LA-13508-MS

Preliminary Risk Assessment of the Southwestern Willow Flycatcher (Empidonax traillii extimus) at the Los Alamos National Laboratory

Los Alamos
NATIONAL LABORATORY

13222

Los Alamos National Laboratory is operated by the University of California for the United States Department of Energy under contract W-7405-ENG-36.

Edited by Hector Hinojosa, Group CIC-1
Photocomposition by Teresa Hiteman, Group ESH-20

LA-13508-MS

UC-902 and UC-908
Issued: October 1998

Preliminary Risk Assessment of the Southwestern Willow Flycatcher (Empidonax traillii extimus) at the Los Alamos National Laboratory

Gilbert J. Gonzales
Anthony F. Gallegos
Mary A. Mullen
Kathryn D. Bennett
Teralene S. Foxx

Los Alamos
NATIONAL LABORATORY
Los Alamos, New Mexico 87545

Table of Contents

Abstract 1

1.0 Introduction and Background 1

2.0 Methods 4
- 2.1 Review Literature 5
- 2.2 Compiling Toxicity Reference Values 5
- 2.3 Delineating Ecological Exposure Units (EEUs), where EEU = Potential Nesting Habitat + HR (foraging area) 6
- 2.4 Choosing Parameters and Assumptions Considering Purpose of Study, Quotient Method Limitations, and other Constraints or Considerations 9
- 2.5 Compiling Data 9
- 2.6 Ecological Risk Estimation 11
- 2.7 Risk Sources 12
- 2.8 Data Collection Design 12
- 2.9 Bioaccumulation and Biomagnification 13
- 2.10 Formulating Risk Conclusion 14
- 2.11 Delineating Further Study Needs 14

3.0 Results 14
- 3.1 Mean Total Risk within Total Nesting Habitat 14
- 3.2 Risk by Nest Site 16
- 3.3 Risk by Location 16
- 3.4 Risk by Contaminant 17

4.0 Discussion 17

5.0 Conclusions 19

Acknowledgment 19

Literature Cited 19

Figures

Figure 1. Location of Ecological Exposure Unit for risk assessment of the southwestern willow flycatcher at Los Alamos National Laboratory. 2

Figure 2. EEU-74 at LANL, the site of the preliminary risk assessment of the southwestern willow flycatcher. 7

Tables

Table 1. The Assumptions, Conditions, and Factors used in Calculating Risk from Contaminants. 10

Table 2. Risk Evaluation Criteria used to Interpret Results of Applying the EPA HQ Method (EPA 1986) 14

Table 3. Mean Hazard Indices, taken as "Total Risk," for the Southwestern Willow Flycatcher for Various Combinations of HR Shape, Forage Weighting, HR Slope, and HR Size (Breeding, Nonbreeding) 15

Table 4. Hazard Indices of Selected Nest Sites for Foraging Scenario #8 16

Table 5. Ranked Hazard Quotients by COPEC for Scenario #5 18

Table A-1a. Toxicity Reference Values (TRVs) used in the Preliminary Risk Assessment of the Southwestern Willow Flycatcher at the Los Alamos National Laboratory 23

Table A-1b. Radionuclide Toxicity Reference Values (TRVs) used in the Preliminary Risk Assessment of the Southwestern Willow Flycatcher at Los Alamos National Laboratory 34

Table A-2. Selected 'Source' HQs Contributed to Seven Hypothetical Nest Sites (Nest #s 40, 23, 19, 28, 62, 9, 88) for Foraging Scenario #8. Scenario #8 is Considered Relatively "Realistic" 35

Preliminary Risk Assessment of the Southwestern Willow Flycatcher (*Empidonax traillii extimus*) at the Los Alamos National Laboratory

Gilbert J. Gonzales, Anthony F. Gallegos, Mary A. Mullen, Kathryn D. Bennett, and Teralene S. Foxx

Abstract

The southwestern willow flycatcher (*Empidonax traillii extimus*) is the fourth threatened or endangered species to undergo a preliminary assessment for estimating potential risk from environmental contaminants at the Los Alamos National Laboratory. The assessments are being conducted as part of a three-year project to develop a habitat management plan for threatened and endangered species and species of concern at the Laboratory. For the preliminary assessment, estimated doses were compared against toxicity reference values to generate hazard indices (HIs). This assessment included a measure of cumulative effects from multiple contaminants (radionuclides, metals, and organic chemicals) to 100 simulated nest sites located within flycatcher potential habitat. Sources of contaminant values were 10,000-ft^2 grid cells within an Ecological Exposure Unit (EEU). This EEU was estimated around the potential habitat and was based on the maximum home range for the flycatcher identified in the scientific literature. The tools used included a custom FORTRAN program, ECORSK5, and a geographic information system. Food consumption and soil ingestion contaminant pathways were addressed in the assessment. Using a four-category risk evaluation, HI results indicate no appreciable impact is expected to the southwestern willow flycatcher. Information on risk by specific geographical location was generated, which can be used to manage contaminated areas, flycatcher habitat, facility siting, and/or facility operations in order to maintain low levels of risk from contaminants.

1.0 Introduction and Background

The Los Alamos National Laboratory (LANL) is located in north-central New Mexico (Figure 1). The southwestern willow flycatcher (*Empidonax traillii extimus*) (referred to as "flycatcher" in this report) is the fourth federally protected species to undergo a preliminary assessment of potential risk from environmental contaminants at LANL. The assessments are being conducted as part of a three-year project to develop a habitat management plan for threatened and endangered (T&E) species and other species of concern at the Laboratory (Foxx et al. 1998). The purpose of the habitat management plan is to provide for the proactive management of T&E species and other species of concern that permanently reside on or utilize LANL property in compliance with the federal Endangered Species Act, the National Environmental Policy Act, and other laws and regulations.

The flycatcher is a federally endangered species and is also listed by the State of New Mexico as endangered. It was listed in New Mexico in 1988 and placed on the federal list in 1995 (Skaggs 1996). The flycatcher requires patches of cottonwood or willow for nesting and foraging. This species has experienced extensive loss and modification of its habitat nationally and is also

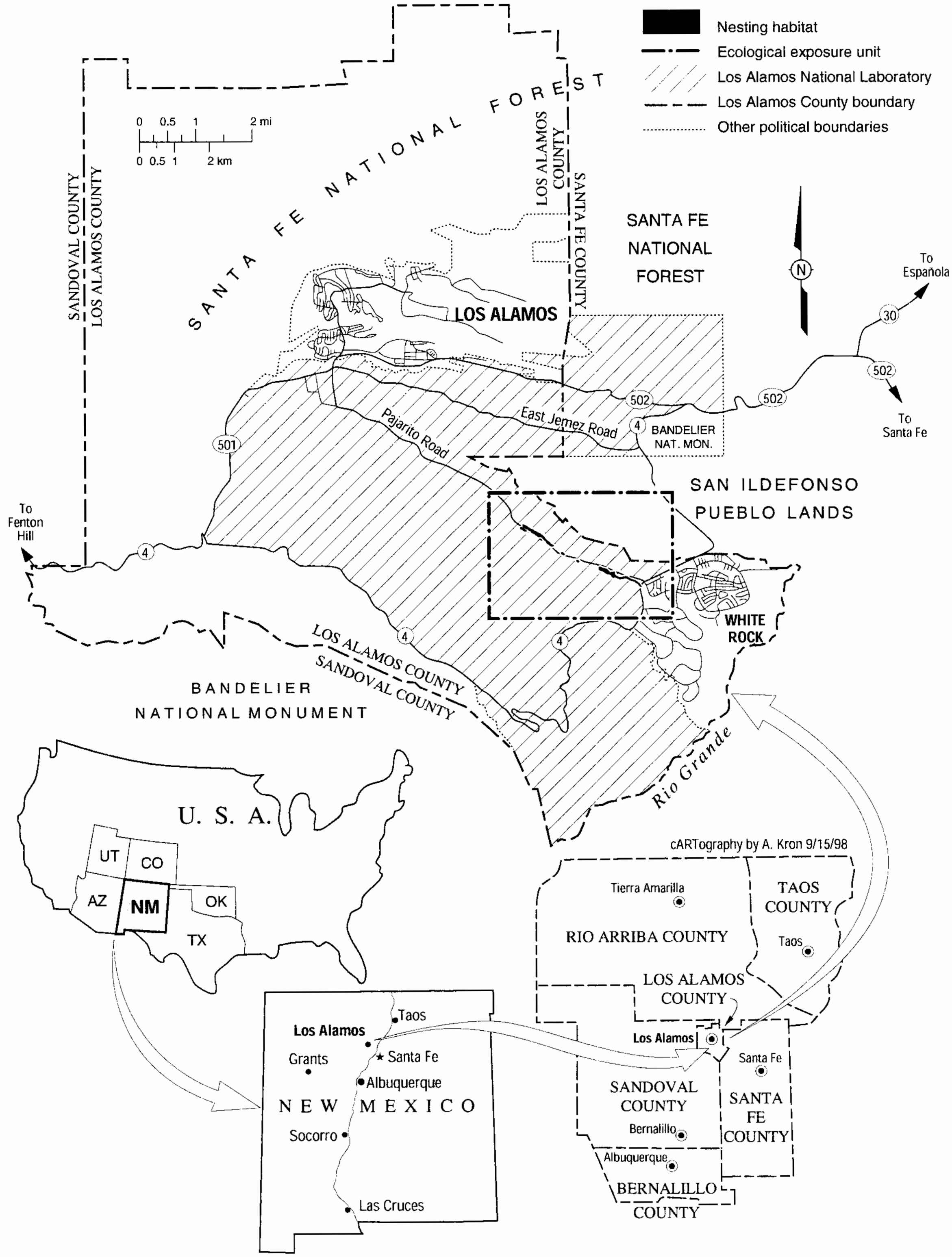

Figure 1. Location of Ecological Exposure Unit for risk assessment of the southwestern willow flycatcher at Los Alamos National Laboratory.

endangered by nest parasitism by the brown-headed cowbird (*Molothrus ater*). The breeding range includes southern California, southern Nevada, southern Utah, Arizona, New Mexico, western Texas, and nothern Mexico. It winters in Mexico, Central America, and northern South America.

Flycatchers inhabit riparian areas, marsh, wetlands, and other areas near water (Gonzales et al. 1996). Areas in lower Pajarito Canyon near the Pajarito wetlands have been qualitatively judged to contain "suitable habitat." The Pajarito wetlands is located in lower Pajarito Canyon and is parallel and immediately adjacent to State Route 502 beginning at the southeast boundary of Technical Area (TA) 18 and extending approximately two miles to the Laboratory's southeast boundary. The canyon serves as one of several drainages for the flanks of the Jemez Mountains. Spring and summer thunderstorms recharge a thin perched aquifer through the canyon which terminates in the wetlands (Purtymun et al. 1990). The wetlands was originally delineated by the U.S. Fish and Wildlife Service as part of the National Wetlands Inventory (Cowardin et al. 1979). Palustrine wetlands dominate the Pajarito wetlands, which are fed by springs, seeps, and runoff from precipitation. Historical data, aerial photographs, and field observations indicate a wetland hydrology that is interrupted. Since the wetlands are transitional between aquatic and terrestrial systems where the water table is usually at or slightly above the surface, aquatic flora and fauna dominate, but terrestrial flora and fauna add to the high biological diversity. Hydric soils in the wetlands support vegetation dominated by hydrophytic plants including Mexican rush (*Juncus mexicanus*), cattails (*Typha* spp.), coyote willow (*Salix* spp.), salt cedar (*Tamarix galliea*), and narrowleaf cottonwood (*Populus angustifolia*) (Banar 1996).

Fauna include many species of insects and birds, at least 23 species of mammals, and at least 15 species of reptiles and amphibians. A detailed listing of species that occur at the wetlands can be found in Banar (1996). LANL's Ecology Group conducts annual surveys for federally listed T&E species and for several State-protected species. During one of three surveys in 1997 for the flycatcher, a migrant flycatcher was sighted in the Pajarito wetlands and at the Rio Grande (Keller 1997). No nesting birds were identified. Subsequent surveys in the same year revealed no additional sightings nor did surveys in 1995, 1996, or 1998.

The flycatcher has never been known to nest on LANL or within Los Alamos County, however, Klingel (1997) has confirmed flycatchers in the Jemez Mountains. Breeding habitat is believed to exist on LANL and Bandelier National Monument, which is adjacent to LANL.

