TECHNICAL SUPPORT FOR
ROCKY MOUNTAIN ARSENAL

FINAL
INTEGRATED ENDANGERMENT ASSESSMENT/ RISK CHARACTERIZATION
VERSION 4.2

VOLUME III of IV

Appendix B, Sections B.5-B.8
and Appendix C

JULY 1994
CONTRACT NO. DAAA05-92-D-0002, Delivery Order 0004

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APPENDIX B
(SECTION B.5)

HHRC SENSITIVITY ANALYSIS

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LIST OF ACRONYMS AND ABBREVIATIONS

CSS	Dust loading factor
DW	Annual frequency of exposure
HHRC	Human Health Risk Characterization
IEA/RC	Integrated Endangerment Assessment/Risk Characterization
PCC	Partial correlation coefficient
PPLV	Preliminary pollutant limit value
RAF	Relative absorption factor
RMA	Rocky Mountain Arsenal
SC	Skin soil covering
SI	Soil ingestion
SRC	Standardized regression coefficient
TE	Exposure duration

B.5 HHRC SENSITIVITY ANALYSIS

This section presents the results of a sensitivity study based on correlation analysis, which ranks the influence of several input parameters on the variability of the cumulative direct preliminary pollutant limit values (PPLVs) for aldrin, dieldrin, chlordane, dibromochloropropane (DBCP), and arsenic.

B.5.1 BACKGROUND

In a Monte Carlo simulation such as that used in the Human Health Risk Characterization (HHRC) program to compute PPLVs, parameters are represented by uncertainty distributions and sampled repeatedly to obtain the distribution for the model output. Once the model has been implemented, it is helpful to conduct a sensitivity analysis to determine which input parameters are most important in affecting model output. Such a sensitivity analysis is an essential step in the identification of those input parameters whose uncertainty drives the level of uncertainty in the model results. Identification of these drivers shows the paths for field and laboratory investigations that would be most productive in narrowing the uncertainty reflected in the output distribution for risk. This enhances the value of the risk assessment as a tool for selecting appropriate remedial action.

The question of uncertainty reduction often arises once a Monte Carlo risk model has been built and quantified using the best available information. If, for example, an investment in additional field or laboratory studies were to be made, which of the model's distributed input parameters should receive the highest priority? Which parameter would yield the greatest increase in confidence in the model's results, if it could be characterized more precisely? Sensitivity studies provide a means of answering these questions. Use of multiple regression in place of simple parametric studies provides a firmer technical basis for such recommendations. This is because the parametric methods often used for sensitivity studies are vulnerable to masking and colinearity effects that can lead to mistakes when ranking input parameters by their importance.

B.5.2 APPROACH

Iman et al. (1985) suggests that multiple regression be used to quantify the sensitivity of the model output to each of the input parameters. The regression model is defined as follows:

$$\hat{y} = b_0 + b_1x_1 + b_2x_2 + ..., \quad (1)$$

where $\hat{y}$ is the value of the output parameter that is predicted by the linear combination of the input parameters x_1, x_2,... .

B.5.2.1 Standardized Regression Coefficients

In the regression model

$$\hat{y} = b_0 + b_1x_1 + b_2x_2 + ..., \quad (2)$$

the regression coefficients b_i measure the unit change in y per unit change in x_i. The slopes b_i are therefore dependent on the units of x_i. To compare the slopes for parameters of different units, the regression coefficients must be standardized as follows:

$$B_i = b_i * \frac{SD_i}{SD_y} \quad (3)$$

where SD_i and SD_y are the standard deviations of the x_i and y samples.

The standardized regression coefficient (SRC) for each input parameter measures the importance of that parameter.

B.5.2.2 Partial Correlation Coefficients

The partial correlation coefficient (PCC) for each input parameter, which is a generalization of the coefficient of correlation (r) in ordinary linear regression, provides a second measure of that parameter's importance in the model. As noted in the standard text by Hamburg (1991), PCCs indicate the separate effect of each of the input parameters on the output parameter, after the influence of all the other input parameters has been taken into account. For example, the PCC designated $r_{y1\cdot2}$ in a model with two input parameters would show the partial correlation between y and x_1 after the effect of x_2 on y had been removed.

A variety of PCCs, each representing a different subset of parameters, can be constructed for a model with multiple input parameters. However, Iman et al. (1985) recommends the use of the full-model PCCs, which measure the contribution of each input parameter that is unique, i.e., the contribution not provided by any other parameter. For instance, the distributed input parameters in a seven-parameter model have the following full-model PCCs:

$$r_{y1\cdot234567},\ r_{y2\cdot134567},\ r_{y3\cdot124567},\ \cdots,$$

where: $r_{y1\cdot234567}$ = correlation between the output ("y") and the first input parameter, given that the remaining input parameters are in the regression model

$r_{y2\cdot134567}$ = correlation between the output ("y") and the second input parameter, given that the remaining input parameters are in the regression model

and so on.

B.5.3 CONDUCT OF THE STUDY

The biological worker's cumulative direct-pathway PPLV for aldrin and its seven distributed input parameters were the focus of this sensitivity study. Aldrin was chosen because of its strong contribution to overall risks at Rocky Mountain Arsenal (RMA), as discussed in the main body

of the Integrated Endangerment Assessment/Risk Characterization (IEA/RC) report. The distributed input parameters for the biological worker direct PPLV calculation are as follows:

DW	Annual frequency of exposure (d/y)
TE	Exposure duration (y) (carcinogens only)
RAF_{dermal}	Relative Absorption Factor for dermal absorption (unitless)
$RAF_{ingestion}$	Relative Absorption Factor for ingestion (unitless)
CSS	Dust loading factor ($\mu g/m^3$)
SC	Skin soil covering (mg/cm^3)
SI	Soil ingestion (mg/d)

For the biological worker scenario, TM is a fixed value (8 hours/day), and therefore, it is not carried through the sensitivity analysis.

The sensitivity analysis was performed for both types of health threat (carcinogen and noncarcinogen). The correlation was accomplished using analytical tools available in the S-PLUS statistical programming language. Results from a 100-sample run were used as input for the multivariate correlation.

The influence of each input parameter was quantified using both PCCs and SRCs. The PCCs and SRCs usually indicate the same order of importance among parameters; however, this is not always the case.

B.5.3.1 Evaluation of Carcinogenic PPLV

The regression analysis performed on the biological worker's direct carcinogenic PPLV for aldrin and its distributed input parameters produced the following set of SRCs and PCCs. These indicate that TE and SI are the most influential parameters, followed by $RAF_{ingestion}$(carc). The remaining variables (RAF_{dermal}[carc], SC, DW, and CSS) each contribute relatively little to variation in the carcinogenic aldrin PPLV for the biological worker.

Carcinogen (Biological Worker, Aldrin)

Parameter	PCC Value	PCC Rank	SRC Value	SRC Rank
TE (y)	+.987	1	-.804	1
SI (mg/d)	+.959	2	-.431	2
$RAF_{ingestion}$	+.740	3	-.152	3
RAF_{dermal}	+.413	4	-.075	4
SC (mg/cm^3)	+.345	5	-.066	5
DW (d/y)	+.076	6	-.026	6
CSS ($\mu g/m^3$)	+.058	7	-.022	7

B.5.3.2 Evaluation of Noncarcinogenic PPLV

The regression analysis performed on the biological worker's direct noncarcinogenic PPLV for aldrin and its distributed input parameters produced the following set of SRCs and PCCs. These indicate that SI is the most influential parameter, followed by $RAF_{ingestion}$[noncarc]. The remaining variables (RAF_{dermal}[noncarc], SC, DW, and CSS) each contribute relatively little to variation in the noncarcinogenic aldrin PPLV for the biological worker.

Noncarcinogen (Biological Worker, Aldrin)

Parameter	PCC Value	PCC Rank	SRC Value	SRC Rank
SI (mg/d)	+.964	1	-.964	1
$RAF_{ingestion}$	+.754	2	-.324	2
RAF_{dermal}	+.497	3	-.182	3
SC (mg/cm^3)	+.395	4	-.147	4
DW (d/y)	+.151	5	-.077	5
CSS ($\mu g/m^3$)	+.067	6	-.049	6
TE (y)	+.0002	7	-.004	7

B.5.4 SENSITIVITY RANKING RESULTS FOR ADDITIONAL CHEMICALS

The procedure described in Section B.5.3 for aldrin was also used to perform a sensitivity study on the cumulative-direct PPLVs for dieldrin, chlordane, DBCP, and arsenic for both the biological worker and industrial worker exposure scenarios. The dermal pathway was not evaluated for arsenic. The results of the sensitivity study are provided in Tables B.5-1 through B.5-3, which show rank, SRC, and PCC, respectively, for each input parameter and chemical/

pathway combination. The ranks in these tables are based on PCC. As shown in these tables, the results for arsenic are based on the soil ingestion and particulate inhalation routes; the dermal route was not evaluated for inorganic chemicals in HHRC.

B.5.4.1 Evaluation of Carcinogenic PPLV

B.5.4.1.1 Biological Worker

The regression analysis performed on the biological worker's direct carcinogenic PPLV for dieldrin, chlordane, DBCP, and arsenic indicates that TE is the most influential parameter. For dieldrin, chlordane, and arsenic, SI is the next most influential parameter. For DBCP, however, SC is the second most influential parameter. The remaining variables contribute relatively little to the variation in the PPLVs, as shown for each chemical in Tables B.5-1 through B.5-3.

B.5.4.1.2 Industrial Worker

The regression analysis performed on the industrial worker's direct carcinogenic PPLV for dieldrin, chlordane, DBCP, and arsenic indicate that TE is the most influential parameter. For dieldrin and arsenic, the second most influential parameter is SI. For chlordane and DBCP, the second most influential parameters are RAF_{dermal} and skin soil covering, respectively. The remaining variables contribute relatively little to the variation in the PPLVs, as shown for each chemical in Tables B.5-1 through B.5-3.

B.5.4.2 Evaluation of Non-Carcinogenic PPLV

B.5.4.2.1 Biological Worker

The regression analysis performed on the Biological Worker's direct noncarcinogenic PPLV for dieldrin, chlordane, and arsenic indicate that soil ingestion (SI) is the most influential parameter contributing to variation in the PPLV. The analysis for DBCP indicates that SC is the most influential parameter for this chemical. For dieldrin, DBCP, and chlordane, RAF_{dermal} is the second most influential parameter, while for arsenic, $RAF_{ingestion}$ is the second most influential parameter. The remaining variables for each chemical contribute relatively little to the variation in the PPLVs, as shown in Tables B.5-1 through B.5-3.

B.5.4.2.2 Industrial Worker

The regression analysis performed on the industrial worker's direct noncarcinogenic PPLV indicates that SI is the most influential parameter for dieldrin and arsenic; RAF_{dermal} is the most influential parameter for chlordane; and SC is the most influential parameter for DBCP. The second most influential parameter for dieldrin and chlordane under this scenario is SC. The second most influential parameters for arsenic and DBCP are $RAF_{ingestion}$ and RAF_{dermal}, respectively.

B.5.5 CONCLUSIONS

The results of this sensitivity study indicate that (1) variability in exposure duration is consistently the most influential contributor to the variability in the direct carcinogenic PPLVs; and (2) variability in soil ingestion, soil covering, $RAF_{ingestion}$, and RAF_{dermal} are influential contributors to variability in direct carcinogenic and noncarcinogenic PPLVs.

B.5.6 REFERENCES

Hamburg, M. 1991. The Coefficient of Correlation. pp. 490-547. Statistical Analysis for Decision Making. 5th ed. Academic Press, New York.

Iman, R.L., M.J. Shortencarier and J.D. Johnson. 1985. A FORTRAN 77 Program and User's Guide for the Calculation of Partial Correlation and Standardized Regression Coefficients. Sandia National Laboratories, Albuquerque, NM. SAND85-0044.

Table B.5-1 Importance of Individual Input Parameters' Contributions to PPLV Variability[1]

Input Parameter	Biological Aldrin Carc Rank	Industrial Aldrin Carc Rank	Biological Dieldrin Carc Rank	Industrial Dieldrin Carc Rank	Biological Chlordane Carc Rank	Industrial Chlordane Carc Rank	Biological DBCP Carc Rank	Industrial DBCP Carc Rank	Biological Arsenic Carc Rank	Industrial Arsenic Carc Rank
TE (y)	1	1	1	1	1	1	1	1	1	1
SI (mg/d)	2	2	2	2	2	4	5	5	2	2
$RAF_{ingestion}$	3	4	3	5	5	5	6	6	3	3
RAF_{dermal}	4	5	4	3	3	2	3	3	na	na
SC (mg/cm^3)	5	3	5	4	4	3	2	2	na	na
DW (d/y)	6	8	6	7	6	6	4	4	5	6
CSS ($\mu g/m^3$)	7	6	7	6	7	7	7	7	4	4
TM (h/d)	na	7	na	8	na	8	na	8	na	5

Input Parameter	Biological Aldrin Noncarc Rank	Industrial Aldrin Noncarc Rank	Biological Dieldrin Noncarc Rank	Industrial Dieldrin Noncarc Rank	Biological Chlordane Noncarc Rank	Industrial Chlordane Noncarc Rank	Biological DBCP Noncarc Rank	Industrial DBCP Noncarc Rank	Biological Arsenic Noncarc Rank	Industrial Arsenic Noncarc Rank
SI (mg/cm^3)	1	1	1	1	1	3	4	4	1	1
$RAF_{ingestion}$	2	5	3	4	4	4	5	7	2	2
RAF_{dermal}	3	6	2	3	2	1	2	2	na	na
SC (mg/cm^3)	4	2	4	2	3	2	1	1	na	na
DW (d/y)	5	7	5	5	5	6	3	3	3	3
CSS ($\mu g/m^3$)	6	3	6	7	6	5	6	5	4	4
TM (h/d)	na	4	na	6	na	7	na	6	na	5
TE (y)	na	na	na	na	na	na	na	na	na	na

Note:

[1] This table reflects the rankings of partial correlation coefficients (PCCs). In each regression analysis, the sets of PCCs and SRCs result in identical rankings with the exception of the following:

(1) In the SRC ranking of industrial aldrin (carc), $RAF_{ingestion}$ and RAF_{dermal} are ranked 5 and 4, respectively;

(2) In the SRC ranking of industrial dieldrin (noncarc), RAF_{dermal} and SC are ranked 2 and 3, repectively.

Table B.5-2 Standardized Regression Coefficients for Direct PPLV Input Parameters

Input Parameter	Biological Aldrin Carc SRC	Industrial Aldrin Carc SRC	Biological Dieldrin Carc SRC	Industrial Dieldrin Carc SRC	Biological Chlordane Carc SRC	Industrial Chlordane Carc SRC	Biological DBCP Carc SRC	Industrial DBCP Carc SRC	Biological Arsenic Carc SRC	Industrial Arsenic Carc SRC
TE (y)	-0.804	-0.938	-0.831	-0.923	-0.863	-0.885	-0.836	-0.939	-0.809	-0.889
SI (mg/d)	-0.431	-0.372	-0.454	-0.356	-0.330	-0.170	-0.023	-0.008	-0.436	-0.472
$RAF_{ingestion}$	-0.152	-0.129	-0.099	-0.075	-0.060	-0.036	-0.004	-0.0011	-0.141	na
RAF_{dermal}	-0.075	-0.130	-0.086	-0.187	-0.229	-0.344	-0.085	-0.089	na	na
SC (mg/cm^3)	-0.066	-0.154	-0.059	-0.172	-0.156	-0.258	-0.370	-0.387	na	-0.012
DW (d/y)	-0.026	-0.006	-0.029	-0.030	-0.048	-0.024	-0.037	-0.010	-0.040	-0.113
CSS ($\mu g/m^3$)	-0.022	-0.037	-0.0070	-0.032	-0.015	-0.016	+0.001	-0.0008	-0.114	-0.086
TM (h/d)	na	-0.026	na	-0.013	na	+0.001	na	-0.0002	na	

Input Parameter	Biological Aldrin Noncarc SRC	Industrial Aldrin Noncarc SRC	Biological Dieldrin Noncarc SRC	Industrial Dieldrin Noncarc SRC	Biological Chlordane Noncarc SRC	Industrial Chlordane Noncarc SRC	Biological DBCP Noncarc SRC	Industrial DBCP Noncarc SRC	Biological Arsenic Noncarc SRC	Industrial Arsenic Noncarc SRC
SI (mg/d)	-0.964	-0.457	-0.918	-0.781	-0.720	-0.415	-0.060	-0.021	-0.961	-0.935
$RAF_{ingestion}$	-0.324	-0.195	-0.172	-0.129	-0.150	-0.070	-0.018	-0.00192	-0.314	-0.280
RAF_{dermal}	-0.182	-0.109	-0.178	-0.377	-0.544	-0.718	-0.219	-0.215	na	na
SC (mg/cm^3)	-0.147	-0.265	-0.155	-0.376	-0.374	-0.501	-0.970	-0.952	na	na
DW (d/y)	-0.077	-0.058	-0.071	-0.054	-0.082	-0.039	-0.099	-0.024	-0.060	-0.015
CSS ($\mu g/m^3$)	-0.049	-0.232	-0.018	-0.009	-0.048	-0.065	+0.002	-0.003	-0.010	-0.011
TE (y)	na	na	na	na	na	na	na	na	na	na
TM (h/d)	na	-0.227	na	-0.045	na	-0.012	na	-0.00197	na	-0.010

Table B.5-3 Full Model Partial Correlation Coefficients for Direct PPLV Input Parameters

Input Parameter	Biological Aldrin Carc PCC	Industrial Aldrin Carc PCC	Biological Dieldrin Carc PCC	Industrial Dieldrin Carc PCC	Biological Chlordane Carc PCC	Industrial Chlordane Carc PCC	Biological DBCP Carc PCC	Industrial DBCP Carc PCC	Biological Arsenic Carc PCC	Industrial Arsenic Carc PCC
TE (y)	0.987	0.972	0.989	0.973	0.969	0.983	0.9996	0.9999	0.991	0.977
SI (mg/d)	0.959	0.837	0.967	0.838	0.831	0.682	0.695	0.544	0.969	0.924
$RAF_{ingestion}$	0.740	0.394	0.576	0.177	0.136	0.090	0.065	0.025	0.765	0.557
RAF_{dermal}	0.413	0.383	0.504	0.571	0.704	0.899	0.968	0.994	na	na
SC (mg/cm^3)	0.345	0.478	0.325	0.550	0.520	0.834	0.998	0.9996	na	na
DW (d/y)	0.076	0.001	0.108	0.033	0.093	0.042	0.852	0.652	0.193	0.008
CSS ($\mu g/m^3$)	0.058	0.049	0.006	0.039	0.010	0.020	0.004	0.012	0.683	0.405
TM (h/d)	na	0.025	na	0.007	na	0.0001	na	0.001	na	0.287

Input Parameter	Biological Aldrin Noncarc PCC	Industrial Aldrin Noncarc PCC	Biological Dieldrin Noncarc PCC	Industrial Dieldrin Noncarc PCC	Biological Chlordane Noncarc PCC	Industrial Chlordane Noncarc PCC	Biological DBCP Noncarc PCC	Industrial DBCP Noncarc PCC	Biological Arsenic Noncarc PCC	Industrial Arsenic Noncarc PCC
SI (mg/d)	0.964	0.228	0.946	0.856	0.849	0.701	0.706	0.616	0.9999	0.999
$RAF_{ingestion}$	0.754	0.051	0.388	0.141	0.199	0.064	0.177	0.013	0.9993	0.990
RAF_{dermal}	0.497	0.017	0.413	0.578	0.772	0.879	0.970	0.994	na	na
SC (mg/cm^3)	0.395	0.093	0.363	0.585	0.614	0.773	0.998	0.9997	na	na
DW (d/y)	0.151	0.005	0.107	0.029	0.072	0.021	0.870	0.683	0.982	0.223
CSS ($\mu g/m^3$)	0.067	0.074	0.007	0.0008	0.025	0.057	0.003	0.034	0.592	0.139
TM (h/d)	na	0.069	na	0.020	na	0.002	na	0.014	na	0.124
TE (y)	na	na	na	na	na	na	na	na	na	na

APPENDIX B
(SECTION B.6)

SUMMARY OF ACUTE AND SUBCHRONIC RESULTS CALCULATED FOR THE HHEA ADDENDUM

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B.6-1 Recreational Visitor, Horizon 0 (0-1 ft): Map of Hazard Quotients (HQs) Exceeding 1.0 Reflecting Acute Exposures to Aldrin/Dieldrin

B.6 SUMMARY OF ACUTE AND SUBCHRONIC RESULTS CALCULATED FOR THE HHEA ADDENDUM

B.6.1 INTRODUCTION

This section provides documentation supporting the acute/subchronic risk evaluation presented in Section 3.2.4. The information summarized in the following tables is based on the results and supporting methodologies included in the HHEA Addendum (EBASCO 1992), which evaluated acute and subchronic hazards for two scenarios: a most likely estimate (MLE) scenario and a reasonable maximum exposure (RME) scenario. In accordance with EPA guidance, the RME analysis was developed to represent a reasonable upperbound estimate of hazards and risks, and thus is the focus of the acute/subchronic evaluation presented in the IEA/RC. Results of the MLE evaluation are provided in the HHEA Addendum.

Acute and subchronic (deterministic) RME PPLVs developed for the cumulative direct exposure pathways are summarized in Volume I of the IEA/RC (Tables 3.2-7 and 3.2-8). The acute and subchronic RME parameters used to estimate these PPLVs are listed in Tables B.6-1 and B.6-2, respectively. The toxicity criteria used for this evaluation are listed in Table B.6-3.

As discussed in Section 3.2.4, the acute and subchronic PPLVs presented in Volume I of the IEA/RC are the same as those originally calculated for the HHEA Addendum, with the following exceptions. PPLVs for aldrin and dieldrin were recalculated for the IEA/RC to reflect revisions of the dermal RAF (all receptor scenarios), the soil covering factor (visitor populations only), and the toxicity criteria. The updated acute/subchronic RfD for aldrin and dieldrin is 1.0E-04 mg/kg/day, which was specifically developed by EPA's Office of Research and Development (1993) and supersedes the subchronic RfD used in the HHEA Addendum (5.0E-05 mg/kg/day). Figure B.6-1 presents a map of soil boring-specific hazard quotients (HQs) for aldrin/dieldrin reflecting the revised exposure parameters and toxicity criteria. HQs shown in this map correspond to the driving receptor scenario (i.e., the scenario for which PPLVs were lowest -- recreational visitor, acute exposures).

B.6.2 FACTORS TO CONSIDER WHEN EVALUATING PPLVS DERIVED FOR ACUTE/SUBCHRONIC ENDPOINTS

A comparison of acute (deterministic), subchronic (deterministic), and chronic (probabilistic) noncarcinogenic PPLVs calculated for visitor populations is provided in Table 3.2-9 (Volume I). As shown in this table, of the chemicals for which both acute and subchronic PPLVs were developed, acute PPLVs for eight COCs are lower than corresponding subchronic PPLVs, and subchronic PPLVs for eight COCs are lower than corresponding chronic PPLVs. Acute PPLVs for four chemicals (aldrin, DDT, dieldrin, and endrin) are lower than both subchronic and chronic PPLVs. Differences in exposure assumptions and the applicability of the toxicity criteria should be considered when evaluating the acute/subchronic results, and, in particular, when comparing the acute/subchronic deterministic PPLVs with corresponding chronic probabilistic PPLVs.

B.6.2.1 Differences in Exposure Assumptions

Acute/subchronic and chronic approaches differ in their use of exposure assumptions. The acute/subchronic exposures are, of course, of shorter duration than the chronic exposures. However, several other differences should be considered. For example, for recreational and regulated/casual visitor populations, both acute and subchronic hazards were calculated assuming exposure to a 10 kg child receptor (2.5 years old), whereas the chronic long-term evaluation assumed a distribution of body weights (corresponding to ages ranging from 0 to 75 years). [The assumption of a child receptor is usually implicit to the evaluation of non-worker population acute or subchronic exposures, as this results in a more conservative (health-protective) analysis.] Consequently, the soil intake (dose) to body weight ratio assumed in estimating acute/subchronic exposures is generally higher than that assumed in the chronic risk evaluation. [However, irrespective of the aforementioned factors, single-event exposures could, in some instances, be much greater than those considered to be chronic.] Also, other RME acute and subchronic parameters, such as oral RAF, dermal RAF, and skin surface area, are different from those used in the chronic risk evaluation for some COCs.

In addition to the actual exposure parameter estimates, another difference between the acute/subchronic and chronic analyses is the way in which the exposure parameters are used to

calculate the PPLVs. The acute/subchronic deterministic analysis used single point (fixed) estimates of exposure parameters to derive a single estimate of hazard; these exposure parameters represent RME parameters. The results of this evaluation thus provide a measure of the hazard to an individual exposed under those conditions. PPLVs based on these estimates are assumed to be protective for an individual exposed to this or a lesser combination of exposure factors. The probabilistic analysis, in contrast, used ranges of exposures potentially occurring within the population. It is assumed that some individuals have a high level of exposure and others have a lower level. The results of this evaluation thus provide an estimate of hazard to the population being evaluated. PPLVs based on the 95th percentile of the resulting hazard distribution are designed to protect at least 95 percent of the individuals within the population.

B.6.2.2 Applicability of Toxicity Criteria

When evaluating the acute/subchronic and chronic risk estimates, one must also consider the degree of uncertainty in the estimates contributed by the toxicity factors. In many cases, acute/subchronic toxicity values were not available for the chemicals being evaluated and a chronic toxicity value may have been substituted. If the substituted toxicity criterion was in fact based on an acute effect, then little additional uncertainty would be associated with the acute PPLV. However, if the toxicity criterion was based on a chronic effect, the acute and subchronic PPLVs are likely to contain more uncertainty than the chronic PPLV estimates.

B.6.3 REFERENCES

RTIC 93011R01

EBASCO (Ebasco Services, Inc.) 1992. Human Health Exposure Assessment Addendum for Rocky Mountain Arsenal. Version 3.2.

EPA (U.S. Environmental Protection Agency) 1990a. Integrated Risk Information System. Toxicity Database.

EPA 1990b. Health Effects Assessment Summary Tables. (HEAST) Office of Health and Environmental Assessment.

Table B.6-1 Acute Reasonable Maximum Exposure (RME) Parameters for Cumulative Direct Soil Exposure Pathway

Parameter Name	Regulated/Casual Visitors		Recreational Visitors		Commercial Workers	Industrial Workers
Soil Ingestion	2 1/2yr	250 mg/day	2 1/2 yr	250 mg/day	100 mg/day	100 mg/day
Breathing Rate	2 1/2yr	2.016 m^3/day	2 1/2 yr	3.98 m^3/day	4.8 m^3/day	20 m^3/day
Dust Load Factor		0.042 mg/m^3		0.042 mg/m^3	0.021 mg/m^3	0.042 mg/m^3
Pulmonary Retention		0.75		0.75	0.75	0.75
Pulmonary Absorption (All compounds)		1 (100 percent)		1 (100 percent)	1 (100 percent)	1 (100 percent)
Daily Exposure Period		8 hours		8 hours	8 hours	8 hours
Annual Exposure Frequency		NA	NA	NA	NA	NA
Lifetime Exposure Duration		NA	NA	NA	NA	NA
Skin Surface Area	2 1/2yr	2,100 cm^2	2 1/2 yr	2,100 cm^2	1,120 cm^2	3,200 cm^2
Soil Covering/1/		0.51 mg/cm^2		0.51 mg/cm^2	0.11 mg/cm^2	1.5 mg/cm^2
Soil Matrix Factor		1.0		1.0	1.0	1.0
Dermal Absorption/1/		0.01 (metals) 0.10 (organics)		0.01 (metals) 0.10 (organics)	0.01 (metals) 0.10 (organics)	0.01 (metals) 0.10 (organics)
Oral Absorption		1 (100 percent)		1 (100 percent)	1 (100 percent)	1 (100 percent)
Body Weight	Child:	10 kg	Child:	10 kg	Adult: 70kg	Adult: 70kg

NA Not Applicable

/1/ RME PPLVs for aldrin and dieldrin were recalculated using an RfD recently updated by the EPA (1.0E-04 mg/kg/day; see Appendix Table B.6-3); this criterion supersedes the value used in the HHEA Addendum. These recalculated PPLVs also reflect the following: (1) dermal RAFs for aldrin and dieldrin were revised to equal 0.0052 and 0.1, respectively, consistent with the assumptions used in the IEA; and (2) concomitant with this revision of the aldrin/dieldrin dermal RAFs, the soil covering assumed for recreational and regulated/casual visitor populations was revised to equal 1.0 mg/cm^2, consistent with recent EPA dermal exposure assessment guidance.

Table B.6-2 Subchronic Reasonable Maximum Exposure (RME) Parameters for Cumulative Direct Soil Exposure Pathway

Parameter Name	Regulated/Casual Visitors		Recreational Visitors		Commercial Workers	Industrial Workers
Soil Ingestion	2 1/2yr 6 yr	250 mg/day 250 mg/day	2 1/2 yr 6 yr	250 mg/day 250 mg/day	100 mg/day	100 mg/day
Breathing Rate	2 1/2 yr 6 yr	2.016 m^3/day 6.38 m^3/day	2 1/2 yr 6 yr	3.98 m^3/day 9.74 m^3/day	4.8 m^3/day	20 m^3/day
Dust Load Factor		0.042 mg/m^3		0.042 mg/m^3	0.021 mg/m^3	0.042 mg/m^3
Pulmonary Retention		0.75		0.75	0.75	0.75
Pulmonary Absorption		1 (100 percent)		1 (100 percent)	1 (100 percent)	1 (100 percent)
Daily Exposure Period		8 hours		8 hours	8 hours	8 hours
Annual Exposure Frequency		108 days/year		108 days/year	253 days/year	253 days/year
Exposure Duration		7 years		7 years	7 years	7 years
Lifetime Exposure Duration/1/		7 years		7 years	7 years	7 years
Skin Surface Area	2 1/2yr 6 yr	2,100 cm^2 2500 cm^2	2 1/2 yr 6 yr	2,100 cm^2 2500 cm^2	1,120 cm^2	3,200 cm^2
Soil Covering/2/		0.51 mg/cm^2		0.51 mg/cm^2	0.11 mg/cm^2	1.5 mg/cm^2
Soil Matrix Factor		1.0		1.0	1.0	1.0
Dermal Absorption/2/		0.01 (metals) 0.10 (organics)		0.01 (metals) 0.10 (organics)	0.01 (metals) 0.10 (organics)	0.01 (metals) 0.10 (organics)
Oral Absorption (all compounds)		1 (100 percent)		1 (100 percent)	1 (100 percent)	1 (100 percent)
Body Weight	Child:	10th percentile (M&F)	Child:	10th percentile (M&F)	Adult: 70kg	Adult: 70kg

NA Not Applicable

/1/ Lifetime exposure duration= Q-Factor. In the SPPPLV equation, the exposure duration is divided by the lifetime exposure duration. Because exposure duration and lifetime exposure duration are the same number, this term defaults to a value of 1.0.

/2/ RME PPLVs for aldrin and dieldrin were recalculated using an RfD recently updated by the EPA (1.0E-04 mg/kg/day; see Appendix Table B.6-3); this criterion supersedes the value used in the HHEA Addendum. These recalculated PPLVs also reflect the following: (1) dermal RAFs for aldrin and dieldrin were revised to equal 0.0052 and 0.1, respectively, consistent with the assumptions used in the IEA; and (2) concomitant with this revision of the aldrin/dieldrin dermal RAFs, the soil covering assumed for recreational and regulated/casual visitor populations was revised to equal 1.0 mg/cm^2, consistent with recent EPA dermal exposure assessment guidance.

Table B.6.3 D_T(RfD) Values for Acute and Subchronic Exposure[1]

Contaminant	Acute D_TING (mg/kg/day)	D_TINH (mg/kg/day)	Subchronic D_TING (mg/kg/day)	Subchronic D_TINH (mg/kg/day)
Aldrin[2,4]	1.0E-04	1.0E-04	1.0E-04	1.0E-04
Arsenic[2]	8.0E-03	2.9E-04	1.0E-03	2.9E-04
Benzene	NA	NA	NA	NA
Cadmium[3]	4.0E-03	1.4E-01	5.0E-04	5.0E-04
Carbon Tetrachloride	4.0E-01	1.8E-01	7.0E-03	2.7E-02
Chlordane[3]	6.0E-03	6.0E-03	6.0E-05	1.4E-04
Chloroacetic Acid	NA	NA	2.0E-02	2.0E-02
Chlorobenzene[2]	2.0E-01	2.0E-01	2.0E-01	5.0E-02
Chloroform[3]	1.8e-01	4.3E-01	1.0E-02	6.8E-03
Chromium VI	1.0E-01	1.0E-01	2.0E-02	5.7E-06
Dibromochloropropane	5.0E-03	5.0E-03	NA	NA
DDE	NA	NA	NA	NA
DDT[2,3]	5.0E-04	5.0E-04	5.0E-04	5.0E-04
1,2-Dichloroethane	NA	NA	NA	NA
1,1-Dichloroethylene[3]	2.0E+00	1.0E+00	9.0E-03	2.3E-02
Dicyclopentadiene	NA	NA	3.0E-01	6.0E-04
Dieldrin[2,4]	1.0E-04	1.0E-04	1.0E-04	1.0E-04
Endrin	2.0E-03	2.0E-03	5.0E-04	5.0E-04
Hexachlorocyclopentadiene	NA	NA	7.0E-02	2.0E-04
Isodrin	NA	NA	NA	NA
Lead	NA	NA	NA	NA
Mercury(Inorganic)[3]	2.0E-01	2.0E-01	3.0E-04	8.5E-05
Methylene Chloride[3]	1.0E+00	4.9E+00	6.0E-02	8.5E-01
1,1,2,2-Tetrachloroethane	NA	NA	NA	NA
Tetrachloroethylene	2.0E-01	1.9E+00	1.0E-01	1.7E-01
Toluene[2]	2.0E+00	4.3E+00	2.0E+00	5.7E-01
Trichloroethylene	2.4E+00	4.3E-01	2.5E+00	2.5E+00

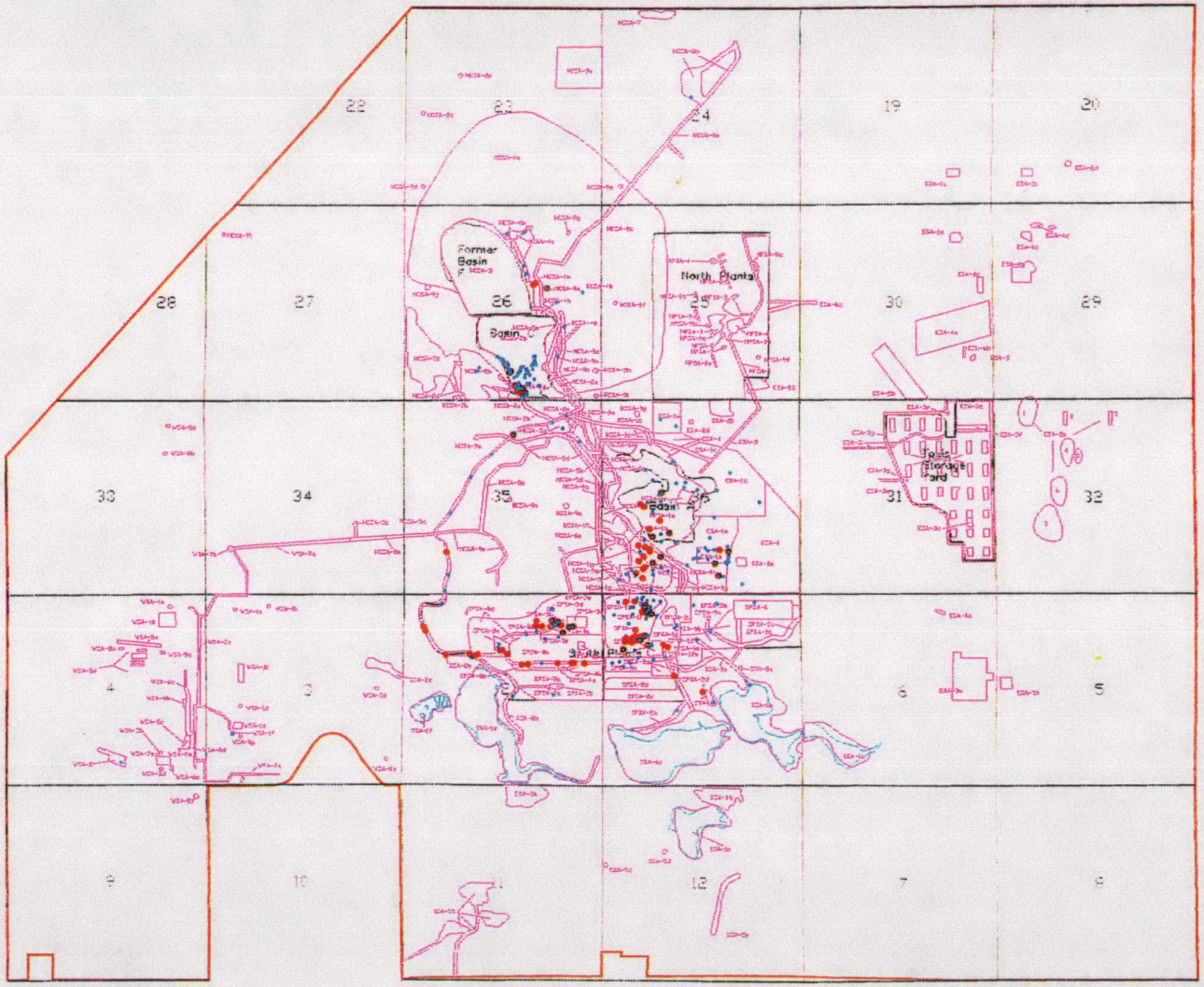
NA Dose-response data not available from EPA.
D_TING Reference dose (RfD) for oral (ingestion) pathway.
D_TINH Reference dose (RfD) for inhalation pathway.

[1] D_Ts were obtained from EPA's Integrated Risk Information System (1990a), the EPA Office of Drinking Water Health Advisories, EPA's Health Effects Assessment Summary Tables (1990b), and Agency for Toxic Substances and Disease Registry toxicology profiles. Oral RfDs and inhalation reference concentrations were given priority over other types of toxicity values.

[2] Acute DT = Subchronic DT for oral and/or inhalation pathway.

[3] Subchronic DT = Chronic DT for oral and/or inhalation pathway (see Appendix Table B.1-10 for chronic DT values).

[4] The acute and subchronic RfD for aldrin and dieldrin, 1.0E-04 mg/kg/day, reflects the December 1992 update by the EPA Office of Research and Development (EPA 1993) and supersedes the criteria used in the HHEA Addendum. This reference dose was based on a neurotoxicity study by Smith et. al. (1976) in which squirrel monkeys were exposed to dieldrin administered by a bolus dose. The no observed adverse effects level (NOAEL) in this study was 0.01 mg/kg/day; the lowest observed adverse effects level (LOAEL) was 0.10 mg/kg/day. The updated RfD was derived by applying an uncertainty factor (UF) of 100 to the NOAEL (0.01 mg/kg/day) value to account for extrapolation from animal data to humans and to protect sensitive individuals.



Legend

- Aldrin and/or Dieldrin HQ > 10
- 1 < Aldrin and/or Dieldrin HQ ≤ 10
- Lake
- 31 Section Number
- Section Line

Note:

The aldrin/dieldrin HQs shown in this map reflect the finalized acute criteria (RfDs) developed for these chemicals and correspond to an acute (deterministic) PPLV of 3.8 mg/kg and 3.7 mg/kg for aldrin and dieldrin, respectively. See Appendix B.6 text for discussion.

N

0 2000 4000

Scale in Feet

Prepared for:
U.S. Army Program Manager
for Rocky Mountain Arsenal

February 1994

Figure B.6-1
Recreational Visitor, Horizon 0 (0-1 ft): Map of Hazard Quotients (HQs) Exceeding 1.0 Reflecting Acute Exposures to Aldrin/Dieldrin
Rocky Mountain Arsenal
Prepared by: ENSERCH Environmental Corp

APPENDIX B
(SECTION B.7)

QUALITATIVE RISK ASSESSMENT DOCUMENTATION

LIST OF TABLES

Table

B.7-1 Summary of Qualitative Assessment Results for Feasibility Study Action SAR Sites

B.7-2 Summary of Qualitative Assessment Results for Feasibility Study No Action SAR Sites

Table B.7-1 Summary of Qualitative Assessment Results for Feasibility Study Action SAR Sites

Medium Group or Subgroup	SAR Site	CAR Site	Agent			Unexploded Ordnance			Number of Drums	Number Structures	Number of USTs
			Potential	Sampled	Detected	Potential	Sampled	Detected			
Munitions Testing Medium Group											
	CSA - 2c	36-NSA	Yes	Yes	No	Yes	No	No	0	0	0
	CSA - 2d	36-NSA	Yes	Yes	No	Yes	No	No	0	0	0
	ESA - 1a	19-1	Yes	Yes	No	Yes	Yes	Yes	0	0	0
	ESA - 1b	20-1	No	No	No	Yes	Yes	No	0	0	0
	ESA - 1c	29-1	No	Yes	No	Yes	Yes	No	0	0	0
	ESA - 1d	30-2	No	Yes	No	Yes	Yes	No	0	0	0
	ESA - 4a	30-1	No	Yes	Yes	Yes	Yes	Yes	0	0	0
	ESA - 4b	29-4	Yes	Yes	No	Yes	Yes	Yes	2	0	0
North Plants Subgroup											
	NPSA - 3	NP	Yes	No	No	No	No	No	0	8	0
	NPSA - 5	NP	Yes	Yes	Yes	No	Yes	No	unknown	1	0
	NPSA - 6	NP	Yes	Yes	Yes	No	Yes	No	unknown	5	0
Toxic Storage Yards Subgroup											
	ESA - 3a	5-2	Yes	Yes	No	No	No	*No	unknown	0	0
	ESA - 3b	6-6	Yes	Yes	Yes	No	No	No	unknown	6	0
	ESA - 3c	31-4	Yes	Yes	Yes	Yes	No	No	unknown	3	0
	ESA - 3d	31-6, -7	Yes	Yes	Yes	No	No	No	unknown	49	0
	ESA - 3e	31-4	Yes	Yes	Yes	No	No	No	unknown	0	0
	ESA - 3f	31-7	Yes	Yes	Yes	No	No	No	0	0	0
	ESA - 3g	31-7	Yes	Yes	Yes	No	No	No	0	0	0
	ESA - 3h	31-7	Yes	Yes	Yes	No	No	No	0	0	0
	ESA - 3i	31-7	Yes	Yes	Yes	No	No	No	0	0	0

Table B.7-1 Summary of Qualitative Assessment Results for Feasibility Study Action SAR Sites

Medium Group or Subgroup	SAR Site	CAR Site	Agent			Unexploded Ordnance			Number of Drums	Number Structures	Number of USTs
			Potential	Sampled	Detected	Potential	Sampled	Detected			
Lake Sediments Medium Group											
	NCSA - 7	24-NSA	No	Yes	No	No	Yes	No	0	1	0
	SSA - 1b	1-2	No	No	No	No	No	No	0	1	0
	SSA - 1c	1-2	No	No	No	No	No	No	0	0	0
	SSA - 1e	2-17	No	No	No	No	No	No	0	2	0
	SSA - 5b	11-2	No	Yes	No	No	No	No	0	0	0
Surficial Soils Medium Group											
	NCSA - 1g Surficial Soils Survey	36-NSA	Yes	Yes	No	Yes	No	No	0	3	0
Ditches/Drainage Medium Group											
	CSA - 2b	36-NSA	Yes	Yes	No	Yes	No	No	0	0	0
	ESA - 6c	30-1	No	Yes	No	No	No	No	0	0	0
	NCSA - 1c	36-8	Yes	Yes	Yes	No	No	No	0	0	0
	NCSA - 1d	36-11	No	Yes	No	No	No	No	0	0	0
	NCSA - 1f	36-8	Yes	Yes	Yes	No	No	No	0	0	0
	NCSA - 2d	26-7	No	Yes	No	No	Yes	No	0	0	0
	NCSA - 5d	35-NSA	No	No	No	No	No	No	0	0	0
	NCSA - 8b	24-6	No	Yes	No	No	No	No	0	5	0
	NPSA - 8c	25-NSA	No	Yes	Yes	No	Yes	No	0	1	0
	NPSA - 9f	25-NSA	No	Yes	Yes	No	Yes	No	0	0	0
	SSA - 2a	1-1	No	Yes	No	No	No	No	0	0	0
	SSA - 2c	3-2, -3	No	Yes	No	No	No	No	0	1	0
	WSA - 1f	3-NSA	No	Yes	No	No	No	No	0	0	0

Table B.7-1 Summary of Qualitative Assessment Results for Feasibility Study Action SAR Sites

Medium Group or Subgroup	SAR Site	CAR Site	Agent			Unexploded Ordnance			Number of Drums	Number Structures	Number of USTs
			Potential	Sampled	Detected	Potential	Sampled	Detected			
Basin A Medium Group											
	NCSA - 1a	36-1, -14	Yes	Yes	Yes	No	No	No	0	1	0
	NCSA - 1e	36-15	Yes	Yes	No	Yes	No	No	0	0	0
Secondary Basins Subgroup											
	NCSA - 2a	26-3	Yes	Yes	Yes	No	No	No	0	0	0
	NCSA - 2b	26-4	Yes	Yes	Yes	No	No	No	0	0	0
	NCSA - 5a	35-3	Yes	Yes	Yes	No	No	No	0	1	0
Former Basin F Subgroup	NCSA - 3	26-6	Yes	Yes	Yes	No	No	No	0	0	0
Basin F Exterior Subgroup											
	NCSA - 4a	26-1	Yes	Yes	No	No	No	No	0	3	0
	NCSA - 4b	26-NSA	No	Yes	No	No	Yes	No	0	4	0
Sanitary/Process Water Sewers Subgroup											
	NCSA - 8a	24-5, 25-2, 26-8, 34-2, 3	No	Yes	No	No	No	No	0	0	0
	SPSA - 11	1-13, 2-18	No	Yes	No	No	No	No	0	0	0
	SPSA - 12	2-UNC	No	Yes	No	No	No	No	0	0	0
	WSA - 7a	3-1, 4-1, 34-2	No	Yes	Yes	No	No	No	0	0	0
Chemical Sewers Subgroup	CSA - 3	36-20	Yes	Yes	Yes	No	No	No	0	0	0
	NCSA - 6a	25-2, 36-20	Yes	Yes	Yes	No	No	No	0	0	0

Table B.7-1 Summary of Qualitative Assessment Results for Feasibility Study Action SAR Sites

Medium Group or Subgroup	SAR Site	CAR Site	Agent			Unexploded Ordnance			Number of Drums	Number Structures	Number of USTs
			Potential	Sampled	Detected	Potential	Sampled	Detected			
	NCSA - 6b	26-9, 35-2, 36-20	Yes	Yes	Yes	No	No	No	0	0	0
	NPSA - 1	25-3	Yes	No	No	No	No	No	0	0	0
	SPSA - 10	1-13, 2-18	Yes	Yes	Yes	No	No	No	0	0	0
Complex Trenches Subgroup	CSA - 1c	36-9, -16, -17	Yes	Yes	Yes	Yes	Yes	Yes	unknown	1	0
Shell Trenches Subgroup	CSA - 1a	36-3	Yes	Yes	Yes	No	Yes	No	0	1	0
Hex Pit Subgroup	SPSA - 1f	1-13	Yes	Yes	Yes	Yes	Yes	No	unknown	1	0
Sanitary Landfills Medium Group											
	CSA - 1d	36-7	No	No	No	No	Yes	No	unknown	1	0
	ESA - 2b	30-4	No	Yes	No	No	Yes	No	1	0	0
	SSA - 4	1-12	No	Yes	No	No	Yes	No	0	0	0
	WSA - 2	4-2	Yes	Yes	No	No	Yes	No	2	0	0
	WSA - 3c	4-3	No	Yes	No	No	Yes	No	0	0	0
	WSA - 5a	4-5	Yes	Yes	No	No	Yes	No	0	0	0
	WSA - 5c	4-5	Yes	Yes	No	No	Yes	No	0	0	0
	WSA - 5d	4-5	Yes	Yes	No	No	Yes	No	0	0	0
Section 36 Lime Basins Subgroup	NCSA - 1b	36-4, -5, -10	Yes	Yes	Yes	No	No	No	150	2	0

Table B.7-1 Summary of Qualitative Assessment Results for Feasibility Study Action SAR Sites

Medium Group or Subgroup	SAR Site	CAR Site	Agent			Unexploded Ordnance			Number of Drums	Number Structures	Number of USTs
			Potential	Sampled	Detected	Potential	Sampled	Detected			
Buried M-1 Pits Subgroup	SPSA - 1e	1-13	Yes	Yes	Yes	Yes	Yes	No	unknown	1	0
South Plants Central Processing Area Subgroup	SPSA - 1a	1-13	Yes	Yes	Yes	Yes	Yes	No	unknown	230	0
South Plants Ditches Subgroup	SPSA - 1d	1-1	No	Yes	No	No	No	No	0	2	0
	SPSA - 2d	1-1	No	Yes	No	No	No	No	0	0	0
	SPSA - 3a	2-1	No	Yes	No	No	No	No	0	0	0
	SPSA - 4a	2-1	No	Yes	No	No	No	No	0	0	0
	SPSA - 5a	1-NSA	No	Yes	No	No	No	No	0	0	0
	SPSA - 8b	2-1	No	Yes	No	No	No	No	0	0	0
	SPSA - 9a	1-1	No	Yes	No	No	No	No	0	0	0
South Plants Tank Farm Subgroup	SPSA - 2a	1-10	Yes	No	No	No	Yes	No	0	11	0
	SPSA - 2b	1-9	No	No	No	No	No	No	0	2	0
South Plants Balance of Areas Subgroup	SPSA - 1b	1-3	Yes	Yes	Yes	No	No	No	0	6	0
	SPSA - 1c	1-5	No	No	No	No	No	No	0	1	0
	SPSA - 1g	1-13	Yes	Yes	Yes	Yes	Yes	No	unknown	59	0

Table B.7-1 Summary of Qualitative Assessment Results for Feasibility Study Action SAR Sites

Medium Group or Subgroup	SAR Site	CAR Site	Agent			Unexploded Ordnance			Number of Drums	Number Structures	Number of USTs
			Potential	Sampled	Detected	Potential	Sampled	Detected			
	SPSA - 2c	1-8	No	No	No	No	No	No	unknown	5	0
	SPSA - 2e	1-13	Yes	Yes	Yes	Yes	Yes	No	unknown	2	0
	SPSA - 3b	2-6	Yes	Yes	Yes	No	No	No	unknown	1	0
	SPSA - 3c	2-8	Yes	Yes	No	No	Yes	No	0	16	0
	SPSA - 3d	2-12	No	Yes	No	No	Yes	No	0	3	0
	SPSA - 3e	2-18	Yes	Yes	Yes	Yes	Yes	No	unknown	27	0
	SPSA - 4b	2-9, -18	No	Yes	No	No	No	No	0	33	0
	SPSA - 5b	1-11	No	Yes	No	No	Yes	No	0	24	0
	SPSA - 7b	2-3	No	Yes	No	No	Yes	No	0	0	0
	SPSA - 7c	2-2, -4, -13, -14	No	Yes	No	Yes	Yes	No	0	2	0
	SPSA - 8a	2-14A	No	Yes	No	No	Yes	No	44	0	0
	SPSA - 9b	1-4, -6	No	No	No	No	No	No	0	1	0
	SPSA - 12b	2-7	No	Yes	No	No	No	No	0	0	0
	SPSA - 12c	2-UNC	No	Yes	No	No	No	No	0	0	0
Buried Sediments Subgroup											
	SSA - 3a	11-1	No	Yes	No	No	No	No	0	0	0
	SSA - 3b	12-1	No	Yes	No	No	No	No	0	0	0
Sand Creek Lateral Subgroup											
	NCSA - 5b	35-4	Yes	Yes	Yes	No	No	No	0	0	0
	NCSA - 5c	35-NSA	No	No	No	No	No	No	0	0	0
	NPSA - 4	25-2	Yes	Yes	Yes	No	Yes	No	unknown	1	0
	SSA - 2b	2-1	No	Yes	No	No	No	No	0	0	0
	WSA - 6a	4-6	No	Yes	No	No	Yes	No	0	5	0

Table B.7-1 Summary of Qualitative Assessment Results for Feasibility Study Action SAR Sites

Medium Group or Subgroup	SAR Site	CAR Site	Agent			Unexploded Ordnance			Number of Drums	Number Structures	Number of USTs
			Potential	Sampled	Detected	Potential	Sampled	Detected			
Section 36 Balance of Areas Subgroup											
	CSA - 1b	36-14, -16, 17	Yes	Yes	Yes	Yes	Yes	Yes	unknown	3	0
	CSA - 2a	36-2	Yes	Yes	Yes	Yes	Yes	Yes	1	1	0
	CSA - 4	36-2, -12, -19	Yes	Yes	Yes	Yes	Yes	Yes	1	9	0
Burial Trenches Subgroup											
	ESA - 2a	32-5, -6	Yes	Yes	Yes	Yes	Yes	No	1200	0	0
	ESA - 2c	30-6	Yes	Yes	Yes	Yes	Yes	Yes	1	0	0

CAR contamination assessment report

SAR study area report

USTs underground storage tanks

Table B.7-2 Summary of Qualitative Assessment Results for Feasibility Study No Action SAR Sites

SAR Site	CAR Site (1)	Site Type	Agent			Unexploded Ordnance			Number of Drums	Number Structures	Number of USTs
			Potential	Sampled	Detected	Potential	Sampled	Detected			
ESA - 3j	31-7	storage	Yes	Yes	No	No	No	No	0	0	0
ESA - 3k	31-NSA	pit	Yes	No	No	No	No	No	0	0	0
ESA - 4c	29-2	trench	Yes	Yes	No	Yes	Yes	No	0	0	0
ESA - 5	30-5	munition disposal	No	Yes	Yes	No	Yes	No	2	2	0
ESA - 6a	6-NSA	NSA	Yes	Yes	No	Yes	Yes	No	0	0	0
ESA - 6b	30-1	NSA	No	Yes	Yes	Yes	Yes	No	0	0	0
ESA - 6d	20-2	NSA	No	No	No	Yes	Yes	No	0	0	0
NCSA - 2c	26-5	basin	Yes	Yes	Yes	No	No	No	0	0	0
NCSA - 8c	34-NSA	NSA	No	No	No	No	No	No	0	1	0
NCSA - 9a	23-NSA	NSA	No	Yes	Yes	No	Yes	No	0	0	0
NCSA - 9b	23-NSA	NSA	No	Yes	No	No	Yes	No	0	0	0
NCSA - 9c	23-NSA	NSA	No	Yes	No	No	Yes	No	0	0	0
NCSA - 9d	23-NSA	NSA	No	Yes	No	No	Yes	No	0	0	0
NCSA - 9e	24-NSA	NSA	No	Yes	No	No	Yes	No	0	0	0
NCSA - 9f	25-NSA	NSA	No	Yes	No	No	Yes	No	0	0	0
NCSA - 9g	26-NSA	NSA	No	Yes	No	No	Yes	No	0	0	0
NCSA - 9h	26-NSA	NSA	No	Yes	No	No	Yes	No	0	0	0
NCSA - 9i	26-NSA	NSA	No	Yes	No	No	Yes	No	0	0	0
NCSA - 9j	26-NSA	NSA	No	Yes	No	No	Yes	No	0	0	0
NCSA - 9k	26-NSA	NSA	No	Yes	No	No	Yes	No	0	0	0
NCSA - 9l	27-NSA	NSA	No	No	No	No	No	No	0	0	0
NCSA - 9m	35-6	firing range	No	No	No	Yes	Yes	No	0	0	0
NCSA - 9n	35-NSA	NSA	No	No	No	No	No	No	0	0	0
NCSA - 9o	35-9	NSA	No	No	No	No	No	No	0	0	0
NCSA - 9p	35-7	NSA	Yes	No	No	Yes	Yes	No	0	0	0
NCSA - 9q	36-10	NSA	No	Yes	No	No	No	No	0	0	0
NCSA - 9r	36-10	NSA	No	Yes	No	No	No	No	0	0	0
NCSA - 9s	36-NSA	NSA	Yes	Yes	No	Yes	No	No	0	0	0

Table B.7-2 Summary of Qualitative Assessment Results for Feasibility Study No Action SAR Sites

SAR Site	CAR Site (1)	Site Type	Agent			Unexploded Ordnance			Number of Drums	Number Structures	Number of USTs
			Potential	Sampled	Detected	Potential	Sampled	Detected			
NPSA - 2	25-NSA	tanks	No	Yes	No	No	Yes	No	0	6	0
NPSA - 7	25-NSA	spill	No	Yes	No	No	Yes	No	0	0	0
NPSA - 8a	25-NSA	ditch	No	Yes	No	No	Yes	No	0	0	0
NPSA - 8b	25-NSA	ditch	No	Yes	No	No	Yes	No	0	0	0
NPSA - 9a	25-NSA	NSA	No	Yes	No	No	Yes	No	0	0	0
NPSA - 9b	25-NSA	NSA	No	Yes	No	No	Yes	No	0	0	0
NPSA - 9c	25-NSA	NSA	No	Yes	No	No	Yes	No	0	0	0
NPSA - 9d	25-NSA	NSA	No	Yes	No	No	Yes	No	0	0	0
NPSA - 9e	25-NSA	NSA	No	Yes	No	No	Yes	No	0	0	0
SPSA - 6	1-7	manuf area	No	No	No	Yes	Yes	No	unknown	18	1
SPSA - 7a	2-1	ditch	No	Yes	No	No	No	No	0	0	0
SPSA - 8c	2-10, -11	manuf area	No	No	No	No	No	No	0	0	0
SSA - 1a	6-2	lake	No	Yes	No	No	No	No	0	0	0
SSA - 1d	12-2	lake	No	No	No	No	No	No	0	0	0
SSA - 1f	2-17	lake	No	No	No	No	No	No	0	0	0
SSA - 5a	1-NSA	NSA	No	Yes	No	No	No	No	0	0	0
SSA - 5c	11-NSA	NSA	No	Yes	No	No	No	No	0	0	0
SSA - 5d	11-NSA	NSA	No	Yes	No	No	No	No	0	0	0
SSA - 5e	11-NSA	ditch	No	Yes	No	No	No	No	0	0	0
WSA - 1a	3-NSA	NSA	No	Yes	No	No	No	No	0	0	0
WSA - 1b	3-NSA	spill	No	Yes	No	No	No	No	0	1	0
WSA - 1c	3-NSA	spill	No	Yes	No	No	No	No	0	0	0
WSA - 1d	3-NSA	NSA	No	Yes	No	No	No	No	0	0	0
WSA - 1e	3-4	spill	No	Yes	No	No	Yes	No	0	0	0
WSA - 1g	3-NSA	NSA	No	Yes	No	No	No	No	0	0	0
WSA - 3a	4-3	landfill	No	Yes	No	No	Yes	No	0	0	0
WSA - 3b	4-3	landfill	No	Yes	No	No	Yes	No	0	0	0
WSA - 3d	4-3	landfill	No	Yes	No	No	Yes	No	0	0	0

Table B.7-2 Summary of Qualitative Assessment Results for Feasibility Study No Action SAR Sites

SAR Site	CAR Site (1)	Site Type	Agent			Unexploded Ordnance			Number of Drums	Number Structures	Number of USTs
			Potential	Sampled	Detected	Potential	Sampled	Detected			
WSA - 4a	4-4	storage	No	Yes	No	No	Yes	No	0	0	0
WSA - 4b	4-4	storage	No	Yes	No	No	Yes	No	0	0	0
WSA - 5b	4-5	landfill	Yes	Yes	No	No	Yes	No	0	0	0
WSA - 6b	4-6	storage	No	Yes	No	No	Yes	No	0	3	0
WSA - 6c	4-6	sewer	No	Yes	No	No	Yes	No	0	1	0
WSA - 6d	4-6	ditch	No	Yes	No	No	Yes	No	0	1	0
WSA - 6e	4-6	ditch	No	Yes	No	No	Yes	No	0	0	0
WSA - 7b	34-2	sewer	No	No	No	No	No	No	0	1	0
WSA - 8a	33-NSA	NSA	No	Yes	No	No	No	No	0	0	0
WSA - 8b	33-NSA	NSA	No	Yes	No	No	No	No	0	0	0
WSA - 8c	3-NSA	NSA	No	Yes	No	No	No	No	0	0	0
WSA - 8d	4-NSA	NSA	No	Yes	No	No	No	No	0	0	0
WSA - 8e	4-NSA	NSA	No	Yes	No	No	No	No	0	0	0
WSA - 8f	9-NSA	NSA	No	Yes	No	No	No	No	0	0	0

1) Results for non-source area CARs not containing SAR sites are not included.

CAR contamination assessment report

SAR study area report

USTs underground storage tanks

APPENDIX B
(SECTION B.8)

DETERMINISTIC PARAMETERS CORRESPONDING TO 5th AND 50th PERCENTILE PPLVs

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B.8-2 Example Input Parameter Values That Lead to 5th and 50th Percentile Direct Carcinogenic PPLVs for Aldrin, Commercial Worker

B.8-3 Example Input Parameter Values That Lead to 5th and 50th Percentile Direct Carcinogenic PPLVs for Aldrin, Industrial Worker

LIST OF ACRONYMS AND ABBREVIATIONS

EPA	U.S. Environmental Protection Agency
HHRC	Human health risk characterization
IEA/RC	Integrated Endangerment Assessment/Risk Characterization
LSH	Latin Hypercube sampling
PPLV	Preliminary pollutant limit value
RAF	Relative absorption factor
SI	Soil ingestion

B.8.1 INTRODUCTION

In the Integrated Endangerment Assessment/Risk Characterization (IEA/RC), direct Preliminary Pollutant Limit Values (PPLVs) are calculated using a probabilistic Latin Hypercube analysis. Thus, an infinite number of deterministic parameter combinations could be used to calculate the 5th or 50th percentile direct PPLV values. This appendix section presents three deterministic combinations of parameters that correspond to the 5th and 50th percentile cumulative direct PPLVs for aldrin at a 10^{-6} cancer risk level. Aldrin was chosen for analysis, because it is identified as a risk-driver, based on the Human health risk characterization (HHRC) results.

In this appendix section, combinations of deterministic parameters are presented for the biological, commercial, and industrial worker receptors. Similar scenarios were not generated for the recreational and regulated/casual visitor receptors because the intermediate HHRC output files necessary to generate this information would require far more on-line data-storage capacity than is available on the HHRC code, due to the use of age-dependent probabilistic parameters for these receptor groups.

The procedures and results of this analysis are described below. Results are also summarized in Tables B.8-1, B.8-2, and B.8-3.

B.8.2 METHODS

Deterministic parameters corresponding to 5th and 50th percentile direct PPLVs were identified for biological, commercial, and industrial workers. For each of these populations, three possible combinations of deterministic parameters were identified for the corresponding 5th and 50th percentile PPLVs. These parameter values were derived from intermediate output files generated by the HHRC program.

B.8.2.1 Case A: Stratified Random Selection of Deterministic Parameters

The first set of parameter values, Case A, represents a likely combination based on the probability of each parameter being selected from its respective distribution, using stratified random sampling methods under a Latin Hypercube Sampling (LHS) routine. This case was chosen to represent a random (though stratified) selection of deterministic parameters.

To estimate the deterministic parameters under Case A, 100 direct PPLVs (one for each LHS sample) were calculated under the HHRC code. The set of parameter values corresponding to the 5th and 50th percentile direct PPLVs (i.e., the 6th and 51st lowest direct PPLVs) were then used to represent the Case A exposure parameter values.

B.8.2.2 Case B: Use of Maximum Oral and Dermal RAFs

The second set of parameter values, Case B, represents a combination which could occur if the dermal and oral relative absorption factors (RAFs) were equal to their maximum distributed values. These parameters were chosen because their variability was identified in the sensitivity analysis (Appendix Section B.5) as having a relatively large influence on the probabilistic PPLV results. Both the oral and the dermal RAFs were fixed at their maximum distributed values to represent a worst case approach for these parameters.

To estimate the deterministic parameters under Case B, the RAF dermal and RAF oral parameter values from each of the 100 LHS samples described above in Section B.8.2.1 were replaced by their maximum distribution values of 0.0052 and 0.65, respectively. All other parameter values were left unchanged. The 100 direct PPLVs were then re-calculated. The set of parameters corresponding to the value which most closely matched the 5th percentile PPLV from Case A was used to represent Case B, 5th percentile. The set of parameters corresponding to the value which most closely matched the 50th percentile PPLV from Case A was used to represent Case B, 50th percentile.

B.8.2.3 Use of 95th Percentile Soil Ingestion Values

The third set of parameter values, Case C, represents a combination which could occur if the soil ingestion (SI) parameter were equal to its 95th percentile value. This case was chosen because the variability in soil ingestion was identified in the sensitivity analysis (Appendix Section B.5) as having a large impact on the probabilistic PPLVs. The 95th percentile value was chosen because it represents an upperbound exposure value.

Because the soil ingestion parameter is population-specific, the 95th percentile values varied among the worker populations. For the biological worker, the 95th percentile soil ingestion value is 106 mg/day, and for the commercial worker, the value is 33 mg/day. For the industrial worker, the 95th percentile value is 50 mg/day, which corresponds to the reasonable maximum worker exposure parameter specified by the U.S. Environmental Protection Agency (EPA) in its Standard Default Exposure Factors (EPA, 1991).

Case C parameter sets for the 5th and 50th percentile direct PPLVs were calculated in the same way as the sets in Case B, except in instead of fixing the RAF parameters, the soil ingestion (SI) parameter values from each of the 100 LHS samples were replaced by their 95th percentile values. The RAF values and all other distributed parameters were left with their randomly generated values.

B.8.3 RESULTS AND CONCLUSIONS

The results of this evaluation are provided in Tables B.8-1, B.8-2, and B.8-3 for the biological, commercial, and industrial worker populations, respectively. These results should be interpreted with caution, as they represent three exposure possibilities out of an infinite number of exposure scenarios. It should also be kept in mind that the results presented here are exclusively for aldrin. For any worker populations, results for each chemical of concern will differ, due to the influence of the chemical-specific parameters, such as RAF and the toxicity criteria.

B.8.4 REFERENCES

RTIC 92232R03

EPA. 1991. Human Health Evaluation Manual, Supplemental Guidance: "Standard Default Exposure Factors." Office of Solid Waste and Emergency Response. Directive No. 9285.6-03. March 25, 1991.

Table B.8-1. Example Input Parameter Values That Lead to 5th and 50th Percentile Direct Carcinogenic PPLVs for Aldrin, Biological Worker[1/2/3]

	50th Percentile			5th Percentile		
	Case A: Random	Case B: Max RAFs	Case C: 95% SI	Case A: Random	Case B: Max RAFs	Case C: 95% SI
			Distributed Input Parameters [4/]			
Exposure Duration, TE (Years)	1.30E+00	9.17E+00	2.16E+00	1.16E+01	1.75E+01	1.20E+01
Percentile:	5	61	23	73	92	75
Soil Ingestion, SI (mg/day)	1.57E+02	10.7E+01	1.06E+02	9.06E+01	4.87E+01	1.06E+02
Percentile:	98	8	95	92	73	95
RAF, Dermal (unitless)	2.33E-03	5.20E-03	4.96E-03	3.78E-03	5.20E-03	1.06E-03
Percentile:	37	99	94	68	99	9
Soil Covering, SC (mg/cm^3)	2.41E-01	3.30E-01	4.94E-01	2.55E-01	2.86E-01	4.76E-01
Percentile:	18	41	74	22	30	71
RAF, Oral (unitless)	5.49E-01	6.50E-01	4.26E-01	5.90E-01	6.50E-01	5.10E-01
Percentile:	74	99	43	84	99	64
Exposure Frequency, DW (days/year)	2.23E+02	2.14E+02	2.14E+02	2.20E+02	2.20E+02	2.12E+02
Percentile	40	13	13	29	29	9
Dust Loading Factor, CSS (mg/m^3)	6.30E-02	3.44E-02	2.21E-02	2.99E-02	8.10E-02	5.50E-02
Percentile:	68	26	7	18	82	59
			Fixed Input Parameters			
Exposure Time, TM (hours/day)	8.00E+00	8.00E+00	8.00E+00	8.00E+00	8.00E+00	8.00E+00
Bodyweight, BW (kg)	67.8	67.8	67.8	67.8	67.8	67.8
Tox. Value, Ingestion (mg/kg/day)	5.90E-08	5.90E-08	5.90E-08	5.90E-08	5.90E-08	5.90E-08
Breathing Rate, BR (m^3/hour)	2.1	2.1	2.1	2.1	2.1	2.1

Table B.8-1. Example Input Parameter Values That Lead to 5th and 50th Percentile Direct Carcinogenic PPLVs for Aldrin, Biological Worker[1/2/3]

	50th Percentile			5th Percentile		
	Case A: Random	Case B: Max RAFs	Case C: 95% SI	Case A: Random	Case B: Max RAFs	Case C: 95% SI
Tox. Value, Inhalation (mg/kg/day)	5.90E-08	5.90E-08	5.90E-08	5.90E-08	5.90E-08	5.90E-08
Fraction Retained, FR (unitless)	0.85	0.85	0.85	0.85	0.85	0.85
Skin Surface Area, SSA (cm^2)	3270	3270	3270	3270	3270	3270
			Single Exposure Pathway PPLVs (mg/kg)			
SPPPLV, dermal	1.94E+02	9.41E+00	2.79E+01	1.30E+01	5.53E+00	2.46E+01
Percentile:	91	49	54	31	20	50
SPPPLV, ingestion	4.15E+00	7.61E+00	4.95E+00	7.64E-01	8.50E-01	7.53E-01
Percentile:	41	68	77	5	9	23
SPPPLV, inhalation	3.98E+02	1.07E+02	7.06E+02	9.56E+01	2.33E+01	5.18E+01
Percentile	80	49	94	43	8	24
			Cumulative Direct PPLVs (mg/kg)			
PPLV, cumulative direct	4.02E+00	4.05E+00	4.18E+00	7.16E-01	7.14E-01	7.21E-01

1/ PPLVs are soil concentrations corresponding to a 10^{-6} risk level, based on biological worker exposure to soil via the ingestion, particulate inhalation, and dermal contact pathways.

2/ Case A = Set of parameter values representing a likely combination based on parameter distributions.
Case B = Set of parameter values with RAF_{dermal} and RAF_{oral} equal to their maximum values of 0.0052 and 0.65 respectively.
Case C = Set of parameters with soil ingestion equal to its 95th percentile value of 106 mg/day.

3/ Exposure and toxicity parameters listed here are discussed in detail in Appendix Sections B.1 and B.3

4/ Distributed input parameter percentiles were approximated by ranking the 100 LHS sample values for each parameter, respectively. The input parameters were given percentile values corresponding to their ranking order. For example, a percentile value of 10 would indicate that the corresponding parameter was the 11th smallest out of 100 LHS sample values. Because the LHS sampling routine uses stratified random sampling, duplicates in LHS sample values for a given parameter can occur when the original parameter distributions are relatively steep and narrow. When a parameter value appeared more than once in the LHS sample, the lowest percentile value was used. See Appendix Section E.8.2 for more information on the LHS sampling process.

Table B.8-2. Example Input Parameter Values That Lead to 5th and 50th Percentile Direct Carcinogenic PPLVs for Aldrin, Commercial Worker [1/2/3/]

	50th Percentile			5th Percentile		
	Case A: Random	Case B: Max RAFs	Case C: 95% SI	Case A: Random	Case B: Max RAFs	Case C: 95% SI
			Distributed Input Parameters [4/]			
Exposure Duration, TE (Years)	2.54E+00	1.31E+00	9.59E-01	8.97E+00	6.96E+00	7.32E+00
Percentile:	53	30	21	88	83	84
Soil Ingestion, SI (mg/day)	6.14E+00	1.19E+01	3.30E+01	2.50E+01	1.84E+01	3.30E+01
Percentile:	25	59	95	89	80	95
RAF, Dermal (unitless)	4.21E-03	5.20E-03	2.46E-03	2.12E-03	5.20E-03	4.06E-03
Percentile:	78	99	40	32	99	75
Soil Covering, SC (mg/cm^3)	5.16E-02	6.34E-02	9.24E-02	6.04E-02	6.92E-02	4.77E-02
Percentile:	37	70	99	62	82	27
RAF, Oral (unitless)	6.34E-01	6.50E-01	3.41E-01	4.02E-01	6.50E-01	3.91E-01
Percentile:	96	99	22	37	99	35
Exposure Frequency, DW (days/year)	2.37E+02	2.36E+02	2.41E+02	2.39E+02	2.38E+02	2.37E+02
Percentile	52	38	93	78	66	52
Dust Loading Factor, CSS (mg/m^3)	5.08E-03	9.20E-03	3.23E-03	2.45E-03	3.81E-03	4.03E-03
Percentile:	56	88	27	14	37	41
Exposure Time, TM (hours/day)	3.39E+00	5.43E+00	6.66E+00	4.84E+00	6.09E+00	9.01E+00
Percentile:	14	27	40	21	34	68
			Fixed Input Parameters			
Bodyweight, BW (kg)	68.7	68.7	68.7	68.7	68.7	68.7
Tox. Value, Ingestion (mg/kg/day)	5.90E-08	5.90E-08	5.90E-08	5.90E-08	5.90E-08	5.90E-08

Table B.8-2. Example Input Parameter Values That Lead to 5th and 50th Percentile Direct Carcinogenic PPLVs for Aldrin, Commercial Worker [1/2/3/]

	50th Percentile			5th Percentile		
	Case A: Random	Case B: Max RAFs	Case C: 95% SI	Case A: Random	Case B: Max RAFs	Case C: 95% SI
Breathing Rate, BR (m^3/hour)	0.83	0.83	0.83	0.83	0.83	0.83
Tox. Value, Inhalation (mg/kg/day)	5.90E-08	5.90E-08	5.90E-08	5.90E-08	5.90E-08	5.90E-08
Fraction Retained, FR (unitless)	0.85	0.85	0.85	0.85	0.85	0.85
Skin Surface Area, SSA (cm^2)	1550	1550	1550	1550	1550	1550
			Single Exposure Pathway PPLVs (mg/kg)			
SPPPLV, dermal	5.12E+02	6.54E+02	1.27E+03	2.43E+02	1.12E+02	1.99E+02
Percentile:	32	68	68	12	13	8
SPPPLV, ingestion	4.42E+01	4.33E+01	3.99E+01	4.81E+00	5.23E+00	4.64E+00
Percentile:	51	63	85	5	13	20
SPPPLV, inhalation	1.22E+04	9.48E+03	2.95E+04	5.76E+03	3.82E+03	2.33E+03
Percentile	56	47	79	34	26	20
			Cumulative Direct PPLVs (mg/kg)			
PPLV, cumulative direct	4.06E+01	4.04E+01	3.86E+01	4.71E+00	4.99E+00	4.53E+00

1/ PPLVs are soil concentrations corresponding to a 10^{-6} risk level, based on commercial worker exposure to soil via the ingestion, particulate inhalation, and dermal contact pathways.

2/ Case A = Set of parameter values representing a likely combination based on parameter distributions.
Case B = Set of parameter values with RAF_{dermal} and RAF_{oral} equal to their maximum values of 0.0052 and 0.65, respectively.
Case C = Set of parameters with soil ingestion equal to its 95th percentile value of 33 mg/day.

3/ Exposure and toxicity parameters listed here are discussed in detail in Appendix Sections B.1 and B.3

4/ Distributed input parameter percentiles were approximated by ranking the 100 LHS sample values for each parameter, respectively. The input parameters were given percentile values corresponding to their ranking order. For example, a percentile value of 10 would indicate that the corresponding parameter was the 11th smallest out of 100 LHS sample values. Because the LHS sampling routine uses stratified random sampling, duplicates in LHS sample values for a given parameter can occur when the original parameter distributions are relatively steep and narrow. When a parameter value appeared more than once in the LHS sample, the lowest percentile value was used. See Appendix Section E.8.2 for more information on the LHS sampling process.

Table B.8-3. Example Input Parameter Values That Lead to 5th and 50th Percentile Direct Carcinogenic PPLVs for Aldrin, Industrial Worker [1/2/3/]

	50th Percentile			5th Percentile		
	Case A: Random	Case B: Max RAFs	Case C: 95% SI	Case A: Random	Case B: Max RAFs	Case C: 95% SI
			Distributed Input Parameters [4/]			
Exposure Duration, TE (Years)	1.51E+00	1.83E+00	1.32E+00	1.36E+01	7.84E+00	4.94E+00
Percentile:	35	41	30	94	86	74
Soil Ingestion, SI (mg/day)	2.23E+01	1.51E+01	5.00E+01	1.22E+01	1.26E+01	5.00E+01
Percentile:	74	57	95	46	48	95
RAF, Dermal (unitless)	4.49E-03	5.20E-03	3.03E-03	3.27E-03	5.20E-03	9.24E-04
Percentile:	84	99	52	57	99	6
Soil Covering, SC (mg/cm^3)	4.74E-01	3.42E-01	4.11E-01	6.79E-01	5.93E-01	8.80E-01
Percentile:	51	26	39	79	70	91
RAF, Oral (unitless)	5.36E-01	6.50E-01	3.65E-01	2.68E-01	6.50E-01	5.77E-01
Percentile:	71	99	28	4	99	81
Exposure Frequency, DW (days/year)	2.38E+02	2.37E+02	2.34E+02	2.34E+02	2.37E+02	2.36E+02
Percentile	66	53	15	15	53	38
Dust Loading Factor, CSS (mg/m^3)	2.09E-02	1.52E-02	2.40E-02	1.33E-02	1.20E-02	3.39E-02
Percentile:	51	28	61	20	15	82
Exposure Time, TM (hours/day)	3.18E+00	2.17E+00	4.67E+00	1.07E+01	1.04E+01	6.06E+00
Percentile:	9	5	19	83	81	33
			Fixed Input Parameters			
Bodyweight, BW (kg)	68.7	68.7	68.7	68.7	68.7	68.7
Tox. Value, Ingestion (mg/kg/day)	5.90E-08	5.90E-08	5.90E-08	5.90E-08	5.90E-08	5.90E-08

Table B.8-3. Example Input Parameter Values That Lead to 5th and 50th Percentile Direct Carcinogenic PPLVs for Aldrin, Industrial Worker [1/2/3/]

	50th Percentile			5th Percentile		
	Case A: Random	Case B: Max RAFs	Case C: 95% SI	Case A: Random	Case B: Max RAFs	Case C: 95% SI
Breathing Rate, BR (m^3/hour)	2.1	2.1	2.1	2.1	2.1	2.1
Tox. Value, Inhalation (mg/kg/day)	5.90E-08	5.90E-08	5.90E-08	5.90E-08	5.90E-08	5.90E-08
Fraction Retained, FR (unitless)	0.85	0.85	0.85	0.85	0.85	0.85
Skin Surface Area, SSA (cm^2)	3270	3270	3270	3270	3270	3270
			Single Exposure Pathway PPLVs (mg/kg)			
SPPPLV, dermal	4.15E+01	4.12E+01	8.22E+01	4.50E+00	5.52E+00	3.34E+01
Percentile:	46	67	61	3	11	38
SPPPLV, ingestion	2.42E+01	2.44E+01	1.83E+01	9.96E+00	6.82E+00	3.08E+00
Percentile:	45	56	73	17	19	16
SPPPLV, inhalation	2.44E+03	4.07E+03	1.67E+03	1.29E+02	2.50E+02	2.42E+02
Percentile	83	90	70	9	24	23
			Cumulative Direct PPLVs (mg/kg)			
PPLV, cumulative direct	1.52E+01	1.53E+01	1.48E+01	3.02E+00	3.01E+00	2.79E+00

1/ PPLVs are soil concentrations corresponding to a 10^{-6} risk level, based on industrial worker exposure to soil via the ingestion, particulate inhalation, and dermal contact pathways.

2/ Case A = Set of parameter values representing a likely combination based on parameter distributions.
Case B = Set of parameter values with RAF_{dermal} and RAF_{oral} equal to their maximum values of 0.0052 and 0.65 respectively.
Case C = Set of parameter with soil ingestion equal to its 95th percentile value of 106 mg/day.

3/ Exposure and toxicity parameters listed here are discussed in detail in Appendix Sections B.1 and B.3

4/ Distributed input parameter percentiles were approximated by ranking the 100 LHS sample values for each parameter, respectively. The input parameters were given percentile values corresponding to their ranking order. For example, a percentile value of 10 would indicate that the corresponding parameter was the 11th smallest out of 100 LHS sample values. Because the LHS sampling routine uses stratified random sampling, duplicates in LHS sample values for a given parameter can occur when the original parameter distributions are relatively steep and narrow. When a parameter value appeared more than once in the LHS sample, the lowest percentile value was used. See Appendix Section E.8.2 for more information on the LHS sampling process.

APPENDIX C
(SECTION C.1)

COMPUTATIONAL METHODOLOGY

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LIST OF ACRONYMS AND ABBREVIATIONS

ARAR	applicable or relevant and appropriate requirement
Army	U.S. Department of the Army
AWQC	ambient water quality criteria
BAF	bioaccumulation factor
BCRL	below certified reporting limit
BMFs	biomagnification factors
CMP	comprehensive monitoring program
COCs	contaminant of concerns
C_{ow}	average exposure area water concentration of contaminant
CPMS	chlorophenylmethyl sulfide
$CPMSO_2$	chlorophenylmethyl sulfone
C_{rep}	representative site concentration
CRL	certified reporting limit
C_{sed}	average exposure area sediment concentration of contaminant
C_w	contaminant concentration in surface water
DBCP	dibromochloropropane
DCPD	dicyclopentadiene
DDE	dichlorodiphenyldichloroethene
DDT	dichlorodiphenyltrichloroethane
EPA	U.S. Environmental Protection Agency
ERC	Ecological Risk Characterization
ESC	average exposure area soil concentration of contaminant
<ESC>	estimated average exposure area soil concentration of contaminant
FR	dietary fraction
FS	Feasibility Study
ft	foot/feet
ft^2	feet square
ha	hectares
HHRC	Human Health Risk Characterization
HI	hazard index
HQ	Hazard Quotient
IEA/RC	Integrated Endangerment Assessment/Risk Characterization
kg/kg-bw/day	kilograms per kilogram of body weight per day
LT	less than
MATC	maximum allowable tissue concentration (micrograms contaminant in tissue per gram body weight)
NOAELs	no observed adverse effects levels
NPL	National Priority List
QA/QC	quality assurance/quality control
ppm	parts per million
R	feed rate (kilogram food per kilogram body weight per day)

LIST OF ACRONYMS AND ABBREVIATIONS
(continued)

RI	Remedial Investigation
RI/FS	Remedial Investigation/Feasibility Study
RMA	Rocky Mountain Arsenal
SAR	Study Area Report
Shell	Shell Oil Company
TC	tissue concentration
TPC	tissue partitioning coefficient
TRV	toxicity reference value (microgram ingested per gram body weight per day)
UFs	uncertainty factor(s)
WASP	Water Quality Analysis Simulation Program

C.1 COMPUTATIONAL METHODOLOGY

C.1.1 INTRODUCTION

To characterize risk to the diverse plants and animals at Rocky Mountain Arsenal (RMA) from the contaminants present as a result of human activities on the site, it was first necessary to select the contaminants of concern (COCs) for biota from among those present and to identify the receptors potentially exposed to those contaminants. The COCs were selected using a set of criteria that evaluated their toxicity and the likelihood of receptors being exposed to them. The receptors were identified as representatives of important food webs that interrelate the biota on RMA in a matrix of predator and prey relationships.

Potential risk to the identified receptors was characterized by estimating the concentrations to which they were exposed and their resulting tissue concentrations and then comparing these measured or predicted site-specific tissue concentrations to toxicological threshold values. This general strategy was implemented as shown in Figure C.1-1, using two basic approaches, a tissue-based approach and a dose-based approach. To calculate potential risk for a particular trophic box and chemical combination, measurements of its tissue concentration were compared to its maximum allowable tissue concentration (MATC); measurements of the tissue concentration in its daily food (and soil/sediment and water) intake were compared to its toxicity reference value (TRV). The estimation of tissue concentrations was necessary in three situations: (1) for terrestrial prey species because soil concentrations are variable across RMA and tissue concentrations were not measured at all locations; (2) for top-level predator trophic boxes (i.e., bald eagle, great horned owl, American kestrel, and great blue heron) because tissue concentrations were not measured anywhere on site for these species; and (3) for aquatic trophic boxes where tissue concentration data for specific trophic box/chemical combinations were missing.

In the first situation, the potential exposure among individuals within a given trophic box varies because the concentrations of COCs in soil vary markedly across RMA. The potential exposure among different trophic boxes varies still more because the size of the exposure area for the trophic boxes varies. The measured tissue concentrations of prey species collected from RMA

are the best available representation of the results of exposing an organism to the variety of soil concentrations at RMA. The mean ratio of these tissues to the "exposure area soil concentration" (ESC) is the biomagnification factor (BMF). Measured tissue concentrations and their associated estimated exposure area soil concentrations (<ESC>s) were used to define a sample BMF distribution for each trophic box/chemical combination. The mean value from this distribution was then used to estimate tissue concentrations associated with trophic box-specific <ESC> values calculated for locations 100 feet apart all across RMA. Three different approaches for defining the BMF distribution are used in this document (Army's, Shell's, and EPA's).

In the second situation, where tissue concentrations for predators are lacking, doses to predator from the estimated tissue concentrations in their food (and soil/sediment and water) can be calculated; this is the dose-based approach. This is done using the prey tissue concentrations estimated above and weighted as to the proportion of the daily diet they comprise; however, to make this dose specific to exposure incurred across RMA, it must be predicted from BMF and <ESC> values at specified locations and adjusted for daily food intake (R). Risk is then based on a comparison of dose to the dose-based toxicity threshold (i.e., TRV). Alternatively, the tissue concentration in a predator (rather than in its food) can be calculated from <ESC> and the predator's BMF calculated by multiplying its bioaccumulation factor (BAF) by its dose from food. The BAF is needed to convert prey BMF to predator BMF because BAF is defined as the ratio of tissue concentrations between a predator and its food. Risk in this case is based on a comparison of tissue concentration to the tissue-based toxicity threshold (i.e., MATC). Again, these calculations can be made for locations 100 feet apart all across RMA.

In the third situation, which applies to aquatic trophic boxes, exposure is to relatively homogeneous concentrations in water. Therefore, the variability of exposure across RMA, other than by lake, is not an issue. Further, because risk could be evaluated only for highly mobile aquatic receptors (e.g., birds) for reasons explained below, even the variability among lakes is not an issue, since a given bird could readily feed at all RMA lakes and was therefore exposed to an average of their contaminants.

The remainder of Appendix Section C.1 is devoted to providing methodological detail on the selection of COCs (Appendix Section C.1.2), identification of target biota receptors (Appendix Section C.1.3), calculation of exposure concentrations (Appendix Section C.1.4), development of BMF (Appendix Section C.1.5), and on the calculation of potential risk from this information (Appendix Section C.1.6). The final discussion (Appendix Section C.1.7) summarizes the quantitative uncertainty analysis that was performed on this overall approach.

C.1.2 SELECTION AND EVALUATION OF ECOLOGICAL RISK CHARACTERIZATION CHEMICALS

The COCs for which ecological risk was characterized were selected in two stages. Initially, seven COCs were selected that had also been identified in both the Biota Remedial Investigation (RI) (ESE 1989) and Biota Comprehensive Monitoring Program (CMP) (RLSA 1992) reports as chemicals that were the most widespread, bioaccumulative, persistent, and most toxic among the chemicals known to be present at RMA. These COCs were the target analytes for biota tissue samples analyzed under these programs, as well as under the ERC, and thus tissue concentrations are available for them. These initial seven COCs are aldrin, dieldrin, endrin, dichlorodiphenyltrichloroethane (DDT), dichlorodiphenyldichloroethene (DDE), arsenic, and mercury. For the purposes of modeling and risk characterization, aldrin was combined with dieldrin, and DDT with DDE because the first (parent) compound in each pair is readily metabolized to the second. With the exception of arsenic, each of the seven COCs bioaccumulates substantively.

During the ERC, Phase II RI data became available and were used to reevaluate the areal extent of chemicals given less importance in the Biota RI because they had been detected in fewer than 5 acres on RMA. As a result of this reevaluation, seven additional contaminants were added to the list of COCs: cadmium, chlordane, chlorophenylmethyl sulfide (CPMS), chlorophenylmethyl sulfone ($CPMSO_2$), copper, dibromochloropropane (DBCP), and dicyclopentadiene (DCPD). Except for chlordane, these contaminants are generally considered nonbioaccumulative. Chlordane is a chlorinated hydrocarbon insecticide that can potentially accumulate in lipid-containing tissue following prolonged exposure to low concentrations in contaminated media.

Cadmium and copper may accumulate in selected tissues under unusual circumstances of high exposure. The four metal COCs (mercury, arsenic, cadmium, and copper) are all naturally occurring in soils at RMA, in addition to being present as a result of anthropogenic activity. Potential risks to biota from these 14 chemicals were evaluated in the ERC.

C.1.3 IDENTIFICATION OF TARGET BIOTA RECEPTORS

Exposure of biota to contaminants can follow pathways of ingestion, imbibition, inhalation, and dermal contact. The primary pathway through which biota are exposed to contaminants on RMA is ingestion, especially for the bioaccumulative COCs (aldrin/dieldrin, DDE/DDT, endrin, and mercury). By definition, bioaccumulative chemicals concentrate to higher levels in each successive level in a food web. To select receptors of concern as a result of exposure from this pathway, a food web was developed to describe the relationships of predator and prey from the level of autotrophs (i.e., self-feeders, or plants) to the top predators in the ecosystems on RMA (e.g., bald eagles, great horned owls).

The food web includes representative site-specific species in food chains originating in aquatic or terrestrial ecosystems that lead to site-specific taxa at the top of the food web. Food webs culminating in four species and a species group were selected for the RMA ecological risk evaluations: the bald eagle (Figure C.1-2), the American kestrel (Figure C.1-3), the great horned owl (Figure C.1-4), the great blue heron (Figure C.1-5), and the shorebird group, represented on RMA by the killdeer (Figure C.1-6). The bald eagle, an endangered species, represents the highest avian trophic level potentially affected by the biomagnification of contaminants at RMA. The American kestrel, also an avian top predator, is abundant at RMA. Food webs for each of the three additional top food-web species (great horned owl, great blue heron, and shorebird) addressed different considerations. While the great horned owl food web generally incorporated terrestrial food chains from the kestrel and bald eagle food webs, this species feeds at night and is a year-round resident at RMA. The great blue heron food web evaluated risk to birds at RMA that consume primarily fish. Since shorebirds probe for food in sediments, the shorebird food web incorporated a pathway of direct exposure to sediments, which is not covered in the other food webs.

To construct each of these food webs, data were collected from literature sources on ecosystems similar to those at RMA, information from regional experts was obtained, and on-site observations were performed to determine major plant and animal species and habitats that occur within site boundaries. From this information trophic boxes, groups of species with similar feeding requirements at the same feeding level, were developed for each food web.

To select the target biota receptors representative of each trophic box, the IEA/RC employed the same approach presented in the Biota RI (ESE 1989) and Biota CMP (RLSA 1992). The information evaluated for the selection of receptors included species abundance, home range, and distribution, as well as whether the species is threatened or endangered, economically or socially important, or an important component of regional food webs. Data on the food habits of each of the representative species at RMA (i.e., the target biota receptors) collected from literature and field observations at RMA were also considered. In addition to the top trophic box representatives (bald eagle, great horned owl, great blue heron, American kestrel, and shorebirds), the other target biota receptors are: black-tailed prairie dog and desert cottontail (medium mammal trophic box); deer mouse and thirteen-lined ground squirrel (small mammal trophic box); bullsnake and toad (reptile and terrestrial amphibian trophic box); mourning dove, vesper sparrow, and western meadowlark (small bird trophic box); mallard, blue-winged teal, and American coot (water bird trophic box); earthworm (earthworm trophic box); grasshoppers and ground beetles (insect trophic box); cheatgrass, kochia, lactuca, morning glory, and sunflower (terrestrial plant trophic box); northern pike and largemouth bass (large fish trophic box); bluegill, bullheads, and channel catfish (small fish trophic box); salamanders (amphibian trophic box); aquatic invertebrates (aquatic invertebrate trophic box); American pondweed, sago pondweed, coontail, and various aquatic macrophytes (aquatic plant trophic box); and plankton (plankton trophic box). Each of the representative target biota receptors below the top trophic boxes was sampled for analysis of its tissues. Samples of great horned owl eggs and American kestrel eggs and juveniles were also collected. These representative target biota receptors were exposed either directly or indirectly (i.e. through eating) to contaminant concentrations in soil, sediment, and/or water. A combined total of 1,897 biota tissue samples were collected under the Biota RI (ESE 1989), the Biota CMP (RLSA 1992), and the ERC. Once off-post control samples, fortuitous

(i.e., found sick or dead) samples, and QA/QC rejections were removed, 1,328 samples remained to provide tissue concentrations representative of the terrestrial and aquatic trophic boxes. Further information on the collection of these biota samples is in Appendix A and Appendix Section C.4.

C.1.4 CALCULATION OF EXPOSURE CONCENTRATIONS

Due to the large area and variable contamination patterns across the RMA, the spatial distribution of risk from terrestrial food-web exposure was modeled based on exposure to contaminant concentrations in the soil. The development of estimated exposure area soil concentrations is described in Appendix Section C.1.4.1.

In contrast, aquatic species were assumed to integrate their exposure over an entire lake, and therefore tissue concentration samples from a given lake adequately described the mean tissue concentration and risk for that lake (as long as sample size and spatial representation were adequate). Birds with aquatic food webs were assumed to be exposed to either a lake-specific mean tissue concentration in aquatic prey items (and aquatic media ingested directly) or, if individuals were likely to divide their feeding time over several lakes, to a mean tissue/media concentration contributed by a group of lakes. Therefore, aquatic risk for these species was estimated based on direct estimates of observed tissue concentrations in the predator or in prey items. The estimation of aquatic prey tissue concentrations is described in C.1.4.2.

C.1.4.1 Characterization of Exposure Concentration for Terrestrial Food Webs

It is necessary to begin the discussion of exposure concentrations by defining terms, particularly to distinguish exposure soil concentration, exposure area soil concentration (ESC), and estimated exposure area soil concentration (<ESC>). These definitions, given below, indicate assumptions and uncertainties in using <ESC> to estimate risk.

Exposure concentrations are the contaminant concentrations in source media (i.e., soil, sediment, and water) that are bioavailable and accessible to the receptor (i.e., the contaminant concentrations to which organisms are exposed). Thus, an individual organism's exposure soil concentration is the bioavailable and accessible contaminant concentration in the actual soil to

which the individual is exposed over a specified interval of time. The exposure area soil concentration (ESC) differs from the exposure soil concentration in that, rather than describing exposure to an organism, it describes the average soil concentration in an area, i.e., an "exposure area". Thus, the ESC is the average contaminant concentration in a specified soil depth profile over a circular area with radius determined on a species-by-species or trophic-box-specific basis. The estimated exposure area soils concentration (<ESC>) is an estimate of the exposure area soil concentration, derived from the RMA soil concentration database using the statistical estimation techniques described in this section. The RMA Soil data base that was used resulted from a March 5, 1993 data pull from D.P. and Associates that was screened and subjected to quality assurance checks as described in Appendix Section D.1.4.1.

The estimated ESCs were used to calculate site-specific RMA biomagnification factors (BMF_{obs}) and potential risk estimates expressed as hazard quotients (HQs) and hazards indices (HIs) for terrestrial food chain trophic boxes. The applications are explained, respectively, in Appendix Sections C.1.5 and C.1.6.

<ESC>s were calculated based on an area-wide average (i.e., an arithmetic mean) concentration, an area being defined as an organism's estimated foraging or exposure area. The trophic-box-specific values for the individual exposure areas, as well as the methods used to develop the values, are described in Appendix Section C.2.4. The area-averaged concentration was computed from spatially interpolated soil concentrations in the 0- to 1-foot (ft) depth interval (except for the prairie dog's exposure area, which incorporates a vertical average for the 0- to 20-ft depth interval). The interpolated soil concentrations were calculated on grid with 100-ft spacing using surrounding actual soil sample concentration data and the inverse distance-squared algorithm. Before the soil data were interpolated, values that were below certified reporting limits (BCRL) were replaced with estimated values when the surrounding data were sufficient. More specifically, exposure area soil concentrations were estimated in three steps: spatial interpolation of BCRL data, interpolation of soil concentrations onto an RMA-wide grid, and averaging of interpolated data within an exposure area to compute <ESC>. These steps are described in further detail below and are illustrated in Appendix Section C.1.4.1.4 using a detailed example

taken from the data. Appendix Section C.1.4.1.5 discusses the rationale for selecting the inverse distance-squared interpolation method.

C.1.4.1.1 Spatial Interpolation of BCRL Data

A replacement value for each BCRL was interpolated based on nearby detections and other estimated BCRLs using the inverse distance-squared algorithm described in Appendix Section C.1.4.1.2. The BCRL data replacement procedure is described in this section.

The spatial interpolation of BCRL data proceeded iteratively. An initial estimate for each grid point was calculated using the detections found within a specified search radius. BCRL data within the search radius were not factored into the estimation during this first iteration, but were used in latter iterations when they had received an estimate. After estimates were calculated for all BCRL samples, each estimate was compared to the associated CRL and adjusted as follows. If the calculated estimate was less than CRL, the BCRL data point was assigned the calculated estimate. If the calculated estimate was greater than or equal to the CRL, the BCRL data point was assigned the CRL value. If no detections were found within the search radius of a given BCRL, then no replacement was made for that BCRL data point. Successive iterations calculated a new estimate for each BCRL data point, each time including both detections and other estimated BCRL values (from the previous iteration) in the calculation. The second iteration estimated values for previously unestimated BCRL data points if some first iteration estimates fell within the search radius, thereby allowing an estimate. The third and fourth iterations were only used to calculate new estimates for BCRL data points that had been previously estimated.

A maximum of six points was used to calculate any given estimate (the six closest points if the search radius included more than six points). The search radii used were 1,200 ft outside of designated sites (including Basin F Exterior and the wind dispersion area) and 400 ft for all other designated sites. A vertical search radius of 5 ft was used with each of these search radii, regardless of the depth of the BCRL sample being estimated. This allowed the inclusion of nearby data from a different depth in the BCRL interpolation for samples in the 0- to 1-ft depth interval as well as for samples from the 1- to 20-ft deptn interval that were used for prairie dog

risk calculations. (The relative scaling of vertical and horizontal distances is discussed in C.1.4.1.2.) Estimates for borings outside of designated sites made use only of data from outside of designated sites to retain differences in soil concentration characteristics within and outside of designated sites.

Depending on the COC, 6.5 to 85.1 percent of the BCRL data points did not receive an estimate during the BCRL interpolations. Further details and a discussion of associated uncertainty are given in Appendix Section E.12.4.2.2.

This treatment of BCRLs differed from that used in the Human Health Risk Characterization (HHRC) because the estimation of the HHRC site-wide representative concentrations (C_{rep}) did not require spatial interpolation. Therefore, established statistical methods for handling BCRL data (e.g., robust method) were applied for the nonspatial HHRC estimation procedure. However, since established BCRL methods do not consider the spatial distribution of samples, they could not be used in the spatial estimation procedure for the ERC.

C.1.4.1.2 Interpolation onto the RMA-Wide Grid

The spatial distribution of RMA-wide soil concentrations was interpolated from soil samples by using the inverse distance-squared algorithm again. Interpolations were created for the 0- to 1-ft depth interval, for use in characterizing exposure for most species, and for the 0- to 20-ft depth interval for use in characterizing exposure for the prairie dog. The general methods used for both methods are described first, followed by specifics pertaining to the 0- to 20-ft interpolation for prairie dog.

For both interpolations, a grid was developed that divided RMA into 100- by 100- by 1-ft blocks. Each point on the grid represented the center of a particular grid block. Concentrations in each block were estimated for each contaminant using the inverse distance-squared algorithm. This algorithm has also been used in the interpolation of contaminant concentrations for the feasibility study at RMA. The inverse distance squared algorithm calculates an estimate for grid point k based on a weighted average of samples that fall within a search radius around k, using the

equation given below. The weights are inversely proportional to the distance between the sample and the grid point to be estimated. A maximum of six samples are used to calculate an estimate for a given grid point; the six closest samples to this point are used if there are more than six samples within the search radius.

$$Estimate_k = \sum_{i \in SR(k)} X_i W_i \qquad (1)$$

where:

k	=	grid point being estimated
SR(k)	=	search radius of grid point k (only 6 closest points)
X_i	=	chemical concentration of sample at location i
W_i	=	$\frac{1}{D(i,k)^2} \div \sum_{i \in SR(k)} \frac{1}{D(i,k)^2}$
D(i,k)	=	distance between i and k

The search radius in equation (1) is specified horizontally for interpolations for both depth intervals, and vertically for the interpolation over 0 to 20 feet. Horizontal search radii were assigned by grouping designated sites according to similarities in contamination characteristics or location as follows: outside designated sites, 1,200 ft; sites in South Plants, 800 ft; sites in the central and north central areas, 750 ft; sites in the eastern, western, southern, and North Plants areas, 400 ft; Shell trenches and complex disposal trenches, 200 ft. A maximum of six points were used in all cases to estimate soil concentration for each model block. Estimates for grid blocks within a given site were based only on samples located within sites of the same site group. In all cases if there was no information to model a given grid block, that block was labeled as "not estimated" (NE).

The above algorithms and specifications were applied to the interpolations for both depth intervals, 0- to 1-ft (general) and 0- to 20-ft (prairie dogs). Interpolated soil concentrations for the 0- to 1-ft depth interval, which were used for all species including prairie dog, were calculated based on samples only from the top 1 foot. The rationale for excluding lower soil

depths from the interpolation was that exposure of most target receptors is primarily to the top 1 ft and contaminant transport processes on RMA imply that surface contamination tends to be much higher and possibly unrelated to contamination at lower depths. Additional specifications used in the interpolation for lower depths are described below.

Prairie dogs are known to burrow to a depth of 20 ft. They may ingest soils throughout this depth range when digging or grooming, although they feed primarily on insects and terrestrial plants, which are exposed primarily to soils near the surface. Therefore, the exposure area soil concentration for prairie dogs was calculated as a weighted average of soil concentrations within the circular prairie dog exposure area, but extending to a depth of 20 ft. The weights, based on the prairie dog dietary fractions for terrestrial plants exposed to the 0- to 1-ft depth interval and soil ingested uniformly from the 0- to 20-ft interval were as follows: 0- to 1-ft depth interval weight, 0.9981; 1- to 20-ft depth interval weight, 0.0019.

Accordingly, exposure area soil concentration estimations for prairie dogs included both a 0- to 1-ft depth interpolation layer and a second interpolation layer for the 1- to 20-ft depth interval within designated sites. Within designated sites, a three-dimensional grid of soil concentrations was constructed by interpolating among the depth-specific data of the sample borings. The concentration for each grid block was estimated from the samples that fell within an elliptical sphere surrounding that grid block. The sphere was defined by a vertical axis that was much shorter than the horizontal axis because concentrations were expected to change faster with depth than laterally. For the three dimensional interpolation, the distance parameter in equation (1) was defined as the elliptical distance, i.e., the true distance normalized to the equation of an ellipsoid. For example, all points on the edge of the ellipsoid have an elliptical distance of 1.0. Interpolated soil concentrations within the 0- to 1-ft layer were calculated based only on samples within the 0- to 1-ft depth interval. Interpolated concentrations within the remaining 1- to 20-ft depth interval were calculated based on a search radius of 10 feet, where samples from the top 0- to 1-ft depth interval were excluded. The 0- to 1-ft samples were excluded from estimations at lower depths and lower samples were excluded from estimation at the 0- to 1-ft depth because, as discussed above, contaminant transport processes on RMA imply that surface contamination

tends to be much higher and possibly unrelated to contamination at lower depths. It was judged that the estimations would be more representative of contaminant concentrations if the 0- to 1-ft and 1- to 20-ft data sets were separated during the interpolation. Outside designated sites, nearly all of the reliable data are from the 0- to 1-ft depth interval.

After all grid blocks were modeled, the three dimensional grid was transformed to a two dimensional grid where each point represented the weighted average concentration for the depth profile associated with this point. Specifically, the concentrations estimated for the 0- to 1-ft and 1- to 20-ft depth intervals for a given column on the three dimensional grid were averaged according to the dietary weights developed above for prairie dog and then assigned to the corresponding point on the two dimensional grid. Exposure area soil concentrations (ESC) for the prairie dog were then calculated (as described in C.1.4.1.3) by averaging concentrations on the two dimensional grid for prairie dog.

C.1.4.1.3 Averaging Within the Exposure Area

Estimated exposure area soil concentration (<ESC>) is the average of the interpolated soil concentrations at all grid points within a given species- or trophic-box-specific exposure area. For the purpose of estimating BMF_{obs}, <ESC> is calculated for an exposure area centered on a specific biota sample collection location. For the characterization of risk, <ESC> is calculated for exposure areas centered at each point of the 100- by 100-ft RMA-wide grid. The <ESC> for a given grid point was used to calculate potential risk at that grid point. If the exposure range for a trophic box was small enough to encompass at most one grid point at a time, the <ESC> value for that grid point is the interpolated value, since there are no other values within the exposure area to be averaged.

If a small fraction of the cells within a given exposure area did not contain soil concentration information, then the ESC for that exposure area was estimated with these cells excluded from the average. If the fraction of cells without concentration estimates was large (e.g. greater than about 1/2) then <ESC> and risk were assigned a value of NE ("not estimated"). The treatment of areas of inadequate soil data and the lake and RMA boundaries, is described in more detail

in Appendix Section D.1.3.4. Nearly all of the areas lacking concentration estimates were either sampled and recorded as BCRL or were not sampled because there was no historic reason for a given COC to be present. Therefore, on the risk maps, the areas lacking risk estimates are combined with areas of no risk, and identified as representing HQ < 1. Special treatment of shorebird, great blue heron, and bald eagle trophic boxes are also described in Appendix Section D.1.3.4. The selection of the exposure area radii is explained in Appendix Section C.2.4.

C.1.4.1.4 Soil Concentration Estimation Example

This section provides a detailed example (involving aldrin concentrations in soil associated with a specific cottontail sample) of how individual soil samples were used to calculate <ESC> from measured surficial soil and boring data. A trophic box-specific <ESC> value was calculated for each model block.

Figure C.1-7 shows a cottontail tissue sample location with its corresponding exposure area circle (radius of 346 feet). In this example, the exposure area overlaps two different designated sites: site CSA-1a (Shell Trenches) and CSA-1b (Complex Disposal Area South).

Soil borings used to estimate aldrin concentrations for grid cells within this exposure area are shown in Figure C.1-8. In general, soil borings both inside and outside of the given exposure area may be used to estimate grid point concentrations within the exposure area. For this example, 45 soil borings were utilized to calculate <ESC> for the exposure area centered around the single cottontail tissue sample. The measured aldrin concentration at each sample location is shown. Concentrations with an LT (less than) designation reflect BCRL data, i.e. data reported as below the certified reporting limit (CRL) value shown.

Spatial interpolation calculations were performed, as detailed in Appendix Section C.1.4.1.1, for all BCRL data points prior to modeling onto the grid. The estimates are based on the spatial interpolation algorithm described in Appendix Section C.1.4.1.1. Table C.1-1 presents results of the first two iterations of the spatial interpolation for the BCRL point indicated by a "★" on Figure C.1-8. For the first iteration, only the six closest points indicated as detections were used

for the estimation, resulting in a value of 0.4796 parts per million (ppm). As this interpolated value was lower than the CRL for this point, the CRL was replaced with the interpolated value. The remaining BCRL soil borings were replaced similarly. For the second and successive iterations, all detections and replaced BCRL points were used for estimation. A new value of 0.3568 ppm was estimated in the second iteration. Again, this value was used to replace the first-iteration value since it was lower than the original CRL. Two additional iterations were completed using the same method to produce a final result of 0.3558 ppm for the interpolated aldrin concentration at the point indicated by a "★" on Figure C.1-9.

Following the BCRL replacement process, the soil data were used to estimate a concentration for each of the grid blocks described above in Appendix Section C.1.4.1.2. Figure C.1-10 shows the grid blocks located within the cottontail exposure area and the concentrations of aldrin modeled for each block. Concentrations for each grid block were calculated individually from nearby borings using the inverse distance squared algorithm described in Appendix Section C.1.4.1.2. Grid blocks were considered to be 1 ft thick and 100 ft^2 in area.

The estimation of grid-block concentrations also used the inverse distance-squared interpolation process. However, the search radius for each grid block was varied to reflect the physical or geographical characteristics of the designated site in which it was found. In this example, concentrations for grid blocks within the Complex Disposal Area South were estimated using a 750-ft search radius, while concentrations for blocks within the Shell Trenches were estimated using a 200-ft search radius. Figure C.1-9 includes search radii circles used for estimating aldrin concentrations for the two sample grid blocks indicated with +. The vertical search radius was 1 ft in all cases. A maximum of six samples was used for any single estimation regardless of the number of samples available within the search radius. The six samples nearest to each grid block were used when more than six samples were located within the search radius.

The grid-block modeling algorithm further constrained the borings used for each block by allowing only borings within the same designated site as the grid block to be used in the estimation for that block unless an adjacent site had similar characteristics. This prevented the

use of data from one site type in estimations for a different site type, and prevented data from designated sites that are contaminated from being used in estimation of soil concentrations in areas where contamination is unlikely and vice versa. For this example, concentrations for grid blocks located within the Shell Trenches were estimated using only those samples located within the trench area, as the surrounding disposal area was determined to have different characteristics. These sample locations are shown in blue in Figure C.1-9. Similarly, estimation for grid blocks located in the Complex Disposal Area did not use data from borings located within the Shell Trenches. The effect can be seen by comparing Figures C.1-9 and C.1-10. Note that grid blocks within the southeast portion of the Shell Trenches area did not use the much higher concentration data (190 ppm) found just south of the site boundary. Although this point is within the search radius, the differences in site characteristics precluded its use. Grid block concentrations inside the Shell Trenches boundary reflect only the data samples found within the Shell Trenches area.

Table C.1-2 illustrates the hand calculation of the inverse distance-squared algorithm for one grid block. The example block is numbered in red on Figure C.1-10. Note that the hand-calculated concentration (0.841 ppm) does not match exactly the computer-calculated value (0.909 ppm) for this block in Figure C.1-10. Since the model considers the center of each grid block (1 ft by 100 ft by 100 ft) to be at a depth of 0.5 ft, distances measured by hand from Figure C.1-9 did not include the vertical component contributing to the true distance between the block and sample location used by the computer. In addition, inaccuracies in measuring distance from the Figure C.1-9, as well as rounding differences between the computer and hand calculations, contributed to the error. This illustrated calculation was applied to each block within the cottontail exposure area.

The <ESC> for aldrin that is associated with the cottontail tissue sample is indicated in Figure C.1-10. This value was calculated as the average of all aldrin concentrations for the blocks within the associated exposure area.

C.1.4.1.5 Selection of Interpolation Method

The inverse distance-squared method was chosen for the soil and sediment spatial interpolations because of its strong advantages in handling BCRL data and in accommodating the separate interpolation of soil data by site, or groups of similar sites, to avoid spatial discontinuities across sites. The three interpolation methods considered for the RMA data are described below followed by further discussion of the rationale for selecting the inverse distance squared method for the RMA data set.

Methods for Interpolation

Three common methods of spatial interpolation were considered for application to the RMA soil and sediment data: inverse distance-squared (the method selected), kriging, and Dirichlet polygons. These methods are all based on the premise of spatial continuity: two data points that are close to each other are more likely to have similar values than two data points that are far apart. Spatial continuity exists in most earth science data sets (Isaaks and Srivastava 1989). The least sophisticated interpolation method considered for application at RMA was Dirichlet tessellation. This method makes the simple assumption that the concentrations at points between measured samples are equal to the concentration of the nearest sample. This rule implies the construction of a network of polygons, each around a single sample, within which concentrations are assumed to equal the value of the sample. The inverse distance-squared and kriging methods assume that the concentrations of points between samples vary smoothly, resulting in gradients between sample locations. For these methods, the estimation incorporates information from not only the nearest neighboring sample, as is done in Dirichlet tessellation, but also other nearby samples. The estimate for a given point is based on a weighted linear combination of nearby sample concentrations.

In the inverse distance-squared method, the weights assigned to each sample are proportional to one divided by the square of the physical distance between the sample and the point to be estimated. Smaller distances imply that the sample has an increased informational value to the estimation point, which in turn implies a higher weight assigned to the particular sample concentration. In kriging the weights are dependent on the "statistical distance" between the

sample and estimation point. The statistical distance incorporates physical distance but is a more sophisticated description of the value of information because it also incorporates the spatial correlations between individual samples contributing to the estimate. For example, if a particular sample occurs near many other samples, the group of samples are spatially correlated and will, therefore, give somewhat redundant information regarding the estimation point. Assuming all else is equal, the kriging weights of each of these correlated samples will be lower than the inverse distance-squared weights. As discussed below, the incorporation of statistical distance rather than physical distance is especially important when the sampling locations are clustered. The three main advantages of kriging are the following: (1) it provides rigorous treatment of spatial correlations due to clustered data, (2) it allows uncertainty to be estimated, and (3) it allows the relationship between inter-point distance and value of information to be fine tuned for a specific data set rather than assumed a priori as in the case of the inverse distance-squared rule.

Selection of Method for RMA

Three characteristics of the RMA data set are especially pertinent to the selection of an interpolation method: (1) abundance of BCRL data, (2) spatial discontinuities caused by site phenomena such as trenches, basins, and other containments, and (3) clustered sampling. The first two characteristics are better dealt with by the inverse distance-squared method than the others.

Abundance of BCRL Data

The BCRL interpolation method discussed in Appendix Section C.1.4.1.1 was developed to make use of the spatial structure of the soil concentration data in estimating likely values for BCRL data. The incorporation of censored data into a kriging framework would be relatively complex and has not yet been published in the statistical literature. In contrast, under the basic premise of the Dirichlet tessellation approach, an estimate for a BCRL data point would based only on the value of its nearest neighbor, an overly simplistic assumption. A Thiessen polygon approach also could have been implemented with BCRLs replaced by the conditional expected values from distributions of soil concentrations in the same area. The inverse distance- squared method and

software was modified to incorporate "less than" information and provide estimates of BCRL data points.

Spatial Discontinuities

RMA soil concentrations are dependent on site-specific activities which are not necessarily spatially continuous. For example, trenches and basins create containments that hinder contaminant transport or diffusion. Because of potential discontinuities, concentrations within a given site were thought to be best estimated from only the samples occurring within this site, or in some cases within adjacent sites that had similar characteristics. Therefore, the soil concentrations were estimated by separate spatial interpolations within each site, and one overall interpolation for all areas outside the sites. The division of the data into designated sites, groups of similar and adjacent sites, and areas outside designated sites, left many data sets with relatively low sample sizes. The sophistication offered by the kriging method (e.g., fine tuning of correlation function, handling of clustered data) did not seem warranted for these small data sets. The specification of kriging parameters (e.g. correlation function) in such cases could be highly subjective. A further consideration is that kriging would require a large increase in analytical complexity and time compared to the inverse distance-squared method.

Clustered Data

RMA soil sampling was highly concentrated in the designated sites, where contamination tended to be highest, and was much less concentrated outside the designated sites. Therefore, taken as a whole, the RMA data are highly clustered, with areas of high sample density corresponding to areas of high concentrations. If data within and outside of sites were interpolated as a single data set, the following interpolation bias, referred to as a "halo effect", would arise: areas surrounding a contaminated site would receive upwardly biased estimates of concentrations from the undue influence of the more dense site data. Dirichlet polygons constructed in highly clustered data are often assigned anomalous shapes and may produce arbitrary or biased estimates. Of the three methods, Kriging minimizes this interpolation bias because it rigorously handles spatial correlation due to clustered data. (However even kriging does not rigorously handle the correlation structure formed by heterogeneity in the underlying variance of soil concentrations

likely to occur at RMA and with hot spot contamination in general.) As described above, the RMA data were not interpolated as a single data set but divided into groups of similar and adjacent sites or areas outside designated sites. Within these groupings, the sample pattern ranged from random to slightly clustered, and therefore interpolation bias was believed to be minimal for all three methods considered. In summary, the inverse distance-squared method was chosen based on the need to incorporate BCRL data points and to interpolate sites separately, and because interpolation bias from clustering was not expected to be substantial when sites were interpolated separately.

C.1.4.2 Characterization of Exposure Concentration for Aquatic Food Webs

The primary contaminant source medium for exposure of biota in the aquatic ecosystem is water. Nearly all of the RMA water sample concentrations were found to be BCRL and therefore exposure water concentrations could not be estimated directly from these samples. An attempt was made to estimate exposure water concentrations from sediment concentrations and then to derive media-based estimates of risk as follows. A single exposure area sediment concentration was estimated for each of the RMA lakes considered in the risk evaluations. These estimates were calculated by replacing BCRL sediment samples with estimates based on the expected value robust (EVR) method, applying the inverse distance-squared algorithm to interpolate sediment concentrations onto a grid (similar to the interpolation of soil data described in Appendix Section C.1.4.1), and then averaging concentrations from all grid blocks within a lake. The estimated average exposure area sediment concentrations for a given lake could then be converted to pore water concentrations, using the equilibrium partitioning concept, and from pore water concentrations to overlying water concentration, using EPA's Water Quality Analysis Simulation Program, version 4.31 (WASP4; Ambrose et al. 1988). These conversions were rejected because of the substantial uncertainty in applying the equilibrium partitioning concept for systems where the percentage of organic carbon in sediments is as high as that observed for RMA lakes (10 to 20 percent). This is the reason exposure area sediment concentrations were not used to estimate risk for trophic boxes with aquatic food chains. Instead, since exposure concentrations in aquatic ecosystems are relatively homogeneous and well represented by the tissue concentrations, aquatic

risk was calculated directly from the ratio of tissue concentration or dose to MATC or TRV, respectively (Appendix Section C.1.6).

For aquatic food chains, measured exposure tissue concentrations were occasionally missing for a particular lake, COC or trophic box. Plankton data were unavailable for East Upper Derby and Upper Derby Lakes and Rod & Gun Club Pond. Aquatic plant data were unavailable for East Upper Derby and Upper Derby Lakes. Aquatic invertebrate data were available only for Lower Derby Lake and Lake Ladora. Amphibian data were available only for Lower Derby Lake. Field data on small fish were available for Upper and Lower Derby Lakes, and Lakes Ladora and Mary. East Upper Derby Lake and Rod & Gun Club Pond were assumed not to contain small fish. Large fish data were available for Lower Derby Lake, Lake Ladora, and Lake Mary; East Upper Derby, Upper Derby, and Rod & Gun Club Pond were assumed not to contain large fish. The individuals of these aquatic trophic boxes were confined to the specific lakes where the trophic box was assumed to occur. For each lake where a trophic box was assumed to occur but lacked data, average tissue concentrations were estimated as the weighted average of the sample averages from the lakes with field data. Sample sizes reported in Appendix Section D.1, Figure D.1-10 were used as weighting factors. Using this method, data were sufficient to estimate lake-specific tissue concentrations for all trophic box/chemical combinations except DDT/DDE concentrations in aquatic invertebrates and amphibians. DDT/DDE was not detected in these trophic boxes in any of the lakes.

For DDT/DDE in aquatic invertebrates and amphibians, average tissue concentrations were calculated using the ratios of measured organochlorine pesticides (OCPs; i.e., DDE/DDT relative to aldrin/dieldrin and to endrin) in tissue found in other aquatic trophic boxes. Aquatic invertebrate (aq.invert.) DDT/DDE tissue concentrations were calculated using ratios of DDT/DDE to aldrin/dieldrin (ald/dld) and DDT/DDE to endrin tissue concentrations in plankton and aquatic plants (aq.plants) as follows:

$$[DDT/DDE]_{aq.invert} = \frac{1}{4} * \left\{ \left(\frac{[DDT/DDE]}{[ald/dld]} \right)_{plankton} + \left(\frac{[DDT/DDE]}{[ald/dld]} \right)_{aq.plants} \right\} * [ald/dld]_{aq.invert}$$

$$+ \frac{1}{4} * \left\{ \left(\frac{[DDT/DDE]}{[endrin]} \right)_{plankton} + \left(\frac{[DDT/DDE]}{[endrin]} \right)_{aq.plants} \right\} * [endrin]_{aq.invert}$$

where the OCP ratios represent the averages over all lakes having tissue concentration data (Lower Derby, Ladora, and Mary for plankton; Lower Derby, Ladora, Rod & Gun Club Pond, and Mary for aquatic plants). Amphibian DDT/DDE tissue concentrations were calculated using ratios of DDT/DDE to aldrin/dieldrin and DDT/DDE to endrin tissue concentrations in small and large fish:

$$[DDT/DDE]_{amphib} = \frac{1}{4} * \left\{ \left(\frac{[DDT/DDE]}{[ald/dld]} \right)_{sm.fish} + \left(\frac{[DDT/DDE]}{[ald/dld]} \right)_{lrg.fish} \right\} * [ald/dld]_{amphib}$$

$$+ \frac{1}{4} * \left\{ \left(\frac{[DDT/DDE]}{[endrin]} \right)_{sm.fish} + \left(\frac{[DDT/DDE]}{[endrin]} \right)_{lrg.fish} \right\} * [endrin]_{amphib}$$

The OCP ratios are averages over all lakes having tissue concentration data (Upper Derby, Lower Derby, Ladora, and Mary for small fish; Lower Derby, Ladora, and Mary for large fish). The great blue heron trophic box is more heavily impacted than the bald eagle by the missing DDE/DDT data replacement algorithms described above, so a sensitivity analysis was performed to evaluate the impact of estimation uncertainty on the great blue heron tissue concentration predictions. The results, reported in Table C.1-3, indicate that heron tissue concentration predictions, and therefore risk estimates, are insensitive to the replacement values used for missing DDE/DDT data.

The bird species with aquatic food chains (shorebird, water bird, bald eagle, and great blue heron) were assumed to be exposed to all the lakes evaluated, since they could readily fly from one to

another. Measured tissue concentrations were available from some lakes for shorebird and water bird. How these data were used to represent all the lakes is described below, as is the estimation of water concentrations to be used as dietary components for water bird and great blue heron. Tissue concentrations were not measured in the bald eagle or great blue heron, so their tissue concentrations from aquatic as well as terrestrial food chains were modeled from tissue concentrations in their prey as described in Appendix Section C.1.5.2.

Water bird data were available for all except East Upper Derby Lake, so the water bird risk characterization was based on the samples from these five lakes. Weighted averages of lake-specific water bird sample averages were calculated, averaging over all lakes except East Upper Derby Lake, and the resulting RMA-wide estimates of average tissue concentration were used to characterize risk to this trophic box. The weighting factors, given in Appendix Section D.1, Figure D.1-15, were based on the assumption that the level of predation at a lake is proportional to the assumed size of the trophic box exposure area at that lake. Exposure areas for water bird were assumed to equal the lake's water surface area.

Shorebird data were available from the vicinity of Lower Derby Lake and Lake Mary. Because this trophic box has both terrestrial and aquatic food chains, these shorebird sample averages were partitioned to attribute a portion of the observed tissue concentration to exposure through the aquatic food web, and the balance to exposure through the terrestrial food web. Partitioning coefficients, derived as detailed in Appendix Section C.1.5.1.4, are given in Appendix Section D.1, Figure D.1-8. The average shorebird tissue concentration for the other four lakes was estimated by the average of the partitioned sample averages for Lower Derby Lake and Lake Mary. For the shorebird, the feeding area was assumed to be a band around the perimeter of the lake, extending inward three feet from the shoreline (Appendix Section D.1, Figure D.1-15). The resulting RMA-wide mean tissue concentrations for water bird and shorebird are given in Appendix Section D.1, Figure D.1-16.

As an estimate of COC concentrations in the water (C_w) that was assumed ingested by the great blue heron, the certified reporting limits (CRLs) were used for aldrin/dieldrin, DLE/DDT, and

endrin, because less than 25 percent of the lake water samples had concentrations above the CRL for the contaminants evaluated. Mercury was the only bioaccumulative contaminant of concern for which measured data could be used because it was detected consistently above its CRL in water samples.

C.1.5 DEVELOPMENT OF BIOMAGNIFICATION FACTORS

As noted in Appendix Section C.1.1, BMF is defined in the IEA/RC as an empirical quantity relating an organism's tissue concentration to its ESC. Terrestrial risk was calculated using spatially distributed population mean tissue concentrations that were estimated based on three sets of site-specific BMFs derived by approaches put forth by the U.S. Army (Army), EPA, and Shell. All three approaches use the same initial data set of measured tissue concentrations and the <ESC> values paired with them. The EPA approach further screened these data. The outputs of direct calculations using these field data are referred to as BMF_{obs} (observed BMFs), which was calculated for prey. BMFs can also be estimated using a food-web model, as was done for top predators. This section describes the development of final BMFs for both prey (Appendix Section C.1.5.1) and top predator (Appendix Section C.1.5.2) trophic boxes.

C.1.5.1 Development of Final BMFs for Prey

The final BMF values used by EPA and Shell for prey were the BMF_{obs} values from their respective approaches. BMF_{obs} from the Army approach was used to derive "calibrated" Army BMFs for prey. Calibrated BMF_{obs} values were available only for prey trophic boxes because tissue concentrations were measured only for prey.

C.1.5.1.1 Implications of the Sampling Design

The sampling design for collecting tissue and soil concentration data affected whether or not they were representative of the site and determined the appropriateness of the way in which they were combined to estimate BMF_{obs}. Under ideal conditions, a sampling design for the collection of data to quantify BMF_{obs} would provide tissue samples representative of a population's exposure to the full range of soil concentrations, and soil samples collected sufficiently near the tissue sampling locations to provide a precise measure of the chemical concentrations in the area where

the organisms were exposed. Under ideal sampling conditions, variability in the tissue concentration/ESC relationship would be due primarily to processes which cannot be accounted for in the risk model (e.g., individual physiology, behavior, age, and bioavailability of contaminants in RMA soils). Under real field circumstances, however, ideal sampling goals are unlikely to be met, adding to the variability in the observed relationship between tissue concentration and ESC. Only a limited number of organisms can be collected without impacting populations. Further, an individual's true exposure area may be different from the assumed exposure area used to estimate its ESC. Accurately pairing tissue concentration and the appropriate ESC is difficult because organisms are mobile and not necessarily collected at the center of their exposure area as is assumed in estimating ESC. Further detail regarding these uncertainties is provided in Appendix Section E.12.

Because the locational association of tissue concentration and ESC added the greatest uncertainty to the calculation of BMF_{obs}, there was considerable discussion as to the appropriate way in which to use these data. Divergent opinions existed as to whether all the pairs of tissue concentration and ESC data should be used (or only a portion of them), whether the data should be used to define tissue concentration and ESC distributions (or calculate individual BMF_{obs} values), and, if tissue concentration and ESC distributions were used, how best to combine them. Three approaches to calculating BMF_{obs} emerged from these discussions: the Army's collocated-distribution approach, Shell's collocated-distribution approach, and EPA's modified paired approach. All three methods are described below. In addition, EPA has prepared a document that describes analyses it has performed and steps it would like to have followed in estimating BMF_{obs} by the EPA approach (see Appendix C.6.2). Appendix C.6.1 is a jointly prepared description of differences between the Army and EPA regarding the process and purpose of BMF estimation.

C.1.5.1.2 Approaches to Calculate BMF_{obs}

All three of the approaches used to calculate BMF_{obs} start with the same initial databases of ESC and tissue concentration. The Army and Shell collocated distribution approaches used the entire tissue concentration and ESC databases. The modified paired approach screened out tissue

concentration/ESC pairs associated with the highest concentrations of aldrin/dieldrin and endrin, as well as the onsite control samples before calculating individual BMFs.

As discussed in Appendix Section C.1.4, ESC was estimated by first interpolating the original soil boring and surficial soil sample data onto a grid. Values for sample borings that were BCRL were replaced where possible with values based on information from surrounding sample borings. At each tissue sample location, <ESC> was calculated as the average of grid point concentrations that fell within the sample's species-specific exposure area. This process is described in Appendix Sections C.1.4.1 and E.12.4.2.2. Total measured values were used for all chemicals, including those that occur naturally (mercury, arsenic, cadmium, and copper). For all trophic boxes, soil data from the 0- to 1-ft depth interval were used to calculate <ESC>; for prairie dogs, data from the 1- to 20-ft depth interval were also used to calculate <ESC>.

Tissue concentration data used in BMF_{obs} were from dressed carcass, whole body, and composite samples. For most trophic boxes, the tissue concentration data were grouped by trophic box to determine BCRL replacement. BCRLs were replaced using the robust method (Gilliom and Helsel 1986) when the number and percentage of detections for a given trophic box were sufficient; in other cases the one-half CRL method was used. In cases where paired data were required (e.g., for the modified paired approach and for summing of concentrations for aldrin and dieldrin or DDE and DDT), the expected value robust method was used in place of the robust method. Methodological details for replacing BCRL tissue concentration data and a table of sample sizes and BCRL replacement methods used for each case are provided in Appendix Section E.12.4.1.1.

For three trophic boxes (small bird, small mammal, and medium mammal), exposure areas for component species differed sufficiently to warrant initial calculation of species-specific BMF_{obs} values when data for a particular chemical were sufficient for this to be done (e.g., aldrin/dieldrin). In these cases, BCRLs were replaced and BMF distributions estimated for each species. A weighted average of these species-specific BMF_{obs} distributions was then used to represent the trophic box BMF distribution in the Army and Shell approaches.

The Army, Shell, and EPA approaches are described below, preceded by the definition of the statistical terminology used in describing them.

Statistical Terminology

Three types of statistical distributions are discussed below. These are the lognormal distribution of a given quantity X, the normal distribution corresponding to the natural logarithm of X, and the approximately normal distribution describing the estimated mean of X. The true descriptors for these distributions (e.g., mean and standard deviation) are unknown. Estimates for these descriptors are calculated from the data based on standard statistical formulas. The terminology used for these descriptors is as follows.

μ_X – the true mean of the probability distribution for X.

σ_X – the true standard deviation of the probability distribution for X.

$\hat{\mu}_X$ – an estimate of μ_x. In this section, $\hat{\mu}_X$ refers to either the arithmetic sample mean or the mean calculated using an estimator specific to the lognormal distribution.

$\hat{\sigma}_x$ – an estimate of σ_X. In this section, $\hat{\sigma}_X$ refers to either the arithmetic sample standard deviation or the standard deviation calculated using an estimator specific to the lognormal distribution.

$\mu_{ln(X)}, \sigma_{ln(X)}$ – the true mean and standard deviation of the probability distribution for the natural logarithm of X.

$\hat{\mu}_{ln(X)}$, $\hat{\sigma}_{ln(X)}$ – estimates of $\mu_{ln(X)}$ and $\sigma_{ln(X)}$. In this section, these terms refer to either the sample mean and standard deviation calculated on the log transformed values, or the estimates back calculated from the arithmetic estimators using formulas specific to the lognormal distribution. It is important to note that $\hat{\mu}_{ln(x)} \neq \ln(\hat{\mu}_x)$.

$\overline{BMF}$ – an estimation of the mean BMF. This quantity depends on the correlation between tissue concentration and <ESC> and thus the correlation between ln(TC) and ln(<ESC>).

$\hat{\mu}_{\overline{BMF}}$, $\hat{\sigma}_{\overline{BMF}}$ – the mean and standard deviation of different estimates of $\overline{BMF}$ that arise from different values of correlation or different bootstrap samples of the data.

r – the correlation between ln(TC) and ln(<ESC>).

$r_{ln(<ESC>),\ ln(BMF)}$ – the correlation between ln(<ESC>) and ln(BMF).

BMF_{obs} Calculation Methods

Army Collocated Distribution Approach

The Army collocated distributions approach implements the following steps for a particular trophic box/chemical combination:

1. Calculate an <ESC> value for each measured tissue concentration as the average concentration of all grid points in the exposure area centered at the location of the tissue sample.

2. Disassociate the pairs of tissue concentration and <ESC> data.

3. Calculate arithmetic sample average and sample standard deviation for the tissue concentration data ($\hat{\mu}_{TC}$, $\hat{\sigma}_{TC}$). Use these estimates as the mean and standard deviation of the lognormal tissue concentration distribution.

4. Calculate arithmetic sample average and sample standard deviation for the <ESC> data ($\hat{\mu}_{<ESC>}$, $\hat{\sigma}_{<ESC>}$). Use these estimates as the mean and standard deviation of the lognormal <ESC> distribution.

5. Derive the values for the parameters of ln(TC) and ln(<ESC>), which are found by rearranging Gilbert's equations 13.7 and 13.8 (1987, p. 167):

$$\ln(TC) \sim \text{Normal}(\hat{\mu}_{\ln(TC)}, \hat{\sigma}_{\ln(TC)}) \quad (2)$$

$$\ln(ESC) \sim \text{Normal}(\hat{\mu}_{\ln(<ESC>)}, \hat{\sigma}_{\ln(<ESC>)}) \quad (3)$$

$$\hat{\mu}_{\ln(TC)} = \ln(\hat{\mu}_{TC}) - \frac{\hat{\sigma}^2_{\ln(TC)}}{2} \quad (4)$$

$$\hat{\sigma}^2_{\ln(TC)} = \ln\left(\left(\frac{\hat{\sigma}^2_{TC}}{\hat{\mu}^2_{TC}}\right) + 1\right) \quad (5)$$

$$\hat{\mu}_{\ln(<ESC>)} = \ln(\hat{\mu}<ESC>) - \frac{\hat{\sigma}^2_{\ln(<ESC>)}}{2} \quad (6)$$

$$\hat{\sigma}^2_{\ln(<ESC>)} = \ln\left(\left(\frac{\hat{\sigma}_{<ESC>^2}}{\hat{\mu}_{<ESC>^2}}\right) + 1\right) \quad (7)$$

6. Calculate the mean ($\hat{\mu}_{\ln(BMF)}$) and variance ($\sigma^2_{\ln(BMF)}$) of the distribution of ln(BMF) as a function of r, the assumed correlation between ln(TC) and ln(ESC), using the definitions of expectation and variance of the differences between two normal random variables (ln(BMF) = ln(TC) - ln(<ESC>)):

$$\hat{\mu}_{\ln(BMF)} = \hat{\mu}_{\ln(TC)} - \hat{\mu}_{\ln(<ESC>)} \quad (8)$$

$$\hat{\sigma}^2_{\ln(BMF)} = \hat{\sigma}^2_{\ln(TC)} + \hat{\sigma}^2_{\ln(<ESC>)} - 2r\hat{\sigma}_{\ln(TC)}\hat{\sigma}_{\ln(<ESC>)} \quad (9)$$

where:

r = assumed (ln(TC), ln(<ESC>)) correlation.

Note that the assumed correlation between ln(TC) and ln(<ESC>) results in a correlation between ln(<ESC>) and the estimates of ln(BMF). That is, while BMF is treated as a constant when estimating risk, estimates of BMF based on observed data are dependent on <ESC> in cases where the correlation between the TC and <ESC> distributions is not high.

7. Compute $\overline{BMF}_{obs}$ as a function of r:

$$\overline{BMF}(r) = \exp\left(\hat{\mu}_{\ln(BMF)} + \frac{\hat{\sigma}^2_{\ln(BMF)}}{2}\right) \quad (10)$$

where:

r enters through $\hat{\sigma}^2_{\ln(BMF)}$. Values for r are drawn from a triangular distribution with limits of 0.3 and 0.7 and a most likely value of 0.5. A total of 100 Latin hypercube samples were drawn from the triangular distribution of r using the Excel/@RISK software program. Each r sample was used in equations (9) and (10) to estimate a value for $\overline{BMF}_{obs}$, resulting in 100 estimates of $\overline{BMF}_{obs}$.

8. Calculate the sample average and sample standard deviation for the $\overline{BMF}_{obs}$ sample:

$$\hat{\mu}_{\overline{BMF}_{obs}} = \frac{\sum_{i=1}^{100} \left(\overline{BMF}_{obs}\right)_i}{100} \quad (11)$$

$$\hat{\sigma}_{\overline{BMF}_{obs}} = \sqrt{\frac{\sum_{i=1}^{100} \left[\left(\overline{BMF}_{obs}\right)_i - \hat{\mu}_{\overline{BMF}_{obs}}\right]^2}{99}} \quad (12)$$

9. Estimate the distribution of $\overline{BMF}_{obs}$ as:

$$\overline{BMF}_{obs} \sim N\left(\hat{\mu}_{\overline{BMF}_{obs}}, \hat{\sigma}_{\overline{BMF}_{obs}}\right) \quad (13)$$

These computations were performed in a batch mode for all chemicals and trophic boxes. Equations were coded in S-Plus, rather than Excel/@RISK, to facilitate batch calculation.

For cases in which species-specific BMFs were calculated, a weighted average of the species-specific distributions was used to define the trophic box (group) distribution, as in equations (14) and (15):

$$\hat{\mu}_{BMF,MDMML} = \hat{\mu}_{BMF,cylu} w_1 + \hat{\mu}_{BMF,syau} w_2 \quad (14)$$

$$\hat{\sigma}^2_{BMF,MDMML} = \hat{\sigma}^2_{BMF,cylu} w_1^2 + \hat{\sigma}^2_{BMF,syau} w_2^2 \quad (15)$$

The weights for each species were as follows: small mammal (deer mouse [PEMA], 0.90; thirteen-lined ground squirrel [SPTR], 0.10), medium mammal (prairie dog [CYLU], 0.72; desert cottontail [SYAU], 0.28), and small bird (vesper sparrow [AOGR], 0.10; western meadowlark [STNE], 0.20; mourning dove [ZEMA], 0.70).

The expected value of the BMF_{obs} distribution for each trophic box/chemical combination calculated by the Army collocated distributions approach is used as the initial value in the Army BMF calibration process, described below in Appendix Section C.1.5.1.6.

Shell Collocated Distribution Approach

Shell's approach is similar to the Army's approach except that different estimators are used in Steps 1 through 4 and different steps are applied subsequent to Step 4.

1. Same as the Army's approach.
2. Same as the Army's approach.
3. Calculate the arithmetic sample mean and standard deviation of the log-transformed tissue concentration data.
4. Calculate the arithmetic sample mean and standard deviation of the log-transformed <ESC> data.
5. Estimate the distribution parameters for $\ln(BMF_{obs})$ using the following equations:

$$\hat{\mu}_{\ln(BMF_{obs})} = \hat{\mu}_{\ln(TC)} - \hat{\mu}_{\ln(<ESC>)} \quad (16)$$

$$\hat{\sigma}^2_{\ln(BMF_{obs})} = MAX((\hat{\sigma}^2_{\ln(TC)} - \hat{\sigma}^2_{\ln(<ESC>)}), 0) \quad (17)$$

Equation (16) is equal to equation (8) of the Army's approach. Equation (17) reflects the assumption that the correlation between <ESC> and BMF equals zero. (Under this assumption, equation (17) is consistent with equation (19).)

6. Estimate the mean BMF_{obs} based on the following property of lognormal distributions:

$$\overline{BMF_{obs}} = EXP(\hat{\mu}_{\ln(BMF_{obs})} + 0.5 * \hat{\sigma}^2_{\ln(BMF_{obs})}) \quad (18)$$

Note that the basic assumption of equation (17) is that the correlation between $\ln(BMF_{obs})$ and ln(<ESC>) is zero, which also implies that the correlation between ln(TC) and ln(<ESC>) is positive and is given by the following equation:

$$\text{Correlation } (\ln(TC), \ln(<ESC>)) = \frac{\hat{\sigma}_{\ln(<ESC>)}}{\hat{\sigma}_{\ln(TC)}} \quad (19)$$

7. Estimate the distribution of the arithmetic mean BMF_{obs} based on bootstrap resampling of the tissue concentration values and estimated ESCs. (Bootstrap resampling is described in Noreen 1989.) This procedure includes five steps (a through e):

   a. Draw N pairs {TC, <ESC>} of data randomly from their individual data sets with replacement, where N is the sample size for the trophic box or species.

   b. Disassociate these pairs {TC, <ESC>}, then calculate the mean and standard deviation for the TC and <ESC> distributions.

$$\hat{\mu}_{\ln(TC)} = \frac{\Sigma \ln(TC)}{N} \quad (20)$$

$$\hat{\sigma}_{\ln(TC)} = \text{Std. Dev. } (\ln(TC)) \quad (21)$$

$$\hat{\mu}_{\ln(ESC)} = \frac{\Sigma \ln(<ESC>)}{N} \quad (22)$$

$$\hat{\sigma}_{\ln(ESC)} = \text{Std. Dev. } (\ln(<ESC>)) \quad (23)$$

c. Calculate $\overline{BMF_{obs}}$ using equations (16), (17) and (18).

d. Repeat Steps a through c 1,000 times to obtain 1,000 estimates of $\overline{BMF_{obs}}$.

e. Calculate the final distribution for μ_{BMFobs} as follows:

$$\hat{\mu}_{\overline{BMF_{obs}}} = \frac{\sum_{i=1}^{1000} (\overline{BMF_{obs}})_i}{1000} \quad (24)$$

$$\hat{\sigma}_{\overline{BMF_{obs}}} = \text{Std. Dev. } (\overline{BMF_{obs}}) \quad (25)$$

where:

$\overline{BMF_{(obs)_i}}$ = i th bootstrap estimate.

When BMF_{obs} was calculated for individual species rather than a trophic box, a weighted average of species-specific values was used for the trophic box as was done in the Army's approach. The expected value of the BMF_{obs} distribution for each trophic box/chemical combination calculated by the Shell collocated distributions approach is used as the final Shell BMF value for that combination.

EPA Modified Paired Approach

The EPA approach uses a subset of the same paired tissue concentration and <ESC> data used in the Army and Shell approaches. Appendix Section C.6.1 contains additional information on the EPA approach, including differences between the EPA and Army approaches. During the process to screen data from this subset, soil data were used to identify areas of RMA from which tissue concentration and <ESC> data pairs would not be used. The purpose of screening data in the modified paired approach was to remove the pairs of tissue concentration and <ESC> data that were associated with particularly high and particularly low soil concentrations. This exclusion of data from the tails of the soil distribution was intended to facilitate a more precise estimate of the mean BMF_{obs} in the range of contaminant levels that are most uncertain with regard to the need for cleanup. The following steps were performed during the screening procedure:

1. Remove from the data set biota samples that fell within a boundary line located 50 ft outside the 10 part per million (ppm) contours for total "drin" (i.e., aldrin plus dieldrin plus endrin) concentrations in soil (i.e., remove tissue concentration data from areas where total "drin" in soil exceeded 10 ppm and from a buffer zone of 50 ft outside the 10-ppm contours). Do this in the five following steps ((a) through (e)):

    a. Develop the boundary and 50-ft contours based on interpolated soil data at each grid point (not actual borings and not <ESC> values) and the sum of concentrations of "drins" (aldrin, dieldrin, and endrin) at each grid point.

b. Display the boundaries and contours on a map, with each contour identified individually (with a letter or number).

c. Add symbols at the collection locations for samples of the following species: earthworm, deer mouse, ground squirrel, prairie dog, cottontail, vesper sparrow, meadowlark, mourning dove, and shorebird. Note that four species of plants and two insect groups occurred at the same locations as the deer mice.

d. Identify (and list for exclusion) all tissue concentration samples that are within the boundary around each designated contour polygon.

e. In cases where very small contour polygons (<5 hectare [ha]) contain tissue concentrations to be excluded, do not exclude them if their associated exposure area is larger than the polygon. (This rule resulted in keeping some mourning dove samples in the data set because small polygons of high concentration (> 10-ppm) made up only a small portion of the individuals exposure area.

2. Remove data collected in control areas at RMA from the tissue concentration database.

3. After the screening process, calculate sample-specific BMF_{obs} values directly as the ratio of tissue concentration/<ESC> for each remaining data pair. Calculations were done for the same trophic box/chemical (or species/chemical) combinations as in the Army and Shell approaches.

   Trophic-box-specific (or species-specific) arithmetic mean BMF_{obs} distributions were defined using the sample arithmetic mean and the sample standard error.

$$\hat{\mu}_{BMF} = \frac{\sum_{i=1}^{N} BMF_i}{N} \tag{26}$$

$$\hat{\sigma}_{\overline{BMF}} = \frac{\text{Std. Dev. (BMF)}}{N^{1/2}} \tag{27}$$

where:

BMF_i = BMF for individual i.

Screening resulted in a reduction of the number of data points by 0 to 54 percent, depending on the trophic box/chemical combination. The smallest data sets (n=6) were not reduced during the screening process. Further discussion of the results of screening is provided in E.12.5.

The expected value of the BMF_{obs} distribution for each trophic box/chemical combination calculated by the EPA modified paired data approach is used as the final EPA BMF value for that combination.

C.1.5.1.3 Rationale for the Three BMF_{obs} Calculation Approaches

The three approaches for calculating BMF_{obs} were developed in response to estimation problems implied by a lack of correlation between the tissue concentrations and associated ESC estimates. Error associated with random sampling reduces the correlation in paired data and imparts an upward bias to estimation of the mean BMF.

Random error affects the estimation of BMF as follows. Sample correlations and graphical analysis of the tissue concentration and <ESC> data indicated a general lack of correlation or, in some cases, a negative correlation, which indicates that <ESC> is not fully representative of the exposure resulting in the tissue concentrations and/or that other factors may have affected tissue concentrations (e.g., off-site exposure for migrant or dispersing individuals). Under ideal collocation of samples, the error in interpolating soil concentrations and in associating the appropriate exposure area with each tissue sample would be minimal. However, even under such ideal collocation, the correlation between tissue concentration and ESC may be relatively low because ESC does not account for individual variability in true exposure due to such factors as physiology, behavior, age, and bioavailability processes in different soils. Variability in the tissue concentration/ESC relationship from these factors appropriately influences both the true mean BMF and the sample mean and so does not impart a bias. In contrast, random error in measuring tissue concentration and ESC, and in assigning a specific exposure area to a specific individual, reduces the sample correlation, increasing the sample mean of the individual BMFs but not influencing the true mean. Therefore, this random error imparts a positive bias to the BMF estimation if the paired approach is used. Random error is always present in sampling and does

not impart a bias to the estimation of the mean for the sampled populations, i.e., the tissue concentration and <ESC> distributions in this case. The bias arises in the estimation of a constructed variable (not sampled directly) such as the ratio of tissue concentration to <ESC> for each pair.

The Army and Shell approaches attempt to avoid this type of bias in BMF estimation by working with tissue concentration and <ESC> distributions, while the EPA approach attempts to minimize the degree of bias by screening the data before working with the constructed values, the individual BMFs. The rationales for these methods are based on considerations of data set screening, collocation assumptions, correlation assumptions, estimation of uncertainty, and application of arithmetic vs logarithmic estimators. Major differences in rationale are discussed below.

Data Set Screening

EPA's approach attempted to reduce variability and nonlinearity in the tissue concentration/<ESC> relationship by discarding parts of the data set associated with extreme soil concentrations. A successful reduction in variability and nonlinearity would tend to increase the correlation and thus reduce the upward bias in estimating the BMF from the paired data. The Army and Shell approaches involved correlation assumptions (discussed below) that reduced the dependency of the BMF estimates on these sources of bias. The Army and Shell collocated distributions approaches imply the underlying assumption that the advantages of screening are outweighed by the disadvantages (lower sample sizes) and therefore screening is not performed for these methods.

Collocation Assumptions

The EPA approach is based on the assumption that each tissue sample and associated ESC estimate are accurately collocated and therefore together provide an independent random sample of BMF. The Army and Shell approaches are based on the assumption that tissue concentration and <ESC> are random samples from collocated distributions; that is, the group of ESC estimates are assumed to be representative of the true exposure area concentrations which gave rise to the

group of tissue concentrations. This assumption is reasonable whether or not the individual samples are accurately paired (individually collocated). In any case where individual samples are collocated, the collocated distribution assumption is met as well. However, the converse is not true. Collocated distributions can be achieved from sampling schemes that result in noncollocated individual samples. For example, if ESC and tissue concentration estimates were drawn randomly from the same general vicinity (no collocated pairing), the distribution of tissue concentrations would be expected to be dependent on the distribution of <ESC> samples. In such a case, the mean BMF would depend on the unknown correlation of the collocated distributions. Because the sampling design underlying the data used in the IEA/RC was not random and attempted to collocate individual tissue concentrations and <ESC>s, the lack of correlation in the data implies uncertainty in both of the assumptions of collocation (pairwise and distributional) used in the three approaches.

If the data are appropriately paired, then an accurate estimate of the mean BMF is provided by utilizing this pairing (i.e., the EPA approach). However, if the data are not appropriately paired, the EPA approach will impart an upward bias to the estimation of the mean BMF, while the Army and Shell distribution approaches may impart either a negative or positive bias, depending on the extent to which their assumptions are realistic for the data set at hand.

Correlation Assumptions

EPA's approach assumes that the data pairing an observed tissue concentration (TC_{obs}) with a "predicted <ESC>" (possibly containing "location error") provides appropriate information on the relationship between TC_{obs} and "estimated actual ESC" (<ESC> without location error). Location error is the error associated with the assumption that tissue samples were taken at the center of the sampled organism's home range. "Predicted <ESC>" is the <ESC> estimate centered at the location where an organism is sampled. "Estimated actual ESC" is the <ESC> concentric with the organism's (unknown) home range.

The Army and Shell approaches assume that the predicted <ESC> and TC_{obs} data are inaccurately paired in the sense that the predicted <ESC> paired with a TC_{obs} contains location error, and

therefore the relationship between the TC_{obs} and actual <ESC> distributions cannot be estimated based on the paired sample data which typically have correlations near zero. If this is the case, then the estimation of the mean BMF will be biased upward. To avoid this suspected bias, the Army and Shell approaches make assumptions regarding the correlation between the variables TC_{obs}, <ESC>, and BMF.

As shown below, any assumption regarding the correlation of TC_{obs} and <ESC> has implications regarding the correlation of <ESC> and BMF, and visa versa. The Army approach restricts the correlation between $\ln(TC_{obs})$ and ln(actual <ESC>) to what the Army assumed to be a plausible range of values. The assumption used in the Army approach implies that BMF and <ESC> are correlated. The rationale for assuming non-zero correlation between BMF and <ESC> is that the IEA/RC estimates risk under the constraint that the true mean BMF and TC_{pred} have zero correlation. (The correlation of BMF and <ESC> implies non-zero correlation between BMF and TC_{obs}. Non-zero correlation between BMF and TC_{obs} is needed to obtain zero correlation between BMF and TC_{pred}, because of errors in the measured values TC_{obs} as estimates of the spatially distributed population mean tissue concentration.) The assumption used in the Shell approach assumes that BMF and <ESC> are uncorrelated and that the estimates of BMF obtained from the available <ESC> data are appropriate for estimating population mean tissue concentrations at RMA. The rationale for assuming zero correlation between BMF and <ESC> is that the IEA/RC estimate risk under the assumption that the true mean BMF and <ESC> have a zero correlation.

The Army and Shell approaches for calculating the variance of $\ln(BMF_{obs})$, and from this the mean BMF_{obs}, both make assumptions about the correlations between TC_{obs}, <ESC>, and BMF_{obs}. They are derived using standard statistical theory from two forms of the same general equation, the first relating TC_{obs}, <ESC>, and BMF_{obs}:

$$BMF_{obs} = \frac{TC_{obs}}{\langle ESC \rangle}$$

$$\ln(BMF_{obs}) = \ln(TC_{obs}) - \ln(\langle ESC \rangle)$$

$$\sigma^2_{\ln(BMF_{obs})} = \sigma^2_{\ln(TC_{obs})} + \sigma^2_{\ln(\langle ESC \rangle)} - 2 \cdot \rho_{(\ln(TC_{obs}),\ln(\langle ESC \rangle))} \cdot \sigma_{\ln(TC_{obs})} \cdot \sigma_{\ln(\langle ESC \rangle)} \qquad (28)$$

and the second relating BMF_{obs}, TC_{pred}, and <ESC>:

$$
\begin{aligned}
TC_{pred} &= BMF_{obs} \cdot \langle ESC \rangle \\
\ln(TC_{pred}) &= \ln(BMF_{obs}) + \ln(\langle ESC \rangle) \\
\sigma^2_{\ln(TC_{pred})} &= \sigma^2_{\ln(BMF_{obs})} + \sigma^2_{\ln(\langle ESC \rangle)} + 2 \cdot \rho_{\ln(BMF_{obs}),\ \ln(\langle ESC \rangle)} \cdot \sigma_{\ln(BMF_{obs})} \cdot \sigma_{\ln(\langle ESC \rangle)} \\
\sigma^2_{\ln(BMF_{obs})} &= \sigma^2_{\ln(TC_{pred})} - \sigma^2_{\ln(\langle ESC \rangle)} \ 2 \cdot \rho_{\ln(BMF_{obs}),\ \ln(\langle ESC \rangle)} \cdot \sigma_{\ln(BMF_{obs})} \cdot \sigma_{\ln(\langle ESC \rangle)}
\end{aligned}
\tag{29}
$$

If one assumes that:

$$\sigma^2_{\ln(TC_{obs})} = \sigma^2_{\ln(TC_{pred})} = \sigma^2_{\ln(TC)}$$

and

$$\rho_{\ln(TC_{obs}),\ \ln(\langle ESC \rangle)} = \rho_{\ln(TC_{pred}),\ \ln(\langle ESC \rangle)} = \rho_{\ln(TC),\ \ln(\langle ESC \rangle)}$$

then equations (28) and (29) are equivalent and therefore indicate that any assumption regarding the values of the correlation between BMF_{obs} and <ESC> implies a formula for the correlation between <ESC> and TC_{obs}, and visa versa. In particular, the Shell method assumes:

$$\text{Relationship(i)} \quad \rho_{\ln(BMF_{obs}),\ \ln(\langle ESC \rangle)} = 0$$

which implies:

$$\text{Relationship(ii)} \quad \rho_{\ln(TC),\ \ln(\langle ESC \rangle)} = \frac{\sigma_{\ln(\langle ESC \rangle)}}{\sigma_{\ln(TC)}}$$

The equivalency of the implications of these relationships can be seen by substituting them into the respective forms of the equation for the variance of $\ln(BMF_{obs})$, that is, relationship (i) is applied using the form given in equation (29) and the relationship (ii) is applied using the form given in equation (28). With these substitutions made, both equations simplify to:

$$\sigma^2_{\ln(BMF_{obs})} = \sigma^2_{\ln(TC)} - \sigma^2_{\ln(\langle ESC \rangle)} \tag{30}$$

subject to the constraint that

$$\sigma^2_{\ln(BMF_{obs})} \geq 0 \qquad (31)$$

Equations (30) and (31) result in equation (27) used in the Shell approach. The variance of $\ln(BMF_{obs})$ can be calculated from either formula by plugging in the assumed variance of zero for $\rho_{\ln(BMFobs),\ \ln(<ESC>)}$ into equation (29) or by estimating $\rho_{\ln(TC),\ \ln(<ESC>)}$ using relationship (ii) and applied using the form given in equation (28). The motivation behind Shell's approach is that if BMF_{obs} and <ESC> are assumed to be independent when risk and TC predictions are made, then BMF_{obs} and <ESC> should be treated as independent when the mean BMF_{obs} is estimated.

The Army method assumes values for the correlation between $\ln(TC_{obs})$ and $\ln(<ESC>)$ and therefore simultaneously implies a relationship for the correlation between $\ln(<ESC>)$ and $\ln(BMF_{obs})$:

$$\rho_{\ln(BMF_{obs}),\ \ln(<ESC>)} = \frac{\rho_{\ln(TC_{obs}),\ \ln(<ESC>)}\sigma_{\ln(TC_{obs})} - \sigma_{\ln(<ESC>)}}{\sigma_{\ln(BMF_{obs})}}$$

The motivation behind the Army's approach is that if BMF and TC_{pred} are defined to be independent, then the correlation between BMF_{obs} and <ESC> should be non-zero. This is because BMF_{obs} is calculated from <ESC> and TC_{obs}, and if BMF_{obs} and TC_{obs} have non-zero correlation, then BMF_{obs} and <ESC> also must have non-zero correlation in order for BMF_{obs} and TC_{pred} to be independent.

Estimation of Uncertainty

The uncertainty in estimating mean BMF from the field data from two interrelated sources: uncertainty of the degree of representativeness of tissue concentration and <ESC> distributions, and uncertainty in the appropriate correlation between these distributions. The Army's approach accounts for these interrelated uncertainties by allowing the correlation between tissue concentration and <ESC> to vary according to a distribution of plausible values, and through its

calibration process. The variation in the correlation results in variation in the estimated mean BMFs. The adjustment of the expected values of the BMF distributions implicitly modifies the underlying tissue concentration, <ESC>, and {tissue concentration, <ESC>} correlation assumptions. Shell's approach accounts from the uncertainty in representativeness and correlation by focusing on the sampling variability in tissue concentration and <ESC> data. It uses bootstrap re-sampling to incorporate sampling variability, which in turn produces variation in the tissue concentration/<ESC> correlation and mean BMF. EPA's approach accounts for the uncertainties of representativeness and correlation by incorporating the sampling variability in the BMF "samples", i.e., the individual tissue concentrations divided by their associated <ESC>s.

Application of Arithmetic vs. Logarithmic Sample Estimators.

The three BMF approaches used different statistical formulas to estimate means and standard deviations of the data distributions. Arithmetic estimators were applied by the Army and EPA approaches, while logarithmic estimators were applied by the Shell method. These different estimators had a large impact on the resulting BMFs, as described in Appendix Section E.12.5. Although both estimators are unbiased for lognormally distributed data, one or both of the estimators were apparently biased for the RMA data due to nonlognormality and the high proportions of BCRL data points. The potential bias is indicated by the fact that the arithmetic estimators tended to produce lower means and variances for the RMA data than the logarithmic estimators. The advantages and disadvantages of these different estimators are discussed in Appendix Section E.12.5. The rationale for selecting the estimators for each method is described below.

The Army's approach uses arithmetic sample estimators, i.e., the mean and variance of the untransformed tissue concentration and <ESC> data, to estimate the parameters of the lognormal distribution. Arithmetic estimators were used in the Army's approach because of its reliance on the robust method for handling BCRL data points. This method estimates replacement values for the BCRLs based on the assumption of lognormality. The main advantage of the robust method for handling BCRLs is that these replacement values can be transformed back to linear space and arithmetic estimators applied, reducing the reliance on the assumption that the entire

data set is lognormal (Gilliom and Helsel 1986). Therefore, the use of arithmetic estimators was considered part of the robust estimation methodology. This same rationale for using arithmetic estimators, even when the data sets are skewed, was applied in the human health risk characterization (HHRC) to estimate C_{rep} because of the high frequency of BCRLs.

Shell's approach used logarithmic sample estimators, i.e., the mean and variance of the log-transformed tissue concentration and <ESC> data. These estimators are the maximum likelihood estimations (MLEs) of the log transformed tissue concentration and <ESC> distributions. These MLEs were used because the parameters of the BMF distributions are functions of the log transformed parameters.

The EPA used arithmetic estimators applied to the BMF estimate associated with each tissue concentration; there was no strong rationale for the use of arithmetic rather than logarithmic estimators. Both sets of estimators have little or no bias for both the mean and standard deviation if the data set is a random sample from a lognormal distribution.

C.1.5.1.4 Special Cases

The shorebird trophic box presented a special case in estimating BMF because it had additive aquatic and terrestrial food-web components, and also tissue data that could be used to calibrate the model. Therefore, measured tissue concentrations in shorebirds were partitioned into aquatic and terrestrial components before being used to estimate the terrestrial BMF_{obs} and to directly calculate aquatic HQs. Estimation of BMF_{obs} involved the following steps: (1) development of tissue partitioning constants; (2) calculation of partitioned tissue concentrations, $TC_{obs,\,AQ}$ and $TC_{obs,TR}$, for each of the 10 tissue samples; and (3) calculation of BMF_{obs} based on $TC_{obs,TR}$ and the <ESC>s associated with the 10 shorebird samples. The first two steps are described in more detail below. The final step was conducted in accordance with each of the three BMF_{obs} approaches as described above. (The partitioned $TC_{obs.AQ}$ values from step 2 were used to directly calculate aquatic HQs.)

The tissue partitioning constants were developed based on the following rationale. The true partitioning fractions (i.e. the true proportions of dose due to aquatic and terrestrial components) vary for individuals according to the aquatic and terrestrial doses they receive. Doses in turn vary according to the individuals location and exposure media concentrations. However, the accuracy of predicting dose for a given sample individual was not sufficient to warrant the calculation of individual partitioning constants. Therefore, a specific set of partitions was calculated for each of the two areas from which tissue samples were taken: area 1, between Lake Ladora and Lake Mary and area 2, between Upper and Lower Derby Lakes.

The tissue partitioning constants (TPC) for shorebird area k were calculated as follows:

$$TPC_{TR,k} = \frac{T_k}{(T_k + A_k)} \tag{32}$$

$$TPC_{AQ,k} = \frac{A_k}{(T_k + A_k)} \tag{33}$$

where:

T_k	=	$BMF_{trplt,k}*C_{soil,k}*FR_{trplt} + BMF_{insct,k}*C_{soil,k}*FR_{insct}$
A_k	=	$TC_{aqinv,k}*FR_{aqinv} + C_{sed,k}*FR_{sed}$
aqinv	=	aquatic invertebrates
sed	=	sediment
trplt	=	terrestrial plants
insct	=	terrestrial insects
$C_{sed,k}$	=	average sediment concentration in area k
$C_{soil,k}$	=	average soil concentration in area k

Note that it is not necessary that A_k and T_k include feeding rate (R_k) since the term cancels in the TPC ratio. For the prey BMFs, BMF_{trplt} and BMF_{insct}, the Army calibrated model BMFs (BMF_{Army}) were used. (For terrestrial plants and insects, the EPA and Shell BMFs are larger than the Army BMFs and, therefore, would have implied a larger terrestrial tissue concentration and

TPC_{TR}, and a lower aquatic tissue concentration and TPC_{AQ}.) FR values were as derived in Appendix Section C.2.2. $C_{sed,k}$ and $C_{soil,k}$ were calculated as the area-weighted average sediment and soil concentrations, respectively, within a given shorebird area. The shorebird areas were defined so that they equaled the number of shorebird tissue samples multiplied by the size of the shorebird exposure area.

Once the tissue partitioning constants were derived, each of the shorebird tissue concentrations was multiplied by the associated tissue partitioning constants to partition it into terrestrial and aquatic components:

$$TC_{obs,TR} = TC_{obs} * TPC_{TR} \quad (34)$$

$$TC_{obs,AQ} = TC_{obs} * TPC_{AQ} \quad (35)$$

The terrestrial component was then used in the calculation of BMF_{obs} for shorebird.

C.1.5.1.5 Development of $BMF_{lit/model}$

This section and Appendix Section C.1.5.1.6 describe the final two steps in developing the Army's calibrated BMF (BMF_{Army}). These steps were designed to integrate field and literature data to obtain a "most informed" estimate of BMF. While BMF_{obs} represents a BMF estimate based entirely on field data, it was not, in general, possible to calculate a literature-dependent BMF for a given trophic box based entirely on literature data for that box. Any literature-dependent estimate of BMF is influenced by uncertainties or errors in the BMFs of prey items. Therefore it is reasonable to reduce uncertainty in the prey BMFs, to the extent possible, before applying the literature BAF to estimate BMF. For this reason, $BMF_{lit/model}$ was defined as that value implied by the literature BAFs and the final calibrated BMFs (BMF_{Army}) for prey trophic boxes, i.e.:

$$\overline{BMF}_{lit/model(k)} = \overline{BAF}_{lit(k)} * \sum_j FR_{k,j} * \overline{BMF}_{Army(j)} \quad (36)$$

where:

$\overline{BMF}_{lit/model(k)}$ = Mean biomagnification factor distribution for predator k predicted by the terrestrial food-web model

$\overline{BMF}_{Army(j)}$ = Weighted average of $\overline{BMF}_{lit/model}$ and $\overline{BMF}_{obs}$ for prey j

$BAF_{lit(k)}$ = Mean bioaccumulation factor distribution for predator k derived from literature values

$FR_{(k, j)}$ = Fraction of predator diet contributed by trophic box j

k = Predator trophic box index variable

j = Prey trophic box index variable

BMF_{Army}, which represents the most informed combination of $BMF_{lit/model}$ and BMF_{obs}, is developed during calibration.

C.1.5.1.6 Development of Calibrated BMF

BMF_{Army} was the final BMF used for prey trophic boxes in the Army's approach. It was developed through a calibration procedure that evaluated two estimates of BMF, BMF_{obs} and $BMF_{lit/model}$, as well as intermediate values, and from these selected a single BMF considered to provide the best prediction of measured tissue concentrations. The values of BMF_{obs} and $BMF_{lit/model}$ represented both field and literature data and therefore were considered to provide the range of likely values for BMF. Specifically, BMF_{Army} was defined as the weighted average of BMF_{obs} and $BMF_{lit/model}$:

$$\overline{BMF}_{Army} = w * \overline{BMF}_{obs} + (1-w) * \overline{BMF}_{lit/model} \quad (37)$$

$$w = \{0, 0.1, 0.2, ..., 0.9, 1.0\} \quad (38)$$

For those trophic boxes having field data appropriate for calculating BMF_{obs} (terrestrial plant, worm, insect, small bird, small mammal, medium mammal, herptile, and shorebird), relative weights for BMF_{obs} and $BMF_{lit/model}$ were assigned individually.

The goal in calibrating BMF was to select a value that was able to reproduce site phenomena; however, the ambiguity in interpreting the relationship between RMA soil and tissue concentration data precluded the use of a single numerical criterion to evaluate alternative BMFs. For example, the BMF that best predicts the measured tissue concentrations from the associated ESC estimates differs considerably for a regression slope approach (described below), and the paired data and collocated distributions approaches. Since the paired data and collocated distribution approaches were used to estimate BMF_{obs} they would provide a circular (unfair) criteria for calibrating BMF; each would always select the BMF_{obs} developed under that particular approach. The paired data and collocation distribution approaches also do not incorporate information contained in the RMA database regarding spatial structure. For these reasons, the calibration protocol evaluated RMA data using two very different types of analyses: the evaluation of tissue concentration versus <ESC> scatter plots, and the spatial comparison of predicted population mean tissue concentrations and observed individual tissue concentrations (using GIS maps). Both analyses relied on professional judgement rather than a numerical criterion for reasons discussed below.

Tissue Concentration vs <ESC> Scatter Plots

Tissue concentrations were compared to <ESC> using scatter plots and professional judgment. The conventional criterion pertaining to a regression analysis of the scatter plots (constrained through the origin) could not be used for reasons discussed below.

The tissue concentration vs <ESC> scatterplots (where tissue concentration and <ESC> were plotted on the Y and X axis, respectively) were used to qualitatively assess the frequency and magnitude of over and underpredictions of measured tissue concentrations. The tissue concentration vs <ESC> scatter plots were visually inspected for each trophic box/chemical combination and predictions of tissue concentration were evaluated relative to the prescribed relationship between tissue concentration and <ESC>:

$$TC = \overline{BMF} * \langle ESC \rangle \qquad (39)$$

where:

TC = biota tissue concentration
<ESC> = estimated exposure area soil concentration

Equation (39) is a formal statement of the assumption that the relationship between tissue concentration and <ESC> is linear, and that when <ESC> equals 0, tissue concentration equals 0. The slope of a straight line through the origin of an {<ESC>, TC} scatterplot is, by equation (39), the BMF. $BMF_{lit/model}$ and BMF_{obs} appear on the {TC, <ESC>} scatterplot as the slopes of two lines through the origin. Equations (37) and (38) define the slope of any line through the origin of the {<ESC>, TC} scatterplot over the range bounded by BMF_{obs} and $BMF_{lit/model}$. Only slopes within this range were considered as admissible values for BMF_{Army}.

If the model equation (39) described the true relationship between the variables ESC and tissue concentration and also the relationship between the paired sample data, a BMF selected by a constrained least squares regression criterion would provide the best estimates of tissue concentrations and risks. In fact, the scatterplots strongly indicated that the paired {<ESC>, TC} data did not follow this prescribed relationship and often had values distributed along the two axes (i.e., high tissue concentrations paired with very low <ESC>s and very low tissue concentrations paired with high <ESC>s). In such cases, the standard least squares regression fit through the origin ignores the values distributed along the y axis near x equals 0 and results in relatively low BMFs. Therefore, this criterion, although considered, was not often used to select a BMF. Instead, a set of eleven candidate BMFs were considered using the tissue

concentration map evaluation protocol described below. The set of BMFs were bounded by $BMF_{lit/model}$ and BMF_{obs} and given by equations (37) and (38).

Tissue Concentration Map Evaluations

A qualitative protocol was developed to evaluate tissue concentration maps. The qualitative protocol was used because the tissue concentration map evaluation depended on nuances of spatial pattern of contamination that could not be adequately characterized by a single numerical criterion.

For a given trophic box/chemical combination, one or more BMFs (each representing a different weighting of BMF_{obs} and $BMF_{lit/model}$) were evaluated using maps of predicted and observed tissue concentration. Maps were produced that displayed the surface of predicted tissue concentrations implied by a given BMF, overlain by symbols indicating the location of measured tissue samples. The concentration class (e.g., 0.1 - 0.5 ppm) was indicated by the color of the predicted tissue concentration (TC_{pred}) surface or the measured tissue concentration (TC_{obs}) symbol so that substantial differences in concentration could be readily identified. Based on these maps, measured tissue concentrations were compared to tissue concentration predictions in the vicinity of each sample location. This information about spatial structure in the data is extremely important in the assessment of tissue concentration predictions because biomagnification in mobile organisms is inherently a spatial process (e.g., the size, shape, habitat characteristics, location, and other spatial properties of hot spots- not just the concentration- determines exposure).

The tissue concentration map analysis follows from the premise that the model used to estimate risk (whether based on literature or site data) should ideally be able to reproduce phenomena that are observed on the site. The strong advantage of evaluating mapped tissue and estimated exposure area soil concentrations is that they reflect minimal assumptions and are therefore less disputable than the (presumably) paired tissue concentration and <ESC> data used in the scatter plots. (Assumptions regarding BCRLs, exposure area size, and spatial interpolation are involved in processing the maps; however, these assumptions cannot be avoided and permeate any use of

the field data.) The map comparison displays the relatively accurate tissue concentration measurements without any assumptions of association. The question is left open as to which <ESC>s represent a possible exposure for a given sample individual. For example, if an individual with a high measured tissue concentration was collected from a point where tissue concentration is predicted to be low, several interpretations are possible. For example, BMF may be underestimated or BMF may be accurate but the sampled individual received a higher exposure from a nearby hot spot than was estimated at its exact collection point. Or, the high measured tissue concentration could be interpreted in conjunction with other nearby low tissue concentrations as an indication of high tissue concentration variability on the edge of a hot spot, a phenomena that may also be predicted by the model. Because proximity and spatial structure are displayed, the tissue concentration maps represent the site data in the most complete manner and with the fewest assumptions possible.

Due to the large number of maps generated, a tabular summary was devised to aid in describing the map comparisons. The map summaries were developed in two steps. First, the quality of individual predictions (TC_{obs} compared to surrounding TC_{pred} values) was evaluated by one of five categories and the fraction of data which fell within each category was estimated. Second, an overall rating was assigned to each map based on the fractions determined in step one, the magnitude of over and under estimates, considerations regarding sample size adequacy, and an assessment of whether an increase or decrease in BMF would enhance the predictions. The categories and ratings are described below.

Individual Prediction Categories

Good: TC_{obs} was within the same class as TC_{pred} value at the exact location where the TC_{obs} individual was collected.

OK: Correct values for TC_{pred} did not occur at the precise sampling location but did occur within a specified "allowable distance" from a given TC_{obs}. Because of the many sources of error in estimating the true exposure area for each TC_{obs}, this case (close proximity of correct tissue concentration estimates) did not represent a clear contradiction of the model estimates. In general, the potential error in correctly identifying the center of the exposure area for a given sample individual is at least as large as the

exposure area radius, since the individual could have been caught at the edge of its exposure area. The allowable distance used to evaluate the "OK" category was approximately one-half the exposure area radius with a minimum of 250 ft imposed to reflect the possibility of a sample location error this large even for very small exposure areas.

Over: TC_{pred} values within the allowable distance from a given TC_{obs} were too high.

Under(hit): TC_{pred} values within the allowable distance of a given TC_{obs} were too low, and TC_{obs} was a detected concentration.

Under(BCRL): TC_{pred} values within the allowable distance of a given TC_{obs} were too low and TC_{obs} was BCRL. Since the true tissue concentration of the sample may be much lower than its estimated BCRL replacement value on the map, this case was not considered to be a definite underestimation.

Overall Ratings

Good: The model closely predicted a substantial portion of the TC_{obs} data. Significant increases or decreases in the BMF would reduce the fit. Small changes in BMF (< 1/4th order of magnitude) may or may not enhance the fit.

OK: The model resulted in a substantial portion of both over and under estimates. While the fit was not good, improvement in the fit was not likely to result from either an increase or decrease in BMF.

Good-Over: The model closely predicted a substantial portion of the data. Improvement was more likely to result from a decrease, rather than increase in BMF.

Good-Under: The model closely predicted a substantial portion of the data. Improvement was more likely to result from an increase, rather than decrease in BMF.

NC: The model was not contradicted by the data; however, the power to discriminate between different BMFs was extremely low.

Poor: The model over/under predicted a substantial portion of the data so that a smaller/larger BMF was indicated.

Map summaries for the final prey BMFs selected using this calibration procedure (BMF_{Army}) are reported in Table C.1-4.

C.1.5.2 Development of Final BMF for Predators

Final BMF values for top predators (bald eagle, great horned owl, American kestrel and great blue heron) were developed differently from those for their prey because appropriate tissue sample data were not available for these predators. In the absence of field data, final BMFs for top predators were developed from a food-web model. This is equivalent to assigning BMF_{obs} a relative weight of zero (w = 0) and $BMF_{lit/model}$ a relative weight of 1. Thus, the final BMF for predators was based on a revision of equation (34):

$$\overline{BMF}_{lit/model(k)} = \overline{BAF}_{lit(k)} * \sum_j FR_{k,j} * \overline{BMF}_{Army(j) \text{ or } Shell(j) \text{ or } EPA(j)} \quad (40)$$

where:

terms in this equation are as defined for equation (36).

More information on this food-web model and the basis for equation (36) is provided below.

In general, a food-web model is a representation of energy (food) flow from lower trophic-(feeding) level biota to upper trophic-level organisms. As applied to contaminant transport, the model is used to simulate the movement of a chemical from the exposure medium (soil, sediment, or water) into successive trophic levels, with the eventual result being its biomagnification in the top predator through the same pathways by which food is transported to the top species (Cohen 1978). Various food-web models were considered for RMA (i.e., Schnoor 1981; Thomann 1981; Spacie and Hamelink 1982; Mackay and Paterson 1981; Barber et al. 1988); however, none of these were directly applicable to multiple food chains in either aquatic or terrestrial ecosystems, so elements from several models were used to develop an RMA-specific approach. The ERC food-web model is an expanded version of the model first applied at RMA

by Fordham and Reagan (1991). For species that spend only a part of their life cycle at RMA, the food web model approach is conservative because it assumes year-round exposure.

The fully developed version of the food-web model addresses both terrestrial and aquatic ecosystems and has parameters developed to estimate BMF for predators and prey in both terrestrial and aquatic food chains from data in the literature. However, as discussed above, site-specific field data were used as the basis for final BMF values whenever possible because the BMF serves as a proportionality constant between site-specific TC and <ESC> data and between toxicological thresholds and TC estimates that reflect site-specific <ESC> data. To be an effective proportionality constant, BMF must also be site-specific. To maximize the site-specificity of BMFs developed for predators, their BMFs were modeled directly from the BMF_{obs} values for their prey, using the portion of the food-web model for terrestrial food chains as follows. Further explanation of the food chain model is provided in Appendix D, and the quantification of the parameters that were used in the IEA/RC is documented in Appendix Section C.2.

In terrestrial food-chain equations, the BMF was computed as a function of the bioaccumulation factor (BAF) and the dietary fraction (i.e., the fraction of any prey species in a predator's diet, represented by "FR" in the model). Aquatic food chains for birds were modeled using the BAF and FR parameters like the terrestrial food chains. The rationale behind the model's calculation of BMF is given in an example below.

