), and the National Toxicology Program did not include either aldrin or dieldrin in its 11th Report on Carcinogens or nominate these chemicals as candidate substances for the 12th Report on Carcinogens. Health Canada (1994) and WHO (2008) accepted the IARC classification of aldrin and dieldrin as Group 3. WHO (2008) went on to state that, “It is considered that all the available information on aldrin and dieldrin taken together, including studies on humans, supports the view that, for practical purposes, these chemicals make very little contribution, if any, to the incidence of cancer in humans.”

Human studies on aldrin and dieldrin including studies conducted prior to and since 1987 do not provide evidence that either aldrin or dieldrin are causally associated with an increased risk of cancer. There is no new evidence from animal studies conducted since 1987 of an increased tumorigenic risk from exposure to aldrin and dieldrin. While the Cameron (2009) study showed an increase in mammary tumors in dieldrin exposed mice, the strain used, FVB-MMTV/neu, was genetically modified to be predisposed to express this type of tumor, and dieldrin was already known to be a tumor promoter in mice (ATSDR 2002b).

Furthermore, whether the tumorigenic response seen in mice is applicable to humans is questionable. Several assessments have concluded that aldrin and dieldrin are nongenotoxic (U.S. EPA 1987; WHO 1989; ATSDR 2002b; WHO 2008). The carcinogenic response has only been seen in mice and not in other laboratory species. Stevenson et al. (1999) theorized that dieldrin-induced oxidative stress or its sequelae result in modulation of gene expression that favors expansion of initiated mouse, but not rat liver cells.

Assuming that aldrin and dieldrin are carcinogens, the methods currently used by U.S. EPA to estimate cancer dose response would decrease the cancer slope factor for aldrin by 5-fold and



the cancer slope factor for dieldrin by 2.3-fold. These decreases in potency are consistent with those observed when the U.S. EPA updated the toxicological review of chlordane in 1997 (U.S. EPA 1997a). Chlordane is an organochlorine pesticide chemically and toxicologically similar to aldrin and dieldrin that has also been detected in soil at Hickam. The updated CSFs for chlordane derived by U.S. EPA in 1997 are roughly 4-fold lower (i.e., less potent) than the previous CSFs, which were not derived based on current U.S. EPA guidelines for carcinogen risk assessment.

Finally, it is important for the reader to have a perspective on the meaning of a 10^{-5} or a 10^{-4} theoretical excess lifetime cancer risk. Theoretical excess lifetime risks are estimated from a high dose exposure and assume a lifetime of exposure. The theoretical relative risk can be expressed as the (excess lifetime risk + background risk) \div background risk. For argument's sake, we will assume that aldrin and dieldrin are associated with an increased risk of liver cancer in humans because they were found in some studies to increase liver tumors in the mouse. The lifetime (background) risk of liver cancer in the U.S. population (through age 85) is 6.6×10^{-3} (NCI 2010). If the theoretical excess lifetime risk is 10^{-4} , the relative risk is approximately 1.02 ($6.6 \times 10^{-3} + 1 \times 10^{-4} / 6.6 \times 10^{-3}$). The population needed to detect such a risk would be 5,244,721. The population of Hawaii is only about 1.3 million. Thus it would take several times the population of Hawaii to even detect a theoretical excess lifetime cancer risk of 1×10^{-4} (if one actually exists).

NONCANCER

EXISTING GUIDANCE VALUES

U.S. EPA (1988, 1990)

An RfD for aldrin of 0.00003 mg/kg-day was derived based on a LOAEL (0.025 mg/kg/day) for liver toxicity in rats and an uncertainty factor of 1000. The study from which the RfD was derived is Fitzhugh et al. (1964).

An RfD for dieldrin of 0.00005 mg/kg-day was derived based on a NOAEL for liver toxicity in rats and an uncertainty factor of 100. The study from which the RfD was derived is Walker et al. (1969).

Table 4. Oral MRLs derived by ATSDR (2002b) for aldrin and dieldrin

	Type of MRL	Study	Effect	Point of Departure	Uncertainty Factor	MRL (mg/kg/day)
Aldrin	Acute	Al Hachim (1971)	Decreased body weight and electroconvulsive shock threshold in offspring	LOAEL (2 mg/kg/day)	1000	0.002
	Chronic	Fitzhugh et al. (1964)	Enlarged hepatocyte, increase in cytoplasmic eosinophilia with peripheral migration of basophilic granules, and possible increases in vacuolation and bile duct proliferation	LOAEL (0.025 mg/kg/day)	1000	0.00003
Dieldrin	Intermediate	Smith et al. (1976)	Impaired learning of a successive discrimination task	NOAEL (0.01 mg/kg/day)	100	0.0001
	Chronic	Walker et al. (1969)	Liver weight was increased at the LOAEL with progression to parenchymal cell changes with progression to parenchymal cell changes including focal hyperplasia at 0.5 mg/kg/day	NOAEL (0.005 mg/kg/day)	100	0.00005

ATSDR (2002b)

ATSDR developed acute and chronic MRLs for aldrin and intermediate and chronic MRLs for dieldrin. These are described in Table 4.

JMPR (1967, 1971, 1977)

The Joint Meeting on Pesticide Residues (JMPR 1967) concluded that the Acceptable Daily Intake (ADI) for aldrin or dieldrin or the sum of both was 0.0001 mg/kg based on a NOAEL of 0.025 mg/kg-day and an uncertainty factor of 250. It is not clear on what factors JMPR based its uncertainty factor.

The NOAEL of 0.025 mg/kg-day was derived from NOAELs of 0.5 ppm in rats and 1 ppm in dogs. In the rat study (Fitzhugh et al. 1964), rats were given feed containing 0.5, 2, 10, 50, 100 and 150 ppm aldrin or dieldrin for up to 2 years. The liver weights and degree of microscopic lesions increased dose-dependently in all dose levels. The authors did not identify a NOAEL, because increased liver weight to body weight ratios were elevated and a minimal degree of microscopic lesions were reported at the lowest dose of 0.5 ppm. However, JMPR identified 0.5 ppm as the level causing no toxicological effect in rats.



In the dog study (Treon and Cleveland 1955), groups of 4 dogs (2/sex) were given 1 or 3 ppm dieldrin in their diet for 68 weeks. The dogs in the 3 ppm group had increased liver/body-weight ratio, and one female in this group had renal damage. In the 1 ppm group, livers were enlarged but no histopathological changes were reported. JMPR identified 1 ppm as the level causing no toxicological effect in dogs.

JMPR re-evaluated the toxicity data for aldrin and dieldrin in 1970 and 1977, and the 1967 ADI of 0.0001 mg/kg-day was endorsed (JMPR 1971, 1977).

Health Canada (1994)

Health Canada adopted the JMPR (1967, 1971, 1977) ADI of 0.0001 mg/kg-day for both aldrin and dieldrin and has used it as the basis for deriving allowable levels of these compounds in drinking water.

New Zealand Ministry for the Environment (2010)

The New Zealand Ministry for the Environment adopted the JMPR (1977) ADI of 0.0001 mg/kg-day for dieldrin. The New Zealand assessment of dieldrin questioned the U.S. EPA and ATSDR description of the critical toxic effects of dieldrin. The U.S. EPA (1990) and ATSDR (2002) both state that they used liver cell changes “characteristic of exposure to organochlorine insecticides” reported by Walker et al. 1969 as the toxicological endpoint for defining the LOAEL of 1 ppm. However, the authors of Walker et al. (1969) state that “no changes in liver cell morphology that could be attributed specifically to chlorinated hydrocarbons occurred in rats receiving 1 ppm dieldrin.” Therefore the New Zealand reviewers endorsed the Fitzhugh et al. (1964) study as providing the more sensitive endpoint.

DATA PUBLISHED SINCE 1987

As described earlier for cancer outcomes, the scientific literature since 1987 was searched utilizing PubMed for any articles related to exposure, cancer, mortality and disease and aldrin/dieldrin in humans. The following search terms were used: ((aldrin) OR dieldrin) AND ((epidemiological studies) OR cancer OR neoplasm OR carcinogenic OR tumor OR maternal OR diabetes). Two-hundred twenty five (225) potentially relevant references were identified. These references were further screened to identify studies of carcinogenicity related to exposure to aldrin and/or dieldrin in humans or animals. *In vitro* studies, environmental and wildlife monitoring reports, and studies of mixtures with other compounds in animals were excluded. Studies that have been reviewed by ATSDR (2002b) were also excluded. Of the remaining studies, thirty seven references considered useful for further evaluation of both carcinogenic and non-cancer evidence for aldrin and dieldrin were identified.

Human Data

Fourteen noncancer epidemiologic studies of aldrin and/or dieldrin were identified from the PubMed search of epidemiologic literature published since 1987 and not included in the ATSDR (2002b) review. The noncancer epidemiologic studies are described in more detail in Appendix B.



Two studies (Weisskopf et al. 2010; Louis et al. 2006) and one review (Li et al. 2005) assessed the risk of Parkinson's Disease associated with exposure to pesticides. Weisskopf et al. (2010) found increased serum levels of dieldrin among cases compared to controls (serum levels of many other pesticides including aldrin were not significantly increased). This study relied on serum samples collected between 1968 and 1972 and analyzed in 2005-2007. The study also relies on a questionnaire administered to study participants at the time the serum samples were collected. The questionnaire included questions on smoking status, cholesterol, hypertension, etc. Both the samples and the baseline characteristics (e.g., smoking, hypertension, etc.) could have changed considerably over the 35-year period between collection and analysis. Furthermore the study did not control for risk factors known to be associated with Parkinson's Disease (e.g., family history, genetic factors, head trauma). Li et al. (2005), in a review of the literature on pesticides and Parkinson's Disease including 27 case-control studies, concluded that the epidemiologic data do not provide sufficient evidence to support a causal association. In a study of essential tremor and serum concentrations of six pesticides including dieldrin, the authors were unable to detect any increased risk from dieldrin exposure (Louis et al. 2006).

Risk of diabetes was assessed by two publications. Montgomery et al. (2008) found an increased risk of diagnosed diabetes among participants of the Agricultural Health Study. The odds ratios were elevated but were not statistically significant when stratified by age, state (North Carolina or Iowa), or weight group. The authors do not specify or delineate between type I and II diabetes, which are known to have different etiologies (CDC 2010). A cross sectional analysis using the National Health and Nutrition Examination Survey did not find an association between dieldrin in serum and diagnosed, undiagnosed, or pre-diabetes; aldrin was not evaluated (Everett & Matheson 2010).

A cohort study by Landgren et al. (2009) examined monoclonal gammopathy of undetermined significance (MGUS) and self-reported pesticide use and pesticide concentrations in serum. Among individuals ever reporting exposure to dieldrin, the relationship with MGUS was significant. However, excess risk of MGUS associated with dieldrin was not attenuated when adjustment was made for the use of other pesticides.

Additional studies including a cross sectional study regarding age at menopause, a cross sectional study examining levels of thyroid hormones, a case control study on cryptorchidism, a cohort study on infant's length of gestation, birth weight and crown-heel length, an experimental study on Leydig cell disruption, a cross sectional study on lymphocyte subsets and a cross sectional study on allergic immune response in women and infants all yielded insignificant results regarding aldrin/dieldrin exposure and their corresponding outcomes (Akkina et al. 2004; Asawasinsopon et al. 2006; Damgaard et al. 2006; Fenster et al. 2005; Fowler et al. 2007; Nagayama et al. 2007; Noakes et al. 2006).

The evidence is not sufficient to conclude that a causal association exists between aldrin and/or dieldrin and Parkinson's Disease, diabetes, or MGUS. The studies are not robust and what data



exist are inconsistent. Studies examining other noncancer endpoints have not found evidence of an effect.

Animal Data

Five animal studies of dieldrin were identified. Three of these were oral gavage studies in mice, and two were intraperitoneal studies in rats. The results are summarized in Table 5.

Four of the five animal studies investigated the effects of dieldrin on perinatal development. Cameron et al (2009) and Foster (2008) each exposed mice to a range of dieldrin doses by oral gavage during gestation and lactation, and both studies showed no effects on birth outcomes. Although the offspring in the Cameron et al (2009) study developed mammary tumors, the strain of mice used was genetically predisposed to develop mammary tumors. The Richardson et al. (2006) study exposed mice to dieldrin perinatally and evaluated specific neurotoxic effects not measured in most developmental toxicity studies. Tarraf et al. (2003) gave rats a single intraperitoneal injection of dieldrin in late-gestation and found effects on dam mammary gland maturation and effects on litter size and pup weight gain. Neither U.S. EPA (1987) nor ATSDR (2002b) reported developmental effects of intraperitoneally-administered dieldrin.

The non-developmental study (Hallegue et al. 2010) investigated the hepatotoxic effects of dieldrin, and the results were consistent with the known hepatotoxicity in studies previously reviewed by U.S. EPA (1987) and ATSDR (2002b).

Overall, none of the more recent studies are likely to impact the current hazard assessment of aldrin or dieldrin.

Table 5. Animal studies on Dieldrin published since 1987 that examined noncancer response.

Study	Type of study	Results	Comment
Hallegue et al. 2010	Single IP injection of dieldrin to male and female rats; 3 or 6 mg/kg bw; hepatic effects measured by serum enzymes and histopathological examination.	Dose-dependent increase in relative liver weight; elevated AST, ALT, bilirubin, and LDH; cytoplasmic vacuolation, focal necrosis and nuclear enlargement of hepatocytes.	Consistent with known hepatotoxic effects of dieldrin in rodents.
Cameron et al. 2009 (also described in Table 3).	Oral gavage of dieldrin to FVB-MMTV/neu female mice; 0.45, 2.25, and 4.5 µg/g daily for 5 days prior to mating and once weekly through gestation and lactation.	No effect on litter size, birth weight or the number of pups surviving to weaning.	Dieldrin caused increased tumor burden in genetically predisposed mice.



Foster et al 2008	Oral gavage of dieldrin to BALB/c mice; 0.45, 2.25, 4.5, and 22.5 µg/g bw throughout mating, pregnancy, and lactation.	Treatments had no effect on fertility parameters in dams or mammary gland morphology at sexual maturity.	
Richardson et al. 2006	Oral gavage of dieldrin to C57BL/6J mice 0.3, 1, or 3 mg/kg every 3 days throughout mating, pregnancy, and lactation.	Altered dopaminergic neurochemistry in the offspring and exacerbated MPTP toxicity.	The authors suggested that perinatal exposure to dieldrin increases the risk of Parkinson's disease.
Tarraf et al. 2003	IP injection of dieldrin to female rats; 2.5 or 15 µM on gestation day 14.	Impaired mammary gland development of dams; reduced litter size; reduced pup weight gain.	

BENCHMARK DOSE

The U.S. EPA (1988, 1990) RfDs for aldrin and dieldrin were derived using a LOAEL and a NOAEL, respectively and uncertainty factors of 1000 and 100 for aldrin and dieldrin, respectively. The current EPA approach would be to use a Benchmark Dose model to determine point of departure. Using the U.S. EPA's current version of the BMDS software, Tetra Tech derived BMDLs for aldrin and dieldrin of 0.0120675 and 0.00837329 mg/kg-day, respectively. See Appendices C and D for explanations of how the benchmark dose results were derived. Using uncertainty factors of 10 (human intraspecies variability) and 10 (interspecies variability), the RfDs for aldrin and dieldrin would be 0.0001 and 0.00008, respectively. A comparison of these RfDs with those of U.S. EPA (1988, 1990) is made in Table 6.

Table 6. Comparison of U.S. EPA (1988) RfD for Aldrin and U.S. EPA (1990) for Dieldrin with RfDs for Aldrin and Dieldrin derived using a benchmark dose approach

	U.S. EPA (1988, 1990) (mg/kg/day)	Benchmark Dose (mg/kg/day)
Aldrin	0.00003	0.0001
Dieldrin	0.00005	0.00008

DISCUSSION

The U.S. EPA (1988, 1990) RfDs for aldrin and dieldrin are 0.00003 mg/kg-day and 0.00005 mg/kg-day, respectively. The RfDs are based on liver toxicity in rats. The ATSDR chronic MRL values for aldrin and dieldrin are the same as the RfDs. The WHO Allowable Daily Intake (ADI) is roughly 3.3-fold and 2-fold higher than the RfDs for aldrin and dieldrin, respectively.



The EPA RfD, the ATSDR chronic MRL (oral), and the JMPR ADI for aldrin are all based on the study by Fitzhugh et al. (1964). In this study, rats were fed diets containing 0.5 to 150 ppm for two years (estimated dose levels of 0.025 to 7.5 mg/kg-day). Fitzhugh et al. (1964) described the liver lesions that they observed as “characteristic of chlorinated insecticide poisoning.” These lesions included enlarged centrilobular hepatic cells (hypertrophy), with increased cytoplasmic oxyphilia, and peripheral migration of basophilic granules. The U.S. EPA (1988) and ATSDR (2002) identified 0.5 ppm as a LOAEL for aldrin in rats, based on these characteristic organochlorine insecticide lesions. ATSDR (2002) noted that “the changes at 0.5 ppm are consistent with a marked hepatic adaptive response associated with induction of the hepatic mixed function oxidase system and proliferation of smooth endoplasmic reticulum. The observation of hepatocellular hypertrophy is consistent with adaptation.” Although ATSDR considered the changes to be “adaptive,” they still considered the responses to be adverse because the enhanced metabolic activity induced by aldrin could potentiate or inhibit toxic responses to other exogenous substances. This reasoning contradicts interpretations by U.S. EPA (1997a, 1997b, 2000b) that adaptive induction of microsomal enzymes should not be considered adverse.

JMPR considered aldrin and dieldrin interchangeable, due to the rapid biotransformation of aldrin to dieldrin in mammalian systems. When JMPR (1967) reviewed the Fitzhugh et al. (1964) study, they identified 0.5 ppm dieldrin as the NOAEL, noting that the hepatic lesions reported at 0.5 ppm dieldrin were “minimal.” The authors of Fitzhugh et al. (1966) classified the lesions seen at 0.5 ppm as “trace or minimal.” JMPR (1967) affirmed this NOAEL with a dog study (Treon and Cleveland 1955) in which a diet including 1 ppm dieldrin produced enlarged livers with no histopathological changes. These nontoxic dose levels in the rat and dog studies were both determined by JMPR (1967) to be equivalent to 0.025 mg/kg-day, to which JMPR applied an uncertainty factor of 250 to derive an ADI of 0.0001 mg/kg-day for aldrin and dieldrin combined.

A study by Walker et al. (1969) is the basis of the EPA RfD and the ATSDR chronic MRL (oral) for dieldrin. In their reviews of Walker et al. (1969), the U.S. EPA (1990) and ATSDR (2002) identified 0.1 ppm (0.005 mg/kg-day) dieldrin as the NOAEL and 1 ppm (0.05 mg/kg-day) as the LOAEL. The critical effect was increased liver weight in female rats. The hepatic lesions observed at 1 ppm were not considered by the authors of Walker et al. (1969) to be associated with organochlorine insecticides. Therefore, the LOAEL of 1 ppm determined by U.S. EPA (1990) and ATSDR (2002) is apparently based solely on increased liver weights in female rats. However, increased liver weight without other signs of liver toxicity (e.g., histopathology or clinical chemistry) is an adaptive response to increased metabolism of the chemical and is generally not considered to be an adverse effect (Sipes and Gandolfi 1991; Amacher et al. 1998). The EPA has determined that increased liver weight and hepatocyte hypertrophy were adaptive non-adverse effects in the IRIS toxicological reviews of chlordane, vinyl chloride, and cumene (U.S. EPA 1997a, 1997b, 2000b). Thus, the NOAEL of the Walker et al. (1969) study would more appropriately be 1 ppm (0.05 mg/kg-day), and the LOAEL should be 10 ppm (0.5 mg/kg-day) where increased liver weights were accompanied by histological changes



(parenchymal cell changes including focal hyperplasia). Compared to the Walker et al. (1969) study, the study by Fitzhugh et al (1964) appears to provide the more sensitive endpoints for hepatic lesions associated with chronic dieldrin exposure.

Chlordane is an organochlorine pesticide chemically and toxicologically similar to aldrin and dieldrin. In its updated toxicological review of chlordane, U.S. EPA (1997a) did not consider increased liver cell volume (hypertrophy) to be an adverse effect. Hypertrophy is commonly associated with ultrastructural adaptive changes involving metabolic activity due to the presence of the toxicant (Sipes and Gandolfi 1991; Amacher et al. 1998). An adaptive increase in relative liver weight if moderate and transitory is not adverse, but if severe and sustained, leads to adverse effects (Williams and Latropoulos 2002). U.S. EPA (1997a) considered hepatic necrosis to be the most clearly adverse noncancerous lesion for chlordane. Hepatic necrosis was not reported in the chronic and intermediate studies of aldrin and dieldrin. The RfDs for chlordane based on U.S. EPA's updated toxicological review (U.S. EPA 1997), are roughly 8-fold higher (i.e., less toxic) than the previous U.S. EPA RfDs.

In considering how the U.S. EPA would calculate RfD values for aldrin and dieldrin if these compounds were reviewed today, one must take into account the complete data set available since the last reviews and changes in the hazard assessment methodology in common practice at the agency. A review of studies published since the previous U.S. EPA reviews raised no new concerns of systemic toxicity and introduced no endpoints more sensitive than those described in the Fitzhugh et al. (1964) study. In a developmental toxicity study by Richardson et al. (2006) mice exposed to dieldrin perinatally reported possible neurodevelopmental effects. While the Richardson et al. (2006) study raises concerns about potential effects in young children, the California EPA (2007) determined that liver toxicity in adult animals was a more sensitive endpoint when assessing non-cancer risk of dieldrin at school sites in California.

At the time of the previous U.S. EPA reviews of aldrin and dieldrin, the use of benchmark dose modeling to determine point of departure was not in common practice. Under the current U.S. EPA guidelines, benchmark dose modeling is preferred to the NOAEL/LOAEL approach if the data set supports appropriate use of the model. In the current review, liver lesion data for chronic dietary exposure to aldrin and dieldrin provided in the Fitzhugh et al. (1964) study were applied to benchmark dose modeling, using the current version of BMDS software provided by the U.S. EPA. The resulting BMDL values, with appropriate uncertainty factors applied, produced RfD values of 0.0001 mg/kg-day for aldrin and 0.00008 mg/kg-day for dieldrin. Interestingly, these benchmark dose-based RfD values are similar to the ADI of 0.0001 mg/kg-day endorsed by JMPR, Health Canada, and the New Zealand Ministry for the Environment.

SUMMARY

Only the U.S. EPA has classified aldrin and dieldrin as probable human carcinogens. Other U.S. agencies in more recent assessments have not classified aldrin or dieldrin as known or probable human carcinogens. The International Agency for Research on Cancer has determined that



aldrin and dieldrin cannot be classified as to their carcinogenicity. The World Health Organization has determined that “these chemicals make very little contribution, if any, to the incidence of cancer in humans.”

The only cancer dose response for aldrin and dieldrin is that done by the U.S. EPA in 1987 based on liver tumors in mice. It is questionable whether the tumors seen in the mouse are relevant for linear low dose extrapolation to humans. It has been generally agreed that aldrin and dieldrin are nongenotoxic. Furthermore, the carcinogenic response has only been seen in mice and not in other laboratory species.

Assuming that aldrin and dieldrin are carcinogens, the methods currently used by U.S. EPA to estimate cancer dose response would decrease the cancer slope factor for aldrin by 5 fold and the cancer slope factor for dieldrin by 2.3 fold. Although a number of cancer epidemiologic studies have been conducted since the U.S. EPA assessment, there is not enough evidence from these studies to conclude that there is a causal association between exposure to aldrin/dieldrin and an increased risk of cancer in humans.

The selection of the endpoints used for the noncancer assessment by U.S. EPA is controversial. U.S. EPA and ATSDR identified the dose of 0.5 ppm in Fitzhugh et al. (1964) as a Lowest Observed Adverse Effect Level (LOAEL) whereas JMPR considered 0.5 ppm to be a No Observed Adverse Effect Level (NOAEL). ATSDR noted that “the changes at 0.5 ppm are consistent with a marked hepatic adaptive response associated with induction of the hepatic mixed function oxidase system and proliferation of smooth endoplasmic reticulum. The observation of hepatocellular hypertrophy is consistent with adaption.” ATSDR considered these changes adverse. U.S. EPA has concluded, however, that adaptive induction of microsomal enzymes should not be considered adverse. U.S. EPA and ATSDR used the increased liver weight in a study on dieldrin by Walker et al. (1969) as the basis to derive the RfD and oral MRL, respectively. U.S. EPA has more recently determined that increased liver weight and hepatocyte hypertrophy were adaptive non-adverse effects in its assessments of chlordane, vinyl chloride, and cumene (U.S. EPA 1997a, 1997b, 2000b). JMPR considered aldrin and dieldrin to be interchangeable (aldrin is rapidly metabolized to dieldrin in the body) and used Fitzhugh et al. (1964) as the basis for the ADI on aldrin and dieldrin combined. The methods currently used by U.S. EPA to estimate non-cancer dose response would produce RfD values for aldrin and dieldrin that are roughly 3.3-fold and 2-fold higher, respectively, than the current USEPA RfDs. The RfDs that would be derived by the current EPA methodology would also be comparable to the ADI determined by JMPR. Table 7 summarizes the existing EPA Cancer Slope Factors and RfDs for aldrin and dieldrin with those that would be derived using current EPA methodology.



Table 7. Comparison of existing U.S. EPA Cancer Slope Factors/RfDs for aldrin and dieldrin with Cancer Slope Factors/RfDs that would be derived using existing EPA methodology

	U.S. EPA (1987) (mg/kg-day)	Benchmark Dose (mg/kg-day)
	Cancer	
Aldrin	17	3.38
Dieldrin	16	6.99
	Non-cancer	
Aldrin	0.00003	0.0001
Dieldrin	0.00005	0.00008



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Appendix A-1: Benchmark Dose Derivation of a Cancer Slope Factor for Aldrin

Introduction

In the IRIS review of aldrin (CAS No. 309-00-2), the U.S. EPA calculated an oral cancer slope factor of $17 \text{ (mg/kg-day)}^{-1}$. This oral cancer slope factor was the geometric mean of two slope factors based on data published by Davis 1965 (re-evaluated by Reuber; cited in Epstein 1975) and NCI 1978. The Davis 1965 study exposed male and female C₃H mice to 0 or 10 ppm aldrin in diet for up to 104 weeks (2 years). IRIS calculated a cancer slope factor of $23 \text{ (mg/kg-day)}^{-1}$ for this study, based on increases in liver tumors in aldrin-exposed mice. The NCI 1978 study exposed male B6C3F1 mice to 0, 4, or 8 ppm aldrin in diet and female B6C3F1 mice to 0, 3, or 6 ppm aldrin, each sex for 80 weeks followed by 10 to 13 weeks of post-exposure observation. IRIS calculated a cancer slope factor of $12 \text{ (mg/kg-day)}^{-1}$ for this study, based on dose-dependent increases in liver tumors in aldrin-exposed male mice. Aldrin-exposed female mice did not show any increase in liver tumor incidence.

Methods

A benchmark dose (BMD) approach was used to derive a new cancer slope factor for aldrin. The US EPA's BMDS 2.1.2 software package was used. BMDS 2.1.2 is the latest version of the BMDS series, released by EPA in June 2010. Benchmark dose analysis requires a control and at least two treatment dose levels. Because the Davis 1965 study only used one treatment dose level, this data set is not appropriate for benchmark dose analysis. The NCI 1978 data set includes a control group and two treatment dose levels and can be applied to a benchmark dose model. The NCI 1978 data as presented in IRIS 1993 were as follows:

Dose (ppm in mouse diet)	Human Equivalent Dose (mg/kg-day)	Tumor Incidence
0	0	3/20
4	0.04	16/49
8	0.08	25/45

Recalculation of Human Equivalent Dose

To arrive at a human equivalent dose from the animal studies, U.S. EPA historically multiplied the doses administered to the animals by the ratio of the animal to human weight to the $1/3$ power. The current approach by U.S. EPA is to apply the "3/4 power" assumption in which the human equivalent dose, in units of mg/kg-day, is equal to the animal dose \times (animal weight in kg/70 kg)^{1/4} (U.S. EPA 1992, 2005).



Assumptions:

- Mouse BW = 0.03 kg (IRIS page for Aldrin)
- Food consumption rate = 6400 mg/day (based on EPA reference values, B6C3F1 mouse, male, chronic; EPA 1982)
- Human Equivalent Dose = Mouse Dose x $(0.03 \text{ kg}/70 \text{ kg})^{1/4}$ = mouse dose x 0.143882

Calculations:

Mouse dose for 4 ppm = $(4/1,000,000) \times (6400 \text{ mg}/0.03 \text{ kg-day}) = 0.853 \text{ mg/kg-day}$

Human Equivalent Dose for 4 ppm = $0.853 \text{ mg/kg-day} \times 0.143882 = 0.12273 \text{ mg/kg-day}$

Mouse dose for 8 ppm = $(8/1,000,000) \times (6400 \text{ mg}/0.03 \text{ kg-day}) = 1.706 \text{ mg/kg-day}$

Human Equivalent Dose for 8 ppm = $1.706 \text{ mg/kg-day} \times 0.143882 = 0.24546 \text{ mg/kg-day}$

NCI 1978 data with Revised HED

Dose (ppm in mouse diet)	Human Equivalent Dose (mg/kg-day)	Tumor Incidence
0	0	3/20
4	0.12273	16/49
8	0.24546	25/45

Benchmark Dose Models

Tumor incidence data are quantal data that the EPA (2000a) recommends for use in a Dichotomous Multistage-Cancer Model. In the analyses for aldrin, dose levels in Human Equivalent Dose were entered with the sample size (N) and tumor incidence data were entered into the BMDS 2.1.2 spreadsheet. The Dichotomous Model Multistage-Cancer Model allows for variation of the Degree of Polynomial to find the best curve fit. In a data set containing two treatment dose levels, the Degree of Polynomial can be set to either 1 or 2. In the first run of the model, Degree of Polynomial was set to 1, and in the second run, this value was changed to 2.



Results

A summary of the BMD analyses of the liver tumor incidence data is presented in the table below, and the BMDS input data, model parameters, and output are presented in subsequent pages. The first run (Degree of Polynomial =1) produced a curve with a good visual fit, and the mathematical tests for a good fit produced values within the acceptable ranges (see table footnotes). The second run, while providing a visually perfect fit to the data points, the P-value of “NA” is difficult to interpret. Based on these factors, the first run is deemed to have the better curve fit, and the cancer slope factor for the NCI 1978 male mouse liver tumor incidence data is **3.39715 (mg/kg-day)⁻¹**.

Summary of Dichotomous Model Multistage-Cancer Model for Aldrin (NCI 1978 male liver tumor data)

Run	Degree of Polynomial	P-value ¹	Highest Scaled Residual ²	AIC ³	Visual Assessment of Curve to Data Points ⁴	BMD	BMDL ⁵	Cancer Slope Factor
1	1	0.5127	-0.501	145.072	Good	0.0426138	0.0294365	3.39715
2	2	NA	0.000	146.641	Excellent	0.0674753	0.0302286	3.30812

1 For the model to be acceptable, P-value must be > 0.1.

2 Scaled residuals report the gap between the curve line and the actual data points; for the model to be acceptable, all scaled residuals must have an absolute value of < 2.

3 The Akaike Information Coefficient (AIC) is used for comparison between models; generally, a lower AIC value indicates a better curve fit to the data.

4 Even when the numbers indicate a good curve fit, a visual inspection of the graph is important to ensure the curve is not wavy or contains other aberrations.

5 BMDL = Lower one-sided confidence limit on the BMD.



BMDS Input Data:

Model Type: Dichotomous		Model Name: Multistage-Cancer		
	Dose	N	Tumor_Incidence	Col4
1	0	20	3	
2	0.12273	49	16	
3	0.24546	45	25	
4				

BMDS Model Parameters – First Run:

<<Column Assignments>>

Dose	Dose
# Subjects in Dose Group	N
Incidence	
% Positive	

<<Optimizer Assignments>>

Iteration	250
Relative Function	1.00E-08
Parameter	1.00E-08

<<Parameter Assignments>>

Parameters	Options	Values
Background	Default	
Beta1	Default	
Beta2	Default	

<<Other Assignments>>

Risk Type	Extra
BMR	0.1000
Confidence Level	0.95
BMD Calculation	<input checked="" type="checkbox"/>
BMDL Curve. Calc.	<input type="checkbox"/>
Dose Groups	3
Degree of Polynomial	1

User Notes:

Data File: Show

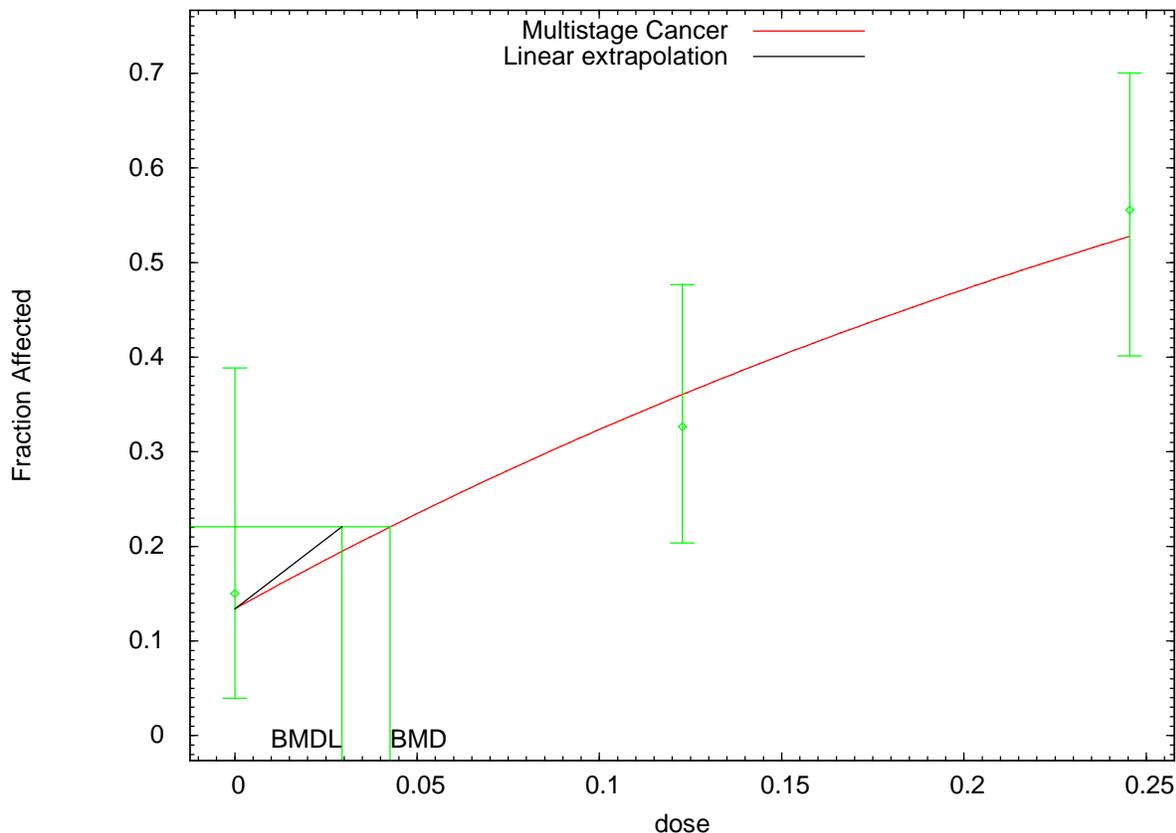
Out File Name: C:\USEPA\BMDS21 2\Data\msc_UntitledData_Setting.out Set

Multistage-Cancer->Dichotomous



First Run Output (Degree of Polynomial = 1)

Multistage Cancer Model with 0.95 Confidence Level



12:33 12/17 2010

```

=====
Multistage Cancer Model. (Version: 1.9; Date: 05/26/2010)
Input Data File: C:/USEPA/BMDS212/Data/msc_UntitledData_Setting.(d)
Gnuplot Plotting File: C:/USEPA/BMDS212/Data/msc_UntitledData_Setting.plt
Fri Dec 17 12:33:28 2010
=====

```

BMDS_Model_Run

The form of the probability function is:

$$P[\text{response}] = \text{background} + (1-\text{background}) * [1 - \text{EXP}(-\text{beta} * \text{dose}^1)]$$

The parameter betas are restricted to be positive

Dependent variable = Tumor_Incidence
 Independent variable = Dose

Total number of observations = 3
 Total number of records with missing values = 0



TETRA TECH

Total number of parameters in model = 2
Total number of specified parameters = 0
Degree of polynomial = 1

Maximum number of iterations = 250
Relative Function Convergence has been set to: 1e-008
Parameter Convergence has been set to: 1e-008

Default Initial Parameter Values

Background = 0.123701
Beta(1) = 2.64162

Asymptotic Correlation Matrix of Parameter Estimates

Table with 2 columns: Parameter, Correlation. Rows: Background, Beta(1).

Parameter Estimates

Table with 5 columns: Interval, Variable, Estimate, Std. Err., 95.0% Wald Confidence (Lower/Upper). Rows: Background, Beta(1).

* - Indicates that this value is not calculated.

Analysis of Deviance Table

Table with 6 columns: Model, Log(likelihood), # Param's, Deviance, Test d.f., P-value. Rows: Full model, Fitted model, Reduced model, AIC.

Goodness of Fit

Table with 6 columns: Dose, Est._Prob., Expected, Observed, Size, Scaled Residual. Rows: 0.0000, 0.1227, 0.2455.

Chi^2 = 0.43 d.f. = 1 P-value = 0.5127

Benchmark Dose Computation



TETRA TECH

Specified effect = 0.1

Risk Type = Extra risk

Confidence level = 0.95

BMD = 0.0426138

BMDL = 0.0294365

BMDU = 0.0797552

Taken together, (0.0294365, 0.0797552) is a 90 % two-sided confidence interval for the BMD

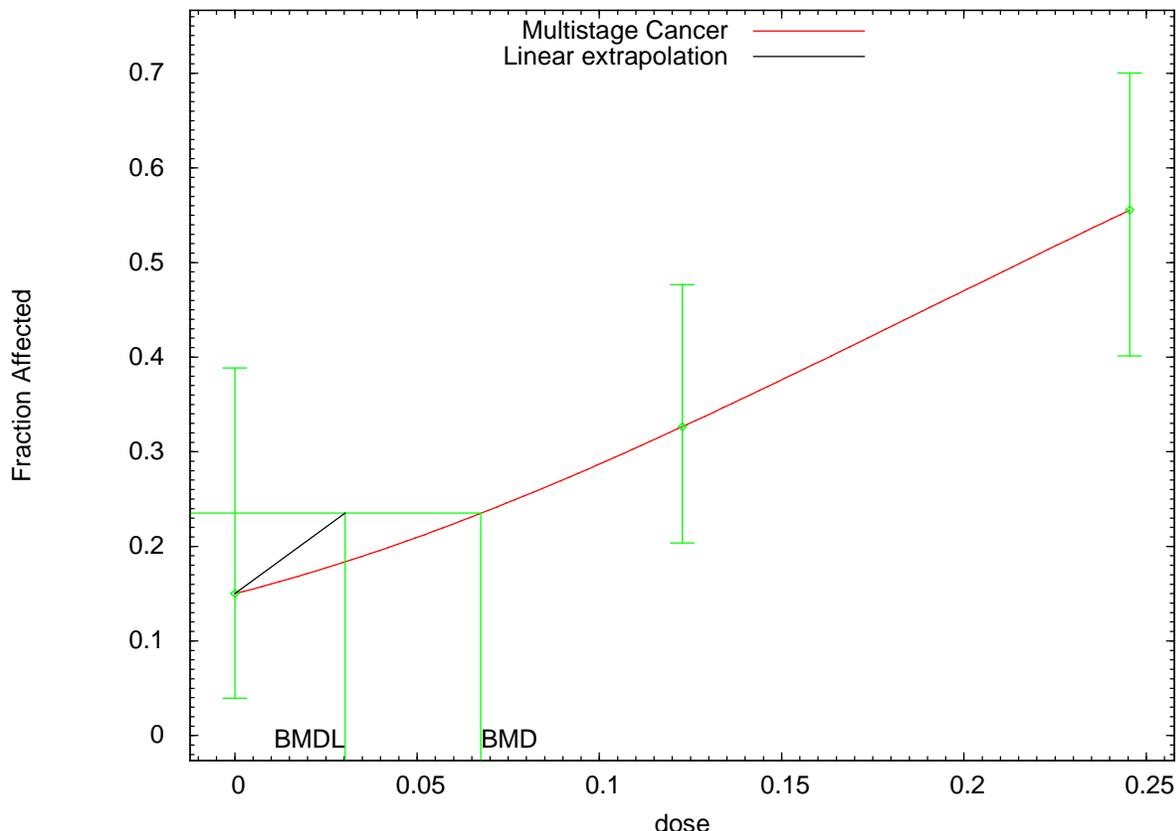
Multistage Cancer Slope Factor = 3.39715



TETRA TECH

Second Run Output (Degree of Polynomial = 2)

Multistage Cancer Model with 0.95 Confidence Level



12:35 12/17 2010

```

=====
Multistage Cancer Model. (Version: 1.9; Date: 05/26/2010)
Input Data File: C:/USEPA/BMDS212/Data/msc_UntitledData_Setting.(d)
Gnuplot Plotting File: C:/USEPA/BMDS212/Data/msc_UntitledData_Setting.plt
Fri Dec 17 12:35:12 2010
=====

```

BMDS_Model_Run

The form of the probability function is:

$$P[\text{response}] = \text{background} + (1-\text{background}) * [1 - \text{EXP}(-\text{beta1} * \text{dose} - \text{beta2} * \text{dose}^2)]$$

The parameter betas are restricted to be positive

Dependent variable = Tumor_Incidence
 Independent variable = Dose

Total number of observations = 3
 Total number of records with missing values = 0
 Total number of parameters in model = 3



TETRA TECH

Total number of specified parameters = 0
Degree of polynomial = 2

Maximum number of iterations = 250
Relative Function Convergence has been set to: 1e-008
Parameter Convergence has been set to: 1e-008

Default Initial Parameter Values

Background = 0.15
Beta(1) = 1.15198
Beta(2) = 6.06877

Asymptotic Correlation Matrix of Parameter Estimates

	Background	Beta(1)	Beta(2)
Background	1	-0.71	0.51
Beta(1)	-0.71	1	-0.95
Beta(2)	0.51	-0.95	1

Parameter Estimates

Interval Limit	Variable	Estimate	Std. Err.	95.0% Wald Confidence	
				Lower Conf. Limit	Upper Conf.
	Background	0.15	*	*	*
	Beta(1)	1.15198	*	*	*
	Beta(2)	6.06877	*	*	*

* - Indicates that this value is not calculated.

Error in computing chi-square; returning 2

Analysis of Deviance Table

Model	Log(likelihood)	# Param's	Deviance	Test d.f.	P-value
Full model	-70.3205	3			
Fitted model	-70.3205	3	0	0	NA
Reduced model	-76.0276	1	11.4143	2	0.003322
AIC:	146.641				

Goodness of Fit

Dose	Est._Prob.	Expected	Observed	Size	Scaled Residual
0.0000	0.1500	3.000	3.000	20	-0.000
0.1227	0.3265	16.000	16.000	49	0.000
0.2455	0.5556	25.000	25.000	45	0.000



TETRA TECH

Chi² = 0.00

d.f. = 0

P-value = NA

Benchmark Dose Computation

Specified effect = 0.1

Risk Type = Extra risk

Confidence level = 0.95

BMD = 0.0674753

BMDL = 0.0302286

BMDU = 0.137475

Taken together, (0.0302286, 0.137475) is a 90 % two-sided confidence interval for the BMD

Multistage Cancer Slope Factor = 3.30812

Appendix A-2: Benchmark Dose Derivation of a Cancer Slope Factor for Dieldrin

Introduction

In the IRIS 1993 review of dieldrin (CAS No. 60-57-1), the U.S. EPA calculated an oral cancer slope factor of 16 (mg/kg-day)⁻¹. This oral cancer slope factor was the geometric mean of 13 slope factors derived from studies of chronic oral (dietary) exposure to dieldrin in mice with dose-related increases in incidence of liver tumors. The table below lists the data sets that IRIS used to calculate its slope factor value. The data sets in bolded type within the table (Walker et al. 1972 and NCI 1978) had adequate study designs for analysis to recalculate slope factors based on benchmark dose modeling.

Sex, Strain	Dose Levels (ppm)	IRIS-calculated Slope Factor	Reference
Male, C3H	0, 10	22	Davis (1965), reevaluated by Reuber 1974 (cited in Epstein 1975)
Female, C3H	0, 10	25	Davis (1965), reevaluated by Reuber 1974 (cited in Epstein 1975)
Male, CF1	0, 0.1, 1, 10	25	Walker et al 1972
Female, CF1	0, 0.1, 1, 10	28	Walker et al 1972
Male, CF1	0, 1.25, 2.5, 5, 10, 20	15	Walker et al 1972
Female, CF1	0, 1.25, 2.5, 5, 10, 20	7.1	Walker et al 1972
Male, CF1	0, 10	55	Thorpe and Walker 1973
Female, CF1	0, 10	26	Thorpe and Walker 1973
Male, B6C3F1	0, 2.5, 5	9.8	NCI (1978)
Male, CF1	0, 10	18	Tennekes et al. 1981
Male, C57B1/6J	0, 10	7.4	Meierhenry et al. 1983
Male, C3H/He	0, 10	8.5	Meierhenry et al. 1983
Male, B6C3F1	0, 10	11	Meierhenry et al. 1983

Methods

A benchmark dose (BMD) approach was used to derive new cancer slope factor for dieldrin. The US EPA's BMDS 2.1.2 software package was used. BMDS 2.1.2 is the latest version of the BMDS series, released by EPA in June 2010. Benchmark dose analysis requires a control and at least two treatment dose levels. Because the studies by Davis 1965, Thorpe and Walker 1973, Tennekes et al 1981, and Meierhenry et al. 1983 each only used one treatment dose level, these data sets are not appropriate for benchmark dose analysis. Each of the Walker et al 1972 and NCI 1978 data sets includes a control group and two or more treatment dose levels and can be applied to a benchmark dose model.

Walker et al. 1972 presented results of two chronic dieldrin experiments in mice: in one experiment, mice of both sexes were exposed to dietary dieldrin for 132 weeks; in the other mice of both sexes were exposed for 128 weeks.



132-Week Male Mouse Tumor Incidence Data from Walker 1973

Dose (ppm in mouse diet)	Human Equivalent Dose ¹ (mg/kg-day)	N	% Mice with Tumors
0	0	288	20
0.1	0.002607	124	26
1.0	0.02607	111	31
10.0	0.2607	94	94

1 See Calculation of Human Equivalent Dose section below.

132-Week Female Mouse Tumor Incidence Data from Walker 1973

Dose (ppm in mouse diet)	Human Equivalent Dose ¹ (mg/kg-day)	N	% Mice with Tumors
0	0	297	13
0.1	0.0025895	90	27
1.0	0.025895	87	37
10.0	0.25895	148	92

1 See Calculation of Human Equivalent Dose section below.

128-Week Male Mouse Tumor Incidence Data from Walker 1973

Dose (ppm in mouse diet)	Human Equivalent Dose ¹ (mg/kg-day)	N	% Mice with Tumors
0	0	78	12
1.25	0.032579	30	20
2.5	0.065158	30	43
5.0	0.13032	30	87
10.0	0.26063	11	45
20.0	0.52127	17	71

1 See Calculation of Human Equivalent Dose section below.



128-Week Female Mouse Tumor Incidence Data from Walker 1973

Dose (ppm in mouse diet)	Human Equivalent Dose ¹ (mg/kg-day)	N	% Mice with Tumors
0	0	78	10
1.25	0.03238	30	17
2.5	0.06476	28	43
5.0	0.12952	30	60
10.0	0.25903	17	53
20.0	0.51807	21	38

¹ See *Calculation of Human Equivalent Dose* section below.

The NCI 1978 study exposed male and female mice for 80 weeks. The female mice did not show a dose-related increase in liver tumor incidences, so only the data from exposure to male mice were analysed.

80-Week Male Mouse Tumor Incidence Data from NCI 1978

Dose (ppm in mouse diet)	Human Equivalent Dose ¹ (mg/kg-day)	N	Number of Mice with Tumors
0	0	20	3
6.1	0.07674	49	16
13.8	0.1535	46	25

¹ See *Calculation of Human Equivalent Dose* section below.

Calculation of Human Equivalent Dose

To arrive at a human equivalent dose from the animal studies, U.S. EPA historically multiplied the doses administered to the animals by the ratio of the animal to human weight to the 1/3 power. The current approach by U.S. EPA is to apply the “3/4 power” assumption in which the human equivalent dose, in units of mg/kg-day, is equal to the animal dose × (animal weight in kg/70 kg)^{1/4} (US EPA 1992, 2005).

Assumptions:

- Male Mouse BW = 0.0373 kg (based on EPA reference values, B6C3F1 mouse, male, chronic; EPA 1982)
- Female mouse BW = 0.0353 kg (based on EPA reference values, B6C3F1 mouse, female, chronic; EPA 1982)



- Food consumption rate = 6400 mg/day (based on EPA reference values, B6C3F1 mouse, male, chronic; EPA 1982)

Benchmark Dose Models

Tumor incidence data are quantal data that the EPA (2000) recommends for use in a Dichotomous Multistage-Cancer Model. Each data set in the above tables was run separately. In the analyses for each data set, dose levels in Human Equivalent Dose were entered with the sample size (N) and tumor incidence data were entered into a BMDS 2.1.2 spreadsheet. The Dichotomous Model Multistage-Cancer Model allows for variation of the Degree of Polynomial to find the best curve fit. If an adequate curve fit cannot be created by manipulation of the Degrees of Polynomial, this may be because the program is trying to fit the curve to the higher dose groups, however the focus in BMDS modeling should be in the range of the lower dose levels. It is therefore sometimes appropriate to exclude data at the higher dose level(s) in order to get a better curve fit at the lower dose levels. However, at least two dose levels above control must remain in the data set.

Results

The BMDS output of the benchmark dose analyses for each of the data sets is presented after the References section. Below are summaries of the output used for comparison of output results to determine the best-fit curve and thus the best benchmark dose-derived cancer slope value for each data set. Explanations of the curve-fit evaluation criteria are in the table footnotes below. Within the tables, P-value and scaled residual values which are acceptable are identified in green text, and those which are not acceptable are identified in red text.

132-Week Male Mouse Tumor Incidence Data from Walker 1973

The 132-week male mouse tumor incidence data from Walker 1973 was analysed in the BMDS 2.1.2 program in two runs, with Degree of Polynomial respectively set to 2 or 3. Both runs produced acceptable curve-fit evaluation results. Based on the comparison of Akaike Information Coefficient (AIC) values, Run 2 indicated the better curve-fit. BMD-derived cancer slope factor is **9.56246** (mg/kg-d)⁻¹.

Run #	Data Set	Degree of Polynomial	Curve-Fit Acceptance			BMD	BMD-derived CSF
			P-value ¹	Highest Scaled Residual ²	AIC ³		
1	All	2	0.2477	1.040	648.896	0.0204274	9.60453
2	All	3	0.2557	1.022	648.85	0.0201651	9.56246

1 For the model to be acceptable, P-value must be > 0.1.

2 Scaled residuals report the gap between the curve line and the actual data points; for the model to be acceptable, all scaled residuals must have an absolute value of < 2.

3 The Akaike Information Coefficient (AIC) is used for comparison between models; a lower AIC value indicates a better curve fit to the data.

**132-Week Female Mouse Tumor Incidence Data from Walker 1973**

The 132-week female mouse tumor incidence data from Walker 1973 was analysed in the BMDs 2.1.2 program in five runs, with Degree of Polynomial set to 1, 2, or 3 with the full data set and 1 or 2 with the highest dose excluded. None of the runs produced a curve with an acceptable fit to the data set. A benchmark dose-derived cancer slope factor was not calculable for this data set.

Run	Data Set	Degree of Polynomial	Curve - Fit Acceptance			BMD	BMD-derived CSF
			P-value ¹	Highest Scaled Residual ²	AIC ³		
1	all	1	0.0235	2.333	534.514	0.0108277	11.1299
2	all	2	0.0235	2.333	534.514	0.0108277	11.1299
3	all	3	0.0235	2.333	534.514	0.0108277	11.1299
4	without top dose	1	0.0117	2.319	455.422	0.00826961	18.0876
5	without top dose	2	0.0117	2.319	455.422	0.00826961	18.0876

1 For the model to be acceptable, P-value must be > 0.1.

2 Scaled residuals report the gap between the curve line and the actual data points; for the model to be acceptable, all scaled residuals must have an absolute value of < 2.

3 The Akaike Information Coefficient (AIC) is used for comparison between models; a lower AIC value indicates a better curve fit to the data.

128-Week Male Mouse Tumor Incidence Data from Walker 1973

The 128-week male mouse tumor incidence data from Walker 1973 was analysed in the BMDs 2.1.2 program in 10 runs. Using the complete data set with Degree of Polynomial respectively set to 1, 2, 3, or 4 each produced the exact same curve, and the curve-fit acceptance criteria were not met. Removal of the highest dose level did not improve the curve fit with the full range of Degree of Polynomial (1-4). In order to improve the curve fit in the lower dose level range, the data set was run again with the top two dose levels excluded. Removal of the top two dose levels produced a curve with acceptable curve-fit results, and Degree of Polynomial values of 2 or 3 produced identical results. Removal of the highest dose levels is justifiable, because the tumor incidence dose-dependently increased up to 5 ppm and then decreased at 10 and 20 ppm. This decrease in tumor incidence at the higher dose levels is likely due to the higher mortality rates at these dose levels, thus the dose-response curve for tumor incidence had an irregular shape. Removal of these top two dose levels produced a more normal dose-response curve and a better curve fit. BMD-derived cancer slope factor is **5.932 (mg/kg-d)⁻¹**.



Run	Data Set	Degree of Polynomial	Curve-Fit Acceptance			BMD	BMD-derived CSF
			P-value ¹	Highest Scaled Residual ²	AIC ³		
1	All	1/2/3/4	0.0000	-2.407	218.672	0.0265497	5.11612
2	Without top dose	1/2/3/4	0.0002	-3.050	190.494	0.0178307	7.55696
3	Without top 2 doses	2/3	0.9282	0.306	153.953	0.0317161	5.932

1 For the model to be acceptable, P-value must be > 0.1.

2 Scaled residuals report the gap between the curve line and the actual data points; for the model to be acceptable, all scaled residuals must have an absolute value of < 2.

3 The Akaike Information Coefficient (AIC) is used for comparison between models; a lower AIC value indicates a better curve fit to the data.

128-Week Female Mouse Tumor Incidence Data from Walker 1973

The 128-week female mouse tumor incidence data from Walker 1973 was analysed in the BMDS 2.1.2 program in eight runs. Using the complete data set with Degree of Polynomial respectively set to 1, 2, 3, or 4 each produced the exact same curve, and the curve-fit acceptance criteria were not met. Exclusion of the highest dose level improved the curve fit with Degree of Polynomial set to 2 or 3, with identical results. Exclusion of the top two dose levels produced a curve with acceptable curve-fit results, and Degree of Polynomial values of 2 or 3 produced identical results. Removal of the highest dose levels is justifiable, because the tumor incidence dose-dependently increased up to 5 ppm and then decreased at 10 and 20 ppm. This decrease in tumor incidence at the higher dose levels is likely due to the higher mortality rates at these dose levels, thus the dose-response curve for tumor incidence had an irregular shape. Removal of these top two dose levels produced a more normal dose-response curve and a better curve fit. Because exclusion of the top dose only and the top two doses each produced acceptable curve fit results, the comparison is decided by the AIC value, which indicated that the exclusion of the top two dose levels produced the better curve fit. BMD-derived cancer slope factor is **7.96094(mg/kg-d)⁻¹**.



Run #	Data Set	Degree of Polynomial	Curve-Fit Acceptance			BMD	BMD-derived CSF
			P-value ¹	Highest Scaled Residual ²	AIC ³		
1	All	1/2/3/4	0.0001	3.243	233.07	0.063535	2.43635
2	Without top dose	2/3	0.1035	1.177	185.673	0.0231772	5.8833
3	Without top 2 doses	2/3	0.2667	0.729	159.398	0.0218267	7.96094

1 For the model to be acceptable, P-value must be > 0.1.

2 Scaled residuals report the gap between the curve line and the actual data points; for the model to be acceptable, all scaled residuals must have an absolute value of < 2.

3 The Akaike Information Coefficient (AIC) is used for comparison between models; a lower AIC value indicates a better curve fit to the data.

80-Week Male Mouse Tumor Incidence Data from NCI 1978

The 80-week male mouse tumor incidence data from Walker 1973 was analysed in the BMDS 2.1.2 program in eight runs. A summary of the BMD analyses of the liver tumor incidence data is presented in the table below, and the BMDS input data, model parameters, and output are presented in subsequent pages. The first run (Degree of Polynomial =1) produced a curve with a good visual fit, and the mathematical tests for a good fit produced values within the acceptable ranges (see table footnotes). The second run, while providing a visually perfect fit to the data points, the P-value of “NA” is difficult to interpret. Based on these factors, the first run is deemed to have the better curve fit, and the cancer slope factor for the NCI 1978 male mouse liver tumor incidence data is **5.29719 (mg/kg-day)⁻¹**.

Run #	Data Set	Degree of Polynomial	Curve-Fit Acceptance			BMD	BMD-derived CSF
			P-value ¹	Highest Scaled Residual ²	AIC ³		
1	All	1	0.5714	-0.435	146.558	0.027485	5.29719
2	All	2	NA	0.000	148.236	0.0411225	5.19367

1 For the model to be acceptable, P-value must be > 0.1.

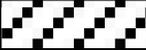
2 Scaled residuals report the gap between the curve line and the actual data points; for the model to be acceptable, all scaled residuals must have an absolute value of < 2.

3 The Akaike Information Coefficient (AIC) is used for comparison between models; a lower AIC value indicates a better curve fit to the data.



Conclusion

Below is a comparison of the EPA-IRIS 1993 cancer slope factors for dieldrin with the cancer slope factors derived by benchmark dose and adjusted to human equivalent doses derived by scaling to the $\frac{3}{4}$ power.

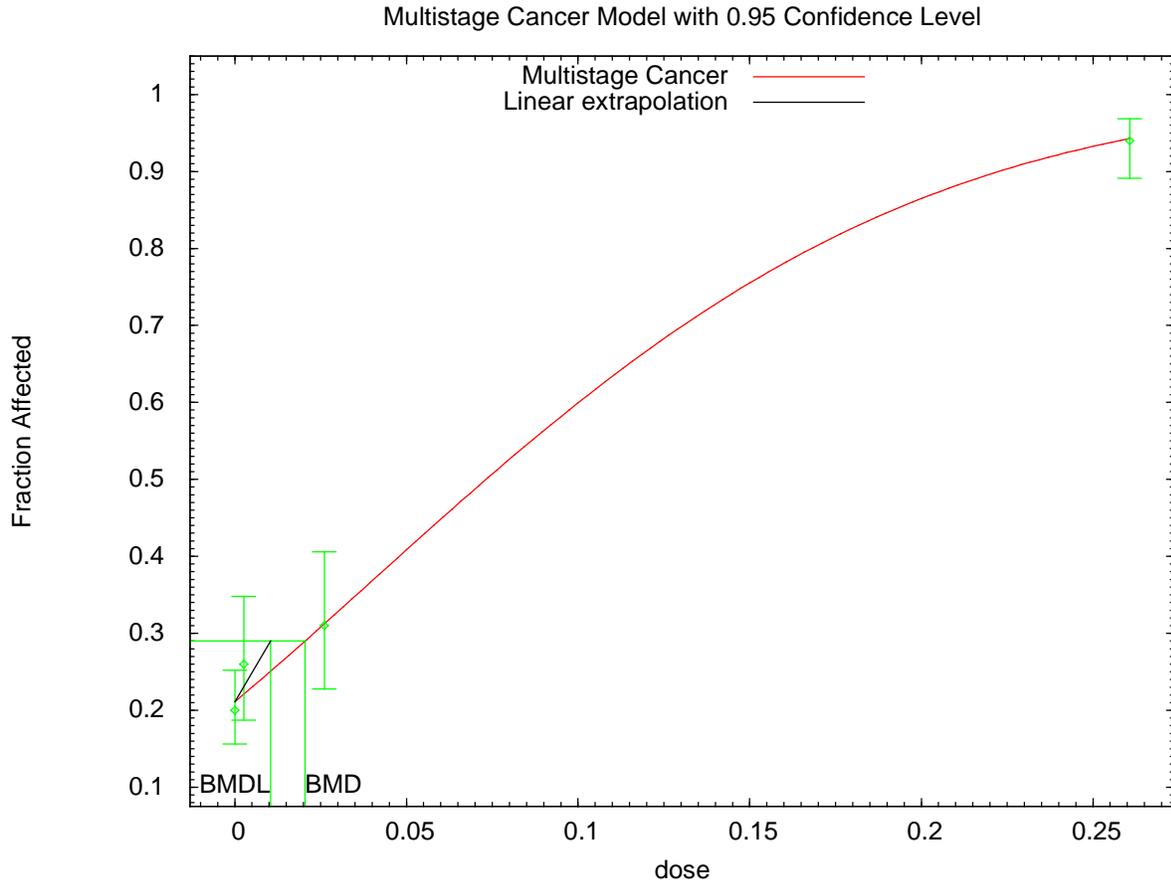
Reference for Data Set (Subjects)	Dose levels in Human Equivalent Dose (mg/kg-day)	Best Curve Fit Data		BMD	BMDL	BMD-Based Cancer Slope Factor (mg/kg-day) ⁻¹	U.S. EPA 1987 Cancer Slope Factor (mg/kg-day) ⁻¹
		P value	Highest scaled residual				
NCI 1978 (male B6C3F1 mice)	0 0.07674 0.1535	0.5714	-0.435	0.027485	0.0188779	5.29719	9.8
Walker et al. 1972 male CF1 mice)	0 0.002607 0.02607 0.2607	0.2557	1.022	0.0201651	0.0104576	9.56246	25
Walker et al. 1972 male CF1 mice)	0 0.02579 0.065158 0.13032	0.9282	0.306	0.0317161	0.0168577	5.932	15
Walker et al. 1972 female CF1 mice)	0 0.03238 0.06476 0.12952	0.2667	0.729	0.0218267	0.0125613	7.96094	26
Geometric mean of four BMD-based cancer slope factors						6.99351	
Geometric mean of 13 cancer slope factors reported by EPA 1987							16



TETRA TECH

BMDS Output

132-Week Male Mouse Tumor Incidence Data from Walker 197 - First Run (Degree of Polynomial = 2):



11:49 12/23 2010

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=====
Multistage Cancer Model. (Version: 1.9; Date: 05/26/2010)
Input Data File: C:/USEPA/BMDS212/Data/msc_UntitledData_Setting.(d)
Gnuplot Plotting File: C:/USEPA/BMDS212/Data/msc_UntitledData_Setting.plt
Thu Dec 23 11:49:42 2010
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```

BMDS_Model_Run

The form of the probability function is:

$$P[\text{response}] = \text{background} + (1-\text{background}) * [1 - \text{EXP}(-\text{beta1} * \text{dose}^1 - \text{beta2} * \text{dose}^2)]$$

The parameter betas are restricted to be positive



TETRA TECH

Dependent variable = %_Tumors
Independent variable = Dose

Total number of observations = 4
Total number of records with missing values = 0
Total number of parameters in model = 3
Total number of specified parameters = 0
Degree of polynomial = 2

Maximum number of iterations = 250
Relative Function Convergence has been set to: 1e-008
Parameter Convergence has been set to: 1e-008

Default Initial Parameter Values

Background = 0.224973
Beta(1) = 4.02918
Beta(2) = 22.1897

Asymptotic Correlation Matrix of Parameter Estimates

	Background	Beta(1)	Beta(2)
Background	1	-0.5	0.45
Beta(1)	-0.5	1	-0.98
Beta(2)	0.45	-0.98	1

Parameter Estimates

Interval Limit	Variable	Estimate	Std. Err.	95.0% Wald Confidence	
				Lower Conf. Limit	Upper Conf. Limit
	Background	0.211425	*	*	*
	Beta(1)	4.741	*	*	*
	Beta(2)	20.404	*	*	*

* - Indicates that this value is not calculated.

Warning: Likelihood for the fitted model larger than the Likelihood for the full model.
Error in computing chi-square; returning 2

Analysis of Deviance Table

Model	Log(likelihood)	# Param's	Deviance	Test d.f.	P-value
Full model	-323.841	4			
Fitted model	-321.448	3	-4.78713	1	2
Reduced model	-474.224	1	300.765	3	<.0001
AIC:	648.896				



TETRA TECH

Goodness of Fit

Dose	Est._Prob.	Expected	Observed	Size	Scaled Residual
0.0000	0.2114	60.890	57.600	288	-0.475
0.0026	0.2212	27.431	32.240	124	1.040
0.0261	0.3127	34.710	34.410	111	-0.062
0.2607	0.9427	165.923	165.440	176	-0.157

Chi² = 1.34 d.f. = 1 P-value = 0.2477

Benchmark Dose Computation

Specified effect = 0.1

Risk Type = Extra risk

Confidence level = 0.95

BMD = 0.0204274

BMDL = 0.0104118

BMDU = 0.0518688

Taken together, (0.0104118, 0.0518688) is a 90 % two-sided confidence interval for the BMD

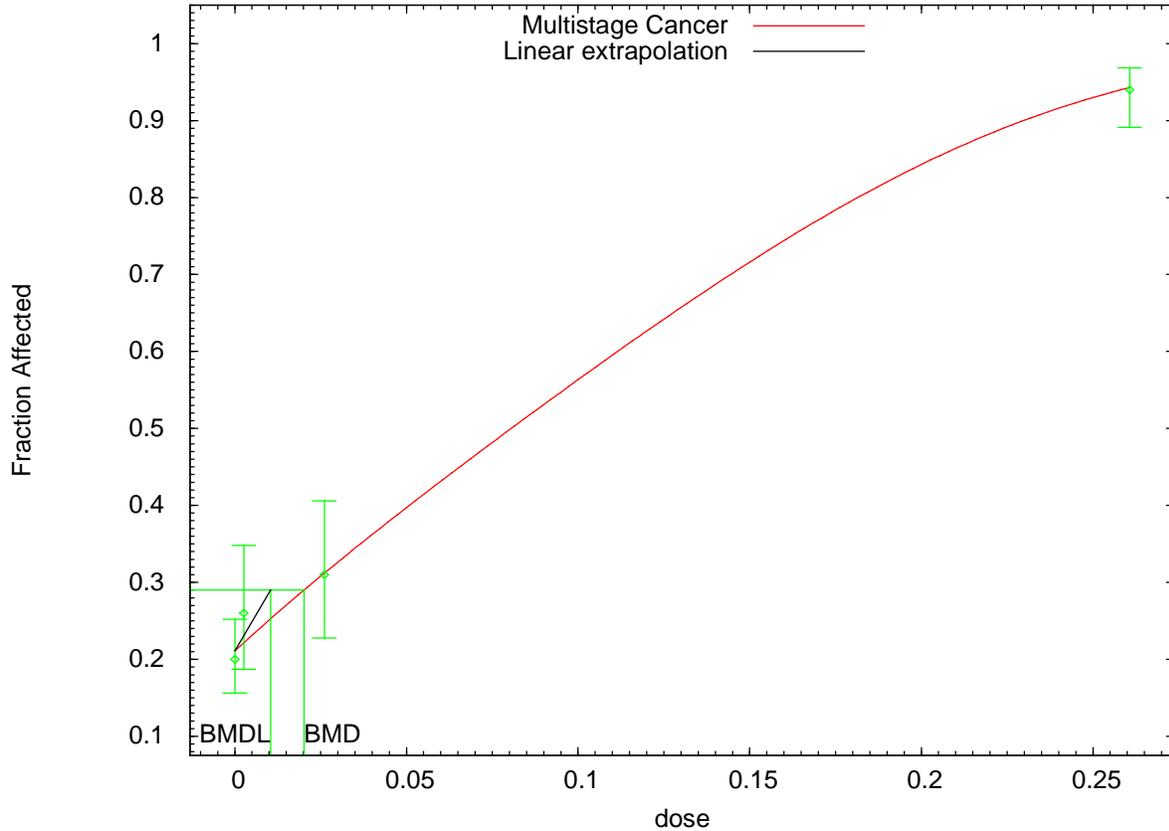
Multistage Cancer Slope Factor = 9.60453



TETRA TECH

132-Week Male Mouse Tumor Incidence Data from Walker 197 - First Run (Degree of Polynomial = 3):

Multistage Cancer Model with 0.95 Confidence Level



11:58 12/23 2010

```

=====
Multistage Cancer Model. (Version: 1.9; Date: 05/26/2010)
Input Data File: C:/USEPA/BMDS212/Data/msc_UntitledData_Setting.(d)
Gnuplot Plotting File: C:/USEPA/BMDS212/Data/msc_UntitledData_Setting.plt
Thu Dec 23 11:58:36 2010
=====

```

BMDS_Model_Run

The form of the probability function is:

$$P[\text{response}] = \text{background} + (1-\text{background}) * [1 - \text{EXP}(-\text{beta1} * \text{dose} - \text{beta2} * \text{dose}^2 - \text{beta3} * \text{dose}^3)]$$

The parameter betas are restricted to be positive

Dependent variable = %_Tumors
Independent variable = Dose

Total number of observations = 4



TETRA TECH

Total number of records with missing values = 0
Total number of parameters in model = 4
Total number of specified parameters = 0
Degree of polynomial = 3

Maximum number of iterations = 250
Relative Function Convergence has been set to: 1e-008
Parameter Convergence has been set to: 1e-008

Default Initial Parameter Values

Background = 0.224641
Beta(1) = 4.55611
Beta(2) = 0
Beta(3) = 77.3888

Asymptotic Correlation Matrix of Parameter Estimates

(*** The model parameter(s) -Beta(2)
have been estimated at a boundary point, or have been specified by
the user,
and do not appear in the correlation matrix)

Table with 4 columns: Parameter, Background, Beta(1), Beta(3). Rows: Background, Beta(1), Beta(3).

Parameter Estimates

Table with 5 columns: Variable, Estimate, Std. Err., Lower Conf. Limit, Upper Conf. Limit. Rows: Background, Beta(1), Beta(2), Beta(3).

* - Indicates that this value is not calculated.

Warning: Likelihood for the fitted model larger than the Likelihood for the full
model.
Error in computing chi-square; returning 2

Analysis of Deviance Table

Table with 6 columns: Model, Log(likelihood), # Param's, Deviance, Test d.f., P-value. Rows: Full model, Fitted model, Reduced model.



TETRA TECH

AIC: 648.85

Goodness of Fit

Dose	Est._Prob.	Expected	Observed	Size	Scaled Residual
0.0000	0.2113	60.842	57.600	288	-0.468
0.0026	0.2219	27.512	32.240	124	1.022
0.0261	0.3120	34.638	34.410	111	-0.047
0.2607	0.9428	165.941	165.440	176	-0.163

Chi² = 1.29 d.f. = 1 P-value = 0.2557

Benchmark Dose Computation

Specified effect = 0.1
Risk Type = Extra risk
Confidence level = 0.95

BMD = 0.0201651

BMDL = 0.0104576

BMDU = 0.0675466

Taken together, (0.0104576, 0.0675466) is a 90 % two-sided confidence interval for the BMD

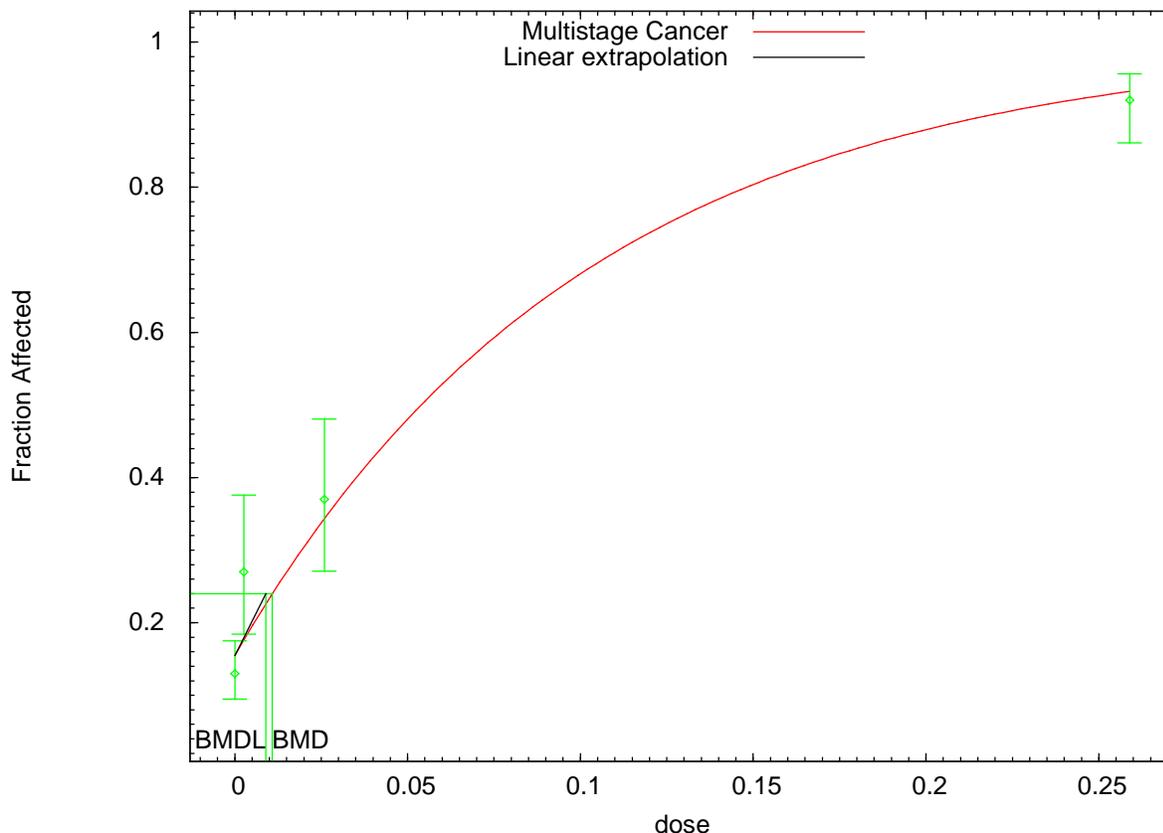
Multistage Cancer Slope Factor = 9.56246



TETRA TECH

132-Week Female Mouse Tumor Incidence Data from Walker 197 - First Run (Degree of Polynomial = 1):

Multistage Cancer Model with 0.95 Confidence Level



13:22 12/23 2010

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=====
Multistage Cancer Model. (Version: 1.9; Date: 05/26/2010)
Input Data File: C:/USEPA/BMDS212/Data/msc_UntitledData_Setting.(d)
Gnuplot Plotting File: C:/USEPA/BMDS212/Data/msc_UntitledData_Setting.plt
Thu Dec 23 13:22:33 2010
=====

```

BMDS_Model_Run

The form of the probability function is:

$$P[\text{response}] = \text{background} + (1-\text{background}) * [1 - \text{EXP}(-\text{beta}1 * \text{dose}^1)]$$

The parameter betas are restricted to be positive

Dependent variable = %_Tumors
 Independent variable = Dose

Total number of observations = 4



TETRA TECH

Total number of records with missing values = 0
Total number of parameters in model = 2
Total number of specified parameters = 0
Degree of polynomial = 1

Maximum number of iterations = 250
Relative Function Convergence has been set to: 1e-008
Parameter Convergence has been set to: 1e-008

Default Initial Parameter Values

Background = 0.197577
Beta(1) = 8.91076

Asymptotic Correlation Matrix of Parameter Estimates

Table with 3 columns: Parameter, Background, Beta(1). Rows: Background, Beta(1).

Parameter Estimates

Table with 5 columns: Variable, Estimate, Std. Err., Lower Conf. Limit, Upper Conf. Limit. Rows: Background, Beta(1).

* - Indicates that this value is not calculated.

Warning: Likelihood for the fitted model larger than the Likelihood for the full model.

Error in computing chi-square; returning 2

Analysis of Deviance Table

Table with 6 columns: Model, Log(likelihood), # Param's, Deviance, Test d.f., P-value. Rows: Full model, Fitted model, Reduced model.

AIC: 534.514

Goodness of Fit

Table with 6 columns: Dose, Est._Prob., Expected, Observed, Size, Scaled Residual. Rows for doses 0.0000, 0.0026, 0.0259, 0.2590.



Chi² = 7.50 d.f. = 2 P-value = 0.0235

Benchmark Dose Computation

Specified effect = 0.1

Risk Type = Extra risk

Confidence level = 0.95

 BMD = 0.0108277

 BMDL = 0.00898478

 BMDU = 0.01312

Taken together, (0.00898478, 0.01312) is a 90 % two-sided confidence interval for the BMD

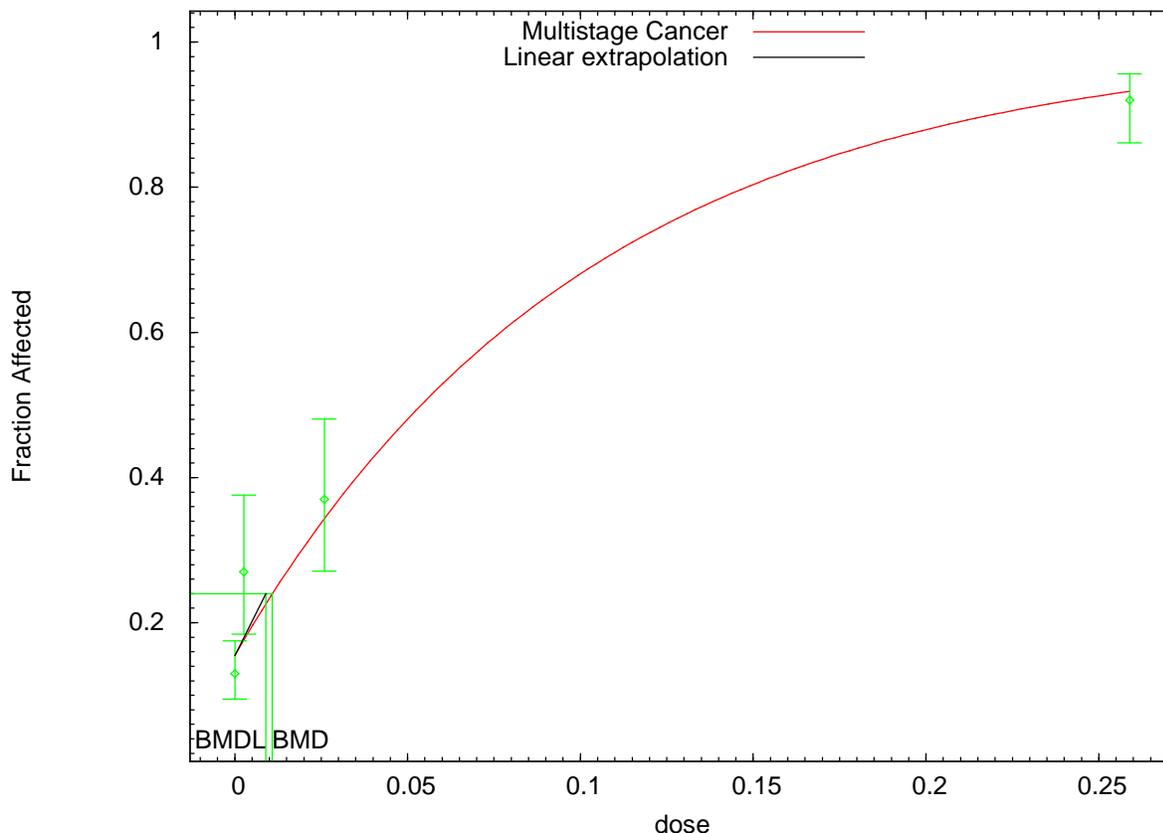
Multistage Cancer Slope Factor = 11.1299



TETRA TECH

132-Week Female Mouse Tumor Incidence Data from Walker 197 - Second Run (Degree of Polynomial = 2):

Multistage Cancer Model with 0.95 Confidence Level



13:16 12/23 2010

```

=====
Multistage Cancer Model. (Version: 1.9; Date: 05/26/2010)
Input Data File: C:/USEPA/BMDS212/Data/msc_UntitledData_Setting.(d)
Gnuplot Plotting File: C:/USEPA/BMDS212/Data/msc_UntitledData_Setting.plt
Thu Dec 23 13:16:20 2010
=====

```

BMDS_Model_Run

The form of the probability function is:

$$P[\text{response}] = \text{background} + (1-\text{background}) * [1 - \text{EXP}(-\text{beta1} * \text{dose} - \text{beta2} * \text{dose}^2)]$$

The parameter betas are restricted to be positive

Dependent variable = %_Tumors
 Independent variable = Dose

Total number of observations = 4



TETRA TECH

Total number of records with missing values = 0
Total number of parameters in model = 3
Total number of specified parameters = 0
Degree of polynomial = 2

Maximum number of iterations = 250
Relative Function Convergence has been set to: 1e-008
Parameter Convergence has been set to: 1e-008

Default Initial Parameter Values

Background = 0.197577
Beta(1) = 8.91076
Beta(2) = 0

Asymptotic Correlation Matrix of Parameter Estimates

(*** The model parameter(s) -Beta(2)
have been estimated at a boundary point, or have been specified by
the user,
and do not appear in the correlation matrix)

	Background	Beta(1)
Background	1	-0.27
Beta(1)	-0.27	1

Parameter Estimates

Interval Limit	Variable	Estimate	Std. Err.	95.0% Wald Confidence	
				Lower Conf. Limit	Upper Conf. Limit
	Background	0.15526	*	*	*
	Beta(1)	9.73063	*	*	*
	Beta(2)	0	*	*	*

* - Indicates that this value is not calculated.

Warning: Likelihood for the fitted model larger than the Likelihood for the full model.

Error in computing chi-square; returning 2

Analysis of Deviance Table

Model	Log(likelihood)	# Param's	Deviance	Test d.f.	P-value
Full model	-265.837	4			
Fitted model	-265.257	2	-1.16053	2	2
Reduced model	-410.462	1	289.25	3	<.0001
AIC:	534.514				

Goodness of Fit



TETRA TECH

Dose	Est._Prob.	Expected	Observed	Size	Scaled Residual
0.0000	0.1553	46.112	38.610	297	-1.202
0.0026	0.1763	15.865	24.300	90	2.333
0.0259	0.3434	29.877	32.190	87	0.522
0.2590	0.9320	137.938	136.160	148	-0.581

Chi² = 7.50 d.f. = 2 P-value = 0.0235

Benchmark Dose Computation

Specified effect = 0.1

Risk Type = Extra risk

Confidence level = 0.95

BMD = 0.0108277

BMDL = 0.00898478

BMDU = 0.0160063

Taken together, (0.00898478, 0.0160063) is a 90 % two-sided confidence interval for the BMD

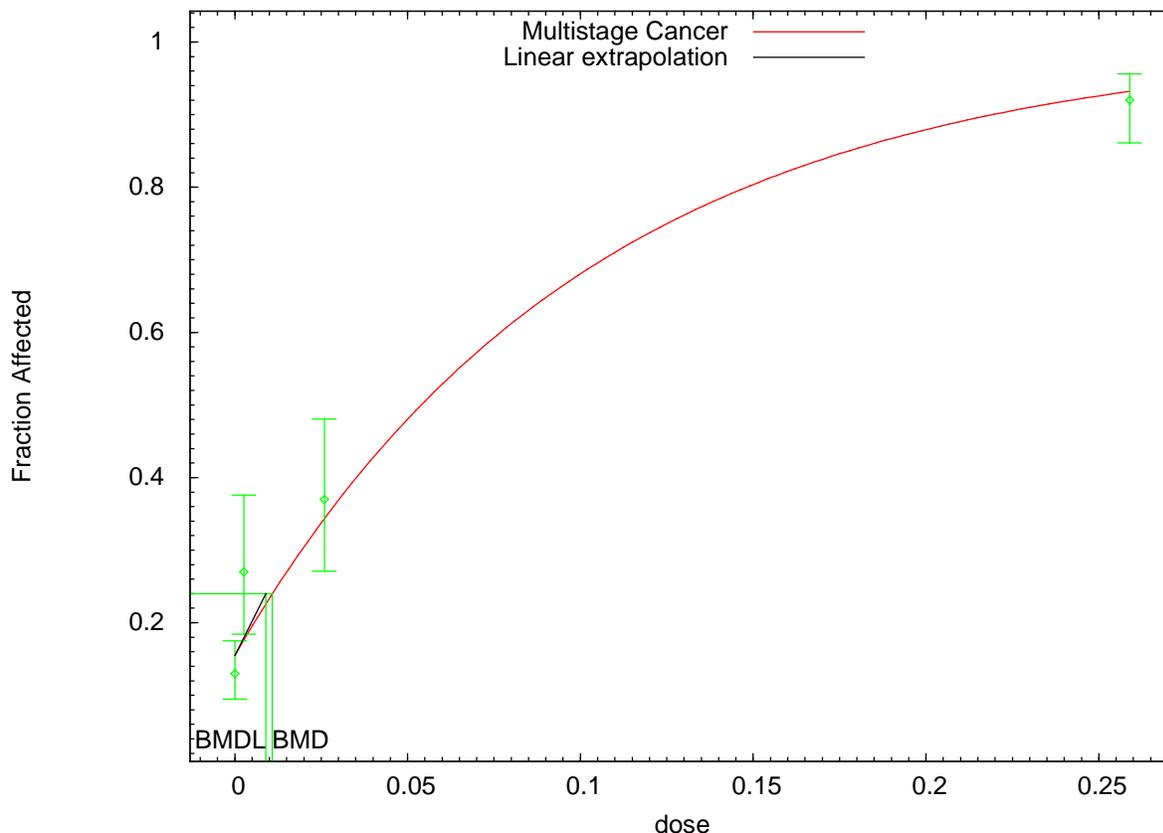
Multistage Cancer Slope Factor = 11.1299



TETRA TECH

132-Week Female Mouse Tumor Incidence Data from Walker 197 - First Run (Degree of Polynomial = 3):

Multistage Cancer Model with 0.95 Confidence Level



13:25 12/23 2010

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=====
Multistage Cancer Model. (Version: 1.9; Date: 05/26/2010)
Input Data File: C:/USEPA/BMDS212/Data/msc_UntitledData_Setting.(d)
Gnuplot Plotting File: C:/USEPA/BMDS212/Data/msc_UntitledData_Setting.plt
Thu Dec 23 13:25:10 2010
=====

```

BMDS_Model_Run

The form of the probability function is:

$$P[\text{response}] = \text{background} + (1-\text{background}) * [1 - \text{EXP}(-\text{beta1} * \text{dose} - \text{beta2} * \text{dose}^2 - \text{beta3} * \text{dose}^3)]$$

The parameter betas are restricted to be positive

Dependent variable = %_Tumors
Independent variable = Dose

Total number of observations = 4



TETRA TECH

Total number of records with missing values = 0
Total number of parameters in model = 4
Total number of specified parameters = 0
Degree of polynomial = 3

Maximum number of iterations = 250
Relative Function Convergence has been set to: 1e-008
Parameter Convergence has been set to: 1e-008

Default Initial Parameter Values

Background = 0.197577
Beta(1) = 8.91076
Beta(2) = 0
Beta(3) = 0

Asymptotic Correlation Matrix of Parameter Estimates

(*** The model parameter(s) -Beta(2) -Beta(3)
have been estimated at a boundary point, or have been specified by
the user,
and do not appear in the correlation matrix)

Table with 3 columns: Variable, Background, Beta(1). Rows: Background, Beta(1).

Parameter Estimates

Table with 5 columns: Variable, Estimate, Std. Err., Lower Conf. Limit, Upper Conf. Limit. Rows: Background, Beta(1), Beta(2), Beta(3).

* - Indicates that this value is not calculated.

Warning: Likelihood for the fitted model larger than the Likelihood for the full model.
Error in computing chi-square; returning 2

Analysis of Deviance Table

Table with 6 columns: Model, Log(likelihood), # Param's, Deviance, Test d.f., P-value. Rows: Full model, Fitted model, Reduced model, AIC.



TETRA TECH

Goodness of Fit

Dose	Est._Prob.	Expected	Observed	Size	Scaled Residual
0.0000	0.1553	46.112	38.610	297	-1.202
0.0026	0.1763	15.865	24.300	90	2.333
0.0259	0.3434	29.877	32.190	87	0.522
0.2590	0.9320	137.938	136.160	148	-0.581

Chi² = 7.50 d.f. = 2 P-value = 0.0235

Benchmark Dose Computation

Specified effect = 0.1

Risk Type = Extra risk

Confidence level = 0.95

BMD = 0.0108277

BMDL = 0.00898478

BMDU = 0.0160063

Taken together, (0.00898478, 0.0160063) is a 90 % two-sided confidence interval for the BMD

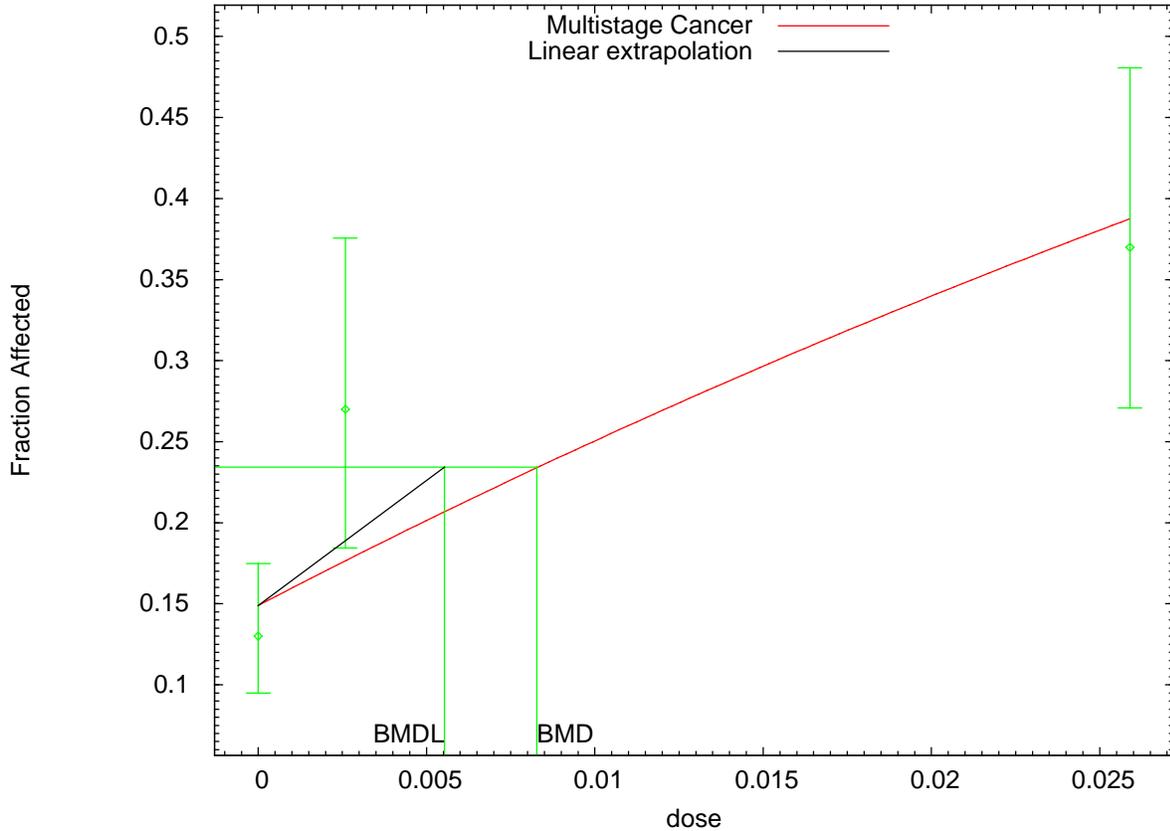
Multistage Cancer Slope Factor = 11.1299



TETRA TECH

132-Week Female Mouse Tumor Incidence Data from Walker 197 - Fourth Run (High Dose Excluded, Degree of Polynomial = 1):

Multistage Cancer Model with 0.95 Confidence Level



13:26 12/23 2010

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=====
Multistage Cancer Model. (Version: 1.9; Date: 05/26/2010)
Input Data File: C:/USEPA/BMDS212/Data/msc_UntitledData_Setting.(d)
Gnuplot Plotting File: C:/USEPA/BMDS212/Data/msc_UntitledData_Setting.plt
Thu Dec 23 13:26:16 2010
=====

```

BMDS_Model_Run

The form of the probability function is:

$$P[\text{response}] = \text{background} + (1-\text{background}) * [1 - \text{EXP}(-\text{beta}1 * \text{dose}^1)]$$

The parameter betas are restricted to be positive

Dependent variable = %_Tumors
Independent variable = Dose



TETRA TECH

Total number of observations = 3
Total number of records with missing values = 0
Total number of parameters in model = 2
Total number of specified parameters = 0
Degree of polynomial = 1

Maximum number of iterations = 250
Relative Function Convergence has been set to: 1e-008
Parameter Convergence has been set to: 1e-008

Default Initial Parameter Values

Background = 0.189465
Beta(1) = 10.0344

Asymptotic Correlation Matrix of Parameter Estimates

Table with 3 columns: Parameter, Background, Beta(1). Rows: Background, Beta(1). Values: 1, -0.44, -0.44, 1.

Parameter Estimates

Table with 5 columns: Variable, Estimate, Std. Err., Lower Conf. Limit, Upper Conf. Limit. Rows: Background, Beta(1). Includes asterisks for missing confidence intervals.

* - Indicates that this value is not calculated.

Analysis of Deviance Table

Table with 6 columns: Model, Log(likelihood), # Param's, Deviance, Test d.f., P-value. Rows: Full model, Fitted model, Reduced model, AIC.

Goodness of Fit

Table with 6 columns: Dose, Est._Prob., Expected, Observed, Size, Scaled Residual. Rows for doses 0.0000, 0.0026, 0.0259.

Chi^2 = 6.36 d.f. = 1 P-value = 0.0117



TETRA TECH

Benchmark Dose Computation

Specified effect = 0.1

Risk Type = Extra risk

Confidence level = 0.95

BMD = 0.00826961

BMDL = 0.00552865

BMDU = 0.0142487

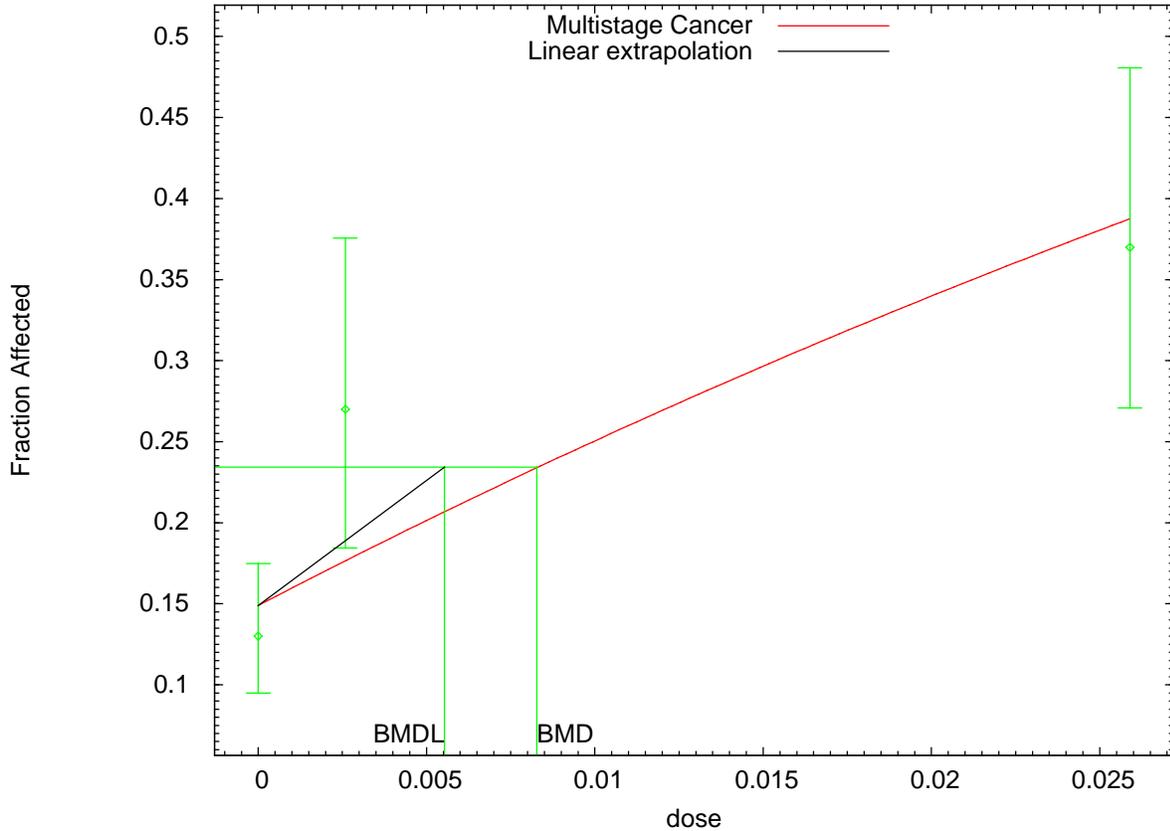
Taken together, (0.00552865, 0.0142487) is a 90 % two-sided confidence interval for the BMD

Multistage Cancer Slope Factor = 18.0876



132-Week Female Mouse Tumor Incidence Data from Walker 197 - Fifth Run (High Dose Excluded, Degree of Polynomial = 2):

Multistage Cancer Model with 0.95 Confidence Level



13:27 12/23 2010

```

=====
Multistage Cancer Model. (Version: 1.9; Date: 05/26/2010)
Input Data File: C:/USEPA/BMDS212/Data/msc_UntitledData_Setting.(d)
Gnuplot Plotting File: C:/USEPA/BMDS212/Data/msc_UntitledData_Setting.plt
Thu Dec 23 13:27:01 2010
=====

```

BMDS_Model_Run

The form of the probability function is:

$$P[\text{response}] = \text{background} + (1-\text{background}) * [1 - \text{EXP}(-\text{beta1} * \text{dose} - \text{beta2} * \text{dose}^2)]$$

The parameter betas are restricted to be positive

Dependent variable = %_Tumors
Independent variable = Dose



TETRA TECH

Total number of observations = 3
Total number of records with missing values = 0
Total number of parameters in model = 3
Total number of specified parameters = 0
Degree of polynomial = 2

Maximum number of iterations = 250
Relative Function Convergence has been set to: 1e-008
Parameter Convergence has been set to: 1e-008

Default Initial Parameter Values

Background = 0.189465
Beta(1) = 10.0344
Beta(2) = 0

Asymptotic Correlation Matrix of Parameter Estimates

(*** The model parameter(s) -Beta(2)
have been estimated at a boundary point, or have been specified by
the user,
and do not appear in the correlation matrix)

Table with 3 columns: Parameter, Background, Beta(1). Rows: Background, Beta(1).

Parameter Estimates

Table with 5 columns: Variable, Estimate, Std. Err., Lower Conf. Limit, Upper Conf. Limit. Rows: Background, Beta(1), Beta(2).

* - Indicates that this value is not calculated.

Analysis of Deviance Table

Table with 6 columns: Model, Log(likelihood), # Param's, Deviance, Test d.f., P-value. Rows: Full model, Fitted model, Reduced model, AIC.

Goodness of Fit

Table with 6 columns: Dose, Est._Prob., Expected, Observed, Size, Scaled Residual.



TETRA TECH

0.0000	0.1491	44.294	38.610	297	-0.926
0.0026	0.1768	15.908	24.300	90	2.319
0.0259	0.3882	33.778	32.190	87	-0.349

Chi² = 6.36 d.f. = 1 P-value = 0.0117

Benchmark Dose Computation

Specified effect = 0.1

Risk Type = Extra risk

Confidence level = 0.95

BMD = 0.00826961

BMDL = 0.00552865

BMDU = 0.0160351

Taken together, (0.00552865, 0.0160351) is a 90 % two-sided confidence interval for the BMD

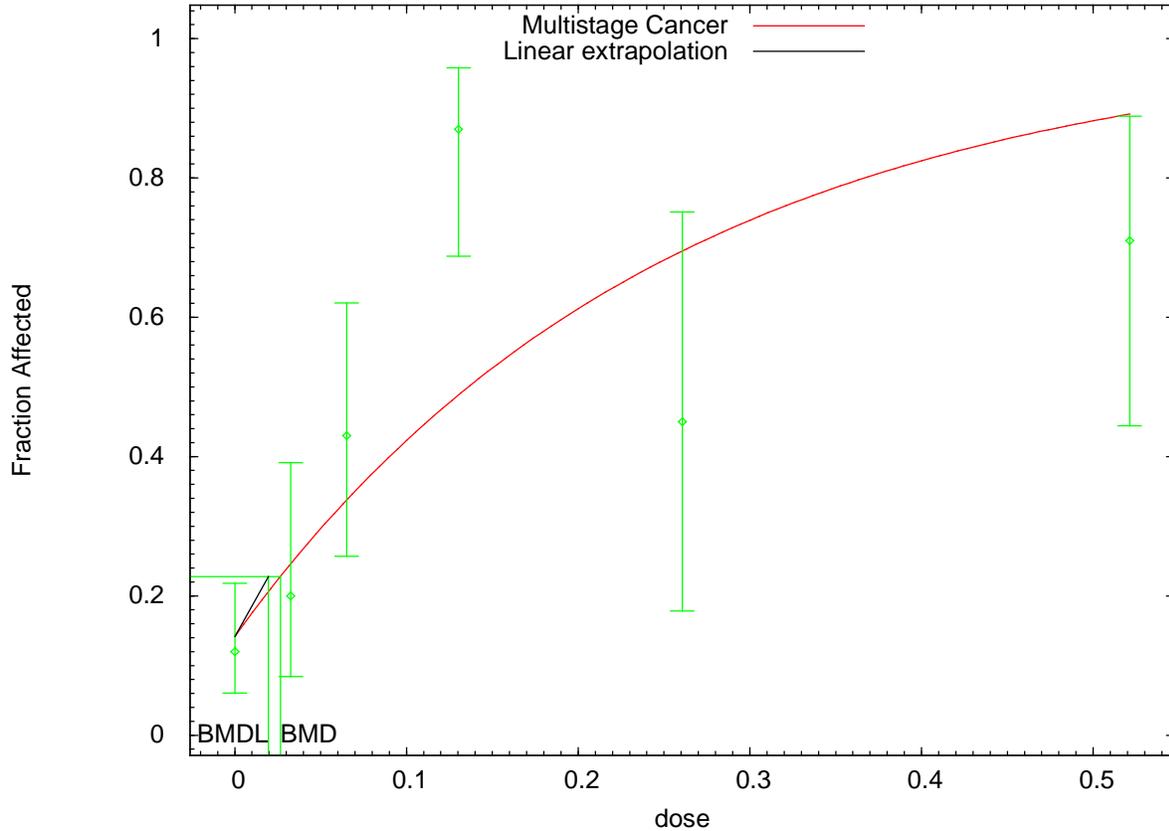
Multistage Cancer Slope Factor = 18.0876



TETRA TECH

128-Week Male Mouse Tumor Incidence Data from Walker 1972 – First set of Runs (Degree of Polynomial = 1, 2, 3, 4 produced exactly the same results):

Multistage Cancer Model with 0.95 Confidence Level



14:58 12/23 2010

```

=====
Multistage Cancer Model. (Version: 1.9; Date: 05/26/2010)
Input Data File: C:/USEPA/BMDS212/Data/msc_UntitledData_Setting.(d)
Gnuplot Plotting File: C:/USEPA/BMDS212/Data/msc_UntitledData_Setting.plt
Thu Dec 23 14:58:56 2010
=====

```

BMDS_Model_Run

The form of the probability function is:

$$P[\text{response}] = \text{background} + (1-\text{background}) * [1 - \text{EXP}(-\text{beta1} * \text{dose}^1 - \text{beta2} * \text{dose}^2)]$$

The parameter betas are restricted to be positive

Dependent variable = Percent_Tumors
Independent variable = Dose



TETRA TECH

Total number of observations = 6
Total number of records with missing values = 0
Total number of parameters in model = 3
Total number of specified parameters = 0
Degree of polynomial = 2

Maximum number of iterations = 250
Relative Function Convergence has been set to: 1e-008
Parameter Convergence has been set to: 1e-008

Default Initial Parameter Values

Background = 0.411936
Beta(1) = 1.5877
Beta(2) = 0

Asymptotic Correlation Matrix of Parameter Estimates

(*** The model parameter(s) -Beta(2)
have been estimated at a boundary point, or have been specified by
the user,
and do not appear in the correlation matrix)

Table with 3 columns: Parameter, Background, Beta(1). Rows: Background, Beta(1).

Parameter Estimates

Table with 5 columns: Variable, Estimate, Std. Err., Lower Conf. Limit, Upper Conf. Limit. Rows: Background, Beta(1), Beta(2).

* - Indicates that this value is not calculated.

Analysis of Deviance Table

Table with 6 columns: Model, Log(likelihood), # Param's, Deviance, Test d.f., P-value. Rows: Full model, Fitted model, Reduced model, AIC.

Goodness of Fit

Table with 6 columns: Dose, Est._Prob., Expected, Observed, Size, Scaled Residual.



TETRA TECH

0.0000	0.1417	11.049	9.360	78	-0.549
0.0326	0.2458	7.373	6.000	30	-0.582
0.0652	0.3372	10.117	12.900	30	1.075
0.1303	0.4882	14.647	26.100	30	4.183
0.2606	0.6949	7.644	4.950	11	-1.764
0.5213	0.8915	15.156	12.070	17	-2.407

Chi² = 28.20 d.f. = 4 P-value = 0.0000

Benchmark Dose Computation

Specified effect = 0.1

Risk Type = Extra risk

Confidence level = 0.95

BMD = 0.0265497

BMDL = 0.0195461

BMDU = 0.0388455

Taken together, (0.0195461, 0.0388455) is a 90 % two-sided confidence interval for the BMD

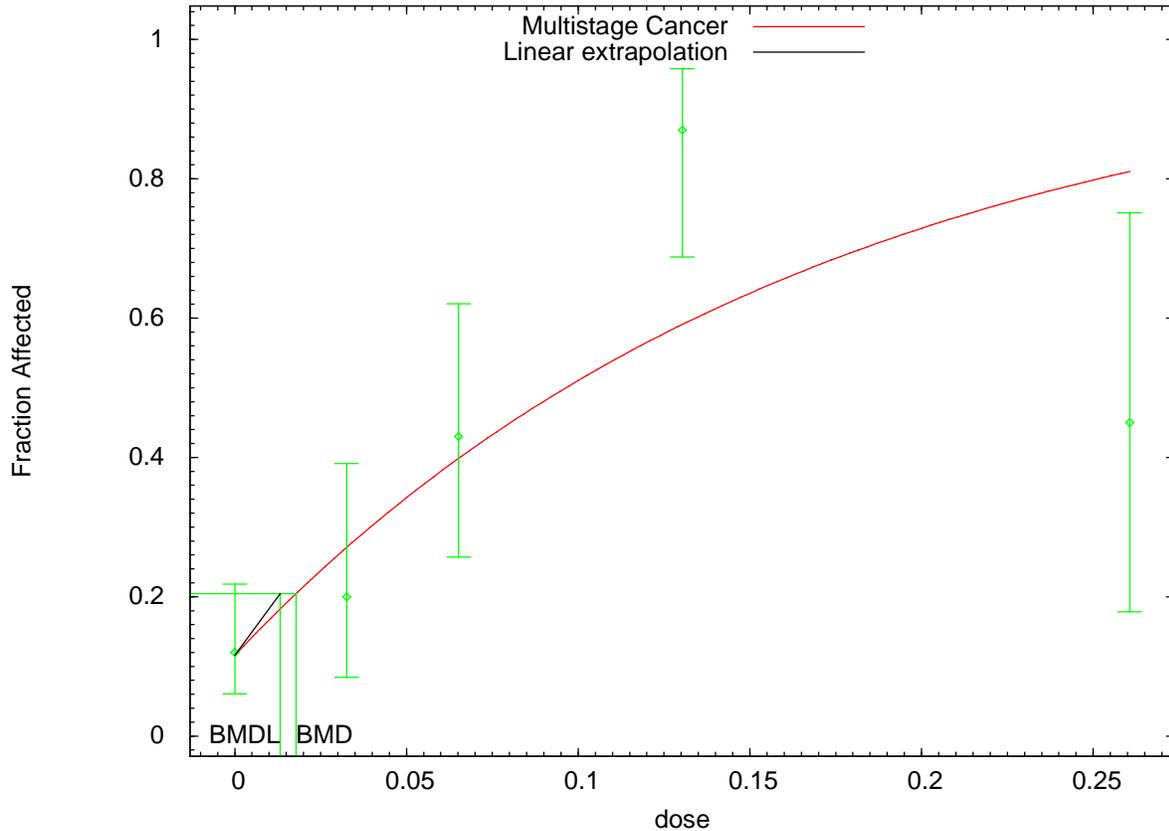
Multistage Cancer Slope Factor = 5.11612



TETRA TECH

128-Week Male Mouse Tumor Incidence Data from Walker 1972 – Second Set of Runs (Excluded top dose level; Degree of Polynomial = 1, 2, 3, 4 produced exactly the same results):

Multistage Cancer Model with 0.95 Confidence Level



15:03 12/23 2010

```

=====
Multistage Cancer Model. (Version: 1.9; Date: 05/26/2010)
Input Data File: C:/USEPA/BMDS212/Data/msc_Dieldrin Walker 73 male T2_Opt.(d)
Gnuplot Plotting File: C:/USEPA/BMDS212/Data/msc_Dieldrin Walker 73 male
T2_Opt.plt

```

Thu Dec 23 15:03:14 2010

=====

BMDS_Model_Run

~~~~~

The form of the probability function is:

$$P[\text{response}] = \text{background} + (1-\text{background}) * [1 - \text{EXP}(-\text{beta1} * \text{dose} - \text{beta2} * \text{dose}^2)]$$

The parameter betas are restricted to be positive

Dependent variable = Percent\_Tumors

Independent variable = Dose



TETRA TECH

Total number of observations = 5
Total number of records with missing values = 0
Total number of parameters in model = 3
Total number of specified parameters = 0
Degree of polynomial = 2

Maximum number of iterations = 250
Relative Function Convergence has been set to: 1e-008
Parameter Convergence has been set to: 1e-008

Default Initial Parameter Values

Background = 0.354288
Beta(1) = 2.79145
Beta(2) = 0

Asymptotic Correlation Matrix of Parameter Estimates

( \*\*\* The model parameter(s) -Beta(2)
have been estimated at a boundary point, or have been specified by
the user,
and do not appear in the correlation matrix )

Table with 3 columns: Parameter, Background, Beta(1). Rows: Background, Beta(1).