Habitat rarity and small, isolated populations make the remaining flycatchers increasingly susceptible to local extirpation through stochastic events such as fire, brood parasitism, predation, depredation, and land development. Pesticides and herbicides in particular have been identified as agents potentially affecting the flycatcher, either through direct toxicity or through effects on their food base (Sogge et al. 1997).

With little southwestern willow flycatcher habitat remaining, widespread events could destroy virtually all remaining habitat throughout all or a significant portion of the subspecies' range. Wildlife specialists believe that it is crucial that the maximum possible number of flycatcher breeding areas be identified and monitored (Sogge et al. 1997), therefore, it is important that any potential risk from contaminants to flycatchers that may inhabit the Pajarito habitat in the future be estimated and monitored over time.

The southwestern willow flycatcher is primarily an insectivore, with both larval and adult stages of insects serving as important foods (Klingel 1997). It forages within and above dense riparian vegetation, taking insects on the wing or gleaning them from foliage (Bent 1942, Marshall 1996). Because insects have a high lipid content, if exposed to contaminants, they typically store relatively high levels of the fat-soluble contaminants. Therefore, lipophyllic contaminants such as dichlorodiphenyltrichloroethane (DDT) and polychlorinated biphenyls (PCBs) should receive particular attention in the ensuing assessment.

The complexity of assessment applied was commensurate with a "Stage 1, Tier 2," or preliminary, assessment as defined in the Methods section. Having previously successfully demonstrated the integration of the custom FORTRAN program ECORSK5, LANL Environmental Restoration's (ER) contaminant database (Facility for Information, Management and Display – FIMAD), and a geographic information system (GIS), the primary objectives of the preliminary risk assessment were to

- semi-quantitatively appraise the potential for contaminants (organic, inorganic, and radionuclide) to impact flycatchers hypothetically nesting in or around LANL;
- evaluate the impact of improvements in model realism on risk, where improvements include (1) inclining the home range (HR) to angles that are similar to flycatcher potential habitat, (2) weighting the foraging process such that foraging, or occupancy, is inversely related to distance from a given nest site, and (3) scaling HR dimensions to flycatcher potential habitat so that HR shapes are proportional to the nesting habitat; and
- identify where further assessment, if any, is required; this includes identifying known and unknown facets of potential effects to assist in the development of a natural resources management plan that includes management of T&E species habitat.

2.0 Methods

Only a summary of the methods is made here as a detailed description of methods has been previously reported in Gonzales et al. 1998; Gallegos et al. 1997a and 1997b; and Gonzales et al. 1997.

The level of risk assessment that we targeted for this study in order to meet the objectives was "Stage 1, Tier 2," which we define as a preliminary risk assessment in which several elements of risk assessment are addressed:

- qualitatively evaluate contaminant release, fate, and transport,
- identify contaminants of potential ecological concern (COPECs),
- identify potential exposure pathways,
- identify known effects through literature review,
- develop a conceptual model,
- characterize the general biology and ecology of the flycatcher relative to potential contaminant exposure, and
- make a preliminary estimate of risk.

For our intents and purposes, the next stage of assessment ("Stage 2, Tier 2" or "effects assessment") for any species and COPECs that require further study would, in addition to the stage 1 elements, add the elements of conducting field studies and performing toxicity tests. A "Tier 3" level of assessment would primarily add a "risk characterization" component in which a final risk determination is made, an uncertainty analysis is conducted, and the significance of risks is established.

The process for conducting the assessment consisted of the following elements.

2.1 Review Literature

A broad range of literature was reviewed on subjects including but not limited to the biology of the species, HR tendencies, related food webs and diet, population histories, historical relationships with contaminants, and species-specific toxicology.

2.2 Compiling Toxicity Reference Values

As described in more detail later, the basis of the method used in this assessment to convey potential impact is to compare contaminant exposure estimates to toxicity reference values (TRVs) using the general formula

$$HQ = Exposure/TRV, \qquad (1)$$

where

HQ = hazard quotient, and
TRV = toxicity reference value.

A TRV is a level, or threshold value, of contaminant below which it is expected that no impact to a species will occur. The TRV method adopts "no observable adverse effects levels" (NOAELs) as the threshold for determining risk. NOAELs are experimentally derived toxicity values based on toxicological studies using a variety of animals. Much variation exists in species used as well as in experimental conditions, and no NOAEL information exists on the flycatcher or other T&E species. Because of these variations and uncertainties, conservative TRVs that would have the tendency to overestimate risk were used. The NOAELs and related information used are listed in Tables A-1a and A-1b in the appendix.

Nonradionuclide TRVs. TRVs chosen for use in quantifying risk from organic and metal COPECs were the chronic NOAELs in units of mg COPEC per kg body wt of the flycatcher per day. In order of descending use, the manner in which NOAELs were compiled was

1) obtained directly from the scientific literature or from published data bases,
2) computed from chronic intake doses, and
3) computed from LD_{50s}—a dose which is lethal to 50% of a test population.

Table A-1a identifies (1) the nonradionuclide NOAELs used in this assessment, (2) references from which the NOAELs were taken or derived, (3) test species on which they are based, (4) the chemical form on which the NOAEL is based, (5) the toxicological test endpoint, and (6) comparison or alternative NOAELs or TRVs which could have been used. The NOAELs for the metal COPECs are based on avian test species. The NOAELs for the organic COPECs are based on laboratory rats. NOAELs can have a substantial impact on risk estimates, therefore it is important to use NOAELs that are based on toxicity testing of species that are as close phylogenetically to the assessed species as possible. Environmental Protection Agency (EPA) data bases largely contain NOAELs that are based on testing laboratory rats. Examples of the impact that NOAELs can have on risk estimates have been previously demonstrated (Gallegos et al. 1997a). The replacement of rat-based NOAELs with NOAELs based on birds is a continuous process in this study, and this report is updated periodically as additional NOAELs and other information become available.

In human risk assessments, reference doses (RfDs) are typically adjusted (lowered) by a factor of 10 to account for the uncertainty of extrapolating RfDs within and between species. Attempts to calculate extrapolations of TRVs have been made by some researchers, however, the methods for doing so vary from one researcher to another. For example, Sample et al. (1995) assumed that "smaller animals have higher metabolic rates and are usually more resistant to toxic chemicals because of more rapid rates of detoxification and that metabolism is proportional to body weight." Conversely, in a study of risk to vertebrates from pesticides, Tiebout and Brugger (1995) predicted that small-bodied insectivores faced the highest risk.

Other possible sources of uncertainty that are not necessarily exclusive of each other include

1. extrapolation of acute dose derived NOAELs to chronic responses,
2. lowest observed adverse effect level (LOAEL) to NOAEL conversions,
3. extrapolation of sensitive-test-species data to nonsensitive or "normal" life stages,
4. extrapolation of less-than-life-span toxicological data to life span,
5. time to achievement of contaminant steady-state in laboratory tests on which NOAELs are based, and laboratory to field extrapolation (Calabrese and Baldwin 1993).

Some of the above-listed factors have the potential to increase or decrease (under- or overestimate) toxicological values. Also, several instances of interdependence of uncertainty factors exist, therefore the assumption that these factors are independent in their application would likely lead to over-conservatism (Calabrese and Baldwin 1993). For these reasons, the authors believe that the collective amount of uncertainty originating from different sources is great enough and/or variable enough such that adjustment for such uncertainty would make the results unusable because of large total margins of introduced error. This uncertainty is more appropriately eliminated or reduced in the next level of risk assessment should the results of this assessment indicate the need.

Radionuclide TRVs. TRVs have been largely unavailable for nonhumans. Radionuclide TRVs are ecological screening action levels (ESALs) in units of picocuries of radionuclide per gram of soil, i.e., pCi/g. For 11 radionuclides, TRVs were back-calculated from an International Atomic Energy Agency (IAEA) dose guideline of 0.1 rad·d^{-1} (IAEA 1992) (Table A-1b). They were derived by SNL (1998) using the dose conversion factors published by Amiro (1997). The IAEA reviewed all available literature on the effects of radiation on non-human biota and proposed a limit of 1.0 rad·d^{-1} as protective of all non-human biota with certain exceptions such as for T&E in which case they recommended 0.1 rad·d^{-1} as the protective level. For an additional 17 radionuclides, human-protective screening action levels, in units of pCi/g, were used (Table A-1b). Although the application of human TRVs to nonhuman biota can result in a large overestimate of risk (Gallegos et al. 1997a), the 17 radionuclides for which this was done contribute very little or no risk at LANL.

2.3 Delineating Ecological Exposure Units (EEUs), where EEU = Potential Nesting Habitat + HR (foraging area)

We define an EEU as an area defined by the biology of a species for which an ecological risk assessment is conducted. The EEU for the flycatcher is shown in Figure 2.

Peters (1993) developed allometric equations for estimating the HR for a number of classes of biota and functional

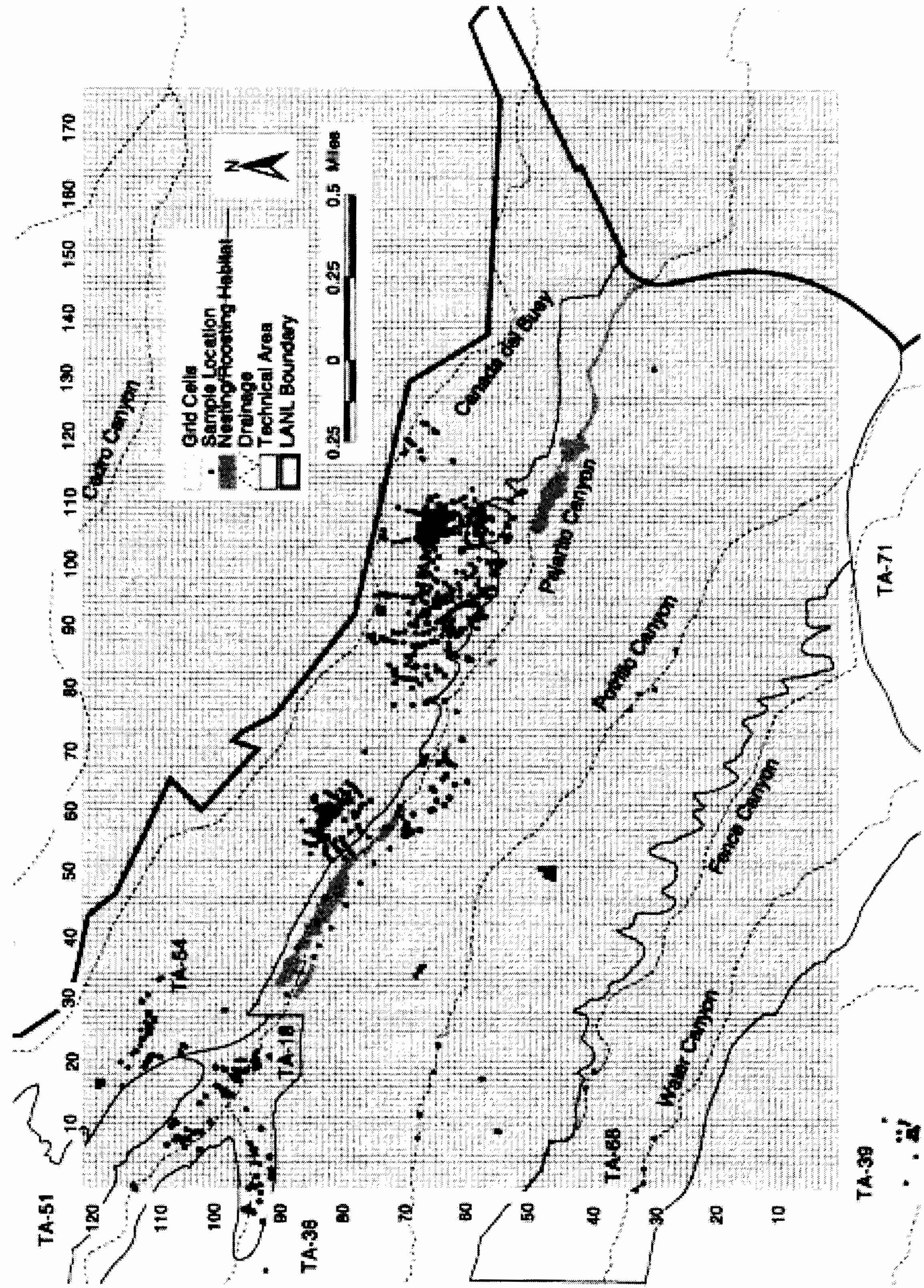

Figure 2. EEU-74 at LANL, the site of the preliminary risk assessment of the southwestern willow flycatcher.

foraging groups as based on body weight. The allometric equation predicts a HR for the flycatcher of only approximately 3.0E-02 km^2, which is in agreement with the literature for the non-breeding season. During the breeding season, however, territorial males can move several hundred meters between singing locations (Sogge et al. 1995, Peterson and Sogge 1996, Marshall 1996, Klingel 1997, Skaggs 1995). Therefore the extreme boundaries of the flycatcher EEU were established by mapping an area that accommodated both the breeding season and non-breeding season HR. The EEU was mapped as approximately 900 m from the extreme-most north, south, west, and east boundary of the nesting habitat. As described later, most foraging scenarios were based on the non-breeding HR of 3.0E-02 km^2, but one of the scenarios simulated an HR of 1.0 km^2 as based on a distance from nest site of approximately 600 m. Since the EEU is oversized, the size of the HR, not of the EEU, dictates which grid cells, and therefore which contaminant values on a spatial basis, enter into calculation of the HI for any given execution of ECORSK. Foraging was weighted in some scenarios such that foraging is inversely related to distance from a given nest site. This simulates the realistic behavior in which the majority of foraging occurs within the nesting habitat (Pajarito wetlands). The quantitative mechanics of this is also described later.