For a simple, straight-line terrestrial food chain of three trophic levels, with the first level equal to the source medium and the third level equal to the top predator, the BMF for level 3 can be expressed as follows:

$$BMF_3 = BAF_3 * BMF_2 \qquad (41)$$

where:

BMF_3 = Biomagnification factor for level 3
BAF_3 = Bioaccumulation factor for level 3
BMF_2 = Biomagnification factor (equals the bioaccumulation factor) for level 2

Bioaccumulation is the process by which a chemical is accumulated into an organism by direct exposure as well as ingestion of food and soil (or other media) and the bioaccumulation factor (BAF) is the ratio of contaminant concentration between a predator and its prey.

If the second trophic level contains two trophic boxes, the equation can be expanded to account for contributions from two prey trophic boxes to the top predator's diet as follows:

$$BMF_3 = BAF_3 * (FR_{3,2A} * BMF_{2A} + FR_{3,2B} * BMF_{2B}) \quad (42)$$

where:

2A and 2B = Trophic boxes in the second level
$FR_{3,2A}$ and $FR_{3,2B}$ = Dietary fractions of trophic boxes 2A and 2B in the diet of the predator trophic box at level 3

This simple equation can be further expanded to accommodate the much greater size and complexity of the RMA food webs.

The top predator BMFs were computed probabilistically because the BAF and prey BMFs used to calculate them are represented by distributions. These distributions were represented by a mean and standard deviation (or other descriptors appropriate to the distribution type) in the model spreadsheets. The probabilistic, rather than deterministic, approach quantified a portion of the uncertainty in the input data and propagated it through the computation of the predator BMFs. The input parameters used in the food-web model are discussed and quantified in Appendix Section C.2.

Some measured tissue concentration data were available for the top predators (American kestrel, bald eagle, and great horned owl). Some of these field data were used in Appendix Section E.12.7.6 to provide a reality check on the tissue concentrations implied by the BMFs estimated using the food-web model. The available kestrel samples consisted of eggs and dressed carcasses of juveniles that had not fledged and therefore received food from adults that foraged largely or exclusively within RMA. Although the juvenile dressed carcass samples could have been used to calculate BMF_{obs}, their concentrations were correlated to the concentrations in egg samples taken from the same nest (R=.67) and the concentrations in juveniles and eggs collected from the same nest were similar. These two observations indicate that the juvenile tissue concentrations were likely to depend in large part on the prenesting exposure of their parents, which are not restricted to RMA. To avoid potential bias, the kestrel data set was not used to estimate BMF_{obs}, but was used for comparison with tissue concentrations implied by the modeled kestrel BMF. The only tissue samples available for bald eagles (blood) and great horned owls (eggs) were not considered to be appropriate for comparison with values that reflected whole body concentrations.

C.1.6 CALCULATION OF POTENTIAL RISK

As stated in the introduction to Appendix Section C.1, calculations of potential risk were based on a comparison of predicted or measured site-specific tissue concentrations to toxicological threshold values using either a tissue-based approach or a dose-based approach. For both approaches, the ways in which risk was calculated for various trophic box/chemical combinations, except where absent data prevented a specific calculation, varied in response to (1) the type of food chains leading to a trophic box and (2) the type of COC being evaluated as follows.

Calculations differed depending on whether a trophic box had only terrestrial food chains, only aquatic food chains, or both leading to it in a food web:

- For trophic boxes with terrestrial food chains, BMFs, however calculated, were multiplied by <ESC> values to predict tissue concentrations for each block in the RMA-wide grid; the comparison of each of these tissue concentrations to a toxicological threshold resulted in a calculation of potential risk.

- For trophic boxes with aquatic food chains, measured tissue concentrations were compared directly to a toxicological threshold to calculate potential risk.

- For trophic boxes with mixed food chains, potential risk was calculated from both terrestrial and aquatic sources.

Regardless of the type of food chains leading to a trophic box, calculations of potential risk to the trophic box also differed depending on whether or not the COC being evaluated was bioaccumulative.

- For the bioaccumulative COCs (aldrin/dieldrin, DDT/DDE, endrin, and mercury), both tissue-based and dose-based calculations were done and the more certain of these values was used.

- For the remaining COCs, only dose-based calculations were done and this application of the dose-based approach considered only contaminant uptake from abiotic media, not from food.

A few special cases that were outside these situations are identified below. Each of these situations, except risk calculations for aquatic food chains and for nonbioaccumulative COCs, uses a BMF. When a BMF was used, calculations were done three times, using final values from each of the BMF approaches.

The remainder of this section provides more information on the ERC calculation of potential risk, first defining risk (Appendix Section C.1.6.1), identifying the data used to quantify risk (Appendix Section C.1.6.2), and then detailing the ways in which it was calculated in each of the situations above (Appendix Section C.1.6.2).

C.1.6.1 Definition of Potential Ecological Risk

The term risk implies that there is some probability of an adverse effect occurring in an exposed or potentially exposed population, e.g., the probability of excess cancer cased in a given human population. For the ERC, risks were quantified on the basis of HQs and His that do not represent probabilities but rather estimates of the magnitude of difference between a measure of exposure (tissue concentration or dose) and a toxicity threshold value considered to be protective (MATC or TRV). It is assumed that the magnitude of the potential adverse effect (risk) will be proportional to the magnitude of the HQ or HI. Based on best professional judgment, an HQ or

HI of 1.0 represents the highest level of chronic exposure that is unlikely to result in adverse effects on populations exposed chronically in the field. For values of HQ or HI greater than 1.0, the potential for adverse effects increases as the HQ or HI value increases. The range of uncertainty in these statements regarding HQs or HIs spans at least one order of magnitude. This uncertainty exists in both directions; hence, some risk may occur at values of HQ or HI as low as 0.1, and no risk may occur at values of HQ or HI as high as 10.

C.1.6.2 Data Used to Quantify Risk

A combined total of 1897 biota tissue samples were collected under three programs: the Biota RI (ESE 1989), the Biota CMP (RLSA 1992), and the ERC. Once off-post control samples, fortuitous (i.e., found dead) samples, and QA/QC rejections were removed, 1328 samples remained to provide tissue concentrations representative of the terrestrial and aquatic trophic boxes. Further information on the collection of these biota samples is in Appendix A and Appendix Section C.4.

Soil concentration data used for risk calculations were described in Appendix Section C.1.4. The soil boring and surficial soil data used in risk calculations (and in BMF calculations) were taken from the RMA environmental database and modified as described in that section through screening, quality assurance checks, spatial interpolation of BCRL samples, interpolation of soil concentrations into an RMA-wide grid, and spatial weighting of interpolated data using trophic-box-specific or species-specific exposure areas to get <ESC>.

Sediment and water concentrations of the bioaccumulative COCs entered the risk calculations indirectly through the tissue concentration data collected from aquatic biota. Water concentrations of the bioaccumulative COCs also entered the risk calculations explicitly in that ingestion of water accounted for 7.1 percent by mass of the assumed diet for the great blue heron. Virtually all of the water concentration measurements for the nonmetal COCs were BCRL. In calculating exposure through direct ingestion of water, these COC concentrations were set equal to their respective CRLs. It was noted in Appendix Section C.1.4.2 that the risk calculation was found to be insensitive to the water concentrations selected (over the range of

zero to the CRL). Measured water concentrations for mercury did exceed CRLs, so the average observed mercury concentration was used in the risk calculations.

C.1.6.3 Calculation of Potential Risk

Potential risk is expressed as a hazard index (HI) for all COCs collectively or a hazard quotient (HQ) for a single chemical. Thus, the total cumulative risk for all contaminants and exposure pathways can be expressed as:

$$Risk_{total} = Hazard\ Index \tag{43}$$

where:

HI is defined as:

$$HI = \sum_i \sum_j \frac{Estimated\ Exposure_{ij}}{Toxicity\ Threshold_{ij}} \tag{44}$$

The i and j refer to contaminant "i" and exposure pathway "j", respectively.

The ratio of the estimated exposure to the toxicity threshold for a single contaminant is defined as the HQ and expressed as:

$$HQ_i = \sum_j \frac{Estimated\ Exposure_{ij}}{Toxicity\ Threshold_{ij}} \tag{45}$$

The estimated exposure can be represented as the contaminant concentration in biota tissue, or the estimated contaminant intake rate (dose) at the point of exposure. The corresponding toxicity thresholds can be represented by the maximum allowable concentration in biota tissue (MATC)

or the maximum allowable intake rate or dose (TRV). Therefore, the HQ for contaminant *i* can be expressed as:

$$HQ_i = \frac{Tissue\,Concentration_i}{MATC_i} \tag{46}$$

or

$$HQ_i = \frac{Dose_i}{TRV_i} \tag{47}$$

for the tissue-based and dose-based approaches, respectively.

C.1.6.2.1 Variations in Risk Calculation for Different Types of Food Chains

Risk Calculations for Terrestrial Food Chains

When the tissue-based approach was used for terrestrial food chains, the tissue concentrations used to calculate potential risk were estimated using BMF and <ESC> so that potential risk could be calculated at each grid point on RMA. Thus, equation (46) can be expanded for terrestrial food chains by replacing tissue concentration with the product of the BMF and <ESC>:

$$(HQ_i)_{terrestrial} = \frac{BMF * <ESC>}{MATC} \tag{48}$$

When the dose-based approach was used for terrestrial food chains, BMF and <ESC> were also used to estimate tissue concentrations at individual grid points; to convert the tissue concentration of the trophic box being evaluated into a dose, R (feed rate) was added to express tissue concentration on a daily basis and BAF was added to convert from the tissue concentration in the trophic box to that in its prey. Thus, equation (47) can be expanded for terrestrial food chains as follows:

$$(HQ_i)_{terrestrial} = \frac{R * BMF * <ESC>}{BAF * TRV} \quad (49)$$

Note that the sum of prey tissue concentrations, represented by their respective BMF and <ESC> values then weighted by the dietary fraction, can be substituted in equation (49) to avoid the use of BAF. Thus:

$$(HQ_i)_{terrestrial} = \frac{R * \sum BMF_{prey} * FR * <ESC>}{TRV} \quad (50)$$

The parameters used above are discussed further in Appendix Section C.2.

Risk Calculations for Aquatic Food Chains

For most of the trophic box/chemical combinations in aquatic food chains, measured tissue data that were considered representative of the relatively homogeneous aquatic environment were available. Therefore, measured tissue concentrations could be used directly in both the tissue-based and dose-based approach equations (equations (46) and (47) above) to calculate risk to aquatic trophic boxes, and estimations of tissue concentrations using BMF were not needed. This is how risk to the water bird was calculated as explained further in Appendix Section C.1.4.2. However, toxicity threshold values (MATC and TRV) were lacking in the literature for trophic boxes representing strictly aquatic organisms such as fish, aquatic plants, and aquatic invertebrates. Therefore, while risk to these trophic boxes could not be calculated, their tissue concentrations were used to estimate the tissue concentrations of and dose to top predators that had aquatic food chains (bald eagle and great blue heron). These calculations are shown in Appendix Section C.1.4.2.

The calculation of potential risk to strictly aquatic organisms by use of the food-web model and by comparison to EPA's ambient water quality criteria (AWQCs) was also investigated. However, both of these approaches required information on COC concentrations in surface water.

Because the COCs (except arsenic and mercury) had few or no detections in analyzed surface water samples, surface water COC concentrations would have had to be estimated. Efforts at estimation using equilibrium partitioning and the WASP model proved too uncertain.

The final approach to evaluating risk to strictly aquatic organisms was to identify the sources of COCs that might be contributing to potential risk and the likely magnitude of that risk. This approach revealed that the ultimate source of contamination found in RMA lake sediments and water is soils from the shoreline and surrounding upland areas. This is qualitatively supported by the documentation of highly elevated aldrin, dieldrin, and endrin sediment concentrations near the north inlet of Upper Derby Lake that are orders of magnitude above sediment concentrations elsewhere in Upper Derby Lake, many of which are BCRL. The inlet sediment concentrations are similar to nearby soil concentrations, which are on the order of 0.1 to 10 ppm. The magnitude of the risk to strictly aquatic trophic boxes from contaminants with their origin in surrounding soils can be assumed lower than the magnitude of risk from aquatic food chains to the bird species evaluated because the strictly aquatic trophic boxes are lower in the food web. For the water bird (assumed to be strictly aquatic but having toxicity threshold values), bald eagle, and shorebird the potential risk is of relatively low magnitude ($2.0 > HI > 1.0$). The great blue heron (HI=13), which consumes primarily predatory fish, exhibited the greatest risk from aquatic food chains.

Risk Calculations for Trophic Boxes with Both Terrestrial and Aquatic Food Chains

The shorebird, eagle, and heron food webs have both terrestrial and aquatic food web components. Therefore, potential risk to these trophic boxes results from both terrestrial and aquatic contributions to their tissue concentrations or doses and their total potential risk can be calculated as the sum of the partial risks from these sources. Partial tissue- and dose-based risks are defined for a single chemical as follows:

$$HQ_{TR} = \frac{TC_{TR}}{MATC} \quad (51)$$

$$HQ_{AQ} = \frac{TC_{AQ}}{MATC} \quad (52)$$

$$HQ_{TR} = \frac{dose_{TR}}{TRV} \quad (53)$$

$$HQ_{AQ} = \frac{dose_{AQ}}{TRV} \quad (54)$$

Total risk is equal to the sum of partial tissue-based or dose-based risks. Thus, for example:

$$HQ_{TOTAL} = \frac{\text{tissue concentration}_{TOTAL}}{MATC} \quad (55)$$

$$= \frac{\text{tissue concentration}_{TR} + \text{tissue concentration}_{AQ}}{MATC} \quad (56)$$

$$= HQ_{TR} + HQ_{AQ} \quad (57)$$

The calculation of total risk based on dose is comparable.

Potential risk to top predator trophic boxes is presented separately in the ERC for terrestrial and aquatic food chain sources. The additive nature of these risks should be kept in mind when evaluating current risk and when considering future scenarios where the balance between terrestrial and aquatic contributions may be varied.

C.1.6.2.2 Variations in Risk Calculation for Different Types of COCs

Of the 14 COCs evaluated by the ERC, six are defined as bioaccumulative: aldrin/dieldrin, DDT/DDE, endrin, and mercury. Chlordane, although it bioaccumulates, was treated with the rest of the COCs as nonbioaccumulative for reasons discussed elsewhere. These two groups of COCs differ in the approaches that were available to evaluate potential risk and in the way dose was defined.

Evaluation of Potential Risk for Bioaccumulative COCs

For the bioaccumulative COCs, potential risk could be evaluated using either the tissue-based or dose-based approach. A slightly different rationale was used to select the final approach for terrestrial and aquatic food chains.

Approach Selection for Bioaccumulative COCs in Terrestrial and Mixed Food Chains

Protocol—The selection of the final approach to be employed in the estimation of potential risk from terrestrial and mixed food chains was based primarily on the uncertainty in the toxicological threshold values (MATC and TRV) for each trophic box/bioaccumulative chemical combination. The aquatic component of mixed food chains was generally treated like the terrestrial food chains because there were no appropriate measured tissue samples for the trophic boxes having mixed food chains. Uncertainty factors (UFs; described in greater detail in Appendix Sections C.2.3 and C.2.5) for the toxicological threshold values were the primary basis for the decision between the tissue-based and dose-based approaches. For each trophic box/chemical combination considered, the numerical values of the UFs were compared, and the threshold value with the lower UF was typically selected. When the UF values were very similar for MATCs and TRVs, other considerations entered into the selection.

The other considerations used in selecting the type of risk calculation approach to be used for bioaccumulative COCs were uncertainty about the BAF, source of information, and the possibility of future sampling. The tissue-based approach incorporates one more level of computation than the dose-based approach. This is because the dose-based approach uses prey tissue concentrations as the dose to the predator, while the tissue-based approach must transform the predator dose into a predator tissue concentration by using the predator's BAF. Thus, when UF values were numerically close, the relative values of the predator BAFs, mean and standard deviation were also evaluated. Further, when the two toxicological endpoints were developed from different papers, the relative strength of the papers and the pertinence of the test organisms were considered. When the two criteria were developed from the same paper, the total UF reflected any differences in extrapolations needed to derive the pre-UF values because of the way data were presented in the paper so that the quality of the paper and pertinence of the test organisms were not an issue. Finally, the dose-based approach was given more weight for the bald eagle trophic box when uncertainty was similar for the two approaches since no post-remediation tissue samples can be taken to test for effectiveness of remediation.

Results—Table C.1-5 summarizes the risk calculation approach selected for each trophic box/ bioaccumulative chemical combination. The UF values associated with MATC and TRV values for each combination are listed in Table C.1-6. Also shown are the relative uncertainty associated with the BAF and other information considered to decide which type of risk calculation approach was more appropriate for each trophic box/chemical combination.

For eagle, heron, owl, and kestrel, the selection of risk calculation approach was based solely on a comparison of the MATC and TRV UFs in all cases except three: aldrin/dieldrin for eagle; aldrin/dieldrin for owl; and aldrin/dieldrin for kestrel. In these three cases, the MATC and TRV UFs were the same, so the dose-based approach was selected on the basis of the assumption that there is less uncertainty in estimating the predator's dose from the available estimate of the average prey tissue concentration than there is in estimating the predator's tissue concentration from the average prey tissue concentration estimate. It is implicit in this assumption that there

is more uncertainty in the BAF needed to predict predator tissue concentration from prey tissue concentration than in the R value needed to adjust prey tissue concentration to a predator dose.

For shorebird, the tissue-based approach was selected for DDT/DDE and endrin and the dose-based approach was selected for aldrin/dieldrin and mercury (for terrestrial food chains only) on the basis of the relative magnitude of MATC and TRV UFs. Use of the tissue-based approach to calculate risk from mercury to this trophic box from aquatic food chains allowed direct use of the partitioned measured shorebird tissue data. Even though the TRV UF was lower, the absence of a BAF for this trophic box/chemical combination precluded the use of shorebird tissue data to calculate its dose.

For both small and medium mammal, the dose-based approach was the only approach used; it had the lower UF for aldrin/dieldrin and DDT/DDE and was the only available approach for endrin and mercury. For small bird, the tissue-based approach was selected for endrin and the dose-based approach was selected for aldrin/dieldrin, DDT/DDE, and mercury.

Approach Selection for Bioaccumulative COCs in Aquatic Food Chains

Protocol—The calculation of risk from aquatic food chains emphasized the use of measured tissue concentrations, which were assumed representative of the lakes from which they were collected. Therefore, the tissue-based approach was generally used whenever measured tissue data were available (without consideration of UFs for MATC and TRV) because it allowed the calculation of risk from unmodified measured data and avoided the additional uncertainty that would be introduced by converting the tissue concentration data into a dose estimate.

Results—For water bird, the tissue-based approach was selected for aldrin/dieldrin, DDT/DDE, and mercury. The water bird MATC UF was twice the TRV UF for aldrin/dieldrin, one and two-thirds the TRV UF for DDT/DDE, and one and one-half times the TRV UF for mercury, but the tissue-based approach was selected for all these cases because measured tissue data could be used. The dose-based approach was selected for endrin, where the MATC UF was three-fourths

the TRV UF; only two of the 67 tissue samples measured contained detectable concentrations of endrin.

Evaluation of Potential Risk for Nonbioaccumulative COCs

For the nonbioaccumulative COCs, a modified version of the dose-based approach was used to evaluate risk because tissue concentrations of these chemicals were not measured at RMA. Therefore, there are no direct measurements of contaminant concentrations in food items, which are a much less important contaminant source for COCs that do not bioaccumulate. Thus, when the dose-based approach is applied to nonbioaccumulative COCs, the dose used is based only on the contaminant contributions from soil/sediment and, in some cases, water.

C.1.6.2.3 Special Cases in Risk Calculation

There are two special cases that require further discussion of their risk calculation: where species-specific rather than trophic-box specific BMFs were calculated and when COCs were naturally occurring as well as present as a result of human activities. Each of these cases is discussed below.

Risk Calculations Using Species-Specific BMFs

The species that were grouped together in a trophic box determined the exposure area appropriate to the trophic box as described in Appendix Section C.2.4. As was noted in Appendix Section C.1.5.1.2, there were a few instances in which exposure ranges were somewhat variable within a trophic box and data were sufficient to calculate species-specific exposure areas (i.e., small bird, small mammal, and medium mammal trophic boxes in combination with aldrin/dieldrin). In these cases, the species-specific BMF_{obs} values were then combined in a weighted average. To calculate risk for these three trophic box/chemical combinations, the <ESC>s calculated using the smallest of the exposure areas available for the trophic box were paired with the weighted average BMF to estimate tissue concentrations for comparison with the appropriate toxicological threshold at each grid point. This is a conservative assumption in the sense that remediation protective of smaller home ranges will always be protective of a larger home range composed of the smaller areas. The use of <ESC>s associated with the smallest exposure range helped

ensure that risk to prairie dog's (which have a smaller exposure area than cottontails) would not be underestimated. This was particularly important because this species is an important prey item for wintering raptors, including the bald eagle. This approach was also used to try to ensure that risk to the diverse species of small birds on RMA would not be underestimated by using the large and atypical exposure area defined for the mourning dove.

Risk Calculations for Naturally Occurring COCs

Four of the COCs are naturally occurring metals: arsenic, cadmium, copper, mercury. For these metals an indicator level range was developed for and used in the RI/FS at RMA (ESE 1986). The indicator range was based on an evaluation of the natural ranges of potential contaminants in soils of the western U.S., the results from chemical analysis of a bulk soil sample collected just off the northeast corner of RMA, and the soil quality data from the uncontaminated portions of 24 of the 27 land sections at RMA. Background levels of metals, defined in the IEA/RC as the upper end of the indicator range, are: arsenic, 10 ppm; mercury, 0.1 ppm; cadmium, 2 ppm; and copper, 35 ppm. ESE (1986) recognized the inherent variability in trace metal concentrations at RMA due to the variety of soil series present, but concluded: "...comparison of these values with action levels selected by the U.S. EPA and various states at NPL sites and with recommended concentrations for land treatment of hazardous waste indicates these levels are very conservative" (ESE 1986, pg 4-18). The types of data on which the indicator range was based are shown in Table C.1-7.

C.1.6.3 Evaluation of Risk

Potential ecological risk at RMA was quantified using total HIs, HIs for chemical groupings, and HQs. Total HI was calculated for all trophic boxes that had available MATCs or TRVs (bald eagle, great horned owl, American kestrel, great blue heron, shorebird, water bird, small bird, medium mammal, and small mammal). For these trophic boxes, HIs were also calculated for three groupings of chemicals. These three chemical groupings were aldrin/dieldrin, DDT/DDE, and endrin; mercury, arsenic, cadmium, and copper; and chlordane, CPMS, $CPMSO_2$, DBCP, and DCPD. Thus, the contributions to total risk of the bioaccumulative COCs (minus mercury), the metals, and the other COCs were evaluated separately. In addition, for the metals grouping,

potential risk was also calculated using <ESC> values from which background concentrations at RMA had been subtracted; this was done to allow consideration of the relative contribution to risk of concentrations from human activities versus naturally occurrence. HQs were calculated for all trophic box/chemical combinations, since their sum is equal to the HI for that combination. The calculations of total HI, HIs for chemical groupings, and HQs just described were repeated three times, once using the Army's BMF, once using Shell's BMF, and once using EPA's BMF.

To evaluate risk from terrestrial food chains on RMA, maps were used because the calculations of risk from concentrations in soil were done for each grid point and vary across the site. Maps were prepared that show the number of trophic boxes with HIs that exceed 1.0, show soil concentrations of individual COCs, show HIs for particularly important trophic boxes, and that show the effect of exposure range size and contaminant concentration magnitude on the size of areas of risk. These maps were based on total HI and on chemical grouping HIs. Some of the maps showed the results of the Army, Shell, and EPA approaches on the same map; others presented these approaches separately. HQs were mapped for the most important (i.e., most widespread, most bioaccumulative, and most toxic) chemicals, and for any other individual chemicals when the HI for their grouping exhibited substantive exceedances. HIs based on concentrations above background were also mapped. Section 4.2 and Appendix Section C.3 provide the results of the ERC.

C.1.7 QUANTITATIVE UNCERTAINTY ANALYSIS

Uncertainties about the variability in the parameters and structures of the models for characterizing risks to representative biota at RMA were identified and analyzed to provide more realistic and informative risk characterizations. As necessitated by the complexity of RMA ecosystems and ambiguities in relevant databases, a wide range of methods were employed to investigate the impacts of process and parameter uncertainties on RMA risks. The analyses are presented in Appendix E.

A number of benefits were derived from the explicit consideration of uncertainty in RMA risk characterizations. For example, analysis of uncertainty about exposure soil concentrations helped

explain the quantitative and qualitative differences between BMFs reported in the scientific literature and those computed for RMA and facilitated the choice of appropriate BMFs for the ERC. As a second example, analysis of the spatial distribution of biota tissue concentration predictions helped explain the lack of correlation between tissue and home-range soil concentration databases. These findings and other implications of uncertainty analyses are discussed in detail in Section 5 and Appendix E.

C.1.8 CALCULATION OF BIOTA SOIL CRITERIA

C.1.8.1 Bioaccumulative COCs

Biota soil criteria for the bioaccumulative COCs, derived for the three BMF calculation approaches, are reported in Section 4, Table 4.6-1. The values were derived using the terrestrial HQ equations (Section 4, equations 8 and 9), which are reproduced as equations 59 and 60:

$$(HQ_i)_{terrestrial} = \frac{BMF \cdot ESC}{MATC} \tag{59}$$

$$(HQ_i)_{terrestrial} = \frac{R \cdot BMF \cdot ESC}{BAF \cdot TRV} \tag{60}$$

The biota soil criterion is the value of ESC for which $(HQ_i)_{terrestrial} = 1$. Thus, criteria are calculated by setting $(HQ_i)_{terrestrial} = 1$ and rearranging equations (8) and (9) to solve for ESC. The resulting average soil concentrations are the biota soil criteria:

$$soil\ criterion = \frac{MATC}{BMF} \tag{61}$$

when risk is calculated by the tissue based approach, or

$$soil\ criterion = \frac{BAF \cdot TRV}{R \cdot BMF} \quad (62)$$

when risk is calculated by the dose based approach. When risk is calculated by the tissue based approach, the term BMF in the biota soil criterion equation (eq. 61) represents the BMF for the trophic box in question, calculated by the Army, EPA, and Shell methods. When risk is calculated by the dose based approach, the term BMF in the biota soil criterion equation (eq. 62) is calculated using the BMFs for the prey trophic boxes and the ERC food web model:

$$BMF = BAF \cdot \sum_{\substack{prey \\ trophic \\ boxes}} FR \cdot BMF_{prey} \quad (63)$$

where FR is the prey fraction and BMF_{prey} is the prey BMF calculated by the Army, EPA, or Shell method. The procedure for selecting the tissue or dose based approach for each trophic box/bioaccumulative COC is described in Appendix Section C.1.6.2.2, beginning on page C.1-60. Selections are summarized in Table C.1-5.

C.1.8.2 Non-Bioaccumulative COCs

Biota soil criteria for the non-bioaccumulative COCs are reported in Table 4.6-2. The dose based approach was used to calculate risk for all "non-bioaccumulative" COCs, so these biota soil criteria were calculated using a modified form of equation (62). For the non-bioaccumulative COCs, it is assumed that exposure to soil contaminants occurs only through direct ingestion of soil (because the contaminant is assumed not to bioaccumulate). This implies that for the direct soil ingestion pathway, BAF = BMF = 1, and for all other exposure pathways within the food web model, BAF = 0. Consequently, equation 62 becomes:

$$soil criterion = \frac{TRV}{FR_{soil} \cdot R} \quad (64)$$

for the non-bioaccumulative COCs, where FR_{soil} is the assumed quantity of ingested soil in the trophic box's diet as a mass fraction of total consumption, and the denominator is a "soil ingestion rate coefficient."

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Table C.1-1 Example Calculations for Spatial Interpolation of a BCRL Data Point

First Iteration

x_i	distance (ft)	d_i	$1/d_i^2$	W_i	x_iW_i
0.0076	44	0.11	82.64	0.815	0.0062
7.40	184	0.46	4.73	0.047	0.3478
0.32	194	0.485	4.25	0.042	0.0134
0.0279	199	0.498	4.03	0.040	0.0011
3.0	206	0.515	3.77	0.037	0.1110
0.0039	285	0.713	1.97	0.019	0.0001
			sum 101.39	1.0	sum 0.4796

Second Iteration

x_i	distance (ft)	d_i	$1/d_i^2$	k_i	x_ik_i
0.0076	44	0.11	82.64	0.723	0.0055
0.18	112	0.28	12.78	0.112	0.0202
0.18	165	0.413	5.86	0.051	0.0092
7.4	184	0.46	4.72	0.041	0.3034
0.32	191	0.478	4.38	0.038	0.0122
0.18	199	0.498	4.03	0.035	0.0063
			sum 114.41	1.0	sum 0.3568

x_i Aldrin concentration of soil sample (ppm)
d_i Normalized distance between BCRL point and soil sample
W_i $1/d_i^2$ divided by sum $1/d_i^2$ to provide the inverse distance squared based weight

Table C.1-2 Example Calculations for Modeling of a Grid Block

x_i	distance (ft)	d_i	$1/d_i^2$	k_i	$x_i k_i$
0.18	198	0.263	14.42	0.163	0.029
0.435	145	0.193	26.75	0.302	0.131
0.134	235	0.313	10.19	0.115	0.015
0.94	220	0.293	11.62	0.131	0.123
3.6	215	0.287	12.17	0.137	0.495
0.31	205	0.273	13.39	0.151	0.047
			sum 88.54	1.0	sum 0.841

x_i Aldrin concentration of soil sample (ppm)
d_i Normalized distance between grid block center and soil sample
k_i $1/d_i^2$ divided by sum $1/d_i^2$ to provide the inverse distance-squared based weight

Table C.1-3 Heron DDE/DDT Tissue Concentration Prediction Sensitivity to Assumed DDE/DDT Concentrations in Aquatic Invertebrates and Amphibians

Lake ¥	Original heron TCpred	Modified heron TCpred*	Percent increase in heron TCpred*
Lower Derby	2.00E + 01	2.31E + 01	16%
Ladora	1.14E + 01	1.36E + 01	19%
Mary	1.34E + 01	1.60E + 01	20%

* when aquatic invertebrate and amphibian tissue concentration predictions are set = 10xTCpred

Lake ¥	Original heron TC predictions	Modified heron TCpred †	Percent decrease in heron TCpred †
Lower Derby	2.00E + 01	1.97E + 01	2%
Ladora	1.14E + 01	1.12E + 01	2%
Mary	1.34E + 01	1.31E + 01	2%

† when aquatic invertebrate and amphibian tissue concentration predictions are set = 0

¥ Sensitivity analysis was limited to Lower Derby, Ladora, and Mary Lakes because these are the only lakes in which all trophic boxes in the heron's food chain (especially aquatic invertebrates, amphibians, and small and large fish) were present when sampling was performed.

Table C.1-4 Quality of TC Predictions for Army Calibrated BMFs

Species/Chemical	N	AD (feet)[1/]	Fraction of Points in Different Prediction Classes					
			Good	OK	Over	Under (HIT)	Under (BCRL)	Rating[2/]
American Kestrel		1,000						
Aldrin/Dieldrin	19		0.37	0.26	0.32	0.05	0	Good
DDE/DDT	19		0.37	0.53	0	0	0.10	Good
Endrin	19		0.05	0.21	0	0	0.74	NC
Mercury	19		0.84	0.11	0	0	0.05	NC
Prairie Dog		250						
Aldrin/Dieldrin	126		0.54	0.15	0.23	0.07	0.01	Good-Over
DDE/DDT	95		0.17	0.31	0	0.01	0.51	NC
Endrin	128		0.09	0.10	0	0.01	0.80	NC
Mercury	110		0.40	0.41	0.19	0	0	Good-Over
Cottontail		250						
Aldrin/Dieldrin	28		0.08	0.33	0.38	0.08	0.13	Good-Over
DDE/DDT	14		0.14	0.29	0	0	0.57	NC
Endrin	24		0.05	0.38	0.33	0	0.24	Good-Over
Mercury	24		0.54	0.42	0	0.04	0	Good
Deer Mouse		250						
Aldrin/Dieldrin	87		0.58	0.19	0.01	0.13	0.09	Good-Under
DDE/DDT	90		0.13	0.33	0.06	0.01	0.47	Good-Over
Endrin	90		0.22	0.35	0.04	0	0.39	Good-Over
Mercury	90		0.03	0.01	0.93	0.03	0	Over
Ground Squirrel		250						
Aldrin/Dieldrin	3		0.33	0.67	0	0	0	Good
DDE/DDT	3		0	0.67	0	0	0.33	NC
Endrin	2		0	1.0	0	0	0	NC
Mercury	2		0	0	1.0	0	0	Over
Mourning Dove		1,000						
Aldrin/Dieldrin	68		0.46	0.21	0.29	0.03	0.01	Good-Over
DDE/DDT	68		0.14	0.52	0	0.02	0.32	Good

Species/Chemical	N	AD (feet)[1/]	Fraction of Points in Different Prediction Classes					
			Good	OK	Over	Under (HIT)	Under (BCRL)	Rating[2/]
Endrin	68		0.42	0.46	0.07	0.05	0	Good
Mercury	68		0.31	0.12	0.07	0	0.50	NC
Meadow Lark		500						
Aldrin/Dieldrin	10		0.3	0.3	0.10	0.3	0	Good
DDE/DDT	10		0	0	0	0	1.0	NC
Endrin	10		0.4	0.6	0	0	0	NC
Mercury	10		0	0	0	0	1.0	NC
Sparrow		500						
Aldrin/Dieldrin	5		0.20	0.60	0	0	0.20	Good
DDE/DDT	5		0	0.80	0	0	0.20	NC
Endrin	5		0	0	0	0	1.0	NC
Mercury	5		0	0.40	0	0	0.60	NC
Shorebird[3/]		500						
Aldrin/Dieldrin	10		0.70	0	0.20	0.10	0	Good
DDE/DDT	10		0.6	0.10	0.20	0.10	0	OK
Endrin	10		0.50	0	0.10	0.40	0	Good-Under
Mercury	10		1.0	0	0	0	0	Good
Bullsnake		250						
Aldrin/Dieldrin	3		0	0.334	0.333	0.333	0	NC
DDE/DDT	3		0.334	0	0	0.333	0.333	NC
Endrin	3		0.334	0.333	0	0	0.333	NC
Mercury	3		0.33	0	0	0	0.67	NC

1/ AD = Allowable distance from TCobs within which TCpred values are considered for class "ok".
2/ Includes qualitative visual assessment of map.
3/ TCobs and TCpred reflect contribution from terrestrial food web only.
NC = Model is not contradicted; however power to discriminate different BMFs is low.
OK = A substantial percentage of over and under estimates occurred.

Table C.1-5 Summary of Selected Risk Calculation Approach

Trophic Box	Chemical			
	Aldrin/Dieldrin	Endrin	DDT/DDE	Mercury
Bald Eagle	dose-based	tissue-based	tissue-based	dose-based
Great Blue Heron	tissue-based	tissue-based	tissue-based	dose-based
Shorebird	dose-based	tissue-based	tissue-based	dose-based*
Great Horned Owl	dose-based	tissue-based	tissue-based	dose-based
American kestrel	dose-based	tissue-based	tissue-based	dose-based
Medium Mammal	dose-based	dose-based	dose-based	dose-based
Small Mammal	dose-based	dose-based	dose-based	dose-based
Small Bird	dose-based	tissue-based	dose-based	dose-based
Water Bird	tissue-based	dose-based	tissue-based	tissue-based

*the tissue-based approach was used for calculation of risk from mercury to shorebird from aquatic food chains; all other trophic boxes having mixed food chains (bald eagle and great blue heron) used the same approach for both aquatic and terrestrial food chains.

Table C.1-6 Information Used to Decide Between the Tissue-Based and Dose-Based Approaches to Risk Evaluation*

	CHEMICAL							
	Aldrin/Dieldrin				DDT/DDE			
Trophic Box	MATC UF	TRV UF	BAF Mean, SD	OTHER	MATC UF	TRV UF	BAF Mean, SD	OTHER
Eagle	30	30	15.9, 3.9	T&E species	3	80	27.1, 2.4	eagle vs. kestrel
Heron	1.5	15	16, 5.1	heron vs. mallard	2	15	93.5, 20	heron vs. bl. duck
Shorebird	20	10	13.3, 4.2	kestrel vs. quail/pigeon	8	50	NA	tern vs. kestrel
Owl	16	16	21.1, 3.4	same paper	12	40	43.7, 2.4	same paper
Kestrel	4	4	10.5, 1.2	same paper	3	10	NA	same paper
Med. Mammal	24	16	NA		60	12	NA	
Sm. Mammal	24	16	NA		60	12	NA	
Small Bird	20	10	6.6, 1.8	kestrel vs. pigeon	375	250	NA	same paper
Water Bird	30	15	16, 5.1	same paper	25	15	96, 26.2	same paper

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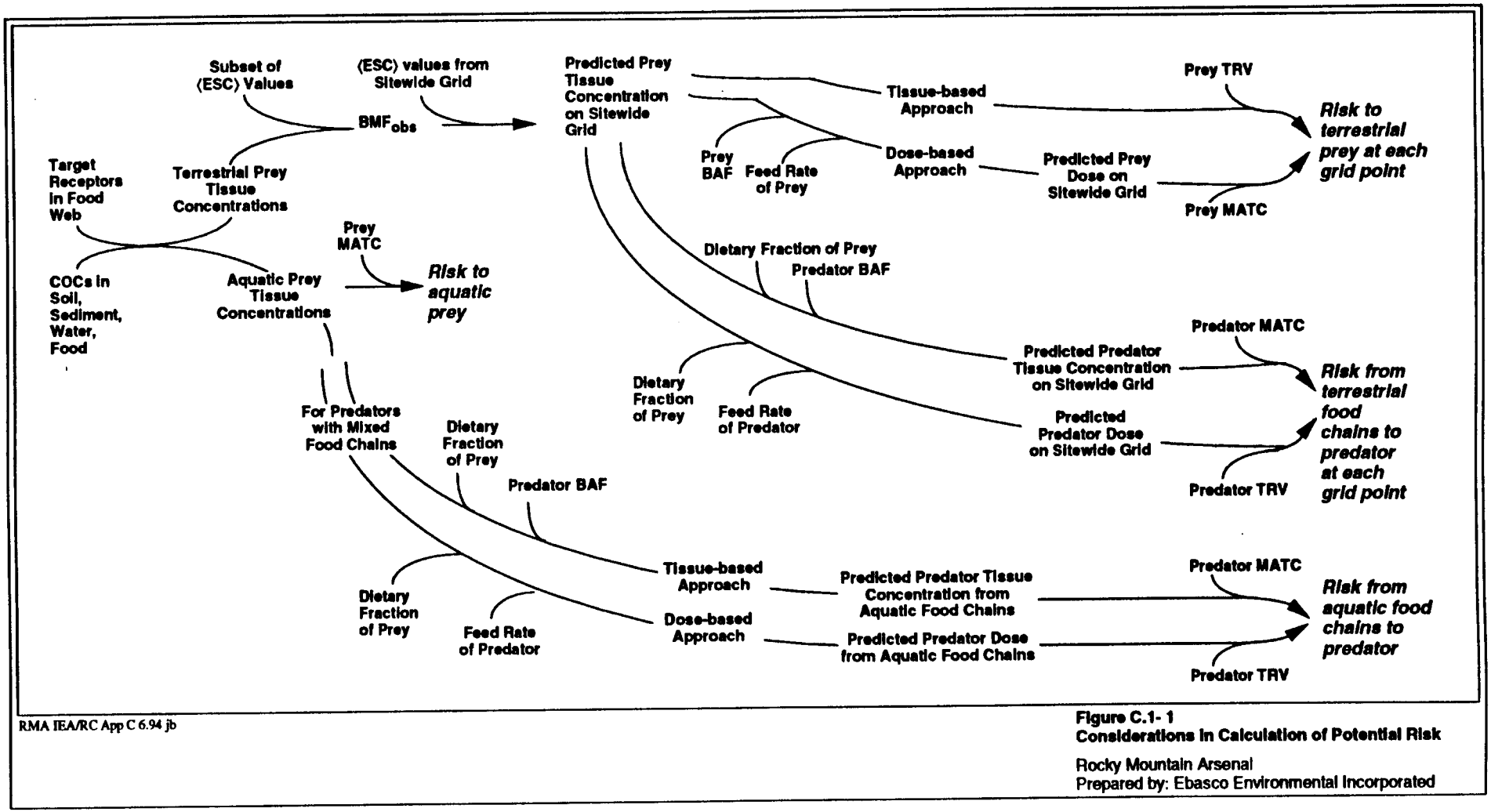
Table C.1-7 Data Used in Development of Indicator Ranges for Metals at RMA

Metal	Number of Detections/Number of Samples	Average Concentration in Western Soils in ppm	Indicator Range in ppm	Comment
arsenic	80/798	5.5	4.7-10	24 of 80 detections in Section 36; more than 90 % of detections <10 ppm
mercury	27/798	0.46	0.05-0.1	18 of 27 detections in Section 36; more than 60 % of detections <0.1 ppm
cadmium	12/798	NA	1-2	generally BCRL in the bulk soil sample
copper	580/798	21	20-35	detections in uncontaminated area samples ranged from 7-55 ppm and were skewed toward the lower end of the range; 60 % of detections <10 ppm

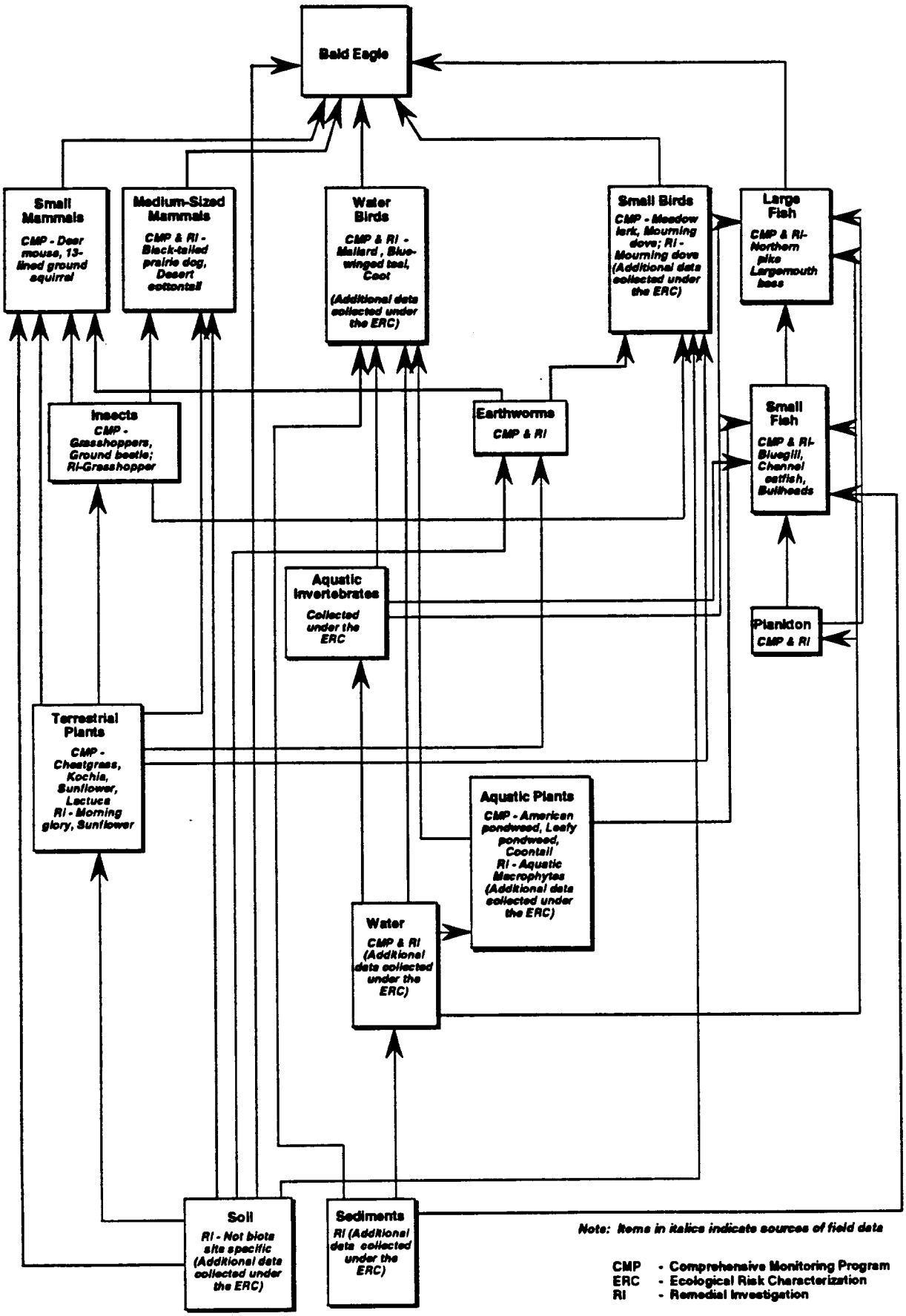
ppm = parts per million
BCRL = below certified reporting limit



RMA IEA/RC App C 6.94 jb

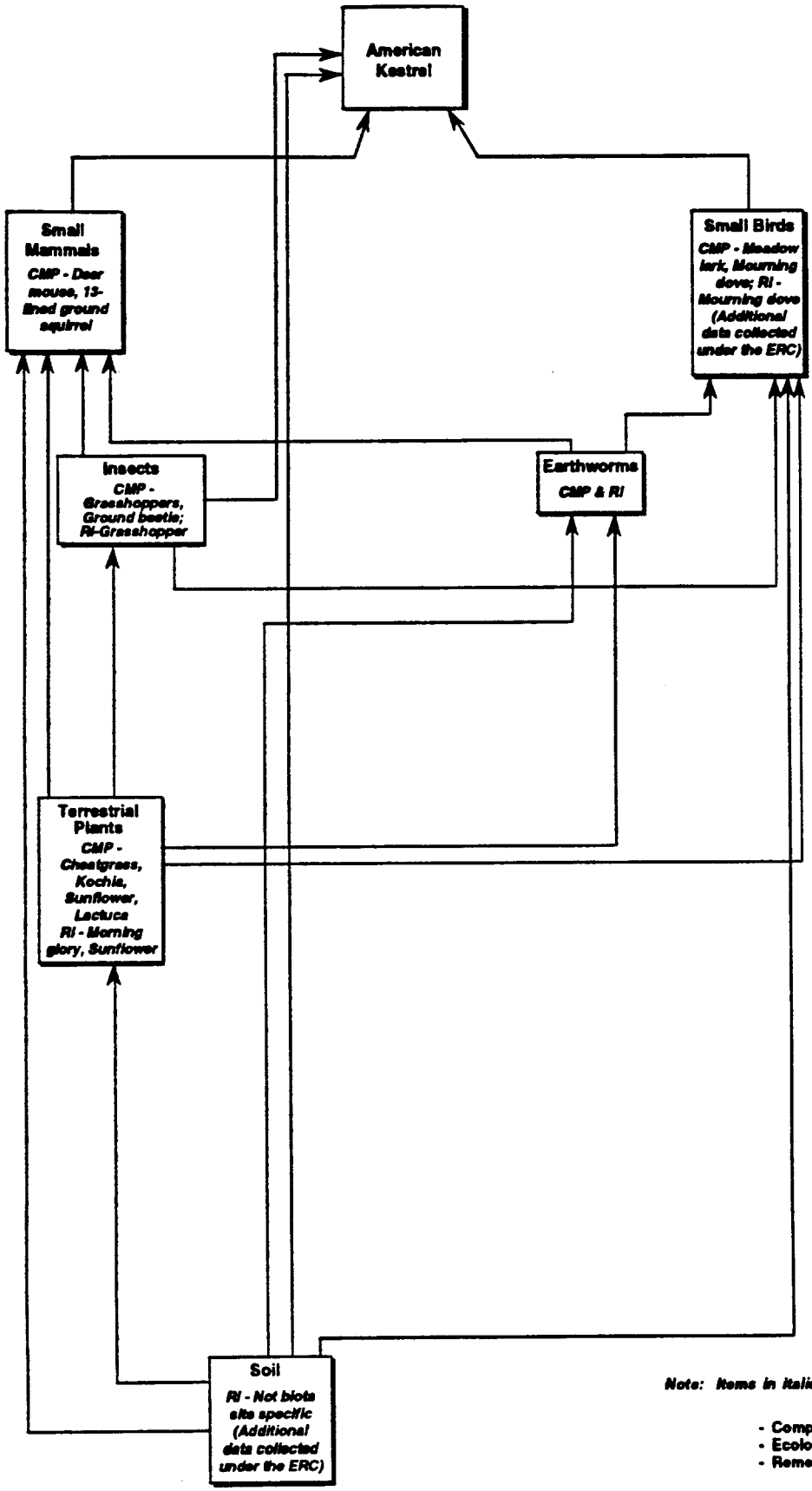
Figure C.1- 1
Considerations in Calculation of Potential Risk

Rocky Mountain Arsenal
Prepared by: Ebasco Environmental Incorporated



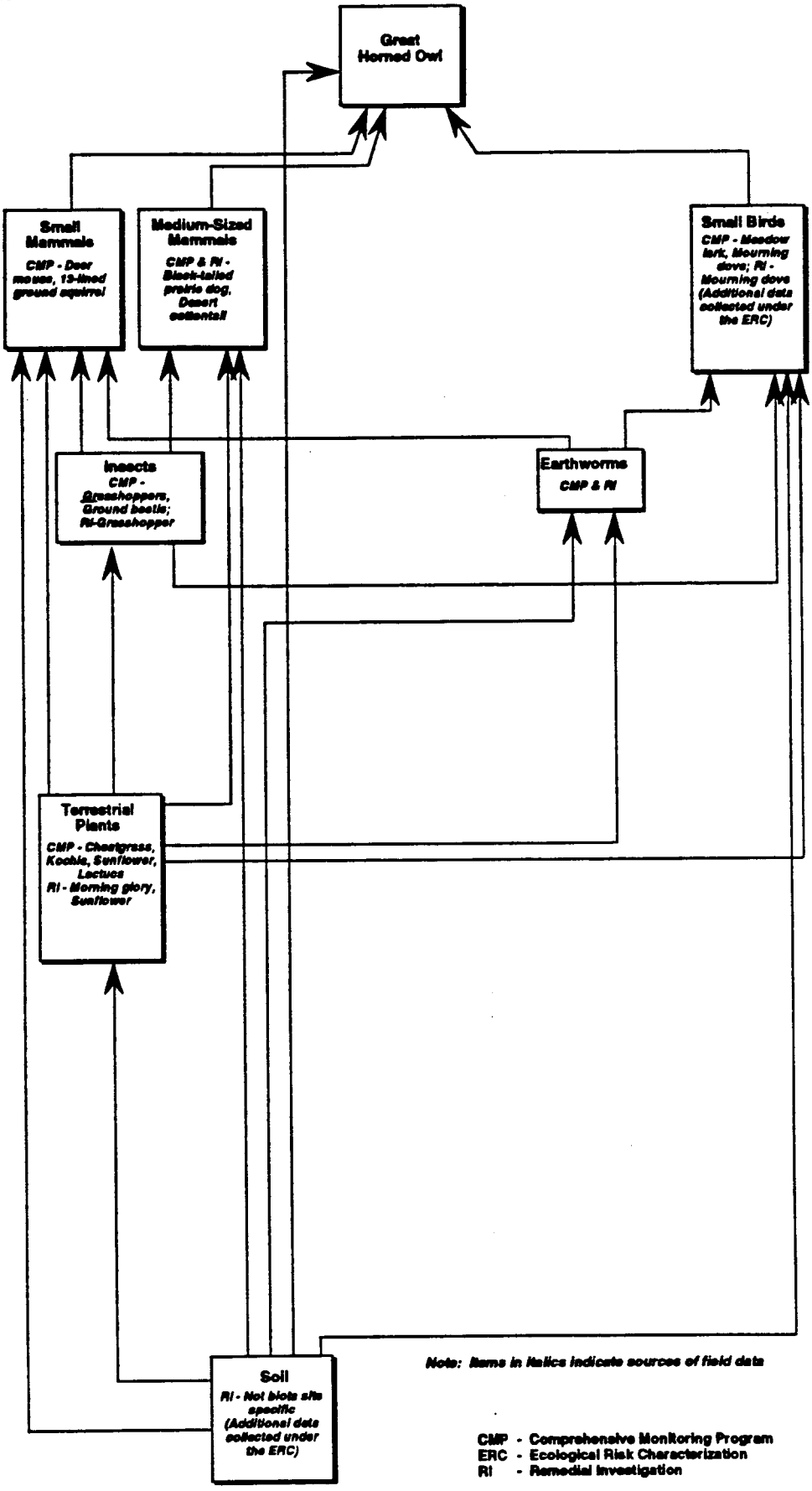
RMA IEA/RC App. C 2.94.jb

Figure C.1-2 • Bald Eagle Food Web
Rocky Mountain Arsenal
Prepared by: Ebasco Services Incorporated



RMA IEA/RC App. C 2.94.jb

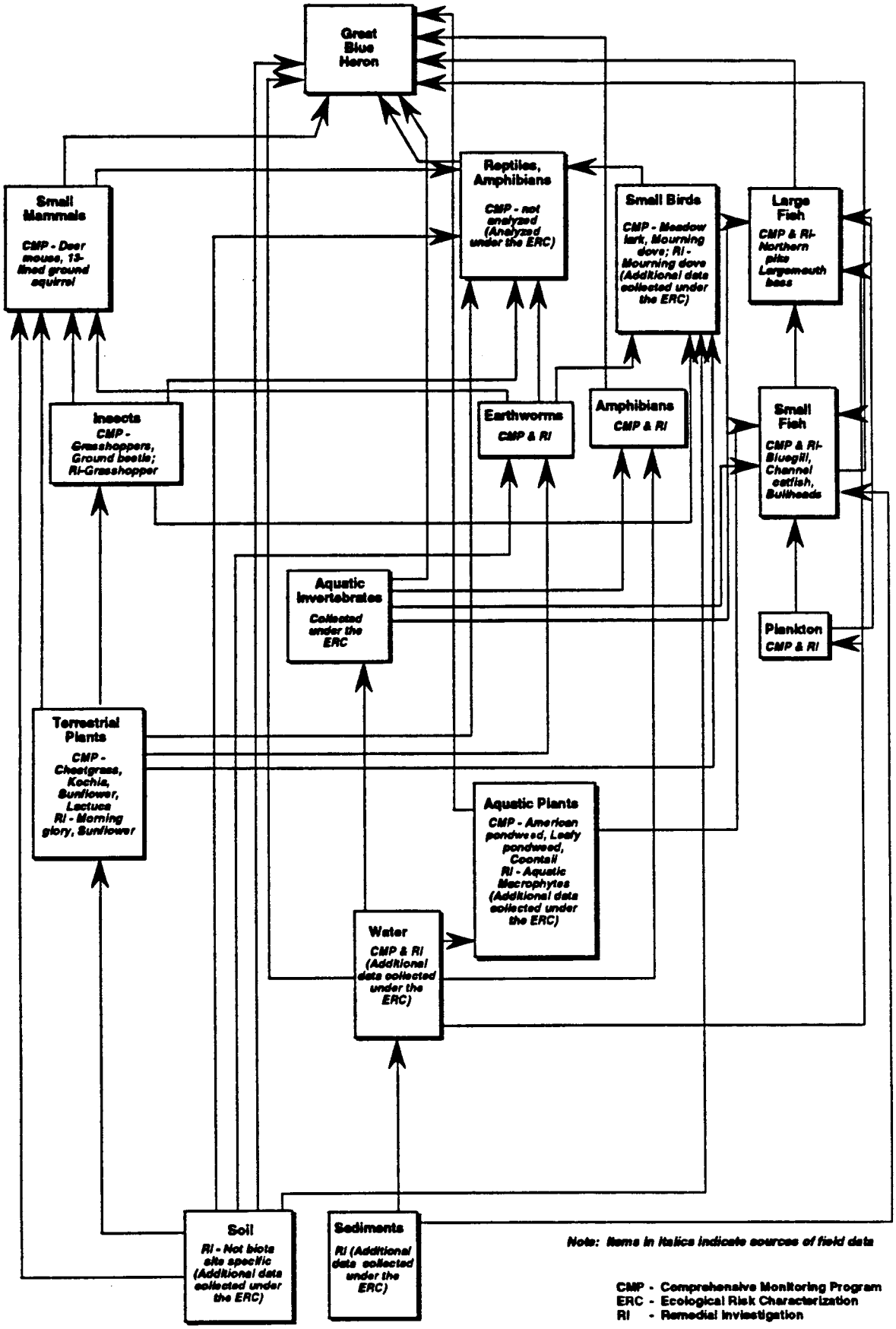
Figure C.1-3 • American Kestrel Food Web
Rocky Mountain Arsenal
Prepared by: Ebasco Services Incorporated



RMA IEA/RC App. C 2.94.jb

Figure C.1-4 • Great Horned Owl Food Web

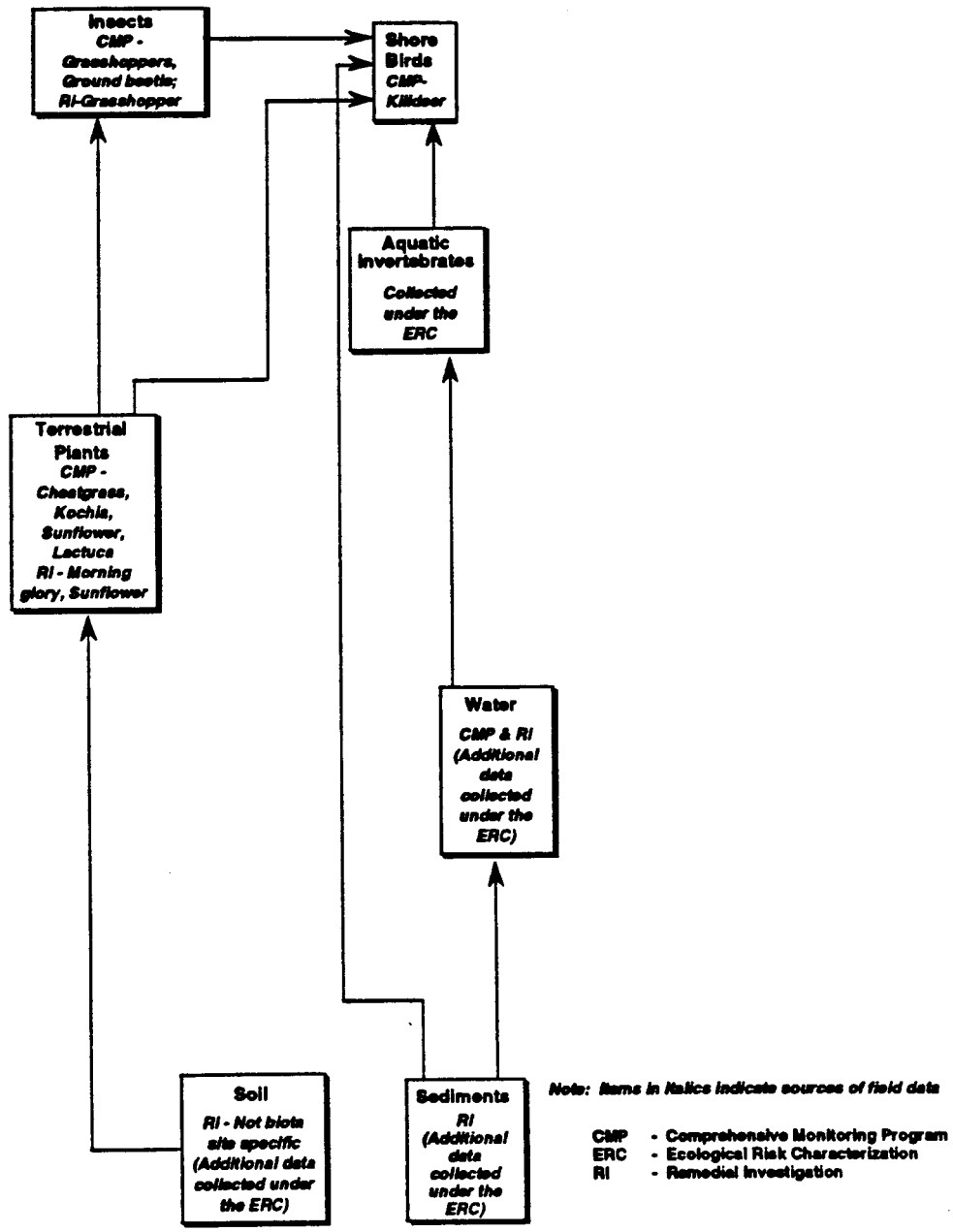
Rocky Mountain Arsenal
Prepared by: Ebasco Services Incorporated



RMA IEA/RC App. C 2.94.jb

Figure C.1-5 • Great Blue Heron Food Web

Rocky Mountain Arsenal
Prepared by: Ebasco Services Incorporated
Revised August 5, 1993



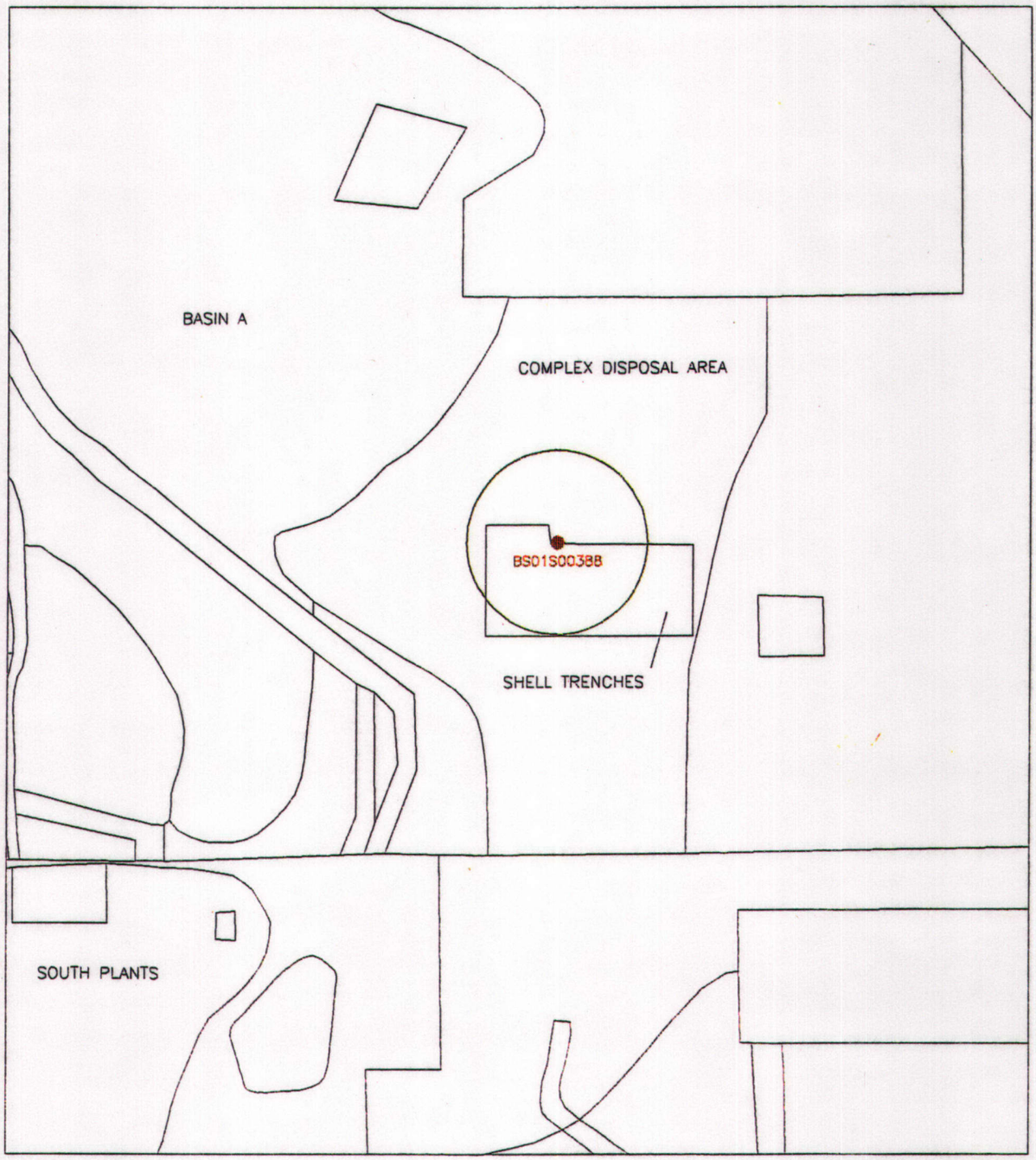
RMA IEA/RC App. C 2.94.jb

Figure C.1-6 • Shorebird Food Web

Rocky Mountain Arsenal
Prepared by: Ebasco Services Incorporated
Revised August 5, 1993

APPENDIX C
(SECTION C.1)

COMPUTATIONAL METHODOLOGY



Legend

SARsite Boundary

Tissue Sample Location

Exposure Area Circle

300 0 300 600 Feet

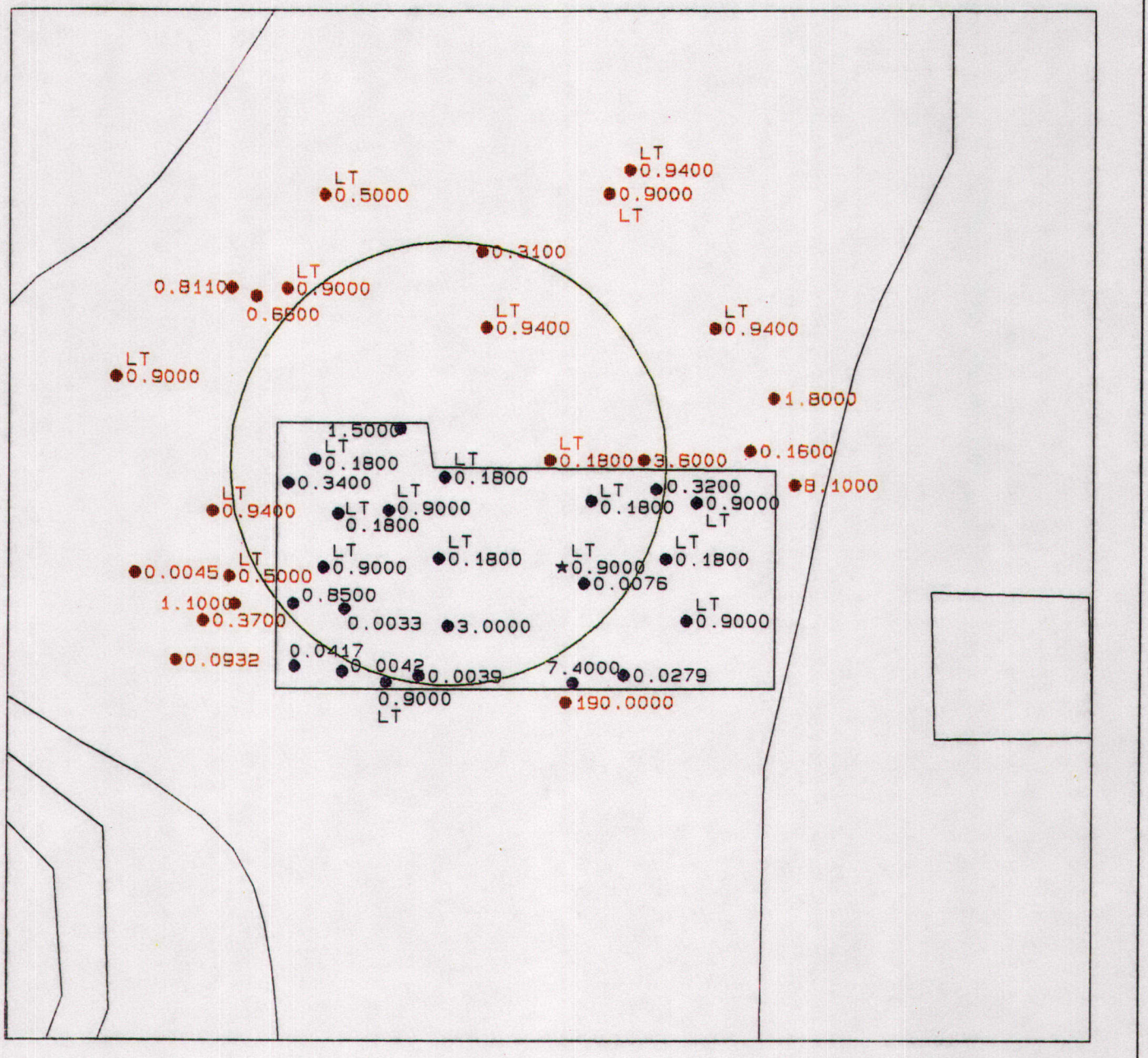
-N-

Prepared for: U.S. Army Program Manager for Rocky Mountain Arsenal

Figure C.1–7

Cottontail Tissue Sample Location and Corresponding Exposure Area

Ebasco Services Incorporated
February 1994



Legend

SARsite Boundary

Soil Sample Locations

Exposure Area Circle

-N-

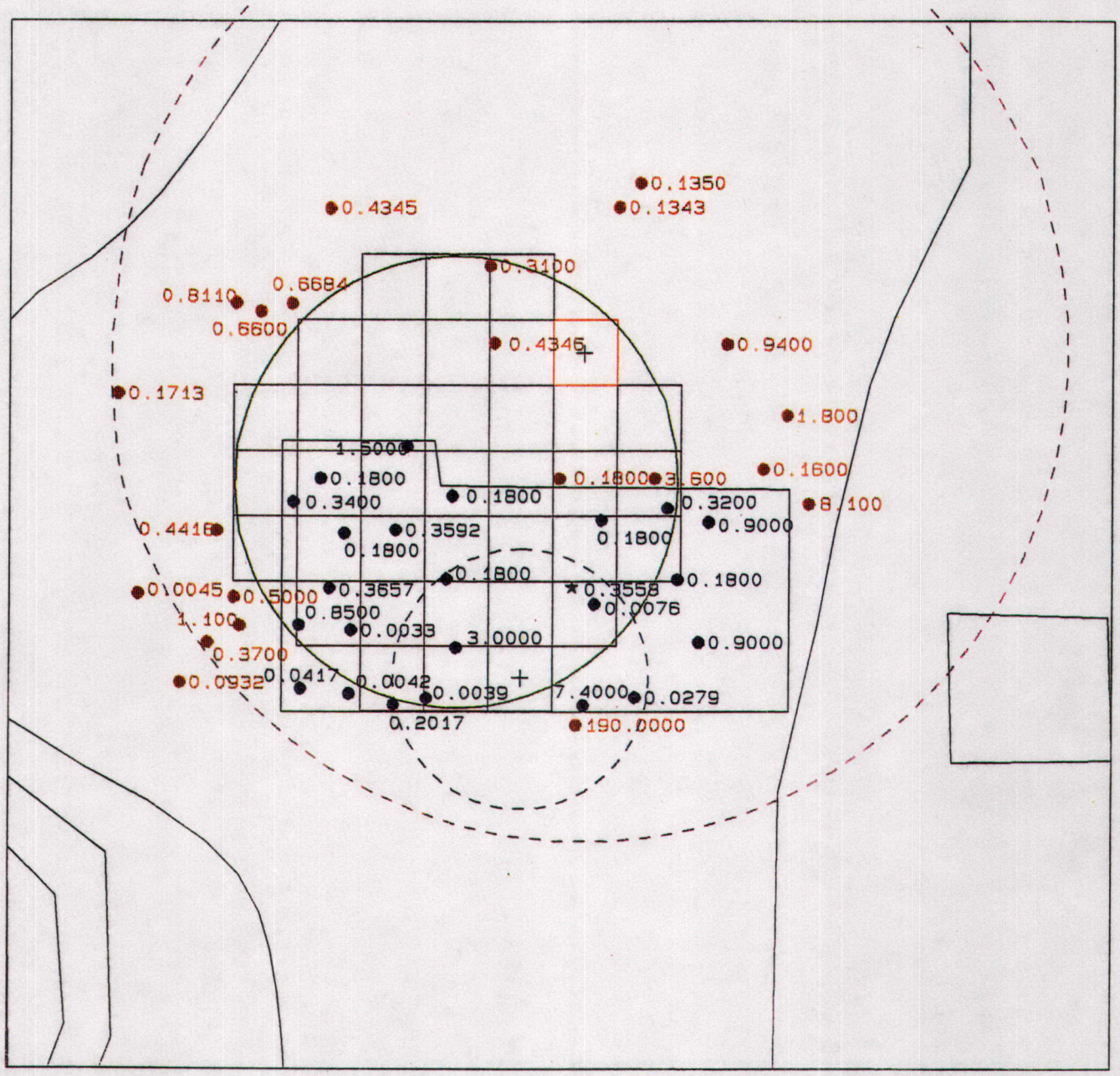
125 0 125 250 Feet

Prepared for: U.S. Army Program Manager for Rocky Mountain Arsenal

Figure C.1-8

Soil Boring Locations and Aldrin Soil Concentrations (ppm) (prior to BCRL spatial interpolation)

Ebasco Services Incorporated
February 1994



Legend

- SARsite Boundary
- Search Radius
- Soil Sample Locations
- Exposure Area Circle

-N-

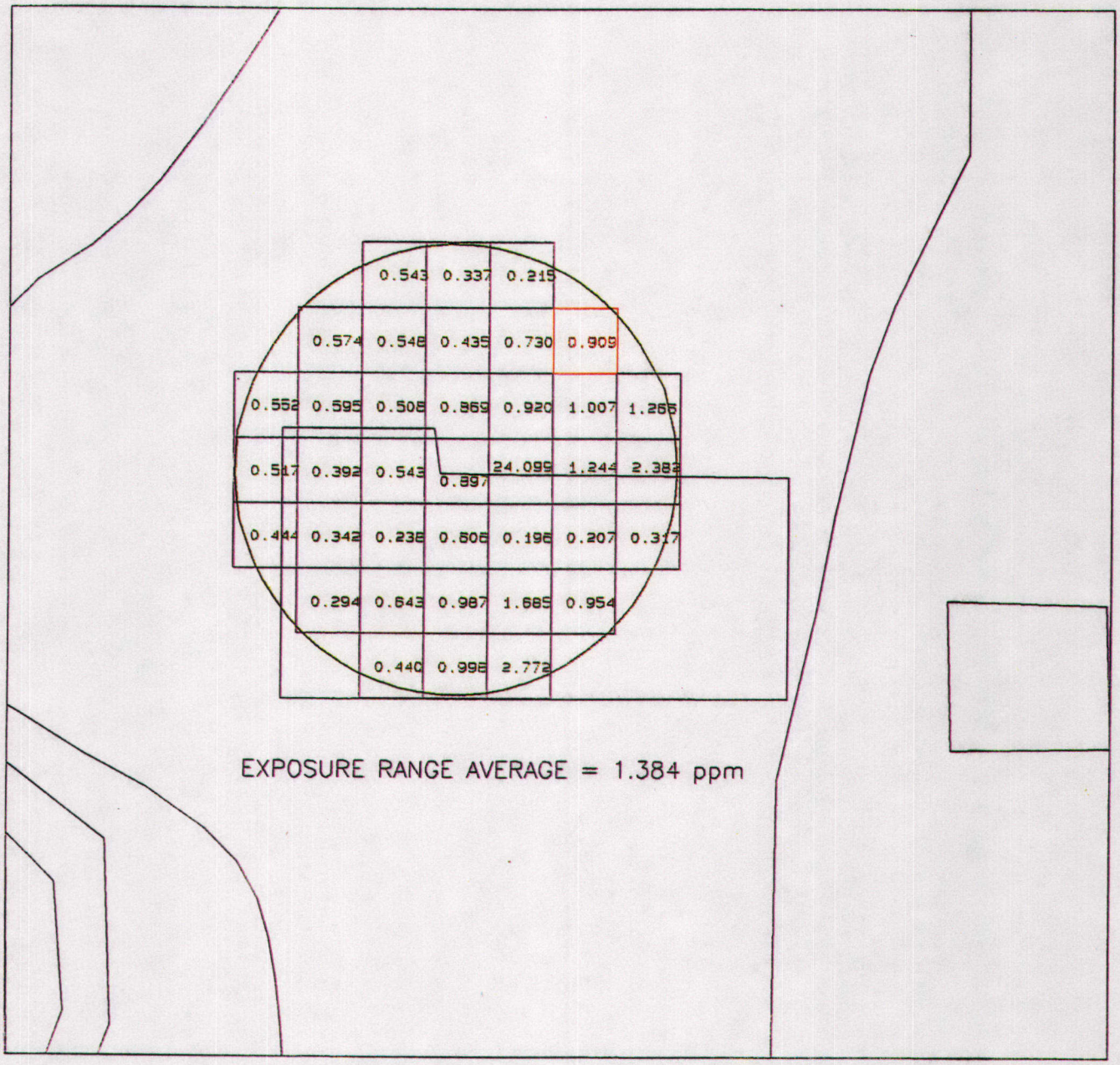
125 0 125 250 Feet

Prepared for: U.S. Army Program Manager for Rocky Mountain Arsenal

Figure C.1-9

Soil Boring Locations and Aldrin Soil Concentrations (ppm) (following BCRL spatial interpolation)

Ebasco Services Incorporated
February 1994



Legend

SARsite Boundary

0.909 Estimated Soil Concentration

Exposure Area Circle

125 0 125 250 Feet

-N-

Prepared for: U.S. Army Program Manager for Rocky Mountain Arsenal

Figure C.1–10

Modeled Grid Soil Concentrations for Aldrin within the Cottontail Exposure Area (ppm)

Ebasco Services Incorporated
February 1994

APPENDIX C

(SECTION C.2)

ECOLOGICAL RISK CHARACTERIZATION PARAMETERS

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LIST OF ACRONYMS AND ABBREVIATIONS

% bw/d	percent body weight per day
µg/l	micrograms per liter
AWQC	Ambient Water Quality Criteria
BAF	bioaccumulation factor
BCRL	below certified reporting limit
BMF	Biomagnification factor
$C_{(0)}$	initial tissue concentration
$C_{(t)}$	tissue concentration at time t
COC	contaminant of concern
CPMS	chlorophenylmethyl sulfide
$CPMSO_2$	chlorophenylmethyl sulfone
CRL	certified reporting limit
DBC	Dose-based criteria
DBCP	dibromochloropropane
DCPD	dicyclopentadiene
DDE	dichlorodiphenyldichloroethene
DDT	dichlorodiphenyltrichloroethane
e	base of natural logarithm system (2.7168)
EA	Endangerment Assessment
EPA	U.S. Environmental Protection Agency
ERC	Ecological Risk Characterization
<ESC>	Estimated exposure area soil concentration
ESE	Environmental Science and Engineering
FEL	Frank effect level, the concentration causing obvious adverse effects
FR	dietary fraction
HHRC	Human Health Risk Characterization
HQ	hazard quotient
HSDB	Hazardous Substances Data Bank
IEA/RC	integrated endangerment assessment/risk characterization
IRIS	Integrated Risk Information System
kg/kg-bw/d	kilograms per kilogram of body weight per day
LD_{50}	lethal dose to 50 percent of population (micrograms contaminant per gram body weight)
LOAEL	Lowest Observed Adverse Effect Level (micrograms contaminant per gram tissue or body weight)
m	meters
m^3/hr	cubic meters per hour
MATC	maximum allowable tissue concentration (micrograms contaminant per gram tissue)
mg/kg/d	milligram per kilogram body weight per day
mg/kg	milligram per kilogram
N	number

NOAEL	No Observed Adverse Effect Level (micrograms contaminant per gram tissue or body weight
OAS	Organizations and State
PBC	tissue-based criteria
R	feed rate (grams food per grams body weight per day)
RfD	reference dose
RI	Remedial Investigation
RMA	Rocky Mountain Arsenal
RRCs	regulatory risk criteria
SEP	Standard Evaluation Procedure
STSC, Inc.	STATGRAPHICS
TRV	toxicity reference value (milligrams contaminant per kilogram body weight per day)
UF	uncertainty factor
USFWS	U.S. Fish and Wildlife Service

C.2 FOOD-WEB MODEL INPUT PARAMETER DEVELOPMENT SUMMARIES

The tissue- and dose-based approaches both use the biomagnification factor (BMF) to predict biomagnification in biota at Rocky Mountain Arsenal (RMA). For species having measured tissue data from RMA, the BMF was calculated as the ratio of measured tissue concentration to <ESC> using three different approaches (Army, Shell, and EPA approaches) as described in Appendix C.1. For the top predators (bald eagle, great horned owl, American kestrel, and great blue heron), appropriate measured tissue concentrations were not available, and the food web model described in Appendix C.1 was used to calculate BMF. When applied to the tissue-based approach, the food web model used prey BMF values, bioaccumulation factor (BAF), and dietary fraction (FR), to calculate predator BMFs. This approach then used the predator BMF and <ESC> values to calculate its tissue concentration for comparison with its literature based MATC value. When applied to the dose-based approach, the food web model used prey BMF values, dietary fraction, feed rate (R), and <ESC> to calculate dose for comparison with its literature based TRV values. The various parameters used in the food web model for these two approaches, as well as the exposure range value used to calculate <ESC> were quantified with data from the literature or, in some cases, from RMA-specific data.

This appendix documents the way in which each of the parameters used in the food web model (BAF, R, and FR) and in the calculation of exposure (<ESC>) and of risk (MATC and TRV) were quantified. In the sections that follow, each of these parameters is also defined and characterized; a characterization of the database available for each parameter is included, as well.

The parameters used in the tissue-based approach were quantified for aldrin/dieldrin, DDT/DDE, endrin and mercury. The parameters used in the dose-based approach were quantified for these same COCs as well as for arsenic, cadmium, chlordane, copper, chlorophenylmethyl sulfide (CPMS), chlorophenylmethyl sulfone ($CPMSO_2$), dibromochloropropane (DBCP), and dicyclopentadiene (DCPD).

It should be noted that the approach to calculating potential risk has gone through a substantive evolution during the preparation of this document. Initially, an updated, probabilistic, and

calibrated version of the approach used in the Biota RI was used for all trophic boxes in the IEA/RC. This meant that the food web model was used to predict BMF values from parameters quantified by the literature for trophic boxes having strictly terrestrial, strictly aquatic, and mixed food chain input. These literature-based BMFs were then calibrated with BMFs calculated from site-specific measured tissue data. The calibrated BMFs were used to calculate criteria for soil, sediment, and water to serve as benchmark values against which concentrations in these media could be compared to calculate potential risk. However, this approach did not adequately account for the averaging of contaminant concentrations that biota do as they move and feed throughout the range of their exposure. With the introduction of spatial averaging considerations to better represent the variability of exposure, the concept of a media criterion became less useful. This is because a criterion represents the average concentration within an exposure range and concentrations at individual locations may be higher or lower than the criterion, so long as collectively they do not result in potential risk. Further, use of the food web model and criterion development for strictly aquatic trophic boxes was forced to use conversions between concentrations in sediment and those in water because CRLs for water were higher than calculated criteria and most concentrations in water were BCRL. This meant that calculation of potential risk via a criterion that was based on BMFs for strictly aquatic trophic boxes was very uncertain. Finally, some parameter literature data were lacking for many strictly aquatic trophic box/chemical combinations. Changes in the initial approach occurred as a result of all of these considerations. The outcome of these changes is the process presented in the IEA/RC, which maximizes the use of site-specific data and minimizes the uncertainty relative to the various types of implementation considered. Appendix E documents the still considerable uncertainty that remains.

The remainder of this section explains the literature search that was done for each of the parameters used in the tissue-based and dose-based approaches. Also presented is the basis for the initial decision to make some of the parameters deterministic (i.e., represented by a single fixed value) and some probabilistic.

Literature Search

Initially, an effort was made to limit the toxicological literature search to those species found at RMA (see the Biota Remedial Investigation [RI] report [ESE 1989] for the complete species list). However, because toxicological references or review articles did not always identify species in key words, the final search was guided by using specific COCs and input parameters as key words (Tables C.2-1 and C.2-2). Articles on obviously inappropriate taxa (e.g., marine species and large, domesticated mammals) were neither reviewed nor incorporated into this report.

Potential literature references were identified and compiled using references from the Biota RI report; Environmental Science and Engineering's (ESE's) in-house BIOTA.BIB database; the RMA Resource Technical Information Center; the U.S. Fish and Wildlife Service (USFWS) Patuxent Wildlife Research Center; DIALOG, a computerized information system; secondary references, and recommendations from the Organizations and State (OAS). References from the Biota RI report and BIOTA.BIB contained the results of the ESE literature search for the Biota RI, including the results of a search of Biosis Preview database information (1969 to 1988) within the DIALOG system. The RMA-specific Resource Technical Information Center, located at RMA, provided articles that were identified from a printout of its card catalog. The USFWS Patuxent Wildlife Research Center has a library of toxicological literature from which requested references on toxicity of the COCs were obtained. Studies evaluated for the TRVs derived for the Off-Post Endangerment Assessment (EA) (HLA 1993) were also considered. In addition, a literature search from 1989 to 1993 was conducted for TRV information on cadmium and copper because these elements were not evaluated in the Off-Post EA. Toxicological studies on cadmium and copper prior to 1989 were reviewed during development of the toxicity assessments for the Biota RI report. The Integrated Risk Information System (IRIS) (EPA 1993) and the Hazardous Substances Data Bank (HSDB) (NLM HAZ 1993), both U.S. Environmental Protection Agency (EPA)-supported electronic databases, were searched for additional information.

DIALOG is a computerized information system containing approximately 400 databases, of which approximately 24 pertain to medicine and bioscience subject categories. Although DIALOG references go back as far as 1908, the system was only searched for the period 1985–90.

DIALOG search strings were developed in consultation with a librarian experienced with the DIALOG search protocols. Only articles written in English were considered.

The search strategy varied between toxicological parameters (BAF, BCF, α, K2, MATC, and TRV) and ecological parameters. For the biota/chemical parameters, the following items were searched for in the Biosis Preview database:

- MATC or TISSUE CONCENTRATION or TISSUE TOXIC or ASSIMILATION or UPTAKE or DEPURATION or LOSS or BIOCONCENTRATION or BIOACCUMULATION or BIOMAGNIFICATION or SOIL INGEST or SOIL FEED or SOIL FOOD or DIET or SOIL EATING.

These items were searched in combination with all nonhuman citations.

For ecological parameters (R, FR, and ER), the following items were searched for in the Zoological Record database:

- FOOD or PREY AVAILABILITY or HABITS or PREFERENCE or SELECTION or PREY ITEM or PREY RESOURCE or PREY UTILIZATION or DIET or FEEDING or FEED or FORAGE or FORAGING.

These items were searched in combination with each of the species sampled to represent the trophic boxes but with the food habits string limited to title or descriptor field and the species limited to title or taxonomic field.

The review of the literature sources listed above resulted in the identification of approximately 2,800 references. These are listed in the dBASE bibliographic file (ECOREFS.EXE) included on the diskette in Appendix Section C.7. The diskette file represents the literature considered and the results of all the literature searches performed including the literature for parameters that are no longer used in the final implementation of the tissue- and dose-based approaches. The literature pertinent to α, K2, and BCF is still included in ECOREFS.EXE, but these values were not used because potential risk was calculated directly from the more certain measured tissue concentration data.

Each literature reference reviewed was given an unique identification number and a single-letter prefix that identified its source. Hardcopies of articles were obtained from various libraries, photocopied, and marked with the unique identification number. Following the initial literature search, additional articles were added as they were identified from various sources. In addition to general articles on exposure range, food webs, toxicity, and feed rate, to name a few, there are many chemical-specific citations. For example, approximately 358 sources provided information on aldrin/dieldrin, approximately 355 sources (several of which provided information on more than one chemical) were selected for information on DDT/DDE, approximately 176 sources were reviewed for information on endrin, and another 422 sources were reviewed for mercury. The 2,800 references are chronologically grouped as follows:

1900–30 =	8
1931–40 =	10
1941–50 =	24
1951–60 =	107
1961–70 =	265
1971–80 =	894
1981–90 =	1,422
1991–93 =	71

All the articles, (or in the case of DIALOG abstracts), compiled in the dBASE citation files were considered, and those that appeared pertinent were tagged for hardcopy retrieval. Each article was selected for review based on its pertinence to populations of biota or habitats at RMA, to the parameters or other measures of toxicity listed in Table C.2-1, and for the toxicological parameters, its reference to the Ecological Risk Characterization (ERC) COCs.

Information recorded from each article on toxicological parameters included: species on which data provided, value and units given, chemical and parameter addressed, trophic box to which applicable, literature citation information, comments on derivations or calculations needed, and where appropriate, associated toxicological endpoints. Articles providing information on toxicological parameters were distributed to individual reviewers who were responsible for summarizing data for individual COCs. In this way, one reviewer would review all articles for one COC, thus ensuring consistency and accuracy in data interpretation as well as a thorough

understanding of the literature pertaining to a particular chemical. Reviewers met often to discuss parameter derivation to ensure consistency across a chemical group as well as for an individual COC. Information recorded from each article on ecological parameters included the applicable model parameter and model trophic box or species, the value and units of the parameter, location of the study, season(s) covered by the study, life stage of the species studied, the food item(s), sample size, and comments. To achieve final agreement on the values for BAF, FR, R, MATC, TRV, and ER, an extensive consensus-building process among the participating scientists representing the OAS was used. The final values that were used in the IEA/RC are provided in Table C.2-3.

A perusal of Table C.2-3 and Sections C.2.1 to C.2.5 reveals that some of the input parameters are expressed as fixed values and some are expressed as distributions. The initial decisions as to whether a parameter should be fixed or stochastic were based on the results of an importance analysis. The importance analysis was performed on a set of deterministic values representing the literature input parameter estimates considered to be the best for a deterministic version of the terrestrial and aquatic model equations. This importance analysis was designed to provide information regarding the relative influence of an individual input parameter's value to the model output value. Importance was determined by the magnitude of change in the final result of the deterministic model equations attributable to changing the value of one input parameter and leaving the others constant. The rationale for this approach is as follows.

If:

$$A = X * Y * Z \quad (1)$$

$$A' = X * 2Y * Z \quad (2)$$

then:

$$\% \text{ change caused by doubling } Y = \frac{A - A'}{A} * 100 \quad (3)$$

The importance analysis compared the results from the systematic adjustment of all model input parameters. In addition, the importance analysis provided information on the parameters that were high contributors to the overall uncertainty of model output.

A ranking system was developed to rank the importance of each input parameter for each top-level trophic box and COC in the terrestrial and aquatic models. Four importance categories were assigned: 1 = important parameter for 90 to 100 percent of COCs, 2 = important parameter for 40 to 90 percent of COCs, 3 = important parameter for 10 percent of COCs, and 4 = not important for any COC. The aggregate rankings of a parameter and its variability among the four top-level trophic boxes evaluated were used to decide which input parameters to fix as deterministic values (i.e., those that did not have much impact on model output or uncertainty) and which input parameters to treat stochastically (i.e., those that did have impact on model output and/or uncertainty) in the probabilistic terrestrial and aquatic models.

The final importance categories that resulted from analysis of the four food webs (i.e., bald eagle, great blue heron, great horned owl, and American kestrel) are shown in Tables C.2-4 and C.2-5 for those parameters that are used in the final ERC protocols. Based on these results, all three of the input parameters for terrestrial food chains (FR, BAF, and MATC) were to be stochastic. As a result of decisions that are explained in the appropriate sections of this appendix, some parameters originally intended to be stochastic later became fixed parameters (MATC, FR); TRV was also used as a fixed parameter.

C.2.1 BIOACCUMULATION FACTOR

C.2.1.1 Parameter Definition and Characteristics

Bioaccumulation of environmental contaminants in food chains, with subsequent biomagnification, has been recognized and documented in the literature for more than three

decades. Bioaccumulation is affected by many of the same factors as bioconcentration and each COC behaves differently within food chains. For example, metal contaminants exhibit different BMFs and BAFs in ecosystems depending on their concentration. Biomagnification is defined as the amplification of a contaminant's concentration from the initial source (e.g., water, soil, or sediment) to a specified target species or trophic level. The BMF reflects uptake and transfer between trophic levels, resulting from both bioconcentration and bioaccumulation, in conjunction with other parameters. BMF can be calculated for each specified organism level or trophic box above the first trophic level.

The BAF is defined as the ratio of the concentration of a contaminant in an organism to the concentration in its diet. Contaminant concentrations were provided for whole-body homogenate samples where data are available and otherwise for specific tissues (e.g., fat, liver, brain) and labeled as such. For terrestrial organisms, BAFs were taken directly from the literature, or when no direct literature values were available, they were calculated as the ratio of tissue concentrations as follows:

$$BAF_j = \sum_{i=1}^{n} \left(\frac{C_j}{C_i} * FR_i \right) \quad (4)$$

where: j = predator's trophic level

i = trophic level for n prey items

For birds with aquatic food chains, the BAF was defined as for terrestrial organisms.

C.2.1.2 Database Characterization

C.2.1.2.1 Literature Description

In the introduction to this section, literature search procedures for BAF were provided that were further detailed in Tables C.2-1 and C.2-2. The final BAF values are presented in Table C.2-6. Characteristics of the specific values and how the BAF values were used are summarized below.

For the bioaccumulative chemicals such as the organochlorine pesticides and mercury, articles were sought that quantify the amount of bioaccumulation for different trophic components. The articles used to derive the BAF values cover various species of terrestrial plants, invertebrates, birds, reptiles, insects, and mammals. The BAF is a direct model input parameter for terrestrial food chains. The BAF values included in Table C.2-6 were taken directly from literature sources.

There are several limitations that affect the ability of the literature data to precisely quantify BAF. For example, the paucity of steady-state data for the contaminants that equilibrate slowly is one factor; many studies were terminated at a given time even if equilibrium was not achieved. Only equilibrium values were used whenever possible. Site-specific food habits data and site-specific environmental factors (e.g., pH, water temperature) are also factors that may affect BAF values. Variation in these factors across studies could result in values seemingly aberrant from others (i.e., outliers).

In addition, many authors failed to mention whether their experiment was performed under steady-state conditions, which is necessary to obtain accurate BAF values. Often papers were not selected because authors failed to report sample size, use of controls, raw data, or statistical results. Furthermore, some BAF values were taken from studies that began several years after contaminant application ("aged" contaminants), while others involved direct dosing of the media or prey item ("fresh" contaminants). Both types of values were used as there were too few studies that examined only the impacts of "aged" chemicals. Since "fresh" contaminants may be more bioavailable than "aged" contaminants (MRI 1991), the BAFs may slightly overestimate risk at RMA. However, this potential is expected to be quite small. Finally, several of the values needed to be converted to the corresponding wet-weight basis. Data were assumed to be on a wet-weight basis and to have reached approximate equilibrium conditions when the authors failed to specify otherwise and data appeared so reasonable as to make this assumption, based on comparison with other values known to be wet-weight and at equilibrium and from other papers by the same author where this information was given, a valid one. As always, the use of an assumption increases the uncertainty in a parameter distribution. However, only values deemed

acceptable on the basis of professional judgment calibrated to field data were used, which reduces uncertainty.

C.2.1.2.2 Data Variability

BAFs generally spanned less than one order of magnitude within a trophic box. Exceptions to this trend include the earthworm trophic box for endrin that spanned 2.5 orders of magnitude and the great blue heron trophic box for mercury that spanned 1.4 orders of magnitude. The range of variability in literature BAF values is considered small in light of species variability and other variable factors. For example, reported values for each parameter are affected by the time at which the measurement is taken (i.e., whether the organism has reached equilibrium with its immediate environment), although only equilibrium values were used whenever possible. Other factors contributing to BAF are mentioned below.

C.2.1.2.3 Final Value Selection and Assessment

All final values represent the best values available in the literature and were accepted based on a consensus of the participating scientists. Long-term studies or studies that indicated a steady-state condition was achieved were used whenever possible. However, studies of short duration were accepted for BAF values when the exposure duration was appropriate for the species under consideration (short-lived organism) or when studies of chronic duration were lacking.

Tissue-specific and carcass values were converted to whole-body measurements when possible. A factor of 1.3 was used to convert from carcass to whole body, and a conversion factor of 0.6 was used to convert from egg to carcass on the basis of data from Wiemeyer et al. (1986) at the U.S. Fish and Wildlife Service Patuxent Wildlife Research Center. The fat to whole-body conversion factor was 0.2. Values given on a dry-weight basis were converted to wet-weight contaminant measurements when possible. Conversion factors were frequently based on data presented in Wiemeyer et al. (1986), although a conversion factor from Gish (1970) was used when paper-specific values were unavailable. Conversion factors from other sources are noted in Table C.2-6.

Acceptable mercury BAF values could not be located in the scientific literature for the insect, earthworm, and reptile trophic boxes. RMA field data were used to derive a BAF for mercury; accordingly, there is no calibration of the model for these trophic boxes. Likewise, no acceptable literature data could be found for endrin in plants or reptiles. Because the toxicity of endrin is relatively similar to that of aldrin/dieldrin, it was deemed appropriate to use aldrin/dieldrin BAFs to represent these trophic levels for endrin.

The data points presented in Table C.2-6 were used to develop data distributions for BAFs for use in the ERC model. Data for distribution development were not grouped ("lumped") unless deemed appropriate by the availability of data (e.g., all bird values for endrin were combined for each bird trophic box), and as determined by the results of the importance analysis of the model input parameters, distributions for BAF values were developed. The methods used to develop distributions for these parameters are summarized below.

C.2.1.3 Distribution Development

The Army used statistical information from the consensus papers, when available, to develop the BAF distribution for each trophic box. Statistical information available in the papers ranged from a standard error about the mean tissue concentration (e.g., Rudolph et al. 1983) to more detailed information such as means and standard deviations about the mean for both male and female tissue concentrations as well as the variance in the dose (e.g., Mendenhall et al. 1983). Statistical information was available for BAFs in the consensus papers for all trophic boxes except insect, small and medium mammal, and reptile for aldrin/dieldrin and reptile for DDE.

C.2.1.3.1 Criteria Used

The combination of statistical information from the literature (whenever available), STATGRAPHICS (when $n \geq 4$), and comparison with other chemicals and trophic boxes was used to determine the standard deviation and distribution type for each trophic box and each chemical. The amount of variability assigned to the distribution was determined based on comparison with like chemicals (e.g., dieldrin for endrin) and closely related trophic boxes (e.g., small fish for large fish).

Generally, when the sample size was two and no statistical information was presented in the papers, a uniform distribution was selected and the consensus values were used as the endpoints. However, if descriptive data from the paper or comparison with other chemicals indicated a high likelihood of substantial variability, then the range was expanded above and below the consensus values. The mammal and reptile trophic boxes had only two values and so were often assigned a uniform distribution (13 out of 72 possible trophic box/chemical combinations).

When the sample size was three and there was no statistical information presented in the consensus papers, a uniform, triangular, or lognormal distribution was assigned, depending on the spread of the values and comparison with other chemicals. Only four trophic box/chemical combinations fell into this category. When sample size was four or greater and statistical information was not available in the papers, STATGRAPHICS was used to assign the distribution type. Nineteen trophic box/chemical combinations fell into this category. For aldrin/dieldrin, the earthworm, terrestrial plant, and plankton trophic boxes contained more than four consensus values (n = 30, 7, and 6, respectively). Only two trophic boxes, insect and earthworm, contained more than four consensus values for endrin (n = 14 and n = 5, respectively). There were 4 trophic boxes containing 4 to 18 consensus values for DDE (bald eagle, insect, earthworm, and terrestrial plants). For each of these trophic box/chemical combinations, an estimated distribution was assessed using the Kolmogorov-Smirnov goodness-of-fit test. When the test indicated that the best fit was a normal distribution, but the data ranged close to zero, the next best fit was chosen, usually lognormal or uniform, to avoid sampling negative values.

When the standard deviation about the mean dose was known from the literature, the following formula was used to calculate the variance in the BAF when one study was recommended for use for a particular trophic box:

$$(S_{BAF,pred})^2 = X_{BAF,pred} * \left[\left(\frac{S_{pred}}{X_{pred}}\right)^2 + \left(\frac{S_{prey}}{X_{prey}}\right)^2\right] \quad (5)$$

where: $S_{BAF,pred}$ = Standard deviation about the mean BAF for the predator

s_{pred} = Standard deviation about the mean tissue concentration in the predator
s_{prey} = Standard deviation about the mean tissue concentration in the prey
$x_{BAF,pred}$ = Mean BAF for the predator
x_{pred} = Mean tissue concentration in the predator
x_{prey} = Mean tissue concentration in the prey

When the variance in the mean tissue concentration in the prey was not given, the variance about the BAF was assumed equal to the variance about the mean tissue concentration in the predator. When more than one reference was used to develop the mean BAF for a particular trophic box (i.e., mean of means), the following formula was used to compute the total standard deviation (S_T) about the mean of means:

$$S_T = \left[\frac{\left[(n_x-1) * S_x^2\right] + \left[(n_y-1) * S_y^2\right] + \left[(n_z-1) * S_z^2\right] + \ldots}{(n_x-1) + (n_y-1) + (n_z-1) + \ldots} \right]^{1/2} \quad (6)$$

where each subscript (x, y, z) denotes the study from which the data came, S^2 denotes the variance about the mean from the specified study, and n stands for the number of individuals involved in the study. This formula was also used for values derived from individual studies if the mean tissue concentrations of males and females were given separately.

C.2.1.3.2 Distributions Developed

The following two examples illustrate calculation of the standard deviation about the mean BAF for the DDE and aldrin/dieldrin based on statistical information presented in the relevant consensus papers in which statistical information was provided. The first column of Table C.2-6 provides the same information (but in less detail) for each chemical/trophic box combination.

DDE

American kestrel: Consensus values of 7.7 and 29 were selected from Rudolph et al. (1983) and Wiemeyer et al. (1986), respectively. Rudolph et al. provided the following information: mean dose = 5.9 ppm, n = 6, mean carcass concentration = 35.3, and se = 1.9 (s = 4.7). Wiemeyer et

al. provided the following information in the paper: mean dose = 2.8 ppm, n = 3, mean carcass concentration = 40.3, and s = 34.7. The information from Wiemeyer et al. was based on data for birds that died as a result of exposure to pesticides. However, the BAF from this study was computed from data for sacrificed birds for which no statistical values were provided. The standard deviation for the mean BAF developed based on the information given above, using equation (5), was greater than the mean value from both papers. Thus, if a normal distribution had been chosen it would have included negative values (mean = 18.4, sd = 19). Therefore, a uniform distribution was chosen as most representative of the true distribution because there was no indication that lower values were any more likely to occur than higher values, as would have been inferred by a lognormal distribution, for this trophic box.

Great horned owl: The consensus value of 43.7 was selected from Mendenhall et al. (1983). Data presented in Mendenhall et al. included the following: mean dose = 2.83 ppm, se = 0.1, n = 10; female mean carcass concentration = 78, se = 0.34, and n = 6; mean male carcass concentration = 112, se = 0.056, and n = 9. To calculate the standard deviation about the mean BAF, several steps were required. First, standard deviations were computed from the associated standard errors and sample sizes ($s = se\sqrt{n}$). Then, the total standard deviation (S_T) associated with the mean of male and female carcass concentrations was computed using equation (6). Finally, the standard deviation associated with the mean BAF was calculated using equation (5). The Mendenhall et al. (1983) study had a mean BAF of 43.7 and a standard deviation of 0.55. It is highly unlikely that this very small standard deviation is a realistic measure of the variability in BAF for all great horned owls at RMA because of differences in species, size, and variability in field conditions. Hence, the four consensus values from the bald eagle trophic box were used to compute a pooled coefficient of variation (CV_p), which was multiplied by the mean owl BAF (x_{gho}) to generate a standard deviation about the mean for the owl trophic box ($CV_p * x_{gho} = s_{gho}$). The data are as follows: CV_p (bald eagle trophic box) = 0.6, x_{owl} = 43.7, and therefore, s_{gho} = 26.2.

Aldrin/dieldrin

Bald eagle: The consensus values of 10.5, 16, and 21.1 were selected from Wiemeyer et al. Braune and Norstrom (1989), and Mendenhall et al. (1983), respectively. Information provided in Wiemeyer et al. included the following: mean dose = 0.28 ppm, n = 6, mean carcass concentration = 1.64 ppm, and s = 1.2. This information was for birds that died; however, the BAF was computed from sacrificed birds for which no statistical information was available. Braune and Norstrom provided the following information: mean = 16, sd = 5.1, and n = 10. Mendenhall et al. provided the following information: mean dose = 0.58 ppm, se = 0.028, n = 10; mean female carcass concentration = 9.2 ppm, se = 0.12, and n = 7; mean male carcass concentration = 9.6 ppm, se = 0.17, and n = 12. Since only the carcass values had associated variability presented in Wiemeyer et al. the standard deviation about the BAF from this paper was assumed to be the same as that associated with the mean carcass concentration (1.2). Moreover, since the standard deviation about the mean BAF was reported by Braune and Norstrom, no further calculations were necessary to use the values from this paper. To calculate the standard deviation about the mean BAF from Mendenhall et al. the steps outlined above for the great horned owl under DDE were followed. The BAF and its associated variability derived from this approach is 21.2 ± 3.4. The three BAF values with associated uncertainty were then used to calculate the variability about the mean BAF for the trophic box, which is ± 3.9 about 15.9. Since the individual BAFs were approximately evenly spaced, the standard deviation was much less than the mean BAF and, since there was no information to suggest otherwise, a normal distribution was chosen for this trophic box/chemical combination.

C.2.2 FEED RATE AND DIETARY FRACTION

C.2.2.1 Parameter Definition and Characteristics

C.2.2.1.1 Feed Rate

The R is defined as the quantity of food ingested by an organism relative to its body weight per unit time kg/kg-bw/d. The feed rate is species-specific and varies with location, season, and the age, size, appetite, reproductive stage, and condition of the organism. Feed/rate is used in the dose-based approach because TRVs are expressed on a per-day basis.

C.2.2.1.2 Dietary Fraction

The FR represents the fraction of the biomass of total food ingested that is contributed by a given food item in the diet of a consumer species. As with feed rate, dietary fraction is species-specific and can vary with location, season, age, reproductive stage, and other individual characteristics of the organism. In addition, dietary fraction can also vary with habitat type since more adaptable species are opportunistic feeders and may use different food sources as they become available in various habitats. The dietary fraction parameter is used in both aquatic and terrestrial food chain equations.

C.2.2.2 Database Characterization

C.2.2.2.1 Literature Description

Literature search procedures for feed rate and dietary fraction were provided in the introduction to Section C.2, along with Tables C.2-1 and C.2-2, which further detail the search. The parameter-specific literature review for feed rate and dietary fraction is summarized below.

The articles reviewed during the literature search provided feed rate and dietary fraction values for raptors, including great horned owl, burrowing owl, barn owl, bald eagle, ferruginous hawk, and American kestrel, fish, waterfowl, small and medium birds, mammals, reptiles (here defined as reptiles and terrestrial amphibians), and insects. No information was found on feed rate or dietary fraction for earthworms. In the literature, feed rate data were generally expressed as, or readily converted to, kg/kg-bw/d. Values for feed rate were reported in terms of both wet and dry weights; however, only values based on wet weight were used in the model. The measurement units for dietary fraction in the literature included percent by volume, percent by occurrence, and percent biomass.

C.2.2.2.2 Parameter Quantification

Values from the literature were converted to the appropriate units. Feed rate values reported in the literature as total daily food intake were converted to a corresponding rate per unit body weight by dividing the reported value by the average body weight (in kilograms [kg]) for that species. Values such as percent body weight per day (% bw/d) were multiplied by the literature-derived average body weight of the species and divided by 100 to convert them to kg/kg-bw/d.

Wet-weight feed rate values were converted to kg/kg-bw/d. Dry-weight measurements were used only when they could be converted to wet-weight equivalents.

All of these measurement units were considered; however, percent biomass was used and converted from the most prevalent form, percent occurrence, in the literature because it is more representative of contaminant loads that are on a mass basis. To base dietary fraction on biomass rather than percent occurrence, a consistent conversion protocol was used. Dietary fraction based on biomass contributed by dietary items was calculated as the product of percent occurrence and representative weight divided by total average biomass (Table C.2-9). To develop average weights for a trophic box, probable RMA prey species in that trophic box were determined from site-specific food-item studies, the literature, or local experts. Next, where weight information was available, the average weights of prey species were calculated from the hundreds of individual weights for species collected on RMA under the Biota CMP. In the instance that body weight information was lacking from RMA, values were selected based on information from local experts, best professional judgment, and field guides, or estimated based on a portion of the predator's body weight. Since the sum of the food items in the diet should equal the total amount of food ingested, the dietary (prey) fractions were summed to 1.0 before the percent biomass of soils/sediment and water ingested were added. The total fractions were then adjusted to sum to 1.0.

The feed rate and dietary fraction values and citations for various trophic boxes are listed in Tables C.2-7 and C.2-8. The number of values for dietary fraction reflects the total number of dietary items consumed by a given trophic box in the model food web (e.g., bald eagle dietary items include water birds, medium mammals, small mammals, and small birds). In some cases, adjustments supported by best professional judgment were based on available knowledge of feeding rates or food habits of relevant or similar species at RMA, or similar study areas in eastern Colorado or the Great Plains.

C.2.2.2.3 Data Variability

Both feed rate and dietary fraction values spanned about two orders of magnitude across all trophic boxes (Tables C.2-7 and C.2-8). Within individual trophic boxes, values for both parameters spanned one order of magnitude and usually much less. For a parameter such as dietary fraction, with absolute boundaries of 0.0 and 1.0, variability is limited by definition. For any particular trophic box, the range of dietary fraction is usually described by a factor of 2 to 10. However, for each dietary item in a particular trophic box, the range of literature values seldom spans more than a factor of 2. Bald eagle and great blue heron have the highest values for feed rate.

Some of the variability is attributable to geographic and seasonal differences among studies (e.g., bald eagle studies in Alaska and coastal areas vs. those from inland areas). To minimize this variability, data were preferentially selected that represented habitat types and geographic areas similar to those at RMA. Further, site-specific data were used whenever available. Variation in reported values for feed rate and dietary fraction is affected by an organism's natural response to changes in its environment, such as seasonal changes. In addition, an individual's sex, life stage, and reproductive state affect these parameters.

C.2.2.2.4 Final Value Selection and Assessment

The merits of the literature data were evaluated in round table discussions. Preference was given to dietary information from geographic and habitat types similar to those at RMA. For those trophic boxes for which there was food-item data from RMA, the RMA-specific dietary fractions were used instead of literature values (Section C.4.2). For those trophic boxes for which no data was available for either feed rate or dietary fraction, best professional judgment based on information from taxonomically related organisms was used to select a value.

C.2.2.3 Distribution Development

C.2.2.3.1 Criteria Used

Based on a review of the literature, the species-specific parameters, feed rate and dietary fraction, are believed to be normally distributed. A normal distribution is typical of many biological variables such as morphometric characteristics and behavioral frequency measurements.

Initially, dietary fraction was to be treated as a probabilistic parameter. Closer inspection revealed that dietary fraction has very limited variability, usually within a factor of 2 to 10, for any trophic box. Finally, the use of site-specific data was facilitated by establishing dietary fraction as a fixed value.

Distributions for feed rate were fit using STATGRAPHICS. Normal distributions developed for all trophic boxes were assessed using the Kolmogorov-Smirnov goodness-of-fit test. A normal distribution fitted to feed rate data was not significantly different from the theoretical normal distribution. Other available model distributions did not produce as good a fit for the majority of feed rate data. Even when an alternative distribution produced a better fit, the developed normal distribution goodness-of-fit significance always was greater than 0.853. The taxon-specific nature of feed rate dictated development of separate distributions for each trophic box. Literature values were considered adequate if three or more data points were available.

C.2.2.3.2 Distributions Developed

Literature values for feedrate (Table C.2-8) were adequate for all trophic boxes: bald eagle, n = 7; great blue heron, n = 7; great horned owl, n = 7; and American kestrel, n = 7.

Values for dietary fraction were comprised from literature values, field studies (Section C.4.2), and professional judgment when either literature values or field values were not available.

C.2.3 MAXIMUM ALLOWABLE TISSUE CONCENTRATION

C.2.3.1 Parameter Definition and Characteristics

The tissue-based method used to estimate ecological risk from the bioaccumulative COCs involves the maximum concentration of contaminant in tissue that is unlikely to be associated with harmful effects. This concentration is referred to as the maximum allowable tissue concentration (MATC). Therefore, MATC, as used in this report, is defined as the whole-body tissue concentration that is unlikely to be harmful to the average individual of a population over prolonged exposure under field conditions. MATC values, expressed as the mass of contaminant per unit of body weight, were derived from data in the literature on tissue concentrations associated with the presence or absence of observed effects in organisms. Literature-based MATC tissue values were divided by uncertainty factors (UFs) to attempt to ensure adequate protection of the biota at RMA.

The MATC is not applicable to contaminants that are readily metabolized and/or rapidly excreted. The MATC applies only to bioaccumulative contaminants that accumulate over extended periods of time to toxic levels in the organism, exerting toxic effects as a function of residue concentration. When the MATC is divided by the site-specific issue concentration of the same organism, the result is a measure of potential risk from the contaminant being evaluated at the site.

C.2.3.2 Database Characterization

C.2.3.2.1 Literature Description

Literature search procedures for MATC data were provided in the introduction to Appendix C.2, along with Tables C.2-1 and C.2-2, which further detail the search. Only literature that indicates a correlation between tissue residues and toxic effects should be relied upon to provide a MATC for assessing toxicity levels.

In the literature, tissue concentration data associated with endpoints for organochlorine pesticides were often available for avian species and sometimes available for mammals. Less information was available for endrin than for the other organochlorine pesticides. Data for potential use in

derivation of MATC for mercury were also available for birds and laboratory mammals. Information that could be used to develop MATCs for fish and other aquatic life is generally lacking in the literature.

Tissue-based values related to the toxicity of all the COCs for the reptile trophic box were unavailable in the literature, and the values related to endrin and mercury for the small and medium mammal trophic boxes were either nonexistent or ambiguous. To date, reptiles have not been a common taxonomic group in toxicity testing. Most of the endrin and mercury toxicity studies on mammals that were reviewed investigated the effects of various dosing regimens without tissue residue measurements. The data compiled from the literature were screened for quality and appropriateness.

C.2.3.2.2 Parameter Quantification

Because most site-specific tissue data and BMFs are reported on a wet-weight basis, all MATC values were converted to a wet-weight concentration before being considered for use in the food-web model.

Tissue concentration values associated with specific endpoints in the literature were often provided for a specific organ or other component of the whole animal. These organ or carcass concentrations were converted to an estimation of the comparable whole-body concentration. Professional judgment and consensus discussions were used to select the most appropriate of these values from the available literature studies. These MATCs, expressed on a whole-body basis, were then divided by a UF to produce final MATC values.

Since many of the tissue residue data were associated with different toxicity endpoints, final MATC values were not summed and averaged to arrive at a final recommended value. Likewise, it was not appropriate to attempt to develop actual or hypothetical distributions. Instead, MATC was treated as a deterministic parameter represented by fixed values.

C.2.3.2.3 Data Variability

The MATC is preferably based on no observed toxic effect levels or concentrations associated with sublethal or minimal toxic effects. However, lethal or seriously adverse tissue concentrations are sometimes the only data reported in the literature. In these cases, one of the UFs divided into the tissue concentration reduced to a no adverse effects level or minimal adverse effects level.

MATC or residue data are often reported for a target organ or carcass, but are not always reported for nontarget organs or the whole body. The BMF for the food-web model is calculated on a whole-body basis (from the BAF and dietary fraction), and represents the amplification of a contaminant through an organism's food chain up to itself from the source media, due to its own bioaccumulative capability and that of others in the food chain. Site-specific tissue data are also generally reported on a whole-body basis. Therefore, all MATC values were converted to a whole-body concentration before use in the food-web model.

Avian toxicity data are relatively common for organochlorine pesticides, especially for lethal residue concentrations in brain tissue. For avian species, organochlorine pesticides stored in adipose tissue may be mobilized during times of stress, such as breeding or migration, and reach toxic levels in the brain. This, in turn, may cause the bird to cease feeding and may result in the death of the bird. Avian brain-to-carcass ratios can be developed for lipid-soluble contaminants such as organochlorine pesticides, but only if these ratios are derived from data in healthy birds in stable body condition. Because brain organochlorine concentrations are regulated by lipid levels, there is a definable relationship between contaminant concentration in the brain and that in carcass lipid levels. Thus, the brain-to-carcass ratio depends on the fraction of lipid in the carcass, and will fluctuate as this fraction changes. The ratio becomes meaningless in the circumstance of lethal or near-lethal poisoning because body lipids are then depleted and the contaminant is mobilized to the brain. It is this situation, and its sometimes questionable and difficult clarification, that has discouraged the use of brain-to-carcass ratios to estimate MATC values.

C.2.3.2.4 Final Value Selection and Assessment

Many of the toxicity data points related to tissue residues were discounted for reasons such as inappropriate toxicity endpoint (e.g., excessive mortality in the group of experimental animals or a histopathological change that could not be associated with a toxic effect on the organism), inappropriate species (e.g., livestock or other species only distantly related to those known to occur at RMA), or poor experimental protocol (e.g., the lack of a control group of experimental animals, small group of experimental animals, or an inaccurate measure of tissue residues). The consensus pre-UF MATCs (Table C.2-10) were selected after intense scrutiny of the scientific literature.

C.2.3.2.5 Uncertainty Factor Development

The UFs applied to the final literature-based, pre-UF MATCs attempt to ensure adequate protection of biota populations. The UFs were developed for the MATC and the TRV (Section C.2.6) approaches in parallel, i.e., it was decided to apply the same rationale and values for each derivation process.

Four uncertainty factor categories were selected to account for 1) the intertaxon variability in toxicological responses to contaminants when extrapolating from the species used in an experimental study to a target species at RMA; 2) the extrapolation from the duration of an experimental study to the chronic exposure being assessed at RMA; 3) the extrapolation from a toxicity endpoint in an experimental study to the desired no adverse effects endpoint for the ecological risk assessment at RMA; and 4) a modifying factor to account for additional sources of uncertainty. The final UF, the product of the results of these four categories, is divided into the pre-UF MATC critical value to determine a final MATC value (Table C.2-11). The same procedure is followed for the derivation of the TRVs.

Intertaxon Variability Extrapolation

For studies with the same species of interest, the minimum amount of uncertainty for the intertaxon variability extrapolation category was 1. The maximum amount of uncertainty was

applied when the study animals were in the same class but a different order as those animals at RMA. Critical values were not extrapolated beyond different orders.

Study Duration Extrapolation

The concentrations that are reported in the literature may reflect biological responses from acute, subchronic, or chronic exposures. Because the food-web model assumes that a contaminant is at equilibrium between an organism and the environment, values from studies employing chronic exposure, where equilibrium has been achieved, are most appropriate to provide data points for the MATC parameter.

Study Endpoints Extrapolation

Generally, endpoints for MATC values are presented as a biological response that varies from death to sublethal effects (e.g., physical deformations, disease, behavioral abnormalities, physiological abnormalities) to no observed effects. For a particular endpoint, the tissue concentration may be presented as a general toxicity level measured when the endpoint was observed, or it may be a more precisely defined lowest observable adverse effect level (LOAEL) or no observed adverse effect level (NOAEL). These more precise endpoints are determined by experiments that precisely measure incremental concentrations to pinpoint the specific concentration at which or before which the endpoint is first observed. A frank effects level (FEL) is that contaminant concentration in the tissue or organism that is highly certain to cause an adverse toxic effect. A decision must be made as to what biological response is an appropriate endpoint for each trophic box/chemical combination and what should be done if the appropriate endpoint is not available.

Modifying Factor

Eight additional sources of uncertainty were summed to comprise the modifying factor. These are adjustments for threatened and endangered species status, endpoint relevance, laboratory to field extrapolation, contaminant presence, unclear endpoint, species sensitivity, tissue to whole-body conversion, and intraspecies variability.

The UF intended to represent a safety factor for threatened and endangered species was used only for the bald eagle. The bald eagle is protected as an endangered species by the Endangered Species Conservation Act (16 U.S.C. 668aa-668cc-6) and the Bald and Golden Eagle Protection Act (16 U.S.C. 668-0668d). The MATC (or the TRV) developed using this UF, therefore, was assumed to be protective of sensitive individuals of this particular species. The remaining trophic boxes represent animal groups for which a MATC (or TRV), protective of populations and representing a concentration that potentially results in minimal adverse effects to some individuals but is protective of the average individual, is appropriate.

The uncertainty associated with relevance of an endpoint resulted when behaviors or pathology could not be directly linked to adverse health effects. Laboratory to field extrapolation uncertainty was applied to studies conducted with laboratory-bred animals such as rats or chickens. Co-contaminant uncertainty resulted from studies in which the results for the contaminant of interest may have been impacted by the presence of other chemicals, such as the administration of DDT or DDE with dieldrin, or the use in an experiment of an organic form of mercury rather than an inorganic form. Endpoint uncertainty resulted when the validity of an endpoint was questionable, such as when the number of deaths in test birds did not exceed the number of deaths observed in control birds. The modification of uncertainty for sensitive species was used when an unusually sensitive species, such as the brown pelican (which is impacted by relatively low concentrations of DDT), was used in a toxicological study. For the derivation of MATCs only, a modifying factor was used when data from one organ were extrapolated to a whole-body basis because of uncertainty about the applicability of the extrapolation ratio to individual animals at RMA. Uncertainty also resulted from intraspecific variability associated with small sample sizes of individuals in experimental groups, toxicity responses related to gender differences, and other variability among individuals as well as from the extrapolation of those differences to different individuals of the same species at RMA.

When the total modifying factor summed from the individual modifying factors had a negative sign, it denoted a reduction in the uncertainty from the eight various issues. The negative modifying factor was replaced with a value of 0.5 and then multiplied with the other categories

of UFs. When the total modifying factor was zero, which denoted a null impact on the overall uncertainty, it was replaced with a value of 1 so that it would not affect the product of the other three UF categories. When the total UF exceeded 400, it was replaced with the value 400 prior to division into the pre-UF MATC. An upper bound was established because at some point uncertainty becomes difficult to define and takes the MATC critical value to a point where only the doubt around the data point is expressed. The upper-bound UF value of 400 is supported by Barnthouse et al. (1990). Barnthouse et al. showed that the maximum uncertainty demonstrated was 417 for acute exposure studies based on the results of extrapolations of various types of toxicity data to obtain lifetime concentrations of triflurallin in water protective of Gulf menhaden and Chesapeake striped bass.

C.2.3.2.6 Uncertainty Factor Summary

Ecological risk assessments are forced to make many assumptions, especially when extrapolating toxicity data across taxa, because quantitative ecological risk assessment is in the formative stages and because there is a lack of sufficient field toxicity studies on many of the receptors of concern. Because many of these assumptions are extremely uncertain, UFs or safety factors have been used for the protection of species of interest.

For example, the Natural Resource Damage Assessment Model for Coastal and Marine Environments estimates potential hazards for aquatic biota using acute toxicity (lethal concentration to 50 percent of a population, or LC_{50}, and lethal dose to 50 percent of a population, or EC_{50}) data. For this model, a hazard value for each aquatic species is derived by dividing the acute toxicity value by 100 to estimate a no-effects level for the species of interest (EPA 1988).

Further, a Standard Evaluation Procedure (SEP) developed by the EPA Office of Pesticide Programs uses safety factors for conducting ecological risk assessments relative to pesticide product registration (1986, 1988). The SEP approach is a modified quotient method, which is similar to the hazard quotient method used in the Integrated Endangerment Assessment/Risk Characterization in which environmental concentrations are compared to environmental toxicity

endpoint values (i.e., regulatory risk criteria, or RRC). Both aquatic and terrestrial receptors are evaluated by this method. The assessments are directed at the population level, with members of threatened and endangered species addressed further by the application of more stringent RRC. For acute toxicity, the RRC are equal to the LC_{50} or lethal dose to 50 percent of population (LD_{50}) divided by a safety factor of either 5, 10, or 20. The general principle of the SEP approach and associated safety factors support the application of smaller UFs to derive MATCs and TRVs, because the total uncertainty associated with the SEP approach is intended to derive acceptable concentrations for acute exposure rather than chronic exposure (HLA 1993).

UFs were initially applied in the Biota RI (ESE 1989) to derive toxicity benchmark values. The Off-Post EA for RMA expanded the uncertainty development presented in the Biota RI (HLA 1993). For the Off-Post EA, a step-wise protocol was used to derive a TRV from a critical study dosage with a UF being applied at each step (UFs were not applied to the MATC values used in the Off-Post EA). The UFs used in the IEA/RC vary from those used in the Biota RI and the Off-Post EA because the derivation of MATCs and TRVs is an evolving process, and new information has become available. The UF values listed in Table C.2-11 were selected on the basis of consensus after thorough discussion of the available literature and application of informed best professional judgment. The total uncertainty values used result in MATCs and TRVs that are reasonably conservative relative to existing toxicological data.

C.2.4 EXPOSURE AREA

C.2.4.1 Parameter Definition and Characteristics

The exposure area parameter defines the area within which an organism is potentially exposed to contaminants. Soil contaminant concentrations averaged within the exposure area provide the <ESC> value used in the calculation of the BMF_{obs} (Section C.1.6) and in the estimation of risk (Section C.1.8). The concept of exposure area can be applied to sediment or water concentrations. Exposure area values for each trophic box, and in some cases for individual species within trophic boxes, were derived from the literature on home range, foraging area, and other areas of use.

Home range is defined as the area traversed by an organism in its normal activities of food gathering, loafing, mating, and caring for its young. Home range is often defined for a species during its breeding season. At this time, individuals use a defined area because their mobility is restricted by the presence of young. Foraging area is that portion of the home range which an individual uses for food gathering. Depending on the species, foraging area may cover the entire home range, or only a relatively small portion of the home range. For example, wide-ranging species, such as carnivores and birds, may have dens or nests in one area, resting areas in another, and feeding areas in a select, small area of high prey density.

For most species, exposure to soil concentrations is expected to result from feeding activities. However, some species may also be exposed to soil concentrations in portions of the home range used for other activities such as burrowing and dusting. Therefore, the selection of home range, foraging area, or some other area of use to represent exposure area varied by species.

C.2.4.2 Database Characterization for Exposure Area

C.2.4.2.1 Literature Description

General literature search procedures were described in the introduction to Section C.2. However, an independent literature search was conducted for information pertinent to the definition of exposure area. Most articles were located in three information databases (Wildlife Review, Wildlife Information Services, and CARL Uncover) or were provided by the technical representatives of the Organizations and State.

Studies on home range are available for most bird and mammal species found at RMA. Most literature studies are directed toward quantifying the areas used by species with relatively predictable use patterns, such as breeding birds or small mammals. Studies for wide-ranging species tend to focus on how far from their nest or den they might feed, not on the area actually used for feeding. No home-range information was available in the literature for shorebirds, insects, earthworms, and terrestrial plants.

C.2.4.2.2 Parameter Quantification

Literature studies on home range were evaluated and screened on the basis of characteristics such as geographic location, habitat, season, and methodology, which determined their usefulness in defining exposure area on RMA. For example, a study of home-range size in a grassland community in Nebraska would be valuable. On the other hand, methodologies such as mark-recapture studies or radio-transmitter studies that determined maximum distances traveled for food were not useful in quantifying RMA home ranges. The screened studies provided ranges of values for comparison and discussion.

Most of the literature studies provided the size of species-specific areas of use. The shape of the areas of use was often irregular and was defined by such factors as adjoining areas of unsuitable habitat, neighboring individuals of varying aggressiveness, and the energy needs of the organism using the area. Even within the area of use, patchiness of habitat often precluded homogeneous use of all portions of the area. However, the exposure area values based on home range were expressed in acres and later assumed to be to circles with their radii expressed in feet. Since this approach assumes that the exposure area has a circular shape and homogeneous use, the exposure area is only an approximation of the true area of use and exposure.

For wide-ranging species, best professional judgment was necessary to define the exposure areas since the area of potential use was often much larger than the area of likely exposure. For example, a bald eagle or great blue heron may range more than 10 miles in search of prey, yet feed consistently in a small area with high prey density.

C.2.4.2.3 Data Variability

There was considerable variability among species in the size of their areas of use. As would be expected, use areas for birds were larger than those for comparably sized mammals, and use areas for large birds and mammals were larger than those for small birds and mammals. Behavioral patterns also influenced the size of areas of use. For example, prairie dogs, which inhabit a burrow system, range less widely than cottontails. Even within a species, the size of the use areas varied given such factors as the quality of the habitat, the availability of the food, and the

aggressiveness of neighboring individuals. For example, home range for kestrels in an industrial complex was larger than in more natural surroundings. Areas of use were variously based on such characteristics as area defended, area of foraging, or area of greatest movement. Best professional judgment was used to determine the area, defined on the basis of activities, that would best correspond with exposure to contaminants. Final values were used deterministically.

C.2.4.2.4 Final Value Selection and Assessment

Best professional judgment and consensus discussions were used to select the home range (or other area of use) values that were most appropriate to estimate exposure area. During the selection process, many values were discounted due to inappropriate methodology or inappropriate values for determining exposure area (i.e., discarding general home range values when more refined values, such as foraging range or defended coterie territories, were available). Conversely, some values were deliberately chosen because they were measured by a researcher known to be an expert with regard to a certain species.

When values were not available for certain species or when all available literature values were discarded, local and regional experts were contacted. Many unpublished values or methodologies giving insight to exposure area were discovered using this method. For example, radioisotope tracer studies on root distributions for terrestrial plants and small-scale insect movement studies were used to estimate an appropriate exposure area for these trophic boxes.

Consensus on final values (Table C.2-13) was achieved in two stages. First, consensus was achieved on lower trophic box species such as terrestrial plants, insects, amphibians and reptiles, small birds, and mammals. Such species were either represented by consistent values in the literature or by exposure areas that could be reasonably approximated for reasons such as low mobility. Within this group, only the mourning dove was problematic, because of its habit of traveling considerable distances away from its nesting territory to obtain water. The distance traveled to water was ultimately ignored for this species and the exposure area was defined as the foraging area around its nest site where most of its exposure was believed to occur. Because organisms with aquatic food chains are exposed to water that is continually mixed within a lake,

even if they do not travel throughout the lake themselves, the entire lake was considered the exposure area.

Consensus on values for the wide-ranging high trophic level species (bald eagle, great blue heron, great horned owl, American kestrel and shorebird) and water birds was more difficult to achieve. Particular care was given the selection of exposure area for these species because they are at or near the top of their food webs and, therefore, experience the greatest biomagnification.

Within this group of six, bald eagle and great blue heron exposure area values were the most difficult to ascertain because both species range widely yet may feed selectively in small areas. The concern was that overestimating exposure area would underestimate risk. Based on consideration of whether the bald eagle exposure area should extend beyond RMA boundaries, or whether it should be restricted to a portion of RMA, the selection of a single exposure area for the bald eagle at RMA was made, which consists of the Bald Eagle Management Area as well as all prairie-dog towns present in April 1993. The shape of this polygon is fixed and is not to be used in formation of a circular estimate of exposure area. The great blue heron exposure area was based on the surface area of each RMA lake plus a terrestrial band equal to 4 percent of the lake surface area as an estimate of the shoreline areas used in foraging. The waterbird exposure area was based only on the surface area of each RMA lake. No upland or shoreline areas were included, even though nests may be found there, since little feeding occurs in these areas at RMA. The shorebird exposure area was a circular area since these species forage in terrestrial areas near the shoreline of the lakes. The exposure areas for great horned owl and American kestrel were the most certain among the six species requiring special attention, because these species exhibit considerable fidelity to their nesting territories when foraging.

C.2.5 TOXICITY REFERENCE VALUES

C.2.5.1 Parameter Definition and Characterization

The dose-based method employed in the IEA/RC to estimate ecological risk and biota criteria is based on the use of a TRV as a benchmark toxicity parameter. Like the reference doses (RfDs) used in human health risk assessment, the TRV represents an estimate, with uncertainty spanning

perhaps an order of magnitude or greater, of a daily dose in mg/kg-bw/day to a receptor that is likely to be without an appreciable risk of deleterious effects. Unlike the MATCs (Section C.2.4), which were identified only for the bioaccumulative COCs, the TRVs were determined for all of the COCs evaluated in the IEA/RC.

The TRV approach developed for the IEA/RC generally follows that developed for the Off-Post EA/Feasibility Study (HLA 1993) and is based on the method used by EPA (1986) to derive human health RfDs. The RfDs represent values protective of human health against systemic toxicity effects. A basic premise of this approach is that homeostatic, compensating, and adaptive mechanisms exist that must be overcome before a toxic endpoint is manifested. With systemic toxicity, therefore, there is a threshold effect. The RfD represents a benchmark dose operationally derived from a NOAEL by the consistent application of UFs that reflect the various types of data sets used to estimate RfDs. That is, the critical toxicity dose from the literature is divided by a value representing the product of all UFs and modifying factors determined to be appropriate on the basis of the quality of the data used to arrive at the NOAEL (HLA 1993). The TRVs used in the IEA/RC were derived in a similar manner, starting with a critical dose obtained from the literature, which was then adjusted by the application of appropriate UFs (including modifying factors) to result in a TRV that is protective of the representative trophic box. The development of the UF values is discussed in Section C.2.4 for the MATC. With one noted exception, the same protocol was used for TRVs.

The development of a TRV was a step-wise process beginning with the review of available toxicological literature for each chemical being evaluated for potential toxic effects to ecological receptors. The available literature was reviewed to identify all experimental and field studies that could be used to establish a critical dose. The preferred studies were those in which the test species was the same as the ecological receptor being evaluated. Unfortunately, the available literature for field studies using avian or wildlife species was very limited, which made reliance on information from laboratory animal studies necessary. The best study located in the literature was then selected to provide the critical dose and the critical toxicological endpoint. If the selected study reported a dietary concentration rather than a dose, the concentration was converted

to a critical study dose rate on the basis of the study animal's feed rate. The critical study dose rate was then divided by the total UF to derive the TRV as described in Section C.2.4.

C.2.5.2 Database Characterization

C.2.5.2.1 Literature Description

In the selection of critical dose values, many variables were considered during review of the toxicological dose data from the literature, including the toxicological endpoints of the study and the characteristics of the test species. The primary toxicological endpoints of interest were effects on reproduction and behavior; toxicological studies reporting potential effects on reproduction were preferred. Other endpoints, such as pathological changes or mortality, were used only if reproduction or behavioral studies were unavailable. Often, toxicity data were unavailable for the species of interest and data from a surrogate species were used, if available. A study with a species of similar size was preferred over a study using a smaller or larger animal. Because the composition of the diet may ultimately influence chemical uptake by the receptor, species with similar dietary habits were selected over species that had different dietary habits. If no data were available for a species in the same class as the species of concern, then no critical value was recommended.

C.2.5.2.2 Parameter Quantification

A summary of the critical study selection process is presented below for the COCs. The critical dose values obtained from the literature sources described below are summarized in Table C.2-14.

Aldrin/dieldrin

Several studies have been conducted documenting the toxicity of aldrin and dieldrin to avian species. A mallard duck study was selected as the most appropriate study to provide a critical dose for the great blue heron and the water bird (Sharma et al. 1976). The dose rate obtained from this study was 0.4 mg/kg-bw/day, which was designated a lowest observed effect level (LOEL) on the basis of a change in aggressive behavior in male birds. LOELs differ from LOAELS in that the observed effects reported may not necessarily be detrimental to an animal's health.

Two raptor studies were used to provide the critical dose for the bald eagle. These were reproductive studies of the American kestrel (Wiemeyer et al. 1986) and barn owl (Mendenhall et al. 1983). Both studies provided a NOAEL for reproductive effects. The critical dose for the eagle derived from these papers was 0.05 mg/kg-bw/day. The Mendenhall et al. reproduction study was also used to provide the critical dose for the great horned owl trophic box as a NOAEL of 0.06 mg/kg-bw/day. The Wiemeyer et al. study provided the critical dose for the American kestrel trophic box as a NOAEL for reproduction of 0.04 mg/kg-bw/day.

A 2-year study of 20 homing pigeons by Robinson and Crabtree (1969) provided the critical dose for the small bird trophic box as a NOAEL of 0.28 mg/kg-bw/day. Toxicological endpoints included mortality, number of birds that failed to return, and tissue residues (e.g., liver, eggs, blood). All of the 18 incubated eggs hatched normally. This study was also used to derive the critical dose for the shorebird, in conjunction with a lethality study of quail by Shellenberger (1978) and a study of quail by Stickel et al. (1969). The critical dose for shorebirds, based on NOAEL values from these three studies, was 0.22 mg/kg-bw/day.

For mammals, a study on reproductive and pathological effects in 440 rats was selected (Harr et al. 1970). The NOAEL for reproduction derived from this study was 0.06 mg/kg-bw/day. Toxicological endpoints included reproductive parameters (dam survival, dam conception, born litter size, and weaned litter size), dieldrin intake, tissue residue, overt signs of toxicity, and lesions. Lethal concentrations, tissue partitioning, and excretion rate were also obtained. Dam survival and conception were lower in the higher dose groups, as was litter size (born and weaned).

Critical dose values for aquatic species were also derived for aldrin/dieldrin. A study by Schuytema et al. (1991) provided a NOAEL of 1.9 micrograms per liter (µg/l) for the leopard frog, which was used as the amphibian critical dose value. Schuytema et al. investigated acute and chronic toxicity, teratogenesis, growth, and bioconcentration in three frog species. The other frog species had NOAEL values of 0.8 µg/l and 11.0 µg/l. On the basis of these observations, the authors concluded that the current EPA AWQC for dieldrin (0.0019 µg/l) is protective of

frogs. A study by Cairns and Scheier (1964) provided a LOAEL of 1.7 μg/l for the pumpkinseed sunfish, which exhibited decreased cruising speed and increased oxygen consumption at this concentration. This critical dose value was used for small fish. The critical dose value for large fish was a NOAEL of 0.12 μg/l, which is based on steelhead trout (Chadwick and Shumway 1969).

DDT/DDE

Several bird studies provided the critical dose values for avian species. A reproductive study of black ducks was used for the great blue heron and water bird trophic box critical doses (Longcore and Stendell 1983). Measurement of tissue residues and eggshell thickness resulted in a LOEL for reproductive effects of 0.06 mg/kg-bw/day.

Two American kestrel studies (Wiemeyer et al. 1986; Lincer 1975) provided the critical dose value used for the bald eagle, kestrel, and the shorebird trophic boxes. These two reproductive studies of the American kestrel resulted in the derivation of a LOAEL of 0.4 mg/kg-bw/day.

A reproductive study of barn owls (Mendenhall et al. 1983) was used to obtain the critical dose for the great horned owl trophic box. The value of 0.3 mg/kg-bw/day was a Frank effect level (FEL) for reproduction and was associated with statistically significant increases in eggshell thinning, egg breakage, embryo mortality, and reduced breeding success per pair of birds.

A reproductive study of finches (Jefferies 1971) provided the critical dose of 0.8 mg/kg-bw/day for the small bird trophic box. This was a LOAEL for reproductive effects.

A reproductive study of rats (Green 1969) provided the critical dose value of 0.35 mg/kg-bw/day for mammals. This was a NOAEL for reproductive effects since chronic exposure to DDT did not change fecundity, fertility growth rate, or litter size in two generations of rats.

Studies of aquatic species provided critical dose values for several trophic boxes. A NOAEL of 0.8 μg/l for behavioral changes in tadpoles (Cooke 1972) was used as the exposure concentration

for the amphibian trophic box. An FEL of 0.74 μg/l for mortality in fathead minnows exposed to DDT in food and water was used as the exposure concentration for the small and large fish trophic boxes (Jarvinen et al. 1977).

Endrin

Two studies for endrin toxicity in avian species provided critical dose values. A reproductive study of ducks (Roylance et al. 1985) provided an NOAEL of 0.05 mg/kg-bw/day as the critical dose for the great blue heron and the waterbird trophic boxes. Egg production, fertility, hatchability, and hatchling survival were unaffected by exposure to endrin at this concentration, although embryo survival was decreased at a higher dose than was selected as the critical value. A reproductive study of screech owls (Fleming et al. 1982) provided a LOAEL of 0.1 mg/kg-bw/day, which was used as the critical dose for the other avian trophic boxes. Reproductive endpoints in this study included number of eggs laid and hatched, number of cracked eggs and eggs laid outside of nest boxes, and number of young birds fledged, which were measured together with carcass and egg residues.

A study of rats and mice provided a critical value dose for mammals (Noda et al. 1972) as a LOAEL of 0.58 mg/kg-bw/day. This value was used for both large and small mammal trophic boxes.

Mercury

One study, a multi-generational reproductive study of mallard ducks, provided a critical mercury dose for birds as a LOAEL of 0.047 mg/kg-bw/day (Heinz 1976). Mercury levels in eggs and tissues were measured together with reproductive endpoints including whole-egg weight and shell thickness, percent of eggs laid outside nest box, percent of cracked eggs, percent of eggs producing normal ducklings, percent of normal hatchlings surviving 1 week, and number of 1-week-old ducklings.

A rat study provided the mercury critical dose for the mammal trophic boxes (Soares et al. 1973) as a NOAEL of 0.17 mg/kg-bw/day. Tissue residues were measured and the endpoints of

lethality and growth were examined in ten weanling rats exposed to mercury in diet for 12 weeks. There was no mortality in this dose group.

Arsenic

A study of ducks provided the critical dose for birds (Van Vleet 1982) as a LOAEL of 18.9 mg/kg-bw/day. A 2-year study of rats was used to obtain the critical dose for mammals as a LOAEL for pathology of 1.5 mg/kg-bw/day (Byron et al. 1967). Body weight was recorded, and hematological measurements (i.e., hemoglobin, hematocrit, and leukocyte counts) were made. Dose-related enlargement of the common bile ducts was noted, and survival was affected at the higher dose levels.

Cadmium

All of the cadmium critical dose values for birds were derived from a single study of doves (Scheuhammer and Templeton 1990). At the NOAEL of 1.8 mg/kg-bw/day, no overt toxicity or mortality was observed. The TRVs developed from this dose differed among the bird trophic boxes due to differences in the UFs applied.

The critical dose values for mammals were derived from a study with rats (Groten et al. 1991) as a NOAEL of 1.8 mg/kg-bw/day. When cadmium accumulation in tissue from this dose was measured over the 4 weeks of exposure, a dose- and time-related increase in liver, kidney, and intestinal concentrations of cadmium was observed, although no effects were reported.

Chlordane

An LD_{50} study of chlordane provided the only toxicity data for birds (Hudson et al. 1984). The LD_{50} was 14.1 mg/kg-bw for quail; an LD_{50} of 1,250 mg/kg-bw was also reported for ducks.

The only critical dose data for mammals was a NOAEL of 1.2 mg/kg-bw/day reported by EPA (1984). This study was summarized in the 1991 Health Effects Assessment Summary Tables.

Copper

Copper toxicity data for birds were limited. A study by Leach et al. (1990) describing growth limitation in chickens provided a critical dose value used for all of the avian trophic boxes. Growth limitation was observed at a dose of 48 mg/kg-bw/day. Chickens were more sensitive to copper toxicity when inadequate calcium was supplied in the diet; at a calcium content of 0.6 percent or less in the diet, body weight decreased in birds consuming a high amount of copper in diet compared to birds consuming a low amount of copper.

The critical dose for copper in mammals was an LD_{50} of 300 milligrams per kilogram (mg/kg) (RTECS 1993). Other data were not found in the literature surveyed.

Chlorophenylmethyl Sulfide

Data for toxicity to avian species were unavailable for this chemical. The only study available to provide the critical dose for mammals was Thake et al. (1979), which was a dietary study of rats. The LOAEL was 14.1 mg/kg-bw/day.

Chlorophenylmethyl Sulfone

Data for toxicity to avian species were unavailable for this chemical. The Thake et al. (1979) dietary study of rats provided a LOAEL of 16.3 mg/kg-bw/day, which is the only value available for mammals.

Dibromochloropropane

Very few studies were available on the toxicity of DBCP to wildlife species. For birds, the only value obtained was an LD_{50} for ducks of 66.8 mg/kg (Hudson et al. 1984). For mammals, a dose rate of 0.6 mg/kg-bw/day was obtained as a NOEL for rats (EPA 1987).

Dicyclopentadiene

A dietary study using bobwhite quail provided the critical dose used for all bird trophic boxes, a LOEL of 400 mg/kg-bw/day (Aulerich et al. 1979). EPA (1991) provided the NOEL dose value for rats of 34 mg/kg-bw/day.

C.2.5.2.3 Data Variability

It is not unusual to observe a wide range in the critical dose values before UFs are applied, because there is inherent intrinsic and extrinsic variability associated with each of the trophic boxes. The variability of the pre-UF dose data is within two orders of magnitude among avian and mammalian species for each COC evaluated. Also, the variability never exceeded two orders of magnitude within the same phylogenetic class for each COC. The data were not segregated based on study type or endpoint, so the variability is partially the result of differences in study type and study endpoint.

The variability was reduced following the application of the total UF to the critical dose values. For mammalian and avian trophic boxes for each COC, the final TRVs were within one order of magnitude. The only exception was for chlordane, for which the small bird TRV was 0.035 mg/kg-bw/day. This value compares to 3.12 mg/kg-bw/day for the water bird.

C.2.5.2.4 Final Value Selection and Assessment

The UF protocol applied to the critical dose values was essentially identical to that described for each UF category in Section C.2.4 for the MATC. The only difference is that the modifying factor subcategory addressing extrapolation from organ or egg to whole body for the MATC was not included in the TRV derivation process.

To calculate TRVs, the critical dose value for a given trophic box/chemical combination was divided by the total UF:

$$\text{TRV} = \frac{\text{Dose}}{\text{Total UF}} \qquad (7)$$

where: TRV = toxicity reference value (mg/kg-bw/day)
Dose = critical study dose value (mg/kg-bw/day)
Total UF = total uncertainty factor

Each of these values, as well as the individual UF values, are listed in Table C.2-15. These TRVs are expected to be protective of the designated trophic boxes through a review and evaluation of the available literature.

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To Install the Ecological Risk Characterization Bibliographic Reference Database (ERCBIBL.dbf)

Summary: These instructions outline a custom Microsoft Windows procedure for installing a dBASE database file into a predetermined directory on your hard disk.

Instructions:

- To ensure proper installation and program execution, please make sure that your computer has a hard disk with a minimum of 5 megabytes of free space.
- Start the computer and enter Microsoft Windows.
- From the Program Manager Window, choose Run from the File Menu.
- Insert the diskette labeled "RC Media Installation Disk 1 of 3" into the 3.5 inch disk drive.
- Type "<d>:Setup" (without the quotes or angle brackets) where <d> is the drive letter where you have inserted the installation diskette.
- Press ENTER.
- Follow instructions on the screen. You will be prompted to enter the drive letter representing the hard disk where you want to install the database file, ERCBIBL.dbf. (The ERCBIBL.dbf database will be installed in the ERCBIBL directory on the drive of your choice.)

Read the ERCBIBL.txt file installed into the ERCBIBL directory for a summary of the database structure and query information.

The bibliographic reference database for the ecological risk characterization of the Rocky Mountain Arsenal Integrated Endangerment Assessment/Risk Characterization (RMA IEA/RC) project is contained on this disk.

The file ERCBIBL.dbf is the result of the previous Windows installation. Because the ECOREFS.DBF file is about 4 megabytes in size, the file will have to be loaded to a hard drive with at least 4 megabytes of free space.

At the DOS prompt for the hard–drive directory onto which the file was copied, type "DBASE" and hit enter. Hit enter when the DBASE IV logo comes onto the screen. At the DBASE dot prompt (or, if using a Control Center hit Alt-E, then choose to exit to dot prompt), type "USE ECOREFS" and hit enter. At the next dot prompt, type "BROWSE" and hit enter. The bibliographic reference database will come onto the screen. To exit the ECOREFS.DBF file, hit the escape key. Then, type quit at the DBASE dot prompt to return to the DOS prompt. If changes or additions are made to the database, the file name should be changed so the original ECOREFS.DBF can be maintained.

The bibliographic reference database for the ecological risk characterization is organized alphabetically by author and linked to the chronological order of publication year followed by the alphabetical ordering of titles. For example, if there are two references by Ytterbaum, S. and one was published in 1989 called Poisoned Ducks, and the other published in 1989 was called Healthy Ducks, then the latter reference will appear first. The fields most likely to be used in searches are the following (listed from left to right) DOCNO2 (document number), AUTHOR, YEAR, TITLE, OTHERNUM (an alternate document number). Listed below are two of the easiest and most useful search commands that can be used to access particular references.

To locate a particular unique document number, author, year, or title: Type "LOCATE FOR" {fieldname} = "condition" and hit enter. Then type "BROWSE" and hit enter to return to viewing the database.

The fieldname is one of those listed above in capital letters (do not include the brackets), and the condition is the document number, the author's name (last name first, followed by initials or first and middle initial), the year, or the exact title (do include the quotation marks).

To locate a particular reference by subject, or if the exact name of the author or exact title is not known, the following search command can be used: Type "LOCATE FOR" "condition" $ {fieldname} and hit enter. Then type "BROWSE" and hit enter to return to viewing the database. The condition, in this case, can be only the author's last name or one or a string of words from the title.

This bibliographic reference database for the ecological risk characterization may be further updated as additional versions of the RMA IEA/RC report are released. Inquiries may be directed to Michael Jones at Enserch Environmental Corporation, Lakewood, CO (303) 988-2202.

Parameter	Definition (units)
Toxilogical Input Parameters	
BAF	bioaccumulation factor (unitless)
BMF	biomagnification factor (unitless); the final value resulting from the food web model
Ecological Input Parameters	
FR	fraction of item i-1 in diet of level i organism (unitless)
R	feeding rate (grams food per gram body weight per day [g/g bw/d])
Toxicity Threshold Types	
ER	exposure range that represents the average area over which an organism forages or is otherwise consistently exposed (represented as a circle of stated acreage or radius)
MATC	maximum allowable tissue concentration of a contaminant (micrograms contaminant per gram tissue [µg/g])
TRV	toxicity reference value for a contaminant when ingested as a dose (micrograms contaminant per gram prey tissue per day)
Other Measures of Toxicity	
FEL	Frank effect level or that level of exposure producing a significant increase in frequency or severity of unmistakable adverse effects
LD_{xx}	Contaminant dose lethal to stated (xx) percent of test organisms (micrograms contaminant per gram body weight [µg/g])
LOAEL	Lowest observed adverse effects level of a contaminant concentration under chronic exposure conditions (stated as a dose or tissue concentration [µg/g])
LOEL	Lowest observed effects level of a contaminant concentration under chronic exposure conditions (stated as a dose or tissue concentration [µg/g])
NOAEL	No observed adverse effects level of a contaminant concentration under chronic exposure conditions (stated as a dose or tissue concentration [µg/g])
NOEL	No observed effects level of a contaminant concentration under chronic exposure conditions (stated as a dose or tissue concentration [µg/g])
TXCTY	Deleterious effects observed from a contaminant concentration without qualifying as a (stated as a dose or tissue concentration [µg/g])

Table C.2-2 Keywords Used in the DIALOG On-Line Search for the Ecological Risk Characterization

Aldrin
Arsenic
Availability
Bioaccumulation
Biomagnification
Dibromochloropropane
DDE
DDT
Dibromochloropropane
Dichlorodiphenyltrichloroethane
Dichlorodiphenylethane
Dieldrin
Diet
Eating
Endrin
Environment
Feed
Food
Forage
Foraging
Habit
MATC
Mercury
Nonhuman
Partition coefficient
Preference
Prey
Resource
Selection
Soil partition
Soil ingestion
Tissue concentration
Toxic
Uptake
Utilization

DDE	Dichlorodiphenyldichloroethene
DDT	Dichlorodiphenyltrichloroethane
K_d	Soil-water partition coefficient normalized to dry weight
K_{oc}	Soil-water partition coefficient normalized to organic carbon
MATC	Maximum allowable tissue concentration

Table C.2-3 Ecological Risk Characterization Model Input Parameter Values

Parameter = Bioaccumulation Factor (BAF)

Biota	Chemical	Distribution	Mean*	Std. Dev.	LOG Mean	LOG Std Dev.	End Point
Small Bird	Aldrin/Dieldrin	Normal	6.6	1.8			
	Endrin	Lognormal	1.0	1.6	0.000	0.470	
	DDE/DDT	Uniform	NA	NA			7.7, 29
	Arsenic	Uniform	NA	NA			0.3, 3
	Mercury	Triangular	0.33	NA			0.001, 2
Small Mammal	Aldrin/Dieldrin	Uniform	NA	NA			0.64, 1.6
	Endrin	Lognormal	0.08	1.0	-2.526	0.001	
	DDE/DDT	Uniform	NA	NA			0.44, 0.98
	Arsenic	Lognormal	0.19	4.7	-1.684	1.543	
	Mercury	Triangular	22.5	NA			0.001, 50
Medium Mammal	Aldrin/Dieldrin	Uniform	NA	NA			0.64, 3.2
	Endrin	Lognormal	0.16	1.1	-1.833	0.095	
	DDE/DDT	Uniform	NA	NA			0.44, 0.98
	Arsenic	Lognormal	0.19	4.7	-1.684	1.543	
	Mercury	Triangular	22.5	NA			0.001, 50
Water Bird	Aldrin/Dieldrin	Normal	16	5.1			
	Endrin	Lognormal	1.0	1.6	0.000	0.470	
	DDE/DDT	Normal	96	26.2			
	Arsenic	Uniform	NA	NA			0.3, 3
	Mercury	Lognormal	4.1	3.4	1.411	1.224	
Kestrel	Aldrin/Dieldrin	Normal	10.5	1.2			
	Endrin	Lognormal	1.0	1.6	0.000	0.470	
	DDE/DDT	Uniform	NA	NA			7.7, 29
	Arsenic	Uniform	NA	NA			0.3, 3
	Mercury	Triangular	0.33	NA			0.001, 2
Owl	Aldrin/Dieldrin	Normal	21.1	3.4			
	Endrin	Lognormal	1.0	1.6	0.000	0.470	
	DDE/DDT	Lognormal	43.7	2.4	3.777	0.875	
	Arsenic	Uniform	NA	NA			0.3, 3
	Mercury	Triangular	0.33	NA			0.001, 2

* Mean = arithmetic mean for normal distribution, geo. mean for lognormal distribution, and apex for triangular distrib.

Table C.2-3 Ecological Risk Characterization Model Input Parameter Values

Parameter = Bioaccumulation Factor (BAF)

Biota	Chemical	Distribution	Mean*	Std. Dev.	LOG Mean	LOG Std Dev.	End Point
Shorebird	Aldrin/Dieldrin	Normal	13.3	4.2			
	Endrin	Lognormal	1.0	1.6	0.000	0.470	
	DDE/DDT	Uniform	NA	NA			7.7, 29
	Arsenic	Uniform	NA	NA			0.3, 3
	Mercury	Triangular	0.33	NA			0.001, 2
Heron	Aldrin/Dieldrin	Normal	16	5.1			
	Endrin	Lognormal	1.0	1.6	0.000	0.470	
	DDE/DDT	Normal	93.5	20			
	Arsenic	Uniform	NA	NA			0.3, 3
	Mercury	Lognormal	4.1	3.4	1.411	1.224	
Bald Eagle	Aldrin/Dieldrin	Normal	15.9	3.9			
	Endrin	Lognormal	1.0	1.6	0.000	0.470	
	DDE/DDT	Lognormal	27.1	2.4	3.300	0.875	
	Arsenic	Uniform	NA	NA			0.3, 3
	Mercury	Triangular	0.33	NA			0.001, 2

* Mean = arithmetic mean for normal distribution, geo. mean for lognormal distribution, and apex for triangular distrib.

Table C.2-3 Ecological Risk Characterization Model Input Parameter Values

Parameter = Dietary Fractions (FR)

Predator	Prey Item	Biomass Fraction*
Terrestrial Food Chain		
Small Birds	Soil	0.057
	Terrestrial Plants	0.113
	Earthworm	0.116
	Insect	0.714
Small Mammals	Soil	0.020
	Terrestrial Plants	0.866
	Earthworm	0.008
	Insect	0.106
Medium Mammal	Soil	0.074
	Terrestrial Plants	0.926
	Insect	0.000
Kestrel	Soil	0.029
	Insect	0.184
	Small Mammal	0.665
	Small Bird	0.122
Owl	Soil	0.029
	Small Mammal	0.121
	Medium Mammal	0.830
	Small Bird	0.020
Heron	Soil	0.036
	Reptile	0.060
	Small Mammal	0.013
	Water	0.071
	Aquatic Plant	0.000
	Aquatic Invertebrates	0.024
	Small Fish	0.186
	Large Fish	0.604
	Amphibian	0.006
Bald Eagle	Soil	0.029
	Small Mammal	0.000
	Medium Mammal	0.936
	Small Bird	0.003
	Waterbird	0.030
	Large Fish	0.002

* Fractions reported as zero are pathways considered to be relatively inconsequential to model output, due to its small values.

Table C.2-3 Ecological Risk Characterization Model Input Parameter Values

Parameter = Dietary Fractions (FR)

Predator	Prey Item	Biomass Fraction*
Aquatic Food Chain		
Water bird	Water	0.019
	Sediment	0.038
	Aquatic Plant	0.942
	Aquatic Invertebrates	0.001
Shorebird	Terrestrial Plants	0.007
	Insect	0.728
	Sediment	0.160
	Aquatic Invertebrates	0.105

* Fractions reported as zero are pathways considered to be relatively inconsequential to model output, due to its small values.

Parameter = Feed Rate (R) **kg/kg body weight/day**

Biota	Distribution	Mean*	Std. Dev.	LOG Mean	LOG Std Dev.
Water Bird	Normal	0.07602	0.0245		
Small Bird	Fixed	0.0879			
Small Mammal	Fixed	0.12			
Medium Mammal	Fixed	0.096			
Shorebird	Lognormal	0.0879	1.652	-2.4315	0.50189
Kestrel	Normal	0.08913	0.02689		
Owl	Normal	0.08913	0.02689		
Heron	Normal	0.08913	0.02689		
Bald Eagle	Normal	0.08913	0.02689		

* Mean = arithmetic mean for normal distribution, geometric mean for lognormal distribution, and apex for triangular distrib.