Parameter Estimates

Table with 5 columns: Variable, Estimate, Std. Err., Lower Conf. Limit, Upper Conf. Limit. Rows: Background, Beta(1), Beta(2).

\* - Indicates that this value is not calculated.

Analysis of Deviance Table

Table with 6 columns: Model, Log(likelihood), # Param's, Deviance, Test d.f., P-value. Rows: Full model, Fitted model, Reduced model, AIC.

Goodness of Fit

Scaled



TETRA TECH

| Dose   | Est._Prob. | Expected | Observed | Size | Residual |
|--------|------------|----------|----------|------|----------|
| 0.0000 | 0.1158     | 9.030    | 9.360    | 78   | 0.117    |
| 0.0326 | 0.2706     | 8.118    | 6.000    | 30   | -0.870   |
| 0.0652 | 0.3983     | 11.950   | 12.900   | 30   | 0.354    |
| 0.1303 | 0.5906     | 17.718   | 26.100   | 30   | 3.112    |
| 0.2606 | 0.8104     | 8.915    | 4.950    | 11   | -3.050   |

Chi<sup>2</sup> = 19.88      d.f. = 3      P-value = 0.0002

Benchmark Dose Computation

Specified effect = 0.1

Risk Type = Extra risk

Confidence level = 0.95

BMD = 0.0178307

BMDL = 0.0132328

BMDU = 0.0256235

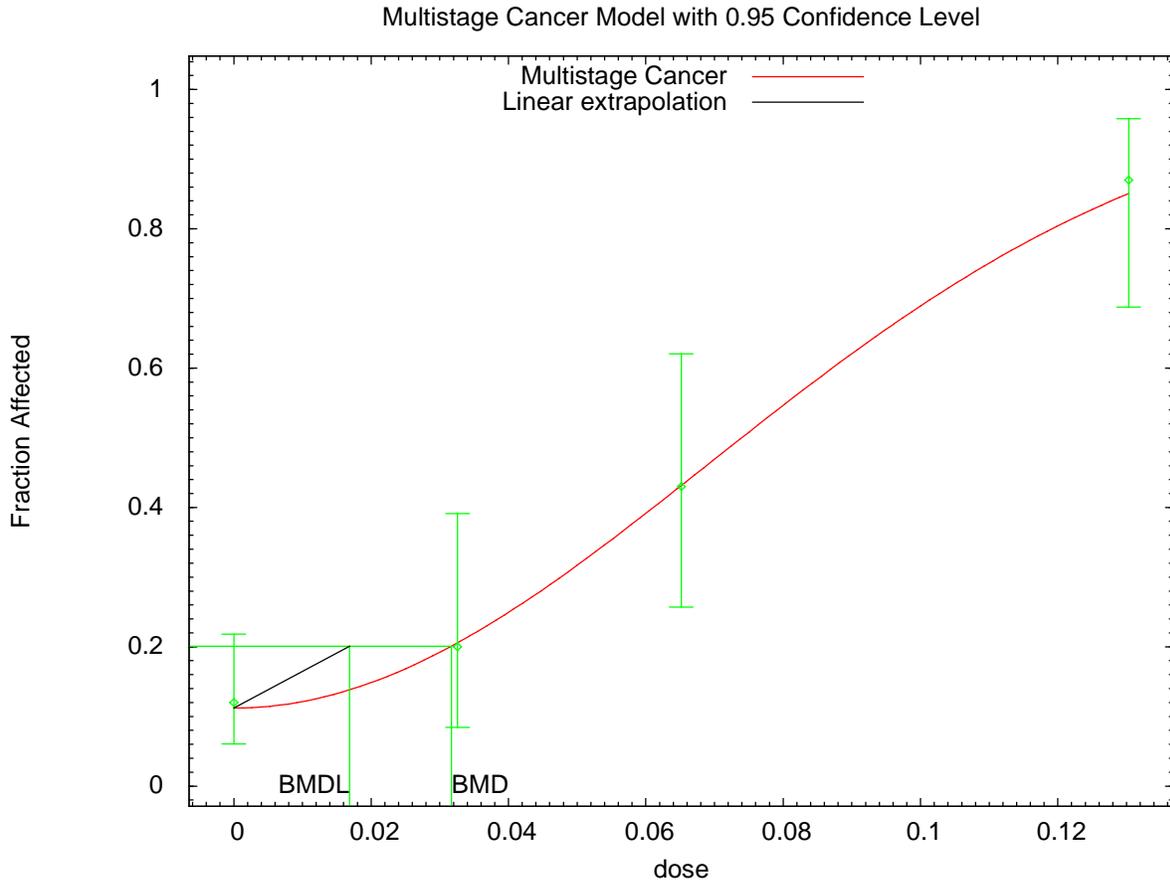
Taken together, (0.0132328, 0.0256235) is a 90 % two-sided confidence interval for the BMD

Multistage Cancer Slope Factor = 7.55696



TETRA TECH

128-Week Male Mouse Tumor Incidence Data from Walker 1972 – Second Set of Runs (Excluded top two dose levels; Degree of Polynomial = 2 or 3 produced exactly the same results):



15:06 12/23 2010

```

=====
Multistage Cancer Model. (Version: 1.9; Date: 05/26/2010)
Input Data File: C:/USEPA/BMDS212/Data/msc_Dieldrin Walker 73 male T2_Opt.(d)
Gnuplot Plotting File: C:/USEPA/BMDS212/Data/msc_Dieldrin Walker 73 male
T2_Opt.plt

```

Thu Dec 23 15:06:02 2010

BMDS\_Model\_Run

The form of the probability function is:

$$P[\text{response}] = \text{background} + (1-\text{background}) * [1 - \text{EXP}(-\text{beta1} * \text{dose} - \text{beta2} * \text{dose}^2)]$$

The parameter betas are restricted to be positive

Dependent variable = Percent\_Tumors



TETRA TECH

Independent variable = Dose

Total number of observations = 4
Total number of records with missing values = 0
Total number of parameters in model = 3
Total number of specified parameters = 0
Degree of polynomial = 2

Maximum number of iterations = 250
Relative Function Convergence has been set to: 1e-008
Parameter Convergence has been set to: 1e-008

Default Initial Parameter Values

Background = 0.100352
Beta(1) = 0
Beta(2) = 113.516

Asymptotic Correlation Matrix of Parameter Estimates

( \*\*\* The model parameter(s) -Beta(1)
have been estimated at a boundary point, or have been specified by
the user,
and do not appear in the correlation matrix )

Table with 2 columns: Parameter, Correlation. Rows: Background, Beta(2).

Parameter Estimates

Table with 5 columns: Variable, Estimate, Std. Err., Lower Conf. Limit, Upper Conf. Limit. Rows: Background, Beta(1), Beta(2).

\* - Indicates that this value is not calculated.

Warning: Likelihood for the fitted model larger than the Likelihood for the full model.
Error in computing chi-square; returning 2

Analysis of Deviance Table

Table with 6 columns: Model, Log(likelihood), # Param's, Deviance, Test d.f., P-value. Rows: Full model, Fitted model, Reduced model.

AIC: 153.953



TETRA TECH

Goodness of Fit

| Dose   | Est._Prob. | Expected | Observed | Size | Scaled Residual |
|--------|------------|----------|----------|------|-----------------|
| 0.0000 | 0.1120     | 8.737    | 9.360    | 78   | 0.224           |
| 0.0326 | 0.2054     | 6.163    | 6.000    | 30   | -0.074          |
| 0.0652 | 0.4308     | 12.923   | 12.900   | 30   | -0.009          |
| 0.1303 | 0.8501     | 25.502   | 26.100   | 30   | 0.306           |

Chi<sup>2</sup> = 0.15      d.f. = 2      P-value = 0.9282

Benchmark Dose Computation

Specified effect = 0.1

Risk Type = Extra risk

Confidence level = 0.95

BMD = 0.0317161

BMDL = 0.0168577

BMDU = 0.0379934

Taken together, (0.0168577, 0.0379934) is a 90 % two-sided confidence interval for the BMD

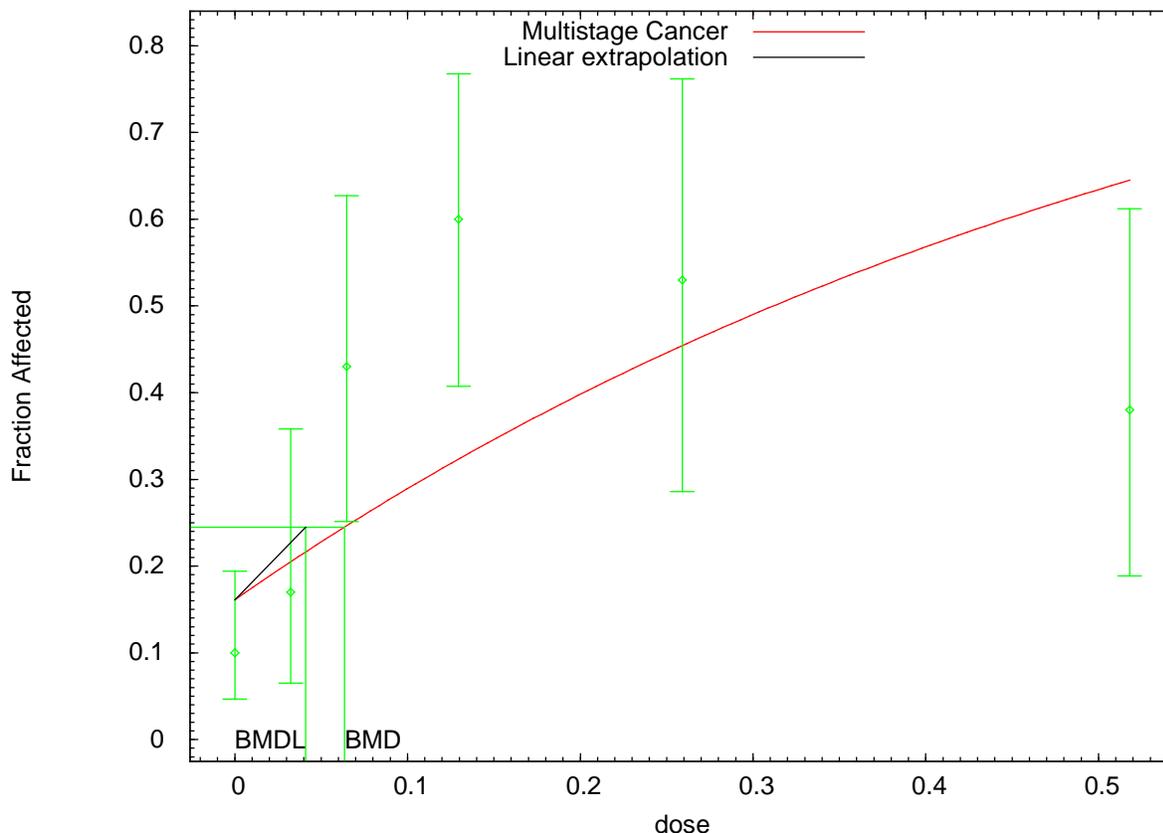
Multistage Cancer Slope Factor = 5.932



TETRA TECH

128-Week Female Mouse Tumor Incidence Data from Walker 1972 – First set of Runs (Degree of Polynomial = 1, 2, 3, 4 produced exactly the same results):

Multistage Cancer Model with 0.95 Confidence Level



13:57 12/23 2010

```

=====
Multistage Cancer Model. (Version: 1.9; Date: 05/26/2010)
Input Data File: C:/USEPA/BMDS212/Data/msc_UntitledData_Setting.(d)
Gnuplot Plotting File: C:/USEPA/BMDS212/Data/msc_UntitledData_Setting.plt
Thu Dec 23 13:57:47 2010
=====

```

BMDS\_Model\_Run

The form of the probability function is:

$$P[\text{response}] = \text{background} + (1-\text{background}) * [1 - \text{EXP}(-\text{beta}1 * \text{dose}^1)]$$

The parameter betas are restricted to be positive

Dependent variable = %\_Tumors  
 Independent variable = Dose

Total number of observations = 6



TETRA TECH

Total number of records with missing values = 0
Total number of parameters in model = 2
Total number of specified parameters = 0
Degree of polynomial = 1

Maximum number of iterations = 250
Relative Function Convergence has been set to: 1e-008
Parameter Convergence has been set to: 1e-008

Default Initial Parameter Values

Background = 0.336733
Beta(1) = 0.537666

Asymptotic Correlation Matrix of Parameter Estimates

Table with 3 columns: Parameter, Background, Beta(1). Rows: Background, Beta(1). Values: 1, -0.65, -0.65, 1.

Parameter Estimates

Table with 5 columns: Interval, Variable, Estimate, Std. Err., 95.0% Wald Confidence (Lower Conf. Limit, Upper Conf. Limit). Rows: Background, Beta(1).

\* - Indicates that this value is not calculated.

Analysis of Deviance Table

Table with 6 columns: Model, Log(likelihood), # Param's, Deviance, Test d.f., P-value. Rows: Full model, Fitted model, Reduced model.

AIC: 233.07

Goodness of Fit

Table with 6 columns: Dose, Est.\_Prob., Expected, Observed, Size, Scaled Residual. Rows: 0.0000, 0.0324, 0.0648, 0.1295, 0.2590, 0.5181.



TETRA TECH

Chi<sup>2</sup> = 24.78

d.f. = 4

P-value = 0.0001

Benchmark Dose Computation

Specified effect = 0.1

Risk Type = Extra risk

Confidence level = 0.95

BMD = 0.063535

BMDL = 0.041045

BMDU = 0.123955

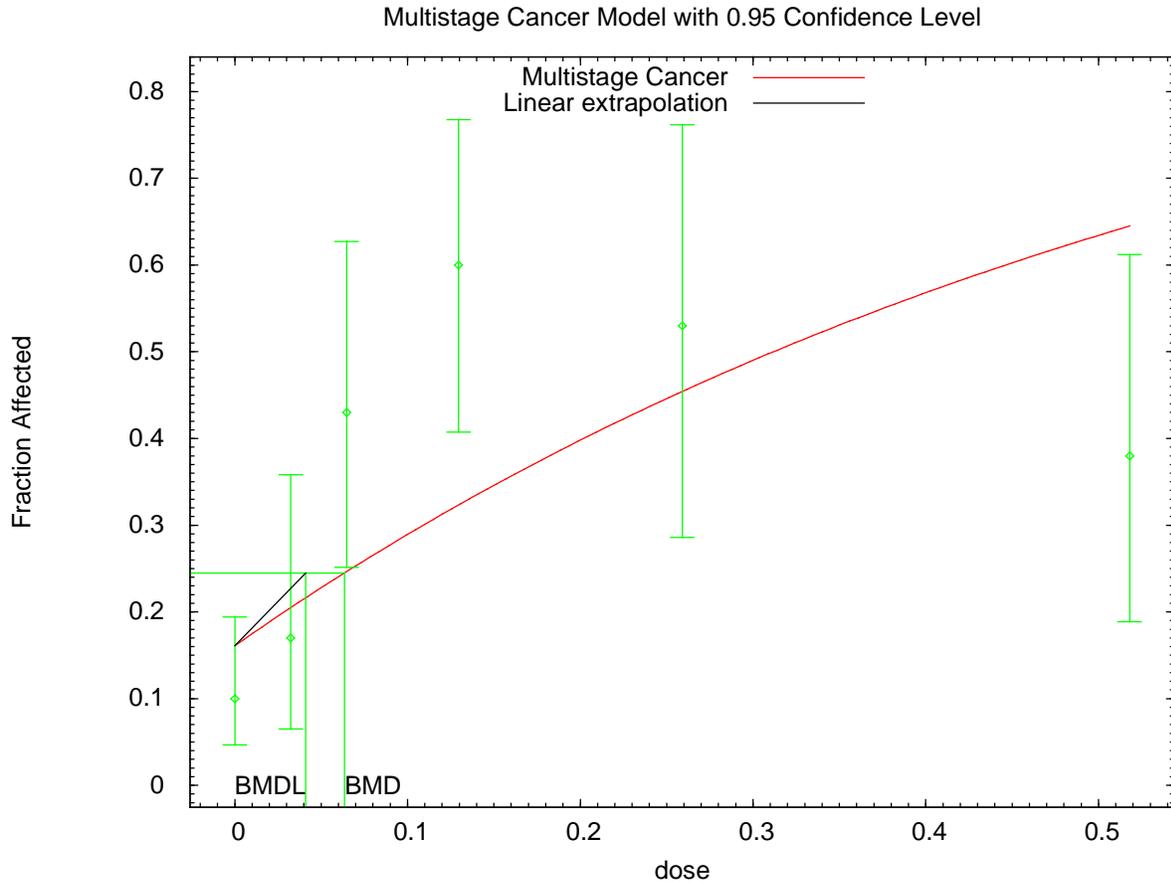
Taken together, (0.041045, 0.123955) is a 90 % two-sided confidence interval for the BMD

Multistage Cancer Slope Factor = 2.43635



TETRA TECH

128-Week Female Mouse Tumor Incidence Data from Walker 1972 – Second set of Runs (Highest dose level excluded; Degree of Polynomial = 2 or 3 produced exactly the same results):



14:21 12/23 2010

```

=====
Multistage Cancer Model. (Version: 1.9; Date: 05/26/2010)
Input Data File: C:/USEPA/BMDS212/Data/msc_Dieldrin Walker 73 fem T2_Opt.(d)
Gnuplot Plotting File: C:/USEPA/BMDS212/Data/msc_Dieldrin Walker 73 fem
T2_Opt.plt

```

Thu Dec 23 14:15:10 2010

BMDS\_Model\_Run

The form of the probability function is:

$$P[\text{response}] = \text{background} + (1-\text{background}) * [1 - \text{EXP}(-\text{beta1} * \text{dose} - \text{beta2} * \text{dose}^2 - \text{beta3} * \text{dose}^3)]$$

The parameter betas are restricted to be positive

Dependent variable = Percent\_Tumors



TETRA TECH

Independent variable = Dose

Total number of observations = 5
Total number of records with missing values = 0
Total number of parameters in model = 4
Total number of specified parameters = 0
Degree of polynomial = 3

Maximum number of iterations = 250
Relative Function Convergence has been set to: 1e-008
Parameter Convergence has been set to: 1e-008

Default Initial Parameter Values

Background = 0.21884
Beta(1) = 2.65653
Beta(2) = 0
Beta(3) = 0

Asymptotic Correlation Matrix of Parameter Estimates

( \*\*\* The model parameter(s) -Beta(2) -Beta(3)
have been estimated at a boundary point, or have been specified by
the user,
and do not appear in the correlation matrix )

Table with 3 columns: Parameter, Background, Beta(1). Rows: Background, Beta(1).

Parameter Estimates

Table with 5 columns: Variable, Estimate, Std. Err., Lower Conf. Limit, Upper Conf. Limit. Rows: Background, Beta(1), Beta(2), Beta(3).

\* - Indicates that this value is not calculated.

Analysis of Deviance Table

Table with 6 columns: Model, Log(likelihood), # Param's, Deviance, Test d.f., P-value. Rows: Full model, Fitted model, Reduced model, AIC.



TETRA TECH

Goodness of Fit

| Dose   | Est._Prob. | Expected | Observed | Size | Scaled Residual |
|--------|------------|----------|----------|------|-----------------|
| 0.0000 | 0.0950     | 7.410    | 7.800    | 78   | 0.150           |
| 0.0324 | 0.2189     | 6.566    | 5.100    | 30   | -0.647          |
| 0.0648 | 0.3258     | 9.122    | 12.040   | 28   | 1.177           |
| 0.1295 | 0.4977     | 14.932   | 18.000   | 30   | 1.120           |
| 0.2590 | 0.7212     | 12.261   | 9.010    | 17   | -1.758          |

Chi<sup>2</sup> = 6.17      d.f. = 3      P-value = 0.1035

Benchmark Dose Computation

Specified effect = 0.1

Risk Type = Extra risk

Confidence level = 0.95

BMD = 0.0231772

BMDL = 0.0169973

BMDU = 0.034489

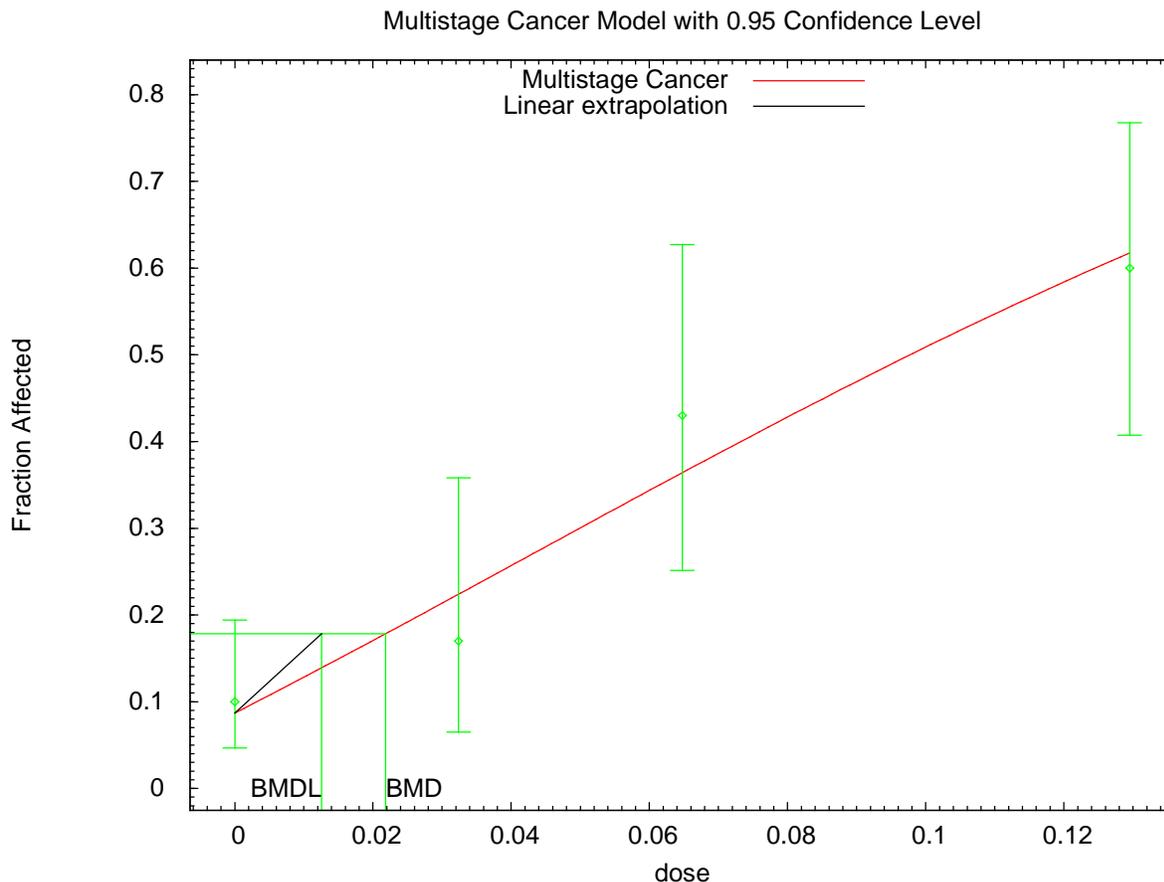
Taken together, (0.0169973, 0.034489) is a 90 % two-sided confidence interval for the BMD

Multistage Cancer Slope Factor = 5.8833



TETRA TECH

128-Week Female Mouse Tumor Incidence Data from Walker 1972 – Third set of Runs (Highest two dose levels excluded; Degree of Polynomial = 2 or 3 produced exactly the same results):



14:32 12/23 2010

```

=====
Multistage Cancer Model. (Version: 1.9; Date: 05/26/2010)
Input Data File: C:/USEPA/BMDS212/Data/msc_Dieldrin Walker 73 fem T2_Opt.(d)
Gnuplot Plotting File: C:/USEPA/BMDS212/Data/msc_Dieldrin Walker 73 fem
T2_Opt.plt

```

Thu Dec 23 14:10:14 2010

BMDS\_Model\_Run

The form of the probability function is:

$$P[\text{response}] = \text{background} + (1-\text{background}) * [1 - \text{EXP}(-\text{beta1} * \text{dose}^1 - \text{beta2} * \text{dose}^2 - \text{beta3} * \text{dose}^3)]$$

The parameter betas are restricted to be positive



TETRA TECH

Dependent variable = Percent\_Tumors
Independent variable = Dose

Total number of observations = 4
Total number of records with missing values = 0
Total number of parameters in model = 4
Total number of specified parameters = 0
Degree of polynomial = 3

Maximum number of iterations = 250
Relative Function Convergence has been set to: 1e-008
Parameter Convergence has been set to: 1e-008

Default Initial Parameter Values
Background = 0.0679795
Beta(1) = 6.40557
Beta(2) = 1.66277
Beta(3) = 0

Asymptotic Correlation Matrix of Parameter Estimates

( \*\*\* The model parameter(s) -Beta(3)
have been estimated at a boundary point, or have been specified by
the user,
and do not appear in the correlation matrix )

Table with 4 columns: Parameter, Background, Beta(1), Beta(2). Rows: Background, Beta(1), Beta(2).

Parameter Estimates

Table with 5 columns: Variable, Estimate, Std. Err., Lower Conf. Limit, Upper Conf. Limit. Rows: Background, Beta(1), Beta(2), Beta(3).

\* - Indicates that this value is not calculated.

Warning: Likelihood for the fitted model larger than the Likelihood for the full model.
Error in computing chi-square; returning 2

Analysis of Deviance Table

Table with 5 columns: Model, Log(likelihood), # Param's, Deviance, Test d.f., P-value



TETRA TECH

|               |          |   |          |   |        |
|---------------|----------|---|----------|---|--------|
| Full model    | -78.3562 | 4 |          |   |        |
| Fitted model  | -76.6989 | 3 | -3.31463 | 1 | 2      |
| Reduced model | -94.8966 | 1 | 33.0807  | 3 | <.0001 |

AIC: 159.398

Goodness of Fit

| Dose   | Est._Prob. | Expected | Observed | Size | Scaled Residual |
|--------|------------|----------|----------|------|-----------------|
| 0.0000 | 0.0870     | 6.783    | 7.800    | 78   | 0.409           |
| 0.0324 | 0.2237     | 6.712    | 5.100    | 30   | -0.706          |
| 0.0648 | 0.3638     | 10.185   | 12.040   | 28   | 0.729           |
| 0.1295 | 0.6171     | 18.513   | 18.000   | 30   | -0.193          |

Chi^2 = 1.23      d.f. = 1      P-value = 0.2667

Benchmark Dose Computation

Specified effect = 0.1  
Risk Type = Extra risk  
Confidence level = 0.95  
BMD = 0.0218267  
BMDL = 0.0125613  
BMDU = 0.0477172

Taken together, (0.0125613, 0.0477172) is a 90 % two-sided confidence interval for the BMD

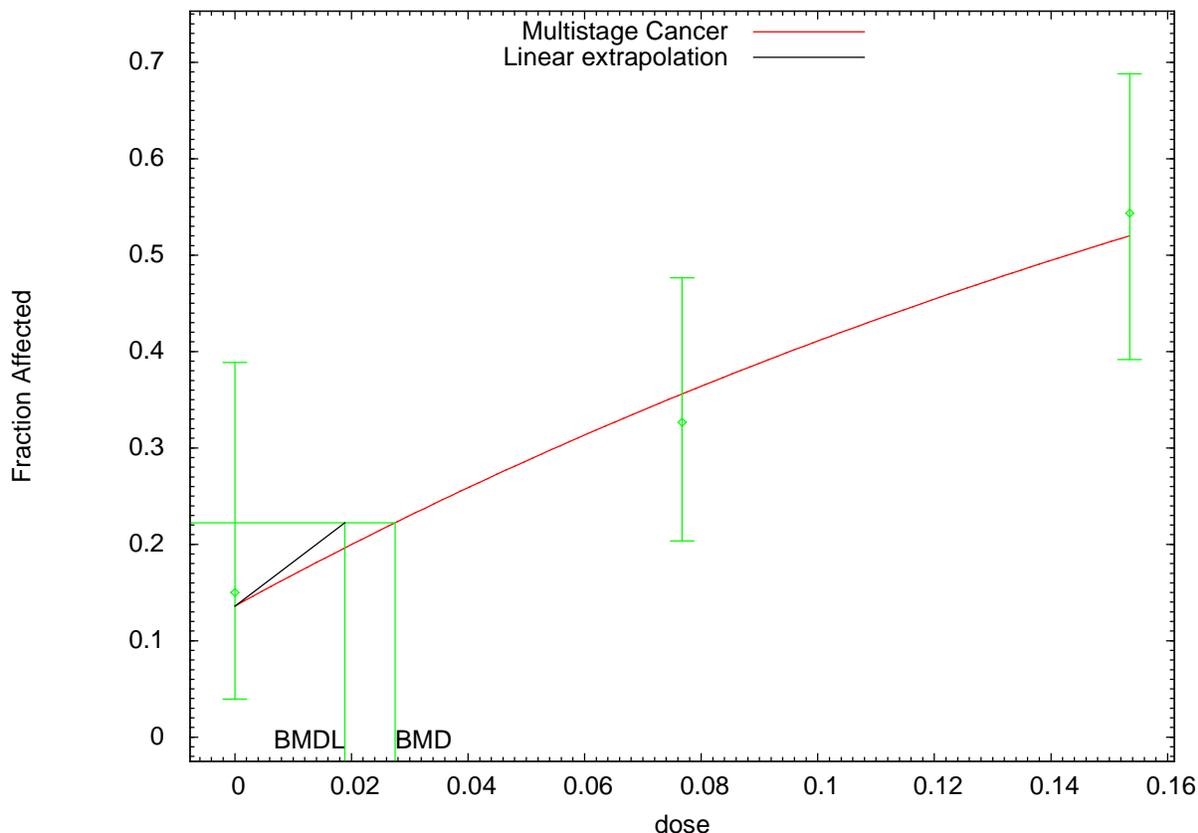
Multistage Cancer Slope Factor = 7.96094



TETRA TECH

### 80-Week Male Mouse Tumor Incidence Data from NCI 1978 – First Run (Degree of Polynomial = 1):

Multistage Cancer Model with 0.95 Confidence Level



09:02 12/20 2010

```

=====
Multistage Cancer Model. (Version: 1.9; Date: 05/26/2010)
Input Data File: C:/USEPA/BMDS212/Data/msc_UntitledData_Setting.(d)
Gnuplot Plotting File: C:/USEPA/BMDS212/Data/msc_UntitledData_Setting.plt
Mon Dec 20 09:02:20 2010
=====

```

BMDS\_Model\_Run

The form of the probability function is:

$$P[\text{response}] = \text{background} + (1-\text{background}) * [1 - \text{EXP}(-\text{beta}1 * \text{dose}^1)]$$

The parameter betas are restricted to be positive

Dependent variable = Tumor\_Incidence  
Independent variable = Dose

Total number of observations = 3



TETRA TECH

Total number of records with missing values = 0
Total number of parameters in model = 2
Total number of specified parameters = 0
Degree of polynomial = 1

Maximum number of iterations = 250
Relative Function Convergence has been set to: 1e-008
Parameter Convergence has been set to: 1e-008

Default Initial Parameter Values

Background = 0.127617
Beta(1) = 4.04956

Asymptotic Correlation Matrix of Parameter Estimates

Table with 3 columns: Parameter, Background, Beta(1). Rows: Background, Beta(1). Values: 1, -0.81, -0.81, 1.

Parameter Estimates

Table with 5 columns: Variable, Estimate, Std. Err., Lower Conf. Limit, Upper Conf. Limit. Rows: Background, Beta(1). Includes 95.0% Wald Confidence interval.

\* - Indicates that this value is not calculated.

Analysis of Deviance Table

Table with 6 columns: Model, Log(likelihood), # Param's, Deviance, Test d.f., P-value. Rows: Full model, Fitted model, Reduced model.

AIC: 146.558

Goodness of Fit

Table with 6 columns: Dose, Est.\_Prob., Expected, Observed, Size, Scaled Residual. Rows: 0.0000, 0.0767, 0.1535.

Chi^2 = 0.32 d.f. = 1 P-value = 0.5714



TETRA TECH

Benchmark Dose Computation

Specified effect = 0.1

Risk Type = Extra risk

Confidence level = 0.95

BMD = 0.027485

BMDL = 0.0188779

BMDU = 0.0526374

Taken together, (0.0188779, 0.0526374) is a 90 % two-sided confidence interval for the BMD

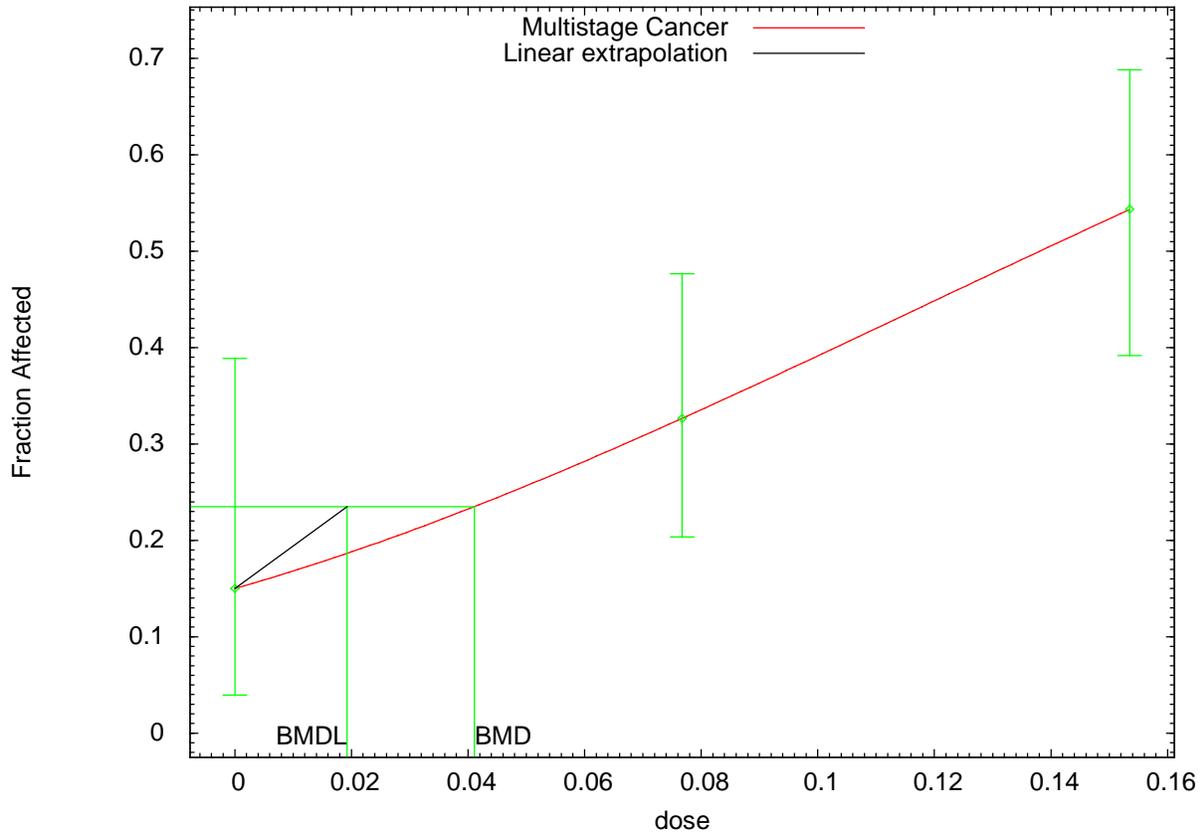
Multistage Cancer Slope Factor = 5.29719



TETRA TECH

80-Week Male Mouse Tumor Incidence Data from NCI 1978 – Second Run (Degree of Polynomial = 2):

Multistage Cancer Model with 0.95 Confidence Level



09:05 12/20 2010

```

=====
Multistage Cancer Model. (Version: 1.9; Date: 05/26/2010)
Input Data File: C:/USEPA/BMDS212/Data/msc_UntitledData_Setting.(d)
Gnuplot Plotting File: C:/USEPA/BMDS212/Data/msc_UntitledData_Setting.plt
Mon Dec 20 09:05:48 2010
=====

```

BMDS\_Model\_Run

The form of the probability function is:

$$P[\text{response}] = \text{background} + (1-\text{background}) * [1 - \text{EXP}(-\text{beta1} * \text{dose} - \text{beta2} * \text{dose}^2)]$$

The parameter betas are restricted to be positive

Dependent variable = Tumor\_Incidence  
Independent variable = Dose



TETRA TECH

Total number of observations = 3  
 Total number of records with missing values = 0  
 Total number of parameters in model = 3  
 Total number of specified parameters = 0  
 Degree of polynomial = 2

Maximum number of iterations = 250  
 Relative Function Convergence has been set to: 1e-008  
 Parameter Convergence has been set to: 1e-008

Default Initial Parameter Values

Background = 0.15  
 Beta(1) = 2.01783  
 Beta(2) = 13.2357

Asymptotic Correlation Matrix of Parameter Estimates

|            | Background | Beta(1) | Beta(2) |
|------------|------------|---------|---------|
| Background | 1          | -0.71   | 0.51    |
| Beta(1)    | -0.71      | 1       | -0.95   |
| Beta(2)    | 0.51       | -0.95   | 1       |

Parameter Estimates

|          |            | 95.0% Wald Confidence |           |                   |                   |
|----------|------------|-----------------------|-----------|-------------------|-------------------|
| Interval | Variable   | Estimate              | Std. Err. | Lower Conf. Limit | Upper Conf. Limit |
| Limit    | Background | 0.15                  | *         | *                 | *                 |
|          | Beta(1)    | 2.01783               | *         | *                 | *                 |
|          | Beta(2)    | 13.2357               | *         | *                 | *                 |

\* - Indicates that this value is not calculated.

Error in computing chi-square; returning 2

Analysis of Deviance Table

| Model         | Log(likelihood) | # Param's | Deviance | Test d.f. | P-value |
|---------------|-----------------|-----------|----------|-----------|---------|
| Full model    | -71.1178        | 3         |          |           |         |
| Fitted model  | -71.1178        | 3         | 0        | 0         | NA      |
| Reduced model | -76.5126        | 1         | 10.7895  | 2         | 0.00454 |
| AIC:          | 148.236         |           |          |           |         |

Goodness of Fit

| Dose   | Est._Prob. | Expected | Observed | Size | Scaled Residual |
|--------|------------|----------|----------|------|-----------------|
| 0.0000 | 0.1500     | 3.000    | 3.000    | 20   | 0.000           |



TETRA TECH

|        |        |        |        |    |       |
|--------|--------|--------|--------|----|-------|
| 0.0767 | 0.3265 | 16.000 | 16.000 | 49 | 0.000 |
| 0.1535 | 0.5435 | 25.000 | 25.000 | 46 | 0.000 |

Chi<sup>2</sup> = 0.00      d.f. = 0      P-value =      NA

Benchmark Dose Computation

Specified effect =            0.1

Risk Type            =        Extra risk

Confidence level =            0.95

BMD =            0.0411225

BMDL =           0.0192542

BMDU =           0.0887233

Taken together, (0.0192542, 0.0887233) is a 90 % two-sided confidence interval for the BMD

Multistage Cancer Slope Factor =            5.19367



## Appendix B – Epidemiologic Studies

The following tables summarize the epidemiologic studies assessing health effects from exposure to aldrin and dieldrin. PubMed was searched for studies published after the 1987 EPA review and not included in the 2002 ATSDR review. Thirty seven studies were identified and assessed. Table 1 contains studies assessing cancer outcomes while Table 2 reviews non-cancer outcomes.

*Table 1- Cancer Studies*

| Study                | Type             | Size/<br>Population                                                                                                                                       | Methods                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | Exposure                                          | Outcome         | Results                                                                                                                                                                                                                                                                                                                                                                                                                   | Notes                                                                                                                                                                              |
|----------------------|------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------|-----------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Belpomme et al. 2009 | Ecological Study | All prostate cancer cases diagnosed between 1995 and 2002 in Guadeloupe and between 1983 and 2002 in Martinique; 2104 cases and 4613 cases, respectively. | Data was collected from the Martinique cancer registry by the Martinique Association for Epidemiological Research on Cancer (AMREC) and data published by urologists at the University Hospital of Pointe-a-Pitre in Guadeloupe. Metropolitan France was used as a comparison by employing data from the French National Cancer Registry. For international comparison, incidence rates from Globocan 2002 (IARC) were used. Mapping was used to correlate the localization of prostate cancer with banana plantations on Martinique and Guadeloupe. | Pesticide use and concentration in adipose tissue | Prostate cancer | Through mapping analysis of soil contamination, the authors found that water contamination from pesticides comes from the banana plantations. The researchers retrospectively proved that a population of individuals examined in 1972 in Martinique for the presence of OC pesticides in their adipose tissue had been contaminated by very high amounts of DDT, DDE, alpha, beta and gamma HCH and aldrin and dieldrin. | Most of the banana plantations are located in the Northern part of the islands. However, the highest prostate cancer incidence rates were in the South-Western part of the island. |

Appendix B- Epidemiologic Studies (Table 1. Cancer)



| Study                                 | Type            | Size/<br>Population                                      | Methods                                                                                                                                                                                                                                                                                                                                                                                                                                                      | Exposure                                                                                                                                                                                | Outcome                               | Results                                                                                                                                                        | Notes                                                                  |
|---------------------------------------|-----------------|----------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------|
| Buczynska & Szadkowska -Stanczyk 2005 | Risk Assessment | 900<br>Inhabitants within 1.5km of 2 Polish dumpsites    | 286 Polish dumpsites were prioritized by their potential hazard, the amount of pesticides dumped there, proximity to residential areas and drinking water intake. The two sites selected had piezometric systems to allow for ground water sampling. 31 different pesticides were detected in ground water. Mean pesticide concentrations in ground water was used to calculate daily intake. Population data was collected from local administration units. | Daily pesticide intake from drinking water                                                                                                                                              | Estimated cancer and non-cancer risks | Dieldrin was detected in water samples but not above the 0.1 ug/l drinking water standard and was not included in the risk estimates. Aldrin was not detected. |                                                                        |
| Cantor et al. 2003                    | Case control    | 74 Non-Hodgkin's Lymphoma cases and 147 matched controls | Serum samples were collected from 25,802 individuals participating in Campaign Against Cancer and Stroke in Washington County, MD in 1974. The samples were cryopreserved so they could be studied in the future. Incident cases of NHL were identified using the Washington County Cancer Registry. Two controls were matched for every one case of NHL.                                                                                                    | Pre-diagnostic levels of chlordane, lindane, beta-hexachlorocyclohexane, transnonachlor, heptachlor, heptachlor epoxide, oxychlorodane, dieldrin and hexachlorobenzene in serum samples | Non-Hodgkin's Lymphoma                | Researchers found no evidence of an association between NHL and serum levels of any of the chemicals that were evaluated.                                      |                                                                        |
| Clary & Ritz 2003                     | Ecological      | 950 pancreatic cancer death cases and                    | Cases were identified from computerized California Death Tape Files living within three selected counties and deaths                                                                                                                                                                                                                                                                                                                                         | Exposure to 18 organochlorine pesticides was determined from usage                                                                                                                      | Death from pancreatic cancer          | A total of 20.15 tons of dieldrin was applied in 48 of 102 zip codes. The highest quartile ranged from 0.32 to 4.43 tons.                                      | No assessment of aldrin. Analysis controlled for age, race, education, |

Appendix B- Epidemiologic Studies (Table 1. Cancer)



| Study             | Type               | Size/<br>Population                                               | Methods                                                                                                                                                                                                                                                                                                                                                                        | Exposure                                                                                                                      | Outcome                             | Results                                                                                                                                                                                                                                                                                                                                                                                            | Notes                                                                                                                                                                    |
|-------------------|--------------------|-------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------|-------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Cocco et al. 2008 | Case Control       | 9,435 non-cancer death controls                                   | occurring between 1989 and 1996. 10 non-cancer death controls, occurring during the same time period and in the same counties, for each case were randomly selected. Logistic regression was used to model total pesticide usage in each zip code for each chemical. To calculate MORs, the highest quartile of pesticide exposure was compared to the bottom three quartiles. | data between 1972-1989 for each zip code in the three counties.                                                               |                                     | The highest quartile of exposure to dieldrin compared to all lesser exposures resulted in a non-significant MOR of 1.52 among subjects having resided in the county for at least 20 years before death. A dose response pattern was not observed for dieldrin exposure.                                                                                                                            | year of death, years living in county, and other pesticides. Study is unable to control for smoking. The latency that is able to be assessed here is only 1 to 12 years. |
|                   |                    | 174 cases, 203 controls                                           | Cases and controls were participants of the EpiLymph study in France, Germany, and Spain. Information was collected by questionnaire and blood samples were taken. Covariates included in the final model included age, gender, education, and center.                                                                                                                         | Measurements of 17 organochlorine pesticides in plasma samples                                                                | Non-Hodgkin's Lymphoma and subtypes | No increased risk of NHL or its subtypes was found to be associated with any of the compounds examined (including aldrin and dieldrin). There were no participants from France or Germany with aldrin or dieldrin plasma concentration levels above the detection limit; among Spanish participants there were 12 controls and 14 cases with detectable aldrin and dieldrin plasma concentrations. | Differences between countries were noted. Retrospective design limits the inferences that can be made about any associations.                                            |
| Engel et al. 2005 | Prospective Cohort | 30,454 women enrolled in the Ag Health Study (309 cases of breast | Participants enrolled between 1993 and 1997 in the Ag Health Study. Cases were identified from population-based cancer registries in Iowa and North Carolina. NDI was used to determine vital status of                                                                                                                                                                        | Use and exposure to 50 specific pesticides was determined by questionnaires administered at enrollment by the women and their | Breast cancer diagnosis             | There was no significantly increased risk among women having reported using aldrin and dieldrin. Among women who did not directly use aldrin and dieldrin but their husbands did, the RR for aldrin was 1.9 (1.3-                                                                                                                                                                                  | The authors classify the relationship between breast cancer and the husband's use of dieldrin as weak. Analysis controlled                                               |

Appendix B- Epidemiologic Studies (Table 1. Cancer)



| Study              | Type               | Size/<br>Population                                                                                                | Methods                                                                                                                                                                                                                                                                                                                                                                            | Exposure                                                                                                               | Outcome           | Results                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | Notes                                                                                                                                                                                                                          |
|--------------------|--------------------|--------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------|-------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Flower et al. 2004 | Prospective Cohort | 17,357 children of Iowa pesticide applicators enrolled in the Ag Health Study (50 incident childhood cancer cases) | Participants who had moved out of state were followed up using personal contacts, motor vehicle records, pesticide registration records, and IRS records. End of follow-up was 12/31/2000.                                                                                                                                                                                         | husbands.                                                                                                              |                   | 2.7) and 2.0 (1.1-3.3) for dieldrin. RRs for 7 other pesticides were also significant among women whose husbands used pesticides. Results were not consistent when stratified by state. Risks were higher in postmenopausal women compared to premenopausal women: the RR for women whose husbands worked with aldrin was 1.7 (1.1-2.6), the RR for dieldrin still wasn't significant. Comparing low and high cumulative exposure groups of women whose husbands used dieldrin to husbands that did not use it, the respective RRs for breast cancer were 1.4 (0.6-3.5) and 3.2 (1.3-8.0). | for age, race, and state of residence.                                                                                                                                                                                         |
|                    |                    |                                                                                                                    | Information on exposure and other variables was provided by parents responding to questionnaires between 1993 and 1997. Cancer cases among children ages 0-19 years were identified from the Iowa Cancer registry for the period 1975-1998 (retro and prospective identification of cases). Cases from North Carolina were excluded based on small numbers. 50 specific pesticides | Use and exposure to 50 specific pesticides was determined by questionnaires administered at enrollment by the parents. | Childhood cancers | Parental use of organochlorine pesticides (including aldrin, DDT, dieldrin, heptachlor, chlordane, lindane, and toxaphene) were not significantly associated with childhood cancers while aldrin was associated with childhood cancers. There were 6 cases, OR= 2.66 (1.08-6.59).                                                                                                                                                                                                                                                                                                          | Data for NC is not available, which may be a weakness based on the inconsistencies seen by Engel et al. Numbers were too small to look at specific types of tumors. Overall, the SIR for all childhood cancers was 1.36 (1.03- |

Appendix B- Epidemiologic Studies (Table 1. Cancer)



| Study              | Type         | Size/<br>Population                | Methods                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | Exposure                                        | Outcome       | Results                                                                                                                                                                                                | Notes                                                                                                                                                                                                                                                                                                                                                                                                                |
|--------------------|--------------|------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------|---------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Gammon et al. 2002 | Case control | 646 cases and 429 controls (women) | were assessed.<br><br>Cases included females residing in Nassau and Suffolk Counties on Long Island, NY who were 20 or older, spoke English and were recently diagnosed with in situ or invasive breast cancer between August 1, 1996 and July 31, 1997. They were identified through pathology labs in all of the hospitals in the Long Island region. Controls were residents of the same counties on Long Island and were frequency matched according to 5-year age group. Controls were identified through random digit dialing and Health Care Financing Administration rosters | Organochlorines (9 including dieldrin) in blood | Breast cancer | There was no significant increased risk in breast cancer in association with the highest quintile of lipid-adjusted serum levels of dieldrin and a dose-response relationship was not apparent either. | 1.79) but only lymphomas (9 cases) and more specifically, Hodgkin's lymphoma (5 cases) were significantly related to parental pesticide exposures. No dose-response relationship was detected.<br><br>"These findings, based on the largest number of samples analyzed to date among primarily white women, do not support the hypothesis that organochlorines increase breast cancer risk among Long Island women." |

Appendix B- Epidemiologic Studies (Table 1. Cancer)



| Study             | Type                       | Size/<br>Population                              | Methods                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | Exposure                              | Outcome                                                               | Results                                                                                                                                                                                                                                                                                                                             | Notes                                                                                                                                                                                                                              |
|-------------------|----------------------------|--------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------|-----------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Høyer et al. 2001 | Cohort nested case control | 161 breast cancer cases and 536 controls         | <p>depending on age. Questionnaires were administered in person by trained interviewers and samples were obtained through nonfasting blood samples.</p> <p>The breast cancer cases and matched controls participated in the Copenhagen City Heart Study (CCHS) between 1976 and 1978. Cases were identified through the Danish Cancer Registry. A random sample of 536 women matched on age and vital statistics served as controls. Information was collected on lifestyle factors, reproductive history and socioeconomic conditions using questionnaires. Serum was frozen and retrieved later for analysis.</p> | Exposure to dieldrin                  | Breast cancer risk and survival according to estrogen receptor status | There was an increased breast cancer risk linked to exposure to dieldrin for women who developed estrogen receptor negative breast tumors. Women with the highest dieldrin levels in their serum generally had tumors that were larger and more often spread at diagnosis when compared to estrogen receptor positive (ERP) tumors. | “The results do not suggest that exposure to potential estrogenic organochlorines leads to development of an ERP breast cancer.” This study had limited statistical power, in particular in the estrogen receptor negative tumors. |
| Høyer et al. 2002 | Cohort nested case control | 162 breast cancer cases and 316 matched controls | <p>The breast cancer cases and matched controls participated in the Copenhagen City Heart Study (CCHS) between 1976 and 1978. Cases diagnosed between the start of the study and 1993 were found through the Danish Cancer Registry. Blood samples were taken without fasting and serum was frozen and stored.</p>                                                                                                                                                                                                                                                                                                  | Exposure to organochlorine pesticides | Breast Cancer and p53 mutation                                        | A non-significant but slightly elevated risk was found in the highest level of exposure for dieldrin among women who developed a tumor with mutant p53. However, a significant dose-response relationship was present for dieldrin in ‘wild-type’ p53 tumors.                                                                       |                                                                                                                                                                                                                                    |

Appendix B- Epidemiologic Studies (Table 1. Cancer)



| Study                 | Type            | Size/<br>Population          | Methods                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | Exposure                                                                                                                              | Outcome                                          | Results                                                                                                                                                                                                                                                                                                                                                                                                                                             | Notes                                                                                  |
|-----------------------|-----------------|------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------|
| Ibarluzea et al. 2004 | Case Control    | 198 cases,<br>260 controls   | Cases and controls were selected from 3 hospitals in Southern Spain from April 1996-June 1998. Cases were women ages 35-70 undergoing surgery for newly diagnosed breast cancer. Controls were women without breast cancer, matched for age and hospital who were undergoing surgery not related to cancer. Interviews were conducted to collect data on sociodemographic factors, reproductive history, fertility, menopausal status, exogenous hormones, diet, tobacco and alcohol consumption, and family history of breast cancer. | 16 Organochlorine pesticides in adipose tissue                                                                                        | Breast cancer                                    | The geometric mean of aldrin in adipose was higher (but not significantly) among cases compared to controls. Overall, the OR for aldrin was 1.55 (1.0-2.4) and was 1.84 (1.06-3.18) among postmenopausal women. The only other significant risk of breast cancer was for lindane among postmenopausal women.                                                                                                                                        | All women were Caucasian. Dieldrin was detected in <40% of the samples.                |
| Mathur et al. 2002    | Cross Sectional | 135 cases and<br>50 controls | Breast cancer cases and controls were recruited from the Birla Cancer Institute, Jaipur, India. Blood samples were collected and questionnaires administered.                                                                                                                                                                                                                                                                                                                                                                          | Questionnaire assessed age, diet, obstetrical and menstrual history, information regarding pesticide use, and geographic information. | Pesticide levels in blood breast cancer patients | Breast cancer patients had significantly higher average aldrin in blood samples than the controls (1.997 vs. 0.115 mg/L). This relationship continued to exist even after stratifying by age group for those aged 31-40 and 41-50 years old; and for all strata when stratified by urban vs. rural populations and for vegetation vs. non-vegetarian diets. Increased levels of DDT, DDE, DDD, HCH and its isomers, and heptachlor were also found. | There were no participants with any occupational or accidental exposure to pesticides. |

Appendix B- Epidemiologic Studies (Table 1. Cancer)



| Study                | Type         | Size/<br>Population                                          | Methods                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | Exposure                                                                                                                        | Outcome                | Results                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | Notes                                                  |
|----------------------|--------------|--------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------|------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------|
| McDuffie et al. 2001 | Case control | 517 Non-Hodgkin's Lymphoma cases and 1506 controls in Canada | Pesticide exposure was obtained through initial postal questionnaires followed by a phone interview for individuals who reported pesticide exposure of 10 h/year or more and a 15% random sample of the remaining individuals. Cases were obtained through provincial cancer registries excluding Quebec where hospital ascertainment was employed. Controls were selected from provincial health insurance records, computerized telephone listings or voters' lists.      | Exposure to herbicides                                                                                                          | Non-Hodgkin's Lymphoma | The odds ratios associating NHL with aldrin were statistically significant. Aldrin was a significant predictor in a multivariate model which included exposure to other major chemical classes or individual pesticides, personal antecedent cancer, a history of cancer among first-degree relatives.                                                                                                                                                                                                |                                                        |
| Purdue et al. 2007   | Cohort       | 51,011 participants from the Ag Health Study                 | Questionnaires were completed at the time of enrollment (1993-1997) including information on occupation, and pesticide use and exposure. Follow-up through December 31, 2002 was conducted using Iowa and North Carolina State Cancer Registries, state death registries, and NDI. Cohort members out of state were identified using IRS records, Motor Vehicle registration databases, and pesticide license registries. Analyses adjusted for age, sex, state, education, | Ever/never use, cumulative exposure, lifetime exposure days, and intensity weighted lifetime exposure to 50 specific pesticides | Cancer                 | 22,409 (48%) of participants ever used insecticides. Leukemia risk was greater than 1.5 (but not significant) with dieldrin use. When stratified by cumulative exposure categories, dieldrin use was significantly associated with an elevated risk of lung cancer among those with >9 days exposure [lifetime days of exposure: RR=2.8 (1.1-7.2) with p-trend=0.02; and intensity-weighted lifetime days of exposure: RR=3.5 (1.6-7.7) with p-trend=0.002]. Conversely, aldrin was associated with a | Insecticide applicators were primarily male and white. |

Appendix B- Epidemiologic Studies (Table 1. Cancer)



| Study                | Type                          | Size/<br>Population                                                          | Methods                                                                                                                                                                                                                                                                                                                                                                                                                     | Exposure                                           | Outcome                | Results                                                                                                                                                                                                                                                                                                                                                           | Notes                                                                                                                                                                                                                                             |
|----------------------|-------------------------------|------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------|------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Quintana et al. 2004 | Nested case control           | 175 Non-Hodgkin's Lymphoma cases and 481 controls taken from original cohort | smoking, alcohol use, cancer family history, and lifetime days of total pesticide application.<br><br>A data set originally collected between 1969 and 1983 by the EPA for the U.S. EPA National Human Adipose Tissue Survey was utilized. Samples of adipose tissue were collected randomly from cadavers and surgery patients. Levels of organochlorine pesticide residues were determined through the collected samples. | Organochlorine pesticide residue in adipose tissue | Non-Hodgkin's Lymphoma | decreasing risk of colon cancer among those exposed to >9 intensity-weighted lifetime days of exposure [RR=0.4 (0.2-1.0) with p-trend=0.04].<br><br>The highest quartile level of dieldrin in adipose tissue was associated with increased risk of NHL (OR=2.70; 1.58-4.61). The p-value for trend was significant for dieldrin as well.                          | There are a few limitations to this study including the collection of exposure information after diagnosis as well as lack of information on variables that could affect organochlorine levels. These variables include diet, occupation and BMI. |
| Ritchie et al. 2003  | Cross Sectional (pilot study) | 58 cases, 99 controls                                                        | Incident prostate cancer cases were identified from 2 Iowa clinics. Cases were pathologically confirmed, newly diagnosed (May 2000 to May 2001), and all were adenocarcinomas. Questionnaires were administered to collect data on age, race, family history, tobacco and alcohol use, sexual partners, STDs, hormone usage. Blood samples were taken to                                                                    | Blood levels of 48 organochlorine compounds        | Prostate cancer        | Aldrin was not detected in any of the study participants. Dieldrin was detected in 29.3% of cases and 38.4% of controls. For those with >0.024 ug/g dieldrin in serum, the adjusted OR for prostate cancer was 0.28 (0.09-0.88) and not significant at lower concentrations. Dieldrin did not remain in the multivariate model of prostate cancer risks (p=0.13). | Cases were more likely to have a history of prostatitis, be overweight, and be married. Other organochlorines were associated with increased risk of prostate cancer.                                                                             |

Appendix B- Epidemiologic Studies (Table 1. Cancer)



| Study                 | Type         | Size/<br>Population                                                    | Methods                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | Exposure                                | Outcome                                  | Results                                                                                                                                                                                                                                                                                                                                                                  | Notes                                                                                                                                                                                                                                                                                                                       |
|-----------------------|--------------|------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------|------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Schroeder et al. 2001 | Case Control | 182 cases and 1245 controls form the Factors Affecting Rural Men study | Authors investigated the role of agricultural risk factors for t(14,18) -positive non-Hodgkin's lymphoma (NHL), compared to t(14,18)-negative. Participants were from Iowa (identified thru the State Health Registry of Iowa) and Minnesota (identified thru active hospital surveillance). Tissues samples from male NHL cases collected by the Factors Affecting Rural Men study were assayed for t(14,18). Controls were recruited using random digit dialing. Controls were white men without hemolympathic cancer, frequency mated on age, state, and vital status. Exposures were determined by interviews with participants or next-of-kin. Data collected included socio-demographic factors, tobacco | Self-reported exposure to 111 compounds | T(14,18)-positive non-Hodgkin's Lymphoma | Aldrin was not associated with t(14,18) positive or negative NHL when comparing to control or positive to negative. Dieldrin was associated with t(14,18)-positive NHL when compared to controls (OR = 3.7, CI 1.9-7.0). Several other chemicals were also significantly associated with t(14,18)-positive NHL including Lindane, Toxaphene, Atrazine, and Phthalimides. | Comparisons of combinations of joint exposures between fumigants and other factors (farming, dairy cattle, chickens, pigs, soybeans, corn, fungicides, organophosphates) resulted in significantly elevated risks of t(14,18)-positive NHL among those exposed to both exposures compared to those without either exposure. |



| Study               | Type         | Size/<br>Population                                                                                                               | Methods                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | Exposure                                               | Outcome                       | Results                                                                                                                                                                                                                                                                                                                                                   | Notes                                                                                                                                                                                                                                                                  |
|---------------------|--------------|-----------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------|-------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Shukla et al. 2001  | Case Control | 30 cases, 30 controls                                                                                                             | and alcohol use, hobbies, pets, medical history, occupational history, and non-occupational exposures.<br>Participants were patients at the surgical unit of a university hospital from March 1997 to Feb. 1999. Controls were cases of cholelithiasis. Bile and blood were collected at the time of surgery.                                                                                                                                                                                                                                                         | Organochlorines in bile                                | Carcinoma of the gall-bladder | Biliary and blood aldrin was higher in cases than controls but the difference was not significant.                                                                                                                                                                                                                                                        | Most participants were postmenopausal housewives (24 cases, 22 controls). All of the men worked in offices.                                                                                                                                                            |
| Sielken et al. 1999 | Cohort       | 570 male employees who worked for at least 1 year in the production of aldrin and dieldrin between Jan. 1, 1954 and Jan. 1, 1970. | Workers were followed-up through Jan 1, 1993. Blood samples were available for 343 participants taken during the exposure period. Lifetime average daily dose was calculated for each participant as the worker's average daily dose in the period between birth and end of follow-up date. Analyses assumed no exposure to aldrin and dieldrin outside of work and that workers weighed 70 kg. Air measurements and biological samples were available for analysis. Dose response was modeled using multistage, multistage Weibull, and proportional hazards models. | Dieldrin and aldrin intake, air and biomonitoring data | Cancer<br>Death               | 118 deaths including 37 cancer deaths as of Jan 1, 1993. 15% of workers had lifetime daily doses > 1ug/kg/day. Multistage and multistage Weibull dose response models showed that cancer risk was less than zero at 1ug/kg/day. Proportional hazards models resulted in estimated risks less than zero for lifetime average daily doses up to 2ug/kg/day. | "The cancer mortality data on these male workers suggest that low-dose exposures to aldrin and dieldrin do not significantly increase human cancer risk and may even decrease the human hazard rate for all types of cancer combined at low doses (e.g., 1ug/kg/day)." |

Appendix B- Epidemiologic Studies (Table 1. Cancer)



| Study                      | Type   | Size/<br>Population                                                                                                               | Methods                                                                                                                                                                                                                                                          | Exposure                                               | Outcome      | Results                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | Notes                                                                                                                                  |
|----------------------------|--------|-----------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------|--------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------|
| Swaen et al. 2002          | Cohort | 570 male employees who worked for at least 1 year in the production of aldrin and dieldrin between Jan. 1, 1954 and Jan. 1, 1970. | Workers were followed through Jan 1, 2001. Blood samples were available for 343 participants taken during the exposure period. Total intake of dieldrin was estimated for all participants. Air measurements and biological samples were available for analysis. | Dieldrin and aldrin intake, air and biomonitoring data | Cancer Death | Estimated dieldrin intake ranged from 11 to 7755 mg (average=737mg). There were 171 deaths and the overall SMR was 75.6 (64.6-87.7). The SMR for all neoplasms was not elevated (SMR=75.5). The only cause of death that was elevated was rectal cancer for the whole cohort and among those in the low intake group (first tertile, mean=270 mg dieldrin intake), SMR=3 (1.1-6.5) based on 6 cases and SMR=6 (1.2-17.2) based on 3 cases, respectively. When stratified by job title, only operators had any significant results, for rectal cancer SMR=5 (1.3-12.7) based on 4 cases and skin cancer SMR=7.5 (1.5-21.5) based on 3 cases. | Small numbers. "...no evidence of an increased risk for cancer of any particular type as a result of exposure to aldrin and dieldrin." |
| van Amelsvoort et al. 2009 | Cohort | 570 male employees who worked for at least 1 year in the production of aldrin and dieldrin between Jan. 1, 1954 and Jan. 1, 1970. | Workers were followed-up through April 30, 2006. Blood samples were available for 343 participants taken during the exposure period.                                                                                                                             | Dieldrin and aldrin intake, air and biomonitoring data | Cancer Death | Estimated dieldrin intake ranged from 11 to 7755 mg (average=737mg). There were 226 deaths, 82 from cancer, giving an SMR of 0.69 (0.60-0.79) for all causes of death and 0.76 (0.61-0.95) for cancer deaths. No specific cause of death or neoplasm was significantly elevated with exposure to aldrin and dieldrin at any level of exposure. However several                                                                                                                                                                                                                                                                              |                                                                                                                                        |

Appendix B- Epidemiologic Studies (Table 1. Cancer)



| Study | Type | Size/<br>Population | Methods | Exposure | Outcome | Results                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | Notes |
|-------|------|---------------------|---------|----------|---------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------|
|       |      |                     |         |          |         | <p>causes were significantly lower than expected: For the total group, cardiovascular disease, other causes, and trachea and lung cancer; cardiovascular disease for the low and moderate intake groups; and among those experiencing high intake all neoplasms, cardiovascular disease, and trachea and lung cancer all had SMRs significantly less than 1. When stratified by job title other causes among assistant operators; all causes among maintenance workers; all causes, cardiovascular disease, respiratory disease, and trachea and lung cancer among operators were all significantly less than 1. Operators had a significantly elevated SMR of 5.76 (1.19-16.8) for skin cancer based on 3 cases.</p> |       |

Appendix B- Epidemiologic Studies (Table 1. Cancer)



| Study            | Type            | Size/<br>Population                                                                                                    | Methods                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | Exposure                                                                           | Outcome                                                      | Results                                                                                                                                                                                                                                                                                                                                                                                                                                  | Notes                                                                                                                               |
|------------------|-----------------|------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------|--------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------|
| Ward et al. 2000 | Case Control    | 150 cases, 150 controls                                                                                                | Among serum donors collected by the Janus Serum Bank in Norway between 1973 and 1991, women who worked outside the home or were resident farmers as of the 1970 or 1980 census. Of those women, breast cancer cases were determined from records of the Norwegian Cancer Registry through Dec. 31, 1993. Cancer-free controls from the same group were matched based on date of sample and date of birth. Additional data on potential confounders was collected from the Janus Serum Bank and Norwegian Cancer Registry. | 71 organochlorine compounds in serum                                               | Breast Cancer                                                | Aldrin and Dieldrin were not associated with breast cancer.                                                                                                                                                                                                                                                                                                                                                                              |                                                                                                                                     |
| Xu et al. 2010   | Cross-sectional | 4,237 in the HANES survey including 4,109 individuals without cancer, 65 prostate cancer cases, 63 breast cancer cases | Participants provided blood samples and information about medical conditions and demographic variables.                                                                                                                                                                                                                                                                                                                                                                                                                   | Serum concentrations of thirteen organochlorine (OC) pesticides including dieldrin | Self-reported physician-diagnosed breast and prostate cancer | There was a marginally significant ( $p=0.04$ ) trend in the Odds Ratios (OR) for prostate cancer when compared by tertiles of serum concentration of dieldrin. The OR for the second tertile was 1.06 (95% CI: 0.30-3.73), the OR for the 3 <sup>rd</sup> tertile was 2.74 (95% CI: 1.01-7.49) as compared to the lowest quartile. No association was found between serum concentrations of any of the OC pesticides and breast cancer. | Due to the nature of the cross-sectional design of this study, causality between OC pesticides and cancer risk cannot be concluded. |



Table 2- Epidemiologic Studies of Non-Cancer Endpoints

| Study                        | Type               | Size/<br>Population                                              | Methods                                                                                                                                                                                                                                                                                                                                                                           | Exposure                                                                  | Outcome                                                                                                              | Results                                                                                                                                                                                                                                                 | Notes                                                                                                                                                         |
|------------------------------|--------------------|------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Akkina et al. 2004           | Cross<br>Sectional | 219<br>menopausal<br>women in<br>Hispanic<br>Health<br>NHANES    | 1982-1984 survey years of the<br>Hispanic Health NHANES were used.<br>Data on age at menopause,<br>reproductive history, demographic<br>variables, other potential confounders<br>were collected as part of the survey.<br>Serum samples were also collected.<br>ANOVA was used to investigate the<br>relationship between age at<br>menopause and serum levels of<br>pesticides. | 18<br>organochlorine<br>pesticides in<br>serum                            | Age at<br>menopause                                                                                                  | Serum levels of dieldrin were above<br>the detection limit (1ppb) in 19<br>individuals (8.7%). Dieldrin was not<br>associated with age at menopause.                                                                                                    | Serum levels of pesticides<br>may not represent exposure<br>at the time of menopause.<br>Time from menopause to<br>survey ranged from 0 to 37<br>years.       |
| Asawasinsopon<br>et al. 2006 | Cross<br>Sectional | 39 mother-<br>infant pairs<br>Chian Pai<br>province,<br>Thailand | Participants were mother-infant pairs<br>having normal, full term pregnancies.<br>Women diagnosed with hypothyroid<br>were ruled out. Questionnaires<br>collected data on lifestyle, pesticide<br>use/exposure, and delivery history.<br>Maternal blood was collected 2-5<br>hours before delivery. Umbilical cord<br>blood was collected when it was cut.                        | Organochlorines<br>in maternal<br>serum and in<br>umbilical cord<br>blood | Levels of<br>thyroid<br>hormones<br>(total<br>thyroxine,<br>free<br>thyroxine,<br>thyroid<br>stimulating<br>hormone) | Level of dieldrin was positively<br>correlated between maternal and<br>umbilical cord blood. However,<br>thyroid hormone levels did not vary<br>with dieldrin levels. Significant<br>decreases in total thyroxine were<br>noted for 3 other pesticides. | This study is very small with<br>only 39 births being<br>analyzed. There is no<br>indication of actual health<br>effects among these<br>children after birth. |

Appendix B- Epidemiologic Studies (Table 2. Non- Cancer)

|                         |                 |                                                                                                   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                                                                               |                                                                                                                                       |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                                                                                             |
|-------------------------|-----------------|---------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------|
| Damgaard et al. 2006    | Case-Control    | 62 milk samples from mothers of cryptorchid boys and 68 milk samples from mothers of healthy boys | A joint longitudinal, prospective birth cohort study was performed by the authors in Finland and Denmark from 1997 to 2001. They examined regional prevalence rates and risk factors for cryptorchidism through questionnaires and biological samples including one breast milk sample per child. From the bank of breast milk samples, the researchers included 65 samples from each country (Denmark and Finland) to examine organochlorine pesticide exposures. Cases were defined as boys with cryptorchidism at birth and controls were defined as boys without cryptorchidism at birth or 3 months old. Breast milk was collected between 1 and 3 months postpartum and was analyzed for 27 OC pesticides. | Organochlorine pesticides in human breast milk                                | Cryptorchidism                                                                                                                        | Eight of the OC pesticides were measurable in all samples (p,p'-DDE, β-HCH, HCB, α-endosulfan oxychloridane, p,p'-DDT, dieldrin, cis-HE). Five were measured in most samples. Seventeen of the 21 OC pesticides including dieldrin were measured in higher median concentrations in case breast milk compared to control breast milk. Except for trans-chlordane, there were no significant differences between cases and controls for individual pesticide chemicals. However, combined statistical analysis of the eight pesticides measured in all samples shows that the levels of pesticides in breast milk were significantly higher in cryptorchid boys. | This study cannot provide proof for a causal relationship because it cannot be proven that exposure preceded disease.       |
| Everett & Matheson 2010 | Cross Sectional | 2341 NHANES participants used to examine exposure to dieldrin                                     | Study of NHANES 1999-2004 survey years. Associations were tested using logistic regression adjusting for age, race, gender, education, poverty income ratio, BMI, waist circumference, physical activity, and family history of diabetes.                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | 8 pesticides and their metabolites were measured in non-fasting blood samples | Diagnosed and undiagnosed diabetes and pre-diabetes (glycohemoglobin 5.7-6.54%) based on self-report and glycohemoglobin measurements | Dieldrin was not associated with total diabetes (diagnosed, undiagnosed, and pre-diabetes) OR=1.19 (0.70-2.04), or to pre-diabetes OR=0.89 (0.61-1.29).                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | No assessment of aldrin, no environmental information, no occupational or residential information was used in the analysis. |

Appendix B- Epidemiologic Studies (Table 2. Non- Cancer)

|                        |              |                                                                                                 |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                                |                                                                   |                                                                                                                                                                                                                                                                                                               |                                                                                                                               |
|------------------------|--------------|-------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------|-------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------|
| Fenster et al.<br>2005 | Cohort       | 385 Latinas living in the Salinas Valley, CA, an agricultural community.                        | Participants were part of a longitudinal birth cohort study, the Center for the Health Assessment of Mothers and Children of Salina project of the Center for Children's Environmental Health Research. Eligible women were <20 weeks gestation, at least 18 years old, eligible for Medi-Cal, and planning on giving birth at the Natividad Medical Center. Data was collected from interviews and medical record abstraction. Serum was drawn from the mothers at approximately 26 weeks gestation and at the hospital before delivery. Models were adjusted for maternal age, parity, country of birth, family income, timing of entry into prenatal care, smoking, total dimethyls at 26 weeks, pregnancy weight gain, prepregnancy BMI, total DAPs in urine at 26 weeks, infant sex, gestational age and gestational age squared. | 11 organochlorine pesticides in maternal serum | Infant's length of gestation, birth weight, and crown-heel length | Neither crude nor adjusted associations between health effects in infants and maternal serum dieldrin concentration during pregnancy were found.                                                                                                                                                              | Results are not generalizable as most women were Latina and born in Mexico, and selection was limited to low-income families. |
| Fowler et al.<br>2007  | Experimental | In vitro exposure of fetal human testis from women undergoing medical termination of pregnancy. | Investigators collected fetal testes from medically terminated normal pregnancies between 13 and 19 weeks of gestation. An in vitro experiment was carried out by exposing testes explants to 0.4ppb, 0.0004ppb or no dieldrin. Investigators performed immunolocalization of marker proteins, 2-dimensional gel electrophoresis and mass spectroscopy, 1-dimensional gel electrophoresis and western blot, and hormone assays.                                                                                                                                                                                                                                                                                                                                                                                                        | Dieldrin in vitro                              | Leydig cell disruption                                            | Dieldrin blocked LH-induced testosterone secretion from fetal testis explants in vitro. Dieldrin also blocked tissue protein concentrations of LH receptor and steroid acute regulatory protein. Dieldrin had no direct toxicological effects on the testis explants and no effect on anti-Mullerian hormone. | There were 2 to 4 specimens available for each treatment group of each experiment.                                            |

Appendix B- Epidemiologic Studies (Table 2. Non- Cancer)

|                      |        |                                                                                                                   |                                                                                                                                                                                                                                                                                                                                                                                    |                                                                   |                                                            |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                                                                                                                                                                                                                                                     |
|----------------------|--------|-------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------|------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Landgren et al. 2009 | Cohort | 678 men participating in the Ag Health Study - stratified random sample of 57,310 licensed pesticide applicators. | Age-adjusted prevalence of MGUS among the men in the Ag Health Study were compared to 9,469 men from MN. Exposure to pesticide was self-reported at time of study enrollment (1993-1997) and serum samples were collected between 2006 and 2008. Logistic regression was used to control for age, education.                                                                       | Self-reported pesticide use and pesticide concentrations in serum | Mono-clonal gammopathy of undetermined significance (MGUS) | Among those ever reporting exposure to dieldrin, the OR for MGUS was 5.6 (1.9-16.6) based on 6 cases. Two other compounds were significantly associated with increased risk of MGUS out of 50 compounds tested.                                                                                                                                                                                                                                                                                                                                                                                                                                      | Excess risk of MGUS associated with dieldrin was not attenuated when adjusted for the use of other pesticides. The comparison group from MN was chosen because the Mayo Clinic had the largest MGUS screening study available at the time this study was conducted. |
| Li et al. 2005       | Review |                                                                                                                   | Comprehensive review of toxicological and epidemiological studies of the association between pesticides and Parkinson's Disease (PD). Analytic epidemiology studies were required to examine pesticide exposure (not farm work or rural residence, and broad descriptions like 'agricultural chemicals') and an outcome based on the PD case definition (i.e., not just a tremor). | Any pesticide, insecticide or herbicide                           | Parkinson's Disease                                        | "We conclude that the animal and epidemiological data reviewed do not provide sufficient evidence to support a causal association between pesticide exposure and Parkinson's disease." 27 case control studies were reviewed, 16 reported no significant association between pesticides, herbicides, and/or insecticides and PD. None of the studies reviewed included any biomarker or environmental data. Base on the epidemiology studies alone, the authors concluded that the evidence is mixed. Dieldrin exposure in animal models is discussed and the authors conclude that it does not cause effects consistent with an animal model of PD. | Only one person scored the studies discussed in the paper.                                                                                                                                                                                                          |

Appendix B- Epidemiologic Studies (Table 2. Non- Cancer)

|                        |              |                                                     |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                                                                                          |                  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                                                                                                                                                                                                                                |
|------------------------|--------------|-----------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------|------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Louis et al. 2006      | Case Control | 136 cases and 144 controls                          | Cases were treated at the Neurological Institute of New York and identified from a database at the Center for Parkinson's disease and other movement disorders. Those with physical signs/diagnoses of Parkinsonism, dystonia, spinocerebellar ataxia were excluded. Controls were ascertained from the same source and from the same zip codes as cases, matched by age-strata, gender, and race. Questionnaires administered by a trained tester; videotaped neurological evaluations; serum samples collected; occupational histories evaluated by an industrial hygienist were all analyzed using Chi-square and student's T-tests, and Pearson correlation coefficients. | Exposure to 6 organochlorine pesticides was assessed by serum concentrations and occupational histories. | Essential Tremor | No association between ET and any of the 6 pesticides tested in serum. Parity (in women) was the only variable significantly associated with log dieldrin.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | The authors report that they needed 160 cases and 160 controls to have adequate statistical power to detect a 20% difference based on a pilot study.                                                                           |
| Montgomery et al. 2008 | Cohort       | 31,787 pesticide applicators in the Ag Health Study | All data was collected from questionnaires at the time of study enrollment and after 5 years. Participants having diabetes at enrollment and those missing information pertaining to diabetes or other covariates (age, state, BMI) were excluded. Lifetime exposure to pesticides was calculated from reported use at enrollment (1993-1997). Only pesticide applicators were included (not family members); 97% were non-Hispanic White and 97% were male.                                                                                                                                                                                                                  | Cumulative number of days and ever/never use of 50 specific pesticides                                   | Diabetes         | 1,176 diagnosed diabetics and 30,611 non-diabetics were self-reported after a 5-year follow-up interview (conducted 1999-2003). The adjusted ORs (95% CI) found for exposure to aldrin are as follows: Ever use- 1.14 (0.97-1.33) compared to never users; 0.01-10 cumulative days of use: 0.84 (0.59-1.19), 10.01-100 days: 1.21(0.89-1.65), and over 100 days: 1.51 (0.88-2.58), with a p-value for trend of 0.08; additionally stratifying by age < and > 60 years and by state resulted in elevated but not significant ORs. When stratified by weight, under and normal, and overweight, individuals had elevated but not significant risks of diabetes with use of aldrin, however, obese individuals reporting ever use of aldrin had an OR=1.31 (1.05-1.63) for diabetes. | Not generalizable- the study was mostly white men, in rural areas. The study does not specify type I or type II diabetes, which are very different in etiology. Diabetes was only self-reported, not confirmed by a physician. |

Appendix B- Epidemiologic Studies (Table 2. Non- Cancer)

|                       |                 |                                                                   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                                                                                                                                            |                                                                                   |                                                                                                                                                                                                       |                                                                                                                                                              |
|-----------------------|-----------------|-------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Nagayama et al. 2007  | Cross Sectional | 92 Japanese mother-infant pairs living in or near Fukuoka, Japan. | Participants were recruited in the months of July and August of 1994-1996. Infants that were carried to term, without congenital abnormalities or disease, with normal pregnancies were included. Breast milk samples were collected 2-4 months after delivery. Peripheral venous blood was collected from infants at about 10 months of age. Lymphocyte subsets and ratio of CD4+ T cell to CD8+ T cell were investigated in vitro.                                                                                                                                       | Pesticides in breast milk                                                                                                                                  | Lymphocyte subsets (CD16+, HLA-DR+, CD4+, CD8+, CD3+, CD20+) percentage and ratio | While other pesticides were significantly associated with increases or decreases in lymphocyte subset percentages, dieldrin was not.                                                                  | There is no consideration of other environmental, viral, bacterial, causes for changes in immune response. No attempt was made to measure exposure in utero. |
| Noakes et al. 2006    | Cross Sectional | 31 women in Western Australia                                     | Participants were randomly selected among pregnant women undergoing caesarean section in 2001-2002, at a Hospital in an area of Western Australia where allergic disease is epidemic. Maternal and neonate blood samples, maternal milk and adipose, and placental tissue was used to determine levels of persistent organic pollutants. Cord blood and maternal blood was collected for cytokine and lymphoproliferation response analyses. Immune responses were investigated in vitro. Data was analyzed by comparing medians and IQRs using Spearman rank correlation. | Persistent organic pollutants in maternal blood, adipose and breast milk, and in cord blood and placental tissue.                                          | Allergic immune response in women and infants                                     | Aldrin was not present at detectable levels in any of the samples. While dieldrin was detected (in 1 adipose sample, 8 breast milk samples) it was not associated with any change in immune response. | All subjects had pollutant levels much less than has previously been associated with any subclinical effects.                                                |
| Tomasallo et al. 2010 | Cohort          | 3847 individuals and 1141 referents                               | Participants were originally recruited in 1993 and sport fish anglers studied in 1986 in the Great Lakes region. They included charter boat captains, their spouses, and sport fish anglers; referents were from the same communities but did not consume sport fish and less than 6 sport fish meals over the previous 10 years. Follow-up surveys were conducted in 1993-1995 by telephone. NDI was used to identify 342 deaths.                                                                                                                                         | Total fish consumption, number of sport fish meals from the Great Lakes. The fish were expected to contain a variety of persistent bioaccumulative toxins. | Mortality                                                                         | Fish consumption was not shown to be associated with any specific cause of death.                                                                                                                     | Dieldrin exposure was not specifically measured or tested.                                                                                                   |

Appendix B- Epidemiologic Studies (Table 2. Non- Cancer)

|                       |              |                         |                                                                                                                                                                                                                                                                  |                                     |                     |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                                                                                                                                                                                                                                                                                                                                                                   |
|-----------------------|--------------|-------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------|---------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Weisskopf et al. 2010 | Case Control | 101 cases, 349 controls | Information on fish consumption and confounders (race, age, gender, BMI, education, annual income, and limited data for smoking and alcohol consumption) were collected from surveys. Analyses included Cox proportional hazards models and calculation of SMRs. | Organochlorine pesticides in serum. | Parkinson's Disease | Dieldrin was the only chemical with any association to Parkinson's disease in this analysis. The average serum concentration of dieldrin was 39.6ng/g lipid and the median was 40 ng/g lipid. Geometric mean serum concentrations of dieldrin differed significantly based on region, smoking, and increase in BMI units per year. Analyses restricted to confirmed cases of never smokers, the OR per IQR was 1.95 (1.26-3.02), and for never smokers over the age of 66 the OR per IQR was 2.55 (1.58-4.39). For all cases, including those not confirmed by medical records but restricted to never smokers, risks were elevated but not significantly. The IQR is 28.2 ng/g lipid of dieldrin. | Aldrin was detected in 11.5% of controls, and 12.9% of cases. Never smokers have a higher risk of PD than ever smokers. The amount of time from collection of the samples to when cases were diagnosed presents problems with interpretation. Other risk factors such as genetics, head trauma, declining estrogen level, and family history were not considered. |
|-----------------------|--------------|-------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------|---------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|



## Appendix C: Benchmark Dose Analysis of Non-Cancer Effects of Aldrin

### Introduction

In the 1993 IRIS document for Aldrin (CAS No. 309-00-2), the U.S. EPA calculated an oral Reference Dose (RfD) of 0.00003 mg/kg/day. The study on which the RfD was based was Fitzhugh et al. 1964, a study in which 12 rats/sex were fed diet containing 0, 0.5, 2, 10, 50, 100, or 150 ppm Aldrin for 2 years. The critical effects in this study were signs of liver toxicity, including enlarged centrilobular hepatic cells, with increased cytoplasmic oxyphilia, and peripheral migration of basophilic granules in dose levels  $\geq 0.5$  ppm. The authors of the paper described these effects as characteristic “chlorinated insecticide” lesions. Liver-to-body weight ratios were statistically significantly higher than controls in all aldrin treatments. The lowest dose of 0.5 ppm in the diet was determined to be the lowest observed adverse effect level (LOAEL). Because 0.5 ppm was the lowest dose level tested, a no observed adverse effect level (NOAEL) was not established. IRIS converted the LOAEL to 0.025 mg/kg-day, using the conversion factor of 1 ppm = 0.05 mg/kg-day. The RfD was formulated by dividing the LOAEL by an uncertainty factor of 1000 rounding:  $(0.025 \text{ mg/kg-day})/1000 = 0.000025 \approx 0.00003$  mg/kg/day. The uncertainty factor was based on extrapolation from animal to human (10), range of human sensitivities (10), and use of a LOAEL rather than a NOAEL (10).

ATSDR (2002) also used the Fitzhugh et al. 1964 study to develop a Minimal Risk Level (MRL) of 0.00003 mg/kg/day for aldrin. The MRL was calculated based on the same reasoning and calculations as the IRIS RfD.

### Method

A benchmark dose (BMD) approach was used to derive a new RfD for aldrin based on the data reported by Fitzhugh et al. 1964. The U.S. EPA’s BMDS 2.1.2 software package was used. BMDS 2.1.2 is the latest version of the BMDS series, released by EPA in June 2010.

One of the strengths of the BMD method is that it uses quantitative data. Unfortunately this strength is also a limitation in that the types of data required are not always available in published studies. The Fitzhugh et al. 1964 paper includes two tables that provide data about the liver toxicity of aldrin. Table 2 provides mean liver weight to body weight ratios for male and female rats that had been treated with 0.5 to 150 ppm aldrin. These data would be good for a BMD analysis by use of a Continuous Data model, except that the Continuous Data model requires means to be accompanied by standard deviations. Table 2 of the Fitzhugh paper does not report standard deviations in its mean organ weights table, so these data cannot be applied in a BMD model.

Table 4 of the Fitzhugh paper (see next page) reports the incidences of “characteristic chlorinated pesticide changes” in the liver of aldrin-treated rats. These are quantal data and can be used in a Dichotomous Model in the BMDS 2.1.2 software. The authors divided the incidences of observed liver lesions into categories of severity (from Trace to Moderate and >



Moderate). For simplicity, the total observations for all lesions were entered into the BMDS data input spreadsheet.

**Table 4 from Fitzhugh et al. 1964 (Note, only Aldrin data were used in this modeling):**

*Table 4. Characteristic "chlorinated insecticide" changes in livers of rats fed aldrin or dieldrin*

| Compound and feeding level (ppm) | Degree of liver change* |   |    |   |         |    | Number microscopically sectioned |
|----------------------------------|-------------------------|---|----|---|---------|----|----------------------------------|
|                                  | N                       | T | VS | S | S-M & M | >M |                                  |
| None                             | 16                      | 1 | 0  | 0 | 0       | 0  | 17                               |
| <b>Aldrin</b>                    |                         |   |    |   |         |    |                                  |
| 0.5                              | 15                      | 4 | 0  | 0 | 0       | 0  | 19                               |
| 2                                | 10                      | 8 | 0  | 1 | 0       | 0  | 19                               |
| 10                               | 11                      | 3 | 7  | 1 | 0       | 0  | 22                               |
| 50                               | 0                       | 0 | 0  | 6 | 10      | 2  | 18                               |
| 100                              | 0                       | 0 | 0  | 0 | 5       | 6  | 11                               |
| 150                              | 0                       | 0 | 0  | 0 | 2       | 7  | 9                                |
| <b>Dieldrin</b>                  |                         |   |    |   |         |    |                                  |
| 0.5                              | 17                      | 4 | 0  | 1 | 0       | 0  | 22                               |
| 2                                | 12                      | 5 | 5  | 1 | 0       | 0  | 23                               |
| 10                               | 7                       | 7 | 3  | 1 | 0       | 0  | 18                               |
| 50                               | 0                       | 0 | 3  | 8 | 6       | 3  | 20                               |
| 100                              | 0                       | 0 | 1  | 1 | 8       | 8  | 18                               |
| 150                              | 0                       | 0 | 0  | 1 | 5       | 5  | 11                               |

\*Among the symbols for the different grades of liver lesions, N=none, T=trace or minimal, VS=very slight, S=slight, and M=moderate. The figures for various degrees of liver lesions are based on the microscopic sections.

In order to make the BMD calculations more applicable to human risk from exposure to aldrin, the dose levels in ppm were converted into Human Equivalent Dose (HED) levels in units of mg/kg-day. The two steps in estimating the HED from the animal dose are: (1) converting the dietary concentrations to milligrams per kilograms per day in the animals; and (2) converting the animal dose to the equivalent human dose. ATSDR and IRIS used an assumption that 1 ppm = 0.05 mg/kg-day to convert the rat dose levels to units of mg/kg-day. The second step used the "3/4 power" assumption where the human equivalent dose, in units of milligrams per kilograms body weight per day, is equal to the animal dose  $\times$  (animal body weight/70)<sup>1/4</sup>, where the rat body weight was estimated from Figure 1 of the Fitzhugh paper to be approximately 450 g, or 0.450 kg. The formulae and table below summarize the calculations to convert rat dose in ppm to HED in mg/kg/day.

$$\text{Rat dose in mg/kg-day} = (\text{dose in ppm}) \times 0.05 \text{ mg/kg-day.}$$

$$\text{Rat dose to HED conversion factor} = (0.450/70)^{1/4} = 0.2831578$$

$$\text{HED in mg/kg-day} = (\text{Rat dose in mg/kg-day}) \times 0.2831578$$

**Calculation of Human Equivalent Dose**

| PPM in Diet | Rat Dose (mg/kg-day) | Human Equivalent Dose (mg/kg-day) |
|-------------|----------------------|-----------------------------------|
| 0           | 0                    | 0                                 |
| 0.5         | 0.025                | 0.0070789                         |
| 2           | 0.1                  | 0.028316                          |
| 10          | 0.5                  | 0.14158                           |
| 50          | 2.5                  | 0.07089                           |
| 100         | 5                    | 1.4158                            |
| 150         | 7.5                  | 2.1237                            |

**Results**

The BMD analysis of the liver lesion data are presented in the table below, and the BMDS input data, model parameters, and output are presented in subsequent pages. The first model was run in the Dichotomous Multistage model, as this is the simplest model for quantal data. The first run results using the entire range of doses were acceptable. In BMDS modeling, the highest dose level is commonly removed to see if it improves the fit of the curve to the data points. In the liver lesion data set, both the full data set and removal of the highest dose produced curves with acceptable p-value and scaled residuals, and the Akaike Information Coefficient (AIC) values were identical.

| Run | Data Set             | P-value <sup>1</sup> | Highest Scaled Residual <sup>2</sup> | AIC <sup>3</sup> | Visual Assessment of Curve to Data Points <sup>4</sup> | BMD       | BMDL <sup>5</sup> |
|-----|----------------------|----------------------|--------------------------------------|------------------|--------------------------------------------------------|-----------|-------------------|
| 1   | All Data             | 0.1835               | 1.938                                | 96.3408          | Good                                                   | 0.0233849 | 0.0120675         |
| 2   | All Except High Dose | 0.1015               | 1.938                                | 96.3408          | Good                                                   | 0.0233849 | 0.0120675         |

1 For the model to be acceptable, P-value must be > 0.1.

2 Scaled residuals report the gap between the curve line and the actual data points; for the model to be acceptable, all scaled residuals must have an absolute value of < 2.

3 The Akaike Information Coefficient (AIC) is used for comparison between models; generally, a lower AIC value indicates a better curve fit to the data.

4 Even when the numbers indicate a good curve fit, a visual inspection of the graph is important to ensure the curve is not wavy or contains other aberrations.

5 BMDL = Lower one-sided confidence limit on the BMD.

**Conclusion**

In both runs of the liver lesion data, with and without the highest dose level, the reported BMD was identical, 0.0233849 mg/kg-d. The BMDL was 0.0120675 mg/kg-d.



TETRA TECH

**BMDS Input Data Set:**

Model Type: Dichotomous      Model Name: Multistage

|   | Dose     | N  | Liver_Changes | Col4 | Col5 |
|---|----------|----|---------------|------|------|
| 1 | 0        | 17 | 1             |      |      |
| 2 | 0.007079 | 19 | 4             |      |      |
| 3 | 0.02832  | 19 | 9             |      |      |
| 4 | 0.1416   | 22 | 11            |      |      |
| 5 | 0.7079   | 18 | 18            |      |      |
| 6 | 1.416    | 11 | 11            |      |      |
| 7 | 2.124    | 9  | 9             |      |      |

**Model Parameters:**

**<<Column Assignments>>**

|                                 |               |
|---------------------------------|---------------|
| <i>Dose</i>                     | Dose          |
| <i># Subjects in Dose Group</i> | N             |
| <i>Incidence</i>                | Liver_Changes |
| <i>% Positive</i>               |               |

**<<Optimizer Assignments>>**

|                          |          |
|--------------------------|----------|
| <i>Iteration</i>         | 250      |
| <i>Relative Function</i> | 1.00E-08 |
| <i>Parameter</i>         | 1.00E-08 |

**<<Parameter Assignments>>**

| Parameters        | Options | Values |
|-------------------|---------|--------|
| <i>Background</i> | Default |        |
| <i>Beta1</i>      | Default |        |
| <i>Beta2</i>      | Default |        |

**<<Other Assignments>>**

|                              |                                     |
|------------------------------|-------------------------------------|
| <i>Risk Type</i>             | Extra                               |
| <i>BMR</i>                   | 0.1000                              |
| <i>Confidence Level</i>      | 0.95                                |
| <i>BMD Calculation</i>       | <input checked="" type="checkbox"/> |
| <i>BMDL Curve Calc.</i>      | <input type="checkbox"/>            |
| <i>Dose Groups</i>           | 6                                   |
| <i>Restrict Betas &gt;=0</i> | <input checked="" type="checkbox"/> |
| <i>Degree of Polynomial</i>  | 2                                   |

**User Notes:**

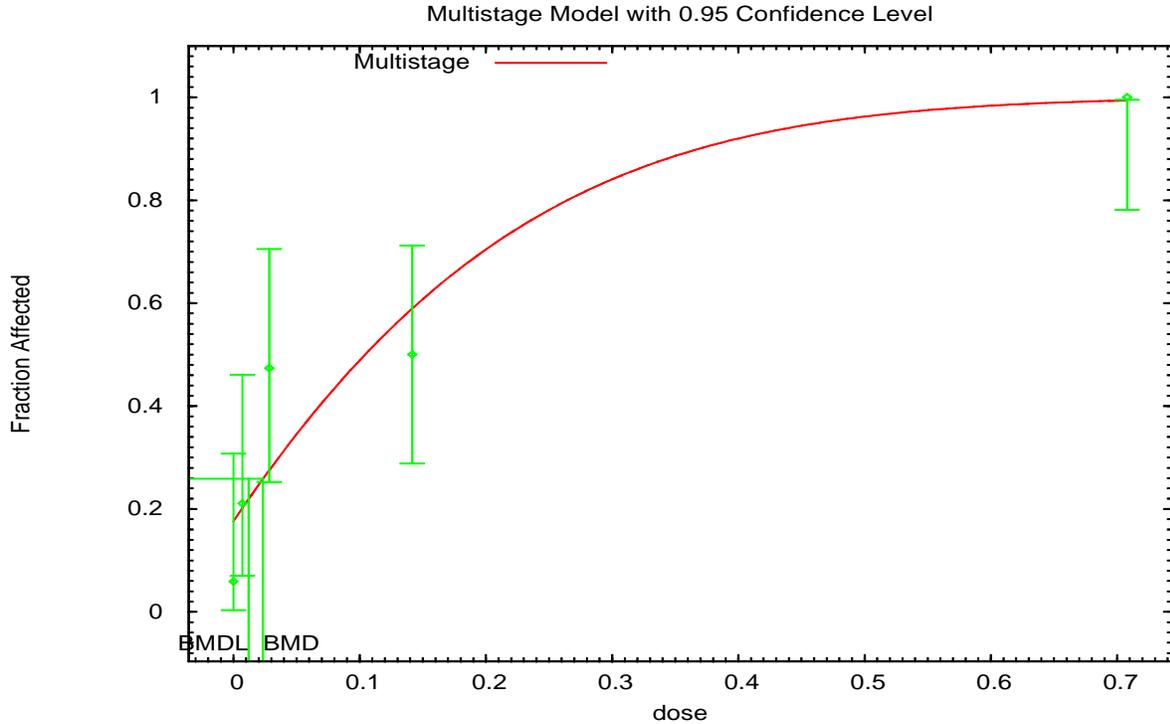
**Data File:** C:\USEPA\BMDS2121Data\Aldrin Liver FX from Fitzhugh 19

**Out File Name:** C:\USEPA\BMDS2121Data\mst\_Aldrin Liver FX from Fitzhug

Multistage -> Dichotomous



Output for Run 1, Complete Data Set (All Dose Levels):



15:53 12/21 2010

```

=====
Multistage Model. (Version: 3.2; Date: 05/26/2010)
Input Data File: C:/USEPA/BMDS212/Data/mst_Aldrin Liver FX from Fitzhugh
1964_Opt.(d)
Gnuplot Plotting File: C:/USEPA/BMDS212/Data/mst_Aldrin Liver FX from
Fitzhugh 1964_Opt.plt
Tue Dec 21 15:52:46 2010
=====

```

BMDS\_Model\_Run

The form of the probability function is:

$$P[\text{response}] = \text{background} + (1-\text{background}) * [1 - \text{EXP}(-\text{beta1} * \text{dose}^{1-\text{beta2}} * \text{dose}^2)]$$

The parameter betas are restricted to be positive

Dependent variable = Liver\_Changes  
Independent variable = Dose

Total number of observations = 7  
Total number of records with missing values = 0  
Total number of parameters in model = 3  
Total number of specified parameters = 0  
Degree of polynomial = 2



TETRA TECH

Maximum number of iterations = 250  
 Relative Function Convergence has been set to: 1e-008  
 Parameter Convergence has been set to: 1e-008

Default Initial Parameter Values

Background = 1  
 Beta(1) = 5.54426e+019  
 Beta(2) = 0

Asymptotic Correlation Matrix of Parameter Estimates

|            | Background | Beta(1) | Beta(2) |
|------------|------------|---------|---------|
| Background | 1          | -0.65   | 0.41    |
| Beta(1)    | -0.65      | 1       | -0.78   |
| Beta(2)    | 0.41       | -0.78   | 1       |

Parameter Estimates

| Interval<br>Limit | Variable   | Estimate | Std. Err. | 95.0% Wald Confidence |             |
|-------------------|------------|----------|-----------|-----------------------|-------------|
|                   |            |          |           | Lower Conf. Limit     | Upper Conf. |
|                   | Background | 0.176075 | *         | *                     | *           |
|                   | Beta(1)    | 4.42317  | *         | *                     | *           |
|                   | Beta(2)    | 3.52018  | *         | *                     | *           |

\* - Indicates that this value is not calculated.

Analysis of Deviance Table

| Model         | Log(likelihood) | # Param's | Deviance | Test d.f. | P-value |
|---------------|-----------------|-----------|----------|-----------|---------|
| Full model    | -41.9743        | 7         |          |           |         |
| Fitted model  | -45.1704        | 3         | 6.39212  | 4         | 0.1717  |
| Reduced model | -79.185         | 1         | 74.4214  | 6         | <.0001  |
| AIC:          | 96.3408         |           |          |           |         |

Goodness of Fit

| Dose   | Est._Prob. | Expected | Observed | Size | Scaled Residual |
|--------|------------|----------|----------|------|-----------------|
| 0.0000 | 0.1761     | 2.993    | 1.000    | 17   | -1.269          |
| 0.0071 | 0.2016     | 3.831    | 4.000    | 19   | 0.097           |
| 0.0283 | 0.2751     | 5.227    | 9.000    | 19   | 1.938           |
| 0.1416 | 0.5896     | 12.971   | 11.000   | 22   | -0.854          |
| 0.7079 | 0.9938     | 17.889   | 18.000   | 18   | 0.334           |
| 1.4160 | 1.0000     | 11.000   | 11.000   | 11   | 0.004           |
| 2.1240 | 1.0000     | 9.000    | 9.000    | 9    | 0.000           |



TETRA TECH

Chi<sup>2</sup> = 6.22      d.f. = 4      P-value = 0.1835

Benchmark Dose Computation

Specified effect = 0.1

Risk Type = Extra risk

Confidence level = 0.95

BMD = 0.0233849

BMDL = 0.0120675

BMDU = 0.0897018

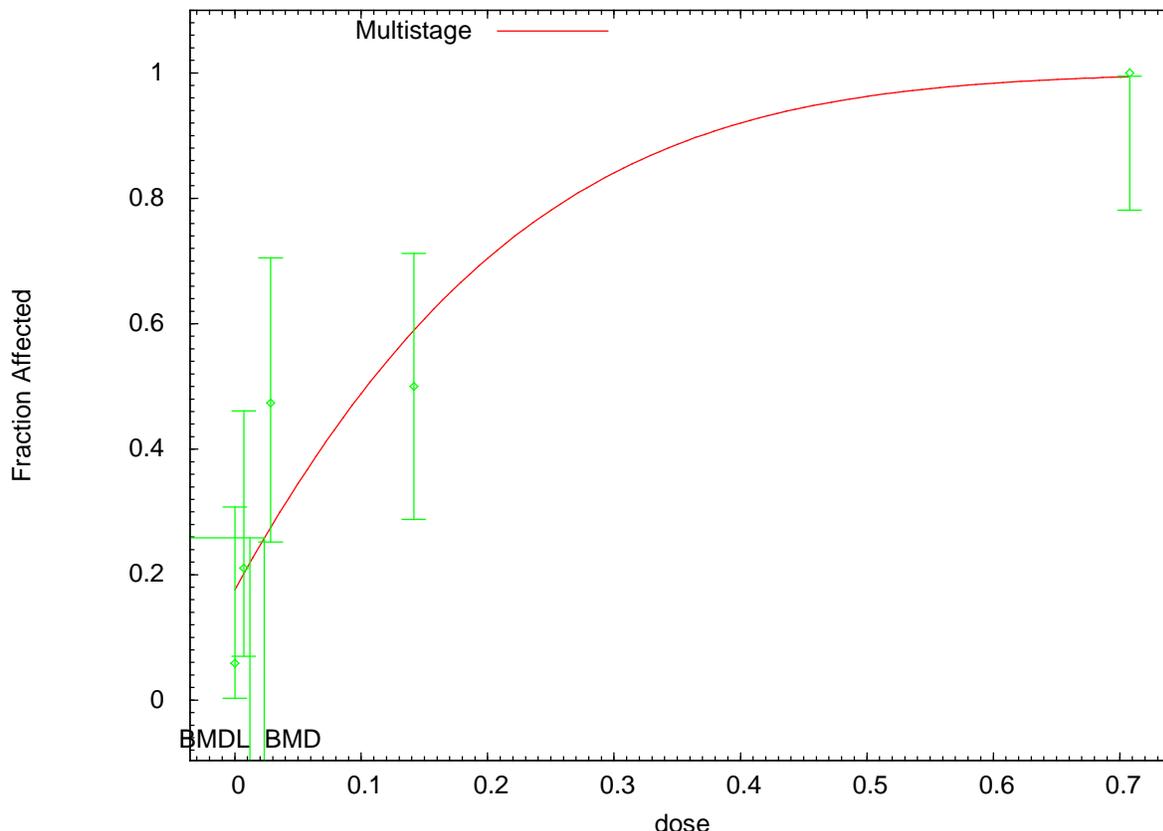
Taken together, (0.0120675, 0.0897018) is a 90 % two-sided confidence interval for the BMD



TETRA TECH

Output of Run 2, Data Set Excluding Highest Dose Group:

Multistage Model with 0.95 Confidence Level



15:53 12/21 2010

```

=====
Multistage Model. (Version: 3.2; Date: 05/26/2010)
Input Data File: C:/USEPA/BMDS212/Data/mst_Aldrin Liver FX from Fitzhugh
1964_Opt.(d)
Gnuplot Plotting File: C:/USEPA/BMDS212/Data/mst_Aldrin Liver FX from
Fitzhugh 1964_Opt.plt
Tue Dec 21 15:51:33 2010
=====

```

BMDS\_Model\_Run

The form of the probability function is:

$$P[\text{response}] = \text{background} + (1-\text{background}) * [1 - \text{EXP}(-\text{beta1} * \text{dose}^{\text{beta2}})]$$

The parameter betas are restricted to be positive

Dependent variable = Liver\_Changes  
 Independent variable = Dose

Total number of observations = 6



TETRA TECH

Total number of records with missing values = 0
Total number of parameters in model = 3
Total number of specified parameters = 0
Degree of polynomial = 2

Maximum number of iterations = 250
Relative Function Convergence has been set to: 1e-008
Parameter Convergence has been set to: 1e-008

Default Initial Parameter Values

Background = 1
Beta(1) = 8.25022e+019
Beta(2) = 0

Asymptotic Correlation Matrix of Parameter Estimates

Table with 4 columns: Parameter, Background, Beta(1), Beta(2). Rows: Background, Beta(1), Beta(2).

Parameter Estimates

Table with 5 columns: Variable, Estimate, Std. Err., Lower Conf. Limit, Upper Conf. Limit. Rows: Background, Beta(1), Beta(2).

\* - Indicates that this value is not calculated.

Analysis of Deviance Table

Table with 6 columns: Model, Log(likelihood), # Param's, Deviance, Test d.f., P-value. Rows: Full model, Fitted model, Reduced model.

AIC: 96.3408

Goodness of Fit

Table with 6 columns: Dose, Est.\_Prob., Expected, Observed, Size, Scaled Residual. Rows: 0.0000, 0.0071, 0.0283.



TETRA TECH

|        |        |        |        |    |        |
|--------|--------|--------|--------|----|--------|
| 0.1416 | 0.5896 | 12.971 | 11.000 | 22 | -0.854 |
| 0.7079 | 0.9938 | 17.889 | 18.000 | 18 | 0.334  |
| 1.4160 | 1.0000 | 11.000 | 11.000 | 11 | 0.004  |

Chi<sup>2</sup> = 6.22      d.f. = 3      P-value = 0.1015

Benchmark Dose Computation

Specified effect = 0.1

Risk Type = Extra risk

Confidence level = 0.95

BMD = 0.0233849

BMDL = 0.0120675

BMDU = 0.0897018

Taken together, (0.0120675, 0.0897018) is a 90 % two-sided confidence interval for the BMD



## Appendix D: Benchmark Dose Analysis of Non-Cancer Effects of Dieldrin

### Introduction

In the 1993 IRIS document for Dieldrin (CAS No. 60-57-1), the U.S. EPA calculated an oral Reference Dose (RfD) of 0.00005 mg/kg/day. The study on which the RfD was based was Walker et al. 1969, a study in which 12 rats/sex were fed diet containing 0, 0.1, 1.0, or 10.0 ppm Dieldrin for 2 years. IRIS converted the ppm dose levels to mg/kg-day, using the conversion factor of 1 ppm = 0.05 mg/kg-day. At the end of 2 years, females fed 1.0 and 10.0 ppm (0.05 and 0.5 mg/kg/day) had increased liver weights and liver-to-body weight ratios ( $p < 0.05$ ). Histopathological examinations revealed liver parenchymal cell changes including focal proliferation and focal hyperplasia at the 10 ppm dose level. These hepatic lesions were considered to be characteristic of exposure to an organochlorine insecticide. The LOAEL was identified by EPA as 1.0 ppm (0.005 mg/kg/day) and the NOAEL as 0.1 ppm (0.005 mg/kg/day). The RfD was formulated by dividing the LOAEL by an uncertainty factor of 100:  $(0.005 \text{ mg/kg-day})/100 = 0.00005 \text{ mg/kg/day}$ . The uncertainty factor was based on extrapolation from animal to human (10) and range of human sensitivities (10).

ATSDR (2002) also used the Walker et al. 1969 study to develop a Minimal Risk Level (MRL) of 0.00005 mg/kg/day for dieldrin. The MRL was calculated based on the same reasoning and calculations as the IRIS RfD.

### Method

A benchmark dose (BMD) approach was used to derive a new RfD for dieldrin. The U.S. EPA's BMDS 2.1.2 software package was used. BMDS 2.1.2 is the latest version of the BMDS series, released by EPA in June 2010.

One of the strengths of the BMD method is that it uses quantitative data. Unfortunately this strength is also a limitation in that the types of data required are not always available in published studies. The data presented in Walker et al. 1969 was not suitable for a BMD model, because the data displaying the sensitive endpoint (liver lesions, Table 5 of Walker et al. 1969) did not represent a clear dose-response, and the authors determined that the liver lesions reported in this table were deemed to not be associated with organochlorine insecticides. The liver weight data in Table 4 of Walker et al. 1969 were a suitable fit for BMD modeling, but liver weight increases in the absence of other signs of liver toxicity (e.g., histopathology or clinical chemistry) is an adaptive response to increased metabolism of the chemical and is generally not considered to be an adverse effect (Sipes and Gandolfi 1991; Amacher et al. 1998). Therefore, Walker et al. 1969 did not present any data set that could be applied to a BMD model.

When JMPR (1967) reviewed the chronic rat toxicity of dieldrin, they identified the liver lesions reported by Fitzhugh et al. 1964 to represent the sensitive endpoint for dieldrin-induced liver toxicity. A BMD model analysis was conducted based on the data reported by Fitzhugh et al. 1964. Table 4 of the Fitzhugh paper (see next page) reports the incidences of "characteristic chlorinated pesticide changes" in the liver of aldrin-treated rats. These are quantal data and



can be used in a Dichotomous Model in the BMDS 2.1.2 software. The authors divided the incidences of observed liver lesions into categories of severity (from Trace to Moderate and > Moderate). For simplicity, the total observations for all lesions were entered into the BMDS data input spreadsheet.