The resultant EEU is shown in Figure 2. The EEU encompasses all or portions of LANL TAs 18, 36, 54, and 68. Each EEU was mapped using a GIS and the GIS software ARC/INFO. ARC/INFO is a GIS software developed by Environmental Systems Research Institute, Inc. (ESRI) (ESRI 1989).

The GIS was used to create spatial data sets, combine information from different spatial data sets, generate a spatial grid, and produce maps. The spatial extent of flycatcher nesting habitat was digitized into ARC/INFO to create a coverage (theme or layer). [Note: Including the EEU, roughly 75% of the 43 mi^2 that make up the Laboratory has been digitized into a personal computer.] This habitat was assigned an attribute coverage factor (map code value). The modeling also required additional coverages to be developed, a grid set, and a forage habitat coverage.

More specifically, a grid was developed that would encompass the spatial extent needed for the modeling activity. In ARC/INFO, a grid was created using the command GENERATE with the fishnet option. Adequate potential release site areal definition was not available for use in the risk estimation method to be described, therefore, an alternative subunit area definition was sought. The requirements for grid size were that sufficient grid cell density was achieved to allow accurate development of spatial risk estimates within the limits of available personal computer capabilities and that presentation of spatial risk data did not appear to achieve greater resolution than is supported by the limitations of the GIS. Based on these criteria the chosen grid cell size was 100 ft by 100 ft. This assignment was assumed to be a conservative measure in most cases. However, provision is made for modification of the animal occupancy estimates if deemed necessary.

The ecological risk model required that each row and column of the grid be designated by a label. In addition, the coordinates of the center of each grid cell were needed. To accomplish this, a program in *Basic,* documented in a previous report (Gallegos et al. 1997b), was developed. These attributes were then added to the grid spatial data set.

The next coverage developed in ARC/INFO was the forage coverage. The forage coverage (EEU) was created by assigning the foraging area—all space between the edge of the nesting area and the edge of the EEU—an attribute factor.

After these three coverages were made, additional information was needed that required combining coverages. When all coverages had been developed, maps were generated either in ARC/PLOT of ARC/INFO or ArcView. ArcView is a desktop GIS for map display, production, and query. It was also developed by ESRI (1989).

2.4 Choosing Parameters and Assumptions Considering Purpose of Study, Quotient Method Limitations, and other Constraints or Considerations

All risk assessment models are an oversimplification of reality, but this must be understood within the context of the stated purpose of any one risk assessment. As stated later in the Discussion section, the primary purpose of this level of assessment is to indicate potential for impact to the flycatcher. A second purpose is to focus additional assessment needs on the most problematic contaminants, the most problematic source areas, and areas related to the receptor(s) of interest or to the COPECs. Considerations of additional assessment are not restricted to the collection of additional empirical data but may involve collection of real data. Hence, the degree to which uncertainties are resolved for any particular assessment versus those which are addressed by making assumptions is also dependent on the purpose of any single assessment. As degree of complexity of a risk assessment lessens, the number of assumptions made and, thus, uncertainties in the study results increase. However, some uncertainties are inherent in any empirical study. For example, a lack of toxicological information such as chronic NOAELs in the scientific community generally results in gross estimation of TRVs or no computation of risk indices for many COPECs.

Table 1 summarizes the assumptions made in this study, categorized according to whether we consider them "conservative," "realistic," or "nonconservative."

Conservative assumptions could err to the side of overstating risk or protecting a species or ecological value.

Nonconservative assumptions could err to the side of understating risk or possibly not protecting a species to all degrees.

2.5 Compiling Data

This included querying and downloading contaminant data from FIMAD, performing additional queries in data base programs for the inclusion of additional input fields such as background concentrations and TRVs, and structuring this information into ECORSK input files. Data used for this risk assessment were collected by ER at LANL by sampling and analyzing soils for inorganic, organic, and radioactive contaminants. Analytical results from this sampling are maintained in an Oracle data base by FIMAD. FIMAD data can be accessed through the command line Structured Query Language or through the graphical interface Databrowser. The data for the risk assessment component of the T&E species project was accessed primarily with the former. Soil sampling data are stored in several tables, depending on the attribute of the data, when the data were collected, and the field unit from which the data were collected.

The data for the T&E species project were compiled from the FIMAD data base for each HR according to the following procedure:

Table 1. The Assumptions, Conditions, and Factors used in Calculating Risk from Contaminants

Conservative (overestimates risk)	Realistic	Nonconservative (underestimates risk)
All COPECs are assumed to have the same type of biological effect.		Risk was not estimated for contaminants for which TRVs were not available.
Radioactive decay of radionuclides was not calculated.	TRVs/NOAELs for metals were based on avian test species and are chronic.	Environmental restoration activities, such as clean-up that makes some COPEC values that are in FIMAD, was not accounted in the assessment.
Antagonism was not assessed.	The mean natural background COPEC values, not UTLs, were used for the inorganics.	The quotient method is not considered probabilistic, therefore the likelihood of any impact predicted is unknown.
The FIMAD data base was assumed to be current and accurate.	The FIMAD data base was assumed to be current and accurate.	The FIMAD data base was assumed to be current and accurate.
TRVs for 11 radionuclides were based on IAEA-suggested protective standard of 0.1 rad·d^{-1} (IAEA 1992). TRVs for 17 radionuclides were based on human screening action levels. Uncertainty factor is not applied to primary values (NOAELs) for extrapolation from toxicology test species to flycatcher.	The average, not maximum, COPEC concentrations were used.	Synergism between two or more COPECs assessed was not factored.
Soil contamination levels measured for one or more sampling points within a 10,000 ft^2 area were assumed for the entire area.	The percent of dietary food intake as soil = 5.	
Sampling by ER Program is biased to locations where higher levels or larger spread of contamination were expected.		
Assumed bioavailability of COPECs = 100%.		
The foraging time, if any, spent foraging outside LANL resulting from migration, can be assumed to occur in areas with less contamination than at LANL.		
Biomagnification factors used were comparatively high.		

1. FIMAD-identified sampling locations within each HR were selected from the sampling locations stored in FIMAD in order to determine which samples were relevant to the T&E species study.

2. Sampling locations were then linked to sample identification numbers and field units to determine where the analytical results would be stored.

3. FIMAD tables were queried for the analytical results. Most FIMAD table data are quality assured prior to loading into FIMAD. Using input from FIMAD (Manzel 1997), we have previously estimated the accuracy of the data used for assessments of T&E species (Gallegos et al. 1997). Based on those estimates, the accuracy is typically expected to be between 95 and 98%.

4. As part of the query language, analytical results were screened to contain only samples with a beginning depth equal to zero. Although higher quantities of contaminants have been found at intermediate soil depths than at shallow depths elsewhere at LANL (Gonzales and Newell 1996), their bioavailability to aboveground biota is unknown. The data were then exported to a personal computer and modified further using Microsoft Access® software.

5. All records were screened by "sample units," and those records not given in grams or kilograms were discarded. All remaining records were converted to mg/kg for organics and heavy metals or to pCi/g for radionuclides, leaving only the surface soil sample data relevant to the T&E species study.

6. For the organics and inorganics, measured soil concentrations reported as below the detection limits of the instrumentation used in the analysis were assigned one-half the detection limit per Gilbert (1987).

7. For radionuclides, "less-than-detectable" values were included without change per DOE (1991).

8. Every sample record was assigned the appropriate cell (100 ft by 100 ft) of the grid covering the feeding area. The grid cells are labeled with the row and column in which they are found. Averages were calculated for each analyte within every grid cell containing at least one record of data. The "grid" was superimposed onto a map of sampling locations that were concentrated around pre-identified "potential release sites." Sample locations were not scattered evenly throughout cells of the grid because generally more samples were taken where higher levels, greater variation, or larger spread of contamination were expected. Consequently, some cell averages include the data from several samples, others include the data from only one sample, while still others have no analytical data. In total, 11,098 records were compiled for the flycatcher in the main input file "eeuinp.dat."

2.6 Ecological Risk Estimation

Ecological risk was estimated using a modified EPA Quotient Method to calculate a relative risk index for inorganic, organic, and radionuclide contaminants from the soil ingestion and food consumption contaminant pathway. For each contaminant in each grid cell, a hazard quotient (HQ) is computed as HQ = Exposure/TRV. These are partial HQs (pHQ). Different levels of pHQs exist and are rolled up into higher level pHQs. For example, a pHQ for one COPEC in one grid cell may be added to pHQs for other COPECs and/or grid cells. When pHQs for all COPECs in all grid cells of a given HR are summed, this constitutes a cumulative HQ or hazard index (HI). The HI can be said to measure cumulative effects, in an additive fashion, of multiple contaminants if the pHQs for all COPECs are added.

The standard error of the mean was also computed, but this variation is primarily caused by the inclusion of different source-contaminant grid cells from one HR to another. Therefore, the origin of the variation represented by the standard error of the mean is heterogeneity of spatial contaminant distribution.

Nonradionuclides. For the nonradionuclide metals and organics, the following simple model was used:

$$HI = Food \times F_s/Bodwt \times \sum_{j=1}^{ncs} Occupj \sum_{l=1}^{ncoc} BMF_l \, Dcj_l/(TRV \times Dar_l). \quad (2)$$

where,

HI = hazard index (also equal to cumulative HQ for all COPECs and all grid cells within a given HR),

Food = amount of food consumed by a given animal, kg/day (calculated from 582 × body weight$^{0.651}$ per EPA 1993),

F_s = fraction of diet as incidental soil (0.05 assumed for flycatcher),

BMF = biomagnification factor (estimated for 15 COPECs)

$Occup_j$ = occupancy factor on the jth contamination site,

$Dc_{j,l}$ = concentration of COPEC in soil (mg COPEC/kg soil) for the jth contamination site of the lth COPEC (Note: Background concentrations of COPECs in soil were not subtracted.)

TRV (toxicity reference value) = consumed dose above which observable adverse effects may occur, mg-COPEC/kg-body weight-day of the lth COPEC,

Dar_l = adjustment factor for D_{rl} above for the lth COPEC,

Bodwt = body weight, kgfwt, of the receptor species,

ncs = number of contamination sites, and

ncoc = number of contaminants in the jth contamination site.

Radionuclides. For radionuclides the following simple model was used:

$$HI = \sum_{j=1}^{ncs} Occup_j \sum_{l=1}^{ncoc} SC_{j,l}/(SAL_{j,l} \times SALa_{j,l}), \quad (3)$$

where,

$SC_{j,l}$ = soil concentration of COPEC, mg-COPEC/kg-soil for the lth COPEC of the jth contamination site,

$SAL_{j,l}$ = soil action level, mg-COPEC/kg-soil for the lth COPEC of the jth contamination site,

$SALa_{j,l}$ = adjustment factor for $SAL_{j,l}$ above,

ncs = number of contamination sites, and

ncoc = number of contaminants in the jth contamination site.

2.7 Risk Sources

Two types (sources) of risk were estimated – these were Unadjusted (Total) Risk and Background Risk. Unadjusted risk is the quantified HI associated with sampling within LANL boundaries. Unadjusted Risk includes risk associated with measured contaminant levels, both background and elevated levels. No adjustment (subtraction) is made for background soil concentrations. Background Risk is the quantified HI associated with the arithmetic mean "natural" (nonradionuclides) and "regional" (radionuclides) concentrations of COPECs in soil. Clifford et al. (1995) have shown that assignment of background levels in Quotient Method risk estimation can be inconsequential in terms of final results.