Table C.2-3 Ecological Risk Characterization Model Input Parameter Values

Parameter = Maximum Allowable Tissue Concentration (MATC)

Biota	Chemical	Distribution	Value
Small Bird	Aldrin/Dieldrin	Fixed	0.15
	Endrin	Fixed	0.052
	DDE/DDT	Fixed	0.14
	Mercury	Fixed	0.017
Small Mammal	Aldrin/Dieldrin	Fixed	0.19
	Endrin	Fixed	NA
	DDE/DDT	Fixed	0.22
	Mercury	Fixed	NA
Medium Mammal	Aldrin/Dieldrin	Fixed	0.19
	Endrin	Fixed	NA
	DDE/DDT	Fixed	0.22
	Mercury	Fixed	NA
Reptile	Aldrin/Dieldrin	Fixed	NA
	Endrin	Fixed	NA
	DDE/DDT	Fixed	NA
	Mercury	Fixed	NA
Kestrel	Aldrin/Dieldrin	Fixed	0.73
	Endrin	Fixed	0.052
	DDE/DDT	Fixed	4.3
	Mercury	Fixed	0.017
Owl	Aldrin/Dieldrin	Fixed	0.76
	Endrin	Fixed	0.087
	DDE/DDT	Fixed	0.53
	Mercury	Fixed	0.017
Water bird	Aldrin/Dieldrin	Fixed	0.24
	Endrin	Fixed	0.09
	DDE/DDT	Fixed	0.18
	Mercury	Fixed	0.01
Shorebird	Aldrin/Dieldrin	Fixed	0.15
	Endrin	Fixed	0.052
	DDE/DDT	Fixed	1.4
	Mercury	Fixed	0.011
Heron	Aldrin/Dieldrin	Fixed	0.87
	Endrin	Fixed	0.043
	DDE/DDT	Fixed	15
	Mercury	Fixed	0.011
Bald Eagle	Aldrin/Dieldrin	Fixed	0.41
	Endrin	Fixed	0.031
	DDE/DDT	Fixed	2.2
	Mercury	Fixed	0.0083

Table C.2-3 Ecological Risk Characterization Model Input Parameter Values

Parameter = Toxicity Reference Values (TRV)

Biota	Chemical	Distribution	Value
Terrestrial Plant	Arsenic	Fixed	1.9
Small Bird	Aldrin/Dieldrin	Fixed	0.028
	Endrin	Fixed	0.002
	DDE/DDT	Fixed	0.003
	Mercury	Fixed	0.0019
	Arsenic	Fixed	0.38
	Copper	Fixed	0.96
	Cadmium	Fixed	0.24
	DCPD	Fixed	8.9
	Chlordane	Fixed	0.035
	CPMS	Fixed	NA
	CPMSO2	Fixed	NA
	DBCP	Fixed	0.17
Small Mammal	Aldrin/Dieldrin	Fixed	0.004
	Endrin	Fixed	0.010
	DDE/DDT	Fixed	0.029
	Mercury	Fixed	0.0014
	Arsenic	Fixed	0.038
	Copper	Fixed	0.75
	Cadmium	Fixed	0.045
	DCPD	Fixed	2.8
	Chlordane	Fixed	0.10
	CPMS	Fixed	0.24
	CPMSO2	Fixed	0.27
	DBCP	Fixed	0.05
Medium Mammal	Aldrin/Dieldrin	Fixed	0.004
	Endrin	Fixed	0.010
	DDE/DDT	Fixed	0.029
	Mercury	Fixed	0.0014
	Arsenic	Fixed	0.038
	Copper	Fixed	0.75
	Cadmium	Fixed	0.045
	DCPD	Fixed	2.8
	Chlordane	Fixed	0.10
	CPMS	Fixed	0.24
	CPMSO2	Fixed	0.27
	DBCP	Fixed	0.05

NA = data not available to calculate a TRV

Table C.2-3 Ecological Risk Characterization Model Input Parameter Values

Parameter = Toxicity Reference Values (TRV)

Biota	Chemical	Distribution	Value
Kestrel	Aldrin/Dieldrin	Fixed	0.01
	Endrin	Fixed	0.002
	DDE/DDT	Fixed	0.04
	Mercury	Fixed	0.0019
	Arsenic	Fixed	0.38
	Copper	Fixed	0.96
	Cadmium	Fixed	0.24
	DCPD	Fixed	8.9
	Chlordane	Fixed	0.035
	CPMS	Fixed	NA
	CPMSO2	Fixed	NA
	DBCP	Fixed	0.17
Owl	Aldrin/Dieldrin	Fixed	0.004
	Endrin	Fixed	0.003
	DDE/DDT	Fixed	0.008
	Mercury	Fixed	0.0019
	Arsenic	Fixed	0.38
	Copper	Fixed	0.96
	Cadmium	Fixed	0.24
	DCPD	Fixed	8.9
	Chlordane	Fixed	0.035
	CPMS	Fixed	NA
	CPMSO2	Fixed	NA
	DBCP	Fixed	0.17
Water brid	Aldrin/Dieldrin	Fixed	0.027
	Endrin	Fixed	0.003
	DDE/DDT	Fixed	0.004
	Mercury	Fixed	0.00094
	Arsenic	Fixed	0.38
	Copper	Fixed	0.96
	Cadmium	Fixed	0.24
	DCPD	Fixed	3.2
	Chlordane	Fixed	3.1
	CPMS	Fixed	NA
	CPMSO2	Fixed	NA
	DBCP	Fixed	0.17

NA = data not available to calculate a TRV

Table C.2-3 Ecological Risk Characterization Model Input Parameter Values

Parameter = Toxicity Reference Values (TRV)

Biota	Chemical	Distribution	Value
Shorebird	Aldrin/Dieldrin	Fixed	0.022
	Endrin	Fixed	0.002
	DDE/DDT	Fixed	0.008
	Mercury	Fixed	0.00094
	Arsenic	Fixed	0.38
	Copper	Fixed	0.96
	Cadmium	Fixed	0.24
	DCPD	Fixed	8.9
	Chlordane	Fixed	0.035
	CPMS	Fixed	NA
	CPMSO2	Fixed	NA
	DBCP	Fixed	0.17
Heron	Aldrin/Dieldrin	Fixed	0.03
	Endrin	Fixed	0.003
	DDE/DDT	Fixed	0.004
	Mercury	Fixed	0.00094
	Arsenic	Fixed	0.38
	Copper	Fixed	0.96
	Cadmium	Fixed	0.24
	DCPD	Fixed	8.9
	Chlordane	Fixed	0.035
	CPMS	Fixed	NA
	CPMSO2	Fixed	NA
	DBCP	Fixed	0.17
Bald Eagle	Aldrin/Dieldrin	Fixed	0.002
	Endrin	Fixed	0.001
	DDE/DDT	Fixed	0.005
	Mercury	Fixed	0.00063
	Arsenic	Fixed	0.19
	Copper	Fixed	0.48
	Cadmium	Fixed	0.10
	DCPD	Fixed	5.3
	Chlordane	Fixed	0.035
	CPMS	Fixed	NA
	CPMSO2	Fixed	NA
	DBCP	Fixed	0.17

NA = data not available to calculate a TRV

Table C.2-4 Importance Categories for Parameters in Aquatic Food Chains

Parameters	Bald Eagle Importance Category	Great Blue Heron Importance Category
MATC	1	1
Fraction Water Bird Aquatic Plant	1	4
Fraction Water Bird Aquatic Invertebrate	4	4
Fraction Generic Predator Large Fish	1	1
Fraction Generic Predator Aquatic Plant	4	4
Fraction Generic Predator Aquatic Invertebrate	4	4
Fraction Generic Predator Amphibian	4	4
Feed Rate Water Bird	1	4
Feed Rate Generic Predator	1	1

@	Assimilation rate
MATC	Maximum allowable tissue concentration
K_{OC}	Soil-water partition coefficient normalized to organic carbon
K2	Depuration (loss) rate
F_{OC}	Fraction of organic carbon content
BCF	Bioconcentration factor

Table C.2-5 Importance Categories for Parameters in Terrestrial Food Chains

Parameter	Bald Eagle Importance Categories	Great Blue Heron Importance Categories	Great Horned Owl Importance Categories	American Kestrel Importance Categories
MATC	1	1	1	1
Fraction Water Bird	4	4	4	4
Fraction Sm. Mammal Ter. Plant	4	4	4	3
Fraction Sm. Mammal Soil	4	4	4	4
Fraction Sm. Mammal Insect	4	1	4	1
Fraction Sm. Mammal Earthworm	4	4	4	4
Fraction Sm. Bird Ter. Plant	2	4	2	3
Fraction Sm. Bird Soil	4	4	4	4
Fraction Sm. Bird Insect	2	4	2	4
Fraction Sm. Bird Earth	2	4	2	2
Fraction Shore Bird Sediment	4	4	4	4
Fraction Shore Bird Aqu. Invert.	4	4	4	4
Fraction Md. Mammal Ter. Plant	4	4	4	4
Fraction Md. Mammal Soil	2	4	2	4
Fraction Md. Mammal Insect	4	4	4	4
Fraction Gen. Pred. Water Bird Ter.	4	4	4	4
Fraction Gen. Pred. Water	4	3	4	4
Fraction Gen. Pred. Soil	3	4	4	4
Fraction Gen. Pred. Sm. Mammal	4	1	4	1
Fraction Gen. Pred. Sm. Bird	1	4	1	1
Fraction Gen. Pred. Md. Mammal	2	4	2	4
Fraction Gen. Pred. Insect	4	4	4	4
Fraction Gen. Pred. Herp.	4	4	4	4
Fraction Earthworm Ter. Plant	4	4	4	4
Fraction Earthworm Soil	2	3	2	2
BAF Water Bird	4	4	4	4
BAF Small Mammal	4	1	4	1
BAF Small Bird	1	4	1	1
BAF Shore Bird	4	4	4	4
BAF Medium Mammal	2	4	2	4
BAF Generic Predator	1	1	1	1

MATC	Maximum allowable tissue concentration	Inverb	Invertebrate
BAF	Bioaccumulation Factor	Ter	Terrestrial
Sm	Small	Md	Medium
Aqy	Aquatic	Gen	Generic
Pred	Predator		

Study Species	Value (s)	Literature Cited	Comments on How BAFs Were Calculated	Distribution of BAF Values
Aldrin/Dieldrin				
Trophic Box—Bald Eagle				
Herring gull	16	Braune and Norstrom 1989, p.961	Whole body wet-weight herring gull BAF, diet of alewife from Lake Ontario.	Normal; am = 15.9; sd = 3.9; kestrel sd from birds that died, combined with owl sd and gull sd.
Kestrel	10.5	Wiemeyer et al. 1986, p.14	Wet-wt; chronic; nonlethal doses; exposed to dieldrin and DDT; lab study; converted to whole-body.	
Barn owl	21.1	Mendenhall et al. 1983, p.237	Wet-wt carcass residues, converted to whole-body, ave. of males and females, dose = 0.58 ppm.	
Trophic Box—American Kestrel				
Kestrel	10.5	Wiemeyer et al. 1986, p.14	Wet-wt; chronic; nonlethal doses; exposed to dieldrin and DDT; lab study; converted to whole-body.	Normal; am = 10.5; sd = 1.2; kestrel sd from birds that died.
Trophic Box—Great Horned Owl				
Barn owl	21.1	Mendenhall et al. 1983, p.237	Wet-wt carcass residues, converted to whole-body; ave. of males and females, dose = 0.58 ppm.	Normal; am = 21.1; sd = 3.4; from data used to derive the BAF.

am = arithmetic mean
sd = standard deviation
wt = weight

Study Species	Value (s)	Literature Cited	Comments on How BAFs Were Calculated	Distribution of BAF Values
Aldrin/Dieldrin (cont.)				
Trophic Box—Great Blue Heron				
Herring gull	16	Braune and Norstrom 1989, p.961	Whole-body wet-wt herring gull BAF, diet of alewife from Lake Ontario.	Normal; am = 16; sd = 5.1; given in paper.
Trophic Box—Shorebird				
Kestrel	10.5	Wiemeyer et al 1986, p.14	Wet-wt; chronic; nonlethal doses; exposed to dieldrin and DDT; lab study; converted to whole-body.	Normal; am = 13.3; sd = 4.2; sd from data in papers.
Herring gull	16	Braune and Norstrom 1989, p.961	Whole body wet-wt herring gull BAF, diet of alewife from Lake Ontario.	
Trophic Box—Water Bird				
Herring gull	16	Braune and Norstrom 1989, p.961	Whole body wet-wt herring gull BAF, diet of alewife from Lake Ontario.	Normal; am = 16; sd = 5.1; given in paper.
Trophic Box—Small Bird				
Quail	2.7	Stickel et al. 1969, p.185	Consensus value; paper supplied by EPA.	Normal; am = 6.6; sd = 1.8; sd from data in papers.
Kestrel	10.5	Wiemeyer et al. 1986, p.14	Wet-wt; chronic; nonlethal doses; exposed to dieldrin and DDT; lab study; converted to whole-body.	

am = arithmetic mean
sd = standard deviation
wt = weight

Study Species	Value (s)	Literature Cited	Comments on How BAFs Were Calculated	Distribution of BAF Values
Endrin				
Trophic Box—Bald eagle				
Chicken	1.5	Cummings et al. 1967, p.421	Endrin in fat of hens (n=15), fed endrin-fortified feed for 14 wks, converted to whole-body (20% lipids); data from Fig. 3.	Lognormal; gm = 1.0; gsd = 1.6; sd based on data from papers; type based on professional judgment (normal gives negative values).
Screech owl	0.6	Fleming et al. 1982, p.465	Screech owls fed 0.75 ppm endrin (n=14) for 83 days, wet-wt carcass data from Table 2 converted to whole-body.	
Mallard	1.2	Spann et al. 1986, p.758	Nonlethal; carcass (no feet, bill, GI, feathers); ave. both sexes; wet-wt; get same result on lipid-weight with 15% lipid in whole body.	
Trophic Box—American Kestrel				
Chicken	1.5	Cummings et al. 1967, p.421	Endrin in fat of hens (n=15), fed endrin-fortified feed for 14 wks, converted to whole-body (20% lipids); data from Fig. 3.	Lognormal; gm = 1.0; gsd = 1.6; sd based on data from papers; type based on professional judgment (normal gives negative values).
Screech owl	0.6	Fleming et al. 1982, p.465	Screech owls fed 0.75 ppm endrin (n=14) for 83 days, wet-wt carcass data from Table 2 converted to whole-body.	
Mallard	1.2	Spann et al. 1986, p.758	Nonlethal; carcass (no feet, bill, GI, feathers); ave. both sexes; wet-wt; get same result on lipid-weight with 15% lipid in whole body.	

am = arithmetic mean
sd = standard deviation
wt = weight

Study Species	Value (s)	Literature Cited	Comments on How BAFs Were Calculated	Distribution of BAF Values
Endrin (cont.)				
Trophic Box—Great Horned Owl				
Chicken	1.5	Cummings et al. 1967, p.421	Endrin in fat of hens (n=15), fed endrin-fortified feed for 14 wks, converted to whole-body (20% lipids); data from Fig. 3.	Lognormal; gm = 1.0; gsd = 1.6; sd based on data from papers; type based on professional judgment (normal gives negative values).
Screech owl	0.6	Fleming et al. 1982, p.465	Screech owls fed 0.75 ppm endrin (n=14) for 83 days, wet-wt carcass data from Table 2 converted to whole-body.	
Mallard	1.2	Spann et al. 1986, p.758	Nonlethal; carcass (no feet, bill, GI, feathers); ave. both sexes; wet-wt; get same result on lipid-weight with 15% lipid in whole body.	
Trophic Box—Great Blue Heron				
Chicken	1.5	Cummings et al. 1967, p.421	Endrin in fat of hens (n=15), fed endrin-fortified feed for 14 wks, converted to whole-body (20% lipids); data from Fig. 3.	Lognormal; gm = 1.0; gsd = 1.6; sd based on data from papers; type based on professional judgment (normal gives negative values).
Screech owl	0.6	Fleming et al. 1982, p.465	Screech owls fed 0.75 ppm endrin (n=14) for 83 days, wet-wt carcass data from Table 2 converted to whole-body.	
Mallard	1.2	Spann et al. 1986, p.758	Nonlethal; carcass (no feet, bill, GI, feathers); ave. both sexes; wet-wt; get same result on lipid-weight with 15% lipid in whole body.	

am = arithmetic mean
sd = standard deviation
wt = weight

Study Species	Value (s)	Literature Cited	Comments on How BAFs Were Calculated	Distribution of BAF Values
Endrin (cont.)				
Trophic Box—Shorebird				
Chicken	1.5	Cummings et al. 1967, p.421	Endrin in fat of hens (n=15), fed endrin-fortified feed for 14 wks, converted to whole-body (20% lipids); data from Fig. 3.	Lognormal; gm = 1.0; gsd = 1.6; sd based on data from papers; type based on professional judgment (normal gives negative values).
Screech owl	0.6	Fleming et al. 1982, p.465	Screech owls fed 0.75 ppm endrin (n=14) for 83 days, wet-wt carcass data from Table 2 converted to whole-body.	
Mallard	1.2	Spann et al. 1986, p.758	Nonlethal; carcass (no feet, bill, GI, feathers); ave. both sexes; wet-wt; get same result on lipid-weight with 15% lipid in whole body.	
Trophic Box—Water Bird				
Chicken	1.5	Cummings et al. 1967, p.421	Endrin in fat of hens (n=15), fed endrin-fortified feed for 14 wks, converted to whole-body (20% lipids); data from Fig. 3.	Lognormal; gm = 1.0; gsd = 1.6; sd based on data from papers; type based on professional judgment (normal gives negative values).
Screech owl	0.6	Fleming et al. 1982, p.465	Screech owls fed 0.75 ppm endrin (n=14) for 83 days, wet-wt carcass data from Table 2 converted to whole-body.	
Mallard	1.2	Spann et al. 1986, p.758	Nonlethal; carcass (no feet, bill, GI, feathers); ave. both sexes; wet-wt; get same result on lipid wt with 15% lipid in whole body.	

am = arithmetic mean
sd = standard deviation
wt = weight

Study Species	Value (s)	Literature Cited	Comments on How BAFs Were Calculated	Distribution of BAF Values
Endrin (cont.)				
Trophic Box—Small Bird				
Chicken	1.5	Cummings et al. 1967, p.421	Endrin in fat of hens (n=15), fed endrin-fortified feed for 14 wks, converted to whole-body (20% lipids); data from Fig. 3.	Lognormal; gm = 1.0; gsd = 1.6; sd based on data from papers; type based on professional judgment (normal gives negative values).
Screech owl	0.6	Fleming et al. 1982, p.465	Screech owls fed 0.75 ppm endrin (n=14) for 83 days, wet-wt carcass data from Table 2 converted to whole-body.	
Mallard	1.2	Spann et al. 1986, p.758	Nonlethal; carcass (no feet, bill, GI, feathers); ave. both sexes; wet-wt; get same result on lipid wt with 15% lipid in whole body.	
Trophic Box—Small Mammal				
Dog	0.08	Richardson et al. 1967, p.217	Consensus value; used with A.I.T. Walker 1969; converted to whole-body from fat; papers and value supplied by EPA.	Lognormal; gm = 0.08; gsd = 1.0; sd based on data in paper; type based on professional judgment.
Trophic Box—Medium Mammal				
Dog	0.16	Richardson et al. 1967, p.217	Consensus value; used with A.I.T. Walker 1969; converted to whole-body from fat; papers and value supplied by EPA.	Lognormal; gm = 0.16; gsd = 1.1; sd based on data in paper; type based on professional judgment.

am = arithmetic mean
sd = standard deviation
wt = weight

Study Species	Value (s)	Literature Cited	Comments on How BAFs Were Calculated	Distribution of BAF Values
DDE/DDT				
Trophic Box—Bald Eagle				
Kestrel	7.7	Rudolph et al. 1983, p.128	Controlled study, kestrels fed 6 ppm DDE wet-wt for 4 mos., converted to whole-body.	Lognormal; gm = 27.1; gsd = 2.4; standard deviation based on statistical information from papers, type based on Statgraphics and professional judgment.
Kestrel	29	Wiemeyer et al. 1986, p.17	Controlled study, wet-wt, converted to whole-body, n=23, dose = 2.8 ppm for 1 yr, Table 8 data.	
Barn owl	43.7	Mendenhall et al. 1983, p.237	Captive barn owls fed 2.83 ppm DDE for 2 yrs, mean of males and females, converted to whole-body.	
Peregrine	55	Enderson and Berger 1968, p.150	Field estimated BAF from 11 prey items, wet-wt egg residues converted to whole-body with info from Wiemeyer et al. 1986.	
Trophic Box—American Kestrel				
Kestrel	7.7	Rudolph et al. 1983, p.128	Controlled study, kestrels fed 6 ppm DDE wet-wt for 4 mos., converted to whole-body.	Uniform; endpoints = 7.7, 29; standard deviation based on data in papers gives negative values, so uniform chosen based on professional judgment.
Kestrel	29	Wiemeyer et al. 1986, p.17	Controlled study, wet-wt, converted to whole-body, n=23, dose = 2.8 ppm for 1 yr, Table 8 data.	

am = arithmetic mean
sd = standard deviation
wt = weight

Study Species	Value (s)	Literature Cited	Comments on How BAFs Were Calculated	Distribution of BAF Values
DDE/DDT (cont.)				
Trophic Box—Great Horned Owl				
Barn owl	43.7	Mendenhall et al. 1983, p.237	Captive barn owls fed 2.83 ppm DDE for 2 yrs, mean of males and females, converted to whole-body.	Lognormal; gm = 43.7; gsd = 2.4; used sd from bald eagle (data from kestrel, owl, and peregrine papers), mean from owl paper.
Trophic Box—Great Blue Heron				
Herring gull	102	Kozie and Anderson 1991, p.41	Field study, wet-wt basis for DDE, carcass converted to whole-body, fish and gull remains from bald eagle nests.	Normal; mean = 93.5; sd = 20; sd based on information in paper.
Herring gull	85	Braune and Norstrom 1989, p.961	Wet-wt DDE residues in whole body of herring gulls eating alewife, n= 10.	
Trophic Box—Shorebird				
Kestrel	7.7	Rudolph et al. 1983, p.128	Controlled study, kestrels fed 6 ppm DDE wet-wt for 4 mos., converted to whole-body.	Uniform; endpoints = 7.7, 29; standard deviation based on data in papers gives negative values, so uniform chosen based on professional judgment.
Kestrel	29	Wiemeyer et al. 1986, p.17	Controlled study, wet-wt, converted to whole-body, n=23, dose = 2.8 ppm for 1 yr, Table 8 data.	

am = arithmetic mean
sd = standard deviation
wt = weight

Study Species	Value (s)	Literature Cited	Comments on How BAFs Were Calculated	Distribution of BAF Values
DDE/DDT (cont.)				
Trophic Box—Waterbird				
Black duck	101	Longcore and Stendell 1977, p.295	Controlled study, dose = 2 ppm wet-wt for 7 mos., mean of male and female carcass converted to whole-body.	Normal; mean = 96, sd = 26.2; statistical information from E113 and D1; type based on professional judgment.
Herring gull	102	Kozie and Anderson 1991, p.41	Field study, wet-wt basis for DDE, carcass converted to whole-body, fish and gull remains from bald eagle nests.	
Herring gull	85	Braune and Norstrom 1989, p.961	Wet-wt DDE residues in whole body of herring gulls eating alewife, n= 10.	
Trophic Box—Small Bird				
Kestrel	7.7	Rudolph et al. 1983, p.128	Controlled study, kestrels fed 6 ppm DDE wet-wt for 4 mos., converted to whole-body.	Uniform; endpoints = 7.7, 29; standard deviation based on data in papers gives negative values, so uniform chosen based on professional judgment.
Kestrel	29	Wiemeyer et al. 1986, p.17	Controlled study, wet-wt, converted to whole-body, n=23, dose = 2.8 ppm for 1 yr, Table 8 data.	
Trophic Box—Small Mammal				
Mouse	0.44	Tomatis et al. 1974, p.886	Lab study, fat levels from 7 mice fed 250 ppm DDE, converted to whole-body (20%) lipids.	Uniform; endpoints = 0.44, 0.98; statistical computations from data in papers very complicated, as both values close to zero uniform chosen.
Vole	0.98	Forsyth et al. 1983, p.1629	6th year of field study, diet-weighted mean of 75% grass, 20% forbs, 5% roots.	

am = arithmetic mean
sd = standard deviation
wt = weight

Study Species	Value (s)	Literature Cited	Comments on How BAFs Were Calculated	Distribution of BAF Values
DDE/DDT (cont.)				
Trophic Box—Medium Mammal				
Mouse	0.44	Tomatis et al. 1974, p.886	Lab study, fat levels from 7 mice fed 250 ppm DDE, converted to whole-body (20%) lipids.	Uniform; endpoints = 0.44, 0.98; statistical computations from data in papers very complicated, as both values close to zero uniform chosen.
Rabbit	0.98	Forsyth et al. 1983, p.1629	6th year of field study, diet weighted mean of 75% grass, 20% forbs, 5% roots; authors state rabbit levels same as those of voles.	
Mercury				
Trophic Box—Bald Eagle				
Red-tailed hawk	0.3	Fimreite and Karstad 1971, p.296	Wet-wt ave. of 3 tissues (brain, breast muscle, liver), n=12, 12 wk exposure, dose = 3.9 ppm.	Triangular; mode = 0.3; endpoints = 0.001, 2.1; based on stats from paper and professional judgment.
Trophic Box—American Kestrel				
Red-tailed hawk	0.3	Fimreite and Karstad 1971, p.296	Wet-wt ave. of 3 tissues (brain, breast muscle, liver), n=12, 12 wk exposure, dose = 3.9 ppm.	Triangular; mode = 0.3; endpoints = 0.001, 2.1; based on stats from paper and professional judgment.
Trophic Box—Great Horned Owl				
Red-tailed hawk	0.3	Fimreite and Karstad 1971, p.296	Wet-wt ave. of 3 tissues (brain, breast muscle, liver), n=12, 12 wk exposure, dose = 3.9 ppm.	Triangular; mode = 0.3; endpoints = 0.001, 2.1; based on stats from paper and professional judgment.

am = arithmetic mean
sd = standard deviation
wt = weight

Study Species	Value (s)	Literature Cited	Comments on How BAFs Were Calculated	Distribution of BAF Values
Mercury (cont.)				
Trophic Box—Great Blue Heron				
Mallard	0.6	Vermeer et al. 1973, p.60	Wet-wt, breast muscles, weighted mean of food items from Table 4, 60% fish, 30% crayfish, 10% dragonfly nymphs.	Lognormal; gm = 4.1; gsd = 3.4; borrowed BAF and its distribution from water bird.
Duck	1.7	Gardiner 1972, p.422	Data from treatment group 2, wet-wt, 35-day exposure to 0.33 ppm, organic form, ave. of heart, breast muscle, liver, kidney.	
Black duck	4	Finley and Stendell 1978, p.60	Wet-wt, ave. of liver, kidney, brain, muscle, and feathers, dose = 3 ppm for 28 wks.	
Wood duck	7.4	Lindsay and Dimmick 1983, p.115	Juvenile wood ducks, n= 50; ave. tissue conc. based on liver, breast muscle, fat, data from Tables 1 & 2, wet-wt basis.	
Mallard	11.9	Heinz 1979, p.396	Wet-wt basis, ave. of liver, kidney, breast muscle, brain, dose = 0.1 ppm wet-wt in food.	
Mallard	14	Heinz 1980, p.384	Wet-wt basis, ave. of liver, kidney, brain, breast muscle, male and female, wild strain and farm-raised, dose = 0.1 ppm wet-weight.	

am = arithmetic mean
sd = standard deviation
wt = weight

Study Species	Value (s)	Literature Cited	Comments on How BAFs Were Calculated	Distribution of BAF Values
Mercury (cont.)				
Trophic Box—Shorebird				
Red-tailed hawk	0.3	Fimreite and Karstad 1971, p.296	Wet-wt ave. of 3 tissues (brain, breast muscle, liver), n=12, 12 wk exposure, dose = 3.9 ppm.	Triangular; mode = 0.3; endpoints = 0.001, 2.1; based on stats from paper and professional judgment.
Trophic Box—Water Bird				
Mallard	0.6	Vermeer et al. 1973, p.60	Wet-wt, breast muscles, weighted mean of food items from Table 4, 60% fish, 30% crayfish, 10% dragonfly nymphs.	Lognormal; gm = 4.1; gsd = 3.4; based on Statgraphics and professional judgment.
Duck	1.7	Gardiner 1972, p.422	Data from treatment group 2, wet-wt, 35-day exposure to 0.33 ppm, organic form, ave. of heart, breast muscle, liver, kidney.	
Black duck	4	Finley and Stendell 1978, p.60	Wet-wt, ave. of liver, kidney, brain, muscle, and feathers, dose = 3 ppm for 28 wks.	
Wood duck	7.4	Lindsay and Dimmick 1983, p.115	Juvenile wood ducks, n= 50; ave. tissue conc. based on liver, breast muscle, fat, data from Tables 1 and 2, wet-wt basis.	
Mallard	11.9	Heinz 1979, p.396	Wet-wt basis, ave. of liver, kidney, breast muscle, brain, dose = 0.1 ppm wet-wt in food.	
Mallard	14	Heinz 1980, p.384	Wet-wt basis, ave. of liver, kidney, brain, breast muscle, male and female, wild strain and farm-raised, dose = 0.1 ppm wet.	

am = arithmetic mean
sd = standard deviation
wt = weight

Study Species	Value (s)	Literature Cited	Comments on How BAFs Were Calculated	Distribution of BAF Values
Mercury (cont.)				
Trophic Box—Small Bird				
Red-tailed hawk	0.3	Fimreite and Karstad 1971, p.296	Wet-wt ave. of 3 tissues (brain, breast muscle, liver), n=12, 12 wk exposure, dose = 3.9 ppm.	Triangular; mode = 0.3; endpoints = 0.001, 2.1; based on stats from paper and professional judgment.
Trophic Box—Small Mammal				
Mink	22.5	Wren et al. 1987, p.444	Liver BAF, fed MeHg, sublethal 0.5 ppm dose for 8 months, assume wet-wt basis.	Triangular; mode = 22.5; endpoints = 0.001, 51.3; based on stats from pater and professioal judgment.
Trophic Box—Medium Mammal				
Mink	22.5	Wren et al. 1987, p.444	Liver BAF, fed MeHg, sublethal 0.5 ppm dose for 8 months, assume wet-wt basis.	Triangular; mode = 22.5; endpoints = 0.001, 51.3; based on stats from paper and professional judgment.
Trophic Box—Reptile/Terretrial Amphibian				
Bullsnake, Toad	1.5	RMA biota/small mammal data	RMA data; snake/mouse	Lognormal; gm = 1.5; gsd = 1.3; Cmedia data used to make professional judgment.

am = arithmetic mean
sd = standard deviation
wt = weight

Trophic Box	Value(s)*	Literature Cited	Comments	Distribution
Bald Eagle	0.0500, 0.110, 0.0911	Palmer, 1988	Lit (bald eagle): 0.0500, 0.110, 0.0911; 0.102, 0.123; 0.0911; 0.0567; n = 7	Normal
	0.102, 0.123, 0.0911	Stalmaster & Gessaman 1984		
	0.0567	Swies 1986		
Great Blue Heron	0.0500, 0.110, 0.0911	Palmer 1988	Lit (bald eagle): 0.0500, 0.110, 0.0911; 0.102, 0.123; 0.0911; 0.0567; n = 7	Normal
	0.102, 0.123, 0.0911	Stalmaster & Gessaman 1984		
	0.0567	Swies 1986		
Great Horned Owl	0.0500, 0.110, 0.0911	Palmer, 1988	Lit (bald eagle): 0.0500, 0.110, 0.0911; 0.102, 0.123; 0.0911; 0.0567; n = 7	Normal
	0.102, 0.123, 0.0911	Stalmaster & Gessaman 1984		
	0.0567	Swies 1986		
American Kestrel	0.0500, 0.110, 0.0911	Palmer, 1988	Lit (bald eagle): 0.0500, 0.110, 0.0911; 0.102, 0.123; 0.0911; 0.0567; n = 7	Normal
	0.102, 0.123, 0.0911	Stalmaster & Gessaman 1984		
American Kestrel (cont'd)	0.0567	Swies 1986		

* Values reported in kilograms per kilogram of body weight per day
Lit = Literature values

Trophic Box	Value(s)*	Literature Cited	Comments	Distribution
Medium Mammal	0.096	Tileston and Lechleitner 1966	Value from white-tailed prairie dogs.	Fixed
Small Mammal	0.12	Sax 1984		Fixed
Small Bird	0.0879	Shuman et al. 1988	Lit (mourning dove): grams offered per day; n = 8; 10, 10, 16, 7.5, 7.5, 16, 7.5, 7.5; and Lit (mourning dove): grams of body weight; n = 2; 120.5, 128.4.	Lognormal GM = 0.0879; GSD = 1.652
Shorebird	0.0879	Shuman et al. 1988	Lit (mourning dove): grams offered per day; n = 8; 10, 10, 16, 7.5, 7.5, 16, 7.5, 7.5; and Lit (mourning dove): grams of body weight; n = 2; 120.5, 128.4.	Lognormal; GM = 0.0879; GSD = 1.652.
Water Bird	0.0565, 0.0522 0.100, 0.0954	Miller 1975 Sax 1984 White & Finley 1978	Lit (mallard, coot): 0.0565, 0.0522; 0.100; 0.0954; n = 4.	Normal

* Values reported in kilograms per kilogram of body weight per day
Lit = Literature values

Trophic Box	Prey Group	Value(s)	Distribution	Literature Cited	Comments
Bald Eagle	Soil	0.03	Fixed	Beyer et.al. 1991	Literature (turkey scats)/Professional judgment: based on 0.062, N = 6
	Small Mammal	0.0-0.036; 0.0		ESE 1988 USFWS 1989	RMA data (bald eagle castings): based on the sum of weighted averages of three winter studies [0.0 and 0.036 (ESE 1988), 0.0, (USFWS 1989) and adjusted for inclusion of soil, N = 364
	Medium Mammal	0.863-0.900; 0.949		ESE 1988 USFWS 1989	RMA data (bald eagle castings): based on the sum of weighted averages of three winter studies [0.863 and 0.900 (ESE 1988), 0.949 (USFWS 1989)], and adjusted for inclusion of soil, N = 364
	Small Bird	0.018-0.030; 0.007		ESE 1988 USFWS 1989	RMA data (bald eagle castings): based on the sum of weighted averages of three winter studies [0.018 and 0.030 (ESE 1988), 0.007 (USFWS 1989)], and adjusted for inclusion of soil, N = 364
	Waterbird	0.054; 0.035; 0.014		ESE 1988 USFWS 1989	RMA data (bald eagle castings): based on the sum of weighted averages of "unknown" category of birds [0.054 and 0.035 (ESE 1988)] and waterfowl data [0.014 (USFWS 1989)] from three winter studies, and adjusted for inclusion of soil, N = 364
	Large Fish	0.0; 0.005; 0.0		ESE 1988 USFWS 1989	RMA data (bald eagle castings): based on sum of weighted averages of three winter studies [0.0 and 0.005 (ESE 1988); 0.0 (USFWS 1989)], and adjusted for inclusion of soil, N = 364
Great Blue Heron	Soil	0.04	Fixed	Beyer et al. 1991	Literature (Canada goose scats)/Professional judgment: based on 0.082, N = 23
	Reptile	0.02		Palmer 1962	Literature (great blue heron): proportioned from 0.0425, N = 1
	Small Mammal	0.04		Palmer 1962	Literature (great blue heron): proportioned from 0.0466, N = 1
	Water	0.08		Palmer 1962	Professional judgment

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	Aquatic Plant	0.02		Palmer 1962	Literature (great blue heron): proportioned from 0.0248, adjusted for inclusion of water, N = 1
	Aquatic Invert.	0.16		Palmer 1962	Literature (great blue heron): proportioned from 0.171, adjusted for inclusion of water, N = 1
	Small Fish	0.37		Palmer 1962	Literature (great blue heron): proportioned from 0.4316, adjusted for inclusion of water, N = 1
	Large Fish	0.24		Palmer 1962	Literature (great blue heron): proportioned from 0.266, adjusted for inclusion of water, N =1
	Amphibian	0.03		Palmer 1962	Literature (great blue heron): proportioned from 0.0425, adjusted for inclusion of water, N =1
Great Horned Owl	Soil	0.03	Fixed	Beyer et al. 1991	Literature (turkey scats)/Professional judgment: based on 0.062
	Small Mammal	0.665		EBASCO 1991d	RMA data (great horned owl nests): based on 0.685 (combined data), and adjusted for inclusion of soil
	Medium Mammal	0.25		EBASCO 1991d	RMA data (great horned owl nests): based on 0.26 (combined data), and adjusted for inclusion of soil
	Small Bird	0.055		EBASCO 1991d	RMA data (great horned owl nests): based on 0.0548 (combined data)
American Kestrel	Soil	0.03	Fixed	Beyer et al. 1991	Literature (turkey scats)/Professional judgment: based on 0.062
	Insect	0.86		EBASCO 1991c	RMA data (American kestrel boxes): based on 0.89 (combined data), and adjusted for inclusion of soil
	Small Mammal	0.093		EBASCO 1991c	RMA data (American kestrel boxes): 0.093, combined data
	Small Bird	0.017		EBASCO 1991c	RMA data (American kestrel boxes): 0.017, combined data

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Medium Mammals	Soil	0.077; 0.063	Fixed	Beyer et al. 1991; Arthur and Gates 1991	Literature (prairie dog scats [12(1)^], jackrabbit scats [>84])/Professional judgment: based on 0.077 (Beyer et al 1991), 0.063 (Arthur and Gates 1991), N=2
	Terrestrial Plant	0.88			Professional judgment
	Insect	0.04			Professional judgment
Small Mammals	Soil	0.03; 0.024; <0.02	Fixed	Garten, 1980; Beyer et al. 1991	Literature (mouse, rat, vole)/Professional judgment: averaged from 0.03 (Garten 1980), 0.024 (Beyer et al 1991), <0.02 (F-904), N = 3
	Terrestrial Plant	0.47			Professional judgment
	Earthworm	0.03			Professional judgment
	Insect	0.48			Professional judgment
Small Birds	Soil	0.06	Fixed	Beyer et al. 1991	Literature (turkey scats): 0.062, N = 1
	Terrestrial Plant	0.17		EBASCO 1991b	RMA data (vesper sparrow): based on 0.20 (combined data), and adjusted for inclusion of earthworms and soil, N = 1
	Earthworm	0.05			Professional judgment
	Insect	0.72		EBASCO 1991b	RMA data (vesper sparrow): based on 0.80 (combined data), and adjusted for inclusion of earthworms and soil, N = 1
Shorebird	Terrestrial Plant	0.02	Fixed		Professional judgment
	Insect	0.69			Professional judgment

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Sediment	0.17; 0.30; 0.073; 0.18; 0.091; 0.35	Beyer et al. 1991 Reeder 1951	Literature (shorebirds, sandpipers, woodcock): averaged from 0.17, 0.30, 0.073, 0.18, 0.091 (Beyer et al 1991); 0.35 (Reeder 1951), N = 6
Aquatic Invert.	0.10		Professional judgment

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Waterbirds	Water	0.02	Fixed		Professional judgment
	Sediment	0.04		Beyer et al.. 1991; Phillips 1922; Cottam 1939	Literature (Canada goose scats [23(1)^], shoveler stomachs [70], ruddy duck observations)/Professional judgment: based on 0.082 (Beyer et al 1991) and qualitative literature information (Phillins 1992, Cottam 1939), N = 23
	Aquatic Plant	0.93		EBASCO 1991a	RMA data (mallard, coot): based on 0.93, averaged from 1.0, 1.0, 0.92, 1.0, 0.83, 1.0, 0.90, 0.80, 0.95, 0.95, 0.90, and adjusted for inclusion of water and sediment, N = 11
	Aquatic Invert.	0.068	Fixed	EBASCO 1991a	RMA data (mallard, coot)/Professional judgment: based on 0.068, averaged from 0.01, 0.17, 0.07, 0.10, 0.20, 0.0, 0.0, 0.0, 0.05, 0.05, 0.10, N = 11

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Table C.2-9 Dietary Fraction Consensus for ERC Model Based on Biomass

MODEL COMPONENTS

Trophic Box	Occurrence \1	Represent. Weight. (g)	Converted Biomass (g)\2	Apportioned Values \3	Biomass Fraction \4	Comments
Bald Eagle						
Soil	0.03	NA	0.030	NA	0.029	Soil likely from prey contact during feeding
Small Mammal	0.005	33	0.165	0.0003	0.000	RMA data vole to deer mice size; Marti 1974
Medium Mammal	0.915	500	457.500	0.9640	0.936	RMA weighted field data p. dog @434g and cottontail @658.5g
Small Bird	0.019	65	1.235	0.0026	0.003	Ave. small and med. passerine (30–100g; Ryder)
Waterbird	0.029	506	14.674	0.0309	0.030	RMA field data for mallards
Large Fish	0.002	500	1.000	0.0021	0.002	RMA probable prey: bass @400g; carp @900g
Great Blue Heron						
Soil	0.04	NA	0.040	NA	0.036	Soil likely from prey contact during feeding
Reptile	0.02	300	6.000	0.0676	0.060	RMA field data for bull snakes
Small Mammal	0.04	33	1.320	0.0149	0.013	RMA data vole to deer mice size; Marti 1974
Water	0.08	NA	0.080	NA	0.071	Professional judgment
Plant Aquatic	0.02	0.1	0.002	0.0000	0.000	Plant likely from prey contact during feeding
Aquatic Invertebrate	0.16	15	2.400	0.0270	0.024	Crayfish most important from RMA data
Small Fish	0.37	50	18.500	0.2083	0.186	RMA weighted data and probable prey about 2 oz.
Large Fish	0.24	250	60.000	0.6755	0.604	RMA probable prey: bass @400g; carp @900g
Amphibian	0.03	20	0.600	0.0068	0.006	RMA probable prey: leopard frog est. @16.6g
Great Horned Owl						
Soil	0.03	NA	0.030	NA	0.029	Soil likely from prey contact during feeding
Small Mammal	0.665	33	21.945	0.125	0.121	RMA data vole to deer mice size; Marti 1974
Medium Mammal	0.25	600	150.000	0.855	0.830	RMA weighted field data P. Dog @434 g and cottontail @658.6 g
Small Bird	0.055	65	3.575	0.020	0.020	Ave. small and med. passerine (30–100g; Ryder)
American Kestrel						
Soil	0.03	NA	0.030	NA	0.029	Soil likely from prey contact during feeding
Insect	0.86	0.6	0.516	0.190	0.184	RMA probable prey:large grasshopper aver. weight. @0.6g
Small Mammal	0.093	20	1.860	0.685	0.665	RMA data vole to deer mice size; Marti 1974
Small Bird	0.017	20	0.340	0.125	0.122	Ave. passerine birds(30–100g; Ryder), downsized for consensus
Medium Mammal						
Soil	0.08	NA	0.080	NA	0.074	Soil likely from prey contact during feeding
Plant Terrain	0.88	60	52.800	0.9995	0.926	Ten percent of live weight. of animal
Insect	0.04	0.6	0.024	0.0005	0.000	RMA probable prey: Large grasshopper aver. weight. @0.6g

Table C.2-9 Dietary Fraction Consensus for ERC Model Based on Biomass

MODEL COMPONENTS

Trophic Box	Occurrence \1	Represent. Weight. (g)	Converted Biomass (g)\2	Apportioned Values \3	Biomass Fraction \4	Comments
Small Mammals						
Soil	0.02	NA	0.020	NA	0.020	Soil likely from adsorption to plant tissue
Plant Terrain	0.47	5	2.350	0.884	0.866	Fifteen percent of live weight. of animal
Earthworm	0.03	0.7	0.021	0.008	0.008	RMA field sample data
Insect	0.48	0.6	0.288	0.108	0.106	RMA probable prey: large grasshopper aver. weight. @0.6g
Small Birds						
Soil	0.06	NA	0.060	NA	0.057	Soil likely from prey contact during feeding
Plant Terrain	0.17	0.2	0.034	0.119	0.113	Weighted est. for seeds in the diet (professional judgment)
Earthworm	0.05	0.7	0.035	0.123	0.116	RMA field sample data
Insect	0.72	0.3	0.216	0.758	0.714	RMA probable prey: grasshopper aver. weight. @0.3g
Shorebirds						
Plant Terrain	0.02	0.1	0.002	0.008	0.007	Plant likely from prey contact during feeding
Insect	0.69	0.3	0.207	0.866	0.728	RMA probable prey: grasshopper aver. weight. @0.3g
Sediment	0.19	NA	0.190	NA	0.160	Sediment likely from prey contact during feeding
Aquatic Invertebrate	0.1	0.3	0.030	0.126	0.105	Coleoptera and Orthoptera most important from RMA data
Waterbirds						
Water	0.02	NA	0.020	NA	0.019	Professional estimate
Sediment	0.04	NA	0.040	NA	0.038	Sediment likely from prey contact during feeding
Plant Aquatic	0.84	30	25.200	0.999	0.942	Six percent of live weight of animal
Aquatic Invertebrate	0.1	0.3	0.030	0.001	0.001	Coleoptera and Orthoptera most important from RMA data

1 = Values used in draft final report (brown cover) based on percent occurrence in diets.
2 = Occurrence times representative values.
3 = Values are re-proportioned from prey items only to equal 100%.
4 = Values to be used in final report (gray cover) based on biomass of dietary items.
ave = average
g = grams
NA = Not applicable because values already in percent mass format.

DDE/DDT

Trophic Box	Value	Source(s)	Endpoint
Kestrel	12.8	Wiemeyer et al.. 1986	NOAEL-r
Bald Eagle	6.5	Wiemeyer et al.. 1984, Kaiser et al.. 1980, Prouty et al.. 1977	NOAEL-r
Great Horned Owl	6.4	Mendenhall et al.. 1983	NOAEL-r
Great Blue Heron	30	Fitzner et al.. 1988	NOAEL-r
Shorebird	11	Fox 1976	NOAEL-r
Water Bird	4.4	Longcore and Stendell 1977	LOAEL-r
Small Bird	54	Jefferies 1971	LOAEL-r
Mammal	13.4	Laug et al.. 1949	NOAEL-p

DDE/DDT

Trophic Box	Comments
Kestrel	Whole-body value, converted from carcass with factor of 1.3; modifying factor needed for co-contamination.
Bald Eagle	Converted from critical level of 3 ppm in egg to carcass (0.6) then to whole body (1.3).
Great Horned Owl	Based on 10% shell thinning, converted to egg level then to carcass from information provided in paper, then to whole body (1.3).
Great Blue Heron	14 ppm wet-weight in eggs assoc. with 10% eggshell thinning, converted to carcass (0.6) and then to whole body (1.3).
Shorebird	4 ppm wet-weight in eggs critical level for adverse reproductive effects, converted to carcass (0.6) then to whole body (1.3).
Water Bird	Egg level of 6.2 ppm wet-weight after adults on clean feed for 2 years., carcass level of female 3.4, converted to whole body (1.3).
Small Bird	Lower fertility, fewer hatched, female fed 12 ppm wet-weight DDE, converted from 15.8 ppm in liver of hatched birds.
Mammal	Fat level after 27 weeks expos. to 5 ppm in diet (dry weight) converted to whole body based on 20% lipids.

Aldrin/Dieldrin

Trophic Box	Value	Source(s)	Endpoint
Kestrel	2.9	Weimeyer et al.. 1986	NOAEL-r
Bald Eagle	12.2	Mendenhall et al.. 1983	NOAEL-r
Great Horned Owl	12.2	Mendenhall et al.. 1983	NOAEL-r
Great Blue Heron	1.3	Ohlendorf et al.. 1981, 1979	NOAEL-m
Shorebird	2.9	Weimeyer et al.. 1986	NOAEL-r
Water Bird	7.1	Sharma et al.. 1976	LOAEL-b
Small Bird	2.9	Weimeyer et al.. 1986	NOAEL-r
Mammal	4.5	Harr et al.. 1970, Walker et al.. 1969	NOEL-r

Aldrin/Dieldrin Trophic Box	Comments
Kestrel	Average of birds that survived, low dose; modifying factors for co-contaminants and unclear endpoint.
Bald Eagle	Based on owl data; modifying factors for threatened and endangered, endpoint unclear.
Great Horned Owl	Strong paper; modifying factor for endpoint unclear.
Great Blue Heron	Field study, value calculated based on 85th percentile (FWS); modifying factor for co-contaminant.
Shorebird	Kestrel value, strong paper; modifying factors for co-contaminants and endpoint unclear.
Water Bird	Based on mallard data, assume 20% lipids for conversion to whole body; modifying factor for endpoint unclear.
Small Bird	Value from kestrel data; modifying factors for co-contaminants and endpoint unclear.
Mammal	Diet of 1.25 ppm wet-wt. multiplied by BAF of 18, then converted from fat to whole body based on 20% lipids.

Endrin

Trophic Box	Value	Source(s)	Endpoint
Kestrel	0.78	Fleming et al.. 1982	NOAEL-r
Bald Eagle	0.78	Fleming et al.. 1982	NOAEL-r
Great Horned Owl	0.78	Fleming et al.. 1982	NOAEL-r
Great Blue Heron	0.13	Ohlendorf et al.. 1979	NOAEL-l
Shorebird	0.78	Fleming et al.. 1982	NOAEL-r
Water Bird	1.4	Ohlendorf et al.. 1979	NOAEL-r
Small Bird	0.78	Fleming et al.. 1982	NOAEL-r
Mammal	–		

Endrin Trophic Box	Comments
Kestrel	Based on screech owl data, n = 1, 0.3 ppm wet-wt. critical level in eggs converted to carcass (0.6) then to whole body (1.3).
Bald Eagle	Based on screech owl data, n = 1, 0.3 ppm wet-wt. critical level in eggs converted to carcass (0.6) then to whole body (1.3).
Great Horned Owl	Based on screech owl data, n = 1, 0.3 ppm wet-wt. critical level in eggs converted to carcass (0.6) then to whole body (1.3).
Great Blue Heron	Field data for herons; modifying factors for co-contaminants and unclear endpoint.
Shorebird	Based on screech owl data, n = 1, 0.3 ppm wet-wt. critical level in eggs converted to carcass (0.6) then to whole body (1.3).
Water Bird	1.1 ppm in mallard carcasses from diet of 1 ppm, carcass:whole body conversion of 1.3, data p. 758.
Small Bird	Based on screech owl data, n = 1, 0.3 ppm wet-wt. critical level in eggs converted to carcass (0.6) then to whole body (1.3).
Mammal	No appropriate data found.

Mercury

Trophic Box	Value	Source(s)	Endpoint
Kestrel	0.83	Heinz 1976	LOAEL-r, b
Bald Eagle	0.83	Heinz 1976	LOAEL-r, b
Great Horned Owl	0.83	Heinz 1976	LOAEL-r, b
Great Blue Heron	0.83	Heinz 1976	LOAEL-l, b
Shorebird	0.83	Heinz 1976	LOAEL-r, b
Water Bird	0.83	Heinz 1976	LOAEL-r, b
Small Bird	0.83	Heinz 1976	LOAEL-r, b
Mammal	–		

Mercury Trophic Box	Comments
Kestrel	Liver value (0.89ppm) for mallards, converted to whole body with regression from Stickel et al. 1977.
Bald Eagle	Liver value (0.89ppm) for mallards, converted to whole body with regression from Stickel et al. 1977.
Great Horned Owl	Liver value (0.89ppm) for mallards, converted to whole body with regression from Stickel et al. 1977.
Great Blue Heron	Liver value (0.89ppm) for mallards, converted to whole body with regression from Stickel et al. 1977.
Shorebird	Liver value (0.89ppm) for mallards, converted to whole body with regression from Stickel et al. 1977.
Water Bird	Liver value (0.89ppm) for mallards, converted to whole body with regression from Stickel et al. 1977.
Small Bird	Liver value (0.89ppm) for mallards, converted to whole body with regression from Stickel et al. 1977.
Mammal	No appropriate data found.

b = behavior
m = mortality
p = pathology
r = reproduction

Basis for Uncertainty	Uncertainty Value Assigned
Intertaxon Variability Extrapolation Category—	
Same species	1
Same genus, different species	2
Same family, different genus	3
Same order, different family	4
Same class, different order	5
Study Duration Extrapolation Category—	
Chronic studies where contaminants attained equilibrium	1
Chronic studies where equilibrium not attained or possibly not attained, including subchronic studies	5
Acute studies	20

Study Endpoint Extrapolation Category—

	Nonlethal	Lethal
No observed effects level	(NOEL): 1	NOEL: 3
No observed adverse effects level	(NOAEL): 1	NOAEL: 3
Lowest observed effects level	(LOEL): 3	LOEL: 10
Lowest observed adverse effect level	(LOAEL): 5	LOAEL: 10
Frank effects level	(FEL): 10	FEL: 15

Modifying Factor Category—	
Threatened and endangered species	0 or 2
Relevance of endpoint to ecological health	-1 to 0
Extrapolating lab to field	0 to 2
Study had co-contaminants	-1 to +1
Endpoint was unclear	-2 to +2
Study species was obviously highly sensitive	-2 to +2
Ratios used to get from organ or egg to whole body	0 to 2*
Intraspecific variability	0 to 2

* Used only for MATC (not TRV) uncertainty factor development.

Table C.2-12 Post-Uncertainty MATC

Aldrin/Dieldrin	Critical Value (mg/kg bw)	Intertaxon (1)	Study Duration (Q2)	Study Endpoints (Q3)	Modifying Factor* (U)	T&E	Endpoint Relevance	Lab to Field	Co-Contam.	Unclear Endpoint	ID. Sensitive Species	Tissue to Whole-Body Ratio	Intraspecific Variability
American Kestrel	2.9	1	1	1	4			1		2			1
Bald Eagle	12.2	5	1	1	6	2		1		2			1
Great Horned Owl	12.2	4	1	1	4			1		2			1
Great Blue Heron	1.3	1	1	3	0.5			0	-1				0
Shorebird	2.9	5	1	1	4			1		2			1
Waterbird	7.1	5	1	3	2		-1	1				1	1
Small Bird	2.9	5	1	1	4			1		2			1
Mammal	4.5	4	1	1	6			2		2		1	1

Trophic Box	Total UF	Final MATC
Amercian Kestrel	4	0.73
Bald Eagle	30	0.41
Great Horned Owl	16	0.76
Great Blue Heron	1.5	0.87
Shorebird	20	0.15
Waterbird	30	0.24
Small Bird	20	0.15
Mammal	24	0.19

Table C.2-12 Post-Uncertainty MATC

DDT/DDE	Critical Value (mg/kg bw)	Intertaxon (1)	Study Duration (Q2)	Study Endpoints (Q3)	Modifying Factor* (U)	T&E	Endpoint Relevance	Lab to Field	Co-Contam.	Unclear Endpoint	ID. Sensitive Species	Tissue to Whole-Body Ratio	Intraspecific Variability
American Kestrel	12.8	1	1	1	3			1				1	1
Bald Eagle	6.5	1	1	1	3	2		0				1	0
Great Horned Owl	6.4	4	1	1	3			1				1	1
Great Blue Heron	30	1	1	1	2			0				1	1
Shorebird	11	4	1	1	2			0				1	1
Waterbird	4.4	5	1	5	1			1			-2		1
Small Bird	54	5	5	5	3			1				1	1
Mammal	13.4	4	5	1	3		-1	2				1	1

Trophic Box	Total UF	Final MATC
American Kestrel	3	4.27
Bald Eagle	3	2.17
Great Horned Owl	12	0.53
Great Blue Heron	2	15.00
Shorebird	8	1.38
Waterbird	25	0.18
Small Bird	375	0.14
Mammal	60	0.22

Endrin	Critical Value (mg/kg bw)	Intertaxon (1)	Study Duration (Q2)	Study Endpoints (Q3)	Modifying Factor* (U)	T&E	Endpoint Relevance	Lab to Field	Co-Contam.	Unclear Endpoint	ID. Sensitive Species	Tissue to Whole-Body Ratio	Intraspecific Variability
American Kestrel	0.78	5	1	1	3			1				1	1
Bald Eagle	0.78	5	1	1	5	2		1				1	1
Great Horned Owl	0.78	3	1	1	3			1				1	1
Great Blue Heron	0.13	1	1	3	0.5								0.5
Shorebird	0.78	5	1	1	3			1				1	1
Waterbird	1.4	5	1	1	3			1				1	1
Small Bird	0.78	5	1	1	3			1				1	1
Mammal	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Trophic Box	Total UF	Final MATC
American Kestrel	15	0.05
Bald Eagle	25	0.03
Great Horned Owl	9	0.09
Great Blue Heron	1.5	0.09
Shorebird	15	0.05
Waterbird	15	0.09
Small Bird	15	0.05
Mammal	NA	NA

Table C.2-12 Post-Uncertainty MATC

Mercury	Critical Value (mg/kg bw)	Intertaxon (1)	Study Duration (Q2)	Study Endpoints (Q3)	Modifying Factor* (U)	T&E	Endpoint Relevance	Lab to Field	Co-Contam.	Unclear Endpoint	ID. Sensitive Species	Tissue to Whole-Body Ratio	Intraspecific Variability
American Kestrel	0.83	5	1	5	2			1	-1			1	1
Bald Eagle	0.83	5	1	5	4	2		1	-1			1	1
Great Horned Owl	0.83	5	1	5	2			1	-1			1	1
Great Blue Heron	0.83	5	1	5	3			1				1	1
Shorebird	0.83	5	1	5	3			1				1	1
Waterbird	0.83	5	1	5	3			1				1	1
Small Bird	0.83	5	1	5	2			1	-1			1	1
Mammal	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Trophic Box	Total UF	Final MATC
American Kestrel	50	0.02
Bald Eagle	100	0.01
Great Horned Owl	50	0.02
Great Blue Heron	75	0.01
Shorebird	75	0.01
Waterbird	75	0.01
Small Bird	50	0.02
Mammal	NA	NA

Total UF = I * Q2 * Q3 * U
U = Sum of factors to right
Final TRV = Critical value/total UF

* Note: If 0<=U<1, replaced with 1; If U<0, replaced with 0.5

Study Species	Value (s) (acres)	Literature Cited	Comments
Trophic Box*—Top Predator			
Bald eagle	8277	Recommendation from USFWS	Bald eagle management unit plus all prairie dog towns present on RMA in April 1993.
Great blue heron	Lake size + 4%	OAS professional judgment	Lake Mary = 12 acres Lake Ladora = 72 acres Lower Derby = 91 acres Upper Derby = 69 acres East Upper Derby = 23 acres Rod and Gun Club Pond = 28 acres
Great horned owl	512	Zeiner 1990	Study best describes owl home range at RMA.
American kestrel	270	Balgooyen 1976	Study best describes kestrel home range at RMA.
Trophic Box*—Medium Mammal			
Black-tailed prairie dog	0.5	Tileston 1966	Also recommended by USFWS.
Cottontail	8.6	USFWS HEP manual	Value recommended from USFWS Habitat Evaluation Procedures Manual for cottontails
Trophic Box*—Small Mammal			
Deer mouse	0.5	Blair 1942	Also OAS professional judgment based on deer mouse foraging range.
13-lined ground squirrel	1.0	Clark 1981, Evans 1951	Mean of 3 values; 0.86, 0.59, 1.63.

Study Species	Value (s) (acres)	Literature Cited	Comments
Trophic Box*—Small Bird			
Mourning Dove	54	Schoener 1968	Study best describes mourning dove home range at RMA.
Meadowlark	15	Bent 1965, Schroeder 1968, Welty 1979, personal communication, Bury USFWS 1992	Studies best describe meadowlark home range at RMA.
Vesper sparrow	2.5	Reed 1985 plus OAS professional judgment	Study best describes vesper sparrow home range at RMA.
Trophic Box*—Reptiles/Amphibians			
Gopher (bull) snake	11	Stickel and Cope 1947 plus OAS professional judgment	Study best describes bull snake home range at RMA.
Trophic Box*—Insects			
Grasshopper	0.010	Personal communication, Kimberly A. with Zoology Department, Colorado State University	Grasshopper nymph movements in a fractal analysis study.
Trophic Box*—Earthworm			
Earthworm	0.022	OAS professional judgment	Based on 5.5m radius.

Study Species	Value (s) (acres)	Literature Cited	Comments
Trophic Box*—Terrestrial Plants			
All annual plants	0.0007	Personal communication, Dr. Leslie Fraley, Radiology Department, Colorado State University	Study using radioisotopes to determine 3-D maps of root distributions.
Trophic Box*—Shorebird			
Killdeer	12	USFWS recommendation plus OAS professional judgment	Defended territory of killdeer from Great Salt Lake Study by Fellows recommended by USFWS consensus reached at 12 acres.
Trophic Box*—Water Bird			
Mallard Blue-winged teal American coot	Lake area where sample was collected	OAS professional judgment	Lake Mary = 12 ac Lake Ladora = 69 ac Lower Derby = 89 ac Upper Derby = 67 ac East Upper Derby = 22 ac Rod and Gun Club Pond = 27 ac

* Exposure ranges for all other species representing aquatic trophic boxes were not calculated. The aquatic environment is relatively homogenous and home range is inappropriate.

ac acres

OAS Organizations and State Subcommittee

USFWS United States Fish and Wildlife Service

Table C.2-14 Critical Dose Values (Pre-UF Toxicity Reference Values)

COC	TROPHIC BOX	SPECIES OF CONCERN	TEST SPECIES	CITATION	ENDPOINT/ STUDY TYPE	PPM IN DIET	DOSE (mg/kg-bw/day)
Aldrin	Heron	great blue heron	mallard	Sharma et al.'76	LOEL[1]	4	0.4
Dieldrin	Eagle	bald eagle	kestrel/owl	Wiemeyer et al.. '86/Mendenhall et al. '83	NOAEL-r[1]	0.28/0.58	0.05 Weimeyer et al.. '86/Mendenhall et al.. '83
	Owl	great horned owl	owl	Mendenhall et al. '83	NOAEL-r[1]	0.58	0.06 Mendenhall et al.. '83
	Kestrel	American kestrel	kestrel	Wiemeyer et al.'86	NOAEL-r[1]	0.28	0.04 Weimeyer et al. '86
	Small bird	mourning dove	domestic pigeon	Robinson & Crabtree '69	NOAEL-r	3	0.28 Robinson and Crabtree '69
	Shorebird	killdeer	quail/pigeon	Shellenberger '78/Stickel et al. '69/Robinson & Crabtree '69	NOAEL-r,l	2	0.22 Shellenberger '78/Stickel et al. '69/Robinson and Crabtree '69
	Water bird	mallard	mallard	Sharma et al.'83	LOEL[1]	4	0.4
	Sm. mammal	deer mouse	rat	Harr et al. '70	NOAEL-r	1.25	0.06
	Med. mammal	prairie dog	rat	Harr et al. '70	NOAEL-r	1.25	0.06
	T. plants	plants	ND	ND	ND	ND	ND
	Insects	insects	ND	ND	ND	ND	ND
	Earthworm	earthworm	ND	ND	ND	ND	ND
	Reptile	toad/snake	ND	ND	ND	ND	ND
Arsenic	Heron	great blue heron	duck	Van Vleet '82	LOAEL	ND	18.9
	Eagle	bald eagle	duck	Van Vleet '82	LOAEL	ND	18.9
	Owl	great horned owl	duck	Van Vleet '82	LOAEL	ND	18.9
	Kestrel	American kestrel	duck	Van Vleet '82	LOAEL	ND	18.9
	Small bird	mourning dove	duck	Van Vleet '82	LOAEL	ND	18.9
	Shorebird	killdeer	duck	Van Vleet '82	LOAEL	ND	18.9
	Water bird	mallard	duck	Van Vleet '82	LOAEL	ND	18.9
	Sm. mammal	deer mouse	rat	Byron et al. '67	LOAEL-p	31	1.5
	Med. mammal	prairie dog	rat	Byron et al. '67	LOAEL-p	31	1.5
	T. plants	plants	grasses	ESE tox. file	field data	NA	19
	Insects	insects	ND	ND	ND	ND	ND
	Earthworm	earthworm	ND	ND	ND	ND	ND
	Reptile	toad/snake	ND	ND	ND	ND	ND
Chlordane	Heron	great blue heron	quail	Hudson et al. '84	LD50	NA	14.1
	Eagle	bald eagle	quail	Hudson et al. '84	LD50	NA	14.1
	Owl	great horned owl	quail	Hudson et al. '84	LD50	NA	14.1
	Kestrel	American kestrel	quail	Hudson et al. '84	LD50	NA	14.1
	Small bird	mourning dove	quail	Hudson et al. '84	LD50	NA	14.1
	Shorebird	killdeer	quail	Hudson et al. '84	LD50	NA	14.1
	Water bird	mallard	duck	Hudson et al. '84	LD50	NA	1250
	Sm. mammal	deer mouse	rat	EPA '84	NOEL	NA	1.2
	Med. mammal	prairie dog	rat	EPA '84	NOEL	NA	1.2
	T. plants	plants	ND	ND	ND	NA	ND
	Insects	insects	ND	ND	ND	ND	ND
	Earthworm	earthworm	ND	ND	ND	ND	ND
	Reptile	toad/snake	ND	ND	ND	ND	ND

1. A modifying factor will be applied for calculation of the total UF.
2. The barn owl may be an unusually sensitive species; this will be taken into account when assigning UFs.
3. The total UF will reflect the fact this is a NOAEL.

COC	TROPHIC BOX	SPECIES OF CONCERN	TEST SPECIES	CITATION	ENDPOINT/ STUDY TYPE	PPM IN DIET	DOSE (mg/kg-bw/day)
CPM-Sulfide	Heron	great blue heron	ND	ND	ND	ND	ND
	Eagle	bald eagle	ND	ND	ND	ND	ND
	Owl	great horned owl	ND	ND	ND	ND	ND
	Kestrel	American kestrel	ND	ND	ND	ND	ND
	Small bird	mourning dove	ND	ND	ND	ND	ND
	Shorebird	killdeer	ND	ND	ND	ND	ND
	Water bird	mallard	ND	ND	ND	ND	ND
	Sm. mammal	deer mouse	rat	Thake et al. '79	LOAEL	281	14.1
	Med. mammal	prairie dog	rat	Thake et al. '79	LOAEL	281	14.1
	T. plants	plants	grasses	field data	NA	NA	0.7
	Insects	insects	ND	ND	ND	ND	ND
	Earthworm	earthworm	ND	ND	ND	ND	ND
	Reptile	toad/snake	ND	ND	ND	ND	ND
CPM-Sulfone	Heron	great blue heron	ND	ND	ND	ND	ND
	Eagle	bald eagle	ND	ND	ND	ND	ND
	Owl	great horned owl	ND	ND	ND	ND	ND
	Kestrel	American kestrel	ND	ND	ND	ND	ND
	Small bird	mourning dove	ND	ND	ND	ND	ND
	Shorebird	killdeer	ND	ND	ND	ND	ND
	Water bird	mallard	ND	ND	ND	ND	ND
	Sm. mammal	deer mouse	rat	Thake et al. '79	LOAEL	325	16.3
	Med. mammal	prairie dog	rat	Thake et al. '79	LOAEL	325	16.3
	T. plants	plants	ND	ND	ND	NA	ND
	Insects	insects	ND	ND	ND	ND	ND
	Earthworm	earthworm	ND	ND	ND	ND	ND
	Reptile	toad/snake	ND	ND	ND	ND	ND
DBCP	Heron	great blue heron	duck	Hudson et al. '84	LD50	NA	66.8 mg/kg
	Eagle	bald eagle	duck	Hudson et al. '84	LD50	NA	66.8 mg/kg
	Owl	great horned owl	duck	Hudson et al. '84	LD50	NA	66.8 mg/kg
	Kestrel	American kestrel	duck	Hudson et al. '84	LD50	NA	66.8 mg/kg
	Small bird	mourning dove	duck	Hudson et al. '84	LD50	NA	66.8 mg/kg
	Shorebird	killdeer	duck	Hudson et al. '84	LD50	NA	66.8 mg/kg
	Water bird	mallard	duck	Hudson et al. '84	LD50	NA	66.8 mg/kg
	Sm. mammal	deer mouse	rat	EPA 1987	NOEL	12.5	0.6
	Med. mammal	prairie dog	rat	EPA 1987	NOEL	12.5	0.6
	T. plants	plants	ND	ND	ND	NA	ND
	Insects	insects	ND	ND	ND	ND	ND
	Earthworm	earthworm	ND	ND	ND	ND	ND
	Reptile	toad/snake	ND	ND	ND	ND	ND
Dicyclo-penta-diene (DCPD)	Heron	great blue heron	BW quail	Aulerichetal'79	LOEL	4000	400
	Eagle	bald eagle	BW quail	Aulerichetal'79	LOEL	4000	400
	Owl	great horned owl	BW quail	Aulerichetal'79	LOEL	4000	1010.0
	Kestrel	American kestrel	BW quail	Aulerichetal'79	LOEL	4000	1010.0
	Small bird	mourning dove	BW quail	Aulerichetal'79	LOEL	4000	1010.0
	Shorebird	killdeer	BW quail	Aulerichetal'79	LOEL	4000	1010.0
	Water bird	mallard	duck	Aulerichetal'79	NOEL-r	320	32
	Sm. mammal	deer mouse	rat	EPA '91	NOEL	690	34
	Med. mammal	prairie dog	rat	EPA 91	NOEL	690	34
	T. plants	plants	grasses	ND	ND	NA	ND
	Insects	insects	ND	ND	ND	ND	ND

1. A modifying factor will be applied for calculation of the total UF.
2. The barn owl may be an unusually sensitive species; this will be taken into account when assigning UFs.
3. The total UF will reflect the fact this is a NOAEL.

Table C.2-14 Critical Dose Values (Pre-UF Toxicity Reference Values)

COC	TROPHIC BOX	SPECIES OF CONCERN	TEST SPECIES	CITATION	ENDPOINT/ STUDY TYPE	PPM IN DIET	DOSE (mg/kg-bw/day)
	Earthworm	earthworm	ND	ND	ND	ND	ND
	Reptile	toad/snake	ND	ND	ND	ND	ND
DDE/DDT	Heron	great blue heron	black duck	Longc&Stend'83	LOEL-r	0.6	0.06 Longcore and Stendell '83
	Eagle	bald eagle	kestrel	Wiemeyer et al.. '86, Lincer '75	LOAEL-r	2.8/3	0.4Wiemeyer et al.. '86/Linar '72
	Owl	great horned owl	owl	Mendenhall '83	FEL-r[3]	2.8	0.3 Mendenhall et al.. '83
	Kestrel	American kestrel	kestrel	Wiemeyer et al.. '86, Lincer '75	LOAEL-r	2.8/3	0.4Wiemeyer et al.. '86/Lincer '72
	Small bird	mourning dove	finch	Jefferies '71	LOAEL-r	4	0.8
	Shorebird	killdeer	kestrel	Wie'86/Lin'72,5	LOAEL-r	2.8/3	0.4 Wiemeyer et al.. '86/Lincer '75
	Water bird	mallard	black duck	Longc&Stend'83	LOEL-r	0.6	0.06 Longcore and Stendell '83
	Sm. mammal	deer mouse	rat	Green '69	FEL-r	7	0.35 Green '69
	Med. mammal	prairie dog	rat	Green '69	FEL-r	7	0.35 Green '69
	T. plants	plants	ND	ND	ND	NA	ND
	Insects	insects	ND	ND	ND	ND	ND
	Earthworm	earthworm	ND	ND	ND	ND	ND
	Reptile	toad/snake	ND	ND	ND	ND	ND
Endrin	Heron	great blue heron	duck	Roylanceetal'85	NOAEL-r[4]	0.5	0.05
	Eagle	bald eagle	owl	Fleming etal'82	LOAEL-r	0.75	0.1
	Owl	great horned owl	owl	Fleming etal'82	LOAEL-r	0.75	0.1
	Kestrel	American kestrel	owl	Fleming etal'82	LOAEL-r	0.75	0.1
	Small bird	mourning dove	owl	Fleming etal'82	LOAEL-r	0.75	0.1
	Shorebird	killdeer	owl	Fleming etal'82	LOAEL-r	0.75	0.1
	Water bird	mallard	duck	Roylanceetal'85	NOAEL-r[4]	0.5	0.05
	Sm. mammal	deer mouse	mouse	Noda et al. '72	LOAEL	ND	0.58
	Med. mammal	prairie dog	mouse	Noda et al. '72	LOAEL	ND	0.58
	T. plants	plants	grasses	ND	ND	ND	ND
	Insects	insects	ND	ND	ND	ND	ND
	Earthworm	earthworm	ND	ND	ND	ND	ND
	Reptile	toad/snake	ND	ND	ND	ND	ND
Mercury	Heron	great blue heron	mallard	Heinz '76	LOAEL-r	0.5	0.047
	Eagle	bald eagle	mallard	Heinz '76	LOAEL-r	0.5	0.047
	Owl	great horned owl	mallard	Heinz '76	LOAEL-r	0.5	0.047
	Kestrel	American kestrel	mallard	Heinz '76	LOAEL-r	0.5	0.047
	Small bird	mourning dove	mallard	Heinz '76	LOAEL-r	0.5	0.047
	Shorebird	killdeer	mallard	Heinz '76	LOAEL-r	0.5	0.047
	Water bird	mallard	mallard	Heinz '76	LOAEL-r	0.5	0.047
	Sm. mammal	deer mouse	rat	Soares et al.'73	NOAEL-l,g	3	0.17
	Med. mammal	prairie dog	rat	Soares et al.'73	NOAEL-l,g	3	0.17
	T. plants	plants	ND	ND	ND	ND	ND
	Insects	insects	ND	ND	ND	ND	ND
	Earthworm	earthworm	ND	ND	ND	ND	ND
	Reptile	toad/snake	ND	ND	ND	ND	ND
	Aquatic invert.	aquatic invert.	ND	EPA	AWQC-c	NA	0.012 µg/l
	Aquatic plants	aquatic plants	ND	EPA	AWQC-c	NA	0.012 µg/l
	Plankton	plankton	ND	EPA	AWQC-c	NA	0.012 µg/l

1. A modifying factor will be applied for calculation of the total UF.
2. The barn owl may be an unusually sensitive species; this will be taken into account when assigning UFs.
3. The total UF will reflect the fact this is a NOAEL.

COC	TROPHIC BOX	SPECIES OF CONCERN	TEST SPECIES	CITATION	ENDPOINT/ STUDY TYPE	PPM IN DIET	DOSE (mg/kg-bw/day)
Cadmium	Heron	great blue heron	mallard	Scheuhammer et al. and Templeton '90	NOAEL	NA	1.8
	Eagle	bald eagle	mallard	Scheuhammer et al. and Templeton "90	NOAEL	NA	1.8
	Owl	great horned owl	mallard	Scheuhammer et al. and Templeton "90	NOAEL	NA	1.8
	Kestrel	American kestrel	mallard	Scheuhammer et al. and Templeton "90	NOAEL	NA	1.8
	Small bird	mourning dove	mallard	Scheuhammer et al. and Templeton "90	NOAEL	NA	1.8
	Shorebird	killdeer	mallard	Scheuhammer et al. and Templeton "90	NOAEL	NA	1.8
	Water bird	mallard	mallard	Scheuhammer et al. and Templeton "90	NOAEL	NA	1.8
	Sm. mammal	deer mouse	rat	Groten et al.'91	NOEL	30	1.8
	Med. mammal	prairie dog	rat	Groten et al.'91	NOEL	30	1.8
	T. plants	plants	rhizobia/clover	Chaudri etal'92	growth limit	NA	7.1 µg/g soil
	Insects	insects	ND	ND	ND	ND	ND
	Earthworm	earthworm	ND	ND	ND	ND	ND
	Reptile	toad/snake	ND	ND	ND	ND	ND
Copper	Heron	great blue heron	chicken	Leach et al. '90	growth limit	480	48
	Eagle	bald eagle	chicken	Leach et al. '90	growth limit	480	48
	Owl	great horned owl	chicken	Leach et al. '90	growth limit	480	48
	Kestrel	American kestrel	chicken	Leach et al. '90	growth limit	480	48
	Small bird	mourning dove	chicken	Leach et al. '90	growth limit	480	48
	Shorebird	killdeer	chicken	Leach et al. '90	growth limit	480	48
	Water bird	mallard	chicken	Leach et al. '90	growth limit	480	48
	Sm. mammal	deer mouse	rat	ND	LD50	NA	300
	Med. mammal	prairie dog	rat	ND	LD50	NA	300
	T. plants	plants	Potomogetan	Greger, Kaut. '91	decr. biomass	NA	875 mg/kg sed.
	Insects	insects	ND	ND	ND	ND	ND
	Earthworm	earthworm	ND	ND	ND	ND	ND
	Reptile	toad/snake	ND	ND	ND	ND	ND

FEL	Frank-effect-level
LOAEL	Lowest observed adverse effect level
LOEL	Lowest observed effect level
NA	Not applicable
ND	No data
NOAEL	No observed adverse effect level
NOEL	No observed effect level
LC50	Lethal concentration affecting 50% of the test population
-r	Reproductive impairment
-g	Growth limiting
-b	Behavioral
-s	Survival
-p	Pathology
-l	Lethality

1. A modifying factor will be applied for calculation of the total UF.
2. The barn owl may be an unusually sensitive species; this will be taken into account when assigning UFs.
3. The total UF will reflect the fact this is a NOAEL.

Table C.2-15 Toxicity Reference Value (Post-UF)

Aldrin/Dieldrin	Critical Value (mg/kg bw/day)	Intertaxon (1)	Study Duration (Q2)	Study Endpoints (Q3)	Modifying Factor* (U)	T&E	Endpoint Relevance	Lab to Field	Co-Contam.	Unclear Endpoint	ID. Sensitive Species	Intraspecific Variability
American Kestrel	0.04	1	1	1	4			1		2		1
Bald eagle	0.05	5	1	1	6	2		1	0	2		1
Great horned owl	0.06	4	1	1	4			1	0	2		1
Great blue heron	0.4	5	1	3	1		-1	1				1
Shorebird	0.22	5	1	1	2			1				1
Water Bird	0.4	5	1	3	1		-1	1				1
Small Bird	0.28	5	1	1	2			1				1
Sm. Mammal	0.06	4	1	1	4			2		1		1
Med. Mammal	0.06	4	1	1	4			2		1		1
Reptile	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Trophic Box	Total UF	Final TRV
American Kestrel	4	0.010
Bald eagle	30	0.002
Great horned owl	16	0.004
Great blue heron	15	0.027
Shorebird	10	0.022
Water Bird	15	0.027
Small Bird	10	0.028
Sm. Mammal	16	0.004
Lg. Mammal	16	0.004
Reptile	NA	NA

Final TRV	Critical value/total UF	TRV	Toxicity Reference Value
NA	not available	U	Sum of factors to right
Total of UF	1* Q2* Q3 *3	UF	Uncertainty Factor

*Note: If 0< = U<1, replaced with 1; If U<0, replaced with 0.5

DDT/DDE	Critical Value (mg/kg bw/day)	Intertaxon (1)	Study Duration (Q2)	Study Endpoints (Q3)	Modifying Factor* (U)	T&E	Endpoint Relevance	Lab to Field	Co-Contam.	Unclear Endpoint	ID. Sensitive Species	Intraspecific Variability
American Kestrel	0.4	1	1	5	2			1				1
Bald eagle	0.4	4	1	5	4	2		1				1
Great horned owl	0.3	4	1	10	1			1		-1		1
Great blue heron	0.06	5	1	3	1			1			-2	1
Shorebird	0.4	5	1	5	2			1				1
Water Bird	0.06	5	1	3	1			1			-2	1
Small Bird	0.8	5	5	5	2			1				1
Sm. Mammal	0.35	4	1	1	3			2				1
Lg. Mammal	0.35	4	1	1	3			2				1
Reptile	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Trophic Box	Total UF	Final TRV
American Kestrel	10	0.040
Bald eagle	80	0.005
Great horned owl	40	0.008
Great blue heron	15	0.004
Shorebird	50	0.008
Water Bird	15	0.004
Small Bird	250	0.003
Sm. Mammal	12	0.029
Med. Mammal	12	0.029
Reptile	NA	NA

Final TRV	Critical value/total UF
NA	not available
Total of UF	1* Q2* Q3 *3

*Note: If 0< = U<1, replaced with 1; If U<0, replaced with 0.5

TRV	Toxicity Reference Value
U	Sum of factors to right
UF	Uncertainty Factor

Endrin	Critical Value (mg/kg bw/day)	Intertaxon (1)	Study Duration (Q2)	Study Endpoints (Q3)	Modifying Factor* (U)	T&E	Endpoint Relevance	Lab to Field	Co-Contam.	Unclear Endpoint	ID. Sensitive Species	Intraspecific Variability
American Kestrel	0.1	5	1	5	2			1				1
Bald eagle	0.1	5	1	5	4	2		1				1
Great horned owl	0.1	3	1	5	2			1				1
Great blue heron	0.05	5	1	1	4			1		2		1
Shorebird	0.1	5	1	5	2			1				1
Water Bird	0.05	5	1	1	4			1		2		1
Small Bird	0.1	5	1	5	2			1				1
Sm. Mammal	0.58	4	1	5	3			2				1
Med. Mammal	0.58	4	1	5	3			2				1
Reptile	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Trophic Box	Total UF	Final TRV
American Kestrel	50	0.002
Bald eagle	100	0.001
Great horned owl	30	0.003
Great blue heron	20	0.003
Shorebird	50	0.002
Water Bird	20	0.003
Small Bird	50	0.002
Sm. Mammals	60	0.010
Med. Mammal	60	0.010
Reptile	NA	NA

Final TRV	Critical value/total UF
NA	not available
Total of UF	1* Q2* Q3 *3

*Note: If 0< = U<1, replaced with 1; If U<0, replaced with 0.5

TRV	Toxicity Reference Value
U	Sum of factors to right
UF	Uncertainty Factor

Table C.2-15 Toxicity Reference Value (Post-UF)

Mercury	Critical Value (mg/kg bw/day)	Intertaxon (1)	Study Duration (Q2)	Study Endpoints (Q3)	Modifying Factor* (U)	T&E	Endpoint Relevance	Lab to Field	Co-Contam.	Unclear Endpoint	ID. Sensitive Species	Intraspecific Variability
American Kestrel	0.047	5	1	5	1			1	-1			1
Bald eagle	0.047	5	1	5	3	2		1	-1			1
Great horned owl	0.047	5	1	5	1			1	-1			1
Great blue heron	0.047	5	1	5	2			1				1
Shorebird	0.047	5	1	5	2			1				1
Water Bird	0.047	5	1	5	2			1				1
Small Bird	0.047	5	1	5	1			1	-1			1
Sm. Mammal	0.17	4	5	3	2			2	-1			1
Med. Mammal	0.17	4	5	3	2			2	-1			1
Reptile	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Trophic Box	Total UF	Final TRV
American Kestrel	25	0.002
Bald eagle	75	0.001
Great horned owl	25	0.002
Great blue heron	50	0.001
Shorebird	50	0.001
Water Bird	50	0.001
Small Bird	25	0.002
Sm. Mammal	120	0.001
Med. Mammal	120	0.001
Reptile	NA	NA

Final TRV	Critical value/total UF
NA	not available
Total of UF	1* Q2* Q3 *3

*Note: If 0< = U<1, replaced with 1; If U<0, replaced with 0.5

TRV	Toxicity Reference Value
U	Sum of factors to right
UF	Uncertainty Factor

Arsenic	Critical Value (mg/kg bw/day)	Intertaxon (1)	Study Duration (Q2)	Study Endpoints (Q3)	Modifying Factor* (U)	T&E	Endpoint Relevance	Lab to Field	Co-Contam.	Unclear Endpoint	ID. Sensitive Species	Intraspecific Variability
American Kestrel	18.9	5	1	5	2			1				1
Bald eagle	18.9	5	1	5	4	2		1				1
Great horned owl	18.9	5	1	5	2			1				1
Great blue heron	18.9	5	1	5	2			1				1
Shorebird	18.9	5	1	5	2			1				1
Water Bird	18.9	5	1	5	2			1				1
Small Bird	18.9	5	1	5	2			1				1
Sm. Mammal	1.5	4	1	5	2		-1	2				1
Med. Mammal	1.5	4	1	5	2		-1	2				1
T. Plants	19				10							
Reptile	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Trophic Box	Total UF	Final TRV
American Kestrel	50	0.378
Bald eagle	100	0.189
Great horned owl	50	0.378
Great blue heron	50	0.378
Shorebird	50	0.378
Water Bird	50	0.378
Small Bird	50	0.378
Sm. Mammal	40	0.038
Lg. Mammal	40	0.038
T. plants	10	1.900
Reptile	NA	NA

Final TRV	Critical value/total UF
NA	not available
Total of UF	1* Q2* Q3 *3

*Note: If 0< = U<1, replaced with 1; If U<0, replaced with 0.5

TRV	Toxicity Reference Value
U	Sum of factors to right
UF	Uncertainty Factor

Copper	Critical Value (mg/kg bw/day)	Intertaxon (1)	Study Duration (Q2)	Study Endpoints (Q3)	Modifying Factor* (U)	T&E	Endpoint Relevance	Lab to Field	Co-Contam.	Unclear Endpoint	ID. Sensitive Species	Intraspecific Variability
American Kestrel	48	5	1	5	2		-1	2				1
Bald eagle	48	5	1	5	4	2	-1	2				1
Great horned owl	48	5	1	5	2		-1	2				1
Great blue heron	48	5	1	5	2		-1	2				1
Shorebird	48	5	1	5	2		-1	2				1
Water Bird	48	5	1	5	2		-1	2				1
Small Bird	48	5	1	5	2		-1	2				1
Sm. Mammal	300	4	20	15	3			2				1
Lg. Mammal	300	4	20	15	3			2				1
T. plants	875											
Reptile	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Trophic Box	Total UF	Final TRV	
American Kestrel	50	0.960	
Bald eagle	100	0.480	
Great horned owl	50	0.960	
Great blue heron	50	0.960	
Shorebird	50	0.960	
Water Bird	50	0.960	
Small Bird	50	0.960	
Sm. Mammal	3600	0.750	UF capped at 400
Med. Mammal	3600	0.750	UF capped at 400
Reptile	NA	NA	

Final TRV	Critical value/total UF
NA	not available
Total of UF	1* Q2* Q3 *3

*Note: If 0< = U<1, replaced with 1; If U<0, replaced with 0.5

TRV	Toxicity Reference Value
U	Sum of factors to right
UF	Uncertainty Factor

Cadmium	Critical Value (mg/kg bw/day)	Intertaxon (1)	Study Duration (Q2)	Study Endpoints (Q3)	Modifying Factor* (U)	T&E	Endpoint Relevance	Lab to Field	Co-Contam.	Unclear Endpoint	ID. Sensitive Species	Intraspecific Variability
American Kestrel	1.8	5	1	1	1.5			1				0.5
Bald eagle	1.8	5	1	1	3.5	2		1				0.5
Great horned owl	1.8	5	1	1	1.5			1				0.5
Great blue heron	1.8	5	1	1	1.5			1				0.5
Shorebird	1.8	5	1	1	1.5			1				0.5
Water Bird	1.8	5	1	1	1.5			1				0.5
Small Bird	1.8	5	1	1	1.5			1				0.5
Sm. Mammal	1.8	4	5	1	2		-1	2				1
Med. Mammal	1.8	4	5	1	2		-1	2				1
T. Plants	7.1											
Reptile	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Trophic Box	Total UF	Final TRV
American Kestrel	7.5	0.240
Bald eagle	17.5	0.103
Great horned owl	7.5	0.240
Great blue heron	7.5	0.240
Shorebird	7.5	0.240
Water Bird	7.5	0.240
Small Bird	7.5	0.240
Sm. Mammals	40	0.045
Med. Mammal	40	0.045
Reptile	NA	NA

Final TRV	Critical value/total UF
NA	not available
Total of UF	1* Q2* Q3 *3

*Note: If 0< = U<1, replaced with 1; If U<0, replaced with 0.5

TRV	Toxicity Reference Value
U	Sum of factors to right
UF	Uncertainty Factor

Table C.2-15 Toxicity Reference Value (Post - UF)

DCPD	Critical Value (mg/kg bw/day)	Intertaxon (1)	Study Duration (Q2)	Study Endpoints (Q3)	Modifying Factor* (U)	T&E	Endpoint Relevance	Lab to Field	Co-Contam.	Unclear Endpoint	ID. Sensitive Species	Intraspecific Variability
American Kestrel	400	5	1	3	3			2				1
Bald eagle	400	5	1	3	5	2		2				1
Great horned owl	400	5	1	3	3			2				1
Great blue heron	400	5	1	3	3			2				1
Shorebird	400	5	1	3	3			2				1
Water Bird	32	5	1	1	2			1				1
Small Bird	400	5	1	3	3			2				1
Sm. Mammal	34	4	1	1	3			2				1
Med. Mammal	34	4	1	1	3			2				1
T. Plants	NA											
Reptile	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Trophic Box	Total UF	Final TRV
American Kestrel	45	8.889
Bald eagle	75	5.333
Great horned owl	45	8.889
Great blue heron	45	8.889
Shorebird	45	8.889
Water Bird	10	3.200
Small Bird	45	8.889
Sm. Mammal	12	2.833
Med. Mammal	12	2.833
Reptile	NA	NA

Final TRV	Critical value/total UF
NA	not available
Total of UF	1* Q2* Q3 *3

*Note: If 0< = U<1, replaced with 1; If U<0, replaced with 0.5

TRV	Toxicity Reference Value
U	Sum of factors to right
UF	Uncertainty Factor

Table C.2-15 Toxicity Reference Value (Post - UF)

Chlordane	Critical Value (mg/kg bw/day)	Intertaxon (1)	Study Duration (Q2)	Study Endpoints (Q3)	Modifying Factor* (U)	T&E	Endpoint Relevance	Lab to Field	Co-Contam.	Unclear Endpoint	ID. Sensitive Species	Intraspecific Variability
American Kestrel	14.1	5	20	15	3			2				1
Bald eagle	14.1	5	20	15	5	2		2				1
Great horned owl	14.1	5	20	15	3			2				1
Great blue heron	14.1	5	20	15	3			2				1
Shorebird	14.1	5	20	15	3			2				1
Water Bird	1250	5	20	15	2			1				1
Small Bird	14.1	5	20	15	3			2				1
Sm. Mammal	1.2	4	1	1	3			2				1
Med. Mammal	1.2	4	1	1	3			2				1
T. Plants	NA											
Reptile	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Trophic Box	Total UF	Final TRV	
American Kestrel	4500	0.035	UF capped at 400
Bald eagle	7500	0.035	UF capped at 400
Great horned owl	4500	0.035	UF capped at 400
Great blue heron	4500	0.035	UF capped at 400
Shorebird	4500	0.035	UF capped at 400
Water Bird	3000	3.125	UF capped at 400
Small Bird	4500	0.035	UF capped at 400
Sm. Mammal	12	0.100	
Med. Mammal	12	0.100	
Reptile	NA	NA	

Final TRV	Critical value/total UF	TRV	Toxicity Reference Value
NA	not available	U	Sum of factors to right
Total of UF	1* Q2* Q3 *3	UF	Uncertainty Factor

*Note: If 0< = U<1, replaced with 1; If U<0, replaced with 0.5

Table C.2-15 Toxicity Reference Value (Post - UF)

CPMS	Critical Value (mg/kg bw/day)	Intertaxon (1)	Study Duration (Q2)	Study Endpoints (Q3)	Modifying Factor* (U)	T&E	Endpoint Relevance	Lab to Field	Co-Contam.	Unclear Endpoint	ID. Sensitive Species	Intraspecific Variability
American Kestrel	ND	NA	NA	NA	NA							
Bald eagle	ND	NA	NA	NA	NA							
Great horned owl	ND	NA	NA	NA	NA							
Great blue heron	ND	NA	NA	NA	NA							
Shorebird	ND	NA	NA	NA	NA							
Water Bird	ND	NA	NA	NA	NA							
Small Bird	ND	NA	NA	NA	NA							
Sm. Mammal	14.1	4	1	5	3		-1	2		1		1
Med. Mammal	14.1	4	1	5	3		-1	2		1		1
T. Plants	0.7											
Reptile	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Trophic Box	Total UF	Final TRV
American Kestrel	NA	ND
Bald eagle	NA	ND
Great horned owl	NA	ND
Great blue heron	NA	ND
Shorebird	NA	ND
Water Bird	NA	ND
Small Bird	NA	ND
Sm. Mammal	60	0.235
Med. Mammal	60	0.235
Reptile	NA	NA

Final TRV	Critical value/total UF
NA	not available
Total of UF	1* Q2* Q3 *3

*Note: If 0< = U<1, replaced with 1; If U<0, replaced with 0.5

TRV	Toxicity Reference Value
U	Sum of factors to right
UF	Uncertainty Factor

Table C.2-15 Toxicity Reference Value (Post - UF)

CPMSO2	Critical Value (mg/kg bw/day)	Intertaxon (I)	Study Duration (Q2)	Study Endpoints (Q3)	Modifying Factor* (U)	T&E	Endpoint Relevance	Lab to Field	Co-Contam.	Unclear Endpoint	ID. Sensitive Species	Intraspecific Variability
American Kestrel	ND	NA	NA	NA	NA							
Bald eagle	ND	NA	NA	NA	NA							
Great horned owl	ND	NA	NA	NA	NA							
Great blue heron	ND	NA	NA	NA	NA							
Shorebird	ND	NA	NA	NA	NA							
Water Bird	ND	NA	NA	NA	NA							
Small Bird	ND	NA	NA	NA	NA							
Sm. Mammal	16.3	4	1	5	3		-1	2		1		1
Med. Mammal	16.3	4	1	5	3		-1	2		1		1
T. Plants	ND	NA	NA	NA	NA							
Reptile	ND	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Trophic Box	Total UF	Final TRV
American Kestrel	NA	ND
Bald eagle	NA	ND
Great horned owl	NA	ND
Great blue heron	NA	ND
Shorebird	NA	ND
Water Bird	NA	ND
Small Bird	NA	ND
Sm. Mammal	60	0.272
Med. Mammal	60	0.272
Reptile	NA	NA

Final TRV	Critical value/total UF
NA	not available
Total of UF	1* Q2* Q3 *3

*Note: If 0< = U<1, replaced with 1; If U<0, replaced with 0.5

TRV	Toxicity Reference Value
U	Sum of factors to right
UF	Uncertainty Factor

Table C.2-15 Toxicity Reference Value (Post - UF)

DBCP	Critical Value (mg/kg bw/day)	Intertaxon (1)	Study Duration (Q2)	Study Endpoints (Q3)	Modifying Factor* (U)	T&E	Endpoint Relevance	Lab to Field	Co-Contam.	Unclear Endpoint	ID. Sensitive Species	Intraspecific Variability
American Kestrel	66.8	5	20	15	2			1				1
Bald eagle	66.8	5	20	15	4	2		1				1
Great horned owl	66.8	5	20	15	2			1				1
Great blue heron	66.8	5	20	15	2			1				1
Shorebird	66.8	5	20	15	2			1				1
Water Bird	66.8	5	20	15	2			1				1
Small Bird	66.8	5	20	15	2			1				1
Sm. Mammal	0.6	4	1	1	3			2				1
Med. Mammal	0.6	4	1	1	3			2				1
T. Plants	ND	NA	NA	NA	NA							
Reptile	ND	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Trophic Box	Total UF	Final TRV	
American Kestrel	3000	0.167	UF capped at 400
Bald eagle	6000	0.167	UF capped at 400
Great horned owl	3000	0.167	UF capped at 400
Great blue heron	3000	0.167	UF capped at 400
Shorebird	3000	0.167	UF capped at 400
Water Bird	3000	0.167	UF capped at 400
Small Bird	3000	0.167	UF capped at 400
Sm. Mammal	12	0.050	
Med. Mammal	12	0.050	
Reptile	NA	NA	

Final TRV	Critical value/total UF	TRV	Toxicity Reference Value
NA	not available	U	Sum of factors to right
Total of UF	1* Q2* Q3 *3	UF	Uncertainty Factor

*Note: If 0< = U<1, replaced with 1; If U<0, replaced with 0.5

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(SECTION C.3)

ADDITIONAL ECOLOGICAL RISK CHARACTERIZATION MAPS

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This appendix section contains additional maps of potential risks to biota and soil contaminant concentrations, as well as sediment contaminant concentration maps. Maps depicting potential risk based on a single approach (i.e., EPA, Army, or Shell), if they were not the intermediate result with respect to areal extent of risk, are located in this appendix section (Figures C.3-1 through C.3-8). Also located in this appendix section are maps of potential risk from chlordane and the nonbioaccumulative organic COCs such as "number of trophic boxes ..." maps for the group at HI>1 and HI>10, and the HQ maps for some of these COCs (Figures C.3-9, C.3-22, C.3-79 through C.3-85); only the Army approach computed potential risks from these COCs. Hazard quotient and HI maps for a number of trophic boxes based on single approaches (Figures C.3-10 through C.3-21, C.3-103 through C.3-111), as well as for single trophic boxes based on all three approaches together (Figures C.3-23 through C.3-78, C.3-93 through C.3-102, C.3-112 through C.3-115), are found here. Finally, soil concentration maps for DDT/DDE (Figure C.3-86), endrin (Figure C.3-87), arsenic (Figure C.3-88), cadmium (Figure C.3-89), copper (Figure C.3-90), DBCP (Figure C.3-91), and chlordane (Figure C.3-92) are located here, as well as sediment contaminant concentration maps of Upper Derby Lake for aldrin (Figure C.3-116), dieldrin (Figure C.3-117), and endrin (Figure C.3-118).

Former Basin F

Basin C

North Plants

Basin A

Toxic Storage Yard

South Plants

22 23 24 19 20

28 27 26 25 30 29

33 34 35 36 31 32

4 3 2 1 6 5

9 10 11 12 7 8

Legend

1 trophic box with HI > 1

2-4 trophic boxes with HI > 1

5-7 trophic boxes with HI > 1

Lake

31 Section Number

Section Line

N

0 2000 4000

Scale in Feet

Prepared for:

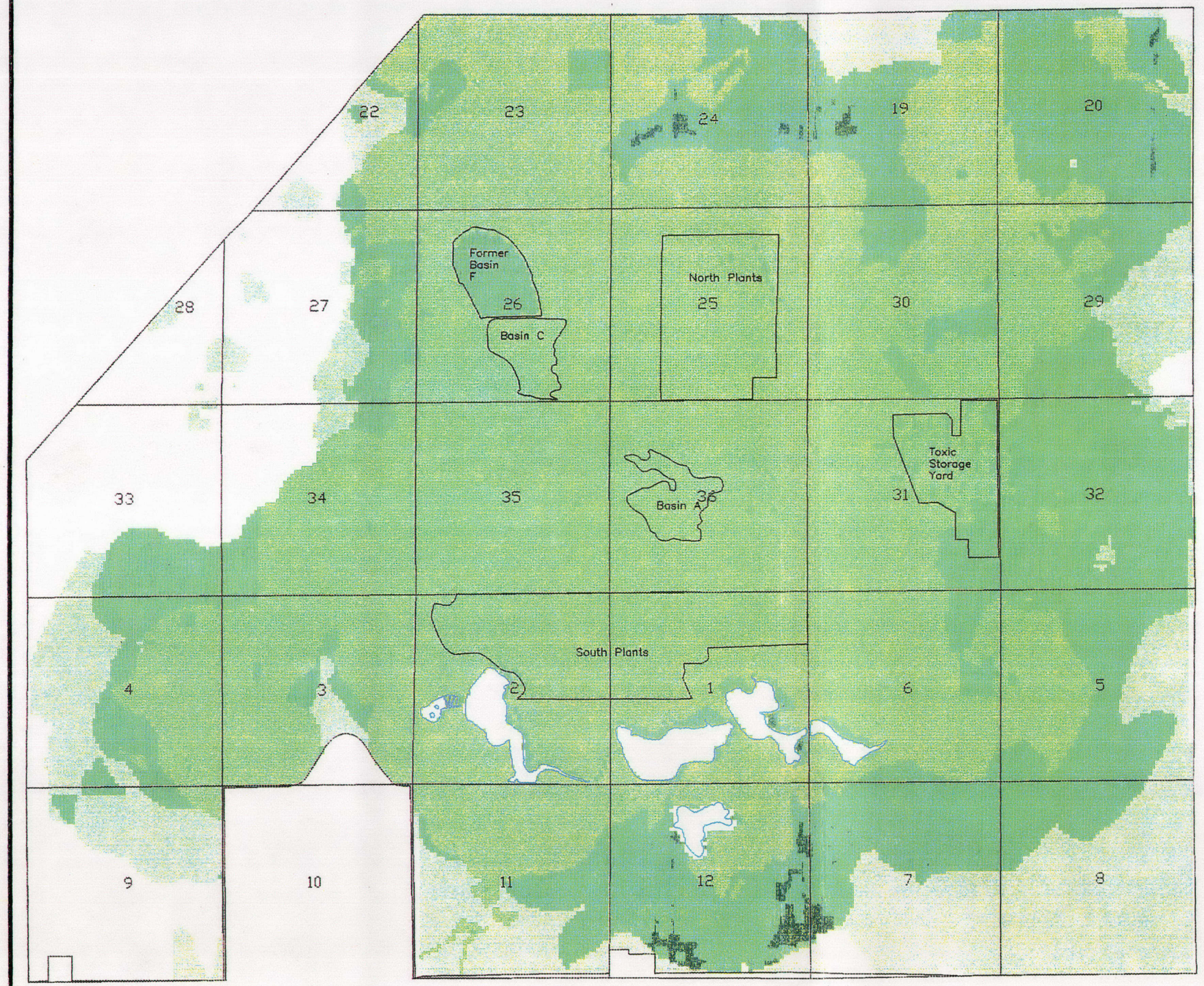
U.S. Army Program Manager
for Rocky Mountain Arsenal

February 1994

Figure C.3-1

Number of Trophic Boxes with Soil Hazard Indices Greater than 1.0 for All COCs Combined Based on the Army Approach

Rocky Mountain Arsenal
Prepared by: ENSERCH Environmental Corp



Legend

- 1 trophic box with HI > 1
- 2-4 trophic boxes with HI > 1
- 5-7 trophic boxes with HI > 1
- Lake
- 31 Section Number
- Section Line

N

0 2000 4000

Scale in Feet

Prepared for:

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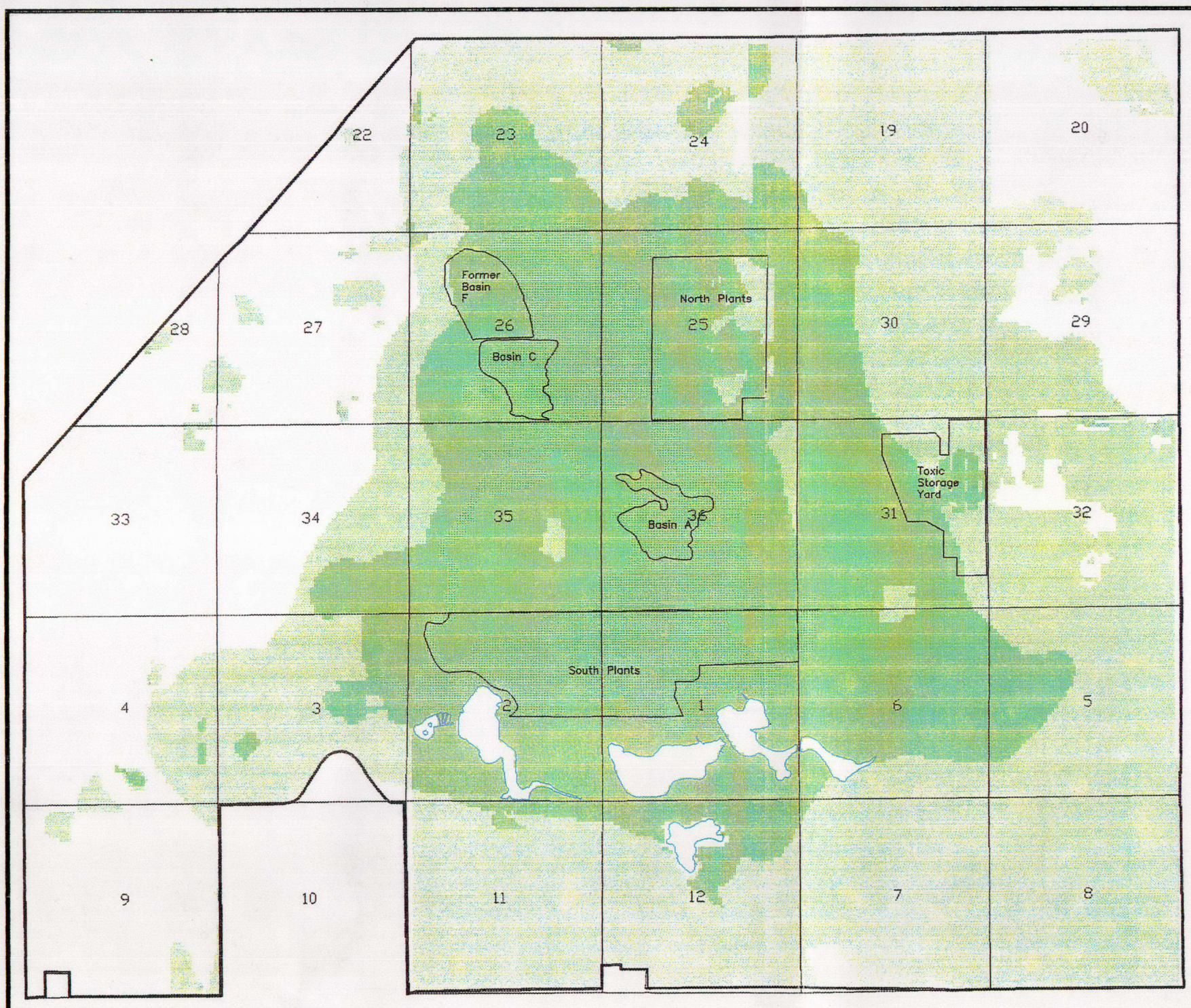
for Rocky Mountain Arsenal

February 1994

Figure C.3-2

Number of Trophic Boxes with Soil Hazard Indices Greater than 1.0 for All COCs Combined Based on the EPA Approach

Rocky Mountain Arsenal
Prepared by: ENSERCH Environmental Corp



Legend

- 1 trophic box with HI > 1
- 2-4 trophic boxes with HI > 1
- 5-7 trophic boxes with HI > 1
- Lake
- 31 Section Number
- Section Line

N

0 2000 4000

Scale in Feet

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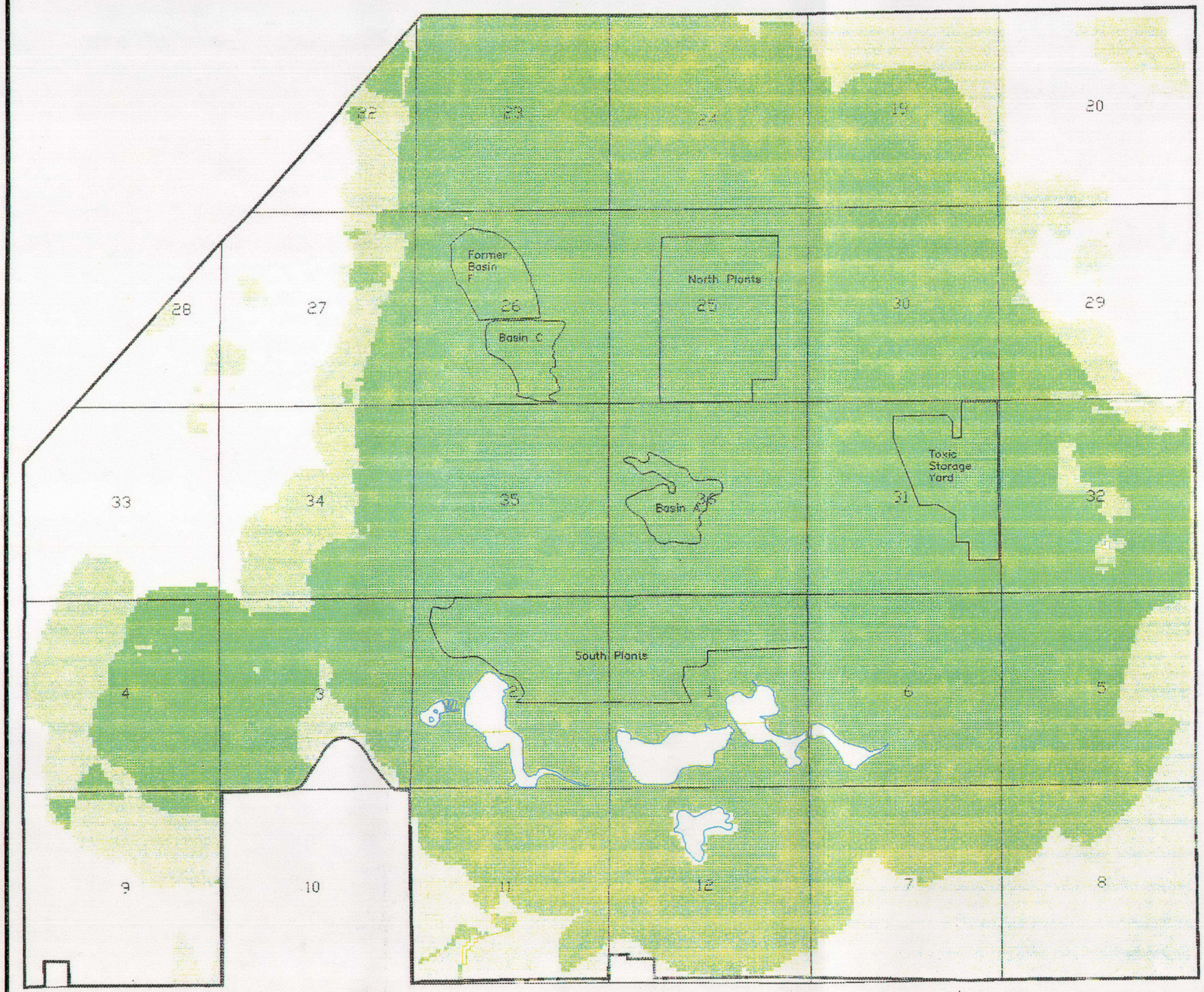
Figure C.3-3

Number of Trophic Boxes with Soil Hazard Indices Greater than 1.0 for Aldrin/Dieldrin, DDT/DDE, and Endrin Combined Based on the Army Approach
Rocky Mountain Arsenal
Prepared by: ENSERCH Environmental Corp



Legend

1 trophic box with HI > 1

2-4 trophic boxes with HI > 1

5-7 trophic boxes with HI > 1

Lake

31 Section Number

Section Line

N

0 2000 4000

Scale in Feet

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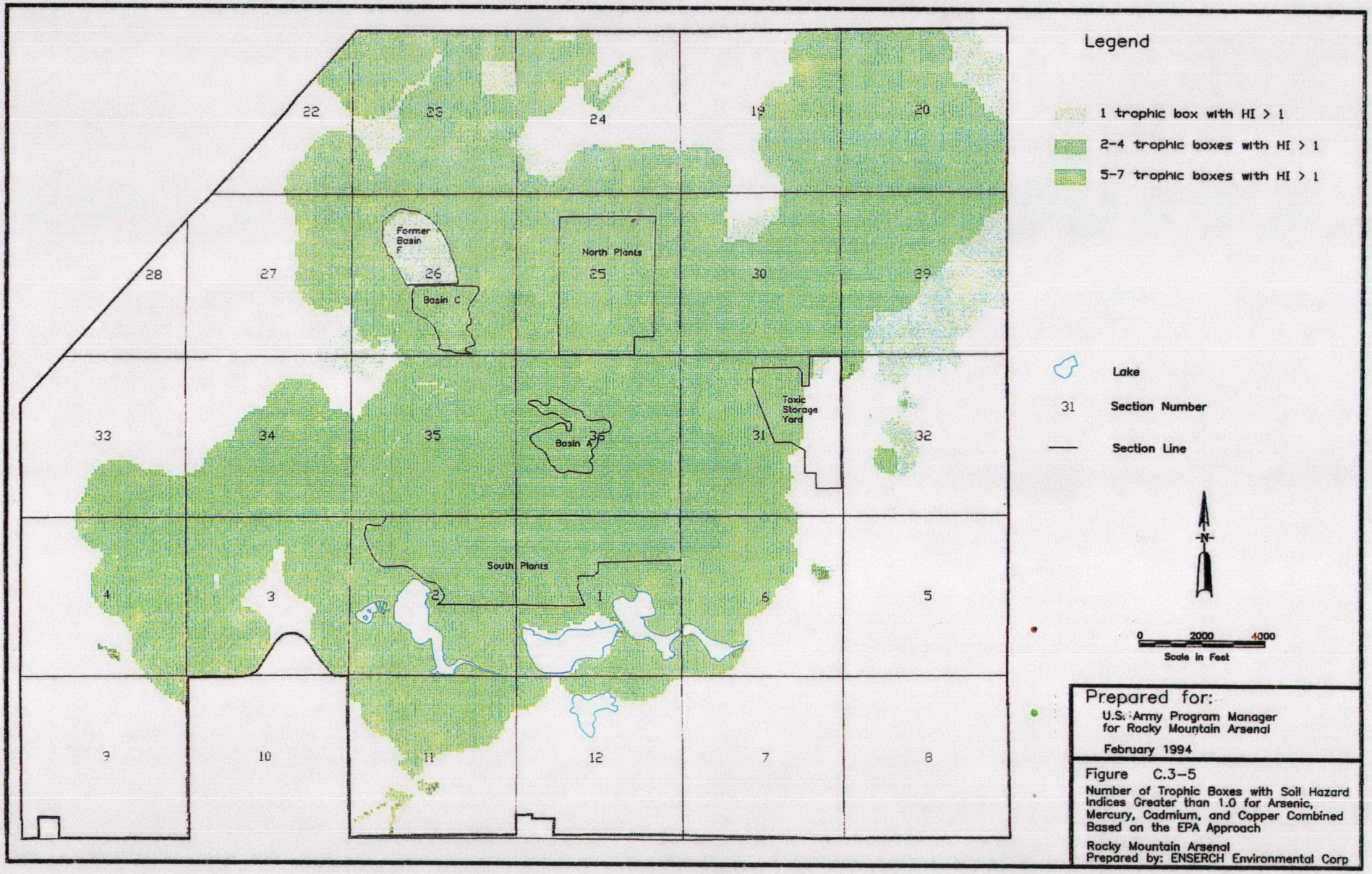
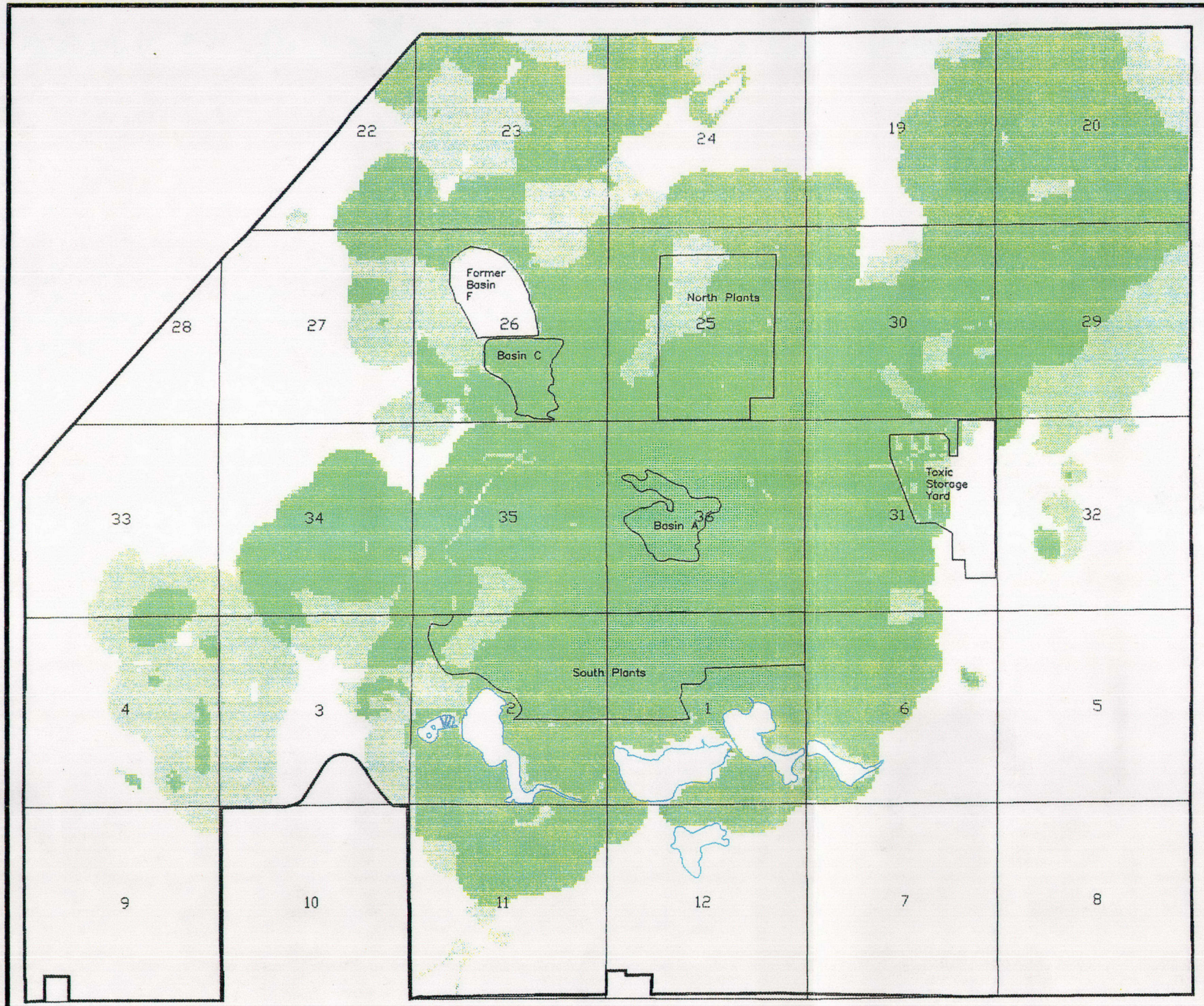
Figure C.3-4

Number of Trophic Boxes with Soil Hazard Indices Greater than 1.0 for Aldrin/Dieldrin, DDT/DDE, and Endrin Combined Based on the EPA Approach

Rocky Mountain Arsenal

Prepared by: ENSERCH Environmental Corp


Legend
1 trophic box with HI > 1
2-4 trophic boxes with HI > 1
5-7 trophic boxes with HI > 1
Lake
31 Section Number
Section Line
Former Basin F
Basin C
North Plants
Basin A
Toxic Storage Yard
South Plants
22
23
24
19
20
28
27
26
25
30
29
33
34
35
36
31
32
4
3
2
1
6
5
9
10
11
12
7
8
N
0
2000
4000
Scale in Feet
Prepared for:
U.S. Army Program Manager for Rocky Mountain Arsenal
February 1994
Figure C.3-5
Number of Trophic Boxes with Soil Hazard Indices Greater than 1.0 for Arsenic, Mercury, Cadmium, and Copper Combined Based on the EPA Approach
Rocky Mountain Arsenal
Prepared by: ENSERCH Environmental Corp



Legend

- 1 trophic box with HI > 1
- 2-4 trophic boxes with HI > 1
- 5-7 trophic boxes with HI > 1
- Lake
- 31 Section Number
- Section Line

N

0 2000 4000

Scale in Feet

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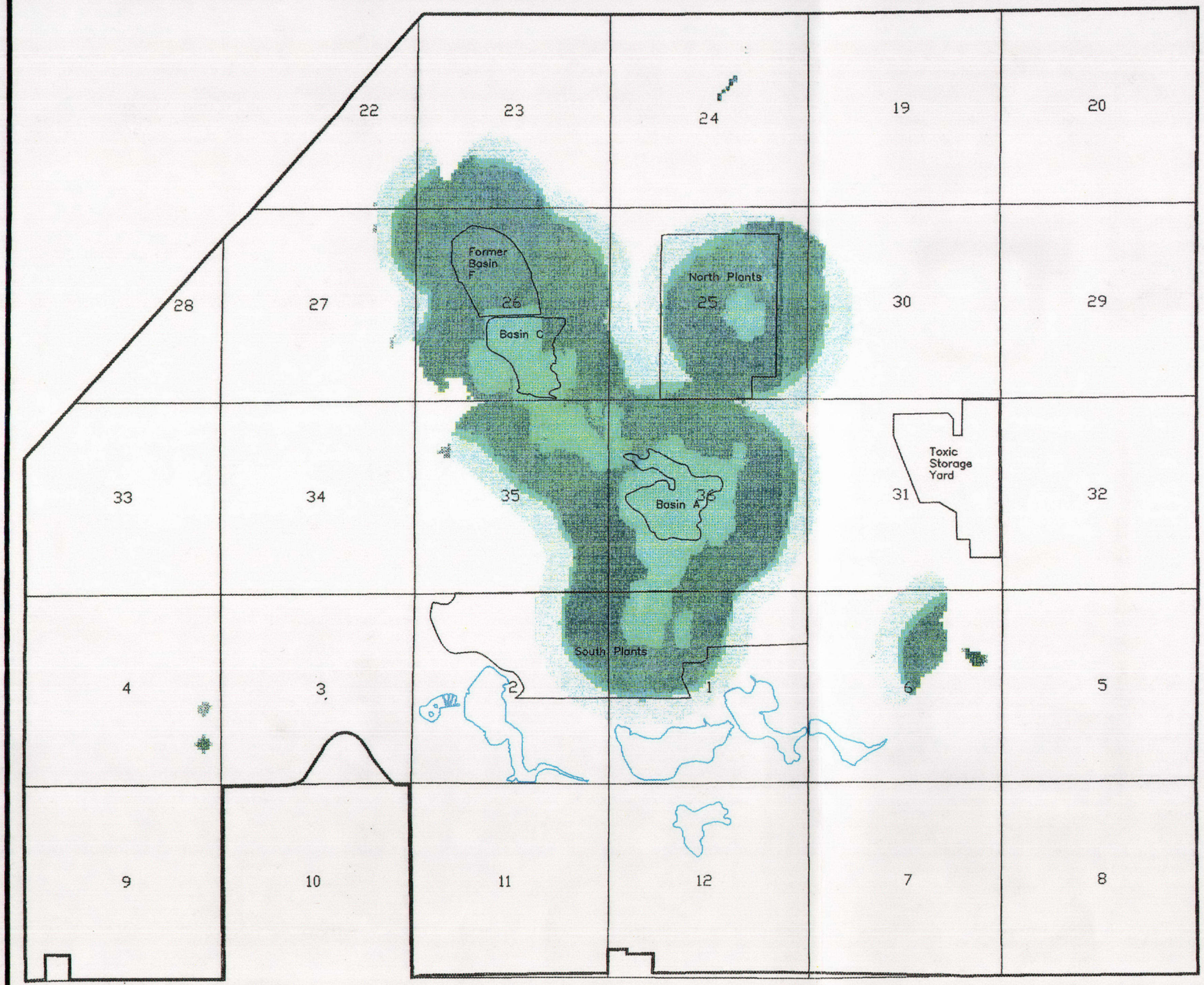
February 1994

Figure C.3-6

Number of Trophic Boxes with Soil Hazard Indices Greater than 1.0 for Arsenic, Mercury, Cadmium, and Copper Combined Based on the Shell Approach

Rocky Mountain Arsenal
Prepared by: ENSERCH Environmental Corp



Legend

- 1 trophic box with HI > 1
- 2-4 trophic boxes with HI > 1
- 5-7 trophic boxes with HI > 1
- Lake
- 31 Section Number
- Section Line

N

0 2000 4000

Scale in Feet

Prepared for:

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for Rocky Mountain Arsenal

February 1994

Figure C.3-7

Number of Trophic Boxes with Soil Hazard Indices Greater than 1.0 for Arsenic, Mercury, Cadmium, and Copper Concentrations Above Indicator Levels Based on the Army Approach

Rocky Mountain Arsenal

Prepared by: ENSERCH Environmental Corp

Former Basin F

Basin C

North Plants

Basin A

Toxic Storage Yard

South Plants

22 23 24 19 20

28 27 26 25 30 29

33 34 35 36 31 32

4 3 2 1 6 5

9 10 11 12 7 8

Legend

1 trophic box with HI > 1

2-4 trophic boxes with HI > 1

5-7 trophic boxes with HI > 1

Lake

31 Section Number

Section Line

N

0 2000 4000

Scale in Feet

Prepared for:

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February 1994

Figure C.3-8

Number of Trophic Boxes with Soil Hazard Indices Greater than 1.0 for Arsenic, Mercury, Cadmium, and Copper Concentrations Above Indicator Levels Based on the EPA Approach

Rocky Mountain Arsenal
Prepared by: ENSERCH Environmental Corp

Legend

- 1 trophic box with HI > 1
- 2-4 trophic boxes with HI > 1
- 5-7 trophic boxes with HI > 1
- Lake
- 31 Section Number
- Section Line

N

0 2000 4000

Scale in Feet

Prepared for:

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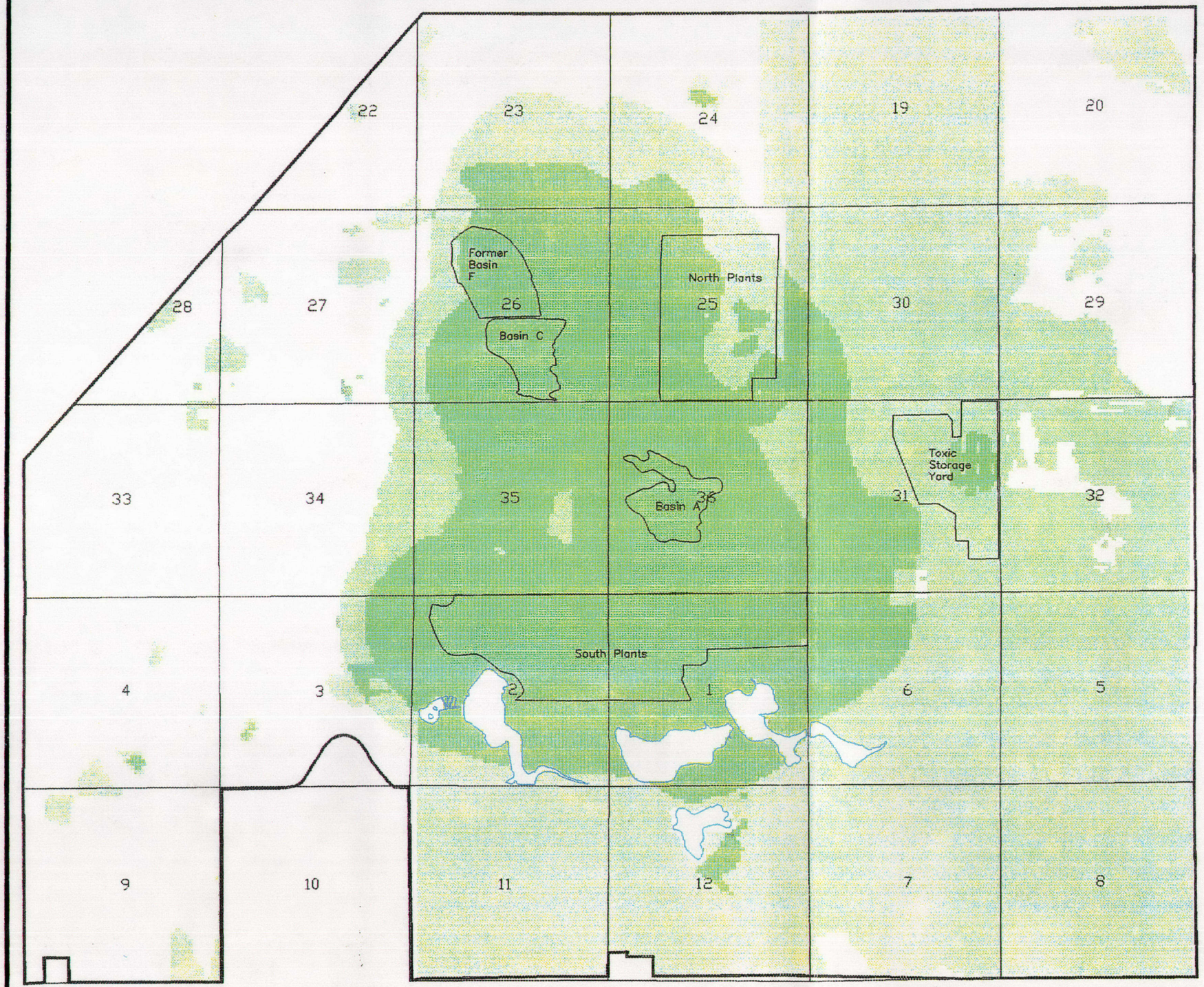
for Rocky Mountain Arsenal

February 1994

Figure C.3-9

Number of Trophic Boxes with Soil Hazard Indices Greater than 1.0 for Chlordane, CPMS, $CPMSO_2$, DCPD, and DBCP Combined Based on the Army Approach

Rocky Mountain Arsenal
Prepared by: ENSERCH Environmental Corp



Legend

- 1 trophic box with HI > 1
- 2-4 trophic boxes with HI > 1
- 5-7 trophic boxes with HI > 1
- Lake
- 31 Section Number
- Section Line

N

0 2000 4000

Scale in Feet

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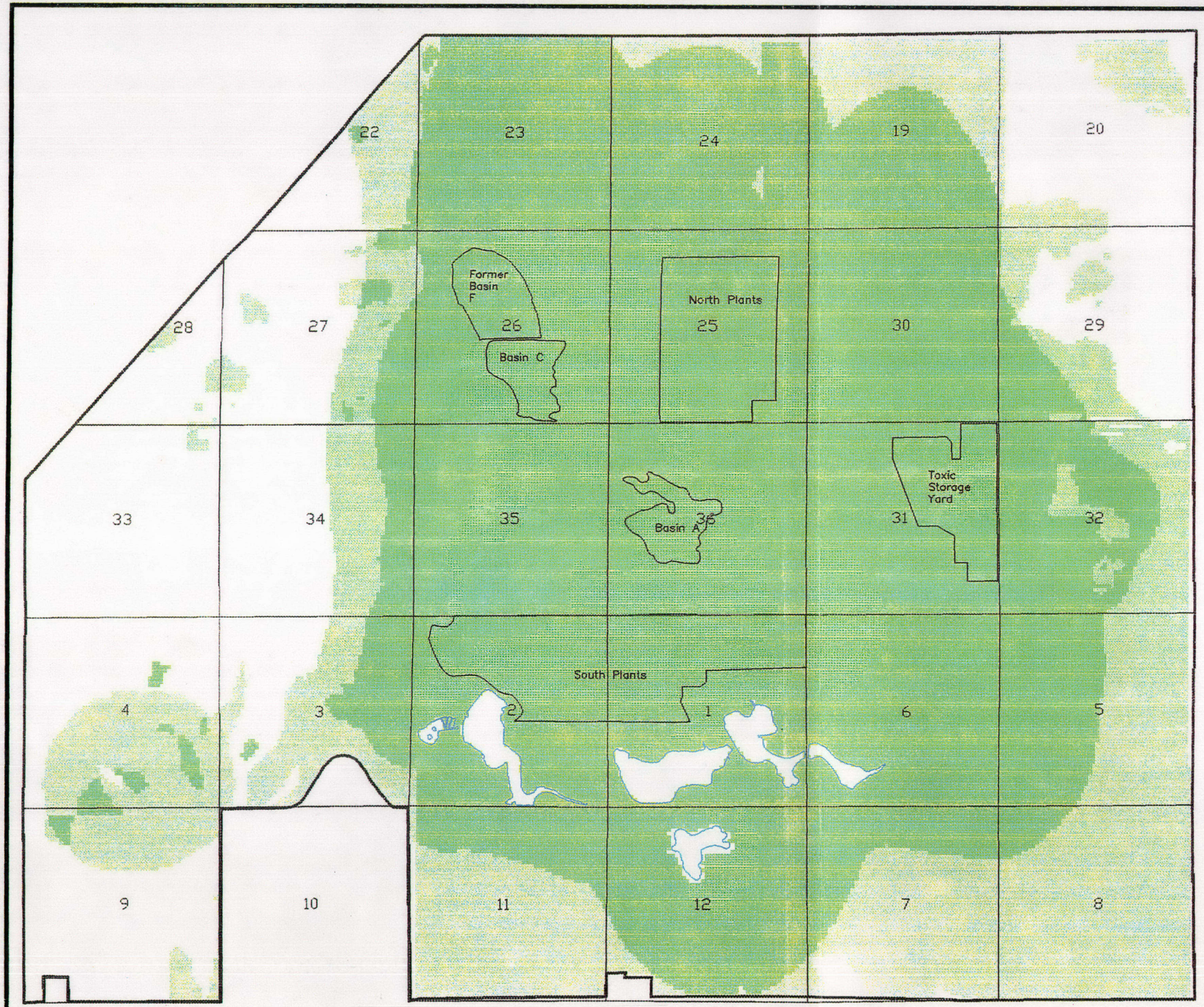
Figure C.3-10

Number of Trophic Boxes with Soil Hazard Quotients Greater than 1.0 for Aldrin/Dieldrin Based on the Army Approach

Rocky Mountain Arsenal
Prepared by: ENSERCH Environmental Corp



Legend

- 1 trophic box with HI > 1
- 2–4 trophic boxes with HI > 1
- 5–7 trophic boxes with HI > 1
- Lake
- 31 Section Number
- Section Line

N

0 2000 4000

Scale in Feet

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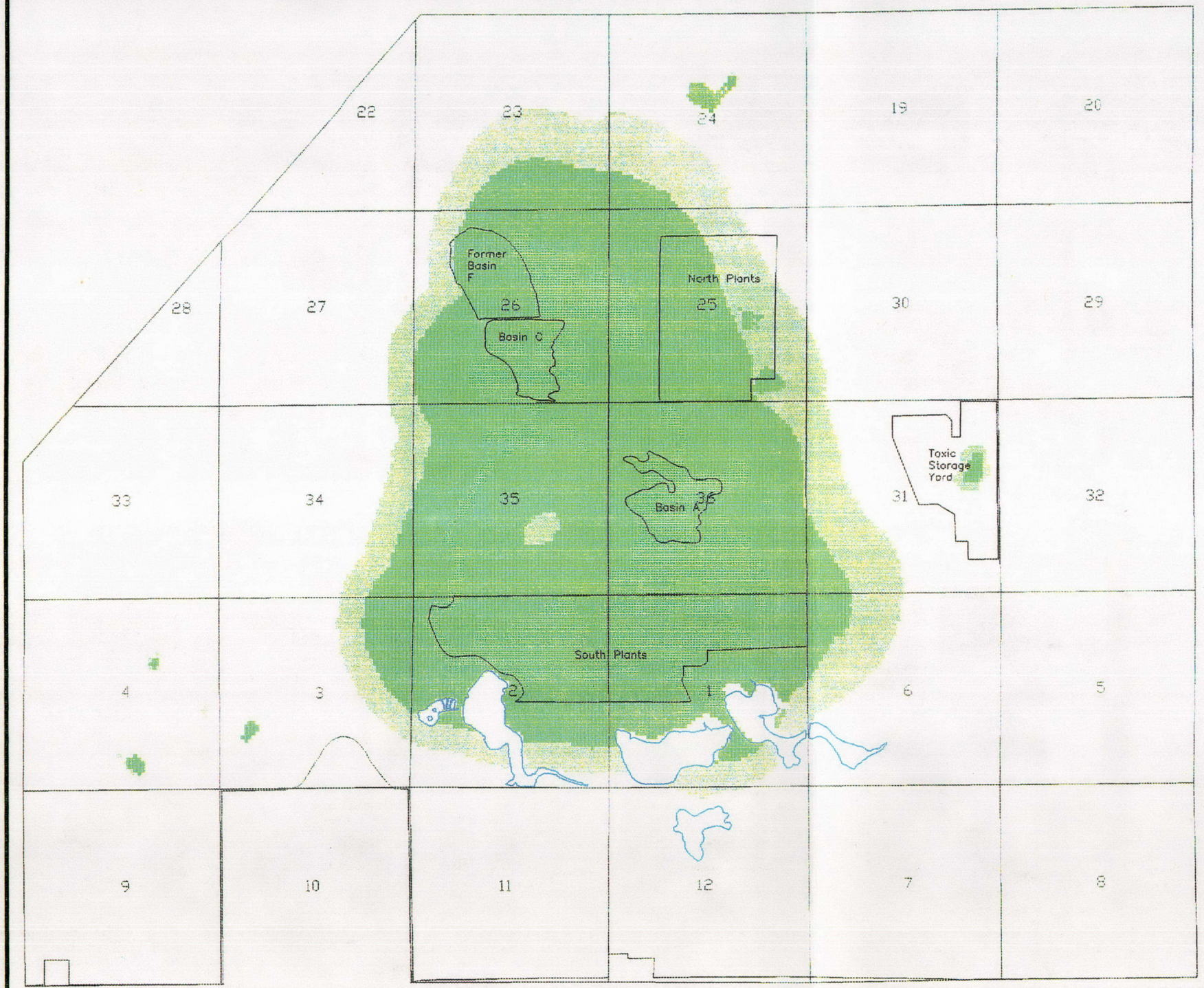
February 1994

Figure C.3–11

Number of Trophic Boxes with Soil Hazard Quotients Greater than 1.0 for Aldrin/Dieldrin Based on the EPA Approach

Rocky Mountain Arsenal
Prepared by: ENSERCH Environmental Corp



Legend

- 1 trophic box with HI > 1
- 2-4 trophic boxes with HI > 1
- 5-7 trophic boxes with HI > 1
- Lake
- 31 Section Number
- Section Line

N

0 2000 4000

Scale in Feet

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February 1994

Figure C.3–12

Number of Trophic Boxes with Soil Hazard Quotients Greater than 1.0 for Aldrin/Dieldrin Based on the Shell Approach

Rocky Mountain Arsenal
Prepared by: ENSERCH Environmental Corp

22 23 24 19 20
28 27 26 25 30 29
33 34 35 36 31 32
4 3 2 1 6 5
9 10 11 12 7 8

Former Basin F
Basin C
North Plants
Basin A
Toxic Storage Yard
South Plants

Legend

1 trophic box with HI > 1

2-4 trophic boxes with HI > 1

5-7 trophic boxes with HI > 1

Lake

31 Section Number

Section Line

N

0 2000 4000

Scale in Feet

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February 1994

Figure C.3-13

Number of Trophic Boxes with Soil Hazard Quotients Greater than 1.0 for DDT/DDE Based on the Army Approach

Rocky Mountain Arsenal
Prepared by: ENSERCH Environmental Corp

Former Basin F

Basin C

North Plants

Basin A

Toxic Storage Yard

South Plants

22 23 24 19 20

28 27 26 25 30 29

33 34 35 36 31 32

4 3 2 1 6 5

9 10 11 12 7 8

Legend

1 trophic box with HI > 1

2-4 trophic boxes with HI > 1

5-7 trophic boxes with HI > 1

Lake

31 Section Number

Section Line

-N-

0 2000 4000

Scale in Feet

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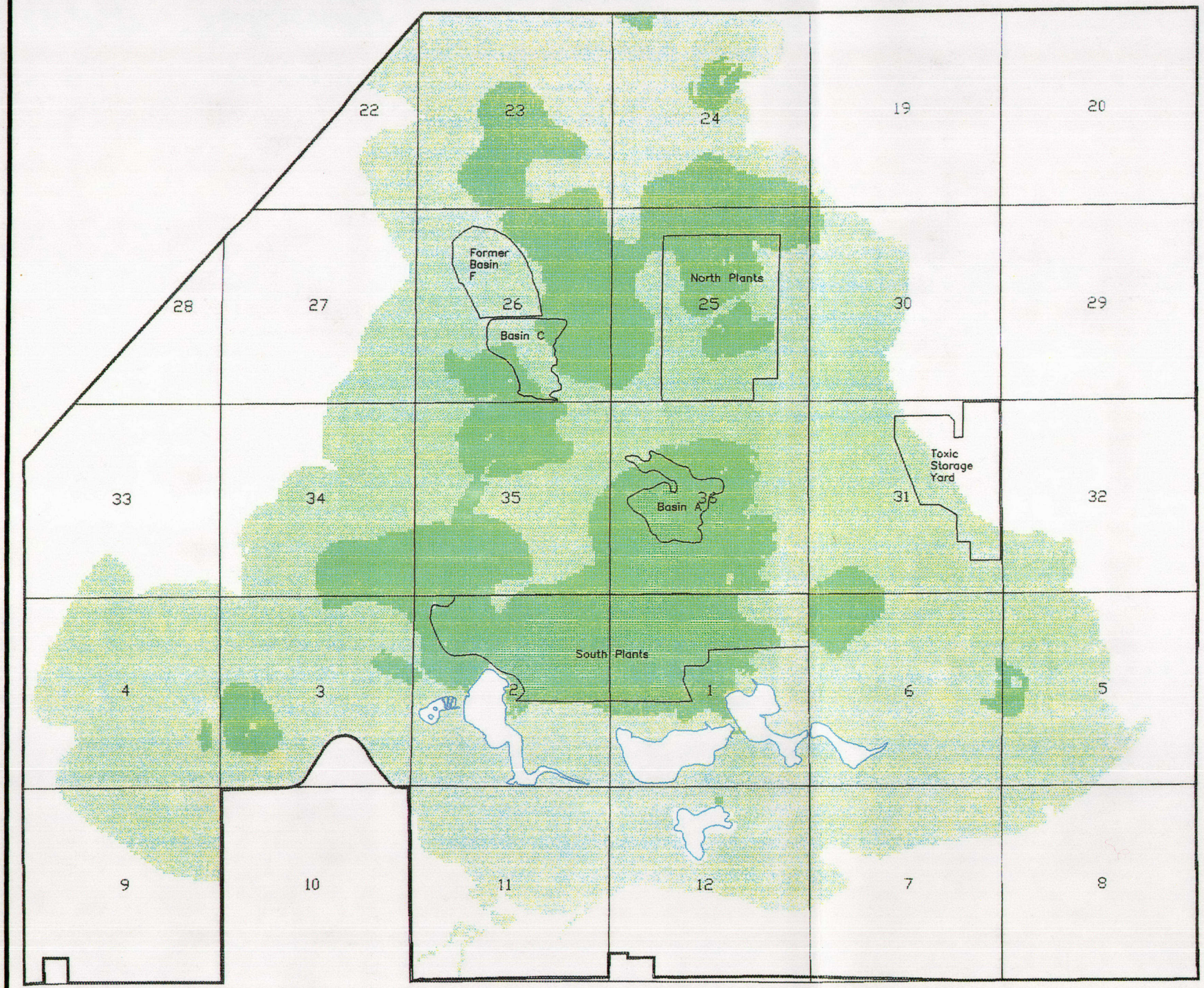
Figure C.3-14

Number of Trophic Boxes with Soil Hazard Quotients Greater than 1.0 for DDT/DDE Based on the EPA Approach

Rocky Mountain Arsenal
Prepared by: ENSERCH Environmental Corp



Legend

- 1 trophic box with HI > 1
- 2-4 trophic boxes with HI > 1
- 5-7 trophic boxes with HI > 1

Lake

31 Section Number

Section Line

N

0 2000 4000

Scale in Feet

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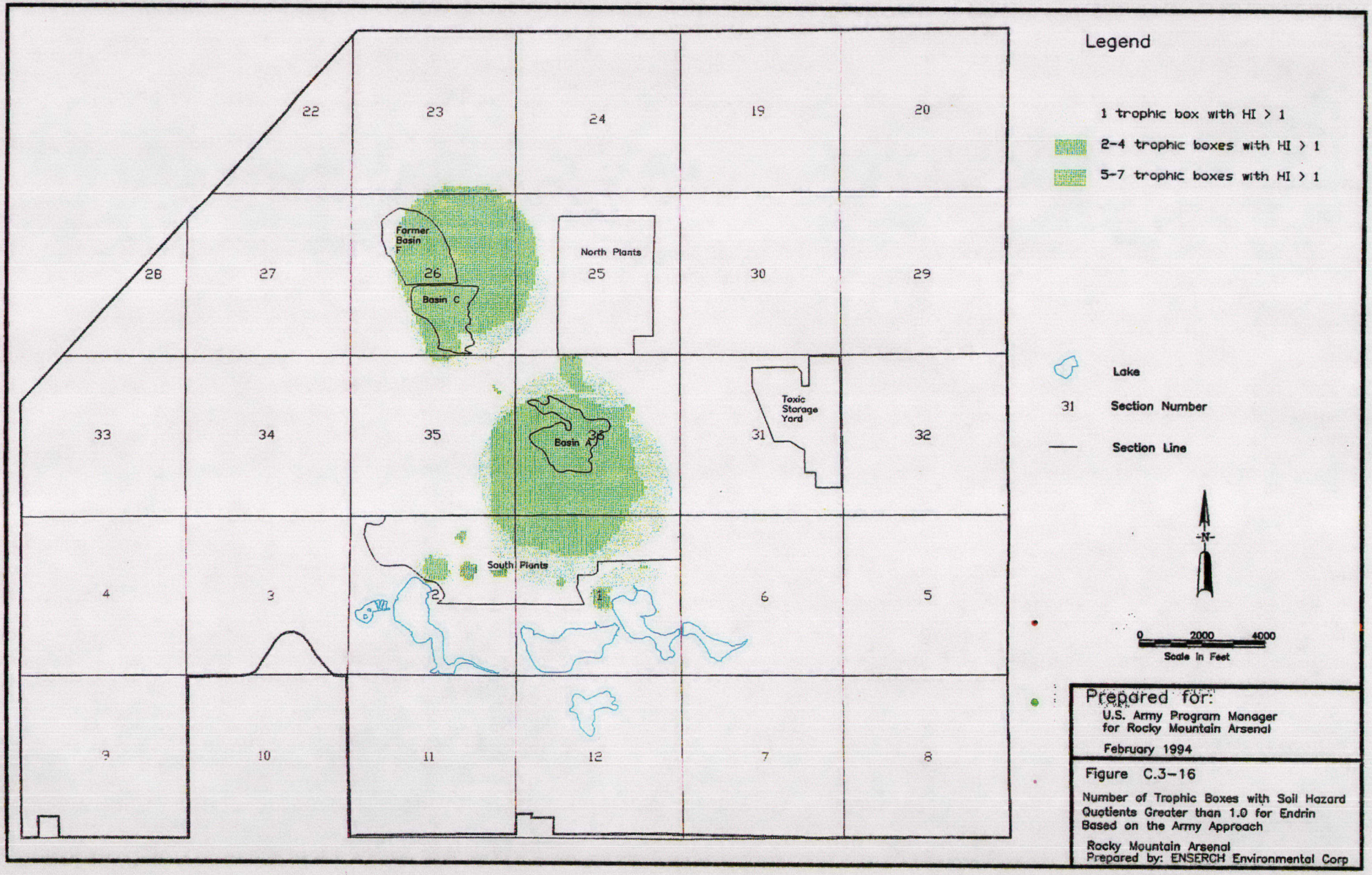
February 1994

Figure C.3-15

Number of Trophic Boxes with Soil Hazard Quotients Greater than 1.0 for DDT/DDE Based on the Shell Approach

Rocky Mountain Arsenal
Prepared by: ENSERCH Environmental Corp


Legend
1 trophic box with HI > 1
2-4 trophic boxes with HI > 1
5-7 trophic boxes with HI > 1
Lake
31 Section Number
Section Line
22
23
24
19
20
28
27
26
25
30
29
33
34
35
36
31
32
4
3
2
1
6
5
9
10
11
12
7
8
Former Basin F
Basin C
North Plants
Basin A
Toxic Storage Yard
South Plants
N
0
2000
4000
Scale in Feet
Prepared for:
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for Rocky Mountain Arsenal
February 1994
Figure C.3-16
Number of Trophic Boxes with Soil Hazard Quotients Greater than 1.0 for Endrin Based on the Army Approach
Rocky Mountain Arsenal
Prepared by: ENSERCH Environmental Corp

Legend

- 1 trophic box with HI > 1
- 2-4 trophic boxes with HI > 1
- 5-7 trophic boxes with HI > 1
- Lake
- 31 Section Number
- Section Line

N

0 2000 4000

Scale in Feet

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February 1994

Figure C.3-17

Number of Trophic Boxes with Soil Hazard Quotients Greater than 1.0 for Endrin Based on the EPA Approach

Rocky Mountain Arsenal
Prepared by: ENSERCH Environmental Corp

Legend

- 1 trophic box with HI > 1
- 2-4 trophic boxes with HI > 1
- 5-7 trophic boxes with HI > 1
- Lake
- 31 Section Number
- Section Line

N

0 2000 4000

Scale in Feet

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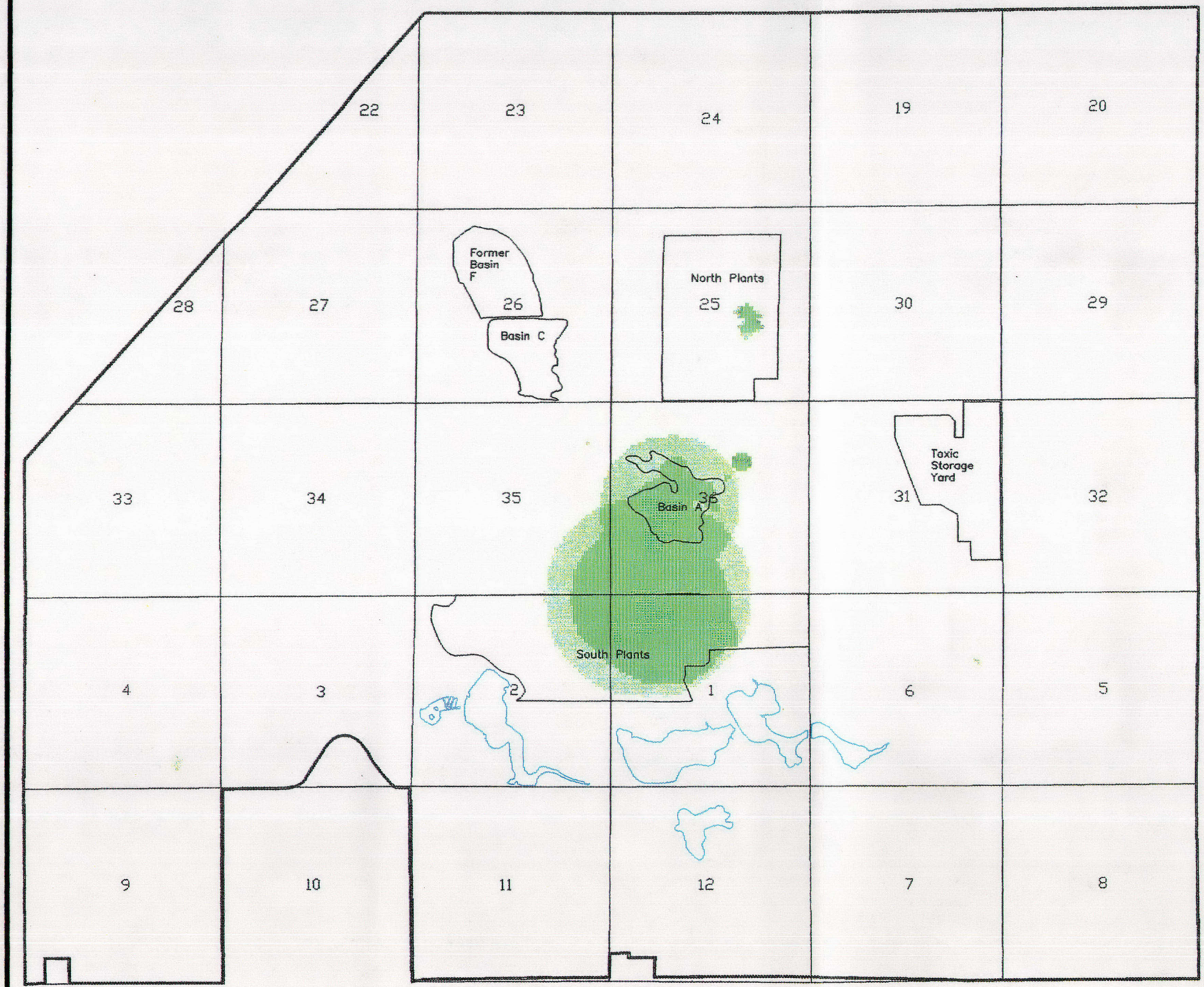
February 1994

Figure C.3-18

Number of Trophic Boxes with Soil Hazard Quotients Greater than 1.0 for Endrin Based on the Shell Approach

Rocky Mountain Arsenal
Prepared by: ENSERCH Environmental Corp



Legend

- 1 trophic box with HI > 10
- 2-4 trophic boxes with HI > 10
- 5-7 trophic boxes with HI > 10
- Lake
- 31 Section Number
- Section Line

N

0 2000 4000

Scale in Feet

Prepared for:

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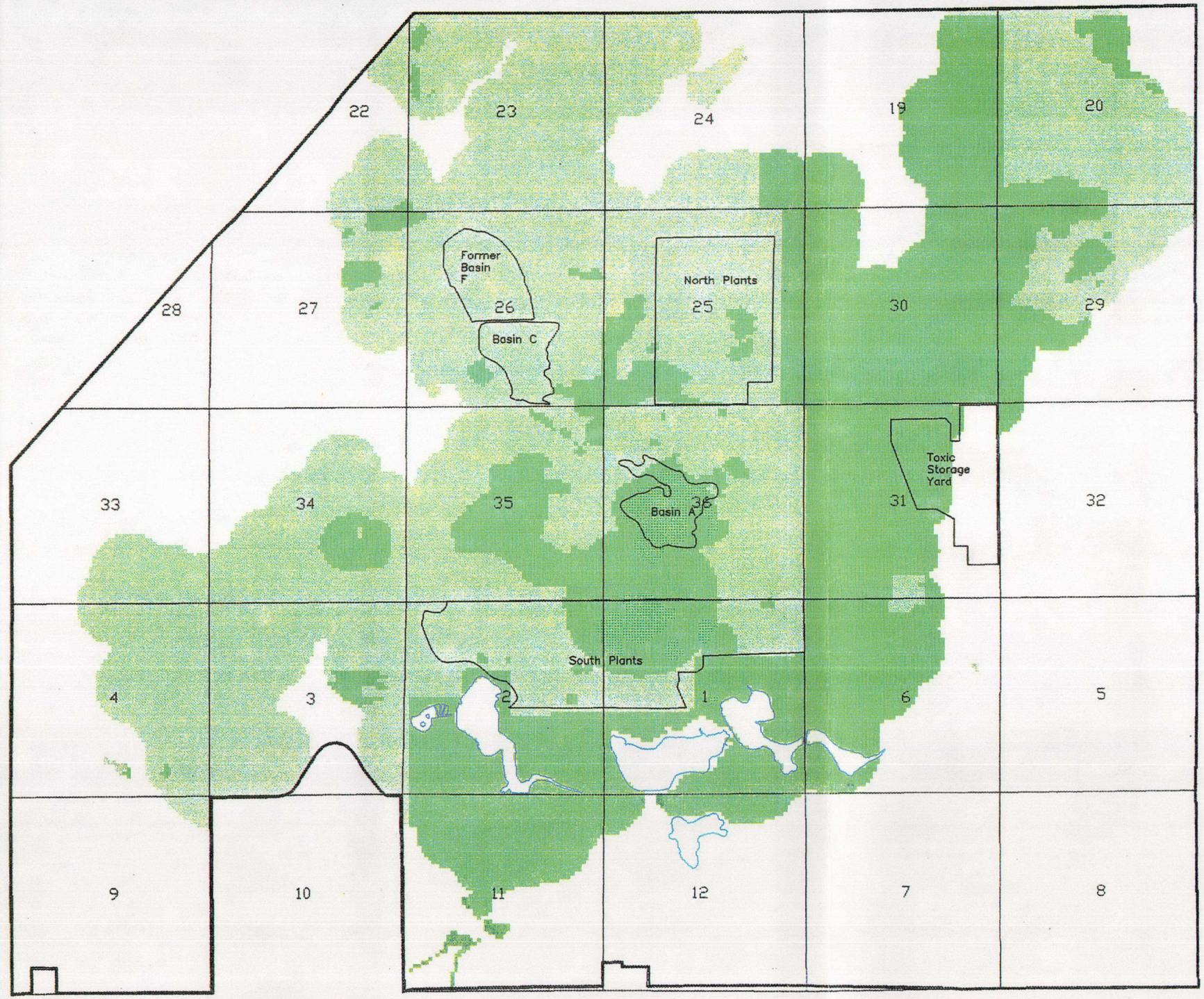
February 1994

Figure C.3-19

Number of Trophic Boxes with Soil Hazard Indices Greater than 10 for Arsenic, Mercury, Cadmium, and Copper Combined Based on the Army Approach

Rocky Mountain Arsenal
Prepared by: ENSERCH Environmental Corp



Legend

- 1 trophic box with HI > 10
- 2-4 trophic boxes with HI > 10
- 5-7 trophic boxes with HI > 10

Lake

31 Section Number

Section Line

N

0 2000 4000

Scale in Feet

Prepared for:

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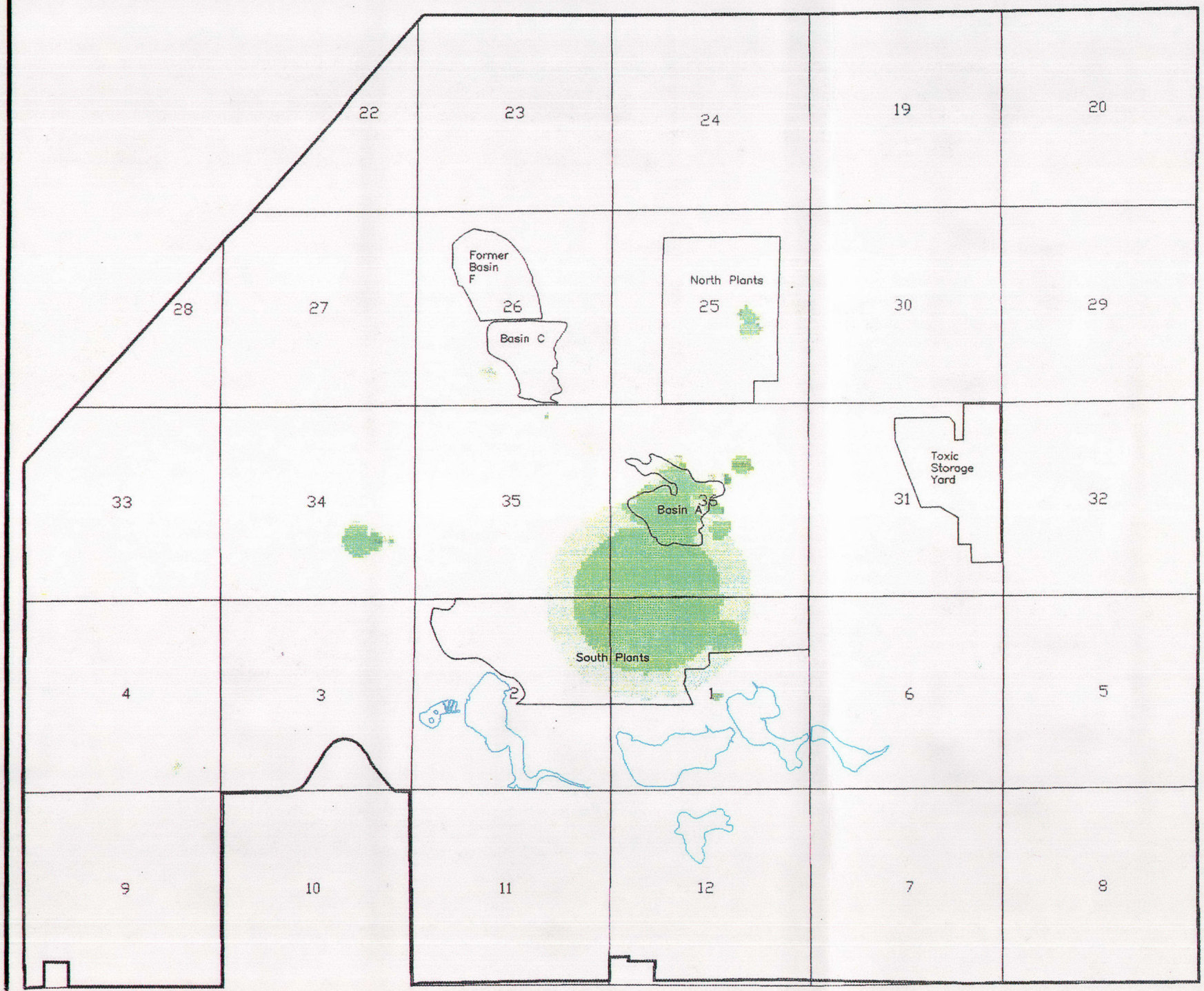
February 1994

Figure C.3-20

Number of Trophic Boxes with Soil Hazard Indices Greater than 10 for Arsenic, Mercury, Cadmium, and Copper Combined Based on the EPA Approach

Rocky Mountain Arsenal
Prepared by: ENSERCH Environmental Corp



Legend

- 1 trophic box with HI > 10
- 2-4 trophic boxes with HI > 10
- 5-7 trophic boxes with HI > 10
- Lake
- 31 Section Number
- Section Line

-N-

0 2000 4000

Scale in Feet

Prepared for:

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February 1994

Figure C.3-21

Number of Trophic Boxes with Soil Hazard Indices Greater than 10 for Arsenic, Mercury, Cadmium, and Copper Combined Based on the Shell Approach

Rocky Mountain Arsenal
Prepared by: ENSERCH Environmental Corp

22 23 24 19 20

28 27 Former Basin F 26 Basin C North Plants 25 30 29

33 34 35 Basin A 36 31 Toxic Storage Yard 32

4 3 2 South Plants 1 6 5

9 10 11 12 7 8

Legend

1 trophic box with HI > 10

2-4 trophic boxes with HI > 10

5-7 trophic boxes with HI > 10

Lake

31 Section Number

Section Line

N

0 2000 4000

Scale in Feet

Prepared for:

U.S. Army Program Manager
for Rocky Mountain Arsenal

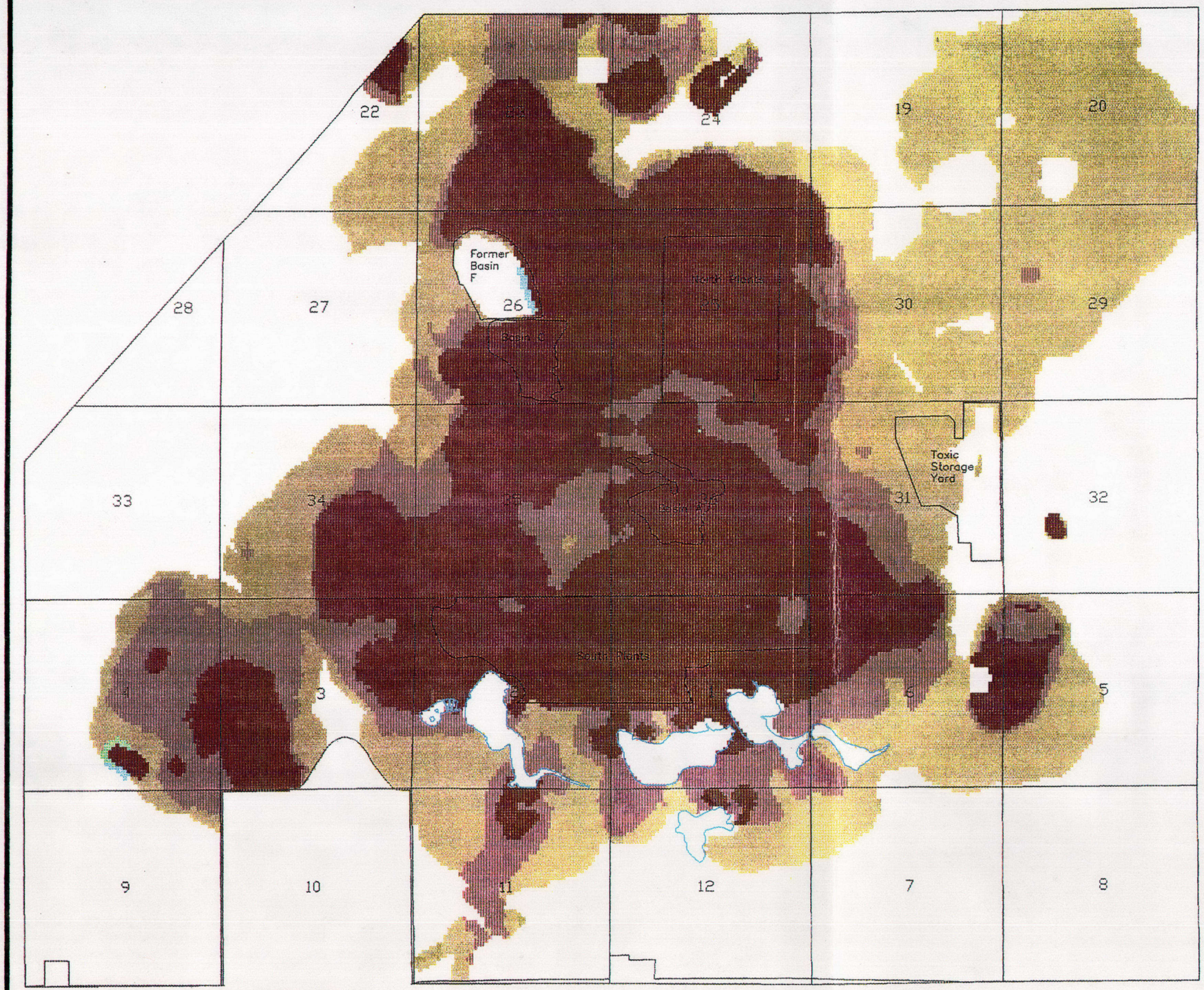
February 1994

Figure C.3-22

Number of Trophic Boxes with Soil Hazard Indices Greater than 10 for Chlordane, CPMS, $CPMSO_2$, DCPD, and DBCP Combined Based on the Army Approach

Rocky Mountain Arsenal

Prepared by: ENSERCH Environmental Corp



Legend

- Army Approach
- EPA Approach
- Army and EPA Approaches
- Shell and EPA Approaches
- Army and Shell and EPA Approaches

Colors show which approaches result in HI > 1 in the areas indicated

- Lake
- 31 Section Number
- Section Line

-N-

0 2000 4000

Scale in Feet

Prepared for:

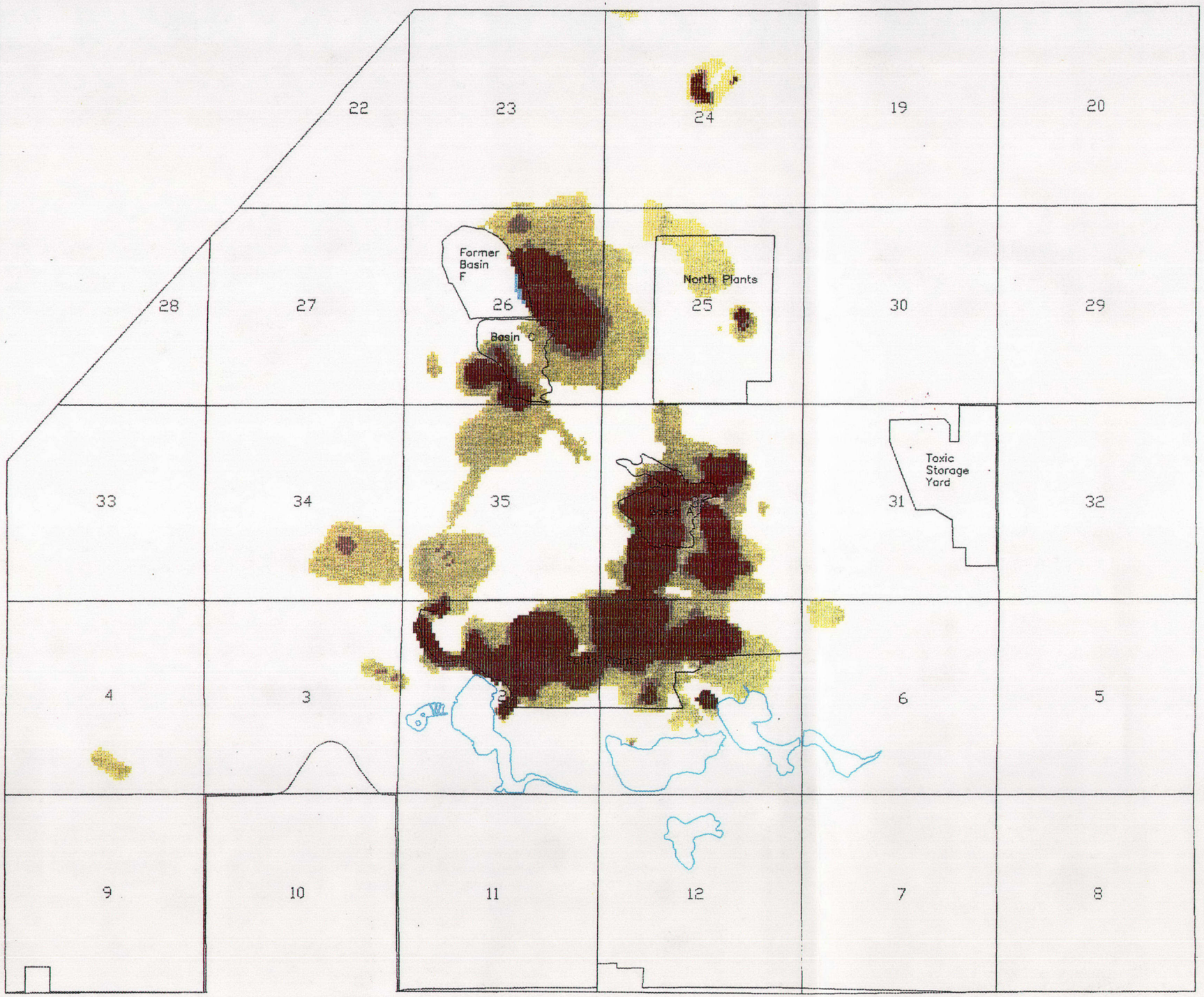
U.S. Army Program Manager
for Rocky Mountain Arsenal

February 1994

Figure C.3-23

Hazard Index Map (HI>1) for the Small Bird Trophic Box Based on the Army, EPA, and Shell Approaches

Rocky Mountain Arsenal
Prepared by: ENSERCH Environmental Corp



Legend

- Army Approach
- EPA Approach
- Army and EPA Approaches
- Shell and EPA Approaches
- Army and Shell and EPA Approaches

Colors show which approaches result in HI > 10 in the areas indicated

- Lake
- 31 Section Number
- Section Line

-N-

0 2000 4000

Scale in Feet

Prepared for:

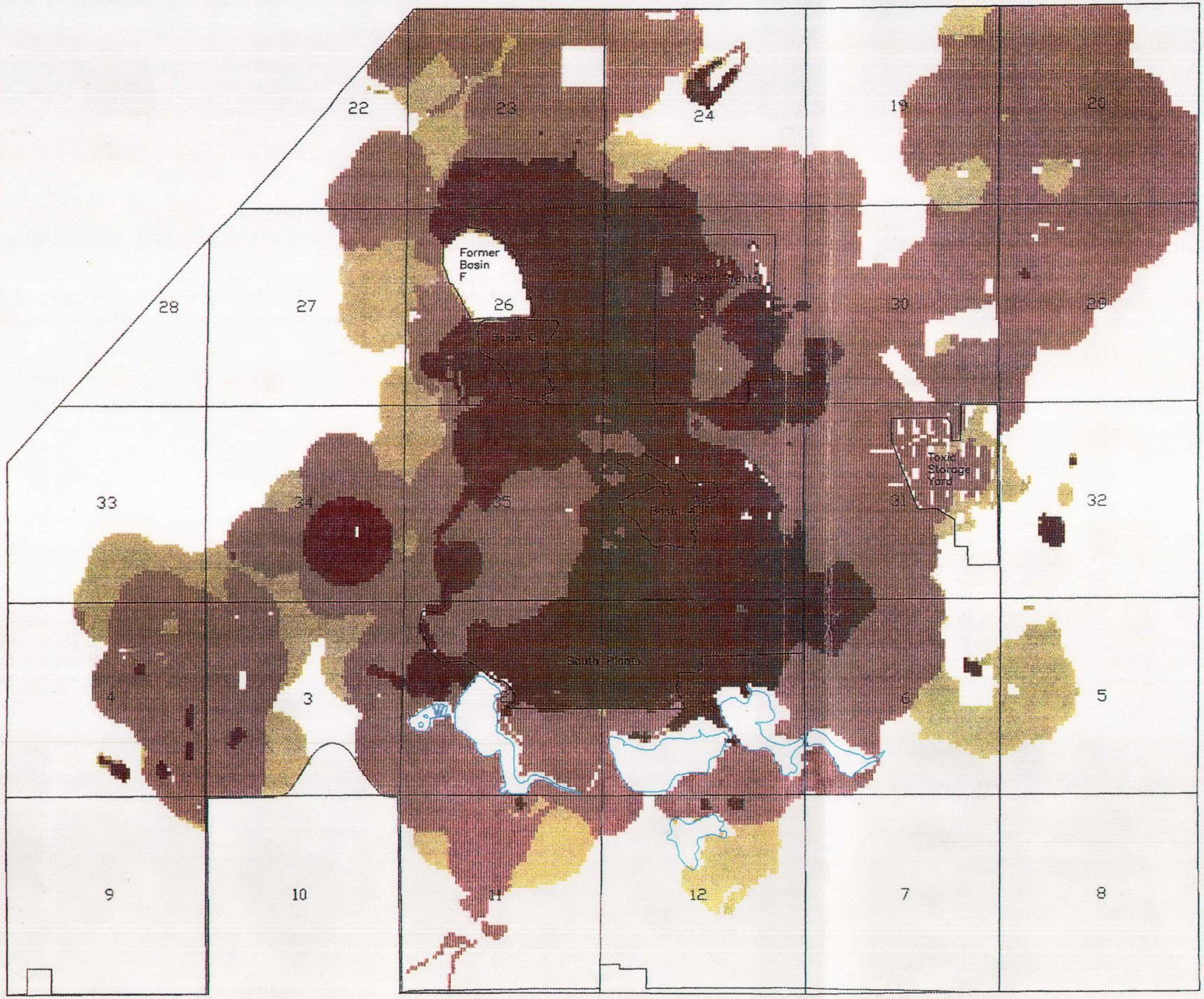
U.S. Army Program Manager
for Rocky Mountain Arsenal

February 1994

Figure C.3–24

Hazard Index Map (HI>10) for the Small Bird Trophic Box Based on the Army, EPA, and Shell Approaches

Rocky Mountain Arsenal
Prepared by: ENSERCH Environmental Corp



Legend

- EPA Approach
- Shell and EPA Approaches
- Army and Shell and EPA Approaches

Colors show which approaches result in HI > 1 in the areas indicated

- Lake
- 31 Section Number
- Section Line

N

0 2000 4000

Scale in Feet

Prepared for:

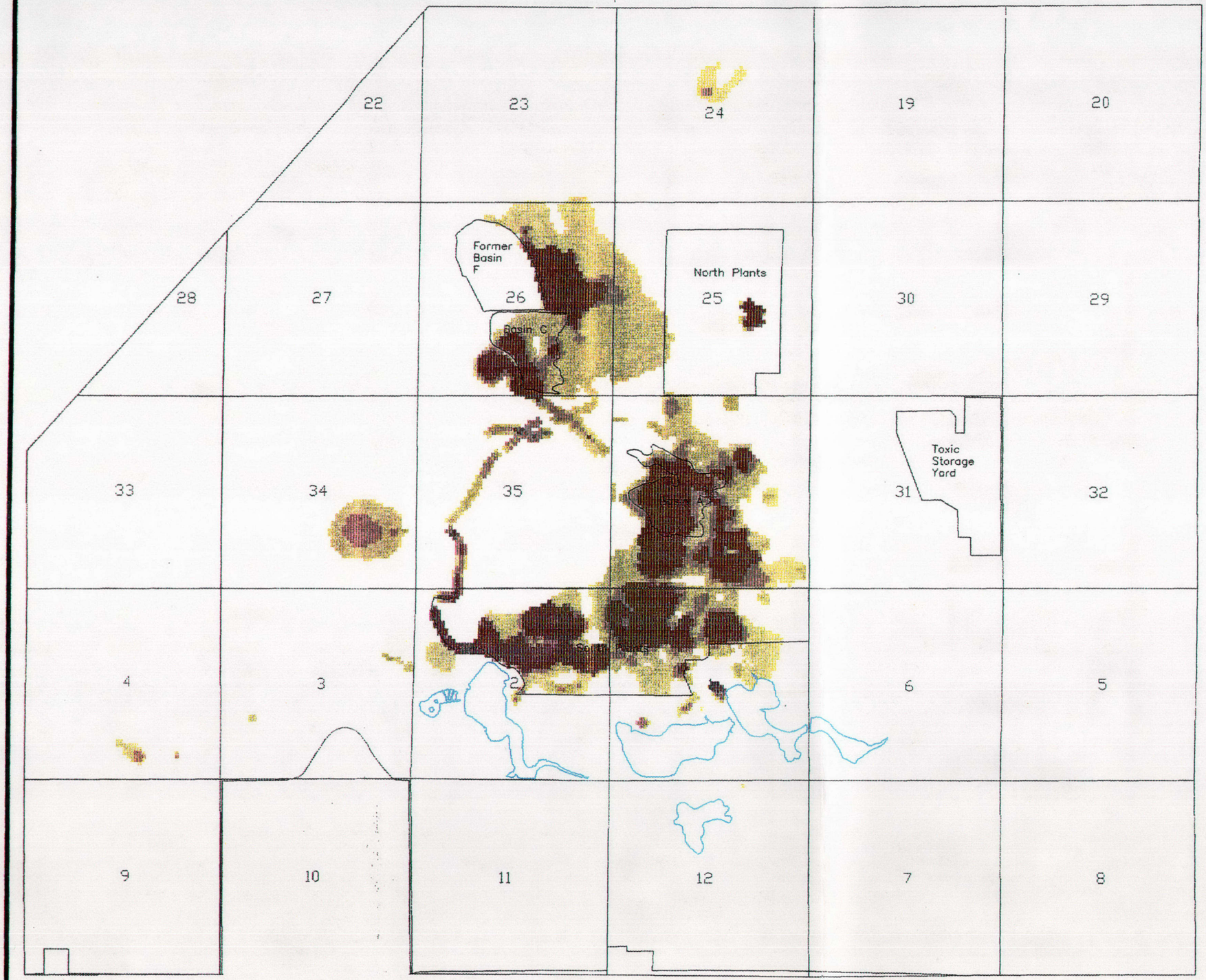
U.S. Army Program Manager
for Rocky Mountain Arsenal

February 1994

Figure C.3-25

Hazard Index Map (HI>1) for the Small Mammal Trophic Box Based on the Army, EPA, and Shell Approaches

Rocky Mountain Arsenal
Prepared by: ENSERCH Environmental Corp



Legend

- EPA Approach
- Shell and EPA Approaches
- Army and Shell and EPA Approaches

Colors show which approaches result in HI > 10 in the areas indicated

- Lake
- 31 Section Number
- Section Line

N

0 2000 4000

Scale in Feet

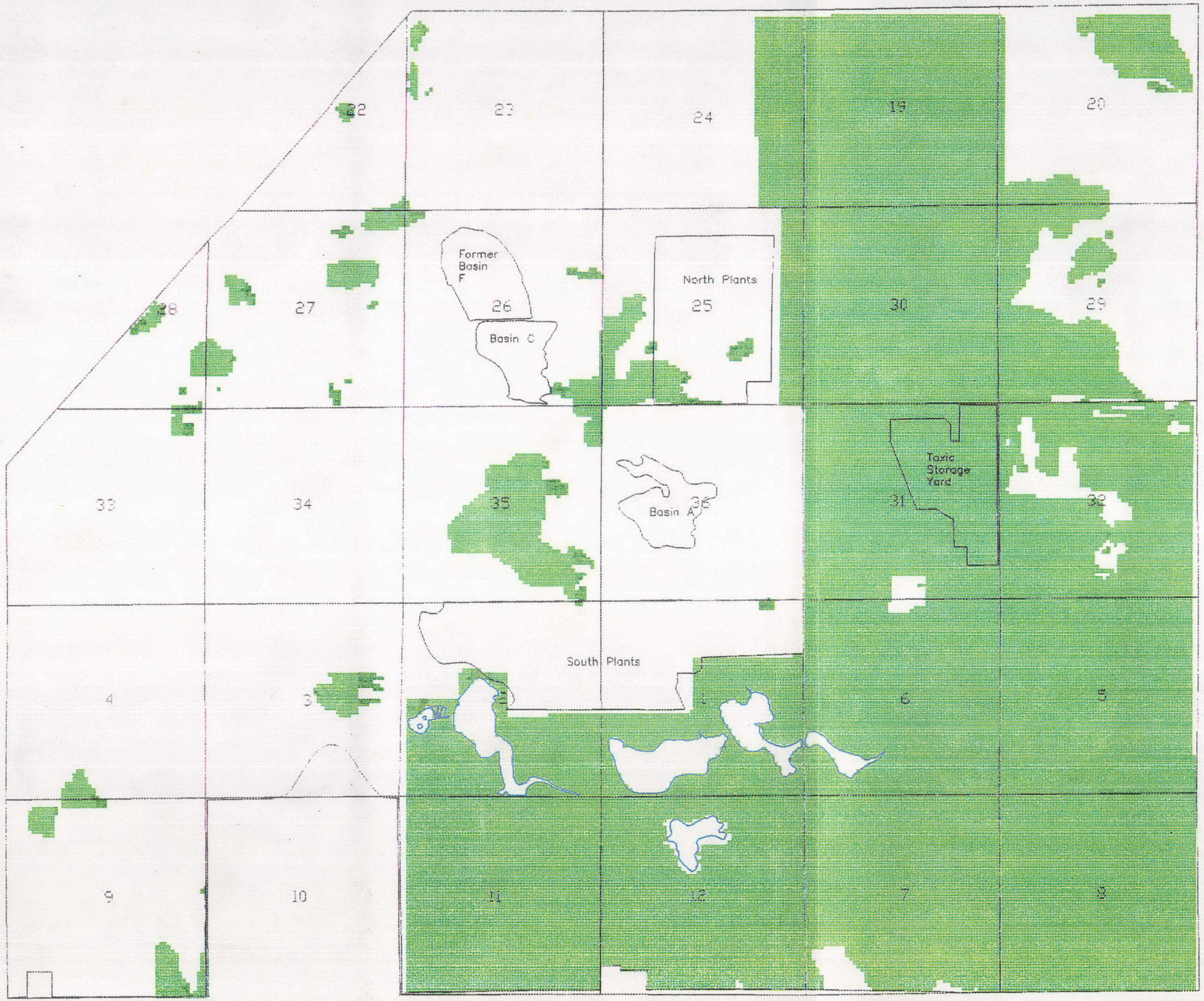
Prepared for:
U.S. Army Program Manager
for Rocky Mountain Arsenal

February 1994

Figure C.3–26

Hazard Index Map (HI>10) for the Small Mammal Trophic Box Based on the Army, EPA, and Shell Approaches

Rocky Mountain Arsenal
Prepared by: ENSERCH Environmental Corp



Legend

Army and EPA Approaches

Colors show which approaches result in HQ > 1 in the areas indicated

Lake

31 Section Number

Section Line

N

0 2000 4000

Scale in Feet

Prepared for:

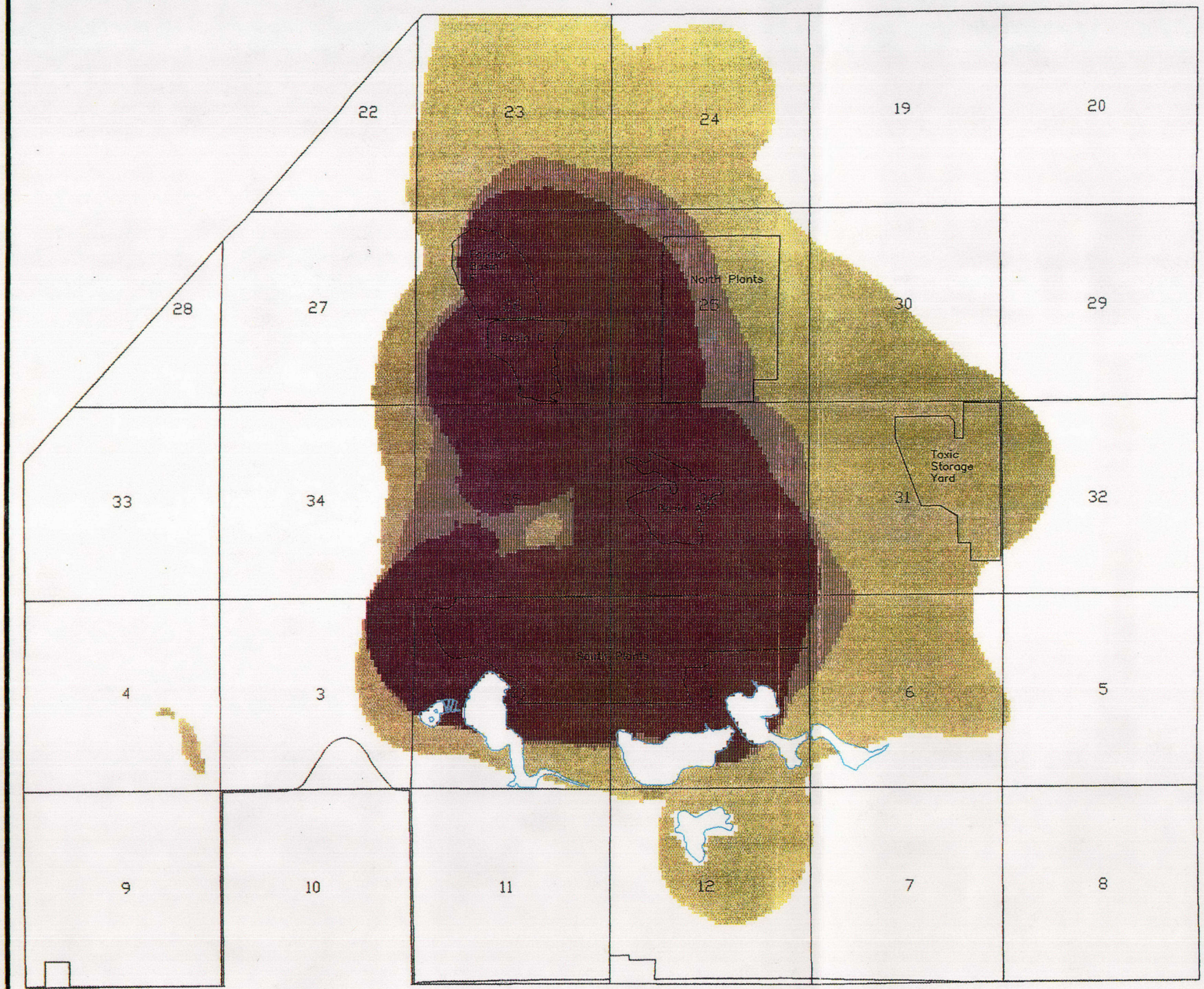
U.S. Army Program Manager
for Rocky Mountain Arsenal

February 1994

Figure C.3–27

Aldrin/Dieldrin Hazard Quotient Map (HQ>1) for the Bald Eagle Trophic Box Based on the Army, EPA, and Shell Approaches

Rocky Mountain Arsenal
Prepared by: ENSERCH Environmental Corp



Legend

- EPA Approach
- Shell and EPA Approaches
- Army and Shell and EPA Approaches

Colors show which approaches result in HQ > 1 in the areas indicated

- Lake
- 31 Section Number
- Section Line

N

0 2000 4000

Scale in Feet

Prepared for:

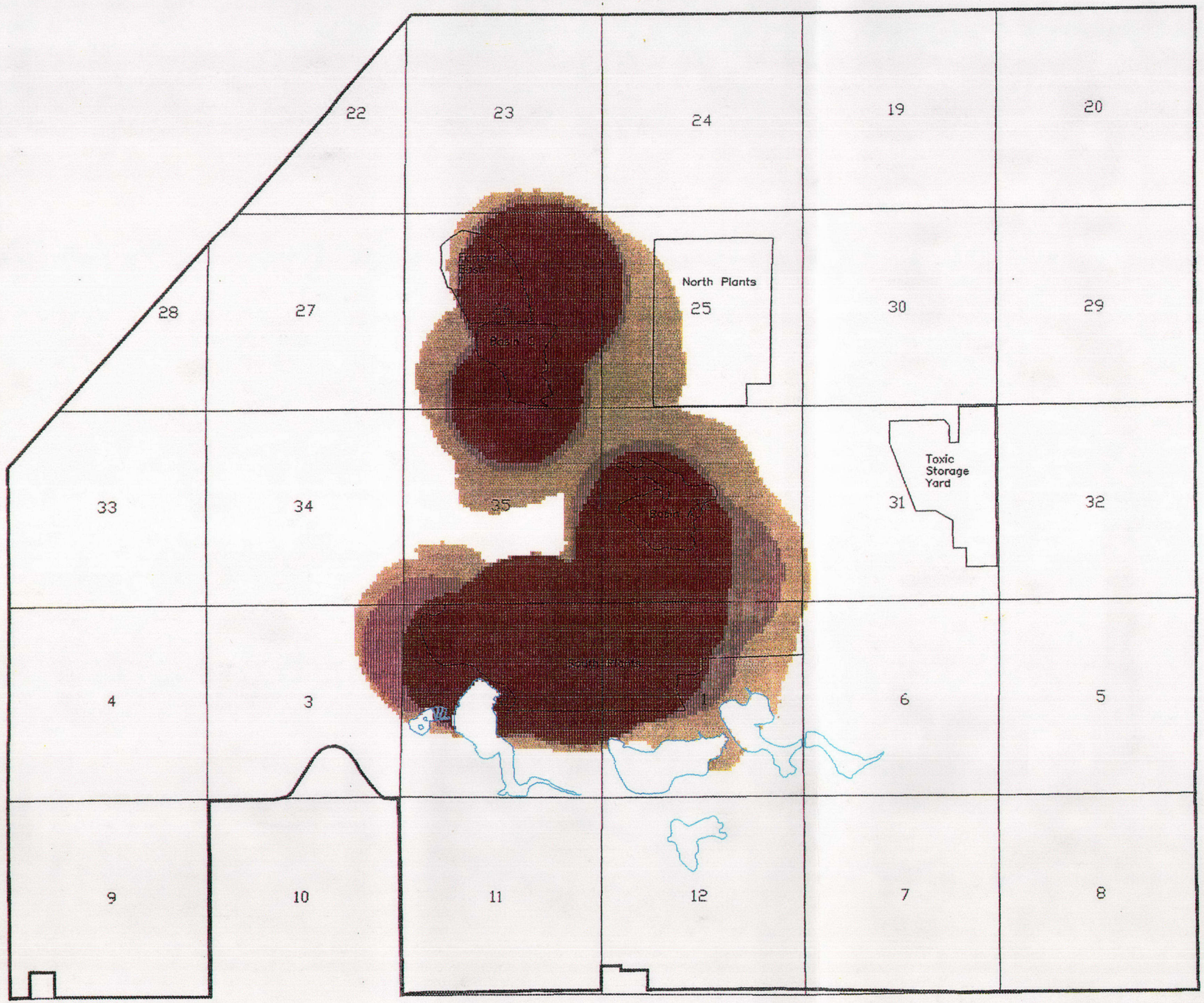
U.S. Army Program Manager
for Rocky Mountain Arsenal

February 1994

Figure C.3-28

Aldrin/Dieldrin Hazard Quotient Map (HQ>1) for the American Kestrel Trophic Box Based on the Army, EPA, and Shell Approaches

Rocky Mountain Arsenal
Prepared by: ENSERCH Environmental Corp



Legend

- EPA Approach
- Shell and EPA Approaches
- Army and Shell and EPA Approaches

Colors show which approaches result in HQ > 10 in the areas indicated

- Lake
- 31 Section Number
- Section Line

N

0 2000 4000

Scale in Feet

Prepared for:

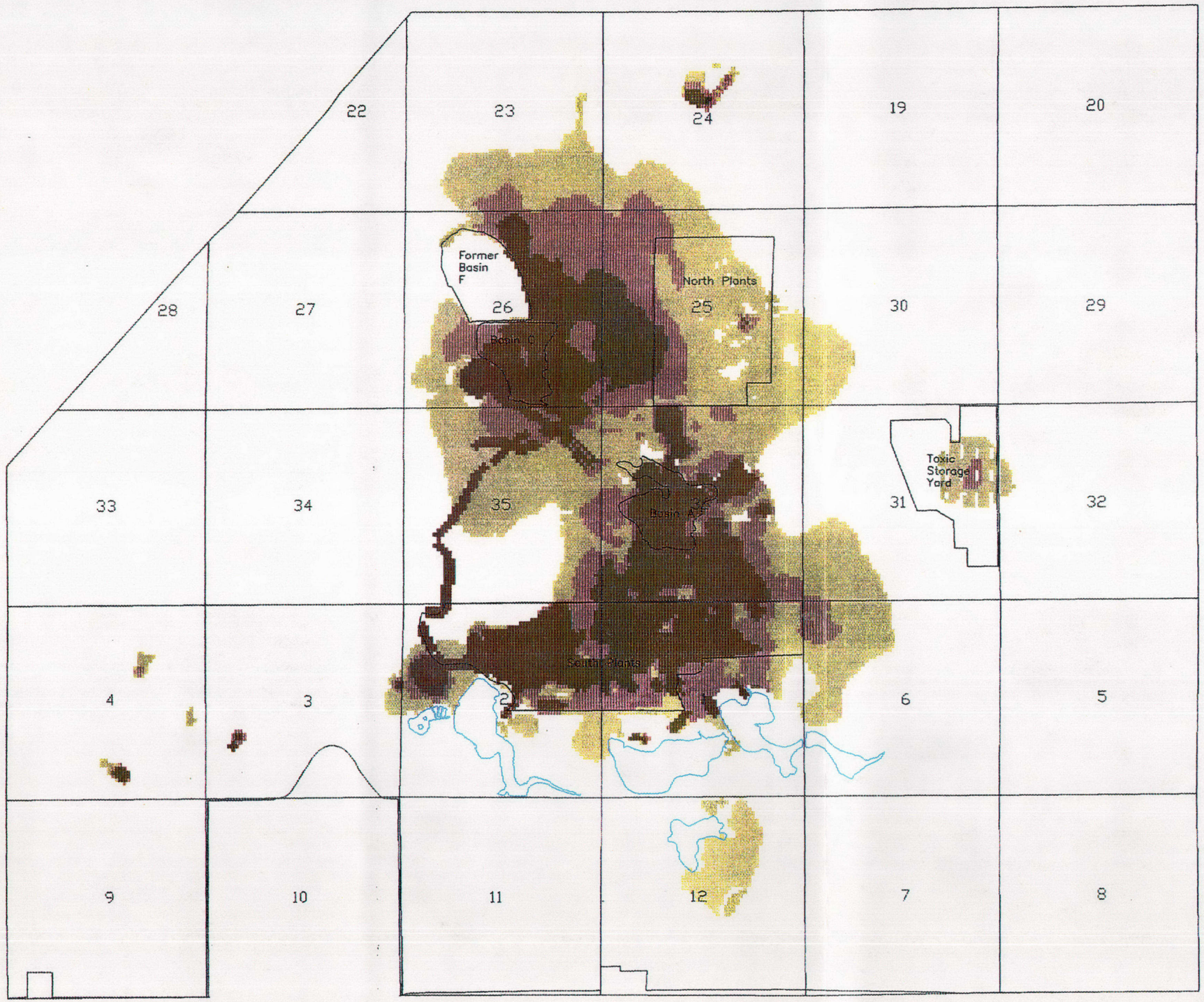
U.S. Army Program Manager
for Rocky Mountain Arsenal