**Table 4 from Fitzhugh et al. 1964 (Note, only Dieldrin data were used in this modeling):**

*Table 4. Characteristic "chlorinated insecticide" changes in livers of rats fed aldrin or dieldrin*

| Compound and feeding level (ppm) | Degree of liver change* |   |    |   |         |    | Number microscopically sectioned |
|----------------------------------|-------------------------|---|----|---|---------|----|----------------------------------|
|                                  | N                       | T | VS | S | S-M & M | >M |                                  |
| None                             | 16                      | 1 | 0  | 0 | 0       | 0  | 17                               |
| <b>Aldrin</b>                    |                         |   |    |   |         |    |                                  |
| 0.5                              | 15                      | 4 | 0  | 0 | 0       | 0  | 19                               |
| 2                                | 10                      | 8 | 0  | 1 | 0       | 0  | 19                               |
| 10                               | 11                      | 3 | 7  | 1 | 0       | 0  | 22                               |
| 50                               | 0                       | 0 | 0  | 6 | 10      | 2  | 18                               |
| 100                              | 0                       | 0 | 0  | 0 | 5       | 6  | 11                               |
| 150                              | 0                       | 0 | 0  | 0 | 2       | 7  | 9                                |
| <b>Dieldrin</b>                  |                         |   |    |   |         |    |                                  |
| 0.5                              | 17                      | 4 | 0  | 1 | 0       | 0  | 22                               |
| 2                                | 12                      | 5 | 5  | 1 | 0       | 0  | 23                               |
| 10                               | 7                       | 7 | 3  | 1 | 0       | 0  | 18                               |
| 50                               | 0                       | 0 | 3  | 8 | 6       | 3  | 20                               |
| 100                              | 0                       | 0 | 1  | 1 | 8       | 8  | 18                               |
| 150                              | 0                       | 0 | 0  | 1 | 5       | 5  | 11                               |

\*Among the symbols for the different grades of liver lesions, N=none, T=trace or minimal, VS=very slight, S=slight, and M=moderate. The figures for various degrees of liver lesions are based on the microscopic sections.

In order to make the BMD calculations more applicable to human risk from exposure to aldrin, the dose levels in ppm were converted into Human Equivalent Dose (HED) levels in units of mg/kg-day. The two steps in estimating the HED from the animal dose are: (1) converting the dietary concentrations to milligrams per kilograms per day in the animals; and (2) converting the animal dose to the equivalent human dose. ATSDR and IRIS used an assumption that 1 ppm = 0.05 mg/kg-day to convert the rat dose levels to units of mg/kg-day. The second step used the "¾ power" assumption where the human equivalent dose, in units of milligrams per kilograms body weight per day, is equal to the animal dose × (animal body weight/70)<sup>1/4</sup>, where the rat body weight was estimated from Figure 1 of the Fitzhugh paper to be approximately 450 g, or 0.450 kg. The formulae and table below summarize the calculations to convert rat dose in ppm to HED in mg/kg/day.

$$\text{Rat dose in mg/kg-day} = (\text{dose in ppm}) \times 0.05 \text{ mg/kg-day.}$$

$$\text{Rat dose to HED conversion factor} = (0.450/70)^{1/4} = 0.2831578$$

$$\text{HED in mg/kg-day} = (\text{Rat dose in mg/kg-day}) \times 0.2831578$$



### Calculation of Human Equivalent Dose

| PPM in Diet | Rat Dose (mg/kg-day) | Human Equivalent Dose (mg/kg-day) |
|-------------|----------------------|-----------------------------------|
| 0           | 0                    | 0                                 |
| 0.5         | 0.10.025             | 0.0070789                         |
| 2           | 0.50.1               | 0.028316                          |
| 10          | 2.50.5               | 0.14158                           |
| 50          | 52.5                 | 0.07089                           |
| 100         | 5                    | 1.4158                            |
| 150         | 7.5                  | 2.1237                            |

### Results

The BMD analysis of the liver lesion data are presented in the table below, and the BMDS input data, model parameters, and output are presented in subsequent pages. The Dichotomous Multistage model was used, as this is the simplest model for quantal data. The first run results using the entire range of doses were acceptable. In BMDS modeling, the highest dose level is commonly removed to see if it improves the fit of the curve to the data points. In the liver lesion data set, both the full data set and removal of the highest dose produced curves with acceptable p-value and scaled residuals, and the Akaike Information Coefficient (AIC) values were identical.

| Run | Data Set             | P-value <sup>1</sup> | Highest Scaled Residual <sup>2</sup> | AIC <sup>2</sup> | Visual Assessment of Curve to Data Points <sup>4</sup> | BMD       | BMDL <sup>5</sup> |
|-----|----------------------|----------------------|--------------------------------------|------------------|--------------------------------------------------------|-----------|-------------------|
| 1   | All Data             | 0.2937               | 1.579                                | 96.2317          | Good                                                   | 0.0136975 | 0.00837329        |
| 2   | All Except High Dose | 0.2937               | 1.579                                | 96.2317          | Good                                                   | 0.0136975 | 0.00837329        |

1 For the model to be acceptable, P-value must be > 0.1.

2 Scaled residuals report the gap between the curve line and the actual data points; for the model to be acceptable, all scaled residuals must have an absolute value of < 2.

3 The Akaike Information Coefficient (AIC) is used for comparison between models; generally, a lower AIC value indicates a better curve fit to the data.

4 Even when the numbers indicate a good curve fit, a visual inspection of the graph is important to ensure the curve is not wavy or contains other aberrations.

5 BMDL = Lower one-sided confidence limit on the BMD.

### Conclusion

In both runs of the liver lesion data, with and without the highest dose level, the reported BMD was identical, 0.0136975 mg/kg-d. The BMDL was 0.00837329 mg/kg-d.



BMDS Input Data Set:

| Model Type: Dichotomous |          | Model Name: Multistage |               |      |
|-------------------------|----------|------------------------|---------------|------|
|                         | Dose     | N                      | Liver_Lesions | Col4 |
| 1                       | 0        | 17                     | 1             |      |
| 2                       | 0.007079 | 22                     | 5             |      |
| 3                       | 0.02823  | 23                     | 11            |      |
| 4                       | 0.1416   | 18                     | 11            |      |
| 5                       | 0.7079   | 20                     | 20            |      |
| 6                       | 1.416    | 18                     | 18            |      |
| 7                       | 2.124    | 11                     | 11            |      |

Model Parameters:

**<<Column Assignments>>**

|                                 |               |
|---------------------------------|---------------|
| <i>Dose</i>                     | Dose          |
| <i># Subjects in Dose Group</i> | N             |
| <i>Incidence</i>                | Liver_Lesions |
| <i>% Positive</i>               |               |

**<<Optimizer Assignments>>**

|                          |          |
|--------------------------|----------|
| <i>Iteration</i>         | 250      |
| <i>Relative Function</i> | 1.00E-08 |
| <i>Parameter</i>         | 1.00E-08 |

**<<Parameter Assignments>>**

| Parameters        | Options | Values |
|-------------------|---------|--------|
| <i>Background</i> | Default |        |
| <i>Beta1</i>      | Default |        |
| <i>Beta2</i>      | Default |        |

**<<Other Assignments>>**

|                              |                                     |
|------------------------------|-------------------------------------|
| <i>Risk Type</i>             | Extra                               |
| <i>BMR</i>                   | 0.1000                              |
| <i>Confidence Level</i>      | 0.95                                |
| <i>BMD Calculation</i>       | <input checked="" type="checkbox"/> |
| <i>BMDL Curve. Calc.</i>     | <input type="checkbox"/>            |
| <i>Dose Groups</i>           | 7                                   |
| <i>Restrict Betas &gt;=0</i> | <input checked="" type="checkbox"/> |
| <i>Degree of Polynomial</i>  | 2                                   |

*User Notes:*

*Data File:*

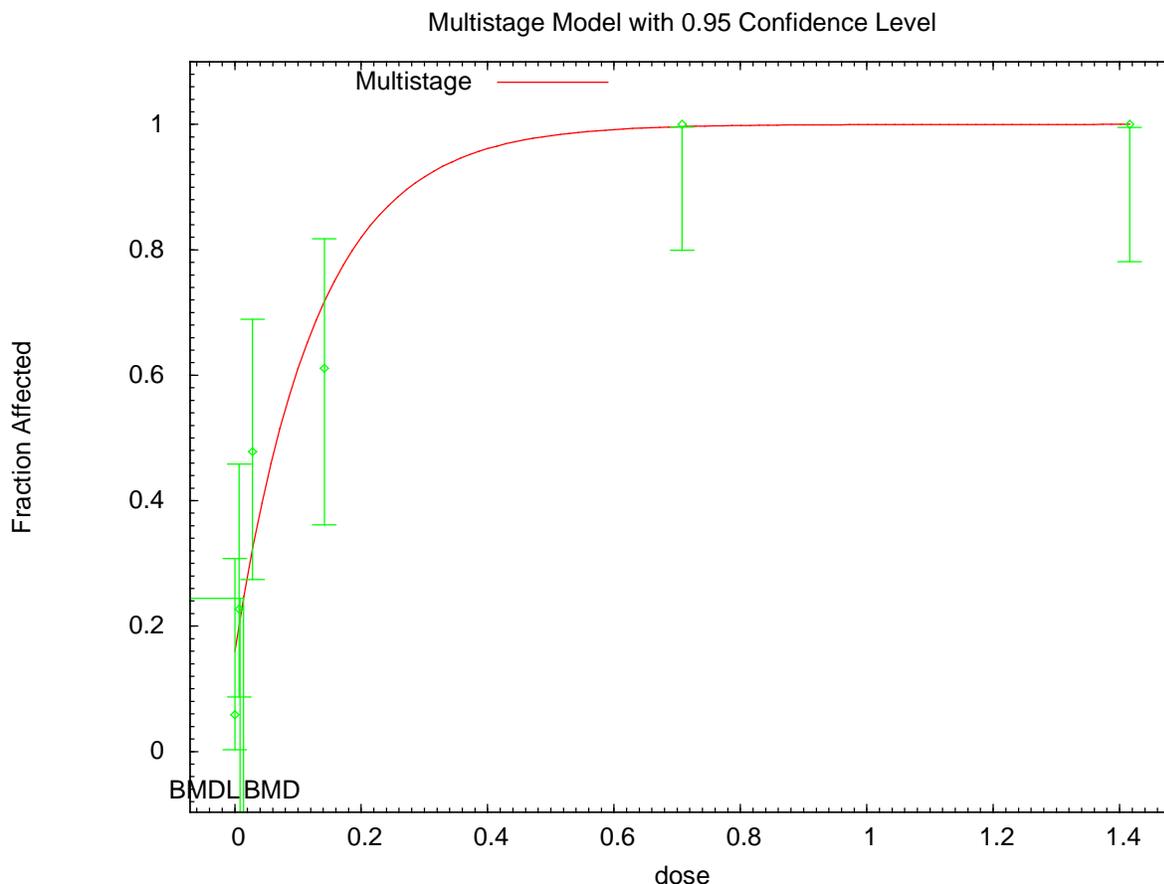
*Out File Name:* C:\USEPA\BMDS212\Data\mst\_UntitledData\_Setting.out

Multistage->Dichotomous



TETRA TECH

Output for Run 1, Complete Data Set (All Dose Levels):



10:07 01/14 2011

```

=====
Multistage Model. (Version: 3.2; Date: 05/26/2010)
Input Data File: C:/USEPA/BMDS212/Data/mst_UntitledData_Setting.(d)
Gnuplot Plotting File: C:/USEPA/BMDS212/Data/mst_UntitledData_Setting.plt
Fri Jan 14 10:07:56 2011
=====

```

BMDS\_Model\_Run

The form of the probability function is:

$$P[\text{response}] = \text{background} + (1-\text{background}) * [1 - \text{EXP}(-\text{beta1} * \text{dose}^1 - \text{beta2} * \text{dose}^2)]$$

The parameter betas are restricted to be positive

Dependent variable = Liver\_Lesions  
 Independent variable = Dose

Total number of observations = 7  
 Total number of records with missing values = 1



TETRA TECH

Total number of parameters in model = 3
Total number of specified parameters = 0
Degree of polynomial = 2

Maximum number of iterations = 250
Relative Function Convergence has been set to: 1e-008
Parameter Convergence has been set to: 1e-008

Default Initial Parameter Values

Background = 1
Beta(1) = 8.25008e+019
Beta(2) = 0

Asymptotic Correlation Matrix of Parameter Estimates

( \*\*\* The model parameter(s) -Beta(2)
have been estimated at a boundary point, or have been specified by
the user,
and do not appear in the correlation matrix )

Table with 3 columns: Variable, Background, Beta(1). Rows: Background, Beta(1).

Parameter Estimates

Table with 5 columns: Interval Limit, Variable, Estimate, Std. Err., Lower Conf. Limit, Upper Conf. Limit. Rows: Background, Beta(1), Beta(2).

\* - Indicates that this value is not calculated.

Analysis of Deviance Table

Table with 6 columns: Model, Log(likelihood), # Param's, Deviance, Test d.f., P-value. Rows: Full model, Fitted model, Reduced model, AIC.

Goodness of Fit

Table with 6 columns: Dose, Est.\_Prob., Expected, Observed, Size, Scaled Residual. Row: 0.0000, 0.1602, 2.724, 1.000, 17, -1.140.



TETRA TECH

|        |        |        |        |    |        |
|--------|--------|--------|--------|----|--------|
| 0.0071 | 0.2048 | 4.505  | 5.000  | 22 | 0.262  |
| 0.0282 | 0.3242 | 7.456  | 11.000 | 23 | 1.579  |
| 0.1416 | 0.7174 | 12.914 | 11.000 | 18 | -1.002 |
| 0.7079 | 0.9964 | 19.927 | 20.000 | 20 | 0.270  |
| 1.4160 | 1.0000 | 18.000 | 18.000 | 18 | 0.017  |

Chi<sup>2</sup> = 4.94      d.f. = 4      P-value = 0.2937

Benchmark Dose Computation

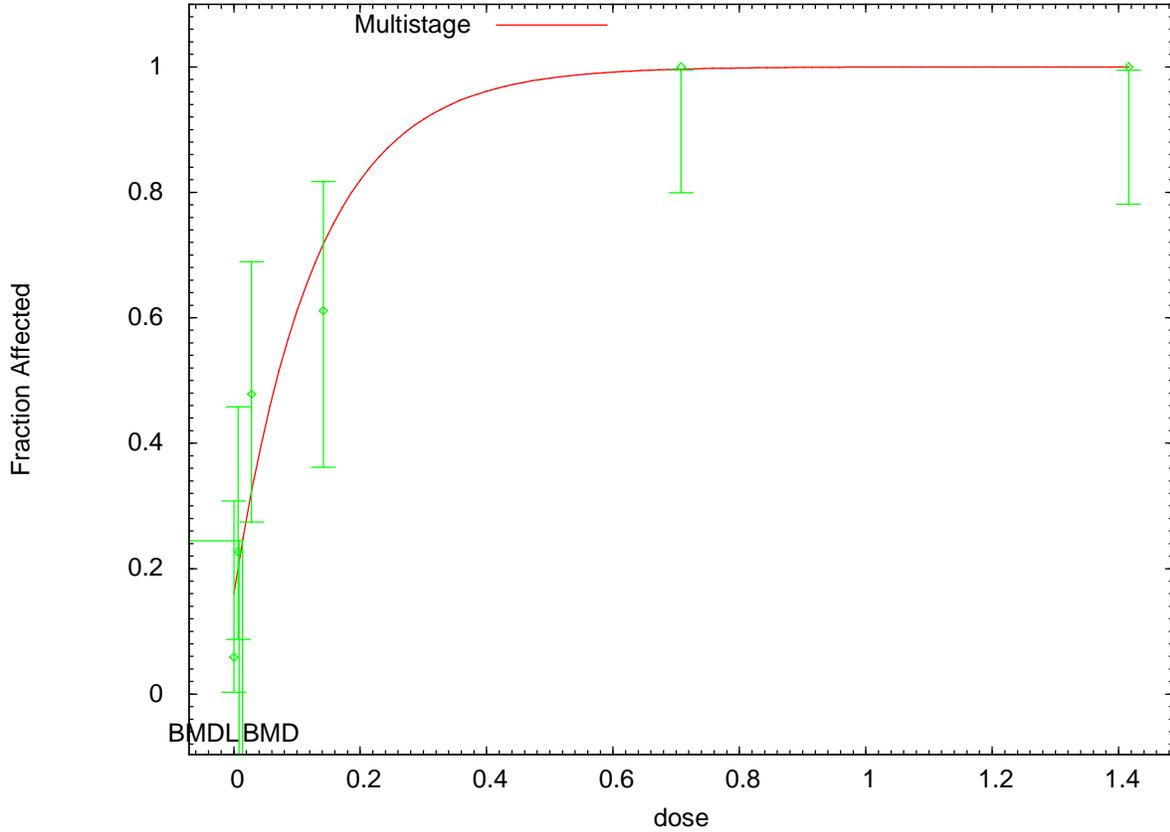
Specified effect = 0.1  
Risk Type = Extra risk  
Confidence level = 0.95  
BMD = 0.0136975  
BMDL = 0.00837329  
BMDU = 0.0418518

Taken together, (0.00837329, 0.0418518) is a 90 % two-sided confidence interval for the BMD



Output of Run 2, Data Set Excluding Highest Dose Group:

Multistage Model with 0.95 Confidence Level



14:30 01/14 2011

```

=====
Multistage Model. (Version: 3.2; Date: 05/26/2010)
Input Data File: C:/USEPA/BMDS212/Data/mst_UntitledData_Setting.(d)
Gnuplot Plotting File: C:/USEPA/BMDS212/Data/mst_UntitledData_Setting.plt
Fri Jan 14 14:30:21 2011
=====