2.8 Data Collection Design

Upon randomly selecting a potential nest site within the defined nesting habitat of the

EEU, the ECORSK5 model develops an HR (foraging area) by adding grid cells in a concentric fashion around the nest and calculates an HQ for each COPEC within each 100- by 100-ft grid cell of the HR. The model repeats this process the number of times specified, which in this case, was for a total of 100 simulations. Contaminated grid cells "selected" during one simulation are "replaced" for possible selection during a subsequent simulation, therefore some grid cells are common between any two simulations, but they also have some differences. Thus, the soil contaminant population is not independent from one simulation to another.

Three factors, programmed in ECORSK5 as options, were varied as a means of performing a sensitivity analysis that measures the effect of increasing model realism on HI values: (1) HR slope was varied between horizontal (or a slope of Ø°) and 33° in a SE to NW direction. These two slope values were combined with two values each for the factors described below—forage weighting and HR scale; (2) weighting of foraging so that occupancy of the flycatcher on any given grid cell during simulated foraging decreases with its distance from a nesting site; thus when foraging is weighted, a species feeds more on grid cells that are close to its nest than on grids further from its nest. Two values of this factor – no weighting and $e^{-r/34}$– were used; $e^{-r/x}$ estimates the relative probability of foraging as a function of radial distance, r, in meters from the center of a foraging area, i.e., nest location. Integration of the equation gives the cumulative probability of foraging at any point r. For the flycatcher, the weighting factor x = 34 m was estimated by scaling from the ratio of HR radius:x for the Mexican spotted owl given in a previous report (Gallegos et al. 1997a). Given x = 34, a flycatcher is expected to do approximately 63% of its foraging within a 36-m radius of its nest site; (3) the ability to scale the width-to-height dimensions of the foraging area, or HR; this feature enables the creation of foraging area shapes around a nesting site that are rectangular rather than square. Rectangular HRs may be dictated by factors such as hunting patterns that are determined by factors such as distribution of prey. The shape and dimensions of an HR may be proportional to the shape of a nesting habitat. As shown in Figure 2, the width of the flycatcher nesting habitat is about four times its height. Two values of this factor, a 1:1 width:height (a square) and a 4:1 w:h rectangle, were combined with two values each of the variables forage weighting and HR slope.

2.9 Bioaccumulation and Biomagnification

Several cases in history have implied that the higher the trophic level of an organism on a food chain, the greater its susceptibility to biomagnification (Leidy 1980). The flycatcher may be subject to relatively high levels of biomagnification because they feed heavily on insects which, with their high lipid contents, theoretically would readily store lipophyllic contaminants such as pesticides. Biomagnification is more apparent in aquatic systems than terrestrial, and recent studies question the validity of biomagnification in terrestrial systems (Laskowski 1991). While biomagnification of the chlorinated hydrocarbons (organochlorines) is fairly well proven (Walker 1990), the concentration of heavy metals in animals is not necessarily a property of food chains (Laskowski 1991). Heavy metal biomagnification has been implicated mostly in mammals (Shore and Douben 1994, Hegstrom and West 1989, Ma 1987). Conclusions to the contrary are that

- heavy metal biomagnification is not a rule in terrestrial food chains (Laskowski 1991, Beyer et al. 1985, Grodzinska et al. 1987, Willamo and Nuorteva 1987, Nuorteva 1988),

- "biomagnification alone cannot lead to very high concentrations of most heavy metals in top carnivores" (Laskowski 1991), and
- "biomagnification cannot be responsible for toxic effects of heavy metals in terrestrial carnivores" (Laskowski 1991).

Nevertheless,

- biomagnification of heavy metals to toxic levels can occur from relatively low concentrations in soil (Ma 1987);
- even if a chemical or its metabolites have high NOAELs in long-term ecotoxicity or toxicity tests, incomplete metabolic elimination of contaminants, also known as bound residues, can result in unacceptable risk from bioaccumulation or biomagnification (Franke et al. 1994).

All foraging scenarios assessed in this study included bioaccumulation factors (BAFs) and biomagnification factors (BMFs) for some COPECs. BAFs for aldrin, dieldrin, endrin, DDT and dichlorodiphenylethelyne (DDE) were 5.35, 5.35, 7.9, 2.62, and 2.62, respectively, taken from Calabrese and Baldwin (1993) for the American kestrel (*Falco sparverius*) in a terrestrial food web. For the same respective COPECs and species in a terrestrial food web, BMFs were 43.0, 43.0, 42.0, 253.0, and 80.4. On average, these terrestrial-based BMFs were 0.301% of the BMFs for aquatic systems published as human health value criteria under the Clean Water Act (EPA 1993). This fraction was used to adjust mean aquatic BMFs for 10 additional COPECs for use in this study. The source of the aquatic BMFs for the 10 additional COPECs was Smith et al. (1988). The adjusted BMFs by COPEC used in this study were anthracene, 2.75; all aroclors, 93.91; benzo(a)pyrene, 4.55; chlordane, 42.44; 1,4-dichlorobenzene, 0.17; lindane, 0.82; mercury, 16.56; phenanthrene, 0.013; pyrene, 58.68; and thallium, 0.36.

2.10 Formulating Risk Conclusion

The risk evaluation criteria used for interpreting hazard index results are shown in Table 2.

2.11 Delineating Further Study Needs

At the level of assessment conducted in this study, any risk conclusion that indicates that some impact is possible (HIs >1.0) results primarily in the recommendation that further study is needed.

Table 2. Risk Evaluation Criteria used to Interpret Results of Applying the EPA HQ Method (EPA 1986)

Hazard Index Range	Conclusion
<1.0	No appreciable impact
1.0 – 10.0	Small potential for impacts
10 – 100	Substantial potential for impacts
>100	Ecological impacts very probable

3.0 Results

3.1 Mean Total Risk within Total Nesting Habitat

Non-breeding Season. Table 3 shows the arithmetic mean of 100 randomly selected nest sites for each of the HR Scaling × Forage Weighting × HR Angle scenarios. None of the mean HIs exceeded 1.0 using a non-breeding season HR of ~3.0E-02 km^2. HIs <1.0 are interpreted as indicative that "no appreciable impact" from all contaminants considered collectively is

Table 3. Mean Hazard Indices, taken as "Total Risk," for the Southwestern Willow Flycatcher for Various Combinations of HR Shape, Forage Weighting, HR Slope, and HR Size (Breeding, Nonbreeding)

	Home Range Unscaled				Home Range Scaled*			
	Foraging Unweighted†		Foraging Weighted‡		Foraging Unweighted		Foraging Weighted	
Factor	**HR Unsloped¥**	**HR Sloped 33°§**	**HR Unsloped**	**HR Sloped 33°**	**HR Unsloped**	**HR Sloped 33°**	**HR Unsloped**	****HR Sloped 33°**
Scenario No.	Scenario #1	Scenario #2	Scenario #3	Scenario #4	Scenario #5	Scenario #6	Scenario #7	Scenario #8
Mean HI, (Nonbreeding#)	0.26 (±0.018)	0.26 (±0.021)	0.26 (±0.20)	0.26 (±0.22)	0.50 (±0.41)	0.24 (±0.06)	0.47 (±0.53)	0.26 (±0.35)
Maximum HI	2.3	2.5	2.4	2.7	5.0	3.6	4.4	3.9
% His >1.0	5	5	5	5	16	7	15	7
Background HI					0.16			
Mean HI, (Breeding##)	NC	NC	NC	NC	0.17 (±0.48)	NC	NC	NC

Note: Mean HI values are the average of 100 randomly selected nest sites; values in parentheses are the mean standard error. All values include bioaccumulation for the soil ingestion pathway and biomagnification for the food consumption pathway for 15 COPECs.

NC = Not calculated.

* Width to height is 4:1.

** Most realistic scenario: (Rectangular HR [4:1 w:h] that is inclined 33° in which simulated foraging is inversely related to distance from nest site).

† Foraging occupancy on each grid cell is equal throughout HR.

‡ Foraging inversely related to distance from nest site at the rate $e^{-r/x}$, where x = 34 m.

¥ In the case of the square, top and bottom sides of the square face north and south, respectively. In the case of the rectangle, the long axis of the HR is horizontal.

§ The long axis of the HR is angled 33° from the horizontal position. A 33° angle is the approximate angle of the nesting habitat.

\# During non-breeding season, HR ≈ 3.0E-02 km^2.

\#\# Territorial males during breeding season, HR ≈ 1.0 km^2

expected (Tables 2 and 3). Background risk contributed a range of 32% to 67% of Total Risk.

Breeding Season. Although the flycatcher usually has a small HR, they can move several hundred meters between singing locations in cases of territorial males (Marshall 1997, Peterson and Sogge 1996, Sogge et al. 1995). Therefore, to account for breeding season HRs, ECORSK5 was executed with specified HRs of 0.5 km^2 (400-m radius) and 1.0 km^2 (~600-m radius) in addition to the typical HR of 0.03 km^2. This was done for the most conservative (highest mean HI) Foraging Scenario, i.e., for Foraging Scenario #5. This resulted in mean HIs of 0.16 (±0.48) and 0.17 (±0.48) for the 0.5 and 1.0 km^2 HRs, respectively. Therefore, movement of territorial males during the breeding season presents no added risk above that during the non-breeding season.

3.2 Risk by Nest Site

Several scenarios had individual nest sites with HIs between 1.0 and 10.0. HI values within this range indicate a "small potential for impacts" (Table 2). The maximum individual nest site HI for all scenarios considered was 5.0, which was at nest site No. 48 in the scenario of a 4:1 width:height HR (rectangle), unweighted foraging, and a horizontal (not angled) HR (Table 3). Background Risk contributed only about 3% (0.16 ± 0.48) of the maximum HI. Scenario #5 is somewhat unrealistic and was applied mainly for the purpose of gaining insight into the effect of improving model realism, i.e., sensitivity analysis. Although "unweighted foraging" and an unscaled (horizontal) HR make the scenario somewhat unrealistic, the influence is marginal because of such a small HR – 3.0E-02 km^2.

For the scenario that generated the highest mean HI (Scenario #5), the proportion of 100 nest site HIs that were greater than 1.0 was 16%. This value compares to 7% for the most realistic scenario (Scenario #8) (Table 4) and 5% for four other scenarios.

Table 4. Hazard Indices of Selected Nest Sites for Foraging Scenario #8

Nest Location			
Column	Row	HI	Nest Site No.
69	62	3.9	40
69	60	3.9	23
69	61	3.4	19
70	59	3.4	28
70	62	3.2	62
71	60	2.9	9
71	57	1.6	88
73	57	0.8	95
74	57	0.8	93
63	69	0.7	48
56	85	0.4	49
76	55	0.3	37
76	55	0.3	99
62	70	0.2	65

3.3 Risk by Location

"Risk Sink." ECORSK5 partitions risk by grid cell location and this is one type of partial HQ calculated. This enables us to identify locations of hypothetical nest sites (grid cells) that have the highest risk ("risk sink") contributed to them from the surrounding contaminant sources ("risk sources"). This is important because there were nest sites with HIs greater than 1.0. For Scenario #8, seven nest sites had HIs >1.0; these were nest site #'s 40, 23, 19, 28, 62, 9, and 88 (Table 4). These nest sites are in the general area of grid cells IDs ranging from Columns 69 – 71 and Rows 59 – 62.

"Risk Sources." Only a few contaminant sources (grid cells) contributed a majority of the risk to the nest sites with the highest HIs. For the seven hypothetical nest sites listed above for Scenario #8, between 81 and 99% of the risk contribution came from five grid cells out of a total of 143 grid cells (Table A-2). The grid cell IDs of these five sources are column/row 69/63, 68/62, 70/63, 68/61, and 68/63 (Table A-2 and Fig. 2). This area is a floodplain with cattails, rushes, and cottonwood.

3.4 Risk by Contaminant

Because ECORSK5 partitions risk by COPEC, contributions of individual contaminants to elevated cumulative risk indices can be examined. For the scenario generating the highest HI (Scenario #5), pentachlorophenol contributed 72% of the risk overall, followed by aluminum at 8%, radium-226 at 6%, thorium-228 at 2%, and DDE, thorium-230 and zinc at 1% each (Table 5). There were 43 grid cells with pentachlorophenol detections. The pentachlorophenol concentrations in soil ranged from 0.4 to 21.8 mg/kg and averaged 1.5 mg/kg, but all except the value of 21.8 mg/kg were within 3.1 mg/kg.