February 1994

Figure C.3-29

Aldrin/Dieldrin Hazard Quotient Map (HQ>10) for the American Kestrel Trophic Box Based on the Army, EPA, and Shell Approaches

Rocky Mountain Arsenal
Prepared by: ENSERCH Environmental Corp



Legend

- EPA Approach
- Shell and EPA Approaches
- Army and Shell and EPA Approaches

Colors show which approaches result in HQ > 1 in the areas indicated

- Lake
- 31 Section Number
- Section Line

-N-

0 2000 4000

Scale in Feet

Prepared for:

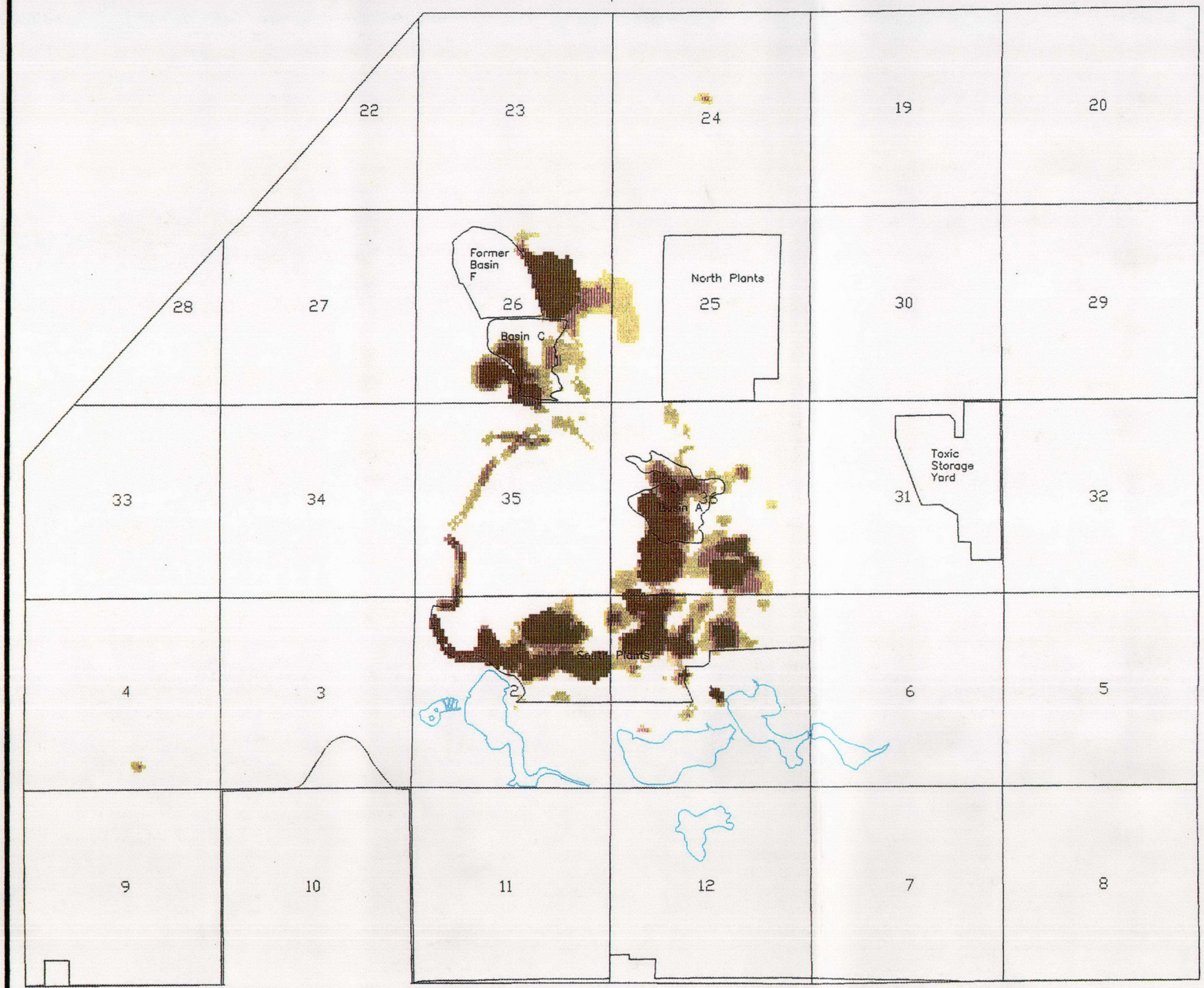
U.S. Army Program Manager
for Rocky Mountain Arsenal

February 1994

Figure C.3-30

Aldrin/Dieldrin Hazard Quotient Map (HQ>1) for the Small Mammal Trophic Box Based on the Army, EPA, and Shell Approaches

Rocky Mountain Arsenal
Prepared by: ENSERCH Environmental Corp



Legend

- EPA Approach
- Shell and EPA Approaches
- Army and Shell and EPA Approaches

Colors show which approaches result in HQ > 10 in the areas indicated

- Lake
- 31 Section Number
- Section Line

N

0 2000 4000

Scale in Feet

Prepared for:

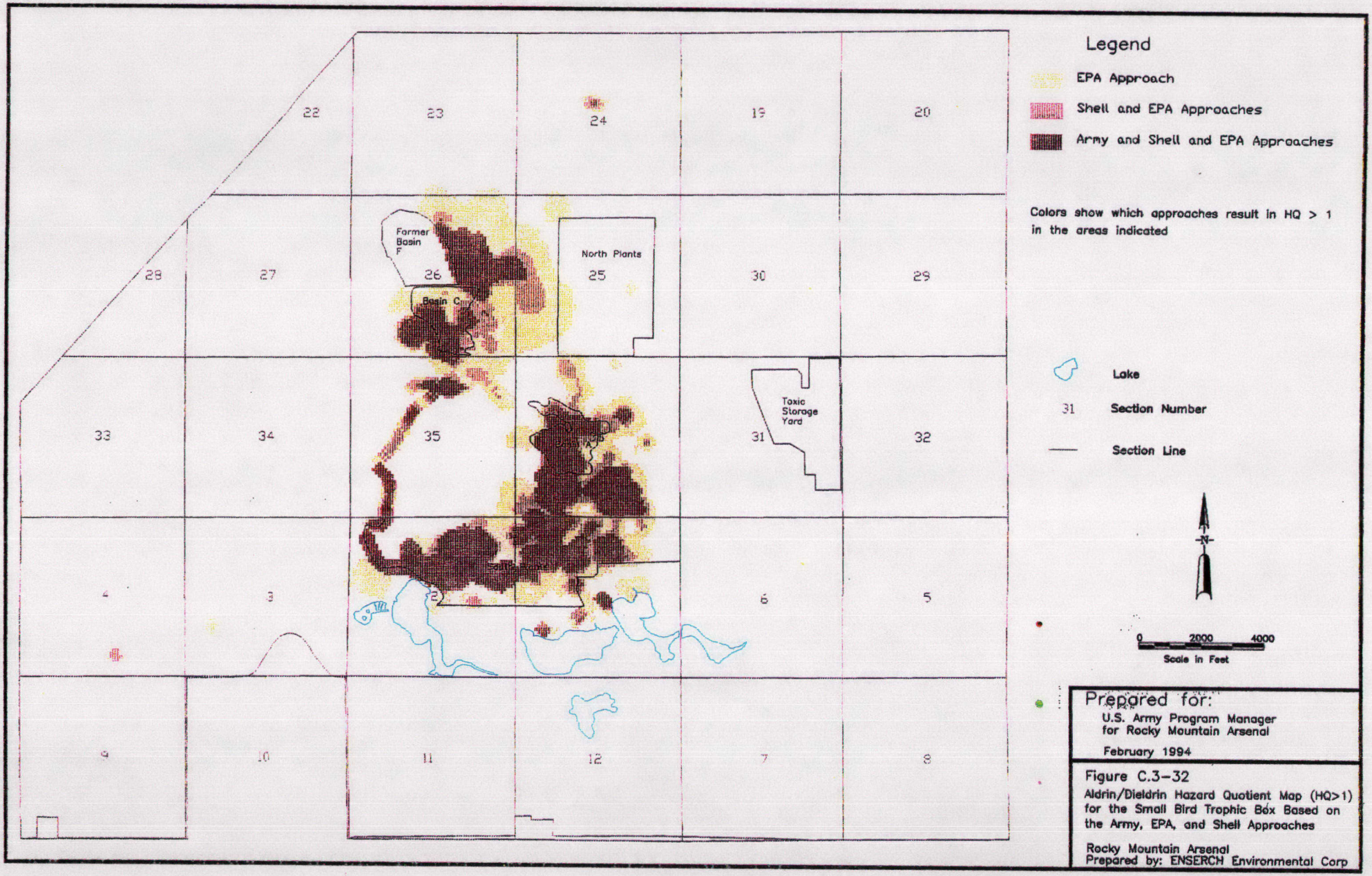
U.S. Army Program Manager
for Rocky Mountain Arsenal

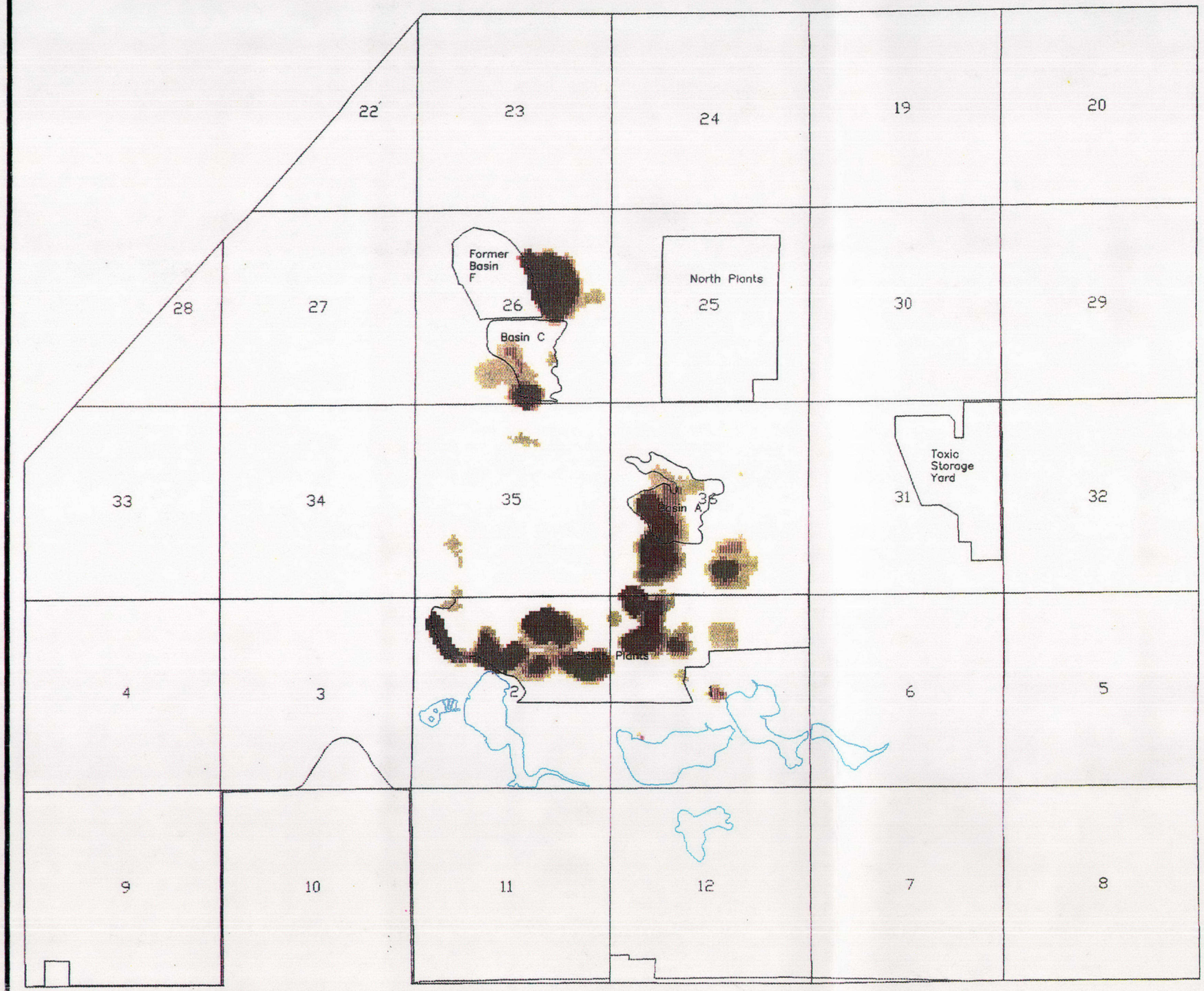
February 1994

Figure C.3-31

Aldrin/Dieldrin Hazard Quotient Map (HQ>10) for the Small Mammal Trophic Box Based on the Army, EPA, and Shell Approaches

Rocky Mountain Arsenal
Prepared by: ENSERCH Environmental Corp


Legend
EPA Approach
Shell and EPA Approaches
Army and Shell and EPA Approaches
Colors show which approaches result in HQ > 1 in the areas indicated
Lake
31 Section Number
Section Line
Former Basin F
Basin C
North Plants
Toxic Storage Yard
22
23
24
19
20
28
27
26
25
30
29
33
34
35
31
32
4
3
2
6
5
9
10
11
12
7
8
N
0
2000
4000
Scale in Feet
Prepared for:
U.S. Army Program Manager for Rocky Mountain Arsenal
February 1994
Figure C.3-32
Aldrin/Dieldrin Hazard Quotient Map (HQ>1) for the Small Bird Trophic Box Based on the Army, EPA, and Shell Approaches
Rocky Mountain Arsenal
Prepared by: ENSERCH Environmental Corp



Legend

- EPA Approach
- Shell and EPA Approaches
- Army and Shell and EPA Approaches

Colors show which approaches result in HQ > 10 in the areas indicated

- Lake
- 31 Section Number
- Section Line

N

0 2000 4000

Scale in Feet

Prepared for:

U.S. Army Program Manager
for Rocky Mountain Arsenal

February 1994

Figure C.3–33

Aldrin/Dieldrin Hazard Quotient Map (HQ>10) for the Small Bird Trophic Box Based on the Army, EPA, and Shell Approaches

Rocky Mountain Arsenal
Prepared by: ENSERCH Environmental Corp

Legend

- EPA Approach
- Shell and EPA Approaches
- Army and Shell and EPA Approaches

Colors show which approaches result in HQ > 1 in the areas indicated

- Lake
- 31 Section Number
- Section Line

N

0 2000 4000

Scale in Feet

Prepared for:

U.S. Army Program Manager
for Rocky Mountain Arsenal

February 1994

Figure C.3-34

Aldrin/Dieldrin Hazard Quotient Map (HQ>1) for the Shorebird Trophic Box Based on the Army, EPA, and Shell Approaches

Rocky Mountain Arsenal
Prepared by: ENSERCH Environmental Corp

Legend

- EPA Approach
- Shell and EPA Approaches
- Army and Shell and EPA Approaches

Colors show which approaches result in HQ > 10 in the areas indicated

- Lake
- 31 Section Number
- Section Line

-N-

0 2000 4000

Scale in Feet

Prepared for:

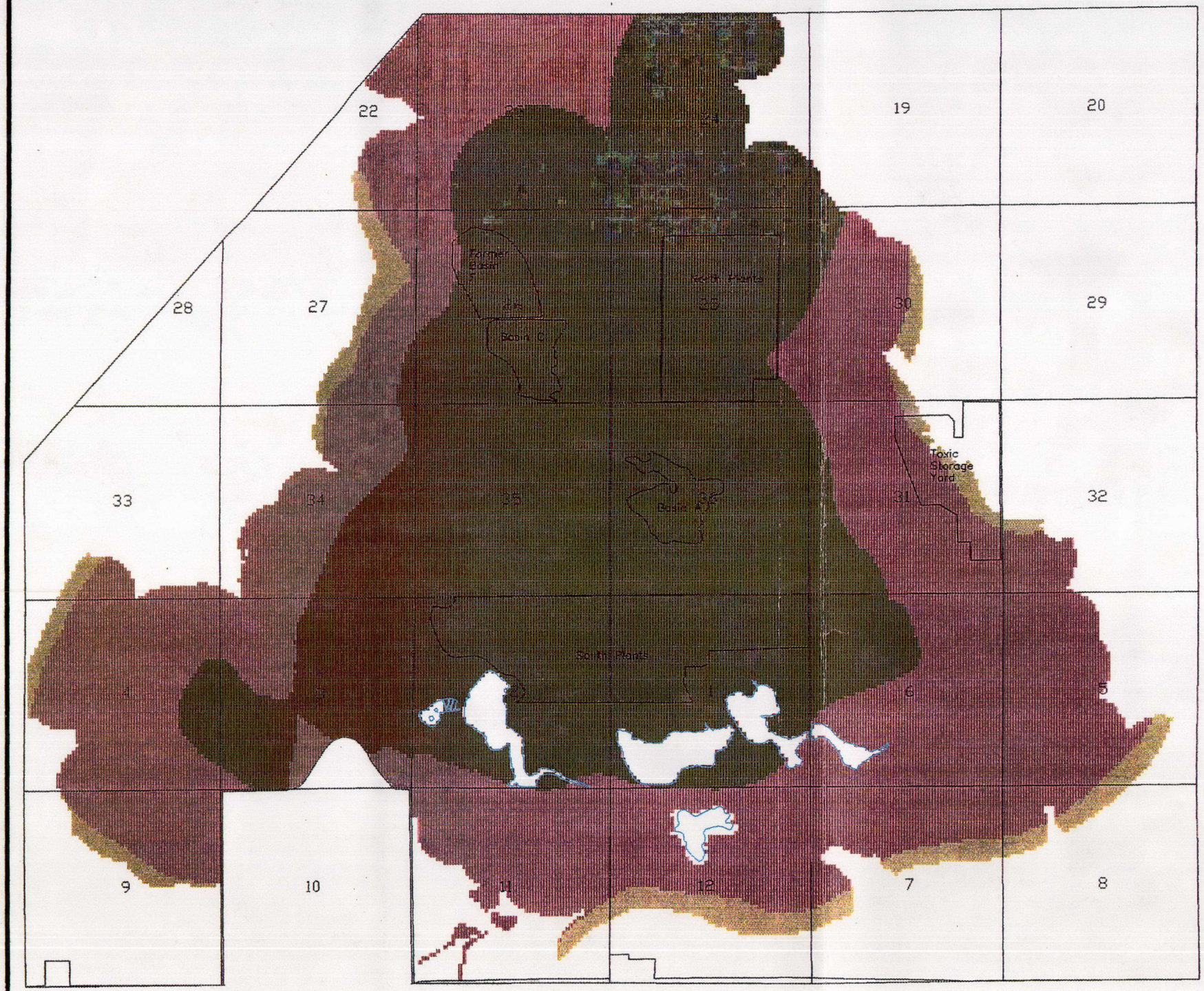
U.S. Army Program Manager
for Rocky Mountain Arsenal

February 1994

Figure C.3-35

Aldrin/Dieldrin Hazard Quotient Map (HQ>10) for the Shorebird Trophic Box Based on the Army, EPA, and Shell Approaches

Rocky Mountain Arsenal
Prepared by: ENSERCH Environmental Corp



Legend

- EPA Approach
- Shell and EPA Approaches
- Army and Shell and EPA Approaches

Colors show which approaches result in HQ > 1 in the areas indicated

- Lake
- 31 Section Number
- Section Line

N

0 2000 4000

Scale in Feet

Prepared for:

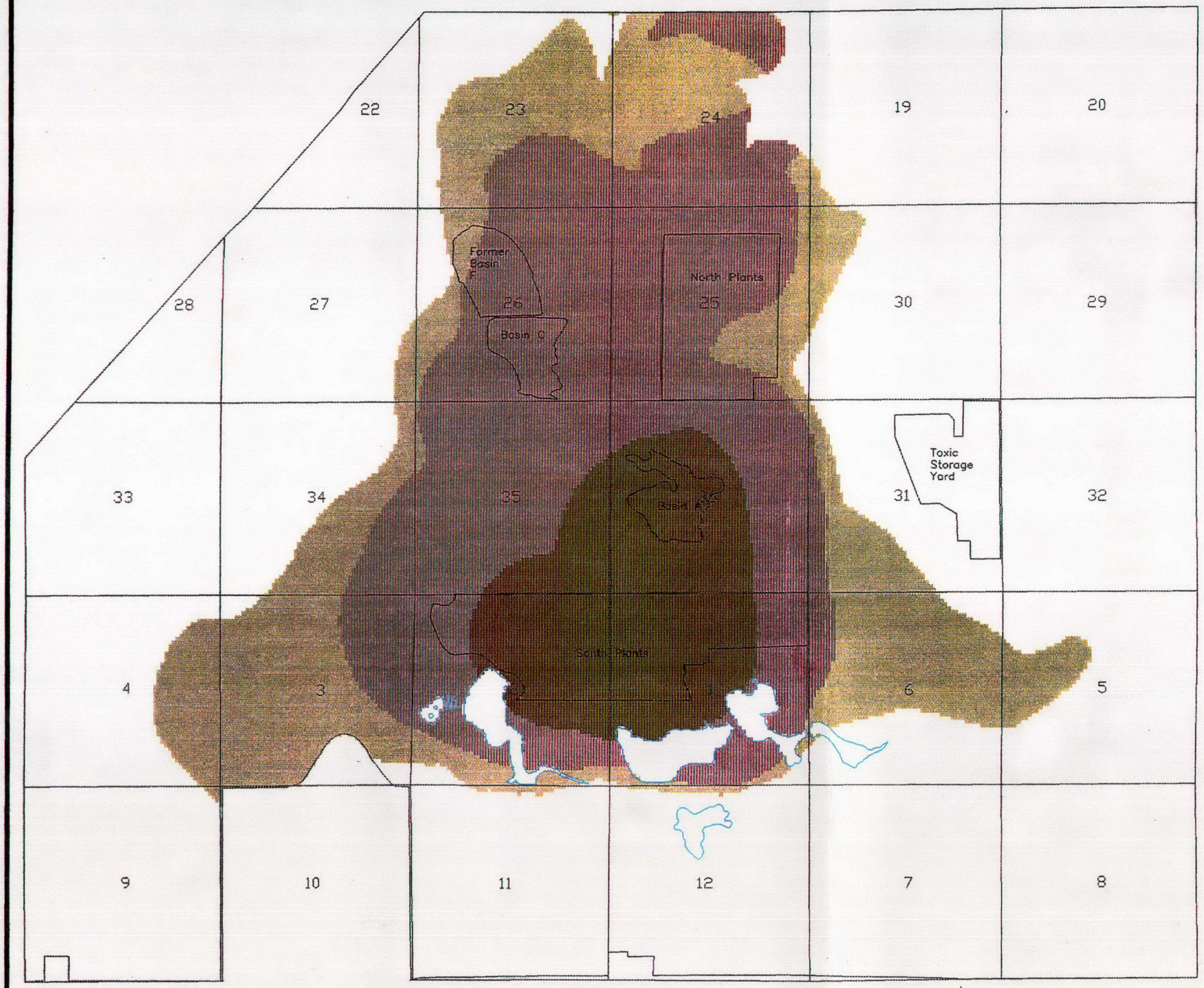
U.S. Army Program Manager
for Rocky Mountain Arsenal

February 1994

Figure C.3–36

DDT/DDE Hazard Quotient Map (HQ>1) for the Great Horned Owl Trophic Box Based on the Army, EPA, and Shell Approaches

Rocky Mountain Arsenal
Prepared by: ENSERCH Environmental Corp



Legend

- EPA Approach
- Shell and EPA Approaches
- Army and Shell and EPA Approaches

Colors show which approaches result in HQ > 10 in the areas indicated

- Lake
- 31 Section Number
- Section Line

-N-

0 2000 4000

Scale in Feet

Prepared for:

U.S. Army Program Manager
for Rocky Mountain Arsenal

February 1994

Figure C.3-37

DDT/DDE Hazard Quotient Map (HQ>10) for the Great Horned Owl Trophic Box Based on the Army, EPA, and Shell Approaches

Rocky Mountain Arsenal
Prepared by: ENSERCH Environmental Corp

Legend

- EPA Approach
- Shell and EPA Approaches
- Army and Shell and EPA Approaches

Colors show which approaches result in HQ > 1 in the areas indicated

- Lake
- 31 Section Number
- Section Line

N

0 2000 4000

Scale in Feet

Prepared for:

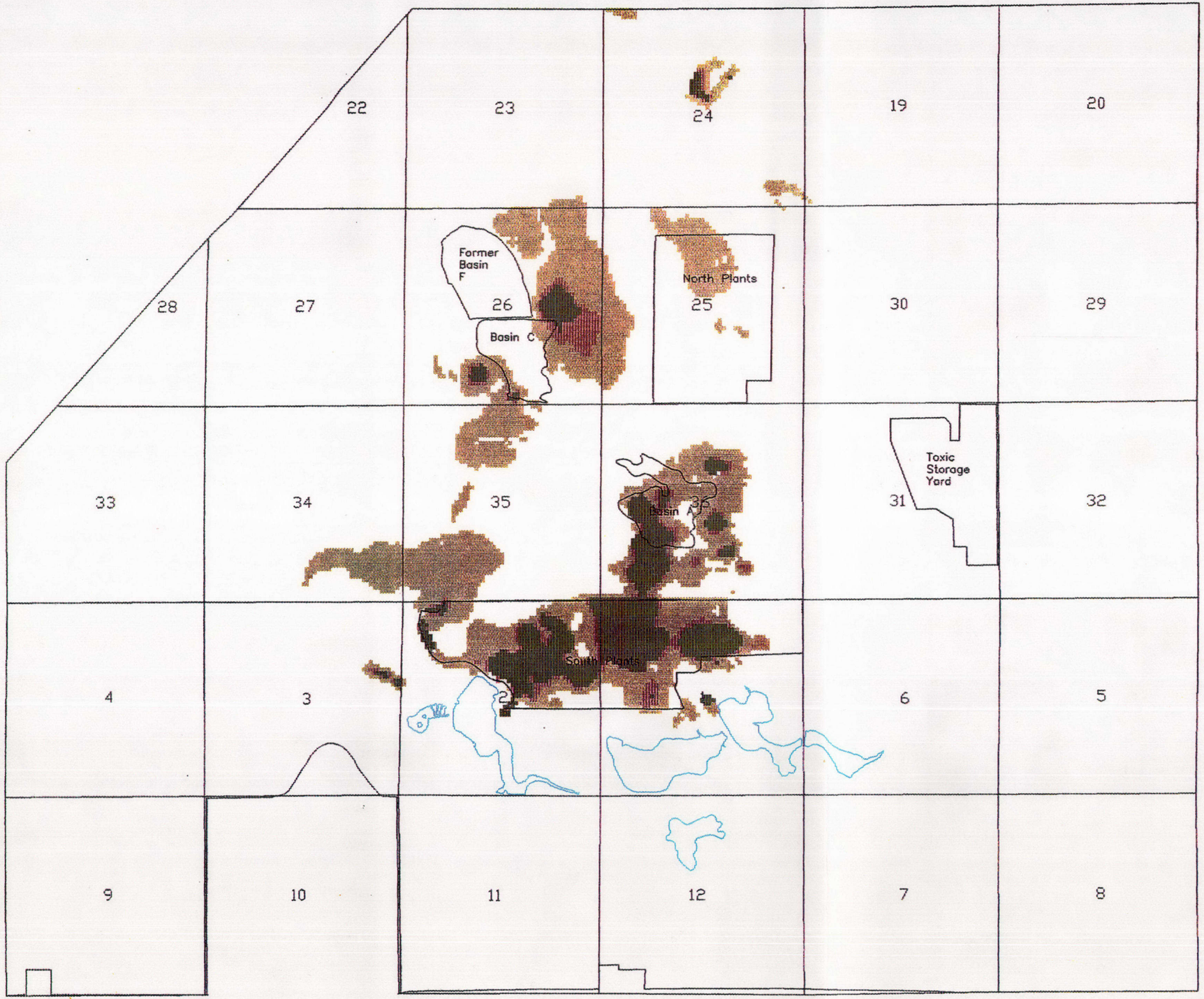
U.S. Army Program Manager
for Rocky Mountain Arsenal

February 1994

Figure C.3-38

DDT/DDE Hazard Quotient Map (HQ>1) for the American Kestrel Trophic Box Based on the Army, EPA, and Shell Approaches

Rocky Mountain Arsenal
Prepared by: ENSERCH Environmental Corp



Legend

- EPA Approach
- Shell and EPA Approaches
- Army and Shell and EPA Approaches

Colors show which approaches result in HQ > 1 in the areas indicated

- Lake
- 31 Section Number
- Section Line

-N-

0 2000 4000

Scale in Feet

Prepared for:

U.S. Army Program Manager for Rocky Mountain Arsenal

February 1994

Figure C.3-39

DDT/DDE Hazard Quotient Map (HQ>1) for the Medium Mammal Trophic Box Based on the Army, EPA, and Shell Approaches

Rocky Mountain Arsenal

Prepared by: ENSERCH Environmental Corp

Legend

- EPA Approach
- Shell and EPA Approaches
- Army and Shell and EPA Approaches

Colors show which approaches result in HQ > 10 in the areas indicated

- Lake
- 31 Section Number
- Section Line

-N-

0 2000 4000

Scale in Feet

Prepared for:

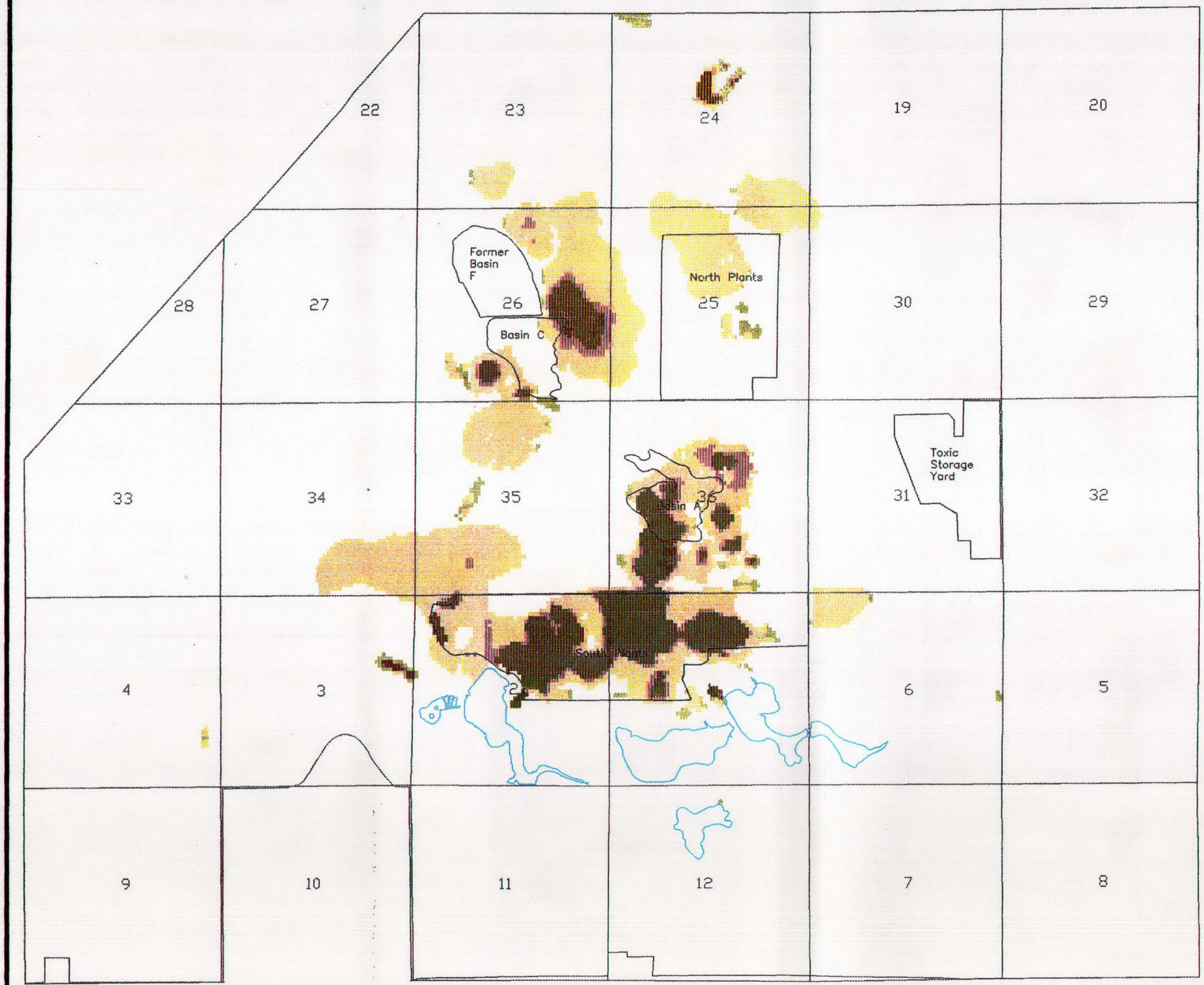
U.S. Army Program Manager
for Rocky Mountain Arsenal

February 1994

Figure C.3–40

DDT/DDE Hazard Quotient Map (HQ>10) for the Medium Mammal Trophic Box Based on the Army, EPA, and Shell Approaches

Rocky Mountain Arsenal
Prepared by: ENSERCH Environmental Corp



Legend

- EPA Approach
- Shell and EPA Approaches
- Army and Shell and EPA Approaches

Colors show which approaches result in HQ > 1 in the areas indicated

Lake

31 Section Number

Section Line

-N-

0 2000 4000

Scale in Feet

Prepared for:
U.S. Army Program Manager
for Rocky Mountain Arsenal

February 1994

Figure C.3-41

DDT/DDE Hazard Quotient Map (HQ>1) for the Small Mammal Trophic Box Based on the Army, EPA, and Shell Approaches

Rocky Mountain Arsenal
Prepared by: ENSERCH Environmental Corp

Legend

- EPA Approach
- Shell and EPA Approaches
- Army and Shell and EPA Approaches

Colors show which approaches result in HQ > 10 in the areas indicated

- Lake
- 31 Section Number
- Section Line

N

0 2000 4000

Scale in Feet

Prepared for:

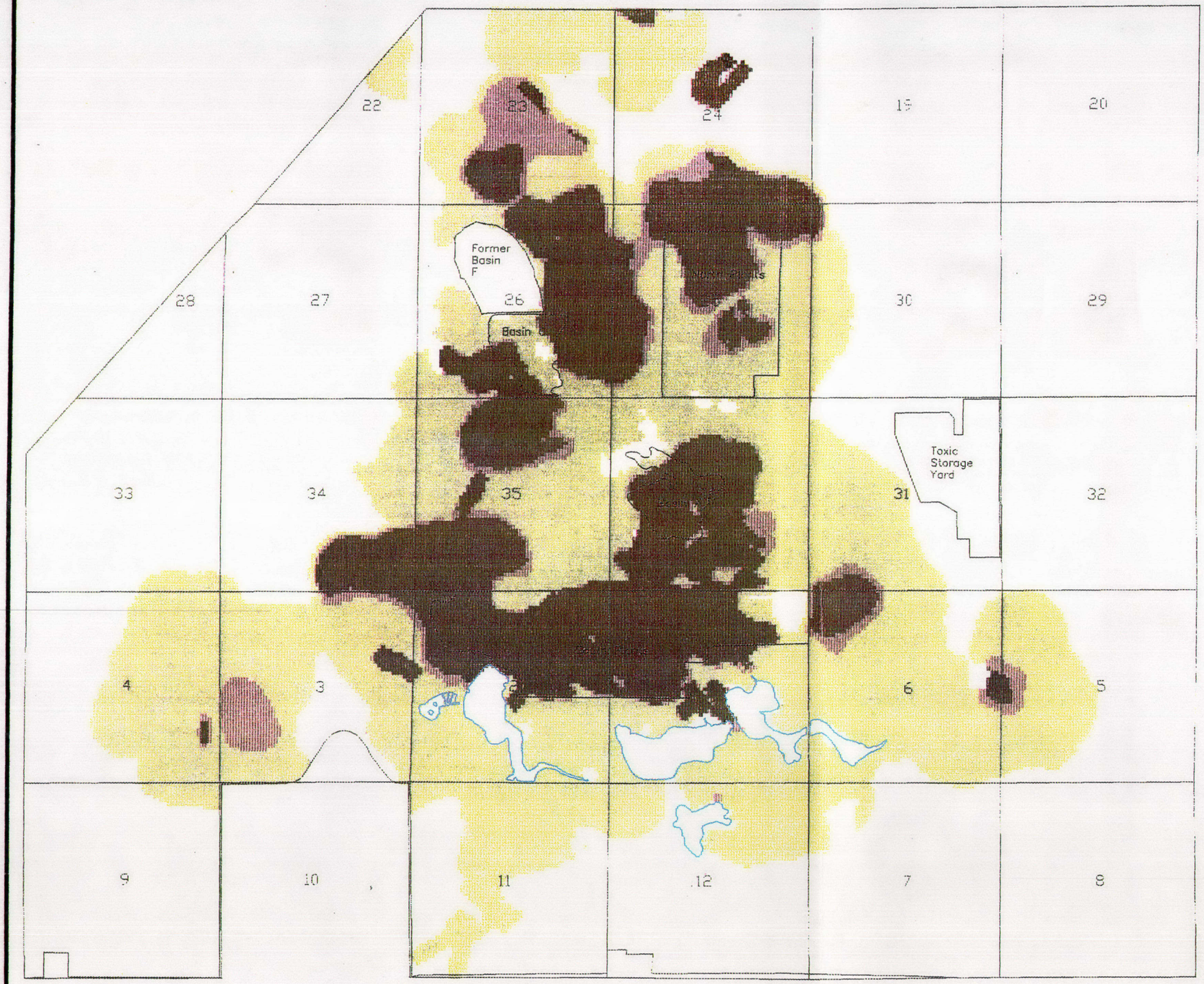
U.S. Army Program Manager
for Rocky Mountain Arsenal

February 1994

Figure C.3–42

DDT/DDE Hazard Quotient Map (HQ>10) for the Small Mammal Trophic Box Based on the Army, EPA, and Shell Approaches

Rocky Mountain Arsenal
Prepared by: ENSERCH Environmental Corp



Legend

- EPA Approach
- Shell and EPA Approaches
- Army and Shell and EPA Approaches

Colors show which approaches result in HQ > 1 in the areas indicated

- Lake
- 31 Section Number
- Section Line

-N-

0 2000 4000
Scale in Feet

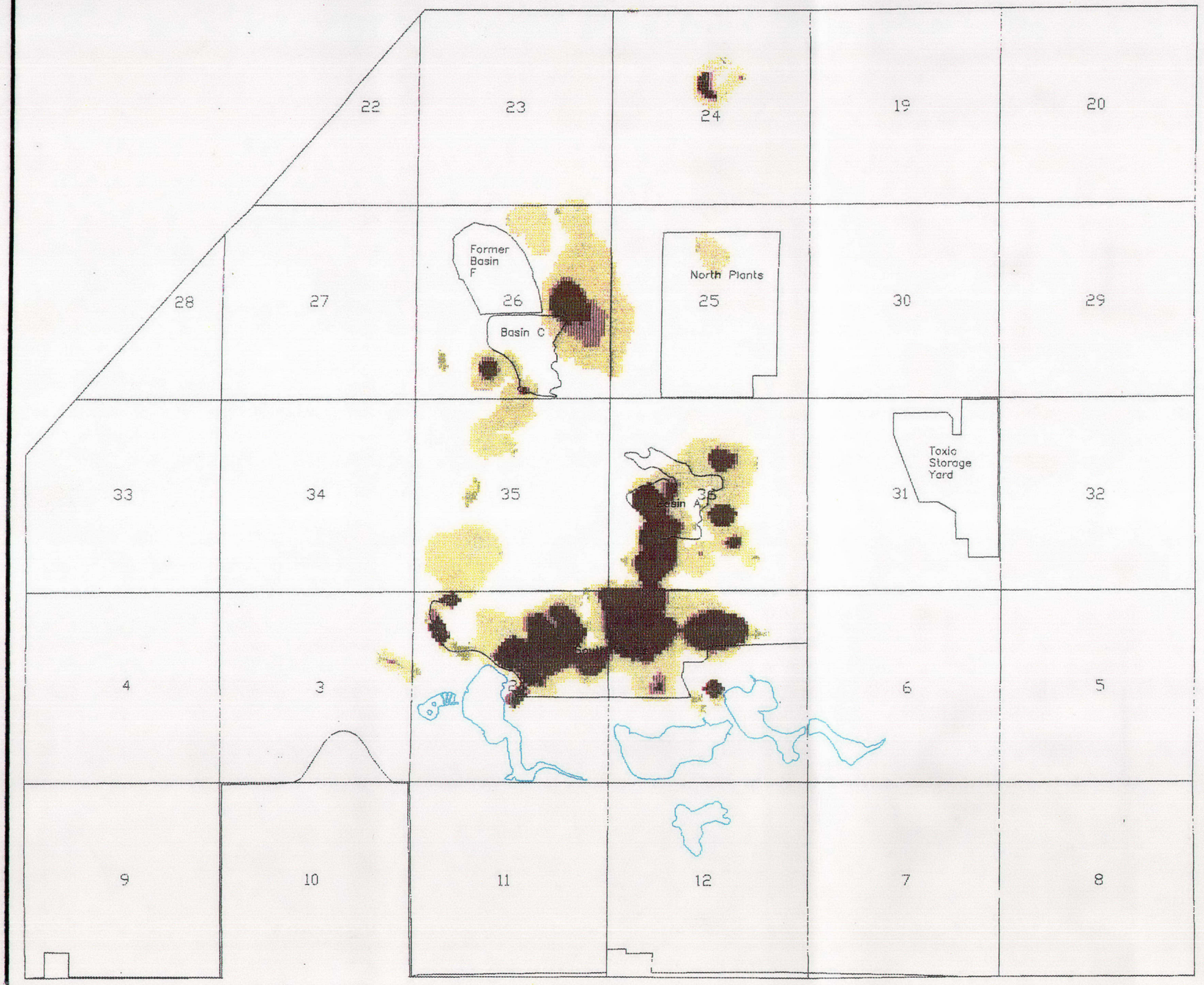
Prepared for:
U.S. Army Program Manager
for Rocky Mountain Arsenal

February 1994

Figure C.3–43

DDT/DDE Hazard Quotient Map (HQ>1) for the Small Bird Trophic Box Based on the Army, EPA, and Shell Approaches

Rocky Mountain Arsenal
Prepared by: ENSERCH Environmental Corp



Legend

- EPA Approach
- Shell and EPA Approaches
- Army and Shell and EPA Approaches

Colors show which approaches result in HQ > 10 in the areas indicated

- Lake
- 31 Section Number
- Section Line

-N-

0 2000 4000

Scale in Feet

Prepared for:

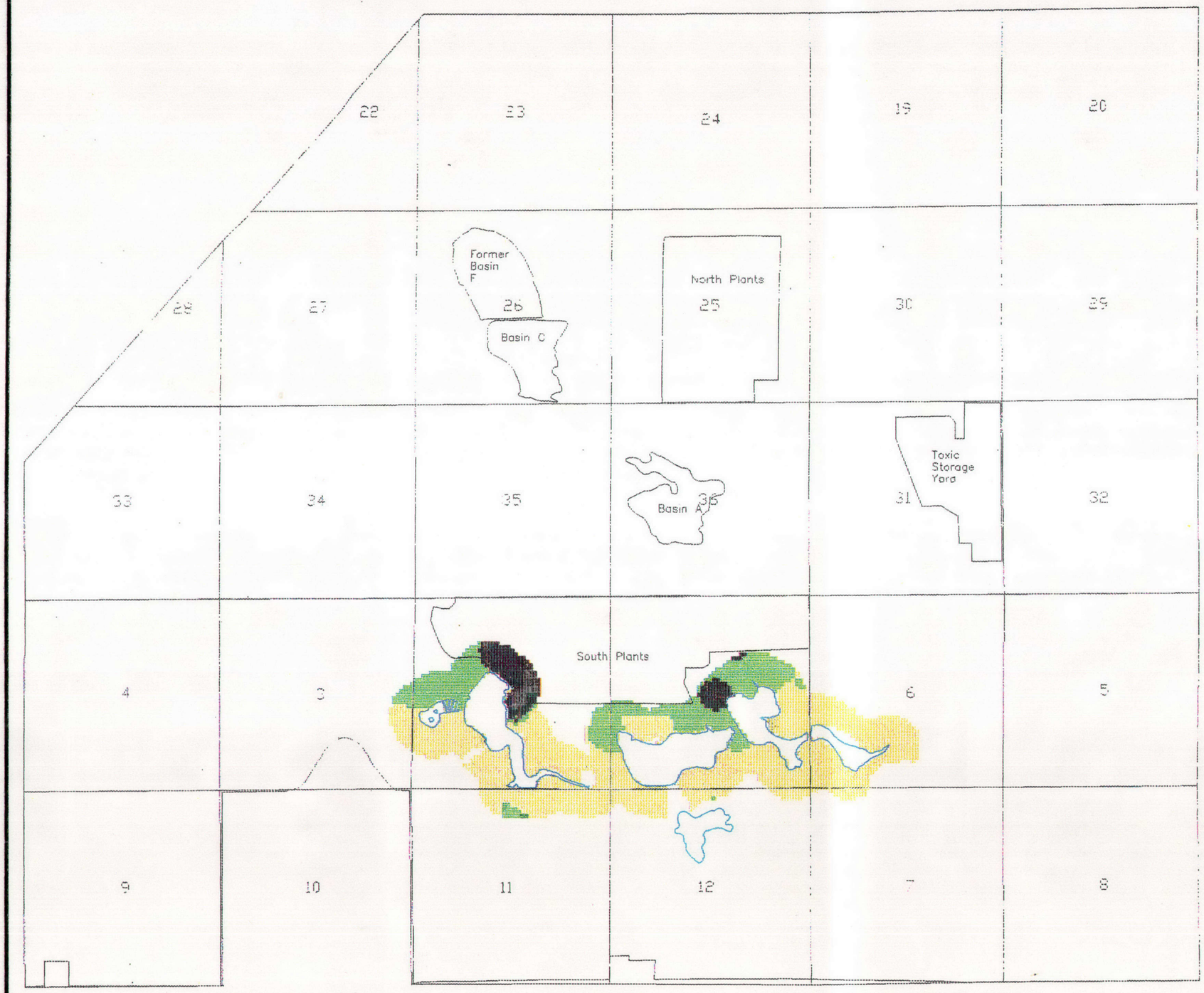
U.S. Army Program Manager
for Rocky Mountain Arsenal

February 1994

Figure C.3–44

DDT/DDE Hazard Quotient Map (HQ>10) for the Small Bird Trophic Box Based on the Army, EPA, and Shell Approaches

Rocky Mountain Arsenal
Prepared by: ENSERCH Environmental Corp



Legend

- EPA Approach
- Army and EPA Approaches
- Army and Shell and EPA Approaches

Colors show which approaches result in HQ > 1 in the areas indicated

- Lake
- 31 Section Number
- Section Line

-N-

0 2000 4000

Scale in Feet

Prepared for:

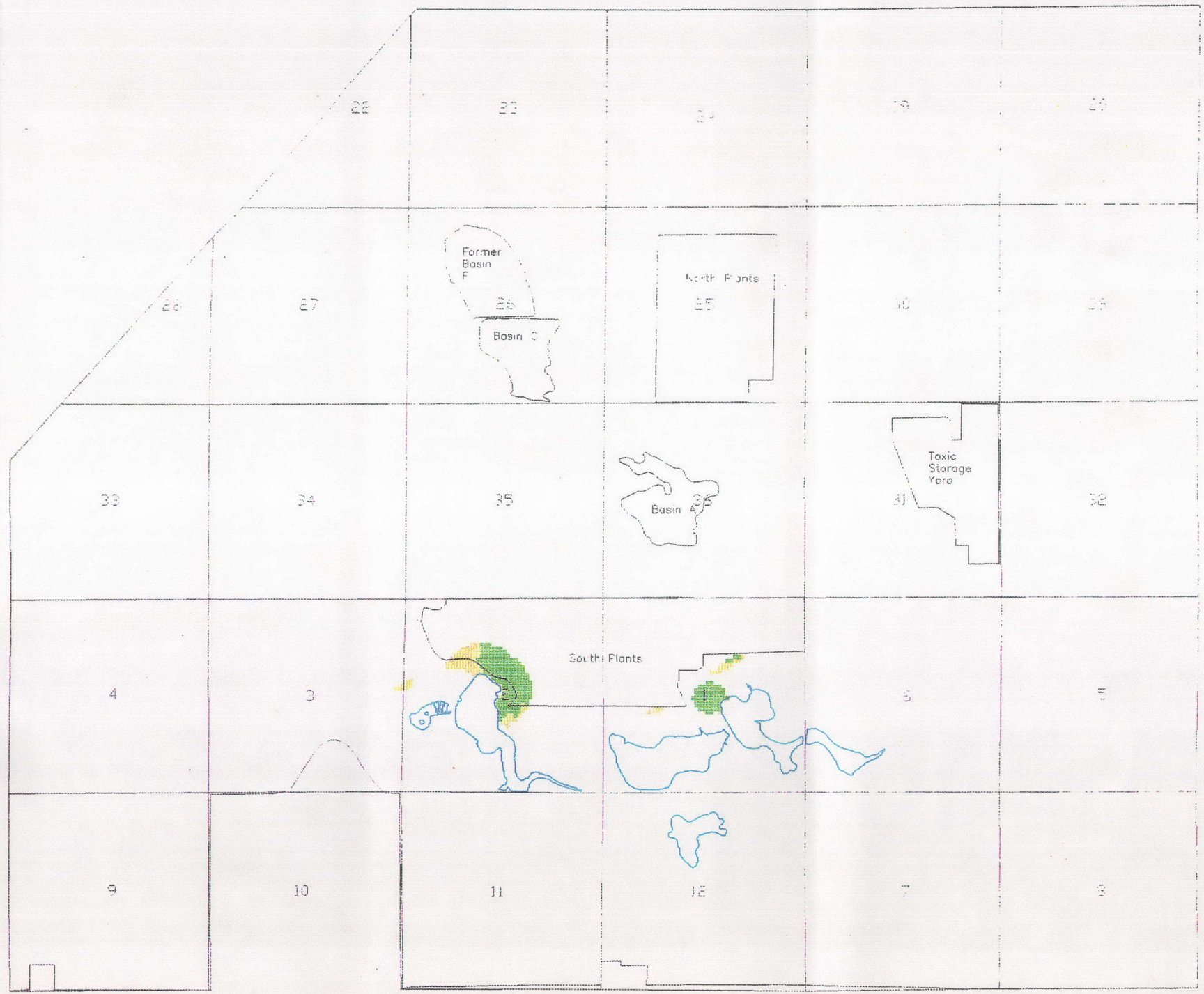
U.S. Army Program Manager
for Rocky Mountain Arsenal

February 1994

Figure C.3-45

DDT/DDE Hazard Quotient Map (HQ>1) for the Shorebird Trophic Box Based on the Army, EPA, and Shell Approaches

Rocky Mountain Arsenal
Prepared by: ENSERCH Environmental Corp



Legend

EPA Approach

Army and EPA Approaches

Colors show which approaches result in HQ > 10 in the areas indicated

Lake

31 Section Number

Section Line

-N-

0 2000 4000

Scale in Feet

Prepared for:

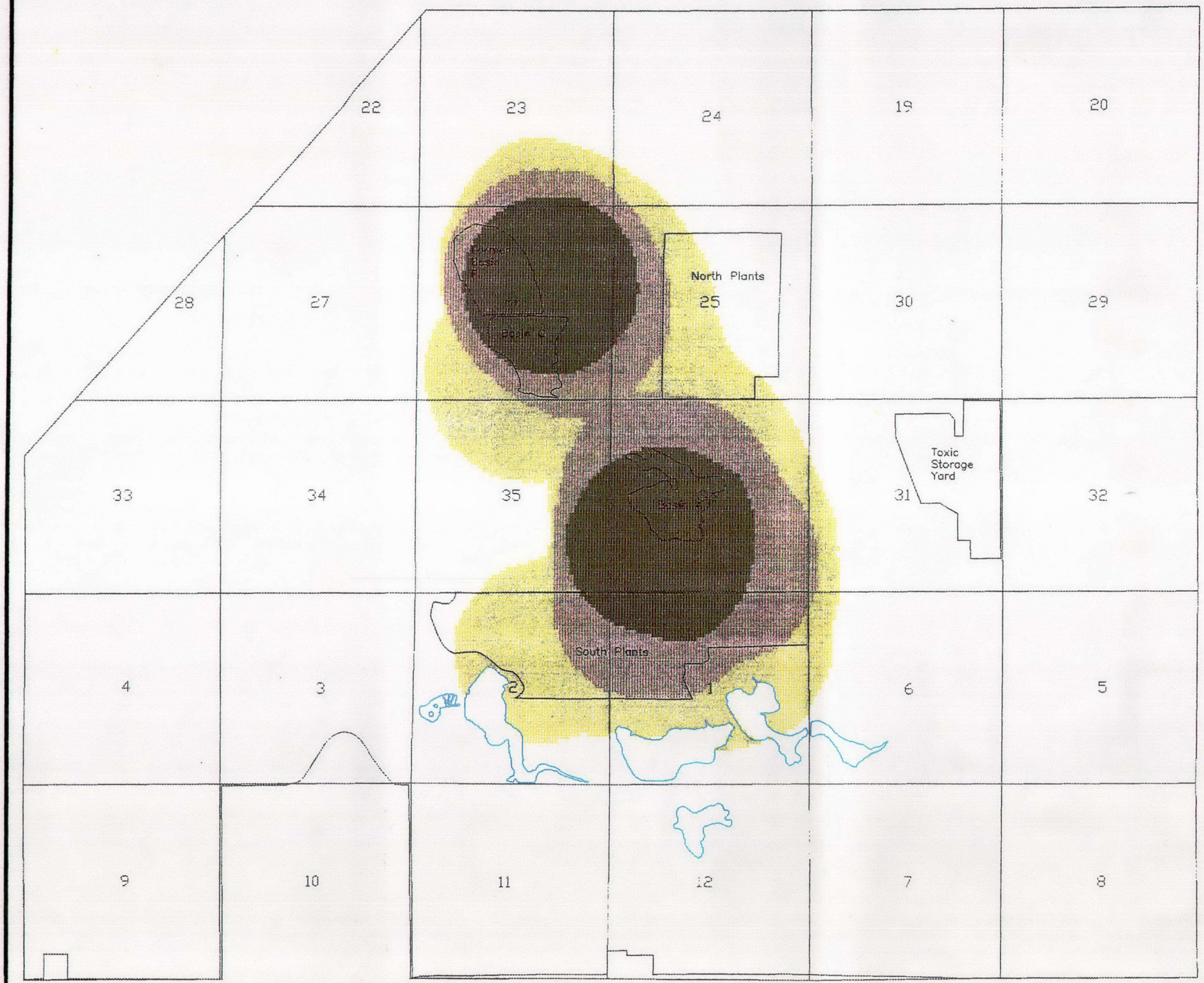
U.S. Army Program Manager
for Rocky Mountain Arsenal

February 1994

Figure C.3–46

DDT/DDE Hazard Quotient Map (HQ>10) for the Shorebird Trophic Box Based on the Army, EPA, and Shell Approaches

Rocky Mountain Arsenal
Prepared by: ENSERCH Environmental Corp



Legend

- EPA Approach
- Shell and EPA Approaches
- Army and Shell and EPA Approaches

Colors show which approaches result in HQ > 1 in the areas indicated

- Lake
- 31 Section Number
- Section Line

-N-

0 2000 4000

Scale in Feet

Prepared for:

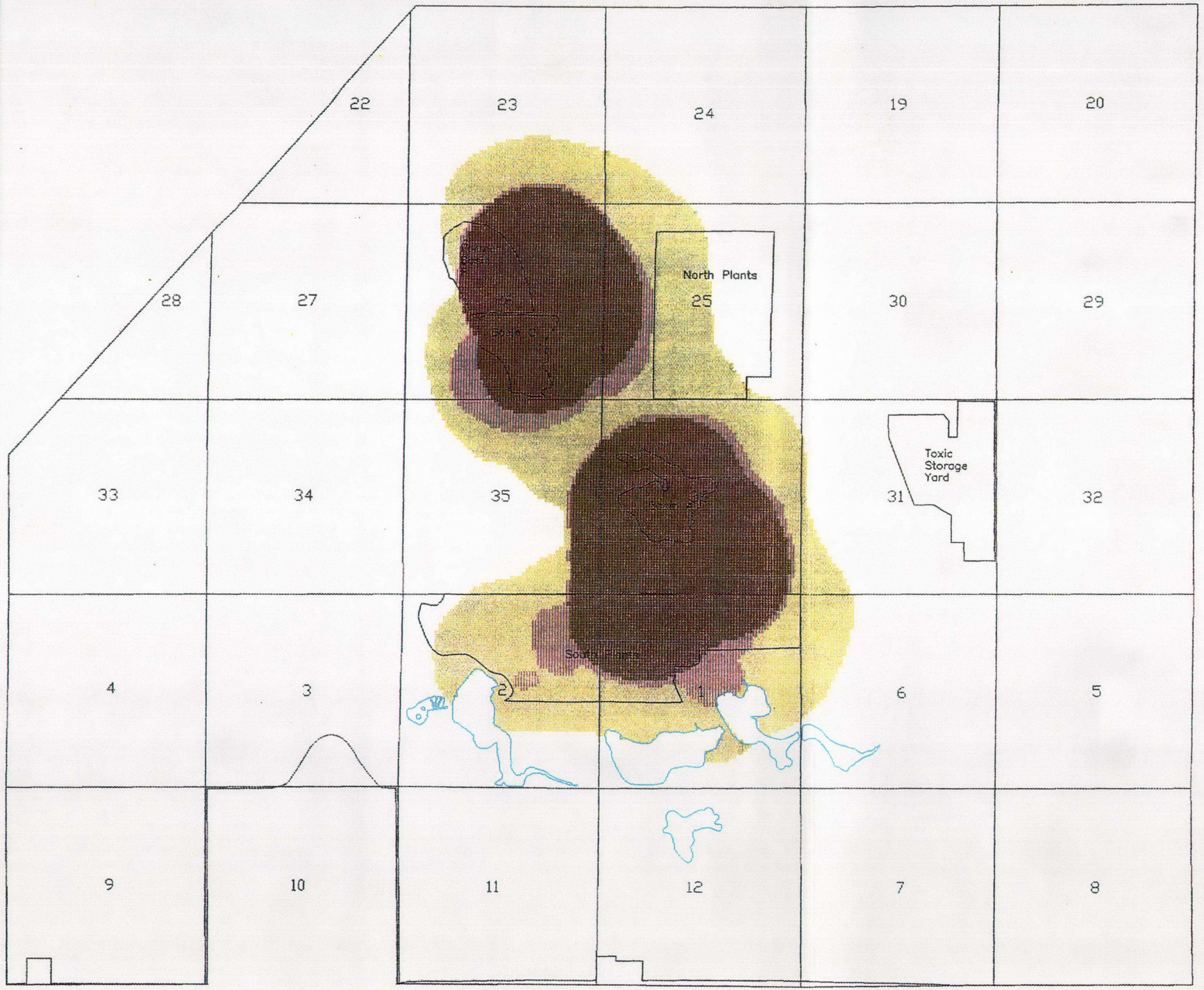
U.S. Army Program Manager
for Rocky Mountain Arsenal

February 1994

Figure C.3-47

Endrin Hazard Quotient Map (HQ>1) for the Great Horned Owl Trophic Box Based on the Army, EPA, and Shell Approaches

Rocky Mountain Arsenal
Prepared by: ENSERCH Environmental Corp



Legend

- EPA Approach
- Shell and EPA Approaches
- Army and Shell and EPA Approaches

Colors show which approaches result in HQ > 1 in the areas indicated

Lake

31 Section Number

Section Line

N

0 2000 4000

Scale in Feet

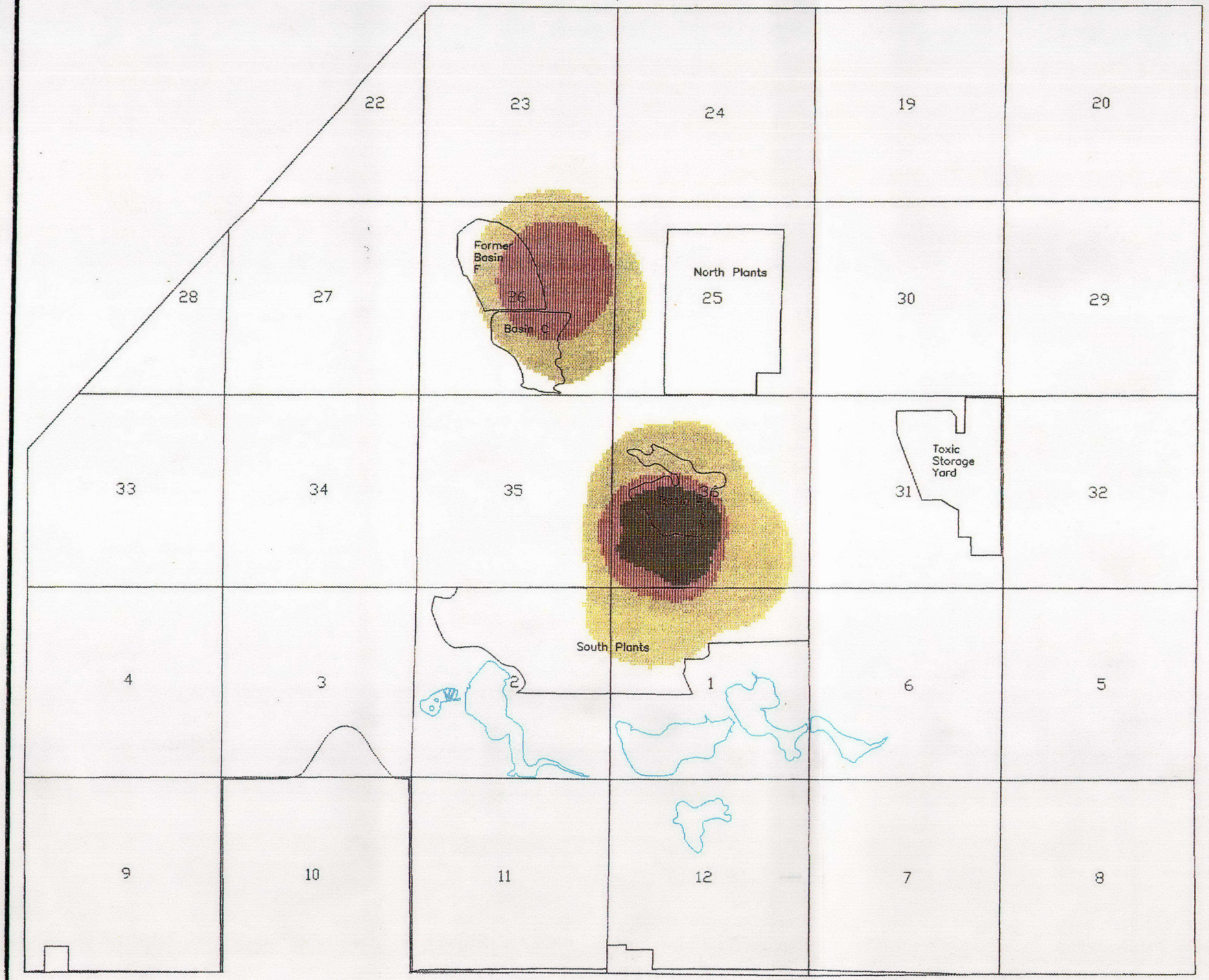
Prepared for:
U.S. Army Program Manager
for Rocky Mountain Arsenal

February 1994

Figure C.3–48

Endrin Hazard Quotient Map (HQ>1) for the American Kestrel Trophic Box Based on the Army, EPA, and Shell Approaches

Rocky Mountain Arsenal
Prepared by: ENSERCH Environmental Corp



Legend

- EPA Approach
- Shell and EPA Approaches
- Army and Shell and EPA Approaches

Colors show which approaches result in HQ > 10 in the areas indicated

Lake

31 Section Number

Section Line

N

0 2000 4000

Scale in Feet

Prepared for:

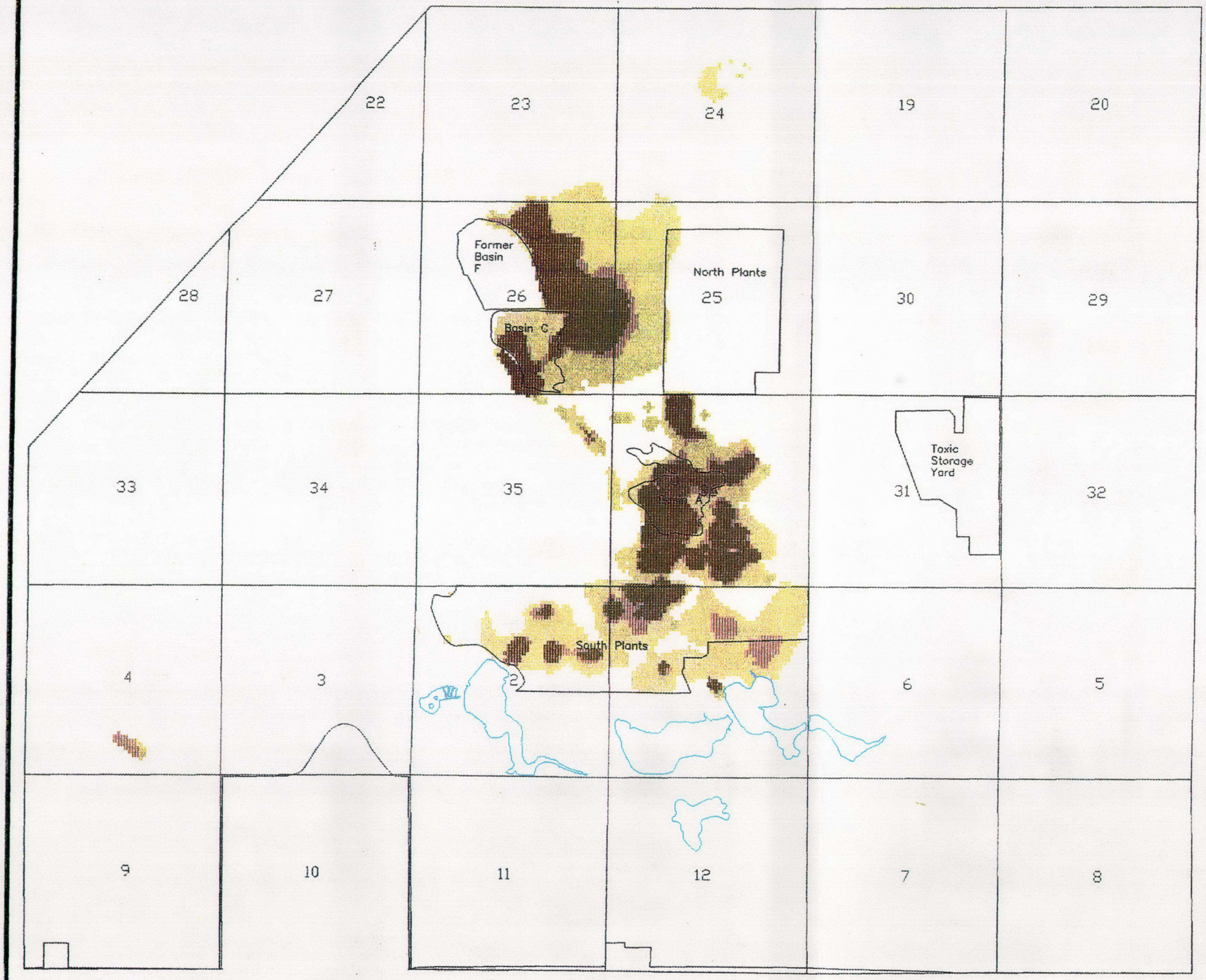
U.S. Army Program Manager
for Rocky Mountain Arsenal

February 1994

Figure C.3–49

Endrin Hazard Quotient Map (HQ>10) for the American Kestrel Trophic Box Based on the Army, EPA, and Shell Approaches

Rocky Mountain Arsenal
Prepared by: ENSERCH Environmental Corp



Legend

- EPA Approach
- Shell and EPA Approaches
- Army and Shell and EPA Approaches

Colors show which approaches result in HQ > 1 in the areas indicated

- Lake
- 31 Section Number
- Section Line

-N-

0 2000 4000

Scale in Feet

Prepared for:
U.S. Army Program Manager
for Rocky Mountain Arsenal

February 1994

Figure C.3–50
Endrin Hazard Quotient Map (HQ>1) for the Medium Mammal Trophic Box Based on the Army, EPA, and Shell Approaches

Rocky Mountain Arsenal
Prepared by: ENSERCH Environmental Corp

22 23 24 19 20

28 27 26 25 30 29

33 34 35 36 31 32

4 3 2 1 6 5

9 10 11 12 7 8

Former Basin F

Basin C

North Plants

Basin A

Toxic Storage Yard

South Plants

Legend

EPA Approach

Shell and EPA Approaches

Army and Shell and EPA Approaches

Colors show which approaches result in HQ > 10 in the areas indicated

Lake

31 Section Number

Section Line

-N-

0 2000 4000

Scale in Feet

Prepared for:

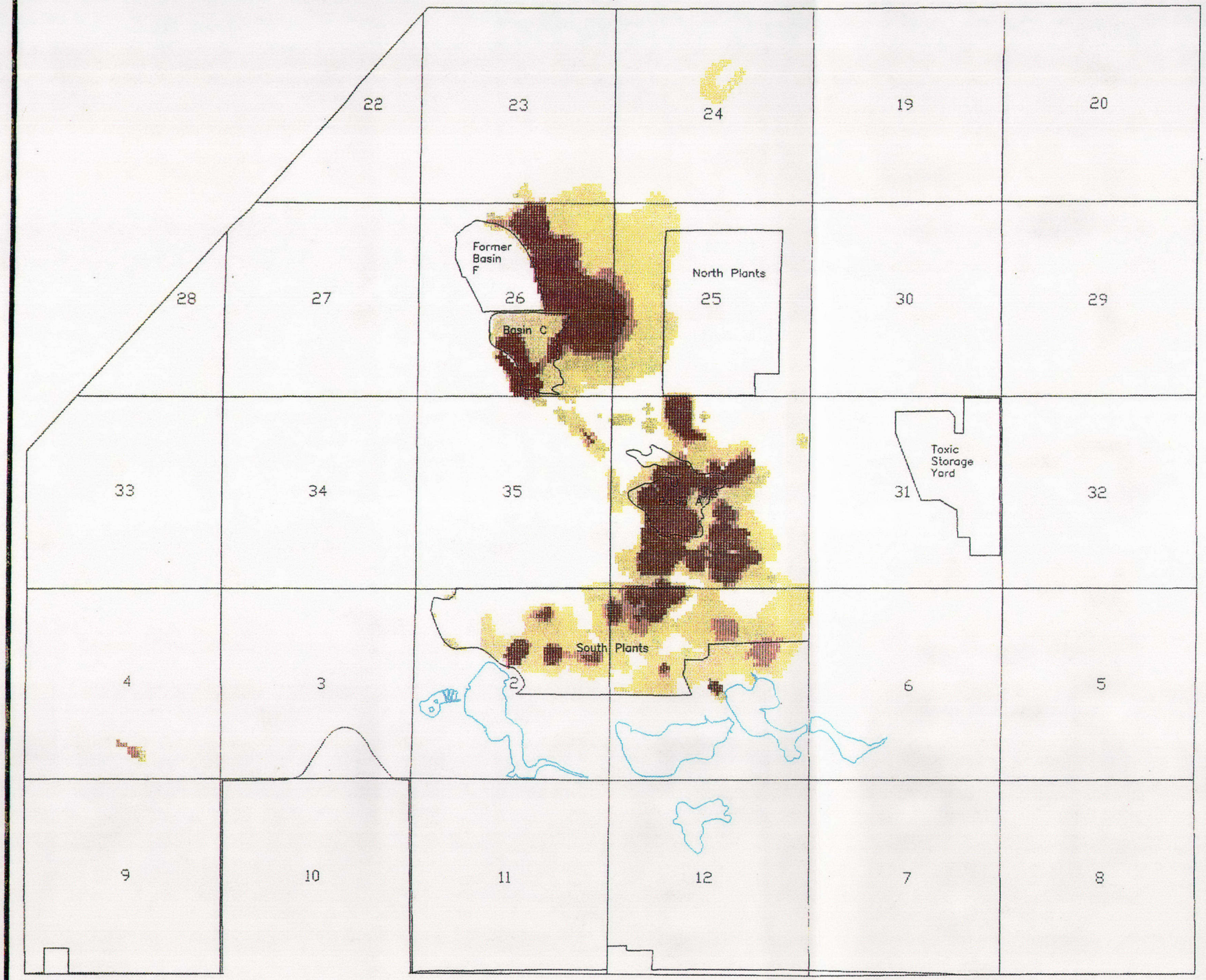
U.S. Army Program Manager
for Rocky Mountain Arsenal

February 1994

Figure C.3-51

Endrin Hazard Quotient Map (HQ>10) for for the Medium Mammal Trophic Box Based on the Army, EPA, and Shell Approaches

Rocky Mountain Arsenal
Prepared by: ENSERCH Environmental Corp



Legend

- EPA Approach
- Shell and EPA Approaches
- Army and Shell and EPA Approaches

Colors show which approaches result in HQ > 1 in the areas indicated

- Lake
- 31 Section Number
- Section Line

-N-

0 2000 4000

Scale in Feet

Prepared for:
U.S. Army Program Manager
for Rocky Mountain Arsenal

February 1994

Figure C.3–52
Endrin Hazard Quotient Map (HQ>1) for the Small Mammal Trophic Box Based on the Army, EPA, and Shell Approaches

Rocky Mountain Arsenal
Prepared by: ENSERCH Environmental Corp

22 23 24 19 20

28 27 26 25 30 29

33 34 35 31 32

4 3 2 1 6 5

9 10 11 12 7 8

Former Basin F

Basin C

North Plants

Basin A

Toxic Storage Yard

South Plants

Legend

- EPA Approach
- Shell and EPA Approaches
- Army and Shell and EPA Approaches

Colors show which approaches result in HQ > 10 in the areas indicated

- Lake
- 31 Section Number
- Section Line

N

0 2000 4000

Scale in Feet

Prepared for:

U.S. Army Program Manager
for Rocky Mountain Arsenal

February 1994

Figure C.3-53

Endrin Hazard Quotient Map (HQ>10) for the Small Mammal Trophic Box Based on the Army, EPA, and Shell Approaches

Rocky Mountain Arsenal
Prepared by: ENSERCH Environmental Corp

22 23 24 19 20

28 27 26 25 30 29

33 34 35 31 32

4 3 2 6 5

9 10 11 12 7 8

Former Basin F

Basin C

North Plants

Basin A

Toxic Storage Yard

South Plants

Legend

- Army Approach
- EPA Approach
- Army and EPA Approaches
- Shell and EPA Approaches
- Army and Shell and EPA Approaches

Colors show which approaches result in HQ > 1 in the areas indicated

Lake

31 Section Number

Section Line

N

0 2000 4000

Scale in Feet

Prepared for:

U.S. Army Program Manager for Rocky Mountain Arsenal

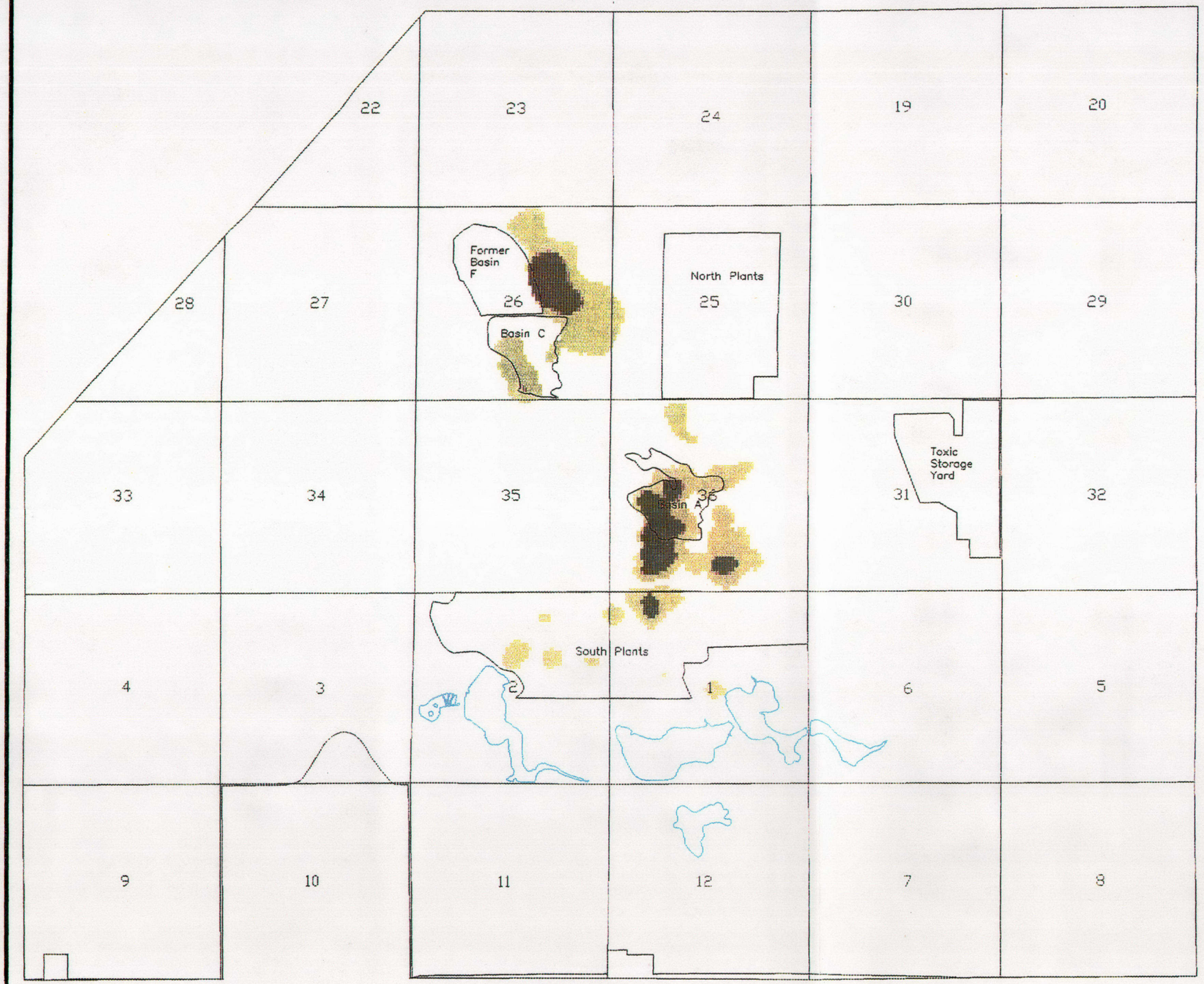
February 1994

Figure C.3–54

Endrin Hazard Quotient Map (HQ>1) for the Small Bird Trophic Box Based on the Army, EPA, and Shell Approaches

Rocky Mountain Arsenal

Prepared by: ENSERCH Environmental Corp



Legend

- EPA Approach
- Shell and EPA Approaches
- Army and Shell and EPA Approaches

Colors show which approaches result in HQ > 10 in the areas indicated

Lake

31 Section Number

Section Line

N

0 2000 4000

Scale in Feet

Prepared for:

U.S. Army Program Manager
for Rocky Mountain Arsenal

February 1994

Figure C.3-55

Endrin Hazard Quotient Map (HQ>10) for the Small Bird Trophic Box Based on the Army, EPA, and Shell Approaches

Rocky Mountain Arsenal
Prepared by: ENSERCH Environmental Corp

Legend

- EPA Approach
- Army and EPA Approaches
- Army and Shell and EPA Approaches

Colors show which approaches result in HQ > 1 in the areas indicated

- Lake
- 31 Section Number
- Section Line

N

0 2000 4000

Scale in Feet

Prepared for:

U.S. Army Program Manager
for Rocky Mountain Arsenal

February 1994

Figure C.3-56

Endrin Hazard Quotient Map (HQ>1) for the Shorebird Trophic Box Based on the Army, EPA, and Shell Approaches

Rocky Mountain Arsenal
Prepared by: ENSERCH Environmental Corp

Legend

- EPA Approach
- Army and EPA Approaches

Colors show which approaches result in HQ > 10 in the areas indicated

- Lake
- 31 Section Number
- Section Line

-N-

0 2000 4000

Scale in Feet

Prepared for:

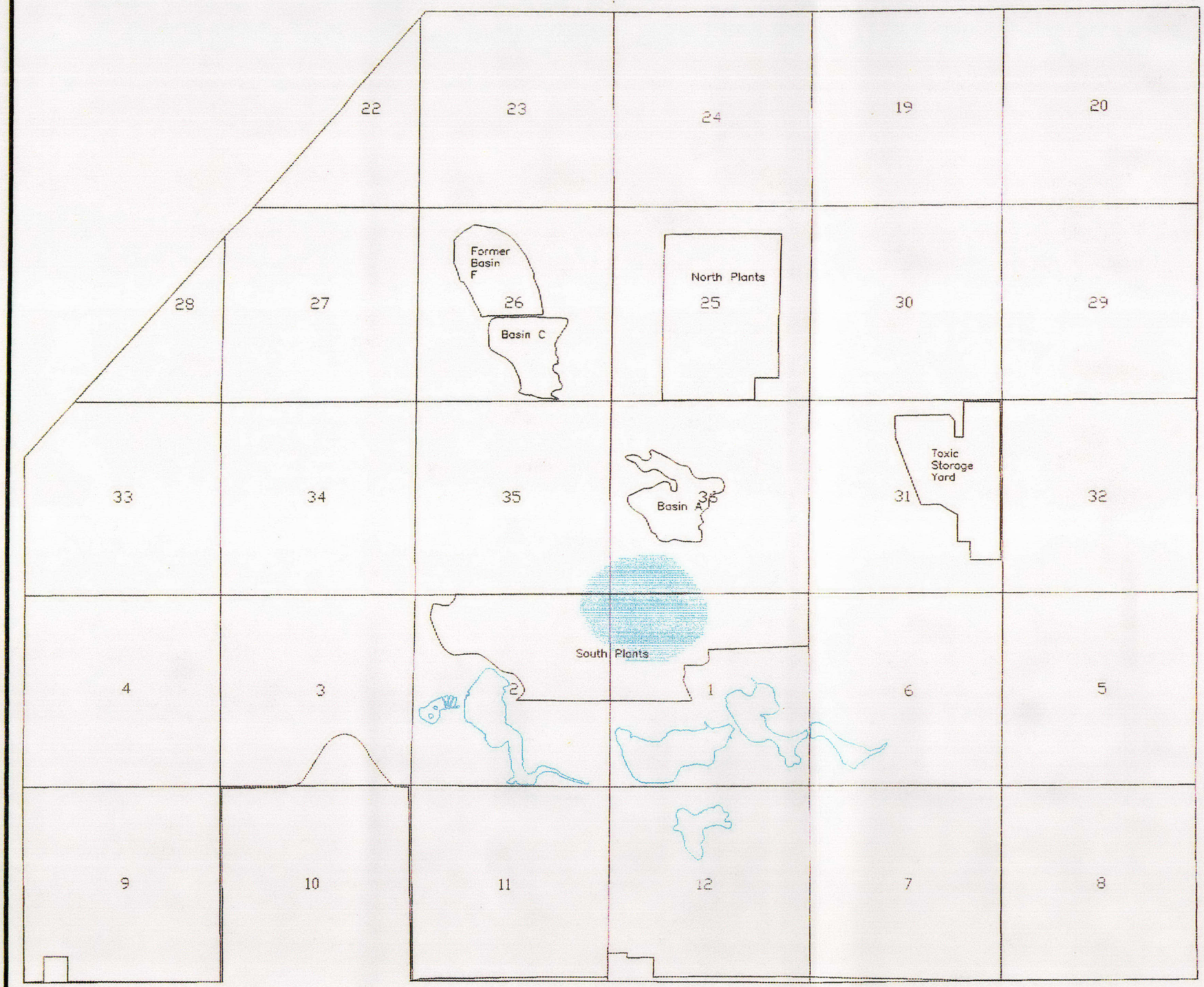
U.S. Army Program Manager
for Rocky Mountain Arsenal

February 1994

Figure C.3–57

Endrin Hazard Quotient Map (HQ>10) for the Shorebird Trophic Box Based on the Army, EPA, and Shell Approaches

Rocky Mountain Arsenal
Prepared by: ENSERCH Environmental Corp



Legend

Hazard Quotient Values

1 – 10

> 10

Lake

31 Section Number

Section Line

N

0 2000 4000

Scale in Feet

Prepared for:

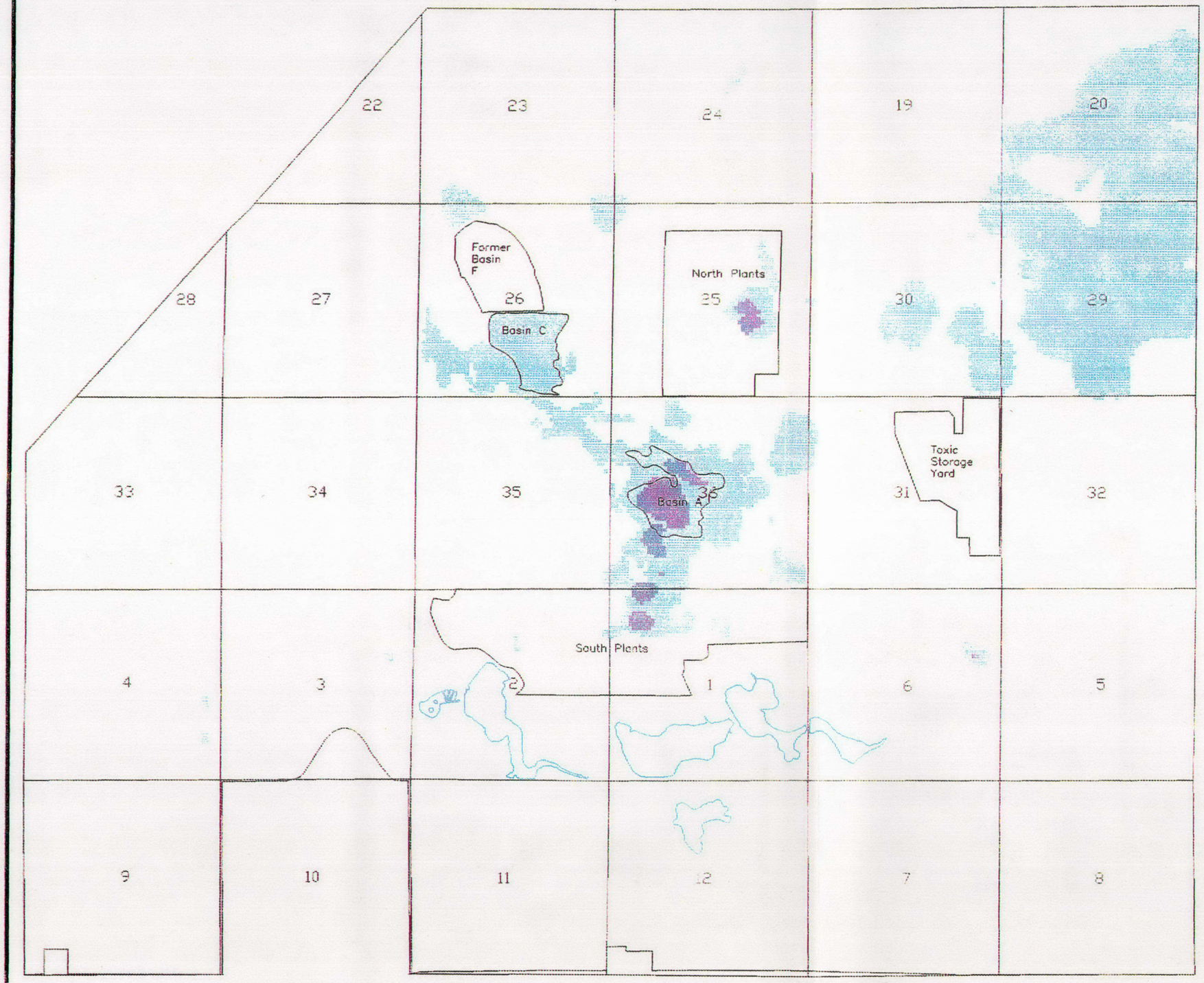
U.S. Army Program Manager
for Rocky Mountain Arsenal

February 1994

Figure C.3–58

Arsenic Hazard Quotient Map
for the American Kestrel Trophic Box
Based on the Army Approach

Rocky Mountain Arsenal
Prepared by: ENSERCH Environmental Corp



Legend

Hazard Quotient Values

1 – 10

> 10

Lake

31 Section Number

Section Line

N

0 2000 4000

Scale in Feet

Prepared for:

U.S. Army Program Manager
for Rocky Mountain Arsenal

February 1994

Figure C.3–59

Arsenic Hazard Quotient Map
for the Medium Mammal Trophic Box
Based on the Army Approach

Rocky Mountain Arsenal
Prepared by: ENSERCH Environmental Corp

Legend

Hazard Quotient Values

1 – 10

> 10

Lake

31 Section Number

Section Line

N

0 2000 4000

Scale in Feet

Prepared for:

U.S. Army Program Manager
for Rocky Mountain Arsenal

February 1994

Figure C.3–60

Arsenic Hazard Quotient Map
for the Small Mammal Trophic Box
Based on the Army Approach

Rocky Mountain Arsenal
Prepared by: ENSERCH Environmental Corp

Legend

Hazard Quotient Values

- 1 – 10
- > 10

- Lake
- 31 Section Number
- Section Line

N

0 2000 4000

Scale in Feet

Prepared for:

U.S. Army Program Manager
for Rocky Mountain Arsenal

February 1994

Figure C.3–61

Arsenic Hazard Quotient Map
for the Small Bird Trophic Box
Based on the Army Approach

Rocky Mountain Arsenal
Prepared by: ENSERCH Environmental Corp

22
23
24
20
28
27
26
25
29
33
34
32
4
3
5
9
10
12
7
8
Former Basin F
Basin C
North Plants
Basin A
South Plants

Legend

Army and Shell and EPA Approaches

Colors show which approaches result in HQ > 1 in the areas indicated

Lake

31 Section Number

Section Line

-N-

0 2000 4000

Scale in Feet

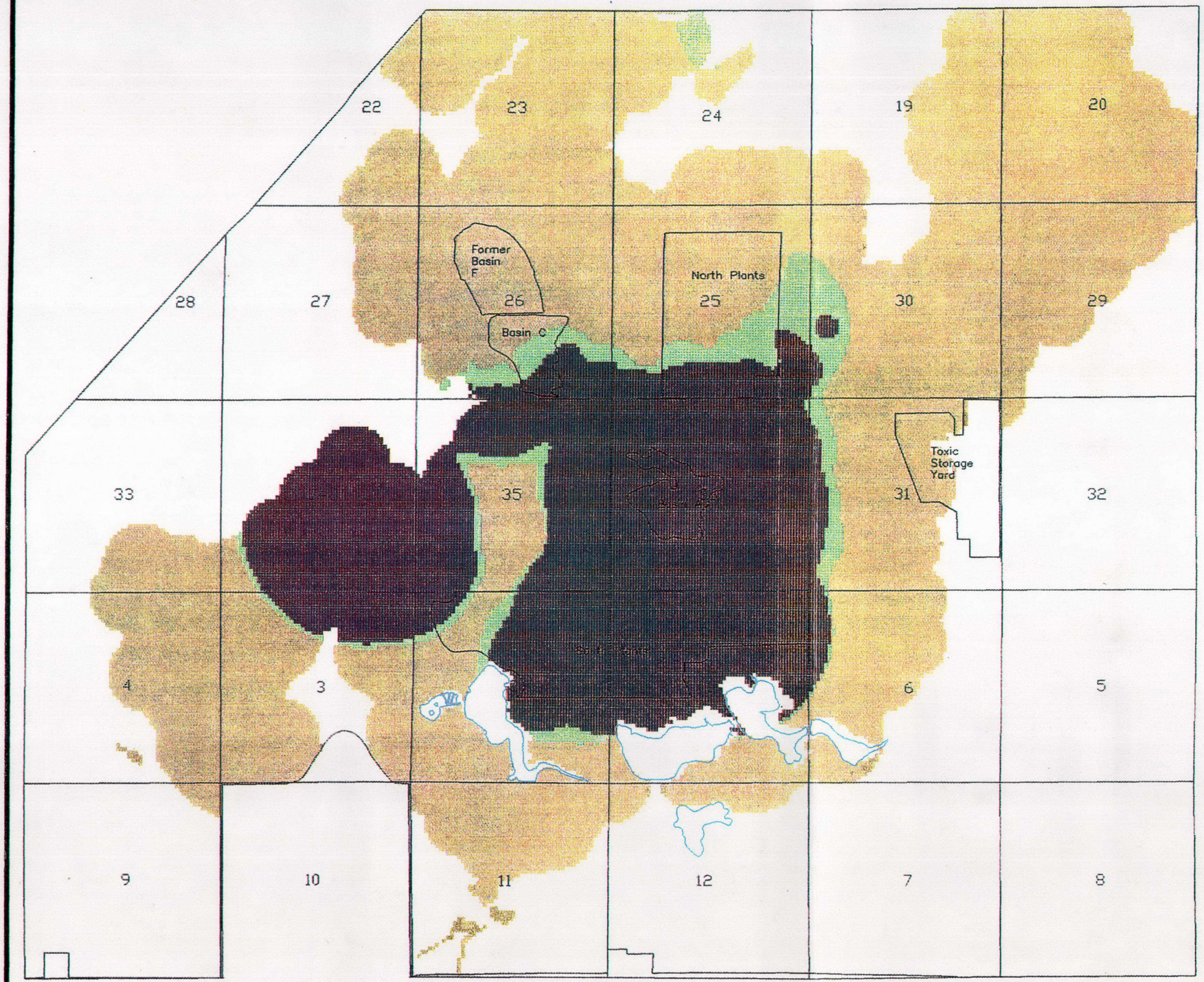
Prepared for:
U.S. Army Program Manager
for Rocky Mountain Arsenal

February 1994

Figure C.3–62

Mercury Hazard Quotient Map (HQ>1) for the Bald Eagle Trophic Box Based on the Army, EPA, and Shell Approaches

Rocky Mountain Arsenal
Prepared by: ENSERCH Environmental Corp



Legend

- EPA Approach
- Army and EPA Approaches
- Army and Shell and EPA Approaches

Colors show which approaches result in HQ > 1 in the areas indicated

- Lake
- 31 Section Number
- Section Line

N

0 2000 4000

Scale in Feet

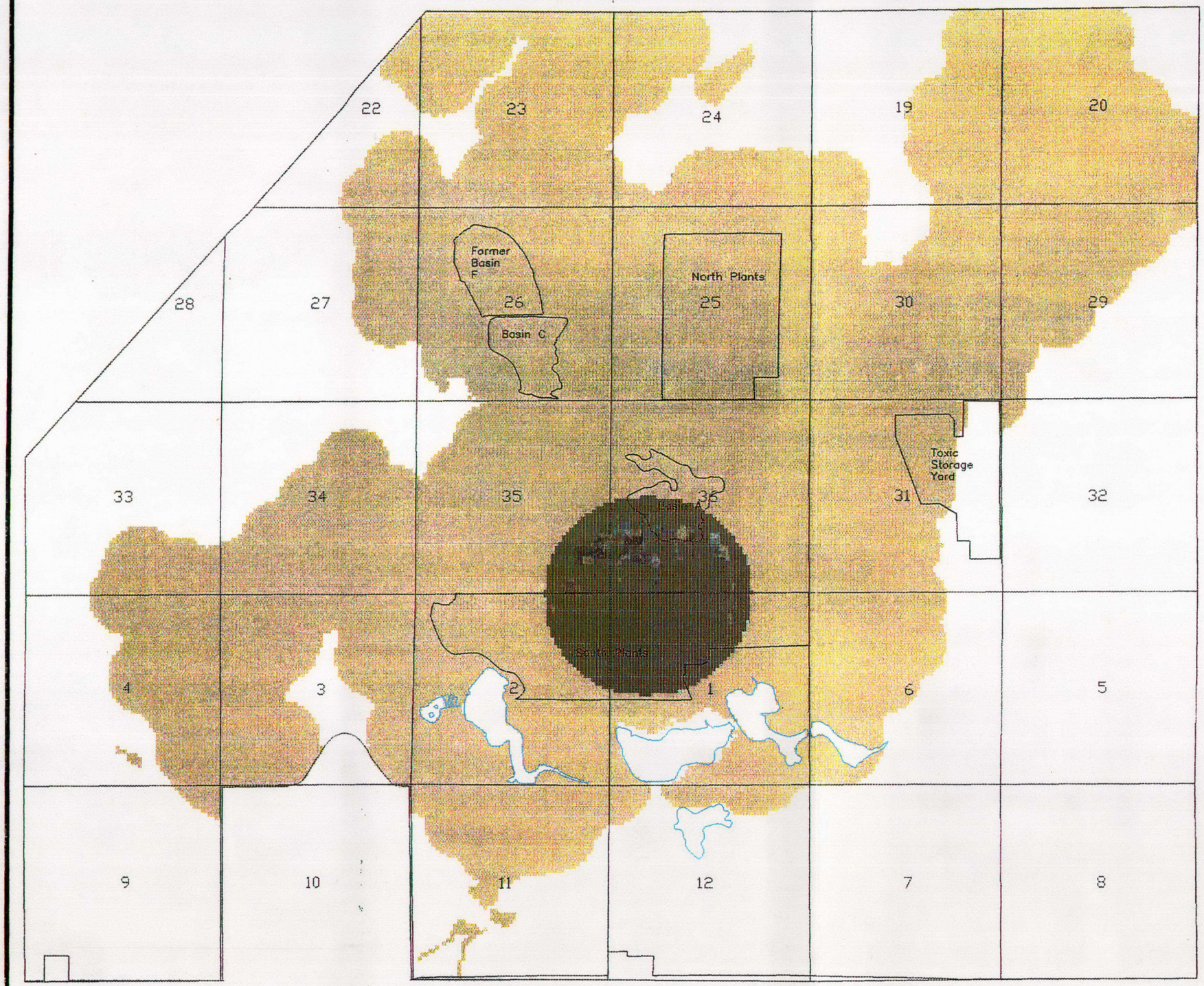
Prepared for:
U.S. Army Program Manager
for Rocky Mountain Arsenal

February 1994

Figure C.3-63

Mercury Hazard Quotient Map (HQ>1) for the Great Horned Owl Trophic Box Based on the Army, EPA, and Shell Approaches

Rocky Mountain Arsenal
Prepared by: ENSERCH Environmental Corp



Legend

- EPA Approach
- Army and EPA Approaches
- Army and Shell and EPA Approaches

Colors show which approaches result in HQ > 10 in the areas indicated

Lake

31 Section Number

Section Line

N

0 2000 4000

Scale in Feet

Prepared for:

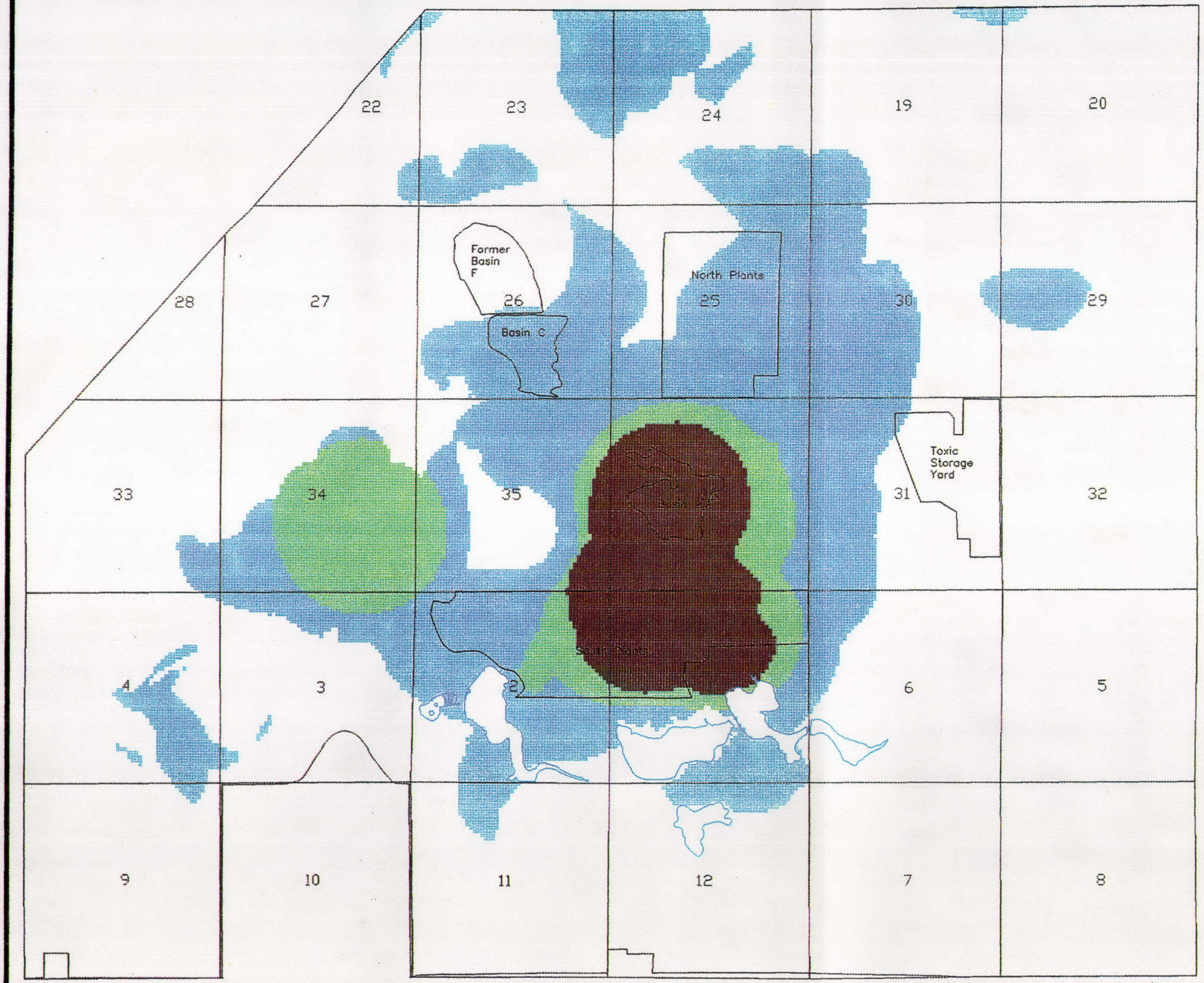
U.S. Army Program Manager
for Rocky Mountain Arsenal

February 1994

Figure C.3–64

Mercury Hazard Quotient Map (HQ>10) for the Great Horned Owl Trophic Box Based on the Army, EPA, and Shell Approaches

Rocky Mountain Arsenal
Prepared by: ENSERCH Environmental Corp



Legend

- Army Approach
- Army and EPA Approaches
- Army and Shell and EPA Approaches

Colors show which approaches result in HQ > 1 in the areas indicated

- Lake
- 31 Section Number
- Section Line

-N-

0 2000 4000

Scale in Feet

Prepared for:

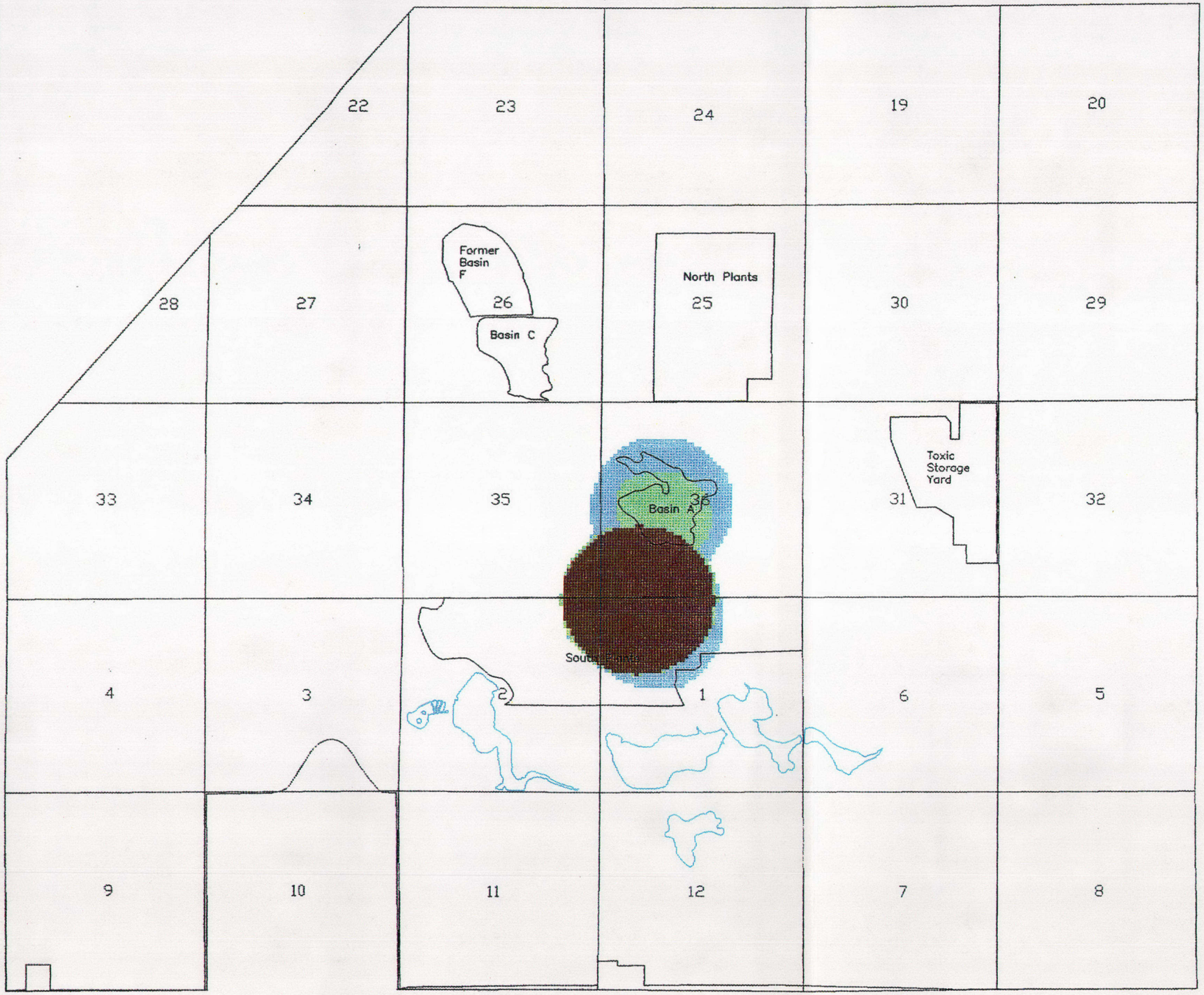
U.S. Army Program Manager
for Rocky Mountain Arsenal

February 1994

Figure C.3-65

Mercury Hazard Quotient Map (HQ>1) for the American Kestrel Trophic Box Based on the Army, EPA, and Shell Approaches

Rocky Mountain Arsenal
Prepared by: ENSERCH Environmental Corp



Legend

- Army Approach
- Army and EPA Approaches
- Army and Shell and EPA Approaches

Colors show which approaches result in HQ > 10 in the areas indicated

- Lake
- 31 Section Number
- Section Line

N

0 2000 4000

Scale in Feet

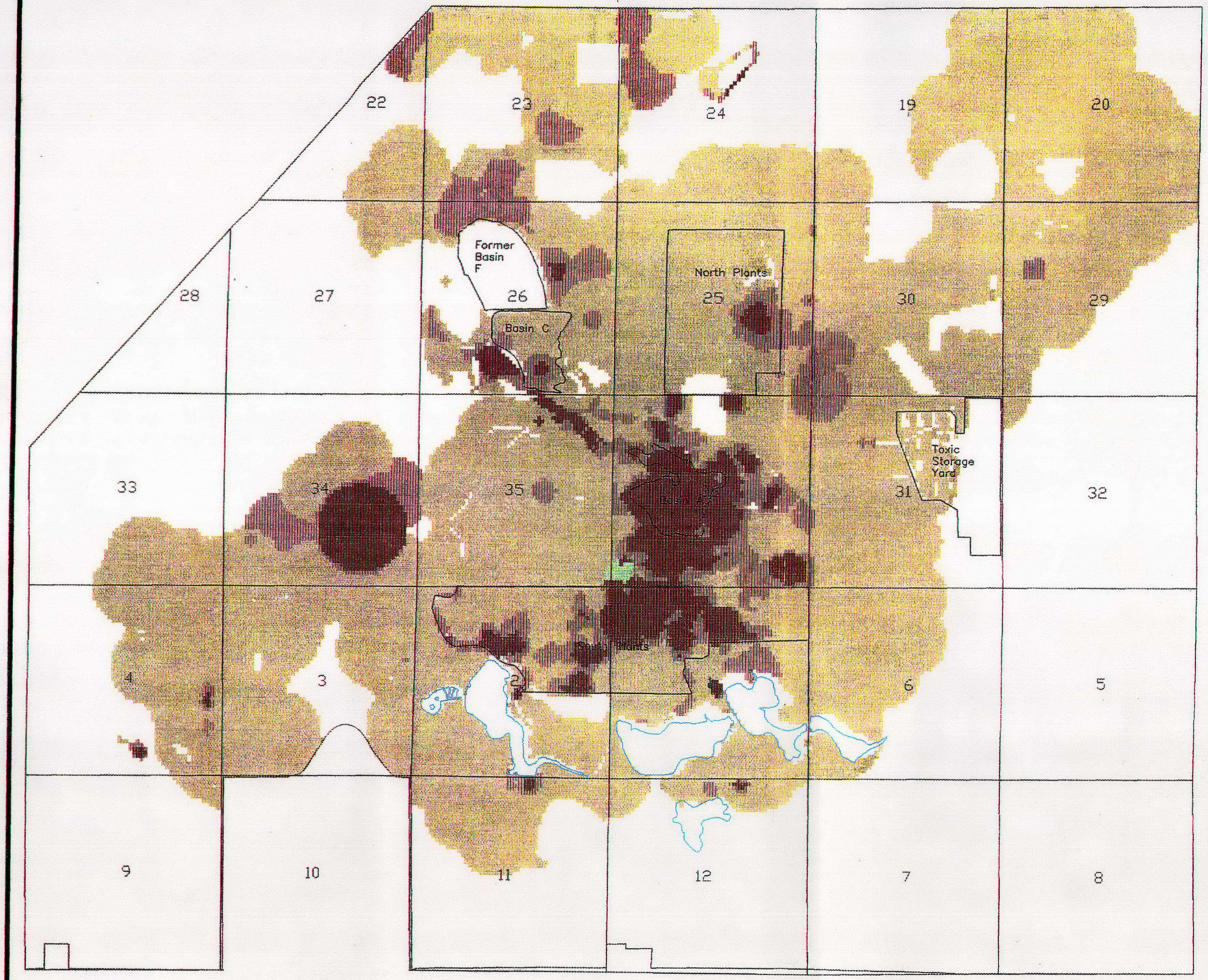
Prepared for:
U.S. Army Program Manager
for Rocky Mountain Arsenal

February 1994

Figure C.3-66

Mercury Hazard Quotient Map (HQ>10) for the American Kestrel Trophic Box Based on the Army, EPA, and Shell Approaches

Rocky Mountain Arsenal
Prepared by: ENSERCH Environmental Corp



Legend

- EPA Approach
- Army and EPA Approaches
- Shell and EPA Approaches
- Army and Shell and EPA Approaches

Colors show which approaches result in HQ > 1 in the areas indicated

Lake

31 Section Number

Section Line

N

0 2000 4000

Scale in Feet

Prepared for:
U.S. Army Program Manager
for Rocky Mountain Arsenal

February 1994

Figure C.3–67

Mercury Hazard Quotient Map (HQ>1) for the Medium Mammal Trophic Box Based on the Army, EPA, and Shell Approaches

Rocky Mountain Arsenal
Prepared by: ENSERCH Environmental Corp

22 23 24 19 20

28 27 Former Basin F 26 Basin C North Plants 25 30 29

33 34 35 31 Toxic Storage Yard 32

4 3 South Plants 2 1 6 5

9 10 11 12 7 8

Legend

- EPA Approach
- Army and EPA Approaches
- Shell and EPA Approaches
- Army and Shell and EPA Approaches

Colors show which approaches result in HQ > 10 in the areas indicated

Lake

31 Section Number

Section Line

N

0 2000 4000

Scale in Feet

Prepared for:

U.S. Army Program Manager
for Rocky Mountain Arsenal

February 1994

Figure C.3–68

Mercury Hazard Quotient Map (HQ>10) for the Medium Mammal Trophic Box Based on the Army, EPA, and Shell Approaches

Rocky Mountain Arsenal
Prepared by: ENSERCH Environmental Corp

Former Basin F

Basin C

North Plants

South Plants

Toxic Storage Yard

22 23 24 19 20

28 27 26 25 30 29

33 34 35 31 32

4 3 2 6 5

9 10 11 12 7 8

Legend

EPA Approach

Shell and EPA Approaches

Army and Shell and EPA Approaches

Colors show which approaches result in HQ > 1 in the areas indicated

Lake

31 Section Number

Section Line

-N-

0 2000 4000

Scale in Feet

Prepared for:

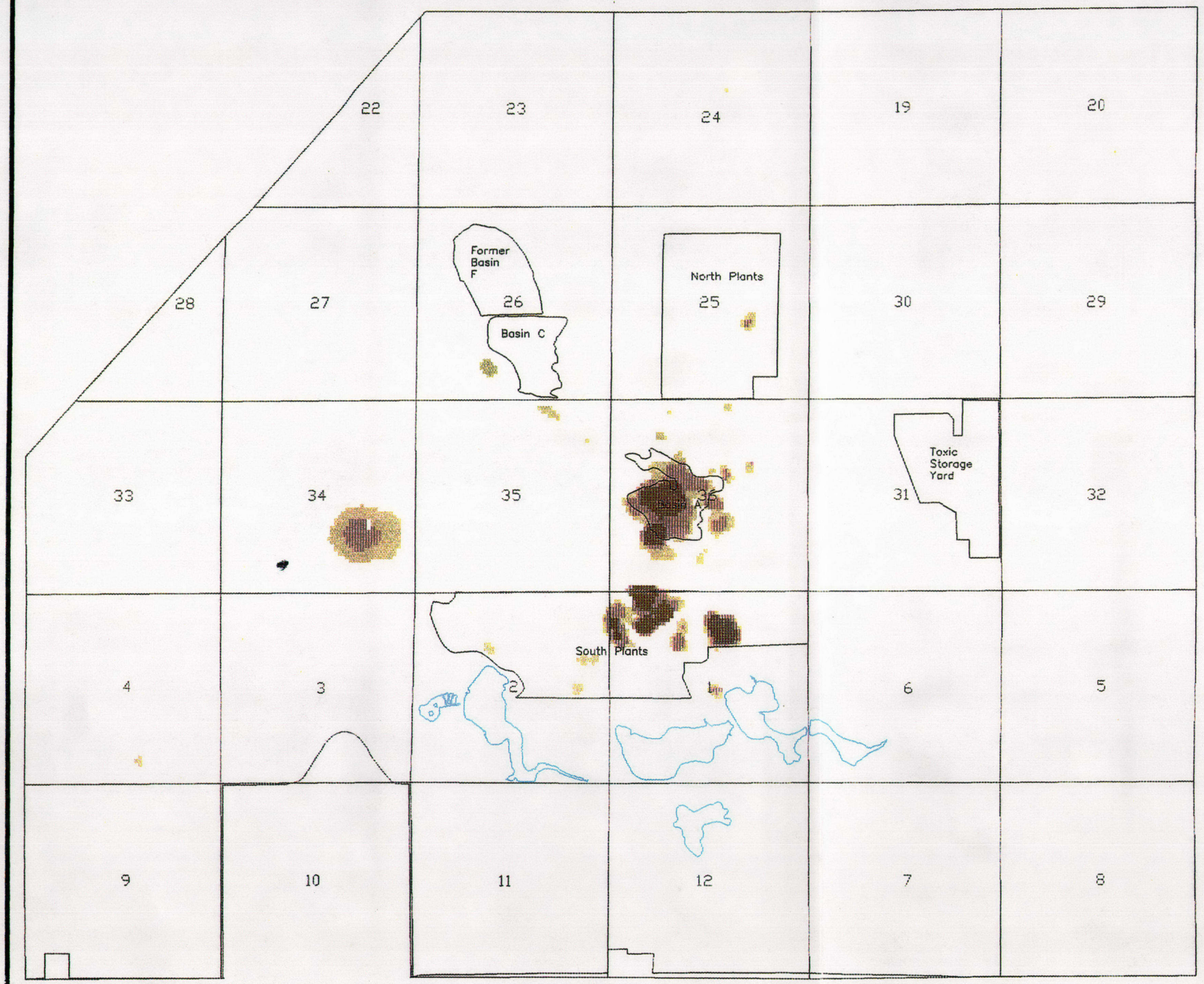
U.S. Army Program Manager
for Rocky Mountain Arsenal

February 1994

Figure C.3-69

Mercury Hazard Quotient Map (HQ>1) for the Small Mammal Trophic Box Based on the Army, EPA, and Shell Approaches

Rocky Mountain Arsenal
Prepared by: ENSERCH Environmental Corp



Legend

- EPA Approach
- Shell and EPA Approaches
- Army and Shell and EPA Approaches

Colors show which approaches result in HQ > 10 in the areas indicated

Lake

31 Section Number

Section Line

N

0 2000 4000

Scale in Feet

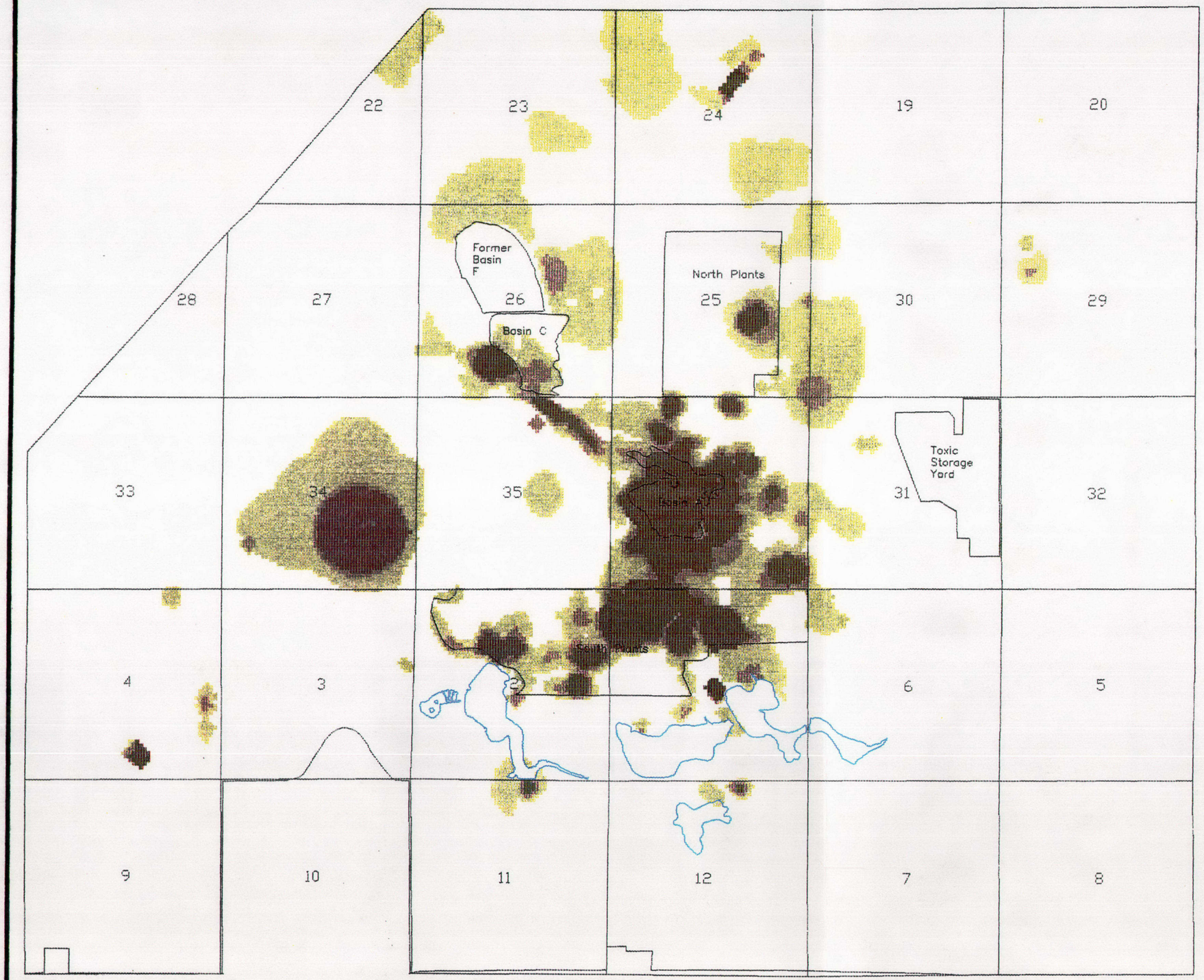
Prepared for:
U.S. Army Program Manager
for Rocky Mountain Arsenal

February 1994

Figure C.3–70

Mercury Hazard Quotient Map (HQ>10) for the Small Mammal Trophic Box Based on the Army, EPA, anhd Shell Approaches

Rocky Mountain Arsenal
Prepared by: ENSERCH Environmental Corp



Legend

- EPA Approach
- Shell and EPA Approaches
- Army and Shell and EPA Approaches

Colors show which approaches result in HQ > 1 in the areas indicated

- Lake
- 31 Section Number
- Section Line

-N-

0 2000 4000

Scale in Feet

Prepared for:

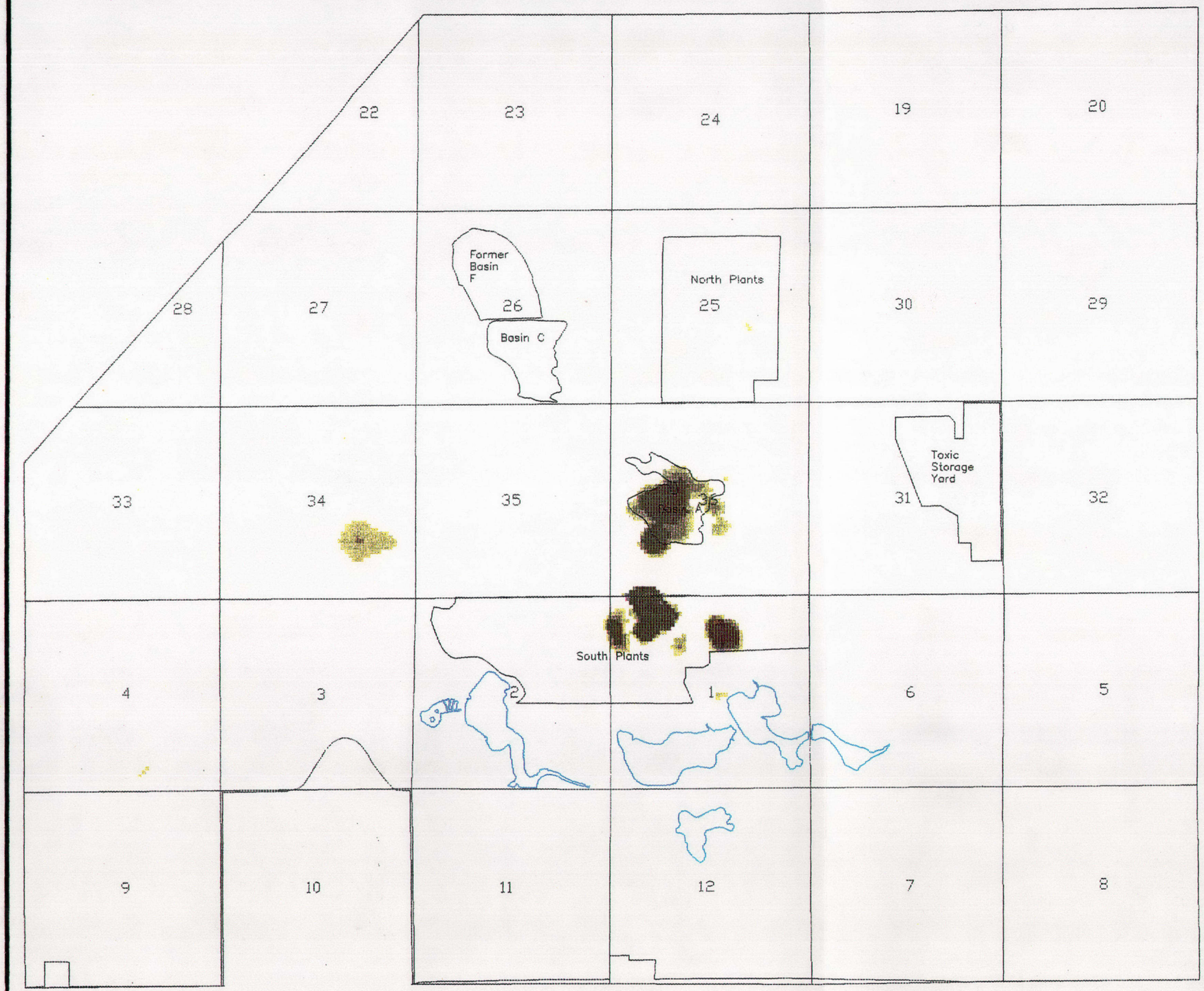
U.S. Army Program Manager
for Rocky Mountain Arsenal

February 1994

Figure C.3–71

Mercury Hazard Quotient Map (HQ>1) for the Small Bird Trophic Box Based on the Army, EPA, and Shell Approaches

Rocky Mountain Arsenal
Prepared by: ENSERCH Environmental Corp



Legend

- EPA Approach
- Shell and EPA Approaches
- Army and Shell and EPA Approaches

Colors show which approaches result in HQ > 10 in the areas indicated

- Lake
- 31 Section Number
- Section Line

-N-

0 2000 4000

Scale in Feet

Prepared for:
U.S. Army Program Manager
for Rocky Mountain Arsenal

February 1994

Figure C.3-72

Mercury Hazard Quotient Map (HQ>10) for the Small Bird Trophic Box Based on the Army, EPA, and Shell Approaches

Rocky Mountain Arsenal
Prepared by: ENSERCH Environmental Corp

Legend

Hazard Quotient Values

- 1 – 10
- > 10

Lake

31 Section Number

Section Line

N

0 2000 4000

Scale in Feet

Prepared for:

U.S. Army Program Manager
for Rocky Mountain Arsenal

February 1994

Figure C.3–73

Cadmium Hazard Quotient Map
for the Medium Mammal Trophic Box
Based on the Army Approach

Rocky Mountain Arsenal
Prepared by: ENSERCH Environmental Corp

Legend

Hazard Quotient Values

- 1 – 10
- > 10

Lake

31 Section Number

Section Line

N

0 2000 4000

Scale in Feet

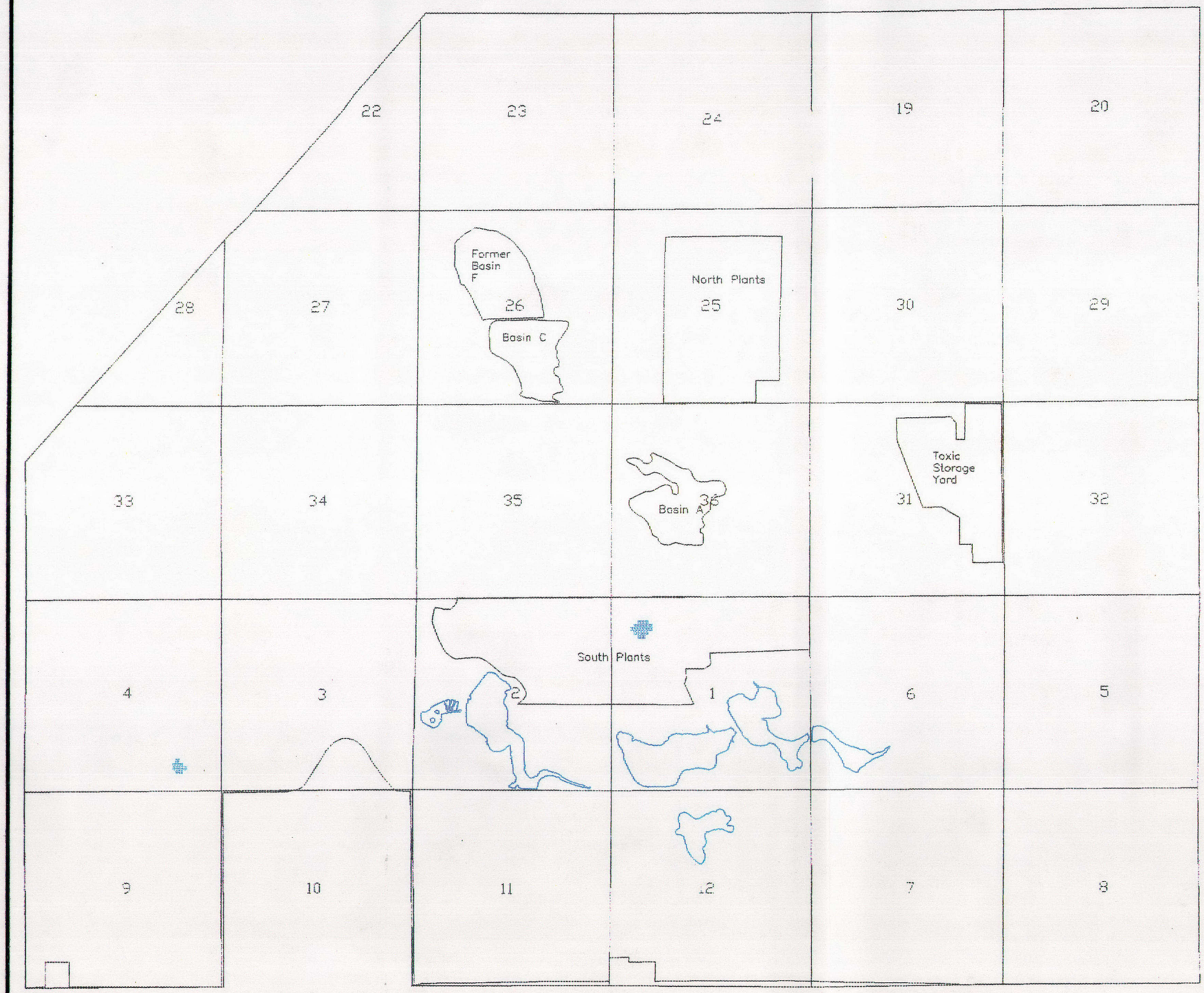
Prepared for:
U.S. Army Program Manager
for Rocky Mountain Arsenal

February 1994

Figure C.3–74

Cadmium Hazard Quotient Map
for the Small Mammal Trophic Box
Based on the Army Approach

Rocky Mountain Arsenal
Prepared by: ENSERCH Environmental Corp



Legend

Hazard Quotient Values

- 1 - 10
- > 10

- Lake
- 31 Section Number
- Section Line

-N-

0 2000 4000

Scale in Feet

Prepared for:

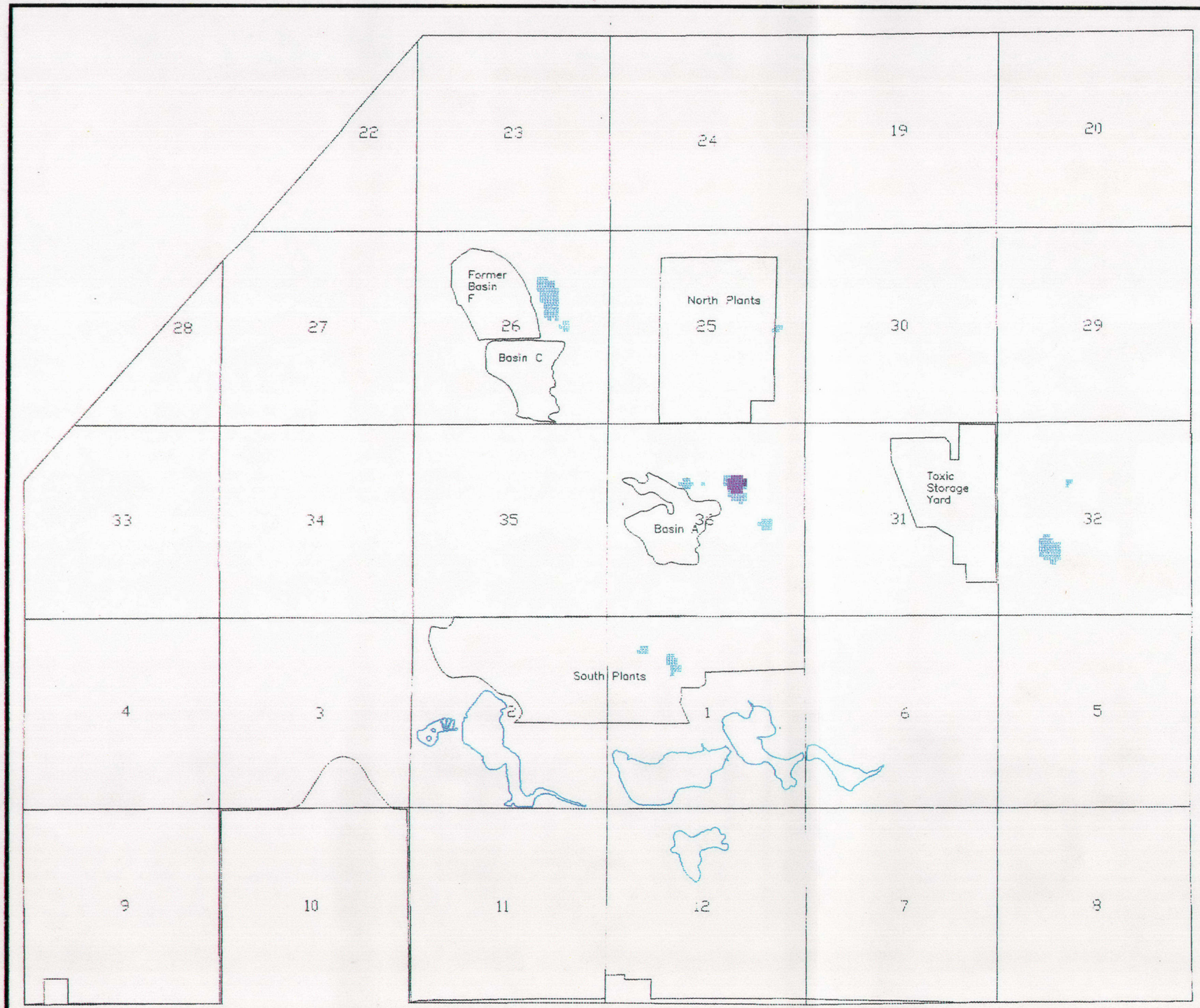
U.S. Army Program Manager
for Rocky Mountain Arsenal

February 1994

Figure C.3-75

Cadmium Hazard Quotient Map
for the Small Bird Trophic Box
Based on the Army Approach

Rocky Mountain Arsenal
Prepared by: ENSERCH Environmental Corp



Legend

Hazard Quotient Values

- 1 – 10
- > 10

- Lake
- 31 Section Number
- Section Line

-N-

0 2000 4000

Scale in Feet

Prepared for:

U.S. Army Program Manager
for Rocky Mountain Arsenal

February 1994

Figure C.3–76

Copper Hazard Quotient Map
for the Medium Mammal Trophic Box
Based on the Army Approach

Rocky Mountain Arsenal
Prepared by: ENSERCH Environmental Corp

Legend

Hazard Quotient Values

- 1 – 10
- > 10

- Lake
- 31 Section Number
- Section Line

-N-

0 2000 4000

Scale in Feet

Prepared for:

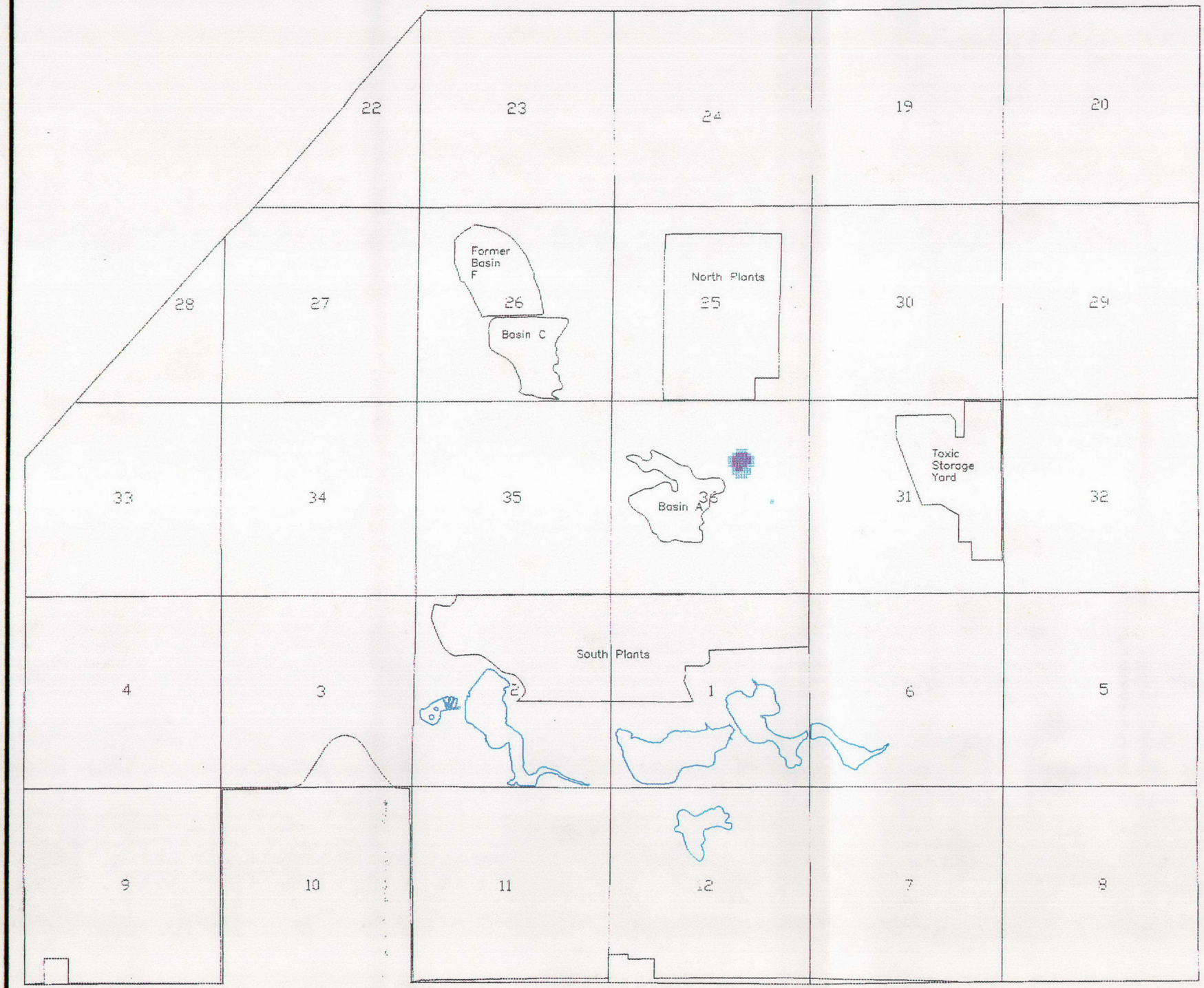
U.S. Army Program Manager
for Rocky Mountain Arsenal

February 1994

Figure C.3–77

Copper Hazard Quotient Map
for the Small Mammal Trophic Box
Based on the Army Approach

Rocky Mountain Arsenal
Prepared by: ENSERCH Environmental Corp



Legend

Hazard Quotient Values

- 1 – 10
- > 10

Lake

31 Section Number

Section Line

N

0 2000 4000

Scale in Feet

Prepared for:

U.S. Army Program Manager
for Rocky Mountain Arsenal

February 1994

Figure C.3–78

Copper Hazard Quotient Map
for the Small Bird Trophic Box
Based on the Army Approach

Rocky Mountain Arsenal
Prepared by: ENSERCH Environmental Corp

22 23 24 19 20

28 27 Former Basin F 26 Basin C North Plants 25 30 29

33 34 35 Basin A 36 31 Toxic Storage Yard 32

4 3 South Plants 2 1 6 5

9 10 11 12 7 8

Legend

Hazard Quotient Values

1 - 10

> 10

Lake

31 Section Number

Section Line

N

0 2000 4000

Scale in Feet

Prepared for:

U.S. Army Program Manager
for Rocky Mountain Arsenal

February 1994

Figure C.3-79

Chlordane Hazard Quotient Map
for the Medium Mammal Trophic Box
Based on the Army Approach

Rocky Mountain Arsenal
Prepared by: ENSERCH Environmental Corp

22 23 24 19 20

28 27 Former Basin F 26 Basin C North Plants 25 30 29

33 34 35 Basin A 36 31 Toxic Storage Yard 32

4 3 South Plants 2 1 6 5

9 10 11 12 7 8

Legend

Hazard Quotient Values

1 - 10

> 10

Lake

31 Section Number

Section Line

N

0 2000 4000

Scale in Feet

Prepared for:

U.S. Army Program Manager
for Rocky Mountain Arsenal

February 1994

Figure C.3-80

Chlordane Hazard Quotient Map
for the Small Mammal Trophic Box
Based on the Army Approach

Rocky Mountain Arsenal
Prepared by: ENSERCH Environmental Corp

22 23 24 19 20

28 27 Former Basin F 26 Basin C North Plants 25 30 29

33 34 35 Basin A 36 31 Toxic Storage Yard 32

4 3 South Plants 2 1 6 5

9 10 11 12 7 8

Legend

Hazard Quotient Values

1 – 10

> 10

Lake

31 Section Number

Section Line

-N-

0 2000 4000

Scale in Feet

Prepared for:

U.S. Army Program Manager
for Rocky Mountain Arsenal

February 1994

Figure C.3–81

Chlordane Hazard Quotient Map
for the Small Bird Trophic Box
Based on the Army Approach

Rocky Mountain Arsenal
Prepared by: ENSERCH Environmental Corp

22 23 24 19 20

28 27 Former Basin F 26 Basin C North Plants 25 30 29

33 34 35 Basin A 36 31 Toxic Storage Yard 32

4 3 South Plants 2 1 6 5

9 10 11 12 7 8

Legend

Hazard Quotient Values

1 – 10

> 10

Lake

31 Section Number

Section Line

-N-

0 2000 4000

Scale in Feet

Prepared for:

U.S. Army Program Manager
for Rocky Mountain Arsenal

February 1994

Figure C.3–82

DBCP Hazard Quotient Map
for the Medium Mammal Trophic Box
Based on the Army Approach

Rocky Mountain Arsenal
Prepared by: ENSERCH Environmental Corp

Legend

Hazard Quotient Values

1 – 10

> 10

Lake

31 Section Number

Section Line

N

0 2000 4000

Scale in Feet

Prepared for:

U.S. Army Program Manager
for Rocky Mountain Arsenal

February 1994

Figure C.3–83

DBCP Hazard Quotient Map
for the Small Mammal Trophic Box
Based on the Army Approach

Rocky Mountain Arsenal
Prepared by: ENSERCH Environmental Corp

22 23 24 19 20

28 27 26 25 30 29

33 34 35 36 31 32

4 3 2 1 6 5

9 10 11 12 7 8

Former Basin F

Basin C

North Plants

Basin A

Toxic Storage Yard

South Plants

Legend

Hazard Quotient Values

1 - 10

> 10

Lake

31 Section Number

Section Line

N

0 2000 4000

Scale in Feet

Prepared for:

U.S. Army Program Manager
for Rocky Mountain Arsenal

February 1994

Figure C.3-84

DBCP Hazard Quotient Map
for the Small Bird Trophic Box
Based on the Army Approach

Rocky Mountain Arsenal
Prepared by: ENSERCH Environmental Corp

22 23 24 19 20

28 27 26 25 30 29

33 34 35 36 31 32

4 3 2 1 6 5

9 10 11 12 7 8

Former Basin F

Basin C

North Plants

Basin A

Toxic Storage Yard

South Plants

Legend

Hazard Quotient Values

1 - 10

> 10

Lake

31 Section Number

Section Line

-N-

0 2000 4000

Scale in Feet

Prepared for:

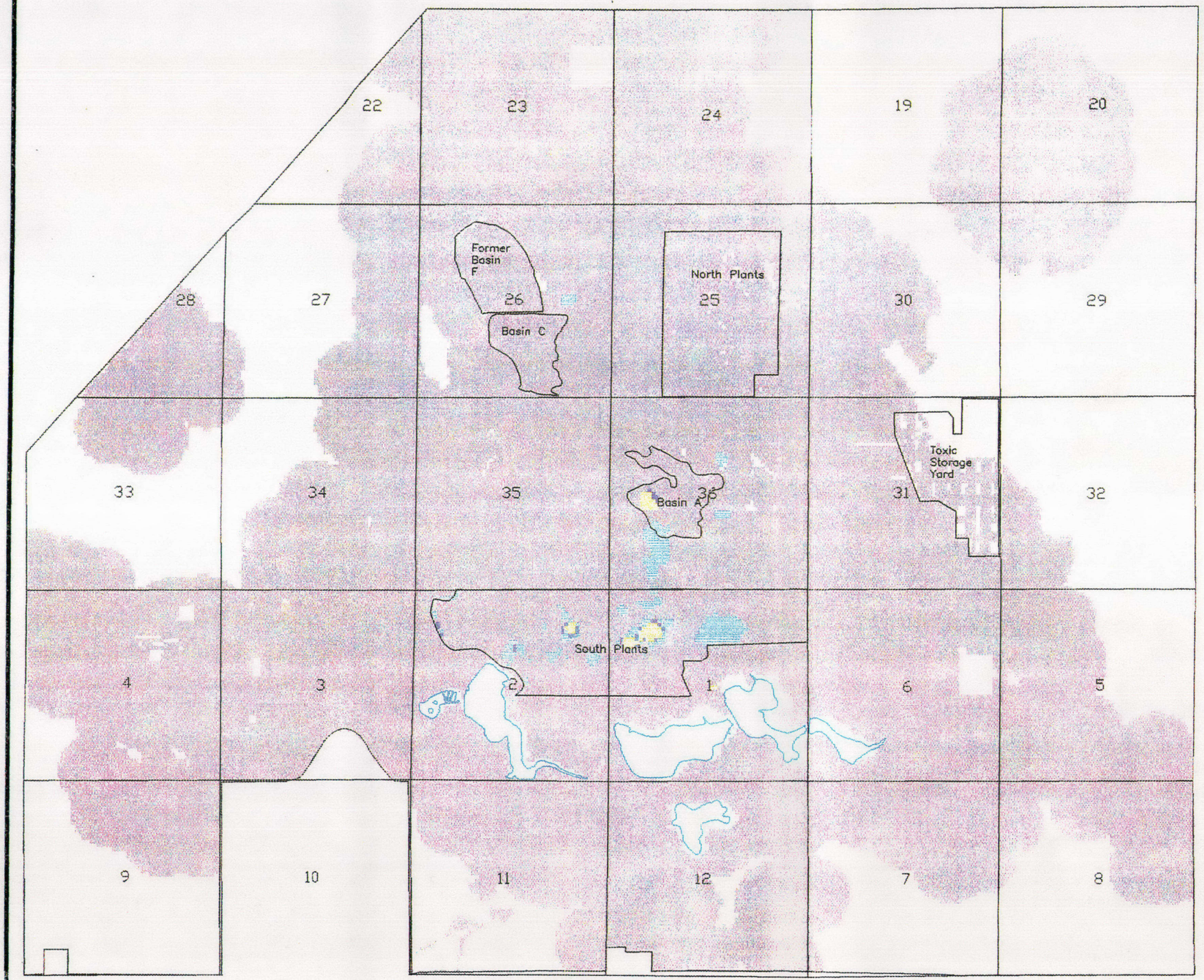
U.S. Army Program Manager
for Rocky Mountain Arsenal

February 1994

Figure C.3-85

DCPD Hazard Quotient Map
for the Small Mammal Trophic Box
Based on the Army Approach

Rocky Mountain Arsenal
Prepared by: ENSERCH Environmental Corp



Legend

Soil Concentrations

- 0 - 1 ppm
- 1 - 5 ppm
- 5 - 10 ppm
- > 10 ppm

Lake

31 Section Number

Section Line

N

0 2000 4000

Scale in Feet

Prepared for:

U.S. Army Program Manager
for Rocky Mountain Arsenal

February 1994

Figure C.3-86

DDT/DDE Soil Concentrations

Rocky Mountain Arsenal
Prepared by: ENSERCH Environmental Corp

22 23 24 19 20

28 27 26 25 30 29

33 34 35 36 31 32

4 3 2 1 6 5

9 10 11 12 7 8

Former Basin F

Basin C

North Plants

Basin A

Toxic Storage Yard

South Plants

Legend

Soil Concentrations

- 0 - 1 ppm
- 1 - 5 ppm
- 5 - 10 ppm
- > 10 ppm

Lake

31 Section Number

Section Line

N

0 2000 4000

Scale in Feet

Prepared for:

U.S. Army Program Manager
for Rocky Mountain Arsenal

February 1994

Figure C.3-87

Endrin Soil Concentrations

Rocky Mountain Arsenal
Prepared by: ENSERCH Environmental Corp

Legend

Soil Concentrations

- 5 – 10 ppm
- 10 – 100 ppm
- 100 – 1000 ppm
- > 1000 ppm

Background Arsenic = 10 ppm

- Lake
- 31 Section Number
- Section Line

N

0 2000 4000

Scale in Feet

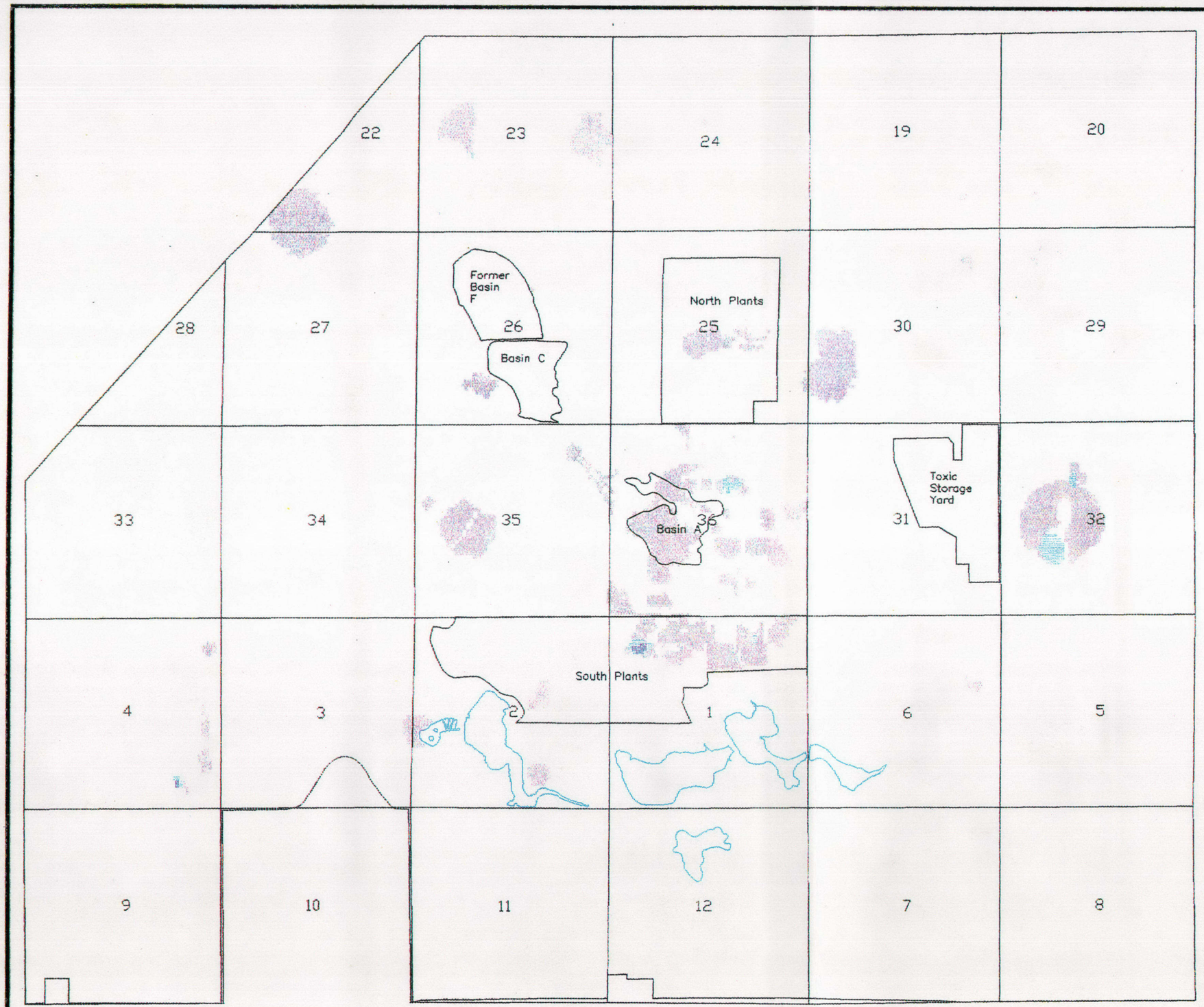
Prepared for:
U.S. Army Program Manager
for Rocky Mountain Arsenal

February 1994

Figure C.3–88

Arsenic Soil Concentrations
(Including Background)

Rocky Mountain Arsenal
Prepared by: ENSERCH Environmental Corp



Legend

Soil Concentrations

- 1 – 10 ppm
- 10 – 100 ppm
- 100 – 1000 ppm
- > 1000 ppm

Background Cadmium = 2.0 ppm

Lake

31 Section Number

Section Line

N

0 2000 4000

Scale in Feet

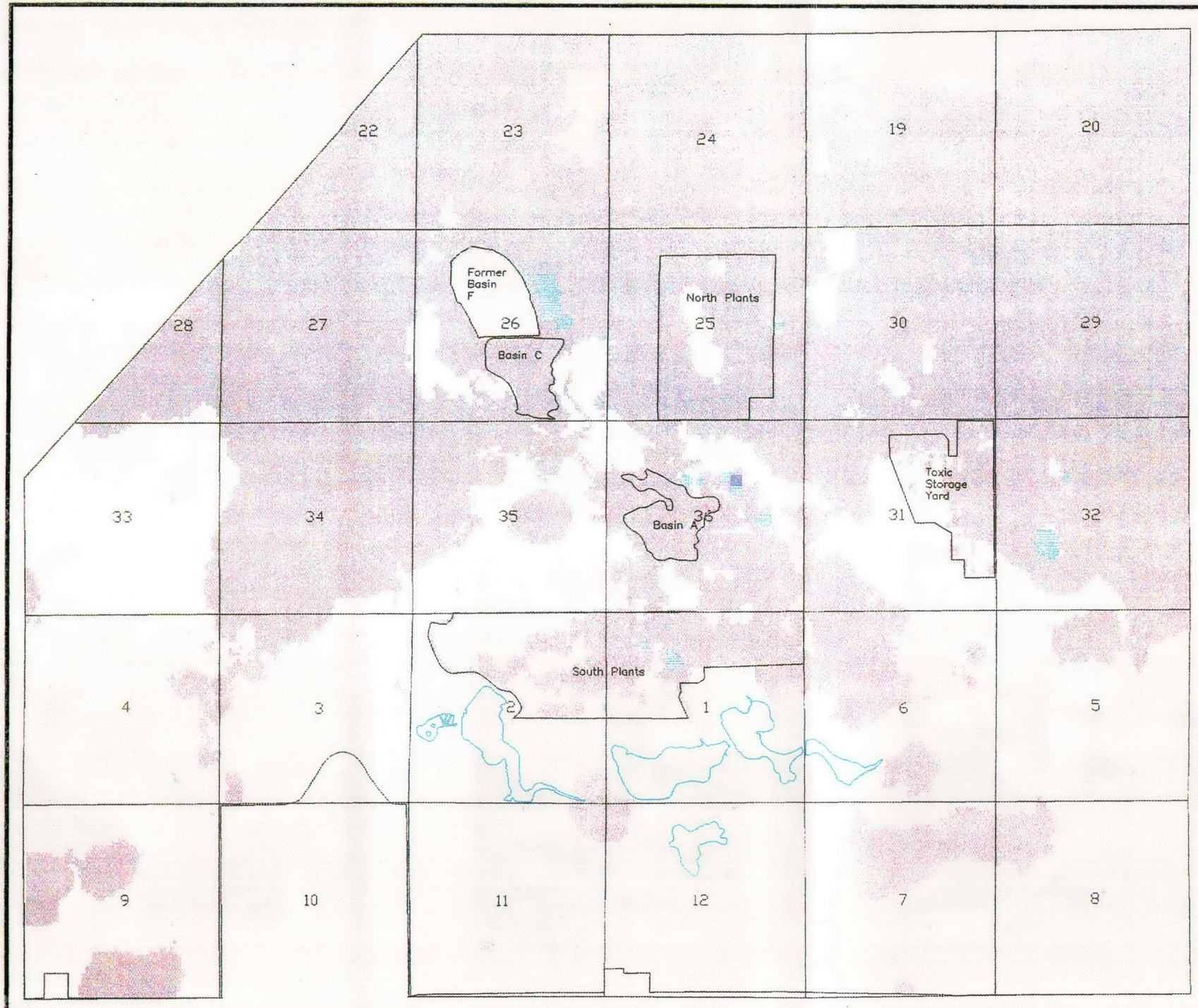
Prepared for:
U.S. Army Program Manager
for Rocky Mountain Arsenal

February 1994

Figure C.3–89

Cadmium Soil Concentrations
(Including Background)

Rocky Mountain Arsenal
Prepared by: ENSERCH Environmental Corp



Legend

Soil Concentrations

- 10 - 100 ppm
- 100 - 1000 ppm
- > 1000 ppm

Background Copper = 35 ppm

- Lake
- 31 Section Number
- Section Line

N

0 2000 4000

Scale in Feet

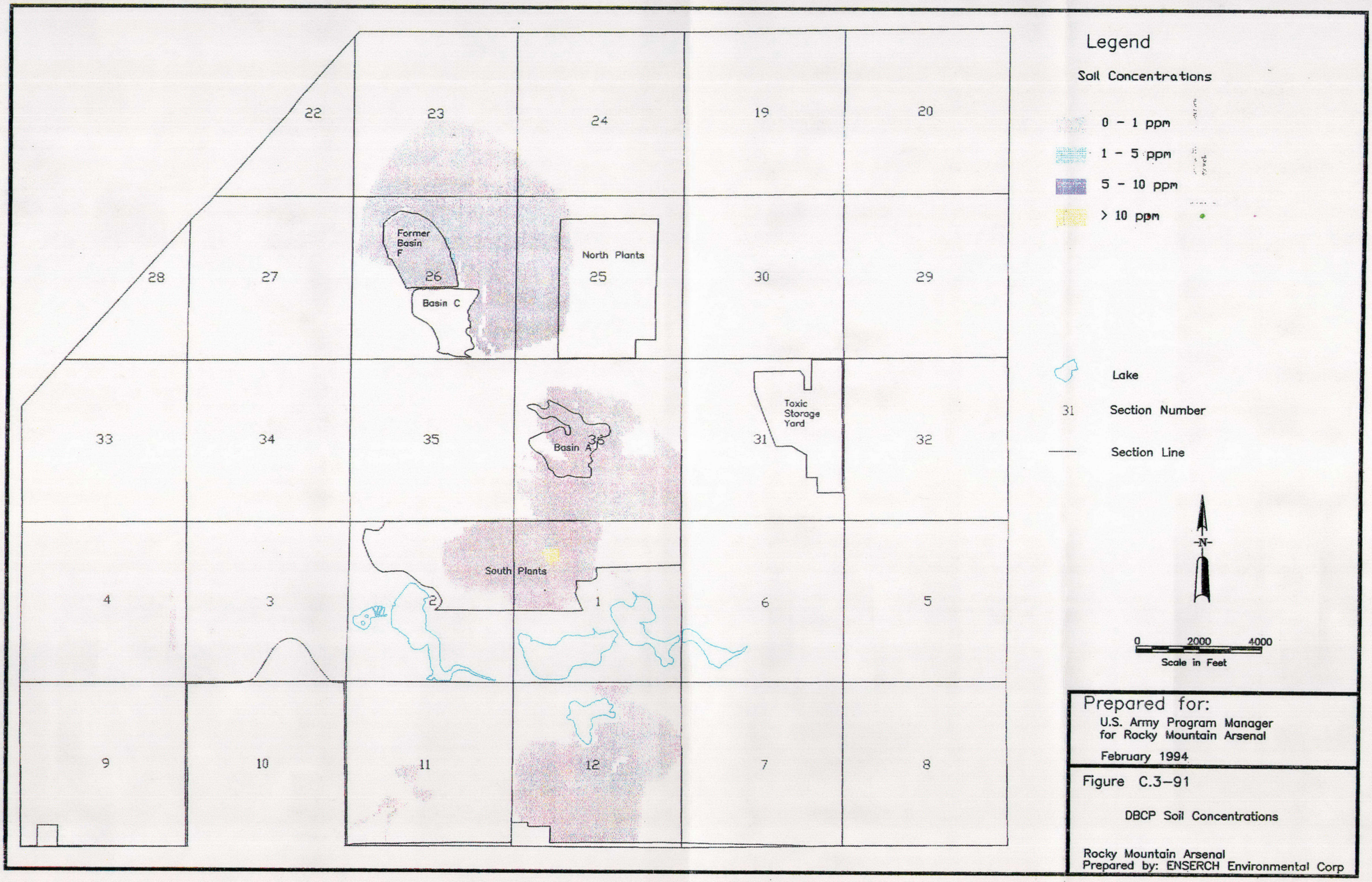
Prepared for:
U.S. Army Program Manager
for Rocky Mountain Arsenal

February 1994

Figure C.3-90

Copper Soil Concentrations
(Including Background)

Rocky Mountain Arsenal
Prepared by: ENSERCH Environmental Corp



Legend

Soil Concentrations

- 0 – 1 ppm
- 1 – 5 ppm
- 5 – 10 ppm
- > 10 ppm

Lake

31 Section Number

Section Line

N

0 2000 4000

Scale in Feet

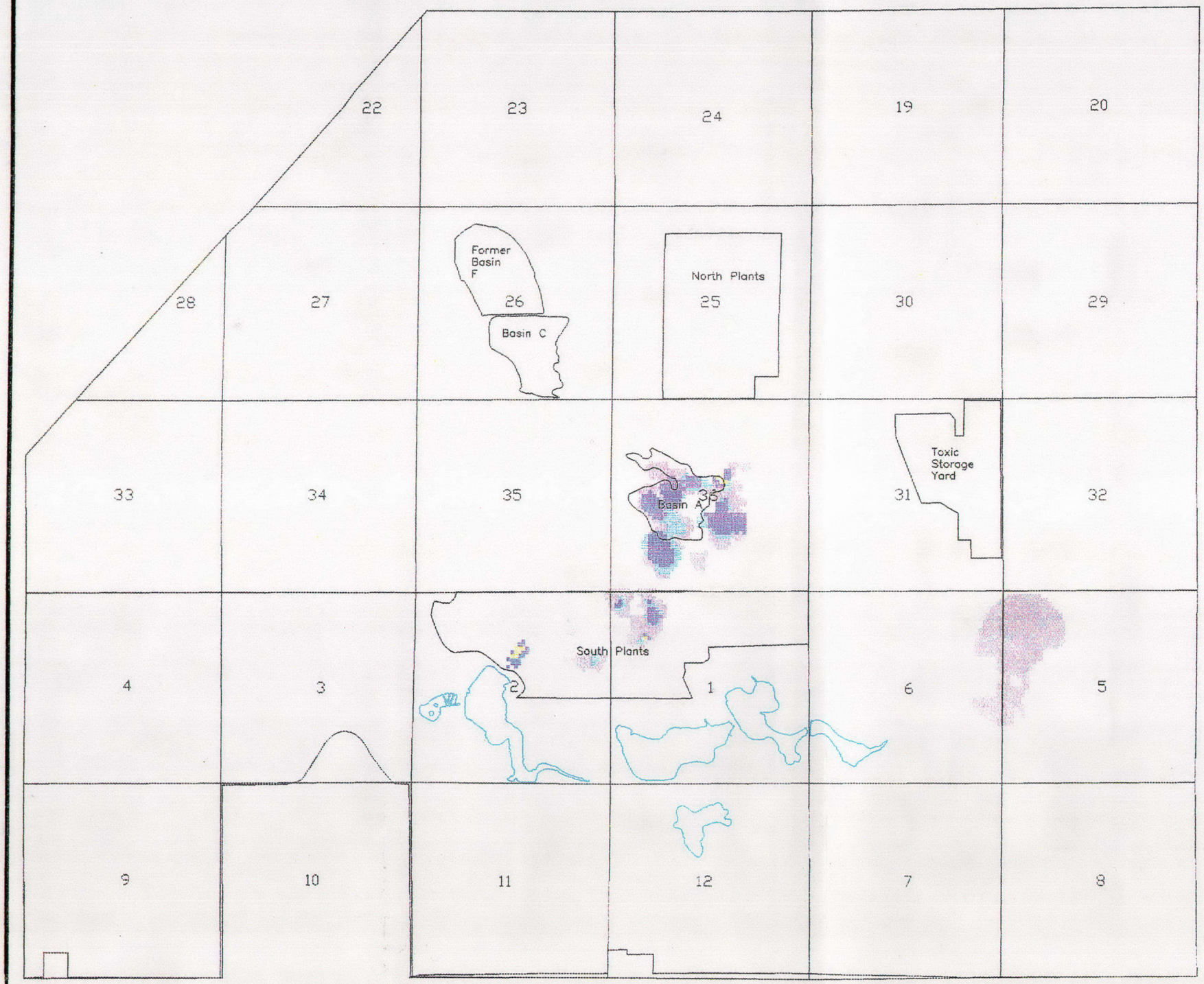
Prepared for:
U.S. Army Program Manager
for Rocky Mountain Arsenal

February 1994

Figure C.3–91

DBCP Soil Concentrations

Rocky Mountain Arsenal
Prepared by: ENSERCH Environmental Corp



Legend

Soil Concentrations

- 1.56 - 5 ppm
- 5 - 10 ppm
- 10 - 100 ppm
- > 100 ppm

Lake

31 Section Number

Section Line

N

0 2000 4000

Scale in Feet

Prepared for:

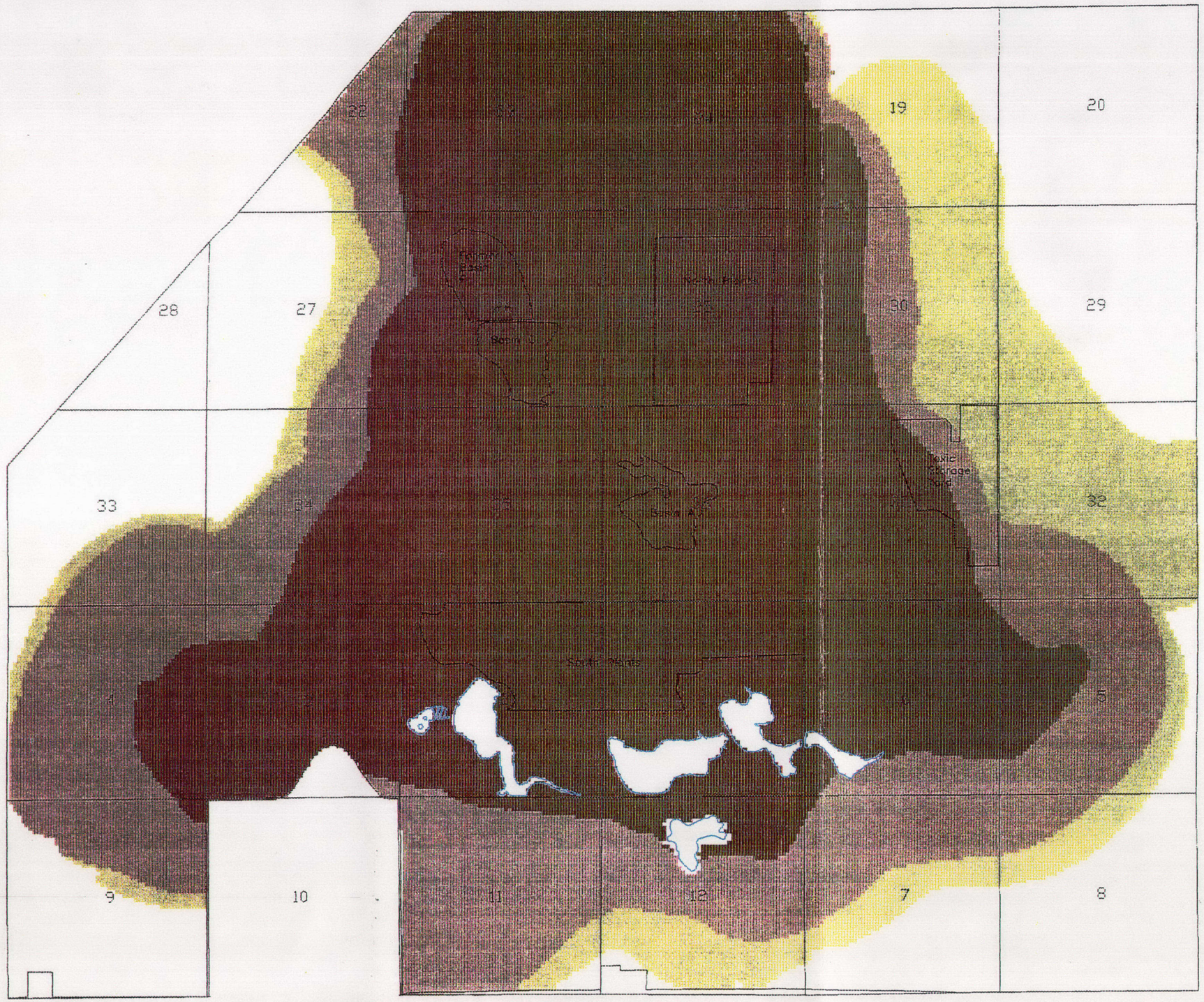
U.S. Army Program Manager
for Rocky Mountain Arsenal

February 1994

Figure C.3-92

Chlordane Soil Concentrations Above Certified Reporting Limits (mean CRL=1.56 ppm)

Rocky Mountain Arsenal
Prepared by: ENSERCH Environmental Corp



Legend

- EPA Approach
- Shell and EPA Approaches
- Army and Shell and EPA Approaches

Colors show which approaches result in HI > 1 in the areas indicated

Lake

31 Section Number

Section Line

N

0 2000 4000

Scale in Feet

Prepared for:

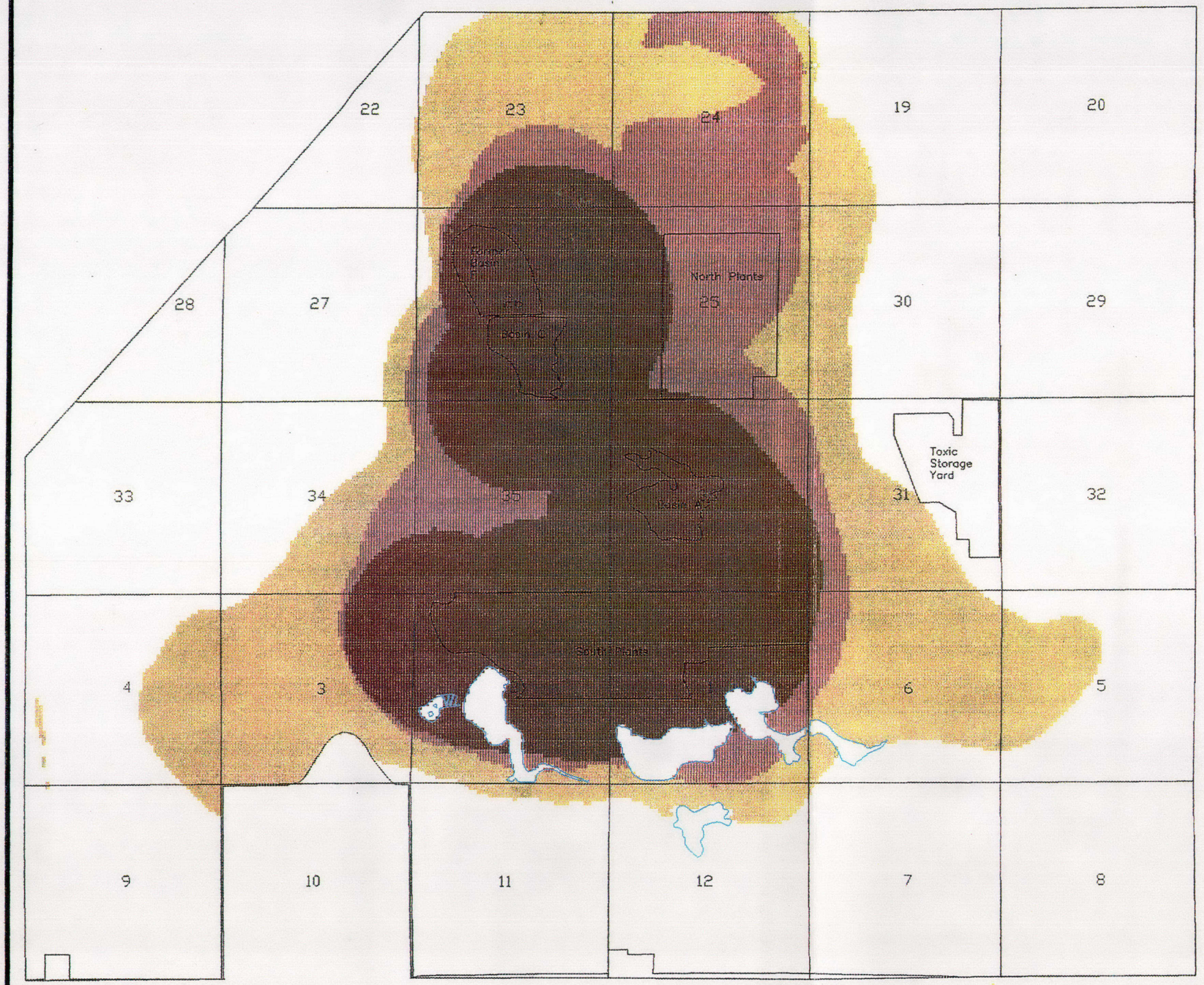
U.S. Army Program Manager
for Rocky Mountain Arsenal

February 1994

Figure C.3–93

Great Horned Owl Map (HI>1) for Aldrin/Dieldrin, DDT/DDE, and Endrin Combined Based on the Army, Shell, and EPA Approaches