```

BMDS\_Model\_Run

~~~~~

The form of the probability function is:

$$P[\text{response}] = \text{background} + (1-\text{background}) * [1 - \text{EXP}(-\text{beta1} * \text{dose} - \text{beta2} * \text{dose}^2)]$$

The parameter betas are restricted to be positive

Dependent variable = Liver_Lesions
Independent variable = Dose

Total number of observations = 6
Total number of records with missing values = 0
Total number of parameters in model = 3
Total number of specified parameters = 0



TETRA TECH

Degree of polynomial = 2

Maximum number of iterations = 250
Relative Function Convergence has been set to: 1e-008
Parameter Convergence has been set to: 1e-008

Default Initial Parameter Values

Background = 1
Beta(1) = 8.25008e+019
Beta(2) = 0

Asymptotic Correlation Matrix of Parameter Estimates

(*** The model parameter(s) -Beta(2)
have been estimated at a boundary point, or have been specified by
the user,
and do not appear in the correlation matrix)

Table with 3 columns: Parameter, Background, Beta(1). Rows: Background, Beta(1).

Parameter Estimates

Table with 5 columns: Variable, Estimate, Std. Err., Lower Conf. Limit, Upper Conf. Limit. Rows: Background, Beta(1), Beta(2).

* - Indicates that this value is not calculated.

Analysis of Deviance Table

Table with 6 columns: Model, Log(likelihood), # Param's, Deviance, Test d.f., P-value. Rows: Full model, Fitted model, Reduced model, AIC.

Goodness of Fit

Table with 6 columns: Dose, Est._Prob., Expected, Observed, Size, Scaled Residual. Rows: 0.0000, 0.0071, 0.0282.



TETRA TECH

0.1416	0.7174	12.914	11.000	18	-1.002
0.7079	0.9964	19.927	20.000	20	0.270
1.4160	1.0000	18.000	18.000	18	0.017

Chi² = 4.94 d.f. = 4 P-value = 0.2937

Benchmark Dose Computation

Specified effect = 0.1
Risk Type = Extra risk
Confidence level = 0.95
BMD = 0.0136975
BMDL = 0.00837329
BMDU = 0.0418518

Taken together, (0.00837329, 0.0418518) is a 90 % two-sided confidence interval for the BMD

APPENDIX E

**Analytical Results and Risk/Hazard Calculations for Decision Units –
2011 HC HHRE EALs**

TABLE E-1
Earhart I-2: Risk and Hazard Calculations - Child Resident^a

Decision Unit	Depth (feet)	Analytical Results (mg/kg)											Child Resident																							Exceed HDOH 2011 HC HHRE Standard? ^e
		Aldrin	Chlordane	Dieldrin	4,4-DDD	4,4-DDE	4,4-DDT	Endrin	Endrin Ketone	Methoxychlor	delta-BHC	Cancer Risk											Noncancer Hazard													
												Aldrin	Chlordane	Dieldrin	4,4-DDD	4,4-DDE	4,4-DDT	Endrin	Endrin Ketone	Methoxychlor	delta-BHC	Cumulative Risk ^b			Aldrin	Chlordane	Dieldrin	4,4-DDD	4,4-DDE	4,4-DDT	Endrin	Endrin Ketone	Methoxychlor	delta-BHC	Hazard Index ^d	
Resident Child - Cancer EALs (mg/kg)	Res. Child - Noncancer EALs (mg/kg)	All Chems			Aldrin and Dieldrin Only	No Aldrin or Dieldrin ^c																														
EAR2-RA-10a-06-1	0.5	0.33	1.1	0.83	0.017	0.12	0.036	0.023	<0.008	<0.012	<0.0098	7.8E-07	2.6E-07	4.1E-06	3.5E-09	3.5E-08	7.8E-09	---	ND	ND	ND	5.2E-06	4.9E-06	3.0E-07	2.7E-02	2.9E-02	8.5E-02	---	---	5.4E-04	7.6E-04	ND	ND	ND	0.14	No
EAR2-RA-10a-06-2	0.5	0.34	0.86	0.83	0.017	0.079	0.026	0.023	<0.008	<0.012	<0.0098	8.1E-07	2.0E-07	4.1E-06	3.5E-09	2.3E-08	5.7E-09	---	ND	ND	ND	5.1E-06	4.9E-06	2.3E-07	2.8E-02	2.2E-02	8.5E-02	---	---	3.9E-04	7.6E-04	ND	ND	ND	0.14	No
EAR2-RA-10a-06-3	0.5	0.19	0.62	0.53	<0.0094	0.052	0.02	<0.011	<0.008	<0.012	<0.0098	4.5E-07	1.5E-07	2.6E-06	ND	1.5E-08	4.3E-09	ND	ND	ND	ND	3.2E-06	3.0E-06	1.7E-07	1.6E-02	1.6E-02	5.4E-02	ND	---	3.0E-04	ND	ND	ND	ND	0.09	No
EAR2-RA-10a-12	1	0.62	0.9	0.94	0.012	0.079	0.02	0.024	<0.008	<0.012	<0.0098	1.5E-06	2.1E-07	4.6E-06	2.5E-09	2.3E-08	4.3E-09	---	ND	ND	ND	6.3E-06	6.1E-06	2.4E-07	5.1E-02	2.3E-02	9.6E-02	---	---	3.0E-04	8.0E-04	ND	ND	ND	0.17	No
EAR2-RA-10b-06	0.5	0.36	2.8	0.95	0.071	0.55	0.36	0.04	<0.008	<0.012	<0.0098	8.6E-07	6.6E-07	4.7E-06	1.5E-08	1.6E-07	7.8E-08	---	ND	ND	ND	6.4E-06	5.5E-06	9.1E-07	3.0E-02	7.3E-02	9.7E-02	---	---	5.4E-03	1.3E-03	ND	ND	ND	0.21	No
EAR2-RA-10b-12	1	0.14	1.8	0.31	0.032	0.6	0.2	0.028	<0.008	<0.012	<0.0098	3.3E-07	4.2E-07	1.5E-06	6.6E-09	1.7E-07	4.3E-08	---	ND	ND	ND	2.5E-06	1.9E-06	6.5E-07	1.1E-02	4.7E-02	3.2E-02	---	---	3.0E-03	9.3E-04	ND	ND	ND	0.09	No
EAR2-RA-11a-06	0.5	3	<0.5	5.9	<0.024	0.15	0.14	0.047	0.067	<0.031	<0.025	7.1E-06	ND	2.9E-05	ND	4.4E-08	3.0E-08	---	---	ND	ND	3.6E-05	3.6E-05	7.4E-08	2.5E-01	ND	6.0E-01	ND	---	2.1E-03	1.6E-03	2.2E-03	ND	ND	0.85	No
EAR2-RA-11a-12	1	1.9	<0.5	5.1	0.03	0.15	0.19	0.033	0.041	<0.031	<0.025	4.5E-06	ND	2.5E-05	6.2E-09	4.4E-08	4.1E-08	---	---	ND	ND	3.0E-05	3.0E-05	9.1E-08	1.6E-01	ND	5.2E-01	---	---	2.8E-03	1.1E-03	1.4E-03	ND	ND	0.68	No
EAR2-RA-11b-06	0.5	5.3	<0.5	8.8	0.038	0.13	0.32	0.06	0.046	<0.031	<0.025	1.3E-05	ND	4.3E-05	7.8E-09	3.8E-08	7.0E-08	---	---	ND	ND	5.6E-05	5.6E-05	1.2E-07	4.3E-01	ND	9.0E-01	---	---	4.8E-03	2.0E-03	1.5E-03	ND	ND	1.34	Yes
EAR2-RA-11b-12	1	5.9	<0.5	7.8	<0.024	0.091	0.12	0.061	0.057	<0.031	<0.025	1.4E-05	ND	3.8E-05	ND	2.6E-08	2.6E-08	---	---	ND	ND	5.2E-05	5.2E-05	5.3E-08	4.8E-01	ND	8.0E-01	ND	---	1.8E-03	2.0E-03	1.9E-03	ND	ND	1.28	Yes
EAR2-RA-11c-06	0.5	1.1	0.84	2.7	<0.024	0.049	<0.04	0.029	<0.02	<0.031	<0.025	2.6E-06	2.0E-07	1.3E-05	ND	1.4E-08	ND	---	---	ND	ND	1.6E-05	1.6E-05	2.1E-07	9.0E-02	2.2E-02	2.8E-01	ND	---	ND	9.6E-04	ND	ND	ND	0.39	No
EAR2-RA-11c-12	1	0.89	0.83	2.7	<0.024	0.044	<0.04	0.031	<0.02	<0.031	<0.025	2.1E-06	1.9E-07	1.3E-05	ND	1.3E-08	ND	---	---	ND	ND	1.6E-05	1.5E-05	2.1E-07	7.3E-02	2.2E-02	2.8E-01	ND	---	ND	1.0E-03	ND	ND	ND	0.37	No
EAR2-RA-11d-06	0.5	0.72	<1	3.4	<0.047	0.064	<0.057	<0.04	<0.062	<0.049	<0.049	1.7E-06	ND	1.7E-05	ND	1.9E-08	ND	ND	ND	ND	ND	1.8E-05	1.8E-05	1.9E-08	5.9E-02	ND	3.5E-01	ND	---	ND	ND	ND	ND	ND	0.41	No
EAR2-RA-11d-12	1	0.6	0.63	2.3	<0.024	0.06	0.052	<0.028	<0.02	<0.031	<0.025	1.4E-06	1.5E-07	1.1E-05	ND	1.7E-08	1.1E-08	ND	ND	ND	ND	1.3E-05	1.3E-05	1.8E-07	4.9E-02	1.6E-02	2.3E-01	ND	---	7.8E-04	ND	ND	ND	ND	0.30	No
EAR2-RA-12a-06	0.5	0.22	0.74	1.1	<0.024	0.046	0.052	<0.028	<0.02	<0.031	<0.025	5.2E-07	1.7E-07	5.4E-06	ND	1.3E-08	1.1E-08	ND	ND	ND	ND	6.1E-06	5.9E-06	2.0E-07	1.8E-02	1.9E-02	1.1E-01	ND	---	7.8E-04	ND	ND	ND	ND	0.15	No
EAR2-RA-12a-12	1	0.25	0.88	1.3	<0.024	0.065	0.082	<0.028	<0.02	<0.031	<0.025	5.9E-07	2.1E-07	6.4E-06	ND	1.9E-08	1.8E-08	ND	ND	ND	ND	7.2E-06	7.0E-06	2.4E-07	2.0E-02	2.3E-02	1.3E-01	ND	---	1.2E-03	ND	ND	ND	ND	0.18	No
EAR2-RA-12b-06	0.5	1.1	1	2.4	<0.024	0.031	<0.04	<0.028	<0.02	<0.031	<0.025	2.6E-06	2.3E-07	1.2E-05	ND	9.0E-09	ND	ND	ND	ND	ND	1.5E-05	1.4E-05	2.4E-07	9.0E-02	2.6E-02	2.4E-01	ND	---	ND	ND	ND	ND	ND	0.36	No
EAR2-RA-12b-12	1	0.97	0.82	2.7	<0.024	0.026	<0.04	<0.028	<0.02	<0.031	<0.025	2.3E-06	1.9E-07	1.3E-05	ND	7.6E-09	ND	ND	ND	ND	ND	1.6E-05	1.6E-05	2.0E-07	8.0E-02	2.1E-02	2.8E-01	ND	---	ND	ND	ND	ND	ND	0.38	No
EAR2-RA-12c-06	0.5	5.4	3.6	3.9	<0.024	0.027	<0.04	<0.028	<0.02	<0.031	<0.025	1.3E-05	8.5E-07	1.9E-05	ND	7.8E-09	ND	ND	ND	ND	ND	3.3E-05	3.2E-05	8.5E-07	4.4E-01	9.4E-02	4.0E-01	ND	---	ND	ND	ND	ND	ND	0.93	No
EAR2-RA-12c-12	1	1.2	2.5	2.3	<0.024	0.027	<0.04	<0.028	<0.02	<0.031	<0.025	2.9E-06	5.9E-07	1.1E-05	ND	7.8E-09	ND	ND	ND	ND	ND	1.5E-05	1.4E-05	5.9E-07	9.8E-02	6.5E-02	2.3E-01	ND	---	ND	ND	ND	ND	ND	0.40	No
EAR2-RA-13a-06	0.5	2.3	<1	7.6	<0.047	<0.048	<0.081	0.058	<0.04	<0.062	<0.049	5.5E-06	ND	3.7E-05	ND	ND	ND	---	---	ND	ND	4.3E-05	4.3E-05	0.0E+00	1.9E-01	ND	7.8E-01	ND	ND	ND	1.9E-03	ND	ND	ND	0.97	No
EAR2-RA-13a-12	1	2	<1	5.2	<0.047	0.057	<0.081	0.068	0.041	<0.062	<0.049	4.8E-06	ND	2.5E-05	ND	1.7E-08	ND	---	---	ND	ND	3.0E-05	3.0E-05	1.7E-08	1.6E-01	ND	5.3E-01	ND	---	ND	2.3E-03	1.4E-03	ND	ND	0.70	No
EAR2-RA-13b-06	0.5	0.84	<1	4.9	<0.047	0.059	<0.081	<0.057	<0.04	<0.062	<0.049	2.0E-06	ND	2.4E-05	ND	1.7E-08	ND	ND	ND	ND	ND	2.6E-05	2.6E-05	1.7E-08	6.9E-02	ND	5.0E-01	ND	---	ND	ND	ND	ND	ND	0.57	No
EAR2-RA-13b-12	1	1.8	<1	3.4	<0.047	<0.048	<0.081	<0.057	<0.04	<0.062	<0.049	4.3E-06	ND	1.7E-05	ND	ND	ND	ND	ND	ND	ND	2.1E-05	2.1E-05	0.0E+00	1.5E-01	ND	3.5E-01	ND	ND	ND	ND	ND	ND	ND	0.49	No
EAR2-RA-13c-06-1	0.5	1.2	<0.5	2.5	<0.024	0.048	0.045	<0.028	<0.02	<0.031	<0.025	2.9E-06	ND	1.2E-05	ND	1.4E-08	9.8E-09	ND	ND	ND	ND	1.5E-05	1.5E-05	2.4E-08	9.8E-02	ND	2.6E-01	ND	---	6.7E-04	ND	ND	ND	ND	0.35	No
EAR2-RA-13c-06-2	0.5	0.51	<0.5	2.6	<0.024	0.061	0.087	<0.028	<0.02	<0.031	<0.025	1.2E-06	ND	1.3E-05	ND	1.8E-08	1.9E-08	ND	ND	ND	ND	1.4E-05	1.4E-05	3.7E-08	4.2E-02	ND	2.7E-01	ND	---	1.3E-03	ND	ND	ND	ND	0.31	No
EAR2-RA-13c-06-3	0.5	0.42	<0.5	2	<0.024	0.033	<0.04	<0.028	<0.02	<0.031	<0.025	1.0E-06	ND	9.8E-06	ND	9.6E-09	ND	ND	ND	ND	ND	1.1E-05	1.1E-05	9.6E-09	3.4E-02	ND	2.0E-01	ND	---	ND	ND	ND	ND	ND	0.24	No
EAR2-RA-13c-12	1	0.82	<0.5	2.6	<0.024	0.04	<0.04	<0.028	<0.02	<0.031	<0.025	1.9E-06	ND	1.3E-05	ND	1.2E-08	ND	ND	ND	ND	ND	1.5E-05	1.5E-05	1.2E-08	6.7E-02	ND	2.7E-01	ND	---	ND	ND	ND	ND	ND	0.33	No
EAR2-RA-13d-06	0.5	0.89	<1	3.7	<0.047	0.12	<0.081	<0.057	<0.04	<0.062	<0.049	2.1E-06	ND	1.8E-05	ND	3.5E-08	ND	ND	ND	ND	ND	2.0E-05	2.0E-05	3.5E-08	7.3E-02	ND	3.8E-01	ND	---	ND	ND	ND	ND	ND	0.45	No
EAR2-RA-13d-12	1	0.73	<1	2.5	<0.047	0.086	<0.081	<0.057	<0.04	<0.062	<0.049	1.7E-06	ND	1.2E-05	ND	2.5E-08	ND	ND	ND	ND	ND	1.4E-05	1.4E-05	2.5E-08	6.0E-02	ND	2.6E-01	ND	---	ND	ND	ND	ND	ND	0.31	No
EAR2-RA-13e-06	0.5	0.94	<1	3.9	0.058	0.14	<0.081	<0.057	<0.04	<																										

TABLE E-1
Earhart I-2: Risk and Hazard Calculations - Child Resident^a

Decision Unit	Depth (feet)	Analytical Results (mg/kg)											Child Resident																	Exceed HDOH 2011 HC HHRE Standard? ^e					
		Aldrin	Chlordane	Dieldrin	4,4-DDD	4,4-DDE	4,4-DDT	Endrin	Endrin Ketone	Methoxychlor	delta-BHC	Cancer Risk											Noncancer Hazard												
												Aldrin	Chlordane	Dieldrin	4,4-DDD	4,4-DDE	4,4-DDT	Endrin	Endrin Ketone	Methoxychlor	delta-BHC	Cumulative Risk ^b			Aldrin	Chlordane	Dieldrin	4,4-DDD	4,4-DDE		4,4-DDT	Endrin	Endrin Ketone	Methoxychlor	delta-BHC
Resident Child - Cancer EALs (mg/kg)	Res. Child - Noncancer EALs (mg/kg)												All Chems	Aldrin and Dieldrin Only	No Aldrin or Dieldrin ^c																				
EAR2-RA-16a-06-1	0.5	1	<1	4.1	<0.047	0.093	<0.081	<0.057	<0.04	<0.062	<0.049	2.4E-06	ND	2.0E-05	ND	2.7E-08	ND	ND	ND	ND	2.3E-05	2.2E-05	2.7E-08	8.2E-02	ND	4.2E-01	ND	----	ND	ND	ND	ND	ND	0.50	No
EAR2-RA-16a-06-2	0.5	1.1	<2	4.6	<0.094	0.11	0.21	<0.11	<0.08	<0.12	<0.098	2.6E-06	ND	2.3E-05	ND	3.2E-08	4.6E-08	ND	ND	ND	2.5E-05	2.5E-05	7.8E-08	9.0E-02	ND	4.7E-01	ND	----	3.1E-03	ND	ND	ND	ND	0.56	No
EAR2-RA-16a-06-3	0.5	0.69	<1	3.3	<0.047	0.074	0.12	<0.057	<0.04	<0.062	<0.049	1.6E-06	ND	1.6E-05	ND	2.2E-08	2.6E-08	ND	ND	ND	1.8E-05	1.8E-05	4.8E-08	5.7E-02	ND	3.4E-01	ND	----	1.8E-03	ND	ND	ND	ND	0.40	No
EAR2-RA-16a-12	1	0.93	<1	4	<0.047	0.066	<0.081	<0.057	<0.04	<0.062	<0.049	2.2E-06	ND	2.0E-05	ND	1.9E-08	ND	ND	ND	ND	2.2E-05	2.2E-05	1.9E-08	7.6E-02	ND	4.1E-01	ND	----	ND	ND	ND	ND	ND	0.48	No
EAR2-RA-16b-06	0.5	0.32	0.56	1.4	<0.024	0.044	0.052	<0.028	0.024	<0.031	<0.025	7.6E-07	1.3E-07	6.9E-06	ND	1.3E-08	1.1E-08	ND	----	ND	7.8E-06	7.6E-06	1.6E-07	2.6E-02	1.5E-02	1.4E-01	ND	----	7.8E-04	ND	8.0E-04	ND	ND	0.18	No
EAR2-RA-16b-12	1	0.42	<0.5	1.2	<0.024	<0.024	<0.04	<0.028	<0.02	<0.031	<0.025	1.0E-06	ND	5.9E-06	ND	ND	ND	ND	ND	6.9E-06	6.9E-06	0.0E+00	3.4E-02	ND	1.2E-01	ND	ND	ND	ND	ND	ND	ND	0.16	No	
EAR2-RA-18a-06	0.5	0.32	0.69	1.8	<0.024	0.17	0.16	<0.028	<0.02	<0.031	<0.025	7.6E-07	1.6E-07	8.8E-06	ND	4.9E-08	3.5E-08	ND	ND	ND	9.8E-06	9.6E-06	2.5E-07	2.6E-02	1.8E-02	1.8E-01	ND	----	2.4E-03	ND	ND	ND	ND	0.23	No
EAR2-RA-18a-12	1	0.27	<0.5	1.1	<0.024	0.15	0.1	<0.028	<0.02	<0.031	<0.025	6.4E-07	ND	5.4E-06	ND	4.4E-08	2.2E-08	ND	ND	ND	6.1E-06	6.0E-06	6.5E-08	2.2E-02	ND	1.1E-01	ND	----	1.5E-03	ND	ND	ND	ND	0.14	No
EAR2-RA-18b-06	0.5	0.059	<0.2	0.38	0.02	0.11	0.1	<0.011	<0.008	<0.012	<0.0098	1.4E-07	ND	1.9E-06	4.1E-09	3.2E-08	2.2E-08	ND	ND	ND	2.1E-06	2.0E-06	5.8E-08	4.8E-03	ND	3.9E-02	----	----	1.5E-03	ND	ND	ND	ND	0.05	No
EAR2-RA-18b-12	1	0.045	<0.1	0.18	0.019	0.11	0.13	<0.0057	<0.004	<0.0062	<0.0049	1.1E-07	ND	8.8E-07	3.9E-09	3.2E-08	2.8E-08	ND	ND	ND	1.1E-06	9.9E-07	6.4E-08	3.7E-03	ND	1.8E-02	----	----	1.9E-03	ND	ND	ND	ND	0.02	No
EAR2-RA-18c-06	0.5	0.32	0.52	1.5	0.031	0.15	0.09	<0.028	<0.02	<0.031	<0.025	7.6E-07	1.2E-07	7.4E-06	6.4E-09	4.4E-08	2.0E-08	ND	ND	ND	8.3E-06	8.1E-06	1.9E-07	2.6E-02	1.4E-02	1.5E-01	----	----	1.3E-03	ND	ND	ND	ND	0.19	No
EAR2-RA-18c-12	1	0.14	<0.5	0.83	<0.024	0.12	0.085	<0.028	<0.02	<0.031	<0.025	3.3E-07	ND	4.1E-06	ND	3.5E-08	1.8E-08	ND	ND	ND	4.5E-06	4.4E-06	5.3E-08	1.1E-02	ND	8.5E-02	ND	----	1.3E-03	ND	ND	ND	ND	0.10	No
EAR2-RA-18d-06	0.5	0.52	0.87	1.2	0.024	0.13	0.099	<0.028	<0.02	<0.031	<0.025	1.2E-06	2.0E-07	5.9E-06	4.9E-09	3.8E-08	2.2E-08	ND	ND	ND	7.4E-06	7.1E-06	2.7E-07	4.3E-02	2.3E-02	1.2E-01	----	----	1.5E-03	ND	ND	ND	ND	0.19	No
EAR2-RA-18d-12	1	0.5	0.61	0.97	0.067	0.14	0.37	<0.028	<0.02	<0.031	<0.025	1.2E-06	1.4E-07	4.8E-06	1.4E-08	4.1E-08	8.0E-08	ND	ND	ND	6.2E-06	5.9E-06	2.8E-07	4.1E-02	1.6E-02	9.9E-02	----	----	5.5E-03	ND	ND	ND	ND	0.16	No
EAR2-RA-19a-06	0.5	0.85	<1	3.1	<0.047	0.078	<0.081	<0.057	<0.04	<0.062	<0.049	2.0E-06	ND	1.5E-05	ND	2.3E-08	ND	ND	ND	ND	1.7E-05	1.7E-05	2.3E-08	7.0E-02	ND	3.2E-01	ND	----	ND	ND	ND	ND	0.39	No	
EAR2-RA-19a-12	1	0.52	0.65	2	<0.024	0.063	0.044	<0.028	<0.02	<0.031	<0.025	1.2E-06	1.5E-07	9.8E-06	ND	1.8E-08	9.6E-09	ND	ND	ND	1.1E-05	1.1E-05	1.8E-07	4.3E-02	1.7E-02	2.0E-01	ND	----	6.6E-04	ND	ND	ND	ND	0.26	No
EAR2-RA-19b-06-1	0.5	2.3	0.56	6.7	<0.024	0.034	<0.04	0.029	0.033	<0.031	<0.025	5.5E-06	1.3E-07	3.3E-05	ND	9.9E-09	ND	----	----	ND	3.8E-05	3.8E-05	1.4E-07	1.9E-01	1.5E-02	6.8E-01	ND	----	ND	9.6E-04	1.1E-03	ND	ND	0.89	No
EAR2-RA-19b-06-2	0.5	2	0.79	7	<0.024	0.032	<0.04	0.044	0.044	<0.031	<0.025	4.8E-06	1.9E-07	3.4E-05	ND	9.3E-09	ND	----	----	ND	3.9E-05	3.9E-05	1.9E-07	1.6E-01	2.1E-02	7.1E-01	ND	----	ND	1.5E-03	1.5E-03	ND	ND	0.90	No
EAR2-RA-19b-06-3	0.5	1.4	0.83	6.2	<0.024	0.053	<0.04	0.041	0.052	<0.031	<0.025	3.3E-06	1.9E-07	3.0E-05	ND	1.5E-08	ND	----	----	ND	3.4E-05	3.4E-05	2.1E-07	1.1E-01	2.2E-02	6.3E-01	ND	----	ND	1.4E-03	1.7E-03	ND	ND	0.77	No
EAR2-RA-19b-12	1	10	0.6	9.4	<0.024	<0.024	<0.04	0.037	0.083	<0.031	<0.025	2.4E-05	1.4E-07	4.6E-05	ND	ND	ND	----	----	ND	7.0E-05	7.0E-05	1.4E-07	8.2E-01	1.6E-02	9.6E-01	ND	ND	ND	1.2E-03	2.8E-03	ND	ND	1.80	Yes
EAR2-RA-19c-06	0.5	1.6	<0.5	4.4	<0.024	0.033	<0.04	0.029	<0.02	<0.031	<0.025	3.8E-06	ND	2.2E-05	ND	9.6E-09	ND	----	----	ND	2.5E-05	2.5E-05	9.6E-09	1.3E-01	ND	4.5E-01	ND	----	ND	9.6E-04	ND	ND	ND	0.58	No
EAR2-RA-19c-12	1	1.1	<0.5	2.7	<0.024	0.025	<0.04	<0.028	<0.02	<0.031	<0.025	2.6E-06	ND	1.3E-05	ND	7.3E-09	ND	ND	ND	ND	1.6E-05	1.6E-05	7.3E-09	9.0E-02	ND	2.8E-01	ND	----	ND	ND	ND	ND	ND	0.37	No
EAR2-RA-19d-06	0.5	0.37	<0.5	1.2	<0.024	0.046	0.087	<0.028	<0.02	<0.031	<0.025	8.8E-07	ND	5.9E-06	ND	1.3E-08	1.9E-08	ND	ND	ND	6.8E-06	6.8E-06	3.2E-08	3.0E-02	ND	1.2E-01	ND	----	1.3E-03	ND	ND	ND	ND	0.15	No
EAR2-RA-19d-12	1	0.78	<0.5	1.6	<0.024	0.036	0.061	<0.028	<0.02	<0.031	<0.025	1.9E-06	ND	7.8E-06	ND	1.0E-08	1.3E-08	ND	ND	ND	9.7E-06	9.7E-06	2.4E-08	6.4E-02	ND	1.6E-01	ND	----	9.1E-04	ND	ND	ND	ND	0.23	No
EAR2-RA-19e-06	0.5	0.94	0.69	2.4	<0.024	0.064	0.041	<0.028	<0.02	<0.031	<0.025	2.2E-06	1.6E-07	1.2E-05	ND	1.9E-08	8.9E-09	ND	ND	ND	1.4E-05	1.4E-05	1.9E-07	7.7E-02	1.8E-02	2.4E-01	ND	----	6.1E-04	ND	ND	ND	ND	0.34	No
EAR2-RA-19e-12	1	0.67	0.58	1.4	<0.024	0.046	<0.04	<0.028	<0.02	<0.031	<0.025	1.6E-06	1.4E-07	6.9E-06	ND	1.3E-08	ND	ND	ND	ND	8.6E-06	8.5E-06	1.5E-07	5.5E-02	1.5E-02	1.4E-01	ND	----	ND	ND	ND	ND	ND	0.21	No
EAR2-RA-19f-06	0.5	0.82	0.95	2.6	<0.024	0.066	<0.04	<0.028	<0.02	<0.031	<0.025	1.9E-06	2.2E-07	1.3E-05	ND	1.9E-08	ND	ND	ND	ND	1.5E-05	1.5E-05	2.4E-07	6.7E-02	2.5E-02	2.7E-01	ND	----	ND	ND	ND	ND	ND	0.36	No
EAR2-RA-19f-12	1	0.86	0.95	1.6	<0.024	0.059	<0.04	<0.028	0.02	<0.031	<0.025	2.0E-06	2.2E-07	7.8E-06	ND	1.7E-08	ND	ND	----	ND	1.0E-05	9.9E-06	2.4E-07	7.0E-02	2.5E-02	1.6E-01	ND	----	ND	ND	6.6E-04	ND	ND	0.26	No
EAR2-RA-19g-06	0.5	0.4	0.83	0.98	<0.024	0.024	<0.04	<0.028	<0.02	<0.031	<0.025	9.5E-07	1.9E-07	4.8E-06	ND	7.0E-09	ND	ND	ND	ND	6.0E-06	5.8E-06	2.0E-07	3.3E-02	2.2E-02	1.0E-01	ND	----	ND	ND	ND	ND	ND	0.15	No
EAR2-RA-19g-12	1	0.81	1.4	1.3	<0.024	0.033	<0.04	<0.028	<0.02	<0.031	<0.025	1.9E-06	3.3E-07	6.4E-06	ND	9.6E-09	ND	ND	ND	ND	8.6E-06	8.3E-06	3.4E-07	6.6E-02	3.7E-02	1.3E-01	ND	----	ND	ND	ND	ND	ND	0.24	No
EAR2-RA-1a-06	0.5	<0.088	<2	<0.085	0.14	0.12	4.8	<0.11	<0.08	<0.12	<0.098	ND	ND	ND	2.9E-08	3.5E-08	1.0E-06	ND	ND	ND	1.1E-06	0.0E+00	1.1E-06	ND	ND	ND	----	----	7.2E-02	ND	ND	ND	ND	0.07	No
EAR2-RA-1a-12	1	<0.088	<2	<0.085	0.2	0.29	7	<0.11	<0.08	<0.12	<0.098	ND	ND	ND	4.1E-08	8.4E-08	1.5E-06	ND	ND	ND	1.6E-06	0.0E+00	1.6E-06	ND	ND	ND	----	----	1.0E-01	ND	ND	ND	ND	0.10	No
EAR2-RA-1b-06	0.5	0.11	0.83	0.47	<0.0094	0.17	0.19	<0.011	<0.008	<0.012	<0.0098	2.6E-07	1.9E-07	2.3E-06	ND	4.9E-08	4.1E-08	ND	ND	ND	2.9E-06	2.6E-06	2.9E-07	9.0E-03	2.2E-02	4.8E-02	ND	----	2.8E-03	ND	ND	ND	ND	0.08	No
EAR2-RA-1b-12	1	0.05	2.2	0.22	<0.0094	0.54	1	<0.011	<0.008	<0.012	<0.0098	1.2E-07	5.2E-07	1.1E-06	ND	1.6E-07	2.2E-07	ND	ND	ND	2.1E-06	1.2E-06	8.9E-07	4.1E-03	5.7E-02	2.2E-02	ND	----	1.5E-02	ND	ND	ND	ND	0.10	No
EAR2-RA-20a-06-1	0.5	0.49	1.2	2	<0.024	0.036	0.045	<0.028	<0.02	<0.031	<0.025	1.2E-06	2.8E-07	9.8E-06	ND																				

TABLE E-1
Earhart I-2: Risk and Hazard Calculations - Child Resident^a

Decision Unit	Depth (feet)	Analytical Results (mg/kg)											Child Resident																							Exceed HDOH 2011 HC HHRE Standard? ^e				
		Aldrin	Chlordane	Dieldrin	4,4-DDD	4,4-DDE	4,4-DDT	Endrin	Endrin Ketone	Methoxychlor	delta-BHC	Cancer Risk											Noncancer Hazard																	
												Aldrin	Chlordane	Dieldrin	4,4-DDD	4,4-DDE	4,4-DDT	Endrin	Endrin Ketone	Methoxychlor	delta-BHC	Cumulative Risk ^b			Aldrin	Chlordane	Dieldrin	4,4-DDD	4,4-DDE	4,4-DDT	Endrin	Endrin Ketone	Methoxychlor	delta-BHC	Hazard Index ^d					
Resident Child - Cancer EALs (mg/kg)	Res. Child - Noncancer EALs (mg/kg)	All Chems			Aldrin and Dieldrin Only	No Aldrin or Dieldrin ^c																																		
EAR2-RA-20L-06	0.5	0.29	1.3	1.1	<0.024	0.09	0.072	<0.028	<0.02	<0.031	<0.025	6.9E-07	3.1E-07	5.4E-06	ND	2.6E-08	1.6E-08	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.17	No
EAR2-RA-20L-12	1	0.16	1.4	0.65	<0.024	0.18	0.13	<0.028	<0.02	<0.031	<0.025	3.8E-07	3.3E-07	3.2E-06	ND	5.2E-08	2.8E-08	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.12	No	
EAR2-RA-21a-06-1	0.5	0.57	<0.5	3.7	<0.024	<0.024	<0.04	<0.028	0.023	<0.031	<0.025	1.4E-06	ND	1.8E-05	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.42	No	
EAR2-RA-21a-06-2	0.5	0.54	<0.5	2.7	<0.024	<0.024	<0.04	<0.028	<0.02	<0.031	<0.025	1.3E-06	ND	1.3E-05	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.32	No	
EAR2-RA-21a-06-3	0.5	1.3	<0.5	3	<0.024	<0.024	<0.04	<0.028	0.026	<0.031	<0.025	3.1E-06	ND	1.5E-05	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.41	No	
EAR2-RA-21a-12	1	0.68	<0.5	2.7	<0.024	<0.024	<0.04	<0.028	0.024	<0.031	<0.025	1.6E-06	ND	1.3E-05	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.33	No	
EAR2-RA-21b-06	0.5	0.46	<0.5	1.9	<0.024	<0.024	<0.04	<0.028	<0.02	<0.031	<0.025	1.1E-06	ND	9.3E-06	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.23	No	
EAR2-RA-21b-12	1	0.14	0.4	0.71	<0.0094	0.017	<0.016	<0.011	<0.008	<0.012	<0.0098	3.3E-07	9.4E-08	3.5E-06	ND	4.9E-09	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.09	No	
EAR2-RA-21c-06	0.5	0.6	<0.5	4	<0.024	0.21	<0.04	<0.028	0.041	<0.031	<0.025	1.4E-06	ND	2.0E-05	ND	6.1E-08	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.46	No	
EAR2-RA-21c-12	1	0.49	<0.5	2	<0.024	0.067	<0.04	<0.028	0.031	<0.031	<0.025	1.2E-06	ND	9.8E-06	ND	1.9E-08	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.24	No	
EAR2-RA-21d-06	0.5	0.9	<0.5	5.5	<0.024	<0.024	<0.04	<0.028	0.044	<0.031	<0.025	2.1E-06	ND	2.7E-05	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.63	No	
EAR2-RA-21d-12	1	0.92	<0.5	3.5	<0.024	<0.024	<0.04	<0.028	0.044	<0.031	<0.025	2.2E-06	ND	1.7E-05	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.43	No	
EAR2-RA-22a-06	0.5	1.5	<2	5.5	<0.094	<0.095	<0.16	<0.11	<0.08	<0.12	<0.098	3.6E-06	ND	2.7E-05	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.68	No	
EAR2-RA-22a-12	1	2.1	<2	5.6	<0.094	<0.095	<0.16	<0.11	<0.08	<0.12	<0.098	5.0E-06	ND	2.7E-05	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.74	No	
EAR2-RA-22b-06	0.5	1.4	<2	4.3	<0.094	<0.095	<0.16	<0.11	<0.08	<0.12	<0.098	3.3E-06	ND	2.1E-05	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.55	No	
EAR2-RA-22b-12	1	2.9	<2	4.9	<0.094	<0.095	<0.16	<0.11	<0.08	<0.12	<0.098	6.9E-06	ND	2.4E-05	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.74	No	
EAR2-RA-22c-06	0.5	0.81	<2	4	<0.094	<0.095	<0.16	<0.11	<0.08	<0.12	<0.098	1.9E-06	ND	2.0E-05	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.47	No	
EAR2-RA-22c-12	1	1	<1	3.2	<0.047	<0.048	<0.081	<0.057	<0.04	<0.062	<0.049	2.4E-06	ND	1.6E-05	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.41	No	
EAR2-RA-22d-06	0.5	0.6	<1	3.1	<0.047	<0.048	<0.081	<0.057	<0.04	<0.062	<0.049	1.4E-06	ND	1.5E-05	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.37	No	
EAR2-RA-22d-12	1	0.39	<0.5	1.4	<0.024	0.029	<0.04	<0.028	<0.02	<0.031	<0.025	9.3E-07	ND	6.9E-06	ND	8.4E-09	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.17	No	
EAR2-RA-23a-06-1	0.5	0.81	<1	1.2	<0.047	<0.048	<0.081	<0.057	<0.04	<0.062	<0.049	1.9E-06	ND	5.9E-06	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.19	No	
EAR2-RA-23a-06-2	0.5	4.1	<2	7.1	<0.094	<0.095	<0.16	<0.11	<0.08	<0.12	<0.098	9.7E-06	ND	3.5E-05	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	1.06	Yes	
EAR2-RA-23a-06-3	0.5	0.35	<0.5	1.7	<0.024	0.048	<0.04	<0.028	<0.02	<0.031	<0.025	8.3E-07	ND	8.3E-06	ND	1.4E-08	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.20	No	
EAR2-RA-23a-12	1	4.7	<2	9.6	<0.094	<0.095	<0.16	<0.11	0.091	<0.12	<0.098	1.1E-05	ND	4.7E-05	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	1.36	Yes	
EAR2-RA-23b-06	0.5	3.2	<2	8.6	<0.094	0.29	<0.16	<0.11	<0.08	<0.12	<0.098	7.6E-06	ND	4.2E-05	ND	8.4E-08	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	1.14	Yes	
EAR2-RA-23b-12	1	1.3	<1	2	<0.047	<0.048	<0.081	<0.057	<0.04	<0.062	<0.049	3.1E-06	ND	9.8E-06	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.31	No	
EAR2-RA-23c-06	0.5	0.79	<1	2.8	<0.047	<0.048	0.12	<0.057	<0.04	<0.062	<0.049	1.9E-06	ND	1.4E-05	ND	ND	2.6E-08	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.35	No	
EAR2-RA-23c-12	1	0.61	<1	2.4	<0.047	<0.048	<0.081	<0.057	<0.04	<0.062	<0.049	1.4E-06	ND	1.2E-05	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.29	No	
EAR2-RA-23d-06	0.5	1.6	1.9	3.3	<0.047	0.065	<0.081	<0.057	<0.04	<0.062	<0.049	3.8E-06	4.5E-07	1.6E-05	ND	1.9E-08	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.52	No		
EAR2-RA-23d-12	1	6	<2	5.6	<0.094	<0.095	<0.16	<0.11	<0.08	<0.12	<0.098	1.4E-05	ND	2.7E-05	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	1.06	Yes	
EAR2-RA-24a-06	0.5	0.41	0.81	1.2	<0.024	0.06	0.072	<0.028	<0.02	<0.031	<0.025	9.7E-07	1.9E-07	5.9E-06	ND	1.7E-08	1.6E-08	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.18	No	
EAR2-RA-24a-12	1	0.42	0.99	1.1	<0.024	0.098	0.067	<0.028	<0.02	<0.031	<0.025	1.0E-06	2.3E-07	5.4E-06	ND	2.8E-08	1.5E-08	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.17	No	
EAR2-RA-24b-06	0.5	0.41	1.1	1.7	<0.0047	0.088	0.083	0.025																																

TABLE E-1
Earhart I-2: Risk and Hazard Calculations - Child Resident^a

Decision Unit	Depth (feet)	Analytical Results (mg/kg)											Child Resident																				Exceed HDOH 2011 HC HHRE Standard? ^e			
		Aldrin	Chlordane	Dieldrin	4,4-DDD	4,4-DDE	4,4-DDT	Endrin	Endrin Ketone	Methoxychlor	delta-BHC	Cancer Risk										Noncancer Hazard														
												Aldrin	Chlordane	Dieldrin	4,4-DDD	4,4-DDE	4,4-DDT	Endrin	Endrin Ketone	Methoxychlor	delta-BHC	Cumulative Risk ^b			Aldrin	Chlordane	Dieldrin	4,4-DDD	4,4-DDE	4,4-DDT	Endrin	Endrin Ketone		Methoxychlor	delta-BHC	Hazard Index ^d
Resident Child - Cancer EALs (mg/kg)	Res. Child - Noncancer EALs (mg/kg)	All Chems			Aldrin and Dieldrin Only	No Aldrin or Dieldrin ^c																														
EAR2-RA-26e-06	0.5	2.7	2.5	6	<0.0094	0.056	0.043	0.05	0.084	<0.012	<0.0098	6.4E-06	5.9E-07	2.9E-05	ND	1.6E-08	9.3E-09	----	----	ND	ND	3.6E-05	3.6E-05	6.1E-07	2.2E-01	6.5E-02	6.1E-01	ND	----	6.4E-04	1.7E-03	2.8E-03	ND	ND	0.90	No
EAR2-RA-26e-12	1	2.8	1.6	4.5	<0.0094	0.05	0.042	0.041	0.081	0.012	<0.0098	6.7E-06	3.8E-07	2.2E-05	ND	1.5E-08	9.1E-09	----	----	ND	ND	2.9E-05	2.9E-05	4.0E-07	2.3E-01	4.2E-02	4.6E-01	ND	----	6.3E-04	1.4E-03	2.7E-03	#####	ND	0.73	No
EAR2-RA-26f-06	0.5	0.5	1.3	2.2	0.056	0.076	0.081	0.026	0.029	<0.0062	<0.0049	1.2E-06	3.1E-07	1.1E-05	1.1E-08	2.2E-08	1.8E-08	----	----	ND	ND	1.2E-05	1.2E-05	3.6E-07	4.1E-02	3.4E-02	2.2E-01	----	----	1.2E-03	8.6E-04	9.6E-04	ND	ND	0.30	No
EAR2-RA-26f-12	1	1.7	0.74	2.9	0.04	0.071	0.063	0.028	0.034	<0.0062	<0.0049	4.0E-06	1.7E-07	1.4E-05	8.2E-09	2.1E-08	1.4E-08	----	----	ND	ND	1.8E-05	1.8E-05	2.2E-07	1.4E-01	1.9E-02	3.0E-01	----	----	9.4E-04	9.3E-04	1.1E-03	ND	ND	0.46	No
EAR2-RA-26g-06	0.5	1.3	1	3.2	<0.047	0.059	0.084	<0.057	<0.04	<0.062	<0.049	3.1E-06	2.3E-07	1.6E-05	ND	1.7E-08	1.8E-08	ND	ND	ND	ND	1.9E-05	1.9E-05	2.7E-07	1.1E-01	2.6E-02	3.3E-01	ND	----	1.3E-03	ND	ND	ND	ND	0.46	No
EAR2-RA-26g-12	1	1	<1	3.9	<0.047	0.05	<0.081	<0.057	<0.04	<0.062	<0.049	2.4E-06	ND	1.9E-05	ND	1.5E-08	ND	ND	ND	ND	ND	2.2E-05	2.1E-05	1.5E-08	8.2E-02	ND	4.0E-01	ND	----	ND	ND	ND	ND	ND	0.48	No
EAR2-RA-27a-06	0.5	2.1	0.61	4.8	<0.024	<0.024	<0.04	<0.028	0.044	<0.031	<0.025	5.0E-06	1.4E-07	2.4E-05	ND	ND	ND	ND	----	----	ND	ND	2.9E-05	2.9E-05	1.4E-07	1.7E-01	1.6E-02	4.9E-01	ND	ND	ND	ND	1.5E-03	ND	0.68	No
EAR2-RA-27a-12	1	2.3	<0.5	3.9	<0.024	<0.024	<0.04	<0.028	0.055	<0.031	<0.025	5.5E-06	ND	1.9E-05	ND	ND	ND	ND	----	----	ND	ND	2.5E-05	2.5E-05	0.0E+00	1.9E-01	ND	4.0E-01	ND	ND	ND	ND	1.8E-03	ND	0.59	No
EAR2-RA-27b-06	0.5	1.6	<0.5	4.2	<0.024	<0.024	<0.04	<0.028	0.028	<0.031	<0.025	3.8E-06	ND	2.1E-05	ND	ND	ND	ND	----	----	ND	ND	2.4E-05	2.4E-05	0.0E+00	1.3E-01	ND	4.3E-01	ND	ND	ND	ND	9.3E-04	ND	0.56	No
EAR2-RA-27b-12	1	1.3	<0.5	1.7	<0.024	<0.024	<0.04	<0.028	<0.02	<0.031	<0.025	3.1E-06	ND	8.3E-06	ND	ND	ND	ND	ND	ND	ND	1.1E-05	1.1E-05	0.0E+00	1.1E-01	ND	1.7E-01	ND	ND	ND	ND	ND	ND	ND	0.28	No
EAR2-RA-27c-06	0.5	3.7	<0.5	5.7	<0.024	<0.024	<0.04	<0.028	0.053	<0.031	<0.025	8.8E-06	ND	2.8E-05	ND	ND	ND	ND	----	----	ND	ND	3.7E-05	3.7E-05	0.0E+00	3.0E-01	ND	5.8E-01	ND	ND	ND	ND	1.8E-03	ND	0.88	No
EAR2-RA-27c-12	1	8.3	<0.5	9.7	<0.024	<0.024	<0.04	0.061	0.16	<0.031	<0.025	2.0E-05	ND	4.8E-05	ND	ND	ND	----	----	ND	ND	6.7E-05	6.7E-05	0.0E+00	6.8E-01	ND	9.9E-01	ND	ND	ND	2.0E-03	5.3E-03	ND	ND	1.67	Yes
EAR2-RA-27d-06	0.5	8.5	<0.5	7.5	<0.024	<0.024	<0.04	0.039	0.15	<0.031	<0.025	2.0E-05	ND	3.7E-05	ND	ND	ND	----	----	ND	ND	5.7E-05	5.7E-05	0.0E+00	7.0E-01	ND	7.7E-01	ND	ND	ND	1.3E-03	5.0E-03	ND	ND	1.46	Yes
EAR2-RA-27d-12	1	13	<0.5	11	0.024	<0.024	<0.04	0.052	0.33	<0.031	<0.025	3.1E-05	ND	5.4E-05	4.9E-09	ND	ND	----	----	ND	ND	8.5E-05	8.5E-05	4.9E-09	#####	ND	#####	----	ND	ND	1.7E-03	1.1E-02	ND	ND	2.19	Yes
EAR2-RA-28a-06-1	0.5	0.82	0.57	2.3	<0.024	0.033	<0.04	<0.028	<0.02	<0.031	<0.025	1.9E-06	1.3E-07	1.1E-05	ND	9.6E-09	ND	ND	ND	ND	ND	1.3E-05	1.3E-05	1.4E-07	6.7E-02	1.5E-02	2.3E-01	ND	----	ND	ND	ND	ND	0.32	No	
EAR2-RA-28a-06-2	0.5	1.2	<1	3.2	<0.047	<0.048	<0.081	<0.057	<0.04	<0.062	<0.049	2.9E-06	ND	1.6E-05	ND	ND	ND	ND	ND	ND	ND	1.9E-05	1.9E-05	0.0E+00	9.8E-02	ND	3.3E-01	ND	ND	ND	ND	ND	ND	0.42	No	
EAR2-RA-28a-06-3	0.5	0.9	<1	3	<0.047	<0.048	<0.081	<0.057	<0.04	<0.062	<0.049	2.1E-06	ND	1.5E-05	ND	ND	ND	ND	ND	ND	ND	1.7E-05	1.7E-05	0.0E+00	7.4E-02	ND	3.1E-01	ND	ND	ND	ND	ND	ND	0.38	No	
EAR2-RA-28a-12	1	1.1	0.5	2.2	<0.024	<0.024	<0.04	<0.028	<0.02	<0.031	<0.025	2.6E-06	1.2E-07	1.1E-05	ND	ND	ND	ND	ND	ND	ND	1.4E-05	1.3E-05	1.2E-07	9.0E-02	1.3E-02	2.2E-01	ND	ND	ND	ND	ND	ND	0.33	No	
EAR2-RA-28b-06	0.5	1.1	1.6	2.8	<0.047	<0.048	<0.081	<0.057	<0.04	<0.062	<0.049	2.6E-06	3.8E-07	1.4E-05	ND	ND	ND	ND	ND	ND	ND	1.7E-05	1.6E-05	3.8E-07	9.0E-02	4.2E-02	2.9E-01	ND	ND	ND	ND	ND	ND	0.42	No	
EAR2-RA-28b-12	1	2.1	<1	3.3	<0.047	<0.048	<0.081	<0.057	<0.04	<0.062	<0.049	5.0E-06	ND	1.6E-05	ND	ND	ND	ND	ND	ND	ND	2.1E-05	2.1E-05	0.0E+00	1.7E-01	ND	3.4E-01	ND	ND	ND	ND	ND	ND	0.51	No	
EAR2-RA-28c-06	0.5	3.7	0.56	6.7	<0.024	0.058	<0.04	0.048	<0.02	<0.031	<0.025	8.8E-06	1.3E-07	3.3E-05	ND	1.7E-08	ND	----	----	ND	ND	4.2E-05	4.2E-05	1.5E-07	3.0E-01	1.5E-02	6.8E-01	ND	----	ND	1.6E-03	ND	ND	1.00	No	
EAR2-RA-28c-12	1	5.6	<2	4.4	<0.094	<0.095	<0.16	<0.11	<0.08	<0.12	<0.098	1.3E-05	ND	2.2E-05	ND	ND	ND	ND	ND	ND	ND	3.5E-05	3.5E-05	0.0E+00	4.6E-01	ND	4.5E-01	ND	ND	ND	ND	ND	ND	0.91	No	
EAR2-RA-28d-06	0.5	2.4	<1	3.4	<0.047	<0.048	<0.081	<0.057	<0.04	<0.062	<0.049	5.7E-06	ND	1.7E-05	ND	ND	ND	ND	ND	ND	ND	2.2E-05	2.2E-05	0.0E+00	2.0E-01	ND	3.5E-01	ND	ND	ND	ND	ND	ND	0.54	No	
EAR2-RA-28d-12	1	11	<2	5.7	<0.094	<0.095	<0.16	<0.11	0.11	<0.12	<0.098	2.6E-05	ND	2.8E-05	ND	ND	ND	ND	----	----	ND	ND	5.4E-05	5.4E-05	0.0E+00	9.0E-01	ND	5.8E-01	ND	ND	ND	3.7E-03	ND	1.48	Yes	
EAR2-RA-29a-06	0.5	9	<1	3.4	<0.047	<0.048	<0.081	<0.057	<0.04	<0.062	<0.049	2.1E-05	ND	1.7E-05	ND	ND	ND	ND	ND	ND	ND	3.8E-05	3.8E-05	0.0E+00	7.4E-01	ND	3.5E-01	ND	ND	ND	ND	ND	1.08	Yes		
EAR2-RA-29a-12	1	3.3	<1	2.9	<0.047	0.058	<0.081	<0.057	<0.04	<0.062	<0.049	7.8E-06	ND	1.4E-05	ND	1.7E-08	ND	ND	ND	ND	ND	2.2E-05	2.2E-05	1.7E-08	2.7E-01	ND	3.0E-01	ND	----	ND	ND	ND	ND	0.57	No	
EAR2-RA-29b-06	0.5	0.7	<0.5	2.2	<0.024	0.056	0.059	<0.028	<0.02	<0.031	<0.025	1.7E-06	ND	1.1E-05	ND	1.6E-08	1.3E-08	ND	ND	ND	ND	1.2E-05	1.2E-05	2.9E-08	5.7E-02	ND	2.2E-01	ND	----	8.8E-04	ND	ND	ND	0.28	No	
EAR2-RA-29b-12	1	1.1	<0.5	2.5	<0.024	<0.024	<0.04	<0.028	<0.02	<0.031	<0.025	2.6E-06	ND	1.2E-05	ND	ND	ND	ND	ND	ND	ND	1.5E-05	1.5E-05	0.0E+00	9.0E-02	ND	2.6E-01	ND	ND	ND	ND	ND	0.35	No		
EAR2-RA-29c-06	0.5	1.7	<1	3.9	<0.047	<0.048	<0.081	<0.057	<0.04	<0.062	<0.049	4.0E-06	ND	1.9E-05	ND	ND	ND	ND	ND	ND	ND	2.3E-05	2.3E-05	0.0E+00	1.4E-01	ND	4.0E-01	ND	ND	ND	ND	ND	0.54	No		
EAR2-RA-29c-12	1	3.4	<1	3.8	<0.047	<0.048	<0.081	<0.057	<0.04	<0.062	<0.049	8.1E-06	ND	1.9E-05	ND	ND	ND	ND	ND	ND	ND	2.7E-05	2.7E-05	0.0E+00	2.8E-01	ND	3.9E-01	ND	ND	ND	ND	ND	0.67	No		
EAR2-RA-2a-06	0.5	0.04	1.2	0.17	<0.0047	0.037	0.063	0.0083	<0.004	<0.0062	<0.0049	9.5E-08	2.8E-07	8.3E-07	ND	1.1E-08	1.4E-08	----	----	ND	ND	1.2E-06	9.3E-07	3.1E-07	3.3E-03	3.1E-02	1.7E-02	ND	----	9.4E-04	2.8E-04	ND	ND	0.05	No	
EAR2-RA-2a-12	1	0.012	3.3	0.11	<0.0094	0.048	0.044	0.022	<0.008	<																										

TABLE E-1
Earhart I-2: Risk and Hazard Calculations - Child Resident^a

Decision Unit	Depth (feet)	Analytical Results (mg/kg)											Child Resident																							Exceed HDOH 2011 HC HHRE Standard? ^e
		Aldrin	Chlordane	Dieldrin	4,4-DDD	4,4-DDE	4,4-DDT	Endrin	Endrin Ketone	Methoxychlor	delta-BHC	Cancer Risk											Noncancer Hazard													
												Aldrin	Chlordane	Dieldrin	4,4-DDD	4,4-DDE	4,4-DDT	Endrin	Endrin Ketone	Methoxychlor	delta-BHC	Cumulative Risk ^b			Aldrin	Chlordane	Dieldrin	4,4-DDD	4,4-DDE	4,4-DDT	Endrin	Endrin Ketone	Methoxychlor	delta-BHC	Hazard Index ^d	
Resident Child - Cancer EALs (mg/kg)	Res. Child - Noncancer EALs (mg/kg)	All Chems			Aldrin and Dieldrin Only	No Aldrin or Dieldrin ^c																														
EAR2-RA-31e-06	0.5	0.017	0.91	0.11	<0.0047	0.0099	0.016	0.0081	<0.004	<0.0062	<0.0049	4.0E-08	2.1E-07	5.4E-07	ND	2.9E-09	3.5E-09	----	ND	ND	ND	8.0E-07	5.8E-07	2.2E-07	1.4E-03	2.4E-02	1.1E-02	ND	----	2.4E-04	2.7E-04	ND	ND	ND	0.04	No
EAR2-RA-31e-12	1	0.012	1.8	0.15	<0.0047	0.029	0.013	0.0095	<0.004	<0.0062	<0.0049	2.9E-08	4.2E-07	7.4E-07	ND	8.4E-09	2.8E-09	----	ND	ND	ND	1.2E-06	7.6E-07	4.3E-07	9.8E-04	4.7E-02	1.5E-02	ND	----	1.9E-04	3.2E-04	ND	ND	ND	0.06	No
EAR2-RA-32a-06-1	0.5	0.16	1.6	0.63	<0.0094	0.014	<0.016	0.014	<0.008	<0.012	<0.0098	3.8E-07	3.8E-07	3.1E-06	ND	4.1E-09	ND	----	ND	ND	ND	3.8E-06	3.5E-06	3.8E-07	1.3E-02	4.2E-02	6.4E-02	ND	----	ND	4.7E-04	ND	ND	ND	0.12	No
EAR2-RA-32a-06-2	0.5	0.08	2	0.52	<0.0047	0.015	0.028	0.015	<0.004	<0.0062	<0.0049	1.9E-07	4.7E-07	2.5E-06	ND	4.4E-09	6.1E-09	----	ND	ND	ND	3.2E-06	2.7E-06	4.8E-07	6.6E-03	5.2E-02	5.3E-02	ND	----	4.2E-04	5.0E-04	ND	ND	ND	0.11	No
EAR2-RA-32a-06-3	0.5	0.11	1.9	0.56	<0.0094	0.015	<0.016	0.017	<0.008	<0.012	<0.0098	2.6E-07	4.5E-07	2.2E-06	ND	4.4E-09	ND	----	ND	ND	ND	3.5E-06	3.0E-06	4.5E-07	9.0E-03	5.0E-02	5.7E-02	ND	----	ND	5.6E-04	ND	ND	ND	0.12	No
EAR2-RA-32a-12	1	0.065	2	0.45	<0.0094	0.01	<0.016	0.011	<0.008	<0.012	<0.0098	1.5E-07	4.7E-07	2.2E-06	ND	2.9E-09	ND	----	ND	ND	ND	2.8E-06	2.4E-06	4.7E-07	5.3E-03	5.2E-02	4.6E-02	ND	----	ND	3.7E-04	ND	ND	ND	0.10	No
EAR2-RA-32b-06	0.5	0.025	1.5	0.12	<0.0047	0.02	0.0097	0.012	<0.004	<0.0062	<0.0049	5.9E-08	3.5E-07	5.9E-07	ND	5.8E-09	2.1E-09	----	ND	ND	ND	1.0E-06	6.5E-07	3.6E-07	2.0E-03	3.9E-02	1.2E-02	ND	----	1.4E-04	4.0E-04	ND	ND	ND	0.05	No
EAR2-RA-32b-12	1	0.025	1.4	0.097	<0.0019	0.013	0.0069	<0.0023	0.0021	<0.0025	<0.002	5.9E-08	3.3E-07	4.8E-07	ND	3.8E-09	1.5E-09	ND	----	ND	ND	8.7E-07	5.3E-07	3.3E-07	2.0E-03	3.7E-02	9.9E-03	ND	----	1.0E-04	7.0E-05	ND	ND	ND	0.05	No
EAR2-RA-32c-06	0.5	0.049	1.3	0.24	<0.0047	0.031	0.03	0.014	<0.004	<0.0062	<0.0049	1.2E-07	3.1E-07	1.2E-06	ND	9.0E-09	6.5E-09	----	ND	ND	ND	1.6E-06	1.3E-06	3.2E-07	4.0E-03	3.4E-02	2.4E-02	ND	----	4.5E-04	4.7E-04	ND	ND	ND	0.06	No
EAR2-RA-32c-12	1	0.04	2	0.16	<0.0047	0.11	0.025	0.012	<0.004	<0.0062	<0.0049	9.5E-08	4.7E-07	7.8E-07	ND	3.2E-08	5.4E-09	----	ND	ND	ND	1.4E-06	8.8E-07	5.1E-07	3.3E-03	5.2E-02	1.6E-02	ND	----	3.7E-04	4.0E-04	ND	ND	ND	0.07	No
EAR2-RA-32d-06	0.5	0.087	1.2	0.37	<0.0047	0.026	0.025	0.017	<0.004	<0.0062	<0.0049	2.1E-07	2.8E-07	1.8E-06	ND	7.6E-09	5.4E-09	----	ND	ND	ND	2.3E-06	2.0E-06	2.9E-07	7.1E-03	3.1E-02	3.8E-02	ND	----	3.7E-04	5.6E-04	ND	ND	ND	0.08	No
EAR2-RA-32d-12	1	0.02	0.72	0.1	<0.0047	0.016	0.013	0.012	<0.004	<0.0062	<0.0049	4.8E-08	1.7E-07	4.9E-07	ND	4.7E-09	2.8E-09	----	ND	ND	ND	7.1E-07	5.4E-07	1.8E-07	1.6E-03	1.9E-02	1.0E-02	ND	----	1.9E-04	4.0E-04	ND	ND	ND	0.03	No
EAR2-RA-33a-06	0.5	3	<1	4.7	<0.047	0.098	<0.081	<0.057	<0.04	<0.062	<0.049	7.1E-06	ND	2.3E-05	ND	2.8E-08	ND	ND	ND	ND	3.0E-05	3.0E-05	2.8E-08	2.5E-01	ND	4.8E-01	ND	----	ND	ND	ND	ND	ND	0.73	No	
EAR2-RA-33a-12	1	2.4	<1	3.7	<0.047	0.079	<0.081	<0.057	<0.04	<0.062	<0.049	5.7E-06	ND	1.8E-05	ND	2.3E-08	ND	ND	ND	ND	2.4E-05	2.4E-05	2.3E-08	2.0E-01	ND	3.8E-01	ND	----	ND	ND	ND	ND	ND	0.57	No	
EAR2-RA-33b-12	1	1.4	<1	3.3	<0.047	0.075	<0.081	<0.057	<0.04	<0.062	<0.049	3.3E-06	ND	1.6E-05	ND	2.2E-08	ND	ND	ND	ND	2.0E-05	2.0E-05	2.2E-08	1.1E-01	ND	3.4E-01	ND	----	ND	ND	ND	ND	ND	0.45	No	
EAR2-RA-33b-6	0.5	3.9	<1	3.2	<0.047	0.064	<0.081	<0.057	<0.04	<0.062	<0.049	9.3E-06	ND	1.6E-05	ND	1.9E-08	ND	ND	ND	ND	2.5E-05	2.5E-05	1.9E-08	3.2E-01	ND	3.3E-01	ND	----	ND	ND	ND	ND	ND	0.65	No	
EAR2-RA-33c-12	1	1.8	<1	2.6	<0.047	0.051	<0.081	<0.057	<0.04	<0.062	<0.049	4.3E-06	ND	1.3E-05	ND	1.5E-08	ND	ND	ND	ND	1.7E-05	1.7E-05	1.5E-08	1.5E-01	ND	2.7E-01	ND	----	ND	ND	ND	ND	ND	0.41	No	
EAR2-RA-33c-6	0.5	1.4	<1	3.3	<0.047	0.055	<0.081	<0.057	<0.04	<0.062	<0.049	3.3E-06	ND	1.6E-05	ND	1.6E-08	ND	ND	ND	ND	2.0E-05	2.0E-05	1.6E-08	1.1E-01	ND	3.4E-01	ND	----	ND	ND	ND	ND	ND	0.45	No	
EAR2-RA-33d-12	1	0.7	<0.5	2.6	<0.024	0.086	0.052	<0.028	<0.02	<0.031	<0.025	1.7E-06	ND	1.3E-05	ND	2.5E-08	1.1E-08	ND	ND	ND	1.4E-05	1.4E-05	3.6E-08	5.7E-02	ND	2.7E-01	ND	----	7.8E-04	ND	ND	ND	ND	0.32	No	
EAR2-RA-33d-6	0.5	0.58	<0.5	1.6	<0.024	0.061	0.077	<0.028	<0.02	<0.031	<0.025	1.4E-06	ND	7.8E-06	ND	1.8E-08	1.7E-08	ND	ND	ND	9.3E-06	9.2E-06	3.4E-08	4.8E-02	ND	1.6E-01	ND	----	1.1E-03	ND	ND	ND	ND	0.21	No	
EAR2-RA-34a-06	0.5	0.93	<2	3.9	<0.094	<0.095	<0.16	<0.11	<0.08	<0.12	<0.098	2.2E-06	ND	1.9E-05	ND	ND	ND	ND	ND	ND	2.1E-05	2.1E-05	0.0E+00	7.6E-02	ND	4.0E-01	ND	ND	ND	ND	ND	ND	ND	0.47	No	
EAR2-RA-34a-12	1	1.3	<1	2.7	<0.047	0.055	<0.081	<0.057	<0.04	<0.062	<0.049	3.1E-06	ND	1.3E-05	ND	1.6E-08	ND	ND	ND	ND	1.6E-05	1.6E-05	1.6E-08	1.1E-01	ND	2.8E-01	ND	----	ND	ND	ND	ND	ND	0.38	No	
EAR2-RA-34b-06	0.5	2.2	<2	3.5	<0.094	0.11	0.77	<0.11	<0.08	<0.12	<0.098	5.2E-06	ND	1.7E-05	ND	3.2E-08	1.7E-07	ND	ND	ND	2.3E-05	2.2E-05	2.0E-07	1.8E-01	ND	3.6E-01	ND	----	1.1E-02	ND	ND	ND	ND	0.55	No	
EAR2-RA-34b-12	1	2.3	<1	2.3	<0.047	0.11	0.18	<0.057	<0.04	<0.062	<0.049	5.5E-06	ND	1.1E-05	ND	3.2E-08	3.9E-08	ND	ND	ND	1.7E-05	1.7E-05	7.1E-08	1.9E-01	ND	2.3E-01	ND	----	2.7E-03	ND	ND	ND	ND	0.43	No	
EAR2-RA-34c-06	0.5	1.5	<1	3.2	<0.047	0.059	<0.081	<0.057	<0.04	<0.062	<0.049	3.6E-06	ND	1.6E-05	ND	1.7E-08	ND	ND	ND	ND	1.9E-05	1.9E-05	1.7E-08	1.2E-01	ND	3.3E-01	ND	----	ND	ND	ND	ND	ND	0.45	No	
EAR2-RA-34c-12	1	2.9	<2	4.8	<0.094	<0.095	<0.16	<0.11	<0.08	<0.12	<0.098	6.9E-06	ND	2.4E-05	ND	ND	ND	ND	ND	ND	3.0E-05	3.0E-05	0.0E+00	2.4E-01	ND	4.9E-01	ND	ND	ND	ND	ND	ND	ND	0.73	No	
EAR2-RA-34d-06	0.5	3	<2	4.3	0.15	<0.095	1.4	<0.11	<0.08	<0.12	<0.098	7.1E-06	ND	2.1E-05	3.1E-08	ND	3.0E-07	ND	ND	ND	2.9E-05	2.8E-05	3.4E-07	2.5E-01	ND	4.4E-01	----	ND	2.1E-02	ND	ND	ND	ND	0.71	No	
EAR2-RA-34d-12	1	6.3	<2	4.9	<0.094	0.2	0.17	<0.11	<0.08	<0.12	<0.098	1.5E-05	ND	2.4E-05	ND	5.8E-08	3.7E-08	ND	ND	ND	3.9E-05	3.9E-05	9.5E-08	5.2E-01	ND	5.0E-01	ND	----	2.5E-03	ND	ND	ND	ND	1.02	No	
EAR2-RA-34e-06	0.5	2.4	<1	2.8	<0.047	0.18	0.1	<0.057	<0.04	<0.062	<0.049	5.7E-06	ND	1.4E-05	ND	5.2E-08	2.2E-08	ND	ND	ND	2.0E-05	1.9E-05	7.4E-08	2.0E-01	ND	2.9E-01	ND	----	1.5E-03	ND	ND	ND	ND	0.48	No	
EAR2-RA-34e-12	1	3.1	<2	3	<0.094	0.17	0.25	<0.11	<0.08	<0.12	<0.098	7.4E-06	ND	1.5E-05	ND	4.9E-08	5.4E-08	ND	ND	ND	2.2E-05	2.2E-05	1.0E-07	2.5E-01	ND	3.1E-01	ND	----	3.7E-03	ND	ND	ND	ND	0.56	No	
EAR2-RA-34f-06	0.5	0.083	0.14	0.32	<0.0047	0.0097	<0.0081	<0.0057	<0.004	<0.0062	<0.0049	2.0E-07	3.3E-08	1.6E-06	ND	2.8E-09	ND	ND	ND	ND	1.8E-06	1.8E-06	3.6E-08	6.8E-03	3.7E-03	3.3E-02	ND	----	ND	ND	ND	ND	ND	0.04	No	
EAR2-RA-34f-12	1	0.011	0.12	0.045	<0.0019	0.012	0.014	<0.0023	<0.0016	<0.0025	<0.002	2.6E-08	2.8E-08	2.2E-07	ND	3.5E-09	3.0E-09	ND	ND	ND	2.8E-07	2.5E-07	3.5E-08	9.0E-04	3.1E-03	4.6E-03	ND	----	2.1E-04	ND	ND	ND	ND	0.01	No	
EAR2-RA-34g-06	0.5	0.68	<1	2.5	<0.047	<0.048	<0.081	<0.057	<0.04	<0.062	<0.049	1.6E-06	ND	1.2E-05	ND	ND	ND	ND	ND	ND	1.4E-05	1.4E-05	0.0E+00	5.6E-02	ND	2.6E-01	ND	ND	ND	ND	ND	ND	0.31	No		
EAR2-RA-34g-12	1	0.73	<0.5	1.7	<0.024	0.032	<0.04	<0.028	<0.02	<0.031	<0.025	1.7E-06	ND	8.3E-06	ND	9.3E-09	ND	ND	ND	ND	1.0E-05	1.0E-05	9.0E-09	6.0E-02	ND	1.7E-01	ND	----	ND	ND	ND	ND	ND	0.23	No	
EAR2-RA-34h-06	0.5	1.5	<2	3.9	<0.094	<0.095	<0.16	<0.																												

TABLE E-1
Earhart I-2: Risk and Hazard Calculations - Child Resident^a

Decision Unit	Depth (feet)	Analytical Results (mg/kg)											Child Resident																					Exceed HDOH 2011 HC HHRE Standard? ^e			
		Aldrin	Chlordane	Dieldrin	4,4-DDD	4,4-DDE	4,4-DDT	Endrin	Endrin Ketone	Methoxychlor	delta-BHC	Cancer Risk											Noncancer Hazard														
												Aldrin	Chlordane	Dieldrin	4,4-DDD	4,4-DDE	4,4-DDT	Endrin	Endrin Ketone	Methoxychlor	delta-BHC	Cumulative Risk ^b			Aldrin	Chlordane	Dieldrin	4,4-DDD	4,4-DDE	4,4-DDT	Endrin	Endrin Ketone	Methoxychlor		delta-BHC	Hazard Index ^d	
Resident Child - Cancer EALs (mg/kg)	Res. Child - Noncancer EALs (mg/kg)	All Chems			Aldrin and Dieldrin Only	No Aldrin or Dieldrin ^c																															
EAR2-RA-37g-06	0.5	0.26	4.1	0.89	<0.024	0.082	0.068	0.032	<0.02	<0.031	<0.025	6.2E-07	9.6E-07	4.4E-06	ND	2.4E-08	1.5E-08	---	ND	ND	ND	6.0E-06	5.0E-06	1.0E-06	2.1E-02	1.1E-01	9.1E-02	ND	---	1.0E-03	1.1E-03	ND	ND	ND	0.22	No	
EAR2-RA-37g-12	1	0.026	2.8	0.16	<0.0047	0.038	0.063	0.023	<0.004	<0.0062	<0.0049	6.2E-08	6.6E-07	7.8E-07	ND	1.1E-08	1.4E-08	---	ND	ND	ND	1.5E-06	8.5E-07	6.8E-07	2.1E-03	7.3E-02	1.6E-02	ND	---	9.4E-04	7.6E-04	ND	ND	ND	0.09	No	
EAR2-RA-37h-06	0.5	0.54	1.7	0.83	<0.024	0.037	0.04	<0.028	<0.02	<0.031	<0.025	1.3E-06	4.0E-07	4.1E-06	ND	1.1E-08	8.7E-09	ND	ND	ND	ND	5.8E-06	5.4E-06	4.2E-07	4.4E-02	4.4E-02	8.5E-02	ND	---	6.0E-04	ND	ND	ND	ND	0.17	No	
EAR2-RA-37h-12	1	1	1.9	1.2	0.029	0.06	0.064	<0.028	<0.02	<0.031	<0.025	2.4E-06	4.5E-07	5.9E-06	6.0E-09	1.7E-08	1.4E-08	ND	ND	ND	ND	8.7E-06	8.3E-06	4.8E-07	8.2E-02	5.0E-02	1.2E-01	---	---	9.6E-04	ND	ND	ND	ND	0.25	No	
EAR2-RA-38a-06-1	0.5	0.29	1.5	1.1	<0.024	0.088	<0.04	<0.028	<0.02	<0.031	<0.025	6.9E-07	3.5E-07	5.4E-06	ND	2.6E-08	ND	ND	ND	ND	ND	6.5E-06	6.1E-06	3.8E-07	2.4E-02	3.9E-02	1.1E-01	ND	---	ND	ND	ND	ND	ND	0.18	No	
EAR2-RA-38a-06-2	0.5	0.38	1	1.2	<0.024	0.043	<0.04	<0.028	<0.02	<0.031	<0.025	9.0E-07	2.3E-07	5.9E-06	ND	1.3E-08	ND	ND	ND	ND	ND	7.0E-06	6.8E-06	2.5E-07	3.1E-02	2.6E-02	1.2E-01	ND	---	ND	ND	ND	ND	ND	0.18	No	
EAR2-RA-38a-06-3	0.5	0.41	1	1.2	<0.024	0.044	0.043	<0.028	<0.02	<0.031	<0.025	9.7E-07	2.3E-07	5.9E-06	ND	1.3E-08	9.3E-09	ND	ND	ND	ND	7.1E-06	6.9E-06	2.6E-07	3.4E-02	2.6E-02	1.2E-01	ND	---	6.4E-04	ND	ND	ND	ND	0.18	No	
EAR2-RA-38a-12	1	0.087	1.8	0.35	<0.0047	0.036	0.015	0.019	<0.004	<0.0062	<0.0049	2.1E-07	4.2E-07	1.7E-06	ND	1.0E-08	3.3E-09	---	ND	ND	ND	2.4E-06	1.9E-06	4.4E-07	7.1E-03	4.7E-02	3.6E-02	ND	---	2.2E-04	6.3E-04	ND	ND	ND	0.09	No	
EAR2-RA-38b-06	0.5	0.76	1.1	1.6	0.026	0.082	0.27	<0.028	<0.02	<0.031	<0.025	1.8E-06	2.6E-07	7.8E-06	5.3E-09	2.4E-08	5.9E-08	ND	ND	ND	ND	1.0E-05	9.6E-06	3.5E-07	6.2E-02	2.9E-02	1.6E-01	---	---	4.0E-03	ND	ND	ND	ND	0.26	No	
EAR2-RA-38b-12	1	0.69	1	1.2	<0.024	0.043	<0.04	<0.028	<0.02	<0.031	<0.025	1.6E-06	2.3E-07	5.9E-06	ND	1.3E-08	ND	ND	ND	ND	ND	7.8E-06	7.5E-06	2.5E-07	5.7E-02	2.6E-02	1.2E-01	ND	---	ND	ND	ND	ND	ND	0.21	No	
EAR2-RA-38c-06	0.5	2	<1	3.5	<0.047	<0.048	<0.081	<0.057	<0.04	<0.062	<0.049	4.8E-06	ND	1.7E-05	ND	ND	ND	ND	ND	ND	ND	2.2E-05	2.2E-05	0.0E+00	1.6E-01	ND	3.6E-01	ND	ND	ND	ND	ND	ND	ND	ND	0.52	No
EAR2-RA-38c-12	1	3.9	<2	5.3	<0.094	<0.095	<0.16	<0.11	<0.08	<0.12	<0.098	9.3E-06	ND	2.6E-05	ND	ND	ND	ND	ND	ND	ND	3.5E-05	3.5E-05	0.0E+00	3.2E-01	ND	5.4E-01	ND	ND	ND	ND	ND	ND	ND	ND	0.86	No
EAR2-RA-38d-06	0.5	8.9	<0.5	6.1	<0.024	0.027	<0.04	0.065	0.071	<0.031	<0.025	2.1E-05	ND	3.0E-05	ND	7.8E-09	ND	---	---	ND	ND	5.1E-05	5.1E-05	7.8E-09	7.3E-01	ND	6.2E-01	ND	---	ND	2.2E-03	2.4E-03	ND	ND	1.35	Yes	
EAR2-RA-38d-12	1	5	<0.5	4.7	<0.024	0.025	<0.04	0.044	0.025	<0.031	<0.025	1.2E-05	ND	2.3E-05	ND	7.3E-09	ND	---	---	ND	ND	3.5E-05	3.5E-05	7.3E-09	4.1E-01	ND	4.8E-01	ND	---	ND	1.5E-03	8.3E-04	ND	ND	0.89	No	
EAR2-RA-38e-06	0.5	1.4	<0.5	3.6	<0.024	0.029	0.074	0.033	<0.02	<0.031	<0.025	3.3E-06	ND	1.8E-05	ND	8.4E-09	1.6E-08	---	ND	ND	ND	2.1E-05	2.1E-05	2.5E-08	1.1E-01	ND	3.7E-01	ND	---	1.1E-03	1.1E-03	ND	ND	ND	0.48	No	
EAR2-RA-38e-12	1	2.2	<0.5	3.7	0.028	0.047	0.063	0.029	<0.02	<0.031	<0.025	5.2E-06	ND	1.8E-05	5.7E-09	1.4E-08	1.4E-08	---	ND	ND	ND	2.3E-05	2.3E-05	3.3E-08	1.8E-01	ND	3.8E-01	---	---	9.4E-04	9.6E-04	ND	ND	ND	0.56	No	
EAR2-RA-3a-06	0.5	0.18	0.25	0.6	<0.0094	0.019	<0.016	0.016	<0.008	<0.012	<0.0098	4.3E-07	5.9E-08	2.9E-06	ND	5.5E-09	ND	---	ND	ND	ND	3.4E-06	3.4E-06	6.4E-08	1.5E-02	6.5E-03	6.1E-02	ND	---	ND	5.3E-04	ND	ND	ND	0.08	No	
EAR2-RA-3a-12	1	0.18	0.22	0.57	<0.0094	0.045	0.023	0.012	<0.008	<0.012	<0.0098	4.3E-07	5.2E-08	2.8E-06	ND	1.3E-08	5.0E-09	---	ND	ND	ND	3.3E-06	3.2E-06	7.0E-08	1.5E-02	5.7E-03	5.8E-02	ND	---	3.4E-04	4.0E-04	ND	ND	ND	0.08	No	
EAR2-RA-3b-06	0.5	0.043	0.18	0.29	<0.0047	0.028	0.015	0.01	<0.004	<0.0062	<0.0049	1.0E-07	4.2E-08	1.4E-06	ND	8.1E-09	3.3E-09	---	ND	ND	ND	1.6E-06	1.5E-06	5.4E-08	3.5E-03	4.7E-03	3.0E-02	ND	---	2.2E-04	3.3E-04	ND	ND	ND	0.04	No	
EAR2-RA-3b-12	1	0.038	0.14	0.24	<0.0047	0.042	0.025	0.0099	<0.004	<0.0062	<0.0049	9.0E-08	3.3E-08	1.2E-06	ND	1.2E-08	5.4E-09	---	ND	ND	ND	1.3E-06	1.3E-06	5.1E-08	3.1E-03	3.7E-03	2.4E-02	ND	---	3.7E-04	3.3E-04	ND	ND	ND	0.03	No	
EAR2-RA-3c-06	0.5	0.67	1.5	2.1	<0.024	0.046	0.068	0.033	<0.02	<0.031	<0.025	1.6E-06	3.5E-07	1.0E-05	ND	1.3E-08	1.5E-08	---	ND	ND	ND	1.2E-05	1.2E-05	3.8E-07	5.5E-02	3.9E-02	2.1E-01	ND	---	1.0E-03	1.1E-03	ND	ND	ND	0.31	No	
EAR2-RA-3c-12	1	0.31	<0.5	0.89	<0.024	0.048	0.074	<0.028	<0.02	<0.031	<0.025	7.4E-07	ND	4.4E-06	ND	1.4E-08	1.6E-08	ND	ND	ND	ND	5.1E-06	5.1E-06	3.0E-08	2.5E-02	ND	9.1E-02	ND	---	1.1E-03	ND	ND	ND	ND	0.12	No	
EAR2-RA-40a-06-1	0.5	1.7	<1	3.8	<0.047	0.05	<0.081	<0.057	<0.04	<0.062	<0.049	4.0E-06	ND	1.9E-05	ND	1.5E-08	ND	ND	ND	ND	ND	2.3E-05	2.3E-05	1.5E-08	1.4E-01	ND	3.9E-01	ND	---	ND	ND	ND	ND	ND	0.53	No	
EAR2-RA-40a-06-2	0.5	0.92	<1	2.3	<0.047	<0.048	<0.081	<0.057	<0.04	<0.062	<0.049	2.2E-06	ND	1.1E-05	ND	ND	ND	ND	ND	ND	ND	1.3E-05	1.3E-05	0.0E+00	7.5E-02	ND	2.3E-01	ND	ND	ND	ND	ND	ND	ND	0.31	No	
EAR2-RA-40a-06-3	0.5	0.76	1	2.2	<0.024	0.031	<0.04	<0.028	<0.02	<0.031	<0.025	1.8E-06	2.3E-07	1.1E-05	ND	9.0E-09	ND	ND	ND	ND	ND	1.3E-05	1.3E-05	2.0E+00	6.2E-02	2.6E-02	2.2E-01	ND	---	ND	ND	ND	ND	ND	0.31	No	
EAR2-RA-40a-12	1	3.9	<2	5.6	<0.094	<0.095	<0.16	<0.11	0.092	<0.12	<0.098	9.3E-06	ND	2.7E-05	ND	ND	ND	---	ND	ND	ND	3.7E-05	3.7E-05	0.0E+00	3.2E-01	ND	5.7E-01	ND	ND	ND	ND	3.1E-03	ND	ND	0.89	No	
EAR2-RA-40b-06	0.5	1.2	<1	3.6	<0.047	0.056	<0.081	<0.057	<0.04	<0.062	<0.049	2.9E-06	ND	1.8E-05	ND	1.6E-08	ND	ND	ND	ND	ND	2.1E-05	2.0E-05	1.6E-08	9.8E-02	ND	3.7E-01	ND	---	ND	ND	ND	ND	ND	0.47	No	
EAR2-RA-40b-12	1	1.6	<1	3	<0.047	0.059	<0.081	<0.057	<0.04	<0.062	<0.049	3.8E-06	ND	1.5E-05	ND	1.7E-08	ND	ND	ND	ND	ND	1.9E-05	1.9E-05	1.7E-08	1.3E-01	ND	3.1E-01	ND	---	ND	ND	ND	ND	ND	0.44	No	
EAR2-RA-40c-06	0.5	4.2	<2	5.5	<0.094	<0.095	<0.16	<0.11	0.086	<0.12	<0.098	1.0E-05	ND	2.7E-05	ND	ND	ND	---	ND	ND	ND	3.7E-05	3.7E-05	0.0E+00	3.4E-01	ND	5.6E-01	ND	ND	ND	2.9E-03	ND	ND	0.91	No		
EAR2-RA-40c-12	1	5.2	<2	2.6	<0.094	<0.095	<0.16	<0.11	0.086	<0.12	<0.098	1.2E-05	ND	1.3E-05	ND	ND	ND	---	ND	ND	ND	2.5E-05	2.5E-05	0.0E+00	4.3E-01	ND	2.7E-01	ND	ND	ND	2.9E-03	ND	ND	0.69	No		
EAR2-RA-40d-06	0.5	0.3	1.3	1	<0.0047	0.025	0.024	0.03	0.0094	<0.0062	<0.0049	7																									

TABLE E-1
Earhart I-2: Risk and Hazard Calculations - Child Resident^a

Decision Unit	Depth (feet)	Analytical Results (mg/kg)											Child Resident																				Exceed HDOH 2011 HC HHRE Standard? ^e						
		Aldrin	Chlordane	Dieldrin	4,4-DDD	4,4-DDE	4,4-DDT	Endrin	Endrin Ketone	Methoxychlor	delta-BHC	Cancer Risk										Noncancer Hazard																	
												Aldrin	Chlordane	Dieldrin	4,4-DDD	4,4-DDE	4,4-DDT	Endrin	Endrin Ketone	Methoxychlor	delta-BHC	Cumulative Risk ^b			Aldrin	Chlordane	Dieldrin	4,4-DDD	4,4-DDE	4,4-DDT	Endrin	Endrin Ketone		Methoxychlor	delta-BHC	Hazard Index ^d			
Resident Child - Cancer EALs (mg/kg)	42.1	42.6	20.4	48.7	34.4	46.0	----	----	----	----	----	1.7E-06	4.0E-07	1.1E-05	ND	1.4E-08	7.2E-09	ND	----	ND	ND	1.3E-05	1.3E-05	4.2E-07	5.7E-02	4.4E-02	2.3E-01	ND	----	4.9E-04	ND	7.6E-04	ND	ND	0.34				
Res. Child - Noncancer EALs (mg/kg)	12.2	38.3	9.8	----	----	67.0	30.1	30.1	501.4	38.3	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
EAR2-RA-43b-06	0.5	0.7	1.7	2.3	<0.0094	0.048	0.033	<0.011	0.023	<0.012	<0.0098	1.7E-06	4.0E-07	1.1E-05	ND	1.4E-08	7.2E-09	ND	----	ND	ND	1.3E-05	1.3E-05	4.2E-07	5.7E-02	4.4E-02	2.3E-01	ND	----	4.9E-04	ND	7.6E-04	ND	ND	0.34	No			
EAR2-RA-43b-12	1	0.78	2.2	1.5	<0.0094	0.064	0.026	<0.011	0.013	<0.012	<0.0098	1.9E-06	5.2E-07	7.4E-06	ND	1.9E-08	5.7E-09	ND	----	ND	ND	9.7E-06	9.2E-06	5.4E-07	6.4E-02	5.7E-02	1.5E-01	ND	----	3.9E-04	ND	4.3E-04	ND	ND	0.27	No			
EAR2-RA-43c-06	0.5	0.34	1.7	1	<0.0094	0.022	0.035	0.03	0.0088	<0.012	<0.0098	8.1E-07	4.0E-07	4.9E-06	ND	6.4E-09	7.6E-09	----	----	ND	ND	6.1E-06	5.7E-06	4.1E-07	2.8E-02	4.4E-02	1.0E-01	ND	----	5.2E-04	1.0E-03	2.9E-04	ND	ND	0.18	No			
EAR2-RA-43c-12	1	0.32	0.45	1.9	0.015	0.05	0.056	0.027	0.013	<0.0062	<0.0049	7.6E-07	1.1E-07	9.3E-06	3.1E-09	1.5E-08	1.2E-08	----	----	ND	ND	1.0E-05	1.0E-05	1.4E-07	2.6E-02	1.2E-02	1.9E-01	----	----	8.4E-04	9.0E-04	4.3E-04	ND	ND	0.23	No			
EAR2-RA-44a-06	0.5	0.3	1.8	1.2	<0.0094	0.043	0.033	0.031	<0.008	<0.012	<0.0098	7.1E-07	4.2E-07	5.9E-06	ND	1.3E-08	7.2E-09	----	----	ND	ND	7.0E-06	6.6E-06	4.4E-07	2.5E-02	4.7E-02	1.2E-01	ND	----	4.9E-04	1.0E-03	ND	ND	ND	0.20	No			
EAR2-RA-44a-12	1	0.27	1.9	0.81	<0.0094	0.033	0.029	0.03	<0.008	<0.012	<0.0098	6.4E-07	4.5E-07	4.0E-06	ND	9.6E-09	6.3E-09	----	----	ND	ND	5.1E-06	4.6E-06	4.6E-07	2.2E-02	5.0E-02	8.3E-02	ND	----	4.3E-04	1.0E-03	ND	ND	ND	0.16	No			
EAR2-RA-44b-06	0.5	1.4	2.2	3.5	<0.0047	0.062	0.04	0.045	0.038	<0.0062	<0.0049	3.3E-06	5.2E-07	1.7E-05	ND	1.8E-08	8.7E-09	----	----	ND	ND	2.1E-05	2.0E-05	5.4E-07	1.1E-01	5.7E-02	3.6E-01	ND	----	6.0E-04	1.5E-03	1.3E-03	ND	ND	0.53	No			
EAR2-RA-44b-12	1	3.3	4.1	6.1	<0.0047	0.063	0.045	0.058	0.12	<0.0062	<0.0049	7.8E-06	9.6E-07	3.0E-05	ND	1.8E-08	9.8E-09	----	----	ND	ND	3.9E-05	3.8E-05	9.9E-07	2.7E-01	1.1E-01	6.2E-01	ND	----	6.7E-04	1.9E-03	4.0E-03	ND	ND	1.00	No			
EAR2-RA-44c-06	0.5	1.2	1.7	2.5	<0.0047	0.068	0.048	0.032	0.029	<0.0062	<0.0049	2.9E-06	4.0E-07	1.2E-05	ND	2.0E-08	1.0E-08	----	----	ND	ND	1.6E-05	1.5E-05	4.3E-07	9.8E-02	4.4E-02	2.6E-01	ND	----	7.2E-04	1.1E-03	9.6E-04	ND	ND	0.40	No			
EAR2-RA-44c-12	1	1.9	1	2.8	0.016	0.19	0.13	0.032	0.03	<0.0062	<0.0049	4.5E-06	2.3E-07	1.4E-05	3.3E-09	5.5E-08	2.8E-08	----	----	ND	ND	1.9E-05	1.8E-05	3.2E-07	1.6E-01	2.6E-02	2.9E-01	----	----	1.9E-03	1.1E-03	1.0E-03	ND	ND	0.47	No			
EAR2-RA-44d-06	0.5	1.1	0.4	2.5	0.01	0.22	0.027	0.027	0.018	<0.0062	<0.0049	2.6E-06	9.4E-08	1.2E-05	2.1E-09	6.4E-09	5.9E-09	----	----	ND	ND	1.5E-05	1.5E-05	1.1E-07	9.0E-02	1.0E-02	2.6E-01	----	----	4.0E-04	9.0E-04	6.0E-04	ND	ND	0.36	No			
EAR2-RA-44d-12	1	2.4	0.49	4.2	0.012	0.24	0.02	0.046	0.04	<0.0062	<0.0049	5.7E-06	1.2E-07	2.1E-05	2.5E-09	7.0E-09	4.3E-09	----	----	ND	ND	2.6E-05	2.6E-05	1.3E-07	2.0E-01	1.3E-02	4.3E-01	----	----	3.0E-04	1.5E-03	1.3E-03	ND	ND	0.64	No			
EAR2-RA-45a-06-1	0.5	0.046	1.1	0.29	<0.0094	0.66	0.37	<0.011	<0.008	<0.012	<0.0098	1.1E-07	2.6E-07	1.4E-06	ND	1.9E-07	8.0E-08	ND	ND	ND	ND	2.1E-06	1.5E-06	5.3E-07	3.8E-03	2.9E-02	3.0E-02	ND	----	5.5E-03	ND	ND	ND	ND	0.07	No			
EAR2-RA-45a-06-2	0.5	0.081	1	0.24	<0.0094	0.36	0.31	<0.011	<0.008	<0.012	<0.0098	1.9E-07	2.3E-07	1.2E-06	ND	1.0E-07	6.7E-08	ND	ND	ND	ND	1.8E-06	1.4E-06	4.1E-07	6.6E-03	2.6E-02	2.4E-02	ND	----	4.6E-03	ND	ND	ND	ND	0.06	No			
EAR2-RA-45a-06-3	0.5	0.056	1	0.25	<0.0094	0.44	0.67	<0.011	<0.008	<0.012	<0.0098	1.3E-07	2.3E-07	1.2E-06	ND	1.3E-07	1.5E-07	ND	ND	ND	ND	1.9E-06	1.4E-06	5.1E-07	4.6E-03	2.6E-02	2.6E-02	ND	----	1.0E-02	ND	ND	ND	ND	0.07	No			
EAR2-RA-45a-12	1	<0.022	1.6	0.14	<0.024	1.2	0.56	<0.028	<0.02	<0.031	<0.025	ND	3.8E-07	6.9E-07	ND	3.5E-07	1.2E-07	ND	ND	ND	ND	1.5E-06	6.9E-07	8.5E-07	ND	4.2E-02	1.4E-02	ND	----	8.4E-03	ND	ND	ND	ND	0.06	No			
EAR2-RA-45b-06	0.5	0.028	0.61	0.18	<0.0047	0.11	0.097	<0.0057	<0.004	<0.0062	<0.0049	6.7E-08	1.4E-07	8.8E-07	ND	3.2E-08	2.1E-08	ND	ND	ND	ND	1.1E-06	9.5E-07	2.0E-07	2.3E-03	1.6E-02	1.8E-02	ND	----	1.4E-03	ND	ND	ND	ND	0.04	No			
EAR2-RA-45b-12	1	0.009	1.6	0.063	<0.0094	0.62	0.4	<0.011	<0.008	<0.012	<0.0098	2.1E-08	3.8E-07	3.1E-07	ND	1.8E-07	8.7E-08	ND	ND	ND	ND	9.7E-07	3.3E-07	6.4E-07	7.3E-04	4.2E-02	6.4E-03	ND	----	6.0E-03	ND	ND	ND	ND	0.05	No			
EAR2-RA-45c-06	0.5	0.057	1.6	0.22	<0.0094	0.57	0.24	<0.011	<0.008	<0.012	<0.0098	1.4E-07	3.8E-07	1.1E-06	ND	1.7E-07	5.2E-08	ND	ND	ND	ND	1.8E-06	1.2E-06	5.9E-07	4.7E-03	4.2E-02	2.2E-02	ND	----	3.6E-03	ND	ND	ND	ND	0.07	No			
EAR2-RA-45c-12	1	0.14	1.9	0.2	<0.0094	0.62	0.28	<0.011	<0.008	<0.012	<0.0098	3.3E-07	4.5E-07	9.8E-07	ND	1.8E-07	6.1E-08	ND	ND	ND	ND	2.0E-06	1.3E-06	6.9E-07	1.1E-02	5.0E-02	2.0E-02	ND	----	4.2E-03	ND	ND	ND	ND	0.09	No			
EAR2-RA-45d-06	0.5	0.15	3.3	0.41	0.01	0.59	0.36	0.015	<0.008	<0.012	<0.0098	3.6E-07	7.7E-07	2.0E-06	2.1E-09	1.7E-07	7.8E-08	----	----	ND	ND	3.4E-06	2.4E-06	1.0E-06	1.2E-02	8.6E-02	4.2E-02	----	----	5.4E-03	5.0E-04	ND	ND	ND	0.15	No			
EAR2-RA-45d-12	1	0.13	2.7	0.25	<0.024	0.77	0.28	<0.028	<0.02	<0.031	<0.025	3.1E-07	6.3E-07	1.2E-06	ND	2.2E-07	6.1E-08	ND	ND	ND	ND	2.5E-06	1.5E-06	9.2E-07	1.1E-02	7.0E-02	2.6E-02	ND	----	4.2E-03	ND	ND	ND	ND	0.11	No			
EAR2-RA-45e-06	0.5	<0.0088	1.5	0.06	<0.0094	0.64	0.22	<0.011	<0.008	<0.012	<0.0098	ND	3.5E-07	2.9E-07	ND	1.9E-07	4.8E-08	ND	ND	ND	ND	8.8E-07	2.9E-07	5.9E-07	ND	3.9E-02	6.1E-03	ND	----	3.3E-03	ND	ND	ND	ND	0.05	No			
EAR2-RA-45e-12	1	<0.0044	1.8	0.017	<0.0047	0.3	0.12	0.011	<0.004	<0.0062	<0.0049	ND	4.2E-07	8.3E-08	ND	8.7E-08	2.6E-08	----	----	ND	ND	6.2E-07	8.3E-08	5.4E-07	ND	4.7E-02	1.7E-03	ND	----	1.8E-03	3.7E-04	ND	ND	ND	0.05	No			
EAR2-RA-45f-06	0.5	0.074	1.5	0.31	<0.0047	0.31	0.19	0.006	<0.004	<0.0062	<0.0049	1.8E-07	3.5E-07	1.5E-06	ND	9.0E-08	4.1E-08	----	----	ND	ND	2.2E-06	1.7E-06	4.8E-07	6.1E-03	3.9E-02	3.2E-02	ND	----	2.8E-03	2.0E-04	ND	ND	ND	0.08	No			
EAR2-RA-45f-12	1	0.036	3.5	0.18	<0.0094	0.5	0.33	0.013	<0.008	<0.012	<0.0098	8.6E-08	8.2E-07	8.8E-07	ND	1.5E-07	7.2E-08	----	----	ND	ND	2.0E-06	9.7E-07	1.0E-06	3.0E-03	9.1E-02	1.8E-02	ND	----	4.9E-03	4.3E-04	ND	ND	ND	0.12	No			
EAR2-RA-46a-06	0.5	0.079	0.72	0.28	<0.0047	0.04	0.04	0.012	<0.004	<0.0062	<0.0049	1.9E-07	1.7E-07	1.4E-06	ND	1.2E-08	8.7E-09	----	----	ND	ND	1.7E-06	1.6E-06	1.9E-07	6.5E-03	1.9E-02	2.9E-02	ND	----	6.0E-04	4.0E-04	ND	ND	ND	0.05	No			
EAR2-RA-46a-12	1	0.033	1.3	0.13	<0.0047	0.05	0.047	0.014	<0.004	<0.0062	<0.0049	7.8E-08	3.1E-07	6.4E-07	ND	1.5E-08	1.0E-08	----	----	ND	ND	1.0E-06	7.2E-07	3.3E-07	2.7E-03	3.4E-02	1.3E-02	ND	----	7.0E-04	4.7E-04	ND	ND	ND	0.05	No			
EAR2-RA-46b-06	0.5	0.003	0.2	0.025	0.0052	0.051	0.11	<0.0023	<0.0016	<0.0025	<0.002	6.7E-09	4.7E-08	1.2E-07	1.1E-09	1.5E-08	2.4E-08	ND	ND	ND	ND	2.2E-07	1.3E-07	8.7E-08	2.3E-04	5.2E-03	2.6E-03	----	----	1.6E-03	ND	ND	ND	ND	0.01	No			
EAR2-RA-46b-12	1	0.003	0.27	0.015	0.0051	0.17	0.15	<0.0028	<0.002	<0.0031	<0.0025	6.7E-09	6.3E-08	7.4E-08	1.0E-09	4.9E-08	3.3E-08	ND	ND	ND	ND	2.3E-07	8.0E-08	1.5E-07	2.3E-04	7.0E-03	1.5E-03	----	----	2.2E-03	ND	ND	ND	ND	0.01	No			
EAR2-RA-46c-06	0.5	0.006	0.28	0.034	0.0022	0.09	0.07	<0.0023	<0.0016	<0.0025	<0.002	1.3E-08	6.6E-08	1.7E-07	4.5E-10	2.6E-08	1.5E-08	ND	ND	ND	ND	2.9E-07	1.8E-07	1.1E-07	4.5E-04	7.3E-03	3.5E-03	----	----	1.0E-03	ND	ND	ND	ND</					

TABLE E-1
Earhart I-2: Risk and Hazard Calculations - Child Resident^a

Decision Unit	Depth (feet)	Analytical Results (mg/kg)										Child Resident																				Exceed HDOH 2011 HC HHRE Standard? ^e							
		Aldrin	Chlordane	Dieldrin	4,4-DDD	4,4-DDE	4,4-DDT	Endrin	Endrin Ketone	Methoxychlor	delta-BHC	Cancer Risk										Noncancer Hazard																	
												Aldrin	Chlordane	Dieldrin	4,4-DDD	4,4-DDE	4,4-DDT	Endrin	Endrin Ketone	Methoxychlor	delta-BHC	Cumulative Risk ^b			Aldrin	Chlordane	Dieldrin	4,4-DDD	4,4-DDE	4,4-DDT	Endrin		Endrin Ketone	Methoxychlor	delta-BHC	Hazard Index ^d			
Resident Child - Cancer EALs (mg/kg)	Res. Child - Noncancer EALs (mg/kg)											All Chems	Aldrin and Dieldrin Only	No Aldrin or Dieldrin ^c																									
EAR2-RA-48b-06-1	0.5	0.43	1.1	1.9	<0.024	0.058	<0.04	<0.028	<0.02	<0.031	<0.025	1.0E-06	2.6E-07	9.3E-06	ND	1.7E-08	ND	ND	ND	ND	ND	ND	ND	1.1E-05	1.0E-05	2.8E-07	3.5E-02	2.9E-02	1.9E-01	ND	----	ND	ND	ND	ND	ND	ND	0.26	No
EAR2-RA-48b-06-2	0.5	0.77	0.78	2.6	<0.024	0.051	<0.04	<0.028	<0.02	<0.031	<0.025	1.8E-06	1.8E-07	1.3E-05	ND	1.5E-08	ND	ND	ND	ND	ND	ND	ND	1.5E-05	1.5E-05	2.0E-07	6.3E-02	2.0E-02	2.7E-01	ND	----	ND	ND	ND	ND	ND	ND	0.35	No
EAR2-RA-48b-06-3	0.5	0.6	1	2.2	<0.024	0.043	<0.04	<0.028	<0.02	<0.031	<0.025	1.4E-06	2.3E-07	1.1E-05	ND	1.3E-08	ND	ND	ND	ND	ND	ND	ND	1.2E-05	1.2E-05	2.5E-07	4.9E-02	2.6E-02	2.2E-01	ND	----	ND	ND	ND	ND	ND	ND	0.30	No
EAR2-RA-48b-12	1	0.62	0.68	2.4	<0.024	0.045	<0.04	<0.028	<0.02	<0.031	<0.025	1.5E-06	1.6E-07	1.2E-05	ND	1.3E-08	ND	ND	ND	ND	ND	ND	ND	1.3E-05	1.3E-05	1.7E-07	5.1E-02	1.8E-02	2.4E-01	ND	----	ND	ND	ND	ND	ND	ND	0.31	No
EAR2-RA-48c-06	0.5	0.94	0.76	2.8	<0.024	0.065	<0.04	<0.028	<0.02	<0.031	<0.025	2.2E-06	1.8E-07	1.4E-05	ND	1.9E-08	ND	ND	ND	ND	ND	ND	ND	1.6E-05	1.6E-05	2.0E-07	7.7E-02	2.0E-02	2.9E-01	ND	----	ND	ND	ND	ND	ND	ND	0.38	No
EAR2-RA-48c-12	1	1	0.67	2.6	<0.024	0.067	<0.04	<0.028	<0.02	<0.031	<0.025	2.4E-06	1.6E-07	1.3E-05	ND	1.9E-08	ND	ND	ND	ND	ND	ND	ND	1.5E-05	1.5E-05	1.8E-07	8.2E-02	1.7E-02	2.7E-01	ND	----	ND	ND	ND	ND	ND	ND	0.36	No
EAR2-RA-48d-06	0.5	0.86	0.69	2.5	<0.024	0.045	<0.04	<0.028	<0.02	<0.031	<0.025	2.0E-06	1.6E-07	1.2E-05	ND	1.3E-08	ND	ND	ND	ND	ND	ND	ND	1.4E-05	1.4E-05	1.8E-07	7.0E-02	1.8E-02	2.6E-01	ND	----	ND	ND	ND	ND	ND	ND	0.34	No
EAR2-RA-48d-12	1	0.75	0.7	2.4	<0.024	0.048	<0.04	<0.028	<0.02	<0.031	<0.025	1.8E-06	1.6E-07	1.2E-05	ND	1.4E-08	ND	ND	ND	ND	ND	ND	ND	1.4E-05	1.4E-05	1.8E-07	6.1E-02	1.8E-02	2.4E-01	ND	----	ND	ND	ND	ND	ND	ND	0.32	No
EAR2-RA-48e-06	0.5	0.12	0.51	0.33	<0.0094	0.083	0.058	0.011	<0.008	<0.012	<0.0098	2.9E-07	1.2E-07	1.6E-06	ND	2.4E-08	1.3E-08	----	ND	ND	ND	ND	2.1E-06	1.9E-06	1.6E-07	9.8E-03	1.3E-02	3.4E-02	ND	----	8.7E-04	3.7E-04	ND	ND	ND	ND	0.06	No	
EAR2-RA-48e-12	1	0.049	2.3	0.17	<0.0094	0.27	0.17	0.018	<0.008	<0.012	<0.0098	1.2E-07	5.4E-07	8.3E-07	ND	7.8E-08	3.7E-08	----	ND	ND	ND	ND	1.6E-06	9.5E-07	6.6E-07	4.0E-03	6.0E-02	1.7E-02	ND	----	2.5E-03	6.0E-04	ND	ND	ND	ND	0.08	No	
EAR2-RA-49a-06	0.5	0.17	0.82	0.7	<0.024	0.13	0.047	<0.028	<0.02	<0.031	<0.025	4.0E-07	1.9E-07	3.4E-06	ND	3.8E-08	1.0E-08	ND	ND	ND	ND	ND	4.1E-06	3.8E-06	2.4E-07	1.4E-02	2.1E-02	7.1E-02	ND	----	7.0E-04	ND	ND	ND	ND	ND	0.11	No	
EAR2-RA-49a-12	1	0.23	1.2	0.65	0.05	0.18	0.91	<0.028	<0.02	<0.031	<0.025	5.5E-07	2.8E-07	3.2E-06	1.0E-08	5.2E-08	2.0E-07	ND	ND	ND	ND	ND	4.3E-06	3.7E-06	5.4E-07	1.9E-02	3.1E-02	6.6E-02	----	----	1.4E-02	ND	ND	ND	ND	ND	0.13	No	
EAR2-RA-49b-06	0.5	0.13	<0.5	0.56	<0.024	0.13	0.069	<0.028	<0.02	<0.031	<0.025	3.1E-07	ND	2.7E-06	ND	3.8E-08	1.5E-08	ND	ND	ND	ND	ND	3.1E-06	3.1E-06	5.3E-08	1.1E-02	ND	5.7E-02	ND	----	1.0E-03	ND	ND	ND	ND	ND	0.07	No	
EAR2-RA-49b-12	1	0.037	<0.5	0.23	0.044	0.57	0.16	<0.028	<0.02	<0.031	<0.025	8.8E-08	ND	1.1E-06	9.0E-09	1.7E-07	3.5E-08	ND	ND	ND	ND	ND	1.4E-06	1.2E-06	2.1E-07	3.0E-03	ND	2.3E-02	----	----	2.4E-03	ND	ND	ND	ND	ND	0.03	No	
EAR2-RA-49c-06	0.5	0.37	<0.5	1.4	<0.024	0.06	0.082	<0.028	<0.02	<0.031	<0.025	8.8E-07	ND	6.9E-06	ND	1.7E-08	1.8E-08	ND	ND	ND	ND	ND	7.8E-06	7.7E-06	3.5E-08	3.0E-02	ND	1.4E-01	ND	----	1.2E-03	ND	ND	ND	ND	ND	0.17	No	
EAR2-RA-49c-12	1	0.17	<0.5	0.63	<0.024	0.048	<0.04	<0.028	<0.02	<0.031	<0.025	4.0E-07	ND	3.1E-06	ND	1.4E-08	ND	ND	ND	ND	ND	ND	3.5E-06	3.5E-06	1.4E-08	1.4E-02	ND	6.4E-02	ND	----	ND	ND	ND	ND	ND	ND	0.08	No	
EAR2-RA-49d-06	0.5	0.53	<0.5	2	0.045	0.23	0.49	<0.028	0.025	<0.031	<0.025	1.3E-06	ND	9.8E-06	9.2E-09	6.7E-08	1.1E-07	ND	----	ND	ND	ND	1.1E-05	1.1E-05	1.8E-07	4.3E-02	ND	2.0E-01	----	----	7.3E-03	ND	8.3E-04	ND	ND	ND	0.25	No	
EAR2-RA-49d-12	1	0.11	0.11	0.55	0.022	0.21	0.44	0.0064	<0.004	<0.0062	<0.0049	2.6E-07	2.6E-08	2.7E-06	4.5E-09	6.1E-08	9.6E-08	----	ND	ND	ND	ND	3.1E-06	3.0E-06	1.9E-07	9.0E-03	2.9E-03	5.6E-02	----	----	6.6E-03	2.1E-04	ND	ND	ND	ND	0.07	No	
EAR2-RA-49e-06	0.5	0.49	<0.5	1.8	<0.024	0.099	0.077	<0.028	<0.02	<0.031	<0.025	1.2E-06	ND	8.8E-06	ND	2.9E-08	1.7E-08	ND	ND	ND	ND	ND	1.0E-05	1.0E-05	4.6E-08	4.0E-02	ND	1.8E-01	ND	----	1.1E-03	ND	ND	ND	ND	ND	0.22	No	
EAR2-RA-49e-12	1	0.17	<0.5	0.67	<0.024	0.08	<0.04	<0.028	<0.02	<0.031	<0.025	4.0E-07	ND	3.3E-06	ND	2.3E-08	ND	ND	ND	ND	ND	ND	3.7E-06	3.7E-06	2.3E-08	1.4E-02	ND	6.8E-02	ND	----	ND	ND	ND	ND	ND	ND	0.08	No	
EAR2-RA-49f-06	0.5	0.31	<0.5	1.1	<0.024	0.12	0.044	<0.028	<0.02	<0.031	<0.025	7.4E-07	ND	5.4E-06	ND	3.5E-08	9.6E-09	ND	ND	ND	ND	ND	6.2E-06	6.1E-06	4.4E-08	2.5E-02	ND	1.1E-01	ND	----	6.6E-04	ND	ND	ND	ND	ND	0.14	No	
EAR2-RA-49f-12	1	0.87	<0.5	1.2	<0.024	0.28	0.084	<0.028	<0.02	<0.031	<0.025	2.1E-06	ND	5.9E-06	ND	8.1E-08	1.8E-08	ND	ND	ND	ND	ND	8.0E-06	7.9E-06	1.0E-07	7.1E-02	ND	1.2E-01	ND	----	1.3E-03	ND	ND	ND	ND	ND	0.20	No	
EAR2-RA-4a-06	0.5	0.016	<0.04	0.073	<0.0019	0.015	0.018	<0.0023	<0.0016	<0.0025	<0.002	3.8E-08	ND	3.6E-07	ND	4.4E-09	3.9E-09	ND	ND	ND	ND	ND	4.0E-07	4.0E-07	8.3E-09	1.3E-03	ND	7.4E-03	ND	----	2.7E-04	ND	ND	ND	ND	ND	0.01	No	
EAR2-RA-4a-12	1	0.016	<0.04	0.04	0.002	0.015	0.019	<0.0023	<0.0016	<0.0025	<0.002	3.8E-08	ND	2.0E-07	4.1E-10	4.4E-09	4.1E-09	ND	ND	ND	ND	ND	2.4E-07	2.3E-07	8.9E-09	1.3E-03	ND	4.1E-03	----	----	2.8E-04	ND	ND	ND	ND	ND	0.01	No	
EAR2-RA-4b-06	0.5	0.021	<0.04	0.072	<0.0019	0.016	0.012	<0.0023	<0.0016	<0.0025	<0.002	5.0E-08	ND	3.5E-07	ND	4.7E-09	2.6E-09	ND	ND	ND	ND	ND	4.1E-07	4.0E-07	7.3E-09	1.7E-03	ND	7.3E-03	ND	----	1.8E-04	ND	ND	ND	ND	ND	0.01	No	
EAR2-RA-4b-12	1	0.008	<0.04	0.056	0.0078	0.035	0.14	<0.0023	<0.0016	<0.0025	<0.002	1.8E-08	ND	2.7E-07	1.6E-09	1.0E-08	3.0E-08	ND	ND	ND	ND	ND	3.3E-07	2.9E-07	4.2E-08	6.2E-04	ND	5.7E-03	----	----	2.1E-03	ND	ND	ND	ND	ND	0.01	No	
EAR2-RA-4c-06	0.5	0.65	<0.5	2.3	<0.024	0.031	<0.04	<0.028	<0.02	<0.031	<0.025	1.5E-06	ND	1.1E-05	ND	9.0E-09	ND	ND	ND	ND	ND	ND	1.3E-05	1.3E-05	9.0E-09	5.3E-02	ND	2.3E-01	ND	----	ND	ND	ND	ND	ND	ND	0.29	No	
EAR2-RA-4c-12	1	0.43	0.89	1.6	<0.024	0.046	<0.04	<0.028	<0.02	<0.031	<0.025	1.0E-06	2.1E-07	7.8E-06	ND	1.3E-08	ND	ND	ND	ND	ND	ND	9.1E-06	8.9E-06	2.2E-07	3.5E-02	2.3E-02	1.6E-01	ND	----	ND	ND	ND	ND	ND	ND	0.22	No	
EAR2-RA-50a-06-1	0.5	0.42	0.52	2	<0.024	0.059	<0.04	<0.028	<0.02	<0.031	<0.025	1.0E-06	1.2E-07	9.8E-06	ND	1.7E-08	ND	ND	ND	ND	ND	ND	1.1E-05	1.1E-05	1.4E-07	3.4E-02	1.4E-02	2.0E-01	ND	----	ND	ND	ND	ND	ND	ND	0.25	No	
EAR2-RA-50a-06-2	0.5	0.52	<0.5	2.5	<0.024	0.085	0.087	<0.028	<0.02	<0.031	<0.025	1.2E-06	ND	1.2E-05	ND	2.5E-08	1.9E-08	ND	ND	ND	ND	ND	1.4E-05	1.3E-05	4.4E-08	4.3E-02	ND	2.6E-01	ND	----	1.3E-03	ND	ND	ND	ND	ND	0.30	No	
EAR2-RA-50a-06-3	0.5	0.47	<0.5	2.2	<0.024	0.063	0.044	<0.028	<0.02	<0.031	<0.025	1.1E-06	ND	1.1E-05	ND	1.8E-08	9.6E-09	ND	ND	ND	ND	ND	1.2E-05	1.2E-05	2.8E-08	3.9E-02	ND	2.2E-01	ND	----	6.6E-04	ND	ND	ND	ND	ND	0.26	No	
EAR2-RA-50a-12	1	0.44	<0.5	2.1	<0.024	0.058	<0.04	<0.028	<0.02	<0.031	<0.025	1.0E-06	ND	1.0E-05	ND	1.7E-08	ND	ND	ND	ND	ND	ND	1.1E-05	1.1E-05	1.7E-08	3.6E-02	ND	2.1E-01	ND	----	ND	ND	ND	ND	ND	ND	0.25	No	
EAR2-RA-50b-06	0.5	0.41	<0.5	1.8	<0.024	0.083	0.049	<0.028	<0.02	<0.031	<0.025	9.7E-07	ND																										

TABLE E-1
Earhart I-2: Risk and Hazard Calculations - Child Resident^a

Decision Unit	Depth (feet)	Analytical Results (mg/kg)										Child Resident																	Exceed HDOH 2011 HC HHRE Standard? ^e							
		Aldrin	Chlordane	Dieldrin	4,4-DDD	4,4-DDE	4,4-DDT	Endrin	Endrin Ketone	Methoxychlor	delta-BHC	Cancer Risk										Noncancer Hazard														
												Aldrin	Chlordane	Dieldrin	4,4-DDD	4,4-DDE	4,4-DDT	Endrin	Endrin Ketone	Methoxychlor	delta-BHC	Cumulative Risk ^b			Aldrin	Chlordane	Dieldrin	4,4-DDD		4,4-DDE	4,4-DDT	Endrin	Endrin Ketone	Methoxychlor	delta-BHC	Hazard Index ^d
Resident Child - Cancer EALs (mg/kg)	Res. Child - Noncancer EALs (mg/kg)	All Chems			Aldrin and Dieldrin Only	No Aldrin or Dieldrin ^c																														
EAR2-RA-51c-06	0.5	0.42	<0.5	2	<0.024	0.044	<0.04	<0.028	<0.02	<0.031	<0.025	1.0E-06	ND	9.8E-06	ND	1.3E-08	ND	ND	ND	ND	ND	1.1E-05	1.1E-05	1.3E-08	3.4E-02	ND	2.0E-01	ND	----	ND	ND	ND	ND	ND	0.24	No
EAR2-RA-51c-12	1	0.6	<0.5	2.5	<0.024	0.044	<0.04	<0.028	<0.02	<0.031	<0.025	1.4E-06	ND	1.2E-05	ND	1.3E-08	ND	ND	ND	ND	ND	1.4E-05	1.4E-05	1.3E-08	4.9E-02	ND	2.6E-01	ND	----	ND	ND	ND	ND	ND	0.30	No
EAR2-RA-51d-06	0.5	1.2	0.55	3.3	<0.024	0.04	<0.04	0.03	<0.02	<0.031	<0.025	2.9E-06	1.3E-07	1.6E-05	ND	1.2E-08	ND	----	ND	ND	ND	1.9E-05	1.9E-05	1.4E-07	9.8E-02	1.4E-02	3.4E-01	ND	----	ND	1.0E-03	ND	ND	ND	0.45	No
EAR2-RA-51d-12	1	1.5	<0.5	3	<0.024	0.051	0.2	<0.028	0.021	<0.031	<0.025	3.6E-06	ND	1.5E-05	ND	1.5E-08	4.3E-08	ND	----	ND	ND	1.8E-05	1.8E-05	5.8E-08	1.2E-01	ND	3.1E-01	ND	----	3.0E-03	ND	7.0E-04	ND	ND	0.43	No
EAR2-RA-51e-06	0.5	0.49	<0.5	1.7	<0.024	0.025	<0.04	<0.028	<0.02	<0.031	<0.025	1.2E-06	ND	8.3E-06	ND	7.3E-09	ND	ND	ND	ND	ND	9.5E-06	9.5E-06	7.3E-09	4.0E-02	ND	1.7E-01	ND	----	ND	ND	ND	ND	ND	0.21	No
EAR2-RA-51e-12	1	0.23	<0.5	0.8	<0.024	0.033	<0.04	<0.028	<0.02	<0.031	<0.025	5.5E-07	ND	3.9E-06	ND	9.6E-09	ND	ND	ND	ND	ND	4.5E-06	4.5E-06	9.6E-09	1.9E-02	ND	8.2E-02	ND	----	ND	ND	ND	ND	ND	0.10	No
EAR2-RA-51f-06	0.5	0.32	<0.5	2.2	<0.024	0.031	<0.04	<0.028	<0.02	<0.031	<0.025	7.6E-07	ND	1.1E-05	ND	9.0E-09	ND	ND	ND	ND	ND	1.2E-05	1.2E-05	9.0E-09	2.6E-02	ND	2.2E-01	ND	----	ND	ND	ND	ND	ND	0.25	No
EAR2-RA-51f-12	1	0.59	<0.5	1.9	<0.024	<0.024	<0.04	<0.028	0.054	<0.031	<0.025	1.4E-06	ND	9.3E-06	ND	ND	ND	ND	----	ND	ND	1.1E-05	1.1E-05	0.0E+00	4.8E-02	ND	1.9E-01	ND	ND	ND	ND	1.8E-03	ND	ND	0.24	No
EAR2-RA-52A-06	0.5	25	<5	8.5	<0.24	<0.24	<0.4	<0.28	<0.2	<0.31	<0.25	5.9E-05	ND	4.2E-05	ND	ND	ND	ND	ND	ND	ND	1.0E-04	1.0E-04	0.0E+00	#####	ND	8.7E-01	ND	ND	ND	ND	ND	ND	ND	2.92	Yes
EAR2-RA-52A-12	1	10	<2.5	4	<0.12	0.13	<0.2	<0.14	<0.1	<0.15	<0.12	2.4E-05	ND	2.0E-05	ND	3.8E-08	ND	ND	ND	ND	ND	4.3E-05	4.3E-05	3.8E-08	8.2E-01	ND	4.1E-01	ND	----	ND	ND	ND	ND	ND	1.23	Yes
EAR2-RA-52B-06	0.5	6.4	<2	7.2	0.11	0.14	0.2	<0.11	0.12	<0.12	<0.098	1.5E-05	ND	3.5E-05	2.3E-08	4.1E-08	4.3E-08	ND	----	ND	ND	5.1E-05	5.0E-05	1.1E-07	5.2E-01	ND	7.3E-01	----	----	3.0E-03	ND	4.0E-03	ND	ND	1.26	Yes
EAR2-RA-52B-12	1	7	<2	5.4	<0.094	0.18	0.25	<0.11	<0.08	<0.12	<0.098	1.7E-05	ND	2.6E-05	ND	5.2E-08	5.4E-08	ND	ND	ND	ND	4.3E-05	4.3E-05	1.1E-07	5.7E-01	ND	5.5E-01	ND	----	3.7E-03	ND	ND	ND	1.13	Yes	
EAR2-RA-52c-06	0.5	0.27	1.2	0.88	<0.024	0.025	<0.04	<0.028	<0.02	<0.031	<0.025	6.4E-07	2.8E-07	4.3E-06	ND	7.3E-09	ND	ND	ND	ND	ND	5.2E-06	5.0E-06	2.9E-07	2.2E-02	3.1E-02	9.0E-02	ND	----	ND	ND	ND	ND	ND	0.14	No
EAR2-RA-52c-12	1	0.25	1.1	0.52	<0.024	<0.024	<0.04	<0.028	<0.02	<0.031	<0.025	5.9E-07	2.6E-07	2.5E-06	ND	ND	ND	ND	ND	ND	ND	3.4E-06	3.1E-06	2.6E-07	2.0E-02	2.9E-02	5.3E-02	ND	ND	ND	ND	ND	ND	ND	0.10	No
EAR2-RA-52d-06	0.5	0.064	2.8	0.4	<0.0094	0.024	0.035	0.02	<0.008	<0.012	<0.0098	1.5E-07	6.6E-07	2.0E-06	ND	7.0E-09	7.6E-09	----	ND	ND	ND	2.8E-06	2.1E-06	6.7E-07	5.2E-03	7.3E-02	4.1E-02	ND	----	5.2E-04	6.6E-04	ND	ND	ND	0.12	No
EAR2-RA-52d-12	1	0.027	1.7	0.17	<0.0047	0.018	0.017	0.015	<0.004	<0.0062	<0.0049	6.4E-08	4.0E-07	8.3E-07	ND	5.2E-09	3.7E-09	----	ND	ND	ND	1.3E-06	9.0E-07	4.1E-07	2.2E-03	4.4E-02	1.7E-02	ND	----	2.5E-04	5.0E-04	ND	ND	ND	0.06	No
EAR2-RA-52e-06	0.5	0.12	1.2	0.8	<0.024	0.03	0.075	<0.028	0.031	<0.031	<0.025	2.9E-07	2.8E-07	3.9E-06	ND	8.7E-09	1.6E-08	ND	----	ND	ND	4.5E-06	4.2E-06	3.1E-07	9.8E-03	3.1E-02	8.2E-02	ND	----	1.1E-03	ND	1.0E-03	ND	ND	0.12	No
EAR2-RA-52e-12	1	0.16	1.4	0.87	<0.024	0.038	<0.04	0.037	0.16	<0.031	<0.025	3.8E-07	3.3E-07	4.3E-06	ND	1.1E-08	ND	----	----	ND	ND	5.0E-06	4.6E-06	3.4E-07	1.3E-02	3.7E-02	8.9E-02	ND	----	ND	1.2E-03	5.3E-03	ND	ND	0.14	No
EAR2-RA-53a-06-1	0.5	0.007	<0.04	0.046	0.0023	0.13	0.032	<0.0023	<0.0016	<0.0025	<0.002	1.6E-08	ND	2.3E-07	4.7E-10	3.8E-08	7.0E-09	ND	ND	ND	ND	2.9E-07	2.4E-07	4.5E-08	5.7E-04	ND	4.7E-03	----	----	4.8E-04	ND	ND	ND	ND	0.01	No
EAR2-RA-53a-06-2	0.5	0.016	<0.1	0.088	<0.0047	0.23	0.044	<0.0057	<0.004	<0.0062	<0.0049	3.8E-08	ND	4.3E-07	ND	6.7E-08	9.6E-09	ND	ND	ND	ND	5.5E-07	4.7E-07	7.6E-08	1.3E-03	ND	9.0E-03	ND	----	6.6E-04	ND	ND	ND	ND	0.01	No
EAR2-RA-53a-06-3	0.5	0.014	<0.1	0.087	<0.0051	0.22	0.073	<0.0057	<0.004	<0.0062	<0.0049	3.3E-08	ND	4.3E-07	1.0E-09	6.4E-08	1.6E-08	ND	ND	ND	ND	5.4E-07	4.6E-07	8.1E-08	1.1E-03	ND	8.9E-03	----	----	1.1E-03	ND	ND	ND	ND	0.01	No
EAR2-RA-53a-12	1	0.014	<0.04	0.035	<0.0019	0.099	0.027	<0.0023	<0.0016	<0.0025	<0.002	3.3E-08	ND	1.7E-07	ND	2.9E-08	5.9E-09	ND	ND	ND	ND	2.4E-07	2.0E-07	3.5E-08	1.1E-03	ND	3.6E-03	ND	----	4.0E-04	ND	ND	ND	ND	0.01	No
EAR2-RA-53b-06	0.5	0.11	<0.2	0.59	<0.0094	0.04	0.032	0.013	0.011	<0.012	<0.0098	2.6E-07	ND	2.9E-06	ND	1.2E-08	7.0E-09	----	----	ND	ND	3.2E-06	3.2E-06	1.9E-08	9.0E-03	ND	6.0E-02	ND	----	4.8E-04	4.3E-04	3.7E-04	ND	ND	0.07	No
EAR2-RA-53b-12	1	0.14	<0.2	0.42	<0.0094	0.078	0.03	0.017	<0.008	<0.012	<0.0098	3.3E-07	ND	2.1E-06	ND	2.3E-08	6.5E-09	----	ND	ND	ND	2.4E-06	2.4E-06	2.9E-08	1.1E-02	ND	4.3E-02	ND	----	4.5E-04	5.6E-04	ND	ND	ND	0.06	No
EAR2-RA-53i-06	0.5	0.053	0.23	0.43	<0.0094	0.019	0.021	<0.011	<0.008	<0.012	<0.0098	1.3E-07	5.4E-08	2.1E-06	ND	5.5E-09	4.6E-09	ND	ND	ND	ND	2.3E-06	2.2E-06	6.4E-08	4.3E-03	6.0E-03	4.4E-02	ND	----	3.1E-04	ND	ND	ND	ND	0.05	No
EAR2-RA-53i-12	1	0.078	0.38	0.51	<0.0094	0.026	0.025	<0.011	<0.008	<0.012	<0.0098	1.9E-07	8.9E-08	2.5E-06	ND	7.6E-09	5.4E-09	ND	ND	ND	ND	2.8E-06	2.7E-06	1.0E-07	6.4E-03	9.9E-03	5.2E-02	ND	----	3.7E-04	ND	ND	ND	ND	0.07	No
EAR2-RA-53j-06-1	0.5	0.071	<0.2	0.45	<0.0094	0.024	0.017	<0.011	<0.008	<0.012	<0.0098	1.7E-07	ND	2.2E-06	ND	7.0E-09	3.7E-09	ND	ND	ND	ND	2.4E-06	2.4E-06	1.1E-08	5.8E-03	ND	4.6E-02	ND	----	2.5E-04	ND	ND	ND	ND	0.05	No
EAR2-RA-53j-06-2	0.5	0.11	<0.2	0.55	<0.0094	0.018	<0.016	<0.011	<0.008	<0.012	<0.0098	2.6E-07	ND	2.7E-06	ND	5.2E-09	ND	ND	ND	ND	ND	3.0E-06	3.0E-06	5.2E-09	9.0E-03	ND	5.6E-02	ND	----	ND	ND	ND	ND	ND	0.07	No
EAR2-RA-53j-06-3	0.5	0.088	<0.2	0.4	<0.0094	0.016	<0.016	<0.011	<0.008	<0.012	<0.0098	2.1E-07	ND	2.0E-06	ND	4.7E-09	ND	ND	ND	ND	ND	2.2E-06	2.2E-06	4.7E-09	7.2E-03	ND	4.1E-02	ND	----	ND	ND	ND	ND	ND	0.05	No
EAR2-RA-53j-12	1	0.043	<0.1	0.25	<0.0047	0.046	0.027	<0.0057	<0.004	<0.0062	<0.0049	1.0E-07	ND	1.2E-06	ND	1.3E-08	5.9E-09	ND	ND	ND	ND	1.3E-06	1.3E-06	1.9E-08	3.5E-03	ND	2.6E-02	ND	----	4.0E-04	ND	ND	ND	ND	0.03	No
EAR2-RA-53k-06	0.5	0.15	<0.5	0.99	<0.024	<0.024	<0.04	<0.028	<0.02	<0.031	<0.025	3.6E-07	ND	4.9E-06	ND	ND	ND	ND	ND	ND	ND	5.2E-06	5.2E-06	0.0E+00	1.2E-02	ND	1.0E-01	ND	ND	ND	ND	ND	ND	ND	0.11	No
EAR2-RA-53k-12	1	0.063	<0.2	0.48	<0.0094	0.027	<0.016	<0.011	<0.008	<0.012	<0.0098	1.5E-07	ND	2.4E-06	ND	7.8E-09	ND	ND	ND	ND	ND	2.5E-06	2.5E-06	7.8E-09	5.2E-03	ND	4.9E-02	ND	----	ND	ND	ND	ND	ND	0.05	No
EAR2-RA-53l-06	0.5	0.45	<0.5	1.7	<0.024	<0.024	<0.04	<0.028	<0.02	<0.031	<0.025	1.1E-06	ND	8.3E-06	ND	ND	ND	ND	ND	ND	ND	9.4E-06	9.4E-06	0.0E+00	3.7E-02	ND	1.7E-01	ND	ND	ND	ND	ND	ND	ND	0.21	No
EAR2-RA-53l-12	1	0.14	<0.5	1.1	<0.024	<0.024	<0.04	<0.028	<0.02	<0.031	<0.025	3.3E-07	ND	5.4E-06	ND	ND	ND	ND	ND	ND	ND	5.7E-06	5.7E-06	0.0E+00	1.1E-02	ND	1.1E-01	ND	ND	ND	ND	ND	ND	ND	0.12	

TABLE E-1
Earhart I-2: Risk and Hazard Calculations - Child Resident^a

Decision Unit	Depth (feet)	Analytical Results (mg/kg)											Child Resident																						Exceed HDOH 2011 HC HHRE Standard? ^e	
		Aldrin	Chlordane	Dieldrin	4,4-DDD	4,4-DDE	4,4-DDT	Endrin	Endrin Ketone	Methoxychlor	delta-BHC	Cancer Risk											Noncancer Hazard													
												Aldrin	Chlordane	Dieldrin	4,4-DDD	4,4-DDE	4,4-DDT	Endrin	Endrin Ketone	Methoxychlor	delta-BHC	Cumulative Risk ^b			Aldrin	Chlordane	Dieldrin	4,4-DDD	4,4-DDE	4,4-DDT	Endrin	Endrin Ketone	Methoxychlor	delta-BHC		Hazard Index ^d
Resident Child - Cancer EALs (mg/kg)	Res. Child - Noncancer EALs (mg/kg)	All Chems			Aldrin and Dieldrin Only	No Aldrin or Dieldrin ^c																														
EAR2-RA-58a-06-1	0.5	1.1	1.1	4.2	<0.024	0.075	0.048	<0.028	0.031	<0.031	<0.025	2.6E-06	2.6E-07	2.1E-05	ND	2.2E-08	1.0E-08	ND	----	ND	ND	2.3E-05	2.3E-05	2.9E-07	9.0E-02	2.9E-02	4.3E-01	ND	----	7.2E-04	ND	1.0E-03	ND	ND	0.55	No
EAR2-RA-58a-06-2	0.5	0.48	1.3	2.6	<0.024	0.075	0.056	<0.028	0.023	<0.031	<0.025	1.1E-06	3.1E-07	1.3E-05	ND	2.2E-08	1.2E-08	ND	----	ND	ND	1.4E-05	1.4E-05	3.4E-07	3.9E-02	3.4E-02	2.7E-01	ND	----	8.4E-04	ND	7.6E-04	ND	ND	0.34	No
EAR2-RA-58a-06-3	0.5	0.63	1.7	3.1	<0.024	0.077	0.062	0.028	0.025	<0.031	<0.025	1.5E-06	4.0E-07	1.5E-05	ND	2.2E-08	1.3E-08	----	----	ND	ND	1.7E-05	1.7E-05	4.3E-07	5.2E-02	4.4E-02	3.2E-01	ND	----	9.3E-04	9.3E-04	8.3E-04	ND	ND	0.41	No
EAR2-RA-58a-12	1	0.83	1.1	3.4	<0.024	0.09	0.073	<0.028	0.029	<0.031	<0.025	2.0E-06	2.6E-07	1.7E-05	ND	2.6E-08	1.6E-08	ND	----	ND	ND	1.9E-05	1.9E-05	3.0E-07	6.8E-02	2.9E-02	3.5E-01	ND	----	1.1E-03	ND	9.6E-04	ND	ND	0.44	No
EAR2-RA-58c-06	0.5	0.59	2	2.8	<0.024	0.12	0.26	<0.028	0.022	<0.031	<0.025	1.4E-06	4.7E-07	1.4E-05	ND	3.5E-08	5.7E-08	ND	----	ND	ND	1.6E-05	1.5E-05	5.6E-07	4.8E-02	5.2E-02	2.9E-01	ND	----	3.9E-03	ND	7.3E-04	ND	ND	0.39	No
EAR2-RA-58c-12	1	0.42	1.9	2	<0.024	0.11	0.074	<0.028	<0.02	<0.031	<0.025	1.0E-06	4.5E-07	9.8E-06	ND	3.2E-08	1.6E-08	ND	ND	ND	ND	1.1E-05	1.1E-05	4.9E-07	3.4E-02	5.0E-02	2.0E-01	ND	----	1.1E-03	ND	ND	ND	ND	0.29	No
EAR2-RA-58d-06	0.5	0.47	1.4	1.8	<0.024	0.083	0.046	<0.028	<0.02	<0.031	<0.025	1.1E-06	3.3E-07	8.8E-06	ND	2.4E-08	1.0E-08	ND	ND	ND	ND	1.0E-05	9.9E-06	3.6E-07	3.9E-02	3.7E-02	1.8E-01	ND	----	6.9E-04	ND	ND	ND	ND	0.26	No
EAR2-RA-58d-12	1	0.49	1.5	2	<0.024	0.087	0.056	<0.028	<0.02	<0.031	<0.025	1.2E-06	3.5E-07	9.8E-06	ND	2.5E-08	1.2E-08	ND	ND	ND	ND	1.1E-05	1.1E-05	3.9E-07	4.0E-02	3.9E-02	2.0E-01	ND	----	8.4E-04	ND	ND	ND	ND	0.28	No
EAR2-RA-58e-06	0.5	0.61	1.3	2.4	<0.024	0.1	0.11	<0.028	0.023	<0.031	<0.025	1.4E-06	3.1E-07	1.2E-05	ND	2.9E-08	2.4E-08	ND	----	ND	ND	1.4E-05	1.3E-05	3.6E-07	5.0E-02	3.4E-02	2.4E-01	ND	----	1.6E-03	ND	7.6E-04	ND	ND	0.33	No
EAR2-RA-58e-12	1	0.52	2.1	2	<0.024	0.12	0.084	<0.028	0.021	<0.031	<0.025	1.2E-06	4.9E-07	9.8E-06	ND	3.5E-08	1.8E-08	ND	----	ND	ND	1.2E-05	1.1E-05	5.5E-07	4.3E-02	5.5E-02	2.0E-01	ND	----	1.3E-03	ND	7.0E-04	ND	ND	0.30	No
EAR2-RA-58f-06	0.5	0.85	1.7	2.8	<0.024	0.12	0.068	<0.028	0.026	<0.031	<0.025	2.0E-06	4.0E-07	1.4E-05	ND	3.5E-08	1.5E-08	ND	----	ND	ND	1.6E-05	1.6E-05	4.5E-07	7.0E-02	4.4E-02	2.9E-01	ND	----	1.0E-03	ND	8.6E-04	ND	ND	0.40	No
EAR2-RA-58f-12	1	0.77	1.4	3	<0.024	0.094	0.06	<0.028	0.028	<0.031	<0.025	1.8E-06	3.3E-07	1.5E-05	ND	2.7E-08	1.3E-08	ND	----	ND	ND	1.7E-05	1.7E-05	3.7E-07	6.3E-02	3.7E-02	3.1E-01	ND	----	9.0E-04	ND	9.3E-04	ND	ND	0.41	No
EAR2-RA-59a-06	0.5	0.58	1.1	1.8	<0.024	0.058	0.042	<0.028	<0.02	<0.031	<0.025	1.4E-06	2.6E-07	8.8E-06	ND	1.7E-08	9.1E-09	ND	ND	ND	ND	1.0E-05	1.0E-05	2.8E-07	4.8E-02	2.9E-02	1.8E-01	ND	----	6.3E-04	ND	ND	ND	ND	0.26	No
EAR2-RA-59a-12	1	1.4	0.85	2.8	<0.024	0.05	<0.04	<0.028	0.026	<0.031	<0.025	3.3E-06	2.0E-07	1.4E-05	ND	1.5E-08	ND	ND	----	ND	ND	1.7E-05	1.7E-05	2.1E-07	1.1E-01	2.2E-02	2.9E-01	ND	----	ND	ND	8.6E-04	ND	ND	0.42	No
EAR2-RA-59b-06	0.5	0.37	1.3	2.5	<0.0094	0.059	0.073	0.033	0.011	<0.012	<0.0098	8.8E-07	3.1E-07	1.2E-05	ND	1.7E-08	1.6E-08	----	----	ND	ND	1.3E-05	1.3E-05	3.4E-07	3.0E-02	3.4E-02	2.6E-01	ND	----	1.1E-03	1.1E-03	3.7E-04	ND	ND	0.32	No
EAR2-RA-59b-12	1	0.46	1.5	1.2	<0.024	0.066	0.04	<0.031	<0.02	<0.031	<0.025	1.1E-06	3.5E-07	5.9E-06	ND	1.9E-08	8.7E-09	----	----	ND	ND	7.4E-06	7.0E-06	3.8E-07	3.8E-02	3.9E-02	1.2E-01	ND	----	6.0E-04	1.2E-03	ND	ND	ND	0.20	No
EAR2-RA-59c-06	0.5	0.98	1.1	3.9	<0.0094	0.06	0.061	0.04	0.04	<0.012	<0.0098	2.3E-06	2.6E-07	1.9E-05	ND	1.7E-08	1.3E-08	----	----	ND	ND	2.2E-05	2.1E-05	2.9E-07	8.0E-02	2.9E-02	4.0E-01	ND	----	9.1E-04	1.3E-03	1.3E-03	ND	ND	0.51	No
EAR2-RA-59c-12	1	1.3	1.3	4.1	<0.0094	0.055	0.051	0.047	0.043	<0.012	<0.0098	3.1E-06	3.1E-07	2.0E-05	ND	1.6E-08	1.1E-08	----	----	ND	ND	2.4E-05	2.3E-05	3.3E-07	1.1E-01	3.4E-02	4.2E-01	ND	----	7.6E-04	1.6E-03	1.4E-03	ND	ND	0.56	No
EAR2-RA-5a-12	1	0.073	<0.1	0.3	0.0073	0.16	0.18	0.0064	<0.004	<0.0062	<0.0049	1.7E-07	ND	1.5E-06	1.5E-09	4.7E-08	3.9E-08	----	----	ND	ND	1.7E-06	1.6E-06	8.7E-08	6.0E-03	ND	3.1E-02	----	----	2.7E-03	2.1E-04	ND	ND	ND	0.04	No
EAR2-RA-5a-6-1	0.5	0.23	<0.5	1.1	<0.024	0.03	<0.04	<0.028	<0.02	<0.031	<0.025	5.5E-07	ND	5.4E-06	ND	8.7E-09	ND	ND	ND	ND	ND	5.9E-06	5.9E-06	8.7E-09	1.9E-02	ND	1.1E-01	ND	----	ND	ND	ND	ND	ND	0.13	No
EAR2-RA-5a-6-2	0.5	0.2	<0.5	0.92	<0.024	0.034	<0.04	<0.028	<0.02	<0.031	<0.025	4.8E-07	ND	4.5E-06	ND	9.9E-09	ND	ND	ND	ND	ND	5.0E-06	5.0E-06	9.9E-09	1.6E-02	ND	9.4E-02	ND	----	ND	ND	ND	ND	ND	0.11	No
EAR2-RA-5a-6-3	0.5	0.34	<0.5	1.4	<0.024	0.047	<0.04	<0.028	<0.02	<0.031	<0.025	8.1E-07	ND	6.9E-06	ND	1.4E-08	ND	ND	ND	ND	ND	7.7E-06	7.7E-06	1.4E-08	2.8E-02	ND	1.4E-01	ND	----	ND	ND	ND	ND	ND	0.17	No
EAR2-RA-5b-12	1	0.81	<0.5	1.2	<0.024	0.19	0.065	<0.028	<0.02	<0.031	<0.025	1.9E-06	ND	5.9E-06	ND	5.5E-08	1.4E-08	ND	ND	ND	ND	7.9E-06	7.8E-06	6.9E-08	6.6E-02	ND	1.2E-01	ND	----	9.7E-04	ND	ND	ND	ND	0.19	No
EAR2-RA-5b-6	0.5	0.26	0.34	1.1	<0.0094	0.095	0.038	0.015	<0.008	<0.012	<0.0098	6.2E-07	8.0E-08	5.4E-06	ND	2.8E-08	8.3E-09	----	----	ND	ND	6.1E-06	6.0E-06	1.2E-07	2.1E-02	8.9E-03	1.1E-01	ND	----	5.7E-04	5.0E-04	ND	ND	ND	0.14	No
EAR2-RA-5c-06	0.5	0.34	<0.5	1.3	<0.024	0.11	0.063	<0.028	<0.02	<0.031	<0.025	8.1E-07	ND	6.4E-06	ND	3.2E-08	1.4E-08	ND	ND	ND	ND	7.2E-06	7.2E-06	4.6E-08	2.8E-02	ND	1.3E-01	ND	----	9.4E-04	ND	ND	ND	ND	0.16	No
EAR2-RA-5c-12	1	0.2	<0.25	0.79	0.013	0.21	0.085	<0.014	<0.01	<0.015	<0.012	4.8E-07	ND	3.9E-06	2.7E-09	6.1E-08	1.8E-08	ND	ND	ND	ND	4.4E-06	4.3E-06	8.2E-08	1.6E-02	ND	8.1E-02	----	----	1.3E-03	ND	ND	ND	ND	0.10	No
EAR2-RA-5d-06	0.5	0.13	<0.25	0.72	<0.012	0.081	0.057	<0.014	<0.01	<0.015	<0.012	3.1E-07	ND	3.5E-06	ND	2.4E-08	1.2E-08	ND	ND	ND	ND	3.9E-06	3.8E-06	3.6E-08	1.1E-02	ND	7.3E-02	ND	----	8.5E-04	ND	ND	ND	ND	0.08	No
EAR2-RA-5d-12	1	0.042	<0.1	0.27	<0.0047	0.14	0.061	<0.0057	<0.004	<0.0062	<0.0049	1.0E-07	ND	1.3E-06	ND	4.1E-08	1.3E-08	ND	ND	ND	ND	1.5E-06	1.4E-06	5.4E-08	3.4E-03	ND	2.8E-02	ND	----	9.1E-04	ND	ND	ND	ND	0.03	No
EAR2-RA-5e-06	0.5	0.35	<1	1.7	<0.047	0.11	<0.081	<0.057	<0.04	<0.062	<0.049	8.3E-07	ND	8.3E-06	ND	3.2E-08	ND	ND	ND	ND	ND	9.2E-06	9.2E-06	3.2E-08	2.9E-02	ND	1.7E-01	ND	----	ND	ND	ND	ND	ND	0.20	No
EAR2-RA-5e-12	1	1	<0.5	2.7	<0.024	0.11	0.049	<0.028	0.026	<0.031	<0.025	2.4E-06	ND	1.3E-05	ND	3.2E-08	1.1E-08	ND	----	ND	ND	1.6E-05	1.6E-05	4.3E-08	8.2E-02	ND	2.8E-01	ND	----	7.3E-04	ND	8.6E-04	ND	ND	0.36	No
EAR2-RA-60a-06-1	0.5	2.6	1.3	5.4	<0.024	0.035	0.064	0.059	0.049	<0.031	<0.025	6.2E-06	3.1E-07	2.6E-05	ND	1.0E-08	1.4E-08	----	----	ND	ND	3.3E-05	3.3E-05	3.3E-07	2.1E-01	3.4E-02	5.5E-01	ND	----	9.6E-04	2.0E-03	1.6E-03	ND	ND	0.80	No
EAR2-RA-60a-06-2	0.5	3.4	2	6.4	<0.024	0.04	0.044	0.064	0.048	<0.031	<0.025	8.1E-06	4.7E-07	3.1E-05	ND	1.2E-08	9.6E-09	----	----	ND	ND	4.0E-05	3.9E-05	4.9E-07	2.8E-01	3.2E-02	6.5E-01	ND	----	6.6E-04	2.1E-03	1.6E-03	ND	ND	0.99	No
EAR2-RA-60a-06-3	0.5	1.1	1.4	2.8	<0.047	<0.048	<0.081	<0.057	<0.04	<0.062	<0.049	2.6E-06	3.3E-07	1.4E-05	ND	ND	ND	ND	ND	ND	ND	1.7E-05	1.6E-05	3.3E-07	9.0E-02	5.7E-02	2.9E-01	ND	ND	ND	ND	ND	ND	0.41	No	
EAR2-RA-60a-12	1	2	2.1	3	<0.024	0.069	0.11																													

TABLE E-1
Earhart I-2: Risk and Hazard Calculations - Child Resident^a

Decision Unit	Depth (feet)	Analytical Results (mg/kg)											Child Resident																							Exceed HDOH 2011 HC HHRE Standard? ^e	
		Aldrin	Chlordane	Dieldrin	4,4-DDD	4,4-DDE	4,4-DDT	Endrin	Endrin Ketone	Methoxychlor	delta-BHC	Cancer Risk											Noncancer Hazard														
												Aldrin	Chlordane	Dieldrin	4,4-DDD	4,4-DDE	4,4-DDT	Endrin	Endrin Ketone	Methoxychlor	delta-BHC	Cumulative Risk ^b			Aldrin	Chlordane	Dieldrin	4,4-DDD	4,4-DDE	4,4-DDT	Endrin	Endrin Ketone	Methoxychlor	delta-BHC	Hazard Index ^d		
Resident Child - Cancer EALs (mg/kg)	Res. Child - Noncancer EALs (mg/kg)												All Chems	Aldrin and Dieldrin Only	No Aldrin or Dieldrin ^c																						
EAR2-RA-62a-06-1	0.5	0.5	1.3	1	<0.024	0.41	0.23	<0.028	<0.02	<0.031	<0.025	1.2E-06	3.1E-07	4.9E-06	ND	1.2E-07	5.0E-08	ND	ND	ND	ND	6.6E-06	6.1E-06	4.7E-07	4.1E-02	3.4E-02	1.0E-01	ND	----	----	3.4E-03	ND	ND	ND	ND	0.18	No
EAR2-RA-62a-06-2	0.5	0.29	1.1	0.72	0.035	0.43	0.5	<0.011	0.0094	<0.012	<0.0098	6.9E-07	2.6E-07	3.5E-06	7.2E-09	1.3E-07	1.1E-07	ND	----	ND	ND	4.7E-06	4.2E-06	5.0E-07	2.4E-02	2.9E-02	7.3E-02	----	----	7.5E-03	ND	3.1E-04	ND	ND	ND	0.13	No
EAR2-RA-62a-06-3	0.5	0.24	0.79	0.63	0.012	0.22	0.12	<0.011	<0.008	<0.012	<0.0098	5.7E-07	1.9E-07	3.1E-06	2.5E-09	6.4E-08	2.6E-08	ND	ND	ND	ND	3.9E-06	3.7E-06	2.8E-07	2.0E-02	2.1E-02	6.4E-02	----	----	1.8E-03	ND	ND	ND	ND	0.11	No	
EAR2-RA-62a-12	1	0.27	0.93	0.47	0.014	0.25	0.12	<0.011	<0.008	<0.012	<0.0098	6.4E-07	2.2E-07	2.3E-06	2.9E-09	7.3E-08	2.6E-08	ND	ND	ND	ND	3.3E-06	2.9E-06	3.2E-07	2.2E-02	2.4E-02	4.8E-02	----	----	1.8E-03	ND	ND	ND	ND	0.10	No	
EAR2-RA-62b-06	0.5	0.068	0.45	0.21	<0.0047	0.032	0.04	<0.0057	<0.004	<0.0062	<0.0049	1.6E-07	1.1E-07	1.0E-06	ND	9.3E-09	8.7E-09	ND	ND	ND	ND	1.3E-06	1.2E-06	1.2E-07	5.6E-03	1.2E-02	2.1E-02	ND	----	6.0E-04	ND	ND	ND	ND	0.04	No	
EAR2-RA-62b-12	1	0.024	0.11	0.092	<0.0019	0.04	0.011	<0.0023	0.0021	<0.0025	<0.002	5.7E-08	2.6E-08	4.5E-07	ND	1.2E-08	2.4E-09	ND	----	ND	ND	5.5E-07	5.1E-07	4.0E-08	2.0E-03	2.9E-03	9.4E-03	ND	----	1.6E-04	ND	7.0E-05	ND	ND	0.01	No	
EAR2-RA-62c-06	0.5	0.26	1.8	0.81	<0.0094	0.11	0.029	0.017	<0.008	<0.012	<0.0098	6.2E-07	4.2E-07	4.0E-06	ND	3.2E-08	6.3E-09	----	ND	ND	ND	5.0E-06	4.6E-06	4.6E-07	2.1E-02	4.7E-02	8.3E-02	ND	----	4.3E-04	5.6E-04	ND	ND	ND	0.15	No	
EAR2-RA-62c-12	1	0.26	0.84	0.55	<0.0094	0.15	0.055	0.011	<0.008	<0.012	<0.0098	6.2E-07	2.0E-07	2.7E-06	ND	4.4E-08	1.2E-08	----	ND	ND	ND	3.6E-06	3.3E-06	2.5E-07	2.1E-02	2.2E-02	5.6E-02	ND	----	8.2E-04	3.7E-04	ND	ND	ND	0.10	No	
EAR2-RA-62d-06	0.5	0.55	1.8	0.9	0.033	0.14	0.048	<0.028	<0.02	<0.031	<0.025	1.3E-06	4.2E-07	4.4E-06	6.8E-09	4.1E-08	1.0E-08	ND	ND	ND	ND	6.2E-06	5.7E-06	4.8E-07	4.5E-02	4.7E-02	9.2E-02	----	----	7.2E-04	ND	ND	ND	ND	0.18	No	
EAR2-RA-62d-12	1	0.49	1.6	0.57	<0.0094	0.26	0.038	0.013	<0.008	<0.012	<0.0098	1.2E-06	3.8E-07	2.8E-06	ND	7.6E-08	8.3E-09	----	ND	ND	ND	4.4E-06	4.0E-06	4.6E-07	4.0E-02	4.2E-02	5.8E-02	ND	----	5.7E-04	4.3E-04	ND	ND	ND	0.14	No	
EAR2-RA-62e-06	0.5	0.66	1.2	0.88	0.052	0.26	0.038	0.027	0.011	<0.012	<0.0098	1.6E-06	2.8E-07	4.3E-06	1.1E-08	7.6E-08	8.3E-09	----	ND	ND	ND	6.3E-06	5.9E-06	3.8E-07	5.4E-02	3.1E-02	9.0E-02	----	----	5.7E-04	9.0E-04	3.7E-04	ND	ND	0.18	No	
EAR2-RA-62e-12	1	1.8	0.96	0.63	<0.024	0.13	<0.04	<0.028	<0.02	<0.031	<0.025	4.3E-06	2.3E-07	3.1E-06	ND	3.8E-08	ND	ND	ND	ND	ND	7.6E-06	7.4E-06	2.6E-07	1.5E-01	2.5E-02	6.4E-02	ND	----	ND	ND	ND	ND	0.24	No		
EAR2-RA-62f-06	0.5	0.087	0.56	0.38	0.032	0.098	0.055	<0.011	<0.008	<0.012	<0.0098	2.1E-07	1.3E-07	1.9E-06	6.6E-09	2.8E-08	1.2E-08	ND	ND	ND	ND	2.2E-06	2.1E-06	1.8E-07	7.1E-03	1.5E-02	3.9E-02	----	----	8.2E-04	ND	ND	ND	ND	0.06	No	
EAR2-RA-62f-12	1	0.16	0.72	0.4	<0.0094	0.19	0.11	<0.011	<0.008	<0.012	<0.0098	3.8E-07	1.7E-07	2.0E-06	ND	5.5E-08	2.4E-08	ND	ND	ND	ND	2.6E-06	2.3E-06	2.5E-07	1.3E-02	1.9E-02	4.1E-02	ND	----	1.6E-03	ND	ND	ND	ND	0.07	No	
EAR2-RA-6a-06	0.5	1.4	<0.5	3.6	<0.024	0.036	<0.04	<0.028	<0.02	<0.031	<0.025	3.3E-06	ND	1.8E-05	ND	1.0E-08	ND	ND	ND	ND	ND	2.1E-05	2.1E-05	1.0E-08	1.1E-01	ND	3.7E-01	ND	----	ND	ND	ND	ND	ND	0.48	No	
EAR2-RA-6a-12	1	5.8	<2	3.9	<0.094	<0.095	<0.16	<0.11	<0.08	<0.12	<0.098	1.4E-05	ND	1.9E-05	ND	ND	ND	ND	ND	ND	ND	3.3E-05	3.3E-05	0.0E+00	4.8E-01	ND	4.0E-01	ND	ND	ND	ND	ND	ND	ND	0.87	No	
EAR2-RA-6b-06	0.5	3.6	<1	3.3	<0.047	0.21	0.34	<0.057	<0.04	<0.062	<0.049	8.6E-06	ND	1.6E-05	ND	6.1E-08	7.4E-08	ND	ND	ND	ND	2.5E-05	2.5E-05	1.3E-07	3.0E-01	ND	3.4E-01	ND	----	5.1E-03	ND	ND	ND	ND	0.64	No	
EAR2-RA-6b-12	1	3.4	<1	1.9	0.065	0.22	0.47	<0.057	<0.04	<0.062	<0.049	8.1E-06	ND	9.3E-06	1.3E-08	6.4E-08	1.0E-07	ND	ND	ND	ND	1.8E-05	1.7E-05	1.8E-07	2.8E-01	ND	1.9E-01	----	----	7.0E-03	ND	ND	ND	ND	0.48	No	
EAR2-RA-6c-06	0.5	46	<5	10	<0.24	<0.24	<0.4	<0.28	0.3	<0.31	<0.25	1.1E-04	ND	4.9E-05	ND	ND	ND	ND	----	ND	ND	1.6E-04	1.6E-04	0.0E+00	#####	ND	#####	ND	ND	ND	ND	1.0E-02	ND	ND	ND	4.79	Yes
EAR2-RA-6c-12	1	36	<5	6.7	<0.24	<0.24	<0.4	<0.28	<0.2	<0.31	<0.25	8.6E-05	ND	3.3E-05	ND	ND	ND	ND	ND	ND	ND	1.2E-04	1.2E-04	0.0E+00	#####	ND	6.8E-01	ND	ND	ND	ND	ND	ND	3.63	Yes		
EAR2-RA-7a-06	0.5	1.1	1.1	2.9	<0.024	0.058	0.053	<0.028	<0.02	<0.031	<0.025	2.6E-06	2.6E-07	1.4E-05	ND	1.7E-08	1.2E-08	ND	ND	ND	ND	1.7E-05	1.7E-05	2.9E-07	9.0E-02	2.9E-02	3.0E-01	ND	----	7.9E-04	ND	ND	ND	ND	0.42	No	
EAR2-RA-7a-12	1	0.82	1.2	2.1	<0.024	0.041	<0.04	<0.028	<0.02	<0.031	<0.025	1.9E-06	2.8E-07	1.0E-05	ND	1.2E-08	ND	ND	ND	ND	ND	1.3E-05	1.2E-05	2.9E-07	6.7E-02	3.1E-02	2.1E-01	ND	----	ND	ND	ND	ND	ND	0.31	No	
EAR2-RA-7b-06	0.5	1.2	2	2.4	<0.024	0.06	<0.04	<0.028	0.022	<0.031	<0.025	2.9E-06	4.7E-07	1.2E-05	ND	1.7E-08	ND	ND	----	ND	ND	1.5E-05	1.5E-05	4.9E-07	9.8E-02	5.2E-02	2.4E-01	ND	----	ND	ND	7.3E-04	ND	ND	0.40	No	
EAR2-RA-7b-12	1	0.42	1.3	1.8	<0.024	0.053	<0.04	<0.028	<0.02	<0.031	<0.025	1.0E-06	3.1E-07	8.8E-06	ND	1.5E-08	ND	ND	ND	ND	ND	1.0E-05	9.8E-06	3.2E-07	3.4E-02	3.4E-02	1.8E-01	ND	----	ND	ND	ND	ND	ND	0.25	No	
EAR2-RA-8a-06	0.5	0.11	<0.25	0.42	<0.012	0.017	<0.02	<0.014	<0.01	<0.015	<0.012	2.6E-07	ND	2.1E-06	ND	4.9E-09	ND	ND	ND	ND	ND	2.3E-06	2.3E-06	4.9E-09	9.0E-03	ND	4.3E-02	ND	----	ND	ND	ND	ND	ND	0.05	No	
EAR2-RA-8a-12	1	0.08	0.48	0.45	<0.012	0.017	<0.02	<0.014	<0.01	<0.015	<0.012	1.9E-07	1.1E-07	2.2E-06	ND	4.9E-09	ND	ND	ND	ND	ND	2.5E-06	2.4E-06	1.2E-07	6.6E-03	1.3E-02	4.6E-02	ND	----	ND	ND	ND	ND	ND	0.07	No	
EAR2-RA-8b-06	0.5	1.3	<0.5	0.94	<0.024	<0.024	<0.04	<0.028	<0.02	<0.031	<0.025	3.1E-06	ND	4.6E-06	ND	ND	ND	ND	ND	ND	ND	7.7E-06	7.7E-06	0.0E+00	1.1E-01	ND	9.6E-02	ND	ND	ND	ND	ND	ND	ND	0.20	No	
EAR2-RA-8b-12	1	0.99	<1	3.2	<0.047	<0.048	<0.081	<0.057	<0.04	<0.062	<0.049	2.4E-06	ND	1.6E-05	ND	ND	ND	ND	ND	ND	ND	1.8E-05	1.8E-05	0.0E+00	8.1E-02	ND	3.3E-01	ND	ND	ND	ND	ND	ND	ND	0.41	No	
EAR2-RA-9a-06	0.5	0.4	1.3	1.7	<0.024	0.11	0.13	<0.028	<0.02	<0.031	<0.025	9.5E-07	3.1E-07	8.3E-06	ND	3.2E-08	2.8E-08	ND	ND	ND	ND	9.6E-06	9.3E-06	3.7E-07	3.3E-02	3.4E-02	1.7E-01	ND	----	1.9E-03	ND	ND	ND	ND	0.24	No	
EAR2-RA-9a-12	1	0.57	1	1.5	<0.024	0.12	0.042	<0.028	<0.02	<0.031	<0.025	1.4E-06	2.3E-07	7.4E-06	ND	3.5E-08	9.1E-09	ND	ND	ND	ND	9.0E-06	8.7E-06	2.8E-07	4.7E-02	2.6E-02	1.5E-01	ND	----	6.3E-04	ND	ND	ND	ND	0.23	No	
EAR2-RA-9b-06	0.5	0.09	0.63	0.46	0.027	0.18	0.28	<0.011	<0.008	<0.012	<0.0098	2.1E-07	1.5E-07	2.3E-06	5.5E-09	5.2E-08	6.1E-08	ND	ND	ND	ND	2.7E-06	2.5E-06	2.7E-07	7.4E-03	1.6E-02	4.7E-02	----	----	4.2E-03	ND	ND	ND	ND	0.07	No	
EAR2-RA-9b-12	1	0.022	0.34	0.15	<0.0024	0.11	0.023	<0.0028	<0.002	<0.0031	<0.0025	5.2E-08	8.0E-08	7.4E-07	ND	3.2E-08	5.0E-09	ND	ND	ND	ND	9.0E-07	7.9E-07	1.2E-07	1.8E-03	8.9E-03	1.5E-02	ND	----	3.4E-04	ND	ND	ND	ND	0.03	No	
EAR2-RA-9c-06	0.5	0.21	0.86	0.93	<0.024	0.029	<0.04	<0.028	<0.02	<0.031	<0.025	5.0E-07	2.0E-07	4.6E-06	ND	8.4E-09	ND	ND	ND	ND	ND	5.3E-06	5.1E-06	2.1E-07	1.7E-02	2.2E-02	9.5E-02	ND	----	ND	ND	ND	ND	ND	0.13	No	
EAR2-RA-9c-12	1	0.088	0.76	0.52	<0.024	0.029	<0.04	<0.028	<0.02	<0.031	<0.025	2.1E-07	1.8E-07	2.5E-06	ND	8.4E-09	ND																				

TABLE E-1
Earhart I-2: Risk and Hazard Calculations - Child Resident^a

Decision Unit	Depth (feet)	Analytical Results (mg/kg)											Child Resident																	Exceed HDOH 2011 HC HHRE Standard? ^e							
		Aldrin	Chlordane	Dieldrin	4,4-DDD	4,4-DDE	4,4-DDT	Endrin	Endrin Ketone	Methoxychlor	delta-BHC	Cancer Risk											Noncancer Hazard														
												Aldrin	Chlordane	Dieldrin	4,4-DDD	4,4-DDE	4,4-DDT	Endrin	Endrin Ketone	Methoxychlor	delta-BHC	Cumulative Risk ^b			Aldrin	Chlordane	Dieldrin	4,4-DDD	4,4-DDE		4,4-DDT	Endrin	Endrin Ketone	Methoxychlor	delta-BHC	Hazard Index ^d	
Resident Child - Cancer EALs (mg/kg)	Res. Child - Noncancer EALs (mg/kg)												All Chems	Aldrin and Dieldrin Only	No Aldrin or Dieldrin ^c																						
EAR2-RA-39c-06	0.5	1.7	2.4	3.7	0.066	0.24	0.45	<0.028	0.025	<0.031	<0.025	4.0E-06	5.6E-07	1.8E-05	1.4E-08	7.0E-08	9.8E-08	ND	----	ND	ND	2.3E-05	2.2E-05	7.4E-07	1.4E-01	6.3E-02	3.8E-01	----	----	6.7E-03	ND	8.3E-04	ND	ND	0.59	No	
EAR2-RA-39c-12	1	2.8	2.6	3.4	0.12	0.25	0.75	<0.028	0.033	<0.031	<0.025	6.7E-06	6.1E-07	1.7E-05	2.5E-08	7.3E-08	1.6E-07	ND	----	ND	ND	2.4E-05	2.3E-05	8.7E-07	2.3E-01	6.8E-02	3.5E-01	----	----	1.1E-02	ND	1.1E-03	ND	ND	0.66	No	
EAR2-RA-39d-06	0.5	0.72	0.73	3	<0.024	0.05	<0.04	<0.028	<0.02	<0.031	<0.025	1.7E-06	1.7E-07	1.5E-05	ND	1.5E-08	ND	ND	ND	ND	ND	1.7E-05	1.6E-05	1.9E-07	5.9E-02	1.9E-02	3.1E-01	ND	----	ND	ND	ND	ND	ND	0.38	No	
EAR2-RA-39d-12	1	0.57	0.55	1.5	<0.024	0.055	<0.04	<0.028	<0.02	<0.031	<0.025	1.4E-06	1.3E-07	7.4E-06	ND	1.6E-08	ND	ND	ND	ND	ND	8.9E-06	8.7E-06	1.5E-07	4.7E-02	1.4E-02	1.5E-01	ND	----	ND	ND	ND	ND	ND	0.21	No	
EAR2-RA-39e-06	0.5	1.3	0.92	4	<0.024	0.03	<0.04	<0.028	<0.02	<0.031	<0.025	3.1E-06	2.2E-07	2.0E-05	ND	8.7E-09	ND	ND	ND	ND	ND	2.3E-05	2.3E-05	2.2E-07	1.1E-01	2.4E-02	4.1E-01	ND	----	ND	ND	ND	ND	ND	0.54	No	
EAR2-RA-39e-12	1	2.6	0.72	3.7	<0.024	0.03	<0.04	<0.028	0.021	<0.031	<0.025	6.2E-06	1.7E-07	1.8E-05	ND	8.7E-09	ND	ND	----	ND	ND	2.4E-05	2.4E-05	1.8E-07	2.1E-01	1.9E-02	3.8E-01	ND	----	ND	ND	7.0E-04	ND	ND	0.61	No	
EAR2-RA-53c-06	0.5	0.059	<0.2	0.48	<0.0094	0.017	0.028	<0.011	<0.008	<0.012	<0.0098	1.4E-07	ND	2.4E-06	ND	4.9E-09	6.1E-09	ND	ND	ND	ND	2.5E-06	2.5E-06	1.1E-08	4.8E-03	ND	4.9E-02	ND	----	4.2E-04	ND	ND	ND	ND	0.05	No	
EAR2-RA-53c-12	1	0.063	<0.2	0.46	<0.0094	0.045	0.031	<0.011	<0.008	<0.012	<0.0098	1.5E-07	ND	2.3E-06	ND	1.3E-08	6.7E-09	ND	ND	ND	ND	2.4E-06	2.4E-06	2.0E-08	5.2E-03	ND	4.7E-02	ND	----	4.6E-04	ND	ND	ND	ND	0.05	No	
EAR2-RA-53d-06	0.5	0.43	<0.5	1.9	<0.024	0.041	0.042	<0.028	<0.02	<0.031	<0.025	1.0E-06	ND	9.3E-06	ND	1.2E-08	9.1E-09	ND	ND	ND	ND	1.0E-05	1.0E-05	2.1E-08	3.5E-02	ND	1.9E-01	ND	----	6.3E-04	ND	ND	ND	ND	0.23	No	
EAR2-RA-53d-12	1	0.2	<0.5	1.2	<0.024	0.039	<0.04	<0.028	<0.02	<0.031	<0.025	4.8E-07	ND	5.9E-06	ND	1.1E-08	ND	ND	ND	ND	ND	6.4E-06	6.4E-06	1.1E-08	1.6E-02	ND	1.2E-01	ND	----	ND	ND	ND	ND	ND	0.14	No	
EAR2-RA-53e-06	0.5	0.1	0.31	0.59	<0.0094	0.023	0.027	0.011	<0.008	<0.012	<0.0098	2.4E-07	7.3E-08	2.9E-06	ND	6.7E-09	5.9E-09	----	ND	ND	ND	3.2E-06	3.1E-06	8.5E-08	8.2E-03	8.1E-03	6.0E-02	ND	----	4.0E-04	3.7E-04	ND	ND	ND	0.08	No	
EAR2-RA-53e-12	1	0.055	0.42	0.27	<0.0047	0.035	0.054	<0.0057	<0.004	<0.0062	<0.0049	1.3E-07	9.9E-08	1.3E-06	ND	1.0E-08	1.2E-08	ND	ND	ND	ND	1.6E-06	1.5E-06	1.2E-07	4.5E-03	1.1E-02	2.8E-02	ND	----	8.1E-04	ND	ND	ND	ND	0.04	No	
EAR2-RA-53f-06	0.5	1.3	0.6	4.1	<0.024	0.043	0.042	<0.028	<0.02	<0.031	<0.025	3.1E-06	1.4E-07	2.0E-05	ND	1.3E-08	9.1E-09	ND	ND	ND	ND	2.3E-05	2.3E-05	1.6E-07	1.1E-01	1.6E-02	4.2E-01	ND	----	6.3E-04	ND	ND	ND	ND	0.54	No	
EAR2-RA-53f-12	1	0.65	<0.5	1.5	0.061	0.32	0.33	<0.028	<0.02	<0.031	<0.025	1.5E-06	ND	7.4E-06	1.3E-08	9.3E-08	7.2E-08	ND	ND	ND	ND	9.1E-06	8.9E-06	1.8E-07	5.3E-02	ND	1.5E-01	----	----	4.9E-03	ND	ND	ND	ND	0.21	No	
EAR2-RA-53g-06	0.5	1.9	<0.5	2.5	<0.024	<0.024	<0.04	<0.028	<0.02	<0.031	<0.025	4.5E-06	ND	1.2E-05	ND	ND	ND	ND	ND	ND	ND	1.7E-05	1.7E-05	0.0E+00	1.6E-01	ND	2.6E-01	ND	ND	ND	ND	ND	ND	ND	ND	0.41	No
EAR2-RA-53g-12	1	6.2	<0.5	2.1	<0.024	0.029	<0.04	<0.028	<0.02	<0.031	<0.025	1.5E-05	ND	1.0E-05	ND	8.4E-09	ND	ND	ND	ND	ND	2.5E-05	2.5E-05	8.4E-09	5.1E-01	ND	2.1E-01	ND	----	ND	ND	ND	ND	ND	0.72	No	
EAR2-RA-53h-06	0.5	0.62	<0.5	1.9	<0.024	0.028	<0.04	<0.028	<0.02	<0.031	<0.025	1.5E-06	ND	9.3E-06	ND	8.1E-09	ND	ND	ND	ND	ND	1.1E-05	1.1E-05	8.1E-09	5.1E-02	ND	1.9E-01	ND	----	ND	ND	ND	ND	ND	0.24	No	
EAR2-RA-53h-12	1	0.73	<0.5	1.9	<0.024	0.027	<0.04	<0.028	<0.02	<0.031	<0.025	1.7E-06	ND	9.3E-06	ND	7.8E-09	ND	ND	ND	ND	ND	1.1E-05	1.1E-05	7.8E-09	6.0E-02	ND	1.9E-01	ND	----	ND	ND	ND	ND	ND	0.25	No	
EAR2-RA-56n-06	0.5	0.72	0.63	3.2	<0.024	0.027	<0.04	<0.028	<0.02	<0.031	<0.025	1.7E-06	1.5E-07	1.6E-05	ND	7.8E-09	ND	ND	ND	ND	ND	1.8E-05	1.7E-05	1.6E-07	5.9E-02	1.6E-02	3.3E-01	ND	----	ND	ND	ND	ND	ND	0.40	No	
EAR2-RA-56n-12	1	0.86	0.51	2.6	<0.024	0.042	<0.04	<0.028	<0.02	<0.031	<0.025	2.0E-06	1.2E-07	1.3E-05	ND	1.2E-08	ND	ND	ND	ND	ND	1.5E-05	1.5E-05	1.3E-07	7.0E-02	1.3E-02	2.7E-01	ND	----	ND	ND	ND	ND	ND	0.35	No	

Notes:

^a Shading highlights DUs that have been excavated as part of the three removal actions (RO#1, RO #2, and RO #3) that have been conducted at the site. These layers have been replaced with clean fill.

^b Three cumulative risk numbers are presented to verify that cumulative risk levels meet all HDOH 2011 HC Human Health Risk Evaluation (HHRE) Standard (HDOH 2011) target risk criteria.

^c Listed cumulative risk is for all chemicals except aldrin and dieldrin.

^d The hazard index represents the sum of all chemical-specific hazard quotients (HQs).

^e The four criteria associated with the 2011 HHRE standard are as follows:

- Criteria #1 - the cumulative excess cancer risk (ECR) for aldrin plus dieldrin must not exceed 1×10^{-4}
- Criteria #2 - the cumulative ECR for all other organochlorine pesticides must not exceed 1×10^{-5}
- Criteria #3 - the cumulative ECR for all chemicals of potential concern (COPCs) must not exceed 1×10^{-4}
- Criteria #4 - the hazard index for all COPCs must not exceed 1.0.

Sources:

Hawai'i Department of Health (HDOH). 2011. Review of *Draft Preliminary Human Health Risk Evaluation Work Plan for Hickam Communities, Joint Base Pearl Harbor-Hickam*. 2011-303-ES. Letter from Eric Sadoyama HDOH to Roger Franklin, Actus Lend Lease LLC. June 7, 2011.

TABLE E-3
Earhart I-3: Risk and Hazard Calculations - Child Resident^a

Decision Unit	Depth (feet)	Analytical Results (mg/kg)									Child Resident																	Exceed HDOH 2011 HC HHRE Standard? ^e						
		Aldrin	Chlordane	Dieldrin	4,4-DDD	4,4-DDE	4,4-DDT	Endosulfan sulfate	Endrin	Endrin Ketone	Cancer Risk									Noncancer Hazard														
											Aldrin	Chlordane	Dieldrin	4,4-DDD	4,4-DDE	4,4-DDT	Endosulfan sulfate	Endrin	Endrin Ketone	Cumulative Risk ^b			Aldrin	Chlordane	Dieldrin	4,4-DDD	4,4-DDE		4,4-DDT	Endosulfan sulfate	Endrin	Endrin Ketone	Hazard Index ^d	
Resident Child - Cancer EALs (mg/kg)	42.1	42.6	20.4	48.7	34.4	46.0	---	---	---												All Chems	Aldrin and Dieldrin Only	No Aldrin or Dieldrin ^c											
Res. Child - Noncancer EALs (mg/kg)	12.2	38.3	9.8	----	----	67.0	602.0	30.1	30.1																									
EAR3-RA-10a-06-1	0.5	0.13	2.1	0.44	0.039	0.17	0.55	<0.024	<0.028	<0.02	3.1E-07	4.9E-07	2.2E-06	8.0E-09	4.9E-08	1.2E-07	ND	ND	ND	3.1E-06	2.5E-06	6.7E-07	1.1E-02	5.5E-02	4.5E-02	----	----	8.2E-03	ND	ND	ND	0.12	No	
EAR3-RA-10a-06-2	0.5	0.12	1.5	0.41	0.087	0.14	0.58	<0.024	<0.028	<0.02	2.9E-07	3.5E-07	2.0E-06	1.8E-08	4.1E-08	1.3E-07	ND	ND	ND	2.8E-06	2.3E-06	5.4E-07	9.8E-03	3.9E-02	4.2E-02	----	----	8.7E-03	ND	ND	ND	0.10	No	
EAR3-RA-10a-06-3	0.5	0.32	1.8	0.56	0.028	0.15	0.16	<0.024	<0.028	<0.02	7.6E-07	4.2E-07	2.7E-06	5.7E-09	4.4E-08	3.5E-08	ND	ND	ND	4.0E-06	3.5E-06	5.1E-07	2.6E-02	4.7E-02	5.7E-02	----	----	2.4E-03	ND	ND	ND	0.13	No	
EAR3-RA-10a-12	1	0.15	1.2	0.34	0.01	0.08	0.1	<0.0098	<0.011	<0.008	3.6E-07	2.8E-07	1.7E-06	2.1E-09	2.3E-08	2.2E-08	ND	ND	ND	2.4E-06	2.0E-06	3.3E-07	1.2E-02	3.1E-02	3.5E-02	----	----	1.5E-03	ND	ND	ND	0.08	No	
EAR3-RA-10b-06	0.5	1.3	2.8	2.1	<0.024	0.14	0.3	<0.024	<0.028	0.032	3.1E-06	6.6E-07	1.0E-05	ND	4.1E-08	6.5E-08	ND	ND	----	1.4E-05	1.3E-05	7.6E-07	1.1E-01	7.3E-02	2.1E-01	ND	----	4.5E-03	ND	ND	1.1E-03	0.40	No	
EAR3-RA-10b-12	1	1.6	1.8	2.3	<0.024	0.19	0.36	<0.024	<0.028	0.049	3.8E-06	4.2E-07	1.1E-05	ND	5.5E-08	7.8E-08	ND	ND	----	1.6E-05	1.5E-05	5.6E-07	1.3E-01	4.7E-02	2.3E-01	ND	----	5.4E-03	ND	ND	1.6E-03	0.42	No	
EAR3-RA-10c-06	0.5	0.7	3.1	1.2	<0.024	0.2	0.21	<0.024	<0.028	0.023	1.7E-06	7.3E-07	5.9E-06	ND	5.8E-08	4.6E-08	ND	ND	----	8.4E-06	7.5E-06	8.3E-07	5.7E-02	8.1E-02	1.2E-01	ND	----	3.1E-03	ND	ND	7.6E-04	0.26	No	
EAR3-RA-10c-12	1	0.98	4.2	1.2	<0.024	0.22	0.26	<0.024	<0.028	<0.02	2.3E-06	9.9E-07	5.9E-06	ND	6.4E-08	5.7E-08	ND	ND	ND	9.3E-06	8.2E-06	1.1E-06	8.0E-02	1.1E-01	1.2E-01	ND	----	3.9E-03	ND	ND	ND	0.32	No	
EAR3-RA-10d-06	0.5	0.39	3.9	1.1	<0.024	0.29	0.29	<0.024	<0.028	<0.02	9.3E-07	9.2E-07	5.4E-06	ND	8.4E-08	6.3E-08	ND	ND	ND	7.4E-06	6.3E-06	1.1E-06	3.2E-02	1.0E-01	1.1E-01	ND	----	4.3E-03	ND	ND	ND	0.3	No	
EAR3-RA-10d-12	1	0.28	3	0.81	0.028	0.42	0.31	<0.024	<0.028	<0.02	6.7E-07	7.0E-07	4.0E-06	5.7E-09	1.2E-07	6.7E-08	ND	ND	ND	5.5E-06	4.6E-06	9.0E-07	2.3E-02	7.8E-02	8.3E-02	----	----	4.6E-03	ND	ND	ND	0.2	No	
EAR3-RA-11a-12	1	0.085	1.8	0.26	0.16	0.25	2.5	<0.024	<0.028	<0.02	2.0E-07	4.2E-07	1.3E-06	3.3E-08	7.3E-08	5.4E-07	ND	ND	ND	2.5E-06	1.5E-06	1.1E-06	7.0E-03	4.7E-02	2.7E-02	----	----	3.7E-02	ND	ND	ND	0.12	No	
EAR3-RA-11a-6	0.5	0.22	1.6	0.64	0.049	0.11	0.59	<0.024	<0.028	<0.02	5.2E-07	3.8E-07	3.1E-06	1.0E-08	3.2E-08	1.3E-07	ND	ND	ND	4.2E-06	3.7E-06	5.5E-07	1.8E-02	4.2E-02	6.5E-02	----	----	8.8E-03	ND	ND	ND	0.13	No	
EAR3-RA-11b-06	0.5	0.5	4	1.1	0.17	0.32	2	<0.024	<0.028	<0.02	1.2E-06	9.4E-07	5.4E-06	3.5E-08	9.3E-08	4.3E-07	ND	ND	ND	8.1E-06	6.6E-06	1.5E-06	4.1E-02	1.0E-01	1.1E-01	----	----	3.0E-02	ND	ND	ND	0.29	No	
EAR3-RA-11b-12	1	0.4	3.2	1.1	0.052	0.25	0.49	<0.024	<0.028	<0.02	9.5E-07	7.5E-07	5.4E-06	1.1E-08	7.3E-08	1.1E-07	ND	ND	ND	7.3E-06	6.3E-06	9.4E-07	3.3E-02	8.4E-02	1.1E-01	----	----	7.3E-03	ND	ND	ND	0.24	No	
EAR3-RA-11c-12	1	0.046	1	0.21	0.024	0.19	0.45	<0.024	<0.028	<0.02	1.1E-07	2.3E-07	1.0E-06	4.9E-09	5.5E-08	9.8E-08	ND	ND	ND	1.5E-06	1.1E-06	3.9E-07	3.8E-03	2.6E-02	2.1E-02	----	----	6.7E-03	ND	ND	ND	0.06	No	
EAR3-RA-11c-6	0.5	0.22	1.6	0.74	<0.024	0.16	0.3	<0.024	<0.028	<0.02	5.2E-07	3.8E-07	3.6E-06	ND	4.7E-08	6.5E-08	ND	ND	ND	4.6E-06	4.2E-06	4.9E-07	1.8E-02	4.2E-02	7.6E-02	ND	----	4.5E-03	ND	ND	ND	0.14	No	
EAR3-RA-12a-12	1	0.72	1.8	1.1	<0.024	0.11	0.15	<0.024	<0.028	<0.02	1.7E-06	4.2E-07	5.4E-06	ND	3.2E-08	3.3E-08	ND	ND	ND	7.6E-06	7.1E-06	4.9E-07	5.9E-02	4.7E-02	1.1E-01	ND	----	2.2E-03	ND	ND	ND	0.22	No	