For the most realistic scenario (Scenario #8), risk was dominated by aluminum (28%), radium-226 (22%), calcium (19%), thorium-228 (8%), thorium-230 (4%), and DDE (4%). Aluminum, radium, and calcium are naturally occurring. Calcium is a macronutrient. The Al concentrations in soil ranged from 541 to 11,685, which are all below the background level of 26,600, indicating that the TRV used for A1 was probably overly conservative.

4.0 Discussion

Although some of the assumptions made for the analysis (Table 1) would tend to underestimate risk and others could cause an overestimate of risk, the results are considered realistically conservative because the number of and magnitude by which the conservative assumptions are likely to have skewed the results toward overestimating risk is greater than the nonconservative assumptions. The most conservative assumptions were that (1) COPECs were assumed to be 100% available for entrance into biological systems, (2) contamination levels measured at one or more sampling points were assumed for an entire 10,000 ft^2, and (3) the biomagnification levels used, which can substantially impact HI results (Gallegos et al. 1997b), were comparatively (Ryti 1998) high (conservative). Unlike previous assessments of T&E species at LANL (Gonzales et al. 1998), many radionuclide TRVs used in this study were not based on human standards, but rather were based on a suggested guideline for non-human biota (IAEA 1992). Therefore, the degree of conservatism of the radionuclide TRVs has been lowered from previous studies on other T&E species (Gonzales et al. 1997b), but the TRVs are still considered conservative (IAEA 1992).

The results on which the risk conclusion was focused include contributions from background and LANL-related sources considered collectively. This distinction is not necessarily relevant from a science perspective. It would become important to dwell on the distinction between these two sources of risk if and when remedial action was to be considered. Considering the level of assessment employed in this study (Phase 1 of Tier 2, or preliminary), if a potential for adverse impact to a species is identified, then the primary focus should be to identify where further assessment is needed. Nevertheless, there is valuable and important use for partitioning the portion of Total Risk contributed by background. If Total Risk of an appreciable magnitude is estimated for any species and background risk dominates the contribution to that risk,

Table 5. Ranked Hazard Quotients by COPEC for Scenario #5

COPEC	pHQ	Std Err	No. Obs.	Rank	% of Total pHQ
Pentachlorophenol	1.03	4.19E-02	20	1	72.20%
Aluminum	0.11	1.44E-04	71	2	7.58%
Radium-226	9.01E-02	0.00E+00	1	3	6.33%
Calcium	7.47E-02	9.60E-05	71	4	5.25%
Thorium-228	2.77E-02	4.83E-03	59	5	1.95%
DDE	1.78E-02	0.00E+00	1	6	1.25%
Thorium-230	1.51E-02	1.04E-02	59	7	1.06%
Zinc	1.38E-02	1.35E-02	79	8	0.97%
DDT [p,p]	6.03E-03	0.00E+00	1	9	0.42%
Barium	5.63E-03	0.00E+00	79	10	0.40%
Cesium-137	4.21E-03	1.03E-03	13	11	0.30%
Aldrin	4.15E-03	0.00E+00	1	12	0.29%
Dieldrin	4.02E-03	0.00E+00	1	13	0.28%
Lead	3.32E-03	2.62E-04	79	14	0.23%
Chromium	2.27E-03	6.39E-05	79	15	0.16%
Sodium	2.16E-03	1.74E-06	71	16	0.15%
Vanadium	1.90E-03	0.00E+00	71	17	0.13%
Magnesium	1.54E-03	0.00E+00	71	18	0.11%
Antimony	1.54E-03	6.63E-04	71	19	0.11%
Silver	1.19E-03	2.77E-03	79	20	0.08%
Beryllium	1.16E-03	0.00E+00	79	21	0.08%
Hexachlorobenzene	1.13E-03	4.06E-05	20	22	0.08%
Selenium	8.43E-04	1.70E-04	71	23	0.06%
Di-n-butyl phthalate	7.18E-04	2.58E-05	20	24	0.05%
Arsenic	6.05E-04	2.90E-07	71	25	0.04%
Manganese	4.55E-04	3.38E-07	71	26	0.03%
Cadmium	4.32E-04	1.31E-05	79	27	0.03%
Endrin Ketone	3.95E-04	0.00E+00	1	28	0.03%
Endrin	3.95E-04	0.00E+00	1	29	0.03%
Endrin Aldehyde	3.95E-04	0.00E+00	1	30	0.03%
Mercury	3.37E-04	4.91E-04	79	31	0.02%
RDX	3.27E-04	8.25E-05	70	32	0.02%
Copper	2.91E-04	1.84E-07	71	33	0.02%
Strontium-90	2.90E-04	0.00E+00	1	34	0.02%
Dichlorophenol [2,4-]	2.63E-04	9.47E-06	20	35	0.02%
Uranium-234	2.56E-04	1.01E-07	12	36	0.02%
Thorium-232	2.55E-04	0.00E+00	59	37	0.02%
Uranium-238	2.50E-04	7.21E-08	12	38	0.02%
Cobalt-60	2.14E-04	5.52E-04	13	39	0.02%
Dinitrophenol [2,4-]	1.95E-04	7.96E-06	20	40	0.01%
Benzoic Acid	1.76E-04	1.28E-05	20	41	0.01%
Dinitrotoluene [2,4-]	1.70E-04	9.69E-05	78	42	0.01%
Thallium	1.67E-04	3.71E-05	71	43	0.01%
Benzidine	1.49E-04	5.76E-06	8	44	0.01%
Bis(2-ethylhexyl) phtalate	9.76E-05	6.79E-05	20	45	0.01%
Hexachloroethane	7.89E-05	2.84E-06	20	46	0.01%
Nickel	7.01E-05	9.57E-08	79	47	0.00%

Note: Scenario #5 had a foraging scheme that is considered conservative, i.e., would tend to overestimate risk.

this may be an indication that the risk model may be overly conservative. The proportion of Total or Unadjusted Risk contributed by background ranged from 32% to 67% for Mean HIs and 3% for the Maximum HI considering all nest sites and all scenarios.

5.0 Conclusions

On average, i.e., based on Mean HIs, no appreciable impacts from contaminants at LANL are expected to the southwestern willow flycatcher. There are isolated nest site HIs (>1.0) that require uncertainty analysis to the extent that the conservatism of the foraging scenarios warrant. These conclusions are based on assumptions that, all considered, are believed to be reasonably conservative, i.e., led to an overestimate of risk. Information on risk by specific geographical location was provided, which can be used to maintain risk to the flycatcher from contaminants at acceptably low levels by managing contaminated areas, flycatcher habitat, facility siting, and facility operations.

Acknowledgment

Special recognition is due Teresa Hiteman for compositing many iterations and Hector Hinojosa for technical editing.

Literature Cited

Amiro BD (1997) Radiological Dose Conversion Factors for Generic Non-human Biota used for Screening Potential Ecological Impacts. J. Environ Radioactivity. 35(1):37–51.

Banar A (1996) Biological Assessment for Environmental Restoration Program Operable Unit 1148 TA-54 and TA-51. Los Alamos National Laboratory report LA-UR-93-1054.

Bent AC (1942) Life Histories of North American Flycatchers, Larks, Swallows, and Their Allies. Smith Inst US Mus Bull 179, Dover Publications, Inc, NY. In Marshall RM (1996) Southwestern Willow Flycatcher, General Background. http://bluegoose.arw.r9.fws.gov/NWRSFiles...r/SWFlycatcherBackground.html#Description (October 1996).

Beyer WN, Pattee OH, Sileo L, Hoffman DJ, Mulherin BM (1985) Metal Contamination in Wildlife Living Near Smelters. Environ. Pollut A 38:63–86. In Laskowski R (1991) Are the Top Carnivores Endangered by Heavy Metal Biomagnification? Oikos 60:387–390.

Calabrese EJ, Baldwin LA (1993) Performing Ecological Risk Assessments. Lewis Publishers, Chelsea, Michigan.

Clifford PA, Barchers DE, Ludwig DF, Sielken RL, Klingensmith JS, Grahm RV, Marcy IB (1995) An Approach to Quantifying Spatial Components of Exposure for Ecological Risk Assessment. Environ Toxicol Chem 14(5):895–906.

Cowardin LM, Carter V, Glet FC, LaRoe ET (1979) Classification of Wetlands and Deep-Water Habitats of the United States. U.S. Fish and Wildlife Service publ. no. FWS/OBS-79/31, Washington D.C.

DOE (U.S. Department of Energy) (1991) Environmental Regulatory Guide for Radiological Effluent Monitoring and Environmental Surveillance. U.S. Department of Energy report DOE/EH-0173T, Washington, D.C.

EPA (U.S. Environmental Protection Agency) (1986) Standard Evaluation Procedure, Ecological Risk Assessment. Hazard Evaluation Division, Environmental Protection Agency report EPA-640/0-85-001.

EPA (US Environmental Protection Agency) (1993) Wildlife Exposure Factors

Handbook, Vol. I and II. Environmental Protection Agency report EPA/600/R-93/187 a & b.

ESRI (Environmental Systems Research Institute) (1989) Triangulated Irregular Networks. ARC/Info User's Manual, Redlands, CA.

Foxx T et al. (1998) Threatened and Endangered Species Habitat Management Plan Overview. Los Alamos National Laboratory report LA-LP-98-112 Draft.

Franke C, Studinger G, Berger G, Bohling S, Bruckmann U, Cohors-Fresenborg D, Johncke U (1994) The Assessment of Bioaccumulation. Chemosphere 29(7):1501–1514.

Gallegos AF, Gonzales GJ, Bennett KD, Pratt LE (1997a) Preliminary Risk Assessment of the Mexican Spotted Owl under a Spatially-Weighted Foraging Regime at the Los Alamos National Laboratory. Los Alamos National Laboratory report LA-13259-MS.

Gallegos AF, Gonzales GJ, Bennett KD, Pratt LE, Cram DS (1997b) A Spatially-Dynamic Preliminary Risk Assessment of the American Peregrine Falcon at the Los Alamos National Laboratory (Version 1). Los Alamos National Laboratory report LA-13321-MS.

Gilbert RO (1987) Statistical Methods for Environmental Pollution Monitoring. Von Nostrand Reinhold, New York, NY.

Gonzales GJ, Gallegos AF, Foxx TE, Fresquez PR, Pratt LE, Mullen MA, Gomez PE (1998) Preliminary Risk Assessment of the Bald Eagle at the Los Alamos National Laboratory. Los Alamos National Laboratory report LA-13399-MS.

Gonzales GJ, Gallegos AF, Foxx, TE (1997) Update Summary of Preliminary Risk Assessments of Threatened and Endangered Species at the Los Alamos National Laboratory. Los Alamos National Laboratory report LA-UR-97-4732.

Gonzales GJ, Newell PG (1996) Ecotoxicological Screen of Potential Release Site 50-006(d) of Operable Unit 1147 of Mortandad Canyon and Relationship to the Radioactive Liquid Waste Treatment Facilities Project. Los Alamos National Laboratory report LA-13148-MS.

Gonzales GJ, Robinson RJ, Cross S, Nottleman H, Foxx T (1996) Literature Review and [Threatened and Endangered] Species Habitat Use Documentation. Los Alamos National Laboratory report LA-UR-96-3526.

Grodzinska K, Godzik B, Darowska E, Pawlowska B (1987) Concentration of Heavy Metals in Trophic Chains of Niepolomice Forest, S. Poland. Ekol. Pol. 35:327–344. In Laskowski R: 1991 Are the Top Carnivores Endangered by Heavy Metal Biomagnification? Oikos 60:387–390.

Hegstrom LJ, West SD (1989) Heavy Metal Accumulation in Small Mammals Following Sewage Sludge Application to Forests. J Environ Qual 18:345–349.

IAEA (International Atomic Energy Agency) (1992) Effects of Ionizing Radiation on Plants and Animals at Levels Implied by Current Radiation Standards. Technical Report Series No. 332 Vienna, Austria.

Keller D (1997) Threatened and Endangered Bird Surveys at Los Alamos National Laboratory: Southwestern Willow Flycatcher. Los Alamos National Laboratory report LA-UR-97-4615.

Kelly E, Gonzales G, Soholt L, Hooten M, Ryti R (1998) Screening Level Ecological Risk Assessment Approach for the Environmental Restoration Project at Los Alamos National Laboratory. Los Alamos National Laboratory report LA-UR-98-1822.

Klingel J (1997) Biota Information System of New Mexico (BISON-M), Version 9/97. NM Dept Game & Fish, Santa Fe, NM.