Rocky Mountain Arsenal
Prepared by: ENSERCH Environmental Corp



Legend

- EPA Approach
- Shell and EPA Approaches
- Army and Shell and EPA Approaches

Colors show which approaches result in HI > 10 in the areas indicated

Lake

31 Section Number

Section Line

N

0 2000 4000

Scale in Feet

Prepared for:

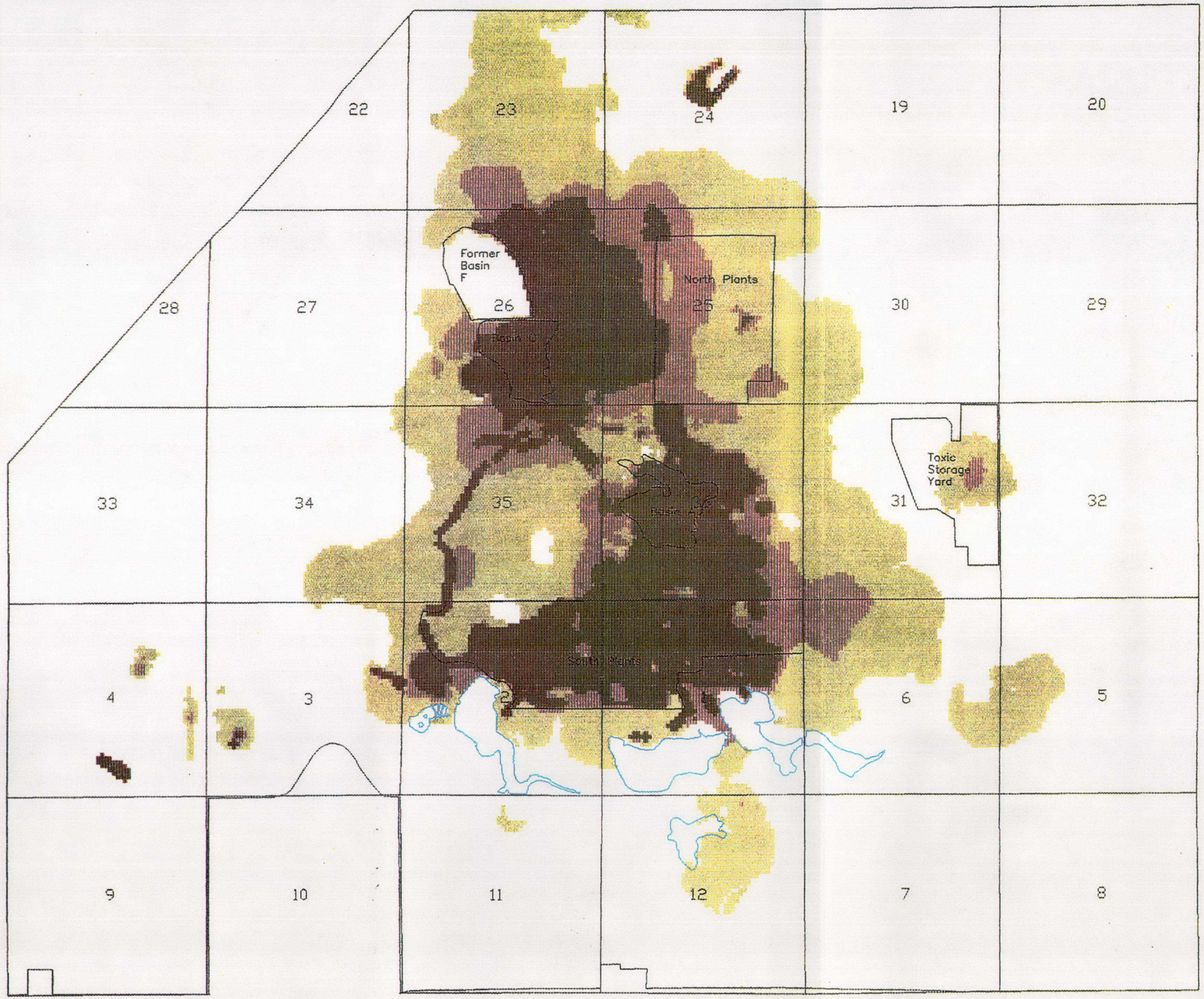
U.S. Army Program Manager
for Rocky Mountain Arsenal

February 1994

Figure C.3–94

Great Horned Owl Map (HI>10) for Aldrin/Dieldrin DDT/DDE, and Endrin Combined Based on the Army, EPA, and Shell Approaches

Rocky Mountain Arsenal
Prepared by: ENSERCH Environmental Corp



Legend

- EPA Approach
- Shell and EPA Approaches
- Army and Shell and EPA Approaches

Colors show which approaches result in HI > 1 in the areas indicated

- Lake
- 31 Section Number
- Section Line

N

0 2000 4000

Scale in Feet

Prepared for:

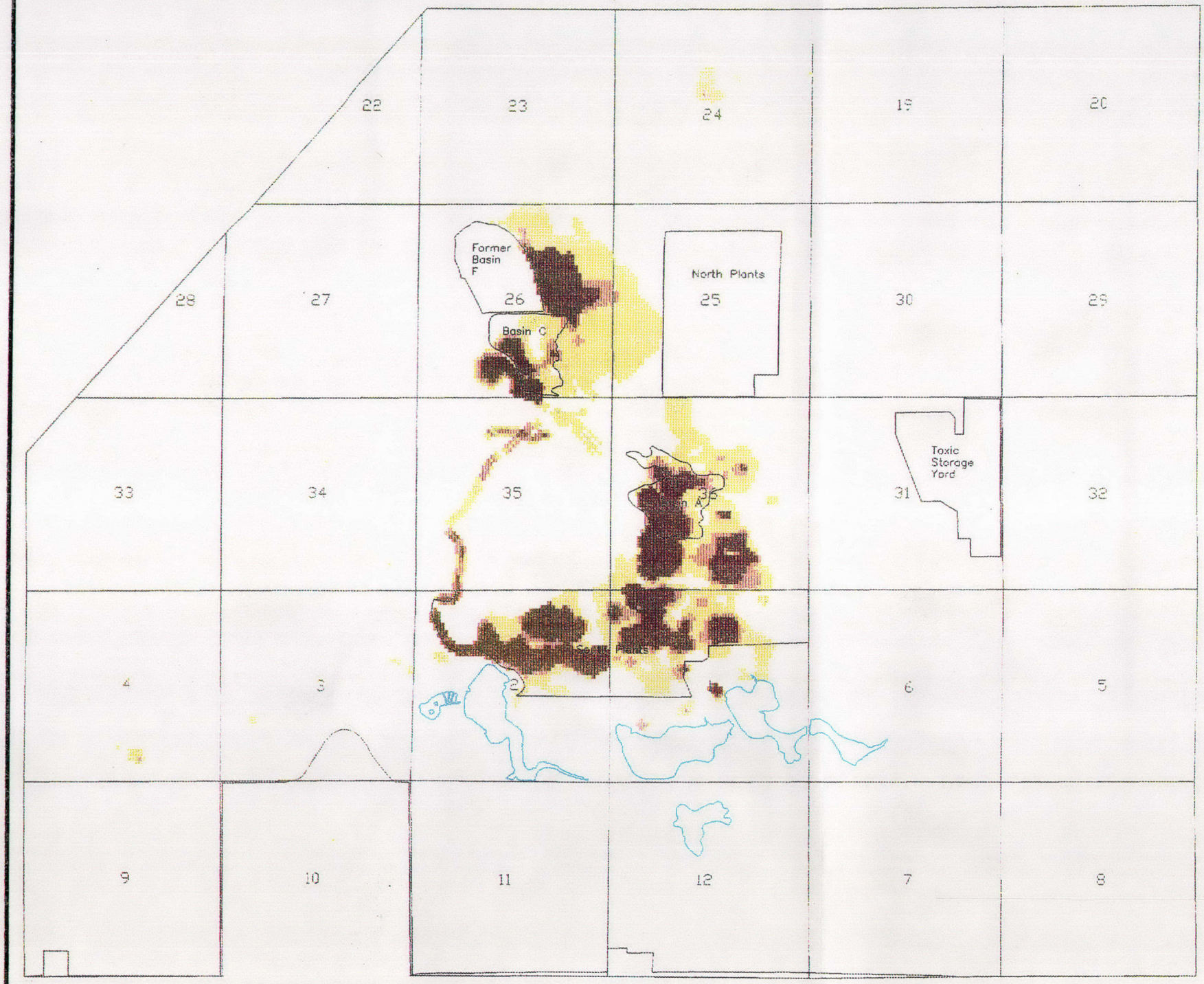
U.S. Army Program Manager
for Rocky Mountain Arsenal

February 1994

Figure C.3-95

Small Mammal Map (HI>1) for Aldrin/Dieldrin, DDT/DDE, and Endrin Combined Based on the Army, EPA, and Shell Approaches

Rocky Mountain Arsenal
Prepared by: ENSERCH Environmental Corp



Legend

- EPA Approach
- Shell and EPA Approaches
- Army and Shell and EPA Approaches

Colors show which approaches result in HI > 10 in the areas indicated

- Lake
- 31 Section Number
- Section Line

N

0 2000 4000

Scale in Feet

Prepared for:

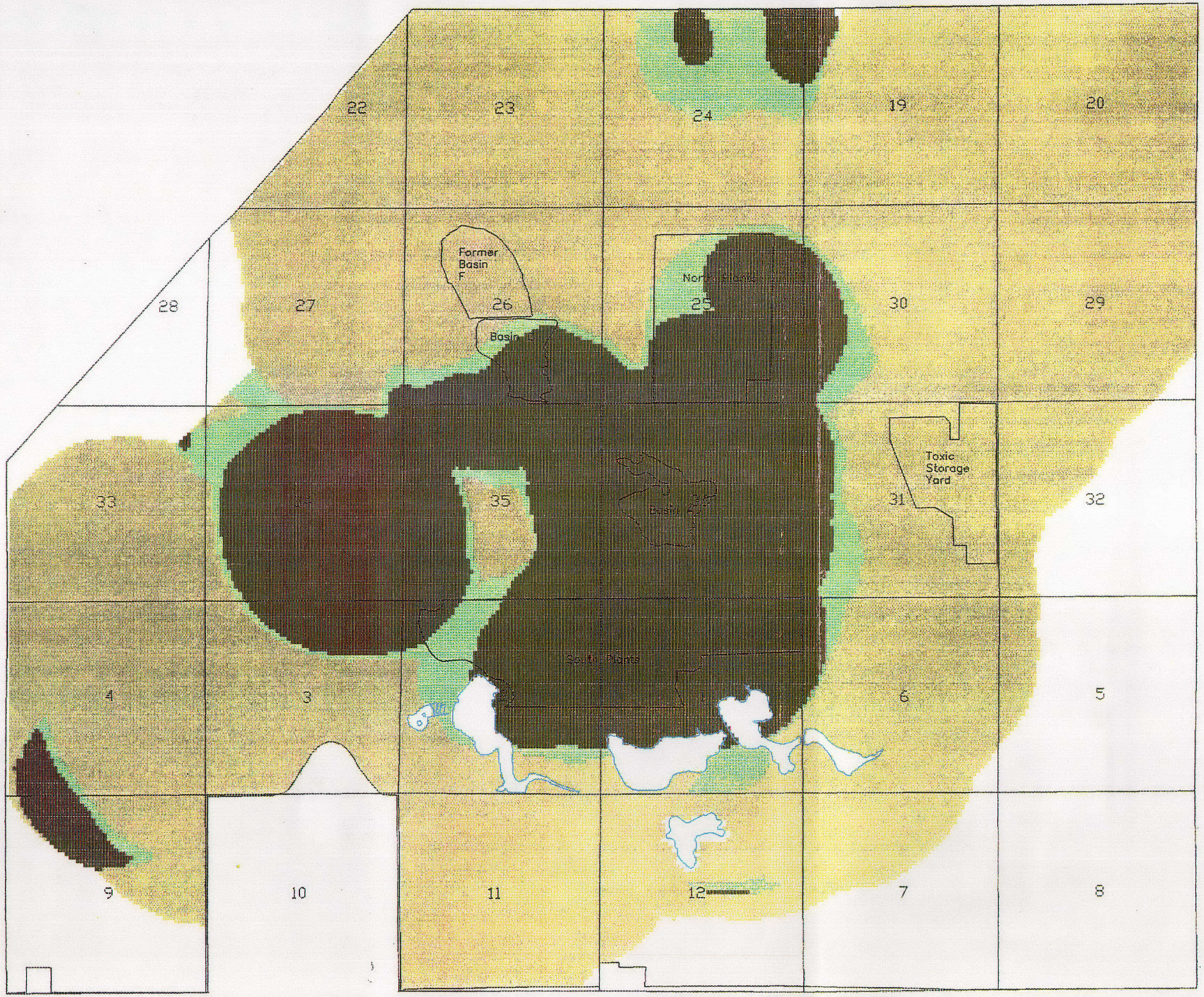
U.S. Army Program Manager
for Rocky Mountain Arsenal

February 1994

Figure C.3-96

Small Mammal Map (HI>10) for Aldrin/Dieldrin, DDT/DDE, and Endrin Combined Based on the Army, EPA, and Shell Approaches

Rocky Mountain Arsenal
Prepared by: ENSERCH Environmental Corp



Legend

- EPA Approach
- Army and EPA Approaches
- Army and Shell and EPA Appproaches

Colors show which approaches result in HI > 1 in the areas indicated

Lake

31 Section Number

Section Line

N

0 2000 4000

Scale in Feet

Prepared for:

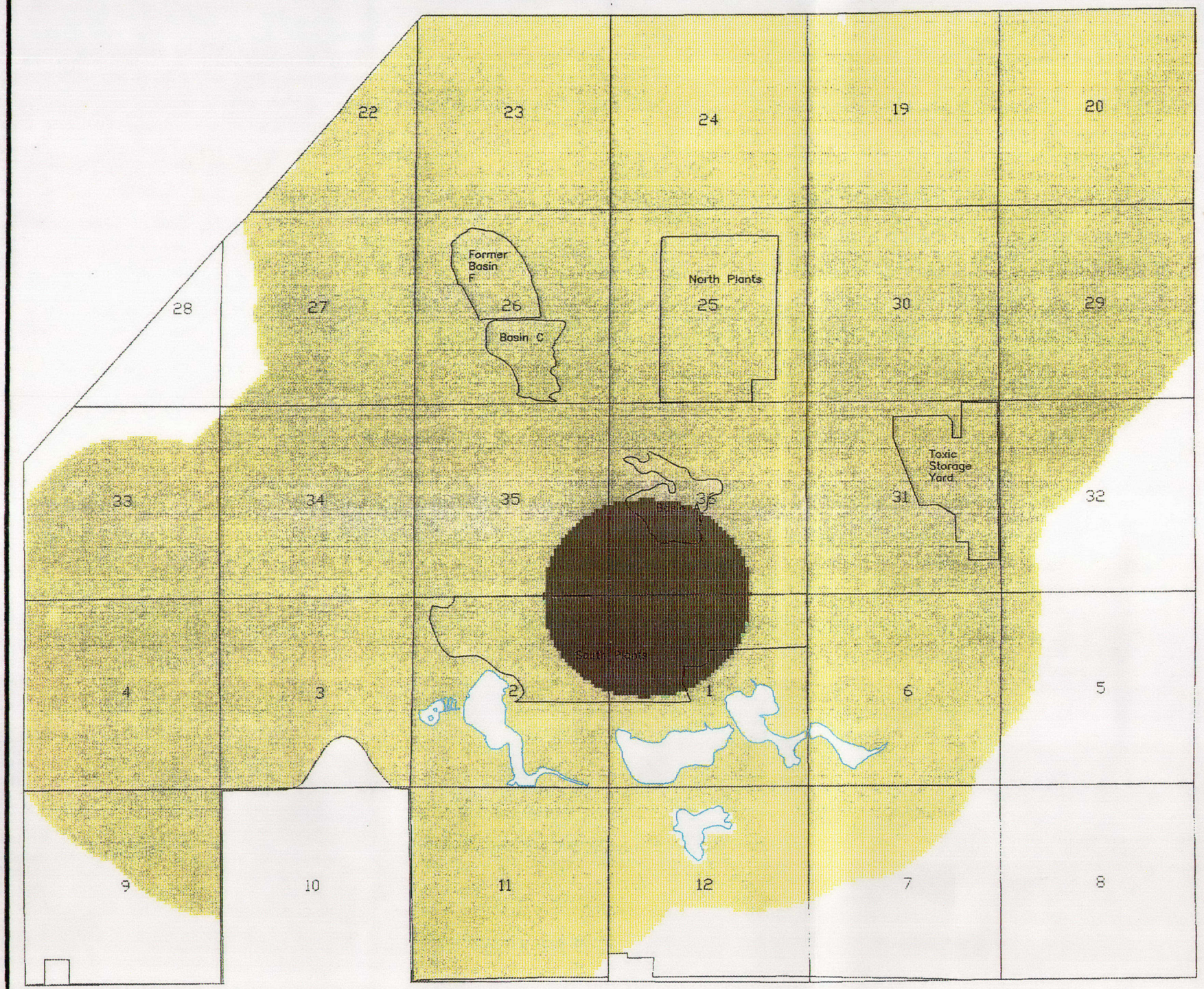
U.S. Army Program Manager
for Rocky Mountain Arsenal

February 1994

Figure C.3-97

Great Horned Owl Map (HI>1) for Mercury, Copper, Cadmium, and Arsenic Combined Based on the Army, EPA, and Shell Approaches

Rocky Mountain Arsenal
Prepared by: ENSERCH Environmental Corp



Legend

- EPA Approach
- Army and EPA Approaches
- Army and Shell and EPA Appproaches

Colors show which approaches result in HI > 10 in the areas indicated

Lake

31 Section Number

Section Line

N

0 2000 4000

Scale in Feet

Prepared for:

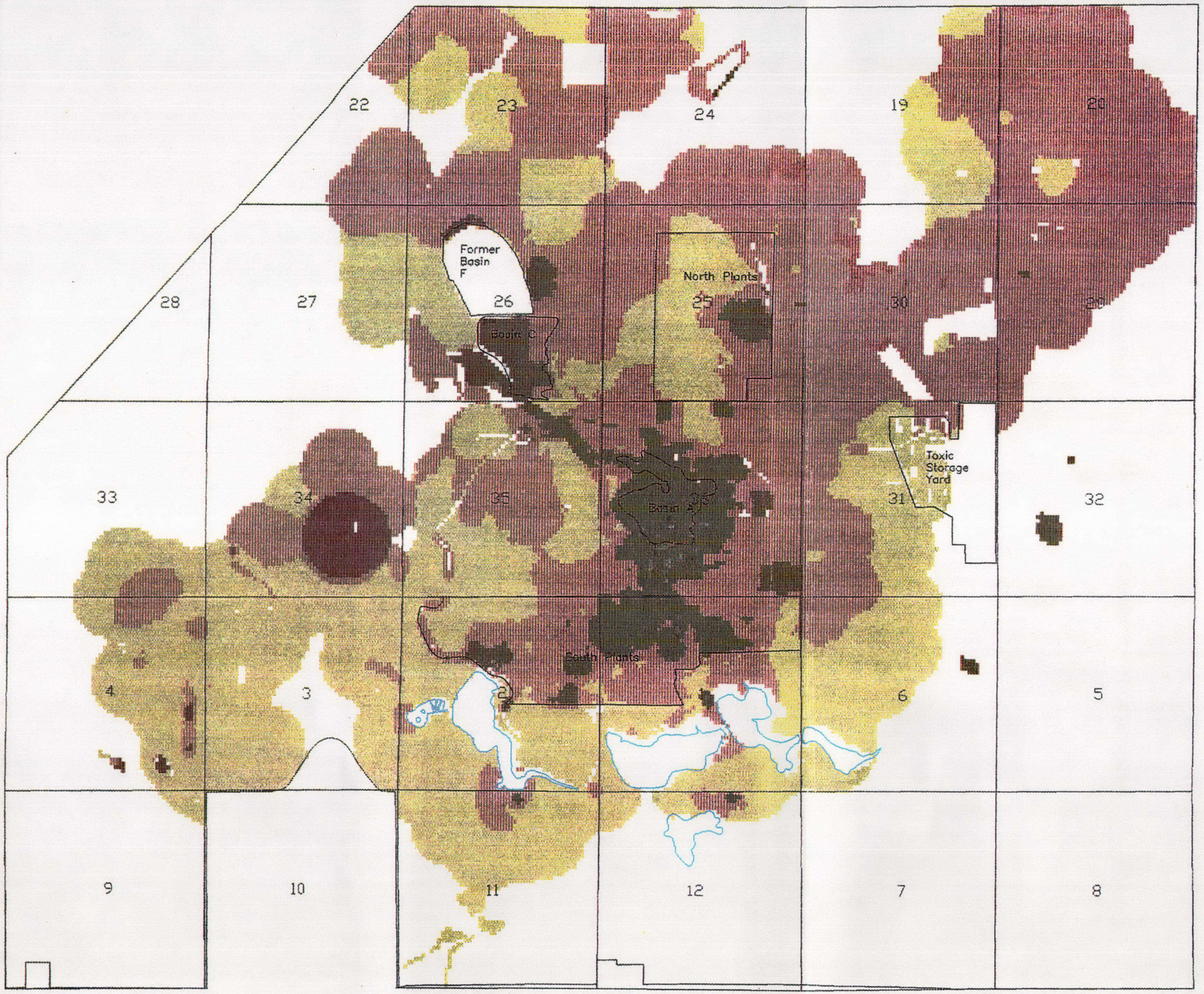
U.S. Army Program Manager
for Rocky Mountain Arsenal

February 1994

Figure C.3–98

Great Horned Owl Map (HI>10) for Mercury, Copper, Cadmium, and Arsenic Combined Based on the Army, EPA, and Shell Approaches

Rocky Mountain Arsenal
Prepared by: ENSERCH Environmental Corp



Legend

- EPA Approach
- Shell and EPA Approaches
- Army and Shell and EPA Approaches

Colors show which approaches result in HI > 1 in the areas indicated

- Lake
- 31 Section Number
- Section Line

N

0 2000 4000

Scale in Feet

Prepared for:

U.S. Army Program Manager for Rocky Mountain Arsenal

February 1994

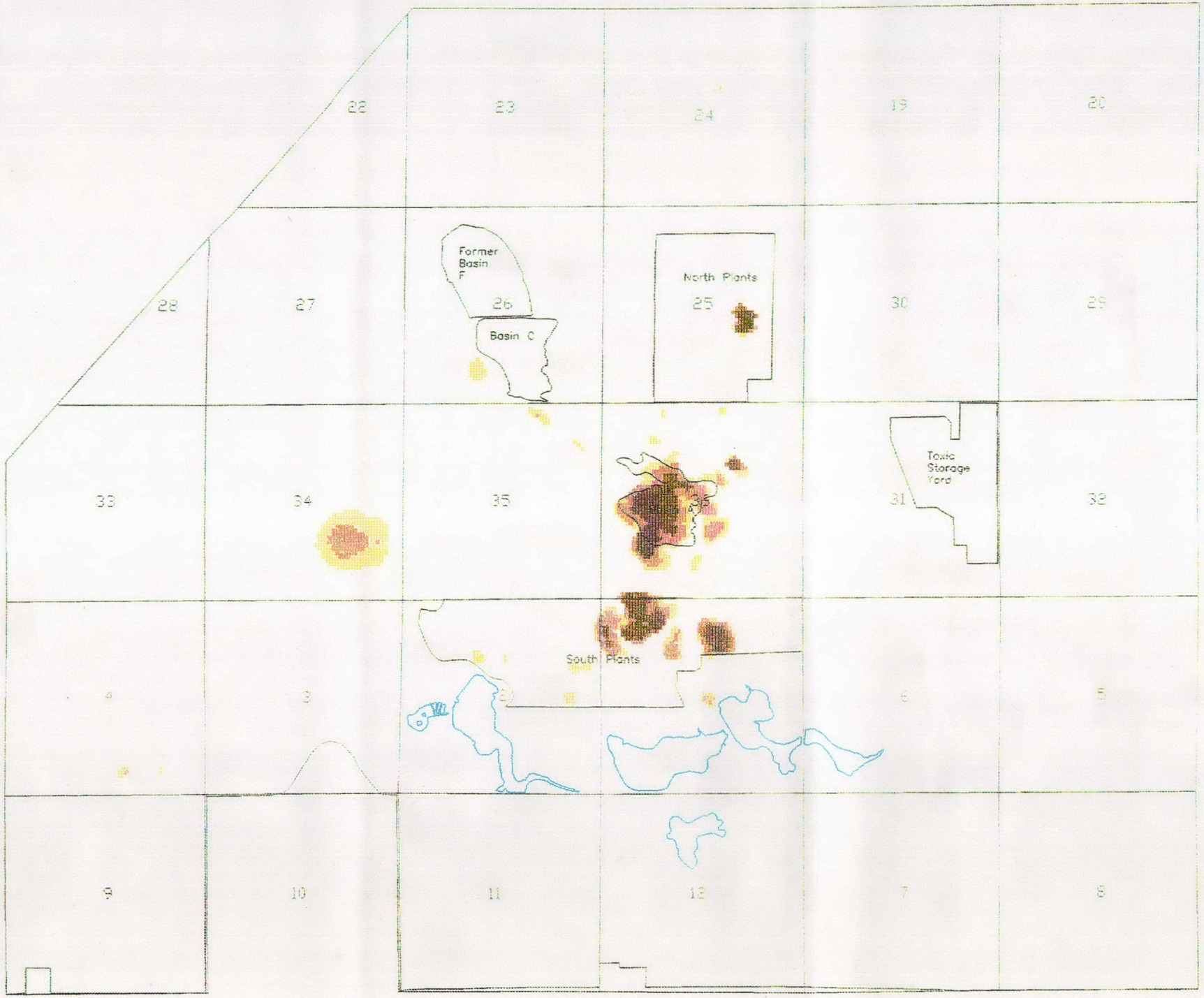
Figure C.3–99

Small Mammal Map (HI>1) for Mercury, Copper, Cadmium, and Arsenic Combined

Based on the Army, EPA, and Shell Approaches

Rocky Mountain Arsenal

Prepared by: ENSERCH Environmental Corp



Legend

- EPA Approach
- Shell and EPA Approaches
- Army and Shell and EPA Approaches

Colors show which approaches result in HI > 10 in the areas indicated

- Lake
- 31 Section Number
- Section Line

N

0 2000 4000

Scale in Feet

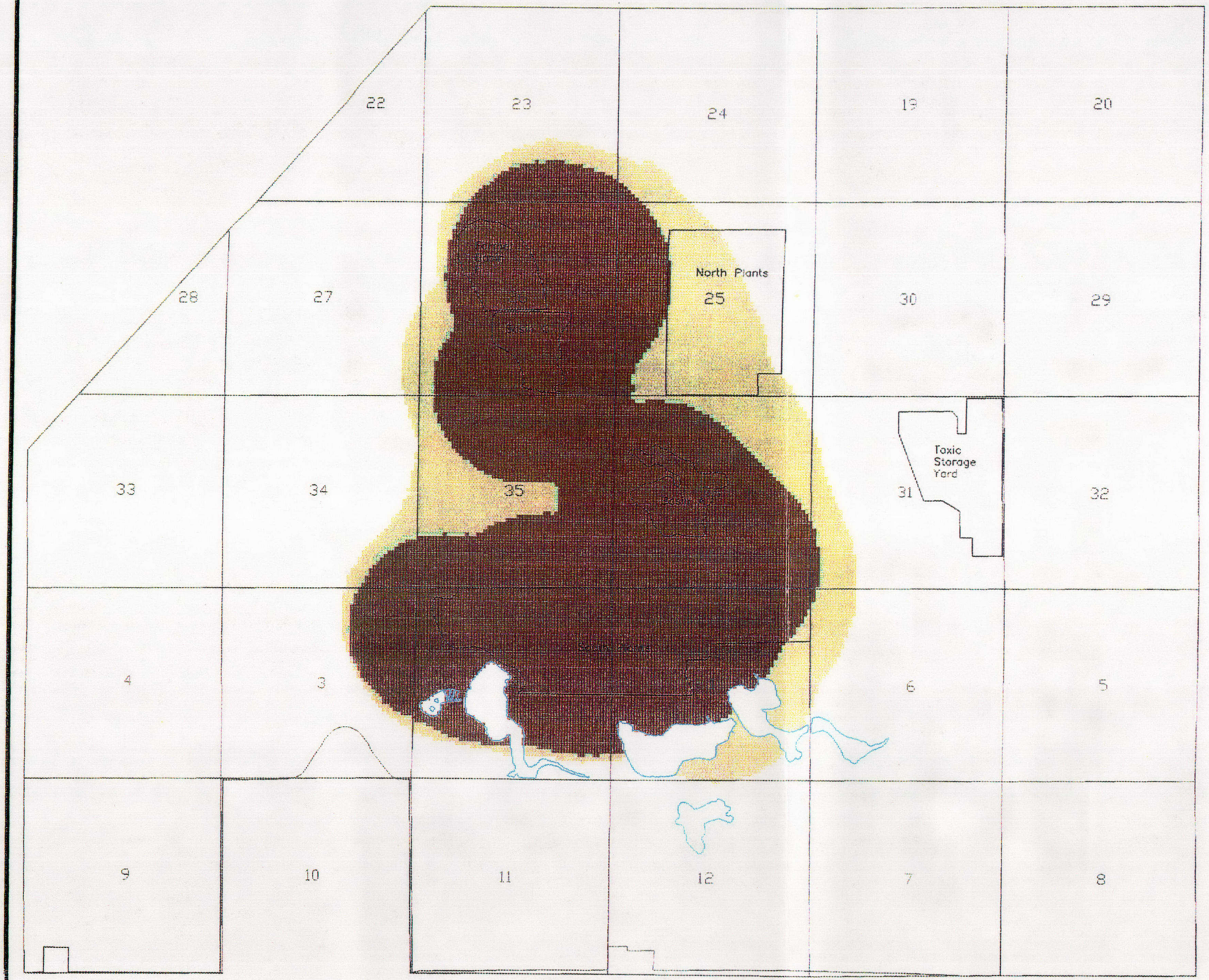
Prepared for:
U.S. Army Program Manager
for Rocky Mountain Arsenal

February 1994

Figure C.3–100

Small Mammal Map (HI>10) for Mercury, Copper, Cadmium, and Arsenic Combined Based on the Army, EPA, and Shell Approaches

Rocky Mountain Arsenal
Prepared by: ENSERCH Environmental Corp



Legend

- EPA Approach
- Army and EPA Approaches
- Army and Shell and EPA Approaches

Colors show which approaches result in HQ > 10 in the areas indicated

- Lake
- 31 Section Number
- Section Line

N

0 2000 4000

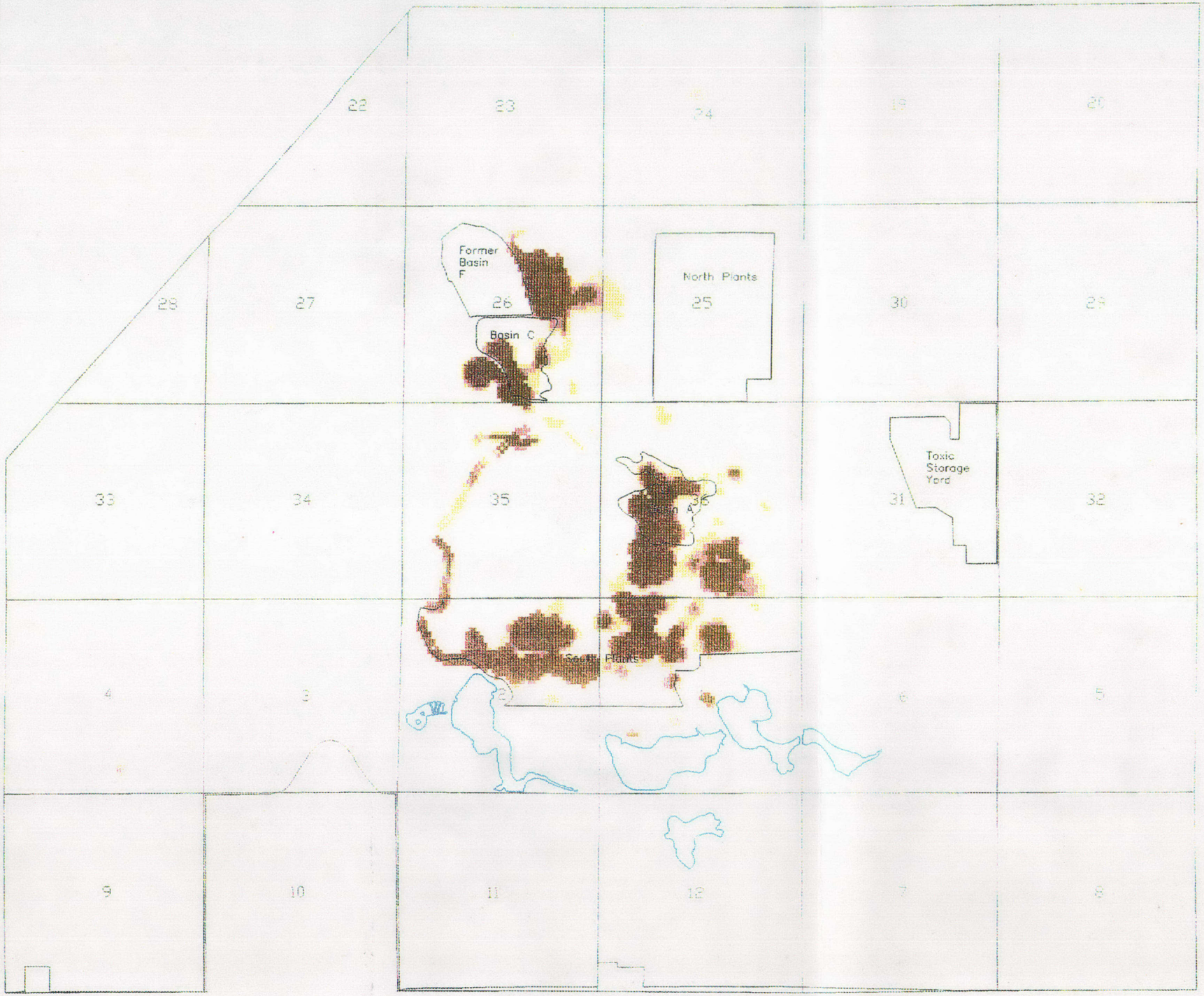
Scale in Feet

Prepared for:
U.S. Army Program Manager
for Rocky Mountain Arsenal

February 1994

Figure C.3–101

Aldrin/Dieldrin Hazard Quotient Map (HQ>10) for the Great Horned Owl Trophic Box Based on the Army, EPA, and Shell Approaches
Rocky Mountain Arsenal
Prepared by: ENSERCH Environmental Corp



Legend

- EPA Approach
- Shell and EPA Approaches
- Army and Shell and EPA Approaches

Colors show which approaches result in HQ > 10 in the areas indicated

- Lake
- 31 Section Number
- Section Line

N

0 2000 4000

Scale in Feet

Prepared for:

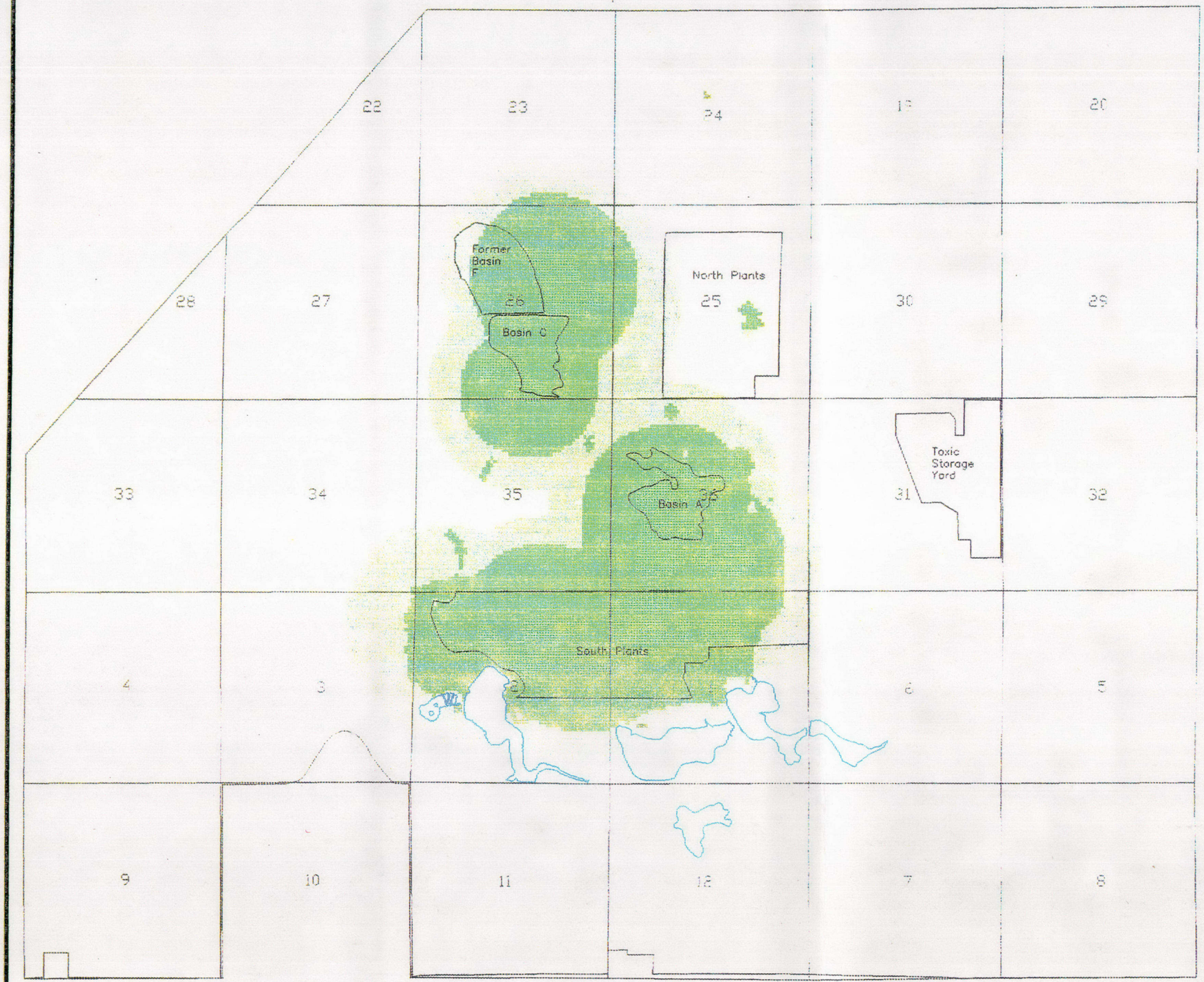
U.S. Army Program Manager
for Rocky Mountain Arsenal

February 1994

Figure C.3–102

Aldrin/Dieldrin Hazard Quotient Map (HQ>10) for the Medium Mammal Trophic Box Based on the Army, EPA, and Shell Approaches

Rocky Mountain Arsenal
Prepared by: ENSERCH Environmental Corp



Legend

1 trophic box with HI > 1

2-4 trophic boxes with HI > 1

5-7 trophic boxes with HI > 1

Lake

31 Section Number

Section Line

N

0 2000 4000

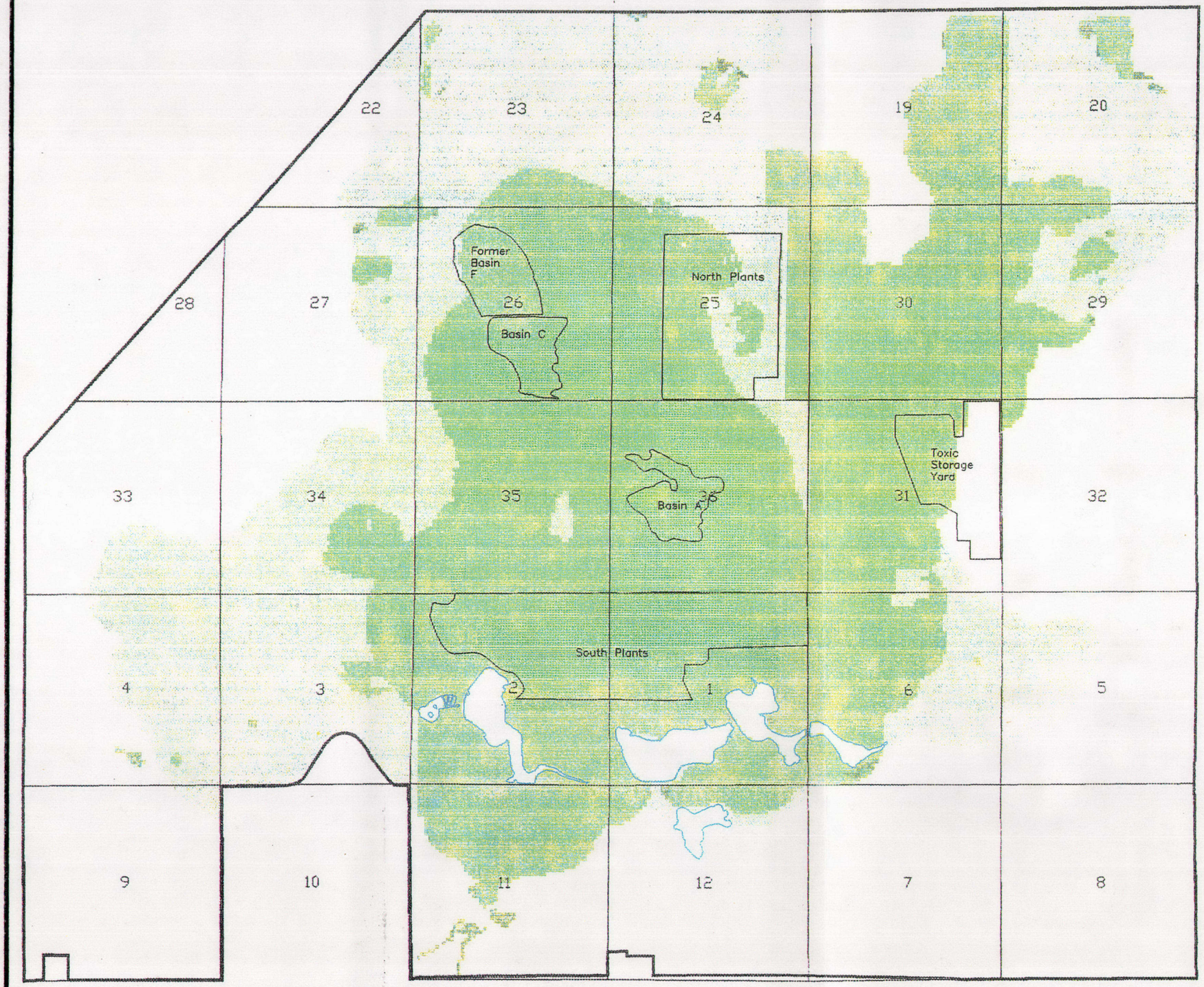
Scale in Feet

Prepared for:
U.S. Army Program Manager
for Rocky Mountain Arsenal

February 1994

Figure C.3-103
Number of Trophic Boxes with Soil Hazard Indices Greater than 10 for All COCs Combined Based on the Army Approach

Rocky Mountain Arsenal
Prepared by: ENSERCH Environmental Corp



Legend

1 trophic box with HI > 10

2-4 trophic boxes with HI > 10

5-7 trophic boxes with HI > 10

Lake

31 Section Number

Section Line

N

0 2000 4000

Scale in Feet

Prepared for:

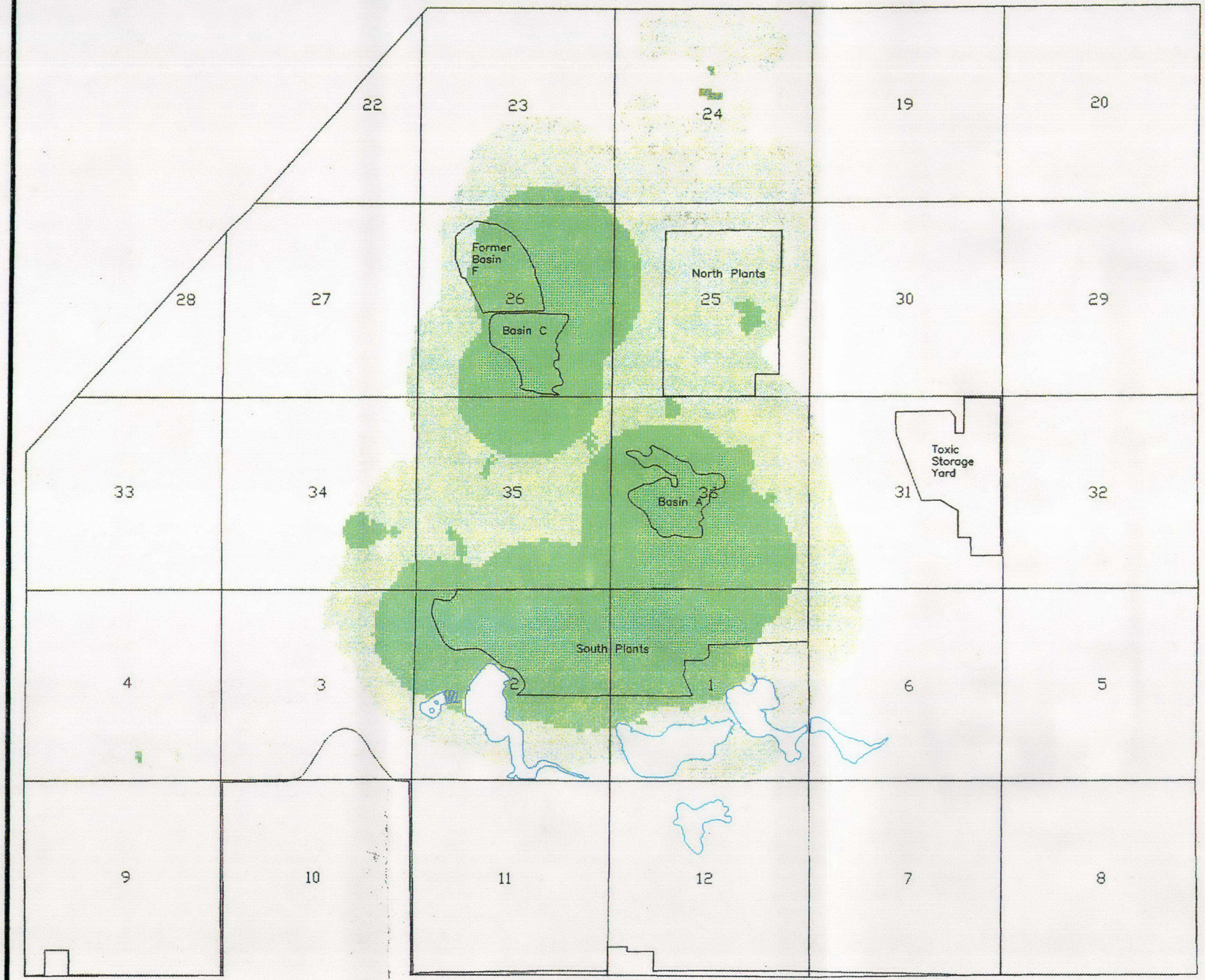
U.S. Army Program Manager
for Rocky Mountain Arsenal

February 1994

Figure C.3-104

Number of Trophic Boxes with Soil Hazard Indices Greater than 10 for All COCs Combined Based on the EPA Approach

Rocky Mountain Arsenal
Prepared by: ENSERCH Environmental Corp



Legend

- 1 trophic box with HI > 10
- 2-4 trophic boxes with HI > 10
- 5-7 trophic boxes with HI > 10
- Lake
- 31 Section Number
- Section Line

N

0 2000 4000

Scale in Feet

Prepared for:

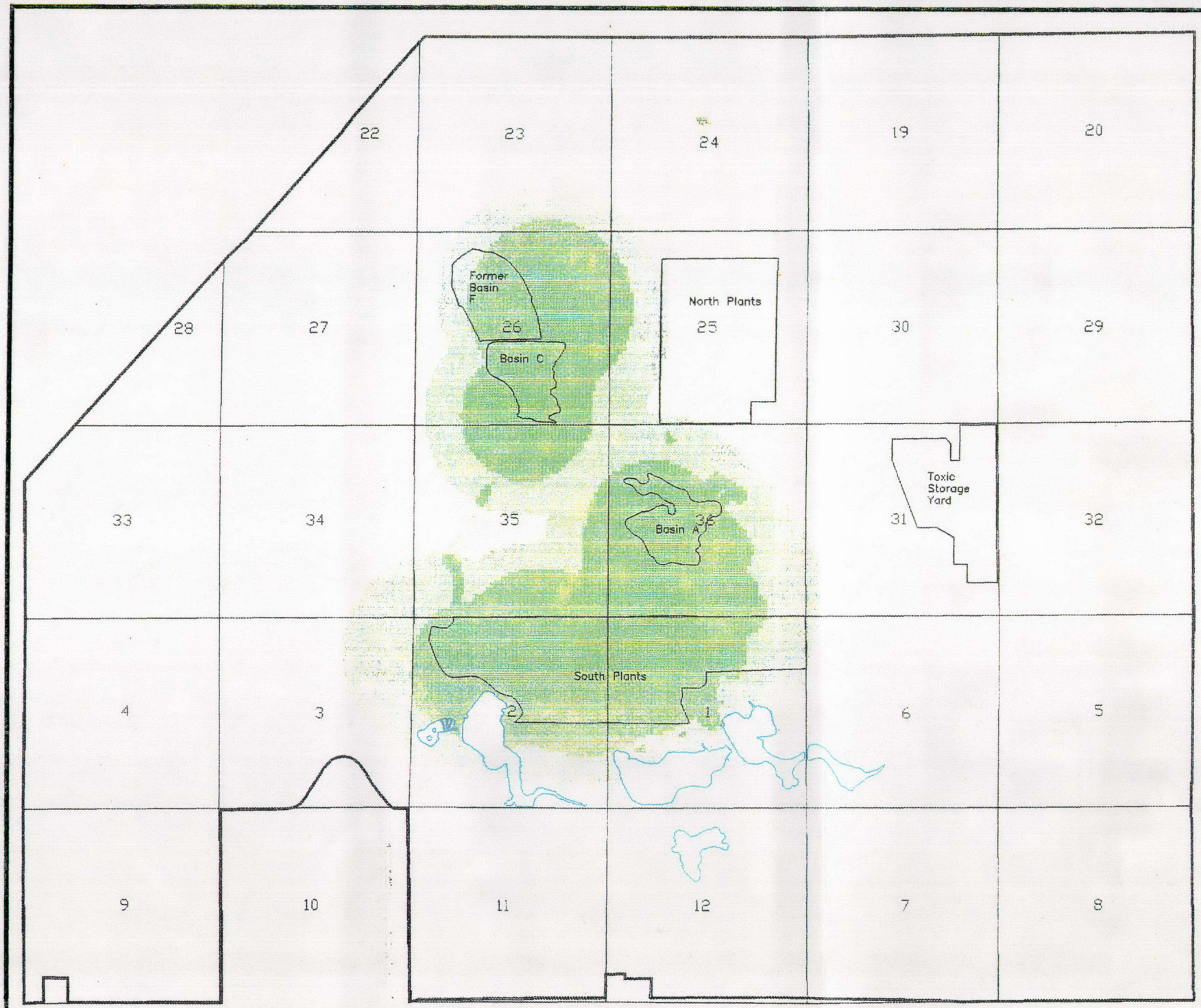
U.S. Army Program Manager
for Rocky Mountain Arsenal

February 1994

Figure C.3-105

Number of Trophic Boxes with Soil Hazard Indices Greater than 10 for All COCs Combined Based on the Shell Approach

Rocky Mountain Arsenal
Prepared by: ENSERCH Environmental Corp



Legend

- 1 trophic box with HI > 10
- 2-4 trophic boxes with HI > 10
- 5-7 trophic boxes with HI > 10
- Lake
- 31 Section Number
- Section Line

N

0 2000 4000

Scale in Feet

Prepared for:

U.S. Army Program Manager
for Rocky Mountain Arsenal

February 1994

Figure C.3–106

Number of Trophic Boxes with Soil Hazard Indices Greater than 10 for Aldrin/Dieldrin, DDT/DDE, and Endrin Combined Based on the Army Approach
Rocky Mountain Arsenal
Prepared by: ENSERCH Environmental Corp

Legend

- 1 trophic box with HI > 10
- 2-4 trophic boxes with HI > 10
- 5-7 trophic boxes with HI > 10
- Lake
- 31 Section Number
- Section Line

N

0 2000 4000

Scale in Feet

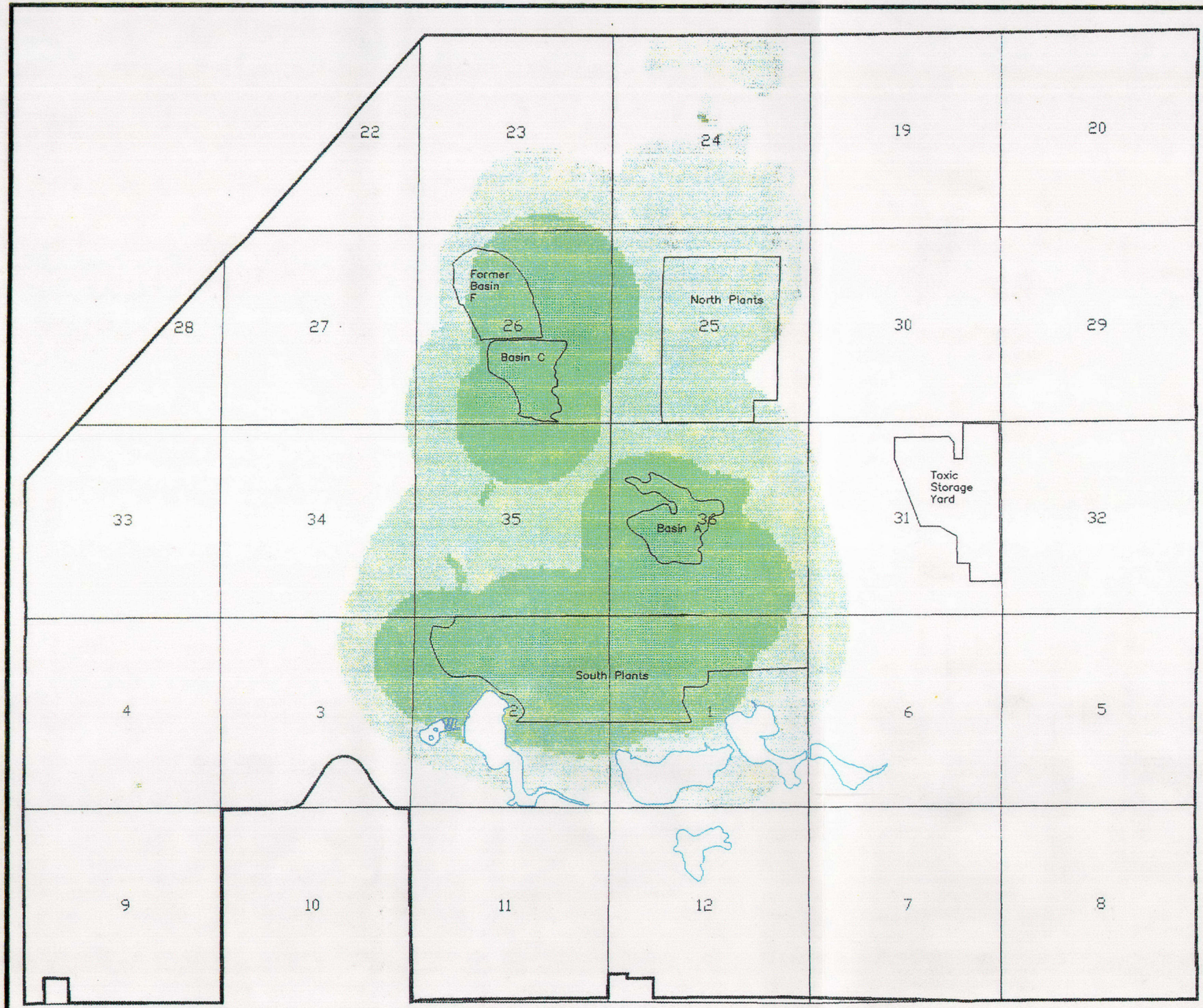
Prepared for:

U.S. Army Program Manager
for Rocky Mountain Arsenal

February 1994

Figure C.3–107

Number of Trophic Boxes with Soil Hazard Indices Greater than 10 for Aldrin/Dieldrin, DDT/DDE, and Endrin Combined Based on the EPA Approach
Rocky Mountain Arsenal
Prepared by: ENSERCH Environmental Corp



Legend

- 1 trophic box with HI > 10
- 2-4 trophic boxes with HI > 10
- 5-7 trophic boxes with HI > 10
- Lake
- 31 Section Number
- Section Line

N

0 2000 4000

Scale in Feet

Prepared for:

U.S. Army Program Manager
for Rocky Mountain Arsenal

February 1994

Figure C.3–108

Number of Trophic Boxes with Soil Hazard Indices Greater than 10 for Aldrin/Dieldrin, DDT/DDE, and Endrin Combined Based on the Shell Approach
Rocky Mountain Arsenal
Prepared by: ENSERCH Environmental Corp

Former Basin F

Basin C

North Plants

Basin A

Toxic Storage Yard

South Plants

22 23 24 19 20

28 27 26 25 30 29

33 34 35 36 31 32

4 3 2 1 6 5

9 10 11 12 7 8

Legend

1 trophic box with HI > 10

2-4 trophic boxes with HI > 10

5-7 trophic boxes with HI > 10

Lake

31 Section Number

Section Line

N

0 2000 4000

Scale in Feet

Prepared for:

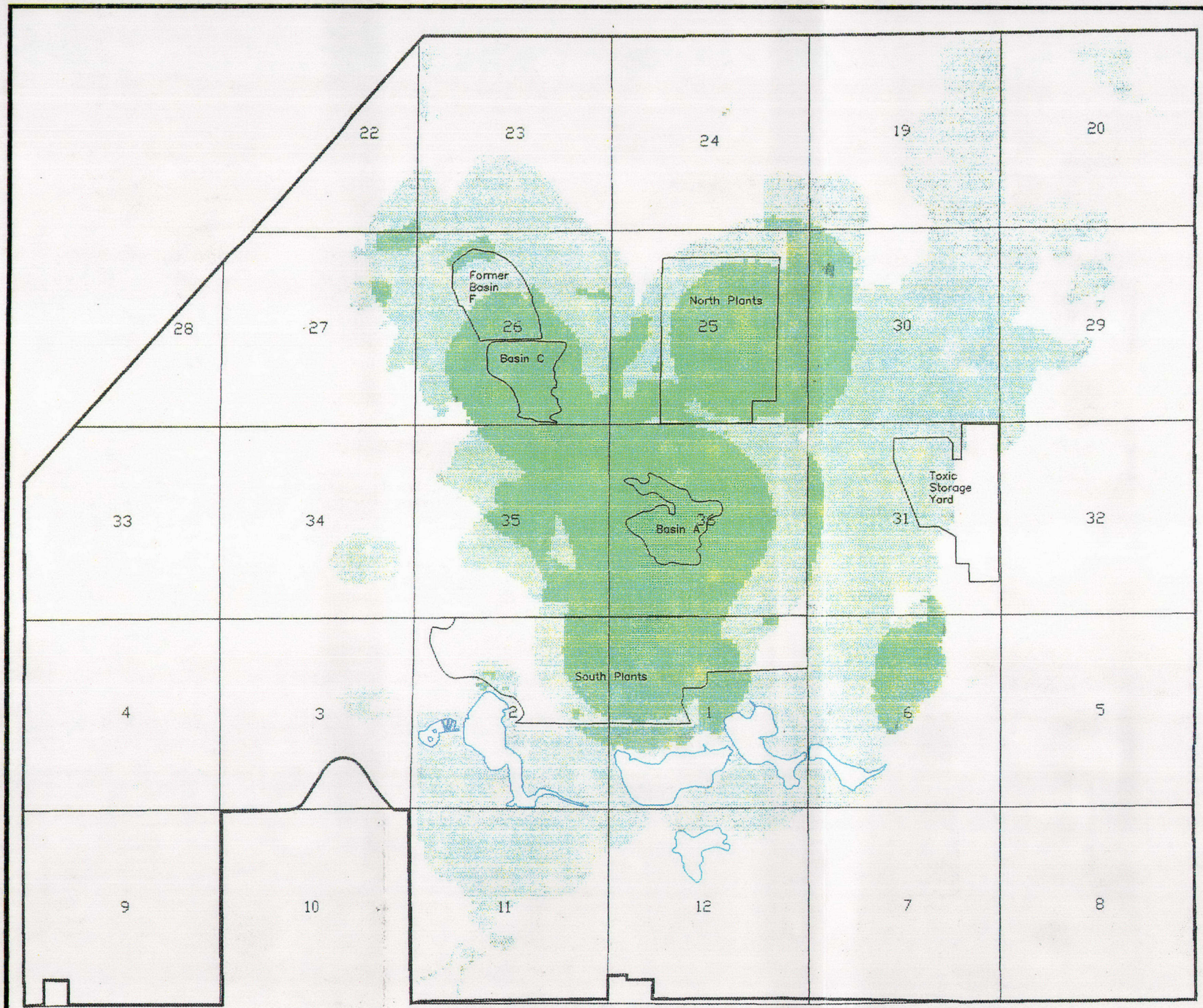
U.S. Army Program Manager
for Rocky Mountain Arsenal

February 1994

Figure C.3-109

Number of Trophic Boxes with Soil Hazard Indices Greater than 10 for Arsenic, Mercury, Cadmium, and Copper Concentrations Above Indicator Levels Based on the Army Approach

Rocky Mountain Arsenal
Prepared by: ENSERCH Environmental Corp



Legend

- 1 trophic box with HI > 10
- 2-4 trophic boxes with HI > 10
- 5-7 trophic boxes with HI > 10
- Lake
- 31 Section Number
- Section Line

N

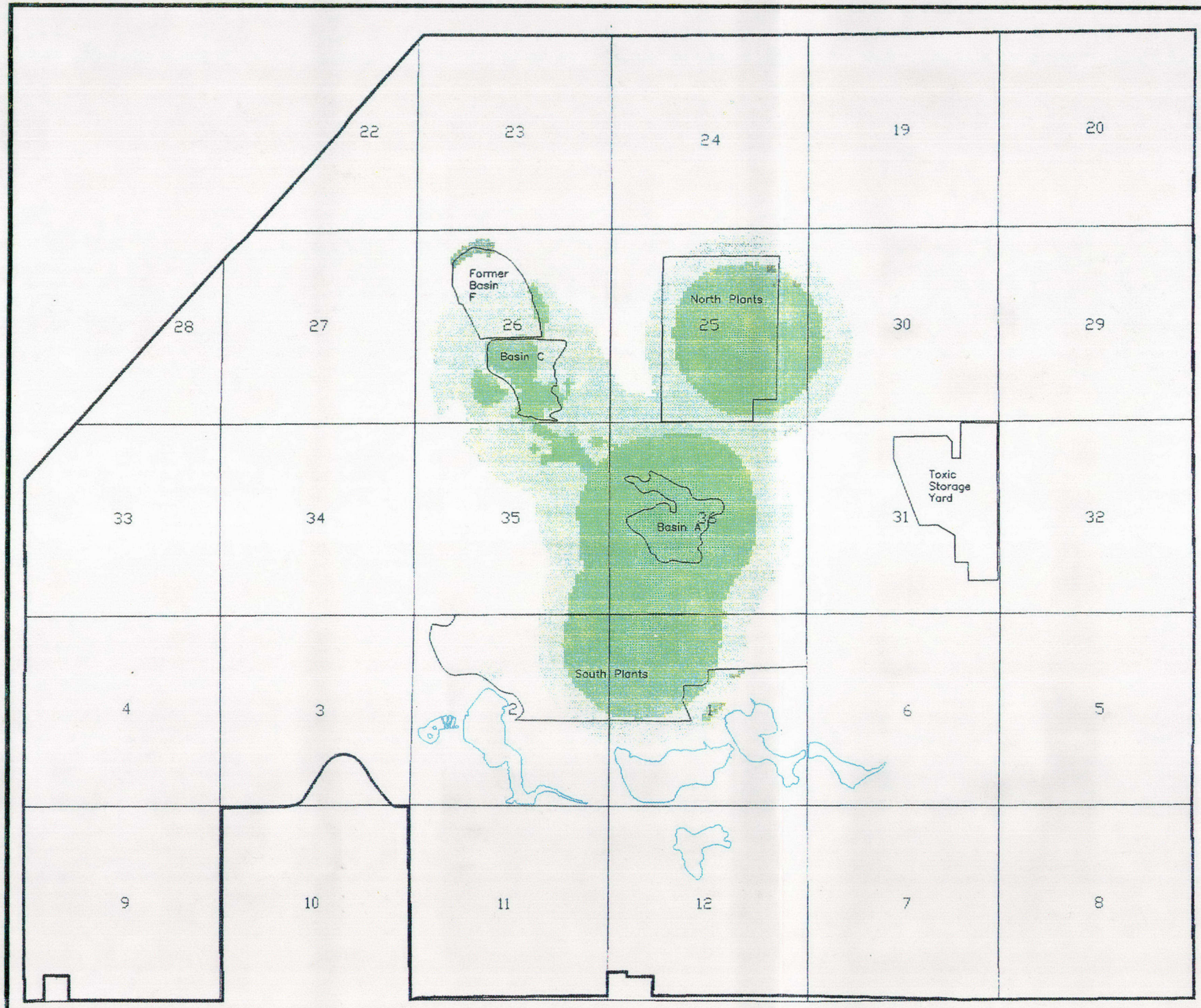
0 2000 4000

Scale in Feet

Prepared for:
U.S. Army Program Manager
for Rocky Mountain Arsenal

February 1994

Figure C.3-110
Number of Trophic Boxes with Soil Hazard Indices Greater than 10 for Arsenic, Mercury, Cadmium, and Copper Concentrations Above Indicator Levels Based on the EPA Approach
Rocky Mountain Arsenal
Prepared by: ENSERCH Environmental Corp



Legend

1 trophic box with HI > 10

2-4 trophic boxes with HI > 10

5-7 trophic boxes with HI > 10

Lake

31 Section Number

Section Line

N

0 2000 4000

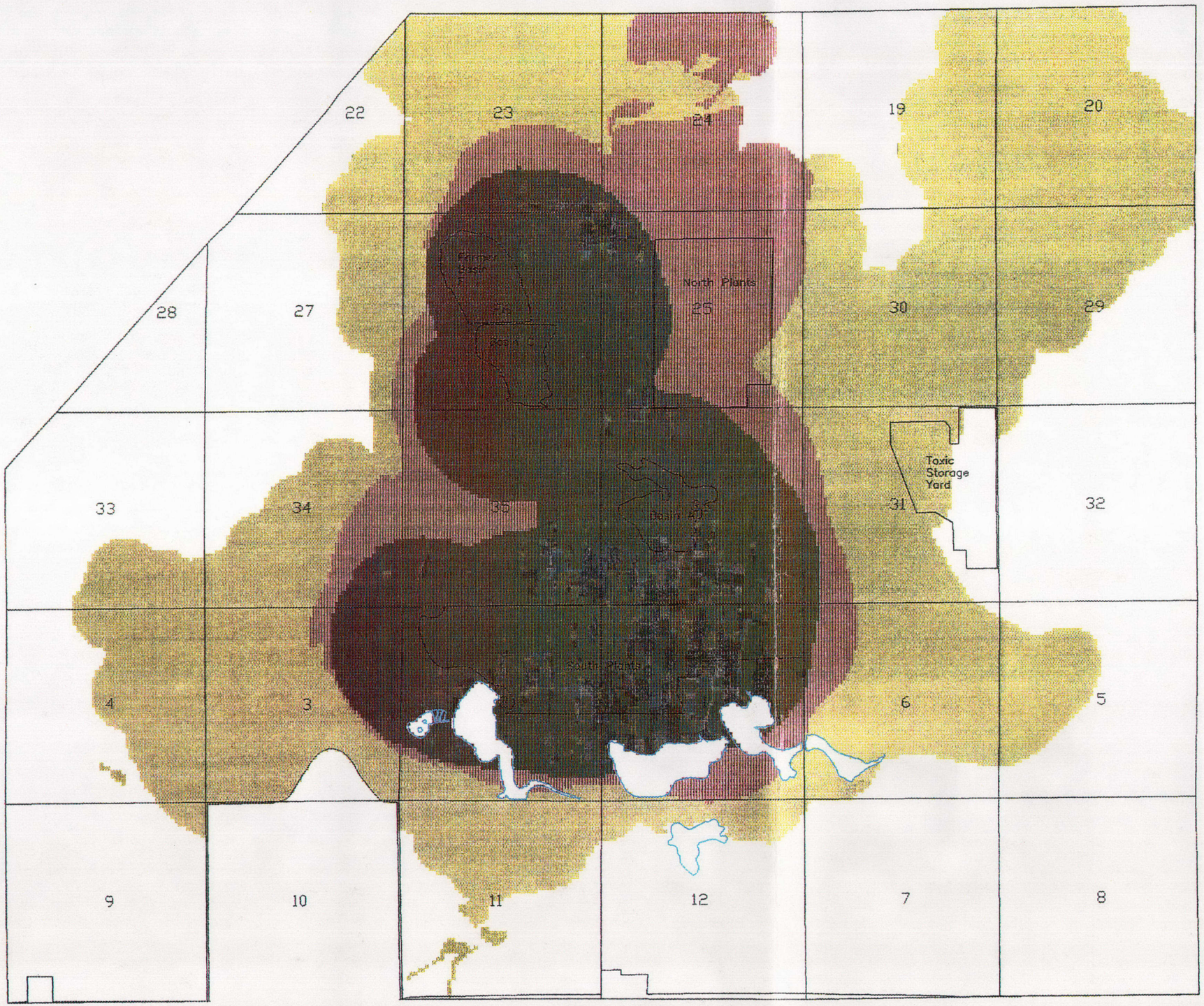
Scale in Feet

Prepared for:
U.S. Army Program Manager
for Rocky Mountain Arsenal

February 1994

Figure C.3-111

Number of Trophic Boxes with Soil Hazard Indices Greater than 10 for Arsenic, Mercury, Cadmium, and Copper Concentrations Above Indicator Levels Based on the Shell Approach
Rocky Mountain Arsenal
Prepared by: ENSERCH Environmental Corp



Legend

- EPA Approach
- Shell and EPA Approaches
- Army and Shell and EPA Approaches

Colors show which approaches result in HI > 10 in the areas indicated

- Lake
- 31 Section Number
- Section Line

N

0 2000 4000

Scale in Feet

Prepared for:

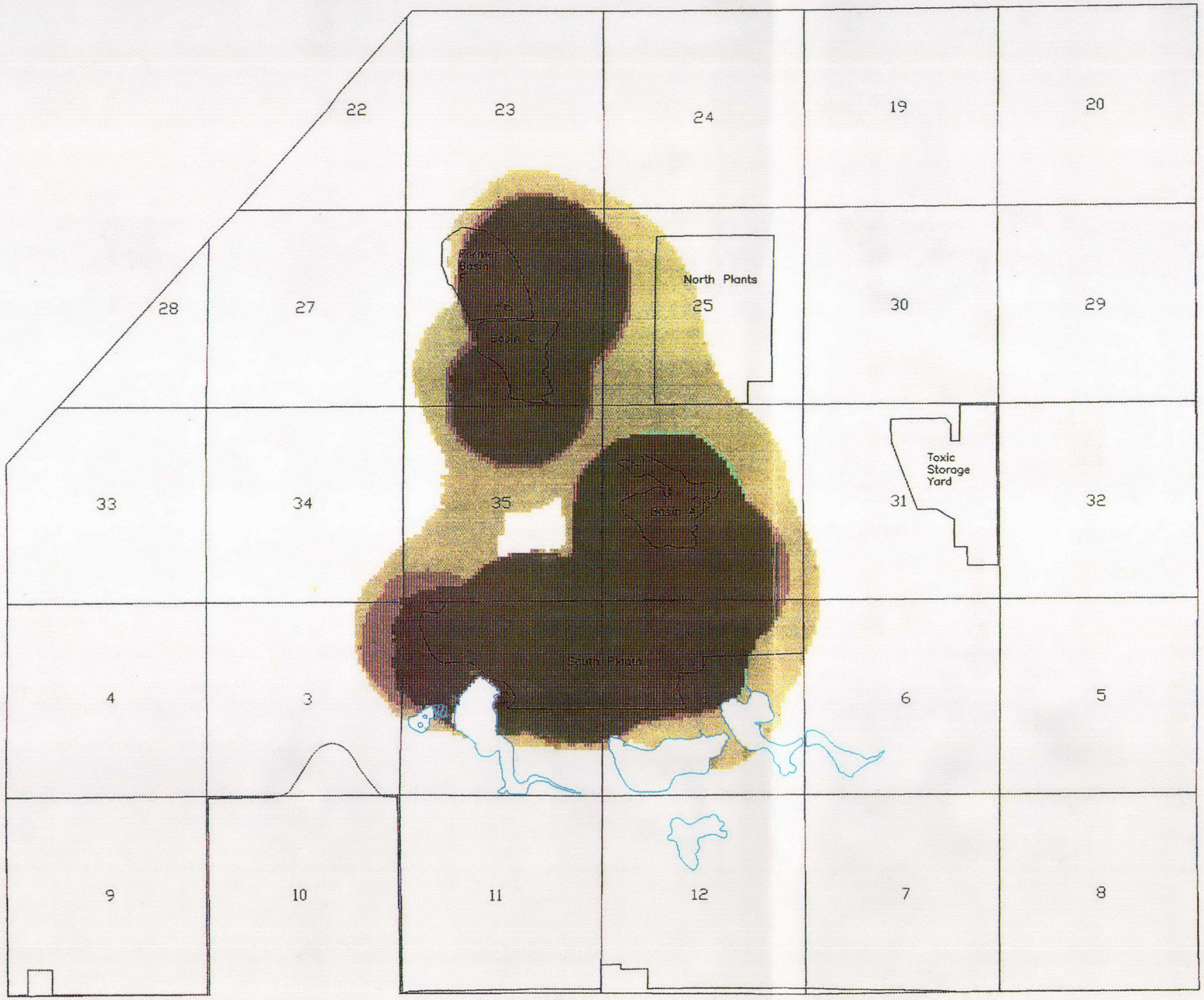
U.S. Army Program Manager
for Rocky Mountain Arsenal

February 1994

Figure C.3–112

Hazard Index Map (HI>10) for the Great Horned Owl Trophic Box Based on the Army, EPA, and Shell Approaches

Rocky Mountain Arsenal
Prepared by: ENSERCH Environmental Corp



Legend

- EPA Approach
- Army and EPA Approaches
- Shell and EPA Approaches
- Army and Shell and EPA Approaches

Colors show which approaches result in HI > 10 in the areas indicated

- Lake
- 31 Section Number
- Section Line

N

0 2000 4000

Scale in Feet

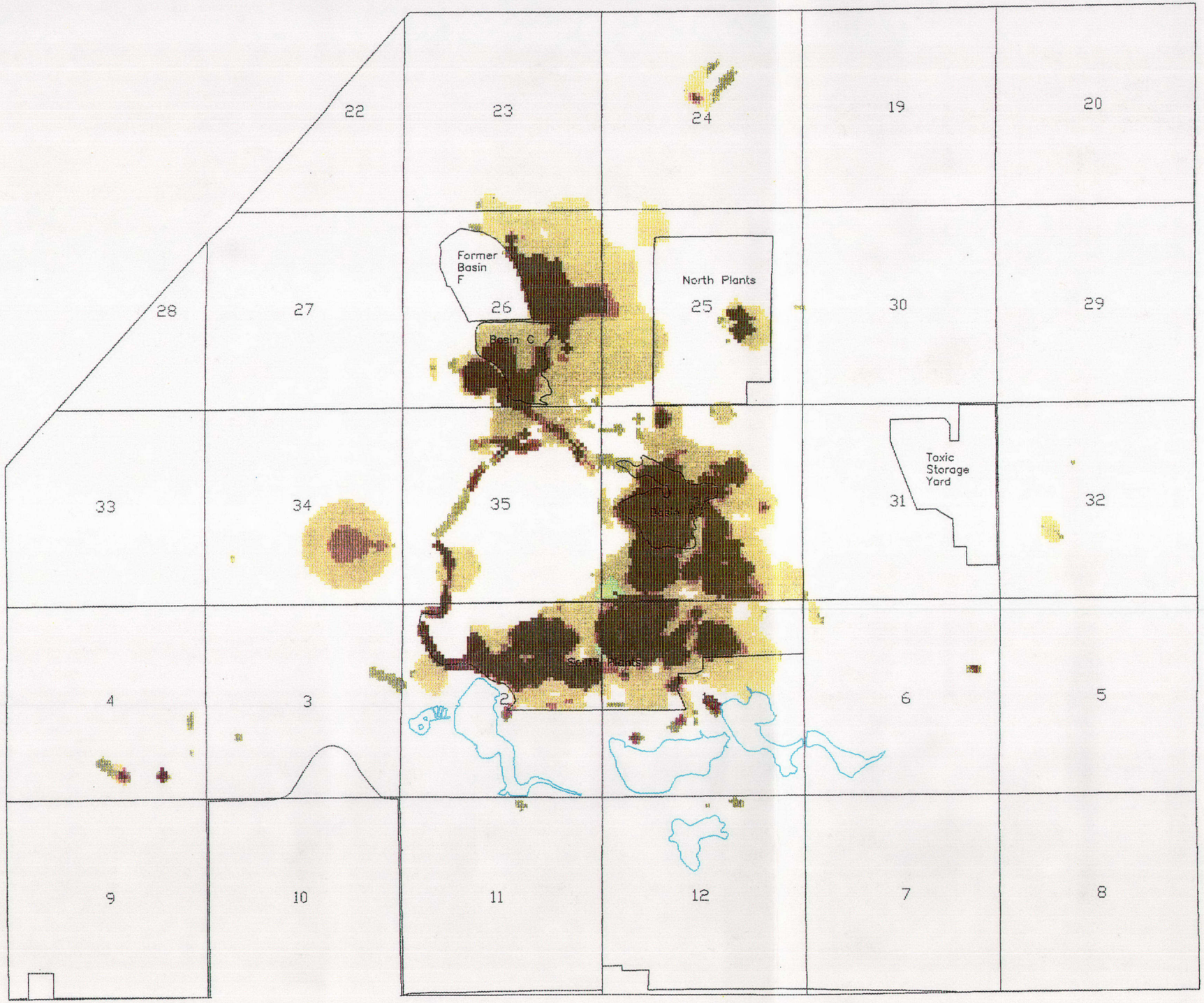
Prepared for:
U.S. Army Program Manager
for Rocky Mountain Arsenal

February 1994

Figure C.3–113

Hazard Index Map (HI>10) for the American Kestrel Trophic Box Based on the Army, EPA, and Shell Approaches

Rocky Mountain Arsenal
Prepared by: ENSERCH Environmental Corp



Legend

- EPA Approach
- Army and EPA Approaches
- Shell and EPA Approaches
- Army and Shell and EPA Approaches

Colors show which approaches result in HI > 10 in the areas indicated

Lake

31 Section Number

Section Line

N

0 2000 4000

Scale in Feet

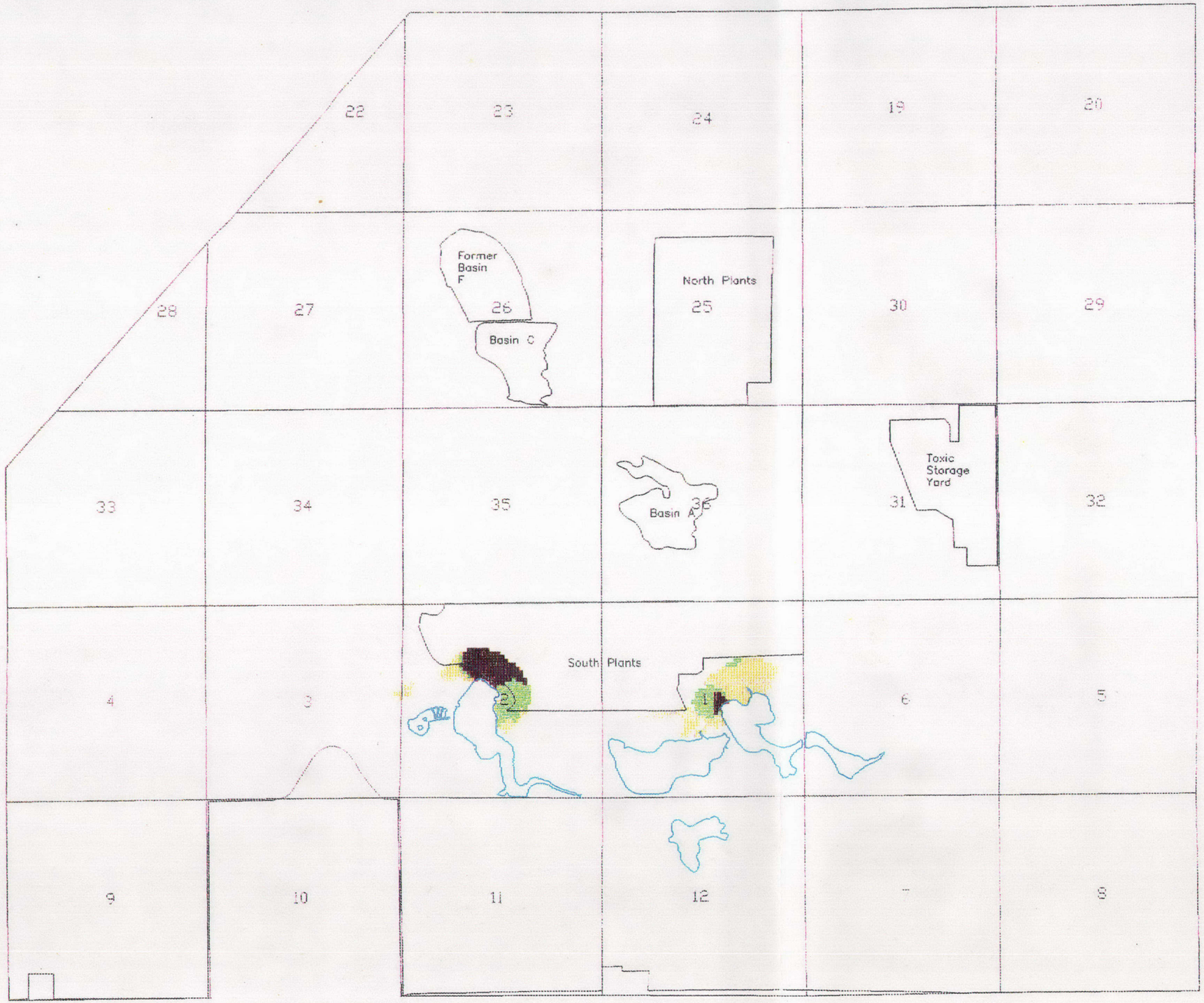
Prepared for:
U.S. Army Program Manager
for Rocky Mountain Arsenal

February 1994

Figure C.3–114

Hazard Index Map (HI>10) for the Medium Mammal Trophic Box Based on the Army, EPA, and Shell Approaches

Rocky Mountain Arsenal
Prepared by: ENSERCH Environmental Corp



Legend

- EPA Approach
- Army and EPA Approaches
- Army and Shell and EPA Approaches

Colors show which approaches result in HI > 10 in the areas indicated

- Lake
- 31 Section Number
- Section Line

-N-

0 2000 4000

Scale in Feet

Prepared for:

U.S. Army Program Manager
for Rocky Mountain Arsenal

February 1994

Figure C.3–115

Hazard Index Map (HI>10) for the Shorebird Trophic Box Based on the Army, EPA, and Shell Approaches

Rocky Mountain Arsenal
Prepared by: ENSERCH Environmental Corp

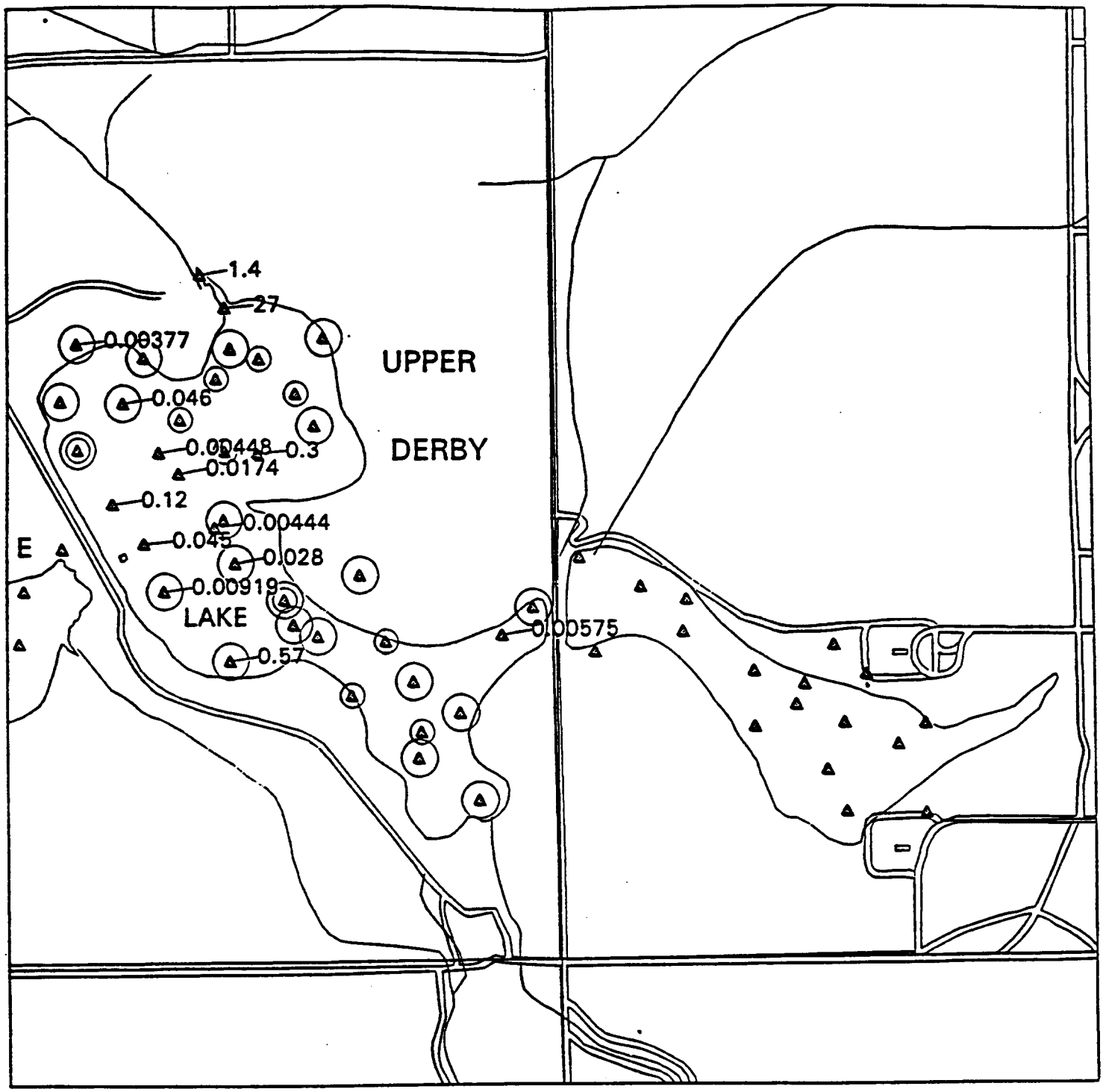


Figure C.3-116

Observed Aldrin Sediment Concentrations (ppm) in Upper Derby Lake (0-1ft. depth profile)

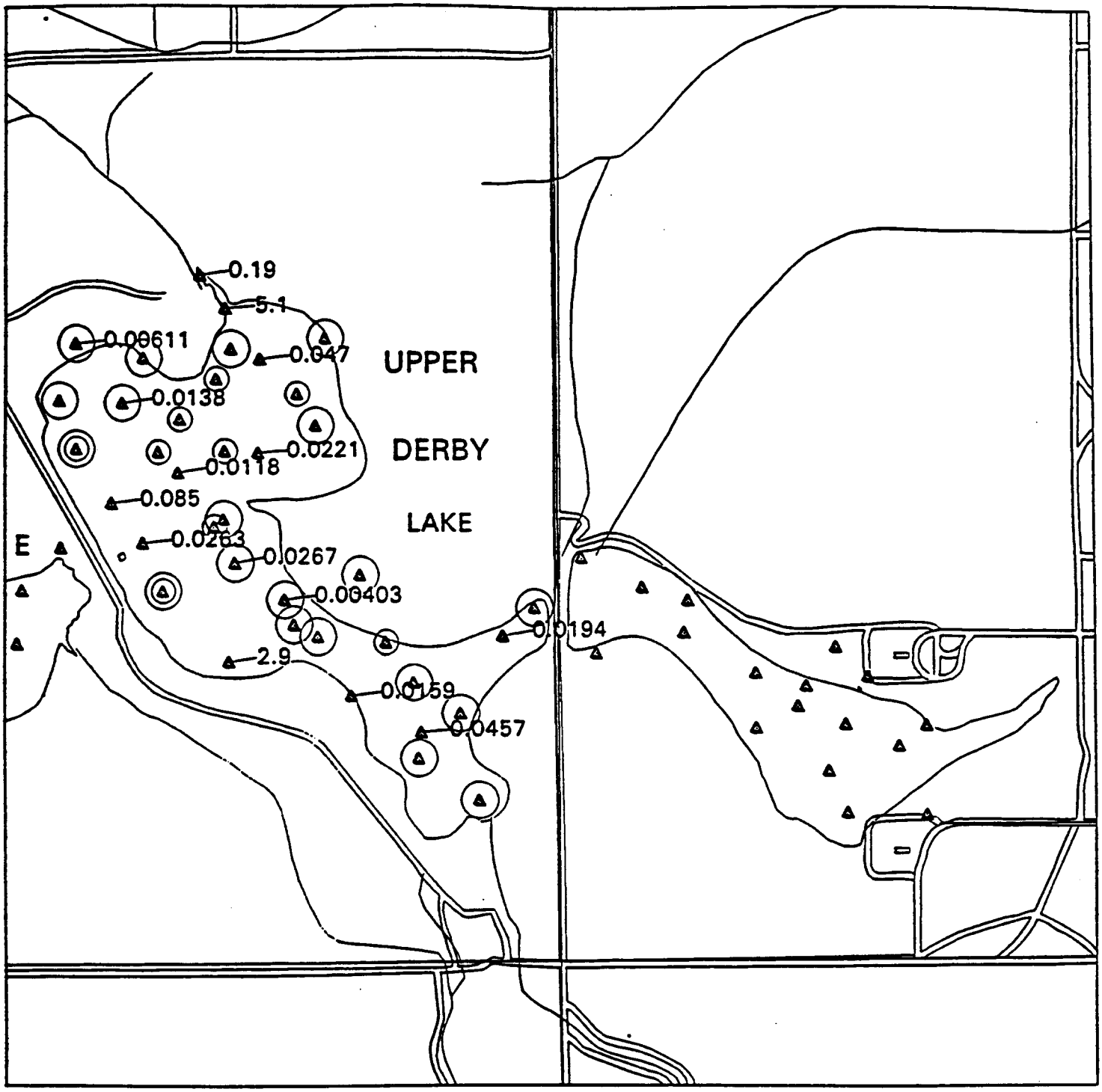


Figure C.3-117

Observed Dieldrin Sediment Concentrations (ppm) in Upper Derby Lake (0-1ft. depth profile)

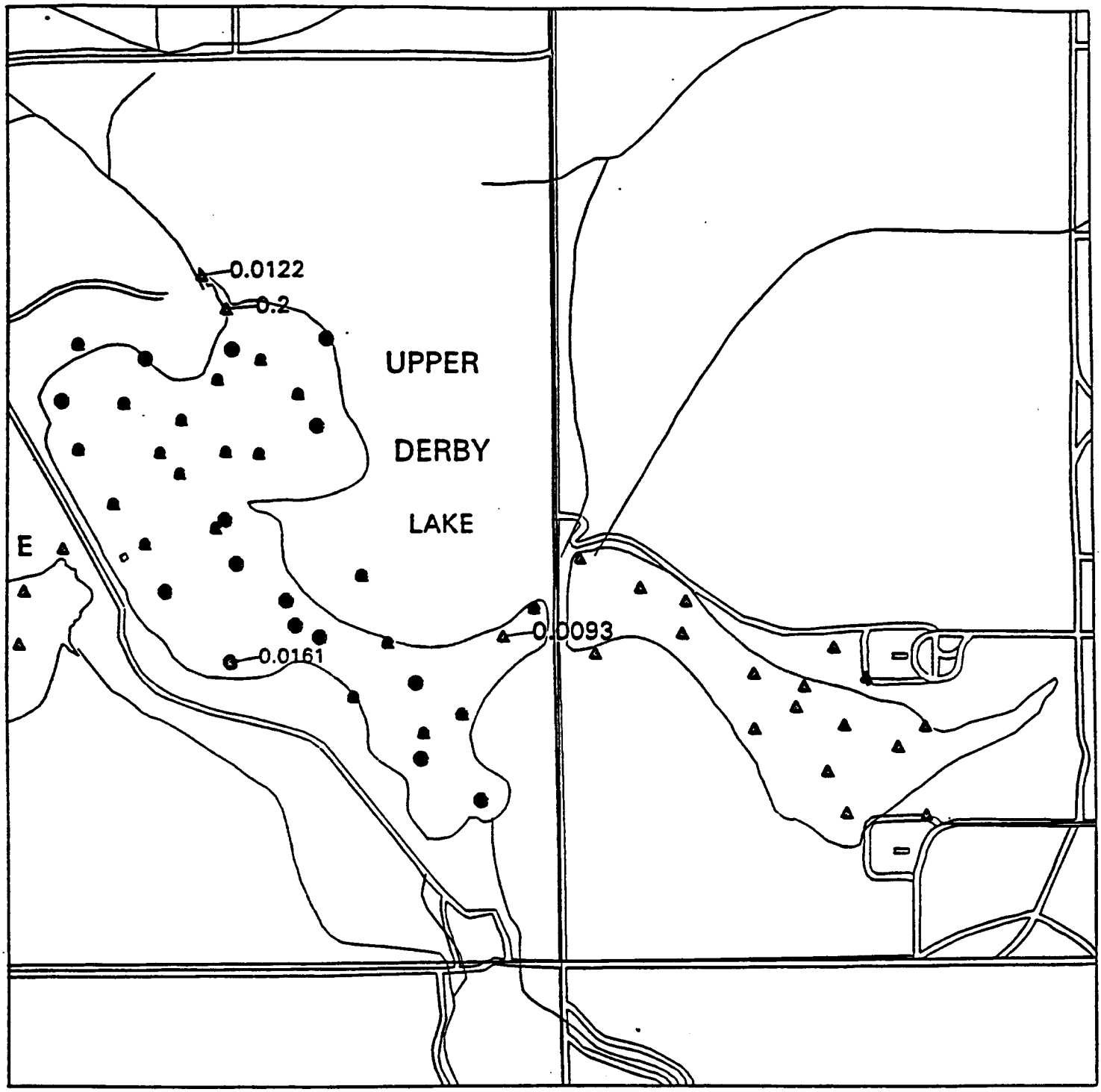


Figure C.3-118

Observed Endrin Sediment Concentrations (ppm)

in Upper Derby Lake (0-1ft. depth profile)

APPENDIX C
(SECTION C.4)

ECOLOGICAL RISK CHARACTERIZATION FIELD SAMPLING PROGRAM

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LIST OF ACRONYMS AND ABBREVIATIONS

BSAs	Biota Study Areas
CMP	Comprehensive Monitoring Program
COCs	contaminant of concern
DDE	dichlorodiphenyldichloroethene
DDT	dichlorodiphenyltrichloroethane
ERC	Ecological Risk Characterization
ft	foot/feet
g	grams
mg/kg	milligrams per kilogram
ml	milliliters
µg/l	micrograms per liter
ppe	personal protective equipment
RI	Remedial Investigation
RMA	Rocky Mountain Arsenal
USATHAMA	U.S. Army Toxic and Hazardous Materials Agency

C.4 ECOLOGICAL RISK CHARACTERIZATION FIELD SAMPLING PROGRAM

Ecological risk characterization (ERC) field sampling efforts were implemented to supplement existing site-specific data from the Biota Remedial Investigation (RI) (ESE 1989) and Biota Comprehensive Monitoring Program (CMP) (RLSA 1992). Sampling occurred for biota, sediment, soil, and water. ERC sampling was designed to provide analytical data for collocated soil, earthworm, deer mouse, and plant samples; analytical data collected at the same time on biota, sediment, and water; data on food habits of selected species on Rocky Mountain Arsenal (RMA); and additional data on small bird tissue samples. The methods and results of the analytical sampling effort are presented in Section C.4.1, and the methods and results of the food-item studies of raptors, water birds, vesper sparrows, and fish at RMA are summarized in Section C.4.2.

C.4.1 ECOLOGICAL RISK CHARACTERIZATION ANALYTICAL SAMPLING PROGRAM

C.4.1.1 Introduction

The ERC sampling program was implemented to augment certain existing RMA databases. Additional biota, water, sediment, and soil samples collected in 1989 and 1990 were analyzed for the seven of the biota contaminants of concern (COCs) (aldrin, dieldrin, dichlorodiphenyldichloroethene [DDE], dichlorodiphenyltrichloroethane [DDT], endrin, arsenic, and mercury). There were two types of supplemental data required (Table C.4-1). The first type of data consisted of COC concentrations for simultaneously collected sediment, water, invertebrate, and fish samples from the aquatic ecosystem; soil samples collected from the precise collection locations of some Biota CMP samples; and small bird, amphibian, and reptile samples from the terrestrial ecosystem. The fish collected were to be of a specific size/age class. The second type of data consisted of selected biota-specific parameters. Specific field procedures used to collect these data are described below. The simultaneous collection of surface water, sediment, and biota samples from the same locations minimized time and location as sources of variability between contaminant concentrations at different levels in aquatic food chains. The ERC sampling program design assumed the concurrent collection of data under the Biota CMP. Further details on the Biota CMP sampling program are in the Final Biota Annual Reports

(RLSA 1990a, b, 1992), and results from the analysis of biota samples are presented in Table C.4-2.

Since recordkeeping protocol, sample preparation, personal protective equipment (PPE), equipment decontamination procedures, schedule, and support services were detailed in an unpublished ERC task plan, the sampling methodology is summarized below. Personnel decontamination procedures are described in the Health and Safety Plan (EBASCO 1988). Sample-handling procedures followed those outlined in the Rocky Mountain Arsenal Chemical Quality Assurance Plan, Version 1.0, July 1989 (PMRMA 1989). Sample analysis was conducted in accordance with certified U.S. Army Toxic and Hazardous Materials Agency (USATHAMA) methods (PMRMA 1989). The results of this field program were combined with data from the Biota RI and Biota CMP to provide the database used to characterize ecological risk.

C.4.1.2 Analytical Study Methods and Results

C.4.1.2.1 Biota

In the ERC biota sampling program, amphibian, reptile, and vesper sparrow samples were needed to provide chemical contaminant data for their respective trophic boxes in the American kestrel food web. Amphibians and reptiles, collected fortuitously under the Biota CMP, were analyzed for contaminants under the ERC program. These included three bullsnake, two composite spadefoot toad, two composite tadpole, and four tiger salamander samples. Vesper sparrows were collected in summer 1990 in the biota study areas (BSAs) near active kestrel boxes (Figure C.4-1). Vesper sparrows were collected with a shotgun or .22 rifle (.22 shotshells). Bullsnakes, spadefoot toads, and amphibians were collected by hand during conduct of Biota CMP field sampling. Insofar as possible, these specimens were collected close to the collection locations of other species in the model. Locations of BSAs and staked sites are shown in Figure C.4-2.

Aquatic biota samples were collected from Lake Ladora and Lower Derby Lake in September 1989. Five sampling stations were established in each lake (Figures C.4-3 and C.4-4). Organisms collected included American pondweed, sago pondweed, plankton, aquatic invertebrates, bluegill, largemouth bass, and northern pike.

Fish specimens were collected from gill nets. Ten northern pike were collected as ERC program samples. From each of these specimens, all but the upper gastrointestinal tract was used as a dressed carcass sample to be chemically analyzed for the target analytes. In addition, ten composite largemouth bass and ten composite bluegill samples were collected from Lake Ladora and Lower Derby Lake under the ERC program and treated similarly. Aquatic plants were harvested with a garden rake at or as close to gill net locations as possible. One additional sample of American pondweed and two additional samples of sago pondweed were collected from each sampling station. Plankton were collected using tow nets pulled behind a small motor boat in the vicinity of fish gill net locations. Water-column invertebrates were collected with dip nets wherever they could be found all along the perimeter of each lake from the shoreline to a depth of 3 feet (ft). Subsamples of the invertebrate samples were to be saved for taxonomic identification, but the number of invertebrate samples was too small to permit this option and all samples had to be composited to achieve sample weight. Taxonomic identification was performed on the single composite sample (taken between the lakes) to the extent possible without detriment to the sample. The sample was later shipped for chemical analysis.

Benthic invertebrates were collected from sieved samples of Ekman dredge hauls. Sediment from the Ekman dredge was composited in a stainless steel pan and washed through sieves with hand-pumped lake water at each sampling station to isolate benthic invertebrates. Invertebrates were to be aggregated at a station and composited among stations until a minimum of 13 grams (g) was collected. However, benthic invertebrates in the lakes were quite sparse in September 1989. The equivalent of 15 full dredge hauls were sieved at each sampling station on each lake, but the minimum sample weight of 13 g required for chemical analysis was never attained.

C.4.1.2.2 Sediments

Sediment samples were collected from Lake Ladora and Lower Derby Lake in September 1989. Five sampling stations were established in each lake in association with biota sampling stations (Figures C.4-3 and C.4-4). Sediments collected with an Ekman dredge from the four corners of a sampling station were composited for each sample. The four corners of a sampling station were located on two lines perpendicular to the ends of the gill net line, each corner being located

10 to 15 ft from the net. A separate sample was collected near the center of the gill net for analysis of volatile organic compounds. Results from the analysis of sediment samples are presented in Tables C.4-3 and C.4-4.

C.4.1.2.3 Soil

Sampling locations for soil were geographically correlated with those of biota whenever possible. Samples were taken (0- to 12-inch depth interval) from 20 staked sites chosen from those locations that exhibited the highest levels of biota contamination during the Biota CMP. This procedure allowed for the comparison of data from these soil samples to data from Biota CMP for samples of earthworms, deer mice, or vegetation from the same locations. The samples were composited from four subsamples surrounding and immediately adjacent to selected earthworm locations (pits), deer mouse trap locations, or vegetation clipping areas sampled during the 1988 or 1989 Biota CMP. Hand augers and clean polybutryate tubes were used to obtain the soil samples. Slide hammers facilitated sample collection. Cores were then sent to a laboratory for chemical analysis. Results of the analysis of soil samples are presented in Table C.4-5.

C.4.1.2.4 Water

Unfiltered water samples were collected from Lake Ladora and Lower Derby Lake in September 1989. Five sampling stations were established in each lake in association with biota and sediment sample collection locations. Water samples were collected 6 inches above the bottom of each lake and, if the water column was more than 3 ft deep, also from the mid-point of the water column. Water subsamples collected from the ends of the gill net and from each side of the net were composited to comprise one sample. A Van Dorn sampler was used to collect samples. Water samples were then sent to a laboratory for chemical analysis. Results of the analysis of surface water samples are presented in Table C.4-6.

C.4.2 ROCKY MOUNTAIN ARSENAL FOOD-ITEM STUDIES

C.4.2.1 Introduction

Food-item studies were used where possible to make the ERC food webs specific to RMA. Birds were selected for food-item studies because they have a proventriculus and gizzard where food items are often still recognizable. Further, raptors—which are at the top of food webs and are, therefore, important indicators of food-web health—regurgitate pellets near frequently used perches or nests that can be easily analyzed for food items. Fish were also selected for food studies because of their higher position in aquatic food webs.

Specific biota collected at RMA for the food-item studies included mallards, American coots, vesper sparrows, bluegill, largemouth bass, and northern pike. Food items eaten at RMA by American kestrels and great horned owls were identified from their pellets and from kestrel nest-box remains. Scientific names are provided in Attachment C.5-1.

Food-item studies include preparing the samples, segregating the contents, identifying the food items, recording the data, and evaluating the data (Korschgen 1980). Data on the amounts and kinds of food consumed can be combined with data on contaminant levels found in food items from the same location to determine and quantify the potential pathways of contamination. The methods and results of these studies are provided below by trophic group or species.

C.4.2.2 Food-Item Study Methods and Results

C.4.2.2.1 Water Birds

Methods

Six mallards and five American coots were collected at RMA in August 1990. Mallard samples were collected from Upper Derby Lake (BSA 10). Coot samples were collected from Lake Mary (BSA 6), Lake Ladora (BSA 7), and Upper Derby Lake (BSA 10). The esophagus and proventriculus were removed and the contents analyzed for food items. Gizzard contents were excluded to reduce bias caused by the rapid digestion of soft foods (Swanson and Bartonek 1970). Tissue samples from these specimens were also submitted for chemical analyses. Food-item samples were preserved in ethyl alcohol, placed in a dissecting tray, and then separated

under a dissecting microscope. Vegetation within the sample was identified. Seeds were identified according to Martin and Barkley (1961), Musil (1963), and the U.S. Forest Service (1974), and compared to reference materials such as plants and invertebrates collected at RMA. Insects and invertebrates were identified to taxonomic order according to Merritt and Cummins (1978) and Needham and Needham (1962).

The total number of identifiable individuals was obtained by counting the maximum number of a single body part (divided by the number of such parts per individual) in the entire sample or in a 10 percent subsample. The total volume of contents was measured by volume displacement in either a 25-milliliter (ml) or a 100-ml graduated cylinder depending on the volume of contents. Measurements were taken to the nearest 0.25 ml when possible. For coots, percent volume of individual items (or inseparable material) was estimated by first determining the percent volume of each item in a 10 percent subsample and then multiplying that percent by the total volume of contents. The 10 percent subsample was determined by using a graduated petri dish. Individual food items (wet) were placed in a known volume of water and the cylinder tapped to remove air bubbles. The percent volume of food items was estimated by dividing the actual or calculated volume of each food item by the total volume of the crop contents (minus the volume of sand present in the sample). Mean volume was calculated as the mean of volumetric percentages (aggregate percentage) as described by Swanson et al. (1974). This method minimizes the effect of a few samples dominating a small sample size (i.e., one or two birds gorging themselves on an infrequently consumed food item).

Results

The results of the mallard food-item study, based on the analysis of esophageal contents of mallards at RMA in August 1990, are presented in Table C.4.7. The mallard esophageal contents were primarily pondweed (*Potamogeten spp.*). Sago pondweed (*Potamogeten pectinatus*) occurred in four of the six samples, while small pondweed (*Potamogeten pusillus)* occurred in three of the six samples. An unidentified species of *Potamogeten* occurred in one of the six samples. *P. pusillus* comprised approximately 73, 86, and 94 percent of the total number of organisms

observed in the three samples that contained *P. pusillus*. Insects were observed in three of the six samples, but accounted for a small percentage of the total esophageal contents.

The results of the American coot food-item study, based on the analysis of crop contents at RMA in August 1990, are presented in Table C.4-8. The American coot crops contained primarily vegetation and sand. Coon tail (*Ceratophyllum spp.*) occurred in all five samples and accounted for a mean of 95 percent of the volume of food items. Other vegetation identified from coots accounted for less than 1 percent of the volume of food items and included advanced algae (*Chara spp.)* and filamentous algae. Insects were found in only one sample and accounted for less than 1 percent of the volume of food items. Invertebrates were found in all samples and included tiny clam-like crustaceans (*Ostracoda*) and snails (*Physa spp*). All invertebrates accounted for approximately 4 percent of the volume of food items.

Based on the esophageal contents of six mallard ducks collected in spring, *Potamogeten* is the most important food item used by mallards at RMA in spring. Aquatic vegetation, specifically *Ceratophyllum,* is the most important food item for American coots at RMA in spring. The information provided in these results is applicable only to food items of mallards or coots at the time and location of collection. Because these results were obtained from a small sample size, they are only useful for determining important food items at the time of capture.

C.4.2.2.2 Vesper Sparrow

Methods

Five vesper sparrows were collected at RMA in June and July 1990. As shown in Figure C.4-1, the samples were collected from the Basin A area (Section 36) Basin F area (Section 26), Sand Creek Lateral area (Section 35), and the Lower Lakes area (Section 11). The esophagus and crop were removed from vesper sparrows for analysis of food items. Gizzard contents were excluded to reduce bias caused by the rapid digestion of soft foods (Swanson and Bartonek 1970). These specimens were also used for chemical analysis of tissues. The esophagus and crops were then preserved in ethyl alcohol, placed in a dissecting tray, and then separated under a dissecting

microscope. Seeds were identified according to Martin and Barkley (1961), Musil (1963), and the U.S. Forest Service (1974), and compared to reference materials such as seeds and insects collected at RMA. Insects and invertebrate were identified to order and family when possible. Total number of identifiable materials (i.e., seeds and insects) was obtained by counting all individual items. The minimum number of individual invertebrates present was determined by counting various mouth parts. Mean volume was calculated as the mean of volumetric percentages (aggregate percentage) as described by Swanson et al. (1974).

Results

The results of the vesper sparrow food-item study, based on the analysis of crop contents at RMA in June and July 1990, are presented in Table C.4-9. Grasshoppers (*Acrididae*) were the most common (four of the five samples) invertebrates in the crops of vesper sparrows; more than 10 individuals occurred in two samples. One sample (B1344C) was dominated by more than 41 individual aphids (*Aphididae*). Another sample (B1411C) consisted solely of grass seeds *(Stipa spp.)*.

The information provided in these results is applicable only to food items of vesper sparrows at the time and location of collection. Because these results were obtained from a small sample size, they are only useful for determining important food items at the time of capture.

C.4.2.2.3 Great Horned Owl

Methods

The food-item study conducted for the great horned owl was centered on pellet analysis, which has been proven as a reliable method in determining the diets of owls (Marti 1987). Pellet analysis involves combining food items into prey groups for which percent occurrence is calculated. Percent occurrence reveals general diet composition and is recommended for food-item studies (Korschgen 1980). Great horned owl pellets were collected from five active nests at RMA in spring 1990 for a study of food items (Figure C.4-5). Nest sites 1 through 5 had been used to provide egg samples for chemical analysis. At the time of pellet collection, nest site 2

had been abandoned, so an alternate nest site, nest site 6, was selected for the food-item study. The tag numbers in the figure (e.g., B1214) represent egg samples collected for analysis.

A total of 68 pellets were collected from the areas below owl nests. Only whole pellets were collected to ensure the food items found were indeed consumed during the spring season. When collected, pellets were placed in plastic bags and labeled. In the laboratory, individual pellets were submersed in water until disintegrated, then separated into invertebrate parts (if any), bones, hair, and feathers. Representative hair samples were made into slides. After prey items were sorted, identifiable parts were compared with the bird and mammal collections at the Denver Natural History Museum and identified to the lowest possible taxonomic level, usually species, for mammals and birds. After identification was complete, a specific bone, usually a left or right jaw bone, was used to determine minimum numbers of individuals. Hair samples were identified as described in Moore et al. (1974) and used to confirm other methods of identification. They were not used to quantify results.

From these results, food items were combined into prey groups for which percent occurrence was calculated. Percent occurrence was calculated by dividing the number of pellets into the number of occurrences of each prey group. The number of occurrences for a prey group was determined by the number of pellets that contained a specific prey group regardless of the number of individuals present. In addition, the total number of individuals by prey group were listed for each nest site. Results for individual nests were also totaled for RMA.

Results

Food items from all nest sites were combined into 17 prey groups: 2 lagomorphs, 11 small rodents, 3 birds, and 1 house cat (Table C.4-10). Overall, deer mice *(Peromyscus spp.)* occurred in pellets most frequently and were most prevalent at nest sites 1, 3, and 4 (Table C.4-10). Kangaroo rats (*Dipodomys ordi*) and all lagomorphs (Leporidae) were most prevalent at nest sites 5 and 6, respectively. Rabbits/hares (Leporidae) and cottontails *(Sylvilagus spp.)* combined represented 43 percent of all prey groups, with cottontails making up more than two-thirds of that group. Kangaroo rats represented 34 percent of all prey groups and were present at every nest

site except nest site 3. Prairie voles (*Microtus ochrogaster*) represented 14 percent of all prey groups. All vole groups combined (i.e., prairie voles, meadow voles [*Microtus pennsylvanicus*] and unknown voles [*Microtus spp.*]) comprised 29 percent. Voles were represented at every nest site. Plains pocket gophers (*Geomys bursarius*) represented 14 percent of all prey groups and were present at nest sites 1, 5 and 6. Also present were harvest mice (*Reithrodontomys spp.*), grasshopper mice (*Onychomys leucogaster*), hispid pocket mice (*Perognathus hispidus*), and unknown small pocket mice (*Perognathus spp.*). Unknown small rodents (Cricetidae) made up 30 percent of all prey groups. The identifiable items in this group were all toothless jaws. The remains of a house cat (*Felis catus*) were found in a pellet at nest site four. Birds were represented by three prey groups: pigeons (*Columba livia*), meadowlark (*Sturnella neglecta*), and medium-sized song birds (unknown Passeriformes). Bird species made up 7 percent of all prey groups.

Percent occurrence gave an overview of diet composition. The primary prey groups for great horned owls at RMA during the period of study were cottontails and hares. Small mammals were also important, with deer mice being the most important species. Although fewer cottontail and hare individuals were caught, they are more important than small mammals because of their larger body size. Birds were the least important group. Infrequent food items, such as a domestic cat, may be overemphasized due to the small sample size of this study.

C.4.2.2.4 American Kestrel

Methods

The summer food items of American kestrels at RMA in 1990 were determined using two methods. One involved sorting nest box contents and identifying prey remains to the lowest identifiable taxonomic level. The other method involved taking representative hair samples from each nest box and identifying the samples to genus or species when possible.

Five active nest boxes at RMA were selected for the food-item study (Table C.4-11 and Figure C.4-6). The entire contents of the box were taken after fledging had occurred as representative

of food items from the time of egg laying to fledging (i.e., one season of reproductive activity) since the nest boxes are cleaned annually. Nest material was sorted into five groups: mammal bones, mammal hair, insect parts, feathers, and miscellaneous materials such as nesting material. Mammal bones were further subdivided into identifiable and unidentifiable parts. The identifiable bones, usually jaw bones, were compared to the Denver Natural History Museum mammal collection, and a minimum count was made using similar parts (e.g., all left jaw bones). Mammal hair samples were mounted on microscope slides and compared to Moore et al. (1974). This method was simply used to indicate the presence or absence of mammal species; no quantitative analysis was attempted. Insect parts were also further subdivided and representative parts were mounted and labeled for future confirmation at the Denver Natural History Museum. All similar identifiable parts were grouped for each nest box and tallied for a minimum number of individuals.

Subsequent to the planning for the first two methods, a third method was added to augment the analysis in which stomach contents of juvenile kestrels collected from three of the five nest boxes were analyzed for chemical analysis of tissues for food items. The stomachs were removed and preserved in 70 percent ethyl alcohol. Individual food items were separated, washed with distilled water, and then identified to the lowest taxonomic level.

Results

The taxonomic level of each prey category (Table C.4-12) was determined by the lowest level identifiable within the group. The taxonomic level for insects was order, but Orthoptera was additionally divided into families due to the large number of individuals identified in this order. Mammals were grouped by genus and birds by family. The total number of individuals was listed (Table C.4-12) and the percent frequencies of occurrence were calculated. Of all the prey categories, grasshoppers (Acrididae) and beetles (Coleoptera) were consumed at all nests. Crickets (Gryllidae), dragonflies (Odonata), and voles (*Microtus spp.*) were consumed at 80 percent of the nests. Bees (Hymenoptera) were found in two (40 percent) of the nest boxes. It was not certain whether the bees were food items or individuals that flew into the nest box and were killed by the kestrels. Cicadas (Homoptera), moths (Lepidoptera), thirteen-lined ground

squirrels *(Spermophilus tridecemlineatus)*, and all avian groups were found in only one (20 percent) of the nest boxes, which indicates that kestrels exploit site-specific prey variations.

The hair analysis revealed only the presence or absence of mammals consumed. Voles were consumed at all nests (Table C.4-12). Deer mice (*Peromyscus spp.*) were consumed at 80 percent of the nests, while hispid pocket mice *(Perognathus hispidus)* and thirteen-lined ground squirrels were consumed at only one (20 percent) of the five nests.

The stomach contents verified results of the two methods discussed above and revealed another prey group not yet discovered (Table C.4-13). Crickets were found in two of the three nest boxes where juveniles were taken. Dragonflies, grasshoppers, a vole, and a deer mouse were found in only one location. In addition, one lizard (Iguanidae) was found in the stomach contents of the juvenile from box 138. Kestrels may totally digest reptiles; therefore, no reptile remains were found with the two study methods.

Kestrels, along with all other falcons, digest a large portion of the bone material they consume (Marti 1987), making food-item identification more difficult. Accordingly, a combination of methods was used to reveal all food resources (e.g., identification of nest materials, hair, and stomach contents). If an investigation of nest materials only had been used in this study, more than half of the mammal species would not have been discovered. Moreover, reptiles were only discovered after investigating the contents of stomachs. Because individuals must be sacrificed, however, this method is not preferred. Sometimes reptile scales can be found in nest materials and keyed to the genus level (Peterson 1991).

C.4.2.2.5 Fish

Methods

At RMA, 40 bluegill, 26 largemouth bass, and 10 northern pike were collected in September 1989. All fish were from either Lake Ladora (BSA 7) or Lower Derby Lake (BSA 8). The stomachs were removed from the fish for content analysis. Stomachs were preserved in ethyl

alcohol, placed in a dissection tray, and then separated under a dissection microscope and contents identified.

Results

Although aquatic invertebrates composed nearly 100 percent of bluegill diet, traces of plant material and one adult Dipteran were also observed. *Chironomus* species (larval flies) and *Daphnia* species occurred in 45 and 35 percent of the samples, respectively (Table C.4-14). Other waterfleas *(Bosmina longirostris)* and *Hydroptila* species (caddisflies) occurred in 25 percent of the samples.

Macroinvertebrates and small fish comprised most of the largemouth bass diet. Water boatmen beetles *(Hesperocorixa sp.)* occurred in 27 percent of the samples and occurred most often in the fall diet (Table C.4-15). Small fish occurred infrequently, but were important in terms of total biomass.

Nine out of ten of the stomachs analyzed for northern pike were either empty or only had a trace amounts of food present (Table C.4-16), so no useful information on the diet of northern pike was acquired. These results are not surprising since predatory fish, such as the northern pike, feed infrequently (i.e., not for several days).

Water fleas of several species and larval flies appear to be the most important food items used by bluegill in fall at RMA. Although 60 percent of the largemouth bass analyzed had empty or nearly empty stomachs, macroinvertebrates and small fish appear to be important dietary groups for this species. The information provided in these results is applicable only to food items of the three species at the time and location of study. Because these results were obtained from a small sample size, they are only useful for determining important food items at the time of capture.

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Table C.4-1 Summary of the Ecological Risk Characterization Field Program

Species Considered for Sampling	ERC Sampling Program Planned	Actual
Aquatic Sites		
Sediment	20	20
Surface Water	20	14
Biota		
Northern Pike	10	10
Largemouth Bass	10*	10*
Bluegill	10*	10*
Mallard		
Plankton		
Invertebrates		
Benthic	10	0
Water–Column	10	1
Aquatic plants	10	6
American Pondweed	2	2
Sago Pondweed	4	4
Terrestrial Sites		
Soil borings	10**	0
Surface Samples	40***	40
Biota		
Prairie Dog		
Terrestrial Plants		
Sunflower		
Kochia		
Cheatgrass		
Lactuca		
Mammals		
Deer Mice		
Thirteen-lined Ground Squirrel		
Reptiles		
Bullsnake	4	3
Amphibians		
Spadefoot Toad	2	2**
Tadpole	2	2
Tiger Salamander	2	4
Earthworms		
Birds		
Vesper Sparrow	5	5
Horned Lark		
Insects		
Grasshoppers		
Ground Beetle		
American Kestrels		
Eggs		
Juvenile		

* Composite Sample
** 1 from each of 10 staked sites
*** 2 composited from 4 locations in the top foot at each of 20 staked sites

Table C.4-2 Ecological Risk Characterization Biota Analytical Results, 1989–90

Tag	Site	Biota Study Area	Species	Group	Tissue	Aldrin		Dieldrin		Endrin		DDE		DDT		Arsenic		Mercury
B0860	5	07	Northern Pike	Large Fish	02	0.1030	L	0.0840	L	0.0740	L	0.1830		0.1180	L	0.4380	L	0.6600
B0862	2	07	Northern Pike	Large Fish	02	0.1030	L	0.0840	L	0.0740	L	0.1000	L	0.1180	L	0.4380	L	0.7030
B0867	1	07	Northern Pike	Large Fish	02	0.1030	L	0.0840	L	0.0740	L	0.1000	L	0.1180	L	0.4380	L	0.2540
B0869	1	07	Northern Pike	Large Fish	02	0.1030	L	0.1910		0.0740	L	0.1130		0.1180	L	0.4380	L	0.4020
B0870	1	07	Northern Pike	Large Fish	02	0.1030	L	0.2120		0.0740	L	0.1600		0.1180	L	0.4380	L	0.3490
B0908	2	08	Northern Pike	Large Fish	02	0.1030	L	0.0840	L	0.0740	L	0.1320		0.1180	L	0.4380	L	0.3470
B0907	2	08	Northern Pike	Large Fish	02	0.1030	L	0.0937		0.0740	L	0.2400		0.1180	L	0.4380	L	0.2960
B0906	5	08	Northern Pike	Large Fish	02	0.1030	L	0.1570		0.0740	L	0.3330		0.1180	L	0.4380	L	0.2840
B0905	5	08	Northern Pike	Large Fish	02	0.1030	L	0.1350		0.0740	L	0.2640		0.1180	L	0.4380	L	0.2110
B0904	3	08	Northern Pike	Large Fish	02	0.1030	L	0.1740		0.0740	L	0.2630		0.1180	L	0.4380	L	0.3640
B0877	1	07	Bluegill	Small Fish	02	0.1030	L	0.1280		0.0740	L	0.1000	L	0.1180	L	0.4380	L	0.0512
B0880	2	07	Bluegill	Small Fish	02	NA		NA		NA		NA		NA		0.4380	L	0.0758
B0882	3	07	Bluegill	Small Fish	02	0.1030	L	0.1200		0.0740	L	0.1000	L	0.1180	L	0.4380	L	0.1060
B0886	4	07	Bluegill	Small Fish	02	0.1030	L	0.0840	L	0.0740	L	0.1000	L	0.1180	L	0.4380	L	0.0653
B0892	5	07	Bluegill	Small Fish	02	0.1030	L	0.0840	L	0.0740	L	0.1000	L	0.1180	L	0.4380	L	0.1480
B0945	2	08	Bluegill	Small Fish	02	0.1030	L	0.1180		0.0740	L	0.1000	L	0.1180	L	0.4380	L	0.0609
B0944	4	08	Bluegill	Small Fish	02	0.1030	L	0.0840	L	0.0740	L	0.1000	L	0.1180	L	0.4380	L	0.0979
B0960	3	08	Bluegill	Small Fish	02	0.1030	L	0.0840	L	0.0740	L	0.1000	L	0.1180	L	0.4380	L	0.0976
B0953	5	08	Bluegill	Small Fish	02	0.1030	L	0.0974		0.0740	L	0.1000	L	0.1180	L	0.4380	L	0.0622
B0992	1	08	Bluegill	Small Fish	02	0.1030	L	0.0944		0.0740	L	0.1000	L	0.1180	L	0.4380	L	0.1740
B0899	1	07	Largemouth Bass	Large Fish	02	0.1030	L	0.0840	L	0.0740	L	0.1000	L	0.1180	L	0.4380	L	0.0564
B0883	4	07	Largemouth Bass	Large Fish	02	0.1030	L	0.0840	L	0.0740	L	0.1000	L	0.1180	L	0.4380	L	0.2950
B0879	2	07	Largemouth Bass	Large Fish	02	0.1030	L	0.1170		0.0740	L	0.1000	L	0.1180	L	0.4380	L	0.0933
B0881	3	07	Largemouth Bass	Large Fish	02	0.1030	L	0.0840	L	0.0740	L	0.1000	L	0.1180	L	0.4380	L	0.0970
B0878	1	07	Largemouth Bass	Large Fish	02	0.1030	L	0.1280		0.0740	L	0.1000	L	0.1180	L	0.4380	L	0.1300
B0943	4	08	Largemouth Bass	Large Fish	02	0.1030	L	0.0840	L	0.0740	L	0.1000	L	0.1180	L	0.4380	L	0.0818
B0946	4	08	Largemouth Bass	Large Fish	02	0.1030	L	0.0840	L	0.0740	L	0.1000	L	0.1180	L	0.4380	L	0.0930
B0947	1	08	Largemouth Bass	Large Fish	02	0.1030	L	0.0840	L	0.0740	L	0.1000	L	0.1180	L	0.4380	L	0.1380
B0959	3	08	Largemouth Bass	Large Fish	02	0.1030	L	0.0840	L	0.0740	L	0.1000	L	0.1180	L	0.4380	L	0.1280
B0954	5	08	Largemouth Bass	Large Fish	02	0.1030	L	0.0840	L	0.0740	L	0.1000	L	0.1180	L	0.4380	L	0.1170

Table C.4-2 Ecological Risk Characterization Biota Analytical Results, 1989–90

Tag	Site	Biota Study Area	Species	Group	Tissue	Aldrin		Dieldrin		Endrin		DDE		DDT		Arsenic		Mercury	
B1460	1	04	Gopher Snake	Herptile	01	0.1030	L	0.4120		0.0740	L	0.1000	L	0.1180	L	0.4380	L	0.0463	L
B1449	24	Sec. 24	Gopher Snake	Herptile	01	0.1030	L	1.2000		0.0740	L	0.2030		0.1180	L	0.4380	L	0.0463	L
B1358	36	01	Vesper Sparrow	Small Bird	02	0.1030	L	0.0840	L	0.0740	L	0.1000	L	0.1180	L	0.4380	L	0.0463	L
B1357	4	01	Vesper Sparrow	Small Bird	02	0.1030	L	0.7750		0.0740	L	0.1000	L	0.1180	L	0.4380	L	0.0463	L
B1327	26	02	Vesper Sparrow	Small Bird	02	0.1030	L	1.9000		0.0740	L	0.1000	L	0.1180	L	0.4380	L	0.0463	L
B1344	2	03	Vesper Sparrow	Small Bird	02	0.1030	L	0.2350		0.0740	L	0.1000	L	0.1180	L	0.4380	L	0.0463	L
B1411	11	05	Vesper Sparrow	Small Bird	02	0.1030	L	0.0840	L	0.0740	L	0.1000	L	0.1180	L	0.4380	L	0.0463	L
B0903	2	07	American Pondweed	Aquatic Plant	08	0.0660	L	0.0590	L	0.0470	L	0.0420	L	0.0750	L	0.3660		0.0574	L
B0980	1	08	American Pondweed	Aquatic Plant	08	0.0660	L	0.0590	L	0.0470	L	0.0420	L	0.0750	L	0.8970		0.0574	L
B0902	2	07	Sago Pondweed	Aquatic Plant	08	0.0660	L	0.0590	L	0.0470	L	0.0420	L	0.0750	L	0.4170		0.0574	L
B0901	3	07	Sago Pondweed	Aquatic Plant	08	0.0660	L	0.0590	L	0.0470	L	0.0420	L	0.0750	L	0.5120		0.0574	L
B0981	8	08	Sago Pondweed	Aquatic Plant	08	0.0660	L	0.0590	L	0.0470	L	0.0420	L	0.0750	L	0.9910		0.0574	L
B0979	1	08	Sago Pondweed	Aquatic Plant	08	0.0660	L	0.0590	L	0.0470	L	0.0420	L	0.0750	L	1.4300		0.0574	L
B1458	2	05	Spadefoot Toad	Herptile	07	0.1030	L	0.4800		0.0740	L	0.1000	L	0.1180	L	NA		NA	
B1459	3A	05	Spadefoot Toad	Herptile	07	0.1030	L	0.8100		0.0740	L	0.1000	L	0.1180	L	0.4380	L	0.0625	
BO797	26	02	Tiger Salamander	Herptile	01	0.2080		2.5000		0.5400		0.1000	L	0.1180	L	NA		0.0747	
BO798	26	02	Tiger Salamander	Herptile	01	0.4130		4.0000		1.0000		0.1000	L	0.1240		0.4380	L	0.0758	
B1008	2	07	Aquatic Invertebrate	Aq. Invertebrate	01	NA		NA		NA		NA		NA		0.4380	L	0.0463	L

Notes:

All concentrations in milligrams per kilogram
Tissue: 01 = whole body, 02 = dressed carcass, 07 = composite, 08 = above-substrate plant
Biota Study Area: 1-5,11 = terrestrial biota study area; 07 = Lake Ladora and 08 = Lower Derby lake
"L" following a concentration indicates a nondetection; i.e., below certified reporting limit
NA = Not Analyzed; DDE = dichlorodiphenyldichloroethene; DDT = dichlorodiphenyltrichloroethane

Table C.4-3 Ecological Risk Characterization Sediment Analytical Results from Lake Ladora, 1989

Biota Study Area	Site Identification	Test Name	Sample Date	Mean Depth (feet)	Below Certified Reporting Limit	Concentration (mg/kg)
07	BS07S00589	Aldrin	89263	0.25	X	0.00190
07	BS07S00189	Aldrin	89264	0.25		0.01310
07	BS07S00289	Aldrin	89264	0.25		0.00718
07	BS07S00489	Aldrin	89263	0.25	X	0.00190
07	BS07S00389	Aldrin	89261	0.25	X	0.00190
07	BS07S00289	Arsenic	89264	0.25	X	2.50000
07	BS07S00189	Arsenic	89264	0.25	X	2.50000
07	BS07S00589	Arsenic	89263	0.25	X	2.50000
07	BS07S00489	Arsenic	89263	0.25	X	2.50000
07	BS07S00389	Arsenic	89261	0.25	X	2.50000
07	BS07S00589	Dieldrin	89263	0.25	X	0.00330
07	BS07S00289	Dieldrin	89264	0.25		0.00518
07	BS07S00389	Dieldrin	89261	0.25	X	0.00330
07	BS07S00489	Dieldrin	89263	0.25	X	0.00330
07	BS07S00189	Dieldrin	89264	0.25		0.00409
07	BS07S00289	Endrin	89264	0.25	X	0.00471
07	BS07S00589	Endrin	89263	0.25	X	0.00580
07	BS07S00389	Endrin	89261	0.25	X	0.00580
07	BS07S00189	Endrin	89264	0.25	X	0.00471
07	BS07S00489	Endrin	89263	0.25	X	0.00580
07	BS07S00489	Mercury	89263	0.25	X	0.05000
07	BS07S00589	Mercury	89263	0.25	X	0.05000
07	BS07S00389	Mercury	89261	0.25	X	0.05000
07	BS07S00289	Mercury	89264	0.25	X	0.05000
07	BS07S00189	Mercury	89264	0.25	X	0.05000
07	BS07S00389	DDE	89261	0.25	X	0.00240
07	BS07S00489	DDE	89263	0.25	X	0.00240
07	BS07S00589	DDE	89263	0.25	X	0.00240
07	BS07S00289	DDE	89264	0.25	X	0.00466
07	BS07S00189	DDE	89264	0.25	X	0.00466
07	BS07S00389	DDT	89261	0.25	X	0.00200
07	BS07S00189	DDT	89264	0.25	X	0.00277
07	BS07S00589	DDT	89263	0.25	X	0.00200
07	BS07S00289	DDT	89264	0.25	X	0.00277
07	BS07S00489	DDT	89263	0.25	X	0.00200

mg/kg Milligrams per kilogram
DDE Dichlorodiphenyldichloroethene
DDT Dichlorodiphenyltrichloroethane
Biota Study Area: 07 = Lake Ladora

Table C.4-4 Ecological Risk Characterization Sediment Analytical Results from Lower Derby Lake, 1989

Biota Study Area	Site Identification	Test Name	Sample Date	Mean Depth (feet)	Below Certified Reporting Limit	Concentration (mg/kg)
08	BS08S00489	Aldrin	89265	0.25		0.02400
08	BS08S00389	Aldrin	89269	0.25		3.40000
08	BS08S00189	Aldrin	89269	0.25		0.01090
08	BS08S00589	Aldrin	89268	0.25		0.03350
08	BS08S00289	Aldrin	89268	0.25		0.00648
08	BS08S00589	Arsenic	89268	0.25		2.50000
08	BS08S00489	Arsenic	89265	0.25	X	2.50000
08	BS08S00189	Arsenic	89269	0.25	X	2.50000
08	BS08S00389	Arsenic	89269	0.25	X	2.50000
08	BS08S00289	Arsenic	89268	0.25	X	2.50000
08	BS08S00389	Dieldrin	89269	0.25		0.07300
08	BS08S00289	Dieldrin	89268	0.25	X	0.00181
08	BS08S00489	Dieldrin	89265	0.25		0.00551
08	BS08S00189	Dieldrin	89269	0.25		0.00579
08	BS08S00589	Dieldrin	89268	0.25		0.00611
08	BS08S00289	Endrin	89268	0.25	X	0.00471
08	BS08S00189	Endrin	89269	0.25	X	0.00471
08	BS08S00589	Endrin	89268	0.25		0.00921
08	BS08S00389	Endrin	89269	0.25		0.01150
08	BS08S00489	Mercury	89265	0.25		1.09000
08	BS08S00189	Mercury	89269	0.25		0.08570
08	BS08S00589	Mercury	89268	0.25	X	0.05000
08	BS08S00389	Mercury	89269	0.25	X	0.05000
08	BS08S00289	Mercury	89269	0.25		0.16100
08	BS08S00589	DDE	89268	0.25		0.00629
08	BS08S00489	DDE	89265	0.25		0.00825
08	BS08S00189	DDE	89269	0.25	X	0.00466
08	BS08S00389	DDE	89269	0.25	X	0.00466
08	BS08S00289	DDE	89268	0.25	X	0.00466
08	BS08S00489	DDT	89265	0.25	X	0.00277
08	BS08S00389	DDT	89269	0.25		0.00795
08	BS08S00589	DDT	89268	0.25	X	0.00277
08	BS08S00289	DDT	89268	0.25	X	0.00277
08	BS08S00189	DDT	89269	0.25	X	0.00277

mg/kg Milligrams per kilogram
DDE Dichlorodiphenyldichloroethene
DDT Dichlorodiphenyltrichloroethane
Biota Study Area:08=Lower Derby lake

Table C.4-5 Ecological Risk Characterization Soil Analytical Results, 1990*

Biota Study Area	Site Identification**	Test Name	Sample Date	Below Certified Reporting Level	Concentration (mg/kg)
4	BS04S002VD	Aldrin	90131		0.34000
4	BS04S003E	Aldrin	90131		0.05680
2	BS02S001ED	Aldrin	90129		0.01220
4	BS04S003V	Aldrin	90131		0.06200
2	BS02S001VD	Aldrin	90129		0.01420
4	BS04S001V	Aldrin	90134		0.12000
2	BS02S02AV	Aldrin	90129		0.01940
4	BS04S001P	Aldrin	90134		0.89000
2	BS02S004V	Aldrin	90129		1.80000
5	BS05S03AE	Aldrin	90129		0.00869
2	BS02S03AP	Aldrin	90130		0.01790
5	BS05S002E	Aldrin	90131		0.01770
3	BS03S002V	Aldrin	90130		0.17000
5	BS05S004E	Aldrin	90131		0.00547
3	BS03S03AV	Aldrin	90130		0.00263
5	BS05S006E	Aldrin	90131		0.04530
3	BS03S001PD	Aldrin	90131		0.14000
5	BS05S002V	Aldrin	90131		0.43000
3	BS03S001VD	Aldrin	90131		0.08750
5	BS05S006V	Aldrin	90131		0.01800
12	BS12S001VD	Aldrin	90134		0.00478
5	BS05S004V	Aldrin	90131		0.00462
12	BS12S001E	Aldrin	90134		0.01410
5	BS05S03AP	Aldrin	90129		0.03350
12	BS12S002E	Aldrin	90134		0.00734
2	BS02S001V	Aldrin	90129		0.01520
1	BS01S02AE	Aldrin	90130	X	0.00211
2	BS02S02AE	Aldrin	90129		0.05340
1	BS01S001P	Aldrin	90130		0.02820
2	BS02S004E	Aldrin	90129		0.02810
1	BS01S005P	Aldrin	90130	X	0.00211
2	BS02S03AV	Aldrin	90130		0.02670
1	BS01S003P	Aldrin	90130		1.10000
3	BSO3S002E	Aldrin	90130		0.18000
4	BS04S002ED	Aldrin	90131		0.07240
3	BS03S03AP	Aldrin	90130		0.00361
2	BS02S001E	Aldrin	90129		0.00783
3	BS03S001P	Aldrin	90131		0.22000
1	BS01S005V	Aldrin	90130	X	0.00211

Biota Study Area	Site Identification**	Test Name	Sample Date	Below Certified Reporting Level	Concentration (mg/kg)
4	BS04S002E	Aldrin	90131		0.24000
4	BS04S002V	Aldrin	90131		0.55000
1	BS01S001V	Aldrin	90130		0.00577
1	BS01S003V	Aldrin	90130		0.09320
3	BS03S001V	Aldrin	90131		0.16000
12	BS12S001ED	Aldrin	90134		0.01360
12	BS12S002V	Aldrin	90134		0.01790
12	BS12S001V	Aldrin	90134		0.01960
1	BS01S02AV	Aldrin	90130	X	0.00211
3	BS03S001VD	Arsenic	90131	X	2.50000
2	BS02S02AV	Arsenic	90129	X	2.50000
3	BS03S001V	Arsenic	90131	X	2.50000
2	BS02S02AE	Arsenic	90129	X	2.50000
3	BS03S001P	Arsenic	90131	X	2.50000
2	BS02S001VD	Arsenic	90129		15.10000
3	BS03S03AP	Arsenic	90130	X	2.50000
2	BS02S001V	Arsenic	90129		16.80000
3	BS03S002E	Arsenic	90130	X	2.50000
2	BS02S001ED	Arsenic	90129		3.37000
2	BS02S03AV	Arsenic	90130	X	2.50000
2	BS02S001E	Arsenic	90129		2.89000
2	BS02S004E	Arsenic	90129		3.70000
12	BS12S001E	Arsenic	90134		6.49000
3	BS03S03AV	Arsenic	90130	X	2.50000
2	BS02S03AP	Arsenic	90130	X	2.50000
2	BS02S004V	Arsenic	90129		37.00000
3	BS03S001PD	Arsenic	90131	X	2.50000
3	BS03S002V	Arsenic	90130	X	2.50000
12	BS12S001V	Arsenic	90134		13.30000
12	BS12S002E	Arsenic	90134		6.71000
12	BS12S001ED	Arsenic	90134		10.60000
12	BS12S001VD	Arsenic	90134		11.00000
12	BS12S002V	Arsenic	90134		13.40000
1	BS01S003P	Arsenic	90130		2.94000
5	BS05S006E	Arsenic	90131	X	2.50000
5	BS05S006V	Arsenic	90131	X	2.50000
1	BS01S005P	Arsenic	90130		16.10000
4	BS04S002ED	Arsenic	90131	X	2.50000
1	BS01S001P	Arsenic	90130	X	2.50000

Biota Study Area	Site Identification**	Test Name	Sample Date	Below Certified Reporting Level	Concentration (mg/kg)
4	BS04S003V	Arsenic	90131	X	2.50000
1	BS01S02AE	Arsenic	90130	X	2.50000
4	BS04S001P	Arsenic	90134		2.91000
4	BS04S002E	Arsenic	90131	X	2.50000
4	BS04S002VD	Arsenic	90131		4.51000
4	BS04S003E	Arsenic	90131		2.65000
5	BS05S004V	Arsenic	90131	X	2.50000
1	BS01S003V	Arsenic	90130		3.52000
5	BS05S03AP	Arsenic	90129	X	2.50000
5	BS05S002V	Arsenic	90131	X	2.50000
5	BS05S004E	Arsenic	90131	X	2.50000
5	BS05S03AE	Arsenic	90129	X	2.50000
5	BS05S002E	Arsenic	90131	X	2.50000
1	BS01S005V	Arsenic	90130		28.30000
1	BS01S001V	Arsenic	90130	X	2.50000
1	BS01S02AV	Arsenic	90130	X	2.50000
4	BS04S002V	Arsenic	90131	X	2.50000
4	BS04S001V	Arsenic	90134	X	2.50000
2	BS02S001E	DDE	90129	X	0.00657
2	BS02S004E	DDE	90129		0.00643
2	BS02S004V	DDE	90129		0.55000
2	BS02S001V	DDE	90129	X	0.00466
2	BS02S02AE	DDE	90129	X	0.00466
2	BS02S02AV	DDE	90129	X	0.00466
2	BS02S001ED	DDE	90129	X	0.00466
2	BS02S001VD	DDE	90129	X	0.00466
2	BS02S03AV	DDE	90130		0.00748
2	BS02S03AP	DDE	90130	X	0.00466
3	BSO3S002E	DDE	90130		0.22000
3	BS03S002V	DDE	90130		0.03190
3	BS03S03AP	DDE	90130	X	0.00466
3	BS03S03AV	DDE	90130		0.32000
1	BS01S001P	DDE	90130		0.00671
1	BS01S001V	DDE	90130	X	0.00466
3	BS03S001PD	DDE	90131		0.42000
1	BS01S02AE	DDE	90130	X	0.00466
3	BS03S001VD	DDE	90131	X	0.00466
1	BS01S02AV	DDE	90130	X	0.00466
12	BS12S001ED	DDE	90134		0.03310

Biota Study Area	Site Identification**	Test Name	Sample Date	Below Certified Reporting Level	Concentration (mg/kg)
4	BS04S002E	DDE	90131	X	0.00466
12	BS12S001VD	DDE	90134	X	0.00466
4	BS04S002ED	DDE	90131	X	0.00466
5	BS05S006E	DDE	90131		0.77000
4	BS04S002V	DDE	90131	X	0.00466
5	BS05S006V	DDE	90131		0.18000
4	BS04S002VD	DDE	90131	X	0.00466
1	BS01S003P	DDE	90130		0.01770
4	BS04S003E	DDE	90131	X	0.00466
1	BS01S005P	DDE	90130		0.85000
4	BS04S003V	DDE	90131	X	0.00466
3	BS03S001P	DDE	90131		0.39000
4	BS04S001V	DDE	90134	X	0.00466
12	BS12S001E	DDE	90134	X	0.00466
4	BS04S001P	DDE	90134		2.10000
12	BS12S002E	DDE	90134	X	0.00466
5	BS05S004E	DDE	90131	X	0.00466
5	BS05S03AE	DDE	90129	X	0.00466
1	BS01S003V	DDE	90130		0.03490
3	BS03S001V	DDE	90131	X	0.00466
12	BS12S001V	DDE	90134		0.04880
12	BS12S002V	DDE	90134	X	0.00466
1	BS01S005V	DDE	90130	X	0.00466
5	BS05S03AP	DDE	90129	X	0.00466
5	BS05S002E	DDE	90131	X	0.00466
5	BS05S002V	DDE	90131	X	0.00466
5	BS05S004V	DDE	90131	X	0.00466
5	BS05S006V	DDT	90131		0.05360
2	BS02S001ED	DDT	90129		0.00584
2	BS02S001E	DDT	90129	X	0.00277
2	BS02S001VD	DDT	90129	X	0.00277
2	BS02S02AE	DDT	90129		0.02470
2	BS02S001V	DDT	90129	X	0.00277
2	BS02S004E	DDT	90129		0.01250
2	BS02S004V	DDT	90129		0.49000
2	BS02S02AV	DDT	90129		0.01410
2	BS02S03AP	DDT	90130	X	0.00277
3	BSO3S002E	DDT	90130	X	0.10000
2	BS02S03AV	DDT	90130		0.01170

Biota Study Area	Site Identification**	Test Name	Sample Date	Below Certified Reporting Level	Concentration (mg/kg)
3	BS03S03AP	DDT	90130		0.00319
3	BS03S03AV	DDT	90130		0.23000
3	BS03S002V	DDT	90130		0.05270
3	BS03S001PD	DDT	90131		0.13000
3	BS03S001V	DDT	90131		0.06350
3	BS03S001P	DDT	90131		0.12000
12	BS12S002V	DDT	90134		0.02360
12	BS12S002E	DDT	90134		0.00690
3	BS03S001VD	DDT	90131		0.03230
12	BS12S001V	DDT	90134		0.02500
12	BS12S001ED	DDT	90134		0.08150
12	BS12S001VD	DDT	90134		0.00595
1	BS01S003P	DDT	90130		1.00000
1	BS01S003V	DDT	90130		0.28000
12	BS12S001E	DDT	90134		0.07150
1	BS01S005V	DDT	90130		0.02450
1	BS01S001P	DDT	90130		0.04720
1	BS01S005P	DDT	90130	X	0.00277
1	BS01S02AE	DDT	90130		0.00703
1	BS01S02AV	DDT	90130		0.00337
1	BS01S001V	DDT	90130		0.00612
4	BS04S002ED	DDT	90131		0.04500
4	BS04S002V	DDT	90131		0.26000
4	BS04S002E	DDT	90131		0.11000
4	BS04S003E	DDT	90131		0.03200
4	BS04S003V	DDT	90131		0.05090
4	BS04S002VD	DDT	90131		0.15000
4	BS04S001P	DDT	90134		1.10000
5	BS05S03AE	DDT	90129		0.00309
4	BS04S001V	DDT	90134		0.05800
5	BS05S002V	DDT	90131		0.74000
5	BS05S002E	DDT	90131		0.01500
5	BS05S03AP	DDT	90129		0.03290
5	BS05S006E	DDT	90131		0.22000
5	BS05S004V	DDT	90131		0.01540
5	BS05S004E	DDT	90131		0.00693
2	BS02S02AE	Dieldrin	90129		0.51000
2	BS02S001VD	Dieldrin	90129		0.53000
2	BS02S001V	Dieldrin	90129		0.68000

Biota Study Area	Site Identification**	Test Name	Sample Date	Below Certified Reporting Level	Concentration (mg/kg)
3	BSO3S002E	Dieldrin	90130		4.70000
2	BS02S004E	Dieldrin	90129		0.56000
2	BS02S03AV	Dieldrin	90130		0.34000
3	BS03S001V	Dieldrin	90131	X	0.00181
3	BS03S03AP	Dieldrin	90130		0.05760
3	BS03S001P	Dieldrin	90131		2.50000
12	BS12S002V	Dieldrin	90134		0.10000
12	BS12S001ED	Dieldrin	90134		0.08800
12	BS12S001VD	Dieldrin	90134		0.05130
2	BS02S02AV	Dieldrin	90129		0.58000
12	BS12S001E	Dieldrin	90134		0.09100
12	BS12S002E	Dieldrin	90134		0.07100
12	BS12S001V	Dieldrin	90134		0.09600
2	BS02S004V	Dieldrin	90129		6.10000
2	BS02S03AP	Dieldrin	90130		0.25000
1	BS01S003P	Dieldrin	90130		11.00000
3	BS03S002V	Dieldrin	90130		4.80000
3	BS03S03AV	Dieldrin	90130		0.06100
1	BS01S005V	Dieldrin	90130		0.13000
1	BS01S003V	Dieldrin	90130	X	0.00181
1	BS01S005P	Dieldrin	90130		3.20000
1	BS01S02AE	Dieldrin	90130		0.03740
1	BS01S001P	Dieldrin	90130		0.50000
1	BS01S001V	Dieldrin	90130		0.04330
4	BS04S002ED	Dieldrin	90131	X	0.00181
1	BS01S02AV	Dieldrin	90130		0.05150
4	BS04S002E	Dieldrin	90131		3.90000
4	BS04S003E	Dieldrin	90131		0.44000
4	BS04S002V	Dieldrin	90131		5.50000
4	BS04S002VD	Dieldrin	90131		3.90000
4	BS04S001P	Dieldrin	90134		2.70000
4	BS04S003V	Dieldrin	90131		0.78000
4	BS04S001V	Dieldrin	90134		0.63000
5	BS05S004V	Dieldrin	90131		0.23000
5	BS05S03AP	Dieldrin	90129		2.50000
5	BS05S002V	Dieldrin	90131		6.80000
5	BS05S002E	Dieldrin	90131		0.52000
5	BS05S006V	Dieldrin	90131		0.51000
5	BS05S03AE	Dieldrin	90129		0.47000

Biota Study Area	Site Identification**	Test Name	Sample Date	Below Certified Reporting Level	Concentration (mg/kg)
2	BS02S001ED	Dieldrin	90129		0.20000
5	BS05S004E	Dieldrin	90131		0.10000
2	BS02S001E	Dieldrin	90129		0.06060
3	BS03S001PD	Dieldrin	90131		3.20000
3	BS03S001VD	Dieldrin	90131	X	0.00181
5	BS05S006E	Dieldrin	90131		2.20000
1	BS01S003P	Endrin	90130		0.70000
5	BS05S006V	Endrin	90131		0.01320
2	BS02S03AP	Endrin	90130		0.01160
5	BS05S004V	Endrin	90131		0.00557
2	BS02S02AV	Endrin	90129		0.01830
5	BS05S002V	Endrin	90131		0.22000
2	BS02S001ED	Endrin	90129		0.00875
5	BS05S03AP	Endrin	90129		0.54000
3	BS03S001VD	Endrin	90131		0.01210
4	BS04S001P	Endrin	90134		0.28000
3	BS03S001PD	Endrin	90131	X	0.00471
4	BS04S003V	Endrin	90131		0.02790
3	BS03S002V	Endrin	90130		0.00838
4	BS04S002VD	Endrin	90131		0.04470
2	BS02S004V	Endrin	90129		0.06540
4	BS04S002ED	Endrin	90131		0.02730
2	BS02S001VD	Endrin	90129		0.02070
1	BS01S02AV	Endrin	90130		0.00586
3	BS03S001V	Endrin	90131		0.01070
1	BS01S001V	Endrin	90130	X	0.00471
3	BS03S001P	Endrin	90131		0.00861
1	BS01S005V	Endrin	90130		0.34000
3	BS03S03AP	Endrin	90130	X	0.00471
1	BS01S003V	Endrin	90130		0.94000
3	BSO3S002E	Endrin	90130		0.02240
5	BS05S004E	Endrin	90131	X	0.00471
2	BS02S03AV	Endrin	90130		0.01600
5	BS05S03AE	Endrin	90129		0.01020
2	BS02S004E	Endrin	90129		0.02350
4	BS04S003E	Endrin	90131		0.05240
2	BS02S02AE	Endrin	90129		0.05860
4	BS04S002E	Endrin	90131		0.06830
2	BS02S001V	Endrin	90129		0.09130

Biota Study Area	Site Identification**	Test Name	Sample Date	Below Certified Reporting Level	Concentration (mg/kg)
1	BS01S001P	Endrin	90130		0.03530
2	BS02S001E	Endrin	90129	X	0.00471
5	BS05S006E	Endrin	90131		0.02090
12	BS12S002V	Endrin	90134		0.01390
4	BS04S001V	Endrin	90134		0.02810
1	BS01S02AE	Endrin	90130	X	0.00471
1	BS01S005P	Endrin	90130		4.60000
5	BS05S002E	Endrin	90131		0.02050
4	BS04S002V	Endrin	90131		0.10000
12	BS12S002E	Endrin	90134		0.00733
12	BS12S001VD	Endrin	90134	X	0.00471
12	BS12S001V	Endrin	90134		0.01430
12	BS12S001ED	Endrin	90134		0.02790
12	BS12S001E	Endrin	90134		0.02350
3	BS03S03AV	Endrin	90130	X	0.00471
1	BS01S003V	Mercury	90130		0.38000
2	BS02S02AE	Mercury	90129	X	0.05000
5	BS05S006E	Mercury	90131	X	0.05000
12	BS12S002V	Mercury	90134		0.25200
5	BS05S004E	Mercury	90131	X	0.05000
12	BS12S002E	Mercury	90134		0.15600
5	BS05S002E	Mercury	90131	X	0.05000
12	BS12S001VD	Mercury	90134	X	0.05000
5	BS05S03AE	Mercury	90129	X	0.05000
12	BS12S001V	Mercury	90134		0.05290
4	BS04S001P	Mercury	90134		0.15200
12	BS12S001ED	Mercury	90134		0.18100
4	BS04S003V	Mercury	90131	X	0.05000
12	BS12S001E	Mercury	90134		0.16200
4	BS04S002VD	Mercury	90131		0.41400
2	BS02S03AV	Mercury	90130	X	0.05000
4	BS04S002ED	Mercury	90131	X	0.05000
2	BS02S001E	Mercury	90129	X	0.05000
1	BS01S003P	Mercury	90130		0.39000

Biota Study Area	Site Identification**	Test Name	Sample Date	Below Certified Reporting Level	Concentration (mg/kg)
2	BS02S004E	Mercury	90129		0.14500
1	BS01S005P	Mercury	90130		0.14700
2	BS02S001V	Mercury	90129		0.08980
1	BS01S001V	Mercury	90130	X	0.05000
2	BS02S03AP	Mercury	90130	X	0.05000
5	BS05S006V	Mercury	90131	X	0.05000
2	BS02S004V	Mercury	90129		0.64200
5	BS05S002V	Mercury	90131		1.70000
2	BS02S02AV	Mercury	90129	X	0.05000
1	BS01S001P	Mercury	90130	X	0.05000
2	BS02S001VD	Mercury	90129		0.05610
4	BS04S003E	Mercury	90131	X	0.05000
2	BS02S001ED	Mercury	90129	X	0.05000
4	BS04S002E	Mercury	90131	X	0.05000
3	BS03S001VD	Mercury	90131	X	0.05000
1	BS01S02AV	Mercury	90130	X	0.05000
3	BS03S001V	Mercury	90131	X	0.05000
5	BS05S004V	Mercury	90131	X	0.05000
3	BS03S001PD	Mercury	90131	X	0.05000
4	BS04S001V	Mercury	90134	X	0.05000
1	BS01S02AE	Mercury	90130	X	0.05000
1	BS01S005V	Mercury	90130	X	0.05000
5	BS05S03AP	Mercury	90129		0.17900
4	BS04S002V	Mercury	90131		0.46300
3	BS03S001P	Mercury	90131	X	0.05000
3	BS03S03AV	Mercury	90130	X	0.05000
3	BS03S03AP	Mercury	90130	X	0.05000
3	BS03S002V	Mercury	90130	X	0.05000
3	BS03S002E	Mercury	90130	X	0.05000

mg/kg Milligrams per kilogram
DDE Dichlorodiphenyldichloroethene
DDT Dichlorodiphenyltrichloroethane
* Mean depth of all samples = 0.5 ft
** Soil samples were collocated with earthworms (E), deer mice (P), or vegetables (V) samples; samples with a "D" are duplicates.

Table C.4-6 Ecological Risk Characterization Surface Water Analytical Results, 1989

Biota Study Area	Site	Test Name	Mean Sample Depth (ft)	Concentration (µg/l)	
7	BS07S00189	Aldrin	4.8	0.050	L
7	BS07S00189	Aldrin	2.0	0.050	L
7	BS07S00289	Aldrin	4.3	0.050	L
7	BS07S00389	Aldrin	10.0	0.050	L
7	BS07S00389	Aldrin	4.5	0.050	L
7	BS07S00489	Aldrin	3.8	0.050	L
7	BS07S00489	Aldrin	7.5	0.050	L
7	BS07S00589	Aldrin	5.5	0.050	L
8	BS08S00289	Aldrin	6.0	0.050	L
8	BS08S00189	Aldrin	2.5	0.050	L
8	BS08S00289	Aldrin	2.0	0.050	L
8	BS08S00389	Aldrin	3.5	0.050	L
8	BS08S00489	Aldrin	3.0	0.050	L
8	BS08S00589	Aldrin	2.5	0.050	L
7	BS07S00189	Arsenic	4.8	2.350	L
7	BS07S00189	Arsenic	2.3	2.440	
7	BS07S00289	Arsenic	4.3	2.740	
7	BS07S00389	Arsenic	10.0	2.440	
7	BS07S00389	Arsenic	4.5	2.350	L
7	BS07S00489	Arsenic	3.8	2.740	
7	BS07S00489	Arsenic	7.5	2.350	L
7	BS07S00589	Arsenic	5.5	2.350	L
8	BS08S00189	Arsenic	2.5	2.740	
8	BS08S00289	Arsenic	6.0	2.440	
8	BS08S00289	Arsenic	2.0	2.350	L
8	BS08S00389	Arsenic	3.5	2.740	
8	BS08S00489	Arsenic	3.0	2.600	
8	BS08S00589	Arsenic	2.5	2.440	
7	BS07S00189	Dieldrin	4.8	0.050	L
7	BS07S00189	Dieldrin	2.0	0.050	L
7	BS07S00289	Dieldrin	4.3	0.050	L
7	BS07S00389	Dieldrin	10.0	0.050	L
7	BS07S00389	Dieldrin	4.5	0.050	L
7	BS07S00489	Dieldrin	3.8	0.050	L
7	BS07S00489	Dieldrin	7.5	0.050	L

Biota Study Area	Site	Test Name	Mean Sample Depth (ft)	Concentration (µg/l)	
7	BS07S00589	Dieldrin	5.5	0.050	L
8	BS08S00289	Dieldrin	6.0	0.050	L
8	BS08S00189	Dieldrin	2.5	0.050	L
8	BS08S00289	Dieldrin	2.0	0.050	L
8	BS08S00389	Dieldrin	3.5	0.050	L
8	BS08S00489	Dieldrin	3.0	0.050	L
8	BS08S00589	Dieldrin	2.5	0.050	L
7	BS07S00189	Endrin	4.8	0.050	L
7	BS07S00189	Endrin	2.0	0.050	L
7	BS07S00289	Endrin	4.3	0.050	L
7	BS07S00389	Endrin	10.0	0.050	L
7	BS07S00389	Endrin	4.5	0.050	L
7	BS07S00489	Endrin	3.8	0.050	L
7	BS07S00489	Endrin	7.5	0.050	L
7	BS07S00589	Endrin	5.5	0.050	L
8	BS08S00289	Endrin	6.0	0.050	L
8	BS08S00189	Endrin	2.5	0.050	L
8	BS08S00289	Endrin	2.0	0.050	L
8	BS08S00389	Endrin	3.5	0.050	L
8	BS08S00489	Endrin	3.0	0.050	L
8	BS08S00589	Endrin	2.5	0.050	L
7	BS07S00189	Mercury	4.8	0.100	L
7	BS07S00189	Mercury	2.3	0.100	L
7	BS07S00289	Mercury	4.3	0.100	L
7	BS07S00389	Mercury	10.0	0.100	L
7	BS07S00389	Mercury	4.5	0.179	
7	BS07S00489	Mercury	3.8	0.100	L
7	BS07S00489	Mercury	7.5	0.100	L
7	BS07S00589	Mercury	5.5	0.100	L
8	BS08S00189	Mercury	2.5	0.100	L
8	BS08S00289	Mercury	6.0	0.100	L
8	BS08S00289	Mercury	2.0	0.100	L
8	BS08S00389	Mercury	3.5	0.100	L
8	BS08S00489	Mercury	3.0	0.100	L
8	BS08S00589	Mercury	2.5	0.100	L

Table C.4-6 Ecological Risk Characterization Surface Water Analytical Results, 1989

Biota Study Area	Site	Test Name	Mean Sample Depth (ft)	Concentration (µg/l)	
7	BS07S00189	DDE	4.8	0.054	L
7	BS07S00189	DDE	2.0	0.054	L
7	BS07S00289	DDE	4.3	0.054	L
7	BS07S00389	DDE	10.0	0.054	L
7	BS07S00389	DDE	4.5	0.054	L
7	BS07S00489	DDE	3.8	0.054	L
7	BS07S00489	DDE	7.5	0.054	L
7	BS07S00589	DDE	5.5	0.054	L
8	BS08S00289	DDE	2.5	0.054	L
8	BS08S00189	DDE	6.0	0.054	L
8	BS08S00289	DDE	2.0	0.054	L
8	BS08S00389	DDE	3.5	0.054	L
8	BS08S00489	DDE	3.0	0.054	L
8	BS08S00589	DDE	2.5	0.054	L
7	BS07S00189	DDT	4.8	0.049	L
7	BS07S00189	DDT	2.0	0.049	L
7	BS07S00289	DDT	4.3	0.049	L
7	BS07S00389	DDT	10.0	0.049	L
7	BS07S00389	DDT	4.5	0.049	L
7	BS07S00489	DDT	3.8	0.049	L
7	BS07S00489	DDT	7.5	0.049	L
7	BS07S00589	DDT	5.5	0.049	L
8	BS07S00589	DDT	2.5	0.049	L
8	BS08S00289	DDT	6.0	0.049	L
8	BS08S00289	DDT	2.0	0.049	L
8	BS08S00389	DDT	3.5	0.049	L
8	BS08S00489	DDT	3.0	0.049	L
8	BS08S00589	DDT	2.5	0.049	L

Notes: "L" following a concentration indicates a nondetection, i.e., below certified reporting limit
Biota Study Area: 7 = Lake Ladora; 8 = Lower Derby Lake
DDE = dichlorodiphenydichloroethene; DDT = dichlorodiphenyltrichloroethane
mg/l = micrograms per liter
RMA.IEA/RC.7/93 js

Table C.4-7 Mallard Food Items Based on Analysis of Esophageal Contents, Rocky Mountain Arsenal, August 1990[1,2] Page 1 of 1

Sample	Description	Seeds			Vegetation	Insects					Invertebrates	TOTAL
		P. pusillus	P. pectinatus	Solanum spp.	Algae/ Leaf matter	Orthop-tera	Coleop-tera	Hymenop-tera	Hemip-tera	Unknown	Unknown	
B1432C	Total #		10.0		NA		1.0		1.0			
	Volume ml		0.2		0.8		Trace		Trace			1.0
	% Volume		25.0		75.0							100.0
B1433C	Total #	~420	~150							1.0		
	Volume ml	1.8	1.2		3.0					Trace		6.0
	% Volume	30.0	20.0		50.0							100.0
B1434C	Total #			5.0	NA							
	Volume ml			0.1	2.9							3.0
	% Volume			3.3	96.7							100.0
B1435C	Total #	~310	~20		NA	1.0	1.0	2.0			25.0	
	Volume ml	1.8	0.1		3.4			0.1			0.1	5.5
	% Volume	32.7	1.8		61.8			1.8			1.8	99.9
B1441C	Total #		~150		NA							
	Volume ml		1.2		2.0							3.2
	% Volume		37.5		62.5							100.0
B1442C	Total #	~740	~34		Trace							
	Volume ml	4.4	0.1									4.5
	% Volume	97.8	2.2									100.0
Total	Volume ml	8.0	2.9	0.1	12.1	Trace	Trace	0.1	Trace	Trace	0.1	23.2
Mean	Volume ml	1.3	0.5	0.0	2.0			0.02			0.02	3.9
	% Volume	26.8	14.4	0.6	57.7			0.3			0.3	100.0

1 Volume measured by water displacement
2 Mean volume is calculated by the aggregate percent method (Swanson et al. 1974)
P. Potamogeten
NA Not Applicable
Trace Less than 0.05 millileters (ml)

Table C.4-8 American Coot Food Items Based on Analysis of Esophageal Contents, Rocky Mountain Arsenal, August 1990[1,2] Page 1 of 1

Sample	Description	Plants			Insects	Invertebrates		
		Ceratophyllum	Chara spp.	Fil. Algae	Plecoptera	Ostracoda	Physa spp.	Total
B1437C	Total #	NA	NA	NA			25	
	Volume ml	8.2	Trace			1.2	0.25	9.65
	% Volume	85.0				12.4	2.6	100.00
B1439C	Total #	NA	NA	NA	1	100		
	Volume ml	8.63	Trace		0.06	0.06		8.75
	% Volume	98.6			0.7	0.7		100.00
B1436C	Total #	NA	NA	NA			2	
	Volume ml	11.6					0.1	11.70
	% Volume	99.1					0.9	100.00
B1421C	Total #	NA	NA	NA		820	16	
	Volume ml	13.1				0.1	0.25	13.45
	% Volume	97.4				0.7	1.9	100.00
B1438C	Total #	NA	NA	NA		61		
	Volume ml	5.97	0.125	0.125		0.03		6.25
	% Volume	95.5	2.0	2.0		0.5		100.00
Total	Total #	NA	NA	NA	1.00	981.00	43.00	1025.00
	Volume ml	47.50	0.13	0.13	0.06	1.39	0.60	49.81
Mean	Total #	NA	NA	NA	0.20	196.20	8.60	
	Volume ml	9.50	0.03	0.03	0.01	0.28	0.12	9.96
	% Volume	95.1	0.4	0.4	0.1	2.9	1.1	100.00

1 Volume measured by water displacement
2 Mean % volume is calculated by the aggregate percent method (Swanson et al. 1974)
NA Not Applicable
Trace Less than .125 milliliters (ml)

Table C.4-9 Vesper Sparrow Food Items Based on Analysis of Crop Contents, Rocky Mountain Arsenal, June and July 1990[1]

Species	B1357C Total #	B1411C Total #	B1344C Total #	B1358C Total #	B1327C Total #
Orthoptera					
Acrididae	4		1	>10	>11
Coleoptera A	1		1	1	
B				1	
Curculionidae					1
Hymenoptera					
Formicidae	1			1	1
Unknown family					1
Dermaptera					2
Homoptera					
Aphididae			>41		
Araneae (Lycosidae)	1				
Diptera Nemotocera	1				
Graminae (Stipa spp.)		~80			

1 Total Number of individuals

Table C.4-10 Great Horned Owl Food Items Based on Analysis of Pellets, Rocky Mountain Arsenal, Spring 1990

Species	Nest 1 n = 13			Nest 3 n = 5			Nest 4 n = 20			Nest 5 n = 10		
	# occur.	% occur.	Total #	# occur.	% occur.	Total #	# occur.	% occur.	Total #	# occur.	% occur.	Total #
Leporidae (all)	3	23.08	3	2	40.00	2	3	15.00	3	3	30.00	3
unknown Leporidae	1	7.69	1	2	40.00	2	1	5.00	1	0	0.00	0
Sylvilagus spp.	2	15.38	2	0	0.00	0	2	10.00	2	3	30.00	3
Dipodomys ordi	2	15.38	2	0	0.00	0	5	5.00	5	4	40.00	4
Perognathus hispidus	0	0.00	0	0	0.00	0	2	10.00	2	1	10.00	1
Perognathus small spp.	0	0.00	0	1	20.00	2	1	5.00	1	1	10.00	1
Reithrodontomys spp.	1	7.69	1	0	0.00	0	1	5.00	2	0	0.00	0
Peromyscus spp.	11	84.62	22	5	100.00	7	20	100.00	61	3	30.00	5
Onychomys leucogaster	1	7.69	1	0	0.00	0	0	0.00	0	0	0.00	0
Microtus ochrogaster	2	15.38	2	2	40.00	2	1	5.00	1	3	30.00	3
Microtus pennsylvanicus	0	0.00	0	3	60.00	3	0	0.00	0	1	10.00	1
Microtus spp.	1	7.69	1	0	0.00	0	0	0.00	0	1	10.00	1
Geomys bursarius	3	23.08	3	0	0.00	0	0	0.00	0	3	30.00	3
unknown Cricetidae	3	23.08	10	0	0.00	0	12	60.00	31	0	0.00	0
Felis catus`	0	0.00	0	0	0.00	0	1	5.00	1	0	0.00	0
Columba livia	1	7.69	1	0	0.00	0	0	0.00	0	0	0.00	0
Sturnella neglecta	1	7.69	1	0	0.00	0	0	0.00	0	1	10.00	1
unknown Passeriformes (mid-sized)	0	0.00	0	0	0.00	0	0	0.00	0	1	10.00	1
Totals			47			16			107			24

Table C.4-10 Summary of Previous Groups for Great Horned Owl Pellet Analysis

Species	Nest 6 n = 20 # occur.	Nest 6 n = 20 % occur.	Nest 6 n = 20 Total #	All Nests n = 68 # occur.	All Nests n = 68 % occur.	All Nests n = 68 Total #
Leporidae (all)	13	65.00	14	24	42.86	25
unknown Leporidae	5	25.00	5	9	16.07	9
Sylvilagus spp.	8	40.00	9	15	26.79	16
Dipodomys ordi	8	40.00	10	19	33.93	21
Perognathus hispidus	0	0.00	0	3	5.36	3
Perognathus small spp.	1	5.00	1	4	7.14	5
Reithrodontomys spp.	1	5.00	1	3	5.36	4
Peromyscus spp.	9	45.00	12	48	85.71	107
Onychomys leucogaster	0	0.00	0	1	1.79	1
Microtus ochrogaster	0	0.00	0	8	14.29	8
Microtus pennsylvanicus	1	5.00	1	5	8.93	5
Microtus spp.	1	5.00	1	3	5.36	3
Geomys bursarius	2	10.00	2	8	14.29	8
unknown Cricetidae	2	10.00	2	17	30.36	43
Felis catus	0	0.00	0	1	1.79	1
Columba livia	0	0.00	0	1	1.79	1
Sturnella neglecta	0	0.00	0	2	3.57	2
unknown Passeriformes (mid-sized)	0	0.00	0	1	1.79	1
Totals			44			238

Table C.4-11 Location of American Kestrel Nest Boxes Used for Analysis of Prey Remains, Rocky Mountain Arsenal, Summer 1990

Box Number	Section	Site Identification
122	SW1/4SE1/4SEC31	BURMB12290
123	NE1/4NE1/4SEC36	BS01B12390
129	NE1/4SE1/4SEC03	BURMB12990
136	NW1/4NW1/4SEC12	BS05B13690
138	NE1/4NE1/4SEC12	BS05B13890

Table C.4-12 American Kestrel Food Items Based on Analysis of Remains in Nest Boxes, Rocky Mountain Arsenal, Summer 1990

Prey Category	Common Names	Box Number					Total	Frequency
Analysis of Prey Body Parts								
Insects		122	123	129	136	138		
Orthoptera	grasshoppers and crickets	21	19	15	31	33	119	100
(Acrididae)	grasshoppers	(13)	(12)	(15)	(25)	(7)	(72)	100
(Gryllidae)	crickets	(8)	(7)	(0)	(6)	(26)	(47)	80
Coleoptera	beetles	6	1	1	4	3	15	100
Odonata	dragonflies	1	0	1	6	5	13	80
Homoptera	cicadas	0	0	0	0	4	4	20
Hymenoptera	bees	1	0	1	0	0	2	40
Lepidoptera	moths	0	1	0	0	0	1	20
Mammals								
Microtus spp.	vole	1	10	1	1	0	13	80
Citellus tridecemlineatus	thirteen-lined ground squirrel	3	0	0	0	0	3	20
Birds								
Columbidae	pigeon	1	0	0	0	0	1	20
Corvidae	magpie	0	0	1	0	0	1	20
Frigillidae	sparrow	0	0	0	0	1	1	20
Analysis of Hair*								
Mammals		122	123	129	136	138		
Microtus spp.	vole	X	X	X	X	X	5	100
Peromyscus spp.	deer mouse	X	X		X	X	4	80
Citellus tridecemlineatus	thirteen-lined ground squirrel		X				1	20
Perognathus hispidus	hispid pocket mouse				X		1	20

* This analysis provides only the presence or absence of mammalian species.