EAR3-RA-12a-6	0.5	0.21	1.6	0.77	<0.024	0.14	0.13	<0.024	<0.028	<0.02	5.0E-07	3.8E-07	3.8E-06	ND	4.1E-08	2.8E-08	ND	ND	ND	4.7E-06	4.3E-06	4.4E-07	1.7E-02	4.2E-02	7.9E-02	ND	----	1.9E-03	ND	ND	ND	0.14	No	
EAR3-RA-12b-06-1	0.5	7.6	9.3	6.2	<0.094	0.18	0.37	<0.098	<0.11	0.14	1.8E-05	2.2E-06	3.0E-05	ND	5.2E-08	8.0E-08	ND	ND	----	5.1E-05	4.8E-05	2.3E-06	6.2E-01	2.4E-01	6.3E-01	ND	----	5.5E-03	ND	ND	4.7E-03	1.50	Yes	
EAR3-RA-12b-06-2	0.5	3.4	4.5	4.2	<0.047	0.18	0.31	<0.049	<0.057	0.066	8.1E-06	1.1E-06	2.1E-05	ND	5.2E-08	6.7E-08	ND	ND	----	3.0E-05	2.9E-05	1.2E-06	2.8E-01	1.2E-01	4.3E-01	ND	----	4.6E-03	ND	ND	2.2E-03	0.83	No	
EAR3-RA-12b-06-3	0.5	2.3	4.8	4.1	0.16	0.29	1.9	<0.049	<0.057	0.063	5.5E-06	1.1E-06	2.0E-05	3.3E-08	8.4E-08	4.1E-07	ND	ND	----	2.7E-05	2.6E-05	1.7E-06	1.9E-01	1.3E-01	4.2E-01	----	----	2.8E-02	ND	ND	2.1E-03	0.76	No	
EAR3-RA-12b-12	1	16	18	11	<0.19	<0.19	<0.32	<0.2	<0.23	0.3	3.8E-05	4.2E-06	5.4E-05	ND	ND	ND	ND	ND	----	9.6E-05	9.2E-05	4.2E-06	#####	4.7E-01	#####	ND	ND	ND	ND	ND	1.0E-02	2.90	Yes	
EAR3-RA-12c-12	1	0.37	2.5	0.54	<0.024	0.13	0.16	<0.024	<0.028	<0.02	8.8E-07	5.9E-07	2.6E-06	ND	3.8E-08	3.5E-08	ND	ND	ND	4.2E-06	3.5E-06	6.6E-07	3.0E-02	6.5E-02	5.5E-02	ND	----	2.4E-03	ND	ND	ND	0.15	No	
EAR3-RA-12c-6	0.5	0.29	2.2	0.77	<0.024	0.12	0.14	<0.024	<0.028	<0.02	6.9E-07	5.2E-07	3.8E-06	ND	3.5E-08	3.0E-08	ND	ND	ND	5.0E-06	4.5E-06	5.8E-07	2.4E-02	5.7E-02	7.9E-02	ND	----	2.1E-03	ND	ND	ND	0.16	No	
EAR3-RA-12d-06	0.5	0.33	2.6	1.1	<0.024	0.1	0.15	<0.024	<0.028	<0.02	7.8E-07	6.1E-07	5.4E-06	ND	2.9E-08	3.3E-08	ND	ND	ND	6.8E-06	6.2E-06	6.7E-07	2.7E-02	6.8E-02	1.1E-01	ND	----	2.2E-03	ND	ND	ND	0.21	No	
EAR3-RA-12d-12	1	0.67	32	2.4	<0.024	0.16	0.23	0.024	<0.028	0.034	1.6E-06	7.5E-06	1.2E-05	ND	4.7E-08	5.0E-08	----	ND	----	2.1E-05	1.3E-05	7.6E-06	5.5E-02	8.4E-01	2.4E-01	ND	----	3.4E-03	#####	ND	1.1E-03	1.14	Yes	
EAR3-RA-12e-06	0.5	0.22	1.9	0.86	<0.024	0.12	0.14	<0.024	<0.028	<0.02	5.2E-07	4.5E-07	4.2E-06	ND	3.5E-08	3.0E-08	ND	ND	ND	5.2E-06	4.7E-06	5.1E-07	1.8E-02	5.0E-02	8.8E-02	ND	----	2.1E-03	ND	ND	ND	0.16	No	
EAR3-RA-12e-12	1	0.046	1	0.17	0.013	0.12	0.14	<0.0049	<0.0057	<0.004	1.1E-07	2.3E-07	8.3E-07	2.7E-09	3.5E-08	3.0E-08	ND	ND	ND	1.2E-06	9.4E-07	3.0E-07	3.8E-03	2.6E-02	1.7E-02	----	----	2.1E-03	ND	ND	ND	0.05	No	
EAR3-RA-13a-06	0.5	0.99	3.8	2.5	<0.024	0.21	0.14	<0.024	<0.028	0.029	2.4E-06	8.9E-07	1.2E-05	ND	6.1E-08	3.0E-08	ND	ND	----	1.6E-05	1.5E-05	9.8E-07	8.1E-02	9.9E-02	2.6E-01	ND	----	2.1E-03	ND	ND	9.6E-04	0.44	No	
EAR3-RA-13a-12	1	0.45	2.3	0.75	<0.0094	0.36	0.24	<0.0098	<0.011	<0.008	1.1E-06	5.4E-07	3.7E-06	ND	1.0E-07	5.2E-08	ND	ND	ND	5.4E-06	4.7E-06	7.0E-07	3.7E-02	6.0E-02	7.7E-02	ND	----	3.6E-03	ND	ND	ND	0.18	No	
EAR3-RA-13b-06	0.5	0.46	2.8	1.5	0.065	0.58	0.92	<0.024	<0.028	0.02	1.1E-06	6.6E-07	7.4E-06	1.3E-08	1.7E-07	2.0E-07	ND	ND	----	9.5E-06	8.4E-06	1.0E-06	3.8E-02	7.3E-02	1.5E-01	----	----	1.4E-02	ND	ND	6.6E-04	0.28	No	
EAR3-RA-13b-12	1	0.46	1.7	1.1	0.048	0.32	0.55	<0.024	<0.028	<0.02	1.1E-06	4.0E-07	5.4E-06	9.9E-09	9.3E-08	1.2E-07	ND	ND	ND	7.1E-06	6.5E-06	6.2E-07	3.8E-02	4.4E-02	1.1E-01	----	----	8.2E-03	ND	ND	ND	0.20	No	
EAR3-RA-13c-06	0.5	0.39	1.8	1	0.032	0.25	0.41	<0.024	<0.028	<0.02	9.3E-07	4.2E-07	4.9E-06	6.6E-09	7.3E-08	8.9E-08	ND	ND	ND	6.4E-06	5.8E-06	5.9E-07	3.2E-02	4.7E-02	1.0E-01	----	----	6.1E-03	ND	ND	ND	0.19	No	
EAR3-RA-13c-12	1	0.22	1.1	0.57	<0.024	0.12	0.24	<0.024	<0.028	<0.02	5.2E-07	2.6E-07	2.8E-06	ND	3.5E-08	5.2E-08	ND	ND	ND	3.7E-06	3.3E-06	3.5E-07	1.8E-02	2.9E-02	5.8E-02	ND	----	3.6E-03	ND	ND	ND	0.11	No	
EAR3-RA-13d-06	0.5	0.16	1.6	0.74	0.025	0.37	0.56	<0.024	<0.0																									

TABLE E-3
Earhart I-3: Risk and Hazard Calculations - Child Resident^a

Decision Unit	Depth (feet)	Analytical Results (mg/kg)									Child Resident																	Exceed HDOH 2011 HC HHRE Standard? ^e					
		Aldrin	Chlordane	Dieldrin	4,4-DDD	4,4-DDE	4,4-DDT	Endosulfan sulfate	Endrin	Endrin Ketone	Cancer Risk									Noncancer Hazard													
											Aldrin	Chlordane	Dieldrin	4,4-DDD	4,4-DDE	4,4-DDT	Endosulfan sulfate	Endrin	Endrin Ketone	Cumulative Risk ^b			Aldrin	Chlordane	Dieldrin	4,4-DDD	4,4-DDE		4,4-DDT	Endosulfan sulfate	Endrin	Endrin Ketone	Hazard Index ^d
Resident Child - Cancer EALs (mg/kg)	42.1	42.6	20.4	48.7	34.4	46.0	---	---	---											All Chems	Aldrin and Dieldrin Only	No Aldrin or Dieldrin ^c											
Res. Child - Noncancer EALs (mg/kg)	12.2	38.3	9.8	----	----	67.0	602.0	30.1	30.1																								
EAR3-RA-15c-06	0.5	0.25	0.66	0.96	<0.024	<0.024	<0.04	<0.024	<0.028	<0.02	5.9E-07	1.5E-07	4.7E-06	ND	ND	ND	ND	ND	ND	5.5E-06	5.3E-06	1.5E-07	2.0E-02	1.7E-02	9.8E-02	ND	ND	ND	ND	ND	ND	0.14	No
EAR3-RA-15c-12	1	0.36	0.84	1	<0.024	0.033	<0.04	<0.024	<0.028	<0.02	8.6E-07	2.0E-07	4.9E-06	ND	9.6E-09	ND	ND	ND	ND	6.0E-06	5.8E-06	2.1E-07	3.0E-02	2.2E-02	1.0E-01	ND	----	ND	ND	ND	ND	0.15	No
EAR3-RA-15d-06	0.5	0.49	1.3	1.5	<0.024	0.052	0.074	<0.024	<0.028	<0.02	1.2E-06	3.1E-07	7.4E-06	ND	1.5E-08	1.6E-08	ND	ND	ND	8.9E-06	8.5E-06	3.4E-07	4.0E-02	3.4E-02	1.5E-01	ND	----	1.1E-03	ND	ND	ND	0.23	No
EAR3-RA-15d-12	1	0.62	1.5	1.4	<0.024	0.07	0.083	<0.024	<0.028	<0.02	1.5E-06	3.5E-07	6.9E-06	ND	2.0E-08	1.8E-08	ND	ND	ND	8.7E-06	8.3E-06	3.9E-07	5.1E-02	3.9E-02	1.4E-01	ND	----	1.2E-03	ND	ND	ND	0.23	No
EAR3-RA-15e-06	0.5	0.43	1.7	1.8	<0.024	0.061	0.059	<0.024	<0.028	<0.02	1.0E-06	4.0E-07	8.8E-06	ND	1.8E-08	1.3E-08	ND	ND	ND	1.0E-05	9.8E-06	4.3E-07	3.5E-02	4.4E-02	1.8E-01	ND	----	8.8E-04	ND	ND	ND	0.26	No
EAR3-RA-15e-12	1	0.37	1.2	1.2	<0.024	<0.024	<0.04	<0.024	<0.028	<0.02	8.8E-07	2.8E-07	5.9E-06	ND	ND	ND	ND	ND	ND	7.0E-06	6.8E-06	2.8E-07	3.0E-02	3.1E-02	1.2E-01	ND	ND	ND	ND	ND	ND	0.18	No
EAR3-RA-15f-06	0.5	0.17	1.5	0.96	<0.024	0.088	0.067	<0.024	<0.028	<0.02	4.0E-07	3.5E-07	4.7E-06	ND	2.6E-08	1.5E-08	ND	ND	ND	5.5E-06	5.1E-06	3.9E-07	1.4E-02	3.9E-02	9.8E-02	ND	----	1.0E-03	ND	ND	ND	0.15	No
EAR3-RA-15f-12	1	0.59	1.2	2.1	<0.024	0.041	0.041	<0.024	<0.028	<0.02	1.4E-06	2.8E-07	1.0E-05	ND	1.2E-08	8.9E-09	ND	ND	ND	1.2E-05	1.2E-05	3.0E-07	4.8E-02	3.1E-02	2.1E-01	ND	----	6.1E-04	ND	ND	ND	0.29	No
EAR3-RA-16a-06	0.5	0.44	3.2	1.2	<0.024	0.21	0.14	<0.024	<0.028	<0.02	1.0E-06	7.5E-07	5.9E-06	ND	6.1E-08	3.0E-08	ND	ND	ND	7.8E-06	6.9E-06	8.4E-07	3.6E-02	8.4E-02	1.2E-01	ND	----	2.1E-03	ND	ND	ND	0.24	No
EAR3-RA-16a-12	1	0.28	1.8	0.53	0.026	0.21	0.36	<0.012	<0.014	<0.01	6.7E-07	4.2E-07	2.6E-06	5.3E-09	6.1E-08	7.8E-08	ND	ND	ND	3.8E-06	3.3E-06	5.7E-07	2.3E-02	4.7E-02	5.4E-02	----	----	5.4E-03	ND	ND	ND	0.13	No
EAR3-RA-16b-06	0.5	0.26	0.99	0.69	0.05	0.08	0.072	<0.024	<0.028	<0.02	6.2E-07	2.3E-07	3.4E-06	1.0E-08	2.3E-08	1.6E-08	ND	ND	ND	4.3E-06	4.0E-06	2.8E-07	2.1E-02	2.6E-02	7.0E-02	----	----	1.1E-03	ND	ND	ND	0.12	No
EAR3-RA-16b-12	1	0.2	0.85	0.39	0.036	0.11	0.097	<0.0098	<0.011	<0.008	4.8E-07	2.0E-07	1.9E-06	7.4E-09	3.2E-08	2.1E-08	ND	ND	ND	2.6E-06	2.4E-06	2.6E-07	1.6E-02	2.2E-02	4.0E-02	----	----	1.4E-03	ND	ND	ND	0.08	No
EAR3-RA-16c-06	0.5	0.11	0.8	0.4	<0.0094	0.03	0.037	<0.0098	<0.011	<0.008	2.6E-07	1.9E-07	2.0E-06	ND	8.7E-09	8.0E-09	ND	ND	ND	2.4E-06	2.2E-06	2.0E-07	9.0E-03	2.1E-02	4.1E-02	ND	----	5.5E-04	ND	ND	ND	0.07	No
EAR3-RA-16c-12	1	0.27	1.4	0.62	<0.0094	0.069	0.093	<0.0098	<0.011	<0.008	6.4E-07	3.3E-07	3.0E-06	ND	2.0E-08	2.0E-08	ND	ND	ND	4.0E-06	3.7E-06	3.7E-07	2.2E-02	3.7E-02	6.3E-02	ND	----	1.4E-03	ND	ND	ND	0.12	No
EAR3-RA-16d-06	0.5	0.72	2.4	1.8	0.048	0.12	0.13	<0.024	<0.028	0.036	1.7E-06	5.6E-07	8.8E-06	9.9E-09	3.5E-08	2.8E-08	ND	ND	----	1.1E-05	1.1E-05	6.4E-07	5.9E-02	6.3E-02	1.8E-01	----	----	1.9E-03	ND	ND	1.2E-03	0.31	No
EAR3-RA-16d-12	1	0.54	1.4	0.87	0.048	0.12	0.14	<0.024	<0.028	<0.02	1.3E-06	3.3E-07	4.3E-06	9.9E-09	3.5E-08	3.0E-08	ND	ND	ND	6.0E-06	5.5E-06	4.0E-07	4.4E-02	3.7E-02	8.9E-02	----	----	2.1E-03	ND	ND	ND	0.17	No
EAR3-RA-16e-06	0.5	0.48	2	1.5	0.057	0.1	0.14	<0.024	<0.028	0.026	1.1E-06	4.7E-07	7.4E-06	1.2E-08	2.9E-08	3.0E-08	ND	ND	----	9.0E-06	8.5E-06	5.4E-07	3.9E-02	5.2E-02	1.5E-01	----	----	2.1E-03	ND	ND	8.6E-04	0.25	No
EAR3-RA-16e-12	1	0.26	1.3	0.82	0.038	0.1	0.12	<0.024	<0.028	<0.02	6.2E-07	3.1E-07	4.0E-06	7.8E-09	2.9E-08	2.6E-08	ND	ND	ND	5.0E-06	4.6E-06	3.7E-07	2.1E-02	3.4E-02	8.4E-02	----	----	1.8E-03	ND	ND	ND	0.14	No
EAR3-RA-17a-06	0.5	0.74	1.7	1.4	<0.024	0.079	0.062	<0.024	<0.028	<0.02	1.8E-06	4.0E-07	6.9E-06	ND	2.3E-08	1.3E-08	ND	ND	ND	9.1E-06	8.6E-06	4.4E-07	6.1E-02	4.4E-02	1.4E-01	ND	----	9.3E-04	ND	ND	ND	0.25	No
EAR3-RA-17a-12	1	0.76	2.4	1.4	<0.024	0.092	0.071	<0.024	<0.028	<0.02	1.8E-06	5.6E-07	6.9E-06	ND	2.7E-08	1.5E-08	ND	ND	ND	9.3E-06	8.7E-06	6.1E-07	6.2E-02	6.3E-02	1.4E-01	ND	----	1.1E-03	ND	ND	ND	0.27	No
EAR3-RA-17b-06	0.5	0.42	1.8	1.2	<0.024	0.083	0.08	<0.024	<0.028	<0.02	1.0E-06	4.2E-07	5.9E-06	ND	2.4E-08	1.7E-08	ND	ND	ND	7.3E-06	6.9E-06	4.6E-07	3.4E-02	4.7E-02	1.2E-01	ND	----	1.2E-03	ND	ND	ND	0.21	No
EAR3-RA-17b-12	1	0.71	1.8	1.1	<0.024	0.078	0.15	<0.024	<0.028	<0.02	1.7E-06	4.2E-07	5.4E-06	ND	2.3E-08	3.3E-08	ND	ND	ND	7.6E-06	7.1E-06	4.8E-07	5.8E-02	4.7E-02	1.1E-01	ND	----	2.2E-03	ND	ND	ND	0.22	No
EAR3-RA-17c-06	0.5	0.41	2	1	<0.024	0.22	0.29	<0.024	<0.028	<0.02	9.7E-07	4.7E-07	4.9E-06	ND	6.4E-08	6.3E-08	ND	ND	ND	6.5E-06	5.9E-06	6.0E-07	3.4E-02	5.2E-02	1.0E-01	ND	----	4.3E-03	ND	ND	ND	0.19	No
EAR3-RA-17c-12	1	0.21	2.4	0.62	<0.024	0.36	0.35	<0.024	<0.028	<0.02	5.0E-07	5.6E-07	3.0E-06	ND	1.0E-07	7.6E-08	ND	ND	ND	4.3E-06	3.5E-06	7.4E-07	1.7E-02	6.3E-02	6.3E-02	ND	----	5.2E-03	ND	ND	ND	0.15	No
EAR3-RA-18a-06-1	0.5	1.4	2.1	2.8	<0.024	0.079	0.092	<0.024	<0.028	0.041	3.3E-06	4.9E-07	1.4E-05	ND	2.3E-08	2.0E-08	ND	ND	----	1.8E-05	1.7E-05	5.4E-07	1.1E-01	5.5E-02	2.9E-01	ND	----	1.4E-03	ND	ND	1.4E-03	0.46	No
EAR3-RA-18a-06-2	0.5	1.4	2.3	2.8	<0.024	0.07	0.091	<0.024	<0.028	0.043	3.3E-06	5.4E-07	1.4E-05	ND	2.0E-08	2.0E-08	ND	ND	----	1.8E-05	1.7E-05	5.8E-07	1.1E-01	6.0E-02	2.9E-01	ND	----	1.4E-03	ND	ND	1.4E-03	0.46	No
EAR3-RA-18a-06-3	0.5	1.6	2.8	3.3	<0.047	0.11	0.13	<0.049	<0.057	0.051	3.8E-06	6.6E-07	1.6E-05	ND	3.2E-08	2.8E-08	ND	ND	----	2.1E-05	2.0E-05	7.2E-07	1.3E-01	7.3E-02	3.4E-01	ND	----	1.9E-03	ND	ND	1.7E-03	0.54	No
EAR3-RA-18a-12	1	1.8	2.4	2.8	<0.024	0.11	0.11	<0.024	<0.028	0.037	4.3E-06	5.6E-07	1.4E-05	ND	3.2E-08	2.4E-08	ND	ND	----	1.9E-05	1.8E-05	6.2E-07	1.5E-01	6.3E-02	2.9E-01	ND	----	1.6E-03	ND	ND	1.2E-03	0.50	No
EAR3-RA-18b-06	0.5	0.65	2.2	1.3	<0.024	0.1	0.12	<0.024	<0.028	0.027	1.5E-06	5.2E-07	6.4E-06	ND	2.9E-08	2.6E-08	ND	ND	----	8.5E-06	7.9E-06	5.7E-07	5.3E-02	5.7E-02	1.3E-01	ND	----	1.8E-03	ND	ND	9.0E-04	0.25	No
EAR3-RA-18b-12	1	0.39	1.7	0.8	<0.024	0.081	0.1	<0.024	<0.028	<0.02	9.3E-07	4.0E-07	3.9E-06	ND	2.4E-08	2.2E-08	ND	ND	ND	5.3E-06	4.8E-06	4.4E-07	3.2E-02	4.4E-02	8.2E-02	ND	----	1.5E-03	ND	ND	ND	0.16	No
EAR3-RA-18c-06	0.5	0.65	1.8	1.4	<0.024	0.15	0.13	<0.024	<0.028	0.029	1.5E-06	4.2E-07	6.9E-06	ND	4.4E-08	2.8E-08	ND	ND	----	8.9E-06	8.4E-06	4.9E-07	5.3E-02	4.7E-02	1.4E-01	ND	----	1.9E-03	ND	ND	9.6E-04	0.25	No
EAR3-RA-18c-12	1	0.17	1	0.51	0.018	0.18	0.22	<0.0098	<0.011	<0.008	4.0E-07	2.3E-07	2.5E-06	3.7E-09	5.2E-08	4.8E-08	ND	ND	ND	3.2E-06	2.9E-06	3.4E-07	1.4E-02	2.6E-02	5.2E-02	----	----	3.3E-03	ND	ND	ND	0.10	No
EAR3-RA-19a-06	0.5	0.69	3.5	2.2	<0.024	0.16	0.19	<0.024	<0.028	0.024	1.6E-06	8.2E-07	1.1E-05	ND	4.7E-08	4.1E-08	ND	ND	----	1.3E-05	1.2E-05	9.1E-07	5.7E-02	9.1E-02	2.2E-01	ND	----	2.8E-03	ND	ND	8.0E-04	0.38	No
EAR3-RA-19a-12	1	0.77	2.9	1.5	<0.024	0.17	0.25	<0.024	<0.028	<0.02	1.8E-06	6.8E-07	7.4E-06	ND	4.9E-08	5.4E-08	ND	ND	ND	1.0E-05	9.2E-06	7.8E-07	6.3E-02	7.6E-02	1.5E-01	ND	----	3.7E-03	ND	ND	ND	0.30	No
EAR3-RA-19b-06	0.5	0.63	4.9	1.8	<0.024	0.23	0.23	<0.024	<																								

TABLE E-3
Earhart I-3: Risk and Hazard Calculations - Child Resident^a

Decision Unit	Depth (feet)	Analytical Results (mg/kg)									Child Resident																	Exceed HDOH 2011 HC HHRE Standard? ^e						
		Aldrin	Chlordane	Dieldrin	4,4-DDD	4,4-DDE	4,4-DDT	Endosulfan sulfate	Endrin	Endrin Ketone	Cancer Risk									Noncancer Hazard														
											Aldrin	Chlordane	Dieldrin	4,4-DDD	4,4-DDE	4,4-DDT	Endosulfan sulfate	Endrin	Endrin Ketone	Cumulative Risk ^b			Aldrin	Chlordane	Dieldrin	4,4-DDD	4,4-DDE		4,4-DDT	Endosulfan sulfate	Endrin	Endrin Ketone	Hazard Index ^d	
Resident Child - Cancer EALs (mg/kg)	42.1	42.6	20.4	48.7	34.4	46.0	---	---	---												All Chems	Aldrin and Dieldrin Only	No Aldrin or Dieldrin ^c											
Res. Child - Noncancer EALs (mg/kg)	12.2	38.3	9.8	----	----	67.0	602.0	30.1	30.1																									
EAR3-RA-20a-06-1	0.5	5.8	3.2	6.3	<0.094	0.27	0.27	<0.098	<0.11	0.097	1.4E-05	7.5E-07	3.1E-05	ND	7.8E-08	5.9E-08	ND	ND	----	4.6E-05	4.5E-05	8.9E-07	4.8E-01	8.4E-02	6.4E-01	ND	----	4.0E-03	ND	ND	3.2E-03	1.21	Yes	
EAR3-RA-20a-06-2	0.5	3.6	3	4.4	<0.094	0.25	0.24	<0.098	<0.11	<0.08	8.6E-06	7.0E-07	2.2E-05	ND	7.3E-08	5.2E-08	ND	ND	ND	3.1E-05	3.0E-05	8.3E-07	3.0E-01	7.8E-02	4.5E-01	ND	----	3.6E-03	ND	ND	ND	0.83	No	
EAR3-RA-20a-06-3	0.5	3.9	2.6	4.7	<0.094	0.2	<0.16	<0.098	<0.11	<0.08	9.3E-06	6.1E-07	2.3E-05	ND	5.8E-08	ND	ND	ND	3.3E-05	3.2E-05	6.7E-07	3.2E-01	6.8E-02	4.8E-01	ND	----	ND	ND	ND	ND	0.87	No		
EAR3-RA-20a-12	1	11	5.5	8.3	<0.19	0.41	0.37	<0.2	<0.23	<0.16	2.6E-05	1.3E-06	4.1E-05	ND	1.2E-07	8.0E-08	ND	ND	ND	6.8E-05	6.7E-05	1.5E-06	9.0E-01	1.4E-01	8.5E-01	ND	----	5.5E-03	ND	ND	ND	1.90	Yes	
EAR3-RA-20b-06	0.5	2	3.1	3.3	<0.047	0.31	0.25	<0.049	<0.057	0.045	4.8E-06	7.3E-07	1.6E-05	ND	9.0E-08	5.4E-08	ND	ND	----	2.2E-05	2.1E-05	8.7E-07	1.6E-01	8.1E-02	3.4E-01	ND	----	3.7E-03	ND	ND	1.5E-03	0.59	No	
EAR3-RA-20b-12	1	1.5	2.6	2.5	<0.047	0.41	0.29	<0.049	<0.057	<0.04	3.6E-06	6.1E-07	1.2E-05	ND	1.2E-07	6.3E-08	ND	ND	ND	1.7E-05	1.6E-05	7.9E-07	1.2E-01	6.8E-02	2.6E-01	ND	----	4.3E-03	ND	ND	ND	0.45	No	
EAR3-RA-21a-06	0.5	0.23	1.4	1	<0.024	0.15	0.055	<0.024	<0.028	<0.02	5.5E-07	3.3E-07	4.9E-06	ND	4.4E-08	1.2E-08	ND	ND	ND	5.8E-06	5.4E-06	3.8E-07	1.9E-02	3.7E-02	1.0E-01	ND	----	8.2E-04	ND	ND	ND	0.16	No	
EAR3-RA-21a-12	1	0.22	1.1	0.74	<0.024	0.033	<0.04	<0.024	<0.028	<0.02	5.2E-07	2.6E-07	3.6E-06	ND	9.6E-09	ND	ND	ND	4.4E-06	4.2E-06	2.7E-07	1.8E-02	2.9E-02	7.6E-02	ND	----	ND	ND	ND	ND	0.12	No		
EAR3-RA-21b-06	0.5	0.078	0.82	0.48	0.026	0.26	0.43	<0.012	<0.014	<0.01	1.9E-07	1.9E-07	2.4E-06	5.3E-09	7.6E-08	9.3E-08	ND	ND	ND	2.9E-06	2.5E-06	3.7E-07	6.4E-03	2.1E-02	4.9E-02	----	----	6.4E-03	ND	ND	ND	0.08	No	
EAR3-RA-21b-12	1	0.0082	0.54	0.096	0.0067	0.13	0.14	<0.0049	<0.0057	<0.004	1.9E-08	1.3E-07	4.7E-07	1.4E-09	3.8E-08	3.0E-08	ND	ND	ND	6.9E-07	4.9E-07	2.0E-07	6.7E-04	1.4E-02	9.8E-03	----	----	2.1E-03	ND	ND	ND	0.03	No	
EAR3-RA-21c-06	0.5	0.041	1.1	0.38	<0.012	0.083	0.037	<0.012	<0.014	<0.01	9.7E-08	2.6E-07	1.9E-06	ND	2.4E-08	8.0E-09	ND	ND	ND	2.3E-06	2.0E-06	2.9E-07	3.4E-03	2.9E-02	3.9E-02	ND	----	5.5E-04	ND	ND	ND	0.07	No	
EAR3-RA-21c-12	1	0.027	1.1	0.28	<0.0094	0.11	0.028	<0.0098	<0.011	<0.008	6.4E-08	2.6E-07	1.4E-06	ND	3.2E-08	6.1E-09	ND	ND	ND	1.7E-06	1.4E-06	3.0E-07	2.2E-03	2.9E-02	2.9E-02	ND	----	4.2E-04	ND	ND	ND	0.06	No	
EAR3-RA-21d-06	0.5	0.092	0.64	0.78	<0.024	0.034	<0.04	<0.024	<0.028	<0.02	2.2E-07	1.5E-07	3.8E-06	ND	9.9E-09	ND	ND	ND	4.2E-06	4.0E-06	1.6E-07	7.5E-03	1.7E-02	8.0E-02	ND	----	ND	ND	ND	ND	0.10	No		
EAR3-RA-21d-12	1	0.16	<0.5	0.84	<0.024	0.025	<0.04	<0.024	<0.028	<0.02	3.8E-07	ND	4.1E-06	ND	7.3E-09	ND	ND	ND	4.5E-06	4.5E-06	7.3E-09	1.3E-02	ND	8.6E-02	ND	----	ND	ND	ND	ND	0.10	No		
EAR3-RA-22a-06	0.5	0.62	1.6	1.8	<0.047	0.052	<0.081	<0.049	<0.057	<0.04	1.5E-06	3.8E-07	8.8E-06	ND	1.5E-08	ND	ND	ND	1.1E-05	1.0E-05	3.9E-07	5.1E-02	4.2E-02	1.8E-01	ND	----	ND	ND	ND	ND	0.28	No		
EAR3-RA-22a-12	1	0.84	2.9	2.1	<0.047	0.064	0.082	<0.049	<0.057	<0.04	2.0E-06	6.8E-07	1.0E-05	ND	1.9E-08	1.8E-08	ND	ND	ND	1.3E-05	1.2E-05	7.2E-07	6.9E-02	7.6E-02	2.1E-01	ND	----	1.2E-03	ND	ND	ND	0.36	No	
EAR3-RA-22b-06	0.5	0.25	1.4	1	<0.024	0.055	0.094	<0.024	<0.028	<0.02	5.9E-07	3.3E-07	4.9E-06	ND	1.6E-08	2.0E-08	ND	ND	ND	5.9E-06	5.5E-06	3.7E-07	2.0E-02	3.7E-02	1.0E-01	ND	----	1.4E-03	ND	ND	ND	0.16	No	
EAR3-RA-22b-12	1	0.26	1.9	0.86	<0.024	0.053	0.082	<0.024	<0.028	<0.02	6.2E-07	4.5E-07	4.2E-06	ND	1.5E-08	1.8E-08	ND	ND	ND	5.3E-06	4.8E-06	4.8E-07	2.1E-02	5.0E-02	8.8E-02	ND	----	1.2E-03	ND	ND	ND	0.16	No	
EAR3-RA-22c-06	0.5	0.67	2.1	1.8	<0.024	0.054	0.06	<0.024	<0.028	<0.02	1.6E-06	4.9E-07	8.8E-06	ND	1.6E-08	1.3E-08	ND	ND	ND	1.1E-05	1.0E-05	5.2E-07	5.5E-02	5.5E-02	1.8E-01	ND	----	9.0E-04	ND	ND	ND	0.29	No	
EAR3-RA-22c-12	1	0.59	1.9	1.6	<0.024	0.044	0.052	<0.024	<0.028	0.023	1.4E-06	4.5E-07	7.8E-06	ND	1.3E-08	1.1E-08	ND	ND	----	9.7E-06	9.2E-06	4.7E-07	4.8E-02	5.0E-02	1.6E-01	ND	----	7.8E-04	ND	ND	7.6E-04	0.26	No	
EAR3-RA-22d-06	0.5	0.37	1.6	1.1	<0.024	0.044	<0.04	<0.024	<0.028	<0.02	8.8E-07	3.8E-07	5.4E-06	ND	1.3E-08	ND	ND	ND	6.7E-06	6.3E-06	3.9E-07	3.0E-02	4.2E-02	1.1E-01	ND	----	ND	ND	ND	ND	0.18	No		
EAR3-RA-22d-12	1	0.17	1.8	0.45	<0.0094	0.044	0.16	<0.0098	<0.011	<0.008	4.0E-07	4.2E-07	2.2E-06	ND	1.3E-08	3.5E-08	ND	ND	ND	3.1E-06	2.6E-06	4.7E-07	1.4E-02	4.7E-02	4.6E-02	ND	----	2.4E-03	ND	ND	ND	0.11	No	
EAR3-RA-23a-06-1	0.5	0.16	1.5	0.52	<0.024	0.095	0.19	<0.024	<0.028	<0.02	3.8E-07	3.5E-07	2.5E-06	ND	2.8E-08	4.1E-08	ND	ND	ND	3.4E-06	2.9E-06	4.2E-07	1.3E-02	3.9E-02	5.3E-02	ND	----	2.8E-03	ND	ND	ND	0.11	No	
EAR3-RA-23a-06-2	0.5	0.12	1.3	0.55	<0.024	0.087	0.23	<0.024	<0.028	<0.02	2.9E-07	3.1E-07	2.7E-06	ND	2.5E-08	5.0E-08	ND	ND	ND	3.4E-06	3.0E-06	3.8E-07	9.8E-03	3.4E-02	5.6E-02	ND	----	3.4E-03	ND	ND	ND	0.10	No	
EAR3-RA-23a-06-3	0.5	0.095	1.3	0.53	<0.024	0.11	0.17	<0.024	<0.028	<0.02	2.3E-07	3.1E-07	2.6E-06	ND	3.2E-08	3.7E-08	ND	ND	ND	3.2E-06	2.8E-06	3.7E-07	7.8E-03	3.4E-02	5.4E-02	ND	----	2.5E-03	ND	ND	ND	0.10	No	
EAR3-RA-23a-12	1	0.064	0.78	0.23	<0.0094	0.056	0.098	<0.0098	<0.011	<0.008	1.5E-07	1.8E-07	1.1E-06	ND	1.6E-08	2.1E-08	ND	ND	ND	1.5E-06	1.3E-06	2.2E-07	5.2E-03	2.0E-02	2.3E-02	ND	----	1.5E-03	ND	ND	ND	0.05	No	
EAR3-RA-23b-06	0.5	0.64	2.5	1.2	0.14	0.6	1.7	<0.024	<0.028	<0.02	1.5E-06	5.9E-07	5.9E-06	2.9E-08	1.7E-07	3.7E-07	ND	ND	ND	8.6E-06	7.4E-06	1.2E-06	5.2E-02	6.5E-02	1.2E-01	----	----	2.5E-02	ND	ND	ND	0.27	No	
EAR3-RA-23b-12	1	0.089	1.3	0.27	0.058	0.32	0.68	<0.024	<0.028	<0.02	2.1E-07	3.1E-07	1.3E-06	1.2E-08	9.3E-08	1.5E-07	ND	ND	ND	2.1E-06	1.5E-06	5.6E-07	7.3E-03	3.4E-02	2.8E-02	----	----	1.0E-02	ND	ND	ND	0.08	No	
EAR3-RA-23c-06	0.5	1.3	3.2	2.6	0.081	0.39	0.93	<0.024	<0.028	0.044	3.1E-06	7.5E-07	1.3E-05	1.7E-08	1.1E-07	2.0E-07	ND	ND	----	1.7E-05	1.6E-05	1.1E-06	1.1E-01	8.4E-02	2.7E-01	----	----	1.4E-02	ND	ND	1.5E-03	0.47	No	
EAR3-RA-23c-12	1	1.8	2.5	2.2	0.047	0.28	0.43	<0.024	<0.028	0.033	4.3E-06	5.9E-07	1.1E-05	9.7E-09	8.1E-08	9.3E-08	ND	ND	----	1.6E-05	1.5E-05	7.7E-07	1.5E-01	6.5E-02	2.2E-01	----	----	6.4E-03	ND	ND	1.1E-03	0.44	No	
EAR3-RA-23d-06	0.5	0.16	0.97	0.43	<0.0094	0.081	0.093	<0.0098	<0.011	<0.008	3.8E-07	2.3E-07	2.1E-06	ND	2.4E-08	2.0E-08	ND	ND	ND	2.8E-06	2.5E-06	2.7E-07	1.3E-02	2.5E-02	4.4E-02	ND	----	1.4E-03	ND	ND	ND	0.08	No	
EAR3-RA-23d-12	1	0.26	1.1	0.5	0.017	0.19	0.2	<0.0098	<0.011	<0.008	6.2E-07	2.6E-07	2.5E-06	3.5E-09	5.5E-08	4.3E-08	ND	ND	ND	3.4E-06	3.1E-06	3.6E-07	2.1E-02	2.9E-02	5.1E-02	----	----	3.0E-03	ND	ND	ND	0.10	No	
EAR3-RA-23e-06	0.5	0.2	2.4	0.5	<0.0094	0.13	0.19	<0.0098	<0.011	<0.008	4.8E-07	5.6E-07	2.5E-06	ND	3.8E-08	4.1E-08	ND	ND	ND	3.6E-06	2.9E-06	6.4E-07	1.6E-02	6.3E-02	5.1E-02	ND	----	2.8E-03	ND	ND	ND	0.13	No	
EAR3-RA-23e-12	1	0.098	1.4	0.25	<0.0047	0.099	0.3	<0.0049	<0.0057	<0.004	2.3E-07	3.3E-07	1.2E-06	ND	2.9E-08	6.5E-08	ND	ND	ND	1.9E-06	1.5E-06	4.2E-07	8.0E-03	3.7E-02	2.6E-02	ND	----	4.5E-03	ND	ND	ND	0.07	No	
EAR3-RA-24a-12	1	0.92	1.9	1.4	0.032	0.35	0.24	<0.024	<0.028	<0.02	2.2E-06	4.5E-07	6.9E-06																					

TABLE E-3
Earhart I-3: Risk and Hazard Calculations - Child Resident^a

Decision Unit	Depth (feet)	Analytical Results (mg/kg)									Child Resident																	Exceed HDOH 2011 HC HHRE Standard? ^e					
		Aldrin	Chlordane	Dieldrin	4,4-DDD	4,4-DDE	4,4-DDT	Endosulfan sulfate	Endrin	Endrin Ketone	Cancer Risk									Noncancer Hazard													
											Aldrin	Chlordane	Dieldrin	4,4-DDD	4,4-DDE	4,4-DDT	Endosulfan sulfate	Endrin	Endrin Ketone	Cumulative Risk ^b			Aldrin	Chlordane	Dieldrin	4,4-DDD	4,4-DDE		4,4-DDT	Endosulfan sulfate	Endrin	Endrin Ketone	Hazard Index ^d
Resident Child - Cancer EALs (mg/kg)	42.1	42.6	20.4	48.7	34.4	46.0	---	---	---											All Chems	Aldrin and Dieldrin Only	No Aldrin or Dieldrin ^c											
Res. Child - Noncancer EALs (mg/kg)	12.2	38.3	9.8	----	----	67.0	602.0	30.1	30.1																								
EAR3-RA-25b-06	0.5	0.16	1.9	0.59	<0.024	0.099	0.12	<0.024	<0.028	<0.02	3.8E-07	4.5E-07	2.9E-06	ND	2.9E-08	2.6E-08	ND	ND	ND	3.8E-06	3.3E-06	5.0E-07	1.3E-02	5.0E-02	6.0E-02	ND	----	1.8E-03	ND	ND	ND	0.12	No
EAR3-RA-25b-12	1	0.25	2.7	0.5	<0.024	0.14	0.12	<0.024	<0.028	<0.02	5.9E-07	6.3E-07	2.5E-06	ND	4.1E-08	2.6E-08	ND	ND	ND	3.7E-06	3.0E-06	7.0E-07	2.0E-02	7.0E-02	5.1E-02	ND	----	1.8E-03	ND	ND	ND	0.14	No
EAR3-RA-25c-06	0.5	0.33	1.3	0.78	<0.024	0.096	0.08	<0.024	<0.028	<0.02	7.8E-07	3.1E-07	3.8E-06	ND	2.8E-08	1.7E-08	ND	ND	ND	5.0E-06	4.6E-06	3.5E-07	2.7E-02	3.4E-02	8.0E-02	ND	----	1.2E-03	ND	ND	ND	0.14	No
EAR3-RA-25c-12	1	0.27	0.87	0.49	<0.024	0.081	0.052	<0.024	<0.028	<0.02	6.4E-07	2.0E-07	2.4E-06	ND	2.4E-08	1.1E-08	ND	ND	ND	3.3E-06	3.0E-06	2.4E-07	2.2E-02	2.3E-02	5.0E-02	ND	----	7.8E-04	ND	ND	ND	0.10	No
EAR3-RA-25d-06	0.5	1	1.7	0.86	<0.024	0.2	0.14	<0.024	<0.028	<0.02	2.4E-06	4.0E-07	4.2E-06	ND	5.8E-08	3.0E-08	ND	ND	ND	7.1E-06	6.6E-06	4.9E-07	8.2E-02	4.4E-02	8.8E-02	ND	----	2.1E-03	ND	ND	ND	0.22	No
EAR3-RA-25d-12	1	0.87	2.9	1.4	<0.024	0.28	0.18	<0.024	<0.028	<0.02	2.1E-06	6.8E-07	6.9E-06	ND	8.1E-08	3.9E-08	ND	ND	ND	9.7E-06	8.9E-06	8.0E-07	7.1E-02	7.6E-02	1.4E-01	ND	----	2.7E-03	ND	ND	ND	0.29	No
EAR3-RA-25e-06	0.5	0.42	3.4	1.2	<0.024	0.15	0.17	<0.024	<0.028	<0.02	1.0E-06	8.0E-07	5.9E-06	ND	4.4E-08	3.7E-08	ND	ND	ND	7.8E-06	6.9E-06	8.8E-07	3.4E-02	8.9E-02	1.2E-01	ND	----	2.5E-03	ND	ND	ND	0.25	No
EAR3-RA-25e-12	1	0.63	7.6	1.6	<0.024	0.15	0.14	<0.024	<0.028	<0.02	1.5E-06	1.8E-06	7.8E-06	ND	4.4E-08	3.0E-08	ND	ND	ND	1.1E-05	9.3E-06	1.9E-06	5.2E-02	2.0E-01	1.6E-01	ND	----	2.1E-03	ND	ND	ND	0.42	No
EAR3-RA-26a-06	0.5	0.15	0.9	0.44	<0.024	0.053	0.047	<0.024	<0.028	<0.02	3.6E-07	2.1E-07	2.2E-06	ND	1.5E-08	1.0E-08	ND	ND	ND	2.8E-06	2.5E-06	2.4E-07	1.2E-02	2.3E-02	4.5E-02	ND	----	7.0E-04	ND	ND	ND	0.08	No
EAR3-RA-26a-12	1	0.058	0.95	0.16	<0.0047	0.0062	0.0087	<0.0049	<0.0057	<0.004	1.4E-07	2.2E-07	7.8E-07	ND	1.8E-09	1.9E-09	ND	ND	ND	1.1E-06	9.2E-07	2.3E-07	4.8E-03	2.5E-02	1.6E-02	ND	----	1.3E-04	ND	ND	ND	0.05	No
EAR3-RA-26b-06	0.5	0.25	0.97	0.7	<0.024	0.031	<0.04	<0.024	<0.028	<0.02	5.9E-07	2.3E-07	3.4E-06	ND	9.0E-09	ND	ND	ND	4.3E-06	4.0E-06	2.4E-07	2.0E-02	2.5E-02	7.1E-02	ND	----	ND	ND	ND	ND	0.12	No	
EAR3-RA-26b-12	1	0.23	0.59	0.61	<0.024	<0.024	<0.04	<0.024	<0.028	<0.02	5.5E-07	1.4E-07	3.0E-06	ND	ND	ND	ND	ND	3.7E-06	3.5E-06	1.4E-07	1.9E-02	1.5E-02	6.2E-02	ND	ND	ND	ND	ND	ND	ND	0.10	No
EAR3-RA-26c-06	0.5	0.45	1.2	0.87	<0.024	0.027	0.044	<0.024	<0.028	<0.02	1.1E-06	2.8E-07	4.3E-06	ND	7.8E-09	9.6E-09	ND	ND	ND	5.6E-06	5.3E-06	3.0E-07	3.7E-02	3.1E-02	8.9E-02	ND	----	6.6E-04	ND	ND	ND	0.16	No
EAR3-RA-26c-12	1	0.22	0.63	0.56	<0.024	0.057	0.041	<0.024	<0.028	<0.02	5.2E-07	1.5E-07	2.7E-06	ND	1.7E-08	8.9E-09	ND	ND	ND	3.4E-06	3.3E-06	1.7E-07	1.8E-02	1.6E-02	5.7E-02	ND	----	6.1E-04	ND	ND	ND	0.09	No
EAR3-RA-26d-06	0.5	0.59	0.78	1.2	<0.024	0.034	<0.04	<0.024	<0.028	<0.02	1.4E-06	1.8E-07	5.9E-06	ND	9.9E-09	ND	ND	ND	7.5E-06	7.3E-06	1.9E-07	4.8E-02	2.0E-02	1.2E-01	ND	----	ND	ND	ND	ND	0.19	No	
EAR3-RA-26d-12	1	0.73	0.97	1.4	<0.024	0.071	0.04	<0.024	<0.028	<0.02	1.7E-06	2.3E-07	6.9E-06	ND	2.1E-08	8.7E-09	ND	ND	ND	8.9E-06	8.6E-06	2.6E-07	6.0E-02	2.5E-02	1.4E-01	ND	----	6.0E-04	ND	ND	ND	0.23	No
EAR3-RA-26e-06	0.5	0.4	1.4	0.93	<0.024	0.054	0.045	<0.024	<0.028	<0.02	9.5E-07	3.3E-07	4.6E-06	ND	1.6E-08	9.8E-09	ND	ND	ND	5.9E-06	5.5E-06	3.5E-07	3.3E-02	3.7E-02	9.5E-02	ND	----	6.7E-04	ND	ND	ND	0.16	No
EAR3-RA-26e-12	1	0.45	1.5	0.9	<0.024	0.037	<0.04	<0.024	<0.028	<0.02	1.1E-06	3.5E-07	4.4E-06	ND	1.1E-08	ND	ND	ND	5.8E-06	5.5E-06	3.6E-07	3.7E-02	3.9E-02	9.2E-02	ND	----	ND	ND	ND	ND	0.17	No	
EAR3-RA-26f-06	0.5	0.1	1.1	0.42	<0.024	0.046	<0.04	<0.024	<0.028	<0.02	2.4E-07	2.6E-07	2.1E-06	ND	1.3E-08	ND	ND	ND	2.6E-06	2.3E-06	2.7E-07	8.2E-03	2.9E-02	4.3E-02	ND	----	ND	ND	ND	ND	0.08	No	
EAR3-RA-26f-12	1	0.13	1.1	0.38	<0.024	<0.024	<0.04	<0.024	<0.028	<0.02	3.1E-07	2.6E-07	1.9E-06	ND	ND	ND	ND	ND	2.4E-06	2.2E-06	2.6E-07	1.1E-02	2.9E-02	3.9E-02	ND	ND	ND	ND	ND	ND	ND	0.08	No
EAR3-RA-27a-06-1	0.5	0.13	1.5	0.4	<0.024	0.059	0.053	<0.024	<0.028	<0.02	3.1E-07	3.5E-07	2.0E-06	ND	1.7E-08	1.2E-08	ND	ND	ND	2.7E-06	2.3E-06	3.8E-07	1.1E-02	3.9E-02	4.1E-02	ND	----	7.9E-04	ND	ND	ND	0.09	No
EAR3-RA-27a-06-2	0.5	0.17	2	0.48	<0.024	0.052	0.063	<0.024	<0.028	<0.02	4.0E-07	4.7E-07	2.4E-06	ND	1.5E-08	1.4E-08	ND	ND	ND	3.3E-06	2.8E-06	5.0E-07	1.4E-02	5.2E-02	4.9E-02	ND	----	9.4E-04	ND	ND	ND	0.12	No
EAR3-RA-27a-06-3	0.5	0.14	1.5	0.43	<0.024	0.035	0.053	<0.024	<0.028	<0.02	3.3E-07	3.5E-07	2.1E-06	ND	1.0E-08	1.2E-08	ND	ND	ND	2.8E-06	2.4E-06	3.7E-07	1.1E-02	3.9E-02	4.4E-02	ND	----	7.9E-04	ND	ND	ND	0.10	No
EAR3-RA-27a-12	1	0.35	2	0.57	<0.024	0.083	0.16	<0.024	<0.028	<0.02	8.3E-07	4.7E-07	2.8E-06	ND	2.4E-08	3.5E-08	ND	ND	ND	4.2E-06	3.6E-06	5.3E-07	2.9E-02	5.2E-02	5.8E-02	ND	----	2.4E-03	ND	ND	ND	0.14	No
EAR3-RA-27b-06	0.5	0.7	3	1.3	0.026	0.096	0.19	<0.024	<0.028	0.022	1.7E-06	7.0E-07	6.4E-06	5.3E-09	2.8E-08	4.1E-08	ND	ND	----	8.8E-06	8.0E-06	7.8E-07	5.7E-02	7.8E-02	1.3E-01	----	----	2.8E-03	ND	ND	7.3E-04	0.27	No
EAR3-RA-27b-12	1	2.7	7.3	1.9	0.032	0.15	0.51	<0.024	<0.028	0.034	6.4E-06	1.7E-06	9.3E-06	6.6E-09	4.4E-08	1.1E-07	ND	ND	----	1.8E-05	1.6E-05	1.9E-06	2.2E-01	1.9E-01	1.9E-01	----	----	7.6E-03	ND	ND	1.1E-03	0.61	No
EAR3-RA-27c-06	0.5	0.49	1.1	0.58	<0.024	0.051	0.093	<0.024	<0.028	<0.02	1.2E-06	2.6E-07	2.8E-06	ND	1.5E-08	2.0E-08	ND	ND	ND	4.3E-06	4.0E-06	2.9E-07	4.0E-02	2.9E-02	5.9E-02	ND	----	1.4E-03	ND	ND	ND	0.13	No
EAR3-RA-27c-12	1	0.48	1.1	0.55	<0.024	0.047	0.084	<0.024	<0.028	<0.02	1.1E-06	2.6E-07	2.7E-06	ND	1.4E-08	1.8E-08	ND	ND	ND	4.1E-06	3.8E-06	2.9E-07	3.9E-02	2.9E-02	5.6E-02	ND	----	1.3E-03	ND	ND	ND	0.13	No
EAR3-RA-28a-06	0.5	0.97	3.5	1.4	<0.024	0.057	0.12	<0.024	<0.028	0.025	2.3E-06	8.2E-07	6.9E-06	ND	1.7E-08	2.6E-08	ND	ND	----	1.0E-05	9.2E-06	8.6E-07	8.0E-02	9.1E-02	1.4E-01	ND	----	1.8E-03	ND	ND	8.3E-04	0.32	No
EAR3-RA-28a-12	1	1.7	4.2	1.7	<0.024	0.048	0.12	<0.024	<0.028	0.053	4.0E-06	9.9E-07	8.3E-06	ND	1.4E-08	2.6E-08	ND	ND	----	1.3E-05	1.2E-05	1.0E-06	1.4E-01	1.1E-01	1.7E-01	ND	----	1.8E-03	ND	ND	1.8E-03	0.42	No
EAR3-RA-28b-06	0.5	2.6	4.7	3	<0.024	0.1	0.17	<0.024	<0.028	0.049	6.2E-06	1.1E-06	1.5E-05	ND	2.9E-08	3.7E-08	ND	ND	----	2.2E-05	2.1E-05	1.2E-06	2.1E-01	1.2E-01	3.1E-01	ND	----	2.5E-03	ND	ND	1.6E-03	0.64	No
EAR3-RA-28b-12	1	1.2	3.3	1.6	<0.024	0.14	0.13	<0.024	<0.028	0.026	2.9E-06	7.7E-07	7.8E-06	ND	4.1E-08	2.8E-08	ND	ND	----	1.2E-05	1.1E-05	8.4E-07	9.8E-02	8.6E-02	1.6E-01	ND	----	1.9E-03	ND	ND	8.6E-04	0.35	No
EAR3-RA-28c-06	0.5	0.48	2.5	1.4	<0.024	0.063	0.098	<0.024	<0.028	0.022	1.1E-06	5.9E-07	6.9E-06	ND	1.8E-08	2.1E-08	ND	ND	----	8.6E-06	8.0E-06	6.3E-07	3.9E-02	6.5E-02	1.4E-01	ND	----	1.5E-03	ND	ND	7.3E-04	0.25	No
EAR3-RA-28c-12	1	0.3	1.5	0.77	<0.024	0.061	0.073	<0.024	<0.028	<0.02	7.1E-07	3.5E-07	3.8E-06	ND	1.8E-08	1.6E-08	ND	ND	ND	4.9E-06	4.5E-06	3.9E-07	2.5E-02	3.9E-02	7.9E-02	ND	----	1.1E-03	ND	ND	ND	0.14	No
EAR3-RA-28d-06	0.5	0.35	1.7	1	<0.024	0.064	0.092	<0.024	<0.028	<0.02	8.3E-07	4.0E-07	4.9E-06	ND																			

TABLE E-3
Earhart I-3: Risk and Hazard Calculations - Child Resident^a

Decision Unit	Depth (feet)	Analytical Results (mg/kg)									Child Resident																	Exceed HDOH 2011 HC HHRE Standard? ^e					
		Aldrin	Chlordane	Dieldrin	4,4-DDD	4,4-DDE	4,4-DDT	Endosulfan sulfate	Endrin	Endrin Ketone	Cancer Risk									Noncancer Hazard													
											Aldrin	Chlordane	Dieldrin	4,4-DDD	4,4-DDE	4,4-DDT	Endosulfan sulfate	Endrin	Endrin Ketone	Cumulative Risk ^b			Aldrin	Chlordane	Dieldrin	4,4-DDD	4,4-DDE		4,4-DDT	Endosulfan sulfate	Endrin	Endrin Ketone	Hazard Index ^d
Resident Child - Cancer EALs (mg/kg)	42.1	42.6	20.4	48.7	34.4	46.0	---	---	---											All Chems	Aldrin and Dieldrin Only	No Aldrin or Dieldrin ^c											
Res. Child - Noncancer EALs (mg/kg)	12.2	38.3	9.8	----	----	67.0	602.0	30.1	30.1																								
EAR3-RA-39a-06	0.5	0.2	2.1	0.69	<0.024	0.1	0.14	<0.024	<0.028	<0.02	4.8E-07	4.9E-07	3.4E-06	ND	2.9E-08	3.0E-08	ND	ND	ND	4.4E-06	3.9E-06	5.5E-07	1.6E-02	5.5E-02	7.0E-02	ND	----	2.1E-03	ND	ND	ND	0.14	No
EAR3-RA-39a-12	1	0.096	1.1	0.3	<0.024	0.076	0.1	<0.024	<0.028	<0.02	2.3E-07	2.6E-07	1.5E-06	ND	2.2E-08	2.2E-08	ND	ND	ND	2.0E-06	1.7E-06	3.0E-07	7.9E-03	2.9E-02	3.1E-02	ND	----	1.5E-03	ND	ND	ND	0.07	No
EAR3-RA-39b-06	0.5	0.23	3.8	1.2	0.13	0.14	2.9	<0.024	<0.028	<0.02	5.5E-07	8.9E-07	5.9E-06	2.7E-08	4.1E-08	6.3E-07	ND	ND	ND	8.0E-06	6.4E-06	1.6E-06	1.9E-02	9.9E-02	1.2E-01	----	----	4.3E-02	ND	ND	ND	0.28	No
EAR3-RA-39b-12	1	0.65	3.3	1.7	<0.024	0.16	0.17	<0.024	<0.028	0.023	1.5E-06	7.7E-07	8.3E-06	ND	4.7E-08	3.7E-08	ND	ND	----	1.1E-05	9.9E-06	8.6E-07	5.3E-02	8.6E-02	1.7E-01	ND	----	2.5E-03	ND	ND	7.6E-04	0.32	No
EAR3-RA-39c-06	0.5	0.2	1.5	0.72	<0.024	0.092	0.1	<0.024	<0.028	<0.02	4.8E-07	3.5E-07	3.5E-06	ND	2.7E-08	2.2E-08	ND	ND	ND	4.4E-06	4.0E-06	4.0E-07	1.6E-02	3.9E-02	7.3E-02	ND	----	1.5E-03	ND	ND	ND	0.13	No
EAR3-RA-39c-12	1	0.16	1.4	0.55	<0.024	0.17	0.18	<0.024	<0.028	<0.02	3.8E-07	3.3E-07	2.7E-06	ND	4.9E-08	3.9E-08	ND	ND	ND	3.5E-06	3.1E-06	4.2E-07	1.3E-02	3.7E-02	5.6E-02	ND	----	2.7E-03	ND	ND	ND	0.11	No
EAR3-RA-3a-06	0.5	0.33	6.1	1.2	<0.024	0.13	0.11	<0.024	<0.028	<0.02	7.8E-07	1.4E-06	5.9E-06	ND	3.8E-08	2.4E-08	ND	ND	ND	8.2E-06	6.7E-06	1.5E-06	2.7E-02	1.6E-01	1.2E-01	ND	----	1.6E-03	ND	ND	ND	0.31	No
EAR3-RA-3a-12	1	0.26	6.1	1.2	<0.024	0.24	0.13	<0.024	<0.028	<0.02	6.2E-07	1.4E-06	5.9E-06	ND	7.0E-08	2.8E-08	ND	ND	ND	8.0E-06	6.5E-06	1.5E-06	2.1E-02	1.6E-01	1.2E-01	ND	----	1.9E-03	ND	ND	ND	0.30	No
EAR3-RA-3b-06	0.5	0.27	1.3	0.67	<0.024	0.091	0.087	<0.024	<0.028	<0.02	6.4E-07	3.1E-07	3.3E-06	ND	2.6E-08	1.9E-08	ND	ND	ND	4.3E-06	3.9E-06	3.5E-07	2.2E-02	3.4E-02	6.8E-02	ND	----	1.3E-03	ND	ND	ND	0.13	No
EAR3-RA-3b-12	1	0.37	1.8	0.81	0.032	0.18	0.28	<0.024	<0.028	<0.02	8.8E-07	4.2E-07	4.0E-06	6.6E-09	5.2E-08	6.1E-08	ND	ND	ND	5.4E-06	4.8E-06	5.4E-07	3.0E-02	4.7E-02	8.3E-02	----	----	4.2E-03	ND	ND	ND	0.16	No
EAR3-RA-40a-06-1	0.5	0.54	4.5	1.7	<0.024	0.12	0.12	<0.024	<0.028	<0.02	1.3E-06	1.1E-06	8.3E-06	ND	3.5E-08	2.6E-08	ND	ND	ND	1.1E-05	9.6E-06	1.1E-06	4.4E-02	1.2E-01	1.7E-01	ND	----	1.8E-03	ND	ND	ND	0.34	No
EAR3-RA-40a-06-2	0.5	0.65	5	1.7	<0.024	0.13	0.16	<0.024	<0.028	<0.02	1.5E-06	1.2E-06	8.3E-06	ND	3.8E-08	3.5E-08	ND	ND	ND	1.1E-05	9.9E-06	1.2E-06	5.3E-02	1.3E-01	1.7E-01	ND	----	2.4E-03	ND	ND	ND	0.36	No
EAR3-RA-40a-06-3	0.5	0.67	5.5	2	<0.024	0.14	0.14	<0.024	<0.028	<0.02	1.6E-06	1.3E-06	9.8E-06	ND	4.1E-08	3.0E-08	ND	ND	ND	1.3E-05	1.1E-05	1.4E-06	5.5E-02	1.4E-01	2.0E-01	ND	----	2.1E-03	ND	ND	ND	0.40	No
EAR3-RA-40a-12	1	0.33	3.4	0.84	<0.024	0.049	0.048	<0.024	<0.028	<0.02	7.8E-07	8.0E-07	4.1E-06	ND	1.4E-08	1.0E-08	ND	ND	ND	5.7E-06	4.9E-06	8.2E-07	2.7E-02	8.9E-02	8.6E-02	ND	----	7.2E-04	ND	ND	ND	0.20	No
EAR3-RA-40b-06	0.5	0.66	7.7	1.7	<0.024	0.16	0.15	<0.024	<0.028	<0.02	1.6E-06	1.8E-06	8.3E-06	ND	4.7E-08	3.3E-08	ND	ND	ND	1.2E-05	9.9E-06	1.9E-06	5.4E-02	2.0E-01	1.7E-01	ND	----	2.2E-03	ND	ND	ND	0.43	No
EAR3-RA-40b-12	1	0.66	7.5	1.3	<0.024	0.095	0.09	<0.024	<0.028	<0.02	1.6E-06	1.8E-06	6.4E-06	ND	2.8E-08	2.0E-08	ND	ND	ND	9.7E-06	7.9E-06	1.8E-06	5.4E-02	2.0E-01	1.3E-01	ND	----	1.3E-03	ND	ND	ND	0.38	No
EAR3-RA-40c-06	0.5	0.42	1.1	0.71	<0.024	0.058	0.06	<0.024	<0.028	<0.02	1.0E-06	2.6E-07	3.5E-06	ND	1.7E-08	1.3E-08	ND	ND	ND	4.8E-06	4.5E-06	2.9E-07	3.4E-02	2.9E-02	7.2E-02	ND	----	9.0E-04	ND	ND	ND	0.14	No
EAR3-RA-40c-12	1	0.34	0.85	0.53	<0.024	0.077	0.057	<0.024	<0.028	<0.02	8.1E-07	2.0E-07	2.6E-06	ND	2.2E-08	1.2E-08	ND	ND	ND	3.6E-06	3.4E-06	2.3E-07	2.8E-02	2.2E-02	5.4E-02	ND	----	8.5E-04	ND	ND	ND	0.10	No
EAR3-RA-40d-12	0.5	4.5	4	3.2	<0.094	<0.095	<0.16	<0.098	<0.11	<0.08	1.1E-05	9.4E-07	1.6E-05	ND	ND	ND	ND	ND	ND	2.7E-05	2.6E-05	9.4E-07	3.7E-01	1.0E-01	3.3E-01	ND	ND	ND	ND	ND	ND	0.80	No
EAR3-RA-40d-6	0.5	1.7	3.1	2.2	<0.024	0.1	0.16	<0.024	<0.028	0.028	4.0E-06	7.3E-07	1.1E-05	ND	2.9E-08	3.5E-08	ND	ND	----	1.6E-05	1.5E-05	7.9E-07	1.4E-01	8.1E-02	2.2E-01	ND	----	2.4E-03	ND	ND	9.3E-04	0.45	No
EAR3-RA-40e-12	1	3.8	3	4.4	<0.094	0.1	<0.16	<0.098	<0.11	<0.08	9.0E-06	7.0E-07	2.2E-05	ND	2.9E-08	ND	ND	ND	ND	3.1E-05	3.1E-05	7.3E-07	3.1E-01	7.8E-02	4.5E-01	ND	----	ND	ND	ND	ND	0.84	No
EAR3-RA-40e-6	0.5	3.2	3.7	4.4	<0.094	<0.095	<0.16	<0.098	<0.11	<0.08	7.6E-06	8.7E-07	2.2E-05	ND	ND	ND	ND	ND	ND	3.0E-05	2.9E-05	8.7E-07	2.6E-01	9.7E-02	4.5E-01	ND	ND	ND	ND	ND	ND	0.81	No
EAR3-RA-40f-12	1	0.36	2.2	0.61	<0.024	0.076	0.08	<0.024	<0.028	<0.02	8.6E-07	5.2E-07	3.0E-06	ND	2.2E-08	1.7E-08	ND	ND	ND	4.4E-06	3.8E-06	5.6E-07	3.0E-02	5.7E-02	6.2E-02	ND	----	1.2E-03	ND	ND	ND	0.15	No
EAR3-RA-40f-6	0.5	0.29	2.2	0.59	<0.024	0.089	0.15	<0.024	<0.028	<0.02	6.9E-07	5.2E-07	2.9E-06	ND	2.6E-08	3.3E-08	ND	ND	ND	4.2E-06	3.6E-06	5.7E-07	2.4E-02	5.7E-02	6.0E-02	ND	----	2.2E-03	ND	ND	ND	0.14	No
EAR3-RA-40g-12	1	6.7	3.1	2.9	<0.094	0.14	<0.16	<0.098	<0.11	<0.08	1.6E-05	7.3E-07	1.4E-05	ND	4.1E-08	ND	ND	ND	ND	3.1E-05	3.0E-05	7.7E-07	5.5E-01	8.1E-02	3.0E-01	ND	----	ND	ND	ND	ND	0.93	No
EAR3-RA-40g-6	0.5	1.4	2.4	2.2	<0.024	0.066	0.062	<0.024	<0.028	0.031	3.3E-06	5.6E-07	1.1E-05	ND	1.9E-08	1.3E-08	ND	ND	----	1.5E-05	1.4E-05	6.0E-07	1.1E-01	6.3E-02	2.2E-01	ND	----	9.3E-04	ND	ND	1.0E-03	0.40	No
EAR3-RA-40h-06	0.5	0.12	<0.5	0.54	<0.024	<0.024	<0.04	<0.024	<0.028	<0.02	2.9E-07	ND	2.6E-06	ND	ND	ND	ND	ND	ND	2.9E-06	2.9E-06	0.0E+00	9.8E-03	ND	5.5E-02	ND	ND	ND	ND	ND	ND	0.06	No
EAR3-RA-40h-12	1	0.23	0.88	0.96	<0.024	<0.024	<0.04	<0.024	<0.028	<0.02	5.5E-07	2.1E-07	4.7E-06	ND	ND	ND	ND	ND	ND	5.5E-06	5.3E-06	2.1E-07	1.9E-02	2.3E-02	9.8E-02	ND	ND	ND	ND	ND	ND	0.14	No
EAR3-RA-40i-06	0.5	0.055	0.99	0.27	<0.024	<0.024	<0.04	<0.024	<0.028	<0.02	1.3E-07	2.3E-07	1.3E-06	ND	ND	ND	ND	ND	ND	1.7E-06	1.5E-06	2.3E-07	4.5E-03	2.6E-02	2.8E-02	ND	ND	ND	ND	ND	ND	0.06	No
EAR3-RA-40i-12	1	0.062	0.74	0.23	<0.0094	<0.0095	<0.016	<0.0098	<0.011	<0.008	1.5E-07	1.7E-07	1.1E-06	ND	ND	ND	ND	ND	ND	1.4E-06	1.3E-06	1.7E-07	5.1E-03	1.9E-02	2.3E-02	ND	ND	ND	ND	ND	ND	0.05	No
EAR3-RA-40j-06	0.5	0.091	0.82	0.33	0.014	0.093	0.26	<0.0098	<0.011	<0.008	2.2E-07	1.9E-07	1.6E-06	2.9E-09	2.7E-08	5.7E-08	ND	ND	ND	2.1E-06	1.8E-06	2.8E-07	7.5E-03	2.1E-02	3.4E-02	----	----	3.9E-03	ND	ND	ND	0.07	No
EAR3-RA-40j-12	1	0.0099	0.35	0.067	<0.0047	0.047	0.038	<0.0049	<0.0057	<0.004	2.4E-08	8.2E-08	3.3E-07	ND	1.4E-08	8.3E-09	ND	ND	ND	4.6E-07	3.5E-07	1.0E-07	8.1E-04	9.1E-03	6.8E-03	ND	----	5.7E-04	ND	ND	ND	0.02	No
EAR3-RA-41a-06-1	0.5	0.1	0.98	0.37	0.026	0.15	0.34	<0.024	<0.028	<0.02	2.4E-07	2.3E-07	1.8E-06	5.3E-09	4.4E-08	7.4E-08	ND	ND	ND	2.4E-06	2.1E-06	3.5E-07	8.2E-03	2.6E-02	3.8E-02	----	----	5.1E-03	ND	ND	ND	0.08	No
EAR3-RA-41a-06-2	0.5	0.15	1.2	0.48	0.032	0.17	0.31	<0.024	<0.028	<0.02	3.6E-07	2.8E-07	2.4E-06	6.6E-09	4.9E-08	6.7E-08	ND	ND	ND	3.1E-06	2.7E-06	4.1E-07	1.2E-02	3.1E-02	4.9E-02	----	----	4.6E-03	ND	ND	ND	0.10	No
EAR3-RA-41a-06-3	0.5	0.13	1.1	0.43	0.032	0.15	0.22	<0.024	<0.028	<0.02	3.1E-07	2.6E-07	2.1E-06	6.6E-09	4.4E-08	4.8E-08	ND																

TABLE E-3
Earhart I-3: Risk and Hazard Calculations - Child Resident^a

Decision Unit	Depth (feet)	Analytical Results (mg/kg)									Child Resident																			Exceed HDOH 2011 HC HHRE Standard? ^e				
		Aldrin	Chlordane	Dieldrin	4,4-DDD	4,4-DDE	4,4-DDT	Endosulfan sulfate	Endrin	Endrin Ketone	Cancer Risk									Noncancer Hazard														
											Aldrin	Chlordane	Dieldrin	4,4-DDD	4,4-DDE	4,4-DDT	Endosulfan sulfate	Endrin	Endrin Ketone	Cumulative Risk ^b			Aldrin	Chlordane	Dieldrin	4,4-DDD	4,4-DDE	4,4-DDT	Endosulfan sulfate		Endrin	Endrin Ketone	Hazard Index ^d	
Resident Child - Cancer EALs (mg/kg)	42.1	42.6	20.4	48.7	34.4	46.0	---	---	---											All Chems	Aldrin and Dieldrin Only	No Aldrin or Dieldrin ^c												
Res. Child - Noncancer EALs (mg/kg)	12.2	38.3	9.8	----	----	67.0	602.0	30.1	30.1																									
EAR3-RA-42a-06-1	0.5	0.083	2.3	0.35	<0.0094	0.41	0.11	<0.0098	0.011	<0.008	2.0E-07	5.4E-07	1.7E-06	ND	1.2E-07	2.4E-08	ND	----	ND	2.6E-06	1.9E-06	6.8E-07	6.8E-03	6.0E-02	3.6E-02	ND	----	1.6E-03	ND	#####	ND	0.10	No	
EAR3-RA-42a-06-2	0.5	0.12	4.9	0.29	<0.0094	0.52	0.22	<0.0098	<0.011	<0.008	2.9E-07	1.2E-06	1.4E-06	ND	1.5E-07	4.8E-08	ND	ND	ND	3.1E-06	1.7E-06	1.3E-06	9.8E-03	1.3E-01	3.0E-02	ND	----	3.3E-03	ND	ND	ND	0.17	No	
EAR3-RA-42a-06-3	0.5	0.048	3.1	0.22	<0.024	0.68	0.2	<0.024	<0.028	<0.02	1.1E-07	7.3E-07	1.1E-06	ND	2.0E-07	4.3E-08	ND	ND	ND	2.2E-06	1.2E-06	9.7E-07	3.9E-03	8.1E-02	2.2E-02	ND	----	3.0E-03	ND	ND	ND	0.11	No	
EAR3-RA-42a-12	1	0.037	6.2	0.089	<0.0094	0.58	0.14	<0.0098	<0.011	<0.008	8.8E-08	1.5E-06	4.4E-07	ND	1.7E-07	3.0E-08	ND	ND	ND	2.2E-06	5.2E-07	1.7E-06	3.0E-03	1.6E-01	9.1E-03	ND	----	2.1E-03	ND	ND	ND	0.18	No	
EAR3-RA-42b-06	0.5	0.075	4	0.26	0.035	0.56	0.37	<0.0098	<0.011	<0.008	1.8E-07	9.4E-07	1.3E-06	7.2E-09	1.6E-07	8.0E-08	ND	ND	ND	2.6E-06	1.5E-06	1.2E-06	6.1E-03	1.0E-01	2.7E-02	----	----	5.5E-03	ND	ND	ND	0.14	No	
EAR3-RA-42b-12	1	0.029	3.7	0.11	0.11	0.83	0.98	<0.024	<0.028	<0.02	6.9E-08	8.7E-07	5.4E-07	2.3E-08	2.4E-07	2.1E-07	ND	ND	ND	2.0E-06	6.1E-07	1.3E-06	2.4E-03	9.7E-02	1.1E-02	----	----	1.5E-02	ND	ND	ND	0.12	No	
EAR3-RA-42c-06	0.5	0.18	1.6	0.57	0.06	0.3	0.27	<0.0098	<0.011	<0.008	4.3E-07	3.8E-07	2.8E-06	1.2E-08	8.7E-08	5.9E-08	ND	ND	ND	3.8E-06	3.2E-06	5.3E-07	1.5E-02	4.2E-02	5.8E-02	----	----	4.0E-03	ND	ND	ND	0.12	No	
EAR3-RA-42c-12	1	0.12	1.9	0.33	0.062	0.33	0.34	<0.0098	<0.011	<0.008	2.9E-07	4.5E-07	1.6E-06	1.3E-08	9.6E-08	7.4E-08	ND	ND	ND	2.5E-06	1.9E-06	6.3E-07	9.8E-03	5.0E-02	3.4E-02	----	----	5.1E-03	ND	ND	ND	0.10	No	
EAR3-RA-42d-06	0.5	0.17	1	0.65	0.033	0.23	0.15	<0.024	<0.028	<0.02	4.0E-07	2.3E-07	3.2E-06	6.8E-09	6.7E-08	3.3E-08	ND	ND	ND	3.9E-06	3.6E-06	3.4E-07	1.4E-02	2.6E-02	6.6E-02	----	----	2.2E-03	ND	ND	ND	0.11	No	
EAR3-RA-42d-12	1	0.09	0.62	0.33	0.024	0.13	0.074	<0.0098	<0.011	<0.008	2.1E-07	1.5E-07	1.6E-06	4.9E-09	3.8E-08	1.6E-08	ND	ND	ND	2.0E-06	1.8E-06	2.0E-07	7.4E-03	1.6E-02	3.4E-02	----	----	1.1E-03	ND	ND	ND	0.06	No	
EAR3-RA-42e-06	0.5	0.063	0.7	0.32	<0.0094	0.082	0.084	<0.0098	<0.011	<0.008	1.5E-07	1.6E-07	1.6E-06	ND	2.4E-08	1.8E-08	ND	ND	ND	1.9E-06	1.7E-06	2.1E-07	5.2E-03	1.8E-02	3.3E-02	ND	----	1.3E-03	ND	ND	ND	0.06	No	
EAR3-RA-42e-12	1	0.029	1	0.13	<0.0094	0.33	0.17	<0.0098	<0.011	<0.008	6.9E-08	2.3E-07	6.4E-07	ND	9.6E-08	3.7E-08	ND	ND	ND	1.1E-06	7.1E-07	3.7E-07	2.4E-03	2.6E-02	1.3E-02	ND	----	2.5E-03	ND	ND	ND	0.04	No	
EAR3-RA-42f-06	0.5	0.27	0.97	0.71	0.046	0.083	0.065	<0.024	<0.028	<0.02	6.4E-07	2.3E-07	3.5E-06	9.4E-09	2.4E-08	1.4E-08	ND	ND	ND	4.4E-06	4.1E-06	2.8E-07	2.2E-02	2.5E-02	7.2E-02	----	----	9.7E-04	ND	ND	ND	0.12	No	
EAR3-RA-42f-12	1	0.11	0.51	0.35	<0.0094	0.033	0.042	<0.0098	<0.011	<0.008	2.6E-07	1.2E-07	1.7E-06	ND	9.6E-09	9.1E-09	ND	ND	ND	2.1E-06	2.0E-06	1.4E-07	9.0E-03	1.3E-02	3.6E-02	ND	----	6.3E-04	ND	ND	ND	0.06	No	
EAR3-RA-42g-06	0.5	0.2	1.1	0.63	0.036	0.074	0.063	<0.024	<0.028	<0.02	4.8E-07	2.6E-07	3.1E-06	7.4E-09	2.2E-08	1.4E-08	ND	ND	ND	3.9E-06	3.6E-06	3.0E-07	1.6E-02	2.9E-02	6.4E-02	----	----	9.4E-04	ND	ND	ND	0.11	No	
EAR3-RA-42g-12	1	0.024	1.3	0.092	0.0048	0.19	0.13	<0.002	<0.0023	<0.0016	5.7E-08	3.1E-07	4.5E-07	9.9E-10	5.5E-08	2.8E-08	ND	ND	ND	9.0E-07	5.1E-07	3.9E-07	2.0E-02	3.4E-02	9.4E-03	----	----	1.9E-03	ND	ND	ND	0.05	No	
EAR3-RA-42h-06	0.5	0.61	1.7	1.6	0.031	0.076	0.093	<0.024	<0.028	0.027	1.4E-06	4.0E-07	7.8E-06	6.4E-09	2.2E-08	2.0E-08	ND	ND	----	9.7E-06	9.3E-06	4.5E-07	5.0E-02	4.4E-02	1.6E-01	----	----	1.4E-03	ND	ND	9.0E-04	0.26	No	
EAR3-RA-42h-12	1	0.72	1.3	1.1	0.029	0.067	0.042	<0.024	<0.028	0.032	1.7E-06	3.1E-07	5.4E-06	6.0E-09	1.9E-08	9.1E-09	ND	ND	----	7.4E-06	7.1E-06	3.4E-07	5.9E-02	3.4E-02	1.1E-01	----	----	6.3E-04	ND	ND	1.1E-03	0.21	No	
EAR3-RA-42i-06	0.5	3.5	2.7	3.4	<0.047	0.075	0.093	<0.049	<0.057	0.12	8.3E-06	6.3E-07	1.7E-05	ND	2.2E-08	2.0E-08	ND	ND	----	2.6E-05	2.5E-05	6.8E-07	2.9E-01	7.0E-02	3.5E-01	ND	----	1.4E-03	ND	ND	4.0E-03	0.71	No	
EAR3-RA-42i-12	1	0.75	2	1.7	<0.024	0.045	<0.04	<0.024	<0.028	0.03	1.8E-06	4.7E-07	8.3E-06	ND	1.3E-08	ND	ND	ND	----	1.1E-05	1.0E-05	4.8E-07	6.1E-02	5.2E-02	1.7E-01	ND	----	ND	ND	ND	1.0E-03	0.29	No	
EAR3-RA-42j-06	0.5	0.34	1.5	1.1	<0.024	0.066	0.098	<0.024	<0.028	0.024	8.1E-07	3.5E-07	5.4E-06	ND	1.9E-08	2.1E-08	ND	ND	----	6.6E-06	6.2E-06	3.9E-07	2.8E-02	3.9E-02	1.1E-01	ND	----	1.5E-03	ND	ND	8.0E-04	0.18	No	
EAR3-RA-42j-12	1	0.36	1.5	1.2	<0.024	0.083	0.13	<0.024	<0.028	<0.02	8.6E-07	3.5E-07	5.9E-06	ND	2.4E-08	2.8E-08	ND	ND	ND	7.1E-06	6.7E-06	4.0E-07	3.0E-02	3.9E-02	1.2E-01	ND	----	1.9E-03	ND	ND	ND	0.19	No	
EAR3-RA-42k-06	0.5	0.95	2.3	2.3	<0.024	0.071	0.11	<0.024	<0.028	0.057	2.3E-06	5.4E-07	1.1E-05	ND	2.1E-08	2.4E-08	ND	ND	----	1.4E-05	1.4E-05	5.8E-07	7.8E-02	6.0E-02	2.3E-01	ND	----	1.6E-03	ND	ND	1.9E-03	0.37	No	
EAR3-RA-42k-12	1	0.54	1.3	1.2	<0.024	0.069	0.088	<0.024	<0.028	0.023	1.3E-06	3.1E-07	5.9E-06	ND	2.0E-08	1.9E-08	ND	ND	----	7.5E-06	7.2E-06	3.4E-07	4.4E-02	3.4E-02	1.2E-01	ND	----	1.3E-03	ND	ND	7.6E-04	0.20	No	
EAR3-RA-42L-06	0.5	0.24	0.83	0.77	<0.024	0.025	<0.04	<0.024	<0.028	<0.02	5.7E-07	1.9E-07	3.8E-06	ND	7.3E-09	ND	ND	ND	ND	4.5E-06	4.3E-06	2.0E-07	2.0E-02	2.2E-02	7.9E-02	ND	----	ND	ND	ND	ND	0.12	No	
EAR3-RA-42L-12	1	0.29	1.1	0.98	<0.0094	0.033	0.054	<0.0098	<0.011	0.019	6.9E-07	2.6E-07	4.8E-06	ND	9.6E-09	1.2E-08	ND	ND	----	5.8E-06	5.5E-06	2.8E-07	2.4E-02	2.9E-02	1.0E-01	ND	----	8.1E-04	ND	ND	6.3E-04	0.15	No	
EAR3-RA-4a-06	0.5	0.42	3.6	1.3	<0.024	0.1	0.14	<0.024	<0.028	<0.02	1.0E-06	8.5E-07	6.4E-06	ND	2.9E-08	3.0E-08	ND	ND	ND	8.3E-06	7.4E-06	9.0E-07	3.4E-02	9.4E-02	1.3E-01	ND	----	2.1E-03	ND	ND	ND	0.26	No	
EAR3-RA-4a-12	1	0.38	7.4	0.88	<0.024	0.18	0.16	<0.024	<0.028	<0.02	9.0E-07	1.7E-06	4.3E-06	ND	5.2E-08	3.5E-08	ND	ND	ND	7.0E-06	5.2E-06	1.8E-06	3.1E-02	1.9E-01	9.0E-02	ND	----	2.4E-03	ND	ND	ND	0.32	No	
EAR3-RA-4b-06	0.5	1.5	7.9	3.4	<0.047	0.18	0.39	<0.049	<0.057	0.042	3.6E-06	1.9E-06	1.7E-05	ND	5.2E-08	8.5E-08	ND	ND	----	2.2E-05	2.0E-05	2.0E-06	1.2E-01	2.1E-01	3.5E-01	ND	----	5.8E-03	ND	ND	1.4E-03	0.68	No	
EAR3-RA-4b-12	1	9.1	20	3.4	<0.19	<0.19	<0.32	<0.2	<0.23	<0.16	2.2E-05	4.7E-06	1.7E-05	ND	ND	ND	ND	ND	ND	4.3E-05	3.8E-05	4.7E-06	7.5E-01	5.2E-01	3.5E-01	ND	ND	ND	ND	ND	1.62	Yes		
EAR3-RA-5a-12	1	1.1	3.3	2.1	0.029	0.24	0.33	<0.024	<0.028	0.04	2.6E-06	7.7E-07	1.0E-05	6.0E-09	7.0E-08	7.2E-08	ND	ND	----	1.4E-05	1.3E-05	9.2E-07	9.0E-02	8.6E-02	2.1E-01	----	----	4.9E-03	ND	ND	1.3E-03	0.40	No	
EAR3-RA-5a-6-1	0.5	1	3	2	<0.024	0.19	0.14	<0.024	<0.028	0.034	2.4E-06	7.0E-07	9.8E-06	ND	5.5E-08	3.0E-08	ND	ND	----	1.3E-05	1.2E-05	7.9E-07	8.2E-02	7.8E-02	2.0E-01	ND	----	2.1E-03	ND	ND	1.1E-03	0.37	No	
EAR3-RA-5a-6-2	0.5	3.8	8.2	4.5	<0.094	0.16	<0.16	<0.098	<0.11	<0.08	9.0E-06	1.9E-06	2.2E-05	ND	4.7E-08	ND	ND	ND	ND	3.3E-05	3.1E-05	2.0E-06	3.1E-01	2.1E-01	4.6E-01	ND	----	ND	ND	ND	ND	0.98	No	
EAR3-RA-5a-6-3	0.5	1.2	3.2	2.2	<0.024	0.15	0.14	<0.024	<0.028	0.034	2.9E-06	7.5E-07	1.1E-05	ND	4.4E-08	3.0E-08	ND	ND	----	1.4E-05	1.4E-05	8.3E-07	9.8E-02	8.4E-02	2.2E-01	ND	----	2.1E-03	ND	ND	1.1E-03	0.41	No	
EAR3-RA-5b-06	0.5	0.37	2.2	1.2	<0.024																													

**TABLE E-3
Earhart I-3: Risk and Hazard Calculations - Child Resident^a**

Decision Unit	Depth (feet)	Analytical Results (mg/kg)									Child Resident																	Exceed HDOH 2011 HC HHRE Standard? ^e					
		Aldrin	Chlordane	Dieldrin	4,4-DDD	4,4-DDE	4,4-DDT	Endosulfan sulfate	Endrin	Endrin Ketone	Cancer Risk									Noncancer Hazard													
											Aldrin	Chlordane	Dieldrin	4,4-DDD	4,4-DDE	4,4-DDT	Endosulfan sulfate	Endrin	Endrin Ketone	Cumulative Risk ^b			Aldrin	Chlordane	Dieldrin	4,4-DDD	4,4-DDE		4,4-DDT	Endosulfan sulfate	Endrin	Endrin Ketone	Hazard Index ^d
Resident Child - Cancer EALs (mg/kg)	42.1	42.6	20.4	48.7	34.4	46.0	----	----	----											All Chems	Aldrin and Dieldrin Only	No Aldrin or Dieldrin ^c											
Res. Child - Noncancer EALs (mg/kg)	12.2	38.3	9.8	----	----	67.0	602.0	30.1	30.1																								
EAR3-RA-8a-06-1	0.5	0.22	1.6	0.71	<0.024	0.13	0.25	<0.024	<0.028	<0.02	5.2E-07	3.8E-07	3.5E-06	ND	3.8E-08	5.4E-08	ND	ND	ND	4.5E-06	4.0E-06	4.7E-07	1.8E-02	4.2E-02	7.2E-02	ND	----	3.7E-03	ND	ND	ND	0.14	No
EAR3-RA-8a-06-2	0.5	0.26	2.1	0.77	<0.024	0.13	0.22	<0.024	<0.028	<0.02	6.2E-07	4.9E-07	3.8E-06	ND	3.8E-08	4.8E-08	ND	ND	ND	5.0E-06	4.4E-06	5.8E-07	2.1E-02	5.5E-02	7.9E-02	ND	----	3.3E-03	ND	ND	ND	0.16	No
EAR3-RA-8a-06-3	0.5	0.19	1.6	0.6	0.032	0.14	0.2	<0.024	<0.028	<0.02	4.5E-07	3.8E-07	2.9E-06	6.6E-09	4.1E-08	4.3E-08	ND	ND	ND	3.9E-06	3.4E-06	4.7E-07	1.6E-02	4.2E-02	6.1E-02	----	----	3.0E-03	ND	ND	ND	0.12	No
EAR3-RA-8a-12	1	0.59	1.3	0.9	0.025	0.15	0.21	<0.024	<0.028	<0.02	1.4E-06	3.1E-07	4.4E-06	5.1E-09	4.4E-08	4.6E-08	ND	ND	ND	6.2E-06	5.8E-06	4.0E-07	4.8E-02	3.4E-02	9.2E-02	----	----	3.1E-03	ND	ND	ND	0.18	No
EAR3-RA-8b-06	0.5	0.089	0.87	0.26	<0.0094	0.15	0.14	<0.0098	<0.011	<0.008	2.1E-07	2.0E-07	1.3E-06	ND	4.4E-08	3.0E-08	ND	ND	ND	1.8E-06	1.5E-06	2.8E-07	7.3E-03	2.3E-02	2.7E-02	ND	----	2.1E-03	ND	ND	ND	0.06	No
EAR3-RA-8b-12	1	0.088	0.65	0.15	0.0066	0.17	0.12	<0.0049	<0.0057	<0.004	2.1E-07	1.5E-07	7.4E-07	1.4E-09	4.9E-08	2.6E-08	ND	ND	ND	1.2E-06	9.4E-07	2.3E-07	7.2E-03	1.7E-02	1.5E-02	----	----	1.8E-03	ND	ND	ND	0.04	No
EAR3-RA-8c-06	0.5	0.17	1.5	0.49	<0.024	0.11	0.18	<0.024	<0.028	<0.02	4.0E-07	3.5E-07	2.4E-06	ND	3.2E-08	3.9E-08	ND	ND	ND	3.2E-06	2.8E-06	4.2E-07	1.4E-02	3.9E-02	5.0E-02	ND	----	2.7E-03	ND	ND	ND	0.11	No
EAR3-RA-8c-12	1	0.25	1.6	0.39	<0.024	0.12	0.13	<0.024	<0.028	<0.02	5.9E-07	3.8E-07	1.9E-06	ND	3.5E-08	2.8E-08	ND	ND	ND	2.9E-06	2.5E-06	4.4E-07	2.0E-02	4.2E-02	4.0E-02	ND	----	1.9E-03	ND	ND	ND	0.10	No
EAR3-RA-9a-06	0.5	0.31	2.3	1.1	<0.024	0.12	0.24	<0.024	<0.028	<0.02	7.4E-07	5.4E-07	5.4E-06	ND	3.5E-08	5.2E-08	ND	ND	ND	6.8E-06	6.1E-06	6.3E-07	2.5E-02	6.0E-02	1.1E-01	ND	----	3.6E-03	ND	ND	ND	0.20	No
EAR3-RA-9a-12	1	0.22	1.6	0.69	<0.024	0.09	0.18	<0.024	<0.028	<0.02	5.2E-07	3.8E-07	3.4E-06	ND	2.6E-08	3.9E-08	ND	ND	ND	4.3E-06	3.9E-06	4.4E-07	1.8E-02	4.2E-02	7.0E-02	ND	----	2.7E-03	ND	ND	ND	0.13	No
EAR3-RA-9b-06	0.5	0.32	2.6	1.1	<0.024	0.14	0.27	<0.024	<0.028	<0.02	7.6E-07	6.1E-07	5.4E-06	ND	4.1E-08	5.9E-08	ND	ND	ND	6.9E-06	6.2E-06	7.1E-07	2.6E-02	6.8E-02	1.1E-01	ND	----	4.0E-03	ND	ND	ND	0.21	No
EAR3-RA-9b-12	1	0.24	2.3	0.82	<0.024	0.17	0.23	<0.024	<0.028	<0.02	5.7E-07	5.4E-07	4.0E-06	ND	4.9E-08	5.0E-08	ND	ND	ND	5.2E-06	4.6E-06	6.4E-07	2.0E-02	6.0E-02	8.4E-02	ND	----	3.4E-03	ND	ND	ND	0.17	No
EAR3-RA-9c-06	0.5	0.47	2.8	1.5	0.029	0.29	0.34	<0.024	<0.028	0.023	1.1E-06	6.6E-07	7.4E-06	6.0E-09	8.4E-08	7.4E-08	ND	ND	----	9.3E-06	8.5E-06	8.2E-07	3.9E-02	7.3E-02	1.5E-01	----	----	5.1E-03	ND	ND	7.6E-04	0.27	No
EAR3-RA-9c-12	1	0.35	2.1	0.85	0.076	0.58	0.72	<0.024	<0.028	<0.02	8.3E-07	4.9E-07	4.2E-06	1.6E-08	1.7E-07	1.6E-07	ND	ND	ND	5.8E-06	5.0E-06	8.3E-07	2.9E-02	5.5E-02	8.7E-02	----	----	1.1E-02	ND	ND	ND	0.18	No
EAR3-RA-9d-06	0.5	0.21	1.7	0.85	<0.024	0.1	0.12	<0.024	<0.028	<0.02	5.0E-07	4.0E-07	4.2E-06	ND	2.9E-08	2.6E-08	ND	ND	ND	5.1E-06	4.7E-06	4.5E-07	1.7E-02	4.4E-02	8.7E-02	ND	----	1.8E-03	ND	ND	ND	0.15	No
EAR3-RA-9d-12	1	0.19	1.3	0.52	0.03	0.17	0.24	<0.024	<0.028	<0.02	4.5E-07	3.1E-07	2.5E-06	6.2E-09	4.9E-08	5.2E-08	ND	ND	ND	3.4E-06	3.0E-06	4.1E-07	1.6E-02	3.4E-02	5.3E-02	----	----	3.6E-03	ND	ND	ND	0.11	No
EAR3-RA-9e-06	0.5	0.63	2.8	1.8	<0.024	0.26	0.28	<0.024	<0.028	0.029	1.5E-06	6.6E-07	8.8E-06	ND	7.6E-08	6.1E-08	ND	ND	----	1.1E-05	1.0E-05	7.9E-07	5.2E-02	7.3E-02	1.8E-01	ND	----	4.2E-03	ND	ND	9.6E-04	0.31	No
EAR3-RA-9e-12	1	0.16	1.7	0.6	0.048	0.52	0.43	<0.024	<0.028	<0.02	3.8E-07	4.0E-07	2.9E-06	9.9E-09	1.5E-07	9.3E-08	ND	ND	ND	4.0E-06	3.3E-06	6.5E-07	1.3E-02	4.4E-02	6.1E-02	----	----	6.4E-03	ND	ND	ND	0.13	No
EAR3-RA-14b-06	0.5	0.44	3	1.5	<0.024	0.15	0.18	<0.024	<0.028	<0.02	1.0E-06	7.0E-07	7.4E-06	ND	4.4E-08	3.9E-08	ND	ND	ND	9.2E-06	8.4E-06	7.9E-07	3.6E-02	7.8E-02	1.5E-01	ND	----	2.7E-03	ND	ND	ND	0.27	No
EAR3-RA-14b-12	1	2.1	12	6.1	<0.094	0.58	0.56	<0.098	<0.11	0.081	5.0E-06	2.8E-06	3.0E-05	ND	1.7E-07	1.2E-07	ND	ND	----	3.8E-05	3.5E-05	3.1E-06	1.7E-01	3.1E-01	6.2E-01	ND	----	8.4E-03	ND	ND	2.7E-03	1.12	Yes

- Notes:**
- ^a Shading highlights DUs that have been excavated as part of the three removal actions (RO#1, RO #2, and RO #3) that have been conducted at the site. These layers have been replaced with clean fill.
 - ^b Three cumulative risk numbers are presented to verify that cumulative risk levels meet all HDOH 2011 HC Human Health Risk Evaluation (HHRE) Standard (HDOH 2011) target risk criteria.
 - ^c Listed cumulative risk is for all chemicals except aldrin and dieldrin.
 - ^d The hazard index represents the sum of all chemical-specific hazard quotients (HQs).
 - ^e The four criteria associated with the 2011 HHRE standard are as follows:

- Criteria #1 - the cumulative excess cancer risk (ECR) for aldrin plus dieldrin must not exceed 1×10^{-4}
- Criteria #2 - the cumulative ECR for all other organochlorine pesticides must not exceed 1×10^{-5}
- Criteria #3 - the cumulative ECR for all chemicals of potential concern (COPCs) must not exceed 1×10^{-4}
- Criteria #4 - the hazard index for all COPCs must not exceed 1.0.

Sources:
Hawai'i Department of Health (HDOH). 2011. Review of *Draft Preliminary Human Health Risk Evaluation Work Plan for Hickam Communities, Joint Base Pearl Harbor-Hickam*. 2011-303-ES. Letter from Eric Sadoyama HDOH to Roger Franklin, Actus Lend Lease LLC. June 7, 2011.

TABLE E-4
Earhart I-3: Risk and Hazard Calculations - Adult Resident^a

Decision Unit	Depth (feet)	Analytical Results (mg/kg)									Adult Resident																	Exceed HDOH 2011 HC HHRE Standard? ^c						
		Aldrin	Chlordane	Dieldrin	4,4-DDD	4,4-DDE	4,4-DDT	Endosulfan sulfate	Endrin	Endrin Ketone	Cancer Risk									Noncancer Hazard														
											Aldrin	Chlordane	Dieldrin	4,4-DDD	4,4-DDE	4,4-DDT	Endosulfan sulfate	Endrin	Endrin Ketone	Cumulative Risk ^b			Aldrin	Chlordane	Dieldrin	4,4-DDD	4,4-DDE		4,4-DDT	Endosulfan sulfate	Endrin	Endrin Ketone	Hazard Index ^d	
Resident Adult - Cancer EALs (mg/kg)	209.4	209.8	101.4	253.6	179.0	223.7	---	---	---												All Chems	Aldrin and Dieldrin Only	No Aldrin or Dieldrin ^c											
Res. Adult - Noncancer EALs (mg/kg)	60.9	188.8	48.7	---	---	326.0	3130.5	156.5	156.5																									
EAR3-RA-15d-06	0.5	0.49	1.3	1.5	<0.024	0.052	0.074	<0.024	<0.028	<0.02	2.3E-07	6.2E-08	1.5E-06	ND	2.9E-09	3.3E-09	ND	ND	ND	1.8E-06	1.7E-06	6.8E-08	8.0E-03	6.9E-03	3.1E-02	ND	---	2.3E-04	ND	ND	ND	0.05	No	
EAR3-RA-15d-12	1	0.62	1.5	1.4	<0.024	0.07	0.083	<0.024	<0.028	<0.02	3.0E-07	7.1E-08	1.4E-06	ND	3.9E-09	3.7E-09	ND	ND	ND	1.8E-06	1.7E-06	7.9E-08	1.0E-02	7.9E-03	2.9E-02	ND	---	2.5E-04	ND	ND	ND	0.05	No	
EAR3-RA-15e-06	0.5	0.43	1.7	1.8	<0.024	0.061	0.059	<0.024	<0.028	<0.02	2.1E-07	8.1E-08	1.8E-06	ND	3.4E-09	2.6E-09	ND	ND	ND	2.1E-06	2.0E-06	8.7E-08	7.1E-03	9.0E-03	3.7E-02	ND	---	1.8E-04	ND	ND	ND	0.05	No	
EAR3-RA-15e-12	1	0.37	1.2	1.2	<0.024	<0.024	<0.04	<0.024	<0.028	<0.02	1.8E-07	5.7E-08	1.2E-06	ND	ND	ND	ND	ND	ND	1.4E-06	1.4E-06	5.7E-08	6.1E-03	6.4E-03	2.5E-02	ND	ND	ND	ND	ND	ND	0.04	No	
EAR3-RA-15f-06	0.5	0.17	1.5	0.96	<0.024	0.088	0.067	<0.024	<0.028	<0.02	8.1E-08	7.1E-08	9.5E-07	ND	4.9E-09	3.0E-09	ND	ND	ND	1.1E-06	1.0E-06	7.9E-08	2.8E-03	7.9E-03	2.0E-02	ND	---	2.1E-04	ND	ND	ND	0.03	No	
EAR3-RA-15f-12	1	0.59	1.2	2.1	<0.024	0.041	0.041	<0.024	<0.028	<0.02	2.8E-07	5.7E-08	2.1E-06	ND	2.3E-09	1.8E-09	ND	ND	ND	2.4E-06	2.4E-06	6.1E-08	9.7E-03	6.4E-03	4.3E-02	ND	---	1.3E-04	ND	ND	ND	0.06	No	
EAR3-RA-16a-06	0.5	0.44	3.2	1.2	<0.024	0.21	0.14	<0.024	<0.028	<0.02	2.1E-07	1.5E-07	1.2E-06	ND	1.2E-08	6.3E-09	ND	ND	ND	1.6E-06	1.4E-06	1.7E-07	7.2E-03	1.7E-02	2.5E-02	ND	---	4.3E-04	ND	ND	ND	0.05	No	
EAR3-RA-16a-12	1	0.28	1.8	0.53	0.026	0.21	0.36	<0.012	<0.014	<0.01	1.3E-07	8.6E-08	5.2E-07	1.0E-09	1.2E-08	1.6E-08	ND	ND	ND	7.7E-07	6.6E-07	1.1E-07	4.6E-03	9.5E-03	1.1E-02	---	---	1.1E-03	ND	ND	ND	0.03	No	
EAR3-RA-16b-06	0.5	0.26	0.99	0.69	0.05	0.08	0.072	<0.024	<0.028	<0.02	1.2E-07	4.7E-08	6.8E-07	2.0E-09	4.5E-09	3.2E-09	ND	ND	ND	8.6E-07	8.0E-07	5.7E-08	4.3E-03	5.2E-03	1.4E-02	---	---	2.2E-04	ND	ND	ND	0.02	No	
EAR3-RA-16b-12	1	0.2	0.85	0.39	0.036	0.11	0.097	<0.0098	<0.011	<0.008	9.6E-08	4.1E-08	3.8E-07	1.4E-09	6.1E-09	4.3E-09	ND	ND	ND	5.3E-07	4.8E-07	5.2E-08	3.3E-03	4.5E-03	8.0E-03	---	---	3.0E-04	ND	ND	ND	0.02	No	
EAR3-RA-16c-06	0.5	0.11	0.8	0.4	<0.0094	0.03	0.037	<0.0098	<0.011	<0.008	5.3E-08	3.8E-08	3.9E-07	ND	1.7E-09	1.7E-09	ND	ND	ND	4.9E-07	4.5E-07	4.1E-08	1.8E-03	4.2E-03	8.2E-03	ND	---	1.1E-04	ND	ND	ND	0.01	No	
EAR3-RA-16c-12	1	0.27	1.4	0.62	<0.0094	0.069	0.093	<0.0098	<0.011	<0.008	1.3E-07	6.7E-08	6.1E-07	ND	3.9E-09	4.2E-09	ND	ND	ND	8.2E-07	7.4E-07	7.5E-08	4.4E-03	7.4E-03	1.3E-02	ND	---	2.9E-04	ND	ND	ND	0.02	No	
EAR3-RA-16d-06	0.5	0.72	2.4	1.8	0.048	0.12	0.13	<0.024	<0.028	0.036	3.4E-07	1.1E-07	1.8E-06	1.9E-09	6.7E-09	5.8E-09	ND	ND	---	2.2E-06	2.1E-06	1.3E-07	1.2E-02	1.3E-02	3.7E-02	---	---	4.0E-04	ND	ND	2.3E-04	0.06	No	
EAR3-RA-16d-12	1	0.54	1.4	0.87	0.048	0.12	0.14	<0.024	<0.028	<0.02	2.6E-07	6.7E-08	8.6E-07	1.9E-09	6.7E-09	6.3E-09	ND	ND	ND	1.2E-06	1.1E-06	8.2E-08	8.9E-03	7.4E-03	1.8E-02	---	---	4.3E-04	ND	ND	ND	0.03	No	
EAR3-RA-16e-06	0.5	0.48	2	1.5	0.057	0.1	0.14	<0.024	<0.028	0.026	2.3E-07	9.5E-08	1.5E-06	2.2E-09	5.6E-09	6.3E-09	ND	ND	---	1.8E-06	1.7E-06	1.1E-07	7.9E-03	1.1E-02	3.1E-02	---	---	4.3E-04	ND	ND	1.7E-04	0.05	No	
EAR3-RA-16e-12	1	0.26	1.3	0.82	0.038	0.1	0.12	<0.024	<0.028	<0.02	1.2E-07	6.2E-08	8.1E-07	1.5E-09	5.6E-09	5.4E-09	ND	ND	ND	1.0E-06	9.3E-07	7.4E-08	4.3E-03	6.9E-03	1.7E-02	---	---	3.7E-04	ND	ND	ND	0.03	No	
EAR3-RA-17a-06	0.5	0.74	1.7	1.4	<0.024	0.079	0.062	<0.024	<0.028	<0.02	3.5E-07	8.1E-08	1.4E-06	ND	4.4E-09	2.8E-09	ND	ND	ND	1.8E-06	1.7E-06	8.8E-08	1.2E-02	9.0E-03	2.9E-02	ND	---	1.9E-04	ND	ND	ND	0.05	No	
EAR3-RA-17a-12	1	0.76	2.4	1.4	<0.024	0.092	0.071	<0.024	<0.028	<0.02	3.6E-07	1.1E-07	1.4E-06	ND	5.1E-09	3.2E-09	ND	ND	ND	1.9E-06	1.7E-06	1.2E-07	1.2E-02	1.3E-02	2.9E-02	ND	---	2.2E-04	ND	ND	ND	0.05	No	
EAR3-RA-17b-06	0.5	0.42	1.8	1.2	<0.024	0.083	0.08	<0.024	<0.028	<0.02	2.0E-07	8.6E-08	1.2E-06	ND	4.6E-09	3.6E-09	ND	ND	ND	1.5E-06	1.4E-06	9.4E-08	6.9E-03	9.5E-03	2.5E-02	ND	---	2.5E-04	ND	ND	ND	0.04	No	
EAR3-RA-17b-12	1	0.71	1.8	1.1	<0.024	0.078	0.15	<0.024	<0.028	<0.02	3.4E-07	8.6E-08	1.1E-06	ND	4.4E-09	6.7E-09	ND	ND	ND	1.5E-06	1.4E-06	9.7E-08	1.2E-02	9.5E-03	2.3E-02	ND	---	4.6E-04	ND	ND	ND	0.04	No	
EAR3-RA-17c-06	0.5	0.41	2	1	<0.024	0.22	0.29	<0.024	<0.028	<0.02	2.0E-07	9.5E-08	9.9E-07	ND	1.2E-08	1.3E-08	ND	ND	ND	1.3E-06	1.2E-06	1.2E-07	6.7E-03	1.1E-02	2.1E-02	ND	---	8.9E-04	ND	ND	ND	0.04	No	
EAR3-RA-17c-12	1	0.21	2.4	0.62	<0.024	0.36	0.35	<0.024	<0.028	<0.02	1.0E-07	1.1E-07	6.1E-07	ND	2.0E-08	1.6E-08	ND	ND	ND	8.6E-07	7.1E-07	1.5E-07	3.4E-03	1.3E-02	1.3E-02	ND	---	1.1E-03	ND	ND	ND	0.03	No	
EAR3-RA-18a-06-1	0.5	1.4	2.1	2.8	<0.024	0.079	0.092	<0.024	<0.028	0.041	6.7E-07	1.0E-07	2.8E-06	ND	4.4E-09	4.1E-09	ND	ND	---	3.5E-06	3.4E-06	1.1E-07	2.3E-02	1.1E-02	5.7E-02	ND	---	2.8E-04	ND	ND	2.6E-04	0.09	No	
EAR3-RA-18a-06-2	0.5	1.4	2.3	2.8	<0.024	0.07	0.091	<0.024	<0.028	0.043	6.7E-07	1.1E-07	2.8E-06	ND	3.9E-09	4.1E-09	ND	ND	---	3.5E-06	3.4E-06	1.2E-07	2.3E-02	1.2E-02	5.7E-02	ND	---	2.8E-04	ND	ND	2.7E-04	0.09	No	
EAR3-RA-18a-06-3	0.5	1.6	2.8	3.3	<0.047	0.11	0.13	<0.049	<0.057	0.051	7.6E-07	1.3E-07	3.3E-06	ND	6.1E-09	5.8E-09	ND	ND	---	4.2E-06	4.0E-06	1.5E-07	2.6E-02	1.5E-02	6.8E-02	ND	---	4.0E-04	ND	ND	3.3E-04	0.11	No	
EAR3-RA-18a-12	1	1.8	2.4	2.8	<0.024	0.11	0.11	<0.024	<0.028	0.037	8.6E-07	1.1E-07	2.8E-06	ND	6.1E-09	4.9E-09	ND	ND	---	3.7E-06	3.6E-06	1.3E-07	3.0E-02	1.3E-02	5.7E-02	ND	---	3.4E-04	ND	ND	2.4E-04	0.10	No	
EAR3-RA-18b-06	0.5	0.65	2.2	1.3	<0.024	0.1	0.12	<0.024	<0.028	0.027	3.1E-07	1.0E-07	1.3E-06	ND	5.6E-09	5.4E-09	ND	ND	---	1.7E-06	1.6E-06	1.2E-07	1.1E-02	1.2E-02	2.7E-02	ND	---	3.7E-04	ND	ND	1.7E-04	0.05	No	
EAR3-RA-18b-12	1	0.39	1.7	0.8	<0.024	0.081	0.1	<0.024	<0.028	<0.02	1.9E-07	8.1E-08	7.9E-07	ND	4.5E-09	4.5E-09	ND	ND	ND	1.1E-06	9.8E-07	9.0E-08	6.4E-03	9.0E-03	1.6E-02	ND	---	3.1E-04	ND	ND	ND	0.03	No	
EAR3-RA-18c-06	0.5	0.65	1.8	1.4	<0.024	0.15	0.13	<0.024	<0.028	0.029	3.1E-07	8.6E-08	1.4E-06	ND	8.4E-09	5.8E-09	ND	ND	---	1.8E-06	1.7E-06	1.0E-07	1.1E-02	9.5E-03	2.9E-02	ND	---	4.0E-04	ND	ND	1.9E-04	0.05	No	
EAR3-RA-18c-12	1	0.17	1	0.51	0.018	0.18	0.22	<0.0098	<0.011	<0.008	8.1E-08	4.8E-08	5.0E-07	7.1E-10	1.0E-08	9.8E-09	ND	ND	ND	6.5E-07	5.8E-07	6.8E-08	2.8E-03	5.3E-03	1.0E-02	---	---	6.7E-04	ND	ND	ND	0.02	No	
EAR3-RA-19a-06	0.5	0.69	3.5	2.2	<0.024	0.16	0.19	<0.024	<0.028	0.024	3.3E-07	1.7E-07	2.2E-06	ND	8.9E-09	8.5E-09	ND	ND	---	2.7E-06	2.5E-06	1.8E-07	1.1E-02	1.9E-02	4.5E-02	ND	---	5.8E-04	ND	ND	1.5E-04	0.08	No	
EAR3-RA-19a-12	1	0.77	2.9	1.5	<0.024	0.17	0.25	<0.024	<0.028	<0.02	3.7E-07	1.4E-07	1.5E-06	ND	9.5E-09	1.1E-08	ND	ND	ND	2.0E-06	1.8E-06	1.6E-07	1.3E-02	1.5E-02	3.1E-02	ND	---	7.7E-04	ND	ND	ND	0.06	No	
EAR3-RA-19b-06	0.5	0.63	4.9	1.8	<0.024	0.23	0.23	<0.024	<0.028	<0.02	3.0E-07	2.3E-07	1.8E-06	ND	1.3E-08	1.0E-08	ND	ND	ND	2.3E-06	2.1E-06	2.6E-07	1.0E-02	2.6E-02	3.7E-02	ND	---	7.1E-04	ND	ND	ND	0.07	No	
EAR3-RA-19b-12	1	0.67	8.6	1.4	<0.024	0.24	0.25	<0.024	<0.028	<0.02	3.2E-07	4.1E-07	1.4E-06	ND	1.3E-08	1.1E-08	ND	ND	ND	2.1E-06	1.7E-06	4.3E-07	1.1E-02	4.6E-02	2.9E-02	ND	---	7.7E-04	ND	ND	ND	0.09	No	
EAR3-RA-19c-06	0.5	0.4	2.3	1.5	<0																													

TABLE E-4
Earhart I-3: Risk and Hazard Calculations - Adult Resident^a

Decision Unit	Depth (feet)	Analytical Results (mg/kg)									Adult Resident																	Exceed HDOH 2011 HC HHRE Standard? ^c					
		Aldrin	Chlordane	Dieldrin	4,4-DDD	4,4-DDE	4,4-DDT	Endosulfan sulfate	Endrin	Endrin Ketone	Cancer Risk									Noncancer Hazard							Hazard Index ^d						
											Aldrin	Chlordane	Dieldrin	4,4-DDD	4,4-DDE	4,4-DDT	Endosulfan sulfate	Endrin	Endrin Ketone	Cumulative Risk ^b			Aldrin	Chlordane	Dieldrin	4,4-DDD			4,4-DDE	4,4-DDT	Endosulfan sulfate	Endrin	Endrin Ketone
Resident Adult - Cancer EALs (mg/kg)	209.4	209.8	101.4	253.6	179.0	223.7	---	---	---												All Chems	Aldrin and Dieldrin Only	No Aldrin or Dieldrin ^c										
Res. Adult - Noncancer EALs (mg/kg)	60.9	188.8	48.7	---	---	326.0	3130.5	156.5	156.5																								
EAR3-RA-30b-12	1	1.5	2.3	1.3	<0.024	0.13	0.22	<0.024	<0.028	0.029	7.2E-07	1.1E-07	1.3E-06	ND	7.3E-09	9.8E-09	ND	ND	---	2.1E-06	2.0E-06	1.3E-07	2.5E-02	1.2E-02	2.7E-02	ND	---	6.7E-04	ND	ND	1.9E-04	0.06	No
EAR3-RA-30b-6	0.5	0.86	2.7	1.2	<0.024	0.052	0.11	<0.024	<0.028	0.02	4.1E-07	1.3E-07	1.2E-06	ND	2.9E-09	4.9E-09	ND	ND	---	1.7E-06	1.6E-06	1.4E-07	1.4E-02	1.4E-02	2.5E-02	ND	---	3.4E-04	ND	ND	1.3E-04	0.05	No
EAR3-RA-30c-12	1	2.2	3.2	2.6	<0.024	0.076	0.1	<0.024	<0.028	0.069	1.1E-06	1.5E-07	2.6E-06	ND	4.2E-09	4.5E-09	ND	ND	---	3.8E-06	3.6E-06	1.6E-07	3.6E-02	1.7E-02	5.3E-02	ND	---	3.1E-04	ND	ND	4.4E-04	0.11	No
EAR3-RA-30c-6	0.5	1.6	2.9	2.3	<0.024	0.097	0.28	<0.024	<0.028	0.047	7.6E-07	1.4E-07	2.3E-06	ND	5.4E-09	1.3E-08	ND	ND	---	3.2E-06	3.0E-06	1.6E-07	2.6E-02	1.5E-02	4.7E-02	ND	---	8.6E-04	ND	ND	3.0E-04	0.09	No
EAR3-RA-31a-12	1	0.33	1.6	0.53	<0.024	0.12	0.055	<0.024	<0.028	<0.02	1.6E-07	7.6E-08	5.2E-07	ND	6.7E-09	2.5E-09	ND	ND	ND	7.7E-07	6.8E-07	8.5E-08	5.4E-03	8.5E-03	1.1E-02	ND	---	1.7E-04	ND	ND	ND	0.02	No
EAR3-RA-31a-6	0.5	0.45	2.4	1	<0.024	0.18	0.14	<0.024	<0.028	<0.02	2.1E-07	1.1E-07	9.9E-07	ND	1.0E-08	6.3E-09	ND	ND	ND	1.3E-06	1.2E-06	1.3E-07	7.4E-03	1.3E-02	2.1E-02	ND	---	4.3E-04	ND	ND	ND	0.04	No
EAR3-RA-31b-12	1	0.18	1.6	0.37	<0.024	0.22	0.11	<0.024	<0.028	<0.02	8.6E-08	7.6E-08	3.6E-07	ND	1.2E-08	4.9E-09	ND	ND	ND	5.4E-07	4.5E-07	9.3E-08	3.0E-03	8.5E-03	7.6E-03	ND	---	3.4E-04	ND	ND	ND	0.02	No
EAR3-RA-31b-6	0.5	0.2	3.6	0.61	<0.024	0.14	0.2	<0.024	<0.028	<0.02	9.6E-08	1.7E-07	6.0E-07	ND	7.8E-09	8.9E-09	ND	ND	ND	8.9E-07	7.0E-07	1.9E-07	3.3E-03	1.9E-02	1.3E-02	ND	---	6.1E-04	ND	ND	ND	0.04	No
EAR3-RA-31c-12	1	1.5	2.6	1.4	<0.024	0.14	0.22	<0.024	<0.028	<0.02	7.2E-07	1.2E-07	1.4E-06	ND	7.8E-09	9.8E-09	ND	ND	ND	2.2E-06	2.1E-06	1.4E-07	2.5E-02	1.4E-02	2.9E-02	ND	---	6.7E-04	ND	ND	ND	0.07	No
EAR3-RA-31c-6	0.5	0.25	1.7	0.67	<0.024	0.11	0.11	<0.024	<0.028	<0.02	1.2E-07	8.1E-08	6.6E-07	ND	6.1E-09	4.9E-09	ND	ND	ND	8.7E-07	7.8E-07	9.2E-08	4.1E-03	9.0E-03	1.4E-02	ND	---	3.4E-04	ND	ND	ND	0.03	No
EAR3-RA-31d-06	0.5	1.6	3.1	2.3	<0.024	0.095	0.24	<0.024	<0.028	0.024	7.6E-07	1.5E-07	2.3E-06	ND	5.3E-09	1.1E-08	ND	ND	---	3.2E-06	3.0E-06	1.6E-07	2.6E-02	1.6E-02	4.7E-02	ND	---	7.4E-04	ND	ND	1.5E-04	0.09	No
EAR3-RA-31d-12	1	3.1	4.6	3.4	<0.047	0.13	0.13	<0.049	<0.057	<0.04	1.5E-06	2.2E-07	3.4E-06	ND	7.3E-09	5.8E-09	ND	ND	ND	5.1E-06	4.8E-06	2.3E-07	5.1E-02	2.4E-02	7.0E-02	ND	---	4.0E-04	ND	ND	ND	0.15	No
EAR3-RA-31e-06	0.5	0.54	2.2	1.3	<0.024	0.067	0.074	<0.024	<0.028	<0.02	2.6E-07	1.0E-07	1.3E-06	ND	3.7E-09	3.3E-09	ND	ND	ND	1.7E-06	1.5E-06	1.1E-07	8.9E-03	1.2E-02	2.7E-02	ND	---	2.3E-04	ND	ND	ND	0.05	No
EAR3-RA-31e-12	1	1.1	2.1	1.5	<0.024	0.095	0.097	<0.024	<0.028	<0.02	5.3E-07	1.0E-07	1.5E-06	ND	5.3E-09	4.3E-09	ND	ND	ND	2.1E-06	2.0E-06	1.1E-07	1.8E-02	1.1E-02	3.1E-02	ND	---	3.0E-04	ND	ND	ND	0.06	No
EAR3-RA-32a-06-1	0.5	0.43	1.6	1.2	<0.024	0.066	0.05	<0.024	<0.028	<0.02	2.1E-07	7.6E-08	1.2E-06	ND	3.7E-09	2.2E-09	ND	ND	ND	1.5E-06	1.4E-06	8.2E-08	7.1E-03	8.5E-03	2.5E-02	ND	---	1.5E-04	ND	ND	ND	0.04	No
EAR3-RA-32a-06-2	0.5	0.28	1.5	0.95	<0.024	0.048	0.11	<0.024	<0.028	<0.02	1.3E-07	7.1E-08	9.4E-07	ND	2.7E-09	4.9E-09	ND	ND	ND	1.1E-06	1.1E-06	7.9E-08	4.6E-03	7.9E-03	2.0E-02	ND	---	3.4E-04	ND	ND	ND	0.03	No
EAR3-RA-32a-06-3	0.5	0.19	1.2	0.68	<0.024	0.04	<0.04	<0.024	<0.028	<0.02	9.1E-08	5.7E-08	6.7E-07	ND	2.2E-09	ND	ND	ND	ND	8.2E-07	7.6E-07	5.9E-08	3.1E-03	6.4E-03	1.4E-02	ND	---	ND	ND	ND	ND	0.02	No
EAR3-RA-32a-12	1	0.48	1.7	1.2	0.025	0.095	0.1	<0.024	<0.028	0.024	2.3E-07	8.1E-08	1.2E-06	9.9E-10	5.3E-09	4.5E-09	ND	ND	---	1.5E-06	1.4E-06	9.2E-08	7.9E-03	9.0E-03	2.5E-02	---	---	3.1E-04	ND	ND	1.5E-04	0.04	No
EAR3-RA-32b-06	0.5	2.5	9	2.8	<0.024	0.11	0.21	<0.024	<0.028	<0.02	1.2E-06	4.3E-07	2.8E-06	ND	6.1E-09	9.4E-09	ND	ND	ND	4.4E-06	4.0E-06	4.4E-07	4.1E-02	4.8E-02	5.7E-02	ND	---	6.4E-04	ND	ND	ND	0.15	No
EAR3-RA-32b-12	1	3.7	9	2.3	<0.024	0.11	0.067	<0.024	<0.028	<0.02	1.8E-06	4.3E-07	2.3E-06	ND	6.1E-09	3.0E-09	ND	ND	ND	4.5E-06	4.0E-06	4.4E-07	6.1E-02	4.8E-02	4.7E-02	ND	---	2.1E-04	ND	ND	ND	0.16	No
EAR3-RA-32c-06	0.5	0.87	2.5	1.5	0.15	0.087	0.049	<0.024	<0.028	0.023	4.2E-07	1.2E-07	1.5E-06	5.9E-09	4.9E-09	2.2E-09	ND	ND	---	2.0E-06	1.9E-06	1.3E-07	1.4E-02	1.3E-02	3.1E-02	---	---	1.5E-04	ND	ND	1.5E-04	0.06	No
EAR3-RA-32c-12	1	2.2	4.4	2.3	0.15	0.13	0.053	<0.024	<0.028	0.052	1.1E-06	2.1E-07	2.3E-06	5.9E-09	7.3E-09	2.4E-09	ND	ND	---	3.5E-06	3.3E-06	2.3E-07	3.6E-02	2.3E-02	4.7E-02	---	---	1.6E-04	ND	ND	3.3E-04	0.11	No
EAR3-RA-32d-06	0.5	0.53	2.2	1.1	0.096	0.089	<0.04	<0.024	<0.028	<0.02	2.5E-07	1.0E-07	1.1E-06	3.8E-09	5.0E-09	ND	ND	ND	1.5E-06	1.3E-06	1.1E-07	8.7E-03	1.2E-02	2.3E-02	---	---	ND	ND	ND	ND	0.04	No	
EAR3-RA-32d-12	1	0.85	2.9	1.3	0.11	0.091	0.042	<0.024	<0.028	0.025	4.1E-07	1.4E-07	1.3E-06	4.3E-09	5.1E-09	1.9E-09	ND	ND	---	1.8E-06	1.7E-06	1.5E-07	1.4E-02	1.5E-02	2.7E-02	---	---	1.3E-04	ND	ND	1.6E-04	0.06	No
EAR3-RA-32e-06	0.5	1.8	2.9	2.4	<0.024	0.063	<0.04	<0.024	<0.028	0.037	8.6E-07	1.4E-07	2.4E-06	ND	3.5E-09	ND	ND	ND	---	3.4E-06	3.2E-06	1.4E-07	3.0E-02	1.5E-02	4.9E-02	ND	---	ND	ND	ND	2.4E-04	0.09	No
EAR3-RA-32e-12	1	4.8	4.1	4	<0.094	<0.095	<0.16	<0.098	<0.11	0.15	2.3E-06	2.0E-07	3.9E-06	ND	ND	ND	ND	---	6.4E-06	6.2E-06	2.0E-07	7.9E-02	2.2E-02	8.2E-02	ND	ND	ND	ND	ND	9.6E-04	0.18	No	
EAR3-RA-32F-06	0.5	0.74	1.2	1.1	<0.0094	0.061	0.056	<0.0098	<0.011	0.023	3.5E-07	5.7E-08	1.1E-06	ND	3.4E-09	2.5E-09	ND	ND	---	1.5E-06	1.4E-06	6.3E-08	1.2E-02	6.4E-03	2.3E-02	ND	---	1.7E-04	ND	ND	1.5E-04	0.04	No
EAR3-RA-32F-12	1	1.2	1.6	1.5	<0.024	0.062	0.055	<0.024	<0.028	0.058	5.7E-07	7.6E-08	1.5E-06	ND	3.5E-09	2.5E-09	ND	ND	---	2.1E-06	2.1E-06	8.2E-08	2.0E-02	8.5E-03	3.1E-02	ND	---	1.7E-04	ND	ND	3.7E-04	0.06	No
EAR3-RA-33a-06	0.5	6.7	3.5	3.9	0.12	0.2	0.43	<0.024	0.035	0.089	3.2E-06	1.7E-07	3.8E-06	4.7E-09	1.1E-08	1.9E-08	ND	---	7.2E-06	7.0E-06	2.0E-07	1.1E-01	1.9E-02	8.0E-02	---	---	1.3E-03	ND	2.2E-04	5.7E-04	0.21	No	
EAR3-RA-33a-12	1	3	1.2	1.7	0.035	0.065	0.1	<0.024	<0.028	0.055	1.4E-06	5.7E-08	1.7E-06	1.4E-09	3.6E-09	4.5E-09	ND	ND	---	3.2E-06	3.1E-06	6.7E-08	4.9E-02	6.4E-03	3.5E-02	---	---	3.1E-04	ND	ND	3.5E-04	0.09	No
EAR3-RA-33b-06	0.5	0.54	1.9	1.2	0.067	0.22	0.14	<0.024	0.039	<0.02	2.6E-07	9.1E-08	1.2E-06	2.6E-09	1.2E-08	6.3E-09	ND	---	1.6E-06	1.4E-06	1.1E-07	8.9E-03	1.0E-02	2.5E-02	---	---	4.3E-04	ND	2.5E-04	ND	0.04	No	
EAR3-RA-33b-12	1	10	2.9	4.9	0.089	0.063	0.1	<0.024	<0.028	<0.02	4.8E-06	1.4E-07	4.8E-06	3.5E-09	3.5E-09	4.5E-09	ND	ND	ND	9.8E-06	9.6E-06	1.5E-07	1.6E-01	1.5E-02	1.0E-01	---	---	3.1E-04	ND	ND	ND	0.28	No
EAR3-RA-33c-06-1	0.5	5.2	4.5	6.3	<0.12	<0.12	<0.2	<0.12	<0.14	0.12	2.5E-06	2.1E-07	6.2E-06	ND	ND	ND	ND	---	8.9E-06	8.7E-06	2.1E-07	8.5E-02	2.4E-02	1.3E-01	ND	ND	ND	ND	ND	7.7E-04	0.24	No	
EAR3-RA-33c-06-2	0.5	3.9	4	5.9	<0.12	<0.12	<0.2	<0.12	<0.14	0.1	1.9E-06	1.9E-07	5.8E-06	ND	ND	ND	ND	---	7.9E-06	7.7E-06	1.9E-07	6.4E-02	2.1E-02	1.2E-01	ND	ND	ND	ND	ND	6.4E-04	0.21	No	
EAR3-RA-33c-06-3	0.5	1.6	2.1	2.6	<0.024	0.033	0.062	<0.024	<0.028	0.061	7.6E-07	1.0E-07	2.6E-06	ND																			

TABLE E-4
Earhart I-3: Risk and Hazard Calculations - Adult Resident^a

Decision Unit	Depth (feet)	Analytical Results (mg/kg)									Adult Resident																	Exceed HDOH 2011 HC HHRE Standard? ^c							
		Aldrin	Chlordane	Dieldrin	4,4-DDD	4,4-DDE	4,4-DDT	Endosulfan sulfate	Endrin	Endrin Ketone	Cancer Risk									Noncancer Hazard															
											Aldrin	Chlordane	Dieldrin	4,4-DDD	4,4-DDE	4,4-DDT	Endosulfan sulfate	Endrin	Endrin Ketone	Cumulative Risk ^b			Aldrin	Chlordane	Dieldrin	4,4-DDD	4,4-DDE		4,4-DDT	Endosulfan sulfate	Endrin	Endrin Ketone	Hazard Index ^d		
Resident Adult - Cancer EALs (mg/kg)	209.4	209.8	101.4	253.6	179.0	223.7	---	---	---												All Chems	Aldrin and Dieldrin Only	No Aldrin or Dieldrin ^c												
Res. Adult - Noncancer EALs (mg/kg)	60.9	188.8	48.7	---	---	326.0	3130.5	156.5	156.5																										
EAR3-RA-42c-06	0.5	0.18	1.6	0.57	0.06	0.3	0.27	<0.0098	<0.011	<0.008	8.6E-08	7.6E-08	5.6E-07	2.4E-09	1.7E-08	1.2E-08	ND	ND	ND	7.6E-07	6.5E-07	1.1E-07	3.0E-03	8.5E-03	1.2E-02	---	---	8.3E-04	ND	ND	ND	0.02	No		
EAR3-RA-42c-12	1	0.12	1.9	0.33	0.062	0.33	0.34	<0.0098	<0.011	<0.008	5.7E-08	9.1E-08	3.3E-07	2.4E-09	1.8E-08	1.5E-08	ND	ND	ND	5.1E-07	3.8E-07	1.3E-07	2.0E-03	1.0E-02	6.8E-03	---	---	1.0E-03	ND	ND	ND	0.02	No		
EAR3-RA-42d-06	0.5	0.17	1	0.65	0.033	0.23	0.15	<0.024	<0.028	<0.02	8.1E-08	4.8E-08	6.4E-07	1.3E-09	1.3E-08	6.7E-09	ND	ND	ND	7.9E-07	7.2E-07	6.9E-08	2.8E-03	5.3E-03	1.3E-02	---	---	4.6E-04	ND	ND	ND	0.02	No		
EAR3-RA-42d-12	1	0.09	0.62	0.33	0.024	0.13	0.074	<0.0098	<0.011	<0.008	4.3E-08	3.0E-08	3.3E-07	9.5E-10	7.3E-09	3.3E-09	ND	ND	ND	4.1E-07	3.7E-07	4.1E-08	1.5E-03	3.3E-03	6.8E-03	---	---	2.3E-04	ND	ND	ND	0.01	No		
EAR3-RA-42e-06	0.5	0.063	0.7	0.32	<0.0094	0.082	0.084	<0.0098	<0.011	<0.008	3.0E-08	3.3E-08	3.2E-07	ND	4.6E-09	3.8E-09	ND	ND	ND	3.9E-07	3.5E-07	4.2E-08	1.0E-03	3.7E-03	6.6E-03	ND	---	2.6E-04	ND	ND	ND	0.01	No		
EAR3-RA-42e-12	1	0.029	1	0.13	<0.0094	0.33	0.17	<0.0098	<0.011	<0.008	1.4E-08	4.8E-08	1.3E-07	ND	1.8E-08	7.6E-09	ND	ND	ND	2.2E-07	1.4E-07	7.4E-08	4.8E-04	5.3E-03	2.7E-03	ND	---	5.2E-04	ND	ND	ND	0.01	No		
EAR3-RA-42f-06	0.5	0.27	0.97	0.71	0.046	0.083	0.065	<0.024	<0.028	<0.02	1.3E-07	4.6E-08	7.0E-07	1.8E-09	4.6E-09	2.9E-09	ND	ND	ND	8.8E-07	8.3E-07	5.6E-08	4.4E-03	5.1E-03	1.5E-02	---	---	2.0E-04	ND	ND	ND	0.02	No		
EAR3-RA-42f-12	1	0.11	0.51	0.35	<0.0094	0.033	0.042	<0.0098	<0.011	<0.008	5.3E-08	2.4E-08	3.5E-07	ND	1.8E-09	1.9E-09	ND	ND	ND	4.3E-07	4.0E-07	2.8E-08	1.8E-03	2.7E-03	7.2E-03	ND	---	1.3E-04	ND	ND	ND	0.01	No		
EAR3-RA-42g-06	0.5	0.2	1.1	0.63	0.036	0.074	0.063	<0.024	<0.028	<0.02	9.6E-08	5.2E-08	6.2E-07	1.4E-09	4.1E-09	2.8E-09	ND	ND	ND	7.8E-07	7.2E-07	6.1E-08	3.3E-03	5.8E-03	1.3E-02	---	---	1.9E-04	ND	ND	ND	0.02	No		
EAR3-RA-42g-12	1	0.024	1.3	0.092	0.0048	0.19	0.13	<0.002	<0.0023	<0.0016	1.1E-08	6.2E-08	9.1E-08	1.9E-10	1.1E-08	5.8E-09	ND	ND	ND	1.8E-07	1.0E-07	7.9E-08	3.9E-04	6.9E-03	1.9E-03	---	---	4.0E-04	ND	ND	ND	0.01	No		
EAR3-RA-42h-06	0.5	0.61	1.7	1.6	0.031	0.076	0.093	<0.024	<0.028	0.027	2.9E-07	8.1E-08	1.6E-06	1.2E-09	4.2E-09	4.2E-09	ND	ND	---	2.0E-06	1.9E-06	9.1E-08	1.0E-02	9.0E-03	3.3E-02	---	---	2.9E-04	ND	ND	1.7E-04	0.05	No		
EAR3-RA-42h-12	1	0.72	1.3	1.1	0.029	0.067	0.042	<0.024	<0.028	0.032	3.4E-07	6.2E-08	1.1E-06	1.1E-09	3.7E-09	1.9E-09	ND	ND	---	1.5E-06	1.4E-06	6.9E-08	1.2E-02	6.9E-03	2.3E-02	---	---	1.3E-04	ND	ND	2.0E-04	0.04	No		
EAR3-RA-42i-06	0.5	3.5	2.7	3.4	<0.047	0.075	0.093	<0.049	<0.057	0.12	1.7E-06	1.3E-07	3.4E-06	ND	4.2E-09	4.2E-09	ND	ND	---	5.2E-06	5.0E-06	1.4E-07	5.7E-02	1.4E-02	7.0E-02	ND	---	2.9E-04	ND	ND	7.7E-04	0.14	No		
EAR3-RA-42i-12	1	0.75	2	1.7	<0.024	0.045	<0.04	<0.024	<0.028	0.03	3.6E-07	9.5E-08	1.7E-06	ND	2.5E-09	ND	ND	ND	---	2.1E-06	2.0E-06	9.8E-08	1.2E-02	1.1E-02	3.5E-02	ND	---	ND	ND	ND	1.9E-04	0.06	No		
EAR3-RA-42j-06	0.5	0.34	1.5	1.1	<0.024	0.066	0.098	<0.024	<0.028	0.024	1.6E-07	7.1E-08	1.1E-06	ND	3.7E-09	4.4E-09	ND	ND	---	1.3E-06	1.2E-06	8.0E-08	5.6E-03	7.9E-03	2.3E-02	ND	---	3.0E-04	ND	ND	1.5E-04	0.04	No		
EAR3-RA-42j-12	1	0.36	1.5	1.2	<0.024	0.083	0.13	<0.024	<0.028	0.02	1.7E-07	7.1E-08	1.2E-06	ND	4.6E-09	5.8E-09	ND	ND	ND	1.4E-06	1.4E-06	8.2E-08	5.9E-03	7.9E-03	2.5E-02	ND	---	4.0E-04	ND	ND	ND	0.04	No		
EAR3-RA-42k-06	0.5	0.95	2.3	2.3	<0.024	0.071	0.11	<0.024	<0.028	0.057	4.5E-07	1.1E-07	2.3E-06	ND	4.0E-09	4.9E-09	ND	ND	---	2.8E-06	2.7E-06	1.2E-07	1.6E-02	1.2E-02	4.7E-02	ND	---	3.4E-04	ND	ND	3.6E-04	0.08	No		
EAR3-RA-42k-12	1	0.54	1.3	1.2	<0.024	0.069	0.088	<0.024	<0.028	0.023	2.6E-07	6.2E-08	1.2E-06	ND	3.9E-09	3.9E-09	ND	ND	---	1.5E-06	1.4E-06	7.0E-08	8.9E-03	6.9E-03	2.5E-02	ND	---	2.7E-04	ND	ND	1.5E-04	0.04	No		
EAR3-RA-42L-06	0.5	0.24	0.83	0.77	<0.024	0.025	<0.04	<0.024	<0.028	<0.02	1.1E-07	4.0E-08	7.6E-07	ND	1.4E-09	ND	ND	ND	---	9.1E-07	8.7E-07	4.1E-08	3.9E-03	4.4E-03	1.6E-02	ND	---	ND	ND	ND	ND	0.02	No		
EAR3-RA-42L-12	1	0.29	1.1	0.98	<0.0094	0.033	0.054	<0.0098	<0.011	0.019	1.4E-07	5.2E-08	9.7E-07	ND	1.8E-09	2.4E-09	ND	ND	---	1.2E-06	1.1E-06	5.7E-08	4.8E-03	5.8E-03	2.0E-02	ND	---	1.7E-04	ND	ND	1.2E-04	0.03	No		
EAR3-RA-4a-06	0.5	0.42	3.6	1.3	<0.024	0.1	0.14	<0.024	<0.028	<0.02	2.0E-07	1.7E-07	1.3E-06	ND	5.6E-09	6.3E-09	ND	ND	ND	1.7E-06	1.5E-06	1.8E-07	6.9E-03	1.9E-02	2.7E-02	ND	---	4.3E-04	ND	ND	ND	0.05	No		
EAR3-RA-4a-12	1	0.38	7.4	0.88	<0.024	0.18	0.16	<0.024	<0.028	<0.02	1.8E-07	3.5E-07	8.7E-07	ND	1.0E-08	7.2E-09	ND	ND	ND	1.4E-06	1.0E-06	3.7E-07	6.2E-03	3.9E-02	1.8E-02	ND	---	4.9E-04	ND	ND	ND	0.06	No		
EAR3-RA-4b-06	0.5	1.5	7.9	3.4	<0.047	0.18	0.39	<0.049	<0.057	0.042	7.2E-07	3.8E-07	3.4E-06	ND	1.0E-08	1.7E-08	ND	ND	---	4.5E-06	4.1E-06	4.0E-07	2.5E-02	4.2E-02	7.0E-02	ND	---	1.2E-03	ND	ND	2.7E-04	0.14	No		
EAR3-RA-4b-12	1	9.1	20	3.4	<0.19	<0.19	<0.32	<0.2	<0.23	<0.16	4.3E-06	9.5E-07	3.4E-06	ND	ND	ND	ND	ND	---	8.7E-06	7.7E-06	9.5E-07	1.5E-01	1.1E-01	7.0E-02	ND	ND	ND	ND	ND	ND	0.33	No		
EAR3-RA-5a-12	1	1.1	3.3	2.1	0.029	0.24	0.33	<0.024	<0.028	0.04	5.3E-07	1.6E-07	2.1E-06	1.1E-09	1.3E-08	1.5E-08	ND	ND	---	2.8E-06	2.6E-06	1.9E-07	1.8E-02	1.7E-02	4.3E-02	---	---	1.0E-03	ND	ND	2.6E-04	0.08	No		
EAR3-RA-5a-6-1	0.5	1	3	2	<0.024	0.19	0.14	<0.024	<0.028	0.034	4.8E-07	1.4E-07	2.0E-06	ND	1.1E-08	6.3E-09	ND	ND	---	2.6E-06	2.4E-06	1.6E-07	1.6E-02	1.6E-02	4.1E-02	ND	---	4.3E-04	ND	ND	2.2E-04	0.07	No		
EAR3-RA-5a-6-2	0.5	3.8	8.2	4.5	<0.094	0.16	<0.16	<0.098	<0.11	<0.08	1.8E-06	3.9E-07	4.4E-06	ND	8.9E-09	ND	ND	ND	---	6.7E-06	6.3E-06	4.0E-07	6.2E-02	4.3E-02	9.2E-02	ND	---	ND	ND	ND	ND	0.20	No		
EAR3-RA-5a-6-3	0.5	1.2	3.2	2.2	<0.024	0.15	0.14	<0.024	<0.028	0.034	5.7E-07	1.5E-07	2.2E-06	ND	8.4E-09	6.3E-09	ND	ND	---	2.9E-06	2.7E-06	1.7E-07	2.0E-02	1.7E-02	4.5E-02	ND	---	4.3E-04	ND	ND	2.2E-04	0.08	No		
EAR3-RA-5b-06	0.5	0.37	2.2	1.2	<0.024	0.14	0.12	<0.024	<0.028	<0.02	1.8E-07	1.0E-07	1.2E-06	ND	7.8E-09	5.4E-09	ND	ND	ND	1.5E-06	1.4E-06	1.2E-07	6.1E-03	1.2E-02	2.5E-02	ND	---	3.7E-04	ND	ND	ND	0.04	No		
EAR3-RA-5b-12	1	0.35	2.2	1	<0.024	0.086	0.087	<0.024	<0.028	<0.02	1.7E-07	1.0E-07	9.9E-07	ND	4.8E-09	3.9E-09	ND	ND	ND	1.3E-06	1.2E-06	1.1E-07	5.7E-03	1.2E-02	2.1E-02	ND	---	2.7E-04	ND	ND	ND	0.04	No		
EAR3-RA-6a-06	0.5	1.6	5.9	4.2	<0.047	0.1	0.55	<0.049	<0.057	0.085	7.6E-07	2.8E-07	4.1E-06	ND	5.6E-09	2.5E-08	ND	ND	---	5.2E-06	4.9E-06	3.1E-07	2.6E-02	3.1E-02	8.6E-02	ND	---	1.7E-03	ND	ND	5.4E-04	0.15	No		
EAR3-RA-6a-12	1	2.3	7.5	5	<0.094	0.097	<0.16	<0.098	<0.11	0.11	1.1E-06	3.6E-07	4.9E-06	ND	5.4E-09	ND	ND	ND	---	6.4E-06	6.0E-06	3.6E-07	3.8E-02	4.0E-02	1.0E-01	ND	---	ND	ND	ND	7.0E-04	0.18	No		
EAR3-RA-6b-06	0.5	0.68	2.4	1.5	<0.024	0.13	0.21	<0.024	<0.028	<0.02	3.2E-07	1.1E-07	1.5E-06	ND	7.3E-09	9.4E-09	ND	ND	ND	1.9E-06	1.8E-06	1.3E-07	1.1E-02	1.3E-02	3.1E-02	ND	---	6.4E-04	ND	ND	ND	0.06	No		
EAR3-RA-6b-12	1	0.79	2.9	2.1	<0.024	0.17	0.23	<0.024	<0.028	0.035	3.8E-07	1.4E-07	2.1E-06	ND	9.9E-09	1.0E-08	ND	ND	---	2.6E-06	2.4E-06	1.6E-07	1.3E-02	1.5E-02	4.3E-02	ND	---	7.1E-04	ND	ND	2.2E-04	0.07	No		
EAR3-RA-7a-06	0.5	0.21	6	0.87	0.027	0.34	1.5																												

**TABLE E-5
Onizuka II-1: Risk and Hazard Calculations - Child Resident**

Decision Unit	Depth (feet)	Analytical Results (mg/kg)						Child Resident															Exceed HDOH 2011 HC HHRE Standard? ^d	
		Aldrin	Chlordane	Dieldrin	4,4-DDD	4,4-DDE	4,4-DDT	Cancer Risk						Noncancer Hazard						Hazard Index ^c				
								Aldrin	Chlordane	Dieldrin	4,4-DDD	4,4-DDE	4,4-DDT	Cumulative Risk ^a			Aldrin	Chlordane	Dieldrin		4,4-DDD	4,4-DDE		4,4-DDT
Resident Child - Cancer EALs (mg/kg)	42.1	42.6	20.4	48.7	34.4	46.0																		
Res. Child - Noncancer EALs (mg/kg)	12.2	38.3	9.8	----	----	67.0								All Chems	Aldrin and Dieldrin Only	No Aldrin or Dieldrin ^b								
ONI-RA-1a-06-1	0.5	0.03	0.95	0.21	0.01	0.053	0.054	7.1E-08	2.2E-07	1.0E-06	2.1E-09	1.5E-08	1.2E-08	1.4E-06	1.1E-06	2.5E-07	2.5E-03	2.5E-02	2.1E-02	----	----	8.1E-04	0.05	No
ONI-RA-1a-06-2	0.5	0.041	1.4	0.21	<0.0047	0.032	0.036	9.7E-08	3.3E-07	1.0E-06	ND	9.3E-09	7.8E-09	1.5E-06	1.1E-06	3.5E-07	3.4E-03	3.7E-02	2.1E-02	ND	----	5.4E-04	0.06	No
ONI-RA-1a-06-3	0.5	0.034	0.9	0.18	<0.0047	0.032	0.04	8.1E-08	2.1E-07	8.8E-07	ND	9.3E-09	8.7E-09	1.2E-06	9.6E-07	2.3E-07	2.8E-03	2.3E-02	1.8E-02	ND	----	6.0E-04	0.05	No
ONI-RA-1a-12	1	0.034	0.77	0.14	<0.0047	0.017	0.03	8.1E-08	1.8E-07	6.9E-07	ND	4.9E-09	6.5E-09	9.6E-07	7.7E-07	1.9E-07	2.8E-03	2.0E-02	1.4E-02	ND	----	4.5E-04	0.04	No
ONI-RA-1b-06	0.5	0.053	1.5	0.21	0.014	0.06	0.059	1.3E-07	3.5E-07	1.0E-06	2.9E-09	1.7E-08	1.3E-08	1.5E-06	1.2E-06	3.9E-07	4.3E-03	3.9E-02	2.1E-02	----	----	8.8E-04	0.07	No
ONI-RA-1b-12	1	0.027	0.99	0.13	0.023	0.044	0.061	6.4E-08	2.3E-07	6.4E-07	4.7E-09	1.3E-08	1.3E-08	9.6E-07	7.0E-07	2.6E-07	2.2E-03	2.6E-02	1.3E-02	----	----	9.1E-04	0.04	No
ONI-RA-1c-06	0.5	0.075	4.1	0.31	<0.024	0.026	0.041	1.8E-07	9.6E-07	1.5E-06	ND	7.6E-09	8.9E-09	2.7E-06	1.7E-06	9.8E-07	6.1E-03	1.1E-01	3.2E-02	ND	----	6.1E-04	0.1	No
ONI-RA-1c-12	1	0.035	5.4	0.16	<0.024	<0.024	<0.04	8.3E-08	1.3E-06	7.8E-07	ND	ND	ND	2.1E-06	8.7E-07	1.3E-06	2.9E-03	1.4E-01	1.6E-02	ND	ND	ND	0.2	No
ONI-RA-2a-06	0.5	0.041	2.8	0.17	0.0056	0.089	0.099	9.7E-08	6.6E-07	8.3E-07	1.1E-09	2.6E-08	2.2E-08	1.6E-06	9.3E-07	7.1E-07	3.4E-03	7.3E-02	1.7E-02	----	----	1.5E-03	0.10	No
ONI-RA-2a-12	1	0.0089	3.2	0.07	<0.0047	0.055	0.062	2.1E-08	7.5E-07	3.4E-07	ND	1.6E-08	1.3E-08	1.1E-06	3.6E-07	7.8E-07	7.3E-04	8.4E-02	7.1E-03	ND	----	9.3E-04	0.09	No
ONI-RA-2b-06	0.5	0.13	4.7	0.45	<0.024	<0.024	0.046	3.1E-07	1.1E-06	2.2E-06	ND	ND	1.0E-08	3.6E-06	2.5E-06	1.1E-06	1.1E-02	1.2E-01	4.6E-02	ND	ND	6.9E-04	0.2	No
ONI-RA-2b-12	1	<0.022	5.5	0.067	<0.024	<0.024	0.064	ND	1.3E-06	3.3E-07	ND	ND	1.4E-08	1.6E-06	3.3E-07	1.3E-06	ND	1.4E-01	6.8E-03	ND	ND	9.6E-04	0.15	No
ONI-RA-2c-06	0.5	0.067	4.3	0.29	<0.0094	0.06	0.08	1.6E-07	1.0E-06	1.4E-06	ND	1.7E-08	1.7E-08	2.6E-06	1.6E-06	1.0E-06	5.5E-03	1.1E-01	3.0E-02	ND	----	1.2E-03	0.1	No
ONI-RA-2c-12	1	0.034	3.9	0.16	<0.0094	0.045	0.066	8.1E-08	9.2E-07	7.8E-07	ND	1.3E-08	1.4E-08	1.8E-06	8.7E-07	9.4E-07	2.8E-03	1.0E-01	1.6E-02	ND	----	9.9E-04	0.12	No
ONI-RA-2d-06	0.5	0.12	3.5	0.34	<0.024	<0.024	0.049	2.9E-07	8.2E-07	1.7E-06	ND	ND	1.1E-08	2.8E-06	2.0E-06	8.3E-07	9.8E-03	9.1E-02	3.5E-02	ND	ND	7.3E-04	0.1	No
ONI-RA-2d-12	1	0.034	3.4	0.1	<0.024	<0.024	<0.04	8.1E-08	8.0E-07	4.9E-07	ND	ND	ND	1.4E-06	5.7E-07	8.0E-07	2.8E-03	8.9E-02	1.0E-02	ND	ND	ND	0.10	No
ONI-RA-2e-06	0.5	0.019	2.3	0.14	<0.0094	0.051	0.056	4.5E-08	5.4E-07	6.9E-07	ND	1.5E-08	1.2E-08	1.3E-06	7.3E-07	5.7E-07	1.6E-03	6.0E-02	1.4E-02	ND	----	8.4E-04	0.08	No
ONI-RA-2e-12	1	0.011	0.8	0.076	<0.0047	0.063	0.051	2.6E-08	1.9E-07	3.7E-07	ND	1.8E-08	1.1E-08	6.2E-07	4.0E-07	2.2E-07	9.0E-04	2.1E-02	7.8E-03	ND	----	7.6E-04	0.03	No
ONI-RA-2f-06	0.5	0.044	1.7	0.19	<0.0047	0.033	0.034	1.0E-07	4.0E-07	9.3E-07	ND	9.6E-09	7.4E-09	1.5E-06	1.0E-06	4.2E-07	3.6E-03	4.4E-02	1.9E-02	ND	----	5.1E-04	0.07	No
ONI-RA-2f-12	1	0.028	1	0.066	<0.0047	0.022	0.023	6.7E-08	2.3E-07	3.2E-07	ND	6.4E-09	5.0E-09	6.4E-07	3.9E-07	2.5E-07	2.3E-03	2.6E-02	6.7E-03	ND	----	3.4E-04	0.04	No
ONI-RA-2g-06	0.5	0.32	3.7	0.86	<0.024	0.068	0.08	7.6E-07	8.7E-07	4.2E-06	ND	2.0E-08	1.7E-08	5.9E-06	5.0E-06	9.1E-07	2.6E-02	9.7E-02	8.8E-02	ND	----	1.2E-03	0.2	No
ONI-RA-2g-12	1	0.083	2.6	0.25	<0.0094	0.077	0.09	2.0E-07	6.1E-07	1.2E-06	ND	2.2E-08	2.0E-08	2.1E-06	1.4E-06	6.5E-07	6.8E-03	6.8E-02	2.6E-02	ND	----	1.3E-03	0.10	No
ONI-RA-2h-06	0.5	0.03	2.4	0.16	<0.0094	0.093	0.054	7.1E-08	5.6E-07	7.8E-07	ND	2.7E-08	1.2E-08	1.5E-06	8.6E-07	6.0E-07	2.5E-03	6.3E-02	1.6E-02	ND	----	8.1E-04	0.08	No
ONI-RA-2h-12	1	0.3	2.8	0.54	<0.024	0.15	0.063	7.1E-07	6.6E-07	2.6E-06	ND	4.4E-08	1.4E-08	4.1E-06	3.4E-06	7.1E-07	2.5E-02	7.3E-02	5.5E-02	ND	----	9.4E-04	0.2	No
ONI-RA-3a-06	0.5	0.076	1.1	0.24	<0.0047	0.021	0.033	1.8E-07	2.6E-07	1.2E-06	ND	6.1E-09	7.2E-09	1.6E-06	1.4E-06	2.7E-07	6.2E-03	2.9E-02	2.4E-02	ND	----	4.9E-04	0.06	No
ONI-RA-3a-12	1	0.056	2.4	0.14	<0.0047	0.038	0.039	1.3E-07	5.6E-07	6.9E-07	ND	1.1E-08	8.5E-09	1.4E-06	8.2E-07	5.8E-07	4.6E-03	6.3E-02	1.4E-02	ND	----	5.8E-04	0.08	No
ONI-RA-3b-06	0.5	0.099	1.3	0.36	0.011	0.064	0.08	2.4E-07	3.1E-07	1.8E-06	2.3E-09	1.9E-08	1.7E-08	2.3E-06	2.0E-06	3.4E-07	8.1E-03	3.4E-02	3.7E-02	----	----	1.2E-03	0.08	No
ONI-RA-3b-12	1	0.12	1.1	0.35	0.0098	0.064	0.061	2.9E-07	2.6E-07	1.7E-06	2.0E-09	1.9E-08	1.3E-08	2.3E-06	2.0E-06	2.9E-07	9.8E-03	2.9E-02	3.6E-02	----	----	9.1E-04	0.08	No
ONI-RA-3c-06	0.5	0.028	1.2	0.11	0.0078	0.068	0.095	6.7E-08	2.8E-07	5.4E-07	1.6E-09	2.0E-08	2.1E-08	9.3E-07	6.1E-07	3.2E-07	2.3E-03	3.1E-02	1.1E-02	----	----	1.4E-03	0.05	No
ONI-RA-3c-12	1	0.029	0.96	0.087	0.017	0.072	0.11	6.9E-08	2.3E-07	4.3E-07	3.5E-09	2.1E-08	2.4E-08	7.7E-07	5.0E-07	2.7E-07	2.4E-03	2.5E-02	8.9E-03	----	----	1.6E-03	0.04	No
ONI-RA-3d-06	0.5	0.027	1.7	0.082	<0.0047	0.022	0.03	6.4E-08	4.0E-07	4.0E-07	ND	6.4E-09	6.5E-09	8.8E-07	4.7E-07	4.1E-07	2.2E-03	4.4E-02	8.4E-03	ND	----	4.5E-04	0.06	No
ONI-RA-3d-12	1	0.095	2.7	0.21	<0.0047	0.036	0.055	2.3E-07	6.3E-07	1.0E-06	ND	1.0E-08	1.2E-08	1.9E-06	1.3E-06	6.6E-07	7.8E-03	7.0E-02	2.1E-02	ND	----	8.2E-04	0.10	No
ONI-RA-4a-06-1	0.5	0.042	1.1	0.14	<0.0047	0.017	0.029	1.0E-07	2.6E-07	6.9E-07	ND	4.9E-09	6.3E-09	1.1E-06	7.9E-07	2.7E-07	3.4E-03	2.9E-02	1.4E-02	ND	----	4.3E-04	0.05	No
ONI-RA-4a-06-2	0.5	0.043	1.2	0.13	<0.0047	0.013	0.029	1.0E-07	2.8E-07	6.4E-07	ND	3.8E-09	6.3E-09	1.0E-06	7.4E-07	2.9E-07	3.5E-03	3.1E-02	1.3E-02	ND	----	4.3E-04	0.05	No
ONI-RA-4a-06-3	0.5	0.033	1.3	0.13	<0.0047	0.022	0.03	7.8E-08	3.1E-07	6.4E-07	ND	6.4E-09	6.5E-09	1.0E-06	7.2E-07	3.2E-07	2.7E-03	3.4E-02	1.3E-02	ND	----	4.5E-04	0.05	No
ONI-RA-4a-12	1	0.015	0.88	0.062	<0.0047	<0.0048	0.033	3.6E-08	2.1E-07	3.0E-07	ND	ND	7.2E-09	5.5E-07	3.4E-07	2.1E-07	1.2E-03	2.3E-02	6.3E-03	ND	ND	4.9E-04	0.03	No
ONI-RA-4b-06	0.5	0.075	1.4	0.21	0.0057	0.04	0.064	1.8E-07	3.3E-07	1.0E-06	1.2E-09	1.2E-08	1.4E-08	1.6E-06	1.2E-06	3.6E-07	6.1E-03	3.7E-02	2.1E-02	----	----	9.6E-04	0.07	No
ONI-RA-4b-12	1	0.087	1.7	0.2	<0.0047	0.015	0.041	2.1E-07	4.0E-07	9.8E-07	ND	4.4E-09	8.9E-09	1.6E-06	1.2E-06	4.1E-07	7.1E-03	4.4E-02	2.0E-02	ND	----	6.1E-04	0.07	No
ONI-RA-4c-06	0.5	0.35	1.9	0.77	<0.024	<0.024	<0.04	8.3E-07	4.5E-07	3.8E-06	ND	ND	ND	5.1E-06	4.6E-06	4.5E-07	2.9E-02	5.0E-02	7.9E-02	ND	ND	ND	0.2	No
ONI-RA-4c-12	1	0.27	1.6	0.54	<0.024	<0.024	<0.04	6.4E-07	3.8E-07	2.6E-06	ND	ND	ND	3.7E-06	3.3E-06	3.8E-07	2.2E-02	4.2E-02	5.5E-02	ND	ND	ND	0.1	No
ONI-RA-5a-06	0.5	0.26	1.9	0.79	<0.024	0.079	0.063	6.2E-07	4.5E-07	3.9E-06	ND	2.3E-08	1.4E-08	5.0E-06	4.5E-06	4.8E-07	2.1E-02	5.0E-02	8.1E-02	ND	----	9.4E-04	0.2	No
ONI-RA-5a-12	1	0.54	2	0.98	<0.024	0.09	0.076	1.3E-06	4.7E-07	4.8E-06	ND	2.6E-08	1.7E-08	6.6E-06	6.1E-06	5.1E-07	4.4E-02	5.2E-02	1.0E-01	ND	----	1.1E-03	0.2	No
ONI-RA-5b-06	0.5	0.23	1.7	0.73	<0.024	0.051	0.048	5.5E-07	4.0E-07	3.6E-06	ND	1.5E-08	1.0E-08	4.5E-06	4.1E-06	4.2E-07	1.9E-02	4.4E-02	7.4E-02	ND	----	7.2E-04	0.1	No
ONI-RA-5b-12	1	0.3	1.9	0.82	<0.024	0.066	0.064	7.1E-07	4.5E-07	4.0E-06	ND	1.9E-08	1.4E-08	5.2E-06	4.7E-06	4.8E-07	2.5E-02	5.0E-02	8.4E-02	ND	----	9.6E-04	0.2	No
ONI-RA-5c-06	0.5	0.32	1.9	1	<0.024	0.051	0.04	7.6E-07	4.5E-07	4.9E-06	ND	1.5E-08	8.7E-09	6.1E-06	5.7E									

TABLE E-5
Onizuka II-1: Risk and Hazard Calculations - Child Resident

Notes:

^a Three cumulative risk numbers are presented to verify that cumulative risk levels meet all HDOH 2011 HC Human Health Risk Evaluation (HHRE) Standard (HDOH 2011) target risk criteria.

^b Listed cumulative risk is for all chemicals except aldrin and dieldrin.

^c The hazard index represents the sum of all chemical-specific hazard quotients (HQs).

^d The four criteria associated with the 2011 HHRE standard are as follows:

Criteria #1 - the cumulative excess cancer risk (ECR) for aldrin plus dieldrin must not exceed 1×10^{-4}

Criteria #2 - the cumulative ECR for all other organochlorine pesticides must not exceed 1×10^{-5}

Criteria #3 - the cumulative ECR for all chemicals of potential concern (COPCs) must not exceed 1×10^{-4}

Criteria #4 - the hazard index for all COPCs must not exceed 1.0.

Sources:

Hawai'i Department of Health (HDOH). 2011. Review of *Draft Preliminary Human Health Risk Evaluation Work Plan for Hickam Communities, Joint Base Pearl Harbor-Hickam*. 2011-303-ES. Letter from Eric Sadoyama HDOH to Roger Franklin, Actus Lend Lease LLC. June 7, 2011.

TABLE E-6
Onizuka II-1: Risk and Hazard Calculations - Adult Resident

Decision Unit	Depth (feet)	Analytical Results (mg/kg)						Adult Resident															Exceed HDOH 2011 HC HHRE Standard? ^d		
		Aldrin	Chlordane	Dieldrin	4,4-DDD	4,4-DDE	4,4-DDT	Cancer Risk						Noncancer Hazard						Hazard Index ^c					
								Aldrin	Chlordane	Dieldrin	4,4-DDD	4,4-DDE	4,4-DDT	Cumulative Risk ^a			Aldrin	Chlordane	Dieldrin		4,4-DDD	4,4-DDE		4,4-DDT	
Resident Adult - Cancer EALs (mg/kg)		209.4	209.8	101.4	253.6	179.0	223.7																		
Res. Adult - Noncancer EALs (mg/kg)		60.9	188.8	48.7	----	----	326.0																		
ONI-RA-1a-06-1	0.5	0.03	0.95	0.21	0.01	0.053	0.054	1.4E-08	4.5E-08	2.1E-07	3.9E-10	3.0E-09	2.4E-09	2.7E-07	2.2E-07	5.1E-08	4.9E-04	5.0E-03	4.3E-03	----	----	1.7E-04	0.010	No	
ONI-RA-1a-06-2	0.5	0.041	1.4	0.21	<0.0047	0.032	0.036	2.0E-08	6.7E-08	2.1E-07	ND	1.8E-09	1.6E-09	3.0E-07	2.3E-07	7.0E-08	6.7E-04	7.4E-03	4.3E-03	ND	----	1.1E-04	0.01	No	
ONI-RA-1a-06-3	0.5	0.034	0.9	0.18	<0.0047	0.032	0.04	1.6E-08	4.3E-08	1.8E-07	ND	1.8E-09	1.8E-09	2.4E-07	1.9E-07	4.6E-08	5.6E-04	4.8E-03	3.7E-03	ND	----	1.2E-04	0.009	No	
ONI-RA-1a-12	1	0.034	0.77	0.14	<0.0047	0.017	0.03	1.6E-08	3.7E-08	1.4E-07	ND	9.5E-10	1.3E-09	1.9E-07	1.5E-07	3.9E-08	5.6E-04	4.1E-03	2.9E-03	ND	----	9.2E-05	0.008	No	
ONI-RA-1b-06	0.5	0.053	1.5	0.21	0.014	0.06	0.059	2.5E-08	7.1E-08	2.1E-07	5.5E-10	3.4E-09	2.6E-09	3.1E-07	2.3E-07	7.8E-08	8.7E-04	7.9E-03	4.3E-03	----	----	1.8E-04	0.01	No	
ONI-RA-1b-12	1	0.027	0.99	0.13	0.023	0.044	0.061	1.3E-08	4.7E-08	1.3E-07	9.1E-10	2.5E-09	2.7E-09	1.9E-07	1.4E-07	5.3E-08	4.4E-04	5.2E-03	2.7E-03	----	----	1.9E-04	0.009	No	
ONI-RA-1c-06	0.5	0.075	4.1	0.31	<0.024	0.026	0.041	3.6E-08	2.0E-07	3.1E-07	ND	1.5E-09	1.8E-09	5.4E-07	3.4E-07	2.0E-07	1.2E-03	2.2E-02	6.4E-03	ND	----	1.3E-04	0.03	No	
ONI-RA-1c-12	1	0.035	5.4	0.16	<0.024	<0.024	<0.04	1.7E-08	2.6E-07	1.6E-07	ND	ND	ND	4.3E-07	1.7E-07	2.6E-07	5.7E-04	2.9E-02	3.3E-03	ND	ND	ND	0.03	No	
ONI-RA-2a-06	0.5	0.041	2.8	0.17	0.0056	0.089	0.099	2.0E-08	1.3E-07	1.7E-07	2.2E-10	5.0E-09	4.4E-09	3.3E-07	1.9E-07	1.4E-07	6.7E-04	1.5E-02	3.5E-03	----	----	3.0E-04	0.02	No	
ONI-RA-2a-12	1	0.0089	3.2	0.07	<0.0047	0.055	0.062	4.3E-09	1.5E-07	6.9E-08	ND	3.1E-09	2.8E-09	2.3E-07	7.3E-08	1.6E-07	1.5E-04	1.7E-02	1.4E-03	ND	----	1.9E-04	0.02	No	
ONI-RA-2b-06	0.5	0.13	4.7	0.45	<0.024	<0.024	0.046	6.2E-08	2.2E-07	4.4E-07	ND	ND	2.1E-09	7.3E-07	5.1E-07	2.3E-07	2.1E-03	2.5E-02	9.2E-03	ND	ND	1.4E-04	0.04	No	
ONI-RA-2b-12	1	<0.022	5.5	0.067	<0.024	<0.024	0.064	ND	2.6E-07	6.6E-08	ND	ND	2.9E-09	3.3E-07	6.6E-08	2.7E-07	ND	2.9E-02	1.4E-03	ND	ND	2.0E-04	0.03	No	
ONI-RA-2c-06	0.5	0.067	4.3	0.29	<0.0094	0.06	0.08	3.2E-08	2.0E-07	2.9E-07	ND	3.4E-09	3.6E-09	5.3E-07	3.2E-07	2.1E-07	1.1E-03	2.3E-02	6.0E-03	ND	----	2.5E-04	0.03	No	
ONI-RA-2c-12	1	0.034	3.9	0.16	<0.0094	0.045	0.066	1.6E-08	1.9E-07	1.6E-07	ND	2.5E-09	3.0E-09	3.7E-07	1.7E-07	1.9E-07	5.6E-04	2.1E-02	3.3E-03	ND	----	2.0E-04	0.02	No	
ONI-RA-2d-06	0.5	0.12	3.5	0.34	<0.024	<0.024	0.049	5.7E-08	1.7E-07	3.4E-07	ND	ND	2.2E-09	5.6E-07	3.9E-07	1.7E-07	2.0E-03	1.9E-02	7.0E-03	ND	ND	1.5E-04	0.03	No	
ONI-RA-2d-12	1	0.034	3.4	0.1	<0.024	<0.024	<0.04	1.6E-08	1.6E-07	9.9E-08	ND	ND	ND	2.8E-07	1.1E-07	1.6E-07	5.6E-04	1.8E-02	2.1E-03	ND	ND	ND	0.02	No	
ONI-RA-2e-06	0.5	0.019	2.3	0.14	<0.0094	0.051	0.056	9.1E-09	1.1E-07	1.4E-07	ND	2.8E-09	2.5E-09	2.6E-07	1.5E-07	1.1E-07	3.1E-04	1.2E-02	2.9E-03	ND	----	1.7E-04	0.02	No	
ONI-RA-2e-12	1	0.011	0.8	0.076	<0.0047	0.063	0.051	5.3E-09	3.8E-08	7.5E-08	ND	3.5E-09	2.3E-09	1.2E-07	8.0E-08	4.4E-08	1.8E-04	4.2E-03	1.6E-03	ND	----	1.6E-04	0.006	No	
ONI-RA-2f-06	0.5	0.044	1.7	0.19	<0.0047	0.033	0.034	2.1E-08	8.1E-08	1.9E-07	ND	1.8E-09	1.5E-09	2.9E-07	2.1E-07	8.4E-08	7.2E-04	9.0E-03	3.9E-03	ND	----	1.0E-04	0.01	No	
ONI-RA-2f-12	1	0.028	1	0.066	<0.0047	0.022	0.023	1.3E-08	4.8E-08	6.5E-08	ND	1.2E-09	1.0E-09	1.3E-07	7.8E-08	5.0E-08	4.6E-04	5.3E-03	1.4E-03	ND	----	7.1E-05	0.007	No	
ONI-RA-2g-06	0.5	0.32	3.7	0.86	<0.024	0.068	0.08	1.5E-07	1.8E-07	8.5E-07	ND	3.8E-09	3.6E-09	1.2E-06	1.0E-06	1.8E-07	5.3E-03	2.0E-02	1.8E-02	ND	----	2.5E-04	0.04	No	
ONI-RA-2g-12	1	0.083	2.6	0.25	<0.0094	0.077	0.09	4.0E-08	1.2E-07	2.5E-07	ND	4.3E-09	4.0E-09	4.2E-07	2.9E-07	1.3E-07	1.4E-03	1.4E-02	5.1E-03	ND	----	2.8E-04	0.02	No	
ONI-RA-2h-06	0.5	0.03	2.4	0.16	<0.0094	0.093	0.054	1.4E-08	1.1E-07	1.6E-07	ND	5.2E-09	2.4E-09	2.9E-07	1.7E-07	1.2E-07	4.9E-04	1.3E-02	3.3E-03	ND	----	1.7E-04	0.02	No	
ONI-RA-2h-12	1	0.3	2.8	0.54	<0.024	0.15	0.063	1.4E-07	1.3E-07	5.3E-07	ND	8.4E-09	2.8E-09	8.2E-07	6.8E-07	1.4E-07	4.9E-03	1.5E-02	1.1E-02	ND	----	1.9E-04	0.03	No	
ONI-RA-3a-06	0.5	0.076	1.1	0.24	<0.0047	0.021	0.033	3.6E-08	5.2E-08	2.4E-07	ND	1.2E-09	1.5E-09	3.3E-07	2.7E-07	5.5E-08	1.2E-03	5.8E-03	4.9E-03	ND	----	1.0E-04	0.01	No	
ONI-RA-3a-12	1	0.056	2.4	0.14	<0.0047	0.038	0.039	2.7E-08	1.1E-07	1.4E-07	ND	2.1E-09	1.7E-09	2.8E-07	1.6E-07	1.2E-07	9.2E-04	1.3E-02	2.9E-03	ND	----	1.2E-04	0.02	No	
ONI-RA-3b-06	0.5	0.099	1.3	0.36	0.011	0.064	0.08	4.7E-08	6.2E-08	3.6E-07	4.3E-10	3.6E-09	3.6E-09	4.7E-07	4.0E-07	7.0E-08	1.6E-03	6.9E-03	7.4E-03	----	----	2.5E-04	0.02	No	
ONI-RA-3b-12	1	0.12	1.1	0.35	0.0098	0.064	0.061	5.7E-08	5.2E-08	3.5E-07	3.9E-10	3.6E-09	2.7E-09	4.6E-07	4.0E-07	5.9E-08	2.0E-03	5.8E-03	7.2E-03	----	----	1.9E-04	0.02	No	
ONI-RA-3c-06	0.5	0.028	1.2	0.11	0.0078	0.068	0.095	1.3E-08	5.7E-08	1.1E-07	3.1E-10	3.8E-09	4.2E-09	1.9E-07	1.2E-07	6.6E-08	4.6E-04	6.4E-03	2.3E-03	----	----	2.9E-04	0.009	No	
ONI-RA-3c-12	1	0.029	0.96	0.087	0.017	0.072	0.11	1.4E-08	4.6E-08	8.6E-08	6.7E-10	4.0E-09	4.9E-09	1.6E-07	1.0E-07	5.5E-08	4.8E-04	5.1E-03	1.8E-03	----	----	3.4E-04	0.008	No	
ONI-RA-3d-06	0.5	0.027	1.7	0.082	<0.0047	0.022	0.03	1.3E-08	8.1E-08	8.1E-08	ND	1.2E-09	1.3E-09	1.8E-07	9.4E-08	8.4E-08	4.4E-04	9.0E-03	1.7E-03	ND	----	9.2E-05	0.011	No	
ONI-RA-3d-12	1	0.095	2.7	0.21	<0.0047	0.036	0.055	4.5E-08	1.3E-07	2.1E-07	ND	2.0E-09	2.5E-09	3.9E-07	2.5E-07	1.3E-07	1.6E-03	1.4E-02	4.3E-03	ND	----	1.7E-04	0.02	No	
ONI-RA-4a-06-1	0.5	0.042	1.1	0.14	<0.0047	0.017	0.029	2.0E-08	5.2E-08	1.4E-07	ND	9.5E-10	1.3E-09	2.1E-07	1.6E-07	5.5E-08	6.9E-04	5.8E-03	2.9E-03	ND	----	8.9E-05	0.009	No	
ONI-RA-4a-06-2	0.5	0.043	1.2	0.13	<0.0047	0.013	0.029	2.1E-08	5.7E-08	1.3E-07	ND	7.3E-10	1.3E-09	2.1E-07	1.5E-07	5.9E-08	7.1E-04	6.4E-03	2.7E-03	ND	----	8.9E-05	0.010	No	
ONI-RA-4a-06-3	0.5	0.033	1.3	0.13	<0.0047	0.022	0.03	1.6E-08	6.2E-08	1.3E-07	ND	1.2E-09	1.3E-09	2.1E-07	1.4E-07	6.5E-08	5.4E-04	6.9E-03	2.7E-03	ND	----	9.2E-05	0.010	No	
ONI-RA-4a-12	1	0.015	0.88	0.062	<0.0047	<0.0048	0.033	7.2E-09	4.2E-08	6.1E-08	ND	ND	1.5E-09	1.1E-07	6.8E-08	4.3E-08	2.5E-04	4.7E-03	1.3E-03	ND	ND	1.0E-04	0.006	No	
ONI-RA-4b-06	0.5	0.075	1.4	0.21	0.0057	0.04	0.064	3.6E-08	6.7E-08	2.1E-07	2.2E-10	2.2E-09	2.9E-09	3.1E-07	2.4E-07	7.2E-08	1.2E-03	7.4E-03	4.3E-03	----	----	2.0E-04	0.01	No	
ONI-RA-4b-12	1	0.087	1.7	0.2	<0.0047	0.015	0.041	4.2E-08	8.1E-08	2.0E-07	ND	8.4E-10	1.8E-09	3.2E-07	2.4E-07	8.4E-08	1.4E-03	9.0E-03	4.1E-03	ND	----	1.3E-04	0.01	No	
ONI-RA-4c-06	0.5	0.35	1.9	0.77	<0.024	<0.024	<0.04	1.7E-07	9.1E-08	7.6E-07	ND	ND	ND	1.0E-06	9.3E-07	9.1E-08	5.7E-03	1.0E-02	1.6E-02	ND	ND	ND	0.03	No	
ONI-RA-4c-12	1	0.27	1.6	0.54	<0.024	<0.024	<0.04	1.3E-07	7.6E-08	5.3E-07	ND	ND	ND	7.4E-07	6.6E-07	7.6E-08	4.4E-03	8.5E-03	1.1E-02	ND	ND	ND	0.02	No	
ONI-RA-5a-06	0.5	0.26	1.9	0.79	<0.024	0.079	0.063																		

TABLE E-6
Onizuka II-1: Risk and Hazard Calculations - Adult Resident

Notes:

^a Three cumulative risk numbers are presented to verify that cumulative risk levels meet all HDOH 2011 HC Human Health Risk Evaluation (HHRE) Standard (HDOH 2011) target risk criteria.

^b Listed cumulative risk is for all chemicals except aldrin and dieldrin.

^c The hazard index represents the sum of all chemical-specific hazard quotients (HQs).

^d The four criteria associated with the 2011 HHRE standard are as follows:

Criteria #1 - the cumulative excess cancer risk (ECR) for aldrin plus dieldrin must not exceed 1×10^{-4}

Criteria #2 - the cumulative ECR for all other organochlorine pesticides must not exceed 1×10^{-5}

Criteria #3 - the cumulative ECR for all chemicals of potential concern (COPCs) must not exceed 1×10^{-4}

Criteria #4 - the hazard index for all COPCs must not exceed 1.0.

Sources:

Hawai'i Department of Health (HDOH). 2011. Review of *Draft Preliminary Human Health Risk Evaluation Work Plan for Hickam Communities, Joint Base Pearl Harbor-Hickam*. 2011-303-ES. Letter from Eric Sadoyama HDOH to Roger Franklin, Actus Lend Lease LLC. June 7, 2011.

**TABLE E-7
Hale Na Koa I-1: Risk and Hazard Calculations - Child Resident**

Decision Unit	Depth (feet)	Analytical Results (mg/kg)					Child Resident															Exceed HDOH 2011 HC HHRE Standard? ^d
		Chlordane	Dieldrin	4,4-DDE	4,4-DDT	Endrin	Cancer Risk					Noncancer Hazard					Hazard Index ^c					
							Chlordane	Dieldrin	4,4-DDE	4,4-DDT	Endrin	Cumulative Risk ^a			Chlordane	Dieldrin		4,4-DDE	4,4-DDT	Endrin		
Resident Child - Cancer EALs (mg/kg)	Res. Child - Noncancer EALs (mg/kg)											All Chems	Aldrin and Dieldrin Only	No Aldrin or Dieldrin ^b								
HNK-OA-1-06	0.5	5.8	0.04	0.045	0.03	<0.0057	1.4E-06	2.0E-07	1.3E-08	6.5E-09	ND	1.6E-06	2.0E-07	1.4E-06	1.5E-01	4.1E-03	----	4.5E-04	ND	0.16	No	
HNK-OA-1-12	1	6.5	0.043	0.046	0.034	<0.0057	1.5E-06	2.1E-07	1.3E-08	7.4E-09	ND	1.8E-06	2.1E-07	1.5E-06	1.7E-01	4.4E-03	----	5.1E-04	ND	0.17	No	
HNK-OA-2-06-1	0.5	7.3	0.029	0.034	<0.04	<0.028	1.7E-06	1.4E-07	9.9E-09	ND	ND	1.9E-06	1.4E-07	1.7E-06	1.9E-01	3.0E-03	----	ND	ND	0.19	No	
HNK-OA-2-06-2	0.5	4	0.016	0.026	0.037	<0.011	9.4E-07	7.8E-08	7.6E-09	8.0E-09	ND	1.0E-06	7.8E-08	9.5E-07	1.0E-01	1.6E-03	----	5.5E-04	ND	0.11	No	
HNK-OA-2-06-3	0.5	5.9	0.024	0.032	0.032	<0.011	1.4E-06	1.2E-07	9.3E-09	7.0E-09	ND	1.5E-06	1.2E-07	1.4E-06	1.5E-01	2.4E-03	----	4.8E-04	ND	0.16	No	
HNK-OA-2-12	1	17	0.04	<0.024	0.065	<0.028	4.0E-06	2.0E-07	ND	1.4E-08	ND	4.2E-06	2.0E-07	4.0E-06	4.4E-01	4.1E-03	ND	9.7E-04	ND	0.45	No	
HNK-OA-3-06	0.5	5.9	0.038	0.037	0.092	<0.011	1.4E-06	1.9E-07	1.1E-08	2.0E-08	ND	1.6E-06	1.9E-07	1.4E-06	1.5E-01	3.9E-03	----	1.4E-03	ND	0.16	No	
HNK-OA-3-12	1	9.8	0.056	0.069	0.11	<0.011	2.3E-06	2.7E-07	2.0E-08	2.4E-08	ND	2.6E-06	2.7E-07	2.3E-06	2.6E-01	5.7E-03	----	1.6E-03	ND	0.26	No	
HNK-OA-4-06	0.5	6.1	0.044	0.043	0.042	<0.011	1.4E-06	2.2E-07	1.3E-08	9.1E-09	ND	1.7E-06	2.2E-07	1.5E-06	1.6E-01	4.5E-03	----	6.3E-04	ND	0.16	No	
HNK-OA-4-12	1	7.4	0.062	0.045	0.039	<0.011	1.7E-06	3.0E-07	1.3E-08	8.5E-09	ND	2.1E-06	3.0E-07	1.8E-06	1.9E-01	6.3E-03	----	5.8E-04	ND	0.20	No	
HNK-OA-5-06	0.5	2.3	0.019	0.032	<0.016	<0.011	5.4E-07	9.3E-08	9.3E-09	ND	ND	6.4E-07	9.3E-08	5.5E-07	6.0E-02	1.9E-03	----	ND	ND	0.06	No	
HNK-OA-5-12	1	5.7	0.049	0.065	0.035	<0.011	1.3E-06	2.4E-07	1.9E-08	7.6E-09	ND	1.6E-06	2.4E-07	1.4E-06	1.5E-01	5.0E-03	----	5.2E-04	ND	0.15	No	
HNK-OA-6-06	0.5	6.8	0.04	0.11	0.071	<0.011	1.6E-06	2.0E-07	3.2E-08	1.5E-08	ND	1.8E-06	2.0E-07	1.6E-06	1.8E-01	4.1E-03	----	1.1E-03	ND	0.18	No	
HNK-OA-7-06	0.5	3.3	0.02	0.24	0.1	<0.011	7.7E-07	9.8E-08	7.0E-08	2.2E-08	ND	9.6E-07	9.8E-08	8.7E-07	8.6E-02	2.0E-03	----	1.5E-03	ND	0.09	No	
HNK-OA-8-06	0.5	3.1	0.017	0.051	0.026	<0.011	7.3E-07	8.3E-08	1.5E-08	5.7E-09	ND	8.3E-07	8.3E-08	7.5E-07	8.1E-02	1.7E-03	----	3.9E-04	ND	0.08	No	
HNK-OA-9-06	0.5	1.8	0.014	0.028	<0.016	0.011	4.2E-07	6.9E-08	8.1E-09	ND	----	5.0E-07	6.9E-08	4.3E-07	4.7E-02	1.4E-03	----	ND	3.7E-04	0.05	No	
HNK-OA-10-06	0.5	3.8	0.026	0.047	0.07	<0.011	8.9E-07	1.3E-07	1.4E-08	1.5E-08	ND	1.0E-06	1.3E-07	9.2E-07	9.9E-02	2.7E-03	----	1.0E-03	ND	0.10	No	
HNK-OA-11-06-1	0.5	2.2	0.018	0.017	0.016	<0.011	5.2E-07	8.8E-08	4.9E-09	3.5E-09	ND	6.1E-07	8.8E-08	5.2E-07	5.7E-02	1.8E-03	----	2.4E-04	ND	0.06	No	
HNK-OA-11-06-2	0.5	1.9	0.016	0.011	<0.016	<0.011	4.5E-07	7.8E-08	3.2E-09	ND	ND	5.3E-07	7.8E-08	4.5E-07	5.0E-02	1.6E-03	----	ND	ND	0.05	No	
HNK-OA-11-06-3	0.5	1.9	0.012	0.025	<0.016	<0.011	4.5E-07	5.9E-08	7.3E-09	ND	ND	5.1E-07	5.9E-08	4.5E-07	5.0E-02	1.2E-03	----	ND	ND	0.05	No	

Notes:

^a Three cumulative risk numbers are presented to verify that cumulative risk levels meet all HDOH 2011 HC Human Health Risk Evaluation (HHRE) Standard (HDOH 2011) target risk criteria.

^b Listed cumulative risk is for all chemicals except aldrin and dieldrin.

^c The hazard index represents the sum of all chemical-specific hazard quotients (HQs).

^d The four criteria associated with the 2011 HHRE standard are as follows:

Criteria #1 - the cumulative excess cancer risk (ECR) for aldrin plus dieldrin must not exceed 1×10^{-4}

Criteria #2 - the cumulative ECR for all other organochlorine pesticides must not exceed 1×10^{-5}

Criteria #3 - the cumulative ECR for all chemicals of potential concern (COPCs) must not exceed 1×10^{-4}

Criteria #4 - the hazard index for all COPCs must not exceed 1.0.

Sources:

Hawai'i Department of Health (HDOH). 2011. Review of *Draft Preliminary Human Health Risk Evaluation Work Plan for Hickam Communities, Joint Base Pearl Harbor-Hickam*. 2011-303-ES. Letter from Eric Sadoyama HDOH to Roger Franklin, Actus Lend Lease LLC. June 7, 2011.

**TABLE E-8
Hale Na Koa I-1: Risk and Hazard Calculations - Adult Resident**

Decision Unit	Depth (feet)	Analytical Results (mg/kg)					Adult Resident														Exceed HDOH 2011 HC HHRE Standard? ^d				
		Chlordane	Dieldrin	4,4-DDE	4,4-DDT	Endrin	Cancer Risk					Noncancer Hazard													
							Chlordane	Dieldrin	4,4-DDE	4,4-DDT	Endrin	Cumulative Risk ^a			Chlordane	Dieldrin	4,4-DDE	4,4-DDT	Endrin	Hazard Index ^c					
Resident Adult - Cancer EALs (mg/kg)	209.8	101.4	179.0	223.7	----																				