Laskowski R (1991) Are the Top Carnivores Endangered by Heavy Metal Biomagnification? Oikos 60:387–390.

Leidy RB (1980) Aquatic Organisms. pp 120–134 In: Introduction to Environmental Toxicology, Guthrie EF, Perry JJ (Eds), Elsevier North Holland, Inc.

Ma WC (1987) Heavy Metal Accumulation in the Mole, *Talpa europea*, and Earthworms as an Indicator of Metal Bioavailability in Terrestrial Environments. Bull Environ Contam Toxicol 30:424–427.

Manzel M (1997) Personal communication. M. Manzel (LANL/FIMAD/ER) to L. Pratt (LANL/ESH-20) in January 1997.

Marshall RM (1996) Southwestern Willow Flycatcher, General Background. http://bluegoose.arw.r9.fws.gov/NWRSFiles…r/SWFlycatcherBackground.html#Description (October 1996).

Menzie CJ, Cura J, Freshman J, Svirsky S (1993) Evaluating Ecological Risks and Developing Remedial Objectives at Forested Wetland Systems in New England, Workshop on Ecological Risk Assessment to Hazardous Waste Site Remediation. Water Environ Federation.

Nuorteva P (1988) Tutkimuksia Metallien Osuudesta Metsia Tuhoavassa Monistressisairaudessa. (Finnish) (The Role of Metals in the Multistress Disease Killing Forests in Europe.) Lounais-Hameen Luonto 75:62–76. In: Laskowski R, 1991 Are the Top Carnivores Endangered by Heavy Metal Biomagnification? Oikos 60:387–390.

Peters RH (1993) The Ecological Implications of Body Size. Cambridge University Press, New York.

Peterson J, Sogge M (1996) Distribution and Breeding Productivity of the Southwestern Willow Flycatcher along the Colorado River in the Grand Junction – 1996. Summary Report, Nat'l Bio Service Colorado Plateau Res Sta/N. Arizona Univ.

Purtymun WD, Suazo D, Johnathon A (1990) Site Description and Activities at Technical Area 54, Area G. Los Alamos National Laboratory unpublished report.

Ryti, R (1998) Personal communication. R. Ryti (Neptune and Co.) to G. Gonzales (LANL/ESH-20) on "Transfer Factors Used in Exposure Models for Inorganic Analytes (July 22, 1998)."

Sample BE, Baron LA, Jackson BL (1995) Preliminary Assessment of the Ecological Risks to Wide-ranging Wildlife Species on the Oak Ridge Reservation. Oak Ridge National Laboratory report DOE/OR/01-1407&D1.

Shore RF, Douben PE (1994) The Ecotoxicological Significance of Cadmium Intake and Residues in Terrestrial Small Mammals. Ecotox and Environ Safety 29:101–112.

Skaggs RW (1996) Population Size, Breeding Biology, and Habitat of Willow Flycatchers in the Cliff-Gila Valley, New Mexico. New Mexico Department of Game and Fish unpublished report, Final Report, Contract #95-516-91, May 28, 1996.

Skaggs, R (1995) Population Size, Breeding Biology, and Habitat of Willow Flycatchers in the Cliff-Gila Valley,

New Mexico – 1995. Final Report, NM Dept Game & Fish, Santa Fe, NM.
Smith JA, Witkowski PJ, Fusillo TV (1988) Man-made Organic Compounds in the Surface Waters of the United States—A Review of Current Understanding. United States Geological Survey circular 1007.
SNL (Sandia National Laboratory) (1998) Radiological Ecological Risk Assessment Methodology. Environmental Restoration Program, Sandia National Laboratories, New Mexico.
Sogge M, Tibbitts T, Van Riper C, May T (1995) Status of the Southwestern Willow Flycatcher along the Colorado River in Grand Canyon National Park – 1995. Summary Report, Nat'l Bio Service Colorado Plateau Res Sta/N. Arizona Univ.
Sogge MK, Marshall RM, Sferra SJ, Tibbitts TJ (1997) A Southwestern Willow Flycatcher Natural History Summary and Survey Protocol. US National Park Service technical report NPS/NAUCPRS/NRTR-97/12 (May 1997), http://www.nbs.nau.edu/FNF/PIF/protocol.html, Organ Pipe, AZ.
Tiebout HM, Brugger KE (1995) Ecological Risk Assessment of Pesticides for Terrestrial Vertebrates: Evaluation and Application of the U.S. Environmental Protection Agency's Quotient Model. Conserv Biol 9(6)1605–1618.
Walker CH (1990) Kinetic Model to Predict Bioaccumulation of Pollutants. Funct Ecol 4:295–301. In: Laskowski R 1991 Are the Top Carnivores Endangered by Heavy Metal Biomagnification? Oikos 60:387–390.
Willamo R, Nuorteva P (1987) The Role of Heavy Metals in Forest Die-Off. In: Anttila P, Kauppi P (eds) Symp Finnish Res Proj Acidification (HAPRO) Ministry of the Environment, Ministry of Agriculture and Forestry, pp 64–67 In: Laskowski R 1991 Are the Top Carnivores Endangered by Heavy Metal Biomagnification? Oikos 60:387–390.

Table A-1a. Toxicity Reference Values (TRVs) used in the Preliminary Risk Assessment of the Southwestern Willow Flycatcher at the Los Alamos National Laboratory

ANALYTE	NOAEL mg/kg/d	Reference (see Gallegos 1997b)	Test Species	Chemical Form	Endpoint, Comment and/or Test Species	Comparison NOAEL (mg/kg/d)	Reference to Comparison Value
Inorganics							
Aluminum	109.700	Carriere et al., 1986	ringed dove	Al (SO_4)	reproduction		
Antimony	0.035	LANL, 1994				0.035 = rat LOAEL, whole body & blood	LANL, 1994 and EPA, 1996
Arsenic	1.160	Whitworth et al., 1991 In: Weston, 1995.	1-d mallard		Chronic NOAEL, behavioral effects	1. 0.001; 2. 0.009 mg/L = human oral NOAEL	1. LANL, 1994; 2. EPA, 1996
Barium	20.800	Johnson et al., 1960	1-day chicks	hydroxide	mortality	0.21= oral human NOAEL for BaCn, cardiovasc. target	LANL, 1994
Boron	28.800	Smith and Anders, 1989	mallard ducks	boric acid	reproduction	28.8	
Beryllium	0.540	EPA, 1993b	rat		Oral rat NOAEL (EPA, 1996)	= oral rat NOAEL (EPA, 1996)	
Cadmium	1.450	White et al., 1978	mallard ducks	chloride	reproduction	1. 0.005; 2. 19.1 = oral NOAEL in rat	1. EES-15 Append; 2. EPA, 1996
Calcium	24.000	Shane and Young, 1968 In: Weston, 1995	White leghorn chick		Chronic death from renal failure	None	
Chromium III	3.810	Hill and Matrone, 1970 In: Weston, 1995	3-wk chick		Chronic weight loss and mortality	1. 1468; 2. 5% = oral NOAEL, rat	1. LANL, 1994; 2. EPA, 1996
Chromium VI	3.800	Hill and Matrone, 1970 In: Weston, 1995	3-wk chick		Chronic NOAEL, body weight	2.4 = oral NOAEL, rat	LANL, 1994 and EPA, 1996
Cobalt							
Copper	46.970	Mehring et al., 1960	1 day chicks	oxide	growth, mortality	5.3 mg = single dose NOAEL, human	
Cyanide	10.800	EPA,1993b	rat		oral NOAEL		
Fluorides	4.500	LANL, 1994				0.06 = oral NOAEL, human	
Hydrogen Fluoride							
Iron							

Table A-1a cont.

ANALYTE	NOAEL mg/kg/d	Reference*	Test Species	Chemical Form	Endpoint, Comment and/or Test Species	Comparison NOAEL (mg/kg/d)	Reference to Comparison Value
Lead	1.130	Edens et al., 1976	Japanese quail	acetate	reproduction	0.9	LANL, 1994
Lithium	480.000	Opresko et al., 1994	red-winged blackbird	$LiCl_2$	NOAEL = 15,000 ppm (feeding dose) x bw/bw; no endpoint stated		
Magnesium	32.000	Opresko et al., 1994	Japanese quail		NOAEL = [1,000 ppm (feeding dose) x bw]/bw; endpoint = physiology	no EPA, 1996 value	
Manganese	9.140	Vohra and Kratzer, 1968 <u>In</u>: Weston, 1995	turkey poults		Acute NOAEL	1. 0.14 = oral human NOAEL; 2. 0.005	1. EPA, 1996; 2. LANL, 1994
Mercury	0.064	Opresko et al., 1994	Japanese quail	HgCl	NOAEL = [2 ppm (feeding dose) x bw]/bw; endpoint = physiology	1. 0.32; 2. 0.0064	1. LANL, 1994; 2. ORNL, CH3Hg NOAEL for mallard
Molybdenum	0.280	Lepore and Miller, 1964 <u>In</u>: Weston, 1995	7-mo hen		50% embryo mortality [LD_{50}] x 0.01		
Nickel	0.676	Weber and Reid, 1968 <u>In</u>: Weston, 1995	1-d chick		wt. gain	1. 5.0; 2.100 ppm = rat diet NOAEL	1. LANL, 1994; 2. EPA, 1996
Nitrate	1.600	LANL, 1994					
Nitrite	1.000	LANL, 1994				10 ppm = oral human NOAEL, methemoglobinemia	EPA 1993b
Potassium		LANL, 1994					
Selenium	0.400	Heinz et al., 1989	mallard duck		reproduction	1. 0.015; 2. 0.853 mg/d = human NOAEL, whole body	1. LANL, 1994; 2. EPA, 1996
Silver	0.344	___ and Jensen, 1975 <u>In</u>: Weston, 1995	1-d chick		Chronic growth and mortality	0.0014	LANL, 1994
Sodium	124.000	Scott et al., 1960 <u>In</u>: Weston, 1995	1-d quail		Chronic NOAEL, "no effects"	20.4 = oral NOAEL in rat, CNS	EPA, 1996

Table A-1a cont.

ANALYTE	NOAEL mg/kg/d	Reference*	Test Species	Chemical Form	Endpoint, Comment and/or Test Species	Comparison NOAEL (mg/kg/d)	Reference to Comparison Value
Thallium	1.200	Opresko et al., 1994	golden eagle	$TlSO_4$	LD_{50} x 0.01	1. 0.22 = oral NOAEL, rat (ThO_2); 2. 0.192 = LC_{50} pheasant.	1. Hudson et al., 1984 In: Weston, 1995.
Vanadium	0.320	Opresko et al., 1994	mallard duck	$VaSO_4$	NOAEL = [10 ppm (feeding dose) x bw]/bw; endpoint=blood chemistry	5 ppm=rat oral diet NOAEL	EPA, 1996
Zinc	1.935	Stahl et al., 1990	white leghorn hens		reproduction	1. 10.1 = chronic "no effects" NOAEL in 1-d chicks; 2. 0.2231 = "acute dose" x 0.01 in great horned owl; 3. 0.1	1. Oh et al., 1979 In: Weston, 1995; 2. Opresko et al., 1994 ; 3. LANL, 1994
Volatile Organic Compounds							
1,1,1,2-Tetrachloroethane						89.300	LANL, 1994
1,1,1-Trichloroethane	1000.0	Lane et al., 1982 In: Opreska, 1994	mouse		reproduction, chronic NOAEL		
1,1,2,2-Tetrachloroethane							
1,1,2-trichloro-1,2,2-trifluoroethane						273.000	LANL, 1994
1,1,2-Trichloroethane						3.900	LANL, 1994
1,1-Dichloroethane							
1,1-Dichloroethene						9.000	LANL, 1994
1,2,3-Trimethyl benzene(d)							
1,2,4-Trimethylbenzene							
1,2-di bromo-3-Chloropropane							
1,2-Dichloroethane	17.2	Alumot et al., 1976b In: Opreska,1994	chicken		reproduction, chronic NOAEL		
1,2-Dichloropropane							
1,3,5-Trimethylbenzene							
1,3- Dichloropropene	3.0	LANL, 1994					
2-Butanone (Methyl ethyl ketone)	1771.0	LANL, 1994					
2-Hexanone(g)							
3-carene(d)							

Table A-1a cont.