X Presence or absence of prey species

Table C.4-13 American Kestrel Food Items Based on Analysis of Juvenile Stomach Contents, Rocky Mountain Arsenal, 1990

Stomach Contents Prey Catagory	Common Names	Box Number		
		129	136	138
Insects				
Orthoptera	grasshoppers and crickets		X	X
(Acrididae)	grasshoppers		(X)	
(Gryllidae)	crickets		(X)	(X)
Odonata	dragonflies		X	
Mammals				
Microtus spp.	vole		X	
Peromyscus spp.	deer mouse	X		
Reptiles				
Iguanidae	lizard			X

X = Presence at prey species
(X) = a subset of X

Table C.4-14 Bluegill Food Items Based on Analysis of Stomach Contents, Rocky Mountain Arsenal, September 1989

Tag #	Location #	Length mm	Weight gm	Fullness Category	Micro-Invertebrates Bosmina Longirostris	Chydorus Sphaericus	Cyclops Biscupidatus	Daphnia Pulex	Daphnia Rosa	Diaptomas Oregonensis
B0992C	BS08S00189	60	3	6	7	16	9	1	3	5
B0886C	BS07S00489	64	5	3						
B0892A	BS07S00589	65	4	6	3		10	3	1	
B0953C	BS08S00589	67	5	6						
B0953A	BS08S00589	70	6	1						
B0886B	BS07S00489	73	6	4						
B0992B	BS08S00189	74	6	3				6		
B0960D	BS08S00389	74	7	4	9	33	24	19		26
B0945D	BS08S00289	75	7	2				3		
B0945A	BS08S00289	76	7	5				6		
B0953B	BS08S00589	85	11	3						
B0960C	BS08S00389	85	18	6						
B0992D	BS08S00189	89	11	3						
B0944C	BS08S00489	89	12	6	72	37	62	48	9	51
B0945B	BS08S00289	93	12	5	12	17	23	31	9	17
B0945C	BS08S00289	93	12	5	63	29	55	40	11	43
B0944B	BS08S00489	94	13	6						
B0944A	BS08S00489	95	13	4						
B0960A	BS08S00389	97	15	6						
B0960B	BS08S00389	100	17	5	77	160	48	103	14	68
B0992A	BS08S00189	100	18	6	3	1		3		
B0944D	BS08S00489	100	19	6						
B0953D	BS08S00589	100	19	1						
B0882B	BS07S00289	122	34	3						
B0892B	BS07S00589	127	31	3				6	1	
B0882C	BS07S00289	127	37	1						
B0886D	BS07S00489	130	40	6	8	7	17	9	30	6
B0892D	BS07S00589	133	41	3						
B0886A	BS07S00489	134	43	6						
B0882A	BS07S00289	135	43	2						
B0882D	BS07S00289	135	43	3						
B0892C	BS07S00589	139	48	5	7	11	3	4	1	11

Tag #	Location #	Length mm	Weight gm	Fullness Category	Micro-Invertebrates Bosmina Longirostris	Chydorus Sphaericus	Cyclops Biscupidatus	Daphnia Pulex	Daphnia Rosa	Diaptomas Oregonensis
B0877A	BS07S00189	NR	NR	1						
B0877B	BS07S00189	NR	NR	6						
B0877C	BS07S00189	NR	NR	6						
B0877D	BS07S00189	NR	NR	6						
B0880A	BS07S00289	NR	NR	3						
B0880B	BS07S00289	NR	NR	3						
B0880C	BS07S00289	NR	NR	4						
B0880D	BS07S00289	NR	NR	3						

1) 1 Empty
2 Trace
3 Full
4 1/2 Full
5 3/4 Full
6 Full
NR Not Recorded
mm milligrams
gm gram
P Present
sp 1 species
spp 2 or more species

Tag #	Location #	Length mm	Weight gm	Fullness Category	Macro-Invertebrates Hesperocorixa SPP	Chironomus SPP	Diptera (Terrestrial)	Hydroptila SP	Lestes SP	Macro- Odonata
B0992C	BS08S00189	60	3	6		2		17		
B0886C	BS07S00489	64	5	3						
B0892A	BS07S00589	65	4	6	2	12				
B0953C	BS08S00589	67	5	6	1	30				
B0953A	BS08S00589	70	6	1						
B0886B	BS07S00489	73	6	4	1					
B0992B	BS08S00189	74	6	3		4		2		
B0960D	BS08S00389	74	7	4						
B0945D	BS08S00289	75	7	2						
B0945A	BS08S00289	76	7	5	3					
B0953B	BS08S00589	85	11	3		7				
B0960C	BS08S00389	85	18	6		27				
B0992D	BS08S00189	89	11	3		9		3		
B0944C	BS08S00489	89	12	6						
B0945B	BS08S00289	93	12	5	1					
B0945C	BS08S00289	93	12	5						
B0944B	BS08S00489	94	13	6		7		5		
B0944A	BS08S00489	95	13	4				6		
B0960A	BS08S00389	97	15	6		29				
B0960B	BS08S00389	100	17	5						
B0992A	BS08S00189	100	18	6	2	23				
B0944D	BS08S00489	100	19	6	6	11				
B0953D	BS08S00589	100	19	1						
B0882B	BS07S00289	122	34	3						1
B0892B	BS07S00589	127	31	3		4		2		
B0882C	BS07S00289	127	37	1						
B0886D	BS07S00489	130	40	6					5	
B0892D	BS07S00589	133	41	3		9		3		
B0886A	BS07S00489	134	43	6						2
B0882A	BS07S00289	135	43	2		1				
B0882D	BS07S00289	135	43	3		3				
B0892C	BS07S00589	139	48	5		2		17		

Tag #	Location #	Length mm	Weight gm	Fullness Category	Macro-Invertebrates Hesperocorixa SPP	Chironomus SPP	Diptera (Terrestrial)	Hydroptila SP	Lestes SP	Macro-Odonata
B0877A	BS07S00189	NR	NR	1						
B0877B	BS07S00189	NR	NR	6	6	10		2		
B0877C	BS07S00189	NR	NR	6	2				1	
B0877D	BS07S00189	NR	NR	6		6				
B0880A	BS07S00289	NR	NR	3			1			
B0880B	BS07S00289	NR	NR	3						
B0880C	BS07S00289	NR	NR	4				5		
B0880D	BS07S00289	NR	NR	3						

1) 1 Empty
2 Trace
3 Full
4 1/2 Full
5 3/4 Full
6 Full
NR Not Recorded
mm milligrams.
gm gram
P Present
sp 1 species
spp 2 or more species

Tag #	Location #	Length mm	Weight gm	Fullness Category	Macro-Invertebrates Orthocladius SP	Physa SP	Polypedilum SP	Unidentified	Macro-Organic Material
B0992C	BS08S00189	60	3	6					
B0886C	BS07S00489	64	5	3				2	
B0892A	BS07S00589	65	4	6	10		1		
B0953C	BS08S00589	67	5	6	1				
B0953A	BS08S00589	70	6	1					
B0886B	BS07S00489	73	6	4		3			
B0992B	BS08S00189	74	6	3					
B0960D	BS08S00389	74	7	4					
B0945D	BS08S00289	75	7	2					
B0945A	BS08S00289	76	7	5					
B0953B	BS08S00589	85	11	3				2	
B0960C	BS08S00389	85	18	6					
B0992D	BS08S00189	89	11	3	1				
B0944C	BS08S00489	89	12	6					
B0945B	BS08S00289	93	12	5					
B0945C	BS08S00289	93	12	5					P
B0944B	BS08S00489	94	13	6					P
B0944A	BS08S00489	95	13	4					
B0960A	BS08S00389	97	15	6	3		3		P
B0960B	BS08S00389	100	17	5					
B0992A	BS08S00189	100	18	6	2		5		
B0944D	BS08S00489	100	19	6	1		1		
B0953D	BS08S00589	100	19	1					
B0882B	BS07S00289	122	34	3					
B0892B	BS07S00589	127	31	3					
B0882C	BS07S00289	127	37	1					
B0886D	BS07S00489	130	40	6		1			
B0892D	BS07S00589	133	41	3			1		
B0886A	BS07S00489	134	43	6					
B0882A	BS07S00289	135	43	2	1			1	
B0882D	BS07S00289	135	43	3	1	2		3	
B0892C	BS07S00589	139	48	5					

Tag #	Location #	Length mm	Weight gm	Fullness Category	Macro-Invertebrates Orthocladius SP	Physa SP	Polypedilum SP	Unidentified	Macro-Organic Material
B0877A	BS07S00189	NR	NR	1					
B0877B	BS07S00189	NR	NR	6					
B0877C	BS07S00189	NR	NR	6					P
B0877D	BS07S00189	NR	NR	6					P
B0880A	BS07S00289	NR	NR	3					
B0880B	BS07S00289	NR	NR	3		1	1		
B0880C	BS07S00289	NR	NR	4					
B0880D	BS07S00289	NR	NR	3	2	2	2	1	

1) 1 Empty
2 Trace
3 Full
4 1/2 Full
5 3/4 Full
6 Full
NR Not Recorded
mm milligrams
gm gram
P Present
sp 1 species
spp 2 or more species

Table C.4-15. Largemouth Bass Food Items Based on Analysis of Stomach Contents, Rocky Mountain Arsenal, September 1989

Tag #	Location #	Length mm	Weight gm	Fullness Category (1)	Macro-Invertebrates Hesperocorixa SP	Chironomus SPP	Lestes SP	Odonata	Unidentified
B0946B	BS08S00489	165	51	3	7				
B0946C	BS08S00489	169	52	1					
B0959B	BS08S00289	174	58	6			3	1	
B0947C	BS08S00189	179	63	4	15				
B0954D	BS08S00589	180	63	4					
B0947D	BS08S00189	182	69	2	1				
B0947B	BS08S00189	187	71	3	15				
BO943C	BS08S00489	190	80	2			3		
B0954A	BS08S00589	195	84	2			1		
B0947A	BS08S00189	195	86	4	11				
B0943B	BS08S00489	195	88	1					
B0954C	BS08S00589	200	91	2			1	1	
B0946A	BS08S00489	204	87	1					
BO954B	BS08S00589	204	114	6	5				
BO943A	BS08S00489	207	91	2	3				
B0959A	BS08S00289	211	107	1					
BO881B	BS07S00189	222	160	2					
BO881A	BS07S00189	251	230	4					
B0899B	BS07S00189	269	264	1					
B0899A	BS07S00189	295	328	4		11			
B0883B	BS07S00489	312	448	2					1
BO883A	BS07S00489	360	277	6					
B0878A	BS07S00189	NR	NR	1					
B0878B	BS07S00189	NR	NR	1					
B0879A	BS07S00289	NR	NR	2		3			
B0879B	BS07S00289	NR	NR	4				7	

(1) 1 Empty
2 Trace
3 1/4 Full
4 1/2 Full
5 3/4 Full
6 Full

sp 1 species
spp 2 or more species
mm millimeter
gm gram
P Present

Table C.4-15. Largemouth Bass Food Items Based on Analysis of Stomach Contents, Rocky Mountain Arsenal, September 1989

Tag #	Location #	Length mm	Weight gm	Fullness Category (1)	Organic Material	Bluegill	Lumbricus SP	Largemouth Bass	Fish Unidentified
B0946B	BS08S00489	165	51	3					
B0946C	BS08S00489	169	52	1					
B0959B	BS08S00289	174	58	6					1
B0947C	BS08S00189	179	63	4					
B0954D	BS08S00589	180	63	4				1	
B0947D	BS08S00189	182	69	2					
B0947B	BS08S00189	187	71	3					
BO943C	BS08S00489	190	80	2					
B0954A	BS08S00589	195	84	2	P				
B0947A	BS08S00189	195	86	4					
B0943B	BS08S00489	195	88	1					
B0954C	BS08S00589	200	91	2					
B0946A	BS08S00489	204	87	1					
BO954B	BS08S00589	204	114	6					2
BO943A	BS08S00489	207	91	2					
B0959A	BS08S00289	211	107	1					
BO881B	BS07S00189	222	160	2	P				
BO881A	BS07S00189	251	230	4					
B0899B	BS07S00189	269	264	1					
B0899A	BS07S00189	295	328	4	P				
B0883B	BS07S00489	312	448	2					
BO883A	BS07S00489	360	277	6		1			
B0878A	BS07S00189	NR	NR	1	P				
B0878B	BS07S00189	NR	NR	1					
B0879A	BS07S00289	NR	NR	2	P				
B0879B	BS07S00289	NR	NR	4					

(1) 1 Empty
2 Trace
3 1/4 Full
4 1/2 Full
5 3/4 Full
6 Full

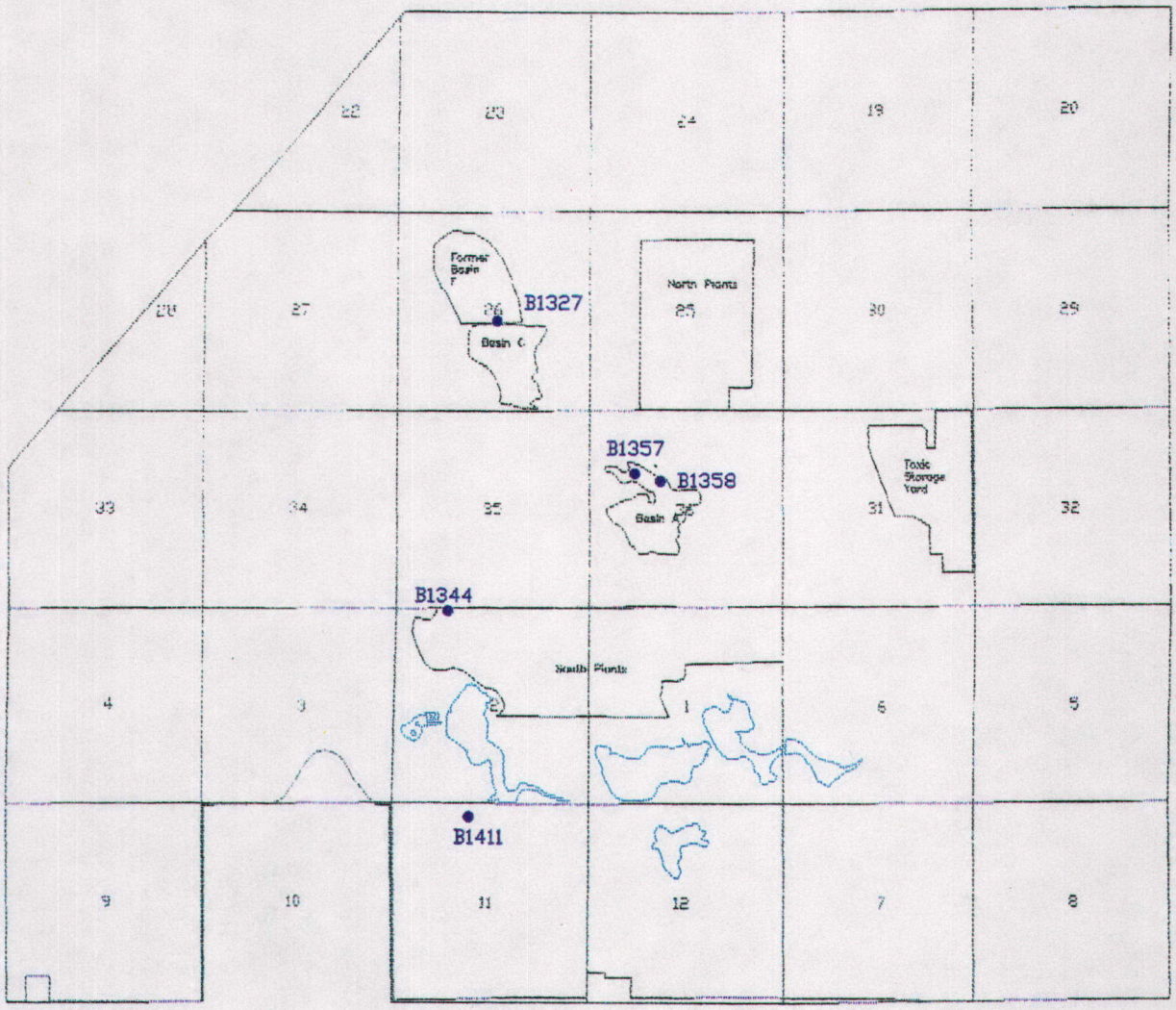
sp 1 species
spp 2 or more species
mm millimeter
gm gram
P Present

Table C.4-16 Northern Pike Food Items Based on Analysis of Stomach Contents, Rocky Mountain Arsenal, September 1989

Tag #	Location #	Fullness Category (1)	Bluegill	Lumbricus SP	Organic Matter (2)
B0860	BS07S00589	1			P
B0862	BS07S00289	2			P
B0867	BS07S00189	2			P
B0869	BS07S00189	1			
B0870	BS07S00189	2		1	
B0904	BS08S00389	1			
B0905	BS08S00589	4	1		
B0906	BS08S00589	1			
B0907	BS08S00289	2			P
B0908	BS08S00289	2			P

(1) 1 Empty
2 Trace
3 1/4 Full
4 1/2 Full
5 3/4 Full
6 Full
sp 1 species
P Present
All fish remains found in stomachs were Bluegill

(2) Present



Legend

Lake

31 Section Number

Section Line

Sample Point
B1411

N

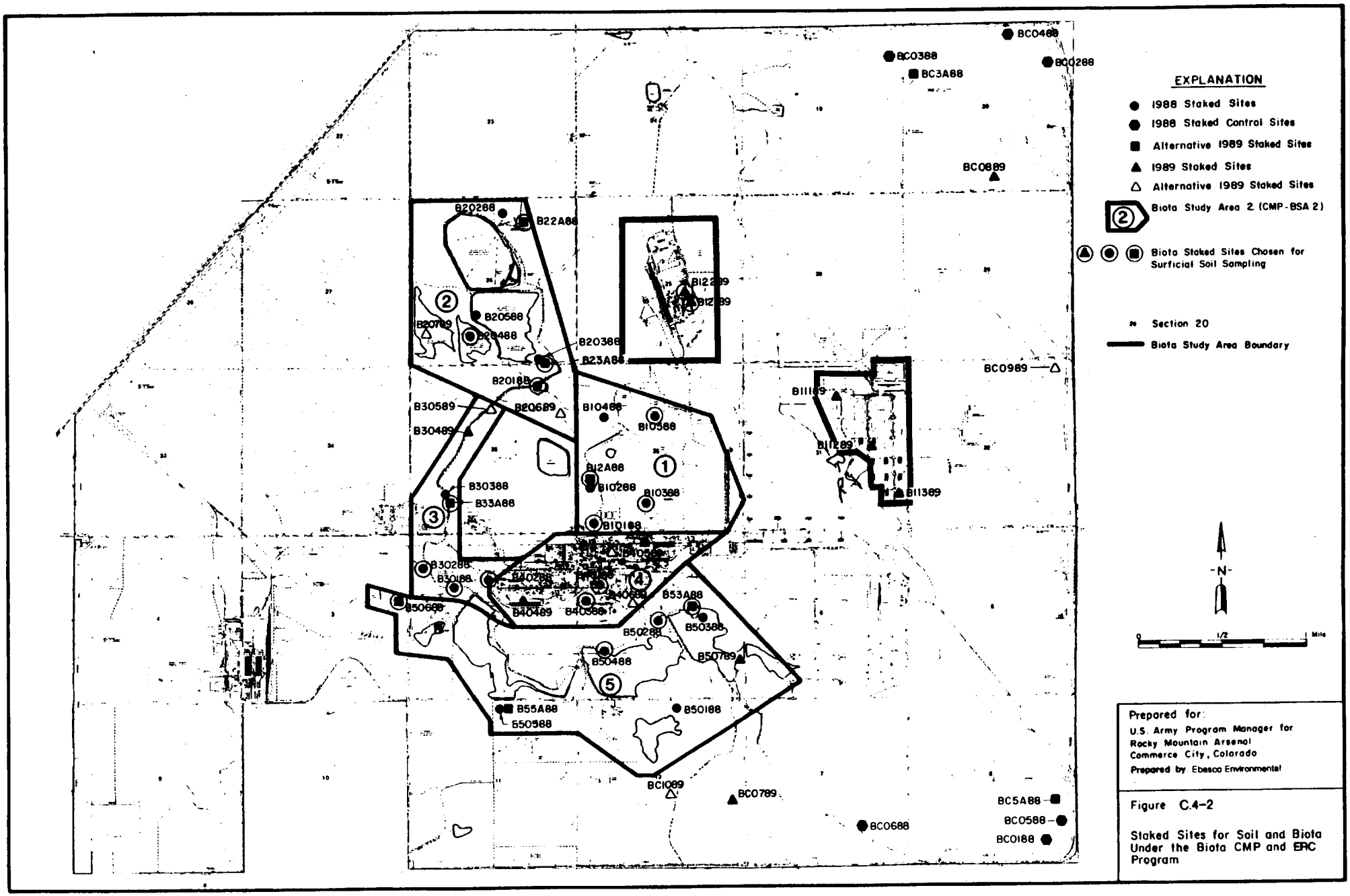
0 2000 4000
Scale in Feet

Prepared for:
U.S. Army Program Manager
for Rocky Mountain Arsenal
February 1994

Figure C.4-1

Location of Vesper Sparrows
Collected for Food Item Study and
Tissue Samples, RMA, 1990

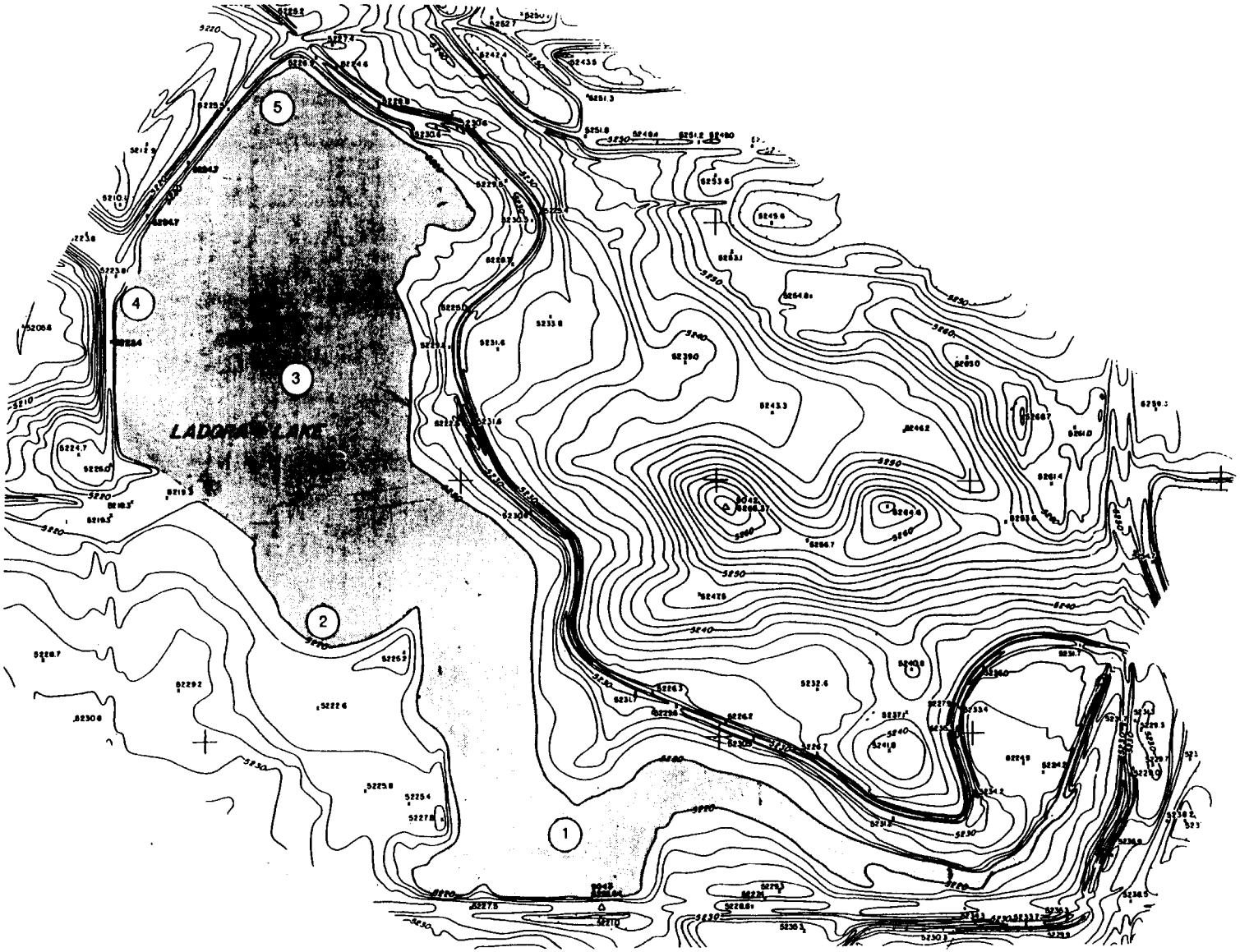
Rocky Mountain Arsenal
Prepared by: ENSERCH Environmental Corp



Prepared for:
U.S. Army Program Manager for
Rocky Mountain Arsenal
Commerce City, Colorado
Prepared by: Ebasco Environmental

Figure C.4-2

Staked Sites for Soil and Biota Under the Biota CMP and ERC Program



EXPLANATION

(1) Aquatic Sampling Station

2' Contour Interval

N

0 400

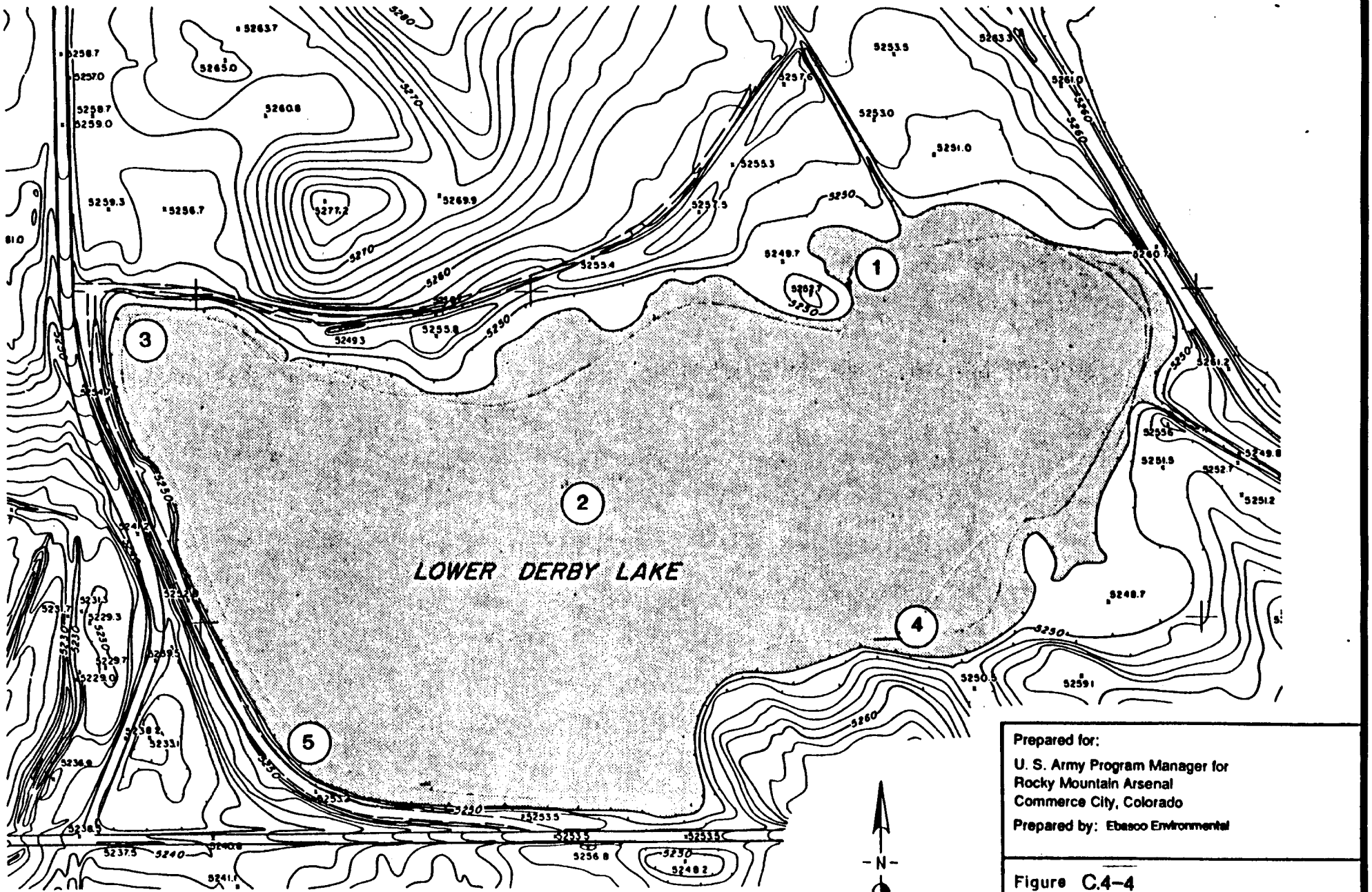
SCALE IN FEET

Prepared for:
U. S. Army Program Manager for
Rocky Mountain Arsenal
Commerce City, Colorado

Prepared by: Ebasco Environmental

Figure C.4-3

Aquatic Sampling Stations
in Lake Ladora, BSA 7



Legend

(1) Aquatic Sampling Station

2' Contour Interval

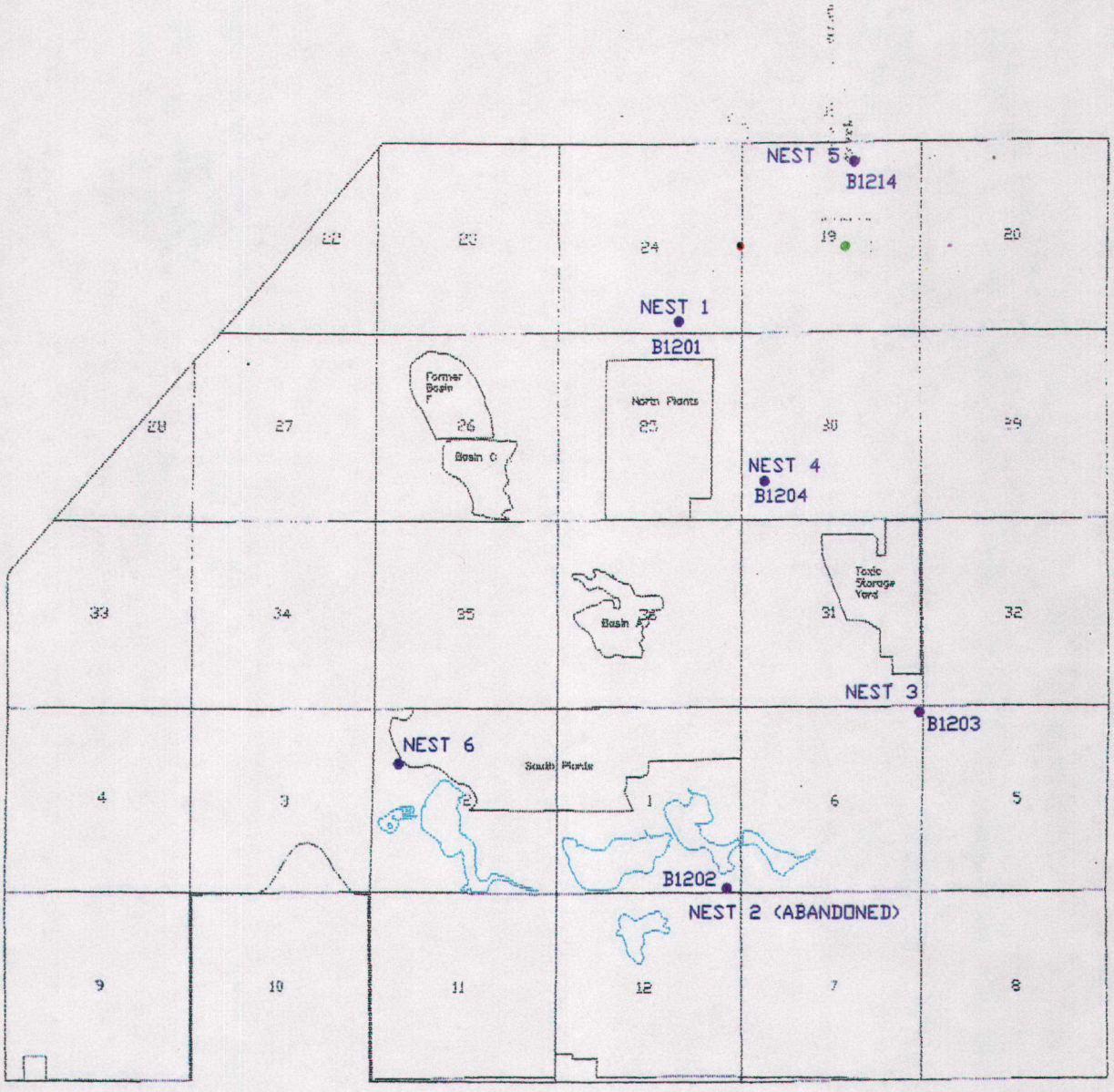
Prepared for:

U. S. Army Program Manager for
Rocky Mountain Arsenal
Commerce City, Colorado

Prepared by: Ebasco Environmental

Figure C.4-4

Aquatic Sampling Stations in Lower Derby Lake, BSA 8



Legend

Lake

31 Section Number

Section Line

NEST 3 / B1203 Sample Point

0 2000 4000

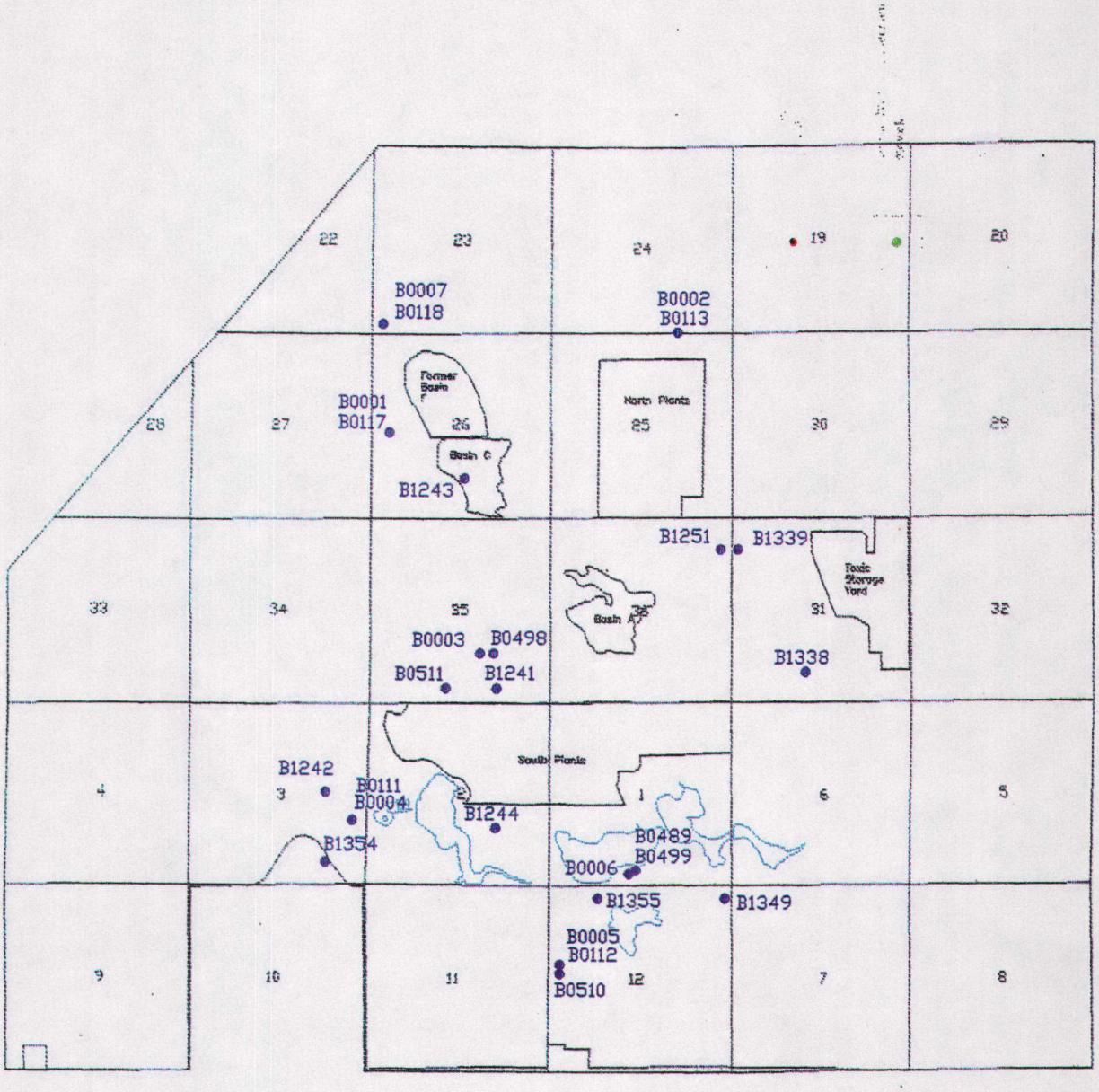
Scale in Feet

Prepared for:
U.S. Army Program Manager
for Rocky Mountain Arsenal
February 1994

Figure C.4-5

Location of Great Horned Owl Nests Used for Food Item Study and Tissue Samples, RMA, 1990

Rocky Mountain Arsenal
Prepared by: ENSERCH Environmental Corp



Legend

Lake

31 Section Number

Section Line

B1349 Sample Point

0 2000 4000

Scale in Feet

Prepared for:
U.S. Army Program Manager
for Rocky Mountain Arsenal
February 1994

Figure C.4-6

Location of American Kestrel Nest Boxes Used for Food Item Study and Tissue Samples, RMA, 1988 and 1990

Rocky Mountain Arsenal
Prepared by: ENSERCH Environmental Corp

APPENDIX C
(SECTION C.5)

ECOLOGICAL STATUS AND HEALTH

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LIST OF ACRONYMS AND ABBREVIATIONS

µg/g	micrograms per gram
AChE	acetylcholinesterase
Army	U.S. Department of the Army
BEMA	Bald Eagle Management Area
BMF	biomagnification factor
BSAs	biota study areas
Buckley	Buckley Air National Guard Base
CRL	certified reporting limit
CMP	Comprehensive Monitoring Program
COC	contaminant of concern
DDE	dichlorodiphenyldichloroethene
DDT	dichlorodiphenyltrichloroethane
EPA	U.S. Environmental Protection Agency
ERC	Ecological Risk Characterization
ESC	estimated soil area concentrations
FDA	U.S. Food and Drug Administration
FR	Federal Register
ft	foot
ft^2	square foot/feet
HI	hazard index
IEA	Integrated Endangerment Assessment
km	kilometer
MATC	maximum allowable tissue concentration
MKE	Morrison-Knudsen Environmental
PCC	Plains Conservation Center
ppm	parts per million
RI	Remedial Investigation
RMA	Rocky Mountain Arsenal
RTIC	Rocky Mountain Arsenal Technical Information Center
Shell	Shell Oil Company
USFWS	U.S. Fish and Wildlife Service

C.5 ECOLOGICAL STATUS AND HEALTH

C.5.1 INTRODUCTION

Information on the ecological status and health of biota populations and communities at Rocky Mountain Arsenal (RMA) was provided to fulfill two general objectives: to provide a general characterization of plant communities, animal habitats, populations and communities at RMA from a regional perspective, and to evaluate the potential for specific ecological effects of RMA contaminants on biota as revealed by defined ecological-effect endpoints. The first objective is consistent with the U.S. Environmental Protection Agency (EPA) guidance on providing site characterization, which provides a context within which to consider risk to receptors of potential contaminants when pathways exist from abiotic media such as soil, sediment, and water. The second objective is consistent with the effects evaluation portion of an ecological risk assessment (EPA 1989a, 1992a) since it identifies the effects of contamination on populations or communities when endpoints appropriate to the contaminants of concern (COCs) have been measured. The studies used for characterizing RMA biota and for the evaluation of effects come from a variety of existing documents that are published and available in the RMA Technical Information Center (RTIC) at RMA, including the Biota Remedial Investigation (RI) (ESE 1989), Biota Comprehensive Monitoring Program (CMP) (RLSA 1990, 1992), and various U.S. Fish and Wildlife (USFWS) studies.

This ecological status and health section is not intended to offset the quantitative characterization of potential ecological risk based on toxicological endpoints. Rather, it is intended to provide context and additional information to guide the interpretation and application of the results of the quantitative characterization of potential ecological risk.

Ecological risk assessment guidance (EPA 1989a) emphasizes and defines effects at the population and community levels. This guidance discusses lethal and sublethal toxicant effects in the context of their impacts at the population level. Updates to current EPA risk assessment guidance acknowledge that while contaminant exposure occurs at the level of an individual organism, populations, communities, and ecosystems are the crucial levels on which to focus

evaluation and management (EPA 1992a, b). In keeping with EPA guidance (1989a) this section incorporates information on the health and status of the population, community, and ecosystem and health at RMA from all available and pertinent sources.

Ecological health must be defined in the context of contaminant effects. For purposes of this risk assessment, ecological health is defined as consisting of the normal range of those ecological characteristics identified by EPA (1989a, pg. 42 to 43) as providing a basis for selecting appropriate assessment endpoints. A population is defined as the individuals of an interbreeding group of organisms of the same species (Hickman et al. 1979). Contamination effects are evaluated in the context of their impacts on populations. Populations are appropriately defined on a species-specific basis. For sedentary species, populations may be definable within the confines of specific contaminated sites. For more mobile species, however, populations cannot be defined and population parameters cannot be measured at anything less than an RMA-wide scale. Such individuals utilize ranges that include contaminated and uncontaminated areas and occasionally include more than one contaminated area. It is these mobile, upper-trophic level species that would be expected to be most sensitive to contaminant effects and that must be assessed in the context of their inclusion in populations that extend beyond the RMA boundaries. These are populations that occupy a particular region characterized by a habitat or habitats that are more or less contiguous and occur within a major biogeographic region (e.g., short grass prairie and associated habitats such as riparian woodland, pasture land, and wetlands).

RMA is unusual among Superfund sites in that it contains extensive areas with low levels of contamination as well as several areas with high levels of contamination. Some other very important attributes of RMA are its large size (27 square miles), proximity to a major urban area, extensive areas of native grassland habitat, and sizable populations of deer, prairie dogs, and raptors. Along the Colorado Front Range—and nationwide—these characteristics make RMA a very unique site for an ecological risk assessment.

C.5.2 ECOLOGICAL CHARACTERIZATION AND STATUS

To provide a context for the consideration of potential risk, ecological data are used to characterize the plant communities, the wildlife habitats these communities provide, and the wildlife species that are present in these communities. This section describes the ecosystems at RMA.

C.5.2.1 Plant Communities and Animal Habitats at Rocky Mountain Arsenal

The structure of RMA plant communities and the wildlife habitats they provide results from interactions between native and introduced species of plants and animals, historical and current land-use practices, and abiotic factors such as climate, geology, and topography. RMA is situated within a temperate grassland region and is part of a broad ecotone (transition zone) between montane and plains habitats. Native vegetation of the region consists primarily of open semiarid grasslands, with some areas of yucca, shrubland, woodland, and riparian habitats. Human societal changes in the region have altered the landscape to a mosaic of agricultural, developed (industrial facilities, residential areas, and successional parcels), and native habitats. At present, 41 percent of the RMA land surface supports early successional vegetation communities; an additional 19 percent of RMA land surface is vegetated by crested wheatgrass, which was used in the 1930s and 1940s to stabilize erodible land (MKE 1989b). The remainder of the vegetated land surface at RMA consists of native grassland (28 percent), and smaller areas with shrubland, patches of yucca, riparian woodlands, cattail marshes and other wetland types, locust and wild plum thickets, upland groves of deciduous trees, and ornamental plantings that collectively comprise the remaining 12 percent of RMA (MKE 1989b; Attachment C.5-2, Rocky Mountain Arsenal Vegetation Classification Map). Each of these varied vegetative groups provides potential wildlife habitat.

The occurrence of native forbs in the grassland areas is variable depending upon substrate and climate (MKE 1989b). Common perennial forbs in addition to those already named include American vetch, prairie clover, silvery lupine, narrowleaf and white penstemon, prairie coneflower, prairie aster, hairy golden-aster, western wallflower, scarlet globemallow, scarlet

butterfly-weed, skeleton-weed, green-thread, evening primrose, sand verbena, and wild buckwheat. Prickly pear cactus and pasture sage may be locally abundant. Annual forbs include woolly plantain, prairie peppergrass, and narrowleaf goosefoot. Six-weeks fescue, an annual grass, is a widespread component of all grasslands.

Riparian woodlands and associated wetland areas occur along water courses. Plains cottonwood and peachleaf willow dominate the overstory, with lesser numbers of box-elder. The understory includes shrubby willows as well as a variety of midgrass and tallgrass species such as yellow Indiangrass, slender wheatgrass, switchgrass, and Canada wildrye. Golden currant, wild rose, chokecherry, and snowberry may also occur in moist areas, and wild plum and hawthorn may form dense thickets in such sites. Cattails and bulrushes may dominate minor drainages. Western wheatgrass and inland saltgrass are conspicuous dominants on bottomlands with finer saline soils.

The occurrence of shrubs and subshrubs is also variable, depending upon substrate and topography. Fringed sage, rubber rabbitbrush, broom snakeweed, and winterfat clusters occur on coarse soils. Sand sagebrush occurs on deep sand soils and yucca on areas where bedrock is near the soil surface. Each of these shrubland types is somewhat limited both at RMA and regionally due to agricultural conversion to cropland and development. Much of the wildlife at RMA depends on the habitat values that shrubland areas provide. There are also many windbreaks and thickets of New Mexico locust (which is a result of landscaping activity by previous landowners) that provide many of the same habitat values as shrublands, but have greater structural diversity.

Non-native weedy forbs and grasses are widespread at RMA as a result of abandoned agricultural fields or other surface disturbances (e.g., tracks and disturbances from vehicular traffic associated with military maneuvers, facility maintenance, and off-road traffic) that removed the existing vegetation but was not followed by revegetation with perennial cover. Further, plant-community development is very slow in the semiarid climate at RMA, especially after exotic, weedy

vegetation is established. Even though dominated by "less desirable" vegetation, weedy habitat receives considerable use by wildlife. In addition, annual and perennial weedy forbs present in other habitats provide forage for a variety of wildlife.

Some minor habitat modification projects have been conducted by USFWS and Shell Oil Company (Shell) to improve habitat for selected wildlife species. While these projects have necessarily involved the alteration of certain habitats through an initial plowing, the total acreage is minimal (i.e., less than 500 acres total), the habitats impacted were of uniformly low wildlife value (e.g., cheatgrass habitats), and the period of low resource availability was restricted to 1 year or less. Although it has not been specifically assessed, the effects of these habitat modification projects on wildlife are expected to have been more beneficial than deleterious.

C.5.2.2 Animals at Rocky Mountain Arsenal

Formal ecological inventories of the biota resources at RMA began in the mid-1970s (RLSA 1988). These inventories have documented a diversity of species that vary in their habitat selectivity. Some species are generally confined to specific habitat types (e.g., Brewer's sparrow requires sagebrush shrublands), while other species inhabit a range of habitat types (e.g., black-billed magpie and coyote can be found in all terrestrial habitats at RMA). For RMA fish communities, management history also plays a particularly important role in determining the species present and their population dynamics.

The species of wildlife, fish, and other terrestrial or aquatic organisms at RMA serve as potential receptors of RMA contaminants present in the soil, sediment, or water of RMA when an exposure pathway is present that allows contaminant uptake. Species that grow in, burrow in, or ingest soil or sediment or that take dust baths in soil may take in contaminants that are present on soil particles. Similarly, species that ingest water or swim in it may take in contaminants that are dissolved in water or adhering to sediment particles suspended in the water. Contaminants that enter RMA food webs in this way are passed from prey to predator species.

C.5.2.2.1 Mammals

Twenty-six species of mammals have been observed at RMA (Attachment C.5-1, Table 2), including all of the common mammals that inhabit the prairie grasslands of the Colorado Front Range (Armstrong 1972; Bissel and Dillon 1982). Desert cottontails, black-tailed jackrabbits, thirteen-lined ground squirrels, black-tailed prairie dogs, kangaroo rats, and numerous other small mammal species make up the major prey base at RMA. Badgers and coyotes are the principle carnivores. Mule deer are abundant in all habitats, and white-tailed deer frequent the riparian woodlands. Areas of musk thistle and cheatgrass can provide cover and green forage for deer in the winter, wetlands occasionally support muskrats and raccoons, and shelter belts provide habitat for fox squirrels, striped skunks, foxes, and other mammals.

C.5.2.2.2 Birds

RMA habitats are primarily open grassland and weedy plains, and a variety of ground-nesting songbirds and other birds preferring such open habitat are common (Attachment C.5-1, Table 1). At least two regionally rare or declining species (Cassin's sparrow and Brewer's sparrow) are relatively common breeding birds at RMA (Webb et al. 1991). Regionally, these two species are restricted to ungrazed sites with dense cover.

Prairie rangelands are often interspersed by woodland, shrubland, or landscaped areas whose trees and shrubs provide potential nesting habitat for raptors, songbirds, and other taxa. Raptor population density and species diversity are comparable to these characteristics of other regional sites (MKE 1989a). Winter raptor populations, particularly of the bald eagle, are a primary attraction for the 20,000 to 30,000 visitors to RMA during this season (USFWS 1992b).

Riparian corridors, woodlands, wetlands, and aquatic habitats also attract particular assemblages of bird species. Areas dominated by an overstory of musk thistle and an understory of cheatgrass support numerous pairs of lark buntings during the summer. In general, the RMA avifauna in these habitats is similar to that in comparable local habitats in the region (MKE 1989a), although the bald eagle winter roost at RMA is one of only five such sites in the region.

One hundred seventy-six species of birds (approximately 40 percent of all bird species recorded in the state of Colorado [Bailey and Niedrach 1965; Chase et al. 1982]) have been observed at RMA (Attachment C.5-1, Table 1). The species richness of RMA avifauna is high relative to that in the region. There is an official Breeding Bird Survey route established on RMA. This route has been assigned to Stratum 36 of the Breeding Bird Survey system on the basis of its natural land use. The breeding bird survey conducted at RMA in 1991 documented 1,456 individuals of 51 species, which was the highest recorded species richness in the region in 1991 (USFWS 1992c). No other route in Stratum 36 has recorded more than 50 species since 1968 (Peterjohn, per. comm.). In 1992 and 1993, RMA recorded 39 and 42 species, respectively (USFWS 1994).

C.5.2.2.3 Reptiles and Amphibians

Although reptiles and amphibians are not common at RMA, several species may be encountered in nearly every habitat type. Incidental observation has recorded 61 percent or 17 of the 28 species of reptiles and amphibians that could potentially occur at RMA (Attachment C.5-1, Table 4). The native grasslands support plains spadefoot toad, short-horned lizard, lesser earless lizard, and prairie rattlesnake. A great number and variety of amphibians and reptiles occur in riparian habitat, including the littoral zone of permanent water and temporary pools. Commonly observed species include tiger salamander, striped chorus frog, leopard frog, painted turtle, and various garter snakes. Other reptiles and amphibians are more or less ubiquitous at RMA. These include plains garter snake, bull snake, eastern yellow-bellied racer, and Woodhouse's toad.

C.5.2.2.4 Aquatic Life

The aquatic resources of RMA include four sizable impoundments (i.e., Upper Derby Lake, Lower Derby Lake, Lake Ladora, and Lake Mary) and one smaller nearby water body (Rod and Gun Club Pond), collectively referred to as the Lower Lakes; three minor water bodies (i.e., North Bog Pond, Havana Pond, and Toxic Storage Yard Pond); and a fairly persistent stream (First Creek). Of these resources, the Lower Lakes occupy the largest volume and support the largest extent of RMA's fisheries, waterfowl, and littoral and limnetic habitats. The Lower Lakes

(except Rod and Gun Club Pond) were also a part of the cooling system for the South Plants manufacturing facilities and so received contaminant input from periodic leaks and spills.

Due to the extensive wildlife, fisheries, and recreational resources they support, as well as to the concurrent issues of contamination, the Lower Lakes have received a good bit of attention from biological investigators since the early 1950s. Waterfowl mortality in the Lower Lakes was one of the first indications of wildlife damages related to operations at RMA. While there had once apparently been a fishery in these lakes, there were no fish present in 1951 (Hyman 1953). Several years later, it was reported that there were no fish or amphibians in the Lower Lakes and that waterfowl die off was estimated to be 2,000 birds per year in late winter and early spring when mud flats were exposed and migrations brought large numbers to the area (Finley 1959). In 1964 and 1965, Upper and Lower Derby Lakes and Lake Ladora were drained and the sediments were removed in an effort to clean the lakes (Rosenlund et al. 1986).

Fisheries were established in the Lower Lakes through stocking in the late 1960s (Bartschi 1968) and population and status trends were monitored on a fairly regular basis through the 1970s (U.S. Army 1973; Bartschi 1975; Rocky Mountain Fisheries Consultants 1977). Species identified in the RMA lakes are listed in Attachment C.5-1, Table 3. While the fisheries have required active management, they have generally been productive with respect to growth and numbers of individuals. In addition to the periodic addition of predatory and/or prey species, the lakes have been managed by adjusting the water levels.

Despite these efforts, contaminants have been reported to occur in the sediments of all four of the large Lower Lakes (Myers et al. 1983; Myers and Greg 1984; Bergersen et al. 1984). Dieldrin and aldrin were the most ubiquitous of contaminants found, with an average dieldrin level in Lower Derby Lake of 0.034 micrograms per gram (µg/g). In Upper and Lower Derby Lakes and Lake Ladora, contaminants reached their highest levels in the upper organic sediments near the inflow points and in the deepest parts of the lakes. In Lake Mary, the contaminants were distributed more evenly through the upper sediments of the lake. Contaminant levels in the

lake water itself were generally below detection limits for all of the bodies of water that were measured. Rosenlund et al. (1986) reported no water samples with contaminant levels above detection limits for any of the four larger lakes. Myers and Greg (1984) reported one water sample from Lake Mary had a dieldrin concentration of 0.02 μg/g.

Contaminants have also been reported to occur in the tissues of the fishes of the Lower Lakes by a number of studies conducted during the 1970s and 1980s (U.S. Army 1975; Thorne 1982; Rosenlund et al. 1986). Rosenlund et al. (1986) reported that, although the principle contaminant sink lies in the sediments, some of the COCs are available to the system via a process of uptake and mobilization by the aquatic vascular plants. They found widespread levels of aldrin and dieldrin that were above detection limits in the biota for these lakes and found a general trend for bioconcentration and bioaccumulation, with the highest levels found in the fatty tissues of the top predator fishes (i.e., largemouth bass and pike). These levels were generally below the U.S. Food and Drug Administration (FDA) action guidelines for commercial fish products (Rosenlund et al. 1986).

MKE (1989c) conducted population-level assessments of the phytoplankton, zooplankton, macroinvertebrate, macrophyte, and fish populations of the Lower Lakes, comparing each of the populations to the rest and to populations in an off-post control lake (McKay Lake, Adams County, Colorado). The control lake was selected because it is similar to the Lower Lakes in size, morphometry, substrate, and fish species composition. The biota communities of the Lower Lakes were generally found to be comparable to the off-post lake and within the expected ranges. The fish communities were "healthy, reproducing and included many large individuals." Differences did occur both between the RMA and control lakes and among RMA lakes themselves. These differences appeared to be predominately attributable to differences in stocking (e.g., predator species introduced) and management regime (e.g., macrophyte density), and not to any trends of contamination. It is imperative that such results of management not be construed as indicative of contaminant effects. For example, in discussing the disappearance of

bullheads from the RMA lakes, USFWS (1993a) states that "bullheads have successfully been eliminated" as a result of stocking of predator species.

USFWS has assessed RMA's fisheries since 1979 through standardized gill net sampling, electrofishing, and an angler satisfaction survey (USFWS 1993a). The focus of this sampling program, as reported, is on the "maintenance of a high quality sport fishery." Data from these samples indicate that populations are within normal parameters of growth rate, weight/length ratio, and numeric distribution for lakes in the region. There are no apparent contaminant effects reported. Angler satisfaction is also very high for the RMA fisheries. There is an active Arsenal Anglers group that considers the RMA lakes the best warm-water fisheries of their type in the state. This is confirmed by a great demand for a limited number of fishing passes that are sold annually. An angler survey conducted by USFWS in 1992 reported that 95 percent of the anglers were satisfied with the number of fish captured, 80 percent were satisfied with the length of fish caught, and 95 percent were satisfied with the overall fishing experience (USFWS 1993a).

Population assessments of the non-avian aquatic resources seem to indicate that, although exposure pathways exist and bioaccumulation and bioconcentration have been demonstrated, there are no apparent effects on wildlife populations from contamination of the lakes. While the confounding effect of the long and extensive history of management of the lakes and their fisheries make it impossible to rule out the possibility that contaminant effects exist, no such effects are specifically indicated. Some concern has been raised, however, concerning the water birds that use the Lower Lakes (see Section C.5.3.2.2). There may also be potential for the levels of contamination found in the fishes to be bioaccumulated by predators such as the bald eagle or the great blue heron. While no discernable effects have been found in the wintering bald eagles, no data are available to assess the population of great blue herons that frequent RMA.

C.5.3 ECOLOGICAL EFFECT INVESTIGATIONS

Contaminant toxicity can produce adverse effects at the individual, population, community, and ecosystem level of organization (EPA 1989a). The ecological effect endpoints that provide pertinent evidence include both assessment endpoints and their associated measurement endpoints, a format appropriate to ecological risk assessments (EPA 1989a).

- Assessment endpoints are formal expressions of the actual environmental values that are to be protected
- The assessment endpoints are environmental characteristics, which, if they were found to be significantly affected, would indicate a need for remediation
- A measurement endpoint is a quantitative expression of an observed or measured effect of the hazard; it is a measurable environmental characteristic that is related to the valued characteristic chosen as an assessment endpoint

Selecting appropriate assessment and measurement endpoints, therefore, depends on the COCs, their toxic effects on individuals and the consequences of these effects at higher levels of ecological organization (EPA 1989a pg. 2-1 to 2-2).

Suter (1989) suggests the use of assessment endpoints to identify the ecological properties and processes that need to be protected or recovered. Given that quantification of assessment endpoints may be too difficult, expensive, or time consuming, surrogate indices or measurement endpoints may be used.

Ecological assessment and measurement endpoints should be reflective of relationships that may exist between contaminant effects and specific sites of contamination, between effects and specific contaminants, or between specific receptors and contaminants. Such endpoints may involve comparison to off-site control areas, comparison to on-site control areas, and/or within-sample correlations to assess these relationships. Suter suggests that indices such as occurrence, abundance, age/size class structure, reproductive performance, yield/production, frequency of gross morbidity, and frequency of mass mortality are valuable measures of population health.

The utility of such indices for the appraisal of ecosystem health and functionality is further supported by an extensive literature that defines the characteristics of disturbed systems (Odum 1985; Schindler 1987; Pratt and Bowens 1992).

EPA (1989a, b) suggests measuring a very similar set of ecological indices (i.e., population abundance, age structure, reproductive potential and fecundity, species diversity, food-web or trophic diversity, nutrient retention or loss, standing crop, and productivity) for use in characterizing the effects of contaminants on populations, communities, and ecosystems. The EPA further recognizes that certain receptors may be particularly important for measurement of endpoints by virtue of special status (e.g., threatened and endangered species), specific susceptibility to chemical contaminants, and/or representative status for specific exposure pathways.

Available data provide important insights into both the general robustness of RMA populations and communities and the extent and severity of potential contamination effects as indicators of ecological health. The investigation of contaminant effects on biota at RMA began with the documentation of waterfowl deaths and fish kills in the 1950s and continued intermittently through the 1970s, leading to the Biota RI studies, Biota CMP, and related USFWS and Shell investigations in the 1980s and 1990s. These studies are summarized in Appendix A. Although many of the ecological investigations used to examine potential contaminant effects were conducted prior to 1989 when EPA issued its initial guidance on conducting ecological risk assessments (EPA 1989a, b), they are consistent with this guidance. For example, although the RMA site encompasses approximately 27 square miles, actual contamination sources within the site are much smaller. Studies of sedentary species (e.g., plants, earthworms, grasshoppers) focused on contaminated areas within RMA to identify potential contaminant effects, while studies of more mobile species (e.g., deer) were conducted throughout RMA to evaluate effects on their RMA-wide populations. Some studies used both on- and off-post controls (e.g., earthworms and grasshoppers), while studies of more mobile species (e.g., waterfowl) used only off-post controls. Ecological effects investigations looked primarily at population-level effects

that could be related to RMA contaminants, such as population abundance and reproductive success. Effects at other levels of organization, including biomarkers in individuals (e.g., acetylcholinesterase [AChE] inhibition, eggshell thinning) and community-level effects (e.g., species richness) were also examined.

The criteria for selecting these effects and for conducting investigations were consistent with the selection of ecological endpoints under current EPA guidance (EPA 1989a). There is substantial information relating to appropriate ecological endpoints. Records on morbidity at RMA, for example, are available for nearly a 40-year time span (Hyman 1953; Sciple 1952; Jensen 1955; Finley 1959). Both qualitative and quantitative floral and faunal observations related to chemical contamination have been conducted intensively for more than a decade (ESE 1989; MKE 1989a, b; RLSA 1990a and 1992). More recently, studies by the USFWS have been conducted that address both contaminant and wildlife management issues. RMA-wide studies of deer, prairie dogs, and burrowing owls, and other species have looked at general population health, reproduction, and other aspects of the population biology of these species that are potential effects of contamination.

While some of these studies were conducted for management purposes, they were designed to investigate potential adverse population effects that could result from RMA contamination and that are pertinent to the ecological risk assessment. These investigations focused on population parameters that are indicative of general population condition. Population density is an appropriate ecological endpoint in most circumstances even when the absence of data on emigration and immigration, important population parameters for some studies, adds uncertainty. If movement of mobile animals is so free that local differences in population density cannot be detected, it is reasonable to assume that the biological population, which ranges across both contaminated and uncontaminated areas, is properly evaluated throughout RMA in the context of its regional abundance. In addition, data on site-specific population parameters not affected by emigration and immigration, such as nesting success and clutch size, were used as more appropriate measurement endpoints whenever they were available.

Identifying appropriate ecological endpoints from among the available RMA data required screening of available information for data pertinent to the endpoints. Many studies were less useful because they were conducted before the extent and pattern of contamination at RMA were known, and their study design thus bears little relationship to these patterns. In addition, contaminants in the RMA environment have varied over time. A review process was conducted across various studies and data sets to screen for bias, power, and relevance. Studies that provide pertinent information on potential contaminant effects are provided in a "weight-of-evidence" approach consistent with EPA guidance. Results are reviewed in conjunction with results of the quantitative exposure assessment to characterize ecological risk.

C.5.3.1 Ecological Effect Endpoints

Ecological effect endpoints were selected that reflect what is occurring within RMA's populations and communities, are sensitive enough to detect effects that may exist, and match with the endpoints being sought in the risk assessment. The numerous ecological studies performed at RMA were evaluated for information pertinent to ecological endpoints at the community and population level as described below. Individual biomarker endpoints were also evaluated. A total of 18 studies conducted by the U.S. Department of the Army (Army) and USFWS provide information on the overall health of biota at RMA and were used in the Integrated Endangerment Assessment (IEA). Of these, six were designed to directly evaluate contaminant effects. While some of the studies have low statistical power due to small sample sizes, the results of the various studies are generally consistent with each other and with the predictions of the quantitative exposure modelling.

C.5.3.1.1 Community-Level Endpoints

The community-level endpoints considered were species richness and trophic diversity. Each of these endpoints provides information on the overall structural diversity of the communities at RMA.

Species Richness

Species richness, the total number of species present, is an appropriate measurement endpoint because contaminants are widely distributed at RMA and could adversely affect populations and, in turn, affect ecosystem organization. In the Biota RI, seven RMA contaminants were considered major COCs based on criteria of toxicity, persistence, and areal distribution in the environment. While specific studies focused on the potential direct effects of major COCs, species richness serves as an appropriate ecological endpoint because it is a broad indicator of community structure and functional completeness.

Species richness was assessed by comparing the number of species present at RMA with the number of species that would be expected (Bailey and Niedrach 1965; Chase et al. 1982; Armstrong 1972; Bissell and Dillon 1982; Hammerson and Langlois 1981) given RMA's location and landscape characteristics. Species richness was also assessed within RMA boundaries by comparing similar habitats in contaminated and uncontaminated sites.

Trophic Diversity

Another effective way of assessing the functional completeness and complexity of biological communities is to evaluate the number and complexity of food chains that describe the successive predator/prey relationships. Food chains are composed of successive trophic (feeding) levels that reflect the number of food energy transfers between prey and predators. Thus, trophic diversity, as reflected in the number of food chains and the number of trophic levels represented in various food chains, serves as a community-level endpoint. Information to assess this aspect of ecosystem health resulted from inventories of species present, observations of their foraging habits, and gut-content analysis of selected species.

C.5.3.1.2 Population-Level Endpoints

Population-level endpoints such as population density may be difficult to interpret for some species because of the mobility of the organisms involved. Selection of the correct measurement endpoints to detect adverse effects must consider complicating factors that could mask an adverse

effect. For example, measuring the population density of migratory raptors or a highly mobile resident species such as deer does not reliably indicate adverse effects because a reduction in the population due to death or reproduction might be masked by factors such as emigration or immigration of individuals from surrounding uncontaminated areas. However, for sedentary species with small home ranges and limited vagility, estimates of population density and reproductive success are appropriate. Additionally, other measurement endpoints at the population level (e.g., nest success, fledgling success) may be appropriate even for migratory species, such as the American kestrel, that produce and raise their young within limited areas of exposure.

Considerable data have been accumulated on the distribution and population densities of several animal species at RMA since the initiation of the RI program in 1985. The endpoints selected for evaluation here are a subset of this information that considers the interpretability of the data in terms of possible contaminant effects. Population-level endpoints considered are relative abundance, reproductive success, and morbidity. Each of these endpoints provides information about the overall robustness of the population.

Relative Abundance

Relative abundance was evaluated by quantitatively comparing the relative numbers of individuals within and among species at RMA to off-post control areas (i.e., Plains Conservation Center [PCC] and Buckley Air National Guard Base [Buckley]) and by comparing contaminated sites to uncontaminated sites at RMA. Randomly selected sampling plots for small birds and small mammals were established in both uncontaminated and relatively contaminated portions of RMA.

Relative abundance or relative density (number of individuals/unit area), is both an assessment and measurement endpoint. Population indices that compare the number of individuals per standard transect/plot at RMA and in control areas are suitable population-level measurement endpoints that provide a basis for comparing RMA with appropriate controls.

Reproductive Success

Reproductive success was evaluated by comparing measures of birth rate, nesting success, recruitment, and/or age class comparisons for several RMA animal species to published values from other studies, as well as by comparing contaminated sites at RMA to uncontaminated sites at RMA and on-post sites to off-post sites. These measurements may reflect direct impacts to reproduction through reduced capacity or indirect impacts through unequal mortality.

The ability of species to reproduce at levels sufficient to maintain healthy populations is an appropriate assessment endpoint at RMA because of the possible direct and indirect effects of RMA contaminants on the various physiological and behavioral mechanisms involved in the reproductive process.

Avian reproductive success was calculated using several measures, including nesting success and fledgling success. Data were collected on mallard, ring-necked pheasant, and American kestrel to represent waterfowl (dabbling ducks), upland game birds, and raptors, respectively. Data were collected in relation to known sites of contamination at RMA and at locations off post. Details of the specific methods, locations, and analyses performed, including statistical analyses, are provided in the Biota RI (ESE 1989).

Morbidity

Morbidity was evaluated from data on the numbers of individuals discovered dead and dying at RMA. Morbidity, supported by analyses of tissues and investigation into cause of death, may be indicative of contamination effects. Care must be taken in evaluating mortality data to consider both the numbers of highly aware observers and the difficulty in finding carcasses in uncultivated habitat. Although the number of dead animals located may be inflated over normal numbers as a result of a large, observant worker population at RMA (particularly in the vicinity of Building 111, the Administration Building), no specific effort has been made to locate and account for all dead animals.

C.5.3.1.3 Individual Endpoints

Selected biomarkers (i.e., AChE inhibition and eggshell thinning) were examined at the individual level. These endpoints are indicative of harmful effects of chemical contamination as reflected in eggshell thinning by dichlorodiphenyltrichloroethane/dichlorodiphenyldichloroethene (DDT/DDE) and AChE reduction by nerve agent. Both of these biomarkers are appropriate for evaluating adverse effects on individuals of threatened or endangered species that by definition have populations reduced to the level where individuals are important, and for detecting effects that might affect populations.

C.5.3.1.4 Evaluation of Bias, Power, and Relevance for Cited Studies

The variety of ecological endpoints selected for evaluation in this risk assessment required the evaluation of data that varied in its appropriateness for risk assessment. As mentioned in the introduction to this section, many of the investigations into the potential adverse effects of RMA contamination were conducted during the Biota RI studies, prior to EPA's issuance of formal guidance for conducting ecological evaluations and ecological risk assessments. Some studies provided data on the general condition of populations of selected species or groups at RMA (e.g., songbird and breeding bird surveys, prairie dog population densities, small mammal abundance studies). However, several investigations were designed specifically to collect biological samples or data in known contaminated areas and control sites and to evaluate effects that are considered to be adverse and that could potentially result from exposure to COCs at RMA (e.g., population densities of earthworms, grasshoppers, and aquatic snails; reproductive success in kestrels, ring-necked pheasants, and mallards; eggshell thinning). Many of the effects data were collected in conjunction with analyses of tissue concentrations in order to strengthen conclusions regarding any observed effects in relation to the presence of contaminants.

Information was obtained from a variety of additional studies that provided useful information on contaminant transport and effects at RMA but that were not appropriate for an experimental-control study design. Data on contaminant concentrations in selected tissues and on the cause of death of hawks and eagles has been collected for individuals found dead at RMA throughout

the Biota RI, Biota CMP, and subsequent USFWS investigations (1986 to the present). Sampling at control sites was deemed inappropriate for this effort because of the adverse effect on raptor populations and because published information exists that establishes relationships between tissue concentrations of major RMA contaminants and adverse effects.

The results of the review of the various RMA studies for their bias, power, and relevance in relation to the endpoints just identified are summarized below. The studies identified in Table C.5-1 were screened from all those available for RMA because they provided data that were relevant to the ecological endpoints. The bias, power, and relevance ratings assigned to the selected studies are provided in Table C.5-2. The criteria used in rating the studies (defined in footnotes to Table C.5-2) should be viewed in an ecological context against a backdrop of natural variability, not viewed in a strictly numerical, statistical context. Because of natural variability, statistical power is not necessarily relevant, and may be misleading. The bias, power, and relevance ratings of the selected studies show that most are of low bias and at least medium power and relevance. For the most part, they meet the rating criteria reasonably. The use of diverse endpoints at different levels of ecological organization is considered a strength of the RMA approach for the Biota RI because it provides a holistic examination of the ecosystem, lending greater confidence to risk estimates (EPA 1993).

When reviewing the selected studies on the following pages, the following considerations are also pertinent:

- RMA is a unique site at which to conduct an ecological risk assessment because of its large size and history. For many of the studies completed at RMA, control sites were selected that were ecologically comparable to RMA with respect to habitat. While not every biotic and abiotic variable in addition to the test variable could be matched exactly, the most appropriate control sites that were available were selected.

- While population factors such as immigration and emigration may influence the measurement of density for mobile species, population density is unlikely to be affected for the less mobile species, especially because the potential for immigration and emigration also occurs at the control sites. In addition, many of the measurement endpoints (e.g., morbidity estimates and reproductive success estimates such as the relative numbers of buck to doe deer, doe to fawn deer, juvenile to adult prairie dogs, and of

American kestrel eggs laid to eggs hatched to juveniles fledged) are unaffected by either immigration of emigration.

- Many of the studies were designed to specifically identify contaminant-related effects at the population level. For example, aquatic snails were collected for population parameters in contaminated and uncontaminated lakes (ESE 1989), and grasshoppers were collected in uncontaminated reference locations, areas of low contamination on post (on-post controls) and areas of high contamination on post (Section 36 and Basin F) (ESE 1989). Population effects in more mobile species of animals were evaluated on a larger scale, such as those population measurements for deer and raptors (ESE 1989; MKE 1989a). In these cases, qualitative comparisons were made relative to impacts on RMA-wide populations. Collectively, the data from these studies support a weight-of-evidence approach to evaluating populational status and health using ecological endpoints.

- Studies such as the analysis of fortuitous animals (mostly raptors) provided valuable data on contaminant concentrations in tissue that could be related to adverse effects. These studies were relevant, but not amenable to power analysis.

C.5.3.2 Investigations of Particular Species or Other Taxonomic Groups

Species-specific studies have been completed for mule deer and white-tailed deer, black-tailed prairie dogs, American kestrels, bald eagles, great horned owls, burrowing owls, ring-necked pheasants, mallards, and mourning doves. In addition, small mammal, cottontail, jackrabbit, raptor, songbird, and invertebrate species groups have been studied. The more wide-ranging of these species were studied throughout RMA and compared to off-post populations. The more sedentary of these species were studied in both contaminated and control areas at RMA and at off-post control areas as well. Ecological endpoints measured in the various sample locations, especially measurements of density, were compared statistically for most of these studies (Table C.5-3). For some of the species, tissue concentrations of contaminants were analyzed from the same locations where density measurements were taken; Table C.5-4 provides the results of the significant statistical comparisons between control and contaminated areas for these species.

C.5.3.2.1 Mammals

Deer

The health and well-being of deer populations at RMA is of great public interest and an important management goal. Mackie et al. (1982), MKE (1989a), and Whittaker (1993) estimated population densities of both mule deer and white-tailed deer at RMA. Whittaker also assessed herd health, productivity, and habitat-use patterns for both species. The USFWS (unpublished data) performed necropsies and collected tissue samples for histopathological analyses from 13 mule deer and 10 white-tailed deer that were collected at RMA in March and April 1991. In all cases, the study area for these investigations was the entire on-post operable unit.

Ecological Endpoints

The above-referenced studies provide data for three assessment endpoints for the deer herds at RMA:

- Relative abundance and distribution
- Reproductive success as indicated by such measurement endpoints as fawning rate, fawn survival, and population growth rate
- General individual health as indicated by such measurement endpoints as muscle mass, fat reserves, physical condition, incidence of disease or parasitism, and incidence of other health-related problems

Study Findings

Mule deer are more common and more widely distributed at RMA than white-tailed deer because most of the on-post habitat is more suitable for mule deer (MKE 1989a; USFWS 1992a). White-tailed deer are essentially limited to the wooded and riparian areas of First Creek and the southern sections. Pellet surveys, which do not differentiate between species, indicate the amount of time spent by deer in different habitats. Significant positive correlations were found for both total vegetation cover and for tall weedy forbs, while significant negative correlations were found for open habitats and habitats dominated by cheatgrass and crested wheatgrass (MKE 1989b).

Weedy forbs provide excellent food sources as well as cover and shelter; open habitats offer little cover. Cheatgrass and crested wheatgrass are poor food resources, except in the spring when shoots are green.

Studies of reproductive potential show abundant populations of both mule deer and white-tailed deer at RMA (MKE 1989a; USFWS 1992a, 1993a). During the past 4 years, the mule deer population has doubled, while the white-tailed deer population has fluctuated around a relatively lower density (Whittaker 1993). Both species produced fawns at rates capable of supporting or increasing their population densities. The primary source of mortality for both species was coyote predation. White-tailed deer fawns, however, had a significantly lower probability of surviving to the age of 30 days because the white-tailed deer fawning season begins first and this species takes the brunt of intense predation (personal communication with D.G. Whittaker, 1993).

Population structure is also a good indicator of productivity and population health. Data from Whittaker (1993) provide indications of the deer populations' structure and relative health. The RMA deer populations are older than most hunted herds. In fact, adults at RMA tend to die of old age. Buck/doe ratios at RMA (1:1.6) are considered excellent in hunting terms compared to populations statewide (1:10), although this comparison must be qualified by the fact that the RMA population is not hunted. The large number of bucks may actually be a detriment as it promotes conflict during the breeding season. In spite of the observed high densities and older age structure, productivity seems to be normal as indicated by fawn/doe ratios (1.5:1) that are normal when compared to ratios for other populations statewide.

The good health of both mule deer and white-tailed deer herds is indicated by the presence of fat reserves at a time of year when such reserves are typically depleted in stressful environments and by generally good physical condition (USFWS 1993b). While fawns generally do not accumulate fat because their energy intake does not exceed that consumed by growth, fat reserves have been documented in fawns born at RMA and indicate their good health. During the winter of 1992-1993, which had above average snowfall along the front range, slightly more winter-

killed deer were observed at RMA than in the previous two winters. This is to be expected since "[o]verwinter...survival is low and condition of survivors is poor after winters of heavy snowfall because deep snow covers much of the of the forage and makes it unavailable" (Connolly 1981). Most of the deer that died were bucks, which is to be expected since bucks expend proportionately more of their fat reserves during the fall rut than does. Necropsies of 18 mule and white-tailed deer collected in March of 1993 revealed that "[T]he overall deer herd health on Rocky Mountain Arsenal appears to be relatively good. In general white-tailed deer are in better physical condition than the mule deer, but no overtly diseased animals of either species were encountered. The physical condition of the mule deer examined indicates that this species is probably near carrying capacity and any substantial population increase could result in a decline in the herd health. White-tailed deer were in good to excellent physical condition. Based on these findings, this species can be maintained near its present level without risks of disease related to mortality.

In qualification of this generally good assessment, however, health-related problems have been observed in a few individuals. These include retention of velvet in four mule deer males, testicular atrophy in four mule deer and one white-tailed deer, presence of an acid-fast bacterium in one male mule deer, and abnormal hoof growth and pelage characteristics potentially related to positive serological virus titers for bluetongue and epizootic hemorrhagic disease.

Study Conclusions and Comparison with Tissue Analyses from Various Studies

Both mule deer and white-tailed deer fawning and survival rates are sufficient to maintain stable populations and the mule deer population has demonstrated a capacity for quite rapid growth. Population growth is benefited by the absence of hunting pressure, but is affected negatively by high predator pressures, primarily from coyotes. Tissue analyses (Attachment C.5-2) indicate that both species are relatively free of contaminant accumulation (ESE 1989; RLSA 1992; USFWS 1993b). The highest level of dieldrin detected in deer was 0.187 parts per million (ppm) in one liver tissue sample, which is just below the whole-body mammal maximum allowable tissue concentration (MATC). The mean concentration of dieldrin in liver tissue samples was about 10

times less than the highest concentration. Note that concentrations in liver tend to be higher than the whole-body concentration for the same individual. Other contaminants detected in deer were as low or lower than dieldrin concentrations relative to their respective whole-body MATC levels (Attachment C.5-2). Given these results, deer species would not be expected to display detrimental effects of contaminant exposure, especially at the population level.

Prairie Dogs

Black-tailed prairie dogs are the major prey for the wintering bald eagle population at RMA as well as for several other raptor species. Thus, this prairie dog species, which lives in close proximity to soil-bound contaminants, provides an important exposure pathway for the bald eagle and other raptors. ESE (1989) and RLSA (1992) studied prairie dog density and distribution at RMA and at off-post locations several miles from RMA. RLSA (1992) documents the population impacts of a campestral plague outbreak at RMA. MKE (1989a) investigated reproductive potential as reflected by the age-class structure of the population (i.e., the proportion of the population made up of juveniles). Data were analyzed statistically on an RMA-wide basis and did not specifically address known sources of contamination. Additional information is provided in the Biota RI (ESE 1989).

Ecological Endpoints

The above-referenced studies provide data for two assessment endpoints for the prairie dog colonies at RMA:

- Relative abundance as measured by abundance indices/density
- Reproductive success as measured by the juvenile-to-adult ratio in the RMA population compared to off-post control areas

Study Findings

In 1988, prairie dogs were found throughout RMA and occupied 4,571 acres at an average density of 49.9 prairie dogs per acre. In the winter of 1988–89, campestral plague infected RMA prairie dogs and almost completely eliminated some colonies. By September 1989, only 247

acres were occupied by prairie dogs; the average density, recorded in October 1990 when the occupied areal extent had increased to 575 acres, was 30.1 prairie dogs per acre (RLSA 1992). Within this time period, there is no pattern evident in the average prairie dog density relative to degree of contamination; the lowest densities were in northeast control plots where the plague may have already begun affecting populations. Since that time, natural reproduction and the relocation of more than 5,800 prairie dogs onto RMA have resulted in a substantial recovery of the prairie dog population (USFWS 1993a). The prairie dog population at RMA achieved a maximum intrinsic rate of increase of 1.05 in the second year following the plague epizootic of 1988-1989. Merriam (1966) demonstrated that under the most favorable conditions the black-tailed prairie dog rate of increase could barely exceed 1.0. It is apparent that prairie dog reproductive potential is reasonably high at RMA (USFWS 1993b).

The percentage of the prairie dog population represented by juveniles at off-post control sites averaged 23 percent higher in 1986 and 20 percent higher in 1987 (i.e., at Buckley and PCC) than at RMA (MKE 1989a). These differences were significant for both years. Recent work (May 1993) completed by USFWS (1993b) found a mean litter size of 4.44 (±1.47, N=27), which is at the high end of the normal range (2.3 to 4.9) found in several other studies (Tileston and Lechleitner 1966; Kerwin 1972; King 1955; and Knowles 1987). Garrett et al. (1982) reported that the ratio of juvenile-to-adult prairie dogs is an indicator of prairie dog reproductive success; that rates of successful pregnancy, litter size, and survival rate in prairie dogs are related to habitat quality; and that mature colonies have a lower number of juveniles. The relatively low juvenile-to-adult ratios for prairie dogs at RMA during 1986 and 1987 may have been related to the maturity of the colonies because habitat analyses during that period indicated that many of the colonies were near carrying capacity.

Retrospective linking of sites where juvenile density was sampled to estimated exposure area soil concentrations of dieldrin (i.e., ESC) indicated that all but one of the prairie dog age-structure observations were made in areas where dieldrin levels were below the detection limit. In these areas, ESC values from exposure ranges centered on the sample sites ranged from 0 to 0.523

ppm. The one sample site (#17) with an ESC value greater than the certified reporting limit (CRL) of 1.195 ppm had 65 percent juvenile prairie dogs in 1986 (which was above the mean of 47 percent) and 62 percent of juvenile prairie dogs in 1987 (which was right at the mean of 62 percent). Sample site #17 was in the northwest quarter of the southwest quarter of Section 31. Sample site #16 (northwest quarter of southwest quarter of Section 24), which had the lowest density recorded (16 percent juvenile prairie dogs in 1986), had 77 percent juvenile prairie dogs in 1987, which was the third highest value recorded. Therefore, any differences in reproductive success among populations at RMA sample sites cannot be legitimately attributed to effects of contamination.

Study Conclusions and Comparison With Tissue Analyses from Various Studies

Average prairie dog population density had no apparent correlation with the general distribution of soil contamination in RMA areas where prairie dogs occur. There were no statistically significant differences ($p>0.05$) in prairie dog densities between the central colony that included portions of Sections 25 and 36, which are possible sources of contamination, and other colonies at RMA. The percentage of juveniles in the population was significantly lower at RMA in 1987 than in the off-post control sites, but about the same in 1993. Tissue concentrations of the COCs were generally below the whole-body MATC levels, except for dieldrin (Attachment C.5-2). All prairie dog samples from Section 36 at RMA had detectable carcass concentrations of dieldrin (mean summer = 2.03 ppm; mean winter = 1.44 ppm) and were as high as 13.4 ppm. These levels are well in excess of the whole-body MATC value for aldrin/dieldrin in medium mammals (0.19 ppm). Prairie dogs from elsewhere at RMA had substantially lower concentrations of dieldrin in carcass samples. However, some of these prairie dog samples contained concentrations of DDE above the whole-body MATC of 0.22 ppm (Attachment C.5-2). Comparison of measured tissue concentrations with whole-body MATC values for prairie dogs indicated that some individuals are likely to be affected by RMA contaminants. However, the effects of campestral plague, which occurs as a well-documented phenomenon in natural populations (RLSA 1992), and the subsequent managed immigration of thousands of prairie dogs,

especially between 1988 and 1990, have obscured any potential population effects of contamination.

Small Mammals

Small mammals provide an important prey base for bird and mammal predators at RMA. Because they reproduce rapidly and are relatively short-lived, their populations respond quickly to environmental factors and contamination. MKE (1989a) characterized the abundance of small mammal populations (i.e., high abundance was indicated by trapping success greater than 10 percent) and quantified their mean abundance (i.e., number captured per 100 trap nights) at RMA relative to reference populations at Buckley. At RMA, small mammal data were collected over 4,635 trap-nights (3,060 in fall 1986; 1,575 in spring 1987) in eight habitats, while at Buckley, data were collected over 540 trap-nights (fall 1986) in three habitats.

Ecological Endpoints

The above-referenced studies provide data for the assessment endpoint of relative abundance as measured by general population abundance and mean abundance.

Study Findings

Populations of small mammals were generally low at RMA during 1986 and capture frequencies were too low to allow statistical analysis of the data. Five sampling locations had moderate to high abundance, and 11 locations had low abundance (MKE 1989a). The trend was somewhat better in 1985 when five locations had low abundance and five locations had moderate to high abundance. The mean abundance of small mammals in certain habitats (native grasslands [RMA—1.2; Buckley—9.4] and crested wheatgrass [RMA—2.8; Buckley—5.6]) was lower at RMA than at Buckley. Mean abundance in cheatgrass habitat was higher at RMA than at Buckley (RMA—8.6; Buckley—3.3).

Overall, small mammal abundance tended to be highest on sites that are characterized as weedy forbs/grasses, followed by sites characterized as wetlands or shrubs/succulents. MKE (1989a)

concluded that these differences in population densities were primarily related to differences in habitat quality and not the result of contaminant effects. This conclusion was based primarily on the qualitative observation that on-post sites located in areas believed to be highly contaminated also supported some of the highest abundances of small mammals. Two of the sites with the highest trapping success, for example, were immediately north of Basin F.

Retrospective linking of sample sites to ESC values for aldrin/dieldrin (calculated using the deer mouse exposure range) indicated that the highest and the eighth highest abundance and trapping success measured in 1986 and 1987 occurred at the two most highly contaminated sites. When the data presented in Table C.5-5 for species count and total individuals trapped were each plotted against the ESC value for their sampling site, no strong trends were apparent for species count. While the site with the highest number of species had an ESC value of zero, the two sites with the highest ESC values were still slightly above the mean number of species per site (1.69), with two species each. The total number of individuals trapped seemed to show a positive correlation with increasing ESC value, particularly if the 24 individuals at the site with the highest ESC value (just east of Basin F) were ignored. While this seeming trend is in part driven in part by low and/or BCRL aldrin/dieldrin concentrations in soil, there is no indication that small mammal abundance was deleteriously affected by aldrin/dieldrin contamination.

Additional perspective is gained by overlaying small mammal sampling sites with areas where the small mammal HI is greater than 1.0 (Figure C.3-25). There are five sites (1, 2, 3, 13, and 27) that fall within the area where HI is greater than 1.0 for at least two of the biomagnification factor (BMF) values used. The average number of small mammals caught at these five sites was 37.8 (trapping success of 20.5 percent) as compared to an average of 13.6 (trapping success 9.8 percent) for all sampling locations outside the area of potential risk. Clearly, factors other than contaminant concentration are having an important influence on small mammal populations.

Study Conclusions and Comparison with Tissue Analyses from Various Studies

Populations of small mammals were generally low at RMA during 1986, with only five sampling locations having moderate to high abundance and 11 locations having low trapping success (MKE 1989a). The trend was somewhat better in 1987 as the populations of five locations were characterized as low and the other five characterized as moderate to high. Comparisons of mean abundance on post to those of the reference populations at Buckley indicated that certain habitats, such as native grasslands (RMA—1.2; Buckley—9.4) and crested wheatgrass (RMA—2.8; Buckley—5.6), produced relatively lower numbers of small mammals on post than off post. Other habitats, such as cheatgrass (RMA—8.6; Buckley—3.3), produced higher mean abundances on post.

Whole-body concentrations of dieldrin in some individual deer mice were quite high—up to 35.0 ppm—which is greatly above the whole-body MATC of 0.19 ppm for small mammals. Detectable levels of aldrin and endrin were also found in whole-body deer mice samples from RMA at concentrations well above the whole-body MATC of 0.19 ppm for aldrin (mammal MATC values were not available for endrin). DDE and DDT concentrations in some whole-body deer mice samples also exceeded the whole-body MATC of 0.22 ppm (Attachment C.5-2). The highest mean abundances of small mammals at RMA were in areas of weedy forbes/grasses north or east of Basin F (MKE 1989a); evaluation of trends between small mammal abundance and ESC values showed no indication that small mammal abundance is deleteriously affected by aldrin/dieldrin contamination.

C.5.3.2.2 Birds

American Kestrel

The American kestrel is a common breeding bird at RMA. Because such birds occupy a high trophic level, they are particularly susceptible to the bioaccumulation and toxicity of organochlorine pesticides. American kestrels make excellent subjects for the study of potential impacts of contamination since they are relatively smaller and have larger brood sizes than many other raptors, and because their populations can be managed because they use nest boxes (Wiemeyer and Lincer 1987). As a result, the several reproductive success and contamination

monitoring studies of RMA kestrels represent the most extensive data set currently available for any species at RMA.

In 1982, a 2-year study was initiated by USFWS to examine the possibility that contaminant residues were having adverse effects upon the reproductive capacity (i.e., clutch size, hatching success, and/or fledgling success) of American kestrels (DeWeese et al. 1982). Concurrent with the measurement of nesting success, egg and nestling samples were collected to test the hypothesis that nesting success/failure could be correlated with contaminant burden. The study was structured around three sampling zones: at RMA, at "near-RMA" control sites (i.e., within 10 miles of RMA), and at "control" control sites (i.e., sites more than 40 miles from RMA). All study sites were in the same general habitat type, but differed somewhat in principal vegetation and habitat characteristics. The near-RMA sites were a combination of mixed deciduous woodlots, riparian woodlands, cultivated fields, and residential/industrial developments. The control sites consisted of one area of shortgrass rangeland, linear woodlots along a permanent river, and shrub-covered foothills.

Kestrel reproductive success at RMA have been repeated in four of the years since 1982–83. In 1986 (ESE 1989), as well as 1988 and 1990 (RLSA 1990, 1992), nest outcome data were combined with egg (not analyzed in 1990) and nestling samples from RMA and off-post control sites for contaminant analyses. In 1991 and 1992, on-post nesting success data were collected (USFWS 1992a; 1993a). Appendix Section C.4 contains a map indicating nest box locations (Figure C.4-6).

Ecological Endpoints

The above-referenced studies provide data for the assessment endpoint of reproductive success as measured at several points in the reproductive cycle (i.e., nesting attempts per available opportunity, clutch size, hatching success, and fledgling success).

Study Findings

DeWeese et al. (1982) reported that, although the average number of eggs in a complete set (i.e., clutch size was similar for the three sampling zones in 1982 (Table C.5-6), relatively fewer nestlings hatched at RMA compared to the other two sampling zones. DeWeese et al. (1982) noted the low average number of young fledged per initiated clutch "near two of the lakes south of the Shell Chemical Plant" and the increase in the average number of young fledged with increasing distance from these lakes. The major cause of poor fledgling numbers was attributed to nestling mortality from predation or other causes such as disturbances due to investigative studies or nest-site competition (DeWeese et al. 1982).

A re-analysis of the 1982 data with 1983 data (DeWeese et al., no date pg. 7-2 and 7-13) resulted in a slight revision of the 1982, but reproductive success was still not statistically different between RMA and the combined results from the two off-post sampling zones. The area of lowest reproductive success and/or nesting attempts for this later analysis was described as a "core area," which includes the area "within the vicinities of Basins A and F and the chemical manufacturing plant." Special note was made by DeWeese et al. (no date pg. 7-2 and 7-13) that the area around Basin F was apparently avoided by breeding kestrels and that all nests located within 1 mile of these three most contaminated areas failed to fledge young.

The field surveys conducted by McEwen and Peterson in 1986 were described in the Biota RI (ESE 1989). The 1986 results indicated that productivity at RMA was "much higher" than in 1982 or 1983 and that on-post productivity was not significantly different from that reported from the control sites. In 1986, the majority of failed nests were concentrated along First Creek in a relatively uncontaminated area.

The 1988 data indicate that a relatively greater number of nests in all study areas failed to produce hatchlings than in previous years (RLSA 1990). Although the differences were not statistically different, percent of nests that were successful and number of young fledged per nesting attempt were slightly higher at the control sites. However, successful nests fledged more nestlings at RMA than at control sites. The pattern of nest-box use in 1988 was also worthy of

note in that the greatest occupancy rate occurred near Basin F, which had not yet been fully remediated and capped. There were, however, no occupied nest boxes in the vicinity of Basin A.

In 1990 (Table C.5-6), the measured reproductive parameters did not differ markedly from those in 1988 either at RMA or in off-post control areas. Exceptions to this generalization were that a lower percentage of attempted nests hatched at RMA in 1990, while a higher percentage of attempted nests hatched in control areas. However, the percentage of hatched nests that fledged young was higher in 1990 at RMA, but lower in control areas.

Monitoring of kestrel reproduction by the USFWS in 1991 indicated similar nesting success in RMA and control areas (USFWS 1992a). Nest box occupancy was poor along the western boundary. Nest failures occurred in Sections 5, 11, 12, 20, and 24, all of which were outside the core area. All of these failed nests were within 1 mile of the RMA boundary.

In six of seven breeding seasons, the number of fledglings per nesting attempt at RMA was lower than that for pooled off-post control areas. Because clutch size and number of nestlings per nest tended to be similar between populations, the qualitative differences in success appear attributable to unequal nestling mortality. In no case, however, were these on-post/off-post differences statistically significant. Despite the fact that the same nest-box locations were monitored at RMA for 7 years, no geographic continuity or pattern is apparent with relation to nest failures among kestrels. While clusters of nest failures have been suggested to occur in specific years (e.g., the core area in 1982 and 1983 and First Creek in 1986), the validity of such a pattern breaks down over the cumulative span of biomonitoring. When all 7 years of data are considered together, no apparent pattern in the geographic location of nest failures at RMA is evident. Sources of variation that significantly contributed to observed differences in reproductive success were the frequency and intensity of interspecific competition for nest boxes and the disturbance of the nest for collection of eggs before the onset of incubation (DeWeese et al., no date).

Separate statistical analyses were performed on three different sets of American kestrel data: 1982 and 1983 data (DeWeese et al. no date); 1986 (ESE 1989); and 1988 and 1990 data (reanalyzed from Enserch in-house Biota CMP records). The information provided in these three studies was not sufficiently comparable for a single analysis to be performed on a composite data set. The 1982/1983 analyses of differences across the 2 years and among three study areas (at RMA, 0.5 to 16 kilometers (km) from RMA, and 68 to 95 km from RMA) in hatching and fledgling success were not statistically significant (2 by 2 chi^2, $p>0.05$). This study also compared, but did not statistically analyze, the occupancy and fledgling success of nests in specific locations within RMA. This comparison found occupancy rates and fledgling success were lower near than far from Basin A, Basin F, and the central area (defined to be more than a mile inside RMA boundaries); areas near South Plants had higher occupancy rates but lower fledgling success than areas far from this site. The 1986 statistical analyses (ANOVA, parametric a priori, Kruskall-Wallis Anova, and nonparametric a priori) compared clutch size, hatchling numbers per nest, fledgling numbers per successful nest and per all nests for control and RMA data using the 1982 and 1983 data as well as the 1986 data. Generally, these comparisons were nonsignificant. Exceptions were that comparisons among years in the number of hatchlings per nest and fledglings per all nests showed significant ($p<0.05$) differences, and that here was a significant difference between RMA and control fledgling numbers for all nests in 1983.

Nest-specific data on reproductive parameters, location at RMA, and tissue-sample concentrations were available only for the 1988 and 1990 studies. American kestrel data on success at each nest from which tissue samples were collected in 1988 and 1990 (i.e., number of eggs, hatchlings, and fledglings per nest) were plotted against kestrel ESC values estimated for the location of the nest site and against contaminant concentrations found in sampled eggs and juveniles using the data found in Table C.5-7. This was done to add information to the Integrated Endangerment Assessment/Risk Characterization (IEA/RC) on potential differences between contaminated and uncontaminated sites at RMA. No trends in nest-success parameters were apparent between years or with changes in kestrel ESC or tissue concentration values. The number of eggs in a clutch did not decrease, nor did the number of hatchlings or fledglings decrease with increasing

concentrations of dieldrin (the most frequently detected analyte) in eggs, juveniles, or soil (as represented by the ESC estimate).

Correlations were investigated statistically for the 1988 and 1990 data, which were combined into one data set, using Pearson's product-moment correlation and Spearmans rank correlation. Correlations of egg concentration, ESC value, and juvenile tissue concentration were investigated relative to each other, and also relative to the number of eggs, number of hatchlings, number of fledglings, number of deaths before hatching, number of nestling deaths, and number of total deaths before fledgling. For dieldrin, no statistically significant Pearson's correlations between the variables were found. The slight negative correlations observed between the ESC values and the three mortality variables are not scientifically reasonable (i.e., mortality should not decrease in response to increasing exposure concentration) and could be spurious, i.e., due entirely to one or a few data points out of 13. Spearman's rank correlations were similar to the Pearson's product-moment correlation and also nonsignificant.

For DDE, a Pearson's correlation of 0.92 occurred between egg concentration and the number of nestling deaths. This correlation was statistically significant at the 0.05 level; however, the high magnitude of this correlation was somewhat spurious, attributed in part to a small sample size (N=5) and the majority of points being concentrated at the origin while the only nonzero number of deaths occurred at the highest egg concentration. The positive correlation of 0.44 between egg concentration and total mortality, while not statistically significant ($p = 0.27$), provided additional, though weak, evidence supporting the hypothesis that mortality is affected by the DDE concentrations in eggs. Spearman's rank correlations were similar to the Pearson's product moment correlations. The Spearman's correlations for egg concentration vs. number of nestling deaths and number of total deaths before fledgling were 0.79 and 0.49, respectively. In the scatter plots for the two sets of variables, both the egg concentrations and the mortality variables indicated that the correlations are not robust; they depend heavily on the location of one out of five data points in the case of egg concentration vs. number of nestling deaths, and two out of eight points in the case of egg concentration vs. number of total deaths before fledgling.

There is no evidence in the data that the dieldrin ESC values, egg concentrations, or juvenile concentrations are positively correlated to either the number of eggs, hatchlings, and fledglings, or the mortality from one stage to another. The slight (nonsignificant) negative correlations between ESC and the mortality variables are not scientifically reasonable and may possibly be explained by the high uncertainty in estimating the exposure concentrations for a given nest location.

The data indicate a possible relationship between egg DDE concentration and mortality, in particular mortality of nestlings. The correlation between these two variables is statistically significant at the 0.05 level, but is based on a total of five data points, with one extreme data point having a very high influence in determining the presence of correlation.

Off-post nest boxes had distinctly lower egg and juvenile tissue dieldrin concentrations than the RMA nest boxes; however, the off-post boxes did not have consistently lower mortalities. Off-post egg and juvenile DDE concentrations were not generally lower than on-post DDE concentrations.

Study Conclusions and Comparison with Tissue Analyses from Various Studies

The trends over time for on-post/off-post comparisons are not consistent. Control areas appear to have larger clutches, a higher percentage of attempted nests that hatched, a higher percentage of hatched nests that fledged, and a greater number of young that fledged per nest attempt. However, the 1986, 1988, and 1990 data show more hatchlings per hatched nest and more young fledged per successful nest at RMA than in the control areas; this trend does not carry into 1991 and 1992 for hatchlings per hatched nest.

The information associated with tissue contaminant data from RMA and off-post control areas (Attachment C.5-2) does not allow identification of possible contributing factors that are related to habitat. However, results of tissue analyses were summarized for each biota study area (BSA) associated with areas of known contamination, the "near-RMA area" (within one-half mile of

BSA boundaries), and the "far-RMA area" (more that one-half mile from BSA boundaries but within RMA). There were no marked differences in the frequency of COC detections between BSA and near-RMA area samples; no samples were collected in the far-RMA area (Attachment C.5-2). Kestrel eggs and nestlings from RMA, but not from control areas, frequently contained levels of dieldrin, which has been implicated in reducing reproductive success of birds (Wiemeyer et al. 1986; Newton et al. 1982). Concentrations of dieldrin in dressed carcasses of some individuals were as high as 3.7 ppm (Attachment C.5-2), which is well above the whole-body MATC of 0.73 ppm for kestrels. The concentrations of dieldrin found in kestrel tissue and the reduced reproductive success in the core area are consistent with exposure pathways and possible adverse effects of contamination and suggest that there was risk associated with dieldrin, particularly in the early 1980s. Dieldrin concentrations in eggs and juveniles tended to be higher on post in 1988 and 1990. However, no trend between nest success and contaminant concentrations were observed in 1988 and 1990 data for dieldrin. The statistically significant correlation between nestling mortality and DDE concentration in eggs may be spurious; it was not generally associated with higher DDE concentrations in eggs or juveniles at RMA.

Bald Eagle

The bald eagle is a federally protected species under the Endangered Species Act (32 Federal Register [FR] 4001; 43 FR 4621) the Migratory Bird Treaty Act, and the Bald Eagle Protection Act (1940), and thus warrants special consideration at the individual level (EPA 1989a). As a predator that feeds high in the food chain, the bald eagle has been shown to be particularly sensitive to the presence and bioaccumulative nature of a number of environmental contaminants (Wiemeyer et al. 1984). Chlorinated hydrocarbons such as DDT, DDE, and polychlorinated biphenyls (PCBs) have been demonstrated to cause reproductive failure in eagles and several other species primarily through eggshell thinning (Grier 1974; Krantz et al. 1970; Newton 1979; Weimeyer et al. 1972).

Information assessing the level of risk posed to bald eagles by RMA contaminants comes from three studies: 1) a study that analyzed food habits, feeding habits, and habitat use of bald eagles

at RMA during the winters of 1986–87 and 1987–88 (ESE 1988b); 2) a regional telemetry study that assessed several aspects of bald eagle ecology including habitat-use patterns, movement patterns, food and feeding habits, and blood and fat deposit levels of a number of contaminants during 1988, 1989, and 1990 (USFWS 1992a, b, 1993a, respectively); and 3) general raptor surveys of RMA that include observations of bald eagles and reflect relative activity patterns and general habitat use during 1991 and 1992 (USFWS 1992a, 1993a).

Ecological Endpoints

Because of the bald eagle's status as a threatened and endangered species, the critical role that each individual plays in the continued viability of its population mandates that risks be considered and expressed in terms of individuals.

Two assessment endpoints are pertinent to individuals in bald eagle populations at RMA:

- Relative abundance as evaluated by surveys and distribution at RMA
- Morbidity as evaluated by potential exposure and general health

While these assessment endpoints have not been directly measured at RMA, the available data are pertinent to these assessment endpoints due to the following:

- Population studies indicate the number of individuals using RMA and establish the maximum annual duration of potential exposure
- Food and feeding habits indicate principal pathways of potential contaminant acquisition (i.e., those prey most frequently fed upon)
- Habitat-use and activity studies reflect the areas frequented by bald eagles and, hence, the areas from which exposure is most appropriately projected
- General health and mortality observations provide very general indications of the extent of gross contamination

Study Results

Bald eagles roost at RMA and its surrounding areas primarily from October through March. The yearly pattern of RMA use can be characterized as follows. Building steadily from a few individuals that arrive in late October, populations peak at as many as 100 individuals, with a 1-night maximum of 38 individuals in late December to mid-January. Usage drops off in late January and slowly declines to no use by mid-March. One pair of eagles nests at nearby Barr Lake, but RMA has not been shown to be a part of this pair's normal home range during the breeding season (USFWS 1992b).

Several factors influence eagle exposure and risk at RMA: total time in residence, food habits, prey distribution, total area-use patterns, and specific habitat-use patterns. The regionally significant concentration of individuals that spend some portion of the winter at RMA move on post and off post at varying times and durations (USFWS 1993a, b). Thus, while a realistic exposure period would be less than 5 months, the possibility exists that individual birds may spend the entire winter period at RMA.

Telemetry data on areas used by bald eagles in 1987 to 1990 (USFWS 1992b) indicate that while individuals frequently move into and out of RMA and the general Denver metropolitan area, RMA is centrally located in the area of use. Thus, while relative exposure is mitigated for more transient individuals, some individuals use RMA intensively. It is not uncommon for individuals to center a majority of their activities at RMA for weeks or months.

Analyses of castings and behavioral observations of bald eagles wintering at RMA indicate that their primary food source is prairie dogs (about 75 percent), with rabbits representing a secondary food source (about 20 percent) (ESE 1988; USFWS 1992b). Thus, exposure is largely confined to those areas of RMA where these prey species exist. Data on the historical and current ranges of prairie dogs at RMA show limited overlap between the areas of prairie dog habitation and the areas of highest contamination either because habitat for prairie dogs is unsuitable or nonexistent

in these areas or because there has been active management to exclude prairie dogs from the areas of highest contamination.

Likewise, the abundance of rabbits is somewhat limited in the highly contaminated zones. Desert cottontails and black-tailed jackrabbits show a distributional relationship to crested wheatgrass, which is limited in contaminated areas, and eastern cottontails are mostly limited to thickets and riparian zones (MKE 1989a).

Bald eagles use wetland/riparian, wetland trees, and dryland trees more frequently than expected on the basis of habitat availability, and use cheatgrass/weedy forb, shrub/succulents, cultivated species, and unclassified areas less frequently than expected. Since the time the bald eagle spent in more contaminated areas is proportionally less, its primary exposure to contamination may come from prey exposed elsewhere.

The majority of bald eagles captured at RMA have been within normal ranges for size, weight, and condition for their age and the time of year they were captured (personal communication, from M. Lockhart of USFWS to Michael Macrander of Shell, 1993). The single bald eagle carcass found at RMA was in the Bald Eagle Management Area (BEMA) at the end of the 1990 wintering season; its condition did not allow determination of the cause of death.

Study Conclusions and Comparison With Tissue Analyses from Various Studies

Bald eagles are present in the vicinity of RMA for only a portion of the year and are on post for some subset of that time. As a result of their habitat-use patterns, bald eagles at RMA use certain habitats and areas disproportionately with respect to their availability. Therefore, they naturally tend to underutilize the more contaminated areas of RMA. The removal of prairie dogs and perch sites from Section 36 (Basin A) further minimized potential exposure. As bald eagles rely on kleptoparasitism (i.e., theft of prey items from other birds of prey, most notably ferruginous hawks) for a significant portion of their diet, it is pertinent that analysis of

ferruginous hawk habitat use reflects a similar habitat-related avoidance of the most highly contaminated areas (USFWS 1993a).

In 90 bald eagle blood samples (70, including eight recaptures, in 1987 to 1989; 20 in 1990 to 1992) and 11 fat samples (1991 to 92) analyzed for trace metals and organochlorine pesticides (USFWS 1992b, 1993a), detectable blood concentrations of arsenic, DDE, and dieldrin were found. No other COCs were detected, although selenium, lead, and PCBs were found. None of the detected concentrations exceeded the lower limits of concern (USFWS 1992b); however, many of the samples were obtained soon after bald eagles arrived at RMA and blood levels of contaminants only provide data on concentrations being transported via the blood at the time of sampling. The current general health of bald eagles at RMA does not reveal any adverse effects of RMA contamination, and bald eagles are unlikely to be significantly exposed to contaminants while wintering at RMA. These two considerations to not suggest that eagles are likely to be adversely affected by contamination at RMA.

Great Horned Owl

The great horned owl, a top predator, is also susceptible to the bioaccumulative characteristics of organochlorine pesticides (Buck 1992). Great horned owls are one of the few raptors with year-round residence and, therefore, high potential exposure at RMA. Accordingly, data that reflect relative survivorship, reproductive potential, exposure, and contaminant burden of great horned owls at RMA are particularly pertinent to the overall assessment of risks.

Three studies include data on great horned owls at RMA. The Biota RI reported results of necropsy and tissue analyses for four great horned owls (ESE 1989). The Biota CMP reported results of analyses of five great horned owl eggs and three adults (RLSA 1992). The USFWS monitored great horned owl nesting locations and reproductive success in 1990, 1991, and 1992 (USFWS 1992a, 1993a). Appendix Section C.4 contains a map indicating nest locations (Figure C.4-5).

Ecological Endpoints

The assessment endpoints pertinent to great horned owl risk at RMA are reproductive potential and mortality. Appropriate measurement endpoints, therefore, include the following:

- Reproductive success as measured and compared among RMA nesting pairs and between RMA populations and published accounts
- Morbidity as measured by cases of potentially injurious contamination

Study Findings

Nesting success of great horned owls has fluctuated during the 3 years for which data have been gathered. In 1990 and 1992, there were 11 breeding attempts in each year, 10 and 11 of which were successful, respectively. In 1991, five of the eight breeding attempts were successful. There was no difference among the 3 years, however, in the number of young fledged per successful nest (range = 1.9 to 2.1).

Data on reproductive success of great horned owls available as number of young observed and number of young branched (i.e., out of the nest but not yet flying) for 29 nests recorded by the USFWS over a period of 3 years (1991, 8 nests; 1992, 11 nests; 1993, 10 nests) were also compared with ESC values for great horned owl exposure areas of 2,660-foot (ft) radius centered on the nest location (Table C.5-8). As can be seen in Table C.5-8, at most of the nests, including the two nests with ESC values greater than 0.5, either two or three young were observed. Not all the observed young survived to leave the nest: one nest in each of four ESC categories (0.01 to 0.02 ppm, 0.02 to 0.03 ppm, 0.05 to 0.06 ppm, and 9.0 to 13.0 ppm) lost a single young; one nest (ESC value of 0.09 to 0.1 ppm) lost both its young, while nests in each of two ESC categories (0.03 to 0.04 ppm and 0.07 to 0.08 ppm) collectively lost seven young, which represents a loss of 30 percent and 70 percent of the young in nests associated with these ESC categories, respectively. This pattern of loss shows no trend associated with exposure concentrations of soil contaminants as expressed by ESC values (Figure C.5-1).

Mortality of great horned owls appears to be an occasional result of contaminant exposure. One great horned owl was observed displaying, and eventually succumbing to, symptoms typical of pesticide poisoning (USFWS 1993b).

Study Conclusions and Comparison With Tissue Analyses from Various Studies

Great horned owls are one of a few species whose individuals may spend their entire lives at RMA. Three years of reproductive data indicate above-average production in 1990 and 1992 (USFWS 1993a).

Because great horned owls are resident species at RMA, it is highly likely that any contaminants in their tissues were acquired on post. Of four great horned owls found dead in 1986, three had detectable levels of dieldrin in both brain and liver tissue samples (Attachment C.5-2). The levels reported for great horned owls were among the highest reported for raptors at RMA. Mercury and DDE were also detected in these samples (ESE 1989). All of the eggs collected in 1990 contained dieldrin, as did all of the muscle and liver samples collected from birds found dead between 1988 and 1990. Endrin, DDT (not in eggs), and especially DDE and mercury, were also found in these samples (RLSA 1992). Maximum concentrations of dieldrin in liver (27.7 ppm, Biota RI; 25.0 ppm, Biota CMP) and DDE (15.5 ppm, Biota RI; 5.40 ppm, Biota CMP) are particularly noteworthy relative to those in other species sampled during the Biota CMP. Maximum brain concentrations of these two chemicals were also quite high (dieldrin, 15.6 ppm; DDE, 10.4 ppm). These concentrations are higher than the whole-body MATC (0.76 ppm) for great horned owls. Thus, results of current studies indicate lethal effects of contaminants in individual great horned owls, although no adverse effects on average production nor population are apparent from the study.

Burrowing Owl

The burrowing owl has been a species of concern over much of its range for more than a decade (Johnsgard 1988) because its populations have been declining over much of its range. This is apparently in response to the expansion of cropland and reduction of burrow-producing colonial

rodents (Butts 1973). Locally, however, the creation of open areas has actually increased local abundance (Wiseman 1986). This raptor, which typically breeds in prairie dog burrows, is unique in that it spends an important portion of its life cycle in direct contact with the soils of RMA.

A study of nest site selection and habitat use of burrowing owls at RMA provided data on habitat requirements, food and feeding habits, and reproductive output (Plumpton 1992). Nests from which at least one individual fledged were recorded as successful. Because burrowing owl nests at RMA were consistently located within active prairie dog colonies, the map for active prairie dog colonies at RMA indicates potential burrowing owl nesting habitat at RMA (RLSA 1992).

Ecological Endpoints

Reproductive success, as measured by nesting success, is the assessment endpoint derived from the data available. Other information, such as habitat-use patterns and food habits, may provide some indication of the relative probability of exposure.

Study Findings

Burrowing owls tended to use sparsely vegetated and roadside habitats, but available data did not allow a quantitative estimate of use proportional to habitat availability. The majority of nest burrows were associated with active prairie dog towns. While invertebrates, small mammals, and passerine birds were all hunted by burrowing owls, small mammals of the genus *Peromyscus* were the key food source.

Table C.5-9 shows that the nesting attempts, number of successful nests, and mean number of young fledged from each nest attempted in 1990 and 1991 were very similar. Detailed information on burrowing owl nest success based on number of live juveniles observed above ground was recorded for the USFWS during 1990 (27 nests), 1991 (40 nests), 1992 (40 nests), and 1993 (43 nests) at RMA. ESC values were calculated from the Ecological Risk Characterization (ERC) database for each of these 150 nest locations using a radius of 2,874 ft for the exposure range (Haug and Oliphant 1990). The number of juveniles ranged from zero

to 9; ESC values ranged from 0.000 to 13.078 ppm. Table C.5-10 shows the relationship of number of burrowing owl juveniles and the ESC values calculated for their nest sites. This comparison of number of juveniles vs. ESC value revealed no trends. Ninety-two percent of the nests (i.e., 138 nests) were associated with ESC values less than 0.125; in fact, 65 percent (i.e., 98 nests) of the nests were associated with ESC values less than 0.05. It can be seen that for the 12 nest sites with ESC values above 0.125 ppm, 58 percent had five or more juveniles. At ESC values at or below 0.125 ppm, 39 percent had five or more juveniles. The only time nine juveniles were found was at two nests in 1990; one of these nests was associated with an ESC value between 0.05 and 0.125 ppm and the other was associated with the highest ESC value calculated for a burrowing owl nest location, 13.08 ppm. These data provide no indication that burrowing owl populations, as reflected in nest success, are adversely affected by mean contaminant levels within their expected exposure range centered on their nest sites.

During 1990, five juvenile burrowing owls were collected and analyzed for aldrin, dieldrin, endrin, DDT, DDE, arsenic, and mercury. Table C.5-11 shows the aldrin/dieldrin tissue concentrations in these juveniles, the aldrin/dieldrin ESC values for the nest location closest to the collection location for the juvenile, and the number of juveniles at this closest nest location. The juvenile with the highest tissue concentration is associated with the nest having the lowest ESC value; the juvenile with the lowest tissue concentration is associated with the next to highest ESC value and the next to lowest number of young. The available data do not show obvious trends in association between reproductive success (based on number of live young observed above ground), ESC, and tissue concentration of burrowing owls.

Study Conclusions and Comparison With Tissue Analyses from Various Studies

The reproductive potential of the burrowing owl may be significant at the individual level, as well as the population level, since it is a species of concern to the public because of declines in its population documented in the 1980s (Johnsgard 1988, Tate and Tate 1982) and at least as far back as the 1960s (Bailey and Niedrach 1965). Burrowing owls at RMA appear to be reproducing at an appreciable rate and offspring produced at RMA are returning and breeding

successfully in the years following the year in which they were banded. The 2-year mean breeding success rate of 4.38 young fledged per nesting pair is higher than for many areas reported in the literature.

Carcasses of burrowing owls collected during the Biota CMP had measurable levels of dieldrin contamination as high as 1.1 ppm, which is just above the whole-body MATC of 0.76 ppm. Thus, while known diet and limited data on tissue levels indicate contaminant exposure for some individuals, population reproductive, fledgling, and breeding return data do not reveal adverse effects on the population at RMA.

All Raptors

Collective studies of all raptor species have been performed at RMA in addition to the species-specific studies of bald eagles, American kestrels, and burrowing owls. The general focus of RMA investigations on raptors is due to their status as upper trophic-level sentinels for the effects of bioaccumulative contamination (Newton 1979) and due to the public interest in raptor populations.

Two types of data are available for investigating ecological effects on raptors at RMA: results from roadside surveys and results from nest monitoring studies. In 1986 and 1987, MKE conducted observational surveys from roadsides at RMA and at two off-post control areas (Adams and Arapaho Counties, Colorado). Population trends and relative abundances of each species were compared between these areas. From August 1991 through May 1992, USFWS conducted weekly or biweekly roadside surveys of raptors along a 24-mile route at RMA (USFWS 1993a). Data collected on raptor abundance were used to monitor population trends, while the data on raptor distribution were used to develop indices of habitat use vs. habitat availability at RMA.

During the springs and summers of 1990 through 1992, USFWS conducted inventories and monitoring studies of RMA raptor nests. Reproductive success was recorded for red-tailed hawks, Swainson's hawks, American kestrels, great horned owls, and long-eared owls.

Ecological Endpoints

Assessment endpoints that may be reflective of contaminant impacts upon raptors are the following:

- Species richness as measured by roadside surveys of species
- Relative abundance as measured by roadside surveys of individual raptors
- Reproductive success as measured by nest success at RMA

Study Findings

Roadside census data (MKE 1989a: Figures 4-14, 4-15, 4-16; Table 5) indicate that RMA supported higher densities of individuals and more species of wintering and breeding raptors than either of two control areas in Adams and Arapahoe Counties (MKE 1989a). While raptors are common at RMA year-round, the abundance of individual species fluctuates in accordance with their individual life cycles and area use patterns. Great horned owls represent the main year-round resident. Burrowing owls, Swainson's hawks, red-tailed hawks, and American kestrels are present primarily as breeding populations. Northern harriers, ferruginous hawks, rough-legged hawks, other owls, and bald eagles are present primarily as wintering populations.

Habitat-use patterns indicate that several species utilize specific RMA habitats in proportions greater than their availability would indicate. Red-tailed hawks tended to utilize wetland habitats to a greater extent than expected, and ferruginous hawks utilized weedy forb habitats to a greater extent than expected.

Study Conclusions and Comparison With Tissue Analyses from Various Studies

As documented from the results of roadside counts (MKE 1989a; USFWS 1993a), total abundance and species richness of raptors at RMA are both quite high. Habitat-use patterns appear to be related to species-specific ecology (e.g., habitat quality, prey abundance, and protection) (USFWS 1993a) rather than attributable to any trends in contamination. These habitat-use patterns affect the potential exposure among species. Bald eagles, red-tailed hawks, and rough-legged hawks, for example, utilize wetland/riparian habitat in proportions greater than occurrence would predict. Because these habitats tend to be less contaminated and/or ecologically impacted, the potential for exposure may be relatively low for these species.

A number of raptor tissues have been analyzed for contaminants in various programs such as American kestrel egg and juvenile samples from early investigations (McEwen 1982), the Biota RI (ESE 1989) and Biota CMP (RLSA 1992) and great horned owl egg samples from the Biota CMP (RLSA 1992). Fortuitous samples were collected from dead and dying individual raptors during the Biota RI (ESE 1989), Biota CMP (RLSA 1992), and ongoing USFWS programs. The reports on these programs contain maps and information on locations of fortuitous samples.

Some of the COCs have been detected in a number of the raptor species collected at RMA including American kestrel, bald eagle, golden eagle, red-tailed hawk, ferruginous hawk, burrowing owl, and great horned owl. The frequency of contaminant detection was higher in kestrels collected on post than those collected off post. Dieldrin is the primary contaminant in the raptor samples that were analyzed and occasionally reached high levels (i.e., as much as 25 to 27.7 ppm in the brain and liver of the great horned owl). Other notable concentrations of dieldrin in fortuitous samples collected at RMA included 9.44 ppm in a red-tailed hawk's brain, 15.6 ppm in a great horned owl's brain, and 9.98 ppm in a ferruginous hawk's brain (Attachment C.5-2). Whole-body MATCs for dieldrin in raptors range from 0.41 (bald eagle) to 0.76 ppm (owl). The brain to whole-body ratio of dieldrin tends to be highly variable, ranging between 0.1 and 2 based on a survey of the general literature.

The high concentrations detected in brain and liver tissue of individuals of some species found dead at RMA are consistent with known exposure pathways and contaminant sources. The levels and frequency of dieldrin and DDE contamination in some raptors at RMA (i.e., American kestrel, ferruginous hawk, and great horned owl) indicate some level of risk for these species. Brain levels of the organochlorine pesticides found in some individuals are within ranges associated with reduced reproductive success or death, and are above the whole-body MATCs (Attachment C.5-2) for organochlorine pesticides in these raptors. While studies of raptor reproduction, abundance, and diversity were not specifically designed to assess potential impacts of contamination, they have not revealed adverse effects to these parameters (USFWS 1993a).

Water Birds

Water birds (i.e., waterfowl and coots) are susceptible to deleterious effects of chemical contamination. By virtue of their close association with environmental media such as water and sediment and the tendencies of these media to act as contaminant sinks, water birds are very likely to be exposed to contaminants at RMA.

In the biota RI, the water bird species present at RMA were compared to those in off-post lakes during the breeding season of 1986 (ESE 1989). Reproductive success was also recorded during this study. In addition, the USFWS has conducted year-round observations of water birds at RMA's lakes and wetlands to identify important habitats and temporal-use patterns.

Ecological Endpoints

Reproductive success, as measured by nest success at RMA, is an assessment endpoint that may be reflective of contaminant impacts upon water birds.

Study Findings

In 1984 and 1986, fewer water bird nests and broods were observed at RMA than would be indicated by habitat availability. No successful mallard broods were observed in 1986, while off-post control areas exhibited normal success (ESE 1989). However, in 1988 through 1990,

pre-flight juveniles of blue-winged teal, mallards, and American coots were collected at RMA and analyzed for contaminant burden. Thus, their presence proves some level of reproduction was occurring for those years. Relative abundance of individual species differed between the lakes of RMA and off-post control areas (MKE 1989a). Likewise, individual RMA lakes have been shown to support differing water bird communities.

Study Conclusions and Comparison With Tissue Analyses from Various Studies

Reproductive success/failure has been documented for water birds, although limited quantitative information exists even for the mallard. Poor water bird reproduction may be the result of such factors as contaminant effects, nest interference by fishermen, high levels of predation, or management-related fluctuating water levels. Among these factors, contamination is of particular concern in closed aquatic systems, which may receive contaminant inflow from widespread surrounding uplands.

In two samples of addled mallard eggs reported in the Biota RI (ESE 1989), dieldrin was the most commonly detected contaminant at levels of 4.89 and 3.0 ppm. The eggs also had DDE levels ranging from 0.606 to 0.919 ppm. The organochlorine pesticide levels were within the range of literature values indicative of adverse reproductive effects and substantially above the whole-body MATC for water birds. Concentrations in eggs tend to be lower than whole-body concentrations from the same individual for DDT/DDE. Aldrin/dieldrin concentrations are not typically measured in eggs.

Upland Game Birds

Important upland game birds such as mourning dove and pheasant are present at RMA. Several studies of upland game birds have been performed to determine potential ecological impacts of contaminants. Data on reproductive potential of pheasants are available on an RMA-wide basis only.

Ecological Endpoints

The assessment endpoints for upland game birds, as available data allow, are the following:

- Reproductive success as measured by brood size and number of broods for pheasants
- Relative abundance as measured by roadside call counts of pheasants and mourning doves at RMA relative to control areas

Study Findings

Abundance of ring-necked pheasants and mourning doves expressed as the number of vocalizations occurring during timed stays at listening stations was compared between RMA and an off-post control area (Weld County, Colorado) (MKE 1989a). Pheasant abundance was significantly higher at RMA (mean number of vocalizations at RMA = 552, Weld County = 108). Conversely, mourning doves had higher population levels at the off-post location (mean number of vocalizations at RMA = 32, Weld County = 110). Generally, mourning doves were not abundant at RMA during the breeding season.

Ring-necked pheasant brood sizes surveyed in 1984 and 1986 at RMA and off-post control areas were smaller at RMA (RMA mean = 1.8; control area mean = 3.2) (MKE 1989a).

Study Conclusions and Comparison With Tissue Analyses from Various Studies

The results of pheasant reproductive surveys are qualitative, but indicate high breeding activity and a low number of successful broods. The low number of successful broods could be the result of contaminants, poor-quality habitat, or high predation pressure. Dieldrin contamination in pheasants and mourning doves was detected at levels ranging up to 5.95 ppm (dressed carcass tissue). Some individuals had concentrations that were substantially above the whole-body MATC for small birds, suggesting that contamination may be partially responsible for the observed poor reproductive success.

<u>Songbirds</u>

Many species of songbirds are present at RMA. Several studies of songbirds have been performed to determine potential ecological impacts of contaminants. Data on reproductive potential of selected species of songbirds are available on an RMA-wide basis only. Information on relative abundance and species richness has also been collected for many of the songbird species.

Ecological Endpoints

Relative abundance, as measured by censuses and breeding bird surveys of on-post vs. off-post songbird species, is the assessment endpoint for songbirds at RMA.

Study Findings

Small bird populations were censused at RMA, Buckley, and PCC. The predominant species were horned larks and western meadowlarks (MKE 1989a). Horned larks were significantly more abundant at PCC, and meadowlarks were more abundant at Buckley. These differences in species abundance were assumed to result from differences in habitat at RMA and the reference locations because no within-site variation was attributable to trends in contamination (MKE 1989a).

The quantitative breeding bird survey results (Table C.5-12) indicate that "grassland songbirds nested at higher densities off site" (MKE 1989a). For all four species evaluated, western meadowlark, horned lark, grasshopper sparrow, and vesper sparrow, densities were highest off post for both crested wheatgrass and native grassland habitats. The results of multiple correlation and principle components analyses attributed the differences in breeding density of these four species to differences in habitat quality, which was evaluated on the basis of 16 independent habitat variables that were grouped as descriptors of habitat complexity, openness, and denseness (MKE 1989a).

Study Conclusions and Comparison With Tissue Analyses from Various Studies

The lower abundance and density of songbirds at RMA relative to control areas have been attributed to differences in habitat (MKE 1989a). Chemical analyses of vesper sparrows, western meadowlarks, mourning doves, and of several species sampled fortuitously revealed no consistent patterns of concentration and spatial distribution, although tissue concentrations of aldrin, dieldrin, and endrin in mourning doves were substantially above the whole-body MATCs for small birds (Attachment C.5-2). Most of the fortuitous samples were collected dead from the lawn in front of Building 111. A Brewer's blackbird was exhibiting muscular tremors when collected in front of a warehouse just east of South Plants; chemical analysis revealed 8.0 ppm dieldrin, which is well above the whole-body MATC of 0.15 ppm. Thus, there is evidence that individual songbirds are being adversely affected by contaminants at RMA.

C.5.3.2.3 Invertebrates

Invertebrates were studied because of their importance in the structure and function of regional ecosystems, because some species are known to bioaccumulate contaminants, and because they can serve as sensitive indicators of contaminant effects (ESE 1989). Each group was sampled at the population level at sites of known contamination and in off-post control areas.

Grasshopper abundance was estimated using standard ocular techniques. Ten 1-ft-square (ft^2) plots were established at 33-ft intervals along five 328-ft transects located in on-post sites of contamination (i.e., the Basins A, C, and F) and similar habitats in off-post control sites at Wellington State Wildlife Area (Larimer County, Colorado) and in Aurora Environmental Park (Adams County, Colorado). Information on exact sampling locations, detailed methods, and statistical analyses is provided in the Biota RI (ESE 1989).

Earthworm population density was estimated by excavating known soil volumes and plots (11 ft^2 in size and dug to a depth of approximately 0.5 ft) and hand sorting the soil to remove earthworms. Sample sites were selected in South Plants, at an on-post control site in Section 5, and an off-post control site at Barr Lake State Park (Weld County, Colorado). Samples at each

location were from the same soil type. Other potential locations in sites of contamination (e.g., Basin A) were not sampled due to a variety of reasons including soil compaction, absence of vegetation, or soil types not suitable to sustain earthworm populations. Data were analyzed by nonparametric methods. Analyses are described in Appendix B of the Biota RI (ESE 1989).

Ecological Endpoints

The assessment endpoint investigated to evaluate whether RMA contaminants adversely affected invertebrate populations was population abundance of selected invertebrate groups: grasshoppers, earthworms, and aquatic snails. The measurement endpoints were the following:

- Grasshoppers—Population density
- Earthworms—Population density
- Aquatic snails—Population density and biomass

Study Findings

For grasshoppers, the analyses showed a nonsignificant ($p>0.05$) statistical difference between controls (on post n=10; off post n=26) and between controls and contaminated samples (n=21) using both parametric and nonparametric tests. This was true even when variation resulting from differences in time of day, temperature, and floral characteristics were removed via multiple regression analysis and the residual variation analyzed among the control and contaminated sites.

For earthworms, results indicated that the on- and off-post control sites were significantly different, and that both control sites were significantly different from the contaminated site. Differences in population density were not consistent with patterns of contamination (e.g., the on-post control site had the highest population density).

For aquatic snails, statistical differences in population density in both 1986 and 1987 were found between RMA lakes and off-post control sites. Statistical differences were also detected between controls for 1986 and 1987 and among RMA lakes for 1986, but not for 1987. Results indicated

a high degree of variability between sites and years. Additional statistical analyses indicated that covariates of aquatic vegetation, snail weight, water temperature, and water pH affected results.

Study Conclusions and Comparison With Tissue Analyses from Various Studies

The above-referenced data indicate no obvious contaminant effects on population density of grasshoppers, earthworms, or aquatic snails.

In grasshopper samples from the population survey areas, none of the organochlorine pesticide COCs, arsenic, mercury were detected in the on- or off-post control sites. Arsenic, dieldrin, endrin, and mercury were found in earthworms from the on-post control and South Plant sites (Attachment C.5-2). Earthworm population and tissue contaminant levels were reported as not indicative of adverse contaminant effects (ESE 1989).

C.5.3.2.4 Terrestrial Vegetation

Terrestrial vegetation is the basis of terrestrial ecosystems, and its biomass is as much as 10 times greater than the biomass of terrestrial animals. Much of the biomass of most plant species is below the ground and in contact with soils and the chemicals in soils. The distribution of vegetation at RMA is documented by good aerial photo coverage of the RMA area dating to 1937 and by a remote sensing program conducted in 1978–79 (Strahler et al. 1979). MKE (1989b) performed extensive sampling of ecological parameters for vegetation both on post and off post. Data for plant species cover, production, phenology, density, as well as plant community floristics, were collected.

Ecological Endpoints

Assessment endpoints for vegetation are species richness, relative abundance, and morbidity of plant communities. Soil contamination may affect these assessment endpoints directly by influencing the presence or growth of particular plant species, as well as indirectly via plant symbiont or decomposition microorganisms that make nutrients available for plant use. Measurement endpoints for these assessment endpoints are the following:

- Structure and species composition at the population and community level, respectively
- Growth and phenology at the population and individual level

Study Findings

Portions of RMA are contaminated with materials that are toxic to plants and that continue to affect vegetation. The Lime Settling Basins in Section 36 are, for example, devoid of vegetation, a condition that is attributable to the toxic chemicals concentrated at these locations. At this time, areas such as this are localized and do not cover a large portion of RMA. Between 1976 and 1978, larger expanses of bare ground were present adjacent to Basin F and other waste basins where surficial deposition of contamination occurred through evaporation of contaminated material. This retrogression most likely occurred when severe drought added stress to plant communities already impacted by contaminant deposition (Strahler et al. 1978). With average precipitation, weedy and early successional species have naturally revegetated these areas, and native grasses that have been seeded at these locations have grown normally.

Aside from these relatively limited areas of high contamination, it is very difficult to discern contaminant effects on vegetation at RMA. The RMA landscape is, generally, a highly modified mosaic with local vegetation being primarily a function of past land uses. Although Strahler et al. (1979) suggested a correlation between contaminated surface water and groundwater flow and plant community successional status, MKE (1986) found that no specific vegetation type is reflective of contamination. Although weedy vegetation is associated with contaminated areas, weedy species are just as likely to dominate in uncontaminated portions of RMA. Weediness is a result of land disturbance, whether the disturbance is the result of facility construction, contaminated waste disposal, or abandonment of agricultural activity. Conversely, native grasslands occur in undisturbed surface areas with surficial contamination, as well as in undisturbed areas remote from contamination. Section 36, one of the most severely contaminated areas of RMA, contains about 25 acres of undisturbed native grassland.

Variables such as total vegetation cover, total productivity, species richness, and phenology are similar between weedy and native vegetation sites within moderately contaminated and noncontaminated sites at RMA as well as at off-post locations (MKE 1989b). The MKE terrestrial plant study investigated 658 locations at three different sites (RMA, 424 locations; Buckley, 121 locations; and Prairie Conservation Center, 113 locations) as to their cover, height, density and production. Statistical comparisons of cover, production, density, and diversity were performed for the major vegetation types (native grassland—RMA, 73 transects; mixed grass prairie—Buckley, 51 transects; mixed grass prairie—PCC, 51 transects; short grass prairie—PCC, 52 transects; crested wheatgrass—RMA, 48 transects; and crested wheatgrass, 49 transects) using one-way ANOVA. In crested wheatgrass, cover and species per transect were significantly lower ($p=0.05$) at RMA than at Buckley, but production and density were not. Other types were not strictly analogous. The total number of species in native grassland at RMA was greater than in any of the other vegetation types at any site. The occurrence of diverse management practices, human activities, and environmental variables at RMA and at the control sites precludes identification of the basis for quantitative differences in vegetation between these sites. In general, habitats at RMA are comprised of healthy plant communities that are proceeding through normal successional processes for semiarid environments.

Study Conclusions and Comparison With Tissue Analyses from Various Studies

The distribution of plants at RMA is affected by localized, high contaminant concentrations as well as by various other factors. A number of plant samples analyzed under the Biota RI and Biota CMP contained low levels of arsenic and OCPs. Arsenic was detected at 4.5 ppm in sunflower leaves collected in Basin A. No phytotoxic effects were exhibited by the plants and it was suggested that the detections of arsenic may have been due to dust deposited on the leaves (ESE 1989). Levels reported during the Biota RI (ESE 1989) for RMA vegetation (Attachment C.5-2) do not suggest direct adverse effects. Similar low levels of contaminants were reported from the Biota CMP, so terrestrial plants proved to be relatively ineffective indicators of the COCs in 1988 through 1990 (RLSA 1992).

C.5.3.3 Investigations of Biomarkers

Biomarkers such as the inhibition of AChE in brain tissue and eggshell thinning are specific possible effects of some of the contaminants found at RMA. Data on these parameters were collected as part of the Biota RI to evaluate whether these adverse effects were occurring at RMA on or near sites of known contamination (ESE 1989). To evaluate AChE inhibition, analyses were performed on brain tissues from mallard, ring-necked pheasant, black-tailed prairie dog, and desert cottontail from sites of contamination at RMA and from control sites more than 40 miles from RMA. Fortuitous samples (three red-tailed hawks, two golden eagles, and one mourning dove) from RMA were also analyzed. Eggshell thinning can be produced by some of the RMA COCs and could result in lower reproductive success for some bird species. Shell thickness and other measurements were made on the eggs of mallards, pheasants, and kestrels that were collected as part of the Biota RI.

Biomarker Endpoints

AChE inhibition and eggshell thinning are not considered ecological endpoints as these measurements are not used to assess parameters of population or community-level status. Rather, these measurements were made because they are known to be indicative of harmful levels of chemical contamination. While eggshell thinning is known to be caused by exposure to harmful levels of DDT/DDE in the diet, AChE inhibition is used as a measure of adverse exposure to organophosphates and chemical compounds with similar activities.

Study Findings

The only significant ($p<0.01$) AChE inhibition (> 20 percent reduction) was found in prairie dogs living in or near the Toxic Storage Yard. The decrease could not be related to known contaminants found in that area, but appeared to result from the naturally occurring concentrations of arsenic and metals compounds associated with the soil type found at that location (ESE 1989). Eggshell thickness did not differ significantly between RMA sites and the off-post control sites (ESE 1989) for mallards, ring-necked pheasants, and American kestrels.

Study Conclusions and Comparison With Tissue Analyses from Various Studies

Results of AChE and eggshell-thinning studies did not indicate that either adverse effect was present at RMA as a result of contamination. Sample sizes for mallard, pheasant, kestrel, prairie dog, and cottontail were sufficient for nonparametric statistical analyses. Incidental data on other species, though inconclusive, were consistent with these results. Details of the statistical analyses are presented in Appendix B of the Biota RI (ESE 1989).

C.5.3.4 Incidences of Mortality

Direct mortality of wildlife as a result of exposure to chemical contamination is a well-documented phenomenon (Connel and Miller 1984). Several RMA COCs are lethal at relatively low doses. Data that provide indications of wildlife mortality at RMA include historic accounts, current observations, and interpretations of mortality events documented by USFWS. Historical reports of significant levels of wildlife mortality at RMA began in the early 1950s (Hyman 1953). At least three studies were conducted in the 1950s specifically to document and investigate the causes of wildlife mortality (Sciple 1952; Jensen 1955; Finley 1959). Fortuitous samples were collected during 1988, 1989, and 1990 (RLSA 1992). Since that time, the USFWS has continued to collect fortuitous samples at RMA.

Ecological Endpoints

In spite of the fact that past occurrences of wildlife mortalities at RMA are not pertinent to the current risk of mortality, documentation of such occurrences provide clear evidence that RMA contaminants have caused mortality. The measurement endpoint that is pertinent to assessing the risk of mortality is the observation of dead, dying, or seriously impaired individual animals.

Study Findings

Caustic releases into the lakes have been thought to cause declines in the fish populations since the late 1940s. Finley (1959) estimated a minimum mortality of 20,000 water birds during a 10-year period. McEwen (1981) recorded the death of numerous ducks with high levels of dieldrin in their tissues in 1955. Hundreds of individuals, including waterfowl, amphibians,

raptors, songbirds, fish, and shorebird species, have been found dead or dying in every decade since 1950 (ESE 1989). Most hawks and owls found dead at RMA and analyzed for contaminants in brain and liver tissues were found to contain dieldrin. Lethal dieldrin brain levels are reported to range between 4 and 20 ppm (Robinson and Crabtree 1967; Coon et al. 1968; Belisle et al. 1972; Mulhern et al. 1970). The brain-tissue concentrations of dieldrin in most raptors (excluding eagles) found dead due to unknown causes at RMA and analyzed fell within this range. During the Biota RI program, numerous dead birds were noticed on the mowed lawns around Building 111 at RMA. Deaths in this area were specifically recorded during the Biota CMP through pedestrian surveys of the Building 111 grounds that continued each spring until specimens were no longer consistently found. The surveys resulted in the collection of mostly American robins and European starlings. In addition to specimens from this area, numerous specimens were collected during the Biota CMP field work at RMA (1988–90). Table C.5-13 provides descriptive information from field notes written between 1988 and 1990 during the Biota CMP about animals exhibiting behavioral abnormalities or animals found dead and showing abnormalities from autopsy reports or necropsies.

Study Conclusions and Comparison With Tissue Analyses from Various Studies

Incidents of extensive wildlife mortality have occurred in the past at RMA. The extent and implications of current mortality are not well documented and poorly understood, but it is substantially less than that documented in the 1950s and 1960s (see Appendix A).

The extensive analytical data reported in the Biota RI (1989) and the subsequent Biota CMP (1988–90) shows variable concentrations of organochlorine pesticides in individuals of all taxa sampled. Dieldrin levels were as high as the 56 ppm reported in a mourning dove carcass found on the lawn of Building 111. Thus, potentially lethal concentrations of organochlorine pesticides, chiefly dieldrin, occur in the tissues of some individuals of certain mammal and bird species (Attachment C.5-2). Dieldrin is the contaminant most likely to be detected at injurious levels and occurs in a variety of trophic levels and species.

Despite the contaminant levels detected, current contamination-related mortality is not believed to be causing deleterious effects on the overall abundance or richness of wildlife populations at RMA. Wildlife resources are generally quite abundant at RMA and the species composition is quite diverse for the Rocky Mountain/plains grassland ecotone of eastern Colorado.

C.5.4 ECOLOGICAL ENDPOINT SUMMARY

This section summarizes the information from the ecological effects investigations into a hierarchy of ecological endpoints consistent with current EPA guidance (EPA 1989a, b). EPA guidance provides for the selection of endpoints at various levels of ecological organization. The selection of endpoints at the individual level, such as endocrine disruption and immunological effects, could conceivably produce adverse effects at the population level, but would be difficult or impossible to evaluate from such an ecological perspective. Consequently, effects at the community and population level were deemed to be more appropriate ecological endpoints.

Several animal species at RMA belong to populations that may range beyond RMA boundaries (e.g., deer, coyote), so population density for these species is a better measure of habitat quality than of adverse effects of contamination. For highly mobile species, it would be appropriate to collect data on immigration and emigration in order to evaluate contaminant effects on population density. This consideration was recognized in selecting endpoints for population density estimates. Only species of small animals with limited mobility were selected for overall population density studies (e.g., aquatic snails, earthworms, prairie dogs). For highly mobile species, endpoints were selected that took into account the mobility, exposure pathways, and potential effects of RMA contaminants. Reproductive success studies on waterfowl and kestrels fall into this category.

C.5.4.1 Community-Level Endpoints

C.5.4.1.1 Species Richness

Data on species richness are provided by studies of plant community structure and species composition by roadside species surveys of raptor diversity. A variety of field tasks, such as the collection of grasshoppers, also provided information on species richness.

Species richness of vegetation as a measure of habitat diversity within RMA ecosystems was difficult to assess because of the anthropogenic disturbance of many areas of contamination. Elevated concentrations of arsenic in soil, sufficient to limit the presence of some plant species, are present at RMA. Other contaminants, including salts and metals, may also adversely affect plants, reducing local species richness of plants and, indirectly, animals by modifying the habitat. However, soil compaction, application of herbicides for weed control, burning, and other activities made it impossible in most areas to distinguish between physical and chemical contaminant effects with any degree of certainty.

The extensive inventories of species conducted at RMA during the last decade by the Army, Shell, USFWS, and the Denver Museum of Natural History have produced data showing that the vertebrate species (i.e., birds, mammals, reptiles, amphibians, and fish) in terrestrial and aquatic ecosystems are typical of similar habitats throughout the region. In fact, RMA ecosystems contain sizable populations of key species including burrowing owls, wintering bald eagles, and coyotes. While the large numbers of individuals within these populations are largely attributable to agriculture and the lack of hunting and consumptive fishing within RMA boundaries, the presence of diverse species (i.e., species richness) and sustained populations is a good indication of general ecosystem health. Specific comparisons of contaminated sites within RMA are difficult to assess because of the absence of specific quantitative ecological data correlated with contaminant concentrations and the extensive noncontaminant-related disturbances associated with these sites. EPA (1989a) states that in such instances interpretation of results must be done with a great deal of caution.

When grasshopper samples were collected, only one species (*Melanoplus sanguinipes*) was represented in samples from contaminated sites at RMA, which compares to the four to six

species found in on- and off-post control samples. However, this difference in species richness between control and contaminated sites was attributed to the reduced vegetation diversity at contaminated sites rather than to a direct effect of chemical contamination on grasshoppers (MKE 1989a).

C.5.4.1.2 Trophic Diversity

Trophic diversity was not studied directly. Rather, data from pellet analysis of raptors, analysis of the contents of guts of various prey species, and numerous direct-foraging observations served as general measurement endpoints. When this information was evaluated together with data on observed species richness at RMA and food-web pathways studies, there was no indication of adverse effects by chemical contamination on the trophic diversity at RMA.

C.5.4.2 Population-Level Endpoints

C.5.4.2.1 Abundance

Data on abundance are provided by studies of (1) deer through surveys of their distribution; (2) prairie dogs through average density surveys; (3) small mammals through documentation of general population abundance and mean abundance during trapping; (4) bald eagles through surveys of individuals and their distribution; (5) raptors through roadside surveys; (6) upland game through roadside call counts at RMA and in control areas; (7) songbirds through censuses and breeding bird surveys; (8) invertebrates through aquatic snail population density and biomass measurement, earthworm population density records, and grasshopper population density indices; and (9) vegetation through a survey of species distribution.

The mule deer population is increasing. Additional data on individual effects and contaminant concentrations support the general conclusion that RMA contamination is not adversely affecting deer populations. Studies of prairie dogs, small mammals, bald eagles and other raptors, upland game birds, songbirds, and invertebrates at RMA either indicated no significant reduction in populations at RMA or reported ambiguous results that were difficult to interpret. Some species, including horned larks and mourning doves, were significantly more abundant at the off-post

control sites than at RMA. While contamination effects are possible, additional analyses indicate that the differences in habitat quality and diversity account for most of the differences observed (MKE 1989a).

C.5.4.2.2 Reproductive Success

Data on reproductive success are provided by studies of (1) deer (based on fawning rate, fawn survival, and population growth rate); (2) prairie dog (based on juvenile-to-adult ratios); (3) American kestrel (based on nesting attempts per available opportunity, clutch size, hatching success, and fledgling success); (4) great horned owl (based on nesting success at various locations at RMA and relative to published data); (5) burrowing owl (based on nesting success); (6) raptors (based on nesting success); (7) water bird (based on nesting success at RMA); and (8) upland game birds (based on brood size and number).

Information on the reproductive success of deer indicates healthy populations. Both mule deer and white-tailed deer are reproducing well, although health-related problems in some individuals have been noted. While prairie dog reproductive success was lower on post than off post, the differences were strongly confounded by the impacts of campestral plague and colony maturity. The trends for small mammal reproductive success were ambiguous and appeared to be related to habitat quality.

Results from the various measurement endpoints evaluated for birds at RMA indicated a possibility of contaminant-related reproductive effects for some species. American kestrel studies documented potentially harmful levels of contamination in some individuals, but significant population effects were not documented. While a greater percentage of nests appeared successful off post, in recent years the nests that were successful on post tended to produce more eggs and more fledged young. Causes of nest failure were not studied. While this higher production per successful nest does not offset the overall greater success rates observed off post, it does indicate that high productivity is possible within contaminated areas. It may also suggest that other unexamined factors, such as predation, human disturbance, and nest site competition, may

contribute to on-post nest failure. Reproductive success of both owl species and of other raptors breeding at RMA appears comparable to or better than data from off-post control areas and to data from related studies conducted in other areas. In mallards studied in 1986, reproductive success was reduced in RMA lakes compared to off-post control sites, and contaminant levels in the two tissue samples taken were elevated, both of which suggest contaminant effects consistent with the modeled exposure routes to this trophic box.

C.5.4.2.3 Morbidity

Data on morbidity are provided by studies of (1) deer mortality and general health (e.g., muscle mass, fat reserves, physical condition, the incidence of disease or parasitism, and the incidence of health-related problems in individuals); (2) bald eagle general health and potential exposure; (3) great horned owl individuals exhibiting symptoms of contamination; (4) fortuitous observations and necropsy of dead and dying raptors as well as accompanying tissue analyses; and (5) vegetation presence, growth, and phenology at the species and individual level.

Most individual deer appear healthy and are free of contaminants. The few instances of health-related problems continue to be evaluated.

The bald eagle winter roost at RMA is one of only five in the region. It has been used consistently since 1986, providing not only a protected roosting site but a dense prey population of prairie dogs nearby. While contaminant levels measured in the blood of captured bald eagles were not above the lower limits of concern, most of the birds were captured soon after their arrival at RMA. The bald eagles' potential exposure to contaminants via the food-web pathway during their stay at RMA (about 5 months) continues to be of concern, and prairie dogs are being kept out of the most contaminated areas of RMA to eliminate potential exposure of eagles from this prey source until these areas have been remediated.

Although a number of great horned owls have been found dead, due allegedly to RMA contaminants, the reproduction rate for the population remains above average.

The numerous factors affecting the presence and distribution of vegetation confound the consideration of plant morbidity.

C.5.4.3 Individual Endpoints

Data on individual endpoints are provided by studies of (1) eggshell thinning (mallards, pheasants, kestrels) and (2) AChE inhibition (pheasant, mallard, prairie dog, desert cottontail, and fortuitous samples of individuals of miscellaneous other species).

AChE and eggshell-thinning studies did not reveal contaminant-related adverse effects in the individuals studied. The results for AChE were statistically supported for species with sufficient sample sizes (mallard, pheasant, kestrel, prairie dog, and cottontail).

C.5.4.4 General Conclusions

Adverse effects of contamination at RMA were severe in the past, as is indicated by the documentation of water bird die offs and fish kills associated with contaminant releases to the lakes. Investigations on the effects of contamination at RMA during the past decade indicate that while some effects may still be present in biota at RMA, the wildlife communities and populations are viable and appear healthy. The ecological effects of the contaminants that have been documented are consistent with the exposure pathways and endpoints developed in the pathways-modeling portion of the risk assessment (e.g., raptor mortality may be a consequence of biomagnification through the food web).

Observations of reduced reproductive success in mallards in RMA lakes and of dead and dying raptors indicate that some adverse effects of contamination may still be occurring. This conclusion is supported by tissue-concentration results and by the exposure pathways model. Likely effects of RMA contamination on individual animals have been observed (e.g., tissue concentrations above MATC values associated with toxicological endpoints in individuals that appeared healthy when collected as intentional specimens; behavioral symptoms and necropsy results indicating contaminants caused or contributed to the death of raptors and carnivores).

From the ecological endpoints that have been measured, these effects are not apparent at the population level at RMA.

C.5.5 UNCERTAINTY AND LIMITATIONS

Sources of uncertainty in the characterization of the status and health of RMA fish and wildlife populations include variability in study methodologies and reporting formats as well as normal biological variability among measured populations. The many ecological studies of RMA varied considerably in their study designs (e.g., sample size, location of control areas, and experimental treatment) and presentation of data. Data on wildlife population trends are not continuous through time and frequently have been derived using different methodologies, which makes them difficult to interpret, particularly given the many sources of natural variability. Natural populations routinely fluctuate on both an annual and a seasonal basis. Some species may only spend a few days or weeks at RMA. Timing of reproduction, relative reproductive success, intensity of predation, level of parasitism, quality and abundance of food sources, and climate all are variables that can positively or negatively affect population levels at any given point in time. Recent data from USFWS breeding bird surveys indicate that some species fluctuate up and down with a periodicity of 10 years or more. Further discussion of the uncertainties associated with the characterization of the status and health of RMA biota can be found in Appendix Section E.12.

The potential for wildlife exposure to contaminants at RMA has also been variable. In spite of the fact that environmental persistence of the chemical contaminants at RMA is long term, a number of intermediate remediation responses have been carried out in the last two decades with the specific purpose of reducing exposure (e.g., draining and dredging of the Lower Lakes, draining and removing sediment from Basin F, installing vegetative and physical barriers at Basin A). Thus, contaminants should currently be less available to biota than they were when some of the biota tissue samples were collected. Although a time lag would be expected between reduction of exposure and a subsequent reduction in tissue concentration, the positive effects of

exposure intervention programs should result in the declining availability and effects of contamination.

Because of variability in the design of past studies, the variability of wildlife exposure, and anticipated resultant reduction in tissue concentrations, data from the long-term monitoring of population trends are needed. A consistent long-term study design would enable separation of contaminant effects on populations from natural long-term population cycles and animal mobility. Such a study could minimize the number of variables that might obscure detection of any correlation between population trends or other ecological effects and contamination. The study could also provide data useful for risk management, facility/refuge management, and regulatory oversight. The biomonitoring program currently being conducted by USFWS is addressing these goals.

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Table C.5-1 Studies Relevant to Ecological Endpoints

Assessment Endpoint	Measurement Endpoint	Relevant Studies (Source)
Reproductive Success	Nesting Success	Water birds (ESE 1989) Raptors (see specific species) Burrowing Owl (Plumpton 1992) Great Horned Owl (USFWS 1992a, 1993a) Kestrel (DeWeese et al., 1982 and undated.; ESE 1989; RLSA 1990, 1992, 1993; USFWS 1992a, 1993a) Pheasant (MKE 1989a) Upland game birds (MKE 1989a)
	Juvenile/Adult ratio Litter size Fawn rate, survival	Prairie Dog (MKE 1989a) Prairie Dog (USFWS 1993b) Mule Deer (MKE 1989a, USFWS 1992a, USFWS 1993a; Whittaker 1993)
Morbidity	Surviability as indicated by potentially toxic contaminant concentrations in tissue	Great Horned Owl (USFWS 1993b; ESE 1989; RLSA 1992) Bald Eagle (USFWS 1992b, 1993a) Raptors (ESE 1989) Kestrel (ESE 1989, RLSA 1992)
	Morbidity as indicated by potential exposure	Bald Eagle (USFWS 1992b)
	Morbidity/health as indicated by muscle mass, fat reserves, physical condition, incidence of disease or parasitism	Mule Deer (USFWS 1993b)
Abundance	Relative abundance	Bald Eagle (USFWS 1992b) Small Mammals (MKE 1989a) Prairie Dog (ESE 1989; USFWS 1993a; MKE 1989a; RLSA 1992) Mule Deer (MKE 1989a, USFWS 1992a; Whittaker 1993) Pheasant (ESE 1989; MKE 1989a) Raptors (ESE 1989; MKE 1989a) Upland game (MKE 1989a) Songbirds (MKE 1989a)
Species Richness and Trophic Diversity	Density	Grasshoppers (ESE 1989) Earthworms (ESE 1989) Aquatic Snails (ESE 1989)
	Numbers of Species Identified	Raptors (ESE 1989; MKE 1989a; USFWS 1993a) Plants (MKE 1989b)

Table C.5-1 Studies Relevant to Ecological Endpoints

Assessment Endpoint	Measurement Endpoint	Relevant Studies (Source)
Vegetation		
Species Richness	Structure and Species Composition	Plants (Strahler et al. 1978; MKE 1986, 1989b)
Relative Abundance	Structure and Species Composition	Plants (Strahler et al. 1978; MKE 1986, 1989b)
Survivability	Growth and Phenology	Plants (Strahler et al. 1978; MKE 1986, 1989b)

Table C.5-2 Bias, Power, and Relevance Ratings of RMA Studies Selected to Evaluate Ecological Endpoints Relevant to Risk Characterization

Study	Bias[1]	Power[2]	Relevance[3]
Aquatic snail population density and biomass	Low	High	Medium
Grasshopper abundance	Low	Medium	High
Earthworm population density	Low	Medium	High
AChE inhibition in mammals and birds	Low	Medium	Low
Eggshell thinning	Low	Medium	High
Prairie dog population density and age ratios	Medium	Medium	Medium
Avian reproductive success (kestrels, pheasants, ducks)	Low	Medium	High
Deer and raptor population density indices	Medium	Medium	Medium
Fortuitous Observations	Medium	NA	High
Other Abundance Studies small mammals, bald eagle, mourning dove, songbird, breeding bird	Medium	Medium	Medium
Other Reproductive Success Studies	Medium	Medium	Medium
Morbidity Studies[4] Deer, great horned owl, bald eagle, vegetation	Medium	Low	Medium

1 Bias is the magnitude and direction of the tendency to measure something other than was intended; measurement bias is a consistent under- or overestimation of the true value in population units. Bias was minimized when: samples were representative of sites of contamination and appropriate control (reference) sites were selected and used.

High: None of the above
Medium: Evaluation of magnitude of potential bias
Low: Samples representative; controls were used and were appropriate

2 Power is the probability of rejecting the null hypothesis when in fact it is false and the alternative hypothesis is correct. Power was maximized when: the study was designed to test contaminant-related effects; appropriate statistical tests were used and site data were compared to appropriate reference area data or regional background values.

High: All of the above
Medium: Some combination of the above (professional judgment)
Low: No statistical design was used
Data were collected RMA-wide

3 Relevance is pertinence to the matter at hand. Relevance was maximized when: endpoint(s) selected were consistent with potential contaminant effects; study was designed to measure the appropriate effect; study focused on sites of contamination; appropriate receptors were identified and investigated and measurement endpoint = assessment endpoint; Note that some studies may be relevant to only some COCs (e.g., eggshell thinning is relevant as an endpoint only for DDE).

High: All or most of the above
Medium: Some combination of the above (professional judgment)
Low: Study not designed to evaluate specific endpoint (effect measurement incidental to purpose of the study)
Study RMA-wide (did not focus on contaminated sites)

4 Study design not appropriate to power analysis

Table C.5-3 Significance of Statistical Comparisons of Selected Ecological Endpoints Between Control and Contaminated Areas

Species, Statistical Test and (Type)	N	Sample Location	$\bar{x}$	Significance	Source
Measurement Endpoint: Density					
Earthworm (No./M^2)					
	4	Off-post Control	2.5	0.01> p >0.001	ESE 1989
ANOVA (P)	5	On-post Control	56	0.05> p >0.01	
Kruskal-Wallis (NP)	5	On-post Treated	2.6		
Grasshopper (No./M^2)					
ANOVA (P)	26	Off-post Control		NS	ESE 1989
Kruskal-Wallis (NP)	10	On-post Control		NS	
Multiple Regression (P)	21	On-post Treated			
Aquatic Snails (No./M^2)					
One-way ANOVA (P)	10	Off-post Control A	563.1	0.001> p (1986, 1987)	ESE 1989
Kruskal-Wallis One-way	10	Off-post Control B	158.6	0.001> p (1986, 1987)	
ANOVA (NP)		On-post Treated			
	10	Lake Mary	118.2	0.001> p (1986, 1987)	
Multiple Regression (P)	10	Gun Club	258.9		
	10	Lake Derby	2.7		
	10	Lake Ladora	9.7		
	10	North Bog	60.1		
Prairie Dogs (No./ha)		Summer			
ANOVA (P)	5	Control W	27.2	NS	ESE 1989
Orthogonal Contrasts	9	Control E	16.22	NS	
	5	On-post Treated	17.6		
		Winter			
	5	Control W	23.5	NS	
	9	Control E	18.5	NS	
	5	On-post Treated	28.75		
Mule Deer (No./sq.mi)					
NA (NA)	5	RMA-wide	8	Total census;	MKE 1989a
	NA	Off-post Control[1]	5	conducted 5 times	
Cottontails (No./mi)					
T-test (P)	4	RMA-wide	0.52	NS	MKE 1989a
	4	Off-post Control	0.49		

P = parametric
NP = nonparametric
p = probability
$\bar{x}$ = mean

NA = not significant
N = # of samples
NA = not applicable
M^2 = square meter

WF = weedy forb
CWF = cheatgrass with weedy forbs
PCA = principal component analysis

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Table C.5-3 Significance of Statistical Comparisons of Selected Ecological Endpoints Between Control and Contaminated Areas

Species, Statistical Test and (Type)	N	Sample Location	$\bar{x}$	Significance	Source
Measurement Endpoint: Density					
Jackrabbits (No./mi)					
T-test (P)	4	RMA-wide	0.35	$p < 0.02$	MKE 1989a
	4	Off-post Control	1.23		
MKE Pheasants					
T-test (P)	20	RMA-wide	552	$p < 0.001$	MKE 1989a
	20	Off-post Control	108		
Measurement Endpoint: Nesting Success					
American Kestral-					
ANOVA (P)		Control	NA	Control vs. RMA:	ESE 1989
Kruskal-Wallis (NP)		RMA-wide		Clutch Size - NS	
		1982		Hatchlings/nest - NS	
		1983		Fledgling/Successful Nest - NS	
		1986		Fledgling/All nests - $p < 0.05$	
Meadowlark (No./plot)					
None for contamination	12	WF RMA	0.6	NA	MKE 1989a
PCA for habitat analysis	61	CWF RMA	0.8		
	6	WF RMA-Sec. 36	1		
	2	CWF RMA-Sec. 36	1		

P = parametric
NP = nonparametric
p = probability
$\bar{x}$ = mean

NA = not significant
N = # of samples
NA = not applicable
M^2 = square meter

WF = weedy forb
CWF = cheatgrass with weedy forbs
PCA = principal component analysis

Table C.5-4 Significant Statistical Comparisons of Tissue Concentrations Between Control and Contaminated Areas Where Ecological Endpoints Were Also Measured For Selected Species*

Species, Chemical-Tissue	Control vs. Contaminated	Onsite Control vs. Offsite Control	Contaminated Site 1 vs. Contaminated Site 2
Earthworms			
Arsenic	S	S	
Grasshoppers			
Aldrin			S
Dieldrin	HS		S
Endrin			S
Arsenic			S
Mallards (arsenic data not available)			
Dieldrin—eggs	VHS		
Dieldrin—fledglings	S		
Mercury—fledglings	S		
Pheasants			
Dieldrin—eggs	VHS		
Cottontails (DDT-DDE data not available)			
Dieldrin	S		
Prairie dogs (DDT-DDE data not available)			
Dieldrin**	VHS	VHS	VHS
American kestrel			
Dieldrin—egg	HS		
Dieldrin—fledgling	S		
Mercury***			

* Comparisons were made for aldrin, dieldrin, endrin, DDT, DDE, arsenic and mercury; only significant comparisons are listed.
S = significant ($0.05 \geq p > 0.01$)
HS = highly significant ($0.01 \geq p > 0.001$)
VHS = very highly significant ($0.001 \geq p$)

** Summer/winter differences were also significant in control (S) and contaminated areas (VHS)

*** Significant differences were found between eggs and fledglings irrespective of location (S)

Source: ESE 1989, Appendix B

Table C.5-5 Small Mammal Trapping Data from Fall 1986 and Spring 1987 on RMA and ESC Values for Trapping Locations

Site #	Species									Totals	Species Count	Trapping Success (percent)	Habitat Type	Aldrin/ Dieldrin ESC in ppm
	Vole		Deer	Mouse					Rat					
				Harvest		Northern Grass-hopper	Pocket		Ord's Kanga-roo					
	Prairie	Meadow		Plains	Western		Hispid	Silkey						
1	1		23							24	2	13	wf/g	1.250
2			88	8						96	2	53	wf/g	0.615
3			2							2	1	1	wf/g*	0.053
4			1							1	1	<1	npg	0
5	1									1	1	<1	wf/g*	0.008
6										0	0	0	wf/g	0.02
7			10							10	1	6	wf/g	–
8			3	3						6	2	3	wf/g	–
9			12			5				17	2	9	np	–
10						1				1	1	<1	npg	0
11			6							6	1	3	wf/g*	0.026
12			28							28	1	16	wf/g	0.121
13			7							7	1	4	wf/g	0.105
14			1							1	1	<1	wf/g*	0
15										0	0	0	wf/g	0.035
16		7	1	1						9	3	5	w	0.019
17			14							14	1	8	wf/g	0

wf/g = weedy forb/grasses
wf/g* = weedy forb/grasses/with crested wheatgrass
w = wetland
ut = upland tree
s/s = shrub succulent
npg = native perennial grasslands

Site #	Species									Totals	Species Count	Trapping Success (percent)	Habitat Type	Aldrin/ Dieldrin ESC in ppm
	Vole		Deer	Mouse					Rat					
				Harvest		Northern Grass-hopper	Pocket		Ord's Kanga-roo					
	Prairie	Meadow		Plains	Western		Hispid	Silkey						
18			25			6			2	33	3	18	s/s	–
19					4					4	1	2	s/s	0
20	1		1		2					4	3	3	w	0
21	19	41	8							68	3	34	w	0.019
22	5				2					7	2	5	ut	0.027
23	8		4		10		4	1		27	5	14	s/s	0
24		2	45		1				40	48	4	24	s/s	0.004
25			6		3					9	2	12	s/s	0.013
26		2	2		3					7	3	4	w	0.018
27			60							60	1	30	wf/g	0.283
28											0	0	s/s	0
29			1							1	1	1	w	–

wf/g = weedy forb/grasses
wf/g* = weedy forb/grasses/with crested wheatgrass
w = wetland
ut = upland tree
s/s = shrub succulent
npg = native perennial grasslands

Table C.5-6 Summary of American Kestrel Reproductive Results 1982–92[1]

		1982	1983	1986	1988	1990	1991	1992
Nest Attempts	RMA	17	24	21	17	21	26	24
	Off-site-N	21	14	9	5	9	12	5
	Off-site-F	14	8					
Clutch Size	RMA	4.59	4.75	4.81	5.00	4.56	5.00	4.54
	Off-site-N	4.67	4.93	4.78	5.00	4.89	4.91	5.00
	Off-site-F	4.71	4.75					
Percent of Nests Hatched	RMA	65	54	81	59	52	85	58
	Off-site-N	70	57	89	60	78	100	80
	Off-site-F	58	88					
Hatchlings/Nest	RMA	3.09	2.85	3.65	3.14	4.18	3.58	3.86
	Off-site-N	2.93	3.25	3.25	2.33	3.57	3.92	4.75
	Off-site-F	3.29	3.00					
Percent of Nests Fledged	RMA	38	50	71	70	73	81	58
	Off-site-N	60	50	89	100	86	92	60
	Off-site-F	38	86					
# Fledged Per Successful Nest	RMA	2.83	2.67	3.13	4.00	4.00	3.90	3.40
	Off-site-N	2.83	3.57	3.12	2.00	3.17	3.90	3.33
	Off-site-F	3.40	3.00					
# Fledged Per Nest Attempt	RMA	1.06	1.33	2.24	1.14	1.52	3.31	2.1
	Off-site-N	1.70	1.79	2.78	1.20	2.11	3.58	2.0
	Off-site-F	1.31	2.57					

Off-site-N = Sampling sites within 10 miles of RMA
Off-site-F = Sampling sites more than 40 milesfrom RMA

[1] Pre-1988 data from ESE 1989 and DeWeese, no date; 1988 and 1990 data from Stollar & Associates, 1992 (RLSA, 1992); 1991 data from USFWS 1992c; 1992 data from USFWS, no date.

Table C.5-7 Kestrel Reproductive Success Versus Contaminant Concentrations of Dieldrin and DDE

Nest Box Number	Dieldrin Egg Conc. in ppm		Dieldrin Juvenile Conc. in ppm		Dieldrin ESC in ppm	Clutch Size		Hatchlings per Nest		Fledglings per Nest	
	88	90	88	90	as of 3/93	88	90	88	90	88	90
RMA - Basin F Area											
113	ND	ND	1.6	ND	0.068	5	ND	5	ND	5	ND
114	1.3	ND	ND	ND	0.068	5	3	0	3	0	3
116	0.403	ND	1.8	ND	0.122	5	ND	5	ND	5	ND
RMA - Basin A Area											
123	ND	ND	ND	0.0336	0.113	ND	5	ND	5	ND	5
RMA - Lower Lakes Area											
136	ND	ND	ND	0.106	0.035	ND	4	ND	4	ND	4
138	ND	ND	ND	0.0328	0.025	5	4	5	4	5	4
RMA - Other Areas											
119	(Lt) 0.084	ND	0.51	ND	0.078	5	ND	5	ND	5	ND
122	ND	ND	ND	0.0748	0.14	ND	5	ND	5	ND	5
129	1.7	ND	1.3	0.072	0.097	5	4	4	4	4	4
134	0.788	ND	0.349	ND	0.018	5	ND	2	ND	0	ND
Off-post Control Areas											
081	(Lt) 0.084	ND	ND	(Lt) 0.018	NA	5	5	0	5	0	5
082	ND	ND	ND	(Lt) 0.018	NA	ND	5	ND	4	ND	4
096	(Lt) 0.084	ND	ND	ND	NA	5	ND	0	ND	0	ND
097	ND	ND	(Lt) 0.084	ND	NA	5	5	3	4	3	4
097	0.0859	ND	(Lt) 0.084	0.0226	NA	-	-	-	-	-	-
100	ND	ND	ND	(Lt) 0.018	NA	ND	5	ND	4	ND	4
102	(Lt) 0.084	ND	ND	ND	NA	ND	5	ND	5	ND	5
102A	ND	ND	0.115	0.0175	NA	5	5	4	5	4	5
103	(Lt) 0.084	ND	(Lt) 0.084	ND	NA	4	5	4	0	4	0

ESC = estimated soil concentrations
ND = no data
NA = not applicable

Table C.5-7 Kestrel Reproductive Success Versus Contaminant Concentrations of Dieldrin and DDE

Nest Box Number	DDE Egg Conc. 88	DDE Egg Conc. 90	DDE Juvenile Conc. 88	DDE Juvenile Conc. 90	DDE ESC in ppm as of 3/93	Clutch Size 88	Clutch Size 90	Hatchlings per Nest 88	Hatchlings per Nest 90	Fledglings per Nest 88	Fledglings per Nest 90
RMA - Basin F Area											
113	ND	ND	0.322	ND	0.01	5	ND	5	ND	5	ND
114	(Lt) 0.1	ND	ND	ND	0.01	5	3	0	3	0	3
116	(Lt) 0.1	ND	(Lt) 0.1	ND	0.007	5	ND	5	ND	5	ND
RMA - Basin A Area											
123	ND	ND	ND	(Lt) 0.063	0.006	ND	5	ND	5	ND	5
RMA - Lower Lakes Area											
136	ND	ND	ND	0.811	0.011	ND	4	ND	4	ND	4
138	ND	ND	ND	(Lt) 0.063	0.008	5	4	5	4	5	4
RMA - Other Areas											
119	(Lt) 0.1	ND	(Lt) 0.1	ND	0.043	5	ND	5	ND	5	ND
122	ND	ND	ND	(Lt) 0.063	0.01	ND	5	ND	5	ND	5
129	0.203	ND	0.275	0.0806	0.02	5	4	4	4	4	4
134	0.352	ND	(Lt) 0.1	ND	0.008	5	ND	2	ND	0	ND
Off-post Control Areas											
081	0.232	ND	ND	(Lt) 0.063	NA	5	5	0	5	0	5
082	ND	ND	ND	(Lt) 0.063	NA	ND	5	ND	4	ND	4
096	(Lt) 0.1	ND	ND	ND	NA	5	ND	0	ND	0	ND
097	ND	ND	0.227	ND	NA	5	5	3	4	3	4
097	0.117	ND	0.244	0.768	NA	ND	ND	ND	ND	ND	ND
100	ND	ND	ND	0.345	NA	ND	5	ND	4	ND	4
102	(Lt) 0.1	ND	ND	ND	NA	ND	5	ND	5	ND	5
102A	ND	ND	(Lt) 0.1	0.184	NA	5	5	4	5	4	5
103	(Lt) 0.1	ND	(Lt) 0.1	ND	NA	4	5	4	0	4	0

ESC = estimated soil concentrations
ND = no data
NA = not applicable

* 09-Feb-94 trr created on 10/05/93

Table C.5-8 ESC Values, Number of Young Observed, and Number of Young Branched from Great Horned Owl Nests Observed in 1991, 1992, and 1993

Nest Number	ESC in ppm	Number of Young	
		Observed	Branched
1991-1	0.032	3	2
-2	0.071	3	–
-3	0.058	3	2
-4	0.021	3	2
-5	0.035	2	–
-6	0.022	2	2
-7	8.678	3	3
-8	0.037	3	–
1992-1	0.011	2	2
-2	0.033	4	4
-3	0.096	2	0
-4	0.076	3	1
-5	0.055	3	3
-6	0.046	2	2
-7	0.045	3	3
-8	0.071	2	0
-9	0.035	3	3
-10	0.016	2	1
-11	0.033	3	2
1993-1	0.126	1	1
-2	0.005	0	0
-3	0.033	3	3
-4	0.035	2	2
-5	12.183	2	1
-6	0.081	2	2
-7	0.001	2	2
-8	0.024	2	2
-9	0.071	2	2
-10	0.151	3	3

Reproductive Parameters	1990	1991
Nest Attempts	23	33
Percent of Attempted Nests Fledged	87	100
Number Fledged/Nest Attempts	4.54	4.29

Table C.5-10 Number of Juvenile Burrowing Owls Associated with ESC Values at their 1990, 1991, 1992, and 1993 Nest Locations*

ESC in ppm	Number of Juveniles at Each Nest										Total Juveniles in ESC Category
	0	1	2	3	4	5	6	7	8	9	
> 0.05	21	1	9	9	18	17	13	6	4		98
0.05 < ≤ 0.125	12		3	7	4	3	5	4	1	1	40
0.125 < ≤ 0.5	2					1					3
0.5 < ≤ 1.0		1									1
1.0 < ≤ 5.0					1		1				2
5.0 < ≤ 7.0					1						1
7.0 < ≤ 12.0									1		1
12.0 < ≤ 14.0						1	1	1		1	4
Overall Total											150

*ESC based on a radius of 2874 feet

Table C.5-11 1990 Juvenile Burrowing Owl Aldrin/Dieldrin Tissue Concentrations versus Data from Closest Nest Location

Juvenile Burrowing Owl	Data from Closest Nest Location		
Sample Tag Number	Aldrin/Dieldrin Tissue Concentration	Aldrin/Dieldrin ESC Value	Number of Juveniles
B1367	0.0514	12.277	7
B1372**	0.2185	13.078	9
B1385**	0.1085	13.078	9
B1490	0.457	4.786	4
B1491	1.107	0.095	8

Breeding Bird Density	Rocky Mountain Arsenal		Buckley Air Force Base		Plains Conservation Center
	Crested Wheatgrass	Native Grassland	Crested Wheatgrass	Native Grassland	Native Grassland
Western Meadowlark	1.1	1.0	1.9	1.6	1.6
Horned Lark	0.2	0.7	0.4	0.9	0.9
Grasshopper Sparrow	1.1	0.3	1.6	1.0	1.8
Vesper Sparrow	0.1	0.0	0.4	0.6	0.9

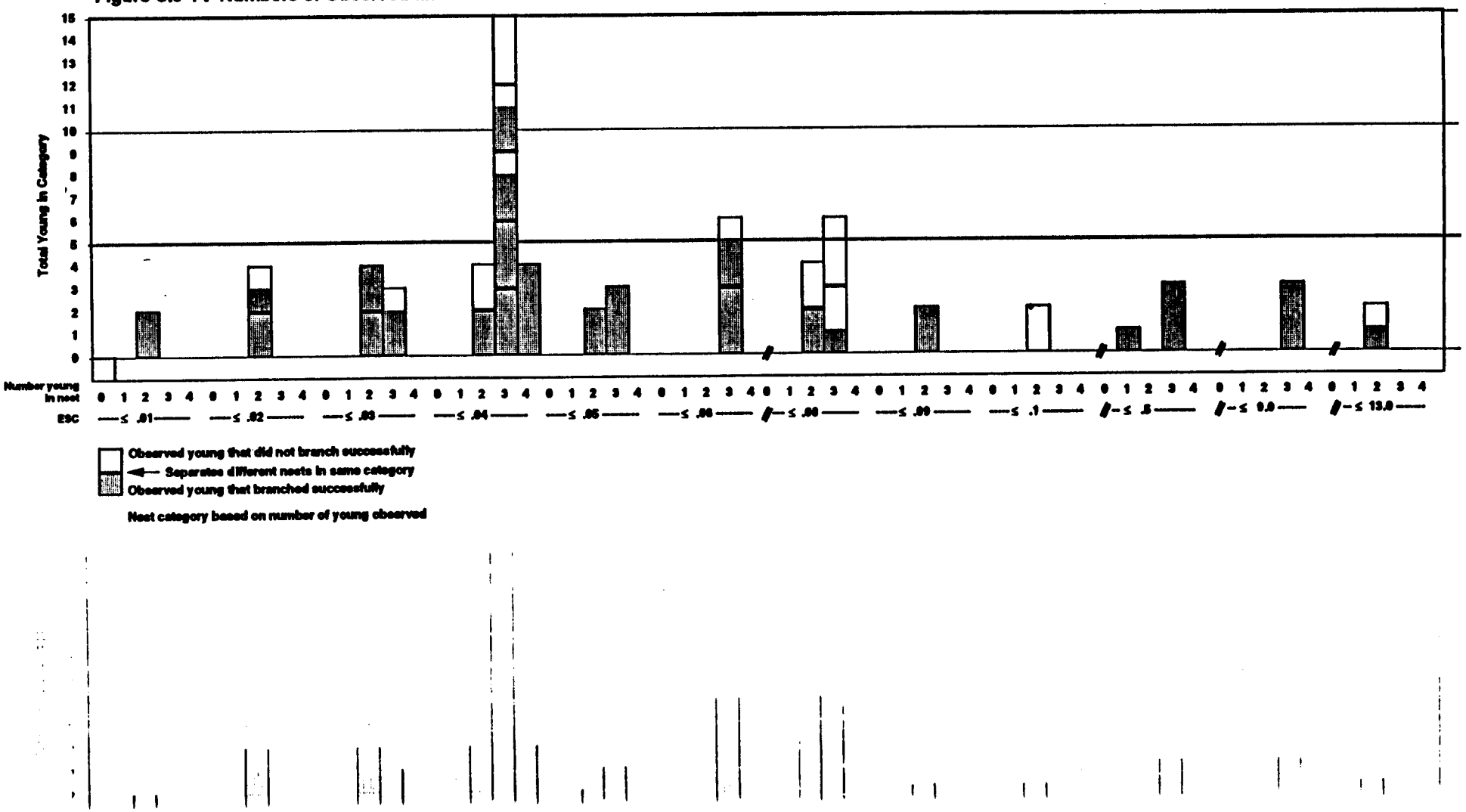
Table C.5-13 Descriptive Information Associated with Animal Mortality on RMA

Species	Comment
American Robin	Right testes discolored.
Meadowlark	Could not fly, emaciated, enlarged gut.
American Kestrel	Found dead in nest box #134 (sample ID #BU1288)
Red-tailed Hawk	Unable to fly, Bldg. 111, captured and caged; died within 5 hrs. of capture, see autopsy report; clenched feet, rested forward on breast while in cage. No apparent gross cause of death.
American Kestrel	Alive, unable to fly, being dive-bombed by other birds; taken into custody, died 1 day later, skull fractures; may have been incapacitated by something (not apparent at autopsy) other than sustained fracture.
Swainson's Hawk (juvenile fledgling)	Found dead after having been observed repeatedly along December 7th Avenue. Probable road kill. No food in crop/gizzard. No apparent aberrations.
Red-tailed Hawk	Found alive; euthanized by Boulder City Birds of Prey Foundation.
Great Horned Owl	Found dead near Bldg. 732.
Badger	Found dead near Section 36 decontamination pad, various tissue samples taken.
Brewer's Blackbird	In convulsions near a South Plants warehouse.
Ferruginous Hawk (adult)	Found dead in Section 25 NE, small amount of blood from nasal passages.
Great Horned Owl (adult)	Found dead in Section 1 NW at base of roost tree with several sticks clutched in talons; eyes gone; no wounds or obvious signs of ill health.
Ferruginous Hawk (adult)	Flew, crashed into a tree and was injured.
American Robin (adult)	Signs of neurological damage (unable to fly or control legs.
Red-tailed Hawk	Very small, no obvious wounds; tail and wings broken, emaciated; taken to Raptor Rehabilitation Center, died 12 hours later.
Rabbit (cottontail?)	Collected in Section 6 near warehouse; alive but weak, died 2 hours later.
Mourning Dove	Found alive but unable to fly, Road C at Bldg. 618.

Table C.5-13 Descriptive Information Associated with Animal Mortality on RMA

Species	Comment
Northern Pike (adult)	Collected by USFWS personnel; spinal deformity and large tumors at base of dorsal fin.
Bull Snake	Found dead one-half mile east of EBASCO base trailer on railroad tracks on December 7th Avenue; later analyzed.
Bldg. 111/112 Dead Bird Patrol	Interview with Dale Moore, Bldg. Groundskeeper: "Past 4 years regularly find dead birds under the trees, especially the clump north of Bldg. 112 parking lot."
Red-tailed Hawk	Found an adult at west side of Upper Derby Lake inlet; unable to fly and panting behavior observed; died later in the day; autopsy performed in Broomfield.
Mourning Dove	Collected an adult in Section 36; had two tumors, one next to beak and other on top of head.
Badger	Found resting, with shallow breathing, went into violent convulsions: twisting, jerking, heaving into air, gasping for breath, teeth gnashing and snarling. Convulsions subsided, followed by labored breathing and wide-eyed, glassy stare; animal attempted to stand, but fell over several times; eventually stood, but lacked complete balance, and charged observer.
Ring-necked Pheasant	Observed flying at full speed into Basin F liquid holding tank; died from impact, turned in for analysis.