Res. Adult - Noncancer EALs (mg/kg)	188.8	48.7	----	326.0	156.5																				
HNK-OA-1-06	0.5	5.8	0.04	0.045	0.03	<0.0057	2.8E-07	3.9E-08	2.5E-09	1.3E-09	ND	3.2E-07	3.9E-08	2.8E-07	3.1E-02	8.2E-04	----	9.2E-05	ND	0.03	No				
HNK-OA-1-12	1	6.5	0.043	0.046	0.034	<0.0057	3.1E-07	4.2E-08	2.6E-09	1.5E-09	ND	3.6E-07	4.2E-08	3.1E-07	3.4E-02	8.8E-04	----	1.0E-04	ND	0.04	No				
HNK-OA-2-06-1	0.5	7.3	0.029	0.034	<0.04	<0.028	3.5E-07	2.9E-08	1.9E-09	ND	ND	3.8E-07	2.9E-08	3.5E-07	3.9E-02	6.0E-04	----	ND	ND	0.0	No				
HNK-OA-2-06-2	0.5	4	0.016	0.026	0.037	<0.011	1.9E-07	1.6E-08	1.5E-09	1.7E-09	ND	2.1E-07	1.6E-08	1.9E-07	2.1E-02	3.3E-04	----	1.1E-04	ND	0.0	No				
HNK-OA-2-06-3	0.5	5.9	0.024	0.032	0.032	<0.011	2.8E-07	2.4E-08	1.8E-09	1.4E-09	ND	3.1E-07	2.4E-08	2.8E-07	3.1E-02	4.9E-04	----	9.8E-05	ND	0.03	No				
HNK-OA-2-12	1	17	0.04	<0.024	0.065	<0.028	8.1E-07	3.9E-08	ND	2.9E-09	ND	8.5E-07	3.9E-08	8.1E-07	9.0E-02	8.2E-04	ND	2.0E-04	ND	0.09	No				
HNK-OA-3-06	0.5	5.9	0.038	0.037	0.092	<0.011	2.8E-07	3.7E-08	2.1E-09	4.1E-09	ND	3.2E-07	3.7E-08	2.9E-07	3.1E-02	7.8E-04	----	2.8E-04	ND	0.0	No				
HNK-OA-3-12	1	9.8	0.056	0.069	0.11	<0.011	4.7E-07	5.5E-08	3.9E-09	4.9E-09	ND	5.3E-07	5.5E-08	4.8E-07	5.2E-02	1.1E-03	----	3.4E-04	ND	0.05	No				
HNK-OA-4-06	0.5	6.1	0.044	0.043	0.042	<0.011	2.9E-07	4.3E-08	2.4E-09	1.9E-09	ND	3.4E-07	4.3E-08	3.0E-07	3.2E-02	9.0E-04	----	1.3E-04	ND	0.0	No				
HNK-OA-4-12	1	7.4	0.062	0.045	0.039	<0.011	3.5E-07	6.1E-08	2.5E-09	1.7E-09	ND	4.2E-07	6.1E-08	3.6E-07	3.9E-02	1.3E-03	----	1.2E-04	ND	0.04	No				
HNK-OA-5-06	0.5	2.3	0.019	0.032	<0.016	<0.011	1.1E-07	1.9E-08	1.8E-09	ND	ND	1.3E-07	1.9E-08	1.1E-07	1.2E-02	3.9E-04	----	ND	ND	0.0	No				
HNK-OA-5-12	1	5.7	0.049	0.065	0.035	<0.011	2.7E-07	4.8E-08	3.6E-09	1.6E-09	ND	3.3E-07	4.8E-08	2.8E-07	3.0E-02	1.0E-03	----	1.1E-04	ND	0.03	No				
HNK-OA-6-06	0.5	6.8	0.04	0.11	0.071	<0.011	3.2E-07	3.9E-08	6.1E-09	3.2E-09	ND	3.7E-07	3.9E-08	3.3E-07	3.6E-02	8.2E-04	----	2.2E-04	ND	0.04	No				
HNK-OA-7-06	0.5	3.3	0.02	0.24	0.1	<0.011	1.6E-07	2.0E-08	1.3E-08	4.5E-09	ND	1.9E-07	2.0E-08	1.8E-07	1.7E-02	4.1E-04	----	3.1E-04	ND	0.02	No				
HNK-OA-8-06	0.5	3.1	0.017	0.051	0.026	<0.011	1.5E-07	1.7E-08	2.8E-09	1.2E-09	ND	1.7E-07	1.7E-08	1.5E-07	1.6E-02	3.5E-04	----	8.0E-05	ND	0.02	No				
HNK-OA-9-06	0.5	1.8	0.014	0.028	<0.016	0.011	8.6E-08	1.4E-08	1.6E-09	ND	----	1.0E-07	1.4E-08	8.7E-08	9.5E-03	2.9E-04	----	ND	7.0E-05	0.01	No				
HNK-OA-10-06	0.5	3.8	0.026	0.047	0.07	<0.011	1.8E-07	2.6E-08	2.6E-09	3.1E-09	ND	2.1E-07	2.6E-08	1.9E-07	2.0E-02	5.3E-04	----	2.1E-04	ND	0.0	No				
HNK-OA-11-06-1	0.5	2.2	0.018	0.017	0.016	<0.011	1.0E-07	1.8E-08	9.5E-10	7.2E-10	ND	1.2E-07	1.8E-08	1.1E-07	1.2E-02	3.7E-04	----	4.9E-05	ND	0.01	No				
HNK-OA-11-06-2	0.5	1.9	0.016	0.011	<0.016	<0.011	9.1E-08	1.6E-08	6.1E-10	ND	ND	1.1E-07	1.6E-08	9.1E-08	1.0E-02	3.3E-04	----	ND	ND	0.01	No				
HNK-OA-11-06-3	0.5	1.9	0.012	0.025	<0.016	<0.011	9.1E-08	1.2E-08	1.4E-09	ND	ND	1.0E-07	1.2E-08	9.2E-08	1.0E-02	2.5E-04	----	ND	ND	0.0	No				

Notes:

^a Three cumulative risk numbers are presented to verify that cumulative risk levels meet all HDOH 2011 HC Human Health Risk Evaluation (HHRE) Standard (HDOH 2011) target risk criteria.

^b Listed cumulative risk is for all chemicals except aldrin and dieldrin.

^c The hazard index represents the sum of all chemical-specific hazard quotients (HQs).

^d The four criteria associated with the 2011 HHRE standard are as follows:

Criteria #1 - the cumulative excess cancer risk (ECR) for aldrin plus dieldrin must not exceed 1×10^{-4}

Criteria #2 - the cumulative ECR for all other organochlorine pesticides must not exceed 1×10^{-5}

Criteria #3 - the cumulative ECR for all chemicals of potential concern (COPCs) must not exceed 1×10^{-4}

Criteria #4 - the hazard index for all COPCs must not exceed 1.0.

Sources:

Hawai'i Department of Health (HDOH). 2011. Review of *Draft Preliminary Human Health Risk Evaluation Work Plan for Hickam Communities, Joint Base Pearl Harbor-Hickam*. 2011-303-ES. Letter from Eric Sadoyama HDOH to Roger Franklin, Actus Lend Lease LLC. June 7, 2011.

APPENDIX F

Hazard and Dose Response Assessment of Chlordane



TETRA TECH

Hazard and Dose Response Assessment of Chlordane

January 13, 2012

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CLEAR SOLUTIONS™

Hazard and Dose Response Assessment of Chlordane

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EXECUTIVE SUMMARY

Chlordane was first produced in 1947 and was used as an insecticide for agricultural crops and livestock, for lawns and gardens, and also for underground treatment around the foundation of homes. In 1978, because of concern over cancer risk, evidence of human exposure and danger to wildlife, EPA canceled its use on food crops and phased out its other above-ground uses. From 1983 to 1988 its only approved use was as a termiticide around home foundations, and all uses were canceled after 1988. However, residues still exist in soils and sediments and chlordane bioaccumulates in fatty tissue of fish and humans; this bioaccumulation is a source of current concern (U.S. EPA 1997).

Using the 1996 Proposed Guidelines for Carcinogen Risk Assessment, the U.S. EPA (1997) characterized chlordane as a likely carcinogen in humans. The National Toxicology Program (2011) does not consider chlordane to be a human carcinogen or to be reasonably anticipated to be a human carcinogen. The International Agency for Research on Cancer (IARC)(2001) determined that the available epidemiological data on chlordane were inadequate to evaluate human cancer risk but that there was sufficient evidence from experimental animals to conclude that chlordane was possibly carcinogenic to humans (Group 2B). Chlordane is not genotoxic (WHO 2008; IARC 2001).

U.S. EPA (1997) estimated an oral Cancer Slope Factor for chlordane of $0.35 \text{ (mg/kg-day)}^{-1}$, based on the geometric mean of the slope factors from five individual data sets. U.S. EPA (1997) derived a Reference Dose (RfD) value for noncancer endpoints (hepatic necrosis) for chlordane of 0.0005 mg/kg-day.

Animal and epidemiology studies published since 1997 offer no evidence that would change the RfD or cancer slope factor estimates described above. However, since the 1997 assessment was conducted, the methodology for quantitative risk assessment has changed, and an RfD and Cancer Slope Factor using this new methodology (Benchmark Dose) have been calculated. The current report updates the literature review of the potential health effects of chlordane in human and animals and describes the results of risk quantification based on the current U.S. EPA (2005) guidelines for cancer and non-cancer endpoints. For both endpoint types (cancer and noncancer) the estimate of risk was increased compared to 1997 estimates.

1.0 INTRODUCTION

This report is organized into two major sections - cancer and noncancer. The cancer and noncancer sections include descriptions of existing hazard evaluations and dose response assessments on chlordane. The sections also include a review of the scientific literature published between January 1997 and July 2011 that was not described in the IARC (2001) review. 1997 was selected as the beginning date of the search since that was the year of the U.S. EPA assessment on chlordane. In addition, the quantitative analyses for cancer and noncancer endpoints (cancer slope factor and reference dose, respectively) have been recalculated using modern benchmark dose modeling methods. Each section concludes with a discussion.

2.0 CANCER

2.1 Hazard Evaluations

2.1.1 U.S. EPA (1997)

U.S. EPA characterized chlordane as a likely carcinogen in humans, based on inadequate evidence of carcinogenicity in human studies, sufficient evidence of hepatocellular carcinomas in multiple mice strains, and several toxicological responses believed to play a role in carcinogenesis. The U.S. EPA stated that the cancer slope factor for oral ingestion was 0.35 mg/(kg-day).

2.1.2 IARC (2001)

IARC (2001) concluded that the evidence of carcinogenicity in humans was inadequate but that the evidence of carcinogenicity in animals was sufficient and thus classified chlordane in Group 2B (*possibly carcinogenic to humans*).

2.1.3 ATSDR (1994)

ATSDR does not classify substances as to their carcinogenic potential in the manner of U.S. EPA, IARC, or NTP but does state in its ToxFAQs (ATSDR 1995) that, "Studies of workers who made or used chlordane do not show that exposure to chlordane is related to cancer, but the information is not sufficient to know for sure."

2.1.4 NTP (2011)

The NTP 12th Report on Carcinogens does not list chlordane as either "known to be a human carcinogen" or "reasonably anticipated to be a human carcinogen."

2.1.5 WHO (2008)

The 3rd edition of the World Health Organization Drinking Water Guidelines states that chlordane produces liver tumors in mice, but that it is not genotoxic. Chlordane can interfere with cell communication *in vitro*, a characteristic of many tumor promoters.

2.2 Data Published Since 1997

The scientific literature since 1997 was searched utilizing the PubMed and Toxline databases for any articles on chlordane related to exposure, cancer, mortality and disease in humans. The following search terms were used: (chlordane) AND ((epidemiological studies) OR cancer OR neoplasm OR carcinogenic OR tumor). One hundred sixty-nine (169) potentially relevant references were identified. These references were further screened to identify studies of carcinogenicity related to exposure to chlordane in humans or animals. *In vitro* studies, environmental and wildlife monitoring reports, and studies of mixtures with other compounds in animals were excluded. Studies that have been reviewed by IARC (2001) were also excluded. Of the remaining studies, 23 references considered useful for further evaluation of carcinogenic effects of chlordane were identified. No animal studies examining the potential carcinogenicity of chlordane published since 1997 were identified.

2.2.1 Human Data

Between 1997 and 2011, 23 epidemiologic studies were identified that assessed various cancer outcomes including non-Hodgkin's lymphoma, leukemia, pancreatic cancer, gastric cancer, rectal cancer, breast cancer, endometrial cancer, prostate cancer, and testicular cancer following exposure to chlordane. The cancer epidemiologic studies are described in more detail in Appendix A.

2.2.1.1 Non-Hodgkin's Lymphoma

Eight case control studies investigated the potential association of chlordane exposure and non-Hodgkin's lymphoma (NHL) (Cantor et al. 2003; Cocco et al. 2008; Colt et al. 2006; Colt et al. 2009; McDuffie et al. 2001; Purdue et al. 2007; Quintana et al. 2004; Schroeder et al. 2001; Spirelli et al. 2007). Four of these studies measured chlordane and its metabolites in human tissues, two studies determined exposure in household dust, and two studies relied on subjects' self-reports of prior exposures.

Cantor et al. (2003) measured several organochlorine pesticides in the serum of 74 NHL patients and 147 matched controls. There was no evidence of an association between NHL risk and serum levels of any of the compounds measured including chlordane, its metabolite oxychlordane, or the congener *trans*-nonachlor. Cocco et al. (2008) measured plasma levels of PCBs and organochlorine pesticides in 174 NHL patients and 203 controls. None of the plasma samples had a detectable oxychlordane level, so no association to NHL was established. Spinelli et al. (2007) measured plasma levels of PCBs and organochlorine pesticides in 422 NHL patients and 548 matched control subjects. A significant association with NHL was found for oxychlordane (highest vs. lowest quartile OR = 2.68, 95% CI 1.69–4.24). α -Chlordane and γ -chlordane were detected in less than 5% of the plasma samples so they were excluded from further analysis. When adjusted for PCBs, the Odds Ratio for NHL and oxychlordane decreased but was still significant. Quintana et al. (2004) analysed samples of adipose tissue from 175 NHL patients and 481 controls. The highest levels of oxychlordane (0.15 – 2.85 ppm) in adipose tissue were associated with a significantly increased risk of NHL (OR=1.79, 95% CI 1.04–3.08). The authors noted, however, that limitations of this study include collection of samples after diagnosis and a lack of information on variables affecting organochlorine levels such as diet, occupation, and body mass index.

Colt et al. (2006, 2009) conducted two case-control studies in which chlordane exposure was determined in NHL patients and matched control subjects by analyzing household dust and carpet dust collected in vacuum cleaner bags. In the 2006 study which compared 682 NHL cases and 513 controls, there was a significant dose-dependent trend between α -chlordane in dust and cases of NHL, but the analogous trend for γ -chlordane was not statistically significant (Colt et al. 2006). In the second dust analysis study, comparing of 1321 NHL patients to 1057 matched controls, NHL was not associated with chlordane in carpet dust (Colt et al. 2009).

In two studies in which chlordane exposure was self-reported by NHL patients and matched controls, McDuffie et al. (2001) found no association between exposure and NHL while Schroeder et al. (2001) found weakly positive associations between chlordane and each of two subtypes of NHL, t(14,18)-positive and t(14,18)-negative NHL.

The majority of the studies failed to show a statistically significant link between chlordane congeners and NHL. A causal association between chlordane congeners and NHL cannot be determined based on the epidemiologic evidence.

2.2.1.2 Breast Cancer

Three case-control studies (Gammon et al. 2002; Ward et al. 2000; Zheng et al. 2000), one cross-sectional study (Xu et al. 2010) and one cohort study (Engel et al. 2005) investigated the association between breast cancer and chlordane exposure. Gammon et al. (2002), in a case-control study conducted on Long Island, NY, did not find a significantly increased risk of breast cancer in association with the highest quintile of lipid-adjusted serum levels of chlordane. A dose-response relationship was not apparent either. Regarding their results, the authors stated, "These findings, based on the largest number of samples analyzed to date among primarily white women, do not support the hypothesis that organochlorines increase breast cancer risk among Long Island women." Ward et al. (2000) found no association between breast cancer and chlordane in serum. Zheng et al. (2000) found no association between breast cancer and oxychlordane in adipose tissue. A cross-sectional study by Xu et al. (2010) found no association between serum concentrations of oxychlordane and breast cancer. Engel et al. (2005) found an increased risk of breast cancer among wives of pesticide applicators who used chlordane, but the results were not consistent when stratified by state (Iowa vs. North Carolina), menopausal status at enrollment, and cumulative dose groups. No increase in breast cancer risk was found among female pesticide applicators that used chlordane. Exposures were self reported. These studies provide inadequate evidence of a causal association between breast cancer and chlordane exposure.

2.2.1.3 Testicular Cancer

In a case-control study done in Norway, chlordane metabolites in serum were elevated but not significantly associated with a risk of testicular germ cell tumor (Purdue et al. 2009). In a case-control study in Sweden, Hardell et al. (2003) found that the odds ratio for testicular cancer was significantly elevated in cases with elevated *cis*-nonachlordane blood lipid concentration. The odds ratios for testicular cancer were not elevated for cases with elevated *trans*-nonachlordane or the sum of chlordanes blood lipid concentrations. The odds ratios for testicular cancer were significantly elevated if the mothers of the cases had elevated *trans*-nonachlordane or *cis*-nonachlordane blood lipid concentrations; the odds ratios were not elevated if the mothers had elevated sum of chlordanes blood lipid concentrations. Testicular germ cell tumors risk was statistically significantly associated with higher plasma levels of p,p'-DDE, *cis*-nonachlor and *trans*-nonachlor but not with α -chlordane, γ -chlordane, oxychlordane (McGlynn et al. 2008).

2.2.1.4 Prostate Cancer

Hardell et al. (2006) found that concentrations of PCB congener 153 and *trans*-chlordane in adipose tissue were significantly increased among 58 prostate cancer cases compared to 20 controls. Oxychlordane, *trans*-nonachlordane, *cis*-nonachlordane, sum of chlordanes, *cis*-hepatochlorepoxyde, or MC6 chlordane were not found to be significantly increased. Ritchie et al. (2003) found that the odds ratio for prostate cancer was significantly increased for lipid-adjusted serum concentrations of 0.020 to 0.032 $\mu\text{g/g}$ oxychlordane, whereas the risk ratio for concentrations of $> 0.032 \mu\text{g/g}$ was not significantly elevated (Ritche et al. 2003). A cross-sectional study by Xu et al. (2010) examined serum concentrations of chlordane and self-reported physician diagnosed prostate cancer. The authors found a marginally significant trend in the odds ratios for prostate cancer when compared by tertiles of serum concentrations of β -hexachlorocyclohexane ($p = 0.02$), *trans*-nonachlor ($p = 0.002$), and dieldrin ($p = 0.04$). The trend for oxychlordane was not significant. Due to the nature of the cross-sectional design of this study, causality between OC pesticide exposure and cancer risk cannot be concluded.

2.2.1.5 Other Cancers

Flower et al. (2004) studied cancer risk among children of pesticide applicators who applied various pesticides including chlordane. Childhood cancer risk was not associated with paternal application of chlordane prior to conception.

No significant association was found between endometrial cancer and adipose tissue concentrations of six chlordane congeners or all six congeners combined (Hardell et al. 2004).

The odds ratio for cases of pancreatic cancer and exposure to the sum of chlordanes was 18.4 (95% CI 2.71-124), indicating a high risk. The odds ratio for hexachlorobenzene was 53 (95% CI 4.64-605). The authors advised that these results were based on a low number of cases (n = 21) and controls (n = 29) and should be interpreted with caution (Hardell et al. 2007).

Mills and Yang (2007) conducted a case-control study of gastric cancer among California farm workers. Exposure was based on pounds of the pesticide applied in the county during the time that the workers worked there. The authors found significant associations of gastric cancer with ever use (vs. never use) of 2,4-D, chlordane, propargite, and triflurin. Significant potential confounders such as smoking, diet, and *H. pylori* infection were not controlled for in the analysis. Purdue et al. (2007) reported a significantly increased risk of rectal cancer and a slight but non-significantly elevated risk of leukemia following exposure to chlordane. The authors concluded, however, that overall there was no clear relationship between organochlorine pesticide use and an increased risk of cancer.

Collectively, these studies do not provide evidence of a causal association between chlordane and an increased risk of cancer. The results are inconsistent. There is no evidence of a dose response or specificity of cancer site. The study designs of several of the studies are limited (cross-sectional, ecological). The self-reported exposure and self-reported disease diagnosis of several of the studies limit their interpretation.

2.2.2 Animal Data

No animal studies examining the potential carcinogenicity of chlordane published since 1997 were identified.

2.3 Current Method of Quantitative Cancer Risk Assessment

The U.S. EPA (1997) assessment used a linearized multistage (Global 86) model to estimate risk which the Agency described as leading to an upper limit on risk. Two slope factors were derived from male and female CD-1 mice data from IRDC (1973); two slope factors were derived from male and female B6C3F1 mice data from an NCI (1977) study; and one slope factor was based on male ICR mice data by Khasawinah and Grutsch (1989). The current U.S. EPA approach to dose response assessment (assuming that the low dose response is linear) is to use a benchmark dose (U.S. EPA 2000). The five data sets that were reviewed by the U.S. EPA in 1997 have been re-analyzed using a modern benchmark dose methodology. The current version of the U.S. EPA's benchmark dose modeling program is BMDS 2.1.2¹ available as a free download from the U.S. EPA's website.

¹ More can be learned about BMDS programs at <http://www.epa.gov/ncea/bmds/about.html>.

2.3.1 Method

The U.S. EPA's BMDS 2.1.2 software was used to model each of the five data sets used by U.S. EPA (1997) in its cancer risk estimates (see Appendices B through F). In each data set, the critical effect was the incidence of liver carcinomas in mice. The benchmark dose approach requires at least two dose groups and a control. All studies had adequate study designs for performance of benchmark dose modeling. The Dichotomous Multistage-Cancer Model was used for each of the cancer data sets. The dose levels were converted from animal dose levels to human equivalent dose (HED) values² as recommended by U.S. EPA (1992, 2011b) for entry into the BMDS spreadsheets. The male and female data sets for the IRDC (1973) study failed to produce acceptable curve fit with the complete data sets. The US EPA's *Benchmark Dose Technical Guidance* (US EPA 2000) allows for the exclusion of the highest dose in order to improve the model fit at the low dose range. By excluding the high dose data for the IRDC (1973) data sets, acceptable curve fits were achieved. In its quantification of cancer risk, the U.S. EPA (1997) also excluded the high dose groups from both the male and female IRDC (1973) data sets. Acceptable curve fits were achieved with each of the remaining data sets (NCI 1977 and Khasawinah and Grutsch 1989) without modification of the input data. Detailed descriptions of the benchmark dose methods and results for each cancer data set are presented in Appendices B through F.

2.3.2 Results

A comparison of the U.S. EPA (1997) cancer risk estimates for chlordane with the estimate derived from the benchmark dose approach is provided in Table 1 (next page). The modern benchmark dose analysis produces a higher cancer slope factor, indicating a slightly higher cancer risk than previously estimated.

Table 1. Comparison of U.S. EPA 1987 cancer slope factors for Chlordane with the Cancer Slope Factors Derived by Current Benchmark Dose Methods

Reference for Data Set (Subjects)	BMD-Based Cancer Slope Factor (mg/kg-day) ⁻¹	U.S. EPA (1997) Cancer Slope Factor (mg/kg-day) ⁻¹
IRDC 1973 (MaleCD-1 Mice)	1.13656	0.858
IRDC 1973 (FemaleCD-1 Mice)	0.700938	0.217
NCI 1977 (Male B6C3F1 Mice)	0.388362	0.345
NCI 1977 (Female B6C3F1 Mice)	0.19928	0.114
Khasawinah and Grutsch 1989 (Male ICR Mice)	0.674034	0.710
Geometric Mean	0.52934	0.35

² HED conversion factor = (animal body weight/human body weight)^¼, where mouse weight = 0.03 kg and human weight = 70 kg.

2.4 Discussion

There is a significant level of uncertainty in regard to whether chlordane should be classified as a human carcinogen. IARC (2001) determined that chlordane is a possible human carcinogen (Group 2B), and the NTP (2011) did not include chlordane in its 12th Report on Carcinogens. WHO (2008) accepted the IARC classification of aldrin and dieldrin as Group 2B. WHO (2008) went on describe that while prolonged dietary exposure to chlordane causes liver tumors in mice, the mechanism is not due to genotoxicity. ATSDR (1995) stated that, “studies of workers who made or used chlordane do not show that exposure to chlordane is related to cancer, but the information is not sufficient to know for sure.” The US EPA (1997) noted that under the proposed 1996 guidelines chlordane would be characterized as a likely carcinogen and estimated the lifetime cancer risk would be approximately 1.75×10^{-4} for ingestion.

Human studies on chlordane including studies conducted prior to and since 2001 do not provide evidence that chlordane is causally associated with an increased risk of cancer. There were no new animal carcinogenicity studies of chlordane conducted since 1997, but studies reviewed by ATSDR (1995), IARC (2001), and US EPA (1997) show that prolonged dietary ingestion of chlordane is carcinogenic to the livers in mice.

Whether the tumorigenic response seen in mice is applicable to humans is questionable. Several assessments have concluded that chlordane is nongenotoxic (U.S. EPA 1997; ATSDR 1994; WHO 2008). Mice are more sensitive to the carcinogenic response than rats. The toxic effects of chlordane on the livers of experimental animals include lipid peroxidation and cell proliferation secondary to cytotoxicity. Chlordane induced hepatic microsomal oxidative enzymes and steroid hormone metabolism in rodents (IARC 2001).

The US EPA (1997) indicated that no populations have been identified as unusually sensitive to the carcinogenic effects of chlordane. The people at most risk are the ones most highly exposed (e.g., farmers who applied chlordane to crops or livestock). No carcinogenic effects have been observed in humans from the small concentrations of chlordane that commonly occur in food (US EPA 1997).

In its efforts to quantify the carcinogenic risk of chlordane, the U.S. EPA (1997) calculated an oral cancer slope factor of $0.35 \text{ (mg/kg-day)}^{-1}$ based on the tumor incidence data of five data set in three strains of mice. This value was derived by geometric mean of the cancer slope factors of five data sets (IRDC 1973; NCI 1977; Khasawinah and Grutsch 1989) that were produced by the GLOBAL.86 linearized multistage model. This method is an older form of benchmark dose modeling. The current method used by U.S. EPA for calculating cancer slope factors is to use the latest available version of U.S. EPA's BMDS software. The current version is BMDS 2.1.2. When BMDS 2.1.2 was used to model the data from the same five data sets (IRDC 1973; NCI 1977; Khasawinah and Grutsch 1989), the geometric mean of the resulting cancer slope factors was $0.52934 \text{ (mg/kg-day)}^{-1}$, approximately 51% higher than the value derived by U.S. EPA (1997). Thus, the current methodology shows a higher cancer risk for chlordane than the previous assessment.

Finally, it is important for the reader to have a perspective on the meaning of a 10^{-5} or a 10^{-4} theoretical excess lifetime cancer risk. Theoretical excess lifetime risks are estimated from a high dose exposure and assume a lifetime of exposure. The theoretical relative risk can be expressed as the $(\text{excess lifetime risk} + \text{background risk}) \div \text{background risk}$. For argument's sake, we will assume that chlordane is associated with an increased risk of liver cancer in humans because they were found in some studies to increase liver tumors in the mouse. The

lifetime (background) risk of liver cancer in the U.S. population (through age 85) is 6.6×10^{-3} (NCI 2010). If the theoretical excess lifetime risk is 10^{-4} , the relative risk is approximately 1.02 ($6.6 \times 10^{-3} + 1 \times 10^{-4} / 6.6 \times 10^{-3}$). The population needed to detect such a risk would be 5,244,721. The population of Hawaii is only about 1.3 million. Thus it would take several times the population of Hawaii to even detect a theoretical excess lifetime cancer risk of 1×10^{-4} (if one actually exists).

3.0 NONCANCER

3.1 Existing Guidance Values

3.1.1 U.S. EPA - U.S. EPA (1997)

The U.S. EPA's most recent review of chlordane set a reference dose (RfD) of 0.0005 mg/kg-day based on a chronic mouse study by Khasawinah and Grutsch (1989) (U.S. EPA 1997). This value replaced a previous U.S. EPA-derived RfD of 0.00006 mg/kg-day (ATSDR 1995; U.S. EPA 1997).

In its evaluation of the Khasawinah and Grutsch (1989) study, the U.S. EPA used the increased incidence of hepatic necrosis over controls to determine that 1 ppm chlordane (0.15 mg/kg-day) was the NOAEL, and 5 ppm chlordane (0.75 mg/kg-day) was the LOAEL. A benchmark concentration modeling was attempted using the THRESH and THRESHW models, but an acceptable curve fit was not achieved (U.S. EPA 1997).

3.1.2 U.S. EPA (2011a) – Office of Water

The U.S. EPA has set an enforceable regulation for chlordane, called a maximum contaminant level (MCL), at 0.002 mg/L or 2 ppb. MCLs are set as close to the health goals as possible, considering cost, benefits and the ability of public water systems to detect and remove contaminants using suitable treatment technologies. The Agency has also set a non-enforceable maximum contaminant level goal (MCLG) of zero chlordane in water. States may set more stringent drinking water MCLGs and MCLs for chlordane than EPA.

3.1.3 ATSDR (1994)

ATSDR developed acute, intermediate, and chronic MRLs for chlordane. These are described in Table 2 below.

Table 2. Oral MRLs derived by ATSDR (1994) for chlordane

Type of MRL	Study	Effect	Point of Departure	Uncertainty Factor	MRL (mg/kg/day)
Acute	Al-Hachim and Al-Baker (1973)	Developmental effects in mice	LOAEL (1 mg/kg/day)	1000	0.001
Intermediate	Khasawinah and Grutsch 1989; Velsicol Chemical Co. 1983	Hepatic effects in female rats	NOAEL (0.055 mg/kg/day)	100	0.0006
Chronic	Khasawinah and Grutsch 1989; Velsicol Chemical Co. 1983	Hepatic effects in rats	NOAEL (0.055 mg/kg/day)	100	0.0006

3.1.4 WHO (2008)

The WHO Guideline for chlordane in drinking water is 0.2 µg/L.

3.1.5 JMPR (1965)

The Joint Meeting on Pesticide Residues (JMPR 1965) reviewed the data that were available at the time and concluded that caution should be exercised, and that every effort should be made to see that the intake of chlordane for humans should be kept at the lowest possible level. The JMPR committee did not identify an Acceptable Daily Intake (ADI) value for chlordane.

According to ATSDR (1994), the JMPR committee issued an ADI value of 0.001 mg/kg in 1978, but an original source for this information could not be located.

3.2 Data Published Since 1997

The scientific literature since 1997 was searched utilizing the PubMed and Toxline databases for any articles related to non-cancer health effects of chlordane in humans and animals. The following search terms were used: ((chlordane) AND ((epidemiological studies OR case control OR cohort) OR (toxicity OR long-term OR short-term OR oral OR gavage OR feed OR inhal* OR dermal OR develop* OR teratogen OR gestation OR maternal OR repro*))). Three hundred thirty-eight (338) potentially relevant references were identified. These references were further screened to identify studies of non-cancer adverse health effects related to exposure to chlordane in humans or animals. *In vitro* studies, environmental and wildlife monitoring reports, and studies of mixtures with other compounds in animals were excluded. Studies that have been reviewed by ATSDR (2001) were also excluded. Of the remaining studies, thirteen human/epidemiology references and four animal studies were considered useful for further evaluation of non-cancer effects of chlordane.

3.2.1 Human Data

Thirteen noncancer epidemiologic studies of chlordane were identified from the PubMed and Toxline searches of epidemiologic literature published since 1997 and not included in the ATSDR (2001) review. The noncancer epidemiologic studies are described in more detail in Appendix A.

Six studies assessed the risks of maternal exposure to chlordane to young offspring. In a cross-sectional study, chlordane in cord blood was observed to have adverse effects on measures of fetal growth, such as birth weight, length, and head circumference, but these effects were not statistically significant. Some PCBs had significant effects on birth weight, length, and head circumference (Tan et al. 2009). A cohort study found no association between oxychlordane in maternal serum and length of gestation, infant birth weight, or crown-heel length (Fenster et al. 2006). In a case-control study, Damgaard et al. (2006) found that the risk of cryptorchidism in male offspring was significantly higher ($p = 0.012$) when the mothers had trans-chlordane in their breast milk, but no association was found between cryptorchidism and oxychlordane or cis-chlordane. A case-control study found that PCBs, DDT, hexachlorobenzene, and chlordane in the breast milk of the mothers was associated with cretinism in the offspring. There were 22 cases and 102 controls. The PCBs and hexachlorobenzene were considered the most effective organochlorine compounds on the incidence of cretinism (Nagayama et al. 2007a). Cross sectional studies on lymphocyte subsets and on allergic immune response in women and infants both yielded nonsignificant results regarding chlordane exposure (Nagayama et al. 2007b; Noakes et al. 2006).

Weisskopf et al. (2010) and Louis et al. (2006) each found no association between serum levels of oxychlordane and Parkinson's Disease.

The risk of diabetes following chlordane exposure was assessed by three studies. Montgomery et al. (2008) found an increased risk of diagnosed diabetes among participants of the Agricultural Health Study. The odds ratios were elevated but were not statistically significant when stratified by age, state (North Carolina or Iowa), or weight group. The authors do not specify or delineate between type I and II diabetes, which are known to have different etiologies (CDC 2010). A cross sectional analysis using the National Health and Nutrition Examination Survey (NHANES) found an association between oxychlordane in blood and total diabetes (diagnosed and undiagnosed). Diagnosed diabetes was self-reported; undiagnosed diabetes were those with glycohemoglobin $\geq 6.5\%$ (Everett & Matheson 2010). Another cross sectional study using NHANES data found that diabetes was positively associated with six persistent organic pollutants including oxychlordane after adjustment for age, sex, race/ethnicity, poverty income ratio, BMI, and waist circumference (Lee et al. 2006). However, the study does not specify type I or type II diabetes, which are different in etiology. Diabetes diagnoses were self-reported and not confirmed by a physician.

A cohort study by Landgren et al. (2009) examined monoclonal gammopathy of undetermined significance (MGUS) and self-reported pesticide use and pesticide concentrations in serum. Among individuals ever reporting exposure to chlordane, the relationship with MGUS was not significant.

A cross sectional study found that oxychlordane in the serum of women had no effect on the age at onset of menopause (Akkina et al. 2004).

The evidence is inadequate to determine a causal association between chlordane exposure and non-cancer effects. Studies of some effects provide conflicting results. Most of the studies are cross-sectional in nature. Exposure is determined by blood or breast milk concentrations and then correlated with an effect. Whether exposure preceded the effect is impossible to determine. Most of the studies of non-cancer effects identified multiple persistent organic pollutants in the blood or breast milk making determination of a causal association with any one or all of these compounds difficult.

3.2.2 Animal Data

Four animal studies of chlordane were identified. Three of these were oral gavage studies in rats, and one was an oral study in mice. The results are summarized in Table 3 (next page).

Al-Omar et al. (2000) investigated the combined effect of exposure to lead and chlordane on the testicular tissues of Swiss mice. The lead effects are of no consequence to the current review of chlordane, but a set of groups were exposed to chlordane without lead. Male Swiss mice were given 0, 75, or 275 mg/kg-day chlordane orally for 35 days. No clinical signs or symptoms were reported. Animals remained healthy throughout the experimental period, and no deaths occurred. Body weights and testes weights were reduced at both dose levels tested. Effects at 275 mg/kg-day included reduced number of Sertoli cells, reduced diameter of the seminiferous tubules, number of spermatogonia, and primary and secondary spermatocytes and spermatids (Al-Omar et al. 2000).

Bondy et al. (2000) studied the toxicity of technical chlordane in rats. Technical chlordane is a mixture of >140 chlordane-related compounds, including 60 to 85% *cis*- and *trans*-chlordane. Rats were given 0, 0.25, 2.5, or 25 mg/kg-day technical chlordane by oral gavage for 28 days. At 0.25 mg/kg-day, water consumption was reduced (not considered an adverse effect without

Table 3. Animal Studies on Chlordane Published since 1997 that Examined Noncancer Effects

Reference	Protocol	Results	Critical Effect Levels
Al-Omar et al. (2000)	Male Swiss mice were given 0, 75, or 275 mg/kg-day chlordane orally for 35 days.	Reduced body weights and testes weights at ≥ 75 mg/kg-day. Reduced number of Sertoli cells, reduced diameter of the seminiferous tubules, number of spermatogonia, and primary and secondary spermatocytes and spermatids at 275 mg/kg-day.	LOAEL = 75 mg/kg-day.
Bondy et al. (2000)	Rats were given 0, 0.25, 2.5, or 25 mg/kg-day chlordane by oral gavage for 28 days.	At 0.25 mg/kg-day, reduced water consumption. At 25 mg/kg-day, reduced food consumption, increased liver weights and histopathological signs in liver tissue, increased kidney weights (males only).	NOAEL = 2.5 mg/kg-day LOAEL = 25 mg/kg-day.
Tyrophonas et al. (2003)	Sprague–Dawley rats were given 0.25, 2.5, or 25 mg/kg-day chlordane by oral gavage for 28 days.	At 25 mg/kg, significantly increased serum immunoglobulin M (IgM) levels in the chlordane-treated females.	NOAEL = 2.5 mg/kg-day LOAEL = 25 mg/kg-day.
Bondy et al. (2003)	Female Sprague–Dawley rats were gavaged with 0, 0.01, 0.1, 1, 2.5, or 10 mg/kg-day oxychlordane for up to 28 days.	At 2.5 mg/kg-day, reduced body weight, histological changes in liver, thyroid and thymus, 4% mortality. At 10 mg/kg-day, rapid body weight loss, significantly reduced food and water consumption, lethargic, unkempt appearance, hunched posture, histological changes in liver and thymus and 100% mortality.	NOAEL = 1 mg/kg-day LOAEL = 2.5 mg/kg-day.

other signs of compromised health). At 25 mg/kg-day, effects included reduced food consumption, increased liver weights and histopathological signs in liver tissue, increased kidney weights (males only). There were no treatment-related effects on body weights, body weight gains, or survival. Metabolites of chlordane accumulated in adipose tissue (Bondy et al. 2000).

Tryphonas et al. (2003) investigated the immunotoxicity of chlordane in rats. Adult male and female Sprague–Dawley rats were given 0.25, 2.5, or 25 mg/kg-day chlordane by oral gavage for 28 days. Significantly increased serum immunoglobulin M (IgM) levels in the chlordane-treated females at the 25 mg/kg dose. There were no chlordane-related effects on the immunoglobulins IgG₁, IgG_{2a}, IgG_{2b}, or IgG_{2c}.

Bondy et al. (2003) studied the toxicity of the chlordane metabolite oxychlordane in female rats. Female Sprague-Dawley rats were gavaged with 0, 0.01, 0.1, 1, 2.5, or 10 mg/kg-day oxychlordane for up to 28 days. No effects were observed in the 0.01, 0.1, and 1 dose groups. At 2.5 mg/kg-day, effects included reduced body weight, histological changes in liver, thyroid and thymus, 4% mortality. At 10 mg/kg-day, there were rapid body weight loss, significantly reduced food and water consumption, lethargic, unkempt appearance, hunched posture, histological changes in liver and thymus and 100% mortality. The authors noted that in this study, the chlordane metabolite oxychlordane was toxic at lower dose levels than the parent compound.

The lowest NOAEL in the recent studies of chlordane is 2.5 mg/kg-day in two studies (Bondy et al. 2000; Tyrophonas et al. 2003), which is higher than the NOAEL of 0.15 mg/kg-day (Khasawinah and Grutsch 1989) used to derive the U.S. EPA's RfD (U.S. EPA 1997). Therefore, none of the more recent studies are likely to impact the current hazard assessment of chlordane.

3.3 Reference Dose Values Based on Benchmark Dose Analysis

In its evaluation of the Khasawinah and Grutsch (1989) study, the U.S. EPA used the increased incidence of hepatic necrosis over controls to determine that 1 ppm chlordane (0.15 mg/kg-day) was the NOAEL, and 5 ppm chlordane (0.75 mg/kg-day) was the LOAEL. A benchmark concentration modeling was attempted using the THRESH and THRESHW models, but an acceptable curve fit was not achieved (U.S. EPA 1997). The current U.S. EPA approach to a non-cancer dose response assessment (assuming a typical sigmoidal dose response curve) is to use a benchmark dose (U.S. EPA 2000) with the current benchmark dose modeling software provided by the U.S. EPA.

3.3.1 Method

The U.S. EPA (1997) determined a reference dose (RfD) for chlordane based on the NOAEL in a chronic dietary study of chlordane in mice (Khasawinah and Grutsch 1989). The critical endpoint was increased incidence of hepatic necrosis in male mice at the middle and high dose levels. The hepatic necrosis incidence data are quantal data for which the US EPA (2000) recommends use of a Dichotomous Model. The U.S. EPA's BMDS 2.1.2 software offers three variations of Dichotomous Models that would be appropriate for the data set. The dose levels were converted from mouse dose levels to human equivalent dose (HED) values³ as recommended by U.S. EPA (1992, 2011b). The liver necrosis incidence data and human equivalent dose levels were entered into a BMDS 2.1.2 spreadsheet and applied to three Dichotomous models: Gamma, Multistage, and Weibull. None of the models produced a curve with an acceptable curve fit to the data with the complete data set. The US EPA's *Benchmark Dose Technical Guidance* (US EPA 2000) allows for the exclusion of the highest dose in order to improve the model fit at the low dose range. When the Gamma, Multistage, and Weibull models were performed on the data set without the highest dose level, each model produced an acceptable curve fit to the data. A detailed description of the benchmark dose method and results for the non-cancer endpoint is presented in Appendix G.

³ HED conversion factor = (animal body weight/human body weight)^{1/4}, where mouse weight = 0.03 kg and human weigh = 70 kg.

3.3.2 Results

Using the US EPA's current version of the BMDS software, Tetra Tech derived a BMDL for chlordane of 0.0288088 mg/kg-day. To derive the RfD values for chlordane, an uncertainty factor of 100 was applied to the BMDL to account for 10x for human variability, 10^{1/2}x for interspecies variation, and 10^{1/2}x for lack of a multigeneration reproductive study (10 x 10^{1/2} x 10^{1/2} = 100).

$$\text{RfD for chlordane} = 0.0288088 \text{ mg/kg-day} \div 100 = 0.000288088 \text{ mg/kg-day}$$

The RfD value of 0.000288088 mg/kg-day for chlordane was rounded up to 0.0003 mg/kg-day. A comparison of this RfD with that of U.S. EPA (1997) is presented in Table 4 (below).

Table 4. Comparison of U.S. EPA 1987 Reference Dose for Chlordane with the Reference Dose Derived by Current Benchmark Dose Methods

	BMD-Based RfD	U.S. EPA (1997) RfD
Data Source	Khasawinah and Grutsch 1989	Khasawinah and Grutsch 1989
Critical Effect	Liver Necrosis in Males	Liver Necrosis in Males
Type of Threshold Dose	BMDL based on Dichotomous Models	NOAEL
Threshold Dose Value (mg/kg-day)	0.0288088	0.15
Uncertainty Factor	100	300
Reference Dose (mg/kg-day)	0.0003	0.0005

3.4 Discussion

The U.S. EPA (1997) RfD for chlordane is 0.0005 mg/kg-day, respectively. The RfD is based on hepatic necrosis (NOAEL = 0.15 mg/kg-day; LOAEL = 0.75 mg/kg-day) after chronic dietary exposure in mice. The ATSDR (1994) chronic oral minimal risk level (MRL) value for chlordane is 0.0006 mg/kg-day, based on the same chronic mouse study. The WHO (2008) guideline for chlordane in drinking water is 0.2 µg/L, based on a provisional tolerable daily intake of 0.0005 mg/kg-day. The U.S. EPA Office of Water's MCL for chlordane in drinking water is 2 µg/L, a value that's 10-fold higher than the WHO guideline, but the MCL goal is zero chlordane in drinking water.

The epidemiology studies published since the ATSDR (2001) review of chlordane do not demonstrate a causal association of chlordane with any non-cancer effects. Maternal exposure to chlordane was associated with effects in offspring such as cryptorchidism and cretinism, but the evidence was insufficient to determine whether these effects were causally associated with chlordane. Studies of whether chlordane exposure may increase the risk of diabetes produced mixed results; furthermore the authors did not distinguish between type I and type II diabetes, which are known to have different etiologies (CDC 2010). Other studies investigating Parkinsonism, MGUS, and age at onset of menopause each showed no association with chlordane exposure.

The subchronic animal toxicity studies of chlordane that have been published since 1997 support the previously reviewed studies that show hepatic toxicity in rodents. These studies also reported effects in other tissues (testes, thyroid, and thymus) that occurred at dose levels higher than the NOAEL on which the RfD as well as the intermediate and chronic MCLs are based. Thus, the recent additional studies do not suggest any toxicities that are more sensitive than the currently recognized critical effects.

The U.S. EPA derived a non-cancer RfD of 0.0005 mg/kg-day for chlordane (U.S. EPA 1997), based on a NOAEL for hepatic necrosis in male mice exposed to chlordane in the diet for 2 years and an uncertainty factor of 300. By applying the same data set to the benchmark dose modeling software currently used by the U.S. EPA and the same uncertainty factor of 100, the RfD is reduced to 0.0003 mg/kg-day.

The difference in the two RfD values can be partially attributed to conversion of the mouse dose level to the human equivalent dose (HED). U.S. EPA (1997) did not convert the mouse dose levels to HED in its derivation of the RfD, but they did do this conversion in the cancer slope factor calculation. It is not clear why the HED was not applied to the non-cancer RfD. As a matter of consistency, this conversion was applied in the benchmark dose calculation of a new RfD. The current conversion method is the “3/4 power” assumption in which the human equivalent dose, in units of mg/kg-day, is equal to the animal dose $\times (0.030/70)^{1/4}$, where 0.030 and 70 represent the body weights of mice and humans, respectively (U.S. EPA 1992, 1997). Thus, the conversion of mouse dose to human dose is based on a factor of 0.143882. Without the conversion to Human Equivalent Dose, the lower limit benchmark dose would be 0.2002 mg/kg-day, and the uncertainty factor of 300 would produce an RfD of 0.0007 mg/kg-day ($0.0002 \text{ mg/kg-day} \div 300 = 0.000667 \text{ mg/kg-day}$).

Another update in the methods of derivation of RfD values is in how uncertainty factors are applied. In its previous assessment of chlordane, the U.S. EPA used an uncertainty factor of 300, based on 10x for human variability, 10x for interspecies species variability, and $10^{1/2}x$ (rounded to 3x) for lack of a full scale multigenerational reproductive study ($10 \times 10 \times 10^{1/2} = 300$). However, the U.S. EPA (2011b) recently published a recommendation that if a human equivalent dose (HED) factor is applied, then the uncertainty factor for interspecies variation can be reduced from 10x to $10^{1/2}x$, rounded to 3x. Therefore, in the current assessments of chlordane, the uncertainty factors applied were 10x for human variability, $10^{1/2}x$ for interspecies variation, and $10^{1/2}x$ for lack of a multigeneration reproductive study ($10 \times 10^{1/2} \times 10^{1/2} = 100$).

4.0 SUMMARY

There is some uncertainty among the regulatory and advisory agencies regarding whether chlordane is a human carcinogen. The US EPA (1997) considers chlordane likely to be a human carcinogen, while IARC (2001) classifies it as a possible human carcinogen. These assessments were based on inadequate evidence of carcinogenicity in humans and sufficient evidence of carcinogenicity in laboratory animals (mice and rats). The NTP (2011) does not consider chlordane to be a human carcinogen or to be reasonably anticipated to be a human carcinogen.

Chlordane is a known carcinogen in rodents, and mice are more sensitive than rats. However, the relevance of the carcinogenicity of chlordane in rodent species to potential human effects is not known. Chlordane is not genotoxic, so an epigenetic mechanism is suspected in rodents. Human studies on chlordane including studies conducted prior to and since the 2001 ATSDR review do not provide evidence that chlordane is causally associated with an increased risk of cancer.

In its 1997 review, the U.S. EPA derived a cancer slope factor of $0.35 \text{ (mg/kg-day)}^{-1}$. A re-analysis of the same data sets using modern benchmark dose modeling produced a cancer slope factor of $\sim 0.53 \text{ (mg/kg-day)}^{-1}$, indicating a slightly higher cancer risk for chlordane than the previous assessment.

The U.S. EPA estimated that the lifetime cancer risk would be approximately 1.75×10^{-4} for ingestion.

The noncancer chronic oral RfD and MRL are 0.0005 mg/kg-day and 0.0006 mg/kg-day , respectively. These were both based on liver toxicity (hepatic necrosis) observed in mice that were exposed to chlordane in their diet for at least 2 years. Thus, liver toxicity is considered the critical effect with chronic exposure to chlordane in rodents. Whether this effect is relevant to humans is unclear, as there are no reports of chlordane-associated liver toxicity in humans. The animal and epidemiological literature on chlordane published since the 1997 U.S. EPA review revealed no new noncancer endpoints of concern.

In its 1997 review, the U.S. EPA derived a RfD of 0.0005 mg/kg-day for chlordane. A re-analysis of the same data sets using modern benchmark dose modeling produced a RfD of 0.0003 mg/kg-day , indicating a slightly higher toxicity for chlordane than the previous assessment.

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APPENDIX A

Epidemiologic Studies

APPENDIX A

EPIDEMIOLOGIC STUDIES

The following tables summarize the epidemiologic studies assessing health effects from exposure to chlordane. PubMed was searched for studies published after the 1997 EPA review. Thirty-six studies were identified and assessed. Table A1 contains studies assessing cancer outcomes while Table A2 reviews non-cancer outcomes.

Table A1- Cancer Studies

Study	Type	Size/ Population	Methods	Exposure	Outcome	Results	Notes
Cantor et al. 2003	Case control	74 Non-Hodgkin's Lymphoma cases and 147 matched controls	Serum samples were collected from 25,802 individuals participating in Campaign Against Cancer and Stroke in Washington County, MD in 1974. The samples were cryopreserved so they could be studied in the future. Incident cases of NHL were identified using the Washington County Cancer Registry. Two controls were matched for every one case of NHL.	Pre-diagnostic levels of chlordane, lindane, beta-hexachlorocyclohexane, transnonachlor, heptachlor, heptachlor epoxide, oxychlorodane, dieldrin and hexachlorobenzene in serum samples	Non-Hodgkin's Lymphoma	Researchers found no evidence of an association between NHL and serum levels of any of the chemicals that were evaluated, including chlordane.	

Study	Type	Size/ Population	Methods	Exposure	Outcome	Results	Notes
Cocco et al. 2008	Case Control	174 cases, 203 controls	Cases and controls were participants of the Epilymph study in France, Germany, and Spain. Information was collected by questionnaire and blood samples were taken. Covariates included in the final model included age, gender, education, and center.	Measurements of 17 organochlorine pesticides in plasma samples	Non-Hodgkin's Lymphoma and subtypes	No increased risk of NHL or its subtypes was found to be associated with any of the compounds examined (including chlordane). There were no participants with chlordane plasma concentration levels above the detection limit (0.20µg/L).	Differences between countries were noted. Retrospective design limits the inferences that can be made about any associations.
Colt et al. 2006	Case control	682 cases and 513 controls; in Iowa and the metropolitan areas of Los Angeles, Detroit, and Seattle.	Examined non Hodgkin lymphoma risk and use of insecticides in the home and garden. Cases were men and women ages 20 to 74 years, newly diagnosed with a first primary NHL between July 1998 and June 2000 and uninfected with HIV. Controls were selected from the from the National Cancer Institute–Surveillance, Epidemiology, and End Results (NCI-SEER) study,	Eighteen insecticides (including α-chlordane and γ-chlordane) detected in household dust and vacuum cleaner bags.	Non-Hodgkin Lymphoma	Risk of non-Hodgkin lymphoma was elevated, but not significantly, in homes that were treated for insects before the 1988 chlordane ban. There was a significant trend of increasing risk with increasing levels of α-chlordane residues in dust ($P_{trend} = 0.04$) and a marginally significant trend for γ-chlordane ($P_{trend} = 0.06$).	

Study	Type	Size/ Population	Methods	Exposure	Outcome	Results	Notes
			frequency matched to cases on age, sex, race, and center. Insecticide levels were measured in dust taken from used vacuum cleaner bags.				
Colt et al. 2009	Case control	1321 cases and 1057 controls; in Iowa, Los Angeles County, and the metropolitan areas of Detroit and Seattle	Examined non Hodgkin lymphoma risk and use of insecticides in the home and garden. Cases were men and women ages 20 to 74 years, newly diagnosed with a first primary NHL between July 1998 and June 2000 and uninfected with HIV. Controls were selected from the from the National Cancer Institute–Surveillance, Epidemiology, and End Results (NCI-SEER) study, frequency matched to cases on age, sex, race, and center. Chlordane exposure was determined from carpet dust	α -Chlordane and PCB180 detected in carpet dust.	Non-Hodgkin Lymphoma	Non-Hodgkin lymphoma was not significantly associated with exposure to chlordane in carpet dust (RR = 0.6, 0.0-1.2; p = 0.051).	

Study	Type	Size/ Population	Methods	Exposure	Outcome	Results	Notes
			samples.				
Engel et al. 2005	Prospective Cohort	30,454 women enrolled in the Ag Health Study (309 cases of breast cancer)	Participants enrolled between 1993 and 1997 in the Ag Health Study. Cases were identified from population-based cancer registries in Iowa and North Carolina. NDI was used to determine vital status of participants. Participants who had moved out of state were followed up using personal contacts, motor vehicle records, pesticide registration records, and IRS records. End of follow-up was 12/31/2000.	Use and exposure to 50 specific pesticides was determined by questionnaires administered at enrollment by the women and their husbands.	Breast cancer diagnosis	There was no significantly increased risk among women having reported using chlordane. Risk was actually reduced among Iowa women who used chlordane (RR = 0.6, 0.4-1.1). Among women who did not directly use chlordane but their husbands did, the RR was 1.7 (1.2-2.5). Results were not consistent when stratified by state. Risks were higher in postmenopausal women compared to premenopausal	Analysis controlled for age, race, and state of residence.

Study	Type	Size/ Population	Methods	Exposure	Outcome	Results	Notes
						women. Risk was increased among postmenopausal women whose husbands used chlordane.	
Flower et al. 2004	Prospective Cohort	17,357 children of Iowa pesticide applicators enrolled in the Ag Health Study (50 incident childhood cancer cases)	Information on exposure and other variables was provided by parents responding to questionnaires between 1993 and 1997. Cancer cases among children ages 0-19 years were identified from the Iowa Cancer registry for the period 1975-1998 (retro and prospective identification of cases). Cases from North Carolina were excluded based on small numbers. 50 specific pesticides were assessed.	Use and exposure to 50 specific pesticides was determined by questionnaires administered at enrollment by the parents.	Childhood cancers	Parental use of organochlorine pesticides (including aldrin, DDT, dieldrin, heptachlor, chlordane, lindane, and toxaphene) were not significantly associated with childhood cancers.	Data for NC is not available, which may be a weakness based on the inconsistencies seen by Engel et al. Numbers were too small to look at specific types of tumors. Overall, the SIR for all childhood cancers was 1.36 (1.03-1.79) but only lymphomas (9 cases) and more specifically, Hodgkin's lymphoma (5 cases) were significantly related to parental pesticide exposures. No dose-response relationship was detected.
Gammon et al. 2002	Case control	646 cases and 429 controls (women)	Cases included females residing in Nassau and Suffolk Counties on Long Island, NY who were 20 or older, spoke English and were recently diagnosed with in situ or	Organochlorines (9 including chlordane) in blood	Breast cancer	There was no significant increased risk in breast cancer associated with chlordane exposure (OR = 0.98, 0.62–1.55).	“These findings, based on the largest number of samples analyzed to date among primarily white women, do not support the hypothesis that organochlorines

Study	Type	Size/ Population	Methods	Exposure	Outcome	Results	Notes
			<p>invasive breast cancer between August 1, 1996 and July 31, 1997. They were identified through pathology labs in all of the hospitals in the Long Island region. Controls were residents of the same counties on Long Island and were frequency matched according to 5-year age group. Controls were identified through random digit dialing and Health Care Financing Administration rosters depending on age. Questionnaires were administered in person by trained interviewers and samples were obtained through nonfasting blood samples.</p>				increase breast cancer risk among Long Island women.”
Hardell et al. 2003	Case control	61 cases with testicular cancer and 58 age-matched	Incident cases with testicular cancer were recruited from 1997 to 2000 from 5 hospitals in Sweden. For each case, a	Maternal exposure to 38 polychlorinated biphenyls (PCBs), <i>p,p'</i> -dichlorodiphenyl-dichloroethylene, hexachlorobenzene	Testicular cancer in offspring males	The only significant difference in concentrations of organochlorines for the sons was	

Study	Type	Size/ Population	Methods	Exposure	Outcome	Results	Notes
		controls. Sweden	control subject free from testicular cancer was drawn from the Swedish Population registry (Stockholm, Sweden). Pesticide exposure was measured by concentrations in the blood of subjects and their mothers.	(HCB), and six chlordane congeners (<i>cis</i> -heptachlordane, <i>cis</i> -chlordane, oxychlordane, MC6, <i>trans</i> -nonachlordane, <i>cis</i> -nonachlordane).		an increased concentration of <i>cis</i> -nonachlordane in cases with testicular cancer (OR = 2.6, 1.2–5.7). Concentrations of <i>trans</i> -nonachlordane, <i>cis</i> -nonachlordane, and sum of chlordanes in mothers of testicular cancer cases were significantly increased compared to control mothers. No consistent different risk pattern was found for seminoma or nonseminoma testicular cancer.	
Hardell et al. 2004	Case control	76 cases and 39 controls. Sweden	Cases were patients undergoing surgery (hysterectomy) either for cancer or a benign disease at the Department of Gynecology, county Hospital in Karlstad, and at	PCBs, PBBs, HCB, DDE, and 6 chlordane congeners in adipose tissue.	Endometrial cancer	The mean concentration of combined chlordane congeners in adipose was 71.4 ng/g (range 22.4 - 208.3 ng/g) in cases and 57.5	

Study	Type	Size/ Population	Methods	Exposure	Outcome	Results	Notes
			<p>the University Hospital in Örebro, Sweden were recruited for the study during 1997–1998. Controls were recruited from the same hospitals. Adipose tissue samples were analysed for concentrations of PCBs, PBBs, HCB, DDE, and 6 chlordane congeners.</p>			<p>ng/g (12.7 - 139 ng/g). No significant association was found between endometrial cancer and any single chlordane congener or all six congeners combined (odds ratio = 0.7; 95% CI = 0.2–1.8).</p>	

Study	Type	Size/ Population	Methods	Exposure	Outcome	Results	Notes
Hardell et al. 2006	Case control	58 cases and 20 controls. Sweden	The study population consisted of all men living in Örebro, Sweden between 1997 and 1999. Cases were men with a newly diagnosed prostate cancer, verified either histopathologically or cytologically. Controls were patients undergoing transurethral resection for presumed benign hyperplasia. Adipose samples were measured for concentrations of persistent organic pollutants, including <i>trans</i> -chlordane and the chlordane metabolites MC6 and oxychlordane.	Persistent organic pollutants (including <i>trans</i> -chlordane and the chlordane metabolites MC6 and oxychlordane) in adipose tissue.	Prostate cancer	The odd ratios of prostate cancer with exposure to <i>trans</i> -chlordane, MC6, and oxychlordane were 3.49 (95% CI = 1.08 –11.2), 2.71 (95% CI = 0.87– 8.42), and 1.90 (95% CI = 0.62–5.79), respectively.	

Study	Type	Size/ Population	Methods	Exposure	Outcome	Results	Notes
Hardell et al. 2007	Case control	21 cases (mean age mean 65, range 37-82) and 58 controls (mean age 64, range 46-80). Sweden	Cases were pancreatic cancer patients recruited 1996 to 1999. All diagnoses were histopathologically confirmed to be exocrine pancreatic adenocarcinoma. Male controls were undergoing transurethral resection for benign prostate hyperplasia during 1997 to 1998 (n = 20), and female controls were hysterectomy patients during 1997-1998 (n = 39). Adipose samples were measured for concentrations of persistent organic pollutants, including chlordane congeners.	Persistent organic pollutants (including cis-heptachlordane, trans-chlordane, oxychlordane, metabolic compound 6 (MC6), trans-nonachlordane, and cis-nonachlordane) in adipose tissue.	Pancreatic cancer	The odds ratio for cases with pancreatic cancer and exposure to the sum of chlordanes was 18.4 (95% CI 2.71-124). There was a significant dose-dependent decrease in survival associated with concentration of chlordanes in adipose (p = 0.01)	The authors advise that these results were based on a low number of cases and should be interpreted with caution.

Study	Type	Size/ Population	Methods	Exposure	Outcome	Results	Notes
McDuffie et al. 2001	Case control	517 Non-Hodgkin's Lymphoma cases and 1506 controls in Canada	Pesticide exposure was obtained through initial postal questionnaires followed by a phone interview for individuals who reported pesticide exposure of 10 h/year or more and a 15% random sample of the remaining individuals. Cases were obtained through provincial cancer registries excluding Quebec where hospital ascertainment was employed. Controls were selected from provincial health insurance records, computerized telephone listings or voters' lists.	Exposure to insecticides	Non-Hodgkin's Lymph-oma	The odds ratios associating NHL with chlordane were not statistically significant.	
McGlynn et al. 2008	Case control	754 cases and 928 controls	Cases were US military servicemen with testicular germ cell tumors 45 years or younger at the time of diagnosis and to have donated at least one serum sample 1987 - 2002. Controls were matched to cases	Organochloride pesticides (including α -chlordane, γ -chlordane, oxychlordane, <i>trans</i> -nonachlor, <i>cis</i> -nonachlor) in serum.	Testicular germ cell tumors	Testicular germ cell tumors risk was statistically significantly associated with higher plasma levels of two chlordane-related compounds: <i>cis</i> -nonachlor (OR = 1.56, 95% CI =	

Study	Type	Size/ Population	Methods	Exposure	Outcome	Results	Notes
			on birth year (within 1 year), race/ethnicity (white, black, other), and date of available serum sample (within 30 days) using the computerized Defense Medical Surveillance System database.. Serum samples were analysed for concentrations of several organochloride pesticides.			1.11 to 2.18, <i>P</i> trend = .009) and <i>trans</i> -nonachlor (OR = 1.46, 95% CI = 1.07 to 2.00, <i>P</i> trend = .026). The other chlordane-related compounds had no significant association with testicular germ cell tumors.	
Mills and Yang 2007	Case control	100 cases and 210 controls.	Cases of newly diagnosed gastric cancer in California farm workers during 1988 to 2003. Control subjects were California residents without stomach cancer matched on age, gender, and ethnicity. Exposure to pesticides was based on employer records and reports to the California pesticide-reporting program.	Exposure to pesticides based on employer records and reports to the California pesticide-reporting program.	Gastric cancer	Use of chlordane was associated with the gastric cancer (OR for ever used vs. never used chlordane = 2.96; 95% CI = 1.48–5.94).	Authors did not collect information on dietary habits, family history, smoking or alcohol consumption.

Study	Type	Size/ Population	Methods	Exposure	Outcome	Results	Notes
Purdue et al. 2007	Cohort	51,011 participants from the Ag Health Study	Questionnaires were completed at the time of enrollment (1993-1997) including information on occupation, and pesticide use and exposure. Follow-up through December 31, 2002 was conducted using Iowa and North Carolina State Cancer Registries, state death registries, and NDI. Cohort members out of state were identified using IRS records, Motor Vehicle registration databases, and pesticide license registries. Analyses adjusted for age, sex, state, education, smoking, alcohol use, cancer family history, and lifetime days of total pesticide application.	Ever/never use, cumulative exposure, lifetime exposure days, and intensity weighted lifetime exposure to 50 specific pesticides	Cancer (multiple types)	22,409 (48%) of participants ever used insecticides. Leukemia risk was greater than 1.5 (but not significant) with chlordane use. There was an increased risk of rectal cancer with use of chlordane but it was not statistically significant (RR 1.7, 1.0–2.8). No association between chlordane exposure and NHL was reported.	Insecticide applicators were primarily male and white.
Purdue et al. 2009	Case control	49 cases and 51 controls. Subject pool was based on serum	Cases had testicular germ cell tumors (27–62 years of age at diagnosis). Controls were matched to cases	Organochlorine pesticides (including chlordane congeners) in serum.	Testicular germ cell tumors	Oxychlordane was not associated with a significant increased risk of testicular germ cell tumors. The tertile	

Study	Type	Size/ Population	Methods	Exposure	Outcome	Results	Notes
		samples collected between 1972 and 1978 at the Norwegian Janus Serum Bank.	on region, blood draw year, and age at blood draw. Serum samples were analysed for organochlorine pesticides, including chlordane congeners.			3 vs. tertile 1 odds ratio (OR _{T3}) for combined chlordane metabolites was 2.0 (95% CI, 0.6–7.2). This was not statistically significant.	
Quintana et al. 2004	Nested case control	175 Non-Hodgkin's Lymphoma cases and 481 controls taken from original cohort	A data set originally collected between 1969 and 1983 by the EPA for the U.S. EPA National Human Adipose Tissue Survey was utilized. Samples of adipose tissue were collected randomly from cadavers and surgery patients. Levels of organochlorine pesticide residues were determined through the collected samples.	Organochlorine pesticide residue in adipose tissue (including the chlordane metabolite oxychlordane)	Non-Hodgkin's Lymphoma	The highest levels of oxychlordane (0.15 – 2.85 ppm) in adipose tissue was associated with increased risk of NHL (OR=1.79; 1.04–3.08). The p-value for trend was significant for chlordane as well (p = 0.0002).	There are a few limitations to this study including the collection of exposure information after diagnosis as well as lack of information on variables that could affect organochlorine levels. These variables include diet, occupation and BMI.
Ritchie et al. 2003	Case control (pilot study)	58 cases, 99 controls	Incident prostate cancer cases were identified from 2 Iowa clinics. Cases were pathologically confirmed, newly diagnosed (May 2000 to May 2001), and all were adenocarcinomas. Questionnaires were	Blood levels of 48 organochlorine compounds (including the chlordane metabolite oxychlordane)	Prostate cancer	Oxychlordane was detected in 91.4% of cases and 81.8% of controls. The adjusted OR for prostate cancer was 3.11 (1.27–7.63) for those with 0.020–0.032 ug/g oxychlordane in serum and 1.23	Cases were more likely to have a history of prostatitis, be overweight, and be married. Other organochlorines were associated with increased risk of prostate cancer.

Study	Type	Size/ Population	Methods	Exposure	Outcome	Results	Notes
			administered to collect data on age, race, family history, tobacco and alcohol use, sexual partners, STDs, hormone usage. Blood samples were taken to test for organochlorines.			(0.42–3.55) for those with 0.032 - 0.1 ug/g oxychlordane in serum. The authors stated that the observed non-linear dose response for oxychlordane might be due to the small sample size.	
Schroeder et al. 2001	Case Control	182 cases and 1245 controls form the Factors Affecting Rural Men study	Authors investigated the role of agricultural risk factors for t(14,18) - positive non-Hodgkin's lymphoma (NHL), compared to t(14,18)-negative. Participants were from Iowa (identified thru the State Health Registry of Iowa) and Minnesota (identified thru active hospital surveillance). Tissues samples from male NHL cases collected by the Factors Affecting Rural Men study were assayed for t(14,18). Controls	Self-reported exposure to 111 compounds	T(14,18)-positive non-Hodgkin's Lymph-oma	Chlordane was weakly associated with both NHL subtypes. Chlordane was weakly associated with t(14,18)-positive NHL when compared to controls (OR = 1.4, 0.7-2.9) and with with t(14,18)-positive NHL when compared to controls (OR = 1.5, 0.9-2.6). Several other chemicals were also significantly associated with t(14,18)-positive NHL including Lindane, Toxaphene,	Comparisons of combinations of joint exposures between fumigants and other factors (farming, dairy cattle, chickens, pigs, soybeans, corn, fungicides, organophosphates) resulted in significantly elevated risks of t(14,18)-positive NHL among those exposed to both exposures compared to those without either exposure.

Study	Type	Size/ Population	Methods	Exposure	Outcome	Results	Notes
			<p>were recruited using random digit dialing. Controls were white men without hemolymphatic cancer, frequency mated on age, state, and vital status. Exposures were determined by interviews with participants or next-of-kin. Data collected included socio-demographic factors, tobacco and alcohol use, hobbies, pets, medical history, occupational history, and non-occupational exposures.</p>			<p>Atrazine, and Phthalimides.</p>	
Spinelli et al. 2007	Case control	422 cases and 460 controls. British Columbia, Canada	<p>Cases were patients with newly diagnosed non-Hodgkin lymphoma aged 20–79 without evidence of HIV infection. Control subjects were frequency matched to cases by sex, age and residential location, randomly selected from the Client Registry of</p>	<p>PCBs and organochlorine pesticides (including α-chlordane, γ-chlordane oxychlordane) in plasma samples</p>	Non-Hodgkin lymphoma	<p>An association with non-Hodgkin lymphoma was found for oxychlordane, a metabolite of the pesticide chlordane (highest vs. lowest quartile OR = 2.68, 1.69–4.24). α-Chlordane and γ-chlordane were not detected in the plasma samples.</p>	

Study	Type	Size/ Population	Methods	Exposure	Outcome	Results	Notes
			the BC Ministry of Health. PCBs and organochlorine pesticides were measured in plasma samples				
Ward et al. 2000	Case Control	150 cases, 150 controls	Among serum donors collected by the Janus Serum Bank in Norway between 1973 and 1991, women who worked outside the home or were resident farmers as of the 1970 or 1980 census. Of those women, breast cancer cases were determined from records of the Norwegian Cancer Registry though Dec. 31, 1993. Cancer-free controls from the same group were matched based on date of sample and date of birth. Additional data on potential confounders was collected from the Janus Serum Bank and Norwegian Cancer Registry.	71 organochlorine compounds in serum (including the chlordane metabolite oxychlordane)	Breast Cancer	Oxychlordane was not associated with breast cancer.	

Study	Type	Size/ Population	Methods	Exposure	Outcome	Results	Notes
Xu et al. 2010	Cross-sectional	4,237 in the HANES survey including 4,109 individuals without cancer, 65 prostate cancer cases, 63 breast cancer cases	Participants provided blood samples and information about medical conditions and demographic variables.	Serum concentrations of thirteen organochlorine (OC) pesticides including the chlordane metabolite oxychlordane	Self-reported physician-diagnosed breast and prostate cancer	The trend in the Odds Ratios (OR) for prostate cancer when compared by tertiles of serum concentration of dieldrin was not significant ($P_{\text{trend}} = 0.06$). The OR for the second tertile was 3.54 (0.91–13.8), the OR for the 3 rd tertile was 3.54 (0.92–13.6) as compared to the lowest quartile. No association was found between serum concentrations of any of the OC pesticides and breast cancer.	Due to the nature of the cross-sectional design of this study, causality between OC pesticides and cancer risk cannot be concluded.
Zheng 2000	Case control	304 cases and 186 controls	Cases were histologically confirmed, incident primary breast-cancer patients. Controls were 186 histologically confirmed incident benign breast-disease. Breast adipose tissue not needed for	Oxychlordane in breast adipose tissue.	Breast cancer	There was no association between breast-cancer risk and mean adipose-tissue levels of oxychlordane.	

Study	Type	Size/ Population	Methods	Exposure	Outcome	Results	Notes
			diagnostic purposes was collected and analysed for oxychlordane.				

Table A2- Epidemiologic Studies of Non-Cancer Endpoints

Study	Type	Size/ Population	Methods	Exposure	Outcome	Results	Notes
Akkina et al. 2004	Cross Sectional	219 menopausal women in Hispanic Health NHANES	1982-1984 survey years of the Hispanic Health NHANES were used. Data on age at menopause, reproductive history, demographic variables, other potential confounders were collected as part of the survey. Serum samples were also collected. ANOVA was used to investigate the relationship between age at menopause and serum levels of pesticides.	18 organochlorine pesticides in serum (including the chlordane metabolite oxychlordane)	Age at menopause	Serum levels of oxychlordane were above the detection limit (1ppb) in 15 individuals (6.9%). Oxychlordane was not associated with age at menopause.	Serum levels of pesticides may not represent exposure at the time of menopause. Time from menopause to survey ranged from 0 to 37 years.
Damgaard et al. 2006	Case-Control	62 milk samples from mothers of cryptorchid boys and 68 milk samples from mothers of healthy boys	A joint longitudinal, prospective birth cohort study was performed by the authors in Finland and Denmark from 1997 to 2001. They examined regional prevalence rates and risk factors for cryptorchidism through questionnaires and biological samples including one breast milk sample per child. From the bank of breast milk samples, the researchers included 65 samples from each country (Denmark and Finland) to examine organochlorine pesticide exposures. Cases were defined as boys with cryptorchidism at birth	Organochlorine pesticides in human breast milk	Crypt-orchidism	Milk from mothers giving birth to cryptorchid boys had significantly higher concentrations of <i>trans</i> -chlordane (mean 0.06 ng/g) than milk from mothers giving birth to healthy boys (mean 0.04 ng/g; $p = 0.012$). Milk concentrations of oxychlordane and <i>cis</i> -chlordane were similar in case and control samples.	This study cannot provide proof for a causal relationship because it cannot be proven that exposure preceded disease.

Study	Type	Size/ Population	Methods	Exposure	Outcome	Results	Notes
			<p>and controls were defined as boys without cryptorchidism at birth or 3 months old. Breast milk was collected between 1 and 3 months postpartum and was analyzed for 27 OC pesticides.</p>				
<p>Everett & Matheson 2010</p>	<p>Cross Sectional</p>	<p>2341 NHANES participants used to examine exposure to dieldrin</p>	<p>Study of NHANES 1999-2004 survey years. Associations were tested using logistic regression adjusting for age, race, gender, education, poverty income ratio, BMI, waist circumference, physical activity, and family history of diabetes.</p>	<p>8 pesticides and their metabolites were measured in non-fasting blood samples</p>	<p>Diagnosed and undiagnosed diabetes and pre-diabetes (glycohemoglobin 5.7-6.54%) based on self-report and glycohemoglobin measurements</p>	<p>The limit of detection for oxychlordane was 14.5 ng/g (lipid adjusted). The odds ratio for total diabetes with exposure to oxychlordane was 2.90 (95% CI 1.78–4.71). The odds ratio for pre-diabetes with exposure to oxychlordane was 1.28 (95% CI 0.88–1.88).</p>	<p>No occupational or residential information was used in the analysis.</p>

Study	Type	Size/ Population	Methods	Exposure	Outcome	Results	Notes
Fenster et al. 2006	Cohort	385 Latinas living in the Salinas Valley, CA, an agricultural community.	Participants were part of a longitudinal birth cohort study, the Center for the Health Assessment of Mothers and Children of Salina project of the Center for Children's Environmental Health Research. Eligible women were <20 weeks gestation, at least 18 years old, eligible for Medi-Cal, and planning on giving birth at the Natividad Medical Center. Data was collected from interviews and medical record abstraction. Serum was drawn from the mothers at approximately 26 weeks gestation and at the hospital before delivery. Models were adjusted for maternal age, parity, country of birth, family income, timing of entry into prenatal care, smoking, total dimethyls at 26 weeks, pregnancy weight gain, prepregnancy BMI, total DAPs in urine at 26 weeks, infant sex, gestational age and gestational age squared.	11 organochlorine pesticides (including the chlordane metabolite oxychlordane) in maternal serum	Infant's length of gestation, birth weight, and crown-heel length	Neither crude nor adjusted associations between health effects in infants and maternal serum oxychlordane concentration during pregnancy were found.	Results are not generalizable as most women were Latina and born in Mexico, and selection was limited to low-income families.

Study	Type	Size/ Population	Methods	Exposure	Outcome	Results	Notes
Landgren et al. 2009	Cohort	678 men participating in the Ag Health Study - stratified random sample of 57,310 licensed pesticide applicators.	Age-adjusted prevalence of MGUS among the men in the Ag Health Study were compared to 9,469 men from MN. Exposure to pesticide was self-reported at time of study enrollment (1993-1997) and serum samples were collected between 2006 and 2008. Logistic regression was used to control for age, education.	Self-reported pesticide use and pesticide concentrations in serum	Mono-clonal gammopathy of undetermined significance (MGUS)	Among those ever reporting exposure to chlordane, the OR for MGUS was 1.3 (0.6-2.6) based on 14 cases. Two other compounds were significantly associated with increased risk of MGUS out of 50 compounds tested.	The comparison group from MN was chosen because the Mayo Clinic had the largest MGUS screening study available at the time this study was conducted.
Lee et al. 2006	Cross sectional	2,016 adult participants in the National Health and Nutrition Examination Survey 1999–2002	Participants were considered to have diabetes if 1) their fasting plasma glucose was ≥ 126 mg/dl or their nonfasting plasma glucose was ≥ 200 mg/dl or 2) they reported a history of physician diagnosed diabetes. Exposure to persistent organic pollutants was determined by analysis of blood samples.	Six of persistent organic pollutants (including the chlordane metabolite oxychlordane)	Diabetes	Diabetes was strongly positively associated with oxychlordane after adjustment for age, sex, race/ethnicity, poverty income ratio, BMI, and waist circumference (odds ratio 6.5; 95% CI = 2.0-21.4; $p < 0.001$).	The study does not specify type I or type II diabetes, which are very different in etiology. Diabetes was diagnoses were self-reported, not confirmed by a physician.
Louis et al. 2006	Case Control	136 cases and 144 controls	Cases were treated at the Neurological Institute of New York and identified from a database at the Center for Parkinson's disease and other movement disorders.	Exposure to 6 organochlorine pesticides (including the chlordane metabolite ooxychlordane)	Essential Tremor	No association between ET and any of the 6 pesticides tested in serum. Parity (in women) was the only variable significantly	The authors report that they needed 160 cases and 160 controls to have adequate statistical power to detect a 20% difference

Study	Type	Size/ Population	Methods	Exposure	Outcome	Results	Notes
			Those with physical signs/diagnoses of Parkinsonism, dystonia, spinocerebellar ataxia were excluded. Controls were ascertained from the same source and from the same zip codes as cases, matched by age-strata, gender, and race. Questionnaires administered by a trained tester; videotaped neurological evaluations; serum samples collected; occupational histories evaluated by an industrial hygienist were all analyzed using Chi-square and student's T-tests, and Pearson correlation coefficients.	was assessed by serum concentrations and occupational histories.		associated with log dieldrin.	based on a pilot study.
Montgomery et al. 2008	Cohort	31,787 pesticide applicators in the Ag Health Study	All data was collected from questionnaires at the time of study enrollment and after 5 years. Participants having diabetes at enrollment and those missing information pertaining to diabetes or other covariates (age, state, BMI) were excluded. Lifetime exposure to pesticides was calculated from reported use at enrollment (1993-1997). Only pesticide applicators were included (not family members); 97% were non-Hispanic White and	Cumulative number of days and ever/never use of 50 specific pesticides	Diabetes	1,176 diagnosed diabetics and 30,611 non-diabetics were self-reported after a 5-year follow-up interview (conducted 1999-2003). The adjusted ORs (95% CI) found for exposure to chlordane are as follows: Ever use, 1.16 (1.01-1.34) compared to never users; 0.01-10 cumulative days of	Not generalizable- the study was mostly white men, in rural areas. The study does not specify type I or type II diabetes, which are very different in etiology. Diabetes was only self-reported, not confirmed by a physician. The study did not control for exercise and diet.

Study	Type	Size/ Population	Methods	Exposure	Outcome	Results	Notes
			97% were male.			use: 1.15 (0.90 - 1.46); 10.01-100 days: 1.18 (0.85 - 1.65); and over 100 days: 1.63 (0.93 - 2.86), with a p-value for trend of 0.05; additionally stratifying by age < and > 60 years and by state resulted in elevated but not significant ORs.	
Nagayama et al. 2007a	Case control	34 cases and 192 controls	Investigated the effects of prenatal exposure to chlordane on the incidence of congenital cretinism in Fukuoka, Japan from 2001 to 2004. Cases were positive neonates of mass-screening for cretinism. Control subjects were neonates without cretinism. Cretinism was determined by serum thyroid stimulating hormone levels >10 IU/ml and free thyroxine levels of <1 mg/dl. Chlordane exposure was determined by chlordane concentrations in	Chlordane in breast milk	Cretinism	Cretinism cases had a mean chlordane concentration in 1.86 ng/g in breast milk, while control milk samples contained a mean of 0.76 ng/g chlordane. The odds ratio of chlordane exposure associated with the induction of cretinism was 6.6 (p = 0.006).	

Study	Type	Size/ Population	Methods	Exposure	Outcome	Results	Notes
			breast milk collected within 4 weeks of birth.				
Nagayama et al. 2007b	Cross Sectional	92 Japanese mother-infant pairs living in or near Fukuoka, Japan.	Participants were recruited in the months of July and August of 1994-1996. Infants that were carried to term, without congenital abnormalities or disease, with normal pregnancies were included. Breast milk samples were collected 2-4 months after delivery. Peripheral venous blood was collected from infants at about 10 months of age. Lymphocyte subsets and ratio of CD4+ T cell to CD8+ T cell were investigated in vitro.	Pesticides in breast milk, including chlordane	Lymphocyte subsets (CD16+, HLA-DR+, CD4+, CD8+, CD3+,CD20+) percentage and ratio	Chlordane concentrations in infant blood ranged from 10 to 454 ng/g lipid. Perinatal exposure to chlordane increased the percentage CD3+ T cells, although not significantly (odds ratio = 1.70; p = 0.069). The authors noted that the clinical significance of these effects is uncertain.	There is no consideration of other environmental, viral, bacterial, causes for changes in immune response. No attempt was made to measure exposure in utero.
Noakes et al. 2006	Cross Sectional	31 women in Western Australia	Participants were randomly selected among pregnant women undergoing caesarean section in 2001-2002, at a Hospital in an area of Western Australia where allergic disease is epidemic. Maternal and neonate blood samples,	Persistent organic pollutants in maternal blood, adipose and breast milk, and in cord blood and placental tissue.	Allergic immune response in women and infants	While chlordane was detected in one maternal blood sample, it was not associated with any change in immune response. Chlordane was not detected in maternal adipose and breast milk, or in cord blood and	All subjects had pollutant levels much less than has previously been associated with any subclinical effects.

Study	Type	Size/ Population	Methods	Exposure	Outcome	Results	Notes
			maternal milk and adipose, and placental tissue was used to determine levels of persistent organic pollutants. Cord blood and maternal blood was collected for cytokine and lymphoproliferation response analyses. Immune responses were investigated in vitro. Data was analyzed by comparing medians and IQRs using Spearman rank correlation.			placental tissue.	
Tan et al. 2009	Cross Sectional	Newborn infants of 41 native Singaporean mothers	Umbilical cord blood samples were collected from the babies of 41 native Singaporean mothers admitted to the National Hospital of Singapore for cesarean section in 2006. Chlordane concentrations in cord blood were compared to birth length, weight and baby head circumference.	Persistent organic pollutants in cord blood.	Birth length, birth weight, head circumference	Chlordane was detected in 33 cord blood samples at a mean concentration of 4.83 ng/g of lipid weight. Chlordane negatively correlated with birth weight, birth length and head circumference. Specific correlation coefficients were not available.	
Weisskopf et al. 2010	Case Control	101 cases, 349 controls	Incident Parkinson's disease cases and controls were identified from the Finnish Mobile Clinic Health	Organochlorine pesticides (including the chlordane metabolite	Parkinson's Disease	Oxychlordane had no association to Parkinson's disease in this analysis. The	Never smokers have a higher risk of PD than ever smokers. The amount of time

Study	Type	Size/ Population	Methods	Exposure	Outcome	Results	Notes
			<p>Examination Survey. The survey collected serum samples between 1968 and 1972 (analyzed in 2005-2007 for organochlorine pesticides). Cases were identified in the Social Insurance Institution's registry and were confirmed by medical records. Controls were matched by age, sex, municipality, and vital status. Logistic Regression was used to analyze the dataset.</p>	<p>oxychlordane) in serum.</p>		<p>average serum concentration of dieldrin was 5.6 ng/g lipid and the median was 5.7 ng/g lipid.</p>	<p>from collection of the samples to when cases were diagnosed presents problems with interpretation. Other risk factors such as genetics, head trauma, declining estrogen level, and family history were not considered.</p>

APPENDIX B

IRDC 1973 Males

APPENDIX B**IRDC 1973 MALES****Study Description**

Groups of 100 male CD-1 mice were fed diets containing analytical grade chlordane at concentrations of 0, 5, 25 or 50 ppm (approximately 0, 0.71, 3.57, or 7.14 mg/kg/day) for 18 mo. The terminal sacrifice was at 19.5 mo. No exposure-related changes in body weight gain or food consumption were observed. Many mice were lost due to autolysis so that only about half of the mice were examined histologically. The number of mice for which tissue was available for histopathological analysis was less in the high dose group than in the other treated groups but comparable to that in controls. U.S. Environmental Protection Agency-sponsored examination of the liver histological slides found statistically significant increased incidence of hepatic carcinomas in males of the 25- and 50-ppm groups (see Table B1 below). No effects were observed other than cancer, even at the highest dose level (U.S. EPA 1997).

Table B5: IRDC 1973 Tumor Incidence Data for Males as presented in U.S. EPA 1997

Dose (ppm in mouse diet)	Human Equivalent Dose (mg/kg-day) ^a	Tumor Incidence (Hepatic Carcinomas)
0	0	3/33
5	0.1022	5/55
25	0.5137	41/52
50	1.0273	32/39

a. Human Equivalent Dose = Mouse Dose x (mouse BW/human BW)^{1/4} = mouse dose x 0.143882.

Evaluation of Cancer Risk by U.S. EPA (1997)

In its evaluation of the male carcinogenicity data reported in the IRDC (1973) study, U.S. EPA (1997) used a GLOBAL.86 computer algorithm, linear multistage procedure, extra risk model. This model produced a low-dose cancer slope factor of 0.858 (mg/kg-day)⁻¹. A good curve fit could not be modeled to the complete data set, so the highest dose level was excluded to produce a model with a good curve fit.

Benchmark Dose Models

Tumor incidence data are quantal data that the US EPA (2000a) recommends for use in a Dichotomous Multistage-Cancer Model. In the analyses for chlordane, dose levels in Human Equivalent Dose were entered with the sample size (N) and tumor incidence data were entered into a BMDS 2.1.2 spreadsheet (see Figure B1, next page). The Dichotomous Model Multistage-Cancer Model allows for variation of the Degree of Polynomial to find the best curve fit. In a data set containing a control group and three treatment dose levels, the Degree of Polynomial can be set to 1, 2, or 3. In the first run of the model, Degree of Polynomial was set to 1 (see Figure B2 below), and in the second and third runs, this value was changed to 2 and 3, respectively. Because the first 3 runs did not produce an acceptable curve fit, the highest dose was excluded from the data set, and the model was run again with the Degree of Polynomial set at 1 and 2 for runs 4 and 5, respectively.

Figure B1. BMDS Input Data

	Human_Dose	Tumor_Incidence	N	Col4	Col5	Cc
1	0	3	33			
2	0.1022	5	55			
3	0.5137	41	52			
4	1.0273	32	39			
5						

Figure B2. BMDS Model Parameters – First Run

<<Column Assignments>>

Dose: Human_Dose

Subjects in Dose Group: N

Incidence: Tumor_Incidence

% Positive: []

<<Optimizer Assignments>>

Iteration: 250

Relative Function: 1.00E-08

Parameter: 1.00E-08

<<Parameter Assignments>>

Parameters	Options	Values
Background	Default	
Beta1	Default	
Beta2	Default	

<<Other Assignments>>

Risk Type: Extra

BMR: 0.1000

Confidence Level: 0.95

BMD Calculation:

BMDL Curve Calc.:

Dose Groups: 4

Degree of Polynomial: 1

User Notes: []

Data File: I:\Aldrin & Dieldrin\Chlordane, DDE, DDD, DDT, and Endrin\ [Show]

Out File Name: I:\Aldrin & Dieldrin\Chlordane, DDE, DDD, DDT, and Endrin\ [Set]

[Save] [Save As ...] [Set Values To Default] [Optimize Initial Param. Values] [Run] [Close]

Multistage-Cancer->Dichotomous

Results

A summary of the BMD analyses of the liver tumor incidence data is presented in Table 2 below, and the BMDS input data, model parameters, and output are presented in subsequent pages. The first run (Degree of Polynomial =1) produced a curve with a poor visual fit, and the mathematical tests for a good fit produced values outside the acceptable ranges (see table footnotes). Subsequent runs with Degree of Polynomial values of 2 or 3 also produced curves with poor fit to the data.

When the complete data set cannot produce an adequate curve fit, it can be acceptable to exclude the data from the highest dose level from the data set. The reason is that in benchmark dose analysis, the effects at the lower dose levels are more important than at the highest dose level. At high dose levels, there may be confounding factors such as toxicity or reduced survival that could affect the shape of the entire curve. By excluding the data at the highest dose level, the algorithms used in the modeling calculations can focus on the lower dose range and produce the best fit to the effects at these dose levels. The fourth and fifth runs were performed after exclusion of the highest dose level (1.0273 mg/kg-day), and the Degree of Polynomials were set to 1 and, respectively. At 1 Degree of Polynomials, the fit was mathematically poor, but an acceptable curve fit was produced in the fifth run of the model in which the Degree of Polynomials was set at 2. Note that in its analysis of these data, U.S. EPA (1997) also excluded the high dose data to produce an acceptable curve fit. Complete output reports for each model run are presented in the following pages.

Table B6. Results of BMD5 Modeling of IRDC 1973 Male Tumor Data

Run #	Data Set	Degree of Polynomial	Curve-Fit Acceptance			BMD	BMD-derived CSF
			P-value ¹	Highest Scaled Residual ²	AIC ³		
1	All	1	0.0028	-2.357	161.058	0.0542653	2.28187
2	All	2	0.0006	-2.267	163.031	0.0570496	2.27957
3	All	3	0.0006	-2.267	163.031	0.0570496	2.27957
4	Excluded high dose	1	0.0014	-2.627	122.923	0.0473776	2.74975
5	Excluded high dose	2	0.3904	-0.630	112.015	0.138495	1.13656

1 For the model to be acceptable, P-value must be > 0.1 .

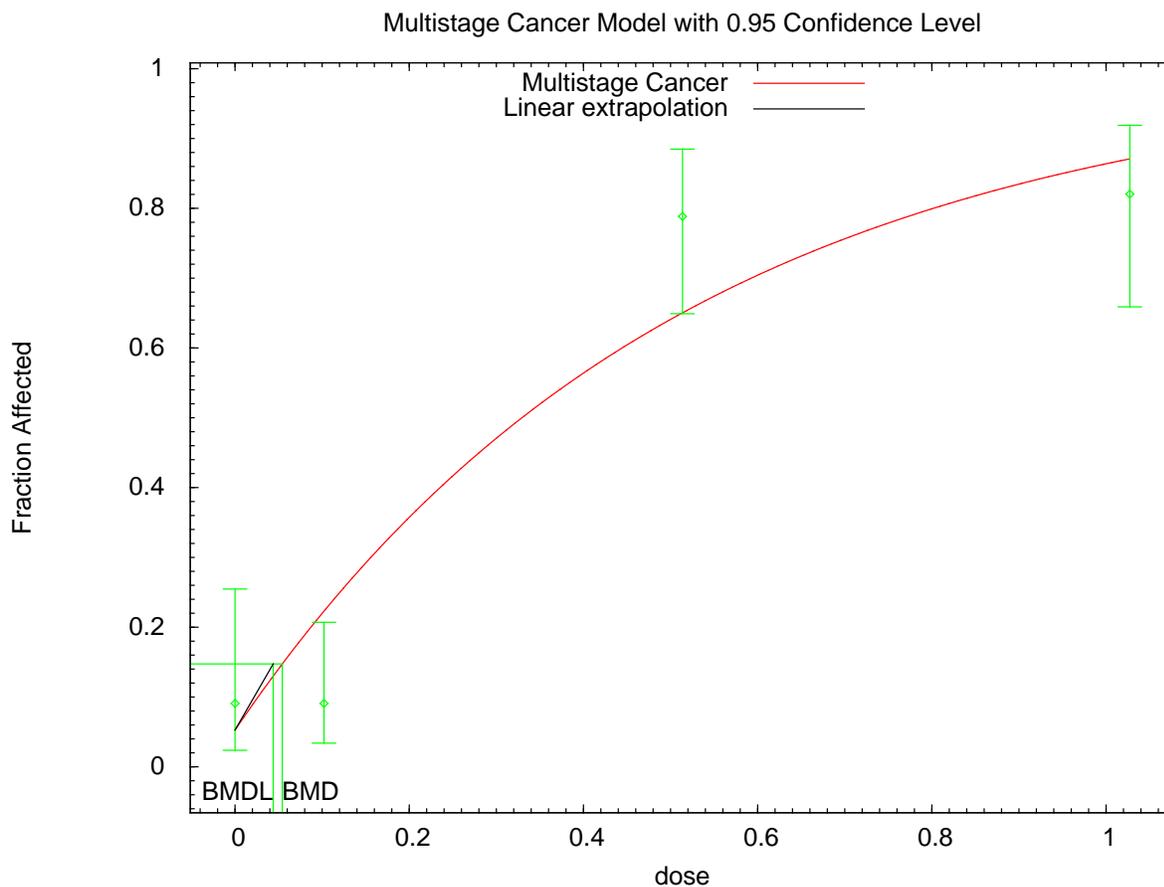
2 Scaled residuals report the gap between the curve line and the actual data points; for the model to be acceptable, all scaled residuals must have an absolute value of < 2 .

3 The Akaike Information Coefficient (AIC) is used for comparison between models; a lower AIC value indicates a better curve fit to the data.

CONCLUSION

By excluding the highest dose level and setting the Degree of Polynomials to 2, Run # 5 produced an acceptable fit, with a benchmark dose of 0.171714 mg/kg-day and an oral cancer slope factor of $1.13656 \text{ (mg/kg-day)}^{-1}$ in male CD-1 mice.

BMDS Output – Run #1