ANALYTE	NOAEL mg/kg/d	Reference*	Test Species	Chemical Form	Endpoint, Comment and/or Test Species	Comparison NOAEL (mg/kg/d)	Reference to Comparison Value
4-hydroxy-4-methyl-2-pentanone(d)							
4-isopropytoluene							
4-Methyl-2-pentanone (MIK)							
Acetone	565.0	Hill and Camardese, 1986	Japanese quail		acute toxicity		
Benzene	26.36	Nawrot and Staples, 1979 In: Opreska, 1994	mouse		reproduction		
Benzoic acid	4.46	LANL, 1994					
Bromobenzene(d)							
Bromochloromethane(d)							
Bromodichloromethane	17.9	EPA, 1993b	mouse		kidney		
Bromoform	17.9	EPA, 1993b	rat		liver, NOEL (no observable effects level)		
Bromomethane	1.4	LANL, 1994					
Carbon disulfide	11.0	EPA, 1993b	rabbit		fetus, NOAEL		
Carbon tetrachloride	16	Alumot et al., 1979b In: Opreska, 1994	rat		reproduction, chronic NOAEL	0.71	LANL, 1994
Chlorobenzene	19.0	LANL, 1994					
Chloroethane							
Chloroethane							
Chloroform	15.0	Palmer et al., 1979 In: Opreska, 1994	rat		liver, kidney, gonad condition, chronic NOAEL	12.9	LANL, 1994
Chloromethane							
cis-1 ,2-Dichloroethene							
cis-1,3-Dichloropropene							
Dibromochloromethane	21.4	EPA, 1993b	rat		liver		
Dibromoethane							
dibromomethane(d)							
Dichlorodifluoromethane (1,2)-(1,3)-(2,2)	15.0	LANL, 1994					
Dichloropropane (1,2)							
Ethyl benzene	97.1	LANL, 1994					

Table A-1a cont.

ANALYTE	NOAEL mg/kg/d	Reference*	Test Species	Chemical Form	Endpoint, Comment and/or Test Species	Comparison NOAEL (mg/kg/d)	Reference to Comparison Value
hexanone (methyl butyl ketone)(d)							
Isopropyl benzene							
Limonene(d)							
Methanol	50.0	EPA 1986e In: Opreska, 1994	rat		mortality, blood chemisrty, NOEL	500.0	LANL, 1994
Methyl Iodide(d)							
Methylene Chloride	5.85	NCA 1986e In: Opreska, 1994	rat		liver histology, chronic NOAEL	5.85	LANL, 1994
n-butylbenzene(d)							
n-Hexane							
Nitrotoluenes							
o-Chlorotoluene	20.0	EPA, 1993b			whole body		
p-Chlorotoluene(d)							
propyl benzene(d)							
Styrene	200.0	LANL, 1994					
Tetrachloroethylene	14.0	EPA, 1993b	mouse		liver, hepatotoxicity		
Toluene	25.98	Nawrot and Staples 1979 In: Opreska, 1994	mouse		reproduction	223.0	LANL, 1994
trans-1,2-Dichloroethene	17.0	LANL, 1994					
Vinyl Chloride	0.17	Feron et al. 1981 In: Opreska, 1994	rat		longevity, mortality		
Xylene (Total)	7.77	Hill and Camardese, 1986 In: Weston, 1995	Japanese quail		acute NOAEL	179.0	LANL, 1994
Trichloropropane (1,2,3)	8	EPA, 1993b	rat		whole body	5.71	LANL, 1994
(2,4-Dicheorophenoxy) propionic acid (dichloroprop)(d)							
1,2,4-Trichlorobenzene	100.0	EPA, 1993b	rat		adrenal	14.8	LANL, 1994
1,2-Dichlorobenzene	85.7	LANL, 1994					
1,3-Dichlorobenzene							
1,4-Dichlorobenzene							
1,4-methan Azulene, decahydro-4,4,8(d)							
2,2-Oxybis(1-chloropropane) (bis[2-chloroisopropyl]ether)							

Table A-1a cont.

ANALYTE	NOAEL mg/kg/d	Reference*	Test Species	Chemical Form	Endpoint, Comment and/or Test Species	Comparison NOAEL (mg/kg/d)	Reference to Comparison Value
2,4,5 - Trichlorophenoxyacetic acid	10.0	EPA, 1993b	rat		kidney, liver NOEL	3.0	LANL, 1994
2,4,5-Trichlorophenoxy Propionic Acid	0.75	EPA, 1993b	dog		liver, NOEL		
2,4,5-Trichlorophenol	100.0	EPA, 1993b	rat		liver, kidney NOEL		
2,4,6-Trichlorophenol							
2,4- D	0.8	Hudson et al., 1984	chuckar		mortality		
2,4-DB	8.0	LANL, 1994					
2,4-Dichlorophenol	0.3	EPA, 1993b	rat		immune system, NOEL		
2,4-Dimethylphenol	50.0	EPA, 1993b	mouse		nervous system, blood		
2,4-Dinitrophenol	2.0	EPA, 1993b	human		eye, LOAEL		
2- Nitrophenol(d)							
2-Chloronaphthalene							
2-Chlorophenol	5.0	EPA, 1993b	rat		reproduction		
2-Methyl-4,6-dimitrophenol(d)							
2-Methylnaphthalene(d)							
trans-1,3-Dichloropropene							
Trichloroethene							
Trichlorofluoromethane	1000	EPA, 1993b	rat		whole body LOAEL	349.0	LANL, 1994
2-Methylnaphthalene(g)							
2-Methylphenol (o-cresol)	50.0	EPA, 1993b	rat		whole body		
2-Nitroaniline, (o-Nitroaniline)							
2-Nitroaniline							
2-Nitrophenol(g)							
2-Nitrophenol)(g)							
2H-1-benzo-pyran-2-one(d)							
3,3'-Dichlorobenzidine							
3-Nitroaniline(m-nitroaniline)(g)							
3-Nitroaniline							
4 -Chloro-3-methylphenol (p-chloro-m-cresol)							

Table A-1a cont.

ANALYTE	NOAEL mg/kg/d	Reference*	Test Species	Chemical Form	Endpoint, Comment and/or Test Species	Comparison NOAEL (mg/kg/d)	Reference to Comparison Value
4,6-Dinitro-2-methylphenol(g) (4,6-dinitro-o-creso)							
4- Nitrophenol							
4-Bromophenvl phenyl ether(d)							
4-Bromophenyl-phenylether(g)							
4-Chloro o-tolyoxyacetic acid(d)							
p-Chloroaniline	12.5	EPA, 1993b	rat		spleen, LOAEL		
4-Chlorophenyl phenyl ether(d)							
4-Chlorophenyl phenylether(g)							
4-Methylphenol (p-cresol)	5.0	EPA, 1993b	rabbit		whole body, NOEL		
4-Nitroaniline(p-nitroaniline)(g)							
4-Nitroaniline							
Acenaphthene	175.0	LANL, 1994					
Acenaphthvlene(d)							
Acenaphthylene(g)							
Adipic ester(d)							
Aldrin	0.0200	Tucker and Crabtree, 1970 <u>In</u>: Weston, 1995	mallard duck		mortality, chronic NOAEL	1) .02 rat; reproduction, chronic NOAEL 2) 0.025	1) Treon and Cleveland 1995 In: Opreska, 1994 2) LANL, 1994
Alpha-BHC							
Aniline							
Anthracene	1000.0	EPA, 1993b	rat		NOEL		
Arochlors (mixed)	0.4759					0.007	LANL, 1994
Aroclor-1248	0.00272	Cecil et al., 1974	chicken		chronic reproductive		
Aroclor-1254	0.0052	Lillie, 1974 <u>In</u>: Weston, 1995	leghorn (pullets)		reproduction, noteratogensis	0.18, ring-necked pheasant, reproduction	Dahlgren et al., 1972 <u>In</u>: Opreska, 1994

Table A-1a cont.

ANALYTE	NOAEL mg/kg/d	Reference*	Test Species	Chemical Form	Endpoint, Comment and/or Test Species	Comparison NOAEL (mg/kg/d)	Reference to Comparison Value
Aroclor-1260	0.468	Heath et al., 1972 In: Weston, 1995	bobwhite (chick)		mortality		
Azobenzene							
Benzene acetic acid(d)							
Benzidine							
Benzo[a]anthracene							
Benzo[a]pyrene							
Benzo[b]fluoranthene							
Benzo[ghi]perylene							
Benzo[k]fluoranthene							
Benzyl alcohol(d)							
Benzyl alcohol							
Beta-BHC							
Bis(2-ethylhexyl)phthalate	1.11	Peakall, 1974 In: Opreska, 1994	ringed dove		reproduction	22.6, white leghorn, chronic effect dose	Wood and Bitman, 1980 In: Weston, 1994
Bis(2chloroethoxy) methane(g)							
Bis-(2-chloroethyl)ether							
Butyl benzyl phthalate	159.0	LANL, 1994					
Carbazole							
Cetyl alcohol(d)							
Chlordane	2.14	Stickel et al., 1983 In: Opreska, 1994	red-winged blackbird		mortality	0.055	LANL, 1994
Chlorophenoxy acetic acid (2-methy-4)							
Chrysene							
Dalapon	8.45	LANL, 1994					
DDD	0.236	Hill et al., 1975	ring-necked pheasant		mortality	165.0	LANL, 1994
DDE	0.00224	Longcore et al., 1971	black duck		egshell thinning	42.0	LANL, 1994
DDT	0.00028	Anderson et al., 1975 In: Opreska, 1994	brown pelican		reproduction	1) 0.00660, mallard, reproduction 2) 0.05	1) Davison and Sell, 1974 In: Weston, 1995 2) LANL, 1994

Table A-1a cont.

ANALYTE	NOAEL mg/kg/d	Reference*	Test Species	Chemical Form	Endpoint, Comment and/or Test Species	Comparison NOAEL (mg/kg/d)	Reference to Comparison Value
delta-BHC(d)							
Di-n-butylphthalate	0.111	Peakall, 1974 In: Opreska, 1994	ringed dove		reproduction		
Di-n-octyl phthalate	175.0	LANL, 1994					
Dibenzo[a,h]anthracene							
Dibenzofuran(d)							
Dicamba	3.0	LANL, 1994					
Dieldrin	0.024	Heath et al., 1972 In: Weston, 1995	bobwhite		mortality, acute LC_{50}	1. 0.077, barn owl, reproduction 2. 0.005	1. Mendenhall et al., 1983 In: Weston, 1995 2. LANL, 1994
Diethylphthalate	4583.0	Lamb et al., In: Opreska, 1994	mouse		reproduction		
Dimethyl phthalate	1000.0	EPA, 1993b	rat		kidney, NOEL		
Dimethylformamide							
Dinoseb	1.0	EPA, 1993b	rat		fetus, LOAEL		
Endosulfan I & II	0.15	EPA, 1993b	rat		kidney, LOAEL		
Endosulfan sulfate(d)							
Endosulfan	10	Abiola, 1992	gray partridge		reproduction		
Endrin	0.3	Spann et al., 1986 In: Opreska, 1994	rat		reproduction	0.025	LANL, 1994
Ethyl acetate	900.0	EPA, 1993b	rat		whole body, NOEL		
Ethylene glycol	200.0	EPA, 1993b	rat		fetus, NOEL		
Fluoranthene	125.0	EPA, 1993b	mouse		kidney, liver, blood		
Fluorine	125.0	LANL, 1994					
Heptachlor Epoxide	0.013	EPA, 1993b	dog		liver, LOAEL		
Heptachlor	0.0880	Hill and Camardese 1986 In: Weston, 1995	Japanese quail		mortality, acute LC_{50}	0.150	LANL, 1994
Hexachlorobenzene	0.080	LANL, 1994					
Hexachlorobutadiene							
Hexachlorocyclopentadiene	7.0	EPA, 1993b	rat		forestomach		
Hexachloroethane	1.0	EPA, 1993	rat		kidney		
Hexadeconoic acid(d)							
Indeno[1,2,3-cd]pyrene							
Isophorone	150.0	EPA, 1993b	dog		kidney, NOEL		

Table A-1a cont.