Figure C.5-1 . Numbers of Observed and Branched Juvenile Great Horned Owls in Individual Nests and Collectively — by ESC Category



ATTACHMENT C.5-1

SPECIES OBSERVED OR POTENTIALLY PRESENT ON RMA

LIST OF TABLES

Table	
1	Birds Identified on RMA
2	Mammals Observed or Potentially Present on RMA
3	Fish Species Identified from the Study Area Lakes
4	Reptiles and Amphibians Observed or Potentially Present on RMA

Species[1]	Season of Occurrence[2]	Relative Abundance[3]	Habitat Preference[4]
Podicopedidae			
Pied-billed grebe *Podilymbus podiceps*	R	C	LP
Eared grebe *Podiceps nigricollis*	M	U	LP
Western grebe *Aechmophorus occidentalis*	M	U	LP
Pelecanidae			
American white pelican *Pelecanus erythrorhynchos*	S	U	LP
Phalacrocoracidae			
Double-crested cormorant *Phalacrocorax auritus*	S	U	LP
Ardeidae			
American bittern *Botaurus lentiginosus*	S	U	CT, LP
Great blue heron *Ardea herodias*	R	U	LP
Snowy egret *Egretta thula*	M	U	LP
Little blue heron *Egretta caerulea*	M	U	LP
Black-crowned night-heron *Nycticorax nycticorax*	S	U	CT, LP
Threskiornithidae			
White-faced ibis *Plegadis chihi*	M	U	LP
Anatidae			
Canada goose *Branta canadensis*	R	A	LP
Green-winged teal *Anas crecca*	S	C	LP

Species[1]	Season of Occurrence[2]	Relative Abundance[3]	Habitat Preference[4]
Mallard *Anas platyrhynchos*	R	A	LP
Northern pintail *Anas acuta*	S	C	LP
Blue-winged teal *Anas discors*	S	C	LP
Cinnamon teal *Anas cyanoptera*	S	U	LP
Northern shoveler *Anas clypeata*	S	C	LP
Gadwall *Anas strepera*	R	A	LP
American wigeon *Anas americana*	R	C	LP
Canvasback *Aythya valisineria*	M	U	LP
Redhead *Aythya americana*	R	C	LP
Ring-necked duck *Aythya collaris*	M	C	LP
Lesser scaup *Aythya affinis*	M	C	LP
Common goldeneye *Bucephala clangula*	M	U	CT, LP
Bufflehead *Bucephala albeola*	M	U	LP
Hooded merganser *Lophodytes cucullatus*	M	U	LP
Common merganser *Mergus merganser*	M	U	LP
Ruddy duck *Oxyura jamaicensis*	M	U	LP

Species[1]	Season of Occurrence[2]	Relative Abundance[3]	Habitat Preference[4]
Cathartidea			
Turkey vulture *Cathartes aura*	S	U	Ubiquitous
Accipitridae			
Osprey *Pandion haliaetus*	M	U	LP
Bald eagle *Haliaeetus leucocephalus*	W	C	RW, GL, WF
Northern harrier *Circus cyaneus*	R	U	GL
Sharp-shinned hawk *Accipiter striatus*	R	U	RW, UG
Cooper's hawk *Accipiter cooperii*	R	U	RW, UG
Swainson's hawk *Buteo swainsoni*	S	C	GL, UG, RW
Red-tailed hawk *Buteo jamaicensis*	S	U	RW, UG
Ferruginous hawk *Buteo regalis*	R	C	GL, WF
Rough-legged hawk *Buteo lagopus*	W	C	GL, WF
Golden eagle *Aquila chrysaetos*	W	U	GL, WF
American kestrel *Falco sparverius*	S	C	GL, WF, UG, RW
Prairie falcon *Falco mexicanus*	S	U	GL, WF
Phaseanadea			
Ring-necked pheasant *Phasianus colchicus*	R	A	WF, CT, RW
Rallidae			
Virginia rail *Rallus limicola*	S	U	CT

Species[1]	Season of Occurrence[2]	Relative Abundance[3]	Habitat Preference[4]
Sora *Porzana carolina*	S	U	CT
American coot *Fulica americana*	R	A	LP
Charadriidae			
Killdeer *Charadrius vociferus*	S	C	LP, GL
Recurvirostridae			
American avocet *Recurvirostra americana*	M	C	LP
Scolopacidae			
Greater yellowlegs *Tringa melanoleuca*	M	U	LP
Lesser yellowlegs *Tringa flavipes*	M	C	LP
Herring gull *Larus argentatus*	R	C	LP
Columbidae			
Rock dove *Columba livia*	R	U	AB
Mourning dove *Zenaida macroura*	R	C	Ubiquitous
Cuculidae			
Yellow-billed cuckoo *Coccyzus americanus*	S	U	RW
Strigidae			
Eastern screech-owl *Otus asio*	R	U	RW, UG
Great horned owl *Bubo virginianus*	R	C	RW, UG
Burrowing owl *Athene cunicularia*	S	A	GL, WF
Long-eared owl *Asio otus*	R	U	RW, UG

Species[1]	Season of Occurrence[2]	Relative Abundance[3]	Habitat Preference[4]
Short-eared owl *Asio flammeus*	W	U	GL, UG, ST
Caprimulgidae			
Common nighthawk *Chordeiles minor*	S	C	Ubiquitous
Apodidae			
Chimney swift *Chaetura pelagica*	S	U	AB
Alcedinidae			
Belted kingfisher *Ceryle alcyon*	S	U	LP
Picidae			
Red-headed woodpecker *Melanerpes erythrocephalus*	S	U	RW, UG
Yellow-bellied sapsucker *Sphyrapicus varius*	M	U	RW, UG
Downy woodpecker *Picoides pubescens*	R	C	RW, UG
Hairy woodpecker *Picoides villosus*	W	U	RW, UG
Northern flicker *Colaptes auratus*	R	C	RW, UG
Tyrannidae			
Western wood-pewee *Contopus sordidulus*	S	U	RW
Willow flycatcher *Empidonax traillii*	M	U	RW
Dusky flycatcher *Empidonax oberholseri*	M	U	RW, UG
Cordilleran flycatcher *Empidonax occidentalis*	S	U	RW
Say's phoebe *Sayornis saya*	S	U	GL, AB

Species[1]	Season of Occurrence[2]	Relative Abundance[3]	Habitat Preference[4]
Western kingbird *Tyrannus verticalis*	S	A	GL, UG
Eastern kingbird *Tyrannus tyrannus*	S	C	GL, UG
Alaudidae			
Horned lark *Eremophila alpestris*	R	A	GL, WF
Hirundinidae			
Tree swallow *Tachycineta bicolor*	M	U	RW
Violet-green swallow *Tachycineta thalassina*	S	U	RW
Northern rough-winged swallow *Stelgidopteryx serripennis*	S	U	RW, GL
Cliff swallow *Hirundo pyrrhonota*	S	U	RW, LP
Barn swallow *Hirundo rustica*	S	C	RW, LP, AB
Corvidae			
Blue jay *Cyanocitta cristata*	R	U	RW, UG
Black-billed magpie *Pica pica*	R	C	RW, UG
American crow *Corvus brachyrhynchos*	R	U	Ubiquitous
Paridae			
Black-capped chickadee *Parus atricapillus*	R	U	RW, UG
Sittidae			
Red-breasted nuthatch *Sitta canadensis*	W	U	RW, UG
White-breasted nuthatch *Sitta carolinensis*	W	U	RW, UG
Certhiidae			

Species[1]	Season of Occurrence[2]	Relative Abundance[3]	Habitat Preference[4]
Brown creeper *Certhia americana*	W	U	RW, UG
Troglodytidae			
House wren *Troglodytes aedon*	S	C	RW,UG
Marsh wren *Cistothorus palustris*	M	U	RW, GT
Muscicapidae			
(Sylviinae)			
Golden-crowned kinglet *Regulus satrapa*	W	U	RW, UG
Ruby-crowned kinglet *Regulus calendula*	M	U	RW, UG
(Turdinae)			
Mountain bluebird *Sialia currucoides*	M	U	GL, UG
Townsend's solitaire *Myadestes townsendi*	W	C	RW, UG
Swainson's thrush *Catharus ustulata*	M	U	RW
Hermit thrush *Catharus guttatus*	M	U	RW
American robin *Turdus migratorius*	R	C	UG, RW
Mimidae			
Gray catbird *dumetella carolinensis*	S	U	RW
Northern mockingbird *Mimus polyglottos*	R	U	UG, ST
Brown thrasher *Toxostoma rufum*	S	U	RW
Motacillidae			
American pipit *Anthus rafescens*	W	C	GL

Species[1]	Season of Occurrence[2]	Relative Abundance[3]	Habitat Preference[4]
Bombycillidae			
Cedar waxwing *Bombycilla cedrorum*	W	U	UG, RW
Laniidae			
Northern shrike *Lanius excubitor*	W	U	UG, GL
Loggerhead shrike *Lanius ludovicianus*	S	U	UG, GL
Sturnidae			
European starling *Sturnus vulgaris*	R	C	AB, RW, UG
Vireonidae			
Solitary vireo *Vireo solitarius*	M	U	RW, UG
Warbling vireo *Vireo gilvus*	S	C	RW
Red-eyed vireo *Vireo olivaceus*	S	U	RW
Emberizidae			
(Parulinae)			
Tennessee warbler *Vermivora peregrina*	M	U	RW, UG
Orange-crowned warbler *Vermivora celata*	M	C	RW, UG
Nashville warbler *Vermivora ruficapilla*	M	U	RW
Northern parula *Parula americana*	M	U	RW
Yellow warbler *Dendroica petechia*	S	C	RW, UG
Chestnut-sided warbler *Dendroica pensylvanica*	M	U	RW
Yellow-rumped warbler *Dendroica coronata*	M	C	RW, UG

Species[1]	Season of Occurrence[2]	Relative Abundance[3]	Habitat Preference[4]
Blackburnian warbler *Dendroica fusca*	M	U	RW
Blackpoll warbler *Dendroica fusca*	M	U	RW, UG
Black-and-white warbler *Mniotilta striata*	M	U	RW
American redstart *Setophaga ruticilla*	M	U	RW
Ovenbird *Seiurus aurocapillus*	M	U	RW
Northern waterthrush *Seiurus noveboracensis*	M	U	RW
MacGillivray's warbler *Oporornis tolmiei*	M	U	RW
Common yellowthroat *Geothlypis trichas*	S	U	CT, RW
Hooded warbler *Wilsonia citrina*	M	U	RW
Wilson's warbler *Wilsonia pusilla*	M	U	RW
Yellow-breasted chat *Icteria virens*	M	U	RW
Rose-breasted grosbeak *Pheucticus ludovicianus*	M	U	RW, UG
Black-headed grosbeak *Pheucticus melanacephalus*	S	U	RW
Blue grosbeak *Guiraca caerulea*	S	U	UG, GL
Lazuli bunting *Passerina amoena*	S	U	RW
Indigo bunting *Passerina cyanea*	S	C	RW
Dickcissel *Spiza americana*	M	U	GL

Species[1]	Season of Occurrence[2]	Relative Abundance[3]	Habitat Preference[4]
Rufous-sided towhee *Pipilo erythrophthalmus*	S	U	RW
Cassin's sparrow *Aimophila cassinii*	M	U	GL, ST
American tree sparrow *Spizella arborea*	W	A	RW, GL, WF
Chipping sparrow *Spizella passerina*	S	U	UG
Clay-colored sparrow *Spizella pallida*	M	U	WF
Bewer's sparrow *Spizella breweri*	M	U	ST
Vesper sparrow *Pooecetes gramineus*	S	C	GL, ST
Lark sparrow *Chondestes grammacus*	S	U	GL, ST, UG
Lark bunting *Calamospiza melanocorys*	S	U	GL
Savannah sparrow *Passerculus sandwichensis*	M	U	GL
Grasshopper sparrow *Ammodramus savannarum*	S	A	GL
Fox sparrow *Passerella iliaca*	M	U	RW
Song sparrow *Melospiza melodia*	R	C	RW, CT
Lincoln's sparrow *Melospiza lincolnii*	M	U	RW, CT
White-throated sparrow *Zonotrichia albicollis*	W	U	UG, WF
White-crowned sparrow *Zonotrichia leucophrys*	W	C	RW, UG, WF
Harris' sparrow *Zonotrichia querula*	W	U	UG, WF

Species[1]	Season of Occurrence[2]	Relative Abundance[3]	Habitat Preference[4]
Dark-eyed junco *Junco hyemalis*	W	A	RW, UG, WF
McCown's longspur *Calcarius mccownii*	M	U	GL
Chestnut-collared longspur *Calcarius ornatus*	M	U	GL
(Icterinae)			
Bobolink *Dolichonyx oryzivorus*	M	U	GL, CT
Red-winged blackbird *Agelaius phoeniceus*	S	C	CT, RW
Western meadowlark *Sturnella neglecta*	R	A	GL
Yellow-headed blackbird *Xanthocephalus xanthocephalus*	S	U	CT
Brewer's blackbird *Euphagus cyanocephalus*	R	C	RW, UG, WF
Common grackle *Quiscalus quiscula*	S	C	RW, UG
Brown-headed cowbird *Molothrus ater*	S	C	RW, UG
Northern oriole *Icterus galbula*	S	C	RW, UG
Fringillidae			
House finch *Carpodacus mexicanus*	R	C	RW, UG, AB
Pine siskin *Carduelis pinus*	W	C	RW, UG
Lesser goldfinch *Carduelis psaltria*	S	C	UG, WF
American goldfinch *Carduelis tristis*	S	U	UG, WF

Species[1]	Season of Occurrence[2]	Relative Abundance[3]	Habitat Preference[4]
Passeridae			
House sparrow *Passer domesticus*	R	C	AB, UG

[1] Nomenclature follows AOU (1983, and supplements)

[2]
- R Resident
- M Migrant
- W Winter
- S Summer

[3]
- A Abundant, regularly present in large numbers
- C Common, regularly present in moderate numbers
- U Unconmmon, regularly present in small numbers, or irregularly present

[4]
- RW Riparian woodland
- UG Upland groves or ornamentals
- LP Lakes and ponds
- CT Cattails or wet meadows
- GL Grasslands
- WF Weedy forbs
- ST Shrublands or thickets
- YU Yucca
- AB Abandoned buildings

Table 2 Mammals Observed or Potentially Present on RMA

Species[1]	Status[2]	Abundance[3]	Habitat[4]
Soricidae			
Masked shrew *Sorex cinereus*	ptl		
Least shrew *Cryptotis parva*	ptl		
Vespertilionidae			
Small-footed myotis *Myotis leibii*	ptl		
Silver-haired bat *Lasionycteris noctivagans*	ptl		
Big brown bat *Eptesicus fuscus*	ptl		
Hoary bat *Lasiurus cinereus*	ptl		
Leporidae			
Eastern cottontail *Sylvilagus floridanus*	obs	C	RW, WF
Desert cottontail *Sylvilagus auduboni*	obs	A	GL, YU, ST
Black-tailed jackrabbit *Lepus californicus*	obs	C	GL, YU, ST
White-tailed jackrabbit *Lepus townsendi*	obs	U	GL
Sciuridae			
Thirteen-lined ground squirrel *Spermophilus tridecemlineatus*	obs	U	GL, WF
Spotted ground squirrel *Spermophilus spilosoma*	obs	U	GL
Black-tailed prairie dog *Cynomys ludovicianus*	obs	A	GL, WF
Fox squirrel *Sciurus niger*	obs	C	RW
Geomyidae			

Species[1]	Status[2]	Abundance[3]	Habitat[4]
Northern pocket gopher *Thomomys talpoides*	ptl		
Plains pocket gopher *Geomys bursarius*	obs	A	GL, ST, WF
Heteromyidae			
Silky pocket mouse *Perognathus flavus*	obs	U	ST, GL
Olive-backed pocket mouse *Perognathus fasciatus*	ptl		
Hispid pocket mouse *Perognathus hispidus*	obs	U	ST, GL
Plains pocket mouse *Perognathus flavescens*	ptl		
Ord kangaroo rat *Dipodomys ordii*	obs	C	YU
Cricetidae			
Plains harvest mouse *Reithrodontomys montanus*	obs	C	WF, GL
Western harvest mouse *Reithrodontomys megalotis*	obs	C	ST
Deer mouse *Peromyscus maniculatus*	obs	A	Ubiquitous
Northern grasshopper mouse *Onychomys leucogaster*	obs	C	GL
Meadow vole *Microtus pennsylvanicus*	obs	C	CT, RW, GL
Prairie vole *Microtus ochrogaster*	obs	C	GL, RW, CT
Muskrat *Ondatra zibethica*	obs	C	LP
Zapodidae			
Meadow jumping mouse *Zapus hudsonius*	ptl		
Erethzontidae			

Species[1]	Status[2]	Abundance[3]	Habitat[4]
Porcupine *Erethizon dorsatum*	ptl		
Castoridae			
Beaver *Castor canadensis*	ptl		
Muridae			
Norway rat *Rattus norvegicus*	ptl		
House mouse *Mus musculus*	ptl		
Canidae			
Coyote *Canis latrans*	obs	C	Ubiquitous
Red fox *Vulpes fulva*	obs	U	Ubiquitous
Swift fox *Vulpes velox* (ESE 1989)		U	
Gray fox *Urocyon cinereoargenteus* (tracks)		U	
Procyonidae			
Raccoon *Procyon lotor*	obs	U	RW, CT
Mustelidae			
Short-tailed weasel *Mustela erminea*	ptl		
Long-tailed weasel *Mustela frenata*	ptl		
Mink *Mustela vison*	ptl		
Badger *Taxidea taxus*	obs	C	GL
Striped skunk *Mephitis mephitis*	obs	U	Ubiquitous
Cervidae			

Species[1]	Status[2]	Abundance[3]	Habitat[4]
Mule deer *Odocoileus hemionus*	obs	A	WR, RW, UG, ST
White-tailed deer *Odocoileus virginianus*	obs	C	RW, ST
Antilocapridae			
Pronghorn *Antilocapra americana*	ptl		

1 Nomenclature follows Armstrong (1972)

2
- obs Observed on the RMA
- ptl Potentially present on the RMA (Armstrong 1972)

3
- A Abundant, regularly present in large numbers
- C Common, regularly present in moderate numbers
- U Uncommon, regularly present in small numbers, or irregularly present

4
- RW Riparian woodland
- LP Lakes and ponds
- UG Upland groves or ornamentals
- CT Cattails or wet meadows
- GL Grasslands
- WF Weedy forbs
- ST Shrublands or thickets
- YU Yucca
- AB Abandoned buildings

Table 3 Fish Species Identified from the Study Area Lakes, 1987 [a]

Species	Lower Derby	Ladora	Mary	McKay[b]
Salmonidae				
Rainbow trout *Salmo gairdneri*				X
Cyprinidae				
Fathead minnow *Pimephales promelas*	X			
Bluntnose minnow *P. notatus*	X			
Common carp *Cyprinus carpio*	X	X	X	X
Catostomidae				
White sucker *Catostomus commersoni*				X
Ictaluridae				
Black bullhead *Ictalurus melas*	X	X		X
Channel catfish *I. punctatus*			X	X
Centrarchidae				
Bluegill *Lepomis macrochirus*	X	X	X	X
Green sunfish *L. cyanellus*	X	X		
Pumpkinseed *L. gibbosus*		X		X
Black crappie *Pomoxis nigromaculatus*			X	X
White crappie *P. annularis*				X
Largemouth bass *Micropterus salmoides*	X	X	X	X
Percidae				
Yellow perch *Perca flavescens*		X		X

Table 3 Fish Species Identified from the Study Area Lakes, 1987 [a]

Species	Lower Derby	Ladora	Mary	McKay[b]
Esocidae				
Northern pike *Esox lucius*	X	X		

Note:

[a] Samples were obtained by electrofishing
[b] Off–post reference lake, Adams County, Colorado

Table 4 Reptiles and Amphibians Observed or Potentially Present on RMA

Species[1]	Status[2]	Abundance[3]	Habitat[4]
Snakes			
Colubridae			
Plains garter snake *Thamnophis radix*	obs	U	Ubiquitous
Common garter snake *Thamnophis sirtalis*	obs	U	Moist areas
Western terrestrial garter snake *Thamnophis elegans*	obs	U	Moist areas
Lined snake *Tropidoclonion lineatum*	ptl		
Northern water snake *Nerodia sipedon*	ptl		
Western hognose snake *Heterodon nasicus*	obs	U	Sandy areas
Milk snake *Lampropeltis triangulum*	ptl		
Bullsnake *Pituophis melanoleucus*	obs	C	Ubiquitous
Smooth green snake *Opheodrys vernalis*	ptl		
Racer *Coluber constrictor*	obs	U	Ubiquitous
Coachwhip *Masticophis flagellum*	ptl		
Viperidae			
Western rattlesnake *Crotalus viridis*	obs	U	Uplands
Lizards			
Scincidae			
Many-lined skink *Eumeces multivirgatus*	obs	U	Wooded areas
Teiidae			
Six-lined racerunner *Cnemidophorus sexlineatus*	ptl		

Species[1]	Status[2]	Abundance[3]	Habitat[4]
Iguanidae			
Eastern fence lizard *Sceloporus undulatus*	ptl		
Short-horned lizard *Phrynosoma douglassi*	obs	U	Sandy areas
Lesser earless lizard *Holbrookia maculata*	obs	U	Sandy areas
FROGS			
Hylidae			
Northern chorus frog *Pseudacris triseriata*	obs	A	Wet areas
Ranidae			
Bullfrog *Rana catesbeiana*	obs	C	Lakes and ponds
Northern leopard frog *Rana pipiens*	obs	C	Wet areas
Toads			
Pelobatidae			
Plains spadefoot *Spea bombifrons*	obs	U	Wet areas
Bufonidae			
Woodhouse's toad *Bufo woodhousei*	obs	C	Wet areas
Great Plains toad *Bufo cognatus*	obs	U	Wet areas
Salamanders			
Ambystomatidae			
Tiger salamander *Ambystoma tigrinum*	obs	U	Lakes and ponds
Turtles			
Trionychidae			
Spiny softshell *Trionyx spiniferus*	ptl		

Table 4 Reptiles and Amphibians Observed or Potentially Present on RMA

Species[1]	Status[2]	Abundance[3]	Habitat[4]
Chelydridae			
Common snapping turtle *Chelydra serpentina*	ptl		
Emydidae			
Western box turtle *Terrapene ornata*	ptl		
Painted turtle *Chrysemys picta*	ptl		

1 Nomenclature follows Smith (1978), and Smith and Brodie (1982)

2 obs Observed on the RMA
ptl Potentially present on the RMA (Hammerson 1986)

3 A Abundant, regularly present in large numbers
C Common, regularly present in moderate numbers
U Uncommon, regularly present in small numbers, or irregularly present

ATTACHMENT C.5-2

CONTAMINANT LEVELS DETECTED IN INTENTIONAL SAMPLES, ON-POST CONTROL SAMPLES, AND OFF-POST CONTROL SAMPLES

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Note: These tables have been reproduced directly from the Biota Remedial Investigation Final Report (ESE 1989).

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Note: These tables have been reproduced directly from the Biota Comprehensive Monitoring Program Final Report (RLSA 1992).

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Note: These tables have been reproduced directly from the MKE (1989) report entitled Wildlife Resources of the Rocky Mountain Arsenal, Adams County, Colorado

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Note: These figures have been reproduced directly from the MKE (1989) report entitled Wildlife Resources of the Rocky Mountain Arsenal, Adams County, Colorado

Breeding Pairs of Raptors Monitored During 1993

Rocky Mountain Arsenal Vegetation Classification

Rocky Mountain Arsenal Prairie Dog Towns, July 1993

Note: These figures have been produced independently or have been extracted from informally published documents

Table 4.3-1. Contaminant Levels in Terrestrial Ecosystems - Terrestrial Program Samples (Page 1 of 2).

Species	Tissue	Location (Section)	Contaminant Level in parts per million (mg/kg wet weight basis)(Range/mean*)						
			Arsenic (n/nt)	Mercury (n/nt)	Aldrin (n/nt)	Dieldrin (n/nt)	Endrin (n/nt)	p,p-DDE (n/nt)	p,p-DDT (n/nt)
TERRESTRIAL PLANTS									
Morning Glory	Whole Plant	RMA, (26, 36)	<0.250-5.35 (1/5)	BDL (5)	BDL (5)	<0.046-0.084 (2/5)	BDL (5)	NRQ	NRQ
	Whole Plant	RMA Control (20)	BDL (1)	BDL (1)	BDL (1)	BDL (1)	BDL (1)	NRQ	NRQ
Sunflower	Flowers	RMA, Basin A	BDL (6)	BDL (6)	BDL (6)	BDL (6)	BDL (6)	NRQ	NRQ
	Flowers	RMA Control (19)	BDL (1)	BDL (1)	BDL (1)	BDL (1)	BDL (1)	NRQ	NRQ
	Leaves								
		RMA Basin A	<0.250-4.51 (4/5), 1.37	BDL (5)	BDL (5)	BDL (5)	BDL (5)	NRQ	NRQ
		RMA Basin C	BDL (1)	BDL (1)	BDL (1)	>0.300 (1)	0.188 (1)	NRQ	NRQ
	Leaves	RMA (19)	BDL (1)	BDL (1)	BDL (1)	BDL (1)	BDL (1)	NRQ	NRQ
INVERTEBRATES									
Earthworms	Whole	RMA, South Plants	BDL (1)	<0.050->2.35 (1/2)	BDL (1)	1.93 (1)	BDL (1)	BDL (1)	BDL (1)
	Whole	RMA Control (5)	0.618-1.53 (8/8) 1.03	<0.050-0.265 (2/8)	BDL (7)	<0.062-5.30 (1/7)	<0.080-0.914 (1/7)	BDL (8)	BDL (8)
	Whole	Offpost Control	BDL (2)	BDL (2)	BDL (1)	BDL (1)	BDL (1)	BDL (1)	BDL (1)
Grasshoppers	Whole	RMA Section 26	BDL (4)	BDL (4)	0.046-5.8 (4/4) 1.59	0.496-7.2 (4/4) 2.53	<0.064-1.65 (3/4) 0.528	BDL (4)	BDL (4)
		RMA Section 36	0.905-6.60 (4/4) 3.17	<0.050-0.108 (2/4) 0.058	BDL (4)	0.271-0.446 (4/4) 0.381	BDL (4)	BDL (4)	BDL (4)
		RMA Control (7, 8)	BDL (3)	BDL (3)	BDL (3)	BDL (3)	BDL (3)	BDL (3)	BDL (3)
		Offpost Control	BDL (2)	BDL (2)	BDL (2)	BDL (2)	BDL (2)	BDL (2)	BDL (2)
VERTEBRATES									
Mallard	Juvenile Carcass	RMA***	NRQ	<0.050-0.066 (2/3) 0.051	BDL (3)	<0.031-0.522 (2/3) 0.201	BDL (3)	<0.094-0.507 (1/3)	BDL (3)
	Adult Carcass	RMA	NRQ	BDL (8)	BDL (8)	<0.031-4.53 (3/8)	BDL (8)	BDL-0.360 (4/8) 0.239	BDL (8)
	Juvenile Carcass	Offpost Control	NRQ	BDL (6)	BDL (6)	BDL (6)	BDL (6)	BDL (6)	BDL (6)
	Adult Carcass	Offpost Control	NRQ	<0.050-0.061 (1/8)	BDL (8)	BDL (8)	BDL (8)	<0.094-1.02 (2/8)	BDL (8)
	Egg	RMA (1)	NRQ	0.173-0.185 (2/2) 0.179	BDL (2)	3.0-4.89 (2/2) 3.94	BDL (2)	0.606-0.919 (2/2) 0.762	BDL (2)
	Egg	Offpost Control	NRQ	<0.050-0.186 (5/10) 0.068	BDL (10)	BDL (10)	BDL (10)	<0.094-1.35 (6/10) 0.302	BDL (2)
Ring-necked pheasant	Juvenile Carcass	RMA	<0.250-1.82 (3/11)	BDL (11)	BDL (12)	<0.031-1.33 (5/12)	BDL (12)	BDL (11)	BDL (11)
	Adult Carcass	RMA	BDL (4)	BDL (4)	BDL (4)	<0.031-2.92 (3/4) 0.767	BDL (4)	BDL (3)	BDL (3)
	Juvenile Carcass	Offpost Control	<0.250-1.40 (2/11)	BDL (11)	BDL (14)	<0.031-18.6 (1/14)	BDL (14)	<0.094-1.34 (1/12)	BDL (12)
	Adult Carcass	Offpost Control	BDL (2)	BDL (2)	BDL (3)	BDL (3)	BDL (3)	BDL (2)	BDL (2)
	Egg	RMA	BDL (10)	BDL (11)	BDL (11)	<0.031-5.38 (9/11) 1.12	<0.40-0.143 (1/11)	BDL (10)	BDL (10)
	Muscle**	RMA	<0.250-4.07 (2/20)	BDL (20)	BDL (20)	<0.018-0.063 (2/20)	BDL (20)	BDL (20)	BDL (20)
		Offpost Control	BDL (2)	BDL (2)	BDL (2)	BDL (2)	BDL (2)	BDL (2)	BDL (2)

Table 4.3-1. Contaminant Levels in Terrestrial Ecosystems - Terrestrial Program Samples (Continued, Page 2 of 2).

Species	Tissue	Location (Section)	Contaminant Level in parts per million (mg/kg wet weight basis)(Range/Mean*)						
			Arsenic (n/nt)	Mercury (n/nt)	Aldrin (n/nt)	Dieldrin (n/nt)	Endrin (n/nt)	p,p-DDE (n/nt)	p,p-DDT (n/nt)
Ring-necked pheasant	Liver**	RMA	NRQ	NRQ	BDL (6)	<0.018-2.3 (4/6) 0.655	BDL-0.091 (1/6)	BDL-0.44 (1/6)	BDL
		Offpost Control	NRQ	NRQ	BDL (2)	BDL (2)	BDL (2)	BDL (2)	BDL
	Egg	Offpost Control	BDL (10)	BDL (11)	BDL (11)	BDL (11)	BDL (11)	BDL (10)	BDL (10)
American Kestrel	Juvenile Carcass	RMA	NRQ	BDL (10)	BDL (10)	<0.031-1.01 (6/10) 0.316	BDL (10)	<0.094-0.219 (1/10)	BDL (10)
	Juvenile Carcass	Offpost Control	NRQ	BDL (8)	BDL (8)	BDL (8)	BDL (8)	<0.094-0.733 (1/8)	BDL (8)
	Egg	RMA	NRQ	<0.050-0.405 (8/34)	BDL (33)	<0.031-3.63 (17/33) >0.512	BDL (33)	<0.094-1.25 (1/29)	BDL (29)
	Egg	Offpost Control	NRQ	<0.050-0.057 (1/11)	BDL (11)	BDL (11)	BDL (11)	<0.094-1.04 (2/11)	BDL (11)
Prairie Dog	Carcass	RMA (36) Summer	<0.250-0.741 (2/9)	BDL (9)	BDL (9)	0.233-13.4 (9/9) 2.03	BDL (9)	NRQ	NRQ
	Carcass	RMA (36) Winter	BDL (5)	BDL (5)	BDL (5)	0.119-6.18 (5/5) 1.44	BDL (5)	NRQ	NRQ
	Carcass	RMA, TSF	<0.250-4.22 (1/5)	BDL (5)	BDL (5)	0.064-0.155 (5/5) 0.114	BDL (5)	NRQ	NRQ
	Carcass	RMA Control Summer (19, 20)	BDL (9)	BDL (9)	BDL (9)	<0.031-0.346 (2/9)	BDL (9)	NRQ	NRQ
	Carcass	RMA Control Winter (20)	BDL (5)	BDL (5)	BDL (5)	<0.031-0.096 (1/5)	BDL (5)	NRQ	NRQ
	Carcass	Offpost Control Summer	BDL (9)	BDL (9)	BDL (8)	BDL (8)	BDL (8)	NRQ	NRQ
	Kidneys	RMA, (36) Winter	BDL (5)	<0.10-0.356 (3/5) 0.178	BDL (5)	<0.248-1.54 (2/5)	BDL (5)	NRQ	NRQ
Cottontail	Muscle	RMA, (36)	BDL (7)	BDL (7)	BDL (7)	<0.031-0.092 (3/7)	BDL (7)	NRQ	NRQ
	Muscle	RMA Control (19, 20)	BDL (7)	BDL (7)	BDL (7)	BDL (7)	BDL (7)	NRQ	NRQ
	Muscle	Offpost Control	BDL (7)	BDL (7)	BDL (7)	BDL (7)	BDL (7)	NRQ	NRQ
Mule Deer	Liver	RMA	BDL (14)	BDL (14)	BDL (14)	<0.031-0.187 (1/14)	BDL (14)	NRQ	NRQ
	Liver	Offpost Control	BDL (2)	BDL (2)	BDL (2)	BDL (2)	BDL (2)	NRQ	NRQ
	Muscle	RMA	BDL (14)	BDL (14)	BDL (14)	BDL (14)	BDL (14)	NRQ	NRQ
	Muscle	Offpost Control	BDL (2)	BDL (2)	BDL (2)	BDL (2)	BDL (2)	NRQ	NRQ

* Mean is calculated when 50 percent or more of samples have detectable contaminant levels. If less than 50 percent of samples have detectable contaminant levels, only the range of values are presented. When calculating the mean, values of ½ the detection limit are substituted for samples that are below detection limit.

BDL Below Detection Limit.

n = Number of samples analyzed that contain detectable contaminant levels, nt = total number of samples.

NRQ Not Requested.

** MKE Sample

*** For highly mobile species (mallard, pheasant, kestrel, mule deer) samples were widespread and RMA was evaluated as a whole entity.

Source: ESE, 1988

Table 4.3-4 Contaminant Levels in Terrestrial Ecosystems - Miscellaneous Samples: Samples ... nance and USFWS Supplemental Samples.

Species	Tissue	Location (Section)	Contaminant Level in parts per million (mg/kg wet weight basis)(Range/Mean*)						
			Arsenic (n/nt)	Mercury (n/nt)	Aldrin (n/nt)	Dieldrin (n/nt)	Endrin (n/nt)	p,p-DDE (n/nt)	p,p-DDT (n/nt)
Blue-winged teal	Liver	RMA Upper Derby	BDL (3)	0.371-1.64 (3/3) 1.07	BDL (3)	0.183-0.281 (3/3) 0.239	BDL (3)	BDL (3)	BDL (3)
	Muscle	RMA Upper Derby	BDL (3)	0.259-0.559 (3/3) 0.391	BDL (3)	0.090-0.164 (3/3) 0.127	BDL (3)	BDL (3)	BDL (3)
Redhead	Liver	RMA Upper Derby	BDL (5)	0.080-0.368 (5/5) 0.211	<0.030-0.088 (1/5)	0.307-0.747 (5/5) 0.458	<0.064-0.074(1/5)	<0.094-0.156(1/5)	BDL (5)
	Muscle	RMA Upper Derby	BDL (5)	<0.050-0.073 (2/5)	BDL (5)	0.117-0.320 (5/5) 0.203	BDL (5)	BDL (5)	BDL (5)
American Coot	Liver	RMA Upper Derby	BDL (9)	0.300-1.77 (9/9) 1.08	BDL (9)	<0.124-0.693 (8/9) 0.291	BDL (9)	BDL (9)	BDL (9)
	Muscle	RMA Upper Derby	BDL (9)	<0.050-0.339 (8/9) 0.179	BDL (9)	<0.062-1.77 (8/9) 0.53	BDL (9)	<0.940-0.313 (2/9)	BDL (9)
Mourning Dove	Carcass	RMA (35)	BDL (2)	BDL (2)	<0.633-1.83 (2/2) 1.23	5.57-56.3 (2/2) 30.9	<0.800-3.44 (1/2) 2.0	BDL (2)	BDL (2)
	Liver	RMA (1)	BDL (1)	BDL (1)	BDL (1)	7.37 (1)	3.74 (1)	BDL (1)	BDL (1)
Bald Eagle	Egg	Barr Lake	BDL	0.099	BDL (1)	0.808 (1)	BDL (1)	6.93 (1)	BDL (1)
Golden Eagle	Liver	RMA**	BDL (1)	<0.050-0.216 (1/2) 0.120	BDL (2)	<0.031-0.221 (1/2) 0.118	BDL (2)	BDL (2)	BDL (2)
	Brain	RMA	BDL (2)	<.098-.257 (2)	BDL (2)	BDL (2)	BDL (2)	BDL (2)	BDL (2)
Ferruginous Hawk	Liver	RMA	BDL (5)	<0.050-0.293 (1/5)	BDL (5)	0.263-4.79 (5/5) 2.66	BDL (5)	BDL (5)	BDL (5)
	Brain	RMA	BDL (5)	<0.050-0.152 (1/5)	BDL (5)	<0.238-9.98 (4/5) 5.07	BDL (5)	BDL (5)	BDL (5)
Red-tailed Hawk	Liver	RMA	BDL (3)	<0.050-0.345 (1/3)	BDL (3)	0.520-6.59 (3/3) 4.10	BDL (3)	<0.313-0.799 (2/3) 0.482	BDL (3)
	Brain	RMA	BDL (3)	<0.050-0.093 (1/3)	BDL (3)	<0.751-9.44 (2/3) 6.34	BDL (3)	BDL (3)	BDL (3)
Great-horned Owl	Liver	RMA	BDL (4)	<0.050-0.086 (2/4) 0.047	BDL (4)	0.143-27.7 (4/4) 11.88	BDL (4)	<0.094-15.5 (3/4) 5.88	BDL (4)
	Brain	RMA	BDL (4)	BDL (4)	BDL (4)	<0.175-15.6 (3/4) 8.80	BDL (4)	<0.529-10.3 (3/4) 3.32	BDL (4)
Northern Harrier	Egg	RMA	BDL (2)	BDL (2)	BDL (2)	0.303-0.676 (2) 0.49	BDL (2)	BDL (2)	BDL (2)
Coyote	Liver	RMA (25)	BDL (1)	BDL (1)	BDL (1)	7.60 (1)	BDL (1)	BDL (1)	BDL (1)
Badger	Liver	RMA (25)	BDL (1)	BDL (1)	BDL (1)	1.64 (1)	BDL (1)	NRQ	NRQ
	Kidneys	RMA (25)	NRQ	NRQ	BDL (1)	0.801 (1)	BDL (1)	NRQ	NRQ

* Mean is calculated when 50 percent or more of samples have detectable contaminant levels. If less than 50 percent of samples have detectable contaminant levels, only the range of values are presented. When calculating the mean, values of ½ the detection limit are substituted for samples that are below detection limit.

BDL Below Detection Limit.

n = Number of samples analyzed that contain detectable contaminant levels, nt = total number of samples.

NRQ Not Requested.

** For highly mobile species (mallard, pheasant, kestrel, mule deer) samples were widespread and RMA was evaluated as a whole entity.

Source: ESE, 1988

Table 4.3-3. Certified Reporting Limits for Biota Analysis Methods

USATHAMA Method Code	Matrix Type	Analyte	Certified Reporting Limit (ug/g)
B-6	Animals and Plants	Arsenic	0.250
C-6	Animals and Plants	Mercury	0.050
D-6	Plants	Aldrin	0.022
		Dieldrin	0.044
		Endrin	0.040
E-6A	Animals	Aldrin	0.020
		Dieldrin	0.031
		Endrin	0.040
F-6A	Animals	p,p'-DDE	0.094
		p,p'-DDT	0.289

Source: ESE, 1988a.

Table 4.3-4. Contaminant Levels in Black-Tailed Prairie Dogs Collected by MKE.

Tissue	Location (Section)	Contaminant Level in parts per million (mg/kg wet weight basis)(Range/Mean*)						
		Arsenic (n/nt)	Mercury (n/nt)	Aldrin (n/nt)	Dieldrin (n/nt)	Endrin (n/nt)	p,p-DDE (n/nt)	p,p-DDT (n/nt)
Muscle and Viscera	RMA (26)	BDL (2)	BDL (2)	BDL (2)	0.33-0.66 (2/2) 0.495	BDL (2)	BDL (2)	BDL (2)
	RMA (36)	BDL (4)	BDL (4)	BDL (4)	0.150-0.800 (4/4) 0.315	BDL (4)	BDL (4)	BDL (4)
	RMA (30)	BDL (4)	BDL (4)	BDL (4)	0.021-0.086 (4/4) 0.045	BDL (4)	BDL (4)	BDL (4)
	RMA (27)	BDL (2)	BDL (2)	BDL (2)	0.027-0.040 (2/2) 0.034	BDL (2)	BDL (2)	BDL (2)
	RMA (9)	BDL (4)	BDL (4)	BDL (4)	BDL (4)	BDL (4)	BDL (4)	BDL (4)
	Buckley	BDL (4)	BDL (4)	BDL (4)	BDL (4)	BDL (4)	BDL (4)	BDL (4)

* Mean is calculated when 50 percent or more of samples have detectable contaminant levels. If less than 50 percent of samples have detectable contaminant levels, only the range of values are presented. When calculating the mean, values of ½ the detection limit are substituted for samples that are below detection limit.

BDL Below Detection Limit.

n = Number of samples analyzed that contain detectable contaminant levels, nt = total number of samples.

Source: MKE, 1988.

Table 4.3-5. Contaminant Levels in Aquatic Ecosystems (page 1 of 2).

C-RMA-09D/MKEAQUA2.WK1
4/12/89

SPECIES	Tissue	Location	Contaminant Level in parts per million (mg/kg wet weight basis) (Range/mean*)						
			Arsenic (n/nt)	Mercury (n/nt)	Aldrin (n/nt)	Dieldrin (n/nt)	Endrin (n/nt)	DDE (n/nt)	p,p'-DDT (n)
AQUATIC PLANTS AND PLANKTON									
Plankton	Composite	RMA Lake Mary, 1986	<0.250-0.432 (1/3)	BDL (3)	BDL (3)	BDL (3)	BDL (3)	BDL (3)	BDL (3)
	Composite	RMA Lake Ladora, 1986	BDL (3)	BDL (3)	BDL (3)	BDL (3)	BDL (3)	BDL (3)	BDL (3)
	Composite	RMA Lower Derby, 1986	BDL (3)	BDL (3)	BDL (3)	BDL (3)	BDL (3)	BDL (3)	BDL (3)
	Composite	RMA North Bog, 1986	BDL (3)	BDL (3)	BDL (3)	BDL (3)	BDL (3)	BDL (3)	BDL (3)
Aquatic Macrophytes	Whole	RMA Lake Mary, 1986	0.465-0.782 (2/2)	BDL (2)	BDL (2)	BDL (2)	BDL (2)	BDL (2)	BDL (2)
	Whole	RMA Lake Ladora, 1986	BDL (2)	BDL (2)	BDL (2)	BDL (2)	BDL (2)	BDL (2)	BDL (2)
	Whole	RMA Lower Derby, 1986	BDL (2)	BDL (2)	BDL (2)	BDL (2)	BDL (2)	BDL (2)	BDL (2)
FISH									
Largemouth Bass	Fillet	Offpost Control 1988	BDL (5)	0.111-0.236 0.152 (5/5)	BDL (5)	BDL (5)	BDL (5)	BDL (5)	BDL (5)
	Remainder	Offpost Control 1988	BDL (5)	0.058-0.120 0.084 (5/5)	BDL (5)	BDL (5)	BDL (5)	BDL (5)	BDL (5)
	Compos. Whole	Offpost Control 1988	BDL (1)	0.084 (1)	BDL (1)	BDL (1)	BDL (1)	BDL (1)	BDL (1)
	Whole(Reconst.)	Offpost Control 1988	BDL (5)	0.086-0.157 0.375 (5/5)	BDL (5)	BDL (5)	BDL (5)	BDL (5)	BDL (5)
Largemouth Bass	Fillet	RMA Lower Derby 1988	BDL (5)	0.176-0.550 0.369 (5/5)	<0.020-0.044 (1/5)	<0.031-0.370 0.212 (4/5)	BDL (5)	<0.094-0.684 0.319 (4/5)	BDL (5)
	Remainder	RMA Lower Derby 1988	BDL (5)	0.190-0.319 0.250 (5/5)	<0.020-0.053 0.031 (4/5)	0.100-0.860 0.486 (5/5)	BDL (5)	0.101-0.839 0.593 (5/5)	BDL (5)
	Compos. Whole	RMA Lower Derby 1988	BDL (1)	0.098 (1)	BDL (1)	BDL (1)	BDL (1)	BDL (1)	BDL (1)
	Whole(Reconst.)	RMA Lower Derby 1988	BDL (5)	0.183-0.394 0.294 (5/5)	BDL (5)	0.067-0.644 0.375 (5/5)	BDL (5)	BDL (5)	BDL (5)
Largemouth Bass	Whole	RMA Lake Mary, 1986	BDL (3)	<0.050-0.101 0.066 (2/3)	BDL (3)	<0.031-0.115 (1/3)	BDL (3)	BDL (3)	BDL (3)
	Fillet	RMA Lake Mary, 1986	BDL (2)	<0.050-0.101 (1/2)	BDL (2)	BDL (2)	BDL (2)	BDL (2)	BDL (2)
	Whole	RMA Lake Ladora, 1986	BDL (3)	0.084-0.235 0.182 (3/3)	BDL (3)	<0.031-0.034 0.027 (2/3)	BDL (3)	BDL (3)	BDL (3)
Largemouth Bass	Whole	RMA Lower Derby, 1986	BDL (3)	<0.050-0.063 (1/3)	BDL (3)	<0.031-0.112 0.072 (2/3)	BDL (3)	BDL (3)	BDL (3)

Table 4.3-5. Contaminant Levels in Aquatic Ecosystems (page 2 of 2).

SPECIES	Tissue	Location	Contaminant Level in parts per million (mg/kg wet weight basis) (Range/mean*)						
			Arsenic (n/nt)	Mercury (n/nt)	Aldrin (n/nt)	Dieldrin (n/nt)	Endrin (n/nt)	DDE (n/nt)	p,p'-DDT (n)
Bluegill	Fillet	RMA Lake Mary, 1986	BDL (3)	<0.050-0.099 0.074 (2/3)	BDL (3)	<0.031-0.041 (1/3)	BDL (3)	BDL (3)	BDL (3)
	Whole	RMA Lake Mary, 1986	BDL (6)	<0.050-0.137 0.061 (3/6)	BDL (6)	<0.031-0.158 0.085 (5/6)	BDL (6)	BDL (6)	BDL (6)
Bluegill	Whole	RMA Lower Derby, 1988	BDL (6)	<0.050-0.091 0.056 (3/6)	BDL (6)	<0.031-0.129 0.074 (4/6)	BDL (6)	BDL (6)	BDL (6)
	Whole	RMA Lower Derby, 1986	BDL (3)	BDL (3)	BDL (3)	0.142-0.161 0.149 (3/3)	BDL (3)	BDL (3)	BDL (3)
Bluegill	Whole	RMA Lake Ladora, 1986	BDL (3)	0.059-0.124 0.084 (3/3)	BDL (3)	0.065-0.153 0.100 (3/3)	BDL (3)	BDL (3)	BDL (3)
Bluegill	Fillet	Offpost Control, 1988	BDL (5)	0.081-0.256 0.188 (5/5)	BDL (5)	BDL (5)	BDL (5)	BDL (5)	BDL (5)
	Remainder	Offpost Control, 1988	BDL (5)	<0.050-0.171 0.104 (4/5)	BDL (5)	BDL (5)	BDL (5)	BDL (5)	BDL (5)
	Compos.(Whole)	Offpost Control, 1988	BDL (2)	BDL (2)	BDL (2)	BDL (2)	BDL (2)	BDL (2)	BDL (2)
	Whole(Reconst.)	Offpost Control, 1988	BDL (5)	0.088-0.178 0.141 (5/5)	BDL (5)	BDL (5)	BDL (5)	BDL (5)	BDL (5)
Northern Pike	Fillet	RMA Lower Derby, 1986	BDL (3)	0.278-0.470 0.405 (3/3)	BDL (3)	BDL (3)	BDL (3)	BDL (3)	BDL (3)
	Fillet	RMA Lake Ladora, 1986	BDL (2)	0.289-0.366 (2/2)	BDL (2)	<0.031-0.044 (1/2)	BDL (2)	BDL (2)	BDL (2)
Fathead Minnows	Composite	RMA North Bog, 1986	BDL (1)	BDL (1)	BDL (1)	BDL (1)	BDL (1)	BDL (1)	BDL (1)
Black Bullhead	Whole	RMA Lower Derby, 1986	BDL (3)	<0.050-0.052 (1/3)	BDL (3)	0.085-0.209 0.144 (3/3)	BDL (3)	<0.094-0.098 (1/3)	BDL (3)

* Mean is calculated when 50 percent or more of samples (n > 2) have detectable contaminant levels. If less than 50 percent of samples have detectable contaminant levels, only the range of values are presented. When calculating the mean, values of 1/2 the detection limit are substituted for 'BDL'.

BDL = Below Detection Limit (Below Certified Reporting Limit).

n = Number of samples analyzed that contain detectable contaminants, nt = total number of samples.

Compos. (Whole) = A number of small fish in a composite sample.

Whole (Reconst.) = A sample comprised of a portion of the fillet and remainder samples reconstituted into a 'whole' sample.

Source: MKE, 1988 and ESE, 1988.

Table 5.1-3 Aldrin Statistical Results for Terrestrial Species Sampled for CMP, 1988 to 1990*

	Total # of Hits	Total # of Samples	Minimum Detected Conc (µg/g)	Maximum Detected Conc (µg/g)	USFWS Geometric Mean**	USFWS Geometric Variance**	USFWS Geometric Std Dev**
ACRI - grasshopper							
CMP-BSA 1	0	16	BCRL	BCRL	NA	NA	NA
2	0	15	BCRL	BCRL	NA	NA	NA
3	0	10	BCRL	BCRL	NA	NA	NA
4	0	10	BCRL	BCRL	NA	NA	NA
5	0	10	BCRL	BCRL	NA	NA	NA
11	0	3	BCRL	BCRL	NA	NA	NA
12	0	2	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	0	66	BCRL	BCRL	NA	NA	NA
Control	0	12	BCRL	BCRL	NA	NA	NA
AQCH - golden eagle (FORTUITOUS)							
Muscle	0	1	BCRL	BCRL	NA	NA	NA
Off RMA	0	1	BCRL	BCRL	NA	NA	NA
Liver	0	1	BCRL	BCRL	NA	NA	NA
Off RMA	0	1	BCRL	BCRL	NA	NA	NA
Brain	0	1	BCRL	BCRL	NA	NA	NA
Off RMA	0	1	BCRL	BCRL	NA	NA	NA
All Samples	0	3	BCRL	BCRL	NA	NA	NA
Off RMA							
ATCU - burrowing owl							
CMP-BSA 2	0	1	BCRL	BCRL	NA	NA	NA
3	0	1	BCRL	BCRL	NA	NA	NA
12	0	1	BCRL	BCRL	NA	NA	NA
RMA NEAR	0	4	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	0	7	BCRL	BCRL	NA	NA	NA
BRTE - cheatgrass							
CMP-BSA 1	0	12	BCRL	BCRL	NA	NA	NA
2	1	13	0.0754	0.0754	NC	NC	NC
3	0	10	BCRL	BCRL	NA	NA	NA
4	0	7	BCRL	BCRL	NA	NA	NA
5	0	13	BCRL	BCRL	NA	NA	NA
11	0	6	BCRL	BCRL	NA	NA	NA
12	1	4	0.254	0.254	NC	NC	NC
All RMA CMP-BSAs	2	65	0.0754	0.254	NC	NC	NC
Control	0	16	BCRL	BCRL	NA	NA	NA
BUJA - red-tailed hawk (FORTUITOUS)							
Muscle							
CMP-BSA 5	0	1	BCRL	BCRL	NA	NA	NA
13	0	1	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	0	2	BCRL	BCRL	NA	NA	NA
Liver							
CMP-BSA 5	0	1	BCRL	BCRL	NA	NA	NA
13	0	1	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	0	2	BCRL	BCRL	NA	NA	NA
All Samples							
CMP-BSA 5	0	2	BCRL	BCRL	NA	NA	NA
13	0	2	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	0	4	BCRL	BCRL	NA	NA	NA

*This table incorporates all available data for all samples (intentional and fortuitous) analyzed under the Biota CMP.

**The USFWS geometric mean includes nonhits and assigns them a value equal to one-half of the lower CRL; descriptive statistics are calculated only when 50% or more of the samples are hits.

BCRL = Below certified reporting limit. This value varied for different labs and in different years.

NA = Not applicable.

NC = Number of detections was less than 50% of the sample size and a mean was not calculated.

Table 5.1-3 Aldrin Statistical Results for Terrestrial Species Sampled for CMP, 1988 to 1990*

	Total # of Hits	Total # of Samples	Minimum Detected Conc (µg/g)	Maximum Detected Conc (µg/g)	USFWS Geometric Mean**	USFWS Geometric Variance**	USFWS Geometric Std Dev**
BURE - ferruginous hawk (FORTUITOUS)							
Muscle							
RMA NEAR	0	1	BCRL	BCRL	NA	NA	NA
Liver							
RMA NEAR	0	1	BCRL	BCRL	NA	NA	NA
All Samples							
RMA NEAR	0	2	BCRL	BCRL	NA	NA	NA
BUSW - Swainson's hawk (FORTUITOUS)							
Muscle							
RMA FAR	0	1	BCRL	BCRL	NA	NA	NA
Liver							
RMA FAR	0	1	BCRL	BCRL	NA	NA	NA
All Samples							
RMA FAR	0	2	BCRL	BCRL	NA	NA	NA
BUVI - great horned owl (FORTUITOUS)							
Muscle							
CMP-BSA 4	0	1	BCRL	BCRL	NA	NA	NA
5	0	1	BCRL	BCRL	NA	NA	NA
12	0	1	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	0	3	BCRL	BCRL	NA	NA	NA
Liver							
CMP-BSA 4	0	1	BCRL	BCRL	NA	NA	NA
5	0	1	BCRL	BCRL	NA	NA	NA
12	0	1	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	0	3	BCRL	BCRL	NA	NA	NA
Brain							
CMP-BSA 4	0	1	BCRL	BCRL	NA	NA	NA
5	0	1	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	0	2	BCRL	BCRL	NA	NA	NA
All Samples							
CMP-BSA 4	0	3	BCRL	BCRL	NA	NA	NA
5	0	3	BCRL	BCRL	NA	NA	NA
12	0	2	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	0	8	BCRL	BCRL	NA	NA	NA
COLE - ground beetles							
CMP-BSA 1	3	5	0.0151	0.330	0.0239	14.4	5.12
2	2	4	0.0160	0.0569	0.0140	2.87	2.79
5	0	1	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	5	10	0.0151	0.330	0.0170	5.59	3.71
Control	0	4	BCRL	BCRL	NA	NA	NA
CYLU - prairie dog							
CMP-BSA 1	0	44	BCRL	BCRL	NA	NA	NA
2	0	21	BCRL	BCRL	NA	NA	NA
3	0	19	BCRL	BCRL	NA	NA	NA
11	0	1	BCRL	BCRL	NA	NA	NA
12	0	5	BCRL	BCRL	NA	NA	NA
RMA NEAR	0	5	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	0	95	BCRL	BCRL	NA	NA	NA
Control	0	20	BCRL	BCRL	NA	NA	NA

*This table incorporates all available data for all samples (intentional and fortuitous) analyzed under the Biota CMP.

**The USFWS geometric mean includes nonhits and assigns them a value equal to one-half of the lower CRL; descriptive statistics are calculated only when 50% or more of the samples are hits.

BCRL = Below certified reporting limit. This value varied for different labs and in different years.

NA = Not applicable.

NC = Number of detections was less than 50% of the sample size and a mean was not calculated.

Table 5.1-3 Aldrin Statistical Results for Terrestrial Species Sampled for CMP, 1988 to 1990*

	Total # of Hits	Total # of Samples	Minimum Detected Conc (µg/g)	Maximum Detected Conc (µg/g)	USFWS Geometric Mean**	USFWS Geometric Variance**	USFWS Geometric Std Dev**
EUCY - Brewer's blackbird (FORTUITOUS)							
CMP-BSA 5	0	1	BCRL	BCRL	NA	NA	NA
FASP - kestrel							
Dressed carcass							
CMP-BSA 1	0	1	BCRL	BCRL	NA	NA	NA
2	0	1	BCRL	BCRL	NA	NA	NA
5	0	2	BCRL	BCRL	NA	NA	NA
RMA NEAR	0	6	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	0	10	BCRL	BCRL	NA	NA	NA
Control	0	9	BCRL	BCRL	NA	NA	NA
Egg							
CMP-BSA 2	0	1	BCRL	BCRL	NA	NA	NA
RMA NEAR	0	1	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	0	5	BCRL	BCRL	NA	NA	NA
Control	0	7	BCRL	BCRL	NA	NA	NA
All Samples	0	5	BCRL	BCRL	NA	NA	NA
CMP-BSA 1	0	1	BCRL	BCRL	NA	NA	NA
2	0	2	BCRL	BCRL	NA	NA	NA
5	0	3	BCRL	BCRL	NA	NA	NA
RMA NEAR	0	11	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	0	17	BCRL	BCRL	NA	NA	NA
Control	0	14	BCRL	BCRL	NA	NA	NA
FASP - kestrel (FORTUITOUS)							
Dressed carcass							
CMP-BSA 5	0	1	BCRL	BCRL	NA	NA	NA
13	0	1	BCRL	BCRL	NA	NA	NA
RMA NEAR	0	1	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	0	3	BCRL	BCRL	NA	NA	NA
HALE - bald eagle (FORTUITOUS)							
Muscle							
RMA NEAR	0	1	BCRL	BCRL	NA	NA	NA
Liver							
RMA NEAR	0	1	BCRL	BCRL	NA	NA	NA
Brain							
RMA NEAR	0	1	BCRL	BCRL	NA	NA	NA
All Samples							
RMA NEAR	0	3	BCRL	BCRL	NA	NA	NA
HEAN - sunflower							
CMP-BSA 1	2	12	0.0238	0.226	NC	NC	NC
2	1	13	0.105	0.105	NC	NC	NC
3	0	10	BCRL	BCRL	NA	NA	NA
4	0	10	BCRL	BCRL	NA	NA	NA
5	0	10	BCRL	BCRL	NA	NA	NA
11	0	3	BCRL	BCRL	NA	NA	NA
12	0	2	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	3	60	0.0238	0.226	NC	NC	NC
Control	0	15	BCRL	BCRL	NA	NA	NA

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NA = Not applicable.

NC = Number of detections was less than 50% of the sample size and a mean was not calculated.

Table 5.1-3 Aldrin Statistical Results for Terrestrial Species Sampled for CMP, 1988 to 1990*

	Total # of Hits	Total # of Samples	Minimum Detected Conc (µg/g)	Maximum Detected Conc (µg/g)	USFWS Geometric Mean**	USFWS Geometric Variance**	USFWS Geometric Std Dev**
KOIR - kochia							
CMP-BSA 1	1	5	0.0970	0.0970	NC	NC	NC
2	0	7	BCRL	BCRL	NA	NA	NA
3	0	4	BCRL	BCRL	NA	NA	NA
5	0	10	BCRL	BCRL	NA	NA	NA
11	0	3	BCRL	BCRL	NA	NA	NA
12	0	2	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	1	31	0.0970	0.0970	NC	NC	NC
Control	0	10	BCRL	BCRL	NA	NA	NA
LASE - wild lettuce							
CMP-BSA 1	0	7	BCRL	BCRL	NA	NA	NA
2	0	1	BCRL	BCRL	NA	NA	NA
3	0	2	BCRL	BCRL	NA	NA	NA
4	0	3	BCRL	BCRL	NA	NA	NA
5	0	1	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	0	14	BCRL	BCRL	NA	NA	NA
Control	0	3	BCRL	BCRL	NA	NA	NA
ODHE - mule deer							
Muscle							
CMP-BSA 1	0	1	BCRL	BCRL	NA	NA	NA
3	0	1	BCRL	BCRL	NA	NA	NA
4	0	1	BCRL	BCRL	NA	NA	NA
RMA FAR	0	1	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	0	4	BCRL	BCRL	NA	NA	NA
Control	0	1	BCRL	BCRL	NA	NA	NA
Liver							
CMP-BSA 1	0	1	BCRL	BCRL	NA	NA	NA
3	0	1	BCRL	BCRL	NA	NA	NA
4	0	1	BCRL	BCRL	NA	NA	NA
RMA FAR	0	1	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	0	4	BCRL	BCRL	NA	NA	NA
Control	0	1	BCRL	BCRL	NA	NA	NA
All Samples							
CMP-BSA 1	0	2	BCRL	BCRL	NA	NA	NA
3	0	2	BCRL	BCRL	NA	NA	NA
4	0	2	BCRL	BCRL	NA	NA	NA
RMA FAR	0	2	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	0	8	BCRL	BCRL	NA	NA	NA
Control	0	2	BCRL	BCRL	NA	NA	NA

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BCRL = Below certified reporting limit. This value varied for different labs and in different years.

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Table 5.1-3 Aldrin Statistical Results for Terrestrial Species Sampled for CMP, 1988 to 1990*

	Total # of Hits	Total # of Samples	Minimum Detected Conc (µg/g)	Maximum Detected Conc (µg/g)	USFWS Geometric Mean**	USFWS Geometric Variance**	USFWS Geometric Std Dev**
ODVI - white-tail deer							
Muscle							
CMP-BSA 5	0	2	BCRL	BCRL	NA	NA	NA
RMA FAR	0	1	BCRL	BCRL	NA	NA	NA
RMA NEAR	0	3	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	0	6	BCRL	BCRL	NA	NA	NA
Control	0	5	BCRL	BCRL	NA	NA	NA
Liver							
CMP-BSA 5	0	2	BCRL	BCRL	NA	NA	NA
RMA FAR	0	1	BCRL	BCRL	NA	NA	NA
RMA NEAR	0	3	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	0	6	BCRL	BCRL	NA	NA	NA
Control	0	5	BCRL	BCRL	NA	NA	NA
All Samples							
CMP-BSA 5	0	4	BCRL	BCRL	NA	NA	NA
RMA FAR	0	2	BCRL	BCRL	NA	NA	NA
RMA NEAR	0	6	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	0	12	BCRL	BCRL	NA	NA	NA
Control	0	10	BCRL	BCRL	NA	NA	NA
OLIG - earthworm							
CMP-BSA 1	0	6	BCRL	BCRL	NA	NA	NA
2	2	7	0.110	0.290	NC	NC	NC
3	0	7	BCRL	BCRL	NA	NA	NA
4	1	5	0.447	0.447	NC	NC	NC
5	0	13	BCRL	BCRL	NA	NA	NA
11	0	4	BCRL	BCRL	NA	NA	NA
12	0	3	BCRL	BCRL	NA	NA	NA
13	0	7	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	3	52	0.110	0.447	NC	NC	NC
Control	0	12	BCRL	BCRL	NA	NA	NA
PEMA - deer mouse							
CMP-BSA 1	1	15	0.700	0.700	NC	NC	NC
2	0	14	BCRL	BCRL	NA	NA	NA
3	3	11	0.119	0.337	NC	NC	NC
4	1	10	2.20	2.20	NC	NC	NC
5	1	15	0.410	0.410	NC	NC	NC
11	0	6	BCRL	BCRL	NA	NA	NA
12	0	4	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	6	75	0.119	2.20	NC	NC	NC
Control	0	15	BCRL	BCRL	NA	NA	NA

*This table incorporates all available data for all samples (intentional and fortuitous) analyzed under the Biota CMP.

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NA = Not applicable.

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Table 5.1-3 Aldrin Statistical Results for Terrestrial Species Sampled for CMP, 1988 to 1990*

	Total # of Hits	Total # of Samples	Minimum Detected Conc (µg/g)	Maximum Detected Conc (µg/g)	USFWS Geometric Mean**	USFWS Geometric Variance**	USFWS Geometric Std Dev**
PHCO - pheasant							
Dressed carcass							
CMP-BSA 2	0	10	BCRL	BCRL	NA	NA	NA
3	0	5	BCRL	BCRL	NA	NA	NA
4	0	1	BCRL	BCRL	NA	NA	NA
5	0	10	BCRL	BCRL	NA	NA	NA
11	0	3	BCRL	BCRL	NA	NA	NA
RMA FAR	0	12	BCRL	BCRL	NA	NA	NA
RMA NEAR	0	6	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	0	47	BCRL	BCRL	NA	NA	NA
Control	0	13	BCRL	BCRL	NA	NA	NA
Liver							
CMP-BSA 2	0	3	BCRL	BCRL	NA	NA	NA
3	0	5	BCRL	BCRL	NA	NA	NA
5	0	8	BCRL	BCRL	NA	NA	NA
11	0	1	BCRL	BCRL	NA	NA	NA
RMA FAR	0	12	BCRL	BCRL	NA	NA	NA
RMA NEAR	0	4	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	0	33	BCRL	BCRL	NA	NA	NA
Control	0	9	BCRL	BCRL	NA	NA	NA
All Samples							
CMP-BSA 2	0	13	BCRL	BCRL	NA	NA	NA
3	0	10	BCRL	BCRL	NA	NA	NA
4	0	1	BCRL	BCRL	NA	NA	NA
5	0	18	BCRL	BCRL	NA	NA	NA
11	0	4	BCRL	BCRL	NA	NA	NA
RMA FAR	0	24	BCRL	BCRL	NA	NA	NA
RMA NEAR	0	10	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	0	80	BCRL	BCRL	NA	NA	NA
Control	0	22	BCRL	BCRL	NA	NA	NA
PIME - bullsnake (FORTUITOUS)							
RMA NEAR	0	1	BCRL	BCRL	NA	NA	NA
PIPI - black-billed magpie (FORTUITOUS)							
CMP-BSA 13	0	1	BCRL	BCRL	NA	NA	NA
SPTR - thirteen-lined groundsquirrel							
CMP-BSA 1	0	2	BCRL	BCRL	NA	NA	NA
2	0	1	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	0	3	BCRL	BCRL	NA	NA	NA
STNE - western meadowlark							
CMP-BSA 2	0	8	BCRL	BCRL	NA	NA	NA
5	0	2	BCRL	BCRL	NA	NA	NA
12	0	10	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	0	5	BCRL	BCRL	NA	NA	NA
Control							
STNE - western meadowlark (FORTUITOUS)							
CMP-BSA 2	0	1	BCRL	BCRL	NA	NA	NA
12	0	1	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	0	2	BCRL	BCRL	NA	NA	NA

*This table incorporates all available data for all samples (intentional and fortuitous) analyzed under the Biota CMP.

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Table 5.1-3 Aldrin Statistical Results for Terrestrial Species Sampled for CMP, 1988 to 1990*

	Total # of Hits	Total # of Samples	Minimum Detected Conc (µg/g)	Maximum Detected Conc (µg/g)	USFWS Geometric Mean**	USFWS Geometric Variance**	USFWS Geometric Std Dev**
STVU - starling							
CMP-BSA 13	0	1	BCRL	BCRL	NA	NA	NA
SYAU - desert cottontail							
Dressed carcass							
CMP-BSA 1	0	3	BCRL	BCRL	NA	NA	NA
2	0	2	BCRL	BCRL	NA	NA	NA
3	0	2	BCRL	BCRL	NA	NA	NA
5	0	4	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	0	11	BCRL	BCRL	NA	NA	NA
Control	0	4	BCRL	BCRL	NA	NA	NA
Muscle							
CMP-BSA 1	0	3	BCRL	BCRL	NA	NA	NA
Liver							
CMP-BSA 1	0	3	BCRL	BCRL	NA	NA	NA
All Samples							
CMP-BSA 1	0	9	BCRL	BCRL	NA	NA	NA
2	0	2	BCRL	BCRL	NA	NA	NA
3	0	2	BCRL	BCRL	NA	NA	NA
5	0	4	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	0	17	BCRL	BCRL	NA	NA	NA
Control	0	4	BCRL	BCRL	NA	NA	NA
SYAU - desert cottontail (FORTUITOUS)							
Muscle	0	1	BCRL	BCRL	NA	NA	NA
CMP-BSA 1							
TATA - badger (FORTUITOUS)							
Muscle							
CMP-BSA 1	0	1	BCRL	BCRL	NA	NA	NA
Liver							
CMP-BSA 1	0	1	BCRL	BCRL	NA	NA	NA
Brain							
CMP-BSA 1	0	1	BCRL	BCRL	NA	NA	NA
Fat							
CMP-BSA 1	0	1	BCRL	BCRL	NA	NA	NA
Solid stomach contents							
CMP-BSA 1	0	1	BCRL	BCRL	NA	NA	NA
Liquid stomach contents							
CMP-BSA 1	0	1	BCRL	BCRL	NA	NA	NA
All Samples							
CMP-BSA 1	0	6	BCRL	BCRL	NA	NA	NA

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NA = Not applicable.

NC = Number of detections was less than 50% of the sample size and a mean was not calculated.

Table 5.1-3 Aldrin Statistical Results for Terrestrial Species Sampled for CMP, 1988 to 1990*

	Total # of Hits	Total # of Samples	Minimum Detected Conc (µg/g)	Maximum Detected Conc (µg/g)	USFWS Geometric Mean**	USFWS Geometric Variance**	USFWS Geometric Std Dev**
TUMI - American robin (FORTUITOUS)							
CMP-BSA 13	0	6	BCRL	BCRL	NA	NA	NA
ZEMA - mourning dove							
CMP-BSA 1	0	11	BCRL	BCRL	NA	NA	NA
2	1	13	0.0227	0.0227	NC	NC	NC
3	0	11	BCRL	BCRL	NA	NA	NA
4	0	16	BCRL	BCRL	NA	NA	NA
5	0	10	BCRL	BCRL	NA	NA	NA
11	0	1	BCRL	BCRL	NA	NA	NA
12	0	3	BCRL	BCRL	NA	NA	NA
RMA NEAR	0	3	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	1	68	0.0227	0.0227	NC	NC	NC
Control	0	10	BCRL	BCRL	NA	NA	NA
ZEMA - mourning dove (FORTUITOUS)							
CMP-BSA 13	1	4	1.30	1.30	NC	NC	NC

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NA = Not applicable.

NC = Number of detections was less than 50% of the sample size and a mean was not calculated.

Table 5.1-4 Dieldrin Statistical Results for Terrestrial Species Sampled for CMP, 1988 to 1990*

	Total # of Hits	Total # of Samples	Minimum Detected Conc (µg/g)	Maximum Detected Conc (µg/g)	USFWS Geometric Mean**	USFWS Geometric Variance**	USFWS Geometric Std Dev**
ACRI - grasshopper							
CMP-BSA 1	12	16	0.0568	1.20	0.171	4.19	3.31
2	13	15	0.0360	0.730	0.145	2.54	2.63
3	9	10	0.0466	2.60	0.353	8.89	4.39
4	6	10	0.172	3.10	0.125	32.7	6.47
5	1	10	0.0389	0.0389	NC	NC	NC
11	0	3	BCRL	BCRL	NA	NA	NA
12	0	2	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	41	66	0.0360	3.10	0.106	11.8	4.81
Control	0	12	BCRL	BCRL	NA	NA	NA
AQCH - golden eagle (FORTUITOUS)							
Muscle							
Off RMA	1	1	0.271	0.271	0.271	NA	NA
Liver							
Off RMA	0	1	BCRL	BCRL	NA	NA	NA
Brain							
Off RMA	0	1	BCRL	BCRL	NA	NA	NA
All Samples							
Control	1	3	0.271	0.271	NC	NC	NC
ATCU - burrowing owl							
CMP-BSA 2	1	1	0.102	0.102	0.102	NA	NA
3	1	1	0.130	0.130	0.130	NA	NA
12	1	1	0.0449	0.0449	0.0449	NA	NA
RMA NEAR	4	4	0.114	1.10	0.331	2.60	2.66
All RMA CMP-BSAs	7	7	0.0449	1.10	0.184	3.06	2.88
BRTE - cheatgrass							
CMP-BSA 1	8	12	0.0331	0.223	0.0593	2.78	2.75
2	8	13	0.0299	0.628	0.0559	3.77	3.16
3	6	9	0.0551	0.540	0.0734	5.97	3.81
4	4	7	0.0553	0.156	0.0458	2.87	2.79
5	2	13	0.145	0.145	NC	NC	NC
11	0	6	BCRL	BCRL	NA	NA	NA
12	0	4	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	28	64	0.0299	0.628	NC	NC	NC
Control	0	16	BCRL	BCRL	NA	NA	NA
BUJA - red-tailed hawk (FORTUITOUS)							
Muscle							
CMP-BSA 5	1	1	0.454	0.454	0.454	NA	NA
13	1	1	3.10	3.10	3.10	NA	NA
All RMA CMP-BSAs	2	2	0.454	3.10	1.19	6.33	3.89
Liver							
CMP-BSA 13	1	1	7.20	7.20	7.20	NA	NA
All Samples							
CMP-BSA 5	1	1	0.454	0.454	0.454	NA	NA
13	2	2	3.10	7.20	4.72	1.43	1.81
All RMA CMP-BSAs	3	3	0.454	7.20	2.16	7.44	4.12

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NA = Not applicable.

NC = Number of detections was less than 50% of the sample size and a mean was not calculated.

Table 5.1-4 Dieldrin Statistical Results for Terrestrial Species Sampled for CMP, 1988 to 1990*

	Total # of Hits	Total # of Samples	Minimum Detected Conc (µg/g)	Maximum Detected Conc (µg/g)	USFWS Geometric Mean**	USFWS Geometric Variance**	USFWS Geometric Std Dev**
BURE - ferruginous hawk (FORTUITOUS)							
Muscle							
RMA NEAR	1	1	11.0	11.0	11.0	NA	NA
Liver							
RMA NEAR	1	1	13.0	13.0	13.0	NA	NA
All Samples							
RMA NEAR	2	2	11.0	13.0	12.0	1.01	1.13
BUSW - Swainson's hawk (FORTUITOUS)							
Muscle							
RMA FAR	0	1	BCRL	BCRL	NA	NA	NA
Liver							
RMA FAR	0	1	BCRL	BCRL	NA	NA	NA
All Samples							
RMA FAR	0	2	BCRL	BCRL	NA	NA	NA
BUVI - great horned owl							
Egg							
CMP-BSA 5	1	1	7.00	7.00	7.00	NA	NA
RMA FAR	1	1	0.236	0.236	0.236	NA	NA
RMA NEAR	3	3	0.590	3.30	1.67	2.31	2.50
All RMA CMP-BSAs	5	5	0.236	7.00	1.50	6.53	3.93
BUVI - great horned owl (FORTUITOUS)							
Muscle							
CMP-BSA 4	1	1	0.178	0.178	0.178	NA	NA
5	1	1	2.60	2.60	2.60	NA	NA
12	1	1	8.10	8.10	8.10	NA	NA
All RMA CMP-BSAs	3	3	0.178	8.10	1.55	46.7	7.10
Liver							
CMP-BSA 5	1	1	25.0	25.0	25.0	NA	NA
All Samples							
CMP-BSA 4	1	1	0.178	0.178	0.178	NA	NA
5	2	2	2.60	25.0	8.06	13.0	4.96
12	1	1	8.10	8.10	8.10	NA	NA
All RMA CMP-BSAs	4	4	0.178	25.0	3.11	89.3	8.33
COLE - ground beetles							
CMP-BSA 1	5	5	0.132	8.00	1.24	18.6	5.52
2	4	4	0.217	2.19	1.01	2.96	2.83
5	1	1	0.215	0.215	0.215	NA	NA
All RMA CMP-BSAs	10	10	0.132	8.00	0.957	6.99	4.03
Control	2	4	0.0343	0.0368	0.0179	1.88	2.21
CYLU - prairie dog							
CMP-BSA 1	38	44	0.0425	4.00	0.167	5.19	3.61
2	17	20	0.0200	0.204	0.0589	1.95	2.27
3	15	18	0.0177	0.219	0.0438	2.43	2.57
11	0	1	BCRL	BCRL	NA	NA	NA
12	4	5	0.0296	0.125	0.0395	2.73	2.72
RMA NEAR	0	5	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	74	93	0.0177	4.00	0.0789	6.07	3.83
Control	0	20	BCRL	BCRL	NA	NA	NA

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**The USFWS geometric mean includes nonhits and assigns them a value equal to one-half of the lower CRL; descriptive statistics are calculated only when 50% or more of the samples are hits.

BCRL = Below certified reporting limit. This value varied for different labs and in different years.

NA = Not applicable.

NC = Number of detections was less than 50% of the sample size and a mean was not calculated.

Table 5.1-4 Dieldrin Statistical Results for Terrestrial Species Sampled for CMP, 1988 to 1990*

	Total # of Hits	Total # of Samples	Minimum Detected Conc (µg/g)	Maximum Detected Conc (µg/g)	USFWS Geometric Mean**	USFWS Geometric Variance**	USFWS Geometric Std Dev**
EUCY - Brewer's blackbird (FORTUITOUS)							
CMP-BSA 5	1	1	8.00	8.00	8.00	NA	NA
FASP - kestrel							
Dressed carcass							
CMP-BSA 1	1	1	0.0336	0.0336	0.0336	NA	NA
2	1	1	1.80	1.80	1.80	NA	NA
5	2	2	0.0328	0.106	0.0590	1.99	2.29
RMA NEAR	6	6	0.0720	1.60	0.355	6.12	3.84
All RMA CMP-BSAs	10	10	0.0328	1.80	0.230	12.2	4.86
Control	3	9	0.0175	0.115	NC	NC	NC
Egg							
CMP-BSA 2	1	1	0.403	0.403	0.403	NA	NA
5	3	4	0.788	1.70	0.520	18.5	5.52
RMA NEAR	4	5	0.403	1.70	0.494	9.02	4.41
All RMA CMP-BSAs	1	5	0.0859	0.0859	NC	NC	NC
Control							
All Samples							
CMP-BSA 1	1	1	0.0336	0.0336	0.0336	NA	NA
2	2	2	0.403	1.80	0.852	3.06	2.88
5	2	2	0.0328	0.106	0.0590	1.99	2.29
RMA NEAR	9	10	0.0720	1.70	0.413	7.51	4.14
All RMA CMP-BSAs	14	15	0.0328	1.80	0.297	10.8	4.67
Control	4	14	0.0175	0.115	NC	NC	NC
FASP - kestrel (FORTUITOUS)							
Dressed carcass							
CMP-BSA 5	1	1	3.70	3.70	3.70	NA	NA
13	1	1	1.70	1.70	1.70	NA	NA
RMA NEAR	1	1	0.461	0.461	0.461	1.05	1.26
All RMA CMP-BSAs	3	3	0.461	3.70	1.43	3.03	2.86
HALE - bald eagle (FORTUITOUS)							
Muscle							
RMA NEAR	1	1	0.276	0.276	0.276	NA	NA
						NA	NA
Liver							
RMA NEAR	1	1	0.109	0.109	0.109	NA	NA
						NA	NA
Brain							
RMA NEAR	1	1	0.112	0.112	0.112	NA	NA
All Samples							
RMA NEAR	3	3	0.109	0.276	0.150	1.32	1.70
HEAN - sunflower							
CMP-BSA 1	5	12	0.0443	0.670	NC	NC	NC
2	5	13	0.0321	0.355	NC	NC	NC
3	3	10	0.0417	0.194	NC	NC	NC
4	8	10	0.0425	0.159	0.0584	2.32	2.50
5	0	10	BCRL	BCRL	NA	NA	NA
11	0	3	BCRL	BCRL	NA	NA	NA
12	0	2	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	21	60	0.0321	0.670	NC	NC	NC
Control	0	15	BCRL	BCRL	NA	NA	NA

*This table incorporates all available data for all samples (intentional and fortuitous) analyzed under the Biota CMP.

**The USFWS geometric mean includes nonhits and assigns them a value equal to one-half of the lower CRL; descriptive statistics are calculated only when 50% or more of the samples are hits.

BCRL = Below certified reporting limit. This value varied for different labs and in different years.

NA = Not applicable.

NC = Number of detections was less than 50% of the sample size and a mean was not calculated.

Table 5.1-4 Dieldrin Statistical Results for Terrestrial Species Sampled for CMP, 1988 to 1990*

	Total # of Hits	Total # of Samples	Minimum Detected Conc (µg/g)	Maximum Detected Conc (µg/g)	USFWS Geometric Mean**	USFWS Geometric Variance**	USFWS Geometric Std Dev**
KOIR - kochia							
CMP-BSA 1	1	5	0.0853	0.0853	NC	NC	NC
2	1	7	0.110	0.110	NC	NC	NC
3	1	4	0.294	0.294	NC	NC	NC
5	1	10	0.0931	0.0931	NC	NC	NC
11	0	3	BCRL	BCRL	NA	NA	NA
12	0	2	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	4	31	0.0853	0.294	NC	NC	NC
Control	0	10	BCRL	BCRL	NA	NA	NA
LASE - wild lettuce							
CMP-BSA 1	3	7	0.0560	0.0860	NC	NC	NC
2	0	1	BCRL	BCRL	NA	NA	NA
3	2	2	0.120	0.336	0.201	1.70	2.07
4	2	3	0.0706	0.0743	0.0537	1.31	1.68
5	0	1	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	7	14	0.0560	0.336	0.0526	1.71	2.08
Control	0	3	BCRL	BCRL	NA	NA	NA
ODHE - mule deer							
Muscle							
CMP-BSA 1	0	1	BCRL	BCRL	NA	NA	NA
3	0	1	BCRL	BCRL	NA	NA	NA
4	0	1	BCRL	BCRL	NA	NA	NA
RMA FAR	0	1	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	0	4	BCRL	BCRL	NA	NA	NA
Control	0	1	BCRL	BCRL	NA	NA	NA
Liver							
CMP-BSA 1	1	1	0.101	0.101	0.101	NA	NA
3	1	1	0.172	0.172	0.172	NA	NA
4	0	1	BCRL	BCRL	NA	NA	NA
RMA FAR	0	1	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	2	4	0.101	0.172	0.0744	1.62	2.00
Control	0	1	BCRL	BCRL	NA	NA	NA
All Samples							
CMP-BSA 1	1	2	0.101	0.101	0.0651	1.47	1.86
3	1	2	0.172	0.172	0.0850	2.70	2.71
4	0	2	BCRL	BCRL	NA	NA	NA
RMA FAR	0	2	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	2	8	0.101	0.172	NC	NC	NC
Control	0	2	BCRL	BCRL	NA	NA	NA

*This table incorporates all available data for all samples (intentional and fortuitous) analyzed under the Biota CMP.

**The USFWS geometric mean includes nonhits and assigns them a value equal to one-half of the lower CRL; descriptive statistics are calculated only when 50% or more of the samples are hits.

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NC = Number of detections was less than 50% of the sample size and a mean was not calculated.

Table 5.1-4 Dieldrin Statistical Results for Terrestrial Species Sampled for CMP, 1988 to 1990*

	Total # of Hits	Total # of Samples	Minimum Detected Conc (µg/g)	Maximum Detected Conc (µg/g)	USFWS Geometric Mean**	USFWS Geometric Variance**	USFWS Geometric Std Dev**
ODVI - white-tail deer							
Muscle							
CMP-BSA 5	0	2	BCRL	BCRL	NA	NA	NA
RMA FAR	0	1	BCRL	BCRL	NA	NA	NA
RMA NEAR	0	3	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	0	6	BCRL	BCRL	NA	NA	NA
Control	0	5	BCRL	BCRL	NA	NA	NA
Liver							
CMP-BSA 5	0	2	BCRL	BCRL	NA	NA	NA
RMA FAR	0	1	BCRL	BCRL	NA	NA	NA
RMA NEAR	2	3	0.0282	0.0895	0.0283	3.74	3.15
All RMA CMP-BSAs	2	6	0.0282	0.0895	NC	NC	NC
Control	0	5	BCRL	BCRL	NA	NA	NA
All Samples							
CMP-BSA 5	0	4	BCRL	BCRL	NA	NA	NA
RMA FAR	0	2	BCRL	BCRL	NA	NA	NA
RMA NEAR	2	6	0.0282	0.0895	NC	NC	NC
All RMA CMP-BSAs	2	12	0.0282	0.0895	NC	NC	NC
Control	0	10	BCRL	BCRL	NA	NA	NA
OLIG - earthworm							
CMP-BSA 1	6	6	0.280	2.90	0.539	2.18	2.42
2	7	7	0.188	3.80	1.40	3.10	2.90
3	6	7	0.0583	0.950	0.203	4.52	3.42
4	5	5	0.175	3.20	0.952	3.76	3.16
5	11	13	0.0435	2.70	0.325	9.37	4.46
11	3	4	0.0240	0.111	0.0381	3.96	3.23
12	3	3	0.191	0.655	0.407	1.55	1.94
13	4	7	0.0275	0.250	0.0680	1.94	2.26
All RMA CMP-BSAs	45	52	0.0240	3.80	0.304	10.5	4.64
Control	0	12	BCRL	BCRL	NA	NA	NA
PEMA - deer mouse							
CMP-BSA 1	13	13	0.122	13.0	2.20	8.66	4.35
2	13	13	0.172	5.90	0.804	4.07	3.27
3	11	11	0.104	13.0	2.47	14.3	5.11
4	9	9	0.239	35.0	3.43	9.05	4.41
5	12	15	0.0304	6.60	0.349	21.0	5.73
11	1	6	0.0335	0.0335	NC	NC	NC
12	2	4	0.0208	0.113	0.0307	3.16	2.92
All RMA CMP-BSAs	61	71	0.0208	35.0	0.717	81.3	8.14
Control	2	15	0.0262	0.111	NC	NC	NC

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Table 5.1-4 Dieldrin Statistical Results for Terrestrial Species Sampled for CMP, 1988 to 1990*

	Total # of Hits	Total # of Samples	Minimum Detected Conc (µg/g)	Maximum Detected Conc (µg/g)	USFWS Geometric Mean**	USFWS Geometric Variance**	USFWS Geometric Std Dev**
PHCO - pheasant							
Dressed carcass							
CMP-BSA 2	9	10	0.0885	5.90	0.275	7.22	4.08
3	4	5	0.0544	0.190	0.0907	1.48	1.87
4	1	1	1.40	1.40	1.40	NA	NA
5	6	10	0.158	4.76	0.180	589	12.5
11	0	3	BCRL	BCRL	NA	NA	NA
RMA FAR	1	12	2.70	2.70	NC	NC	NC
RMA NEAR	0	6	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	21	47	0.0544	5.90	NC	NC	NC
Control	0	13	BCRL	BCRL	NA	NA	NA
Liver							
CMP-BSA 2	2	3	0.867	2.20	0.431	72.5	7.92
3	5	5	0.0282	0.646	0.277	5.25	3.62
5	6	8	0.165	5.95	0.326	82.2	8.16
11	0	1	BCRL	BCRL	NA	NA	NA
RMA FAR	2	12	0.151	0.180	NC	NC	NC
RMA NEAR	1	4	0.0247	0.0247	NC	NC	NC
All RMA CMP-BSAs	16	33	0.0247	5.95	NC	NC	NC
Control	0	9	BCRL	BCRL	NA	NA	NA
All Samples							
CMP-BSA 2	11	13	0.0885	5.90	0.305	9.35	4.46
3	9	10	0.0282	0.646	0.159	3.52	3.07
4	1	1	1.40	1.40	1.40	NA	NA
5	12	18	0.158	5.95	0.234	197	9.97
11	0	4	BCRL	BCRL	NA	NA	NA
RMA FAR	3	24	0.151	2.70	NC	NC	NC
RMA NEAR	1	10	0.0247	0.0247	NC	NC	NC
All RMA CMP-BSAs	37	80	0.0247	5.95	NC	NC	NC
Control	0	22	BCRL	BCRL	NA	NA	NA
PIME - bullsnake (FORTUITOUS)							
RMA NEAR	1	1	0.457	0.457	0.457	NA	NA
PIPI - black-billed magpie (FORTUITOUS)							
CMP-BSA 13	1	1	5.10	5.10	5.10	NA	NA
SPTR - thirteen-lined ground squirrel							
CMP-BSA 1	2	2	0.545	1.10	0.774	1.28	1.64
2	1	1	0.758	0.758	0.758	NA	NA
All RMA CMP-BSAs	3	3	0.545	1.10	0.769	1.13	1.42
STNE - western meadowlark							
CMP-BSA 2	8	8	0.0370	2.10	0.203	12.9	4.94
5	1	2	0.0618	0.0618	0.0236	6.40	3.91
All RMA CMP-BSAs	9	10	0.0370	2.10	0.132	20.4	5.68
Control	0	5	BCRL	BCRL	NA	NA	NA
STNE - western meadowlark (FORTUITOUS)							
CMP-BSA 2	1	1	4.40	4.40	4.40	NA	NA
12	1	1	6.50	6.50	6.50	NA	NA
All RMA CMP-BSAs	2	2	4.40	6.50	5.35	1.08	1.32
STVU - starling (FORTUITOUS)							
CMP-BSA 13	1	1	5.90	5.90	5.90	NA	NA

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NA = Not applicable.

NC = Number of detections was less than 50% of the sample size and a mean was not calculated.

	Total # of Hits	Total # of Samples	Minimum Detected Conc (µg/g)	Maximum Detected Conc (µg/g)	USFWS Geometric Mean**	USFWS Geometric Variance**	USFWS Geometric Std Dev**
SYAU - desert cottontail							
Dressed carcass							
CMP-BSA 1	2	3	0.374	0.525	0.202	6.55	3.94
2	2	2	2.70	6.00	4.02	1.38	1.76
3	2	2	0.273	1.50	0.640	4.27	3.34
5	2	4	0.0899	0.101	0.0633	1.25	1.61
All RMA CMP-BSAs	8	11	0.0899	6.00	0.281	22.1	5.81
Control	0	4	BCRL	BCRL	NA	NA	NA
Muscle							
CMP-BSA 1	0	3	BCRL	BCRL	NA	NA	NA
Liver							
CMP-BSA 1	3	3	0.562	2.20	1.28	1.69	2.06
All Samples							
CMP-BSA 1	5	9	0.374	2.20	0.222	16.4	5.32
2	2	2	2.70	6.00	4.02	1.38	1.76
3	2	2	0.273	1.50	0.640	4.27	3.34
5	2	4	0.0899	0.101	0.0633	1.25	1.61
All RMA CMP-BSAs	11	17	0.0899	6.00	0.263	22.3	5.82
Control	0	4	BCRL	BCRL	NA	NA	NA
SYAU - desert cottontail (FORTUITOUS)							
Liver							
CMP-BSA 1	1	1	0.890	0.890	0.890	NA	NA
TATA - badger (FORTUITOUS)							
Muscle							
CMP-BSA 1	1	1	1.20	1.20	1.20	NA	NA
Liver							
CMP-BSA 1	1	1	9.90	9.90	9.90	NA	NA
Brain							
CMP-BSA 1	1	1	0.321	0.321	0.321	NA	NA
Fat							
CMP-BSA 1	1	1	29.0	29.0	29.0	NA	NA
Solid stomach contents							
CMP-BSA 1	0	1	BCRL	BCRL	NA	NA	NA
Liquid stomach contents							
CMP-BSA 1	1	1	0.295	0.295	0.295	NA	NA
All Samples							
CMP-BSA 1	5	6	0.295	29.0	1.05	361	11.3
TUMI - American robin (FORTUITOUS)							
Dressed carcass							
CMP-BSA 13	6	6	1.20	19.0	8.02	2.94	2.83
ZEMA - mourning dove							
CMP-BSA 1	9	11	0.0179	8.00	0.0934	159	9.50
2	12	13	0.0271	3.81	0.267	37.3	6.70
3	8	11	0.127	2.00	0.142	39.6	6.81
4	11	16	0.0178	1.71	0.0676	54.6	7.39
5	3	10	0.0221	0.0667	NC	NC	NC
11	0	1	BCRL	BCRL	NA	NA	NA
12	2	3	0.0497	1.52	0.0879	917	13.6
RMA NEAR	0	3	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	45	68	0.0178	8.00	0.0739	68.3	7.81
Control	0	10	BCRL	BCRL	NA	NA	NA
ZEMA - mourning dove (FORTUITOUS)							
CMP-BSA 13	4	4	7.80	32.0	14.3	1.42	1.81

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NC = Number of detections was less than 50% of the sample size and a mean was not calculated.

Table 5.1-5 Endrin Statistical Results for Terrestrial Species Sampled for CMP, 1988 to 1990*

	Total # of Hits	Total # of Samples	Minimum Detected Conc (µg/g)	Maximum Detected Conc (µg/g)	USFWS Geometric Mean**	USFWS Geometric Variance**	USFWS Geometric Std Dev**
ACRI - grasshopper							
CMP-BSA 1	2	16	0.0423	0.155	NC	NC	NC
2	0	15	BCRL	BCRL	NA	NA	NA
3	0	10	BCRL	BCRL	NA	NA	NA
4	1	10	0.233	0.233	NC	NC	NC
5	1	10	0.0981	0.0981	NC	NC	NC
11	0	3	BCRL	BCRL	NA	NA	NA
12	0	2	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	4	66	0.0423	0.233	NC	NC	NC
Control	0	12	BCRL	BCRL	NA	NA	NA
AQCH - golden eagle (FORTUITOUS)							
Muscle							
Off RMA	0	1	BCRL	BCRL	NA	NA	NA
Liver							
Off RMA	0	1	BCRL	BCRL	NA	NA	NA
Brain							
Off RMA	0	1	BCRL	BCRL	NA	NA	NA
All Samples							
Off RMA	0	3	BCRL	BCRL	NA	NA	NA
ATCU - burrowing owl							
CMP-BSA 2	0	1	BCRL	BCRL	NA	NA	NA
3	0	1	BCRL	BCRL	NA	NA	NA
12	0	1	BCRL	BCRL	NA	NA	NA
RMA NEAR	1	4	0.0585	0.0585	NC	NC	NC
All RMA CMP-BSAs	1	7	0.0585	0.0585	NC	NC	NC
BRTE - cheatgrass							
CMP-BSA 1	0	12	BCRL	BCRL	NA	NA	NA
2	1	13	0.116	0.116	NC	NC	NC
3	0	10	BCRL	BCRL	NA	NA	NA
4	0	7	BCRL	BCRL	NA	NA	NA
5	1	13	0.0963	0.0963	NC	NC	NC
11	0	6	BCRL	BCRL	NA	NA	NA
12	0	4	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	2	65	0.0963	0.116	NC	NC	NC
Control	0	16	BCRL	BCRL	NA	NA	NA
BUJA - red-tailed hawk (FORTUITOUS)							
Muscle							
CMP-BSA 5	0	1	BCRL	BCRL	NA	NA	NA
13	0	1	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	0	2	BCRL	BCRL	NA	NA	NA
Liver							
CMP-BSA 5	0	1	BCRL	BCRL	NA	NA	NA
13	1	1	0.125	0.125	0.125	NA	NA
All RMA CMP-BSAs	1	2	0.125	0.125	0.0680	2.10	2.37
All Samples							
CMP-BSA 5	0	2	BCRL	BCRL	NA	NA	NA
13	1	2	0.125	0.125	0.0680	2.10	2.37
All RMA CMP-BSAs	1	4	0.125	0.125	NC	NC	NC

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NC = Number of detections was less than 50% of the sample size and a mean was not calculated.

Table 5.1-5 Endrin Statistical Results for Terrestrial Species Sampled for CMP, 1988 to 1990*

	Total # of Hits	Total # of Samples	Minimum Detected Conc (µg/g)	Maximum Detected Conc (µg/g)	USFWS Geometric Mean**	USFWS Geometric Variance**	USFWS Geometric Std Dev**
BURE - ferruginous hawk (FORTUITOUS)							
Muscle							
RMA NEAR	0	1	BCRL	BCRL	NA	NA	NA
Liver							
RMA NEAR	1	1	0.233	0.233	0.233	NA	NA
All Samples							
RMA NEAR	1	2	0.233	0.233	0.0928	5.44	3.67
BUSW - Swainson's hawk (FORTUITOUS)							
Muscle							
RMA FAR	0	1	BCRL	BCRL	NA	NA	NA
Liver							
RMA FAR	0	1	BCRL	BCRL	NA	NA	NA
All Samples							
RMA FAR	0	2	BCRL	BCRL	NA	NA	NA
BUVI - great horned owl							
Egg							
CMP-BSA 5	1	1	0.181	0.181	0.181	NA	NA
RMA FAR	0	1	BCRL	BCRL	NA	NA	NA
RMA NEAR	1	3	0.103	0.103	NC	NC	NC
All RMA CMP-BSAs	2	5	0.103	0.181	NC	NC	NC
BUVI - great horned owl (FORTUITOUS)							
Muscle							
CMP-BSA 4	0	1	BCRL	BCRL	NA	NA	NA
5	0	1	BCRL	BCRL	NA	NA	NA
12	0	1	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	0	3	BCRL	BCRL	NA	NA	NA
Liver							
CMP-BSA 5	1	1	0.386	0.386	0.386	NA	NA
Brain							
CMP-BSA 4	0	1	BCRL	BCRL	NA	NA	NA
12	0	1	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	0	2	BCRL	BCRL	NA	NA	NA
All Samples							
CMP-BSA 4	0	2	BCRL	BCRL	NA	NA	NA
5	1	2	0.386	0.386	0.120	15.6	5.25
12	0	2	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	1	6	0.386	0.386	0.0547	2.50	2.60
COLE - ground beetles							
CMP-BSA 1	3	5	0.0702	0.350	0.0716	6.97	4.03
2	3	4	0.0646	0.0975	0.0535	1.75	2.11
5	0	1	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	6	10	0.0646	0.350	0.0555	3.41	3.03
Control	0	4	BCRL	BCRL	NA	NA	NA

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NA = Not applicable.

NC = Number of detections was less than 50% of the sample size and a mean was not calculated.

Table 5.1-5 Endrin Statistical Results for Terrestrial Species Sampled for CMP, 1988 to 1990*

	Total # of Hits	Total # of Samples	Minimum Detected Conc (µg/g)	Maximum Detected Conc (µg/g)	USFWS Geometric Mean**	USFWS Geometric Variance**	USFWS Geometric Std Dev**
CYLU - prairie dog							
CMP-BSA 1	2	44	0.177	0.190	NC	NC	NC
2	0	21	BCRL	BCRL	NA	NA	NA
3	0	19	BCRL	BCRL	NA	NA	NA
11	0	1	BCRL	BCRL	NA	NA	NA
12	0	5	BCRL	BCRL	NA	NA	NA
RMA NEAR	0	5	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	2	95	0.177	0.190	NC	NC	NC
Control	0	20	BCRL	BCRL	NA	NA	NA
EUCY - Brewer's blackbird (FORTUITOUS)							
CMP-BSA 5	0	1	BCRL	BCRL	NA	NA	NA
FASP - kestrel							
Dressed carcass							
CMP-BSA 1	0	1	BCRL	BCRL	NA	NA	NA
2	0	1	BCRL	BCRL	NA	NA	NA
5	0	2	BCRL	BCRL	NA	NA	NA
RMA NEAR	0	6	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	0	10	BCRL	BCRL	NA	NA	NA
Control	0	9	BCRL	BCRL	NA	NA	NA
Egg							
CMP-BSA 2	0	1	BCRL	BCRL	NA	NA	NA
5	0	1	BCRL	BCRL	NA	NA	NA
RMA NEAR	0	5	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	0	7	BCRL	BCRL	NA	NA	NA
Control	0	5	BCRL	BCRL	NA	NA	NA
All Samples							
CMP-BSA 1	0	1	BCRL	BCRL	NA	NA	NA
2	0	2	BCRL	BCRL	NA	NA	NA
5	0	3	BCRL	BCRL	NA	NA	NA
RMA NEAR	0	11	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	0	17	BCRL	BCRL	NA	NA	NA
Control	0	14	BCRL	BCRL	NA	NA	NA
FASP - kestrel (FORTUITOUS)							
Dressed carcass							
CMP-BSA 5	0	1	BCRL	BCRL	NA	NA	NA
13	0	1	BCRL	BCRL	NA	NA	NA
RMA NEAR	0	1	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	0	3	BCRL	BCRL	NA	NA	NA
HALE - bald eagle (FORTUITOUS)							
Muscle							
RMA NEAR	0	1	BCRL	BCRL	NA	NA	NA
Liver							
RMA NEAR	0	1	BCRL	BCRL	NA	NA	NA
Brain							
RMA NEAR	0	1	BCRL	BCRL	NA	NA	NA
All Samples							
RMA NEAR	0	3	BCRL	BCRL	NA	NA	NA

*This table incorporates all available data for all samples (intentional and fortuitous) analyzed under the Biota CMP.
**The USFWS geometric mean includes nonhits and assigns them a value equal to one-half of the lower CRL; descriptive statistics are calculated only when 50% or more of the samples are hits.
BCRL = Below certified reporting limit. This value varied for different labs and in different years.
NA = Not applicable.
NC = Number of detections was less than 50% of the sample size and a mean was not calculated.

Table 5.1-5 Endrin Statistical Results for Terrestrial Species Sampled for CMP, 1988 to 1990*

	Total # of Hits	Total # of Samples	Minimum Detected Conc (µg/g)	Maximum Detected Conc (µg/g)	USFWS Geometric Mean**	USFWS Geometric Variance**	USFWS Geometric Std Dev**
HEAN - sunflower							
CMP-BSA 1	1	12	0.550	0.550	NC	NC	NC
2	1	13	0.114	0.114	NC	NC	NC
3	0	10	BCRL	BCRL	NA	NA	NA
4	0	10	BCRL	BCRL	NA	NA	NA
5	0	10	BCRL	BCRL	NA	NA	NA
11	0	3	BCRL	BCRL	NA	NA	NA
12	0	2	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	2	60	0.114	0.550	NC	NC	NC
Control	0	15	BCRL	BCRL	NA	NA	NA
KOIR - kochia							
CMP-BSA 1	1	5	0.0583	0.0583	NC	NC	NC
2	0	7	BCRL	BCRL	NA	NA	NA
3	0	4	BCRL	BCRL	NA	NA	NA
5	0	10	BCRL	BCRL	NA	NA	NA
11	0	3	BCRL	BCRL	NA	NA	NA
12	0	2	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	1	31	0.0583	0.0583	NC	NC	NC
Control	0	10	BCRL	BCRL	NA	NA	NA
LASE - wild lettuce							
CMP-BSA 1	0	7	BCRL	BCRL	NA	NA	NA
2	0	1	BCRL	BCRL	NA	NA	NA
3	0	2	BCRL	BCRL	NA	NA	NA
4	0	3	BCRL	BCRL	NA	NA	NA
5	0	1	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	0	14	BCRL	BCRL	NA	NA	NA
Control	0	3	BCRL	BCRL	NA	NA	NA
ODHE - mule deer							
Muscle							
CMP-BSA 1	0	1	BCRL	BCRL	NA	NA	NA
3	0	1	BCRL	BCRL	NA	NA	NA
4	0	1	BCRL	BCRL	NA	NA	NA
RMA FAR	0	1	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	0	4	BCRL	BCRL	NA	NA	NA
Control	0	1	BCRL	BCRL	NA	NA	NA
Liver							
CMP-BSA 1	0	1	BCRL	BCRL	NA	NA	NA
3	0	1	BCRL	BCRL	NA	NA	NA
4	0	1	BCRL	BCRL	NA	NA	NA
RMA FAR	0	1	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	0	4	BCRL	BCRL	NA	NA	NA
Control	0	1	BCRL	BCRL	NA	NA	NA
All Samples							
CMP-BSA 1	0	2	BCRL	BCRL	NA	NA	NA
3	0	2	BCRL	BCRL	NA	NA	NA
4	0	2	BCRL	BCRL	NA	NA	NA
RMA FAR	0	2	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	0	8	BCRL	BCRL	NA	NA	NA
Control	0	2	BCRL	BCRL	NA	NA	NA

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Table 5.1-5 Endrin Statistical Results for Terrestrial Species Sampled for CMP, 1988 to 1990*

	Total # of Hits	Total # of Samples	Minimum Detected Conc (µg/g)	Maximum Detected Conc (µg/g)	USFWS Geometric Mean**	USFWS Geometric Variance**	USFWS Geometric Std Dev**
ODVI - white-tail deer							
Muscle							
CMP-BSA 5	0	2	BCRL	BCRL	NA	NA	NA
RMA FAR	0	1	BCRL	BCRL	NA	NA	NA
RMA NEAR	0	3	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	0	6	BCRL	BCRL	NA	NA	NA
Control	0	5	BCRL	BCRL	NA	NA	NA
Liver							
CMP-BSA 5	0	2	BCRL	BCRL	NA	NA	NA
RMA FAR	0	1	BCRL	BCRL	NA	NA	NA
RMA NEAR	0	3	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	0	6	BCRL	BCRL	NA	NA	NA
Control	0	5	BCRL	BCRL	NA	NA	NA
All Samples							
CMP-BSA 5	0	4	BCRL	BCRL	NA	NA	NA
RMA FAR	0	2	BCRL	BCRL	NA	NA	NA
RMA NEAR	0	6	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	0	12	BCRL	BCRL	NA	NA	NA
Control	0	10	BCRL	BCRL	NA	NA	NA
OLIG - earthworm							
CMP-BSA 1	3	6	0.0603	0.120	0.0555	1.28	1.64
2	4	6	0.111	0.561	0.142	3.98	3.24
3	1	7	0.100	0.100	NC	NC	NC
4	1	5	0.107	0.107	NC	NC	NC
5	1	12	0.479	0.479	NC	NC	NC
11	0	4	BCRL	BCRL	NA	NA	NA
12	1	1	0.0485	0.0485	0.0485	1.55	1.94
13	0	7	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	11	48	0.0485	0.561	NC	NC	NC
Control	0	12	BCRL	BCRL	NA	NA	NA
PEMA - deer mouse							
CMP-BSA 1	2	15	0.0934	0.910	NC	NC	NC
2	0	14	BCRL	BCRL	NA	NA	NA
3	0	11	BCRL	BCRL	NA	NA	NA
4	0	10	BCRL	BCRL	NA	NA	NA
5	0	15	BCRL	BCRL	NA	NA	NA
11	0	6	BCRL	BCRL	NA	NA	NA
12	0	4	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	2	75	0.0934	0.910	NC	NC	NC
Control	0	15	BCRL	BCRL	NA	NA	NA

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Table 5.1-5 Endrin Statistical Results for Terrestrial Species Sampled for CMP, 1988 to 1990*

	Total # of Hits	Total # of Samples	Minimum Detected Conc (µg/g)	Maximum Detected Conc (µg/g)	USFWS Geometric Mean**	USFWS Geometric Variance**	USFWS Geometric Std Dev**
PHCO - pheasant							
Dressed carcass							
CMP-BSA 2	0	10	BCRL	BCRL	NA	NA	NA
3	0	5	BCRL	BCRL	NA	NA	NA
4	0	1	BCRL	BCRL	NA	NA	NA
5	0	10	BCRL	BCRL	NA	NA	NA
11	0	3	BCRL	BCRL	NA	NA	NA
RMA FAR	0	12	BCRL	BCRL	NA	NA	NA
RMA NEAR	0	6	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	0	47	BCRL	BCRL	NA	NA	NA
Control	0	13	BCRL	BCRL	NA	NA	NA
Liver							
CMP-BSA 2	0	3	BCRL	BCRL	NA	NA	NA
3	0	5	BCRL	BCRL	NA	NA	NA
5	0	8	BCRL	BCRL	NA	NA	NA
11	0	1	BCRL	BCRL	NA	NA	NA
RMA FAR	0	12	BCRL	BCRL	NA	NA	NA
RMA NEAR	0	4	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	0	33	BCRL	BCRL	NA	NA	NA
Control	0	9	BCRL	BCRL	NA	NA	NA
All Samples							
CMP-BSA 2	0	13	BCRL	BCRL	NA	NA	NA
3	0	10	BCRL	BCRL	NA	NA	NA
4	0	1	BCRL	BCRL	NA	NA	NA
5	0	18	BCRL	BCRL	NA	NA	NA
11	0	4	BCRL	BCRL	NA	NA	NA
RMA FAR	0	24	BCRL	BCRL	NA	NA	NA
RMA NEAR	0	10	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	0	80	BCRL	BCRL	NA	NA	NA
Control	0	22	BCRL	BCRL	NA	NA	NA
PIME - bullsnake (FORTUITOUS)							
RMA NEAR	0	1	BCRL	BCRL	NA	NA	NA
PIPI - black-billed magpie (FORTUITOUS)							
CMP-BSA 13	0	1	BCRL	BCRL	NA	NA	NA
SPTR - thirteen-lined ground squirrel							
CMP-BSA 1	0	1	BCRL	BCRL	NA	NA	NA
2	0	1	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	0	2	BCRL	BCRL	NA	NA	NA
STNE - western meadowlark							
CMP-BSA 2	1	8	0.0584	0.0584	NC	NC	NC
5	0	2	BCRL	BCRL	NA	NA	NA
12	1	10	0.0584	0.0584	NC	NC	NC
All RMA CMP-BSAs	0	5	BCRL	BCRL	NA	NA	NA
Control							
STNE - western meadowlark (FORTUITOUS)							
CMP-BSA 2	0	1	BCRL	BCRL	NA	NA	NA
12	1	1	0.130	0.130	0.130	NA	NA
All RMA CMP-BSAs	1	2	0.130	0.130	0.0694	2.20	2.43

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Table 5.1-5 Endrin Statistical Results for Terrestrial Species Sampled for CMP, 1988 to 1990*

	Total # of Hits	Total # of Samples	Minimum Detected Conc (µg/g)	Maximum Detected Conc (µg/g)	USFWS Geometric Mean**	USFWS Geometric Variance**	USFWS Geometric Std Dev**
STVU - starling (FORTUITOUS)							
CMP-BSA 13	1	1	0.394	0.394	0.394	NA	NA
SYAU - desert cottontail							
Dressed carcass							
CMP-BSA 1	0	3	BCRL	BCRL	NA	NA	NA
2	0	2	BCRL	BCRL	NA	NA	NA
3	0	2	BCRL	BCRL	NA	NA	NA
5	0	4	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	0	11	BCRL	BCRL	NA	NA	NA
Control	0	4	BCRL	BCRL	NA	NA	NA
Muscle							
CMP-BSA 1	0	3	BCRL	BCRL	NA	NA	NA
Liver							
CMP-BSA 1	0	3	BCRL	BCRL	NA	NA	NA
All Samples							
CMP-BSA 1	0	9	BCRL	BCRL	NA	NA	NA
2	0	2	BCRL	BCRL	NA	NA	NA
3	0	2	BCRL	BCRL	NA	NA	NA
5	0	4	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	0	17	BCRL	BCRL	NA	NA	NA
Control	0	4	BCRL	BCRL	NA	NA	NA
SYAU - desert cottontail (FORTUITOUS)							
Liver							
CMP-BSA 1	0	1	BCRL	BCRL	NA	NA	NA
TATA - badger (FORTUITOUS)							
Muscle							
CMP-BSA 1	0	1	BCRL	BCRL	NA	NA	NA
Liver							
CMP-BSA 1	0	1	BCRL	BCRL	NA	NA	NA
Brain							
CMP-BSA 1	0	1	BCRL	BCRL	NA	NA	NA
Fat							
CMP-BSA 1	0	1	BCRL	BCRL	NA	NA	NA
Solid stomach contents							
CMP-BSA 1	0	1	BCRL	BCRL	NA	NA	NA
Liquid stomach contents							
CMP-BSA 1	0	1	BCRL	BCRL	NA	NA	NA
All Samples							
CMP-BSA 1	0	6	BCRL	BCRL	NA	NA	NA

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NA = Not applicable.

NC = Number of detections was less than 50% of the sample size and a mean was not calculated.

Table 5.1-5 Endrin Statistical Results for Terrestrial Species Sampled for CMP, 1988 to 1990*

	Total # of Hits	Total # of Samples	Minimum Detected Conc (µg/g)	Maximum Detected Conc (µg/g)	USFWS Geometric Mean**	USFWS Geometric Variance**	USFWS Geometric Std Dev**
TUMI - American robin (FORTUITOUS)							
Dressed carcass							
CMP-BSA 13	3	6	0.100	0.980	0.103	5.94	3.80
ZEMA - mourning dove							
CMP-BSA 1	2	11	0.0651	0.218	NC	NC	NC
2	6	13	0.0732	0.338	NC	NC	NC
3	2	11	0.0529	0.102	NC	NC	NC
4	1	16	0.253	0.253	NC	NC	NC
5	0	10	BCRL	BCRL	NA	NA	NA
11	0	1	BCRL	BCRL	NA	NA	NA
12	1	3	0.0779	0.0779	NC	NC	NC
RMA NEAR	0	3	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	12	68	0.0529	0.338	NC	NC	NC
Control	0	10	BCRL	BCRL	NA	NA	NA
ZEMA - mourning dove (FORTUITOUS)							
CMP-BSA 13	2	4	0.316	1.30	0.154	21.0	5.73

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**The USFWS geometric mean includes nonhits and assigns them a value equal to one-half of the lower CRL; descriptive statistics are calculated only when 50% or more of the samples are hits.

BCRL = Below certified reporting limit. This value varied for different labs and in different years.

NA = Not applicable.

NC = Number of detections was less than 50% of the sample size and a mean was not calculated.

Table 5.1-6 DDT Statistical Results for Terrestrial Species Sampled for CMP, 1988 to 1990*

	Total # of Hits	Total # of Samples	Minimum Detected Conc (µg/g)	Maximum Detected Conc (µg/g)	USFWS Geometric Mean**	USFWS Geometric Variance**	USFWS Geometric Std Dev**
ACRI - grasshopper							
CMP-BSA 1	0	16	BCRL	BCRL	NA	NA	NA
2	1	15	0.143	0.143	NC	NC	NC
3	0	10	BCRL	BCRL	NA	NA	NA
4	1	10	0.182	0.182	NC	NC	NC
5	0	10	BCRL	BCRL	NA	NA	NA
11	1	3	0.134	0.134	NC	NC	NC
12	0	2	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	3	66	0.134	0.182	NC	NC	NC
Control	0	12	BCRL	BCRL	NA	NA	NA
AQCH - golden eagle (FORTUITOUS)							
Muscle							
Off RMA	0	1	BCRL	BCRL	NA	NA	NA
Liver							
Off RMA	0	1	BCRL	BCRL	NA	NA	NA
Brain							
Off RMA	0	1	BCRL	BCRL	NA	NA	NA
All Samples							
Off RMA	0	3	BCRL	BCRL	NA	NA	NA
ATCU - burrowing owl							
CMP-BSA 2	0	1	BCRL	BCRL	NA	NA	NA
3	0	1	BCRL	BCRL	NA	NA	NA
12	0	1	BCRL	BCRL	NA	NA	NA
RMA NEAR	0	4	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	0	7	BCRL	BCRL	NA	NA	NA
BRTE - cheatgrass							
CMP-BSA 1	0	12	BCRL	BCRL	NA	NA	NA
2	0	13	BCRL	BCRL	NA	NA	NA
3	0	10	BCRL	BCRL	NA	NA	NA
4	0	7	BCRL	BCRL	NA	NA	NA
5	1	13	0.117	0.117	NC	NC	NC
11	0	6	BCRL	BCRL	NA	NA	NA
12	1	4	0.118	0.118	NC	NC	NC
All RMA CMP-BSAs	2	65	0.117	0.118	NC	NC	NC
Control	0	16	BCRL	BCRL	NA	NA	NA
BUJA - red-tailed hawk (FORTUITOUS)							
Muscle							
CMP-BSA 5	0	1	BCRL	BCRL	NA	NA	NA
13	0	1	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	0	2	BCRL	BCRL	NA	NA	NA
Liver							
CMP-BSA 5	0	1	BCRL	BCRL	NA	NA	NA
13	0	1	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	0	2	BCRL	BCRL	NA	NA	NA
All Samples							
CMP-BSA 5	0	2	BCRL	BCRL	NA	NA	NA
13	0	2	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	0	4	BCRL	BCRL	NA	NA	NA

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NC = Number of detections was less than 50% of the sample size and a mean was not calculated.

Table 5.1-6 DDT Statistical Results for Terrestrial Species Sampled for CMP, 1988 to 1990*

	Total # of Hits	Total # of Samples	Minimum Detected Conc (µg/g)	Maximum Detected Conc (µg/g)	USFWS Geometric Mean**	USFWS Geometric Variance**	USFWS Geometric Std Dev**
BURE - ferruginous hawk (FORTUITOUS)							
Muscle							
RMA NEAR	0	1	BCRL	BCRL	NA	NA	NA
Liver							
RMA NEAR	0	1	BCRL	BCRL	NA	NA	NA
All Samples							
RMA NEAR	0	2	BCRL	BCRL	NA	NA	NA
BUSW - Swainson's hawk (FORTUITOUS)							
Muscle							
RMA FAR	0	1	BCRL	BCRL	NA	NA	NA
Liver							
RMA FAR	0	1	BCRL	BCRL	NA	NA	NA
All Samples							
RMA FAR	0	2	BCRL	BCRL	NA	NA	NA
BUVI - great horned owl							
Egg							
CMP-BSA 5	0	1	BCRL	BCRL	NA	NA	NA
RMA FAR	0	1	BCRL	BCRL	NA	NA	NA
RMA NEAR	0	3	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	0	5	BCRL	BCRL	NA	NA	NA
BUVI - great horned owl (FORTUITOUS)							
Muscle							
CMP-BSA 4	0	1	BCRL	BCRL	NA	NA	NA
5	0	1	BCRL	BCRL	NA	NA	NA
12	0	1	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	0	3	BCRL	BCRL	NA	NA	NA
Liver							
CMP-BSA 5	1	1	0.243	0.243	0.243	NA	NA
All Samples							
CMP-BSA 4	0	1	BCRL	BCRL	NA	NA	NA
12	0	1	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	0	2	BCRL	BCRL	NA	NA	NA
COLE - ground beetles							
CMP-BSA 1	0	5	BCRL	BCRL	NA	NA	NA
2	0	4	BCRL	BCRL	NA	NA	NA
5	0	1	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	0	10	BCRL	BCRL	NA	NA	NA
Control	0	4	BCRL	BCRL	NA	NA	NA
CYLU - prairie dog							
CMP-BSA 1	0	44	BCRL	BCRL	NA	NA	NA
2	0	21	BCRL	BCRL	NA	NA	NA
3	1	19	0.159	0.159	NC	NC	NC
11	0	1	BCRL	BCRL	NA	NA	NA
12	0	5	BCRL	BCRL	NA	NA	NA
RMA NEAR	0	5	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	1	95	0.159	0.159	NC	NC	NC
Control	0	20	BCRL	BCRL	NA	NA	NA
EUCY - Brewer's blackbird (FORTUITOUS)							
CMP-BSA 5	0	1	BCRL	BCRL	NA	NA	NA

*This table incorporates all available data for all samples (intentional and fortuitous) analyzed under the Biota CMP.

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BCRL = Below certified reporting limit. This value varied for different labs and in different years.

NA = Not applicable.

NC = Number of detections was less than 50% of the sample size and a mean was not calculated.

Table 5.1-6 DDT Statistical Results for Terrestrial Species Sampled for CMP, 1988 to 1990*

	Total # of Hits	Total # of Samples	Minimum Detected Conc (µg/g)	Maximum Detected Conc (µg/g)	USFWS Geometric Mean**	USFWS Geometric Variance**	USFWS Geometric Std Dev**
FASP - kestrel							
Dressed carcass							
CMP-BSA 1	0	1	BCRL	BCRL	NA	NA	NA
2	0	1	BCRL	BCRL	NA	NA	NA
5	0	2	BCRL	BCRL	NA	NA	NA
RMA NEAR	0	6	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	0	10	BCRL	BCRL	NA	NA	NA
Control	1	9	0.141	0.141	NC	NC	NC
Egg							
CMP-BSA 2	0	1	BCRL	BCRL	NA	NA	NA
5	0	1	BCRL	BCRL	NA	NA	NA
RMA NEAR	0	5	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	0	7	BCRL	BCRL	NA	NA	NA
Control	0	5	BCRL	BCRL	NA	NA	NA
All Samples							
CMP-BSA 1	0	1	BCRL	BCRL	NA	NA	NA
2	0	2	BCRL	BCRL	NA	NA	NA
5	0	3	BCRL	BCRL	NA	NA	NA
RMA NEAR	0	11	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	0	17	BCRL	BCRL	NA	NA	NA
Control	1	14	0.141	0.141	NC	NC	NC
FASP - kestrel (FORTUITOUS)							
Dressed carcass							
CMP-BSA 5	0	1	BCRL	BCRL	NA	NA	NA
13	0	1	BCRL	BCRL	NA	NA	NA
RMA NEAR	0	1	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	0	3	BCRL	BCRL	NA	NA	NA
HALE - bald eagle (FORTUITOUS)							
Muscle							
RMA NEAR	0	1	BCRL	BCRL	NA	NA	NA
Liver							
RMA NEAR	0	1	BCRL	BCRL	NA	NA	NA
Brain							
RMA NEAR	0	1	BCRL	BCRL	NA	NA	NA
All Samples							
RMA NEAR	0	3	BCRL	BCRL	NA	NA	NA
HEAN - sunflower							
CMP-BSA 1	1	12	0.146	0.146	NC	NC	NC
2	0	13	BCRL	BCRL	NA	NA	NA
3	0	10	BCRL	BCRL	NA	NA	NA
4	0	10	BCRL	BCRL	NA	NA	NA
5	0	10	BCRL	BCRL	NA	NA	NA
11	0	3	BCRL	BCRL	NA	NA	NA
12	0	2	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	1	60	0.146	0.146	NC	NC	NC
Control	0	15	BCRL	BCRL	NA	NA	NA

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BCRL = Below certified reporting limit. This value varied for different labs and in different years.

NA = Not applicable.

NC = Number of detections was less than 50% of the sample size and a mean was not calculated.

Table 5.1-6 DDT Statistical Results for Terrestrial Species Sampled for CMP, 1988 to 1990*

	Total # of Hits	Total # of Samples	Minimum Detected Conc (µg/g)	Maximum Detected Conc (µg/g)	USFWS Geometric Mean**	USFWS Geometric Variance**	USFWS Geometric Std Dev**
KOIR - kochia							
CMP-BSA 1	0	5	BCRL	BCRL	NA	NA	NA
2	1	7	0.0908	0.0908	NC	NC	NC
3	0	4	BCRL	BCRL	NA	NA	NA
5	0	10	BCRL	BCRL	NA	NA	NA
11	0	3	BCRL	BCRL	NA	NA	NA
12	0	2	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	1	31	0.0908	0.0908	NC	NC	NC
Control	0	10	BCRL	BCRL	NA	NA	NA
LASE - wild lettuce							
CMP-BSA 1	0	7	BCRL	BCRL	NA	NA	NA
2	0	1	BCRL	BCRL	NA	NA	NA
3	0	2	BCRL	BCRL	NA	NA	NA
4	0	3	BCRL	BCRL	NA	NA	NA
5	0	1	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	0	14	BCRL	BCRL	NA	NA	NA
Control	0	3	BCRL	BCRL	NA	NA	NA
ODHE - mule deer							
Muscle							
CMP-BSA 1	0	1	BCRL	BCRL	NA	NA	NA
3	0	1	BCRL	BCRL	NA	NA	NA
4	0	1	BCRL	BCRL	NA	NA	NA
RMA FAR	0	1	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	0	4	BCRL	BCRL	NA	NA	NA
Control	0	1	BCRL	BCRL	NA	NA	NA
Liver							
CMP-BSA 1	0	1	BCRL	BCRL	NA	NA	NA
3	0	1	BCRL	BCRL	NA	NA	NA
4	0	1	BCRL	BCRL	NA	NA	NA
RMA FAR	0	1	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	0	4	BCRL	BCRL	NA	NA	NA
Control	0	1	BCRL	BCRL	NA	NA	NA
All Samples							
CMP-BSA 1	0	2	BCRL	BCRL	NA	NA	NA
3	0	2	BCRL	BCRL	NA	NA	NA
4	0	2	BCRL	BCRL	NA	NA	NA
RMA FAR	0	2	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	0	8	BCRL	BCRL	NA	NA	NA
Control	0	2	BCRL	BCRL	NA	NA	NA

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**The USFWS geometric mean includes nonhits and assigns them a value equal to one-half of the lower CRL; descriptive statistics are calculated only when 50% or more of the samples are hits.

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NA = Not applicable.

NC = Number of detections was less than 50% of the sample size and a mean was not calculated.

Table 5.1-6 DDT Statistical Results for Terrestrial Species Sampled for CMP, 1988 to 1990*

	Total # of Hits	Total # of Samples	Minimum Detected Conc (µg/g)	Maximum Detected Conc (µg/g)	USFWS Geometric Mean**	USFWS Geometric Variance**	USFWS Geometric Std Dev**
ODVI - white-tail deer							
Muscle							
CMP-BSA 5	0	2	BCRL	BCRL	NA	NA	NA
RMA FAR	0	1	BCRL	BCRL	NA	NA	NA
RMA NEAR	0	3	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	0	6	BCRL	BCRL	NA	NA	NA
Control	0	5	BCRL	BCRL	NA	NA	NA
Liver							
CMP-BSA 5	0	2	BCRL	BCRL	NA	NA	NA
RMA FAR	0	1	BCRL	BCRL	NA	NA	NA
RMA NEAR	0	3	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	0	6	BCRL	BCRL	NA	NA	NA
Control	0	5	BCRL	BCRL	NA	NA	NA
All Samples							
CMP-BSA 5	0	4	BCRL	BCRL	NA	NA	NA
RMA FAR	0	2	BCRL	BCRL	NA	NA	NA
RMA NEAR	0	6	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	0	12	BCRL	BCRL	NA	NA	NA
Control	0	10	BCRL	BCRL	NA	NA	NA
OLIG - earthworm							
CMP-BSA 1	1	6	0.259	0.259	NC	NC	NC
2	0	7	BCRL	BCRL	NA	NA	NA
3	0	7	BCRL	BCRL	NA	NA	NA
4	0	5	BCRL	BCRL	NA	NA	NA
5	2	13	0.155	0.177	NC	NC	NC
11	0	4	BCRL	BCRL	NA	NA	NA
12	0	3	BCRL	BCRL	NA	NA	NA
13	4	7	0.127	1.49	0.154	4.07	3.27
All RMA CMP-BSAs	7	52	0.127	1.49	NC	NC	NC
Control	1	12	0.148	0.148	NC	NC	NC
PEMA - deer mouse							
CMP-BSA 1	3	15	0.154	0.362	NC	NC	NC
2	0	14	BCRL	BCRL	NA	NA	NA
3	0	11	BCRL	BCRL	NA	NA	NA
4	0	10	BCRL	BCRL	NA	NA	NA
5	0	15	BCRL	BCRL	NA	NA	NA
11	0	6	BCRL	BCRL	NA	NA	NA
12	0	4	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	3	75	0.154	0.362	NC	NC	NC
Control	0	15	BCRL	BCRL	NA	NA	NA

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BCRL = Below certified reporting limit. This value varied for different labs and in different years.

NA = Not applicable.

NC = Number of detections was less than 50% of the sample size and a mean was not calculated.

Table 5.1-6 DDT Statistical Results for Terrestrial Species Sampled for CMP, 1988 to 1990*

	Total # of Hits	Total # of Samples	Minimum Detected Conc (µg/g)	Maximum Detected Conc (µg/g)	USFWS Geometric Mean**	USFWS Geometric Variance**	USFWS Geometric Std Dev**
PHCO - pheasant							
Dressed carcass							
CMP-BSA 2	0	10	BCRL	BCRL	NA	NA	NA
3	0	5	BCRL	BCRL	NA	NA	NA
4	0	1	BCRL	BCRL	NA	NA	NA
5	0	10	BCRL	BCRL	NA	NA	NA
11	0	3	BCRL	BCRL	NA	NA	NA
RMA FAR	0	12	BCRL	BCRL	NA	NA	NA
RMA NEAR	0	6	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	0	47	BCRL	BCRL	NA	NA	NA
Control	0	13	BCRL	BCRL	NA	NA	NA
Liver							
CMP-BSA 2	0	3	BCRL	BCRL	NA	NA	NA
3	0	5	BCRL	BCRL	NA	NA	NA
5	0	8	BCRL	BCRL	NA	NA	NA
11	0	1	BCRL	BCRL	NA	NA	NA
RMA FAR	0	12	BCRL	BCRL	NA	NA	NA
RMA NEAR	0	4	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	0	33	BCRL	BCRL	NA	NA	NA
Control	0	9	BCRL	BCRL	NA	NA	NA
All Samples							
CMP-BSA 2	0	13	BCRL	BCRL	NA	NA	NA
3	0	10	BCRL	BCRL	NA	NA	NA
4	0	1	BCRL	BCRL	NA	NA	NA
5	0	18	BCRL	BCRL	NA	NA	NA
11	0	4	BCRL	BCRL	NA	NA	NA
RMA FAR	0	24	BCRL	BCRL	NA	NA	NA
RMA NEAR	0	10	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	0	80	BCRL	BCRL	NA	NA	NA
Control	0	22	BCRL	BCRL	NA	NA	NA
PIME - bullsnake (FORTUITOUS)							
RMA NEAR	0	1	BCRL	BCRL	NA	NA	NA
PIPI - black-billed magpie (FORTUITOUS)							
CMP-BSA 13	1	1	0.207	0.207	0.207	NA	NA
SPTR - thirteen-lined ground squirrel							
CMP-BSA 1	0	2	BCRL	BCRL	NA	NA	NA
2	0	1	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	0	3	BCRL	BCRL	NA	NA	NA
STNE - western meadowlark							
CMP-BSA 2	0	8	BCRL	BCRL	NA	NA	NA
5	0	2	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	0	10	BCRL	BCRL	NA	NA	NA
Control	0	5	BCRL	BCRL	NA	NA	NA
STNE - western meadowlark (FORTUITOUS)							
CMP-BSA 2	0	1	BCRL	BCRL	NA	NA	NA
12	0	1	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	0	2	BCRL	BCRL	NA	NA	NA

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Table 5.1-6 DDT Statistical Results for Terrestrial Species Sampled for CMP, 1988 to 1990*

	Total # of Hits	Total # of Samples	Minimum Detected Conc (µg/g)	Maximum Detected Conc (µg/g)	USFWS Geometric Mean**	USFWS Geometric Variance**	USFWS Geometric Std Dev**
STVU - starling (FORTUITOUS)							
CMP-BSA 13	0	1	BCRL	BCRL	NA	NA	NA
SYAU - desert cottontail							
Dressed carcass							
CMP-BSA 1	0	3	BCRL	BCRL	NA	NA	NA
2	0	2	BCRL	BCRL	NA	NA	NA
3	0	2	BCRL	BCRL	NA	NA	NA
5	0	4	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	0	11	BCRL	BCRL	NA	NA	NA
Control	0	4	BCRL	BCRL	NA	NA	NA
Muscle							
CMP-BSA 1	0	3	BCRL	BCRL	NA	NA	NA
Liver							
CMP-BSA 1	0	3	BCRL	BCRL	NA	NA	NA
All Samples							
CMP-BSA 1	0	9	BCRL	BCRL	NA	NA	NA
2	0	2	BCRL	BCRL	NA	NA	NA
3	0	2	BCRL	BCRL	NA	NA	NA
5	0	4	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	0	17	BCRL	BCRL	NA	NA	NA
Control	0	4	BCRL	BCRL	NA	NA	NA
SYAU - desert cottontail (FORTUITOUS)							
Muscle							
CMP-BSA 1	0	1	BCRL	BCRL	NA	NA	NA
Liver							
CMP-BSA 1	0	1	BCRL	BCRL	NA	NA	NA
All Samples							
CMP-BSA 1	0	2	BCRL	BCRL	NA	NA	NA
TATA - badger (FORTUITOUS)							
Muscle							
CMP-BSA 1	0	1	BCRL	BCRL	NA	NA	NA
Liver							
CMP-BSA 1	0	1	BCRL	BCRL	NA	NA	NA
Brain							
CMP-BSA 1	0	1	BCRL	BCRL	NA	NA	NA
Fat							
CMP-BSA 1	1	1	0.539	0.539	0.539	NA	NA
Solid stomach contents							
CMP-BSA 1	0	1	BCRL	BCRL	NA	NA	NA
Liquid stomach contents							
CMP-BSA 1	0	1	BCRL	BCRL	NA	NA	NA
All Samples							
CMP-BSA 1	1	6	0.539	0.539	NC	NC	NC

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NA = Not applicable.

NC = Number of detections was less than 50% of the sample size and a mean was not calculated.

Table 5.1-6 DDT Statistical Results for Terrestrial Species Sampled for CMP, 1988 to 1990*

	Total # of Hits	Total # of Samples	Minimum Detected Conc (µg/g)	Maximum Detected Conc (µg/g)	USFWS Geometric Mean**	USFWS Geometric Variance**	USFWS Geometric Std Dev**
TUMI - American robin (FORTUITOUS)							
Dressed carcass							
CMP-BSA 13	2	6	0.339	0.950	NC	NC	NC
ZEMA - mourning dove							
CMP-BSA 1	0	11	BCRL	BCRL	NA	NA	NA
2	0	13	BCRL	BCRL	NA	NA	NA
3	0	11	BCRL	BCRL	NA	NA	NA
4	0	16	BCRL	BCRL	NA	NA	NA
5	0	10	BCRL	BCRL	NA	NA	NA
11	0	1	BCRL	BCRL	NA	NA	NA
12	0	3	BCRL	BCRL	NA	NA	NA
RMA NEAR	0	3	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	0	68	BCRL	BCRL	NA	NA	NA
Control	0	10	BCRL	BCRL	NA	NA	NA
ZEMA - mourning dove (FORTUITOUS)							
CMP-BSA 13	1	4	0.308	0.308	NC	NC	NC

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**The USFWS geometric mean includes nonhits and assigns them a value equal to one-half of the lower CRL; descriptive statistics are calculated only when 50% or more of the samples are hits.

BCRL = Below certified reporting limit. This value varied for different labs and in different years.

NA = Not applicable.

NC = Number of detections was less than 50% of the sample size and a mean was not calculated.

Table 5.1-7 DDE Statistical Results for Terrestrial Species Sampled for CMP, 1988 to 1990*

	Total # of Hits	Total # of Samples	Minimum Detected Conc (µg/g)	Maximum Detected Conc (µg/g)	USFWS Geometric Mean**	USFWS Geometric Variance**	USFWS Geometric Std Dev**
ACRI - grasshopper							
CMP-BSA 1	0	16	BCRL	BCRL	NA	NA	NA
2	0	15	BCRL	BCRL	NA	NA	NA
3	0	10	BCRL	BCRL	NA	NA	NA
4	0	10	BCRL	BCRL	NA	NA	NA
5	0	10	BCRL	BCRL	NA	NA	NA
11	0	3	BCRL	BCRL	NA	NA	NA
12	0	2	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	0	66	BCRL	BCRL	NA	NA	NA
Control	0	12	BCRL	BCRL	NA	NA	NA
AQCH - golden eagle (FORTUITOUS)							
Muscle							
Off RMA	1	1	0.639	0.639	0.639	NA	NA
Liver							
Off RMA	1	1	0.124	0.124	0.124	NA	NA
Brain							
Off RMA	0	1	BCRL	BCRL	NA	NA	NA
All Samples							
Off RMA	2	3	0.124	0.639	0.158	5.30	3.64
ATCU - burrowing owl							
CMP-BSA 2	0	1	BCRL	BCRL	NA	NA	NA
3	1	1	0.0764	0.0764	0.0764	NA	NA
12	0	1	BCRL	BCRL	NA	NA	NA
RMA NEAR	1	4	0.197	0.197	NC	NC	NC
All RMA CMP-BSAs	2	7	0.0764	0.197	NC	NC	NC
BRTE - cheatgrass							
CMP-BSA 1	0	12	BCRL	BCRL	NA	NA	NA
2	0	13	BCRL	BCRL	NA	NA	NA
3	0	10	BCRL	BCRL	NA	NA	NA
4	0	7	BCRL	BCRL	NA	NA	NA
5	1	13	0.0692	0.0692	NC	NC	NC
11	0	6	BCRL	BCRL	NA	NA	NA
12	0	4	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	1	65	0.0692	0.0692	NC	NC	NC
Control	0	16	BCRL	BCRL	NA	NA	NA
BUJA - red-tailed hawk (FORTUITOUS)							
Muscle							
CMP-BSA 5	0	1	BCRL	BCRL	NA	NA	NA
13	0	1	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	0	2	BCRL	BCRL	NA	NA	NA
Liver							
CMP-BSA 13	1	1	0.145	0.145	0.145	NA	NA
All Samples							
CMP-BSA 5	0	1	BCRL	BCRL	NA	NA	NA
13	1	2	0.145	0.145	0.0851	1.76	2.12
All RMA CMP-BSAs	1	3	0.145	0.145	NC	NC	NC

*This table incorporates all available data for all samples (intentional and fortuitous) analyzed under the Biota CMP.

**The USFWS geometric mean includes nonhits and assigns them a value equal to one-half of the lower CRL; descriptive statistics are calculated only when 50% or more of the samples are hits.

BCRL = Below certified reporting limit. This value varied for different labs and in different years.

NA = Not applicable.

NC = Number of detections was less than 50% of the sample size and a mean was not calculated.

	Total # of Hits	Total # of Samples	Minimum Detected Conc (µg/g)	Maximum Detected Conc (µg/g)	USFWS Geometric Mean**	USFWS Geometric Variance**	USFWS Geometric Std Dev**
BURB - ferruginous hawk (FORTUITOUS)							
Muscle							
RMA NEAR	0	1	BCRL	BCRL	NA	NA	NA
Liver							
RMA NEAR	0	1	BCRL	BCRL	NA	NA	NA
All Samples							
RMA NEAR	0	2	BCRL	BCRL	NA	NA	NA
BUSW - Swainson's hawk (FORTUITOUS)							
Muscle							
RMA FAR	0	1	BCRL	BCRL	NA	NA	NA
Liver							
RMA FAR	0	1	BCRL	BCRL	NA	NA	NA
All Samples							
RMA FAR	0	2	BCRL	BCRL	NA	NA	NA
BUVI - great horned owl							
Egg							
CMP-BSA 5	1	1	1.01	1.01	1.01	NA	NA
RMA FAR	1	1	0.285	0.285	0.285	NA	NA
RMA NEAR	3	3	0.587	0.729	0.659	1.01	1.12
All RMA CMP-BSAs	5	5	0.285	1.01	0.607	1.24	1.60
BUVI - great horned owl (FORTUITOUS)							
Muscle							
CMP-BSA 4	0	1	BCRL	BCRL	NA	NA	NA
5	1	1	0.501	0.501	0.501	NA	NA
12	1	1	0.667	0.667	0.667	NA	NA
All RMA CMP-BSAs	2	3	0.501	0.667	0.256	7.52	4.14
Liver							
CMP-BSA 5	1	1	5.40	5.40	5.40	NA	NA
All Samples							
CMP-BSA 4	0	1	BCRL	BCRL	NA	NA	NA
5	2	2	0.501	5.40	1.64	16.9	5.37
12	1	1	0.667	0.667	0.667	NA	NA
All RMA CMP-BSAs	3	4	0.501	5.40	0.548	39.3	6.79
COLE - ground beetles							
CMP-BSA 1	1	5	0.0688	0.0688	NC	NC	NC
2	0	4	BCRL	BCRL	NA	NA	NA
5	1	1	0.355	0.355	0.355	NA	NA
All RMA CMP-BSAs	2	10	0.0688	0.355	NC	NC	NC
Control	0	4	BCRL	BCRL	NA	NA	NA
CYLU - prairie dog							
CMP-BSA 1	1	44	0.301	0.301	NC	NC	NC
2	0	21	BCRL	BCRL	NA	NA	NA
3	1	19	0.204	0.204	NC	NC	NC
11	0	1	BCRL	BCRL	NA	NA	NA
12	0	5	BCRL	BCRL	NA	NA	NA
RMA NEAR	0	5	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	2	95	0.204	0.301	NC	NC	NC
Control	0	20	BCRL	BCRL	NA	NA	NA

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NA = Not applicable.

NC = Number of detections was less than 50% of the sample size and a mean was not calculated.

Table 5.1-7 DDE Statistical Results for Terrestrial Species Sampled for CMP, 1988 to 1990*

	Total # of Hits	Total # of Samples	Minimum Detected Conc (µg/g)	Maximum Detected Conc (µg/g)	USFWS Geometric Mean**	USFWS Geometric Variance**	USFWS Geometric Std Dev**
BUCY - Brewer's blackbird (FORTUITOUS)							
CMP-BSA 5	1	1	1.10	1.10	1.10	NA	NA
FASP - kestrel							
Dressed carcass							
CMP-BSA 1	0	1	BCRL	BCRL	NA	NA	NA
2	0	1	BCRL	BCRL	NA	NA	NA
5	1	2	0.811	0.811	0.160	196	9.94
RMA NEAR	3	6	0.0806	0.322	0.0908	2.55	2.63
All RMA CMP-BSAs	4	10	0.0806	0.811	NC	NC	NC
Control	5	9	0.184	0.768	0.124	3.84	3.19
Egg							
CMP-BSA 2	0	1	BCRL	BCRL	NA	NA	NA
5	0	1	BCRL	BCRL	NA	NA	NA
RMA NEAR	2	5	0.203	0.352	NC	NC	NC
All RMA CMP-BSAs	2	7	0.203	0.352	NC	NC	NC
Control	2	5	0.117	0.232	NC	NC	NC
All Samples							
CMP-BSA 1	0	1	BCRL	BCRL	NA	NA	NA
2	0	2	BCRL	BCRL	NA	NA	NA
5	1	3	0.811	0.811	NC	NC	NC
RMA NEAR	5	11	0.0806	0.352	NC	NC	NC
All RMA CMP-BSAs	6	17	0.0806	0.811	NC	NC	NC
Control	7	14	0.117	0.768	0.106	2.78	2.75
FASP - kestrel (FORTUITOUS)							
Dressed carcass							
CMP-BSA 5	1	1	0.401	0.401	0.401	NA	NA
13	1	1	0.122	0.122	0.122	NA	NA
RMA NEAR	1	1	0.114	0.114	0.114	NA	NA
All RMA CMP-BSAs	3	3	0.114	0.401	0.177	1.65	2.03
HALE - bald eagle (FORTUITOUS)							
Muscle							
RMA NEAR	1	1	1.70	1.70	1.70	NA	NA
Liver							
RMA NEAR	1	1	0.404	0.404	0.404	NA	NA
Brain							
RMA NEAR	1	1	0.400	0.400	0.400	NA	NA
All Samples							
RMA NEAR	3	3	0.400	1.70	0.650	2.00	2.30
HEAN - sunflower							
CMP-BSA 1	0	12	BCRL	BCRL	NA	NA	NA
2	0	13	BCRL	BCRL	NA	NA	NA
3	0	10	BCRL	BCRL	NA	NA	NA
4	0	10	BCRL	BCRL	NA	NA	NA
5	0	10	BCRL	BCRL	NA	NA	NA
11	0	3	BCRL	BCRL	NA	NA	NA
12	0	2	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	0	60	BCRL	BCRL	NA	NA	NA
Control	2	15	0.0483	0.0499	NC	NC	NC

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Table 5.1-7 DDE Statistical Results for Terrestrial Species Sampled for CMP, 1988 to 1990*

	Total # of Hits	Total # of Samples	Minimum Detected Conc (µg/g)	Maximum Detected Conc (µg/g)	USFWS Geometric Mean**	USFWS Geometric Variance**	USFWS Geometric Std Dev**
KOIR - kochia							
CMP-BSA 1	0	5	BCRL	BCRL	NA	NA	NA
2	0	7	BCRL	BCRL	NA	NA	NA
3	0	4	BCRL	BCRL	NA	NA	NA
5	0	10	BCRL	BCRL	NA	NA	NA
11	0	3	BCRL	BCRL	NA	NA	NA
12	0	2	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	0	31	BCRL	BCRL	NA	NA	NA
Control	0	10	BCRL	BCRL	NA	NA	NA
LASE - wild lettuce							
CMP-BSA 1	0	7	BCRL	BCRL	NA	NA	NA
2	0	1	BCRL	BCRL	NA	NA	NA
3	0	2	BCRL	BCRL	NA	NA	NA
4	0	3	BCRL	BCRL	NA	NA	NA
5	0	1	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	0	14	BCRL	BCRL	NA	NA	NA
Control	0	3	BCRL	BCRL	NA	NA	NA
ODHE - mule deer							
Muscle							
CMP-BSA 1	0	1	BCRL	BCRL	NA	NA	NA
3	0	1	BCRL	BCRL	NA	NA	NA
4	0	1	BCRL	BCRL	NA	NA	NA
RMA FAR	0	1	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	0	4	BCRL	BCRL	NA	NA	NA
Control	0	1	BCRL	BCRL	NA	NA	NA
Liver							
CMP-BSA 1	0	1	BCRL	BCRL	NA	NA	NA
3	0	1	BCRL	BCRL	NA	NA	NA
4	0	1	BCRL	BCRL	NA	NA	NA
RMA FAR	0	1	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	0	4	BCRL	BCRL	NA	NA	NA
Control	0	1	BCRL	BCRL	NA	NA	NA
All Samples							
CMP-BSA 1	0	2	BCRL	BCRL	NA	NA	NA
3	0	2	BCRL	BCRL	NA	NA	NA
4	0	2	BCRL	BCRL	NA	NA	NA
RMA FAR	0	2	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	0	8	BCRL	BCRL	NA	NA	NA
Control	0	2	BCRL	BCRL	NA	NA	NA

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NA = Not applicable.

NC = Number of detections was less than 50% of the sample size and a mean was not calculated.

	Total # of Hits	Total # of Samples	Minimum Detected Conc (µg/g)	Maximum Detected Conc (µg/g)	USFWS Geometric Mean**	USFWS Geometric Variance**	USFWS Geometric Std Dev**
ODVI - white-tail deer							
Muscle							
CMP-BSA 5	0	2	BCRL	BCRL	NA	NA	NA
RMA FAR	0	1	BCRL	BCRL	NA	NA	NA
RMA NEAR	0	3	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	0	6	BCRL	BCRL	NA	NA	NA
Control	0	5	BCRL	BCRL	NA	NA	NA
Liver							
CMP-BSA 5	0	2	BCRL	BCRL	NA	NA	NA
RMA FAR	0	1	BCRL	BCRL	NA	NA	NA
RMA NEAR	0	3	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	0	6	BCRL	BCRL	NA	NA	NA
Control	0	5	BCRL	BCRL	NA	NA	NA
All Samples							
CMP-BSA 5	0	4	BCRL	BCRL	NA	NA	NA
RMA FAR	0	2	BCRL	BCRL	NA	NA	NA
RMA NEAR	0	6	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	0	12	BCRL	BCRL	NA	NA	NA
Control	0	10	BCRL	BCRL	NA	NA	NA
OLIG - earthworm							
CMP-BSA 1	0	6	BCRL	BCRL	NA	NA	NA
2	2	7	0.169	0.170	NC	NC	NC
3	1	7	0.120	0.120	NC	NC	NC
4	1	5	0.675	0.675	NC	NC	NC
5	3	13	0.110	1.30	NC	NC	NC
11	0	4	BCRL	BCRL	NA	NA	NA
12	0	3	BCRL	BCRL	NA	NA	NA
13	5	7	0.432	1.40	0.296	7.80	4.19
All RMA CMP-BSAs	12	52	0.110	1.40	NC	NC	NC
Control	0	12	BCRL	BCRL	NA	NA	NA
PEMA - deer mouse							
CMP-BSA 1	1	15	0.877	0.877	NC	NC	NC
2	0	14	BCRL	BCRL	NA	NA	NA
3	2	11	0.120	0.151	NC	NC	NC
4	2	10	0.478	1.90	NC	NC	NC
5	0	15	BCRL	BCRL	NA	NA	NA
11	0	6	BCRL	BCRL	NA	NA	NA
12	0	4	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	5	75	0.120	1.90	NC	NC	NC
Control	0	15	BCRL	BCRL	NA	NA	NA

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NC = Number of detections was less than 50% of the sample size and a mean was not calculated.

Table 5.1-7 DDE Statistical Results for Terrestrial Species Sampled for CMP, 1988 to 1990*

	Total # of Hits	Total # of Samples	Minimum Detected Conc (µg/g)	Maximum Detected Conc (µg/g)	USFWS Geometric Mean**	USFWS Geometric Variance**	USFWS Geometric Std Dev**
PHCO - pheasant							
Dressed carcass							
CMP-BSA 2	0	10	BCRL	BCRL	NA	NA	NA
3	1	5	0.214	0.214	NC	NC	NC
4	1	1	0.430	0.430	0.430	NA	NA
5	3	10	0.0701	0.172	NC	NC	NC
11	0	3	BCRL	BCRL	NA	NA	NA
RMA FAR	1	12	0.319	0.319	NC	NC	NC
RMA NEAR	0	6	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	6	47	0.0701	0.430	NC	NC	NC
Control	0	13	BCRL	BCRL	NA	NA	NA
Liver							
CMP-BSA 2	0	3	BCRL	BCRL	NA	NA	NA
3	2	4	0.109	0.129	0.0611	1.80	2.16
5	5	8	0.144	0.810	0.146	4.88	3.52
11	0	1	BCRL	BCRL	NA	NA	NA
RMA FAR	0	12	BCRL	BCRL	NA	NA	NA
RMA NEAR	0	4	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	7	32	0.109	0.810	NC	NC	NC
Control	0	9	BCRL	BCRL	NA	NA	NA
All Samples							
CMP-BSA 2	0	13	BCRL	BCRL	NA	NA	NA
3	3	9	0.109	0.214	NC	NC	NC
4	1	1	0.430	0.430	0.430	NA	NA
5	8	18	0.0701	0.810	NC	NC	NC
11	0	4	BCRL	BCRL	NA	NA	NA
RMA FAR	1	24	0.319	0.319	NC	NC	NC
RMA NEAR	0	10	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	13	79	0.0701	0.810	NC	NC	NC
Control	0	22	BCRL	BCRL	NA	NA	NA
PIME - bullsnake (FORTUITOUS)							
RMA NEAR	0	1	BCRL	BCRL	NA	NA	NA
PIPI - black-billed magpie (FORTUITOUS)							
CMP-BSA 13	1	1	2.20	2.20	2.20	NA	NA
SPTR - thirteen-lined ground squirrel							
CMP-BSA 1	0	2	BCRL	BCRL	NA	NA	NA
2	0	1	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	0	3	BCRL	BCRL	NA	NA	NA
STNE - western meadowlark							
CMP-BSA 2	0	8	BCRL	BCRL	NA	NA	NA
5	0	2	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	0	10	BCRL	BCRL	NA	NA	NA
Control	1	5	0.123	0.123	NC	NC	NC
STNE - western meadowlark (FORTUITOUS)							
CMP-BSA 2	1	1	0.149	0.149	0.149	NA	NA
12	0	1	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	1	2	0.149	0.149	0.0863	1.82	2.16
STVU - starling (FORTUITOUS)							
CMP-BSA 13	1	1	4.30	4.30	4.30	NA	NA

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Table 5.1-7 DDE Statistical Results for Terrestrial Species Sampled for CMP, 1988 to 1990*

	Total # of Hits	Total # of Samples	Minimum Detected Conc (µg/g)	Maximum Detected Conc (µg/g)	USFWS Geometric Mean**	USFWS Geometric Variance**	USFWS Geometric Std Dev**
SYAU - desert cottontail							
Dressed carcass							
CMP-BSA 1	0	3	BCRL	BCRL	NA	NA	NA
2	0	2	BCRL	BCRL	NA	NA	NA
3	0	2	BCRL	BCRL	NA	NA	NA
5	0	4	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	0	11	BCRL	BCRL	NA	NA	NA
Control	0	4	BCRL	BCRL	NA	NA	NA
Muscle							
CMP-BSA 1	0	3	BCRL	BCRL	NA	NA	NA
Liver							
CMP-BSA 1	0	3	BCRL	BCRL	NA	NA	NA
All Samples							
CMP-BSA 1	0	9	BCRL	BCRL	NA	NA	NA
2	0	2	BCRL	BCRL	NA	NA	NA
3	0	2	BCRL	BCRL	NA	NA	NA
5	0	4	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	0	17	BCRL	BCRL	NA	NA	NA
Control	0	4	BCRL	BCRL	NA	NA	NA
SYAU - desert cottontail (FORTUITOUS)							
Muscle							
CMP-BSA 1	0	1	BCRL	BCRL	NA	NA	NA
Liver							
CMP-BSA 1	0	1	BCRL	BCRL	NA	NA	NA
All Samples							
CMP-BSA 1	0	2	BCRL	BCRL	NA	NA	NA
TATA - badger (FORTUITOUS)							
Muscle							
CMP-BSA 1	0	1	BCRL	BCRL	NA	NA	NA
Liver							
CMP-BSA 1	0	1	BCRL	BCRL	NA	NA	NA
Brain							
CMP-BSA 1	0	1	BCRL	BCRL	NA	NA	NA
Fat							
CMP-BSA 1	1	1	0.506	0.506	0.506	NA	NA
Solid stomach contents							
CMP-BSA 1	0	1	BCRL	BCRL	NA	NA	NA
Liquid stomach contents							
CMP-BSA 1	0	1	BCRL	BCRL	NA	NA	NA
All Samples							
CMP-BSA 1	1	6	0.506	0.506	NC	NC	NC

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BCRL = Below certified reporting limit. This value varied for different labs and in different years.
NA = Not applicable.
NC = Number of detections was less than 50% of the sample size and a mean was not calculated.

Table 5.1-7 DDE Statistical Results for Terrestrial Species Sampled for CMP, 1988 to 1990*

	Total # of Hits	Total # of Samples	Minimum Detected Conc (µg/g)	Maximum Detected Conc (µg/g)	USFWS Geometric Mean**	USFWS Geometric Variance**	USFWS Geometric Std Dev**
TUMI - American robin (FORTUITOUS)							
Dressed carcass							
CMP-BSA 13	5	6	1.40	8.30	2.39	56.4	7.45
ZEMA - mourning dove							
CMP-BSA 1	0	11	BCRL	BCRL	NA	NA	NA
2	0	13	BCRL	BCRL	NA	NA	NA
3	0	11	BCRL	BCRL	NA	NA	NA
4	1	16	0.0766	0.0766	NC	NC	NC
5	0	10	BCRL	BCRL	NA	NA	NA
11	0	1	BCRL	BCRL	NA	NA	NA
12	1	3	0.942	0.942	NC	NC	NC
RMA NEAR	0	3	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	2	68	0.0766	0.942	NC	NC	NC
Control	0	10	BCRL	BCRL	NA	NA	NA
ZEMA - mourning dove (FORTUITOUS)							
CMP-BSA 13	1	4	0.455	0.455	NC	NC	NC

*This table incorporates all available data for all samples (intentional and fortuitous) analyzed under the Biota CMP.

**The USFWS geometric mean includes nonhits and assigns them a value equal to one-half of the lower CRL; descriptive statistics are calculated only when 50% or more of the samples are hits.

BCRL = Below certified reporting limit. This value varied for different labs and in different years.

NA = Not applicable.

NC = Number of detections was less than 50% of the sample size and a mean was not calculated.

Table 5.1-8 Arsenic Statistical Results for Terrestrial Species Sampled for CMP, 1988 to 1990*

	Total # of Hits	Total # of Samples	Minimum Detected Conc (µg/g)	Maximum Detected Conc (µg/g)	USFWS Geometric Mean**	USFWS Geometric Variance**	USFWS Geometric Std Dev**
ACRI - grasshopper							
CMP-BSA 1	3	16	0.521	0.992	NC	NC	NC
2	0	15	BCRL	BCRL	NA	NA	NA
3	0	10	BCRL	BCRL	NA	NA	NA
4	1	10	1.01	1.01	NC	NC	NC
5	0	10	BCRL	BCRL	NA	NA	NA
11	0	3	BCRL	BCRL	NA	NA	NA
12	0	2	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	4	66	0.521	1.01	NC	NC	NC
Control	0	12	BCRL	BCRL	NA	NA	NA
AQCH - golden eagle (FORTUITOUS)							
Muscle	0	1	BCRL	BCRL	NA	NA	NA
Off RMA							
Liver							
Off RMA	0	1	BCRL	BCRL	NA	NA	NA
Brain							
Off RMA	0	1	BCRL	BCRL	NA	NA	NA
All Samples							
Control	0	3	BCRL	BCRL	NA	NA	NA
ATCU - burrowing owl							
CMP-BSA 2	0	1	BCRL	BCRL	NA	NA	NA
3	0	1	BCRL	BCRL	NA	NA	NA
12	0	1	BCRL	BCRL	NA	NA	NA
RMA NEAR	0	4	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	0	7	BCRL	BCRL	NA	NA	NA
BRTE - cheatgrass							
CMP-BSA 1	0	12	BCRL	BCRL	NA	NA	NA
2	1	13	0.481	0.481	NC	NC	NC
3	0	10	BCRL	BCRL	NA	NA	NA
4	1	7	0.600	0.600	NC	NC	NC
5	0	13	BCRL	BCRL	NA	NA	NA
11	0	6	BCRL	BCRL	NA	NA	NA
12	4	4	0.880	1.11	0.993	1.01	1.10
All RMA CMP-BSAs	6	65	0.481	1.11	NC	NC	NC
Control	0	16	BCRL	BCRL	NA	NA	NA
BUJA - red-tailed hawk (FORTUITOUS)							
Liver							
CMP-BSA 5	0	1	BCRL	BCRL	NA	NA	NA
13	0	1	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	0	2	BCRL	BCRL	NA	NA	NA
BURB - ferruginous hawk (FORTUITOUS)							
Liver							
RMA NEAR	0	1	BCRL	BCRL	NA	NA	NA
BUSW - Swainson's hawk (FORTUITOUS)							
Liver	0	1	BCRL	BCRL	NA	NA	NA
RMA FAR							

*This table incorporates all available data for all samples (intentional and fortuitous) analyzed under the Biota CMP.

**The USFWS geometric mean includes nonhits and assigns them a value equal to one-half of the lower CRL; descriptive statistics are calculated only when 50% or more of the samples are hits.

BCRL = Below certified reporting limit. This value varied for different labs and in different years.

NA = Not applicable.

NC = Number of detections was less than 50% of the sample size and a mean was not calculated.

Table 5.1-8 Arsenic Statistical Results for Terrestrial Species Sampled for CMP, 1988 to 1990*

	Total # of Hits	Total # of Samples	Minimum Detected Conc (µg/g)	Maximum Detected Conc (µg/g)	USFWS Geometric Mean**	USFWS Geometric Variance**	USFWS Geometric Std Dev**
BUVI - great horned owl							
Egg							
CMP-BSA 5	0	1	BCRL	BCRL	NA	NA	NA
RMA FAR	0	1	BCRL	BCRL	NA	NA	NA
RMA NEAR	0	3	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	0	5	BCRL	BCRL	NA	NA	NA
BUVI - great horned owl (FORTUITOUS)							
Liver							
CMP-BSA 4	0	1	BCRL	BCRL	NA	NA	NA
5	0	1	BCRL	BCRL	NA	NA	NA
12	0	1	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	0	3	BCRL	BCRL	NA	NA	NA
Brain							
CMP-BSA 4	0	1	BCRL	BCRL	NA	NA	NA
12	0	1	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	0	2	BCRL	BCRL	NA	NA	NA
All Samples							
CMP-BSA 4	0	2	BCRL	BCRL	NA	NA	NA
5	0	1	BCRL	BCRL	NA	NA	NA
12	0	2	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	0	5	BCRL	BCRL	NA	NA	NA
COLE - ground beetles							
CMP-BSA 1	5	5	0.623	3.42	1.51	1.62	2.00
2	2	5	1.14	1.35	NC	NC	NC
5	1	2	0.468	0.468	0.242	2.39	2.54
All RMA CMP-BSAs	8	12	0.468	3.42	0.578	4.75	3.48
Control	0	3	BCRL	BCRL	NA	NA	NA
CYLU - prairie dog							
CMP-BSA 1	11	26	0.430	2.67	NC	NC	NC
2	1	21	0.435	0.435	NC	NC	NC
3	3	19	0.468	0.528	NC	NC	NC
11	0	1	BCRL	BCRL	NA	NA	NA
12	0	5	BCRL	BCRL	NA	NA	NA
RMA NEAR	0	5	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	15	77	0.430	2.67	NC	NC	NC
Control	2	20	0.502	0.517	NC	NC	NC
EUCY - Brewer's blackbird (FORTUITOUS)							
CMP-BSA 5	0	1	BCRL	BCRL	NA	NA	NA

*This table incorporates all available data for all samples (intentional and fortuitous) analyzed under the Biota CMP.

**The USFWS geometric mean includes nonhits and assigns them a value equal to one-half of the lower CRL; descriptive statistics are calculated only when 50% or more of the samples are hits.

BCRL = Below certified reporting limit. This value varied for different labs and in different years.

NA = Not applicable.

NC = Number of detections was less than 50% of the sample size and a mean was not calculated.

Table 5.1-8 Arsenic Statistical Results for Terrestrial Species Sampled for CMP, 1988 to 1990*

	Total # of Hits	Total # of Samples	Minimum Detected Conc (µg/g)	Maximum Detected Conc (µg/g)	USFWS Geometric Mean**	USFWS Geometric Variance**	USFWS Geometric Std Dev**
FASP - kestrel							
Dressed carcass							
CMP-BSA 1	0	1	BCRL	BCRL	NA	NA	NA
2	0	1	BCRL	BCRL	NA	NA	NA
5	0	2	BCRL	BCRL	NA	NA	NA
RMA NEAR	0	6	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	0	10	BCRL	BCRL	NA	NA	NA
Control	0	9	BCRL	BCRL	NA	NA	NA
Egg							
CMP-BSA 2	0	1	BCRL	BCRL	NA	NA	NA
5	0	1	BCRL	BCRL	NA	NA	NA
RMA NEAR	0	5	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	0	7	BCRL	BCRL	NA	NA	NA
Control	0	4	BCRL	BCRL	NA	NA	NA
All Samples							
CMP-BSA 1	0	1	BCRL	BCRL	NA	NA	NA
2	0	2	BCRL	BCRL	NA	NA	NA
5	0	3	BCRL	BCRL	NA	NA	NA
RMA NEAR	0	11	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	0	17	BCRL	BCRL	NA	NA	NA
Control	0	13	BCRL	BCRL	NA	NA	NA
FASP - kestrel (FORTUITOUS)							
Dressed carcass							
CMP-BSA 5	0	1	BCRL	BCRL	NA	NA	NA
13	0	1	BCRL	BCRL	NA	NA	NA
RMA NEAR	0	1	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	0	3	BCRL	BCRL	NA	NA	NA
HALE - bald eagle (FORTUITOUS)							
Liver							
RMA NEAR	0	1	BCRL	BCRL	NA	NA	NA
Brain							
RMA NEAR	0	1	BCRL	BCRL	NA	NA	NA
All Samples							
RMA NEAR	0	2	BCRL	BCRL	NA	NA	NA
HEAN - sunflower							
CMP-BSA 1	2	12	0.374	2.26	NC	NC	NC
2	1	13	0.456	0.456	NC	NC	NC
3	0	10	BCRL	BCRL	NA	NA	NA
4	2	10	0.482	0.877	NC	NC	NC
5	0	10	BCRL	BCRL	NA	NA	NA
11	0	3	BCRL	BCRL	NA	NA	NA
12	1	2	0.563	0.563	0.265	3.10	2.90
All RMA CMP-BSAs	6	60	0.374	2.26	NC	NC	NC
Control	0	15	BCRL	BCRL	NA	NA	NA

*This table incorporates all available data for all samples (intentional and fortuitous) analyzed under the Biota CMP.

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BCRL = Below certified reporting limit. This value varied for different labs and in different years.

NA = Not applicable.

NC = Number of detections was less than 50% of the sample size and a mean was not calculated.

Table 5.1-8 Arsenic Statistical Results for Terrestrial Species Sampled for CMP, 1988 to 1990*

	Total # of Hits	Total # of Samples	Minimum Detected Conc (µg/g)	Maximum Detected Conc (µg/g)	USFWS Geometric Mean**	USFWS Geometric Variance**	USFWS Geometric Std Dev**
KOIR - kochia							
CMP-BSA 1	3	5	0.353	1.17	0.306	2.41	2.56
2	0	7	BCRL	BCRL	NA	NA	NA
3	0	4	BCRL	BCRL	NA	NA	NA
5	0	10	BCRL	BCRL	NA	NA	NA
11	0	3	BCRL	BCRL	NA	NA	NA
12	1	2	0.334	0.334	0.204	1.62	2.00
All RMA CMP-BSAs	4	31	0.334	1.17	NC	NC	NC
Control	0	10	BCRL	BCRL	NA	NA	NA
LASE - wild lettuce							
CMP-BSA 1	0	7	BCRL	BCRL	NA	NA	NA
2	0	1	BCRL	BCRL	NA	NA	NA
3	0	2	BCRL	BCRL	NA	NA	NA
4	1	3	0.965	0.965	NC	NC	NC
5	0	1	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	1	14	0.965	0.965	NC	NC	NC
Control	0	3	BCRL	BCRL	NA	NA	NA
ODHE - mule deer							
Muscle							
CMP-BSA 1	0	1	BCRL	BCRL	NA	NA	NA
3	0	1	BCRL	BCRL	NA	NA	NA
4	0	1	BCRL	BCRL	NA	NA	NA
RMA FAR	0	1	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	0	4	BCRL	BCRL	NA	NA	NA
Control	0	1	BCRL	BCRL	NA	NA	NA
Liver							
CMP-BSA 1	0	1	BCRL	BCRL	NA	NA	NA
3	0	1	BCRL	BCRL	NA	NA	NA
4	0	1	BCRL	BCRL	NA	NA	NA
RMA FAR	0	1	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	0	4	BCRL	BCRL	NA	NA	NA
Control	0	1	BCRL	BCRL	NA	NA	NA
All Samples							
CMP-BSA 1	0	2	BCRL	BCRL	NA	NA	NA
3	0	2	BCRL	BCRL	NA	NA	NA
4	0	2	BCRL	BCRL	NA	NA	NA
RMA FAR	0	2	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	0	8	BCRL	BCRL	NA	NA	NA
Control	0	2	BCRL	BCRL	NA	NA	NA

*This table incorporates all available data for all samples (intentional and fortuitous) analyzed under the Biota CMP.

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BCRL = Below certified reporting limit. This value varied for different labs and in different years.

NA = Not applicable.

NC = Number of detections was less than 50% of the sample size and a mean was not calculated.

Table 5.1-8 Arsenic Statistical Results for Terrestrial Species Sampled for CMP, 1988 to 1990*

	Total # of Hits	Total # of Samples	Minimum Detected Conc (µg/g)	Maximum Detected Conc (µg/g)	USFWS Geometric Mean**	USFWS Geometric Variance**	USFWS Geometric Std Dev**
ODVI - white-tail deer							
Muscle							
CMP-BSA 5	0	2	BCRL	BCRL	NA	NA	NA
RMA FAR	0	1	BCRL	BCRL	NA	NA	NA
RMA NEAR	0	3	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	0	6	BCRL	BCRL	NA	NA	NA
Control	0	5	BCRL	BCRL	NA	NA	NA
Liver							
CMP-BSA 5	0	2	BCRL	BCRL	NA	NA	NA
RMA FAR	0	1	BCRL	BCRL	NA	NA	NA
RMA NEAR	0	3	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	0	6	BCRL	BCRL	NA	NA	NA
Control	0	5	BCRL	BCRL	NA	NA	NA
All Samples							
CMP-BSA 5	0	4	BCRL	BCRL	NA	NA	NA
RMA FAR	0	2	BCRL	BCRL	NA	NA	NA
RMA NEAR	0	6	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	0	12	BCRL	BCRL	NA	NA	NA
Control	0	10	BCRL	BCRL	NA	NA	NA
OLIG - earthworm							
CMP-BSA 1	6	6	1.06	2.22	1.36	1.11	1.39
2	7	7	1.41	3.23	1.75	1.09	1.33
3	6	6	0.708	1.38	0.923	1.07	1.29
4	5	5	0.682	3.45	1.36	1.47	1.86
5	13	13	0.621	2.18	1.06	1.12	1.41
11	4	4	1.31	2.05	1.65	1.03	1.20
12	1	1	110	110	110	NA	NA
13	7	7	1.15	2.19	1.36	1.05	1.25
All RMA CMP-BSAs	49	49	0.621	110	1.40	1.73	2.09
Control	11	12	0.636	1.27	0.776	1.21	1.55
PEMA - deer mouse							
CMP-BSA 1	2	15	0.547	1.06	NC	NC	NC
2	0	14	BCRL	BCRL	NA	NA	NA
3	0	11	BCRL	BCRL	NA	NA	NA
4	0	10	BCRL	BCRL	NA	NA	NA
5	0	15	BCRL	BCRL	NA	NA	NA
11	0	6	BCRL	BCRL	NA	NA	NA
12	2	4	1.16	2.50	0.531	7.12	4.06
All RMA CMP-BSAs	4	75	0.547	2.50	NC	NC	NC
Control	0	15	BCRL	BCRL	NA	NA	NA

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Table 5.1-8 Arsenic Statistical Results for Terrestrial Species Sampled for CMP, 1988 to 1990*

	Total # of Hits	Total # of Samples	Minimum Detected Conc (µg/g)	Maximum Detected Conc (µg/g)	USFWS Geometric Mean**	USFWS Geometric Variance**	USFWS Geometric Std Dev**
PHCO - pheasant							
Dressed carcass							
CMP-BSA 2	0	10	BCRL	BCRL	NA	NA	NA
3	0	4	BCRL	BCRL	NA	NA	NA
4	0	1	BCRL	BCRL	NA	NA	NA
5	0	8	BCRL	BCRL	NA	NA	NA
11	0	3	BCRL	BCRL	NA	NA	NA
RMA FAR	0	6	BCRL	BCRL	NA	NA	NA
RMA NEAR	0	1	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	0	33	BCRL	BCRL	NA	NA	NA
Control	0	8	BCRL	BCRL	NA	NA	NA
Liver							
CMP-BSA 2	0	6	BCRL	BCRL	NA	NA	NA
3	0	4	BCRL	BCRL	NA	NA	NA
5	0	7	BCRL	BCRL	NA	NA	NA
11	0	3	BCRL	BCRL	NA	NA	NA
RMA FAR	0	6	BCRL	BCRL	NA	NA	NA
RMA NEAR	0	1	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	0	27	BCRL	BCRL	NA	NA	NA
Control	0	8	BCRL	BCRL	NA	NA	NA
All Samples							
CMP-BSA 2	0	16	BCRL	BCRL	NA	NA	NA
3	0	8	BCRL	BCRL	NA	NA	NA
4	0	1	BCRL	BCRL	NA	NA	NA
5	0	15	BCRL	BCRL	NA	NA	NA
11	0	6	BCRL	BCRL	NA	NA	NA
RMA FAR	0	12	BCRL	BCRL	NA	NA	NA
RMA NEAR	0	2	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	0	60	BCRL	BCRL	NA	NA	NA
Control	0	16	BCRL	BCRL	NA	NA	NA
PIME - bullsnake (FORTUITOUS)							
RMA NEAR	0	1	BCRL	BCRL	NA	NA	NA
PIPI - black-billed magpie (FORTUITOUS)							
CMP-BSA 13	0	1	BCRL	BCRL	NA	NA	NA
SPTR - thirteen-lined ground squirrel							
CMP-BSA 1	0	2	BCRL	BCRL	NA	NA	NA
2	0	1	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	0	3	BCRL	BCRL	NA	NA	NA
STNE - western meadowlark							
CMP-BSA 2	0	8	BCRL	BCRL	NA	NA	NA
5	0	2	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	0	10	BCRL	BCRL	NA	NA	NA
Control	0	5	BCRL	BCRL	NA	NA	NA
STNE - western meadowlark (FORTUITOUS)							
CMP-BSA 2	0	1	BCRL	BCRL	NA	NA	NA
12	0	1	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	0	2	BCRL	BCRL	NA	NA	NA
STVU - starling (FORTUITOUS)							
CMP-BSA 13	0	1	BCRL	BCRL	NA	NA	NA

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NA = Not applicable.

NC = Number of detections was less than 50% of the sample size and a mean was not calculated.

	Total # of Hits	Total # of Samples	Minimum Detected Conc (µg/g)	Maximum Detected Conc (µg/g)	USFWS Geometric Mean**	USFWS Geometric Variance**	USFWS Geometric Std Dev**
SYAU - desert cottontail							
Dressed carcass							
CMP-BSA 1	0	3	BCRL	BCRL	NA	NA	NA
2	0	2	BCRL	BCRL	NA	NA	NA
3	0	2	BCRL	BCRL	NA	NA	NA
5	0	4	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	0	11	BCRL	BCRL	NA	NA	NA
Control	0	4	BCRL	BCRL	NA	NA	NA
Liver							
CMP-BSA 1	0	3	BCRL	BCRL	NA	NA	NA
All Samples							
CMP-BSA 1	0	6	BCRL	BCRL	NA	NA	NA
2	0	2	BCRL	BCRL	NA	NA	NA
3	0	2	BCRL	BCRL	NA	NA	NA
5	0	4	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	0	14	BCRL	BCRL	NA	NA	NA
Control	0	4	BCRL	BCRL	NA	NA	NA
SYAU - desert cottontail (FORTUITOUS)							
Liver							
CMP-BSA 1	0	1	BCRL	BCRL	NA	NA	NA
TATA - badger (FORTUITOUS)							
Liver							
CMP-BSA 1	0	1	BCRL	BCRL	NA	NA	NA
Brain							
CMP-BSA 1	0	1	BCRL	BCRL	NA	NA	NA
Fat							
CMP-BSA 1	0	1	BCRL	BCRL	NA	NA	NA
Solid stomach contents							
CMP-BSA 1	0	1	BCRL	BCRL	NA	NA	NA
Liquid stomach contents							
CMP-BSA 1	0	1	BCRL	BCRL	NA	NA	NA
All Samples							
CMP-BSA 1	0	5	BCRL	BCRL	NA	NA	NA
TUMI - American robin (FORTUITOUS)							
Dressed carcass							
CMP-BSA 13	0	6	BCRL	BCRL	NA	NA	NA
ZEMA - mourning dove							
CMP-BSA 1	0	11	BCRL	BCRL	NA	NA	NA
2	1	13	2.63	2.63	NC	NC	NC
3	0	11	BCRL	BCRL	NA	NA	NA
4	0	16	BCRL	BCRL	NA	NA	NA
5	0	10	BCRL	BCRL	NA	NA	NA
11	0	1	BCRL	BCRL	NA	NA	NA
12	0	3	BCRL	BCRL	NA	NA	NA
RMA NEAR	0	3	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	1	68	2.63	2.63	NC	NC	NC
Control	0	10	BCRL	BCRL	NA	NA	NA
ZEMA - mourning dove (FORTUITOUS)							
CMP-BSA 13	0	4	BCRL	BCRL	NA	NA	NA

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Table 5.1-9 Mercury Statistical Results for Terrestrial Species Sampled for CMP, 1988 to 1990*

	Total # of Hits	Total # of Samples	Minimum Detected Conc (µg/g)	Maximum Detected Conc (µg/g)	USFWS Geometric Mean**	USFWS Geometric Variance**	USFWS Geometric Std Dev**
ACRI - grasshopper							
CMP-BSA 1	0	11	BCRL	BCRL	NA	NA	NA
2	0	10	BCRL	BCRL	NA	NA	NA
3	0	6	BCRL	BCRL	NA	NA	NA
4	0	6	BCRL	BCRL	NA	NA	NA
5	0	5	BCRL	BCRL	NA	NA	NA
11	0	1	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	0	39	BCRL	BCRL	NA	NA	NA
Control	0	7	BCRL	BCRL	NA	NA	NA
AQCH - golden eagle (FORTUITOUS)							
Muscle							
Off RMA	1	1	0.140	0.140	0.140	NA	NA
Liver							
Off RMA	1	1	0.304	0.304	0.304	NA	NA
Brain							
Off RMA	1	1	0.0969	0.0969	0.0969	NA	NA
All Samples							
Off RMA	3	3	0.0969	0.304	0.160	1.41	1.79
ATCU - burrowing owl							
CMP-BSA 2	0	1	BCRL	BCRL	NA	NA	NA
3	0	1	BCRL	BCRL	NA	NA	NA
12	0	1	BCRL	BCRL	NA	NA	NA
RMA NEAR	0	4	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	0	7	BCRL	BCRL	NA	NA	NA
BRTE - cheatgrass							
CMP-BSA 1	0	8	BCRL	BCRL	NA	NA	NA
2	0	8	BCRL	BCRL	NA	NA	NA
3	0	6	BCRL	BCRL	NA	NA	NA
4	0	4	BCRL	BCRL	NA	NA	NA
5	0	8	BCRL	BCRL	NA	NA	NA
11	0	3	BCRL	BCRL	NA	NA	NA
12	0	2	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	0	39	BCRL	BCRL	NA	NA	NA
Control	0	11	BCRL	BCRL	NA	NA	NA
BUJA - red-tailed hawk (FORTUITOUS)							
Muscle							
CMP-BSA 5	0	1	BCRL	BCRL	NA	NA	NA
13	0	1	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	0	2	BCRL	BCRL	NA	NA	NA
Liver							
CMP-BSA 5	1	1	0.0489	0.0489	0.0489	NA	NA
13	0	1	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	1	2	0.0489	0.0489	0.0336	1.32	1.70
All Samples							
CMP-BSA 5	1	2	0.0489	0.0489	0.0336	1.32	1.70
13	0	2	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	1	4	0.0489	0.0489	NC	NC	NC

*This table incorporates all available data for all samples (intentional and fortuitous) analyzed under the Biota CMP.