```

=====
Multistage Cancer Model. (Version: 1.9; Date: 05/26/2010)
Input Data File: I:\Aldrin & Dieldrin\Chlordane, DDE, DDD, DDT, and
Endrin\BMDS Output Files\msc_Chlordane Cancer IRDC 1973 Male_Opt.(d)
Gnuplot Plotting File: I:\Aldrin & Dieldrin\Chlordane, DDE, DDD, DDT, and
Endrin\BMDS Output Files\msc_Chlordane Cancer IRDC 1973 Male_Opt.plt
Tue Jun 21 13:57:40 2011
=====

```

BMDS_Model_Run

~~~~~

The form of the probability function is:

$$P[\text{response}] = \text{background} + (1-\text{background}) * [1 - \text{EXP}(-\text{beta}1 * \text{dose}^1)]$$

The parameter betas are restricted to be positive

Dependent variable = Tumor\_Incidence  
 Independent variable = Human\_Dose

Total number of observations = 4  
 Total number of records with missing values = 0  
 Total number of parameters in model = 2

Total number of specified parameters = 0  
 Degree of polynomial = 1

Maximum number of iterations = 250  
 Relative Function Convergence has been set to: 1e-008  
 Parameter Convergence has been set to: 1e-008

Default Initial Parameter Values  
 Background = 0.1338  
 Beta(1) = 1.75697

Asymptotic Correlation Matrix of Parameter Estimates

|            | Background | Beta(1) |
|------------|------------|---------|
| Background | 1          | -0.54   |
| Beta(1)    | -0.54      | 1       |

Parameter Estimates

| Interval<br>Limit | Variable   | Estimate  | Std. Err. | 95.0% Wald Confidence |             |
|-------------------|------------|-----------|-----------|-----------------------|-------------|
|                   |            |           |           | Lower Conf. Limit     | Upper Conf. |
|                   | Background | 0.0527681 | *         | *                     | *           |
|                   | Beta(1)    | 1.94158   | *         | *                     | *           |

\* - Indicates that this value is not calculated.

Analysis of Deviance Table

| Model         | Log(likelihood) | # Param's | Deviance | Test d.f. | P-value  |
|---------------|-----------------|-----------|----------|-----------|----------|
| Full model    | -71.9933        | 4         |          |           |          |
| Fitted model  | -78.5288        | 2         | 13.071   | 2         | 0.001451 |
| Reduced model | -123.265        | 1         | 102.543  | 3         | <.0001   |
| AIC:          | 161.058         |           |          |           |          |

Goodness of Fit

| Dose   | Est._Prob. | Expected | Observed | Size | Scaled Residual |
|--------|------------|----------|----------|------|-----------------|
| 0.0000 | 0.0528     | 1.741    | 3.000    | 33   | 0.980           |
| 0.1022 | 0.2233     | 12.279   | 5.000    | 55   | -2.357          |
| 0.5137 | 0.6506     | 33.832   | 41.000   | 52   | 2.085           |
| 1.0273 | 0.8711     | 33.973   | 32.000   | 39   | -0.943          |

Chi^2 = 11.75      d.f. = 2      P-value = 0.0028

Benchmark Dose Computation

Specified effect = 0.1

Risk Type = Extra risk

Confidence level = 0.95

BMD = 0.0542653

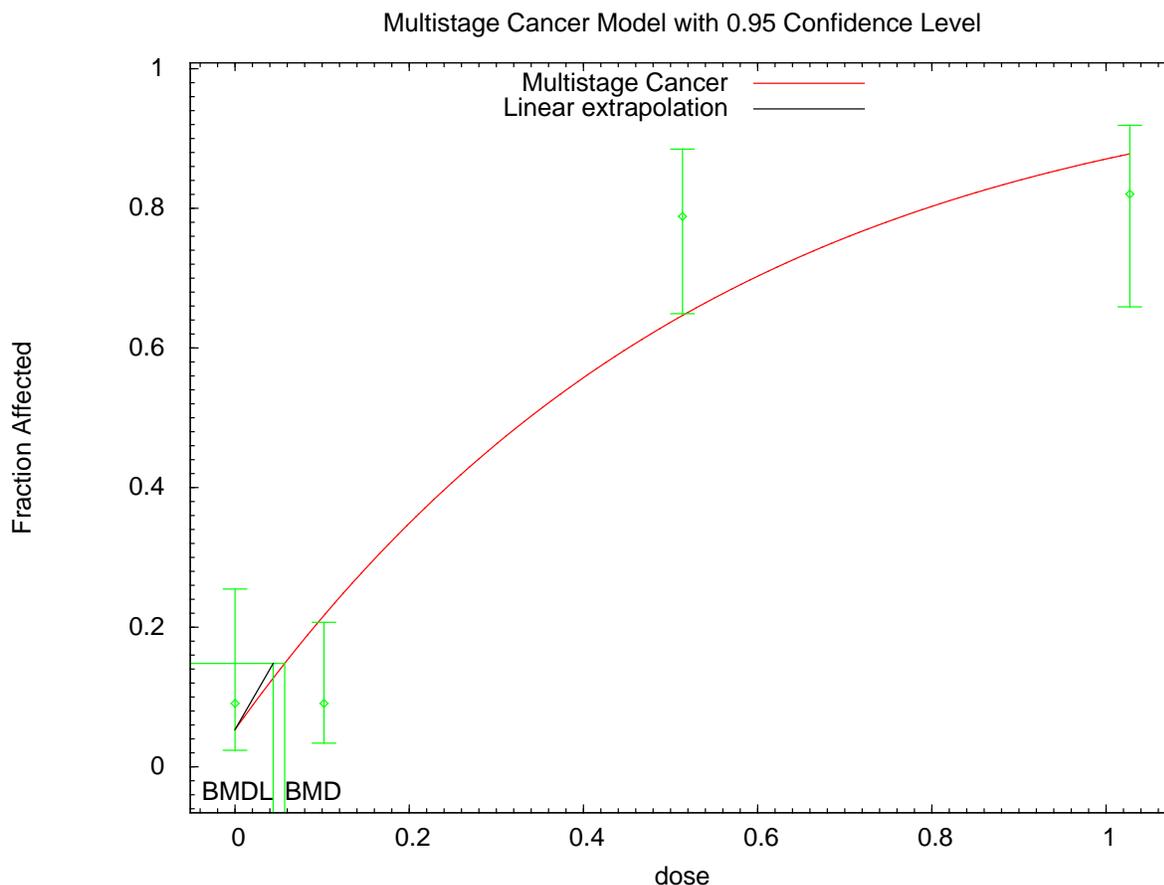
BMDL = 0.0438237

BMDU = 0.0683979

Taken together, (0.0438237, 0.0683979) is a 90 % two-sided confidence interval for the BMD

Multistage Cancer Slope Factor = 2.28187

**BMD5 Output – Run #2 (Same Input Data, Changed Degree of Polynomial to 2)**



```

=====
Multistage Cancer Model. (Version: 1.9; Date: 05/26/2010)
Input Data File: I:\Aldrin & Dieldrin\Chlordane, DDE, DDD, DDT, and
Endrin\BMD5 Output Files\msc_Chlordane Cancer IRDC 1973 Male_Opt.(d)
Gnuplot Plotting File: I:\Aldrin & Dieldrin\Chlordane, DDE, DDD, DDT, and
Endrin\BMD5 Output Files\msc_Chlordane Cancer IRDC 1973 Male_Opt.plt
Tue Jun 21 13:38:05 2011
=====

```

BMD5\_Model\_Run

The form of the probability function is:

$$P[\text{response}] = \text{background} + (1-\text{background}) * [1 - \text{EXP}(-\text{beta1} * \text{dose} - \text{beta2} * \text{dose}^2)]$$

The parameter betas are restricted to be positive

Dependent variable = Tumor\_Incidence  
 Independent variable = Human\_Dose

```

Total number of observations = 4
Total number of records with missing values = 0
Total number of parameters in model = 3
Total number of specified parameters = 0

```

Degree of polynomial = 2

Maximum number of iterations = 250  
 Relative Function Convergence has been set to: 1e-008  
 Parameter Convergence has been set to: 1e-008

Default Initial Parameter Values

Background = 0.1338  
 Beta(1) = 1.75697  
 Beta(2) = 0

Asymptotic Correlation Matrix of Parameter Estimates

|            | Background | Beta(1) | Beta(2) |
|------------|------------|---------|---------|
| Background | 1          | -0.48   | 0.32    |
| Beta(1)    | -0.48      | 1       | -0.93   |
| Beta(2)    | 0.32       | -0.93   | 1       |

Parameter Estimates

| Interval<br>Limit | Variable   | Estimate  | Std. Err. | 95.0% Wald Confidence |             |
|-------------------|------------|-----------|-----------|-----------------------|-------------|
|                   |            |           |           | Lower Conf. Limit     | Upper Conf. |
|                   | Background | 0.0535298 | *         | *                     | *           |
|                   | Beta(1)    | 1.83824   | *         | *                     | *           |
|                   | Beta(2)    | 0.150527  | *         | *                     | *           |

\* - Indicates that this value is not calculated.

Analysis of Deviance Table

| Model         | Log(likelihood) | # Param's | Deviance | Test d.f. | P-value   |
|---------------|-----------------|-----------|----------|-----------|-----------|
| Full model    | -71.9933        | 4         |          |           |           |
| Fitted model  | -78.5156        | 3         | 13.0446  | 1         | 0.0003042 |
| Reduced model | -123.265        | 1         | 102.543  | 3         | <.0001    |

AIC: 163.031

Goodness of Fit

| Dose   | Est._Prob. | Expected | Observed | Size | Scaled Residual |
|--------|------------|----------|----------|------|-----------------|
| 0.0000 | 0.0535     | 1.766    | 3.000    | 33   | 0.954           |
| 0.1022 | 0.2169     | 11.928   | 5.000    | 55   | -2.267          |
| 0.5137 | 0.6462     | 33.603   | 41.000   | 52   | 2.145           |
| 1.0273 | 0.8778     | 34.235   | 32.000   | 39   | -1.093          |

Chi^2 = 11.85      d.f. = 1      P-value = 0.0006

Benchmark Dose Computation

Specified effect = 0.1

Risk Type = Extra risk

Confidence level = 0.95

BMD = 0.0570496

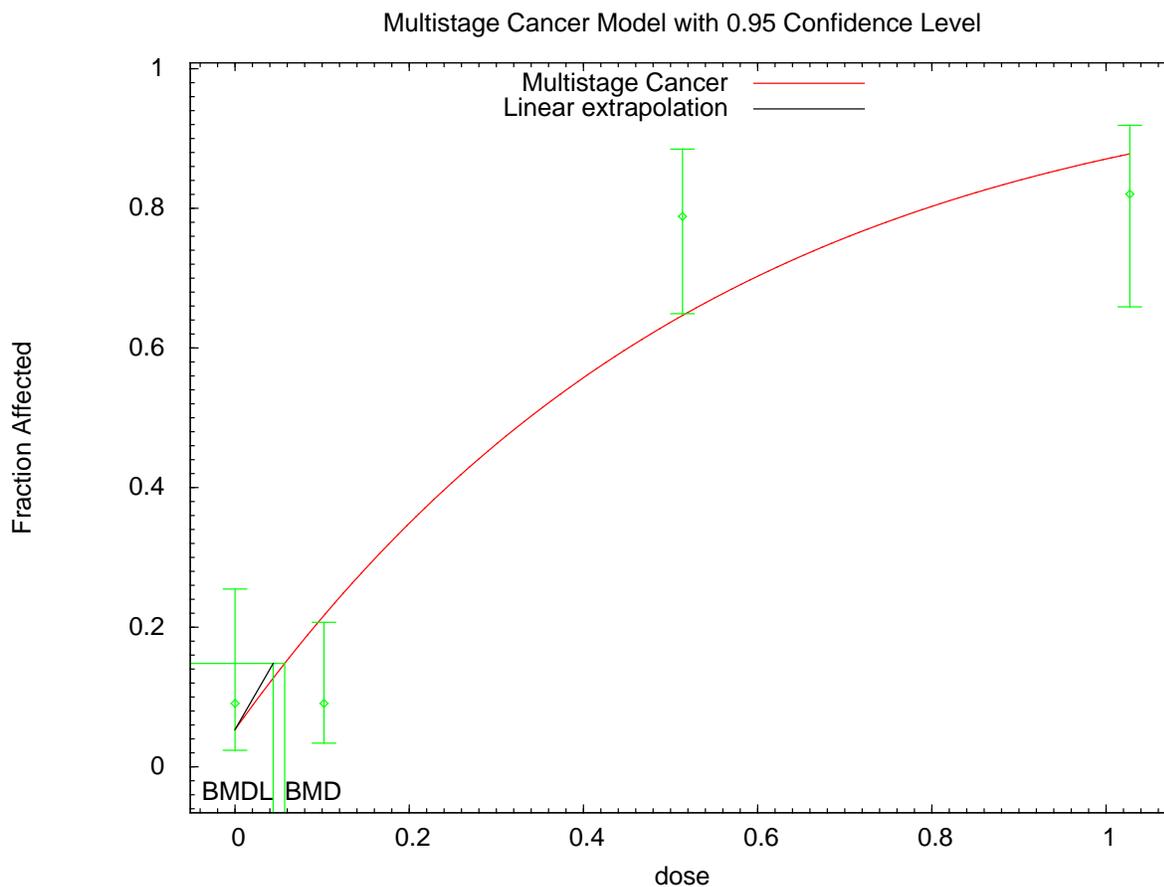
BMDL = 0.043868

BMDU = 0.11374

Taken together, (0.043868, 0.11374) is a 90 % two-sided confidence interval for the BMD

Multistage Cancer Slope Factor = 2.27957

**BMDS Output - Run #3 (Same Input Data, Changed Degree of Polynomial to 3):**



```

=====
Multistage Cancer Model. (Version: 1.9; Date: 05/26/2010)
Input Data File: I:\Aldrin & Dieldrin\Chlordane, DDE, DDD, DDT, and
Endrin\BMDS Output Files\msc_Chlordane Cancer IRDC 1973 Male_Opt.(d)
Gnuplot Plotting File: I:\Aldrin & Dieldrin\Chlordane, DDE, DDD, DDT, and
Endrin\BMDS Output Files\msc_Chlordane Cancer IRDC 1973 Male_Opt.plt
Tue Jun 21 13:54:57 2011
=====

```

```

BMDS_Model_Run
~~~~~

```

The form of the probability function is:

$$P[\text{response}] = \text{background} + (1-\text{background}) * [1 - \text{EXP}(-\text{beta1} * \text{dose} - \text{beta2} * \text{dose}^2 - \text{beta3} * \text{dose}^3)]$$

The parameter betas are restricted to be positive

Dependent variable = Tumor\_Incidence  
 Independent variable = Human\_Dose

Total number of observations = 4  
 Total number of records with missing values = 0  
 Total number of parameters in model = 4

Total number of specified parameters = 0  
 Degree of polynomial = 3

Maximum number of iterations = 250  
 Relative Function Convergence has been set to: 1e-008  
 Parameter Convergence has been set to: 1e-008

Default Initial Parameter Values  
 Background = 0.1338  
 Beta(1) = 1.75697  
 Beta(2) = 0  
 Beta(3) = 0

Asymptotic Correlation Matrix of Parameter Estimates

( \*\*\* The model parameter(s) -Beta(3)  
 have been estimated at a boundary point, or have been specified by  
 the user,  
 and do not appear in the correlation matrix )

|            | Background | Beta(1) | Beta(2) |
|------------|------------|---------|---------|
| Background | 1          | -0.48   | 0.32    |
| Beta(1)    | -0.48      | 1       | -0.93   |
| Beta(2)    | 0.32       | -0.93   | 1       |

Parameter Estimates

| Interval<br>Limit | Variable   | Estimate  | Std. Err. | 95.0% Wald Confidence |                   |
|-------------------|------------|-----------|-----------|-----------------------|-------------------|
|                   |            |           |           | Lower Conf. Limit     | Upper Conf. Limit |
|                   | Background | 0.0535298 | *         | *                     | *                 |
|                   | Beta(1)    | 1.83824   | *         | *                     | *                 |
|                   | Beta(2)    | 0.150527  | *         | *                     | *                 |
|                   | Beta(3)    | 0         | *         | *                     | *                 |

\* - Indicates that this value is not calculated.

Analysis of Deviance Table

| Model         | Log(likelihood) | # Param's | Deviance | Test d.f. | P-value   |
|---------------|-----------------|-----------|----------|-----------|-----------|
| Full model    | -71.9933        | 4         |          |           |           |
| Fitted model  | -78.5156        | 3         | 13.0446  | 1         | 0.0003042 |
| Reduced model | -123.265        | 1         | 102.543  | 3         | <.0001    |
| AIC:          | 163.031         |           |          |           |           |

Goodness of Fit

| Dose  | Est._Prob. | Expected | Observed | Size | Scaled Residual |
|-------|------------|----------|----------|------|-----------------|
| ----- |            |          |          |      |                 |

|        |        |        |        |    |        |
|--------|--------|--------|--------|----|--------|
| 0.0000 | 0.0535 | 1.766  | 3.000  | 33 | 0.954  |
| 0.1022 | 0.2169 | 11.928 | 5.000  | 55 | -2.267 |
| 0.5137 | 0.6462 | 33.603 | 41.000 | 52 | 2.145  |
| 1.0273 | 0.8778 | 34.235 | 32.000 | 39 | -1.093 |

Chi<sup>2</sup> = 11.85      d.f. = 1      P-value = 0.0006

Benchmark Dose Computation

Specified effect =            0.1

Risk Type            =        Extra risk

Confidence level =            0.95

          BMD =            0.0570496

          BMDL =           0.043868

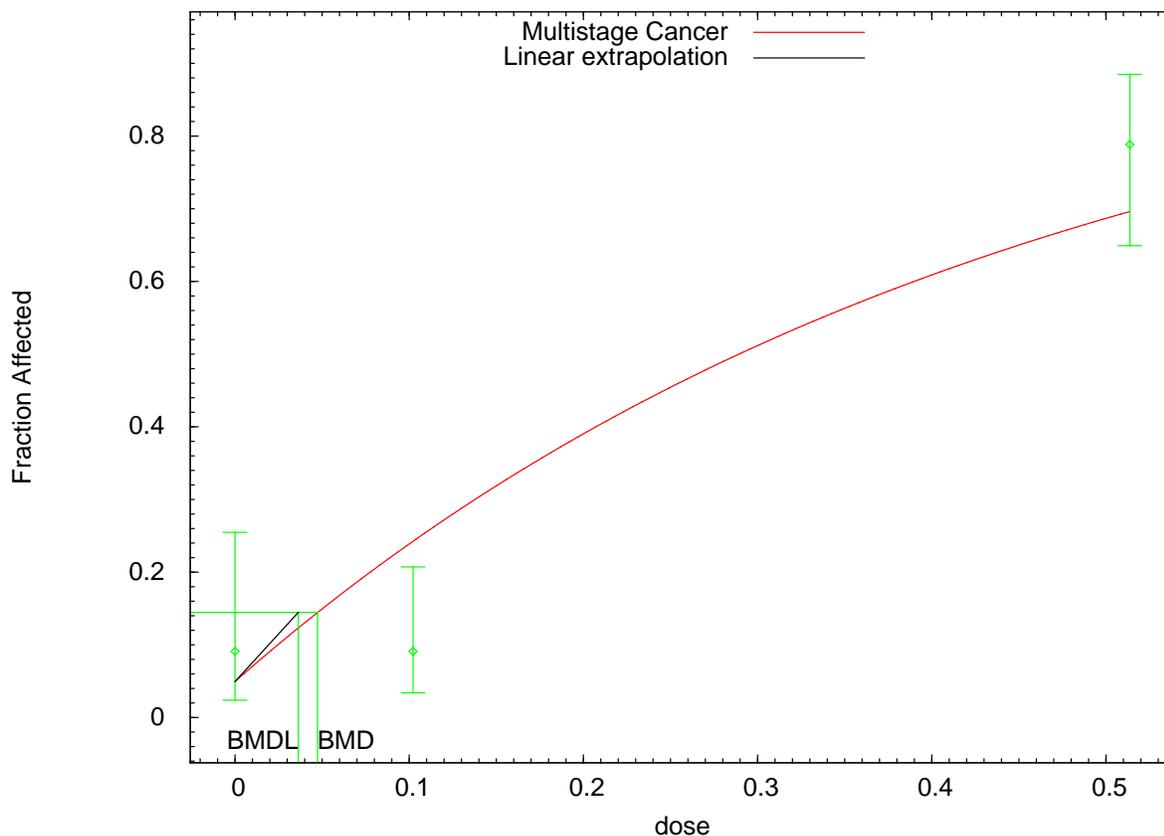
          BMDU =           0.11374

Taken together, (0.043868, 0.11374) is a 90      % two-sided confidence interval for the BMD

Multistage Cancer Slope Factor =            2.27957

**BMDS Output – Run #4 (Exclude High Dose, Degree of Polynomial =1)**

Multistage Cancer Model with 0.95 Confidence Level



09:13 06/22 2011

```

=====
Multistage Cancer Model. (Version: 1.9; Date: 05/26/2010)
Input Data File: I:\Aldrin & Dieldrin\Chlordane, DDE, DDD, DDT, and
Endrin\BMDS Output Files\msc_Chlordane Cancer IRDC 1973 Male_Opt.(d)
Gnuplot Plotting File: I:\Aldrin & Dieldrin\Chlordane, DDE, DDD, DDT, and
Endrin\BMDS Output Files\msc_Chlordane Cancer IRDC 1973 Male_Opt.plt
Wed Jun 22 09:13:36 2011
=====

```

BMDS\_Model\_Run

The form of the probability function is:

$$P[\text{response}] = \text{background} + (1-\text{background}) * [1 - \text{EXP}(-\text{beta} * \text{dose}^1)]$$

The parameter betas are restricted to be positive

Dependent variable = Tumor\_Incidence  
 Independent variable = Human\_Dose

```

Total number of observations = 3
Total number of records with missing values = 0
Total number of parameters in model = 2
Total number of specified parameters = 0

```

Degree of polynomial = 1

Maximum number of iterations = 250  
 Relative Function Convergence has been set to: 1e-008  
 Parameter Convergence has been set to: 1e-008

Default Initial Parameter Values

Background = 0  
 Beta(1) = 3.04053

Asymptotic Correlation Matrix of Parameter Estimates

|            | Background | Beta(1) |
|------------|------------|---------|
| Background | 1          | -0.5    |
| Beta(1)    | -0.5       | 1       |

Parameter Estimates

|          |            | 95.0% Wald Confidence |           |                   |                   |
|----------|------------|-----------------------|-----------|-------------------|-------------------|
| Interval | Variable   | Estimate              | Std. Err. | Lower Conf. Limit | Upper Conf. Limit |
| Limit    | Background | 0.0495381             | *         | *                 | *                 |
|          | Beta(1)    | 2.22385               | *         | *                 | *                 |

\* - Indicates that this value is not calculated.

Analysis of Deviance Table

| Model         | Log(likelihood) | # Param's | Deviance | Test d.f. | P-value   |
|---------------|-----------------|-----------|----------|-----------|-----------|
| Full model    | -53.6393        | 3         |          |           |           |
| Fitted model  | -59.4614        | 2         | 11.6441  | 1         | 0.0006441 |
| Reduced model | -90.6425        | 1         | 74.0064  | 2         | <.0001    |
| AIC:          | 122.923         |           |          |           |           |

Goodness of Fit

| Dose   | Est._Prob. | Expected | Observed | Size | Scaled Residual |
|--------|------------|----------|----------|------|-----------------|
| 0.0000 | 0.0495     | 1.635    | 3.000    | 33   | 1.095           |
| 0.1022 | 0.2428     | 13.352   | 5.000    | 55   | -2.627          |
| 0.5137 | 0.6967     | 36.231   | 41.000   | 52   | 1.439           |

Chi^2 = 10.17      d.f. = 1      P-value = 0.0014

Benchmark Dose Computation

Specified effect = 0.1  
 Risk Type = Extra risk

Confidence level = 0.95

BMD = 0.0473776

BMDL = 0.0363669

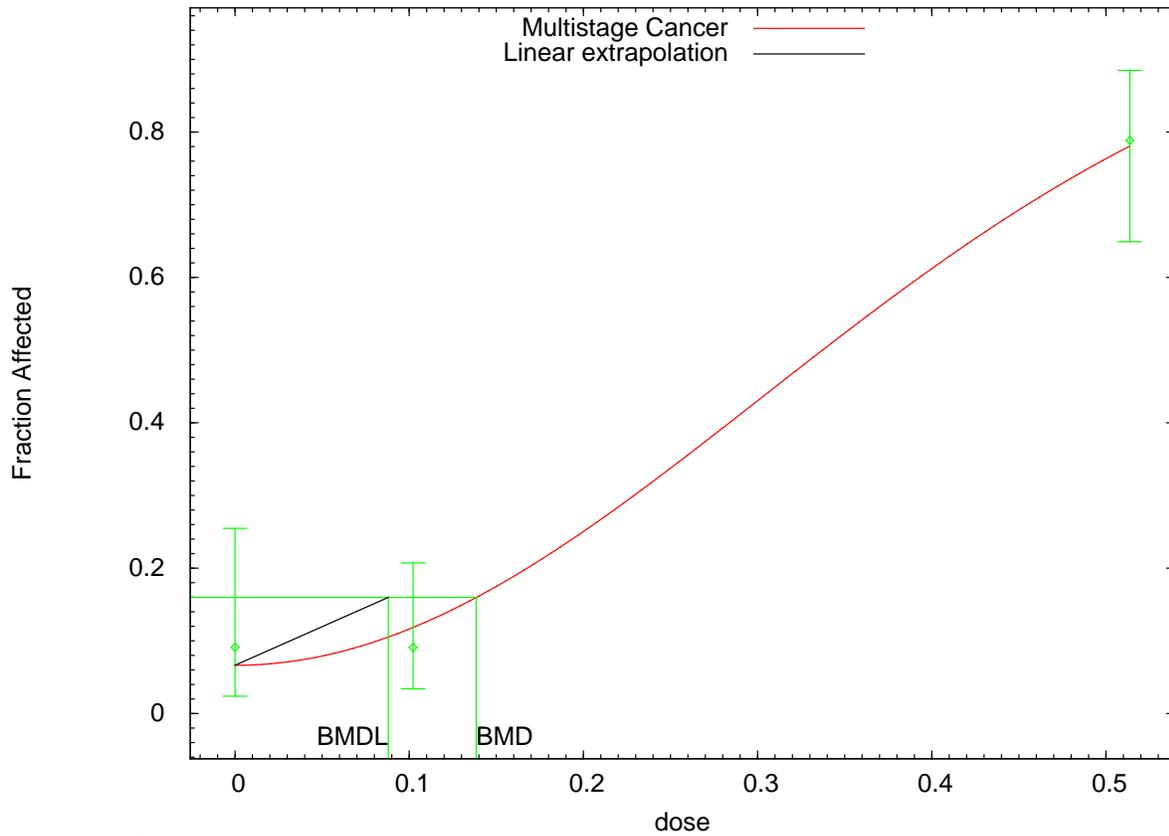
BMDU = 0.0635563

Taken together, (0.0363669, 0.0635563) is a 90 % two-sided confidence interval for the BMD

Multistage Cancer Slope Factor = 2.74975

**BMDS Output – Run #5 (Exclude High Dose, Degree of Polynomial =2)**

Multistage Cancer Model with 0.95 Confidence Level



09:10 06/22 2011

```

=====
Multistage Cancer Model. (Version: 1.9; Date: 05/26/2010)
Input Data File: I:\Aldrin & Dieldrin\Chlordane, DDE, DDD, DDT, and
Endrin\BMDS Output Files\msc_Chlordane Cancer IRDC 1973 Male_Opt.(d)
Gnuplot Plotting File: I:\Aldrin & Dieldrin\Chlordane, DDE, DDD, DDT, and
Endrin\BMDS Output Files\msc_Chlordane Cancer IRDC 1973 Male_Opt.plt
Wed Jun 22 09:10:57 2011
=====

```

BMDS\_Model\_Run

The form of the probability function is:

$$P[\text{response}] = \text{background} + (1-\text{background}) * [1 - \text{EXP}(-\text{beta1} * \text{dose} - \text{beta2} * \text{dose}^2)]$$

The parameter betas are restricted to be positive

Dependent variable = Tumor\_Incidence  
 Independent variable = Human\_Dose

```

Total number of observations = 3
Total number of records with missing values = 0
Total number of parameters in model = 3
Total number of specified parameters = 0

```

Degree of polynomial = 2

Maximum number of iterations = 250  
 Relative Function Convergence has been set to: 1e-008  
 Parameter Convergence has been set to: 1e-008

Default Initial Parameter Values

Background = 0.0643391  
 Beta(1) = 0  
 Beta(2) = 5.62989

Asymptotic Correlation Matrix of Parameter Estimates

( \*\*\* The model parameter(s) -Beta(1)  
 have been estimated at a boundary point, or have been specified by  
 the user,  
 and do not appear in the correlation matrix )

|            | Background | Beta(2) |
|------------|------------|---------|
| Background | 1          | -0.4    |
| Beta(2)    | -0.4       | 1       |

Parameter Estimates

| Interval<br>Limit | Variable   | Estimate  | Std. Err. | 95.0% Wald Confidence |             |
|-------------------|------------|-----------|-----------|-----------------------|-------------|
|                   |            |           |           | Lower Conf. Limit     | Upper Conf. |
|                   | Background | 0.0662971 | *         | *                     | *           |
|                   | Beta(1)    | 0         | *         | *                     | *           |
|                   | Beta(2)    | 5.49301   | *         | *                     | *           |

\* - Indicates that this value is not calculated.

Analysis of Deviance Table

| Model         | Log(likelihood) | # Param's | Deviance | Test d.f. | P-value |
|---------------|-----------------|-----------|----------|-----------|---------|
| Full model    | -53.6393        | 3         |          |           |         |
| Fitted model  | -54.0076        | 2         | 0.736507 | 1         | 0.3908  |
| Reduced model | -90.6425        | 1         | 74.0064  | 2         | <.0001  |
| AIC:          | 112.015         |           |          |           |         |

Goodness of Fit

| Dose   | Est._Prob. | Expected | Observed | Size | Scaled Residual |
|--------|------------|----------|----------|------|-----------------|
| 0.0000 | 0.0663     | 2.188    | 3.000    | 33   | 0.568           |
| 0.1022 | 0.1184     | 6.510    | 5.000    | 55   | -0.630          |
| 0.5137 | 0.7809     | 40.606   | 41.000   | 52   | 0.132           |

Chi^2 = 0.74      d.f. = 1      P-value = 0.3904

Benchmark Dose Computation

Specified effect = 0.1

Risk Type = Extra risk

Confidence level = 0.95

BMD = 0.138495

BMDL = 0.0879846

BMDU = 0.162032

Taken together, (0.0879846, 0.162032) is a 90 % two-sided confidence interval for the BMD

Multistage Cancer Slope Factor = 1.13656

## **APPENDIX C**

**IRDC 1973 Females**

**APPENDIX C****IRDC 1973 FEMALES****Study Description**

Groups of female CD-1 mice were fed diets containing analytical grade chlordane at concentrations of 0, 5, 25 or 50 ppm (approximately 0, 0.71, 3.57, or 7.14 mg/kg/day) for 18 mo. The terminal sacrifice was at 19.5 mo. No exposure-related changes in body weight gain or food consumption were observed. Many mice were lost due to autolysis so that only about half of the mice were examined histologically. The number of mice for which tissue was available for histopathological analysis was less in the high dose group than in the other treated groups but comparable to that in controls. U.S. Environmental Protection Agency-sponsored examination of the liver histological slides found statistically significant increased incidence of hepatic carcinomas in females of the 25- and 50-ppm groups (see Table C1 below). No effects were observed other than cancer, even at the highest dose level (U.S. EPA 1997).

**Table C1. IRDC 1973 Females data as presented in U.S. EPA 1997**

| Dose (ppm in mouse diet) | Human Equivalent Dose (mg/kg-day) <sup>a</sup> | Tumor Incidence (Hepatic Carcinomas) |
|--------------------------|------------------------------------------------|--------------------------------------|
| 0                        | 0                                              | 0/45                                 |
| 5                        | 0.1022                                         | 0/61                                 |
| 25                       | 0.5137                                         | 32/50                                |
| 50                       | 1.0273                                         | 26/37                                |

a. Human Equivalent Dose = Mouse Dose x (mouse BW/human BW)<sup>1/4</sup> = mouse dose x 0.143882.

**Evaluation of Cancer Risk by U.S. EPA (1997)**

In its evaluation of the female carcinogenicity data reported in the IRDC (1973) study, U.S. EPA (1997) used a GLOBAL.86 computer algorithm, linear multistage procedure, extra risk model. This model produced a low-dose cancer slope factor of 0.217 (mg/kg-day)<sup>-1</sup>. A good curve fit could not be modeled to the complete data set, so the highest dose level was excluded to produce a model with a good curve fit.

**Benchmark Dose Models**

Tumor incidence data are quantal data that the US EPA (2000a) recommends for use in a Dichotomous Multistage-Cancer Model. In the analyses for chlordane, dose levels in Human Equivalent Dose were entered with the sample size (N) and tumor incidence data were entered into a BMDS 2.1.2 spreadsheet (see Figure 1). The Dichotomous Model Multistage-Cancer Model allows for variation of the Degree of Polynomial to find the best curve fit. In a data set containing a control group and three treatment dose levels, the Degree of Polynomial can be set to 1, 2, or 3. In the first run of the model, Degree of Polynomial was set to 1 (see Figure C2), and in the second and third runs, this value was changed to 2 and 3, respectively. Because the first 3 runs did not produce an acceptable curve fit, the highest dose was excluded from the data set, and the model was run again with the Degree of Polynomial set at 1 and 2 for runs 4 and 5, respectively.

Figure C1. BMD5 Input Data

|   | Human_Dose | Tumor_Incidence | N  | Col4 | Col5 | C |
|---|------------|-----------------|----|------|------|---|
| 1 | 0          | 0               | 45 |      |      |   |
| 2 | 0.1022     | 0               | 61 |      |      |   |
| 3 | 0.5137     | 32              | 50 |      |      |   |
| 4 | 1.0273     | 26              | 37 |      |      |   |
| 5 |            |                 |    |      |      |   |

Figure C2. BMD5 Model Parameters – First Run

**<<Column Assignments>>**

|                                 |                 |
|---------------------------------|-----------------|
| <b>Dose</b>                     | Human_Dose      |
| <b># Subjects in Dose Group</b> | N               |
| <b>Incidence</b>                | Tumor_Incidence |
| <b>% Positive</b>               |                 |

**<<Other Assignments>>**

|                             |                                     |
|-----------------------------|-------------------------------------|
| <b>Risk Type</b>            | Extra                               |
| <b>BMR</b>                  | 0.1000                              |
| <b>Confidence Level</b>     | 0.95                                |
| <b>BMD Calculation</b>      | <input checked="" type="checkbox"/> |
| <b>BMDL Curve Calc.</b>     | <input type="checkbox"/>            |
| <b>Dose Groups</b>          | 4                                   |
| <b>Degree of Polynomial</b> | 1                                   |

**<<Optimizer Assignments>>**

|                          |          |
|--------------------------|----------|
| <b>Iteration</b>         | 250      |
| <b>Relative Function</b> | 1.00E-08 |
| <b>Parameter</b>         | 1.00E-08 |

**<<Parameter Assignments>>**

| Parameters        | Options | Values |
|-------------------|---------|--------|
| <b>Background</b> | Default |        |
| <b>Beta1</b>      | Default |        |
| <b>Beta2</b>      | Default |        |

**User Notes:** \_\_\_\_\_

**Data File:** I:\Aldrin & Dieldrin\Chlordane, DDE, DDD, DDT, and Endrin\ Show

**Out File Name:** I:\Aldrin & Dieldrin\Chlordane, DDE, DDD, DDT, and Endrin\ Set

Buttons: Save, Save As ..., Set Values To Default, Optimize Initial Param. Values, Run, Close

Multistage-Cancer->Dichotomous

## Results

A summary of the BMD analyses of the liver tumor incidence data is presented in Table C2 below, and the BMDS input data, model parameters, and output are presented in subsequent pages. The first run (Degree of Polynomial =1) produced a curve with a poor visual fit, and the mathematical tests for a good fit produced values outside the acceptable ranges (see table footnotes). Subsequent runs with Degree of Polynomial values of 2 or 3 also produced curves with poor fit to the data.

When the complete data set cannot produce an adequate curve fit, it can be acceptable to exclude the data from the highest dose level from the data set. The reason is that in benchmark dose analysis, the effects at the lower dose levels are more important than at the highest dose level. At high dose levels, there may be confounding factors such as toxicity or reduced survival that could affect the shape of the entire curve. By excluding the data at the highest dose level, the algorithms used in the modeling calculations can focus on the lower dose range and produce the best fit to the effects at these dose levels. The fourth and fifth runs were performed after exclusion of the highest dose level (1.0273 mg/kg-day), and the Degree of Polynomials were set to 1 and, respectively. At 1 Degree of Polynomials, the fit was mathematically poor, but an acceptable curve fit was produced in the fifth run of the model in which the Degree of Polynomials was set at 2. Note that in its analysis of these data, U.S. EPA (1997) also excluded the high dose data to produce an acceptable curve fit.

Complete output reports for each model run are presented in the following pages.

**Table C2. Results of BMDS Modeling of IRDC 1973 Female Tumor Data**

| Run # | Data Set           | Degree of Polynomial | Curve-Fit Acceptance |                                      |                  | BMD       | BMD-derived CSF |
|-------|--------------------|----------------------|----------------------|--------------------------------------|------------------|-----------|-----------------|
|       |                    |                      | P-value <sup>1</sup> | Highest Scaled Residual <sup>2</sup> | AIC <sup>3</sup> |           |                 |
| 1     | All                | 1                    | 0.0036               | -2.946                               | 133.527          | 0.0809358 | 1.53736         |
| 2     | All                | 2                    | 0.0005               | -2.243                               | 134.101          | 0.131411  | 1.43797         |
| 3     | All                | 3                    | 0.0005               | -2.243                               | 134.101          | 0.131425  | 1.43797         |
| 4     | Excluded high dose | 1                    | 0.0019               | -3.073                               | 88.0827          | 0.0747971 | 1.77674         |
| 5     | Excluded high dose | 2                    | 0.2862               | -1.523                               | 72.0797          | 0.171714  | <b>0.700938</b> |

1 For the model to be acceptable, P-value must be > 0.1.

2 Scaled residuals report the gap between the curve line and the actual data points; for the model to be acceptable, all scaled residuals must have an absolute value of < 2.

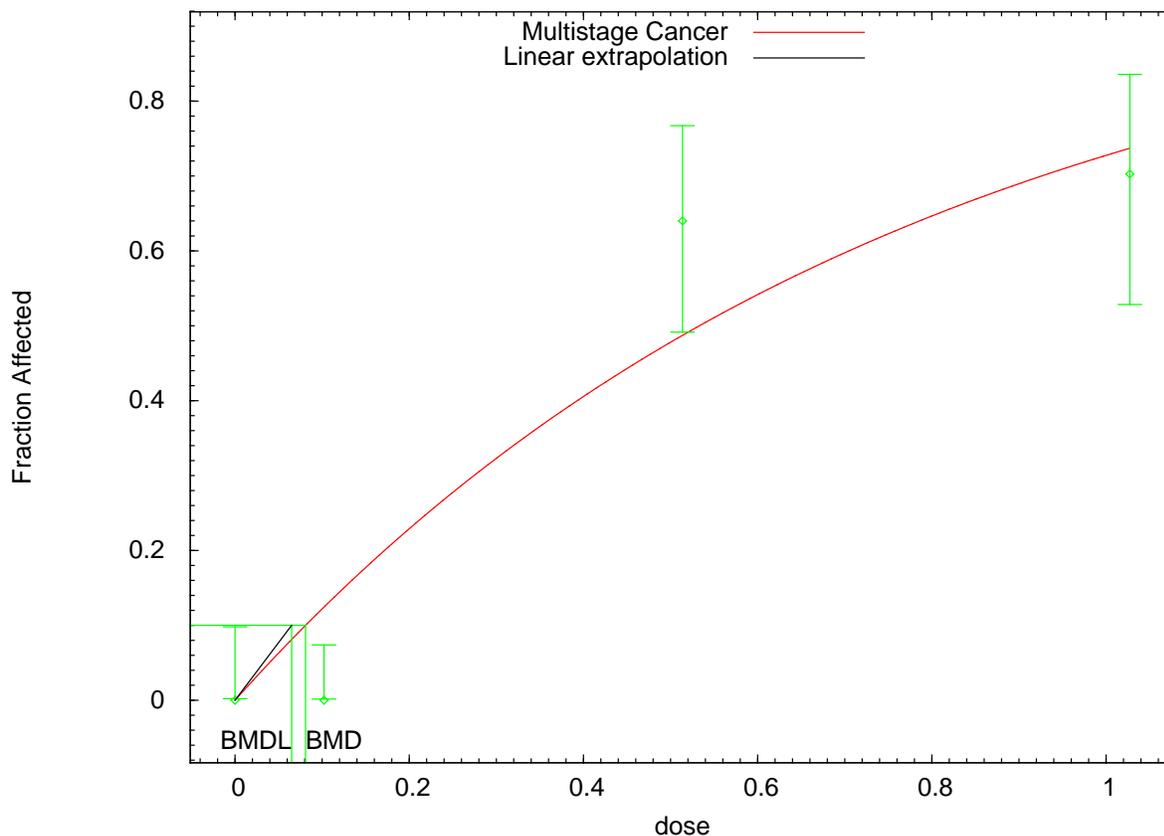
3 The Akaike Information Coefficient (AIC) is used for comparison between models; a lower AIC value indicates a better curve fit to the data.

## CONCLUSION

By excluding the highest dose level and setting the Degree of Polynomials to 2, Run # 5 produced an acceptable fit, with a benchmark dose of 0.171714 mg/kg-day and an oral cancer slope factor of 0.700938 (mg/kg-day)<sup>-1</sup> in female CD-1 mice.

**BMDS Output – Run #1:**

Multistage Cancer Model with 0.95 Confidence Level



14:27 06/21 2011

```

=====
Multistage Cancer Model. (Version: 1.9; Date: 05/26/2010)
Input Data File: I:\Aldrin & Dieldrin\Chlordane, DDE, DDD, DDT, and
Endrin\BMDS Output Files\msc_Chlordane Cancer IRDC 1973 Female_Opt.(d)
Gnuplot Plotting File: I:\Aldrin & Dieldrin\Chlordane, DDE, DDD, DDT, and
Endrin\BMDS Output Files\msc_Chlordane Cancer IRDC 1973 Female_Opt.plt
Tue Jun 21 14:27:14 2011
=====

```

BMDS\_Model\_Run

The form of the probability function is:

$$P[\text{response}] = \text{background} + (1-\text{background}) * [1 - \text{EXP}(-\text{beta}1 * \text{dose}^1)]$$

The parameter betas are restricted to be positive

Dependent variable = Tumor\_Incidence  
 Independent variable = Human\_Dose

Total number of observations = 4  
 Total number of records with missing values = 0  
 Total number of parameters in model = 2

Total number of specified parameters = 0  
 Degree of polynomial = 1

Maximum number of iterations = 250  
 Relative Function Convergence has been set to: 1e-008  
 Parameter Convergence has been set to: 1e-008

Default Initial Parameter Values  
 Background = 0.0231577  
 Beta(1) = 1.30292

Asymptotic Correlation Matrix of Parameter Estimates

( \*\*\* The model parameter(s) -Background  
 have been estimated at a boundary point, or have been specified by  
 the user,  
 and do not appear in the correlation matrix )

Beta(1)  
 Beta(1) 1

Parameter Estimates

| Interval<br>Limit | Variable   | Estimate | Std. Err. | 95.0% Wald Confidence |                   |
|-------------------|------------|----------|-----------|-----------------------|-------------------|
|                   |            |          |           | Lower Conf. Limit     | Upper Conf. Limit |
|                   | Background | 0        | *         | *                     | *                 |
|                   | Beta(1)    | 1.30178  | *         | *                     | *                 |

\* - Indicates that this value is not calculated.

Analysis of Deviance Table

| Model         | Log(likelihood) | # Param's | Deviance | Test d.f. | P-value       |
|---------------|-----------------|-----------|----------|-----------|---------------|
| Full model    | -55.1875        | 4         |          |           |               |
| Fitted model  | -65.7633        | 1         | 21.1517  | 3         | 9.791077e-005 |
| Reduced model | -117.981        | 1         | 125.588  | 3         | <.0001        |
| AIC:          | 133.527         |           |          |           |               |

Goodness of Fit

| Dose   | Est._Prob. | Expected | Observed | Size | Scaled Residual |
|--------|------------|----------|----------|------|-----------------|
| 0.0000 | 0.0000     | 0.000    | 0.000    | 45   | 0.000           |
| 0.1022 | 0.1246     | 7.599    | 0.000    | 61   | -2.946          |
| 0.5137 | 0.4876     | 24.382   | 32.000   | 50   | 2.155           |
| 1.0273 | 0.7375     | 27.286   | 26.000   | 37   | -0.480          |

Chi^2 = 13.56      d.f. = 3      P-value = 0.0036

Benchmark Dose Computation

Specified effect = 0.1

Risk Type = Extra risk

Confidence level = 0.95

BMD = 0.0809358

BMDL = 0.0650465

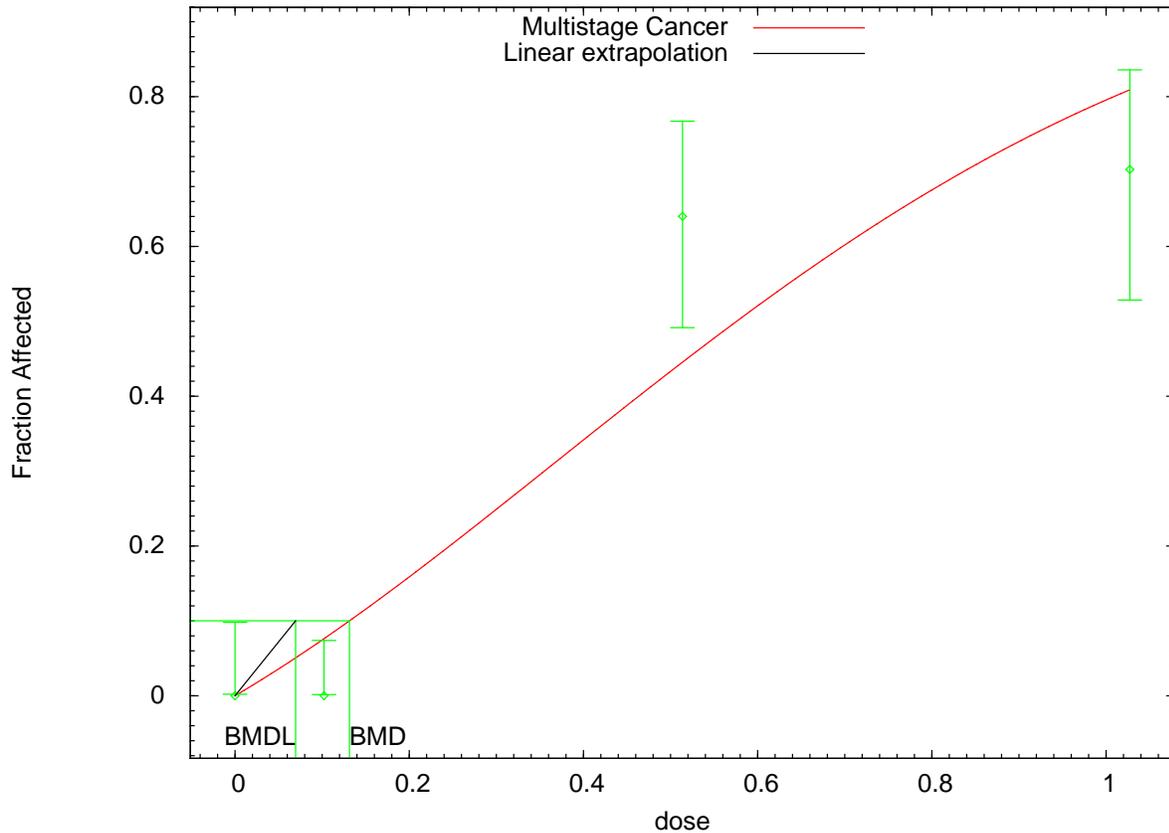
BMDU = 0.102142

Taken together, (0.0650465, 0.102142) is a 90 % two-sided confidence interval for the BMD

Multistage Cancer Slope Factor = 1.53736

**BMDS Output – Run #2 (Same Input Data, Changed Degree of Polynomial to 2)**

Multistage Cancer Model with 0.95 Confidence Level



14:32 06/21 2011

```
=====
Multistage Cancer Model. (Version: 1.9; Date: 05/26/2010)
Input Data File: I:\Aldrin & Dieldrin\Chlordane, DDE, DDD, DDT, and
Endrin\BMDS Output Files\msc_Chlordane Cancer IRDC 1973 Female_Opt.(d)
Gnuplot Plotting File: I:\Aldrin & Dieldrin\Chlordane, DDE, DDD, DDT, and
Endrin\BMDS Output Files\msc_Chlordane Cancer IRDC 1973 Female_Opt.plt
Tue Jun 21 14:32:06 2011
=====
```

BMDS\_Model\_Run

The form of the probability function is:

$$P[\text{response}] = \text{background} + (1-\text{background}) * [1 - \text{EXP}(-\text{beta1} * \text{dose}^{1-\text{beta2}} * \text{dose}^2)]$$

The parameter betas are restricted to be positive

Dependent variable = Tumor\_Incidence  
Independent variable = Human\_Dose

```
Total number of observations = 4
Total number of records with missing values = 0
Total number of parameters in model = 3
Total number of specified parameters = 0
```

Degree of polynomial = 2

Maximum number of iterations = 250  
 Relative Function Convergence has been set to: 1e-008  
 Parameter Convergence has been set to: 1e-008

Default Initial Parameter Values

Background = 0.0231577  
 Beta(1) = 1.30292  
 Beta(2) = 0

Asymptotic Correlation Matrix of Parameter Estimates

( \*\*\* The model parameter(s) -Background  
 have been estimated at a boundary point, or have been specified by  
 the user,  
 and do not appear in the correlation matrix )

|         | Beta(1) | Beta(2) |
|---------|---------|---------|
| Beta(1) | 1       | -0.94   |
| Beta(2) | -0.94   | 1       |

Parameter Estimates

|          |            | 95.0% Wald Confidence |           |                   |                   |
|----------|------------|-----------------------|-----------|-------------------|-------------------|
| Interval | Variable   | Estimate              | Std. Err. | Lower Conf. Limit | Upper Conf. Limit |
| Limit    | Background | 0                     | *         | *                 | *                 |
|          | Beta(1)    | 0.682991              | *         | *                 | *                 |
|          | Beta(2)    | 0.903843              | *         | *                 | *                 |

\* - Indicates that this value is not calculated.

Analysis of Deviance Table

| Model         | Log(likelihood) | # Param's | Deviance | Test d.f. | P-value        |
|---------------|-----------------|-----------|----------|-----------|----------------|
| Full model    | -55.1875        | 4         |          |           |                |
| Fitted model  | -65.0503        | 2         | 19.7257  | 2         | 5.2074697e-005 |
| Reduced model | -117.981        | 1         | 125.588  | 3         | <.0001         |
| AIC:          | 134.101         |           |          |           |                |

Goodness of Fit

| Dose   | Est._Prob. | Expected | Observed | Size | Scaled Residual |
|--------|------------|----------|----------|------|-----------------|
| 0.0000 | 0.0000     | 0.000    | 0.000    | 45   | 0.000           |
| 0.1022 | 0.0762     | 4.647    | 0.000    | 61   | -2.243          |
| 0.5137 | 0.4453     | 22.266   | 32.000   | 50   | 2.770           |
| 1.0273 | 0.8090     | 29.933   | 26.000   | 37   | -1.645          |

Chi<sup>2</sup> = 15.41      d.f. = 2      P-value = 0.0005

Benchmark Dose Computation

Specified effect =            0.1

Risk Type            =        Extra risk

Confidence level =            0.95

          BMD =            0.131411

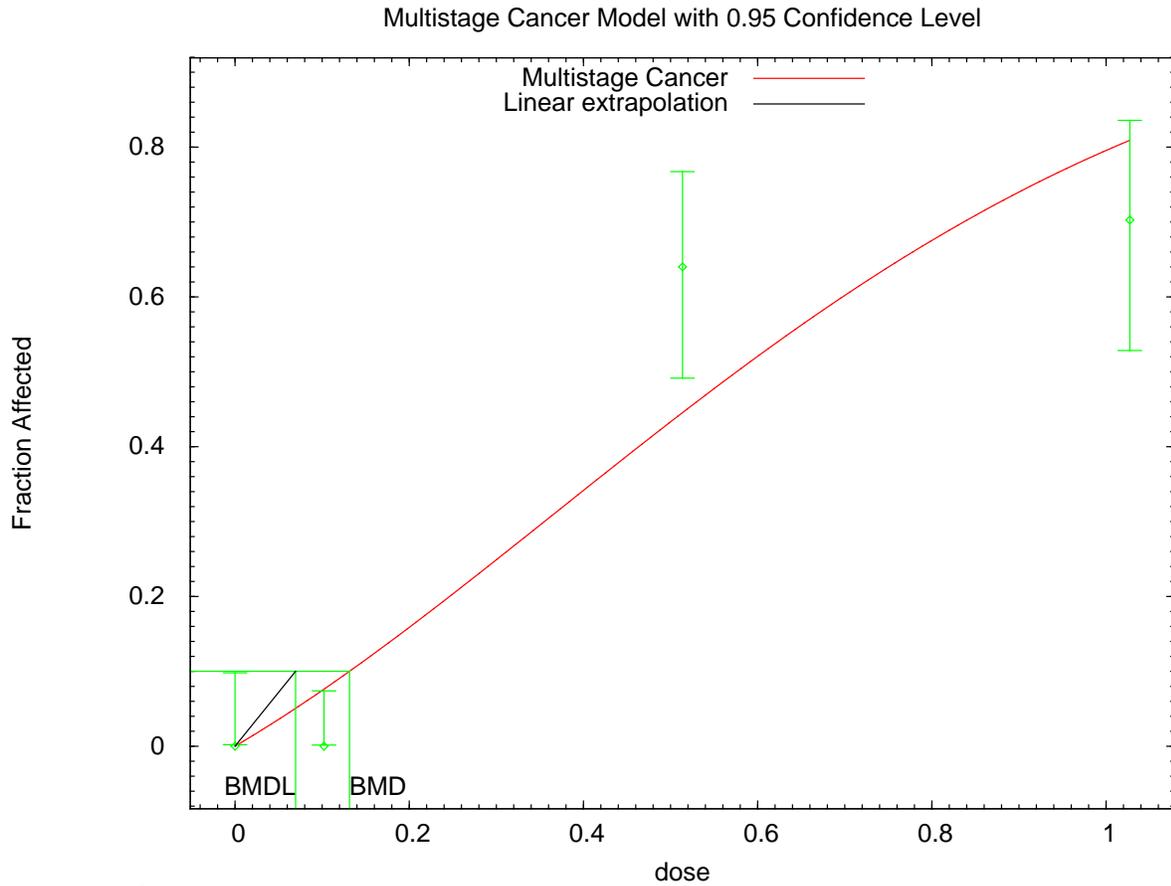
          BMDL =           0.0695426

          BMDU =           0.253191

Taken together, (0.0695426, 0.253191) is a 90      % two-sided confidence interval for the BMD

Multistage Cancer Slope Factor =            1.43797

**BMDS Output – Run #3 (Same Input Data, Changed Degree of Polynomial to 3)**



```

=====
Multistage Cancer Model. (Version: 1.9; Date: 05/26/2010)
Input Data File: I:\Aldrin & Dieldrin\Chlordane, DDE, DDD, DDT, and
Endrin\BMDS Output Files\msc_Chlordane Cancer IRDC 1973 Female_Opt.(d)
Gnuplot Plotting File: I:\Aldrin & Dieldrin\Chlordane, DDE, DDD, DDT, and
Endrin\BMDS Output Files\msc_Chlordane Cancer IRDC 1973 Female_Opt.plt
Tue Jun 21 14:33:04 2011
=====

```

```

BMDS_Model_Run
~~~~~

```

The form of the probability function is:

$$P[\text{response}] = \text{background} + (1-\text{background}) * [1 - \text{EXP}(-\text{beta}1 * \text{dose}^1 - \text{beta}2 * \text{dose}^2 - \text{beta}3 * \text{dose}^3)]$$

The parameter betas are restricted to be positive

Dependent variable = Tumor\_Incidence  
 Independent variable = Human\_Dose

Total number of observations = 4  
 Total number of records with missing values = 0  
 Total number of parameters in model = 4

Total number of specified parameters = 0  
 Degree of polynomial = 3

Maximum number of iterations = 250  
 Relative Function Convergence has been set to: 1e-008  
 Parameter Convergence has been set to: 1e-008

Default Initial Parameter Values  
 Background = 0.0231577  
 Beta(1) = 1.30292  
 Beta(2) = 0  
 Beta(3) = 0

Asymptotic Correlation Matrix of Parameter Estimates

( \*\*\* The model parameter(s) -Background -Beta(3)  
 have been estimated at a boundary point, or have been specified by  
 the user,  
 and do not appear in the correlation matrix )

|         | Beta(1) | Beta(2) |
|---------|---------|---------|
| Beta(1) | 1       | -0.94   |
| Beta(2) | -0.94   | 1       |

Parameter Estimates

| Interval<br>Limit | Variable   | Estimate | Std. Err. | 95.0% Wald Confidence |                   |
|-------------------|------------|----------|-----------|-----------------------|-------------------|
|                   |            |          |           | Lower Conf. Limit     | Upper Conf. Limit |
|                   | Background | 0        | *         | *                     | *                 |
|                   | Beta(1)    | 0.682863 | *         | *                     | *                 |
|                   | Beta(2)    | 0.904027 | *         | *                     | *                 |
|                   | Beta(3)    | 0        | *         | *                     | *                 |

\* - Indicates that this value is not calculated.

Analysis of Deviance Table

| Model         | Log(likelihood) | # Param's | Deviance | Test d.f. | P-value        |
|---------------|-----------------|-----------|----------|-----------|----------------|
| Full model    | -55.1875        | 4         |          |           |                |
| Fitted model  | -65.0503        | 2         | 19.7257  | 2         | 5.2074697e-005 |
| Reduced model | -117.981        | 1         | 125.588  | 3         | <.0001         |
| AIC:          | 134.101         |           |          |           |                |

Goodness of Fit

| Dose   | Est._Prob. | Expected | Observed | Size | Scaled Residual |
|--------|------------|----------|----------|------|-----------------|
| 0.0000 | 0.0000     | 0.000    | 0.000    | 45   | 0.000           |
| 0.1022 | 0.0762     | 4.647    | 0.000    | 61   | -2.243          |

|        |        |        |        |    |        |
|--------|--------|--------|--------|----|--------|
| 0.5137 | 0.4453 | 22.266 | 32.000 | 50 | 2.770  |
| 1.0273 | 0.8090 | 29.934 | 26.000 | 37 | -1.645 |

Chi<sup>2</sup> = 15.41      d.f. = 2      P-value = 0.0005

Benchmark Dose Computation

Specified effect = 0.1

Risk Type = Extra risk

Confidence level = 0.95

BMD = 0.131425

BMDL = 0.0695426

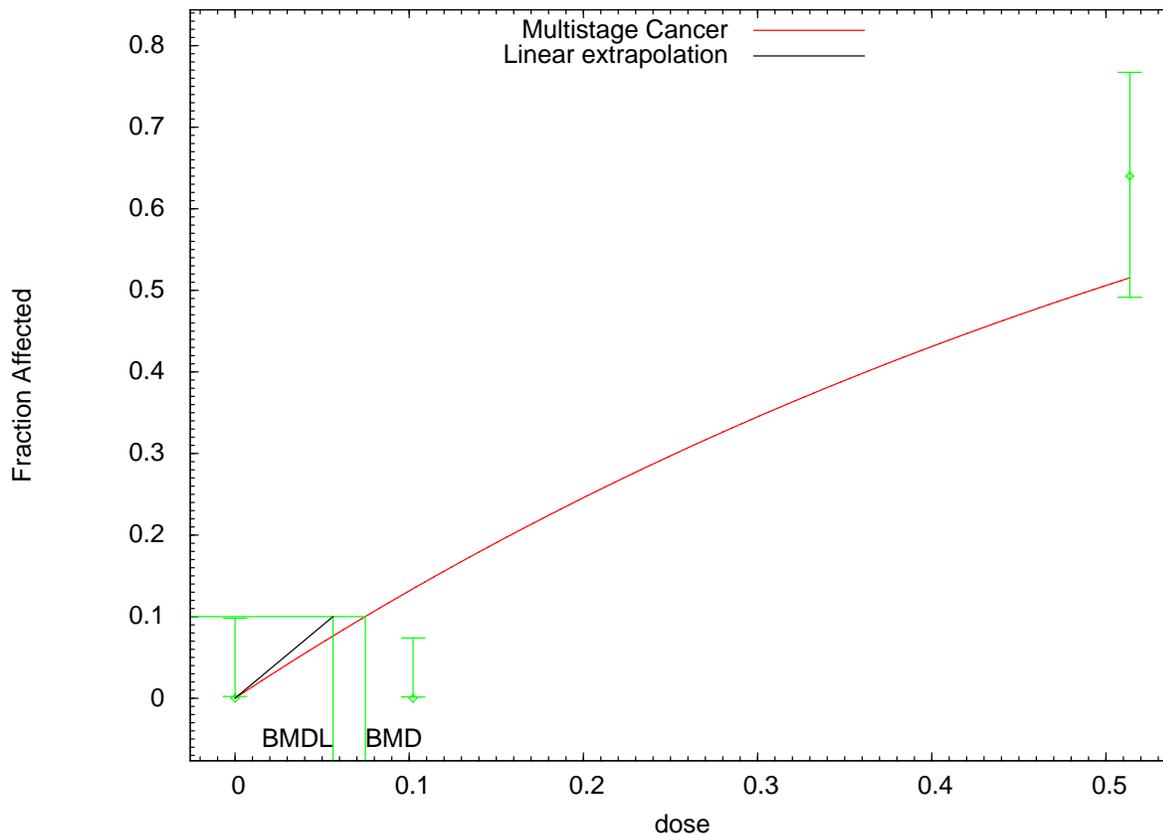
BMDU = 0.253191

Taken together, (0.0695426, 0.253191) is a 90 % two-sided confidence interval for the BMD

Multistage Cancer Slope Factor = 1.43797

**BMDS Output – Run #4 (Exclude High Dose, Degree of Polynomial =1)**

Multistage Cancer Model with 0.95 Confidence Level



14:41 06/21 2011

```

=====
Multistage Cancer Model. (Version: 1.9; Date: 05/26/2010)
Input Data File: I:\Aldrin & Dieldrin\Chlordane, DDE, DDD, DDT, and
Endrin\BMDS Output Files\msc_Chlordane Cancer IRDC 1973 Female_Opt.(d)
Gnuplot Plotting File: I:\Aldrin & Dieldrin\Chlordane, DDE, DDD, DDT, and
Endrin\BMDS Output Files\msc_Chlordane Cancer IRDC 1973 Female_Opt.plt
Tue Jun 21 14:41:10 2011
=====

```

BMDS\_Model\_Run

The form of the probability function is:

$$P[\text{response}] = \text{background} + (1-\text{background}) * [1 - \text{EXP}(-\text{beta}1 * \text{dose}^1)]$$

The parameter betas are restricted to be positive

Dependent variable = Tumor\_Incidence  
 Independent variable = Human\_Dose

```

Total number of observations = 3
Total number of records with missing values = 0
Total number of parameters in model = 2
Total number of specified parameters = 0

```

Degree of polynomial = 1

Maximum number of iterations = 250

Relative Function Convergence has been set to: 1e-008

Parameter Convergence has been set to: 1e-008

Default Initial Parameter Values

Background = 0  
Beta(1) = 2.13051

Asymptotic Correlation Matrix of Parameter Estimates

( \*\*\* The model parameter(s) -Background  
have been estimated at a boundary point, or have been specified by  
the user,  
and do not appear in the correlation matrix )

Beta(1)

Beta(1) 1

Parameter Estimates

| Interval<br>Limit | Variable   | Estimate | Std. Err. | 95.0% Wald Confidence |                   |
|-------------------|------------|----------|-----------|-----------------------|-------------------|
|                   |            |          |           | Lower Conf. Limit     | Upper Conf. Limit |
|                   | Background | 0        | *         | *                     | *                 |
|                   | Beta(1)    | 1.40862  | *         | *                     | *                 |

\* - Indicates that this value is not calculated.