ANALYTE	NOAEL mg/kg/d	Reference*	Test Species	Chemical Form	Endpoint, Comment and/or Test Species	Comparison NOAEL (mg/kg/d)	Reference to Comparison Value
Lindane (gamma BHC)	0.244	Hill and Camardese, 1986 In: Weston, 1995	Japanese quail		mortality	1. 2.0, mallard duck, reproduction 2. 0.33	1. Chakravarty et al., 1986 In: Opreska, 1994 2.LANL, 1994
Mecoprop (MCPP)	3.0	LANL, 1994					
Mecoprop(d)							
Methoxychlor	3.16	Hill and Camardese, 1986 In: Weston, 1995	Japanese quail		mortality, acute LC_{50}	1. 4.0, rat, reproduction 2. 5.01	1. Gray et al., 1988, In: Opreska, 1994 2. LANL, 1994
N-Nitrosodi-N-propylamine							
N-Nitrosodimethylamine							
N-Nitrosodiphenylamine							
Naphthalene	1.39	Wildlife Intn'l Ltd. 1985 In: Weston, 1995	bobwhite quail		acute NOAEL		
Nitrobenzene	4.6	LANL, 1994					
Octacosane(d)							
Octadeconoic acid(d)							
Octamethyleyclotetrasiloxane(d)							
PCB (aroclors)	0.007	LANL, 1994					
Pentachlorophenol	3.8E-4	Stedman et al., 1980 In: Weston, 1995	broiler chick		chronic effect dose	3.0	LANL, 1994
Phenanthrene carboxylic acid(d)							
Phenanthrene(d)							
Phenanthrene(g)							
Phenol	60.0	EPA, 1993b	rat		fetus		
Phthalate ester(d)							
Pyrene	75.0	EPA, 1993b	mouse		kidney		
Tetradecanoic acid(d)							
Toxaphene	8.0	Kennedy et al., 1973 In: Opreska, 1994	rat		reproduction, chronic NOAEL		
Vinyl Acetate	100.0	LANL, 1994					
High Explosives							
1,3,5-TNB (trinitrobenzene)	0.51	EPA, 1993b	rat		spleen		
1,3-DNB (dinitrobenzene)	0.4	EPA, 1993b	rat		spleen		

Table A-1a cont.

ANALYTE	NOAEL mg/kg/d	Reference*	Test Species	Chemical Form	Endpoint, Comment and/or Test Species	Comparison NOAEL (mg/kg/d)	Reference to Comparison Value
2,4,6-TNT (trinitrotoluene)	0.5	EPA, 1993b	dog		liver, LOAEL		
2,4-DNT (dinitrotoluene)	0.2	EPA, 1993b	dog		CNS		
2,6-DNT (dinitrotoluene)							
2-amino-2,6-DNT (aminodinitrotoluene) (g)							
2-amino-4.6-Dimitrotoluene (d)							
4-amino-2,6-DNT (aminodinitrotoluene) (g)							
Ammonium nitrate (g)							
Barium nitrate (soluble barium)							
CEF (tri[b-chloroethyl] phosphate) (g)							
DPA (diphenylyamine)	2.5	EPA, 1993	dog		whole body, NOEL		
HMX (cyclotetramethylenete-tranitramine	50.0	LANL, 1994					
Nitrocellulose (non-toxic) (g/k)							
Nitromethane(g)							
NP (bis[2,2-dinitropropyl] acetyl/formal)(g)							
PETN (pentaerythritolletranitrate)							
RDX (trimethylenetrinitramine)	0.30	LANL, 1994					
TATB (triaminotrinitrobenzene) (g)							
Tetryl (N-methyl-N,2,4,6-tetranitrobenzeneamine)							

Gallegos (1997b)

Table A-1b. Radionuclide Toxicity Reference Values (TRVs) used in the Preliminary Risk Assessment of the Southwestern Willow Flycatcher at Los Alamos National Laboratory

Radionuclide	ESAL (pCi/g)	Reference	Human SAL (pCi/g)
Americium-241	200.0	SNL 1998	17.0
Carbon-14	41.0	FIMAD	41.0
Cerium-144	56.0	FIMAD	56.0
Cesium-134	1.8	FIMAD	1.8
Cesium-137	290.0	SNL 1998	4.0
Cobalt-57	40.0	FIMAD	40.0
Cobalt-60	0.9	FIMAD	0.9
Gross Alpha Activity			
Iodine-129	41.0	FIMAD	41.0
Manganese-54	3.4	FIMAD	3.4
Plutonium-238	390.0	SNL 1998	20.0
Plutonium-239	420.0	SNL 1998	18.0
Potassium-40	12.0	FIMAD	12.0
Radium-226	2.8	SNL 1998	5.0
Radium-228	5.0	FIMAD	5.0
Ruthenium-106	14.0	FIMAD	14.0
Sodium-22	1.3	FIMAD	1.3
Strontium-90	39.0	SNL 1998	5.9
Technetium-99	38.0	FIMAD	38.0
Thorium-228	1.7	FIMAD	1.7
Thorium-230	5.0	FIMAD	5.0
Thorium-232	310.0	SNL 1998	5.0
Tritium	1.2E+05	SNL 1998	820.0
Uranium-233	86.0	FIAMD	86.0
Uranium-234	250.0	SNL 1998	86.0
Uranium-235	240.0	SNL 1998	18.0
Uranium-238	240.0	SNL 1998	59.0
Depleted Uranium	59.0	FIMAD	59.0
Uranium	66.0	FIMAD	66.0

Table A-2. Selected 'Source' HQs Contributed to Seven Hypothetical Nest Sites (Nest #s 40, 23, 19, 28, 62, 9, 88) for Foraging Scenario #8. Scenario #8 is Considered Relatively "Realistic"

Nest Site No. 40					Nest Site No. 23					Nest Site No. 19					Nest Site No. 28				
Col.	Row	pHQ	% of Total	Cumulative Total	Col.	Row	pHQ	% of Total	Cumulative Total	Col.	Row	pHQ	% of Total	Cumulative Total	Col.	Row	pHQ	% of Total	Cumulative Total
69	63	0.84	21	21%	68	61	1.49	38	38%	68	61	1.08	32	32%	72	60	1.29	38	38%
68	62	0.77	20	41%	68	62	0.67	17	55%	68	62	0.70	20	52%	68	61	0.78	23	60%
70	63	0.61	15	56%	69	63	0.36	9	64%	69	63	0.45	13	65%	68	62	0.36	11	71%
68	61	0.57	14	71%	72	60	0.35	9	73%	70	63	0.38	11	76%	70	63	0.29	8	80%
68	63	0.54	14	84%	70	63	0.33	8	81%	68	63	0.34	10	86%	69	63	0.25	7	87%
68	64	0.29	7	92%	68	63	0.29	7	89%	68	64	0.16	5	91%	68	63	0.17	5	92%
66	63	0.11	3	94%	68	64	0.14	4	92%	72	60	0.15	4	96%	68	64	8.28E-02	2	
72	60	7.75E-02	2		65	61	0.12	3	95%	66	63	9.65E-02	3		65	61	7.26E-02	2	
65	63	4.81E-02	1		66	63	0.11	3	98%	65	63	4.62E-02	1		66	63	5.66E-02	2	
69	66	4.55E-02	1		65	63	5.73E-02	1		64	65	7.67E-03	0		64	61	3.13E-02	1	
68	66	4.14E-02	1		62	62	7.52E-03	0		62	64	2.33E-03	0		65	63	3.02E-02	1	
64	65	9.75E-03	0		62	64	3.12E-03	0		61	65	8.66E-04	0		62	62	4.49E-03	0	
62	64	2.40E-03	0		61	63	2.01E-03	0		63	65	3.95E-05	0		62	64	1.69E-03	0	
61	65	9.44E-04	0		61	65	1.11E-03	0		11	100	0.00E+00	0		11	100	0.00E+00	0	
63	65	4.72E-05	0		63	65	4.60E-05	0		14	102	0.00E+00	0		14	102	0.00E+00	0	
11	100	0.00E+00	0		11	100	0.00E+00	0		6	102	0.00E+00	0		6	102	0.00E+00	0	
14	102	0.00E+00	0		14	102	0.00E+00	0		9	102	0.00E+00	0		9	102	0.00E+00	0	
6	102	0.00E+00	0		6	102	0.00E+00	0		9	103	0.00E+00	0		9	103	0.00E+00	0	
9	102	0.00E+00	0		9	102	0.00E+00	0		23	104	0.00E+00	0		23	104	0.00E+00	0	
9	103	0.00E+00	0		9	103	0.00E+00	0		7	104	0.00E+00	0		7	104	0.00E+00	0	
23	104	0.00E+00	0		23	104	0.00E+00	0		8	104	0.00E+00	0		8	104	0.00E+00	0	
7	104	0.00E+00	0		7	104	0.00E+00	0		11	105	0.00E+00	0		11	105	0.00E+00	0	
8	104	0.00E+00	0		8	104	0.00E+00	0		23	105	0.00E+00	0		23	105	0.00E+00	0	
11	105	0.00E+00	0		11	105	0.00E+00	0		7	105	0.00E+00	0		7	105	0.00E+00	0	
23	105	0.00E+00	0		23	105	0.00E+00	0		8	105	0.00E+00	0		8	105	0.00E+00	0	
7	105	0.00E+00	0		7	105	0.00E+00	0		10	106	0.00E+00	0		10	106	0.00E+00	0	
8	105	0.00E+00	0		8	105	0.00E+00	0		11	106	0.00E+00	0		11	106	0.00E+00	0	
10	106	0.00E+00	0		10	106	0.00E+00	0		10	107	0.00E+00	0		10	107	0.00E+00	0	
11	106	0.00E+00	0		11	106	0.00E+00	0		7	107	0.00E+00	0		7	107	0.00E+00	0	
10	107	0.00E+00	0		10	107	0.00E+00	0		21	108	0.00E+00	0		21	108	0.00E+00	0	

Table A-2 cont.

Nest Site No. 62					Nest Site No. 9					Nest Site No. 88				
Col.	Row	pHQ	% of Total	Cumulative Total	Col.	Row	pHQ	% of Total	Cumulative Total	Col.	Row	pHQ	% of Total	Cumulative Total
70	63	1.13	35	35%	72	60	1.80	62	62%	72	60	1.13	72	
69	63	0.75	23	59%	70	63	0.28	10	72%	68	61	0.22	14	
68	62	0.41	13	71%	68	61	0.27	9	81%	68	62	9.92E-02	6	
68	63	0.33	10	82%	69	63	0.18	6	88%	65	59	6.96E-02	4	
68	64	0.22	7	88%	68	62	0.17	6	94%	65	61	2.84E-02	2	
72	60	0.20	6	95%	68	63	9.59E-02	3		64	61	1.32E-02	1	
66	63	5.95E-02	2		68	64	5.41E-02	2		11	100	0.00E+00	0	
69	66	5.26E-02	2		66	63	2.24E-02	1		14	102	0.00E+00	0	
68	66	3.90E-02	1		65	63	1.06E-02	0		6	102	0.00E+00	0	
68	67	1.69E-02	1		64	65	1.82E-03	0		9	102	0.00E+00	0	
64	65	5.73E-03	0		63	65	9.20E-06	0		9	103	0.00E+00	0	
63	65	2.70E-05	0		11	100	0.00E+00	0		23	104	0.00E+00	0	
11	100	0.00E+00	0		14	102	0.00E+00	0		7	104	0.00E+00	0	
14	102	0.00E+00	0		6	102	0.00E+00	0		8	104	0.00E+00	0	
6	102	0.00E+00	0		9	102	0.00E+00	0		11	105	0.00E+00	0	
9	102	0.00E+00	0		9	103	0.00E+00	0		23	105	0.00E+00	0	
9	103	0.00E+00	0		23	104	0.00E+00	0		7	105	0.00E+00	0	
23	104	0.00E+00	0		7	104	0.00E+00	0		8	105	0.00E+00	0	
7	104	0.00E+00	0		8	104	0.00E+00	0		10	106	0.00E+00	0	
8	104	0.00E+00	0		11	105	0.00E+00	0		11	106	0.00E+00	0	
11	105	0.00E+00	0		23	105	0.00E+00	0		10	107	0.00E+00	0	
23	105	0.00E+00	0		7	105	0.00E+00	0		7	107	0.00E+00	0	
7	105	0.00E+00	0		8	105	0.00E+00	0		21	108	0.00E+00	0	
8	105	0.00E+00	0		10	106	0.00E+00	0		33	108	0.00E+00	0	
10	106	0.00E+00	0		11	106	0.00E+00	0		34	108	0.00E+00	0	
11	106	0.00E+00	0		10	107	0.00E+00	0		21	109	0.00E+00	0	
10	107	0.00E+00	0		7	107	0.00E+00	0		21	110	0.00E+00	0	
7	107	0.00E+00	0		21	108	0.00E+00	0		28	110	0.00E+00	0	
21	108	0.00E+00	0		33	108	0.00E+00	0		31	110	0.00E+00	0	
33	108	0.00E+00	0		34	108	0.00E+00	0		30	111	0.00E+00	0	

Los Alamos
NATIONAL LABORATORY
Los Alamos, New Mexico 87545