Analysis of Deviance Table

| Model         | Log(likelihood) | # Param's | Deviance | Test d.f. | P-value        |
|---------------|-----------------|-----------|----------|-----------|----------------|
| Full model    | -32.6709        | 3         |          |           |                |
| Fitted model  | -43.0413        | 1         | 20.7409  | 2         | 3.1345763e-005 |
| Reduced model | -79.1591        | 1         | 92.9763  | 2         | <.0001         |

AIC: 88.0827

Goodness of Fit

| Dose   | Est._Prob. | Expected | Observed | Size | Scaled Residual |
|--------|------------|----------|----------|------|-----------------|
| 0.0000 | 0.0000     | 0.000    | 0.000    | 45   | 0.000           |
| 0.1022 | 0.1341     | 8.179    | 0.000    | 61   | -3.073          |
| 0.5137 | 0.5150     | 25.750   | 32.000   | 50   | 1.769           |

Chi^2 = 12.57 d.f. = 2 P-value = 0.0019

Benchmark Dose Computation

Specified effect = 0.1

Risk Type = Extra risk

Confidence level = 0.95

BMD = 0.0747971

BMDL = 0.0562829

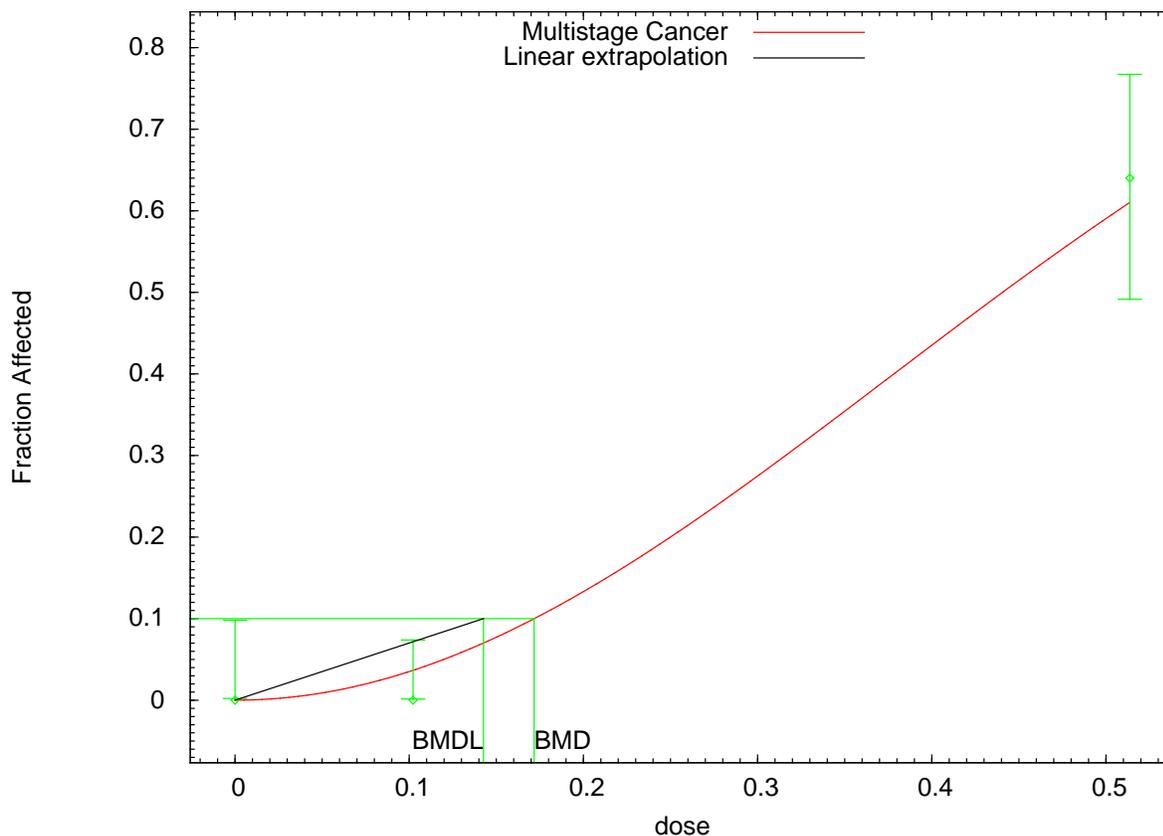
BMDU = 0.102116

Taken together, (0.0562829, 0.102116) is a 90 % two-sided confidence interval for the BMD

Multistage Cancer Slope Factor = 1.77674

**BMDS Output – Run #5 (Exclude High Dose, Degree of Polynomial =2)**

Multistage Cancer Model with 0.95 Confidence Level



14:44 06/21 2011

```

=====
Multistage Cancer Model. (Version: 1.9; Date: 05/26/2010)
Input Data File: I:\Aldrin & Dieldrin\Chlordane, DDE, DDD, DDT, and
Endrin\BMDS Output Files\msc_Chlordane Cancer IRDC 1973 Female_Opt.(d)
Gnuplot Plotting File: I:\Aldrin & Dieldrin\Chlordane, DDE, DDD, DDT, and
Endrin\BMDS Output Files\msc_Chlordane Cancer IRDC 1973 Female_Opt.plt
Tue Jun 21 14:44:21 2011
=====

```

BMDS\_Model\_Run

~~~~~

The form of the probability function is:

$$P[\text{response}] = \text{background} + (1-\text{background}) * [1 - \text{EXP}(-\text{beta1} * \text{dose}^{1-\text{beta2}} * \text{dose}^2)]$$

The parameter betas are restricted to be positive

Dependent variable = Tumor_Incidence
 Independent variable = Human_Dose

Total number of observations = 3
 Total number of records with missing values = 0
 Total number of parameters in model = 3

Total number of specified parameters = 0
 Degree of polynomial = 2

Maximum number of iterations = 250
 Relative Function Convergence has been set to: 1e-008
 Parameter Convergence has been set to: 1e-008

Default Initial Parameter Values

Background = 0
 Beta(1) = 0
 Beta(2) = 3.94488

Asymptotic Correlation Matrix of Parameter Estimates

(*** The model parameter(s) -Background -Beta(1)
 have been estimated at a boundary point, or have been specified by
 the user,
 and do not appear in the correlation matrix)

Beta(2)
 Beta(2) 1

Parameter Estimates

		95.0% Wald Confidence			
Interval	Variable	Estimate	Std. Err.	Lower Conf. Limit	Upper Conf. Limit
Limit	Background	0	*	*	*
	Beta(1)	0	*	*	*
	Beta(2)	3.57328	*	*	*

* - Indicates that this value is not calculated.

Analysis of Deviance Table

Model	Log(likelihood)	# Param's	Deviance	Test d.f.	P-value
Full model	-32.6709	3			
Fitted model	-35.0398	1	4.73787	2	0.09358
Reduced model	-79.1591	1	92.9763	2	<.0001
AIC:	72.0797				

Goodness of Fit

Dose	Est._Prob.	Expected	Observed	Size	Scaled Residual
0.0000	0.0000	0.000	0.000	45	0.000
0.1022	0.0366	2.235	0.000	61	-1.523
0.5137	0.6105	30.526	32.000	50	0.427

Chi^2 = 2.50 d.f. = 2 P-value = 0.2862

Benchmark Dose Computation

Specified effect = 0.1

Risk Type = Extra risk

Confidence level = 0.95

BMD = 0.171714

BMDL = 0.142666

BMDU = 0.201042

Taken together, (0.142666, 0.201042) is a 90 % two-sided confidence interval for the BMD

Multistage Cancer Slope Factor = 0.700938

APPENDIX D

NCI 1977 Males

APPENDIX D**NCI 1977 MALES****Study Description**

Groups of 50 male B6C3F1 mice were fed diets with low and high concentrations of analytical chlordane for 80 weeks, and then observed for 10 weeks. The low- and high-dose groups were tested at different calendar times, but each exposed group was tested with a concurrent control. Chlordane dietary concentrations were changed during the study. Time-weighted average concentrations were 29.9 and 56.2 ppm for male mice. These concentrations correspond to approximate average doses of 4.3 and 8.0 mg/kg-day. Matched controls consisted of 10 male mice. A pooled control group consisted of the matched-control mice and 70 male untreated mice from similar bioassays conducted during periods that overlapped with the chlordane bioassay by at least a year. Surviving mice were sacrificed at 90 to 91 weeks. Major organs and tissues from all mice were examined grossly and microscopically.

Survival of male mice in both exposed groups was significantly decreased relative to control males. Exposure-related neoplastic or nonneoplastic lesions in mice were restricted to the liver. Statistically significant elevated incidences for hepatocellular carcinomas, relative to controls, were found in low- and high-dose male mice (see Table D1 below). Hepatocellular carcinomas were described as displaying a spectrum of histological features. At one end of the spectrum, nodules of hepatocytes with only moderate changes (from normal hepatocytes) in staining characteristics, size and shape of cells, and lobular architecture occurred. At the other end of the spectrum, tumors with clearly anaplastic cytologic characteristics and no resemblance to normal lobular architecture occurred. Metastasis to the lung occurred in two high-dose males. No effects were observed other than cancer, even at the highest dose tested (U.S. EPA 1997).

Table D1. NCI 1977 Males data as presented in U.S. EPA 1997

Dose (ppm in mouse diet)	Human Equivalent Dose (mg/kg-day) ^a	Tumor Incidence (Hepatocellular Carcinomas)
0 (pooled controls)	0	17/92
0 (matched controls)	0	2/18
29.9	0.6187	16/48
56.2	1.1511	43/49

a. Human Equivalent Dose = Mouse Dose x (mouse BW/human BW)^{1/4} = mouse dose x 0.143882.

Evaluation of Cancer Risk by U.S. EPA (1997)

In its evaluation of the male carcinogenicity data reported in the NCI (1977) study, U.S. EPA (1997) used a GLOBAL.86 computer algorithm, linear multistage procedure, extra risk model. This model produced a low-dose cancer slope factor of 0.345 (mg/kg-day)⁻¹.

Benchmark Dose Models

Tumor incidence data are quantal data that the US EPA (2000a) recommends for use in a Dichotomous Multistage-Cancer Model. In the analyses for chlordane, dose levels in

Human Equivalent Dose were entered with the sample size (N) and tumor incidence data were entered into a BMDS 2.1.2 spreadsheet (see Figure D1). The Dichotomous Model Multistage-Cancer Model allows for variation of the Degree of Polynomial to find the best curve fit. In the first run of the model, Degree of Polynomial was set to 1 (see Figure D2), and in the second and third runs, this value was changed to 2 and 3, respectively.

Figure D1. BMDS Input Data

	Human_Dose	Tumor_Incidence	N	Col4	Col5	C
▶ 1	0	17	92			
2	0	2	18			
3	0.6187	16	48			
4	1.1511	43	49			
5						

Figure D2. BMD5 Model Parameters – First Run

The screenshot shows the BMD5 software interface with the following settings:

- Column Assignments:**
 - Dose: Human_Dose
 - # Subjects in Dose Group: N
 - Incidence: Tumor_Incider
 - % Positive: (empty)
- Other Assignments:**
 - Risk Type: Extra
 - BMR: 0.1000
 - Confidence Level: 0.95
 - BMD Calculation:
 - BMDL Curve Calc.:
 - Dose Groups: 4
 - Degree of Polynomial: 1
- Optimizer Assignments:**
 - Iteration: 250
 - Relative Function: 1.00E-08
 - Parameter: 1.00E-08
- Parameter Assignments:**

Parameters	Options	Values
Background	Default	
Beta1	Default	
Beta2	Default	

At the bottom, the 'Data File' and 'Out File Name' are both set to 'I:\Aldrin & Dieldrin\Chlordane, DDE, DDD, DDT, and Endrin\'. The 'Run' button is highlighted.

Results

A summary of the BMD analyses of the liver tumor incidence data is presented in Table D2, next page, and the BMD5 input data, model parameters, and output are presented in subsequent pages. The first two runs (Degree of Polynomial =1 or 2) produced a curve with a poor visual fit, and the mathematical tests for a good fit produced values outside the acceptable ranges (see table footnotes). Run #3 with Degree of Polynomial value set to 3 also produced a curve with a good fit to the data. Complete output reports for each model run are presented in the following pages.

Table D2. Benchmark Dose Model Results for NCI 1977 Males

Run #	Data Set	Degree of Polynomial	Curve-Fit Acceptance			BMD	BMD-derived CSF
			P-value ¹	Highest Scaled Residual ²	AIC ³		
1	All	1	0.0006	-2.916	217.853	0.107135	1.21417
2	All	2	0.0823	-1.723	207.372	0.303643	0.477583
3	All	3	0.6102	-0.631	203.186	0.445766	0.388362

1 For the model to be acceptable, P-value must be > 0.1 .

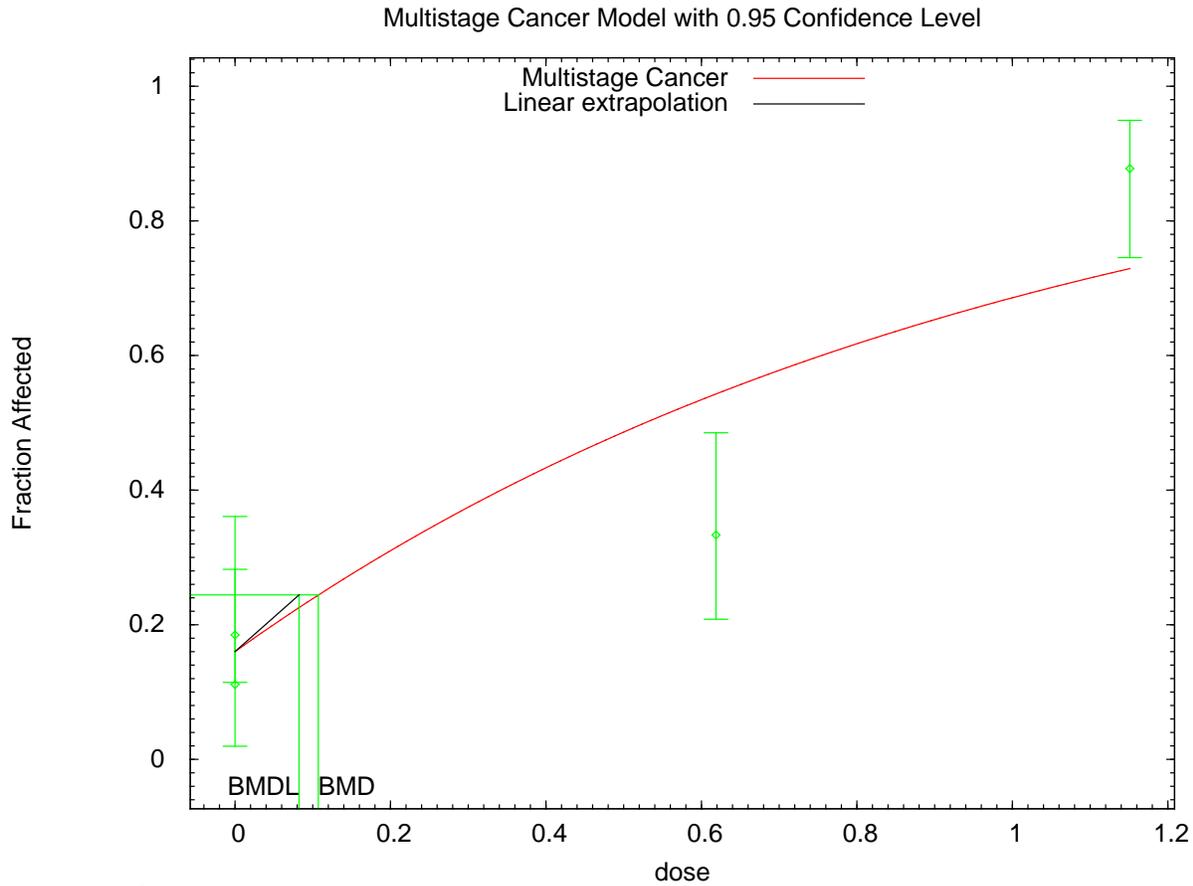
2 Scaled residuals report the gap between the curve line and the actual data points; for the model to be acceptable, all scaled residuals must have an absolute value of < 2 .

3 The Akaike Information Coefficient (AIC) is used for comparison between models; a lower AIC value indicates a better curve fit to the data.

Conclusion

The highest scaled residual values are above 2 and P-values were less than 0.1 in runs 1 and 2, making these curves unacceptable fits to the data. Run # 3 produced an acceptable fit, with a benchmark dose of 0.445766 mg/kg-day and an oral cancer slope factor of $0.388362 \text{ (mg/kg-day)}^{-1}$ in B6C3F1 male mice.

BMDS Output – Run #1



15:25 06/21 2011

```

=====
Multistage Cancer Model. (Version: 1.9; Date: 05/26/2010)
Input Data File: I:\Aldrin & Dieldrin\Chlordane, DDE, DDD, DDT, and
Endrin\BMDS Output Files\msc_Chlordane Cancer NCI 1977 Male_Opt.(d)
Gnuplot Plotting File: I:\Aldrin & Dieldrin\Chlordane, DDE, DDD, DDT, and
Endrin\BMDS Output Files\msc_Chlordane Cancer NCI 1977 Male_Opt.plt
Tue Jun 21 15:25:33 2011
=====

```

BMDS_Model_Run

The form of the probability function is:

$$P[\text{response}] = \text{background} + (1-\text{background}) * [1 - \text{EXP}(-\text{beta}1 * \text{dose}^1)]$$

The parameter betas are restricted to be positive

Dependent variable = Tumor_Incidence
 Independent variable = Human_Dose

Total number of observations = 4
 Total number of records with missing values = 0
 Total number of parameters in model = 2
 Total number of specified parameters = 0

Degree of polynomial = 1

Maximum number of iterations = 250
 Relative Function Convergence has been set to: 1e-008
 Parameter Convergence has been set to: 1e-008

Default Initial Parameter Values

Background = 0.0284584
 Beta(1) = 1.53245

Asymptotic Correlation Matrix of Parameter Estimates

	Background	Beta(1)
Background	1	-0.46
Beta(1)	-0.46	1

Parameter Estimates

		95.0% Wald Confidence			
Interval	Variable	Estimate	Std. Err.	Lower Conf. Limit	Upper Conf. Limit
Limit	Background	0.160239	*	*	*
	Beta(1)	0.983441	*	*	*

* - Indicates that this value is not calculated.

Analysis of Deviance Table

Model	Log(likelihood)	# Param's	Deviance	Test d.f.	P-value
Full model	-99.077	4			
Fitted model	-106.927	2	15.6994	2	0.0003899
Reduced model	-137.134	1	76.1134	3	<.0001
AIC:	217.853				

Goodness of Fit

Dose	Est._Prob.	Expected	Observed	Size	Scaled Residual
0.0000	0.1602	14.742	17.000	92	0.642
0.0000	0.1602	2.884	2.000	18	-0.568
0.6187	0.5430	26.064	16.000	48	-2.916
1.1511	0.7293	35.735	43.000	49	2.336

Chi^2 = 14.69 d.f. = 2 P-value = 0.0006

Benchmark Dose Computation

Specified effect = 0.1

Risk Type = Extra risk

Confidence level = 0.95

BMD = 0.107135

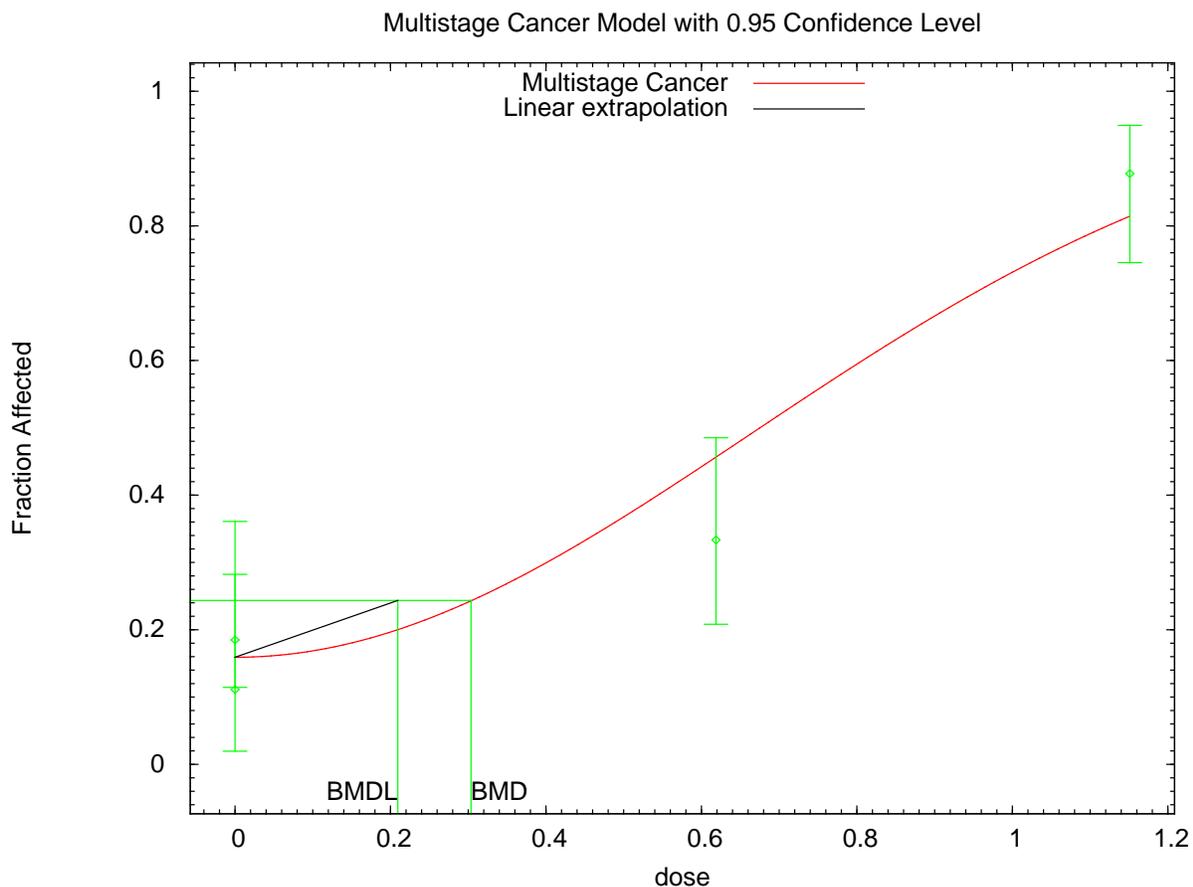
BMDL = 0.082361

BMDU = 0.144557

Taken together, (0.082361, 0.144557) is a 90 % two-sided confidence interval for the BMD

Multistage Cancer Slope Factor = 1.21417

BMDS Output – Run #2 (Same Input Data, Changed Degree of Polynomial to 2)



15:29 06/21 2011

```

=====
Multistage Cancer Model. (Version: 1.9; Date: 05/26/2010)
Input Data File: I:\Aldrin & Dieldrin\Chlordane, DDE, DDD, DDT, and
Endrin\BMDS Output Files\msc_Chlordane Cancer NCI 1977 Male_Opt.(d)
Gnuplot Plotting File: I:\Aldrin & Dieldrin\Chlordane, DDE, DDD, DDT, and
Endrin\BMDS Output Files\msc_Chlordane Cancer NCI 1977 Male_Opt.plt
Tue Jun 21 15:29:06 2011
=====
    
```

BMDS_Model_Run

The form of the probability function is:

$$P[\text{response}] = \text{background} + (1-\text{background}) * [1 - \text{EXP}(-\text{beta1} * \text{dose} - \text{beta2} * \text{dose}^2)]$$

The parameter betas are restricted to be positive

Dependent variable = Tumor_Incidence
 Independent variable = Human_Dose

```

Total number of observations = 4
Total number of records with missing values = 0
Total number of parameters in model = 3
Total number of specified parameters = 0
    
```

Degree of polynomial = 2

Maximum number of iterations = 250
 Relative Function Convergence has been set to: 1e-008
 Parameter Convergence has been set to: 1e-008

Default Initial Parameter Values

Background = 0.0741387
 Beta(1) = 0
 Beta(2) = 1.47526

Asymptotic Correlation Matrix of Parameter Estimates

(*** The model parameter(s) -Beta(1)
 have been estimated at a boundary point, or have been specified by
 the user,
 and do not appear in the correlation matrix)

	Background	Beta(2)
Background	1	-0.4
Beta(2)	-0.4	1

Parameter Estimates

		95.0% Wald Confidence			
Interval	Variable	Estimate	Std. Err.	Lower Conf. Limit	Upper Conf. Limit
Limit	Background	0.159333	*	*	*
	Beta(1)	0	*	*	*
	Beta(2)	1.14275	*	*	*

* - Indicates that this value is not calculated.

Analysis of Deviance Table

Model	Log(likelihood)	# Param's	Deviance	Test d.f.	P-value
Full model	-99.077	4			
Fitted model	-101.686	2	5.21836	2	0.0736
Reduced model	-137.134	1	76.1134	3	<.0001
AIC:	207.372				

Goodness of Fit

Dose	Est._Prob.	Expected	Observed	Size	Scaled Residual
0.0000	0.1593	14.659	17.000	92	0.667
0.0000	0.1593	2.868	2.000	18	-0.559
0.6187	0.4572	21.945	16.000	48	-1.723
1.1511	0.8151	39.938	43.000	49	1.127

Chi² = 4.99 d.f. = 2 P-value = 0.0823

Benchmark Dose Computation

Specified effect = 0.1

Risk Type = Extra risk

Confidence level = 0.95

 BMD = 0.303643

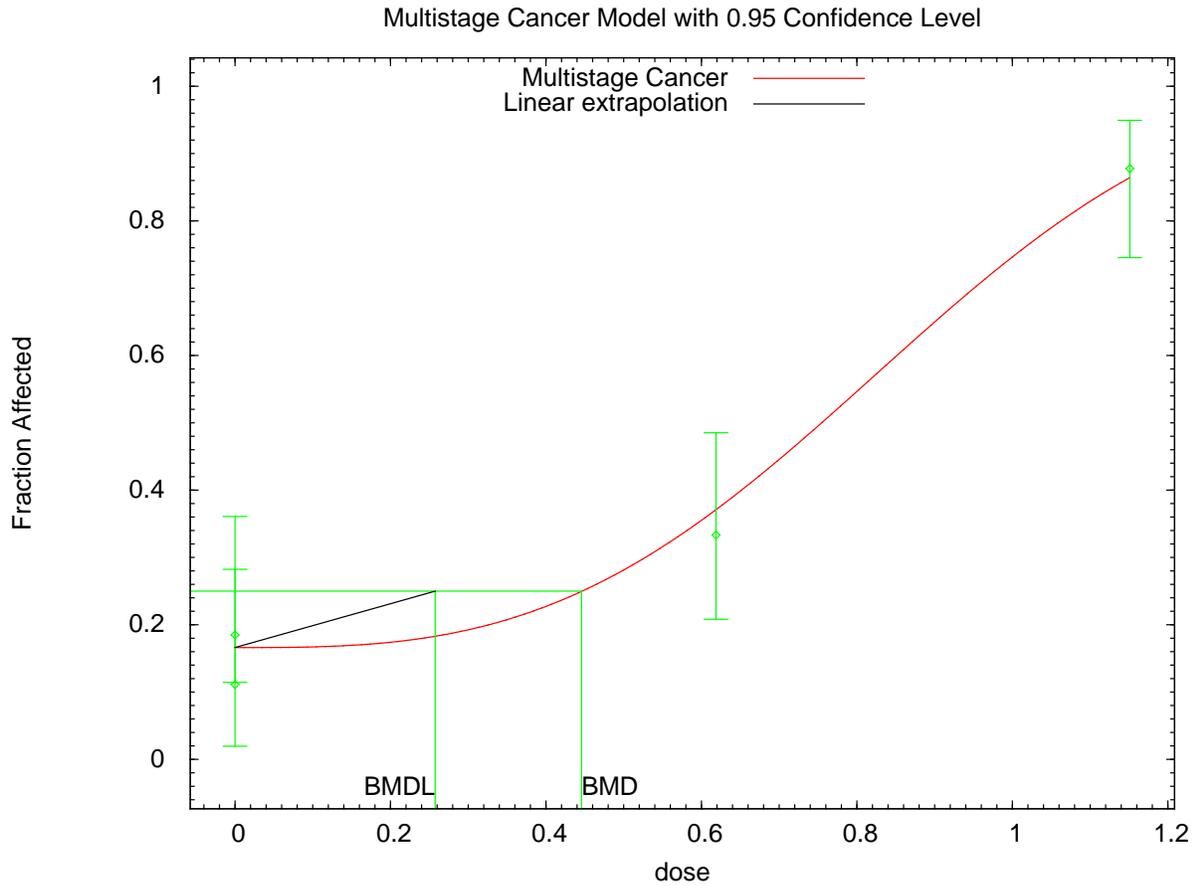
 BMDL = 0.209388

 BMDU = 0.353256

Taken together, (0.209388, 0.353256) is a 90 % two-sided confidence interval for the BMD

Multistage Cancer Slope Factor = 0.477583

BMDS Output – Run #3 (Same Input Data, Changed Degree of Polynomial to 3)



```

=====
Multistage Cancer Model. (Version: 1.9; Date: 05/26/2010)
Input Data File: I:\Aldrin & Dieldrin\Chlordane, DDE, DDD, DDT, and
Endrin\BMDS Output Files\msc_Chlordane Cancer NCI 1977 Male_Opt.(d)
Gnuplot Plotting File: I:\Aldrin & Dieldrin\Chlordane, DDE, DDD, DDT, and
Endrin\BMDS Output Files\msc_Chlordane Cancer NCI 1977 Male_Opt.plt
Tue Jun 21 15:30:20 2011
=====

```

```

BMDS_Model_Run
~~~~~

```

The form of the probability function is:

$$P[\text{response}] = \text{background} + (1-\text{background}) * [1 - \text{EXP}(-\text{beta1} * \text{dose} - \text{beta2} * \text{dose}^2 - \text{beta3} * \text{dose}^3)]$$

The parameter betas are restricted to be positive

Dependent variable = Tumor_Incidence
 Independent variable = Human_Dose

Total number of observations = 4
 Total number of records with missing values = 0
 Total number of parameters in model = 4

Total number of specified parameters = 0
 Degree of polynomial = 3

Maximum number of iterations = 250
 Relative Function Convergence has been set to: 1e-008
 Parameter Convergence has been set to: 1e-008

Default Initial Parameter Values
 Background = 0.133863
 Beta(1) = 0
 Beta(2) = 0
 Beta(3) = 1.27847

Asymptotic Correlation Matrix of Parameter Estimates

(*** The model parameter(s) -Beta(1) -Beta(2)
 have been estimated at a boundary point, or have been specified by
 the user,
 and do not appear in the correlation matrix)

	Background	Beta(3)
Background	1	-0.35
Beta(3)	-0.35	1

Parameter Estimates

Interval Limit	Variable	Estimate	Std. Err.	95.0% Wald Confidence	
				Lower Conf. Limit	Upper Conf.
	Background	0.16648	*	*	*
	Beta(1)	0	*	*	*
	Beta(2)	0	*	*	*
	Beta(3)	1.18948	*	*	*

* - Indicates that this value is not calculated.

Analysis of Deviance Table

Model	Log(likelihood)	# Param's	Deviance	Test d.f.	P-value
Full model	-99.077	4			
Fitted model	-99.5928	2	1.0316	2	0.597
Reduced model	-137.134	1	76.1134	3	<.0001
AIC:	203.186				

Goodness of Fit

Dose	Est._Prob.	Expected	Observed	Size	Scaled Residual
0.0000	0.1665	15.316	17.000	92	0.471
0.0000	0.1665	2.997	2.000	18	-0.631

0.6187	0.3711	17.813	16.000	48	-0.542
1.1511	0.8642	42.344	43.000	49	0.273

Chi² = 0.99 d.f. = 2 P-value = 0.6102

Benchmark Dose Computation

Specified effect = 0.1

Risk Type = Extra risk

Confidence level = 0.95

BMD = 0.445766

BMDL = 0.257492

BMDU = 0.49589

Taken together, (0.257492, 0.49589) is a 90 % two-sided confidence interval for the BMD

Multistage Cancer Slope Factor = 0.388362

APPENDIX E

NCI 1977 Females

APPENDIX E**NCI 1977 FEMALES****Study Description**

Groups of 50 female B6C3F1 mice were fed diets with low and high concentrations of analytical chlordane for 80 weeks, and then observed for 10 weeks. The low-and high-dose groups were tested at different calendar times, but each exposed group was tested with a concurrent control. Chlordane dietary concentrations were changed during the study. Time-weighted average concentrations were 30.1 and 63.8 ppm for female mice. These concentrations correspond to approximate average doses of 4.3 and 9.1 mg/kg-day. Matched controls consisted of 10 female untreated mice. A pooled control group consisted of the matched-control mice and 80 female untreated mice from similar bioassays conducted during periods that overlapped with the chlordane bioassay by at least a year. Surviving mice were sacrificed at 90 to 91 weeks. Major organs and tissues from all mice were examined grossly and microscopically.

Survival of exposed female mice was essentially the same as control female mice. Exposure-related neoplastic or nonneoplastic lesions in mice were restricted to the liver. Statistically significant elevated incidences for hepatocellular carcinomas, relative to controls, were found in high-dose female mice (see Table E1 below). Hepatocellular carcinomas were described as displaying a spectrum of histological features. At one end of the spectrum, nodules of hepatocytes with only moderate changes (from normal hepatocytes) in staining characteristics, size and shape of cells, and lobular architecture occurred. At the other end of the spectrum, tumors with clearly anaplastic cytologic characteristics and no resemblance to normal lobular architecture occurred. Metastasis to the lung occurred in two high-dose males and three high-dose females. No effects were observed other than cancer, even at the highest dose tested (50 ppm) (U.S. EPA 1997).

Table E1. NCI 1977 Females data as presented in U.S. EPA 1997

Dose (ppm in mouse diet)	Human Equivalent Dose (mg/kg-day) ^a	Tumor Incidence (Hepatocellular Carcinomas)
0 (pooled controls)	0	3/78
0 (matched controls)	0	0/19
29.9	0.6187	3/47
56.2	1.3093	34/49

a. Human Equivalent Dose = Mouse Dose x (mouse BW/human BW)^{1/4} = mouse dose x 0.143882.

Evaluation of Cancer Risk by U.S. EPA (1997)

In its evaluation of the female carcinogenicity data reported in the NCI (1977) study, U.S. EPA (1997) used a GLOBAL.86 computer algorithm, linear multistage procedure, extra risk model. This model produced a low-dose cancer slope factor of 0.114 (mg/kg-day)⁻¹.

Benchmark Dose Models

Tumor incidence data are quantal data that the US EPA (2000a) recommends for use in a Dichotomous Multistage-Cancer Model. In the analyses for chlordane, dose levels in Human Equivalent Dose were entered with the sample size (N) and tumor incidence data were entered into a BMDS 2.1.2 spreadsheet (see Figure E1). The Dichotomous Model Multistage-Cancer Model allows for variation of the Degree of Polynomial to find the best curve fit. In the first run of the model, Degree of Polynomial was set to 1 (see Figure E2), and in the second and third runs, this value was changed to 2 and 3, respectively.

Figure E1. BMDS Input Data

	Human_Dose	Tumor_Incidence	N	Col4	Col5	C
1	0	3	78			
2	0	0	19			
3	0.6187	3	47			
4	1.3093	34	49			
5						

Figure E2. BMD5 Model Parameters – First Run

<<Column Assignments>>			<<Other Assignments>>	
<i>Dose</i>	Human_Dose	▼	<i>Risk Type</i>	Extra
<i># Subjects in Dose Group</i>	N	▼	<i>BMR</i>	0.1000
<i>Incidence</i>	Tumor_Incider	▼	<i>Confidence Level</i>	0.95
<i>% Positive</i>		▼	<i>BMD Calculation</i>	<input checked="" type="checkbox"/>
			<i>BMDL Curve. Calc.</i>	<input type="checkbox"/>
			<i>Dose Groups</i>	4
			<i>Degree of Polynomial</i>	1

<<Optimizer Assignments>>	
<i>Iteration</i>	250
<i>Relative Function</i>	1.00E-08
<i>Parameter</i>	1.00E-08

<<Parameter Assignments>>		
Parameters	Options	Values
<i>Background</i>	Default	▼
<i>Beta1</i>	Default	▼
<i>Beta2</i>	Default	▼

User Notes: _____

Data File: I:\Aldrin & Dieldrin\Chlordane, DDE, DDD, DDT, and Endrin\ Show

Out File Name: I:\Aldrin & Dieldrin\Chlordane, DDE, DDD, DDT, and Endrin\ Set

Save Save As ... Set Values To Default Optimize Initial Param. Values Close

Multistage-Cancer->Dichotomous

Results

A summary of the BMD analyses of the liver tumor incidence data is presented in Table E2, next page, and the BMD5 input data, model parameters, and output are presented in subsequent pages. The first two runs (Degree of Polynomial =1 or 2) produced a curve with a poor visual fit, and the mathematical tests for a good fit produced values outside the acceptable ranges (see table footnotes). Run #3 with Degree of Polynomial value set to 3 also produced a curve with a good fit to the data.

Complete output reports for each model run are presented in the following pages.

Table E2. Benchmark Dose Model Results for NCI 1977 Females

Run #	Data Set	Degree of Polynomial	Curve-Fit Acceptance			BMD	BMD-derived CSF
			P-value ¹	Highest Scaled Residual ²	AIC ³		
1	All	1	0.0001	-3.500	136.228	0.199682	0.659862
2	All	2	0.0154	-2.371	122.476	0.446958	0.274698
3	All	3	0.2219	-1.317	115.876	0.607616	0.19928

1 For the model to be acceptable, P-value must be > 0.1 .

2 Scaled residuals report the gap between the curve line and the actual data points; for the model to be acceptable, all scaled residuals must have an absolute value of < 2 .

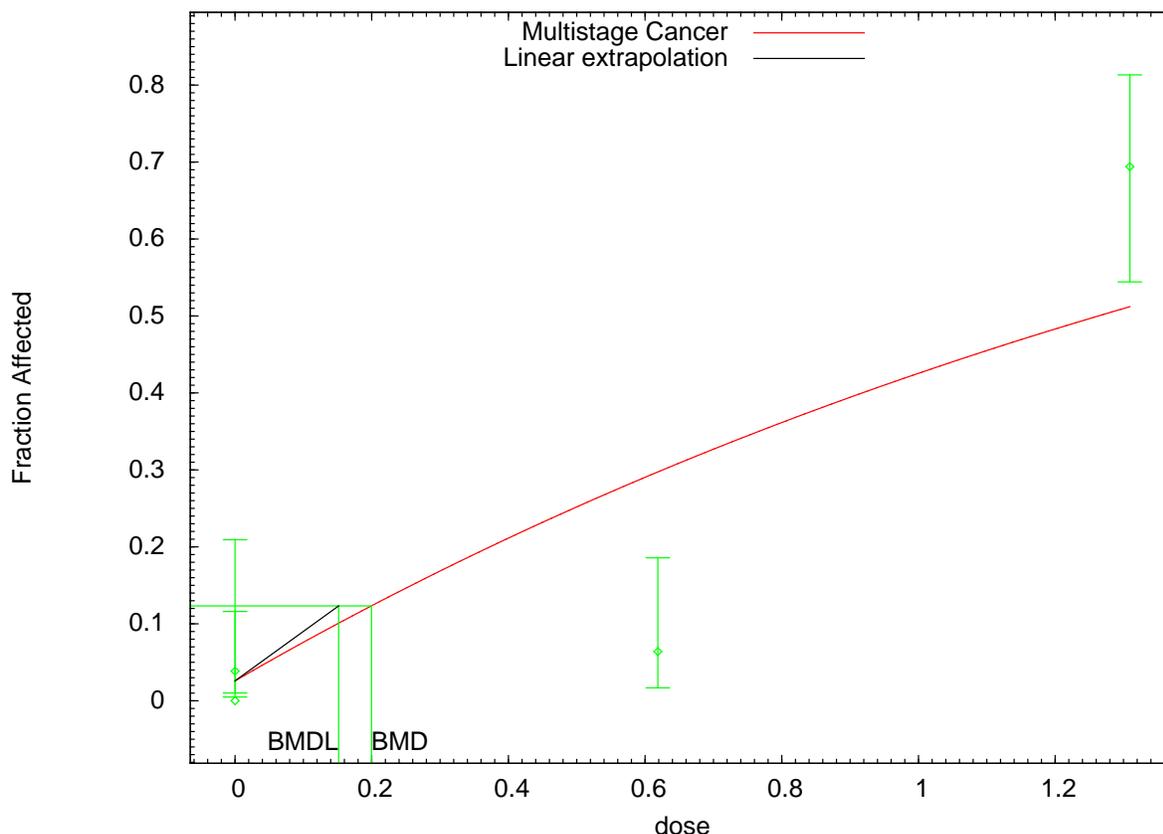
3 The Akaike Information Coefficient (AIC) is used for comparison between models; a lower AIC value indicates a better curve fit to the data.

Conclusion

The highest scaled residual values are above 2 and P-values were less than 0.1 in runs 1 and 2, making these curves unacceptable fits to the data. Run # 3 produced an acceptable fit, with a benchmark dose of 0.607616 mg/kg-day and an oral cancer slope factor of $0.19928 \text{ (mg/kg-day)}^{-1}$ in B6C3F1 female mice.

BMDS Output – Run #1

Multistage Cancer Model with 0.95 Confidence Level



15:43 06/21 2011

```
=====
Multistage Cancer Model. (Version: 1.9; Date: 05/26/2010)
Input Data File: I:\Aldrin & Dieldrin\Chlordane, DDE, DDD, DDT, and
Endrin\BMDS Output Files\msc_Chlordane Cancer NCI 1977 Male_Opt.(d)
Gnuplot Plotting File: I:\Aldrin & Dieldrin\Chlordane, DDE, DDD, DDT, and
Endrin\BMDS Output Files\msc_Chlordane Cancer NCI 1977 Male_Opt.plt
Tue Jun 21 15:43:43 2011
=====
```

BMDS_Model_Run

The form of the probability function is:

$$P[\text{response}] = \text{background} + (1-\text{background}) * [1 - \text{EXP}(-\text{beta}1 * \text{dose}^1)]$$

The parameter betas are restricted to be positive

Dependent variable = Tumor_Incidence
Independent variable = Human_Dose

Total number of observations = 4
Total number of records with missing values = 0
Total number of parameters in model = 2
Total number of specified parameters = 0

Degree of polynomial = 1

Maximum number of iterations = 250
 Relative Function Convergence has been set to: 1e-008
 Parameter Convergence has been set to: 1e-008

Default Initial Parameter Values

Background = 0
 Beta(1) = 0.830175

Asymptotic Correlation Matrix of Parameter Estimates

	Background	Beta(1)
Background	1	-0.49
Beta(1)	-0.49	1

Parameter Estimates

		95.0% Wald Confidence			
Interval	Variable	Estimate	Std. Err.	Lower Conf. Limit	Upper Conf. Limit
Limit	Background	0.0257589	*	*	*
	Beta(1)	0.527642	*	*	*

* - Indicates that this value is not calculated.

Analysis of Deviance Table

Model	Log(likelihood)	# Param's	Deviance	Test d.f.	P-value
Full model	-54.0548	4			
Fitted model	-66.1141	2	24.1187	2	5.790267e-006
Reduced model	-98.487	1	88.8645	3	<.0001
AIC:	136.228				

Goodness of Fit

Dose	Est._Prob.	Expected	Observed	Size	Scaled Residual
0.0000	0.0258	2.009	3.000	78	0.708
0.0000	0.0258	0.489	0.000	19	-0.709
0.6187	0.2971	13.964	3.000	47	-3.500
1.3093	0.5118	25.076	34.000	49	2.550

Chi^2 = 19.76 d.f. = 2 P-value = 0.0001

Benchmark Dose Computation

Specified effect = 0.1

Risk Type = Extra risk

Confidence level = 0.95

BMD = 0.199682

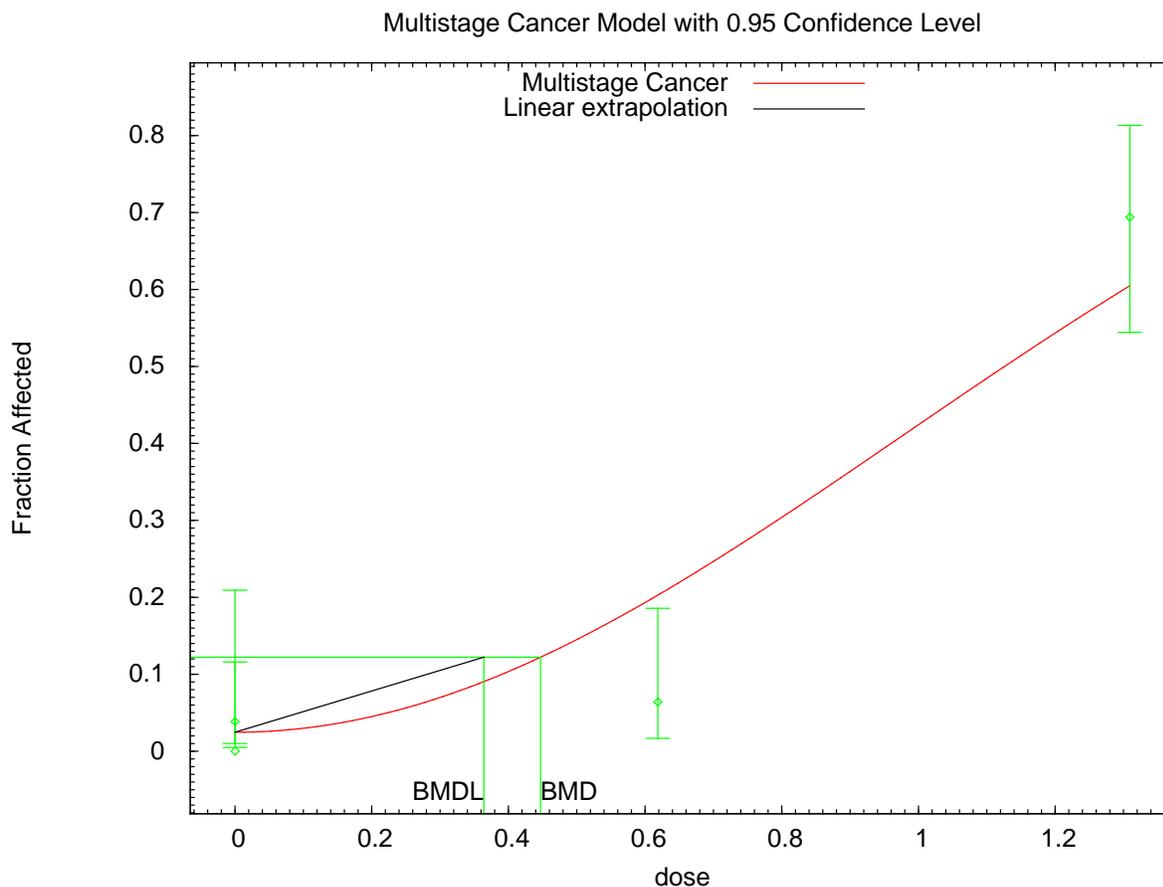
BMDL = 0.151547

BMDU = 0.271371

Taken together, (0.151547, 0.271371) is a 90 % two-sided confidence interval for the BMD

Multistage Cancer Slope Factor = 0.659862

BMDS Output – Run #2 (Same Input Data, Changed Degree of Polynomial to 2)



15:44 06/21 2011

```

=====
Multistage Cancer Model. (Version: 1.9; Date: 05/26/2010)
Input Data File: I:\Aldrin & Dieldrin\Chlordane, DDE, DDD, DDT, and
Endrin\BMDS Output Files\msc_Chlordane Cancer NCI 1977 Male_Opt.(d)
Gnuplot Plotting File: I:\Aldrin & Dieldrin\Chlordane, DDE, DDD, DDT, and
Endrin\BMDS Output Files\msc_Chlordane Cancer NCI 1977 Male_Opt.plt
Tue Jun 21 15:44:30 2011
=====
    
```

BMDS_Model_Run

The form of the probability function is:

$$P[\text{response}] = \text{background} + (1-\text{background}) * [1 - \text{EXP}(-\text{beta1} * \text{dose} - \text{beta2} * \text{dose}^2)]$$

The parameter betas are restricted to be positive

Dependent variable = Tumor_Incidence
 Independent variable = Human_Dose

```

Total number of observations = 4
Total number of records with missing values = 0
Total number of parameters in model = 3
Total number of specified parameters = 0
    
```

Degree of polynomial = 2

Maximum number of iterations = 250
 Relative Function Convergence has been set to: 1e-008
 Parameter Convergence has been set to: 1e-008

Default Initial Parameter Values

Background = 0
 Beta(1) = 0
 Beta(2) = 0.694318

Asymptotic Correlation Matrix of Parameter Estimates

(*** The model parameter(s) -Beta(1)
 have been estimated at a boundary point, or have been specified by
 the user,
 and do not appear in the correlation matrix)

	Background	Beta(2)
Background	1	-0.42
Beta(2)	-0.42	1

Parameter Estimates

		95.0% Wald Confidence			
Interval	Variable	Estimate	Std. Err.	Lower Conf. Limit	Upper Conf. Limit
Limit	Background	0.0245859	*	*	*
	Beta(1)	0	*	*	*
	Beta(2)	0.527404	*	*	*

* - Indicates that this value is not calculated.

Analysis of Deviance Table

Model	Log(likelihood)	# Param's	Deviance	Test d.f.	P-value
Full model	-54.0548	4			
Fitted model	-59.238	2	10.3665	2	0.00561
Reduced model	-98.487	1	88.8645	3	<.0001
AIC:	122.476				

Goodness of Fit

Dose	Est._Prob.	Expected	Observed	Size	Scaled Residual
0.0000	0.0246	1.918	3.000	78	0.791
0.0000	0.0246	0.467	0.000	19	-0.692
0.6187	0.2029	9.536	3.000	47	-2.371
1.3093	0.6051	29.648	34.000	49	1.272

Chi² = 8.34 d.f. = 2 P-value = 0.0154

Benchmark Dose Computation

Specified effect = 0.1

Risk Type = Extra risk

Confidence level = 0.95

 BMD = 0.446958

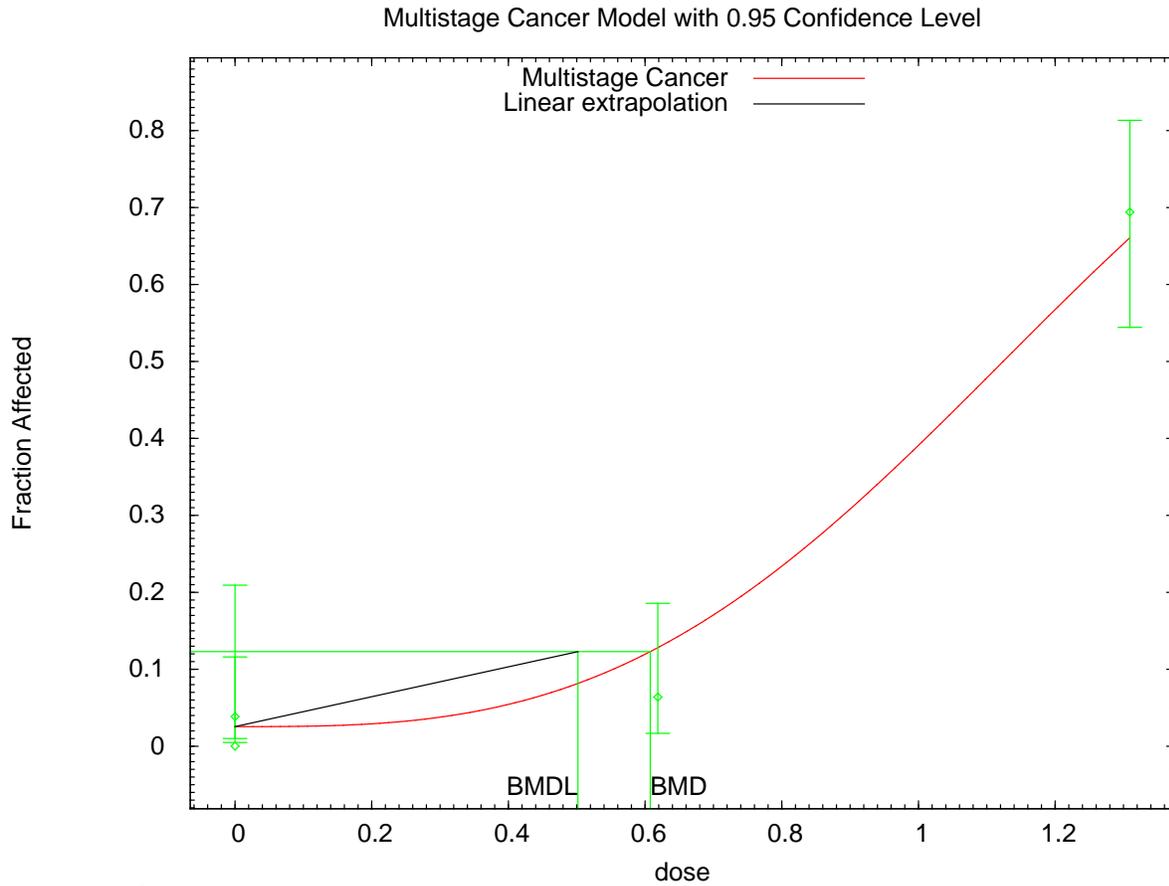
 BMDL = 0.364036

 BMDU = 0.520966

Taken together, (0.364036, 0.520966) is a 90 % two-sided confidence interval for the BMD

Multistage Cancer Slope Factor = 0.274698

BMDS Output – Run #3 (Same Input Data, Changed Degree of Polynomial to 3)



15:45 06/21 2011

```

=====
Multistage Cancer Model. (Version: 1.9; Date: 05/26/2010)
Input Data File: I:\Aldrin & Dieldrin\Chlordane, DDE, DDD, DDT, and
Endrin\BMDS Output Files\msc_Chlordane Cancer NCI 1977 Male_Opt.(d)
Gnuplot Plotting File: I:\Aldrin & Dieldrin\Chlordane, DDE, DDD, DDT, and
Endrin\BMDS Output Files\msc_Chlordane Cancer NCI 1977 Male_Opt.plt
Tue Jun 21 15:45:13 2011
=====
    
```

BMDS_Model_Run

The form of the probability function is:

$$P[\text{response}] = \text{background} + (1-\text{background}) * [1 - \text{EXP}(-\text{beta1} * \text{dose}^1 - \text{beta2} * \text{dose}^2 - \text{beta3} * \text{dose}^3)]$$

The parameter betas are restricted to be positive

Dependent variable = Tumor_Incidence
 Independent variable = Human_Dose

```

Total number of observations = 4
Total number of records with missing values = 0
Total number of parameters in model = 4
Total number of specified parameters = 0
    
```

Degree of polynomial = 3

Maximum number of iterations = 250
 Relative Function Convergence has been set to: 1e-008
 Parameter Convergence has been set to: 1e-008

Default Initial Parameter Values

Background = 0
 Beta(1) = 0
 Beta(2) = 0
 Beta(3) = 0.526927

Asymptotic Correlation Matrix of Parameter Estimates

(*** The model parameter(s) -Beta(1) -Beta(2)
 have been estimated at a boundary point, or have been specified by
 the user,
 and do not appear in the correlation matrix)

	Background	Beta(3)
Background	1	-0.38
Beta(3)	-0.38	1

Parameter Estimates

Interval Limit	Variable	Estimate	Std. Err.	95.0% Wald Confidence	
				Lower Conf. Limit	Upper Conf.
	Background	0.0254073	*	*	*
	Beta(1)	0	*	*	*
	Beta(2)	0	*	*	*
	Beta(3)	0.469667	*	*	*

* - Indicates that this value is not calculated.

Analysis of Deviance Table

Model	Log(likelihood)	# Param's	Deviance	Test d.f.	P-value
Full model	-54.0548	4			
Fitted model	-55.938	2	3.76638	2	0.1521
Reduced model	-98.487	1	88.8645	3	<.0001
AIC:	115.876				

Goodness of Fit

Dose	Est._Prob.	Expected	Observed	Size	Scaled Residual
0.0000	0.0254	1.982	3.000	78	0.733
0.0000	0.0254	0.483	0.000	19	-0.704
0.6187	0.1280	6.016	3.000	47	-1.317

1.3093 0.6604 32.358 34.000 49 0.495
Chi² = 3.01 d.f. = 2 P-value = 0.2219

Benchmark Dose Computation

Specified effect = 0.1

Risk Type = Extra risk

Confidence level = 0.95

 BMD = 0.607616

 BMDL = 0.501807

 BMDU = 0.673959

Taken together, (0.501807, 0.673959) is a 90 % two-sided confidence interval for the BMD

Multistage Cancer Slope Factor = 0.19928

APPENDIX F

Khasawinah and Grutsch 1989 Male (Cancer)

APPENDIX F**KHASAWINAH AND GRUTSCH 1989 MALE (CANCER)****Study Description**

ICR mice (80/sex/group) were given 0, 1, 5, or 12.5 ppm technical chlordane in the diet for 104 weeks. The study authors reported that average doses corresponded to 0, 0.15, 0.75, and 1.875 mg/kg-day, based on an assumed food consumption of 15% of the body weight per day. Exposure-related neoplastic and nonneoplastic lesions were restricted to the liver. Statistically significant increased incidences, relative to controls, were found for the following nonneoplastic lesions: hepatocellular swelling (hypertrophy) in male and female mice in the 5- and 12.5-ppm groups, hepatic fatty degeneration in 12.5-ppm males, and hepatic necrosis in 5- and 12.5-ppm male mice. Male mice in the 12.5-ppm group showed statistically significant elevated incidence of hepatocellular adenomas (also called hepatocellular nodules by the study authors) and hepatic hemangiomas compared with controls. The hepatic hemangiomas were described as benign tumors of capillary cells associated with the hepatocellular adenomas. The 1989 report mentions the occurrence of liver adenocarcinomas but does not present incidence data. However, the earlier report of this assay, Velsicol Chemical Corporation (1983), cited by U.S. EPA (1986), shows that the hepatocellular carcinoma incidence in males as described in Table F1 below (U.S. EPA 1997).

Table F1. Khasawinah and Grutsch 1989 Male data as presented in U.S. EPA (1997)

Dose (ppm in mouse diet)	Human Equivalent Dose (mg/kg-day) ^a	Tumor Incidence (Hepatocellular Carcinomas)
0	0	3/71
1	0.0216	3/71
5	0.1079	7/72
12.5	0.2698	9/72

a. Human Equivalent Dose = Mouse Dose x (mouse BW/human BW)^{1/4} = mouse dose x 0.143882.

Evaluation of Cancer Risk by U.S. EPA (1997)

In its evaluation of the male carcinogenicity data reported in the Khasawinah and Grutsch (1989) study, U.S. EPA (1997) used a GLOBAL.86 computer algorithm, linear multistage procedure, extra risk model. This model produced a low-dose cancer slope factor of 0.710 (mg/kg-day)⁻¹.

Benchmark Dose Models

Tumor incidence data are quantal data that the US EPA (2000a) recommends for use in a Dichotomous Multistage-Cancer Model. In the analyses for chlordane, dose levels in Human Equivalent Dose were entered with the sample size (N) and tumor incidence data were entered into a BMDS 2.1.2 spreadsheet (see Figure F1). The Dichotomous Model Multistage-Cancer Model allows for variation of the Degree of Polynomial to find the best curve fit. In the first run of the model, Degree of Polynomial was set to 1 (see

Figure F2), and in the second and third runs, this value was changed to 2 and 3, respectively.

Figure F1. BMDS Input Data

	Human_Dose	Tumor_Incidence	N	Col4
1	0	3	71	
2	0.0216	3	71	
3	0.1079	7	72	
4	0.2698	9	72	

Figure F2. BMDS Model Parameters – First Run

<<Column Assignments>>

Dose	Human_Dose
# Subjects in Dose Group	N
Incidence	Tumor_Incidence
% Positive	

<<Optimizer Assignments>>

Iteration	250
Relative Function	1.00E-08
Parameter	1.00E-08

<<Parameter Assignments>>

Parameters	Options	Values
Background	Default	
Beta1	Default	
Beta2	Default	

<<Other Assignments>>

Risk Type	Extra
BMR	0.1000
Confidence Level	0.95
BMD Calculation	<input checked="" type="checkbox"/>
BMDL Curve Calc.	<input type="checkbox"/>
Dose Groups	4
Degree of Polynomial	1

User Notes:

Data File: I:\Aldrin & Dieldrin\Chlordane, DDE, DDD, DDT, and Endrin\ Show

Out File Name: I:\Aldrin & Dieldrin\Chlordane, DDE, DDD, DDT, and Endrin\ Set

Buttons: Save, Save As ..., Set Values To Default, Optimize Initial Param. Values, Run, Close

Multistage-Cancer->Dichotomous

Results

A summary of the BMD analyses of the liver tumor incidence data is presented in Table F2, below. The run (Degree of Polynomial =1) produced a curve with a good fit to the data set. Runs 2 and 3 produced produced curves identical to Run 1. Complete output reports for each model run are presented in the following pages.

Table F2. Benchmark Dose Model Results for Khasawinah and Grutsch 1989 Males

Run #	Data Set	Degree of Polynomial	Curve-Fit Acceptance			BMD	BMD-derived CSF
			P-	Highest Scaled	AIC ³		

			value ¹	Residual ²			
1	All	1	0.8083	-0.288	154.308	0.27855	0.674034
2	All	2	0.8083	-0.288	154.308	0.27855	0.674034
3	All	3	0.8083	-0.288	154.308	0.27855	0.674034

1 For the model to be acceptable, P-value must be > 0.1.

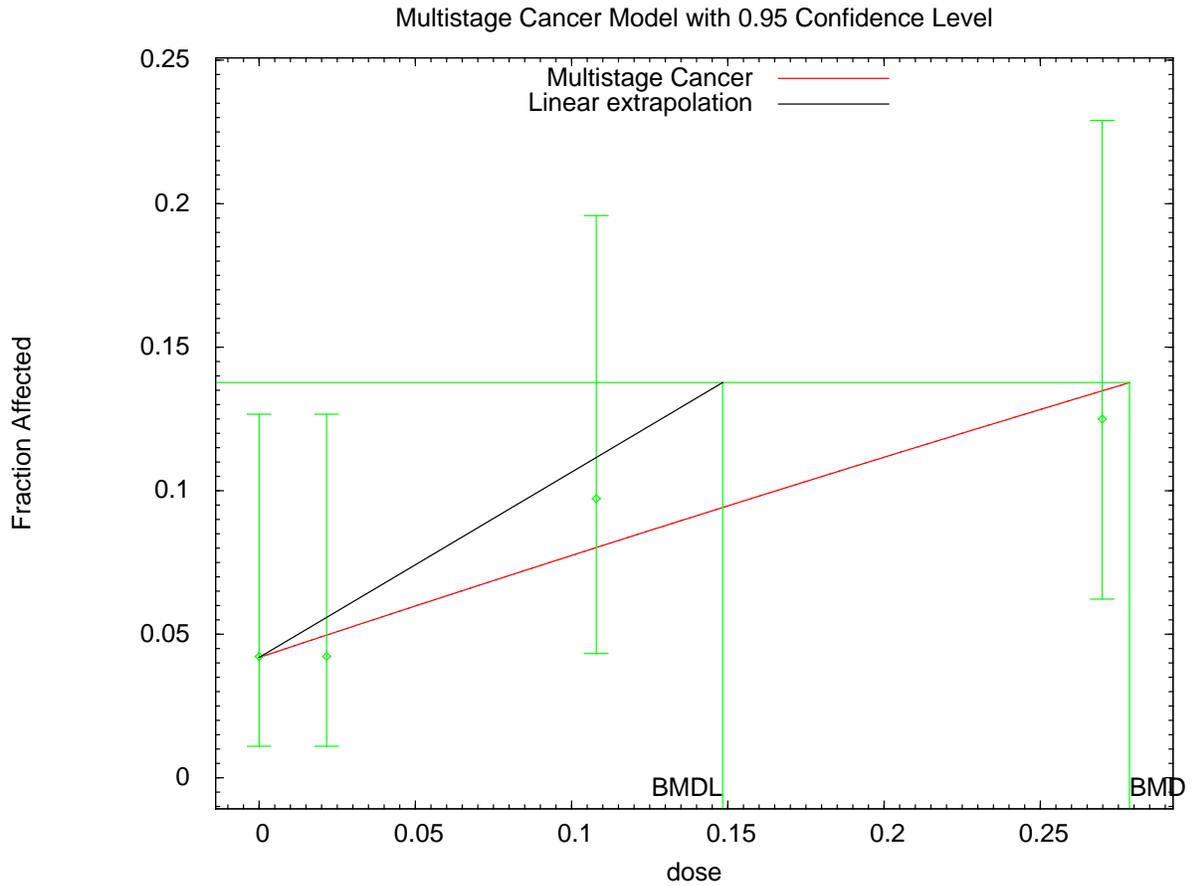
2 Scaled residuals report the gap between the curve line and the actual data points; for the model to be acceptable, all scaled residuals must have an absolute value of < 2.

3 The Akaike Information Coefficient (AIC) is used for comparison between models; a lower AIC value indicates a better curve fit to the data.

Conclusion

The highest scaled residual values are above 2 and P-values were less than 0.1 in runs 2 and 3, making these curves unacceptable fits to the data. Run # 1 produced an acceptable fit, with a benchmark dose of 0.27855 mg/kg-day and an oral cancer slope factor of 0.674034 (mg/kg-day)⁻¹ in male ICR mice.

BMDS Output – Run #1



11:04 06/22 2011

```

=====
Multistage Cancer Model. (Version: 1.9; Date: 05/26/2010)
Input Data File: I:\Aldrin & Dieldrin\Chlordane, DDE, DDD, DDT, and
Endrin\BMDS Output Files\msc_Chlordane Cancer Khasawinah 1989 Male_Opt.(d)
Gnuplot Plotting File: I:\Aldrin & Dieldrin\Chlordane, DDE, DDD, DDT, and
Endrin\BMDS Output Files\msc_Chlordane Cancer Khasawinah 1989 Male_Opt.plt
Wed Jun 22 11:04:57 2011
=====

```

BMDS_Model_Run

The form of the probability function is:

$$P[\text{response}] = \text{background} + (1-\text{background}) * [1 - \text{EXP}(-\text{beta}1 * \text{dose}^1)]$$

The parameter betas are restricted to be positive

Dependent variable = Tumor_Incidence
 Independent variable = Human_Dose

```

Total number of observations = 4
Total number of records with missing values = 0
Total number of parameters in model = 2
Total number of specified parameters = 0

```

Degree of polynomial = 1

Maximum number of iterations = 250
 Relative Function Convergence has been set to: 1e-008
 Parameter Convergence has been set to: 1e-008

Default Initial Parameter Values

Background = 0.0444238
 Beta(1) = 0.351594

Asymptotic Correlation Matrix of Parameter Estimates

	Background	Beta(1)
Background	1	-0.69
Beta(1)	-0.69	1

Parameter Estimates

Interval Limit	Variable	Estimate	Std. Err.	95.0% Wald Confidence	
				Lower Conf. Limit	Upper Conf. Limit
	Background	0.0418935	*	*	*
	Beta(1)	0.378246	*	*	*

* - Indicates that this value is not calculated.

Analysis of Deviance Table

Model	Log(likelihood)	# Param's	Deviance	Test d.f.	P-value
Full model	-74.9467	4			
Fitted model	-75.154	2	0.414699	2	0.8127
Reduced model	-77.5602	1	5.22694	3	0.1559
AIC:	154.308				

Goodness of Fit

Dose	Est._Prob.	Expected	Observed	Size	Scaled Residual
0.0000	0.0419	2.974	3.000	71	0.015
0.0216	0.0497	3.528	3.000	71	-0.288
0.1079	0.0802	5.775	7.000	72	0.531
0.2698	0.1348	9.709	9.000	72	-0.245

Chi² = 0.43 d.f. = 2 P-value = 0.8083

Benchmark Dose Computation

Specified effect = 0.1

Risk Type = Extra risk

Confidence level = 0.95

BMD = 0.27855

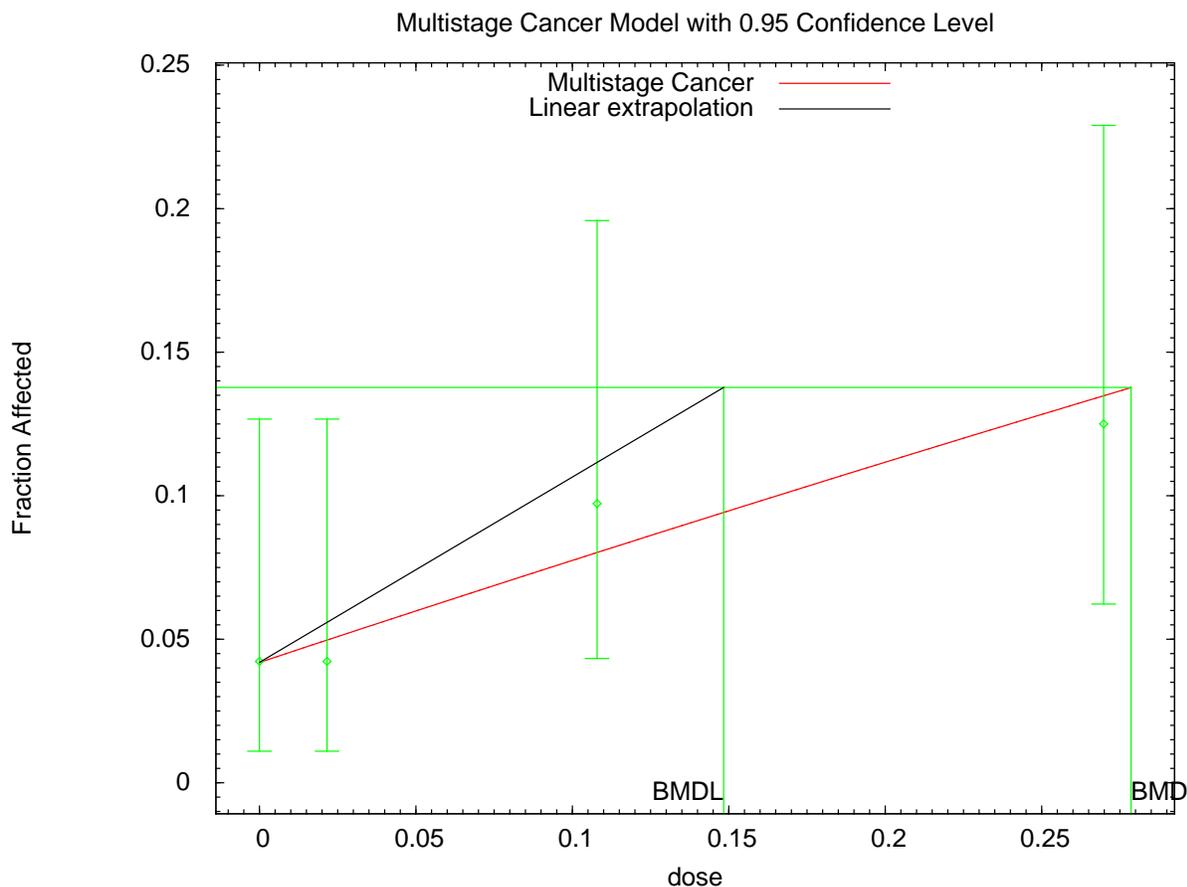
BMDL = 0.14836

BMDU = 1.16966

Taken together, (0.14836, 1.16966) is a 90 % two-sided confidence interval for the BMD

Multistage Cancer Slope Factor = 0.674034

BMDS Output – Run #2 (Same Input Data, Changed Degree of Polynomial to 2)



17:09 11/08 2011

```
=====
Multistage Cancer Model. (Version: 1.9; Date: 05/26/2010)
Input Data File: I:\Aldrin & Dieldrin\Chlordane, DDE, DDD, DDT, and
Endrin\BMDS Output Files\msc_Chlordane Cancer Khasawinah 1989 Male_Opt.(d)
Gnuplot Plotting File: I:\Aldrin & Dieldrin\Chlordane, DDE, DDD, DDT, and
Endrin\BMDS Output Files\msc_Chlordane Cancer Khasawinah 1989 Male_Opt.plt
Tue Nov 08 17:09:00 2011
=====
```

BMDS_Model_Run

The form of the probability function is:

$$P[\text{response}] = \text{background} + (1-\text{background}) * [1 - \text{EXP}(-\text{beta1} * \text{dose}^1 - \text{beta2} * \text{dose}^2)]$$

The parameter betas are restricted to be positive

Dependent variable = Tumor_Incidence
 Independent variable = Human_Dose

Total number of observations = 4
 Total number of records with missing values = 0
 Total number of parameters in model = 3
 Total number of specified parameters = 0

Degree of polynomial = 2

Maximum number of iterations = 250
 Relative Function Convergence has been set to: 1e-008
 Parameter Convergence has been set to: 1e-008

Default Initial Parameter Values

Background = 0.0444238
 Beta(1) = 0.351594
 Beta(2) = 0

Asymptotic Correlation Matrix of Parameter Estimates

(*** The model parameter(s) -Beta(2)
 have been estimated at a boundary point, or have been specified by
 the user,
 and do not appear in the correlation matrix)

	Background	Beta(1)
Background	1	-0.69
Beta(1)	-0.69	1

Parameter Estimates

Interval Limit	Variable	Estimate	Std. Err.	95.0% Wald Confidence	
				Lower Conf. Limit	Upper Conf.
	Background	0.0418935	*	*	*
	Beta(1)	0.378246	*	*	*
	Beta(2)	0	*	*	*

* - Indicates that this value is not calculated.

Analysis of Deviance Table

Model	Log(likelihood)	# Param's	Deviance	Test d.f.	P-value
Full model	-74.9467	4			
Fitted model	-75.154	2	0.414699	2	0.8127
Reduced model	-77.5602	1	5.22694	3	0.1559
AIC:	154.308				

Goodness of Fit

Dose	Est._Prob.	Expected	Observed	Size	Scaled Residual
0.0000	0.0419	2.974	3.000	71	0.015
0.0216	0.0497	3.528	3.000	71	-0.288
0.1079	0.0802	5.775	7.000	72	0.531
0.2698	0.1348	9.709	9.000	72	-0.245

Chi² = 0.43 d.f. = 2 P-value = 0.8083

Benchmark Dose Computation

Specified effect = 0.1

Risk Type = Extra risk

Confidence level = 0.95

 BMD = 0.27855

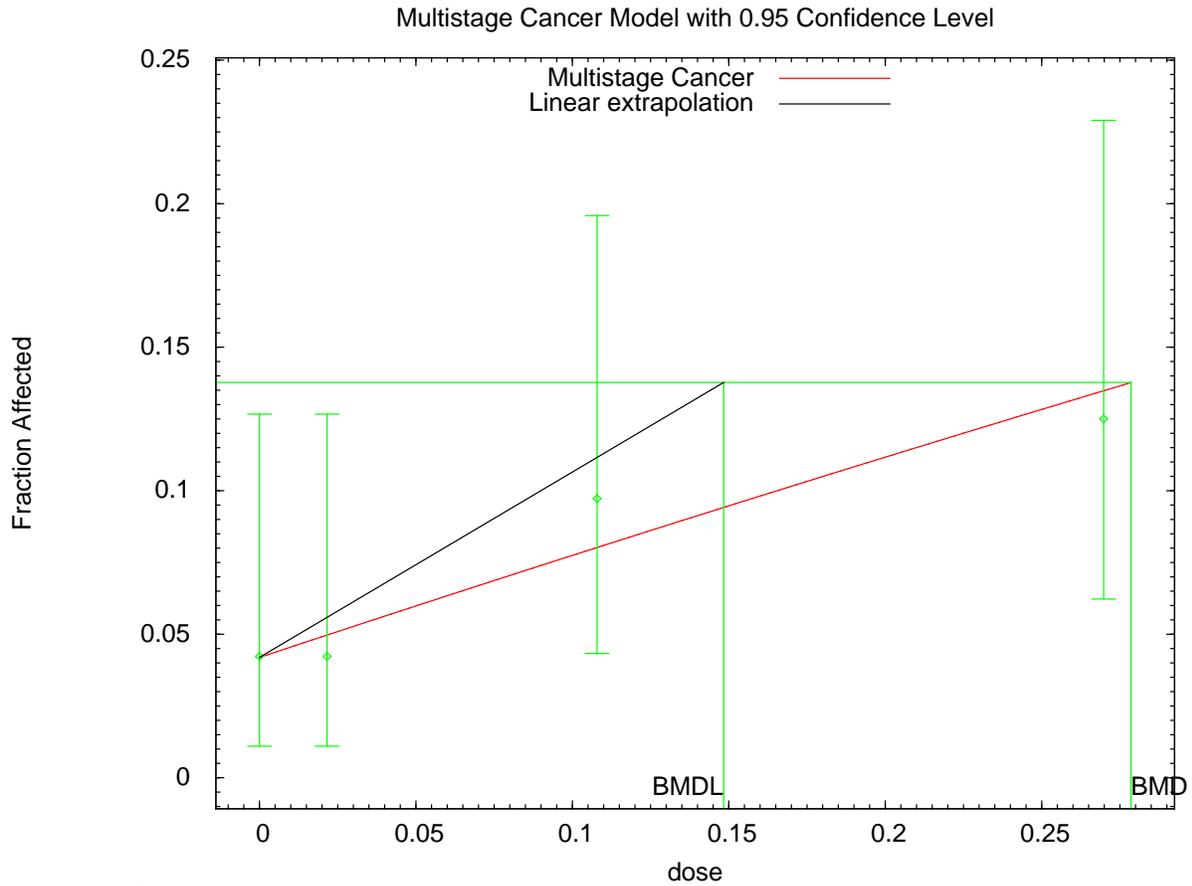
 BMDL = 0.14836

 BMDU = 1.16966

Taken together, (0.14836, 1.16966) is a 90 % two-sided confidence interval for the BMD

Multistage Cancer Slope Factor = 0.674034

BMDS Output – Run #3 (Same Input Data, Changed Degree of Polynomial to 3)



17:10 11/08 2011

```

=====
Multistage Cancer Model. (Version: 1.9; Date: 05/26/2010)
Input Data File: I:\Aldrin & Dieldrin\Chlordane, DDE, DDD, DDT, and
Endrin\BMDS Output Files\msc_Chlordane Cancer Khasawinah 1989 Male_Opt.(d)
Gnuplot Plotting File: I:\Aldrin & Dieldrin\Chlordane, DDE, DDD, DDT, and
Endrin\BMDS Output Files\msc_Chlordane Cancer Khasawinah 1989 Male_Opt.plt
Tue Nov 08 17:10:51 2011
=====
    
```

BMDS_Model_Run

The form of the probability function is:

$$P[\text{response}] = \text{background} + (1-\text{background}) * [1 - \text{EXP}(-\text{beta1} * \text{dose}^1 - \text{beta2} * \text{dose}^2 - \text{beta3} * \text{dose}^3)]$$

The parameter betas are restricted to be positive

Dependent variable = Tumor_Incidence
 Independent variable = Human_Dose

```

Total number of observations = 4
Total number of records with missing values = 0
Total number of parameters in model = 4
Total number of specified parameters = 0
    
```

Degree of polynomial = 3

Maximum number of iterations = 250
 Relative Function Convergence has been set to: 1e-008
 Parameter Convergence has been set to: 1e-008

Default Initial Parameter Values

Background = 0.0444238
 Beta(1) = 0.351594
 Beta(2) = 0
 Beta(3) = 0

Asymptotic Correlation Matrix of Parameter Estimates

(*** The model parameter(s) -Beta(2) -Beta(3)
 have been estimated at a boundary point, or have been specified by
 the user,
 and do not appear in the correlation matrix)

	Background	Beta(1)
Background	1	-0.69
Beta(1)	-0.69	1

Parameter Estimates

Interval Limit	Variable	Estimate	Std. Err.	95.0% Wald Confidence	
				Lower Conf. Limit	Upper Conf.
	Background	0.0418935	*	*	*
	Beta(1)	0.378246	*	*	*
	Beta(2)	0	*	*	*
	Beta(3)	0	*	*	*

* - Indicates that this value is not calculated.

Analysis of Deviance Table

Model	Log(likelihood)	# Param's	Deviance	Test d.f.	P-value
Full model	-74.9467	4			
Fitted model	-75.154	2	0.414699	2	0.8127
Reduced model	-77.5602	1	5.22694	3	0.1559
AIC:	154.308				

Goodness of Fit

Dose	Est._Prob.	Expected	Observed	Size	Scaled Residual
0.0000	0.0419	2.974	3.000	71	0.015
0.0216	0.0497	3.528	3.000	71	-0.288
0.1079	0.0802	5.775	7.000	72	0.531

0.2698 0.1348 9.709 9.000 72 -0.245
Chi² = 0.43 d.f. = 2 P-value = 0.8083

Benchmark Dose Computation

Specified effect = 0.1

Risk Type = Extra risk

Confidence level = 0.95

 BMD = 0.27855

 BMDL = 0.14836

 BMDU = 1.16966

Taken together, (0.14836, 1.16966) is a 90 % two-sided confidence interval for the BMD

Multistage Cancer Slope Factor = 0.674034

APPENDIX G

Khasawinah and Grutsch 1989 Male (Non-Cancer)

APPENDIX G**KHASAWINAH AND GRUTSCH 1989 MALE (NON-CANCER)****Study Description**

ICR mice (80/sex/group) were given 0, 1, 5, or 12.5 ppm technical chlordane in the diet for 104 weeks. The study authors reported that average doses corresponded to 0, 0.15, 0.75, and 1.875 mg/kg-day, based on an assumed food consumption of 15% of the body weight per day. Exposure-related effects were restricted to the liver.

Statistically significant increased absolute and relative liver weights were seen in high-dose males (200 and 203%) and females (144 and 129%) compared to control values at the end of the study. Absolute but not relative liver weight also was elevated significantly ($p < 0.05$) in the females exposed to 1 (22%) and 5 ppm (14%).

Statistically significant increased incidences over controls were found for hepatocellular swelling (hypertrophy) in 5- and 12.5-ppm males and females, and hepatic fatty degeneration was observed in 12.5-ppm males and 5- and 12.5-ppm females. Hepatic necrosis was noted in males only, including controls (7/80) and the 1-ppm (8/80), 5-ppm (25/80), and 12.5-ppm (27/80) groups. Hepatic necrosis is the most adverse lesion of those occurring at 5 ppm and is judged as the critical effect over both fatty degeneration and hepatocellular swelling (hypertrophy). Based on the increased incidence of hepatic necrosis over controls, 1 ppm chlordane (0.15 mg/kg-day) was the NOAEL, and 5 ppm chlordane (0.75 mg/kg-day) was the LOAEL (U.S. EPA 1997).

Table G1. Dose Response Data for Critical Non-Cancer Endpoint (Khasawinah and Grutsch 1989)

Dose (ppm in mouse diet)	Estimated Mouse Dose (mg/kg-day)	Human Equivalent Dose (mg/kg-day) ^a	Incidence of Hepatic Necrosis
0	0	0	7/80
1	0.15	0.0216	8/80
5	0.75	0.1079	25/80
12.5	1.875	0.2698	27/80

a. Human Equivalent Dose = Mouse Dose x (mouse BW/human BW)^{1/4} = mouse dose x 0.143882 (U.S. EPA 1997).

Evaluation of Non-Cancer Risk by U.S. EPA (1997)

In its evaluation of the Khasawinah and Grutsch (1989) study, U.S. EPA (1997) used the increased incidence of hepatic necrosis over controls to determine that 1 ppm chlordane (0.15 mg/kg-day) was the NOAEL, and 5 ppm chlordane (0.75 mg/kg-day) was the LOAEL. A benchmark concentration modeling was attempted using the THRESH and THRESHW models, but an acceptable curve fit was not achieved.

Benchmark Dose Models

The hepatic necrosis incidence data reported by Khasawinah and Grutsch (1989) are quantal data that the US EPA (2000) recommends for use in a Dichotomous Model.

The BMDS 2.1.2 software offers three variations of Dichotomous Models that would be appropriate for the data set. The liver necrosis incidence data from Khasawinah and Grutsch (1989a) were entered into a BMDS 2.1.2 spreadsheet and applied to three models: Gamma, Multistage, and Weibull. With the complete data set, none of the models produced a curve with an acceptable curve fit to the data. The US EPA's *Benchmark Dose Technical Guidance* (US EPA 2000) allows for the exclusion of the highest dose in order to improve the model fit at the low dose range. When the Gamma, Multistage, and Weibull models were performed on the data set without the highest dose level, each model produced an acceptable curve fit to the data.

Figure G1. BMDS Input Data

	Dose_ppm	lic_necrosis_incic	N	Col4	Col5	Col6
1	0	7	80			
2	1	8	80			
3	5	25	80			
4	12.5	27	80			
5						

Figure G2. BMDS Model Parameters for First Run

<<Column Assignments>>		<<Other Assignments>>	
Dose	Dose_ppm	Risk Type	Extra
# Subjects in Dose Group	N	BMR	0.1000
Incidence	Hepatic_necr	Confidence Level	0.95
% Positive		BMD Calculation	<input checked="" type="checkbox"/>
		BMDL Curve Calc.	<input type="checkbox"/>
		Dose Groups	4
		Restrict Power >=1	<input checked="" type="checkbox"/>
<<Optimizer Assignments>>			
Iteration	250		
Relative Function	1.00E-08		
Parameter	1.00E-08		
<<Parameter Assignments>>			
Parameters	Options	Values	
Background	Default		
Slope	Default		
Power	Default		

User Notes: BMDS Model Run

Data File: I:\Aldrin & Dieldrin\Chlordane, DDE, DDD, DDT, and Endrin\ Show

Out File Name: I:\Aldrin & Dieldrin\Chlordane, DDE, DDD, DDT, and Endrin\ Set

Buttons: Save, Save As ..., Set Values To Default, Optimize Initial Param. Values, Run, Close

Gamma->Dichotomous

Results

A summary of the BMD analyses of the liver tumor incidence data is presented in Table G2, below. All three models (Gamma, Multistage, Weibull) produced curves with unacceptable fit to the data, as indicated by P-values below 0.1. When the models were run after exclusion of the high dose group the curve fits were identical for the three

models and all met the acceptance criteria. The BMD values varied some, ranging from 0.0618713 to 0.0646652 mg/kg-day, but the BMDL was identical in all three models at 0.288088 mg/kg-day. The Gamma model produced the most conservative BMD value. Complete output reports for each model run are presented in the following pages.

Table G2. Benchmark Dose Model Results for Khasawinah and Grutsch 1989 Males

Run #	Data Set	Model	Curve-Fit Acceptance			BMD (mg/kg-day)	BMDL (mg/kg-day)
			P-value ¹	Highest Scaled Residual ²	AIC ³		
1	All	Gamma	0.0952	1.832	309.656	0.0714173	0.0511554
2	All	Multistage	0.0952	1.832	309.656	0.071418	0.0511554
3	All	Weibull	0.0952	1.832	309.656	0.0714179	0.0511554
4	Excluded high dose	Gamma	NA	0.000	204.862	0.0618713	0.0288088
5	Excluded high dose	Multistage	NA	0.000	204.862	0.0646652	0.0288088
6	Excluded high dose	Weibull	NA	0.000	204.862	0.0637524	0.0288088

1 For the model to be acceptable, P-value must be > 0.1

2 Scaled residuals report the gap between the curve line and the actual data points; for the model to be acceptable, all scaled residuals must have an absolute value of < 2.

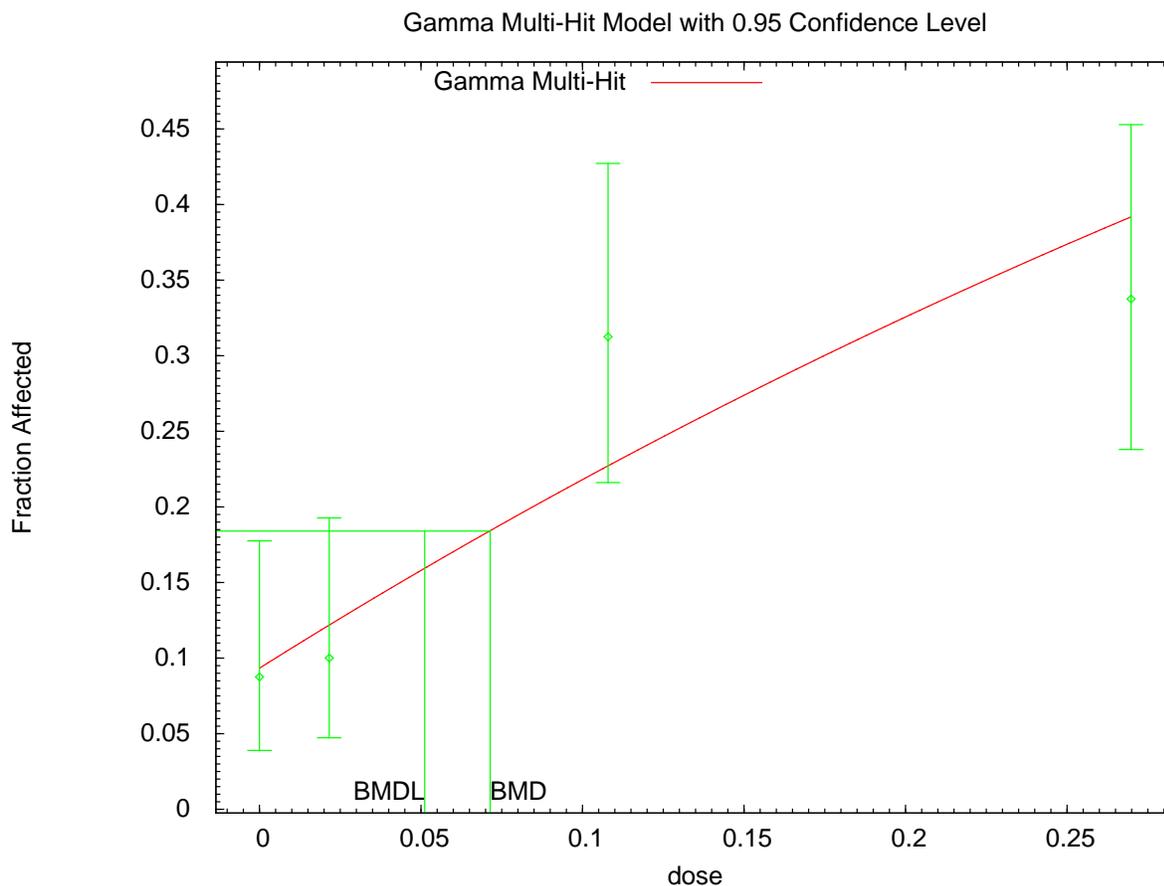
3 The Akaike Information Coefficient (AIC) is used for comparison between acceptable models; a lower AIC value indicates a better curve fit to the data.

4 P-value of "NA" is not explained in the *Benchmark Dose Technical Guidance* (US EPA 2000), but the visual inspection of these curves indicate an excellent fit to the data..

Conclusion

The highest scaled residual values are above 2 and P-values were less than 0.1 in runs #4, #5, and #6, making these curves acceptable fits to the data. Run #4, the Gamma model, produced the most conservative BMD value at 0.618713 mg/kg-day, but all three models (with the high dose data excluded) produced the same BMDL value of 0.0288088 mg/kg-day.

BMDS Output: Run #1 (Complete Data Set; Gamma Model)



10:22 06/24 2011

```

=====
Gamma Model. (Version: 2.15; Date: 10/28/2009)
Input Data File: I:\Aldrin & Dieldrin\Chlordane, DDE, DDD, DDT, and
Endrin\BMDS Output Files\gam_Chlordane Non-Cancer Khasawinah 1989 Male_Opt.(d)
Gnuplot Plotting File: I:\Aldrin & Dieldrin\Chlordane, DDE, DDD, DDT, and
Endrin\BMDS Output Files\gam_Chlordane Non-Cancer Khasawinah 1989 Male_Opt.plt
Fri Jun 24 10:22:51 2011
=====
    
```

BMDS_Model_Run

The form of the probability function is:

$P[\text{response}] = \text{background} + (1 - \text{background}) * \text{CumGamma}[\text{slope} * \text{dose}, \text{power}]$,
 where CumGamma(.) is the cumulative Gamma distribution function

Dependent variable = Hepatic_necrosis_incidence
 Independent variable = HED
 Power parameter is restricted as power >=1

Total number of observations = 4
 Total number of records with missing values = 0
 Maximum number of iterations = 250
 Relative Function Convergence has been set to: 1e-008

Parameter Convergence has been set to: 1e-008

Default Initial (and Specified) Parameter Values

Background = 0.097561
 Slope = 4.02907
 Power = 1.3

Asymptotic Correlation Matrix of Parameter Estimates

(*** The model parameter(s) -Power
 have been estimated at a boundary point, or have been specified by
 the user,
 and do not appear in the correlation matrix)

	Background	Slope
Background	1	-0.55
Slope	-0.55	1

Parameter Estimates

Interval Limit	Variable	Estimate	Std. Err.	95.0% Wald Confidence	
				Lower Conf. Limit	Upper Conf.
0.145209	Background	0.0933299	0.0264694	0.0414509	
2.14181	Slope	1.47528	0.340073	0.80875	
	Power	1	NA		

NA - Indicates that this parameter has hit a bound implied by some inequality constraint and thus has no standard error.

Analysis of Deviance Table

Model	Log(likelihood)	# Param's	Deviance	Test d.f.	P-value
Full model	-150.58	4			
Fitted model	-152.828	2	4.49651	2	0.1056
Reduced model	-164.201	1	27.2419	3	<.0001
AIC:	309.656				

Goodness of Fit

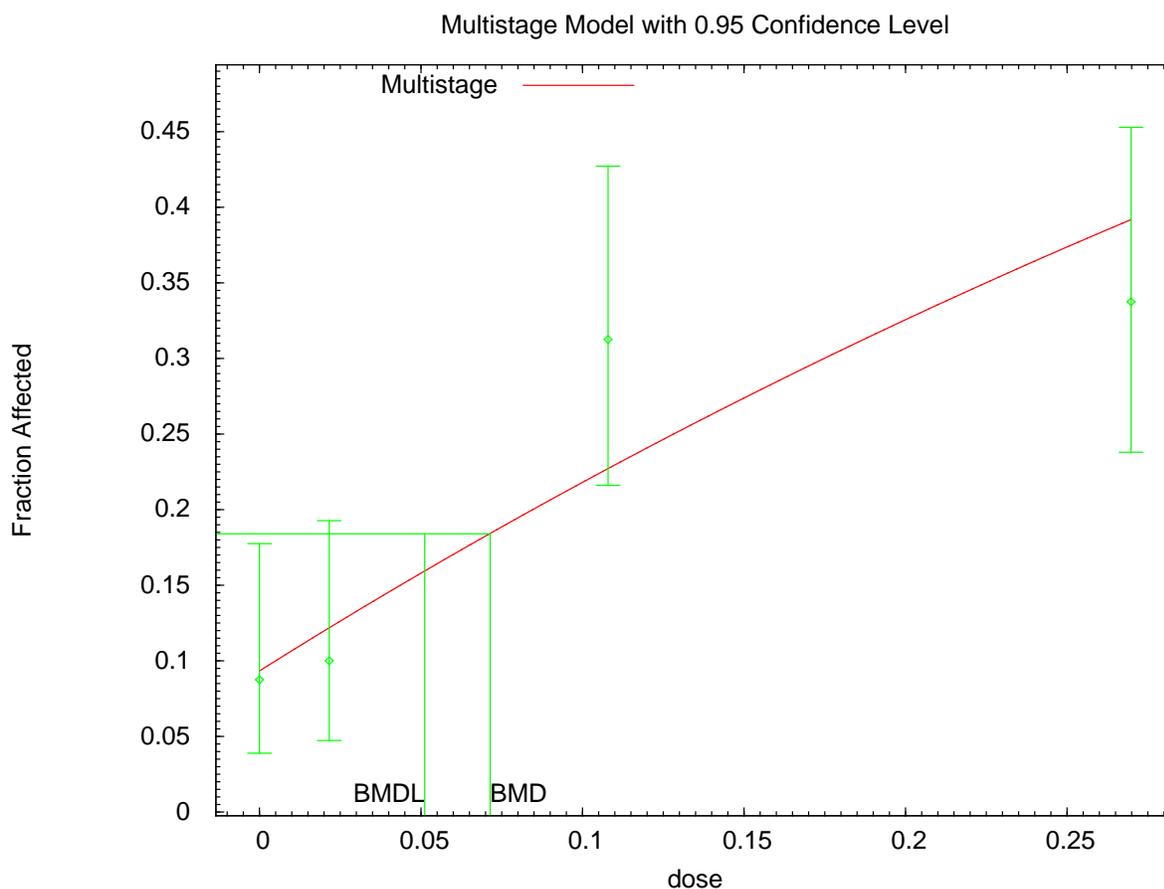
Dose	Est._Prob.	Expected	Observed	Size	Scaled Residual
0.0000	0.0933	7.466	7.000	80	-0.179
0.0216	0.1218	9.741	8.000	80	-0.595
0.1079	0.2268	18.140	25.000	80	1.832
0.2698	0.3910	31.283	27.000	80	-0.981

Chi^2 = 4.70 d.f. = 2 P-value = 0.0952

Benchmark Dose Computation

Specified effect = 0.1
Risk Type = Extra risk
Confidence level = 0.95
BMD = 0.0714173
BMDL = 0.0511554

BMDS Output – Run #2 (Complete Data Set; Multistage Model)



10:24 06/24 2011

```

=====
Multistage Model. (Version: 3.2; Date: 05/26/2010)
Input Data File: I:\Aldrin & Dieldrin\Chlordane, DDE, DDD, DDT, and
Endrin\BMDS Output Files\mst_Chlordane Non-Cancer Khasawinah 1989 Male_Opt.(d)
Gnuplot Plotting File: I:\Aldrin & Dieldrin\Chlordane, DDE, DDD, DDT, and
Endrin\BMDS Output Files\mst_Chlordane Non-Cancer Khasawinah 1989 Male_Opt.plt
Fri Jun 24 10:24:02 2011
=====
    
```

BMDS_Model_Run

The form of the probability function is:

$$P[\text{response}] = \text{background} + (1-\text{background}) * [1 - \text{EXP}(-\text{beta1} * \text{dose}^1 - \text{beta2} * \text{dose}^2)]$$

The parameter betas are restricted to be positive

Dependent variable = Hepatic_necrosis_incidence
 Independent variable = HED

```

Total number of observations = 4
Total number of records with missing values = 0
Total number of parameters in model = 3
Total number of specified parameters = 0
    
```

Degree of polynomial = 2

Maximum number of iterations = 250
 Relative Function Convergence has been set to: 1e-008
 Parameter Convergence has been set to: 1e-008

Default Initial Parameter Values

Background = 0.115338
 Beta(1) = 1.23505
 Beta(2) = 0

Asymptotic Correlation Matrix of Parameter Estimates

(*** The model parameter(s) -Beta(2)
 have been estimated at a boundary point, or have been specified by
 the user,
 and do not appear in the correlation matrix)

	Background	Beta(1)
Background	1	-0.68
Beta(1)	-0.68	1

Parameter Estimates

Interval Limit	Variable	Estimate	Std. Err.	95.0% Wald Confidence	
				Lower Conf. Limit	Upper Conf.
	Background	0.0933303	*	*	*
	Beta(1)	1.47527	*	*	*
	Beta(2)	0	*	*	*

* - Indicates that this value is not calculated.

Analysis of Deviance Table

Model	Log(likelihood)	# Param's	Deviance	Test d.f.	P-value
Full model	-150.58	4			
Fitted model	-152.828	2	4.49651	2	0.1056
Reduced model	-164.201	1	27.2419	3	<.0001
AIC:	309.656				

Goodness of Fit

Dose	Est._Prob.	Expected	Observed	Size	Scaled Residual
0.0000	0.0933	7.466	7.000	80	-0.179
0.0216	0.1218	9.741	8.000	80	-0.595
0.1079	0.2268	18.140	25.000	80	1.832
0.2698	0.3910	31.283	27.000	80	-0.981

Chi² = 4.70 d.f. = 2 P-value = 0.0952

Benchmark Dose Computation

Specified effect = 0.1

Risk Type = Extra risk

Confidence level = 0.95

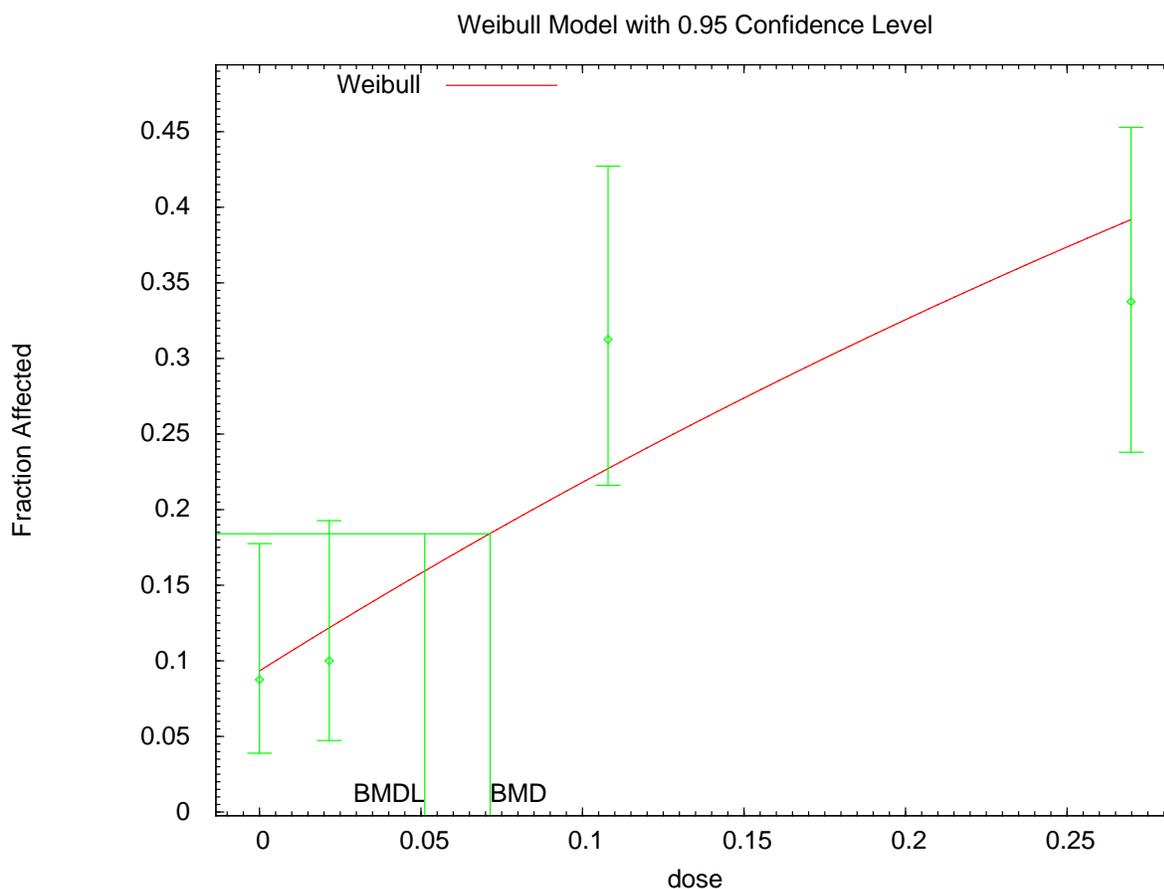
 BMD = 0.071418

 BMDL = 0.0511554

 BMDU = 0.114943

Taken together, (0.0511554, 0.114943) is a 90 % two-sided confidence interval for the BMD

BMDS Output – Run #3 (Complete Data Set; Weibull Model)



10:24 06/24 2011

```

=====
Weibull Model using Weibull Model (Version: 2.15; Date: 10/28/2009)
Input Data File: I:\Aldrin & Dieldrin\Chlordane, DDE, DDD, DDT, and
Endrin\BMDS Output Files\wei_Chlordane Non-Cancer Khasawinah 1989 Male_Opt.(d)
Gnuplot Plotting File: I:\Aldrin & Dieldrin\Chlordane, DDE, DDD, DDT, and
Endrin\BMDS Output Files\wei_Chlordane Non-Cancer Khasawinah 1989 Male_Opt.plt
Fri Jun 24 10:24:55 2011
=====
    
```

BMDS_Model_Run

The form of the probability function is:

$$P[\text{response}] = \text{background} + (1-\text{background}) * [1 - \text{EXP}(-\text{slope} * \text{dose}^{\text{power}})]$$

Dependent variable = Hepatic_necrosis_incidence
 Independent variable = HED
 Power parameter is restricted as power >= 1.000000

Total number of observations = 4
 Total number of records with missing values = 0
 Maximum number of iterations = 250
 Relative Function Convergence has been set to: 1e-008
 Parameter Convergence has been set to: 1e-008

Default Initial (and Specified) Parameter Values

Background = 0.097561
 Slope = 1.16783
 Power = 1

Asymptotic Correlation Matrix of Parameter Estimates

(*** The model parameter(s) -Power have been estimated at a boundary point, or have been specified by the user, and do not appear in the correlation matrix)

	Background	Slope
Background	1	-0.55
Slope	-0.55	1

Parameter Estimates

Interval Limit	Variable	Estimate	Std. Err.	95.0% Wald Confidence	
				Lower Conf. Limit	Upper Conf.
0.145209	Background	0.0933303	0.0264694	0.0414511	
2.14179	Slope	1.47527	0.340071	0.808741	
	Power	1	NA		

NA - Indicates that this parameter has hit a bound implied by some inequality constraint and thus has no standard error.

Analysis of Deviance Table

Model	Log(likelihood)	# Param's	Deviance	Test d.f.	P-value
Full model	-150.58	4			
Fitted model	-152.828	2	4.49651	2	0.1056
Reduced model	-164.201	1	27.2419	3	<.0001
AIC:	309.656				

Goodness of Fit

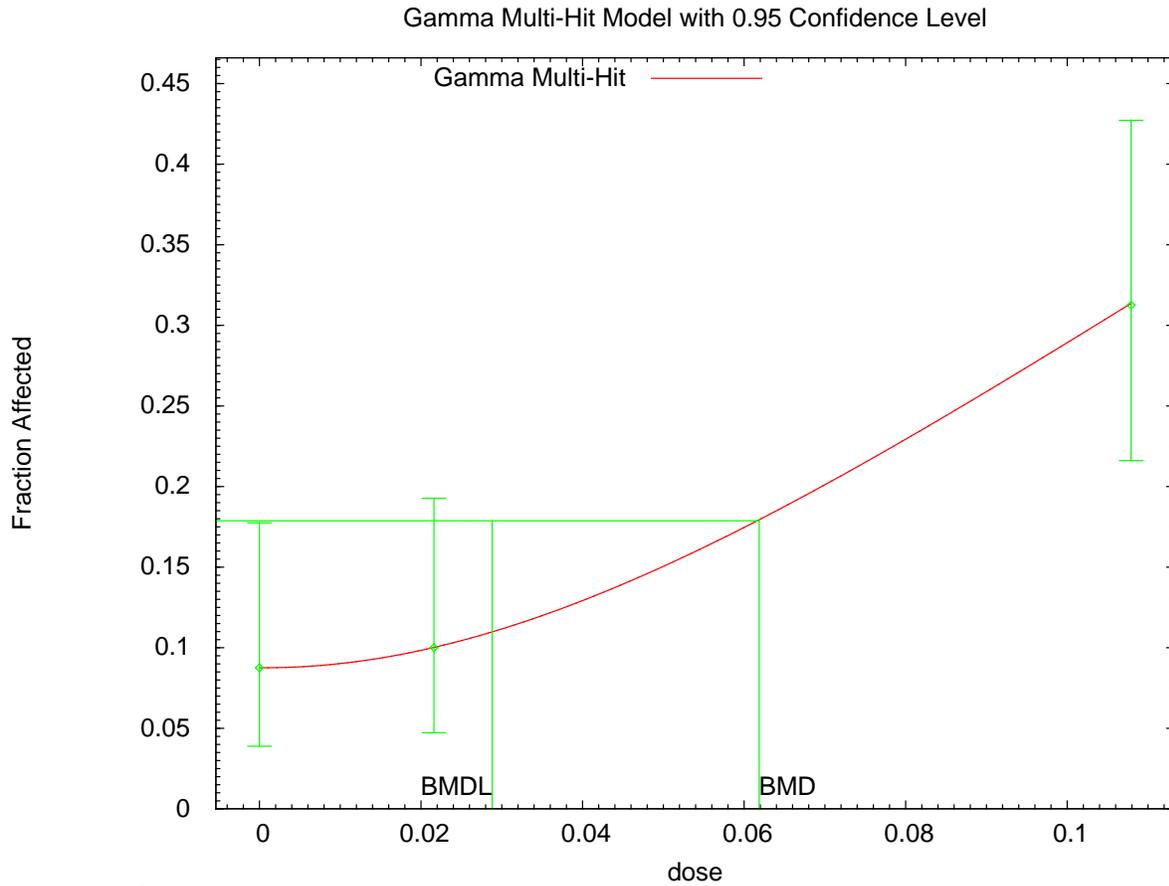
Dose	Est._Prob.	Expected	Observed	Size	Scaled Residual
0.0000	0.0933	7.466	7.000	80	-0.179
0.0216	0.1218	9.741	8.000	80	-0.595
0.1079	0.2268	18.140	25.000	80	1.832
0.2698	0.3910	31.283	27.000	80	-0.981

Chi^2 = 4.70 d.f. = 2 P-value = 0.0952

Benchmark Dose Computation

Specified effect = 0.1
Risk Type = Extra risk
Confidence level = 0.95
BMD = 0.0714179
BMDL = 0.0511554

BMDS Output – Run #4 (Excluded High Dose; Gamma Model)



10:25 06/24 2011

```

=====
Gamma Model. (Version: 2.15; Date: 10/28/2009)
Input Data File: I:\Aldrin & Dieldrin\Chlordane, DDE, DDD, DDT, and
Endrin\BMDS Output Files\gam_Chlordane Non-Cancer Khasawinah 1989 Male_Opt.(d)
Gnuplot Plotting File: I:\Aldrin & Dieldrin\Chlordane, DDE, DDD, DDT, and
Endrin\BMDS Output Files\gam_Chlordane Non-Cancer Khasawinah 1989 Male_Opt.plt
Fri Jun 24 10:25:48 2011
=====

```

BMDS_Model_Run

The form of the probability function is:

$P[\text{response}] = \text{background} + (1 - \text{background}) * \text{CumGamma}[\text{slope} * \text{dose}, \text{power}]$,
 where CumGamma(.) is the cumulative Gamma distribution function

Dependent variable = Hepatic_necrosis_incidence
 Independent variable = HED
 Power parameter is restricted as power >=1

Total number of observations = 3
 Total number of records with missing values = 0
 Maximum number of iterations = 250
 Relative Function Convergence has been set to: 1e-008
 Parameter Convergence has been set to: 1e-008

Default Initial (and Specified) Parameter Values

Background = 0.097561
 Slope = 5.65445
 Power = 1.52662

Asymptotic Correlation Matrix of Parameter Estimates

	Background	Slope	Power
Background	1	0.63	0.66
Slope	0.63	1	1
Power	0.66	1	1

Parameter Estimates

Interval Limit	Variable	Estimate	Std. Err.	95.0% Wald Confidence	
				Lower Conf. Limit	Upper Conf.
0.149408	Background	0.0875014	0.0315858	0.0255944	
51.1006	Slope	9.74126	21.1021	-31.6181	
8.23466	Power	2.13478	3.11224	-3.96509	

Analysis of Deviance Table

Model	Log(likelihood)	# Param's	Deviance	Test d.f.	P-value
Full model	-99.4308	3			
Fitted model	-99.4308	3	8.14856e-009	0	NA
Reduced model	-108.135	1	17.4078	2	0.0001659
AIC:	204.862				

Goodness of Fit

Dose	Est._Prob.	Expected	Observed	Size	Scaled Residual
0.0000	0.0875	7.000	7.000	80	-0.000
0.0216	0.1000	8.000	8.000	80	0.000
0.1079	0.3125	25.000	25.000	80	0.000

Chi^2 = 0.00 d.f. = 0 P-value = NA

Benchmark Dose Computation

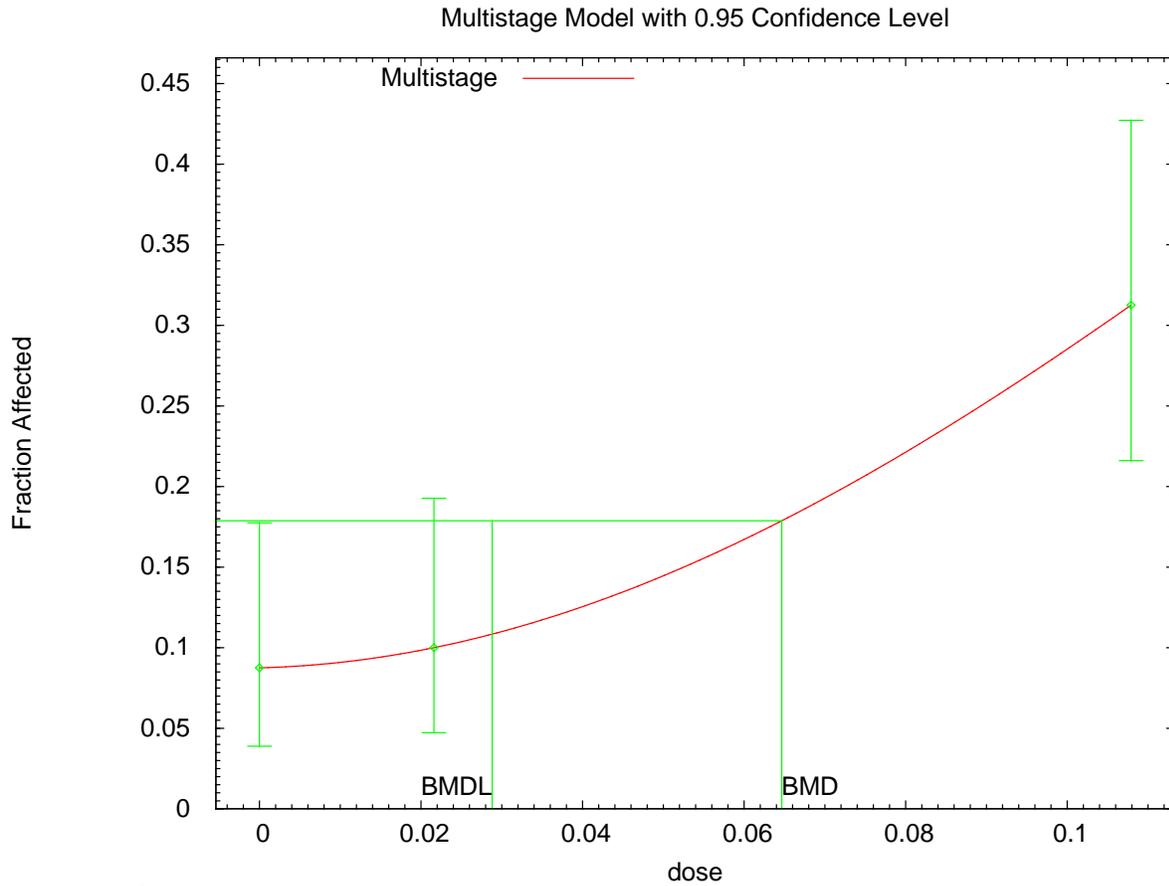
Specified effect = 0.1
 Risk Type = Extra risk

Confidence level = 0.95

BMD = 0.0618713

BMDL = 0.0288088

BMDS Output – Run #5 (Excluded High Dose; Multistage Model)



10:26 06/24 2011

```

=====
Multistage Model. (Version: 3.2; Date: 05/26/2010)
Input Data File: I:\Aldrin & Dieldrin\Chlordane, DDE, DDD, DDT, and
Endrin\BMDS Output Files\mst_Chlordane Non-Cancer Khasawinah 1989 Male_Opt.(d)
Gnuplot Plotting File: I:\Aldrin & Dieldrin\Chlordane, DDE, DDD, DDT, and
Endrin\BMDS Output Files\mst_Chlordane Non-Cancer Khasawinah 1989 Male_Opt.plt
Fri Jun 24 10:26:23 2011
=====
    
```

BMDS_Model_Run

The form of the probability function is:

$$P[\text{response}] = \text{background} + (1-\text{background}) * [1 - \text{EXP}(-\text{beta1} * \text{dose} - \text{beta2} * \text{dose}^2)]$$

The parameter betas are restricted to be positive

Dependent variable = Hepatic_necrosis_incidence
Independent variable = HED

```

Total number of observations = 3
Total number of records with missing values = 0
Total number of parameters in model = 3
Total number of specified parameters = 0
    
```

Degree of polynomial = 2

Maximum number of iterations = 250
 Relative Function Convergence has been set to: 1e-008
 Parameter Convergence has been set to: 1e-008

Default Initial Parameter Values

Background = 0.0875
 Beta(1) = 0.141657
 Beta(2) = 23.0057

Asymptotic Correlation Matrix of Parameter Estimates

	Background	Beta(1)	Beta(2)
Background	1	-0.69	0.61
Beta(1)	-0.69	1	-0.99
Beta(2)	0.61	-0.99	1

Parameter Estimates

Interval Limit	Variable	Estimate	Std. Err.	95.0% Wald Confidence	
				Lower Conf. Limit	Upper Conf. Limit
	Background	0.0875	*	*	*
	Beta(1)	0.141657	*	*	*
	Beta(2)	23.0057	*	*	*

* - Indicates that this value is not calculated.

Error in computing chi-square; returning 2

Analysis of Deviance Table

Model	Log(likelihood)	# Param's	Deviance	Test d.f.	P-value
Full model	-99.4308	3			
Fitted model	-99.4308	3	2.84217e-014	0	NA
Reduced model	-108.135	1	17.4078	2	0.0001659
AIC:	204.862				

Goodness of Fit

Dose	Est._Prob.	Expected	Observed	Size	Scaled Residual
0.0000	0.0875	7.000	7.000	80	-0.000
0.0216	0.1000	8.000	8.000	80	-0.000
0.1079	0.3125	25.000	25.000	80	-0.000

Chi^2 = 0.00 d.f. = 0 P-value = NA

Benchmark Dose Computation

Specified effect = 0.1

Risk Type = Extra risk

Confidence level = 0.95

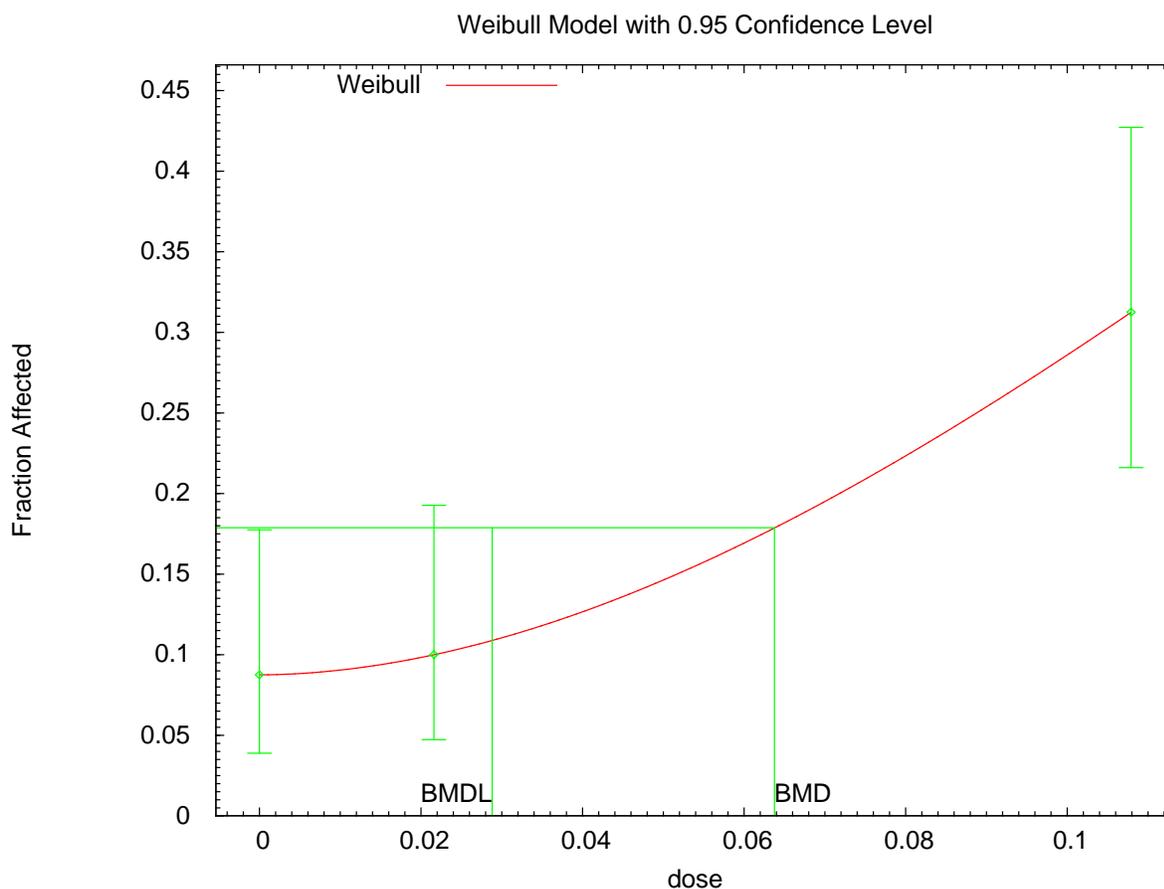
BMD = 0.0646652

BMDL = 0.0288088

BMDU = 0.0875789

Taken together, (0.0288088, 0.0875789) is a 90 % two-sided confidence interval for the BMD

BMDS Output – Run #6 (Excluded High Dose; Weibull Model)



10:27 06/24 2011

```

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Weibull Model using Weibull Model (Version: 2.15; Date: 10/28/2009)
Input Data File: I:\Aldrin & Dieldrin\Chlordane, DDE, DDD, DDT, and
Endrin\BMDS Output Files\wei_Chlordane Non-Cancer Khasawinah 1989 Male_Opt.(d)
Gnuplot Plotting File: I:\Aldrin & Dieldrin\Chlordane, DDE, DDD, DDT, and
Endrin\BMDS Output Files\wei_Chlordane Non-Cancer Khasawinah 1989 Male_Opt.plt
Fri Jun 24 10:27:02 2011
=====

```

BMDS_Model_Run

The form of the probability function is:

$$P[\text{response}] = \text{background} + (1-\text{background}) * [1-\text{EXP}(-\text{slope} * \text{dose}^{\text{power}})]$$

Dependent variable = Hepatic_necrosis_incidence
 Independent variable = HED
 Power parameter is restricted as power >= 1.000000

Total number of observations = 3
 Total number of records with missing values = 0
 Maximum number of iterations = 250
 Relative Function Convergence has been set to: 1e-008
 Parameter Convergence has been set to: 1e-008

Default Initial (and Specified) Parameter Values

Background = 0.097561
 Slope = 6.14827
 Power = 1.38948

Asymptotic Correlation Matrix of Parameter Estimates

	Background	Slope	Power
Background	1	0.64	0.66
Slope	0.64	1	1
Power	0.66	1	1

Parameter Estimates

Interval	Variable	Estimate	Std. Err.	95.0% Wald Confidence
Limit				Lower Conf. Limit Upper Conf.
0.149423	Background	0.0875002	0.031594	0.0255771
198.704	Slope	18.5579	91.9128	-161.588
6.28487	Power	1.87858	2.24815	-2.52771

Analysis of Deviance Table

Model	Log(likelihood)	# Param's	Deviance	Test d.f.	P-value
Full model	-99.4308	3			
Fitted model	-99.4308	3	4.82032e-011	0	NA
Reduced model	-108.135	1	17.4078	2	0.0001659
AIC:	204.862				

Goodness of Fit

Dose	Est._Prob.	Expected	Observed	Size	Scaled Residual
0.0000	0.0875	7.000	7.000	80	-0.000
0.0216	0.1000	8.000	8.000	80	-0.000
0.1079	0.3125	25.000	25.000	80	-0.000

Chi^2 = 0.00 d.f. = 0 P-value = NA

Benchmark Dose Computation

Specified effect = 0.1
 Risk Type = Extra risk
 Confidence level = 0.95

BMD = 0.0637524

BMDL = 0.0288088



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