**The USFWS geometric mean includes nonhits and assigns them a value equal to one-half of the lower CRL; descriptive statistics are calculated only when 50% or more of the samples are hits.

BCRL = Below certified reporting limit. This value varied for different labs and in different years.

NA = Not applicable.

NC = Number of detections was less than 50% of the sample size and a mean was not calculated.

	Total # of Hits	Total # of Samples	Minimum Detected Conc (µg/g)	Maximum Detected Conc (µg/g)	USFWS Geometric Mean**	USFWS Geometric Variance**	USFWS Geometric Std Dev**
BURE - ferruginous hawk (FORTUITOUS)							
Muscle							
RMA NEAR	0	1	BCRL	BCRL	NA	NA	NA
Liver							
RMA NEAR	1	1	0.0760	0.0760	0.0760	NA	NA
All Samples							
RMA NEAR	1	2	0.0760	0.0760	0.0419	2.03	2.32
BUSW - Swainson's hawk (FORTUITOUS)							
Muscle							
RMA FAR	0	1	BCRL	BCRL	NA	NA	NA
Liver							
RMA FAR	0	1	BCRL	BCRL	NA	NA	NA
All Samples							
RMA FAR	0	2	BCRL	BCRL	NA	NA	NA
BUVI - great horned owl							
Egg							
CMP-BSA 5	1	1	0.106	0.106	0.106	NA	NA
RMA FAR	0	1	BCRL	BCRL	NA	NA	NA
RMA NEAR	0	3	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	1	5	0.106	0.106	NC	NC	NC
BUVI - great horned owl (FORTUITOUS)							
Muscle							
CMP-BSA 4	0	1	BCRL	BCRL	NA	NA	NA
5	1	1	0.0643	0.0643	0.0643	NA	NA
12	1	1	0.0664	0.0664	0.0664	NA	NA
All RMA CMP-BSAs	2	3	0.0643	0.0664	0.0462	1.43	1.82
Liver							
CMP-BSA 4	0	1	BCRL	BCRL	NA	NA	NA
5	1	1	0.131	0.131	0.131	NA	NA
12	1	1	0.0581	0.0581	0.0581	NA	NA
All RMA CMP-BSAs	2	3	0.0581	0.131	0.0561	2.12	2.38
All Samples							
CMP-BSA 4	0	2	BCRL	BCRL	NA	NA	NA
5	2	2	0.0643	0.131	0.0918	1.29	1.65
12	2	2	0.0581	0.0664	0.0621	1.01	1.10
All RMA CMP-BSAs	4	6	0.0581	0.131	0.0509	1.58	1.96
COLE - ground beetles							
CMP-BSA 1	0	5	BCRL	BCRL	NA	NA	NA
2	1	5	0.0589	0.0589	NC	NC	NC
5	0	2	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	1	12	0.0589	0.0589	NC	NC	NC
Control	0	3	BCRL	BCRL	NA	NA	NA
CYLU - prairie dog							
CMP-BSA 1	0	26	BCRL	BCRL	NA	NA	NA
2	0	21	BCRL	BCRL	NA	NA	NA
3	1	19	0.0472	0.0472	NC	NC	NC
11	0	1	BCRL	BCRL	NA	NA	NA
12	0	5	BCRL	BCRL	NA	NA	NA
RMA NEAR	0	5	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	1	77	0.0472	0.0472	NC	NC	NC
Control	0	20	BCRL	BCRL	NA	NA	NA

*This table incorporates all available data for all samples (intentional and fortuitous) analyzed under the Biota CMP.

**The USFWS geometric mean includes nonhits and assigns them a value equal to one-half of the lower CRL; descriptive statistics are calculated only when 50% or more of the samples are hits.

BCRL = Below certified reporting limit. This value varied for different labs and in different years.

NA = Not applicable.

NC = Number of detections was less than 50% of the sample size and a mean was not calculated.

Table 5.1-9 Mercury Statistical Results for Terrestrial Species Sampled for CMP, 1988 to 1990*

	Total # of Hits	Total # of Samples	Minimum Detected Conc (µg/g)	Maximum Detected Conc (µg/g)	USFWS Geometric Mean**	USFWS Geometric Variance**	USFWS Geometric Std Dev**
BUCY - Brewer's blackbird (FORTUITOUS)							
CMP-BSA 5	0	1	BCRL	BCRL	NA	NA	NA
FASP - kestrel							
Dressed carcass							
CMP-BSA 1	0	1	BCRL	BCRL	NA	NA	NA
2	0	1	BCRL	BCRL	NA	NA	NA
5	0	2	BCRL	BCRL	NA	NA	NA
RMA NEAR	0	6	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	0	10	BCRL	BCRL	NA	NA	NA
Control	0	9	BCRL	BCRL	NA	NA	NA
Egg							
CMP-BSA 2	0	1	BCRL	BCRL	NA	NA	NA
5	0	1	BCRL	BCRL	NA	NA	NA
RMA NEAR	0	5	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	0	7	BCRL	BCRL	NA	NA	NA
Control	0	4	BCRL	BCRL	NA	NA	NA
All Samples							
CMP-BSA 1	0	1	BCRL	BCRL	NA	NA	NA
2	0	2	BCRL	BCRL	NA	NA	NA
5	0	3	BCRL	BCRL	NA	NA	NA
RMA NEAR	0	11	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	0	17	BCRL	BCRL	NA	NA	NA
Control	0	13	BCRL	BCRL	NA	NA	NA
FASP - kestrel (FORTUITOUS)							
Dressed carcass							
CMP-BSA 5	0	1	BCRL	BCRL	NA	NA	NA
13	0	1	BCRL	BCRL	NA	NA	NA
RMA NEAR	0	1	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	0	3	BCRL	BCRL	NA	NA	NA
HALE - bald eagle (FORTUITOUS)							
Muscle							
RMA NEAR	1	1	0.0542	0.0542	0.0542	NA	NA
Liver							
RMA NEAR	1	1	0.153	0.153	0.153	NA	NA
Brain							
RMA NEAR	0	1	BCRL	BCRL	NA	NA	NA
All Samples							
RMA NEAR	2	3	0.0542	0.153	0.0577	2.45	2.57
HEAN - sunflower							
CMP-BSA 1	0	7	BCRL	BCRL	NA	NA	NA
2	0	8	BCRL	BCRL	NA	NA	NA
3	0	6	BCRL	BCRL	NA	NA	NA
4	0	6	BCRL	BCRL	NA	NA	NA
5	0	7	BCRL	BCRL	NA	NA	NA
12	0	2	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	0	36	BCRL	BCRL	NA	NA	NA
Control	0	10	BCRL	BCRL	NA	NA	NA

*This table incorporates all available data for all samples (intentional and fortuitous) analyzed under the Biota CMP.
**The USFWS geometric mean includes nonhits and assigns them a value equal to one-half of the lower CRL; descriptive statistics are calculated only when 50% or more of the samples are hits.
BCRL = Below certified reporting limit. This value varied for different labs and in different years.
NA = Not applicable.
NC = Number of detections was less than 50% of the sample size and a mean was not calculated.

Table 5.1-9 Mercury Statistical Results for Terrestrial Species Sampled for CMP, 1988 to 1990*

	Total # of Hits	Total # of Samples	Minimum Detected Conc (µg/g)	Maximum Detected Conc (µg/g)	USFWS Geometric Mean**	USFWS Geometric Variance**	USFWS Geometric Std Dev**
KOIR - kochia							
CMP-BSA 1	0	5	BCRL	BCRL	NA	NA	NA
2	0	7	BCRL	BCRL	NA	NA	NA
3	0	4	BCRL	BCRL	NA	NA	NA
5	0	8	BCRL	BCRL	NA	NA	NA
11	0	1	BCRL	BCRL	NA	NA	NA
12	0	2	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	0	27	BCRL	BCRL	NA	NA	NA
Control	0	10	BCRL	BCRL	NA	NA	NA
LASE - wild lettuce							
CMP-BSA 1	0	7	BCRL	BCRL	NA	NA	NA
2	0	1	BCRL	BCRL	NA	NA	NA
3	0	2	BCRL	BCRL	NA	NA	NA
4	0	3	BCRL	BCRL	NA	NA	NA
5	0	1	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	0	14	BCRL	BCRL	NA	NA	NA
Control	0	3	BCRL	BCRL	NA	NA	NA
ODHE - mule deer							
Muscle							
CMP-BSA 1	0	1	BCRL	BCRL	NA	NA	NA
3	0	1	BCRL	BCRL	NA	NA	NA
4	0	1	BCRL	BCRL	NA	NA	NA
RMA FAR	0	1	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	0	4	BCRL	BCRL	NA	NA	NA
Control	0	1	BCRL	BCRL	NA	NA	NA
Liver							
CMP-BSA 1	0	1	BCRL	BCRL	NA	NA	NA
3	0	1	BCRL	BCRL	NA	NA	NA
4	0	1	BCRL	BCRL	NA	NA	NA
RMA FAR	0	1	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	0	4	BCRL	BCRL	NA	NA	NA
Control	0	1	BCRL	BCRL	NA	NA	NA
All Samples							
CMP-BSA 1	0	2	BCRL	BCRL	NA	NA	NA
3	0	2	BCRL	BCRL	NA	NA	NA
4	0	2	BCRL	BCRL	NA	NA	NA
RMA FAR	0	2	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	0	8	BCRL	BCRL	NA	NA	NA
Control	0	2	BCRL	BCRL	NA	NA	NA

*This table incorporates all available data for all samples (intentional and fortuitous) analyzed under the Biota CMP.

**The USFWS geometric mean includes nonhits and assigns them a value equal to one-half of the lower CRL; descriptive statistics are calculated only when 50% or more of the samples are hits.

BCRL = Below certified reporting limit. This value varied for different labs and in different years.

NA = Not applicable.

NC = Number of detections was less than 50% of the sample size and a mean was not calculated.

Table 5.1-9 Mercury Statistical Results for Terrestrial Species Sampled for CMP, 1988 to 1990*

	Total # of Hits	Total # of Samples	Minimum Detected Conc (µg/g)	Maximum Detected Conc (µg/g)	USFWS Geometric Mean**	USFWS Geometric Variance**	USFWS Geometric Std Dev**
ODVI - white-tail deer							
Muscle							
CMP-BSA 5	0	2	BCRL	BCRL	NA	NA	NA
RMA FAR	0	1	BCRL	BCRL	NA	NA	NA
RMA NEAR	0	3	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	0	6	BCRL	BCRL	NA	NA	NA
Control	0	5	BCRL	BCRL	NA	NA	NA
Liver							
CMP-BSA 5	0	2	BCRL	BCRL	NA	NA	NA
RMA FAR	0	1	BCRL	BCRL	NA	NA	NA
RMA NEAR	0	3	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	0	6	BCRL	BCRL	NA	NA	NA
Control	0	5	BCRL	BCRL	NA	NA	NA
All Samples							
CMP-BSA 5	0	4	BCRL	BCRL	NA	NA	NA
RMA FAR	0	2	BCRL	BCRL	NA	NA	NA
RMA NEAR	0	6	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	0	12	BCRL	BCRL	NA	NA	NA
Control	0	10	BCRL	BCRL	NA	NA	NA
OLIG - earthworm							
CMP-BSA 1	6	6	0.0586	0.141	0.0906	1.15	1.45
2	5	7	0.0550	0.103	0.0528	1.45	1.84
3	3	7	0.0474	0.0688	NC	NC	NC
4	3	5	0.0621	0.132	0.0493	1.76	2.12
5	8	13	0.0534	0.169	0.0487	1.57	1.95
11	1	4	0.0519	0.0519	NC	NC	NC
12	3	3	0.0596	0.144	0.0996	1.23	1.58
13	4	6	0.0534	0.0971	0.0493	1.43	1.82
All RMA CMP-BSAs	33	51	0.0474	0.169	0.0508	1.50	1.89
Control	2	12	0.0561	0.0595	NC	NC	NC
PEMA - deer mouse							
CMP-BSA 1	2	15	0.123	0.807	NC	NC	NC
2	1	14	0.0579	0.0579	NC	NC	NC
3	0	11	BCRL	BCRL	NA	NA	NA
4	0	10	BCRL	BCRL	NA	NA	NA
5	1	15	0.107	0.107	NC	NC	NC
11	0	6	BCRL	BCRL	NA	NA	NA
12	1	4	0.338	0.338	NC	NC	NC
All RMA CMP-BSAs	5	75	0.0579	0.807	NC	NC	NC
Control	2	15	0.0563	0.0641	NC	NC	NC

*This table incorporates all available data for all samples (intentional and fortuitous) analyzed under the Biota CMP.

**The USFWS geometric mean includes nonhits and assigns them a value equal to one-half of the lower CRL; descriptive statistics are calculated only when 50% or more of the samples are hits.

BCRL = Below certified reporting limit. This value varied for different labs and in different years.

NA = Not applicable.

NC = Number of detections was less than 50% of the sample size and a mean was not calculated.

Table 5.1-9 Mercury Statistical Results for Terrestrial Species Sampled for CMP, 1988 to 1990*

	Total # of Hits	Total # of Samples	Minimum Detected Conc (µg/g)	Maximum Detected Conc (µg/g)	USFWS Geometric Mean**	USFWS Geometric Variance**	USFWS Geometric Std Dev**
PHCO - pheasant							
Dressed carcass							
CMP-BSA 2	2	10	0.106	0.122	NC	NC	NC
3	0	5	BCRL	BCRL	NA	NA	NA
4	0	1	BCRL	BCRL	NA	NA	NA
5	0	10	BCRL	BCRL	NA	NA	NA
11	0	3	BCRL	BCRL	NA	NA	NA
RMA FAR	0	6	BCRL	BCRL	NA	NA	NA
RMA NEAR	0	6	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	2	41	0.106	0.122	NC	NC	NC
Control	0	13	BCRL	BCRL	NA	NA	NA
Liver							
CMP-BSA 2	0	4	BCRL	BCRL	NA	NA	NA
3	0	4	BCRL	BCRL	NA	NA	NA
5	0	7	BCRL	BCRL	NA	NA	NA
RMA FAR	0	6	BCRL	BCRL	NA	NA	NA
RMA NEAR	0	2	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	0	23	BCRL	BCRL	NA	NA	NA
Control	0	9	BCRL	BCRL	NA	NA	NA
All Samples							
CMP-BSA 2	2	14	0.106	0.122	NC	NC	NC
3	0	9	BCRL	BCRL	NA	NA	NA
4	0	1	BCRL	BCRL	NA	NA	NA
5	0	17	BCRL	BCRL	NA	NA	NA
11	0	3	BCRL	BCRL	NA	NA	NA
RMA FAR	0	12	BCRL	BCRL	NA	NA	NA
RMA NEAR	0	8	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	2	64	0.106	0.122	NC	NC	NC
Control	0	22	BCRL	BCRL	NA	NA	NA
PIME - bullsnake (FORTUITOUS)							
RMA NEAR	0	1	BCRL	BCRL	NA	NA	NA
PIPI - black-billed magpie (FORTUITOUS)							
CMP-BSA 13	0	1	BCRL	BCRL	NA	NA	NA
SPTR - thirteen-lined ground squirrel							
CMP-BSA 1	0	1	BCRL	BCRL	NA	NA	NA
2	0	1	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	0	2	BCRL	BCRL	NA	NA	NA
STNE - western meadowlark							
CMP-BSA 2	0	8	BCRL	BCRL	NA	NA	NA
5	0	2	BCRL	BCRL	NA	NA	NA
12	0	10	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	0	5	BCRL	BCRL	NA	NA	NA
Control							
STNE - western meadowlark (FORTUITOUS)							
CMP-BSA 2	0	1	BCRL	BCRL	NA	NA	NA
12	0	1	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	0	2	BCRL	BCRL	NA	NA	NA
STVU - starling (FORTUITOUS)							
CMP-BSA 13	1	1	0.0477	0.0477	0.0477	NA	NA

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NC = Number of detections was less than 50% of the sample size and a mean was not calculated.

Table 5.1-9 Mercury Statistical Results for Terrestrial Species Sampled for CMP, 1988 to 1990*

	Total # of Hits	Total # of Samples	Minimum Detected Conc (µg/g)	Maximum Detected Conc (µg/g)	USFWS Geometric Mean**	USFWS Geometric Variance**	USFWS Geometric Std Dev**
SYAU - desert cottontail							
Dressed carcass							
CMP-BSA 1	0	3	BCRL	BCRL	NA	NA	NA
2	0	2	BCRL	BCRL	NA	NA	NA
3	0	2	BCRL	BCRL	NA	NA	NA
5	0	4	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	0	11	BCRL	BCRL	NA	NA	NA
Control	0	4	BCRL	BCRL	NA	NA	NA
Muscle							
CMP-BSA 1	0	2	BCRL	BCRL	NA	NA	NA
Liver							
CMP-BSA 1	0	3	BCRL	BCRL	NA	NA	NA
All Samples							
CMP-BSA 1	0	8	BCRL	BCRL	NA	NA	NA
2	0	2	BCRL	BCRL	NA	NA	NA
3	0	2	BCRL	BCRL	NA	NA	NA
5	0	4	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	0	16	BCRL	BCRL	NA	NA	NA
Control	0	4	BCRL	BCRL	NA	NA	NA
SYAU - desert cottontail (FORTUITOUS)							
Muscle							
CMP-BSA 1	0	1	BCRL	BCRL	NA	NA	NA
Liver							
CMP-BSA 1	0	1	BCRL	BCRL	NA	NA	NA
All Samples							
CMP-BSA 1	0	2	BCRL	BCRL	NA	NA	NA
TATA - badger (FORTUITOUS)							
Muscle							
CMP-BSA 1	0	1	BCRL	BCRL	NA	NA	NA
Liver							
CMP-BSA 1	0	1	BCRL	BCRL	NA	NA	NA
Brain							
CMP-BSA 1	0	1	BCRL	BCRL	NA	NA	NA
Fat							
CMP-BSA 1	0	1	BCRL	BCRL	NA	NA	NA
Solid stomach contents							
CMP-BSA 1	0	1	BCRL	BCRL	NA	NA	NA
Liquid stomach contents							
CMP-BSA 1	0	1	BCRL	BCRL	NA	NA	NA
All Samples							
CMP-BSA 1	0	6	BCRL	BCRL	NA	NA	NA

*This table incorporates all available data for all samples (intentional and fortuitous) analyzed under the Biota CMP.

**The USFWS geometric mean includes nonhits and assigns them a value equal to one-half of the lower CRL; descriptive statistics are calculated only when 50% or more of the samples are hits.

BCRL = Below certified reporting limit. This value varied for different labs and in different years.

NA = Not applicable.

NC = Number of detections was less than 50% of the sample size and a mean was not calculated.

Table 5.1-9 Mercury Statistical Results for Terrestrial Species Sampled for CMP, 1988 to 1990*

	Total # of Hits	Total # of Samples	Minimum Detected Conc (µg/g)	Maximum Detected Conc (µg/g)	USFWS Geometric Mean**	USFWS Geometric Variance**	USFWS Geometric Std Dev**
TUMI - American robin (FORTUITOUS)							
Dressed carcass							
CMP-BSA 13	1	6	0.0623	0.0623	NC	NC	NC
ZEMA - mourning dove							
CMP-BSA 1	0	11	BCRL	BCRL	NA	NA	NA
2	0	13	BCRL	BCRL	NA	NA	NA
3	0	11	BCRL	BCRL	NA	NA	NA
4	0	16	BCRL	BCRL	NA	NA	NA
5	0	10	BCRL	BCRL	NA	NA	NA
11	0	1	BCRL	BCRL	NA	NA	NA
12	0	3	BCRL	BCRL	NA	NA	NA
RMA NEAR	0	3	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	0	68	BCRL	BCRL	NA	NA	NA
Control	0	10	BCRL	BCRL	NA	NA	NA
ZEMA - mourning dove (FORTUITOUS)							
CMP-BSA 13	1	4	0.400	0.400	NC	NC	NC

*This table incorporates all available data for all samples (intentional and fortuitous) analyzed under the Biota CMP.

**The USFWS geometric mean includes nonhits and assigns them a value equal to one-half of the lower CRL; descriptive statistics are calculated only when 50% or more of the samples are hits.

BCRL = Below certified reporting limit. This value varied for different labs and in different years.

NA = Not applicable.

NC = Number of detections was less than 50% of the sample size and a mean was not calculated.

Pages TABLE 5.1-10 through TABLE 5.1-17 are missing from the original.

Table 5.1-18 Aldrin Statistical Results for Aquatic Species Sampled for CMP, 1988 to 1990*

	Total # of Hits	Total # of Samples	Minimum Detected Conc (µg/g)	Maximum Detected Conc (µg/g)	USFWS Geometric Mean**	USFWS Geometric Variance**	USFWS Geometric Std Dev**
AMBY - salamander (FORTUITOUS)							
CMP-BSA 2	2	2	0.208	0.413	0.293	1.27	1.62
ANDI - blue-winged teal							
Dressed Carcass							
CMP-BSA 10	0	4	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	0	4	BCRL	BCRL	NA	NA	NA
Control	0	5	BCRL	BCRL	NA	NA	NA
ANPL - mallard							
Dressed Carcass							
CMP-BSA 10	1	13	0.0934	0.0934	NC	NC	NC
All RMA CMP-BSAs	1	13	0.0934	0.0934	NC	NC	NC
Control	0	11	BCRL	BCRL	NA	NA	NA
Liver							
CMP-BSA 10	0	9	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	0	9	BCRL	BCRL	NA	NA	NA
Control	0	5	BCRL	BCRL	NA	NA	NA
All Samples							
CMP-BSA 10	1	22	0.0934	0.0934	NC	NC	NC
All RMA CMP-BSAs	1	22	0.0934	0.0934	NC	NC	NC
Control	0	16	BCRL	BCRL	NA	NA	NA
CEDE - eoontail							
CMP-BSA 6	0	7	BCRL	BCRL	NA	NA	NA
7	0	6	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	0	13	BCRL	BCRL	NA	NA	NA
Control	0	5	BCRL	BCRL	NA	NA	NA
CHVO - killdeer							
CMP-BSA 5	0	5	BCRL	BCRL	NA	NA	NA
6	0	3	BCRL	BCRL	NA	NA	NA
8	0	2	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	0	10	BCRL	BCRL	NA	NA	NA
Control	0	5	BCRL	BCRL	NA	NA	NA
ESLU - northern pike							
CMP-BSA 7	0	3	BCRL	BCRL	NA	NA	NA
8	0	4	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	0	7	BCRL	BCRL	NA	NA	NA
Control	0	10	BCRL	BCRL	NA	NA	NA
FUAM - American coot							
CMP-BSA 6	0	4	BCRL	BCRL	NA	NA	NA
7	1	8	0.0658	0.0658	NC	NC	NC
9	0	1	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	1	13	0.0658	0.0658	NC	NC	NC
Control	0	15	BCRL	BCRL	NA	NA	NA

*This table incorporates all available data for all samples (intentional and fortuitous) analyzed under the Biota CMP.

**The USFWS geometric mean includes nonhits and assigns them a value equal to one-half of the lower CRL; descriptive statistics are calculated only when 50% or more of the samples are hits.

BCRL = Below certified reporting limit. This value varied for different labs and in different years.

NA = Not applicable.

NC = Number of detections was less than 50% of the sample size and a mean was not calculated.

Table 5.1-18 Aldrin Statistical Results for Aquatic Species Sampled for CMP, 1988 to 1990*

	Total # of Hits	Total # of Samples	Minimum Detected Conc (µg/g)	Maximum Detected Conc (µg/g)	USFWS Geometric Mean**	USFWS Geometric Variance**	USFWS Geometric Std Dev**
ICNB and ICMB - bullhead							
Whole body							
CMP-BSA 6	0	1	BCRL	BCRL	NA	NA	NA
8	0	10	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	0	11	BCRL	BCRL	NA	NA	NA
Control	0	9	BCRL	BCRL	NA	NA	NA
Composite							
CMP-BSA 10	3	5	0.0196	0.0673	0.0173	2.73	2.72
All RMA CMP-BSAs	3	5	0.0196	0.0673	0.0173	2.73	2.72
Control	0	2	BCRL	BCRL	NA	NA	NA
All Samples							
CMP-BSA 6	0	1	BCRL	BCRL	NA	NA	NA
8	0	10	BCRL	BCRL	NA	NA	NA
10	3	5	0.0196	0.0673	0.0173	2.73	2.72
All RMA CMP-BSAs	3	16	0.0196	0.0673	NC	NC	NC
Control	0	11	BCRL	BCRL	NA	NA	NA
ICPU - channel catfish							
CMP-BSA 6	0	12	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	0	12	BCRL	BCRL	NA	NA	NA
Control	0	15	BCRL	BCRL	NA	NA	NA
LEMA - bluegill							
Whole body							
CMP-BSA 6	0	10	BCRL	BCRL	NA	NA	NA
7	0	14	BCRL	BCRL	NA	NA	NA
8	0	15	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	0	39	BCRL	BCRL	NA	NA	NA
Control	0	14	BCRL	BCRL	NA	NA	NA
Composite							
CMP-BSA 6	0	5	BCRL	BCRL	NA	NA	NA
7	0	1	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	0	6	BCRL	BCRL	NA	NA	NA
All Samples							
CMP-BSA 6	0	15	BCRL	BCRL	NA	NA	NA
7	0	15	BCRL	BCRL	NA	NA	NA
8	0	15	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	0	45	BCRL	BCRL	NA	NA	NA
Control	0	14	BCRL	BCRL	NA	NA	NA
MISA - largemouth bass							
CMP-BSA 6	0	14	BCRL	BCRL	NA	NA	NA
7	0	15	BCRL	BCRL	NA	NA	NA
8	0	15	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	0	44	BCRL	BCRL	NA	NA	NA
Control	0	15	BCRL	BCRL	NA	NA	NA
PLAN - plankton							
CMP-BSA 6	0	10	BCRL	BCRL	NA	NA	NA
7	0	10	BCRL	BCRL	NA	NA	NA
8	0	10	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	0	30	BCRL	BCRL	NA	NA	NA
Control	0	10	BCRL	BCRL	NA	NA	NA

*This table incorporates all available data for all samples (intentional and fortuitous) analyzed under the Biota CMP.

**The USFWS geometric mean includes nonhits and assigns them a value equal to one-half of the lower CRL; descriptive statistics are calculated only when 50% or more of the samples are hits.

BCRL = Below certified reporting limit. This value varied for different labs and in different years.

NA = Not applicable.

NC = Number of detections was less than 50% of the sample size and a mean was not calculated.

Table 5.1-18 Aldrin Statistical Results for Aquatic Species Sampled for CMP, 1988 to 1990*

	Total # of Hits	Total # of Samples	Minimum Detected Conc (µg/g)	Maximum Detected Conc (µg/g)	USFWS Geometric Mean**	USFWS Geometric Variance**	USFWS Geometric Std Dev**
POND - American pondweed							
CMP-BSA 6	0	8	BCRL	BCRL	NA	NA	NA
7	0	8	BCRL	BCRL	NA	NA	NA
8	0	8	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	0	24	BCRL	BCRL	NA	NA	NA
Control	0	10	BCRL	BCRL	NA	NA	NA
POPE - sago pondweed							
CMP-BSA 6	0	6	BCRL	BCRL	NA	NA	NA
7	0	6	BCRL	BCRL	NA	NA	NA
8	0	6	BCRL	BCRL	NA	NA	NA
9	0	4	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	0	22	BCRL	BCRL	NA	NA	NA
Control	0	10	BCRL	BCRL	NA	NA	NA

*This table incorporates all available data for all samples (intentional and fortuitous) analyzed under the Biota CMP.

**The USFWS geometric mean includes nonhits and assigns them a value equal to one-half of the lower CRL; descriptive statistics are calculated only when 50% or more of the samples are hits.

BCRL = Below certified reporting limit. This value varied for different labs and in different years.

NA = Not applicable.

NC = Number of detections was less than 50% of the sample size and a mean was not calculated.

Table 5.1-19 Dieldrin Statistical Results for Aquatic Species Sampled for CMP, 1988 to 1990*

	Total # of Hits	Total # of Samples	Minimum Detected Conc (µg/g)	Maximum Detected Conc (µg/g)	USFWS Geometric Mean**	USFWS Geometric Variance**	USFWS Geometric Std Dev**
AMBY - salamander (FORTUITOUS)							
CMP-BSA 2	2	2	2.50	4.00	3.16	1.12	1.39
ANDI - blue-winged teal							
Dressed Carcass							
CMP-BSA 10	4	4	0.204	0.571	0.349	1.24	1.59
All RMA CMP-BSAs	4	4	0.204	0.571	0.349	1.24	1.59
Control	0	5	BCRL	BCRL	NA	NA	NA
ANPL - mallard							
Dressed Carcass							
CMP-BSA 10	15	15	0.0697	4.20	0.398	4.59	3.44
All RMA CMP-BSAs	15	15	0.0697	4.20	0.398	4.59	3.44
Control	0	11	BCRL	BCRL	NA	NA	NA
Liver							
CMP-BSA 10	10	10	0.179	1.50	0.516	1.53	1.92
All RMA CMP-BSAs	10	10	0.179	1.50	0.516	1.53	1.92
Control	0	5	BCRL	BCRL	NA	NA	NA
All Samples							
CMP-BSA 10	25	25	0.0697	4.20	0.441	2.90	2.81
All RMA CMP-BSAs	25	25	0.0697	4.20	0.441	2.90	2.81
Control	0	16	BCRL	BCRL	NA	NA	NA
CEDE - eastern cottontail							
CMP-BSA 6	0	7	BCRL	BCRL	NA	NA	NA
7	0	6	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	0	13	BCRL	BCRL	NA	NA	NA
Control	0	5	BCRL	BCRL	NA	NA	NA
CHVO - killdeer							
CMP-BSA 5	5	5	0.920	6.80	2.34	1.81	2.16
6	3	3	0.895	1.37	1.07	1.05	1.25
8	2	2	0.154	1.14	0.419	7.42	4.12
All RMA CMP-BSAs	10	10	0.154	6.80	1.31	2.68	2.70
Control	0	5	BCRL	BCRL	NA	NA	NA
ESLU - northern pike							
CMP-BSA 7	2	3	0.242	0.283	0.142	3.07	2.88
8	4	4	0.202	0.273	0.226	1.02	1.14
All RMA CMP-BSAs	6	7	0.202	0.283	0.185	1.56	1.95
Control	0	10	BCRL	BCRL	NA	NA	NA
FUAM - American coot							
CMP-BSA 6	5	5	0.0202	0.301	0.102	2.70	2.71
7	11	11	0.0735	0.207	0.128	1.12	1.41
9	0	1	BCRL	BCRL	NA	NA	NA
10	1	1	0.110	0.110	0.110	NA	NA
All RMA CMP-BSAs	17	18	0.0202	0.301	0.112	1.45	1.84
Control	0	15	BCRL	BCRL	NA	NA	NA

*This table incorporates all available data for all samples (intentional and fortuitous) analyzed under the Biota CMP.

**The USFWS geometric mean includes nonhits and assigns them a value equal to one-half of the lower CRL; descriptive statistics are calculated only when 50% or more of the samples are hits.

BCRL = Below certified reporting limit. This value varied for different labs and in different years.

NA = Not applicable.

NC = Number of detections was less than 50% of the sample size and a mean was not calculated.

Table 5.1-19 Dieldrin Statistical Results for Aquatic Species Sampled for CMP, 1988 to 1990*

	Total # of Hits	Total # of Samples	Minimum Detected Conc (µg/g)	Maximum Detected Conc (µg/g)	USFWS Geometric Mean**	USFWS Geometric Variance**	USFWS Geometric Std Dev**
ICNB and ICMB - bullhead							
Whole body							
CMP-BSA 6	1	1	0.155	0.155	0.155	NA	NA
8	3	10	0.0350	0.285	NC	NC	NC
All RMA CMP-BSAs	4	11	0.0350	0.285	NC	NC	NC
Control	0	9	BCRL	BCRL	NA	NA	NA
Composite							
CMP-BSA 10	5	5	0.105	0.240	0.155	1.09	1.34
All RMA CMP-BSAs	5	5	0.105	0.240	0.155	1.09	1.34
Control	0	2	BCRL	BCRL	NA	NA	NA
All Samples							
CMP-BSA 6	1	1	0.155	0.155	0.155	NA	NA
8	3	10	0.0350	0.285	NC	NC	NC
10	5	5	0.105	0.240	0.155	1.09	1.34
All RMA CMP-BSAs	9	16	0.0350	0.285	0.0571	3.77	3.17
Control	0	11	BCRL	BCRL	NA	NA	NA
ICPU - channel catfish							
CMP-BSA 6	9	12	0.0301	0.618	0.0682	10.4	4.62
All RMA CMP-BSAs	9	12	0.0301	0.618	0.0682	10.4	4.62
Control	0	15	BCRL	BCRL	NA	NA	NA
LEMA - bluegill							
Whole body							
CMP-BSA 6	2	10	0.0194	0.0258	NC	NC	NC
7	14	14	0.0203	0.515	0.109	2.84	2.78
8	12	15	0.0348	0.444	0.0802	7.77	4.19
All RMA CMP-BSAs	28	39	0.0194	0.515	0.0653	5.07	3.58
Control	0	14	BCRL	BCRL	NA	NA	NA
Composite							
CMP-BSA 6	0	5	BCRL	BCRL	NA	NA	NA
7	1	1	0.0209	0.0209	0.0209	NA	NA
All RMA CMP-BSAs	1	6	0.0209	0.0209	NC	NC	NC
All Samples							
CMP-BSA 6	2	15	0.0194	0.0258	NC	NC	NC
7	15	15	0.0203	0.515	0.0978	3.16	2.92
8	12	15	0.0348	0.444	0.0802	7.77	4.19
All RMA CMP-BSAs	29	45	0.0194	0.515	0.0511	6.15	3.85
Control	0	14	BCRL	BCRL	NA	NA	NA
MISA - largemouth bass							
CMP-BSA 6	9	14	0.0199	0.222	0.0308	2.33	2.51
7	13	15	0.0428	0.778	0.108	3.50	3.06
8	14	14	0.0216	0.384	0.102	2.00	2.30
All RMA CMP-BSAs	36	43	0.0199	0.778	0.0704	3.43	3.03
Control	0	15	BCRL	BCRL	NA	NA	NA
PLAN - plankton							
CMP-BSA 6	0	10	BCRL	BCRL	NA	NA	NA
7	0	10	BCRL	BCRL	NA	NA	NA
8	0	10	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	0	30	BCRL	BCRL	NA	NA	NA
Control	0	10	BCRL	BCRL	NA	NA	NA

*This table incorporates all available data for all samples (intentional and fortuitous) analyzed under the Biota CMP.

**The USFWS geometric mean includes nonhits and assigns them a value equal to one-half of the lower CRL; descriptive statistics are calculated only when 50% or more of the samples are hits.

BCRL = Below certified reporting limit. This value varied for different labs and in different years.

NA = Not applicable.

NC = Number of detections was less than 50% of the sample size and a mean was not calculated.

Table 5.1-19 Dieldrin Statistical Results for Aquatic Species Sampled for CMP, 1988 to 1990*

	Total # of Hits	Total # of Samples	Minimum Detected Conc (µg/g)	Maximum Detected Conc (µg/g)	USFWS Geometric Mean**	USFWS Geometric Variance**	USFWS Geometric Std Dev**
POND - American pondweed							
CMP-BSA 6	0	8	BCRL	BCRL	NA	NA	NA
7	0	8	BCRL	BCRL	NA	NA	NA
8	0	8	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	0	24	BCRL	BCRL	NA	NA	NA
Control	0	10	BCRL	BCRL	NA	NA	NA
POPE - sago pondweed							
CMP-BSA 6	0	6	BCRL	BCRL	NA	NA	NA
7	0	6	BCRL	BCRL	NA	NA	NA
8	0	6	BCRL	BCRL	NA	NA	NA
9	0	4	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	0	22	BCRL	BCRL	NA	NA	NA
Control	0	10	BCRL	BCRL	NA	NA	NA

*This table incorporates all available data for all samples (intentional and fortuitous) analyzed under the Biota CMP.
**The USFWS geometric mean includes nonhits and assigns them a value equal to one-half of the lower CRL; descriptive statistics are calculated only when 50% or more of the samples are hits.
BCRL = Below certified reporting limit. This value varied for different labs and in different years.
NA = Not applicable.
NC = Number of detections was less than 50% of the sample size and a mean was not calculated.

Table 5.1-20 Endrin Statistical Results for Aquatic Species Sampled for CMP, 1988 to 1990*

	Total # of Hits	Total # of Samples	Minimum Detected Conc (µg/g)	Maximum Detected Conc (µg/g)	USFWS Geometric Mean**	USFWS Geometric Variance**	USFWS Geometric Std Dev**
AMBY - salamander (FORTUITOUS)							
CMP-BSA 2	2	2	0.540	1.00	0.735	1.21	1.55
ANDI - blue-winged teal							
Dressed Carcass							
CMP-BSA 10	0	4	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	0	4	BCRL	BCRL	NA	NA	NA
Control	0	5	BCRL	BCRL	NA	NA	NA
ANPL - mallard							
Dressed Carcass							
CMP-BSA 10	1	15	0.104	0.104	NC	NC	NC
All RMA CMP-BSAs	1	15	0.104	0.104	NC	NC	NC
Control	0	11	BCRL	BCRL	NA	NA	NA
Liver							
CMP-BSA 10	0	10	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	0	10	BCRL	BCRL	NA	NA	NA
Control	0	5	BCRL	BCRL	NA	NA	NA
All Samples							
CMP-BSA 10	1	25	0.104	0.104	NC	NC	NC
All RMA CMP-BSAs	1	25	0.104	0.104	NC	NC	NC
Control	0	16	BCRL	BCRL	NA	NA	NA
CEDE - eastern cottontail							
CMP-BSA 6	0	7	BCRL	BCRL	NA	NA	NA
7	0	6	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	0	13	BCRL	BCRL	NA	NA	NA
Control	0	5	BCRL	BCRL	NA	NA	NA
CHVO - killdeer							
CMP-BSA 5	2	5	0.0861	0.101	NC	NC	NC
6	3	3	0.0714	0.195	0.111	1.30	1.67
8	0	2	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	5	10	0.0714	0.195	0.0543	2.71	2.71
Control	0	5	BCRL	BCRL	NA	NA	NA
ESLU - northern pike							
CMP-BSA 7	0	3	BCRL	BCRL	NA	NA	NA
8	0	4	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	0	7	BCRL	BCRL	NA	NA	NA
Control	0	10	BCRL	BCRL	NA	NA	NA
FUAM - American coot							
CMP-BSA 6	0	5	BCRL	BCRL	NA	NA	NA
7	1	11	0.135	0.135	NC	NC	NC
9	0	1	BCRL	BCRL	NA	NA	NA
10	0	1	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	1	18	0.135	0.135	NC	NC	NC
Control	0	15	BCRL	BCRL	NA	NA	NA

*This table incorporates all available data for all samples (intentional and fortuitous) analyzed under the Biota CMP.

**The USFWS geometric mean includes nonhits and assigns them a value equal to one-half of the lower CRL; descriptive statistics are calculated only when 50% or more of the samples are hits.

BCRL = Below certified reporting limit. This value varied for different labs and in different years.

NA = Not applicable.

NC = Number of detections was less than 50% of the sample size and a mean was not calculated.

Table 5.1-20 Endrin Statistical Results for Aquatic Species Sampled for CMP, 1988 to 1990*

	Total # of Hits	Total # of Samples	Minimum Detected Conc (µg/g)	Maximum Detected Conc (µg/g)	USFWS Geometric Mean**	USFWS Geometric Variance**	USFWS Geometric Std Dev**
ICNE and ICME - bullhead							
Whole body							
CMP-BSA 6	0	1	BCRL	BCRL	NA	NA	NA
8	1	10	0.0791	0.0791	NC	NC	NC
All RMA CMP-BSAs	1	11	0.0791	0.0791	NC	NC	NC
Control	0	9	BCRL	BCRL	NA	NA	NA
Composite							
CMP-BSA 10	0	5	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	0	5	BCRL	BCRL	NA	NA	NA
Control	0	2	BCRL	BCRL	NA	NA	NA
All Samples							
CMP-BSA 6	0	1	BCRL	BCRL	NA	NA	NA
8	1	10	0.0791	0.0791	NC	NC	NC
10	0	5	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	1	16	0.0791	0.0791	NC	NC	NC
Control	0	11	BCRL	BCRL	NA	NA	NA
ICPU - channel catfish							
CMP-BSA 6	1	12	0.101	0.101	NC	NC	NC
All RMA CMP-BSAs	1	12	0.101	0.101	NC	NC	NC
Control	0	15	BCRL	BCRL	NA	NA	NA
LEMA - bluegill							
Whole body							
CMP-BSA 6	0	10	BCRL	BCRL	NA	NA	NA
7	0	14	BCRL	BCRL	NA	NA	NA
8	1	15	0.0976	0.0976	NC	NC	NC
All RMA CMP-BSAs	1	39	0.0976	0.0976	NC	NC	NC
Control	0	14	BCRL	BCRL	NA	NA	NA
Composite							
CMP-BSA 6	0	5	BCRL	BCRL	NA	NA	NA
7	0	1	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	0	6	BCRL	BCRL	NA	NA	NA
All Samples							
CMP-BSA 6	0	15	BCRL	BCRL	NA	NA	NA
7	0	15	BCRL	BCRL	NA	NA	NA
8	1	15	0.0976	0.0976	NC	NC	NC
All RMA CMP-BSAs	1	45	0.0976	0.0976	NC	NC	NC
Control	0	14	BCRL	BCRL	NA	NA	NA
MISA - largemouth bass							
CMP-BSA 6	1	14	0.0518	0.0518	NC	NC	NC
7	1	15	0.0478	0.0478	NC	NC	NC
8	0	15	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	2	44	0.0478	0.0518	NC	NC	NC
Control	0	15	BCRL	BCRL	NA	NA	NA
PLAN - plankton							
CMP-BSA 6	0	10	BCRL	BCRL	NA	NA	NA
7	0	10	BCRL	BCRL	NA	NA	NA
8	0	10	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	0	30	BCRL	BCRL	NA	NA	NA
Control	0	10	BCRL	BCRL	NA	NA	NA

*This table incorporates all available data for all samples (intentional and fortuitous) analyzed under the Biota CMP.

**The USFWS geometric mean includes nonhits and assigns them a value equal to one-half of the lower CRL; descriptive statistics are calculated only when 50% or more of the samples are hits.

BCRL = Below certified reporting limit. This value varied for different labs and in different years.

NA = Not applicable.

NC = Number of detections was less than 50% of the sample size and a mean was not calculated.

Table 5.1-20 Endrin Statistical Results for Aquatic Species Sampled for CMP, 1988 to 1990*

	Total # of Hits	Total # of Samples	Minimum Detected Conc (µg/g)	Maximum Detected Conc (µg/g)	USFWS Geometric Mean**	USFWS Geometric Variance**	USFWS Geometric Std Dev**
POND - American pondweed							
CMP-BSA 6	0	8	BCRL	BCRL	NA	NA	NA
7	0	8	BCRL	BCRL	NA	NA	NA
8	0	8	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	0	24	BCRL	BCRL	NA	NA	NA
Control	0	10	BCRL	BCRL	NA	NA	NA
POPE - sago pondweed							
CMP-BSA 6	0	6	BCRL	BCRL	NA	NA	NA
7	0	6	BCRL	BCRL	NA	NA	NA
8	0	6	BCRL	BCRL	NA	NA	NA
9	0	4	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	0	22	BCRL	BCRL	NA	NA	NA
Control	0	10	BCRL	BCRL	NA	NA	NA

*This table incorporates all available data for all samples (intentional and fortuitous) analyzed under the Biota CMP.

**The USFWS geometric mean includes nonhits and assigns them a value equal to one-half of the lower CRL; descriptive statistics are calculated only when 50% or more of the samples are hits.

BCRL = Below certified reporting limit. This value varied for different labs and in different years.

NA = Not applicable.

NC = Number of detections was less than 50% of the sample size and a mean was not calculated.

Table 5.1-21 DDT Statistical Results for Aquatic Species Sampled for CMP, 1988 to 1990*

	Total # of Hits	Total # of Samples	Minimum Detected Conc (µg/g)	Maximum Detected Conc (µg/g)	USFWS Geometric Mean**	USFWS Geometric Variance**	USFWS Geometric Std Dev**
AMBY - salamander (FORTUITOUS)							
CMP-BSA 2	1	2	0.124	0.124	0.0855	1.32	1.69
ANDI - blue-winged teal							
Dressed Carcass							
CMP-BSA 10	0	4	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	0	4	BCRL	BCRL	NA	NA	NA
Control	0	5	BCRL	BCRL	NA	NA	NA
ANPL - mallard							
Dressed Carcass							
CMP-BSA 10	0	15	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	0	15	BCRL	BCRL	NA	NA	NA
Control	0	11	BCRL	BCRL	NA	NA	NA
Liver							
CMP-BSA 10	0	10	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	0	10	BCRL	BCRL	NA	NA	NA
Control	0	5	BCRL	BCRL	NA	NA	NA
All Samples							
CMP-BSA 10	0	25	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	0	25	BCRL	BCRL	NA	NA	NA
Control	0	16	BCRL	BCRL	NA	NA	NA
CEDE - eastern cottontail							
CMP-BSA 6	0	7	BCRL	BCRL	NA	NA	NA
7	0	6	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	0	13	BCRL	BCRL	NA	NA	NA
Control	0	5	BCRL	BCRL	NA	NA	NA
CHVO - killdeer							
CMP-BSA 5	3	5	0.171	1.03	0.355	3.87	3.20
6	2	3	0.955	1.22	0.425	13.7	5.04
8	0	2	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	5	10	0.171	1.22	0.268	5.66	3.73
Control	0	5	BCRL	BCRL	NA	NA	NA
ESLU - northern pike							
CMP-BSA 7	0	3	BCRL	BCRL	NA	NA	NA
8	1	4	0.134	0.134	NC	NC	NC
All RMA CMP-BSAs	1	7	0.134	0.134	NC	NC	NC
Control	0	10	BCRL	BCRL	NA	NA	NA
FUAM - American coot							
CMP-BSA 6	0	5	BCRL	BCRL	NA	NA	NA
7	1	11	0.569	0.569	NC	NC	NC
9	0	1	BCRL	BCRL	NA	NA	NA
10	0	1	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	1	18	0.569	0.569	NC	NC	NC
Control	0	15	BCRL	BCRL	NA	NA	NA

*This table incorporates all available data for all samples (intentional and fortuitous) analyzed under the Biota CMP.
**The USFWS geometric mean includes nonhits and assigns them a value equal to one-half of the lower CRL; descriptive statistics are calculated only when 50% or more of the samples are hits.
BCRL = Below certified reporting limit. This value varied for different labs and in different years.
NA = Not applicable.
NC = Number of detections was less than 50% of the sample size and a mean was not calculated.

Table 5.1-21 DDT Statistical Results for Aquatic Species Sampled for CMP, 1988 to 1990*

	Total # of Hits	Total # of Samples	Minimum Detected Conc (µg/g)	Maximum Detected Conc (µg/g)	USFWS Geometric Mean**	USFWS Geometric Variance**	USFWS Geometric Std Dev**
ICNE and ICMB - bullhead							
Whole body							
CMP-BSA 6	0	1	BCRL	BCRL	NA	NA	NA
8	0	10	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	0	11	BCRL	BCRL	NA	NA	NA
Control	0	9	BCRL	BCRL	NA	NA	NA
Composite							
CMP-BSA 10	0	5	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	0	5	BCRL	BCRL	NA	NA	NA
Control	0	2	BCRL	BCRL	NA	NA	NA
Whole body							
CMP-BSA 6	0	1	BCRL	BCRL	NA	NA	NA
8	0	10	BCRL	BCRL	NA	NA	NA
10	0	5	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	0	16	BCRL	BCRL	NA	NA	NA
Control	0	11	BCRL	BCRL	NA	NA	NA
ICPU - channel catfish							
CMP-BSA 6	0	12	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	0	12	BCRL	BCRL	NA	NA	NA
Control	0	15	BCRL	BCRL	NA	NA	NA
LEMA - bluegill							
Whole body							
CMP-BSA 6	0	10	BCRL	BCRL	NA	NA	NA
7	0	14	BCRL	BCRL	NA	NA	NA
8	0	15	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	0	39	BCRL	BCRL	NA	NA	NA
Control	0	14	BCRL	BCRL	NA	NA	NA
Composite							
CMP-BSA 6	0	5	BCRL	BCRL	NA	NA	NA
7	0	1	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	0	6	BCRL	BCRL	NA	NA	NA
All Samples							
CMP-BSA 6	0	15	BCRL	BCRL	NA	NA	NA
7	0	15	BCRL	BCRL	NA	NA	NA
8	0	15	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	0	45	BCRL	BCRL	NA	NA	NA
Control	0	14	BCRL	BCRL	NA	NA	NA
MISA - largemouth bass							
CMP-BSA 6	1	14	0.267	0.267	NC	NC	NC
7	1	15	0.299	0.299	NC	NC	NC
8	1	15	0.144	0.144	NC	NC	NC
All RMA CMP-BSAs	3	44	0.144	0.299	NC	NC	NC
Control	0	15	BCRL	BCRL	NA	NA	NA
PLAN - plankton							
CMP-BSA 6	0	10	BCRL	BCRL	NA	NA	NA
7	0	10	BCRL	BCRL	NA	NA	NA
8	0	10	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	0	30	BCRL	BCRL	NA	NA	NA
Control	0	10	BCRL	BCRL	NA	NA	NA

*This table incorporates all available data for all samples (intentional and fortuitous) analyzed under the Biota CMP.

**The USFWS geometric mean includes nonhits and assigns them a value equal to one-half of the lower CRL; descriptive statistics are calculated only when 50% or more of the samples are hits.

BCRL = Below certified reporting limit. This value varied for different labs and in different years.

NA = Not applicable.

NC = Number of detections was less than 50% of the sample size and a mean was not calculated.

Table 5.1-21 DDT Statistical Results for Aquatic Species Sampled for CMP, 1988 to 1990*

	Total # of Hits	Total # of Samples	Minimum Detected Conc (µg/g)	Maximum Detected Conc (µg/g)	USFWS Geometric Mean**	USFWS Geometric Variance**	USFWS Geometric Std Dev**
POND - American pondweed							
CMP-BSA 6	0	8	BCRL	BCRL	NA	NA	NA
7	0	8	BCRL	BCRL	NA	NA	NA
8	0	8	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	0	24	BCRL	BCRL	NA	NA	NA
Control	0	10	BCRL	BCRL	NA	NA	NA
POPE - sago pondweed							
CMP-BSA 6	0	6	BCRL	BCRL	NA	NA	NA
7	0	6	BCRL	BCRL	NA	NA	NA
8	0	6	BCRL	BCRL	NA	NA	NA
9	0	4	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	0	22	BCRL	BCRL	NA	NA	NA
Control	0	10	BCRL	BCRL	NA	NA	NA

*This table incorporates all available data for all samples (intentional and fortuitous) analyzed under the Biota CMP.

**The USFWS geometric mean includes nonhits and assigns them a value equal to one-half of the lower CRL; descriptive statistics are calculated only when 50% or more of the samples are hits.

BCRL = Below certified reporting limit. This value varied for different labs and in different years.

NA = Not applicable.

NC = Number of detections was less than 50% of the sample size and a mean was not calculated.

Table 5.1-22 DDE Statistical Results for Aquatic Species Sampled for CMP, 1988 to 1990*

	Total # of Hits	Total # of Samples	Minimum Detected Conc (µg/g)	Maximum Detected Conc (µg/g)	USFWS Geometric Mean**	USFWS Geometric Variance**	USFWS Geometric Std Dev**
AMBY - salamander (FORTUITOUS)							
CMP-BSA 2	0	2	BCRL	BCRL	NA	NA	NA
ANDI - blue-winged teal							
Dressed Carcass							
CMP-BSA 10	2	4	0.105	0.127	0.0603	1.77	2.13
All RMA CMP-BSAs	2	4	0.105	0.127	0.0603	1.77	2.13
Control	0	5	BCRL	BCRL	NA	NA	NA
ANPL - mallard							
Dressed Carcass							
CMP-BSA 10	7	15	0.101	0.408	NC	NC	NC
All RMA CMP-BSAs	7	15	0.101	0.408	NC	NC	NC
Control	6	11	0.0668	0.146	0.0677	1.15	1.46
Liver							
CMP-BSA 10	1	10	0.638	0.638	NC	NC	NC
All RMA CMP-BSAs	1	10	0.638	0.638	NC	NC	NC
Control	0	5	BCRL	BCRL	NA	NA	NA
All Samples							
CMP-BSA 10	8	25	0.101	0.638	NC	NC	NC
All RMA CMP-BSAs	8	25	0.101	0.638	NC	NC	NC
Control	6	16	0.0668	0.146	NC	NC	NC
CEDE - cocktail							
CMP-BSA 6	0	7	BCRL	BCRL	NA	NA	NA
7	0	6	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	0	13	BCRL	BCRL	NA	NA	NA
Control	0	5	BCRL	BCRL	NA	NA	NA
CHVO - killdeer							
CMP-BSA 5	5	5	0.883	7.20	3.31	2.03	2.32
6	3	3	2.56	28.8	7.02	4.88	3.52
8	2	2	0.283	3.70	1.02	27.2	6.16
All RMA CMP-BSAs	10	10	0.283	28.8	3.28	4.61	3.44
Control	5	5	0.169	0.561	0.250	1.28	1.64
ESLU - northern pike							
CMP-BSA 7	2	3	0.118	0.430	0.136	3.23	2.95
8	4	4	0.312	0.602	0.407	1.08	1.32
All RMA CMP-BSAs	6	7	0.118	0.602	0.255	2.16	2.41
Control	0	10	BCRL	BCRL	NA	NA	NA
FUAM - American coot							
CMP-BSA 6	4	5	0.166	0.241	0.146	2.13	2.39
7	2	11	0.209	0.359	NC	NC	NC
9	0	1	BCRL	BCRL	NA	NA	NA
10	0	1	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	6	18	0.166	0.359	NC	NC	NC
Control	0	15	BCRL	BCRL	NA	NA	NA

*This table incorporates all available data for all samples (intentional and fortuitous) analyzed under the Biota CMP.

**The USFWS geometric mean includes nonhits and assigns them a value equal to one-half of the lower CRL; descriptive statistics are calculated only when 50% or more of the samples are hits.

BCRL = Below certified reporting limit. This value varied for different labs and in different years.

NA = Not applicable.

NC = Number of detections was less than 50% of the sample size and a mean was not calculated.

Table 5.1-22 DDE Statistical Results for Aquatic Species Sampled for CMP, 1988 to 1990*

	Total # of Hits	Total # of Samples	Minimum Detected Conc (µg/g)	Maximum Detected Conc (µg/g)	USFWS Geometric Mean**	USFWS Geometric Variance**	USFWS Geometric Std Dev**
ICNE and ICME - bullhead							
Whole body							
CMP-BSA 6	1	1	0.425	0.425	0.425	NA	NA
8	0	10	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	1	11	0.425	0.425	NC	NC	NC
Control	0	9	BCRL	BCRL	NA	NA	NA
Composite							
CMP-BSA 10	0	5	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	0	5	BCRL	BCRL	NA	NA	NA
Control	0	2	BCRL	BCRL	NA	NA	NA
All Samples							
CMP-BSA 6	1	1	0.425	0.425	0.425	NA	NA
8	0	10	BCRL	BCRL	NA	NA	NA
10	0	5	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	1	16	0.425	0.425	NC	NC	NC
Control	0	11	BCRL	BCRL	NA	NA	NA
ICPU - channel catfish							
CMP-BSA 6	8	12	0.0661	0.376	0.110	2.62	2.67
All RMA CMP-BSAs	8	12	0.0661	0.376	0.110	2.62	2.67
Control	1	15	0.178	0.178	NC	NC	NC
LEMA - bluegill							
Whole body							
CMP-BSA 6	0	10	BCRL	BCRL	NA	NA	NA
7	0	14	BCRL	BCRL	NA	NA	NA
8	0	15	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	0	39	BCRL	BCRL	NA	NA	NA
Control	0	14	BCRL	BCRL	NA	NA	NA
Composite							
CMP-BSA 6	0	5	BCRL	BCRL	NA	NA	NA
7	0	1	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	0	6	BCRL	BCRL	NA	NA	NA
All Samples							
CMP-BSA 6	0	15	BCRL	BCRL	NA	NA	NA
7	0	15	BCRL	BCRL	NA	NA	NA
8	0	15	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	0	45	BCRL	BCRL	NA	NA	NA
Control	0	14	BCRL	BCRL	NA	NA	NA
MISA - largemouth bass							
CMP-BSA 6	10	14	0.0741	0.247	0.0915	1.51	1.90
7	6	15	0.112	0.164	NC	NC	NC
8	10	15	0.0718	0.613	0.0887	2.11	2.37
All RMA CMP-BSAs	26	44	0.0718	0.613	0.0806	1.73	2.10
Control	0	15	BCRL	BCRL	NA	NA	NA
PLAN - plankton							
CMP-BSA 6	0	10	BCRL	BCRL	NA	NA	NA
7	0	10	BCRL	BCRL	NA	NA	NA
8	0	10	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	0	30	BCRL	BCRL	NA	NA	NA
Control	0	10	BCRL	BCRL	NA	NA	NA

*This table incorporates all available data for all samples (intentional and fortuitous) analyzed under the Biota CMP.

**The USFWS geometric mean includes nonhits and assigns them a value equal to one-half of the lower CRL; descriptive statistics are calculated only when 50% or more of the samples are hits.

BCRL = Below certified reporting limit. This value varied for different labs and in different years.

NA = Not applicable.

NC = Number of detections was less than 50% of the sample size and a mean was not calculated.

Table 5.1-22 DDE Statistical Results for Aquatic Species Sampled for CMP, 1988 to 1990*

	Total # of Hits	Total # of Samples	Minimum Detected Conc (µg/g)	Maximum Detected Conc (µg/g)	USFWS Geometric Mean**	USFWS Geometric Variance**	USFWS Geometric Std Dev**
POND - American pondweed							
CMP-BSA 6	0	8	BCRL	BCRL	NA	NA	NA
7	0	8	BCRL	BCRL	NA	NA	NA
8	0	8	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	0	24	BCRL	BCRL	NA	NA	NA
Control	0	10	BCRL	BCRL	NA	NA	NA
POPE - sago pondweed							
CMP-BSA 6	0	6	BCRL	BCRL	NA	NA	NA
7	0	6	BCRL	BCRL	NA	NA	NA
8	0	6	BCRL	BCRL	NA	NA	NA
9	0	4	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	0	22	BCRL	BCRL	NA	NA	NA
Control	0	10	BCRL	BCRL	NA	NA	NA

*This table incorporates all available data for all samples (intentional and fortuitous) analyzed under the Biota CMP.
**The USFWS geometric mean includes nonhits and assigns them a value equal to one-half of the lower CRL; descriptive statistics are calculated only when 50% or more of the samples are hits.
BCRL = Below certified reporting limit. This value varied for different labs and in different years.
NA = Not applicable.
NC = Number of detections was less than 50% of the sample size and a mean was not calculated.

Table 5.1-23 Arsenic Statistical Results for Aquatic Species Sampled for CMP, 1988 to 1990*

	Total # of Hits	Total # of Samples	Minimum Detected Conc (µg/g)	Maximum Detected Conc (µg/g)	USFWS Geometric Mean**	USFWS Geometric Variance**	USFWS Geometric Std Dev**
AMBY - salamander (FORTUITOUS)							
CMP-BSA 2	0	1	BCRL	BCRL	NA	NA	NA
ANDI - blue-winged teal							
Dressed Carcass							
CMP-BSA 10	0	4	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	0	4	BCRL	BCRL	NA	NA	NA
ANPL - mallard							
Dressed Carcass							
CMP-BSA 10	0	9	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	0	9	BCRL	BCRL	NA	NA	NA
Control	0	12	BCRL	BCRL	NA	NA	NA
Liver							
CMP-BSA 10	0	6	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	0	6	BCRL	BCRL	NA	NA	NA
Control	0	5	BCRL	BCRL	NA	NA	NA
All Samples							
CMP-BSA 10	0	15	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	0	15	BCRL	BCRL	NA	NA	NA
Control	0	17	BCRL	BCRL	NA	NA	NA
CEDE - eocntail							
CMP-BSA 6	4	6	0.357	0.656	0.294	1.62	2.00
7	0	6	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	4	12	0.357	0.656	NC	NC	NC
Control	5	5	0.521	0.761	0.632	1.02	1.16
CHVO - killdeer							
CMP-BSA 5	0	5	BCRL	BCRL	NA	NA	NA
6	0	3	BCRL	BCRL	NA	NA	NA
8	0	2	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	0	10	BCRL	BCRL	NA	NA	NA
Control	0	5	BCRL	BCRL	NA	NA	NA
ESLU - northern pike							
CMP-BSA 7	0	3	BCRL	BCRL	NA	NA	NA
8	0	4	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	0	7	BCRL	BCRL	NA	NA	NA
Control	1	10	0.407	0.407	NC	NC	NC
FUAM - American coot							
CMP-BSA 6	0	4	BCRL	BCRL	NA	NA	NA
7	0	7	BCRL	BCRL	NA	NA	NA
9	0	1	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	0	12	BCRL	BCRL	NA	NA	NA
Control	0	10	BCRL	BCRL	NA	NA	NA

*This table incorporates all available data for all samples (intentional and fortuitous) analyzed under the Biota CMP.

**The USFWS geometric mean includes nonhits and assigns them a value equal to one-half of the lower CRL; descriptive statistics are calculated only when 50% or more of the samples are hits.

BCRL = Below certified reporting limit. This value varied for different labs and in different years.

NA = Not applicable.

NC = number of detections was less than 50% of the sample size and a mean was not calculated.

Table 5.1-23 Arsenic Statistical Results for Aquatic Species Sampled for CMP, 1988 to 1990*

	Total # of Hits	Total # of Samples	Minimum Detected Conc (µg/g)	Maximum Detected Conc (µg/g)	USFWS Geometric Mean**	USFWS Geometric Variance**	USFWS Geometric Std Dev**
ICNB and ICME - bullhead							
Whole body							
CMP-BSA 6	0	1	BCRL	BCRL	NA	NA	NA
8	0	10	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	0	11	BCRL	BCRL	NA	NA	NA
Control	0	9	BCRL	BCRL	NA	NA	NA
Composite							
CMP-BSA 10	0	5	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	0	5	BCRL	BCRL	NA	NA	NA
Control	0	2	BCRL	BCRL	NA	NA	NA
All Samples							
CMP-BSA 6	0	1	BCRL	BCRL	NA	NA	NA
8	0	10	BCRL	BCRL	NA	NA	NA
10	0	5	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	0	16	BCRL	BCRL	NA	NA	NA
Control	0	11	BCRL	BCRL	NA	NA	NA
ICPU - channel catfish							
CMP-BSA 6	0	12	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	0	12	BCRL	BCRL	NA	NA	NA
Control	1	15	2.42	2.42	NC	NC	NC
LEMA - bluegill							
Whole body							
CMP-BSA 6	0	10	BCRL	BCRL	NA	NA	NA
7	0	10	BCRL	BCRL	NA	NA	NA
8	0	10	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	0	30	BCRL	BCRL	NA	NA	NA
Control	0	10	BCRL	BCRL	NA	NA	NA
MISA - largemouth bass							
CMP-BSA 6	0	9	BCRL	BCRL	NA	NA	NA
7	0	10	BCRL	BCRL	NA	NA	NA
8	0	10	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	0	29	BCRL	BCRL	NA	NA	NA
Control	0	10	BCRL	BCRL	NA	NA	NA
PLAN - plankton							
CMP-BSA 6	15	15	0.459	1.33	0.635	1.10	1.36
7	4	15	0.329	0.495	NC	NC	NC
8	7	15	0.371	0.723	NC	NC	NC
10	0	5	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	26	50	0.329	1.33	0.274	1.88	2.21
Control	15	15	0.358	1.09	0.577	1.11	1.39

*This table incorporates all available data for all samples (intentional and fortuitous) analyzed under the Biota CMP.

**The USFWS geometric mean includes nonhits and assigns them a value equal to one-half of the lower CRL; descriptive statistics are calculated only when 50% or more of the samples are hits.

BCRL = Below certified reporting limit. This value varied for different labs and in different years.

NA = Not applicable.

NC = number of detections was less than 50% of the sample size and a mean was not calculated.

Table 5.1-23 Arsenic Statistical Results for Aquatic Species Sampled for CMP, 1988 to 1990*

	Total # of Hits	Total # of Samples	Minimum Detected Conc (µg/g)	Maximum Detected Conc (µg/g)	USFWS Geometric Mean**	USFWS Geometric Variance**	USFWS Geometric Std Dev**
POND - American pondweed							
CMP-BSA 6	3	13	0.356	0.446	NC	NC	NC
7	1	13	0.373	0.373	NC	NC	NC
8	4	8	0.397	0.685	0.257	1.85	2.19
10	0	5	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	8	39	0.356	0.685	NC	NC	NC
Control	14	15	0.378	3.40	0.784	1.95	2.26
POPE - sago pondweed							
CMP-BSA 6	4	6	0.326	0.805	0.325	1.88	2.21
7	1	6	0.338	0.338	NC	NC	NC
8	6	6	0.462	2.90	0.861	1.56	1.95
9	4	4	0.283	1.35	0.589	1.84	2.18
All RMA CMP-BSAs	15	22	0.283	2.90	0.381	2.40	2.55
Control	4	9	1.97	4.17	NC	NC	NC

*This table incorporates all available data for all samples (intentional and fortuitous) analyzed under the Biota CMP.

**The USFWS geometric mean includes nonhits and assigns them a value equal to one-half of the lower CRL; descriptive statistics are calculated only when 50% or more of the samples are hits.

BCRL = Below certified reporting limit. This value varied for different labs and in different years.

NA = Not applicable.

NC = number of detections was less than 50% of the sample size and a mean was not calculated.

Table 5.1-24 Mercury Statistical Results for Aquatic Species Sampled for CMP, 1988 to 1990*

	Total # of Hits	Total # of Samples	Minimum Detected Conc (µg/g)	Maximum Detected Conc (µg/g)	USFWS Geometric Mean**	USFWS Geometric Variance**	USFWS Geometric Std Dev**
AMBY - salamander (FORTUITOUS)							
CMP-BSA 2	2	2	0.0747	0.0758	0.0752	1.00	1.01
ANDI - blue-winged teal							
Dressed Carcass							
CMP-BSA 10	4	4	0.0816	0.338	0.167	1.57	1.96
All RMA CMP-BSAs	4	4	0.0816	0.338	0.167	1.57	1.96
Control	5	5	0.0529	0.216	0.104	1.44	1.83
ANPL - mallard							
Dressed Carcass							
CMP-BSA 10	8	15	0.0558	0.242	0.0498	1.76	2.12
All RMA CMP-BSAs	8	15	0.0558	0.242	0.0498	1.76	2.12
Control	10	12	0.0528	0.143	0.0592	1.30	1.67
Liver							
CMP-BSA 10	9	9	0.0585	0.353	0.158	1.56	1.95
All RMA CMP-BSAs	9	9	0.0585	0.353	0.158	1.56	1.95
Control	4	5	0.101	0.679	0.121	4.22	3.32
All Samples							
CMP-BSA 10	17	24	0.0558	0.353	0.0769	2.28	2.48
All RMA CMP-BSAs	17	24	0.0558	0.353	0.0769	2.28	2.48
Control	14	17	0.0528	0.679	0.0731	1.92	2.24
CEDE - cocktail							
CMP-BSA 6	0	6	BCRL	BCRL	NA	NA	NA
7	0	5	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	0	11	BCRL	BCRL	NA	NA	NA
Control	0	5	BCRL	BCRL	NA	NA	NA
CHVO - killdeer							
CMP-BSA 5	5	5	0.0518	0.117	0.0818	1.10	1.36
6	3	3	0.0832	0.105	0.0965	1.02	1.14
8	1	2	0.109	0.109	0.0522	2.96	2.83
All RMA CMP-BSAs	9	10	0.0518	0.117	0.0786	1.25	1.60
Control	3	5	0.0639	0.305	0.0702	3.30	2.98
ESLU - northern pike							
CMP-BSA 7	3	3	0.375	0.448	0.413	1.01	1.09
8	4	4	0.200	0.347	0.249	1.07	1.29
All RMA CMP-BSAs	7	7	0.200	0.448	0.309	1.11	1.39
Control	7	10	0.0803	0.186	0.0756	1.92	2.24
FUAM - American coot							
CMP-BSA 6	2	5	0.0571	0.0834	NC	NC	NC
7	3	11	0.0538	0.0596	NC	NC	NC
9	0	1	BCRL	BCRL	NA	NA	NA
10	0	1	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	5	18	0.0538	0.0834	NC	NC	NC
Control	6	15	0.0674	0.180	NC	NC	NC

*This table incorporates all available data for all samples (intentional and fortuitous) analyzed under the Biota CMP.

**The USFWS geometric mean includes nonhits and assigns them a value equal to one-half of the lower CRL; descriptive statistics are calculated only when 50% or more of the samples are hits.

BCRL = Below certified reporting limit. This value varied for different labs and in different years.

NA = Not applicable.

NC = Number of detections was less than 50% of the sample size and a mean was not calculated.

Table 5.1-24 Mercury Statistical Results for Aquatic Species Sampled for CMP, 1988 to 1990*

	Total # of Hits	Total # of Samples	Minimum Detected Conc (µg/g)	Maximum Detected Conc (µg/g)	USFWS Geometric Mean**	USFWS Geometric Variance**	USFWS Geometric Std Dev**
ICNB and ICMB - bullhead							
Whole body							
CMP-BSA 6	1	1	0.264	0.264	0.264	NA	NA
8	7	10	0.0504	0.0863	0.0479	1.32	1.69
All RMA CMP-BSAs	8	11	0.0504	0.264	0.0559	1.67	2.05
Control	0	9	BCRL	BCRL	NA	NA	NA
Composite							
CMP-BSA 10	5	5	0.0787	0.138	0.0999	1.06	1.27
All RMA CMP-BSAs	5	5	0.0787	0.138	0.0999	1.06	1.27
Control	0	2	BCRL	BCRL	NA	NA	NA
All Samples							
CMP-BSA 6	1	1	0.264	0.264	0.264	NA	NA
8	7	10	0.0504	0.0863	0.0479	1.31	1.69
10	5	5	0.0787	0.138	0.0999	1.06	1.27
All RMA CMP-BSAs	13	16	0.0504	0.264	0.0670	1.54	1.93
Control	0	11	BCRL	BCRL	NA	NA	NA
ICPU - channel catfish							
CMP-BSA 6	8	12	0.0465	0.0938	0.0453	1.31	1.68
All RMA CMP-BSAs	8	12	0.0465	0.0938	0.0453	1.31	1.68
Control	9	15	0.0583	0.430	0.0660	2.66	2.69
LEMA - bluegill							
Whole body							
CMP-BSA 6	10	10	0.0572	0.138	0.0825	1.08	1.31
7	9	14	0.0610	0.202	0.0563	1.70	2.07
8	14	15	0.0603	0.205	0.0987	1.35	1.73
All RMA CMP-BSAs	33	39	0.0572	0.205	0.0771	1.45	1.84
Control	12	14	0.0529	0.275	0.0925	1.81	2.16
Composite							
CMP-BSA 6	5	5	0.0534	0.119	0.0922	1.11	1.39
7	1	1	0.189	0.189	0.189	NA	NA
All RMA CMP-BSAs	6	6	0.0534	0.189	0.104	1.19	1.51
All Samples							
CMP-BSA 6	15	15	0.0534	0.138	0.0856	1.08	1.33
7	10	15	0.0610	0.202	0.0610	1.81	2.16
8	14	15	0.0603	0.205	0.0987	1.35	1.73
All RMA CMP-BSAs	39	45	0.0534	0.205	0.0802	1.42	1.81
Control	12	14	0.0529	0.275	0.0925	1.81	2.16
MISA - largemouth bass							
CMP-BSA 6	14	14	0.0917	0.303	0.227	1.11	1.37
7	15	15	0.0615	0.610	0.248	1.57	1.96
8	14	15	0.0599	0.626	0.128	1.89	2.22
All RMA CMP-BSAs	43	44	0.0599	0.626	0.192	1.61	1.99
Control	12	15	0.0529	0.198	0.0757	1.52	1.91
PLAN - plankton							
CMP-BSA 6	0	10	BCRL	BCRL	NA	NA	NA
7	0	10	BCRL	BCRL	NA	NA	NA
8	0	10	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	0	30	BCRL	BCRL	NA	NA	NA
Control	0	10	BCRL	BCRL	NA	NA	NA

*This table incorporates all available data for all samples (intentional and fortuitous) analyzed under the Biota CMP.

**The USFWS geometric mean includes nonhits and assigns them a value equal to one-half of the lower CRL; descriptive statistics are calculated only when 50% or more of the samples are hits.

BCRL = Below certified reporting limit. This value varied for different labs and in different years.

NA = Not applicable.

NC = Number of detections was less than 50% of the sample size and a mean was not calculated.

Table 5.1-24 Mercury Statistical Results for Aquatic Species Sampled for CMP, 1988 to 1990*

	Total # of Hits	Total # of Samples	Minimum Detected Conc (µg/g)	Maximum Detected Conc (µg/g)	USFWS Geometric Mean**	USFWS Geometric Variance**	USFWS Geometric Std Dev**
POND - American pondweed							
CMP-BSA 6	0	13	BCRL	BCRL	NA	NA	NA
7	0	13	BCRL	BCRL	NA	NA	NA
8	1	8	0.0514	0.0514	NC	NC	NC
10	1	5	0.0543	0.0543	NC	NC	NC
All RMA CMP-BSAs	2	39	0.0514	0.0543	NC	NC	NC
Control	0	15	BCRL	BCRL	NA	NA	NA
POPE - sago pondweed							
CMP-BSA 6	0	6	BCRL	BCRL	NA	NA	NA
7	0	6	BCRL	BCRL	NA	NA	NA
8	0	6	BCRL	BCRL	NA	NA	NA
9	0	4	BCRL	BCRL	NA	NA	NA
All RMA CMP-BSAs	0	22	BCRL	BCRL	NA	NA	NA
Control	0	10	BCRL	BCRL	NA	NA	NA

*This table incorporates all available data for all samples (intentional and fortuitous) analyzed under the Biota CMP.

**The USFWS geometric mean includes nonhits and assigns them a value equal to one-half of the lower CRL; descriptive statistics are calculated only when 50% or more of the samples are hits.

BCRL = Below certified reporting limit. This value varied for different labs and in different years.

NA = Not applicable.

NC = Number of detections was less than 50% of the sample size and a mean was not calculated.

TABLE 4-2

RELATIVE ABUNDANCE OF SMALL MAMMALS AT RMA, FALL 1986[1]

Species	Tall Weedy Forbs	Short Weedy Forbs	Cheatgrass	Crested Wheatgrass	Native Grass	[2]Shrubs/ Yucca	Cottonwoods
Deer Mouse	31.9	15.6	8.3	2.5	0.3	13.9	1.1
Plains Harvest Mouse	2.2	--	--	--	--	--	1.1
Western Harvest Mouse	--	--	--	--	--	2.2	--
Northern Grasshopper Mouse	--	--	--	--	0.6	3.3	--
Meadow Vole	--	--	--	--	--	--	7.8
Prairie Vole	0.3	--	0.3	0.3	0.3	--	--
Ord's Kangaroo Rat	--	--	--	--	--	1.1	--
Total	34.4	15.6	8.6	2.8	1.2	20.5	10.0
Locations[3]	2,12	17	1,6,13,15	3,5,11,14	4,10	18,19	16

1 Relative abundance = number caught per 100 trap-nights.
2 Shrubs include sand sagebrush and rubber rabbitbrush.
3 Locations shown on Figure 3-8.

TABLE 4-3

RELATIVE ABUNDANCE OF SMALL MAMMALS AT RMA, SPRING 1987[1]

Species	Weedy Forbs	[2]Shrubs/ Yucca	[3]Thickets	Cattails/ Rushes	Streamside Meadows	Cottonwoods
Deer Mouse	30.0	9.8	2.7	2.6	1.0	1.0
Western Harvest Mouse	--	2.2	2.2	3.1	1.5	--
Meadow Vole	--	0.4	--	11.7	1.0	--
Prairie Vole	--	1.6	2.2	5.7	--	--
Silky Pocket Mouse	--	0.2	--	--	--	--
Hispid Pocket Mouse	--	0.8	--	--	--	--
Ord's Kangaroo Rat	--	2.5	--	--	--	--
Total	30.0	17.5	7.1	23.1	3.5	1.0
Locations[4]	27	23,24,28	22,25	20,21	26	29

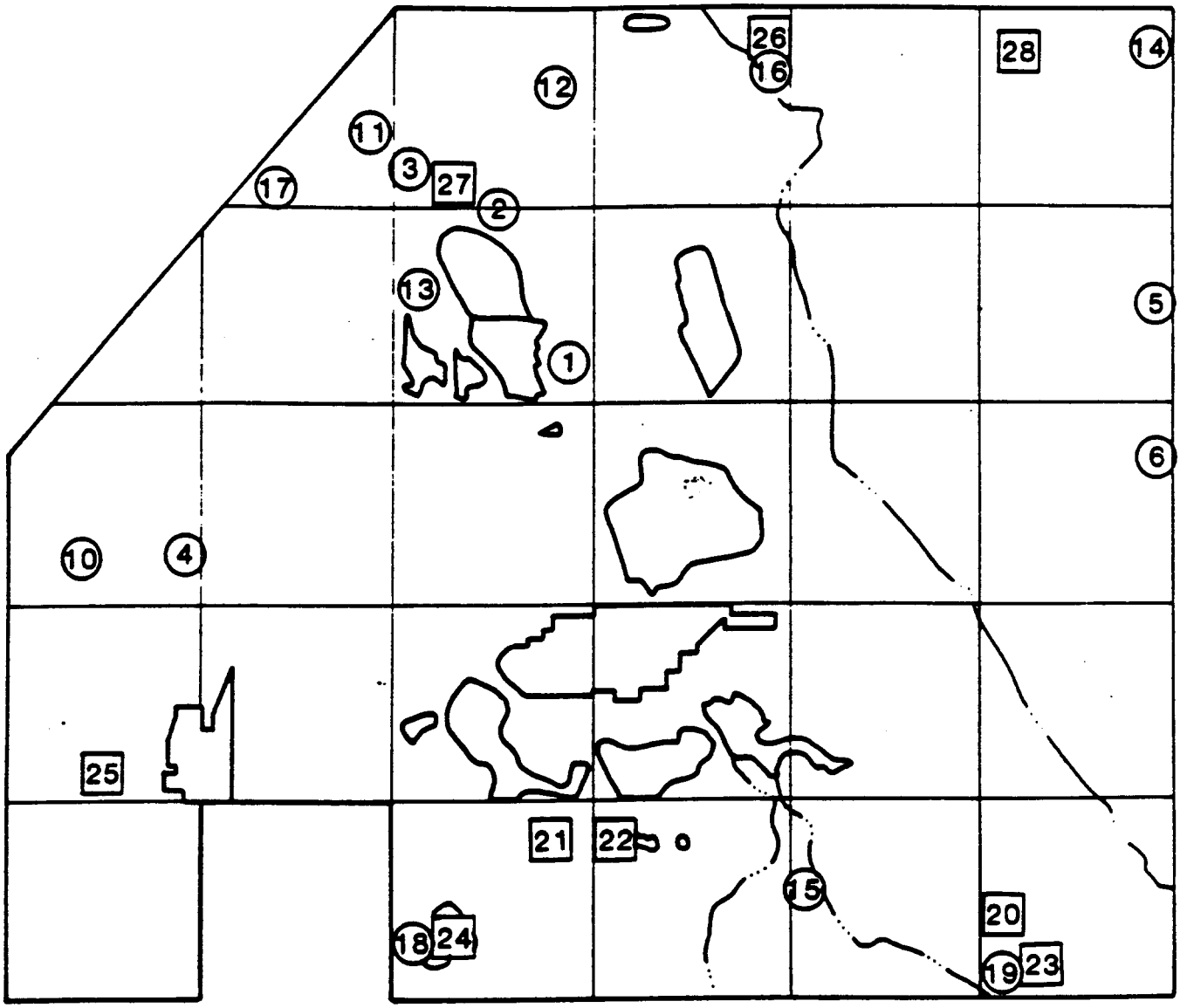
1 Relative abundance = number caught per 100 trap-nights.
2 Shrubs include sand sagebrush and rubber rabbitbrush.
3 Thickets include New Mexico locust and American plum.
4 Locations shown on Figure 3-8.

Table 5. Raptors observed along the Arsenal road survey during the winter period and the entire survey period of 1991-92.

	1991-92 (Oct-Mar)				1991-92 (Aug-May)			
Species	N	AVG	%	RANGE	N	AVG	%	RANGE
Red-tailed hawk	96	(5.1)	24.2	(1-17)	154	(4.8)	23.5	(0-17)
Rough-legged hawk	68	(3.6)	17.1	(0-9)	68	(3.6)	10.4	(0-9)
Ferruginous hawk	119	(6.3)	30.0	(0-16)	126	(3.9)	19.2	(0-16)
Bald eagle	53	(2.8)	13.4	(0-7)	53	(2.8)	8.1	(0-7)
Golden eagle	14	(0.7)	3.5	(0-2)	14	(0.7)	2.4	(0-2)
American kestrel	24	(1.3)	6.0	(0-13)	93	(2.9)	14.2	(0-13)
Unknown buteo	11	(0.6)	2.8	(0-2)	16	(0.5)	2.4	(0-2)
Northern harrier	5	(0.3)	1.3	(0-2)	5	(0.3)	0.7	(0-2)
Merlin	3	(0.2)	0.8	(0-1)	3	(0.2)	0.5	(0-1)
Prairie falcon	4	(0.2)	1.0	(0-1)	4	(0.2)	0.6	(0-1)
Swainson's hawk	--	(----)	----	----	22	(0.7)	3.4	(0-5)
Burrowing owl	--	(----)	----	----	90	(2.8)	13.7	(0-17)
Total raptors	397	(20.9)	----	(15-32)	648	(20.3)	----	(9-32)

N = number observed
AVG = average
% = percent of total

Pg 32-34 from MKE 1989



LEGEND

(2) 1986 sampling location

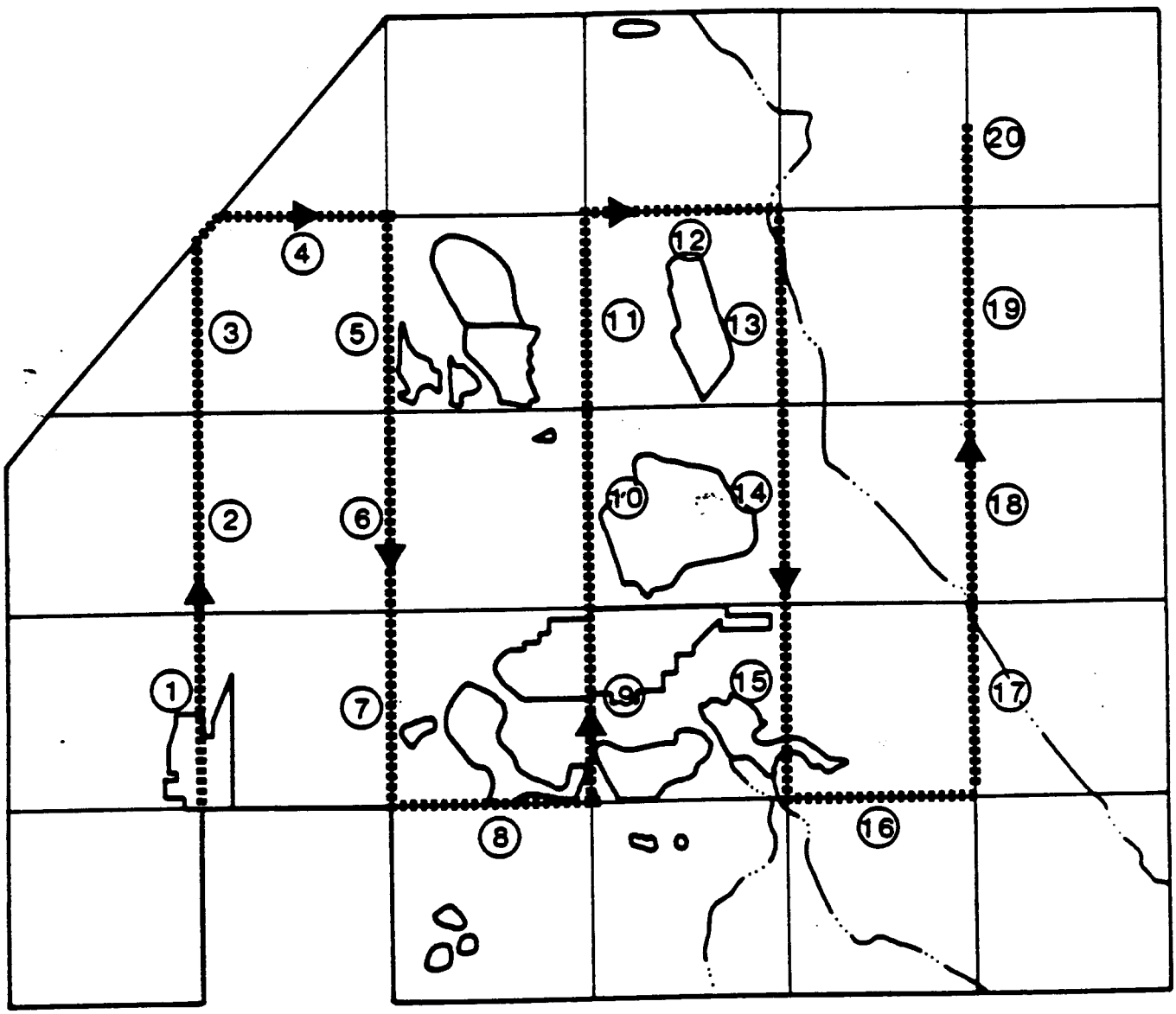
[20] 1987 sampling location

Rocky Mountain Arsenal

Figure 3-6.

Small Mammal Trapping Locations

MORRISON-KNUDSEN ENGINEERS, INC.



Note: Circled numbers represent listening stations.

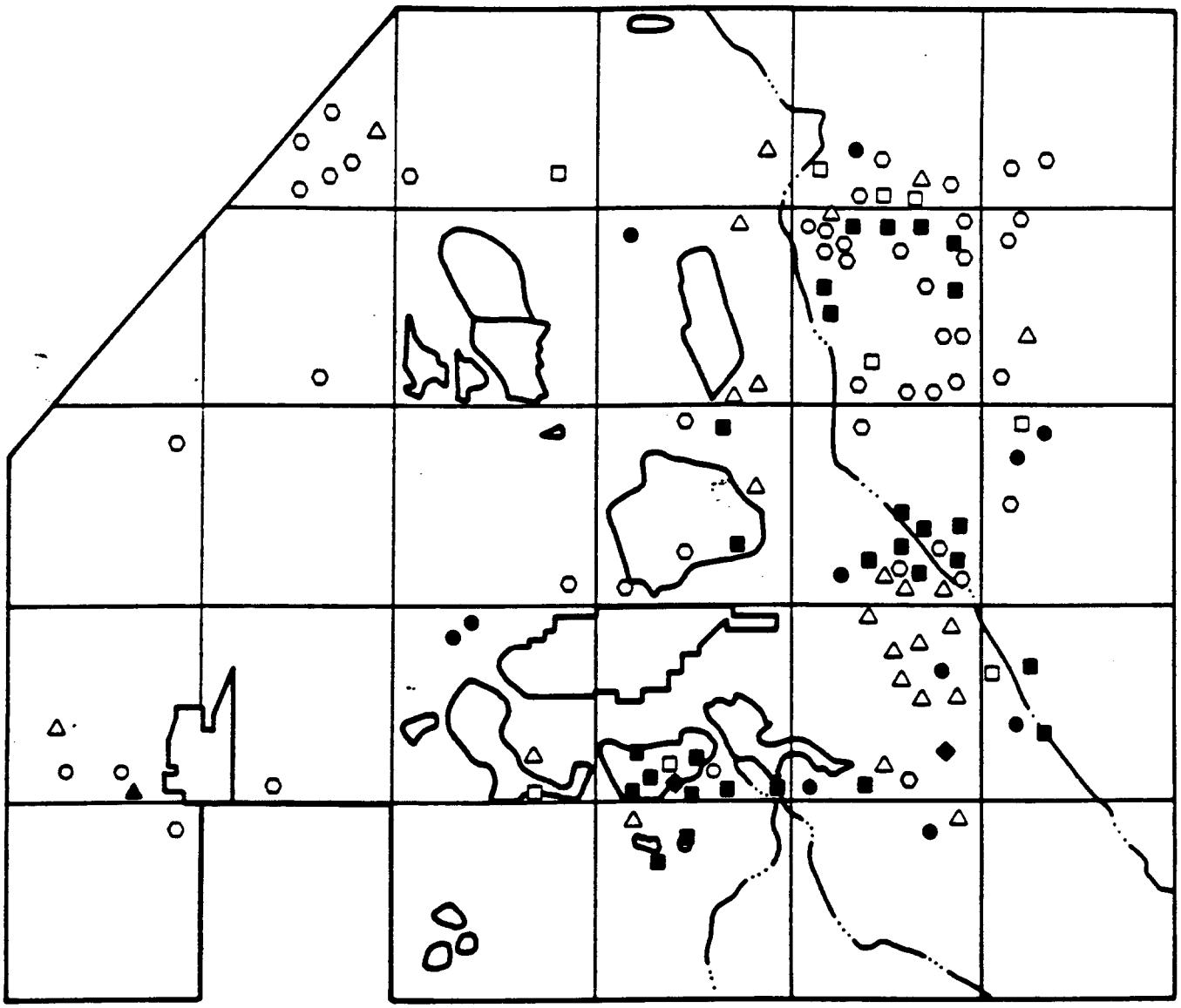
Rocky Mountain Arsenal

Figure 3-12.

Pheasant and Dove Survey Route

MORRISON-KNUDSEN ENGINEERS, INC.

Pg 37 From MKE-1989



Note: Symbols represent sightings from seven counts.

LEGEND

- □ Northern harrier
- ○ Red-tailed hawk
- ○ Ferruginous hawk
- △ Rough-legged hawk
- ■ Bald eagle
- ● Golden eagle
- ● Prairie falcon
- ▲ Great horned owl

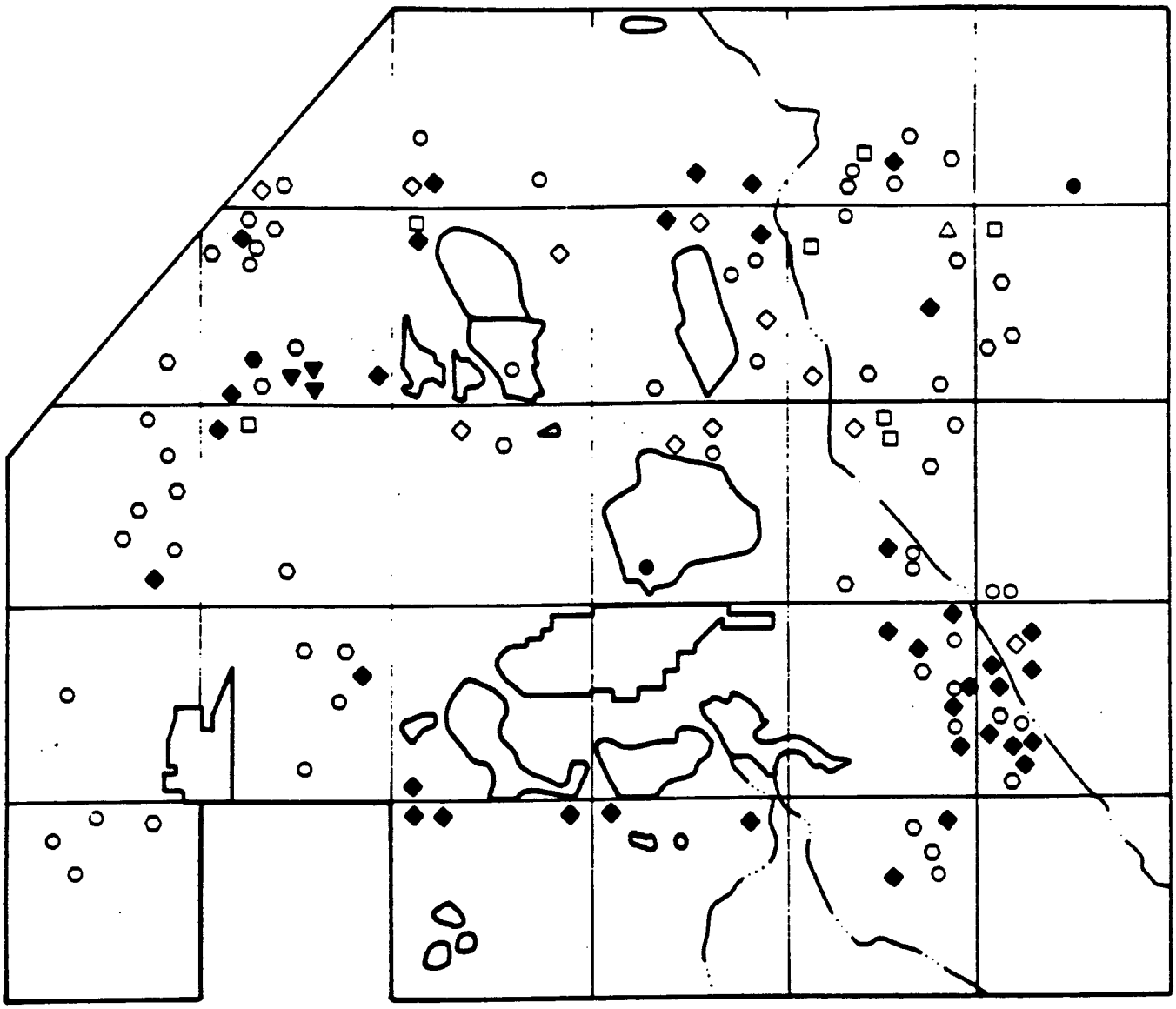
Rocky Mountain Arsenal

Figure 4-14.

Raptor Roadside Counts,
Winter 1985-86

MORRISON-KNUDSEN ENGINEERS, INC.

Pg 32-34 from MKE-1989



Note: Symbols represent sightings from six counts.

LEGEND

- □ Northern harrier
- ○ Red-tailed hawk
- ◇ Swainson's hawk
- ○ Ferruginous hawk
- ● Golden eagle
- ◆ American kestrel
- ● Prairie falcon
- ▼ Burrowing owl

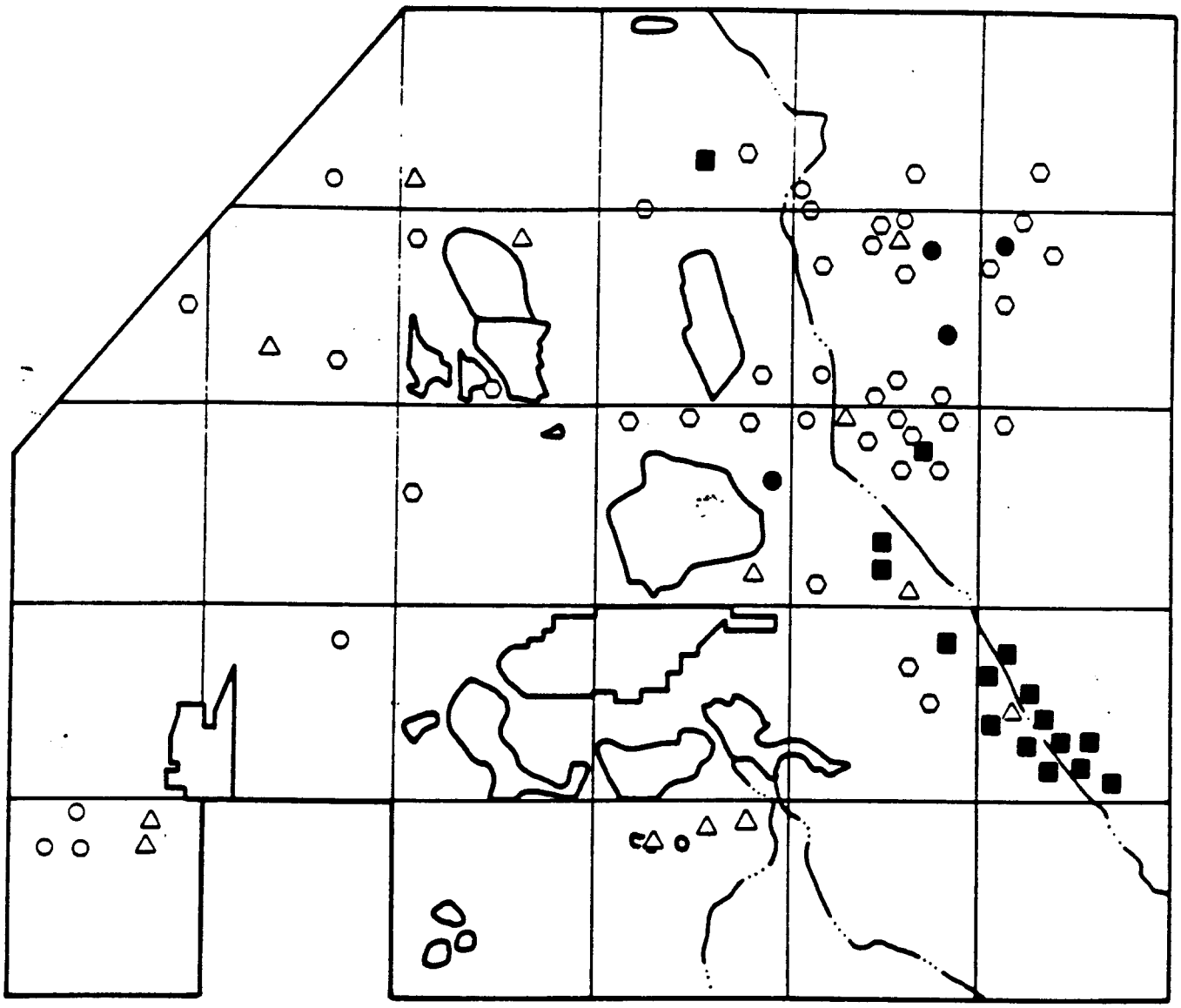
Rocky Mountain Arsenal

Figure 4-15.

Raptor Roadside Counts,
Spring 1986

MORRISON-KNUDSEN ENGINEERS, INC

Pg 32-34 from MKE-1989



Note: Symbols represent sightings from three counts.

LEGEND

- ○ Red-tailed hawk
- ○ Ferruginous hawk
- △ Rough-legged hawk
- ■ Bald eagle
- ● Golden eagle
- ● Prairie falcon

Rocky Mountain Arsenal

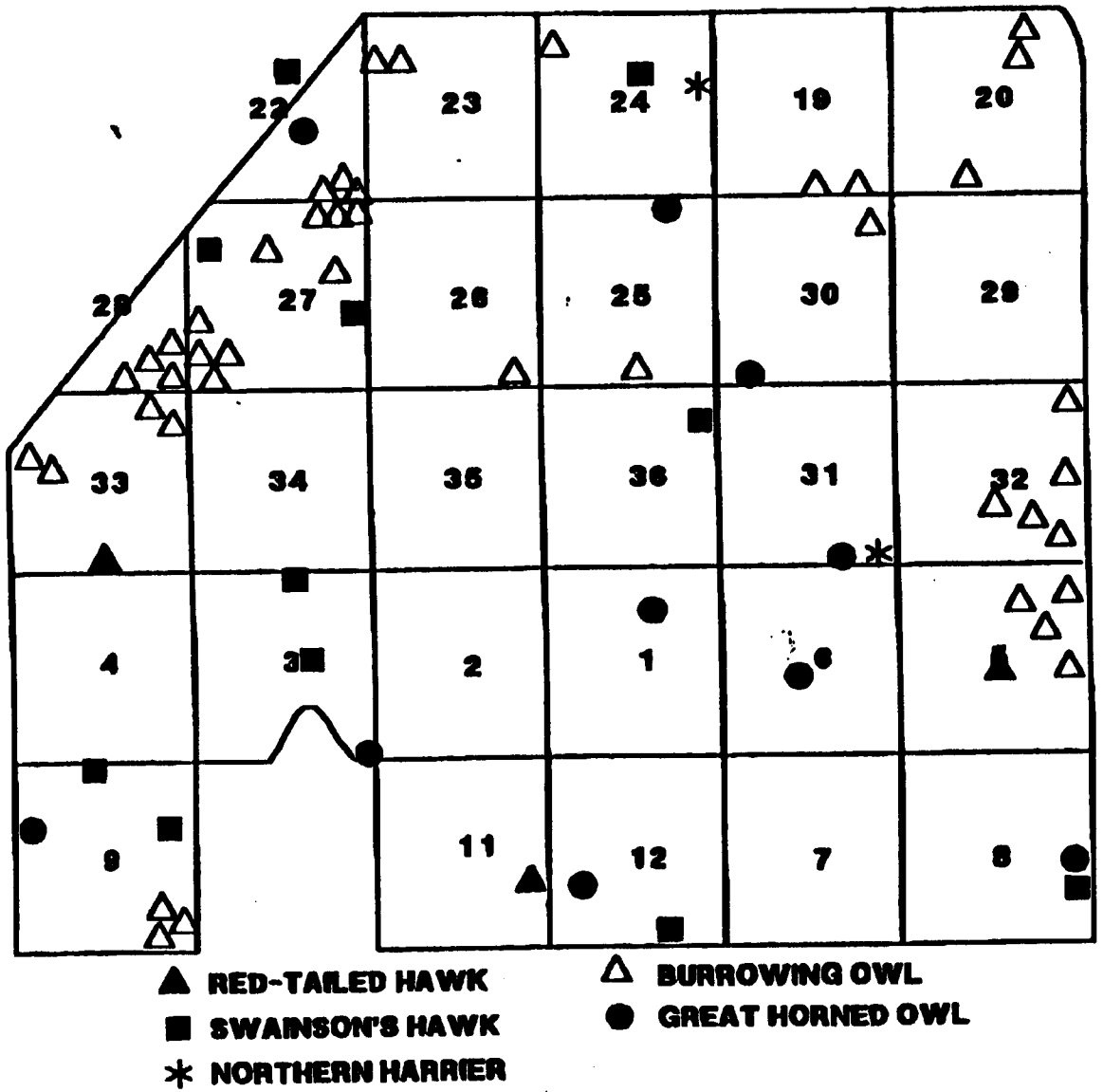
Figure 4-16.

Raptor Roadside Counts,
Winter 1986-87

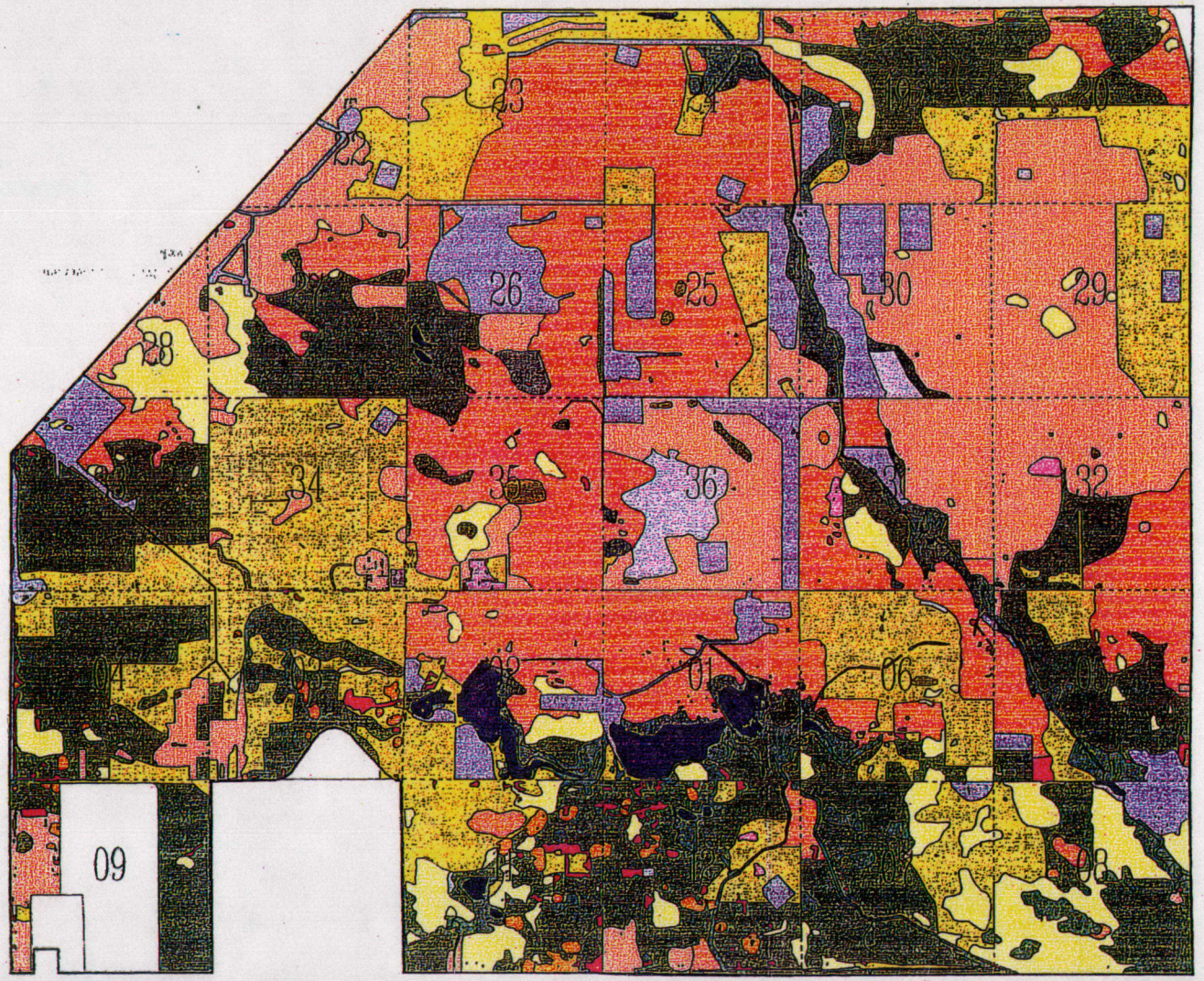
MORRISON-KNUDSEN ENGINEERS, INC.

Pg 32-34 from MKE - 1989

Breeding pairs of raptors monitored during 1993.



AUG 04 '93 08:13AM MK 1700 LINCOLN SIE 4000 DENVER P.2



ROCKY MOUNTAIN ARSENAL VEGETATION CLASSIFICATION

LEGEND

- Weedy forbs
- Cheatgrass/weedy forbs
- Native perennial grassland
- Crested wheatgrass stand
- Shrubland/succulents
- Locust thicket
- Wetland
- Tree grove
- Lawn
- Seeded area
- Cereal rye
- Cobble soil vegetation
- Alfalfa/sweetclover
- Water
- Bare ground
- Research area
- Unclassified

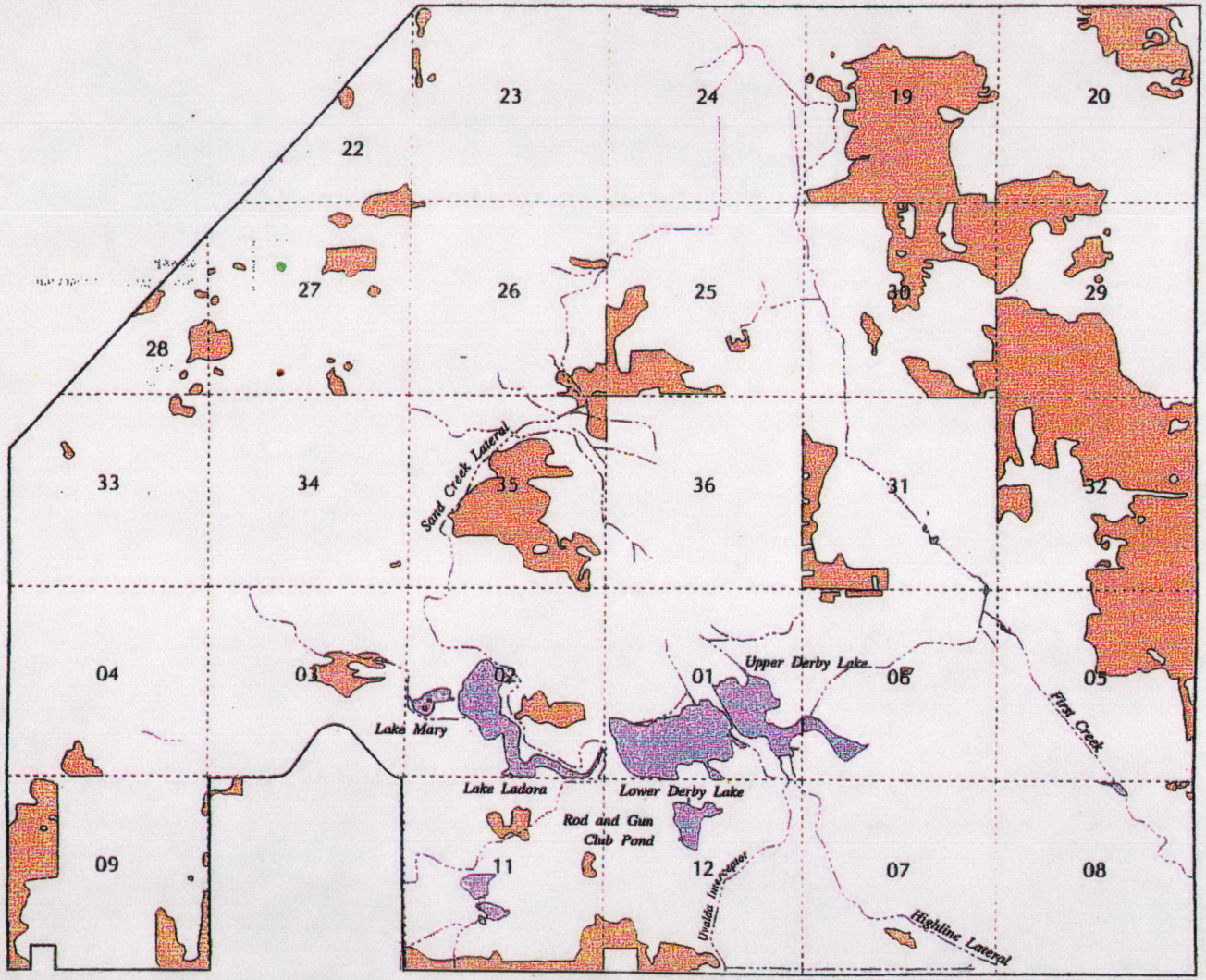
MORRISON KNUDSEN CORPORATION
Environmental Services Division

N

SCALE 1 : 38,000

1 .5 0 MILE

December 1992



ROCKY MOUNTAIN ARSENAL PRAIRIE DOG TOWNS July 1993

LEGEND

Hydrography

- Stream
- Water

Boundaries

- RMA Boundary
- Section Line

- Prairie Dog Town

MORRISON KNUDSEN CORPORATION
Environmental Services Division

-N-

SCALE 1 : 36,000

1 .5 0 MILE

August 11, 1993

ATTACHMENT C.5-3

INFORMATION ON FORTUITOUS SAMPLES COLLECTED BY THE U.S. FISH AND WILDLIFE SERVICE BETWEEN 1990 AND 1993

This attachment contains information on fortuitous samples collected by the U.S. Fish and Wildlife Service between 1990 and 1993. Three types of information are included: (1) a list of biota samples that have been submitted for chemical analysis but for which analytical data have not been received; (2) a list of biota samples for which chemical analyses have been completed, together with their analytical results; and (3) a tabular summary of necropsy results for biota samples that have been thus examined.

It should be noted that fortuitous samples by definition represent specimens of sick or dead individuals. As in all prior biota sampling programs on RMA, professional judgement was used in selecting sick or dead organisms to be evaluated. For example, top carnivore mammals and birds (including primarily raptors) were always collected unless there was some contraindication such as extreme decay. Road killed prairie dogs were not collected, because their cause of death was obvious and because numerous samples have already been analyzed under the Biota RI and Biota CMP.

It should also be noted that the samples that were analyzed do not necessarily reflect only exposure to RMA contaminants or situations. Carnivores, especially the raptors, range widely for food. Except for the great horned owl, the raptors on RMA also migrate to other locales in some seasons, spending only the winter or summer on RMA or simply passing through during migration. Therefore, although the following data on fortuitous samples (and that elsewhere in the IEA/RC) provides information pertinent to the status and health of biota on RMA, it may also reflect exposure to areas outside RMA and can only be used in a qualitative sense.

Table C.5-3.1 U.S. Fish and Wildlife Service, Rocky Mountain Arsenal National Wildlife Area, Sample Log (Purchase Order #DAAA05-94-A-0001)

Sample #	Species	Tissue	Location	Date Collected
11088-001	Barn Owl	Brain	North Plants	10/14/92
11088-002	Barn Owl	Brain	North Plants	10/14/92
923-05002	Badger	Liver	7th by fire st.	9/22*
923-05002	Badger	Brain	7th by fire st.	9/92
11298-001	Great Horned Owl	Liver	South Plants	7/30/92
11298-001	Great Horned Owl	Brain	South Plants	7/30/92
10943-001	Great Horned Owl	Brain	South Plants	7/30/92
11410-001	Bald Eagle	Liver	From Buckley	2/27/93
11410-001	Bald Eagle	Brain	From Buckley	2/27/93
AR-19	American Robin	Whole Body	Bldg. 111	6/17/93
HF-21	House Finch	Whole Body	Bldg. 111	6/14/93
HF-24	House Finch	Whole Body	Bldg. 111	6/17/93
02	Sharp-shinned Hawk	Whole Body	Bldg. 111	4/27/93
03	Western Kingbird	Whole Body	Bldg. 111	6/7/93
04	American Robin	Whole Body	Bldg. 111	6/22/93
05	American Robin	Whole Body	Bldg. 111	6/20/93
09	House Finch	Whole Body	Bldg. 111	6/14/93

* These samples constitute a reanalysis of this badger specimen to verify earlier analytical results on this specimen were not subject to adequate QA/QC.

Note: An additional 285 samples were submitted to a laboratry for residue analysis but the data reported from these samples may have been improperly reported and are under investigation; no samples aliquots were retained that could be subjected to verifying analyses.

Table C.5-3.2 Analytical Data Received on Fortuitous Samples Collected and Submitted for Analysis by U.S. Fish and Wildlife Service

Species Analyzed	Analytical Results	Comments
Badger 923-5002	Liver: 13 ppm dieldrin Subcutaneous fat: 75 ppm dieldrin	Analyzed by University of California Veterinary Diagnostic Laboratory; methods used differ from the USATHAMA protocols, particularly regarding quality control procedures

Table C.5-3.3 Synopsis of Necropsy Data on Fortuitous Samples Collected and Submitted for Fish and Wildlife Service

Species Necropsied	Comments	Diagnosis
Swainson's Hawk Specimen 10802-001	(10802-001) Little fat; unremarkable observations on bacteria, viruses, brain cholinesterase, liver lead, and histopathology	(10802-001) Cause of death undetermined
Starling Specimen 2336	(2336) Unremarkable cholinesterase observations	(2336) None
Great Horned Owl Specimen 10943	(10943) No obvious subcutaneous, pericardial, or peritoneal fat; emaciated from no apparent cause; unremarkable observations on liver lead, bacteria, viruses, cholinesterase, and histopathology; minor inflammation of heart tissues; talons of both feet tightly clenched	(10943) Emaciation
Specimen 11298	(11298) Talons tightly clenched; abundant subcutaneous, pericardial and peritoneal fat; found under power line with burn mark on wing; scant intestinal contents; severe fungal dermatitis; observations unremarkable of organ histopathology, cholinesterase	(11298) Electrocution, severe fungal dermatitis

Table C.5-3.3 Synopsis of Necropsy Data on Fortuitous Samples Collected and Submitted for Fish and Wildlife Service

Species Necropsied	Comments	Diagnosis
Badger Specimen 923-5002	(923-5002) Alive when collected; fair to poor body condition; hind limb paralysis; generally unremarkable histopathology, cholinesterase, and parasite infestations; no apparent cause of paralysis from examination of spinal column or evidence of tick paralysis	(923-5002) Cause of paralysis undetermined by necropsy; results of chemical analysis of liver, kidney, brain, and subcutaneous fat for organophosphates and organochlorines reported in Table C.5-2.2
Barn Owl Specimen 11088-001	(11088-001) No subcutaneous, pericardial, or peritoneal fat; cause of severe emaciation not evident; unremarkable observations regarding cholinesterase levels, bacteria, viruses, infectious disease, and organ histopathology; marked autolysis of specimen	(11088-001) Emaciation
Specimen 11088-002	(11088-002) Alive when collected, but died shortly; observations generally same as for 11088-001	(11088-002) Emaciation

ATTACHMENT C.5-4

EPA'S POSITION ON HEALTH AND DIVERSITY

EPA'S POSITION

APPENDIX C.5, ECOLOGICAL STATUS AND HEALTH OF BIOTA POPULATIONS AT ROCKY MOUNTAIN ARSENAL

EPA invoked dispute on this issue on September 20, 1993. A series of intensive technical meetings failed to achieve a text on which the parties of RMA (Army, Shell, USFWS, EPA, and State of Colorado) could reach consensus. Therefore, the RMA Council resolved that, in order to finalize the IEA/RC, the parties' dissenting opinions would be presented in this document. This submittal is EPA's opinion.

Throughout the main text of the IEA/RC, numerous references are made to "ecological measurement endpoint" studies which are said to indicate that "the overall ecosystems and animal communities have retained their integrity and most wildlife populations appear healthy." It is further stated that "the available data on ecological measurement endpoints do not reveal adverse effects of chemical contamination on trophic diversity at RMA." Similar statements are also made regarding adverse effects of chemical contamination on other "ecological measurement endpoints" such as reproductive success, abundance, survivability, structural diversity of the ecosystem, population robustness, morbidity, species richness, and other endpoints.

While all of these characteristics may be valid, **the extent to which biological studies at RMA were designed to measure these characteristics as measurement or assessment endpoints relative to exposure to a stressor was very limited.** Regarding exposure analysis, EPA's Framework for Ecological Risk Assessment (EPA/630/R-92/001, February, 1992) states at Section 3.1.3 "The next step is to combine the spatial and temporal distributions of both the ecological component and the stressor to evaluate exposure." and "The most common approach to exposure analysis is to measure concentrations or amounts of a stressor and combine them with assumptions about co-occurrence, contact, or uptake." It is also stated (Section 3.2.1), "Controlled ... field tests ... can provide strong causal evidence linking a stressor with a response and can also help discriminate between multiple stressors."

Although the ecological assessment endpoint studies summarized in Appendix C.5 did provide some ecological measurements for selected locations at RMA, **they did not measure endpoints relative to exposure to a stressor.** They were not controlled field tests designed to provide evidence as to whether or not there was a link between stressors (contaminant concentrations in soil) and responses (endpoints such as those described above). In addition,

o Very few of the studies referenced in Appendix C.5 were conceived or designed as part of the ecological risk assessment (ERA) for RMA,

o Very few, if any, of the studies were quantitatively or spatially linked to stressors, i.e., contaminant concentrations, and

o Although some studies claimed to compare "contaminated" versus "uncontaminated" areas, no measurements of soil contamination were part of these studies and very few, if any, of the studies drew any conclusions regarding the potential ecological impacts of soil contamination at specific locations.

o Most of the studies were conducted mainly in the less contaminated areas of RMA, with few or no observations in the more contaminated areas.

The studies summarized in Appendix C.5 are appropriate to discuss in Section 5.2 (Uncertainties Associated with the Ecological Risk Characterization) and in Appendix E, but reference to these studies should be deleted from the rest of the main text because **they did not measure endpoints relative to exposure to stressors and, therefore, are not directly comparable to the quantitative results of the ERC. These studies should also not be interpreted as a "reality check" on the results of the ERC.**

EPA has reviewed Appendix C.5, as presented by the Army in the March 3, 1994 version of the IEA/RC,and also key studies cited by the Army in Appendix C.5. The results of this review are presented as EPA's opinion regarding the Ecological Status and Health of RMA biota (Attachment 3). In general, each of the studies reviewed had several aspects in common:

o The precise location of biota tissue sample collections or ecological outcomes was not identified or co-located relative to specific locations of soil contamination.

o A few of the studies compared observations at locations within or near the core contaminated areas with peripheral locations, assuming, without verification, that the former were highly contaminated, but the latter were not. This is an unwarranted assumption due to the heterogeneity of soil contamination at RMA.

o With one exception (songbirds), very few observations were made in the core-contaminated areas.

The results of these studies appear to support general conclusions regarding the status of wildlife species on RMA as a whole, but do not provide information regarding the actual

status, health or ecological effects on biota at specific locations relative to soil contamination. As a result, most of the studies cited actually have high potential for bias and low power; many also have low relevance as explained below. EPA's overall conclusion concerning Appendix C.5, Ecological Status and Health, is that, generally, the field studies were not adequately designed to assess the potential effects of contaminants on RMA biota at the individual, population, or community level. Hence, they are of little or no value in testing hypotheses about the potential ecological effects of soil contaminants at RMA. Some animals collected at RMA have tissue levels of contaminants that exceed the MATC, and at least a few appear to have been lethally poisoned. Several species do occur and even breed successfully close to core contaminated areas. Except for a few American kestrels, however, the actual exposure of these animals has not been characterized. Hence, the available information on RMA biota neither confirms nor refutes the predictions of the ERC. Implications otherwise are misleading.

EPA believes that the text of the following sections should be modified as follows:

C.5.4.4.1 Status and Diversity

The status and diversity of the biota at RMA are reasonably well characterized as a result of extensive studies conducted in recent years. RMA is situated within a temperate grassland region and is part of a broad transition zone between montane and plains habitats. Native vegetation of the region consists primarily of open semiarid grasslands, with some areas of yucca, shrubland, woodland, and riparian habitats. The terrestrial vegetation has been modified by past agricultural activities and more recent industrial activities, including localized effects of contamination, remediation, and vegetation management (Sections C.5.2.1, and C.5.3.2.4). Probably as a result of these activities, the terrestrial vegetation is somewhat impoverished (lower structural complexity) compared to that at selected offsite control areas (MKE 1989a). RMA also includes four manmade lakes which are subject to management for angling. Three of these lakes were heavily contaminated in the past and were drained for sediment removal in 1964-65 (Section 5.2.2.4).

RMA supports a wide variety of animal species, including 26 species of mammals, 176 species of birds, 17 species of reptiles and amphibians, and a number of fish species (Section C.5.2.2). RMA has noteworthy populations of several species, including mule deer, white-tailed deer, black-tailed prairie dogs, burrowing owls, and wintering raptors, including a significant winter roost of bald eagles. These and other species (e.g., American badger, coyote, ring-necked pheasant) appear to benefit from the restrictions on human access, lack of hunting, and management activities at RMA, whereas predatory fish (largemouth bass, pike)

benefit from active management for sport fishing (catch and release).

Population sizes (total numbers of individuals within RMA boundaries) have been determined or estimated for a number of species, including mule deer, white-tailed deer, black-tailed prairie dog, great horned owl, burrowing owl, American kestrel, and other breeding raptors. The winter roost of bald eagles is counted on a weekly basis. Information on population density or other indices of population (e.g., trapping frequency, transect counts) is available for other species, including terrestrial invertebrates (grasshoppers, earthworms) and aquatic organisms. Reproductive success has been measured for mule deer, great horned owls, burrowing owls, mallards, and American kestrels, and indices of reproductive success are available for several other species. However, population dynamics have not been studied and there is no information on survival, dispersal, immigration, or emigration. In addition, ecosystem-level studies (e.g., trophic diversity, nutrient cycling, or primary productivity) have not been conducted on RMA. Although the diets of several predatory species have been reported, there is no systemic information on the structure or complexity of food webs. Such a study would include a quantitative evaluation of the diet in prey consumed by the predator species.

The available information on the biota of RMA is useful in characterizing the resources at risk, specifically in documenting which species occur in or near the more contaminated parts of RMA. In particular, there is useful information on the status, numbers, and distribution of some species that are likely to be most highly exposed to bioaccumulative contaminants (e.g., burrowing mammals, predatory fish, and predatory birds). However, little information is available to date on predatory mammals.

C.5.4.4.2 Ecological Health

Except for a study of deer (Section C.5.3.2.1), no studies of the health of individual animals have been conducted at RMA. USFWS has necropsied many birds but analysts did not speculate on the cause of death. The data on these birds (see Table C.51), however, includes conditions such as lack of fat and no food in the gut, as well as behavioral signs in some individuals, that are consistent with pesticide poisoning.

Major incidents of wildlife mortality attributable to poisoning have been reported at RMA in the past, particularly in the 1950s. These incidents primarily involved waterfowl and other aquatic organisms. Overt mortality of these species appears to have been reduced by the dredging of the lakes (1964-65) and Basin F (1988-1989). More recently, individuals of several terrestrial bird species (great horned owl, red-tailed hawk, ferruginous hawk,

mourning dove) have been found dead at RMA with tissue concentrations of dieldrin within the lethal range (Sections C.5.3.2.2, C.5.3.4). In recent years, numerous dead birds (mostly American robins and starlings) have been found dead at RMA, especially on the lawns surrounding Building 111 (Section C.5.3.4).

No information is available on the population dynamics or metapopulation structure of animal species at RMA. Specifically, there is no information on survival rates or rates of dispersal of animals among subpopulations within RMA (e.g., movements between more contaminated and less contaminated parts of the site). Lacking such information, it is difficult to draw conclusions about the viability or self-sustainability of populations or subpopulations at any spatial scale within RMA. Numbers of black-tailed prairie dogs increased rapidly following an epizootic plague in 1988-89, the increase being much larger than the number of animals released in the reintroduction program (USFWS 1993a, 1993b). For species with little or no potential for immigration (e.g., deer, fish), the continued presence of significant numbers at RMA indicates that the total populations must be self-sustaining. For species with small dispersal ranges (e.g., earthworms), self-sustaining local subpopulations clearly exist within RMA, but the spatial distribution of these species within RMA has not been characterized.

The only species for which population densities have been compared to those at well-characterized offpost control sites are four species of songbirds (MKE 1989a). For these species, frequencies of encounter in summer (an index of breeding density) were lower on RMA than at the control sites; this difference was statistically associated with more homogeneous and less complex habitats at RMA. Although offpost control sites have been used in several other studies, these sites were either inadequately characterized or were substantially different in habitat from the RMA study-sites, precluding rigorous comparisons.

EPA considers the concept of ecological "health" to be inadequately defined and not useful for application to communities and ecosystems.

C.5.4.4.3 Effects of Contamination on Biota

RMA is unusual among Superfund sites in that it contains large areas with little or no contamination levels, as well as substantial areas with high contamination levels. Hence, studies of population characteristics that are conducted on an RMA-wide scale are subject to confounding by mixing animals that are relatively unexposed with animals that are exposed to varying degrees. The appropriate spatial scale for study and analysis of potential effects of contamination, therefore, should be determined on a species-by-species basis, taking into

consideration the scale of change in contamination levels and the scale over which individual animals of each species use the habitat.

The outcome of the risk assessment conducted under the IEA/RC is a set of predictions that animals are at high risk of adverse effects in central areas of RMA and at low risk in peripheral areas. The central ("core contaminated") areas are those in which the average levels of soil contamination are high, but the actual distribution of contaminants within these areas is very patchy and many locations have low or undetectable levels. Likewise, the peripheral areas have low average levels of soil contamination, but include locations where low to moderate levels of contaminants have been detected. The location of the boundary between areas of high risk and low risk is very uncertain (because of uncertainties in the process of risk assessment and disputes about risk assessment procedures) and varies from species to species (because of differences in factors controlling exposure, spatial averaging over home ranges, and differences in sensitivity to toxic effects).

If the predictions of the risk assessment are correct, one would expect gradients of effects within RMA from the contaminated core areas to the less contaminated peripheral areas. Field investigations within RMA, if properly conducted, might serve to confirm or to refute these predictions. If the effects are confirmed, field investigations might serve further to define the areas over which the effects take place, and their consequences for populations and communities on larger scales.

The major effects predicted by the risk assessment include lack of occupation (e.g., because of reductions in prey populations or other habitat impairments), increased mortality, and/or reduced reproductive success. Each of these effects could be measured directly with appropriately designed studies. Increased mortality or reduced reproductive success may be detected indirectly by observations of gradients in population density. However, such observations need to be interpreted carefully in relation to the population dynamics of these species under study. Effects of increased mortality or reduced reproductive success may be offset partially or fully by net immigration from surrounding areas where effects are smaller or absent. Hence, although the observation that numbers of animals are present in or near the core contaminated areas provides useful information on abundance and density in these areas, the comparison of this information to results of the ERC is ambiguous unless survival rates or reproductive rates are measured, or unless rates of immigration and emigration are measured or taken into account through modelling.

Studies of several species (e.g., black-tailed prairie dogs, small mammals, songbirds, American kestrels, wintering raptors),

have characterized the distribution, density, and/or reproductive success of animals at various locations within RMA (Section C.5.3.2). These and other species have been recorded in numbers close to and even within the core contaminated areas of RMA (e.g., RMA Section 26), indicating locally high potential for exposure. With three exceptions, however, none of these studies included characterization of actual exposure or even measurement of soil contamination levels at the study sites, and the locations of the study sites were not recorded precisely enough for the post hoc estimation of potential exposure. Retrospective investigation of the relationship between endpoints observed in some of these studies and exposure to contaminants (as attempted by the Army in Sections C.5.3.2.1 and C.5.3.2.2) is not possible because of the imprecise location of study sites, inconsistent and unreliable measures of exposure, focusing of studies in uncontaminated areas, and other problems.

The three exceptions mentioned in the last paragraph are the studies of invertebrates (Section C.5.3.2.3) and American kestrels (Section C.5.3.2.2). Each of these studies included measurements of tissue concentrations of contaminants in individual organisms that were studied. The invertebrate study (ESE 1989) involved collection of earthworms at one contaminated site and grasshoppers at two contaminated sites, as well as onpost and offpost controls. For earthworms, only one study sample was analyzed for organochlorine contaminants, so this study does not provide sufficient information on potential effects. For grasshoppers, contaminants were detected in the study sample and not in controls, but the sampling methods were not sufficiently standardized to draw conclusions about potential differences in population density.

The only studies conducted at RMA to date that are useful in testing hypotheses about potential effects of contaminants are those of American kestrels (Section C.5.3.2.2). Although these studies included offpost control sites, these were poorly matched for habitat and other characteristics and the most informative comparisons are those that can be made within RMA. The earliest studies (DeWeese et al. unpublished) suggested a strong within-RMA gradient in nest occupancy and productivity, both being low within 1 mile of the core contaminated areas, intermediate in areas between 1 and 2 miles from them, and high in areas more than 2 miles from them. These gradients have not been clearly indicated in subsequent studies (ESE 1989, RLSA 1992, USFWS 1992a, 1993), but data on occupancy have not been reported and only a few nest boxes have been placed near the core contaminated areas. Moreover, concentrations in eggs and fledglings were very variable, even within clutches and broods, and were not closely related to distance from the core contaminated areas (ESE 1989). Retrospective analysis of the relationship between various measures of reproductive success and various measures of contamination (Section C.5.3.2.2) yielded inconclusive results,

in part because of inadequate study design, but primarily because very few of the study pairs were significantly exposed to contaminants. The key variable of nest box occupation was not examined in this analysis.

Overall, therefore, the results of the kestrel studies are inconclusive in assessing potential ecological effects caused by RMA contaminants. However, they do show that a few pairs of kestrels nest close to the core contaminated areas and that some of these pairs raise young to fledgling. A more systematic study would be needed to define effects on the kestrel population.

C.5.4.4.4 Conclusions

The field studies of biota conducted at RMA are useful in describing the status of many plant and animal species, including in some cases information on population sizes or density and/or distribution within RMA. They are thus useful in defining the resources at risk. However, little information is available on the "health", exposure, or contamination effects of individual animals or populations.

EPA's overall conclusion concerning Appendix C.5, Ecological Status and Health, is that, generally, the field studies were not adequately designed to assess the potential effects of contaminants on RMA biota at the individual, population, or community level. Hence, they are of little or no value in testing the hypotheses about effects that can be derived from the risk characterization. Some animals collected at RMA have tissue levels of contaminants that exceed the MATC, and at least a few appear to have been lethally poisoned. Several species occur and even breed successfully close to core contaminated areas. Except for a few American kestrels, however, the actual exposure of these animals has not been characterized. Hence, the available information on RMA biota neither confirms nor refutes the predictions of the risk characterization. Implications otherwise are misleading.

Summary of Attachments

The EPA position stated herein includes four Attachments as follows:

Attachment 1: EPA's definitions and categorization of bias, power, and relevance.

Attachment 2: EPA's statement concerning the appropriate scale for investigation of population impairments.

Attachment 3: A detailed analysis of the studies used to support the Army's conclusions regarding the status and health of invertebrates, small mammals, prairie dogs,

songbirds, American kestrel, burrowing owl, and bald eagle, as well as biomarkers and fortuitous samples.

Attachment 4: Retrospective linking of data on measurement endpoints to soil concentrations.

ATTACHMENT 1

EPA's Definitions and Categorization of Bias, Power, and Relevance

General Introduction

A number of different investigations of the biota of the Rocky Mountain Arsenal (RMA) have been carried out. In Appendix C.5 of the IEA/RC, the Army reviews these investigations and draws inferences about the "status" and "health" of the biota and ecosystems of RMA. Although the inferential process is not stated formally, three different types of questions are addressed:

1. What is the "status" of the biological populations and communities at RMA?
2. How "healthy" are the organisms, populations, and ecosystems at RMA?
3. To what extent have the "status" and "health" of the biota at RMA been impaired by the contamination there?

Status

"Status" is not defined in the IEA/RC, but the term appears to be used more or less synonymously with "diversity." Diversity includes both species richness and trophic diversity (Section C.5.3.1.1). However, there is no formal information on trophic diversity ("the number of food chains and the number of trophic levels represented in various food chains", p. C.5-15) at RMA, so most information on the "status" of the biota at RMA consists of estimates of species richness, with some information on absolute and relative abundances. Species richness ("the total number of species present", p. C.5-14) is estimated by selecting a group of taxa to be evaluated (e.g., small birds), selecting an area, selecting survey methods, and enumerating the species encountered. Although the concept and procedure are straightforward, each of the four steps listed in the preceding sentence affect and determine the reliability and relevance of the results.

In principle, information on status can be used in two ways: (a) to define the resources at risk: (b) to identify elements of the biota as being of "high" status or "low" status. The latter would be necessary to identify impairment of status attributable to contamination (see below). Ranking the status of the biota in this way implies a scale against which the status can be measured, which usually requires a comparison with an unimpaired or "normal" system (see below).

Health

"Ecological health" is defined on p. C.5-2 as "consisting of the

normal range of those ecological characteristics identified by EPA (1989a, pg. 42 to 43) as providing a basis for selecting appropriate assessment endpoints." EPA has objected to this definition on the grounds that it is so vague as to be meaningless and unintelligible. Moreover, the Army states that for mobile, upper-trophic level species, contaminant effects must be assessed in the context of their inclusion in populations that extend beyond the RMA boundaries. "These are populations that occupy a particular region characterized by a habitat or habitats that are more or less contiguous and occur within a major biogeographic region", p. (C.5-2). However, none of the mobile, upper trophic level species was actually assessed in this context, so the Army's definition is not useful or meaningful for the IEA/RC.

"Ecological health" is not a well defined term or concept in ecology, and EPA considers that the concept is not appropriate or useful in the IEA/RC. As used by the Army in the IEA/RC, the term appears to include four components:

1. "Health" of individuals: presence or absence of anatomical, physiological, or pathological conditions that would indicate ill-health.

2. "Health" of populations: presence or absence of population characteristics (e.g., numbers, distribution, reproductive rate, mortality rate, recruitment rate, net immigration rate, age structure) that would indicate impairment or lack of viability.

3. "Health" of communities: presence or absence of community characteristics (e.g., species richness, trophic diversity) that would indicate impoverishment.

4. "Health" of ecosystem: presence or absence of structural or functional ecosystem characteristics (e.g., productivity, stability) that would indicate impairment or dysfunction.

Each of these components is defined in terms of presence or absence of impairment, i.e., "good health" is defined as the lack of signs of ill-health. This feature probably corresponds to the word "normal" in the Army's definition, quoted above. To define "health" in this way implies a comparison with an unimpaired or "normal" system (see next section).

Evidence for ecological effects related to contamination

The general question posed is: To what extent have the biota at RMA experienced ecological effects due to contamination? This question can be addressed by comparisons at several levels:

1. Comparison of characteristics of the RMA biota with "normal"

characteristics for the species, community, or ecosystem.

2. Comparison of characteristics of the RMA biota with data on regional populations, communities, or ecosystems.
3. Comparison of characteristics of the RMA biota with data on populations, communities, or ecosystems in selected control sites.
4. Comparison of characteristics of the biota in areas of RMA close to contaminated zones with those of biota in areas farther from contaminated zones.
5. Comparison of characteristics of the biota in areas of RMA known to be highly contaminated with those of the biota in areas of RMA known to be less highly contaminated.
6. Correlation of characteristics of the biota with levels of contaminants in different areas.
7. Correlation of characteristics of the biota with specific measures of exposure (e.g., tissue concentrations).

These comparisons are arranged in increasing order of specificity, i.e., the later comparisons provide more specific evidence for relationships between contaminants and differences in the measured characteristics than do the earlier comparisons. At all levels of comparison, however, the results have to be evaluated for bias, power, and relevance.

Bias

General Definition. The magnitude and direction of the tendency to measure something other than what was intended (Table C.5-2, footnote 1, in the IEA/RC, and Table 3-1, footnote 1, in EPA's Attachment 3 to these comments).

Application to Investigations of Biota at RMA and Inferences about Status and Health. In ecology, bias is rarely measured directly because this requires knowledge of the "true" value of the characteristic being measured for comparison with the measured value. Bias can occasionally be estimated by theoretical analysis of the measurement process, or by repeated measurements over a range of the factors thought likely to introduce bias. However, these methods of estimating bias have not been used at RMA. What is at issue, therefore, is potential bias. The question to be addressed is whether the observations were designed and executed in such a way as to minimize bias. Specific questions include the following:

1. Were the observations representative of the individuals, population, or community which was the intended object of study? For example, if the intended object of study is the small mammal population of the entire RMA, were the samples or observations appropriately randomized with respect to location, habitat, and other factors that might introduce bias?
2. If an off-site control area is used, was it appropriately

matched to the study site in terms of all factors likely to affect the characteristic being measured? Is it justifiable to assume that the off-site control area was uncontaminated?

3. If an on-site control area is used, was it appropriately matched to the study area in terms of all factors likely to affect the characteristic being measured except level of contamination? Was the level of contamination at both the study and control areas measured?
4. If within-site comparisons are made among study areas, were the areas appropriately matched in terms of all factors likely to affect the characteristic being measured except levels of contamination? Were the levels of contamination measured in comparable ways in all study areas? If not, is there a reliable basis for the assumption that some areas were more contaminated than others?
5. If endpoints are compared to tissue concentrations or other measures of the exposure of individual animals, were these individual animals appropriately matched in terms of all factors likely to affect the characteristic being measured except levels of exposure? Were the levels of exposure measured in comparable ways in all the organisms?

Unless all the relevant questions can be answered in the affirmative, the potential for bias cannot be categorized as "low".

Typically, ecological systems are very variable in time and space and are influenced by many uncontrolled factors. Without very careful attention to design of sampling and matching of control and study areas, the potential for bias is usually very large.

Criteria for categorizing potential bias

LOW: 1. Study design fully documented and sufficient to make samples or observations representative of intended object of study; and

2a. control areas fully described and characterized, and matched to study areas in terms of all factors likely to affect the characteristic being measured except levels of exposure; or (in case comparisons are made among samples with different levels of contamination)

2b. samples matched in terms of all factors likely to affect the characteristic being measured except levels of exposure; levels of exposure measured in comparable ways among samples.

HIGH: One or other of the above criteria not met (e.g., samples not representative, control areas not described or characterized, areas not appropriately matched, or

samples not appropriately matched).

MEDIUM: One or other of the above criteria not fully met (e.g., control areas inadequately characterized, or areas or samples incompletely matched).

In all three cases, professional judgment is required to interpret and apply the terms "sufficient," "representative," "fully," "matched," etc.

Power

General Definition. The probability of rejecting the null hypothesis when in fact it is false and the alternative hypothesis is correct (Table C.5-2, footnote 2, in the IEA/RC, and Table 3-1, footnote 2 of EPA's Attachment 3 in these comments).

Application to Investigations of Biota at RMA and Inferences about Health and Diversity. The term "power" has a precise meaning and definition in statistics, where null and alternative hypotheses also can be framed in precise terms. In ecology, the term "power" has a much broader meaning, and it is often difficult to frame null and alternative hypotheses precisely. In the context of RMA, null hypotheses can be framed in terms like the following:

-the average abundance of species X on RMA is not lower than that in similar habitats in the western United States;

-characteristic A of species X is not lower on RMA than in matched control site C;

-characteristic A of species X is not lower in contaminated areas of RMA than in less contaminated areas of RMA;

-characteristic A of species X is not correlated with exposure to contaminant Q among selected sites within RMA.

Although some of these ecological null hypotheses can be translated into precise statistical hypotheses about measurement endpoints, this translation is sometimes uncertain or incomplete, because the measurement endpoints are not precisely related to the biological characteristics that are the subject of the ecological hypotheses. For example, characteristic "A" might be reproductive success; statistical tests conducted on components of reproductive success, such as clutch-size or number of chicks fledged, may not cover all the components that are affected by the contaminant. Thus, although the concept of ecological power includes the statistical power of the statistical test that is conducted, it also includes other elements. In general, ecological systems (populations, communities, and ecosystems) are very "noisy" and are influenced by a wide variety of uncontrolled variables. Unless this "noise" is taken into account, the power of comparisons can easily be overestimated.

Criteria for categorizing power.

HIGH: 1. Close correspondence between the quantities that are measured and the biological characteristics that are under investigation; and

2. ability of the study design to capture the major sources of variance in the quantities that are measured; and

3. (statistical power) ability of the study design to detect an ecologically meaningful difference in the quantities that are measured if such a difference in fact exists and is related to levels of contamination.

LOW: One or more of the above three criteria not met.

MEDIUM: Uncertainty about one or more of the above criteria.

In all three cases, professional judgment is needed to interpret and apply these criteria, including the words "close", "major", and "ecologically meaningful."

Relevance

General Definition. Pertinent to the matter at hand (Table C.5-2 of the IEA/RC, footnote 3, and Table 3-1 , footnote 3, of EPA's Attachment 3 in these comments)

Application to Investigations of Biota at RMA and Inferences about Status and Health. The "matter at hand" is the extent to which the "status" and "health" of the biota at RMA have been impaired by the contamination there. Hence, a study is "relevant" if it provides unambiguous evidence that some characteristic of the biota that falls within the definitions of "status" or "health" has or has not been impaired by the contamination there. To do so, the study must be related to an *a priori* hypothesis about the effects of specific contaminants on RMA biota, and this hypothesis must be consistent with or be suggested by the results of the risk assessment. For example, a study comparing specific reproductive elements of reproductive success (eggshell thinning and chick survival) in individual pairs of American kestrels with residue levels of OCPs in their diets, tissues, or eggs would have high relevance. However, a study comparing the total numbers or average density of American kestrels on RMA with those at a comparable site elsewhere would have low relevance, because the risk assessment indicates that the survival and/or reproductive success of kestrels may be affected in certain parts of the site but not in others; this does not yield a prediction of a change in total numbers or average density without population modelling.

Criteria for categorizing relevance

HIGH: 1. The study involves a measurement endpoint related to an a priori hypothesis that the endpoint would be affected by one of the contaminants present at RMA; and
2. the measurement endpoint reflects some aspect of "status" or "health" as outlined above; and
3. the a priori hypothesis is consistent with the predictions of the ecological risk characterization; and
4. the study is carried out on a scale appropriate to this prediction.

LOW: One or more of the above criteria is not met.

MEDIUM: Uncertainty about one or more of the above criteria.

In all three cases, professional judgment is needed to interpret and apply these criteria, including the words "related," "consistent," and "appropriate."

ATTACHMENT 2

Appropriate Scale for Investigation of Population Impairments

One of the general issues raised by EPA in its comments on the IEA/RC is the issue of spatial scale. RMA is unusual among Superfund sites in that it contains large areas with low or zero contamination levels, as well as substantial areas with high contamination levels. Hence, studies of population characteristics that are conducted on an RMA-wide scale are subject to confounding by mixing animals that are unexposed with animals that are exposed to varying degrees. EPA believes that the appropriate spatial scale for study and analysis of potential effects of contamination should be determined on a species-by-species basis, taking into consideration the scale of gradients in contamination and the scale over which individual animals of each species use the habitat.

The outcome of the risk assessment conducted under the IEA/RC is a set of predictions that animals are at high risk of adverse effects in central areas of RMA and at low risk in peripheral areas. The location of the boundary between areas of high risk and low risk is very uncertain (because of uncertainties in the process of risk assessment and disputes about procedure) and varies from species to species (because of differences in factors controlling exposure, spatial averaging over home ranges, and differences in sensitivity to toxic effects).

If the predictions of the risk assessment are correct, one would expect gradients of effects within RMA from the contaminated core areas to the uncontaminated peripheral areas. Field investigations within RMA, if properly conducted, might serve to confirm or to refute these predictions. If the effects are confirmed, field investigations might serve further to define the areas over which the effects take place, and their consequences for populations and communities on larger scales.

The major effects predicted by the risk assessment include lack of occupation (e.g., because of reductions in prey populations or other habitat impairments), increased mortality, and/or reduced reproductive success. Each of these effects could be measured directly with appropriately designed studies. Increased mortality or reduced reproductive success may be detected indirectly by observations of gradients in population density. However, such observations need to be interpreted carefully in relation to the population dynamics of the species under study. Effects of increased mortality or reduced reproductive success may be offset partially or fully by net immigration from surrounding areas where effects are smaller or absent. Hence, the observation that numbers of animals are present in the more contaminated areas is ambiguous unless survival rates or reproductive rates are measured, or unless rates of immigration

and emigration are measured or taken into account through modelling.

EPA believes, therefore, that investigation of potential effects of contamination of the biota of RMA requires: (i) studies conducted on a scale smaller than the site; and (ii) explicit consideration of population dynamics of the species studies, including rates of dispersal. Several field studies at RMA have in fact been conducted on scales smaller than the site, and the Army has attempted to interpret them by comparing measurement endpoints between putatively contaminated and uncontaminated areas. EPA believes that none of these studies provides strong evidence either for or against the predictions of the risk assessment (in part because of objectives that were unrelated to the ERC, or errors of interpretation, as documented in this report, and in part because none of the studies has been interpreted in terms of dispersal or other elements of population dynamics). However, EPA agrees with the general assumption underlying the Army's interpretation of these studies: comparisons between contaminated and uncontaminated areas, if correctly designed, executed, and interpreted, could provide useful information about the existence, magnitude, and spatial scale of adverse effects of RMA contamination at the individual, population, or community level.

Nevertheless, the Army appears to believe that the results of the field investigations can only be interpreted at the scale of the entire site, and evidence of impairment in one part of the site would not be significant unless effects could be demonstrated on the entire RMA population.

In the text of Appendix C.5, the Army generally uses the term "population" as though it applied to the entire population of a species within the RMA boundary. EPA disagrees with the Army's positions on the appropriate scale for population assessment, for the following reasons:

1. The Army's positions are internally inconsistent. Although the Army states that "populations cannot be defined and population parameters cannot be measured at anything less than an RMA-wide scale," the Army cites and conducts a number of analyses comparing population parameters between "contaminated" and "uncontaminated" areas within RMA. The Army's retrospective analyses comparing measurements of ecological endpoints among sites within RMA with values of ESC are examples of these analyses, and are applied to some of the most wide-ranging and mobile species (e.g., American kestrel, burrowing owl, great horned owl).

2. The boundary of RMA is not a natural ecological boundary and populations within the boundary are not isolated from those outside it.

3. Although the Army states that the "mobile, upper-trophic level species...must be assessed in the context of their inclusion in populations that extend outside the RMA boundaries", Appendix C.5 does not in fact assess any species in this context.

4. At least in the breeding season, most of the "mobile, upper trophic level species" are, in fact, limited to territories or discrete home ranges that are much smaller than the entire site. It is therefore meaningful and legitimate to analyze data on these species by individual territory or subpopulation (as the Army does in several cases). As an example, one of the species considered by the Army for which individuals range over the entire site (or larger areas) during the period for which they are assessed is the bald eagle. Although individual bald eagles may focus their feeding (and hence, their exposure) within limited parts of the site, EPA agrees that population assessment of bald eagles should be based on the entire group using the site as a roost.

5. For example, there is nothing in the ecological literature to indicate that populations can only be defined and studied on a scale on which they are isolated from neighboring populations. Recent ecological textbooks make it clear that populations can be defined and studied at any scale: "arbitrarily at the convenience of the investigator" (Ricklefs 1990); "boundaries are determined by an investigator's purpose or convenience" (Begon et al. 1990).

EPA believes that the appropriate spatial scale for study is the scale of the predictions which the studies are designed to test. Depending on the species, this scale may be that between the core area with high average contaminant levels and the peripheral areas with low average contaminant levels, or on a smaller scale of local contamination gradients within the core area.

At RMA, the appropriate spatial scale for study is the scale of the predictions which the studies are designed to test. Depending on species, this scale may be that between the core area with high average contamination levels and the peripheral areas with low average contamination levels, or on a smaller scale of local contamination gradients within the core area.

ATTACHMENT 3

EPA's Review of Key Documents pertaining to RMA Ecological Status and Health

This attachment summarizes EPA's review of many of the documents cited by the Army in Appendix C.5, Ecological Status and Health. Our review of each study included the following types of information: who conducted the study and the dates of study, the purpose of the study, summary and results, a comparison of the Army's and EPA's conclusions, the differences between the Army's and EPA's conclusions, the relation of the study to issues raised by EPA in its September 20, 1993 comments on Appendix C.5, and EPA's characterization of bias, power, and relevance. EPA's characterization of bias, power, and relevance for each study is summarized in Table 3-1 of this attachment.

Aquatic Snail Population Density and Biomass.

Study conducted by: Environmental Science and Engineering, Inc.(ESE, 1989); pages B-27 through B-33; pages 5-311, 5-316, and 3-18.

Purpose of study: "...invertebrate groups were selected for population studies as a means of evaluating potential effects on their populations (pages 3-18, 5-316).

Dates of study: 1986, 1987

Summary of study:

Aquatic snails were surveyed to provide information on total body weights and snail densities. Snail densities and total weights were estimated from seven sites in each of two years (1986 and 1987), although the same sites were not evaluated in each year (page B-27).

Aquatic snails from RMA lakes, including Lake Mary, Rod and Gun Club Lake, Lake Derby (Upper or Lower not specified), and Lake Ladora sampled compared with three control sites labeled as Wellington A,B, and C., The statistical tables associated with this report also repeatedly refer to an RMA lake identified as "North Bay" (pages B-29, B-30, B-31, and B-32). It is presumed that the authors intended to indicate the RMA waterbody known as North Bog.

As previously noted, the study incorporated five RMA lakes, regarded as "contaminated sites", and three offpost controls. However, only seven sites were sampled and compared in each of two different years (1986 and 1987). Thus, the same sites were not evaluated in each year (page B-29). For example, the five RMA lakes were compared against Wellington A and Wellington B in 1986, and with Wellington A and Wellington C in 1987 (page B-27). Analyses for contaminant burdens were not made.

Summary of results:

Snail densities and snail total weights were compared statistically between RMA lakes and the control sties. The lack of correspondence in sampling and analytical sites prevented the use of either the two-way ANOVA or ANOVA methods for evaluating the effect of either year or "contamination level" on snail density or snail weight (page B-27). Instead, separate one way ANOVA analyses comparing snail densities and total weights across sites was performed for each year. Statistically significant relationships were established, although substantially different statistical variances were observed. In fact, the authors state:

> ...[t]he very highly significant heteroscedasticity detected by the Fmax Test is of considerable concern...(page B-27).

The authors report their findings in a section labeled "Remarks" (pages B-28-B-33). Their comments were as follows:

"Variances were very highly heteroscedastic for all four analyses ($p << 0.001$). Even though the results of the parametric analyses are reported in full, subsequent consideration will only focus on the results from the Kruskal-Wallis one way ANOVA by ranks (for both usual and residual ANOVAs).

- Density 1986 - the significant differences among the seven sites were, in part, affected by differences between controls, differences among the contaminated sites, and differences between controls as a group and contaminated sites as a group (Table B2-1). Although the covariates significantly affected snail density, similar differences among sites persisted in the ANOVA by ranks on the residuals, with the exception that mean values among the contaminated sites were indistinguishable.

- Density 1987 - The significant differences among the seven sites were, in part, affected by differences between controls, differences among the contaminated sites, and differences between controls as a group and contaminated sites as a group (Table B2-2). Although the covariates significantly affected snail density, similar differences among sites persisted in the ANOVA by ranks on the residuals, with the exception that mean differences between control sites as a group and contaminated sites as a group did not obtain significance.

- Weight 1986 - The significant differences among the seven sites were, in part, affected by differences between controls, differences among the contaminated sites, and differences between controls as a group and contaminated sites as a group (Table B2-3). Although the covariates significantly affected total snail weight, similar differences among sites persisted in the ANOVA by ranks on the residuals without exception.

- Weight 1987 - The significant differences among the seven sites were, in part, affected by differences among the contaminated sites, and differences between controls as a group and contaminated sites as a group (Table B2-4). Although the covariates significantly affected total snail weight, similar differences among sites persisted in the ANOVA by ranks on the residuals, with the exception that an additional difference between controls was revealed."

The authors summarized their finding in a conclusory section of the document. Their conclusions are as follows (page 5-311):

> The results of statistical analyses indicated that a very high degree of variability exists among sites and between years. Multiple regression analyses of snail results with the covariates of vegetation (substrate) weights, temperature, and pH indicated that these factors affected results.

> Interpretation of these analyses suggests that differences between on-post (contaminated) sites and off-post (control) areas are attributable to a number of environmental factors, some of which vary with time (e.g., temperature, amount of substrate, etc.) The lack of contaminant analyses for aquatic snails and the lack of pattern in variability do not allow any conclusions with respect to the possible effects of RMA contaminants on aquatic snail populations of RMA.

EPA's conclusion:

This study does not provide useful information for assessing aquatic snail population densities or total weights because the multiple regression analyses of snail results with the covariates of substrate, weight, temperature, and pH indicated these factors affected the results of the study. As a consequence, the authors note that differences between onpost and offpost sites are attributable to a number of environmental factors, some of which vary with time, notably temperature, and substrate (page 5-311). The large differences in statistical variances ("highly significant heteroscedasticity") ranging from F_{max} = 6,424.6 to F_{max} = 27,996.4 for aquatic snail density and F_{max} = 1,100.0 to F_{max} = 58,900.8 for total snail weight caused the authors "considerable concern" (page B-27).

The statistical variation and the interference of the covariates with variables of interest do not allow the data to be used to draw inferences or conclusions. EPA agrees with the authors who state (page 5-311):

> The lack of contaminant analyses for aquatic snails and the lack of pattern in variability do not allow any conclusions with respect to the possible effects of RMA contaminants on aquatic snail populations at RMA.

Army's conclusions:

The above-referenced data indicate no obvious contaminant effects on population density of grasshoppers, earthworms, or aquatic snails (page C.5-53).

Differences between EPA's and Army's conclusions:

EPA believes the Army's conclusion with respect to aquatic snails is unwarranted. The Army summarizes the study by suggesting that there are "...no obvious effects on population density of ...aquatic snails." What is not stated is that the data themselves do not allow effects on either population densities or total weights to be assessed. The authors of the study specifically summarize their findings by indicating that the data, "...do not allow **any conclusions** with respect to possible effects of RMA contaminants on aquatic snail populations at RMA" [emphasis added]. EPA concurs with this conclusion.

Bias, power, and relevance:

Aquatic snail population density and biomass was included in the Army's table of bias, power and relevance (Table C5-2). The Army has categorized bias, power, and relevance for aquatic snail studies as low, high, and medium, respectively. EPA's categorization of bias, power, and relevance is as follows:

Categorization		Comments
Aquatic Snail Population Density and Biomass		
Bias	HIGH	Variables of interest could not be reliably measured because of confounding covariates including substrate, weight, temperature, and pH. Time variable environmental factors were a particular problem.
Power	LOW	The null hypothesis could not be rejected because of confounding covariates. The lack of contaminant analyses and the lack of a pattern in variability obviated conclusions drawn from the data.
Relevance	LOW	No a priori hypothesis is presented. If the study had appropriately and consistently used control sites throughout the study, had accounted for environmental variation, and had used measurements of contaminants in substrate and snail tissue, it could have yielded useful information regarding population density and total weight in relation to contaminant levels. However, there is no a priori basis for predicting that aquatic snails would be affected at the contaminant concentrations occurring at RMA.

Invertebrates

Study conducted by: Environmental Science and Engineering, Inc., (ESE, 1989), Pages 3-18 through 19, 4-32 through 4-36.

Purpose of Study:

> ...invertebrate groups were selected for population studies as a means of evaluating potential contaminant effects on their populations (pages 3-18, 5-316).

Dates of Study: Earthworms: Spring, 1987
Grasshoppers: Summer, 1986, 1987

Summary of Study: Invertebrates were surveyed to provide information on occurrence, distribution, and relative abundance (page 3-15). Following the survey, earthworms and grasshoppers were also collected for contaminant analysis (arsenic, aldrin, dieldrin, endrin, mercury, DDT, and DDE) (page 4-32).

Earthworms were sampled at one onpost "control" site (in Section 5), one offpost control site (Barr Lake), and one onpost "contaminated" site (South Plants). Plots (1 m square, dug to a depth of approximately 15 cm) were randomly selected at each location, except for South Plants, where sampling was limited to areas of suitable substrate (page 5-319). Four such plots were located at the offpost control site, five plots were located at the onpost control site, and five plots were located in South Plants. Information was neither provided nor referenced regarding soil contamination, and the precise locations of study areas were not reported. Descriptions of the Barr Lake control site (page 3-7) were too general to ascertain whether the control site was adequately selected or not. The onpost "control" site may have been inadequately selected.

Grasshopper abundance was estimated at two onpost "contaminated" sites (Sections 26 and 36), at two onpost control sites (Sections 7 and 8), and at two offpost control sites. Grasshoppers were counted within 0.1m^2 plots at 10-m intervals along five 100-m transects located in each onpost and offpost area. As for earthworms, information regarding soil contamination and precise locations of study areas were not reported. Following the population surveys, grasshoppers were collected for contaminant analysis along the population transects. Descriptions of the offpost control sites (page 3-9) were too general to determine adequacy of control site selection. In addition, it appears that numerous variables, such as time of day, temperature, and floral characteristics were not comparable for sampling at the different sites (page B-33).

Summary of Results:

Population Studies: For earthworms, results of population comparisons indicated that onpost and offpost controls were significantly different, and that controls as a group were significantly different from the South Plants site (page 5-319).

For grasshoppers, the sample results were highly variable, and statistical analyses indicated no significant differences among sites (page 5-317). However, "[d]ifferences in time of day, temperature, and floral characteristics (height and density) associated with each of the quadrats could have a confounding effect on grasshopper density beyond that directly associated with the statistical treatments described..." (page B-33).

Contaminant Analysis: Contaminant levels in RMA invertebrates are presented on Figure 4.3-2, and discussed in the text of Section 4.3.2.2. For earthworms, only two samples (only one analyzed for OCPs) were collected from the onpost "contaminated" site (location not specified, and no soil measurements taken) in South Plants, eight were collected from the onpost control site, and two were collected from the offpost control site at Barr Lake. For the offpost control earthworm samples, no COCs were detected. For the onpost samples, arsenic was observed in all eight samples from the onpost control site, but not in the South Plants ("contaminated site") sample, dieldrin was detected in the South Plants sample and in one of seven onpost control samples, endrin was detected only in one of the onpost control samples, and mercury was detected in two samples (second earthworm sample from "contaminated site" analyzed for mercury only) from South Plants, and in two of eight samples from the onpost control site.

Results indicated significant differences among the three sites. When the two control sites were pooled and compared to the "contaminated" site, only comparisons for arsenic yielded significant differences. However, the Army stated that ..."Due to low sample sizes, differences between onpost control and contaminated sites may have remained undetected" (page 4-35). EPA agrees. Since the sample sizes are so small, the statistical power of such a study to draw any conclusions regarding statistical differences in contaminant concentrations among sites is virtually non-existent. In addition, since no information is provided regarding soil contamination levels, comparison is meaningless in terms of assessing impairment.

For grasshoppers, neither DDE nor DDT was detected in any of the samples. Arsenic and mercury were detected at only one of the "contaminated" sites (Section 36), aldrin and endrin were detected at only one of the "contaminated" sites (Section 26), and dieldrin was detected in both Section 26 and 36 samples. All analytes were below detection in onpost and offpost control samples. Results varied among the COCs regarding significant or non-significant differences between contaminated, pooled contaminated, control, and pooled control sites. No conclusions were drawn regarding statistical analysis of contaminant levels in grasshoppers (page 4-36).

EPA's Conclusions:

Status: This study did not provide useful information regarding the status of earthworms or grasshoppers Arsenal-wide because the sample locations were too few, and it is unclear how onpost "contaminated" versus onpost "control" sites were selected. In addition, for grasshoppers, variations in time of day, temperature, and floral characteristics were not controlled among the sites. If this study were designed using larger sample sizes and selection of "contaminated" versus "uncontaminated" sites on the basis of actual soil contamination values, this study might have provided useful population data for comparison among sites. This information could have been useful in the "weight-of-evidence" approach used by the Army. The current data, however, cannot be used for that purpose.

Health: The study provided no information on the "health" of earthworms or grasshoppers at RMA at the individual, population, or community level.

Impairment: The study did not provide information on the possible impairment of invertebrates at RMA, in that there was no attempt to measure or estimate contaminant exposure and resultant toxic effects. In addition, the high dieldrin detection in earthworms in the onpost "control" area indicates that this area should have been considered part of the "contaminated" site, and not used as a "control" site. Had sites been selected on the basis of actual soil contamination values, and soil and biota samples co-located, and a larger sample size used, this study might have provided quantitative information regarding contamination levels in earthworms and grasshoppers in contaminated versus uncontaminated sites. As it stands, no information regarding the impairment of earthworm or grasshopper populations can be ascertained from the Biota RI.

Army's Conclusions:
For earthworm densities, results indicated that the on- and offpost control sites were significantly different, and that both control sites were significantly different from the contaminated site... (page C.5-52).

The ... data indicate no obvious contaminant effects on population density of grasshoppers or earthworms. Earthworm population and tissue contaminant levels were reported as not indicative of adverse contaminant effects (ESE 1989) (page C.5-53).

Differences in population density for earthworms were not consistent with patterns of contamination (e.g., the onpost control site had the highest population density) (page C.5-52).

Differences between EPA's and Army's Conclusions: EPA believes the Army's conclusions are unjustified, for several reasons:

Earthworms

1. For earthworms, the study reports that significant

differences between the control sites and the contaminated site were significant only for arsenic, and that ..."Due to low sample sizes, differences between onpost control and contaminated sites may have remained undetected."

2. Comparisons of Figure 4.3-2 and Table B.2-7 in the earthworm study show that five sample plots were located in South plants, resulting in a mean density of 2.6 worms, and two composite samples for analysis; five sample plots were located in the Section 5 onpost control area, resulting in a mean density of 56 worms, and eight composite samples for analysis; and four sample plots were located at Barr Lake, resulting in a mean density of 2.5 worms, and two composite samples for analysis. Of the eight samples analyzed from Section 5, one had a dieldrin hit much higher than the detection in the sample from South Plants.

Since it is not apparent that either the onpost "contaminated" or "control" sites or location of sample plots were selected on the basis of actual soil contamination levels, it is likely that one of the earthworm sample plots located in Section 5 may have intersected an unanticipated "hot spot". The onpost control site may have therefore been inappropriately selected, and the resulting comparisons are meaningless. In fact, it may have been more appropriate to pool the date from the onpost "contaminated" site with the onpost "control" site, and compare results to the offpost control site. It is therefore inappropriate to draw conclusions that "earthworm densities were not consistent with patterns of contamination".

3. The sample sizes used in this study are insufficient to draw any conclusions regarding the comparative densities of earthworm populations. Based on the mean density and variance values reported on Table B.2-7, the small sample sizes render these data unusable for drawing any statistical comparisons of field observations. For example, for the South Plants site, to obtain a mean of 2.6 with a variance of 33.8, at 80 percent confidence and 20 percent precision (80 percent confidence and 20 percent precision are typically the minimally acceptable parameters to allow inferences about populations), a minimum of 297 sample plots would be required. The Army sampled from 5 sample plots. The resulting mean and variance are associated with 25 percent confidence and 50 percent precision. As a result, conclusions regarding earthworm populations from these data are virtually meaningless.

4. The lack of evaluation of actual exposure to soil contamination negates any attempt to draw conclusions regarding effect of contaminants on earthworm or grasshopper populations at the Arsenal.

5. The statement that differences in population density were not consistent with patterns of contamination may be attributable to the process of site selection, rather than any contamination effects (see issue 2, above).

6. No statement was found in the study reporting that earthworm population and tissue contaminant levels were not indicative of adverse contaminant effects.

Grasshoppers

1. Population characteristics cannot be compared among "contaminated" and onpost or offpost "control" sites, since there was no effort made to collect sample data under similar environmental and vegetative conditions.

2. Grasshopper tissue samples were not co-located with any soil data, nor was information presented that actual soil concentrations in the vicinity of grasshopper samples was known. Therefore, no inferences can be made regarding contaminant effects on population densities of grasshoppers.

3. The sample sizes used in this study are also insufficient to draw any conclusions regarding abundance of grasshopper populations. Based on the mean density and variance values reported on Table B.2-5, the small sample sizes render these data unusable for drawing any statistical comparisons of field observations. For example, for the contaminated site, to obtain a mean of 8.92 with a variance of 247.27, at 80 percent confidence and 20 percent precision, a minimum of 185 sample plots would be required. The Army sampled from 26 sample plots. As a result, conclusions regarding grasshopper populations from these data are virtually meaningless.

Relation of This Study to Issues Raised by EPA:

1. Definition of Ecological "Health". The Biota RI provided no information on the "health" of earthworm or grasshopper populations at RMA.

2. Appropriateness of Offpost Control Areas. For earthworms, not only was the offpost control area inadequately described in comparison to the "contaminated" site, but the onpost control site appears to have been erroneously selected as a control site. For grasshoppers, the offpost control sites were described too generally to ascertain their appropriateness as control sites.

3. Spatial Scale and Within-RMA Comparisons. The spatial scale for these relatively sedentary species seemed appropriate. The within-RMA comparisons, however, are inconclusive, since no attempt was made to determine actual soil contamination levels at either "contaminated" or "control" sites. Conclusions regarding contaminant effects on population densities of invertebrates are, therefore, inappropriate and misleading.

4. Relationship of Ecological Characteristics to Contamination Levels. No information was collected,

presented, or used regarding soil contamination levels in the areas where population densities were studied.

5. Population Characteristics. Sample sizes of four and five are insufficient to draw conclusions regarding population characteristics of earthworms. For grasshoppers, sample sizes appear adequate to make inferences about relative numbers, but no other population characteristics were studied.

6. Treatment of Uncertainty. No discussion of uncertainty was presented either in the study report, or in the Army's summary of it.

Bias, power, and relevance:

Both grasshopper abundance and earthworm population density were included in the Army's table of bias, power, and relevance ratings (Table C.5-2). The Army categorized bias, power, and relevance for both grasshopper abundance and earthworm abundance as low, medium, and high, respectively. EPA's categorization of bias, power, and relevance are as follows:

	Categorization	Comments
Earthworms		
Bias	HIGH	Only two sites were evaluated on RMA using very small sample sizes. The study sites were not selected to be representative of contaminated and uncontaminated areas, and the study site locations were not matched for other factors that would affect earthworm density.
Power	LOW	Sample sizes were much too low to detect differences between control and contaminated sites.
Relevance	LOW	Whereas the Army cites studies of bioaccumulation in earthworms by Korschgen and Beyer and Gish, there was no a priori hypothesis presented that contaminants at the levels found might affect earthworm abundance.
Grasshoppers:		
Bias	HIGH	Study and control sites were not matched for environmental characteristics.
Power	MEDIUM	Sample sizes were adequate to assess differences between a contaminated and an uncontaminated site, had the study been designed for this purpose. However, to extrapolate Arsenal-wide, a larger number of sample locations would have

		been required.
Relevance	MEDIUM	If the study had included enough samples to yield adequate power (including actual measurements of soil contaminants), it could have yielded useful information regarding population density of grasshoppers in relation to contaminant levels.

Biomarker Endpoints

The Army has cited the use of two biomarker endpoints used as indices of "harmful levels of chemical contamination" (page C.5-55-56). These biomarkers included acetylcholinesterase (AChE) inhibition in brain tissue and eggshell thinning. The Army asserts (page C.5-55) that these biomarkers, "... are specific possible effects of some of the contaminants at RMA." The application of these parameters is considered below.

Study conducted by: Data on these parameters were collected as part of the Biota RI (ESE 1989).

Purpose of study: "... to evaluate whether these adverse effects of (AChE inhibition and eggshell thinning) were occurring at RMA on or near sites of known contamination" (IEA/RC, p. C.5-56). However, the Biota RI did not state this or any other purpose of the studies.

Summary of studies:

AChE analyses were performed on brain tissues of several species including mallard, ring-necked pheasant, black-tailed prairie dog and desert cottontail within the RMA boundaries and from control sites more than 40 miles from RMA (page C.5-56). Additionally, six fortuitous specimens from the RMA were examined, i.e., three red-tailed hawks, two golden eagles, and one mourning dove.

Eggshell thinning was investigated in the eggs of mallards, pheasants, and kestrels. These samples were collected as part of the Biota RI (page C.5-56).

Summary of results:

AChE inhibition was found only in prairie dogs living in or near the Toxic Storage Yard. The reductions were greater than 20 percent and were statistically significant ($p < 0.01$). The decrease could not be directly related to any observed contaminant in the area, but appeared to be associated with concentrations of arsenic and other metallic substances at the site (ESE 1989, p. 5-321).

Eggshell thinning was not observed in samples of ring-necked pheasant or American kestrel eggs on the RMA as compared with off-post control sites. The data for mallards were inconclusive because only one egg was collected onpost (ESE 1989, Table 5.3-7).

EPA's conclusions:

AChE inhibition is classically a function of exposure to organophosphorus-based compounds. Given the Army's continued reassurances regarding the lack of Agent on the grounds of RMA, and the fact that the COCs at RMA are primarily organochlorine-based substances, AChE testing is not appropriate for assessing the adverse effects of RMA compounds of concern. This contention is supported by the USFWS data on fortuitous samples. Of the several dozen AChE analyses performed at necropsy on animals

suffering frank and apparent symptoms of unknown origin, AChE inhibition studies have been uniformly negative. AChE analyses are inappropriate for evaluating the adverse effects on individuals and populations at the RMA because these analyses do not address the major contaminating substances, i.e., organochlorine compounds, at RMA.

Eggshell-thinning studies have the potential for identifying effects of exposure to DDE. However, ring-necked pheasants are known to be insensitive to this effect of DDE, so the inclusion of this species in the studies was inappropriate. Only one mallard egg was collected onpost, so the study had zero power to detect an effect in this species. In addition, the Risk Characterization indicates that the potential for exposure of mallards was very low (HQ of 0.05 for DDE/DDT, Figure D.1-20). For American kestrels, likewise, there is no evidence for significant exposure to DDE at any of the sample sites (Table C.5-7). Thus, there is no a priori hypothesis that eggshell thinning would have occurred in any of the samples, so the studies have low relevance.

Army's conclusions:

> Results of AChE and eggshell thinning studies did not indicate that either adverse effect was present at RMA as a result of contamination. Sample sizes for mallard, pheasant, kestrel, prairie dog, and cottontail were sufficient for nonparametric statistical analysis. Incidental data on other species, though inconclusive, were consistent with these results (pages C.5-56-57).

Differences between EPA's and Army's Conclusions:

EPA does not believe AChE inhibition is an appropriate biomarker for evaluation of adverse effects of the contaminants of concern on individuals or populations at the RMA. AChE testing is useful for determining the effects of Agent or organophosphorus compounds. However, since the COCs at the RMA are primarily organochlorine substances, the application of AChE testing would produce no useful information regarding the impacts of the principal COCs. EPA believes that inclusion of this parameter and the conclusions drawn relative to it are inappropriate.

EPA regards the eggshell thinning studies as irrelevant for the reasons stated. Hence, the Army's claim that this effect was not present at RMA is inappropriate. It is unclear how the Army can regard a sample size of 1 (mallard, onpost) as sufficient for nonparametric statistical analysis.

Bias, power and relevance:

Both AChE inhibition and eggshell thinning are included in the Army's table of bias, power and relevance (Table C.5-2). The Army has categorized bias, power and relevance for AChE inhibition as low, medium, and low, and eggshell thinning as low, medium and high. EPA's categorization of bias, power and relevance are as follows:

	Categorization	Comments
AChE Inhibition		
Bias	HIGH	Control areas uncharacterized..
Power	LOW	Small sample sizes (1 to 9 per species).
Relevance	LOW	AChE testing would be appropriate for organophosphates, but not for the COCs at RMA. In addition to the lack of relevance to COCs at RMA, no a priori hypothesis was presented, as this investigation was a part of the Biota RI.
Eggshell Thinning		
Bias	HIGH	Control areas uncharacterized.
Power	LOW-MEDIUM	Sample sizes of 1 for mallard, 7 for pheasants, 22 for kestrel.
Relevance	LOW	No evidence of significant exposure to DDE at any of the study locations for any of the species; pheasant known to be insensitive to this effect.

Prairie Dogs

The Army cited three major studies (MKE 1989a, ESE 1989, RLSA 1992) in its assessment of the status and health of black-tailed prairie dogs at RMA. These three studies will be evaluated sequentially in this section. The Army also cited background information from several published studies and information on the current status of prairie dogs from USFWS (1993a, 1993b); this information will be considered only in evaluating and comparing conclusions.

STUDY I (MKE 1989a)

Study conducted by: Morrison-Knudsen Environmental Services, Inc. (MKE, 1989a) Pages 1, 18-20, 53-57.

Purpose of Study.

> "...to (1) document the distribution and relative abundance of [prairie dogs] across the RMA, (2) evaluate [prairie dogs] use at RMA in relation to habitat types and contamination sources, and (3) compare [prairie dogs] use at RMA with selected offsite areas" (p. 1).

Dates of Study. June 1986 and May 1987 (p. 18).

Summary of Study. Prairie dogs were observed at 20 locations in 1986 and at the same 20 locations in 1987. The locations were selected by driving along roads and choosing observation points when at least 30 animals could be seen from a vehicle. Most locations were in peripheral parts of RMA; only two were near contaminated areas (p. 19). Six control sites were located at Buckley Air National Guard Base or Plains Conservation Center in 1986 and 20 in 1987. Neither RMA nor control sites were described. The only observations recorded at both RMA and control sites were the relative numbers of adult and juvenile animals.

Summary of Results. Results were presented in Table 4-1 (p. 55). The proportion of juvenile animals at RMA was significantly lower than that at the control sites in both years. The report attributes these differences to "normal ecological factors," citing superior habitat at the control sites and higher predation rates at RMA. The report concluded that contamination could not be causally involved, because the average proportion of juveniles at the four locations closest to contamination areas was higher in each year than that at the more distant locations (p. 57). No information on contamination was either reported or referenced, however.

STUDY II (ESE 1989)

Study conducted by: Environmental Science and Engineering, Inc. (ESE, 1989). Pages 1-1, 3-16 to 3-17, 4-51 to 4-56, 5-322 to 5-331.

Purpose of Study.

Part of the Biota Remedial Investigation (Biota RI), whose overall purpose was to present an overall environmental contamination assessment of biota within the RMA Study Area. (p. 1-1). Specific objectives of the Biota RI included evaluation of data on contamination, provision of specific information on the migration and accumulation of contaminants in regional food webs, and assessment of environmental effects of RMA contamination (pp. 1-8, 1-12). Objectives of the prairie dog study were to estimate minimum population densities and overall distribution of prairie dogs on RMA, to determine the relationship of this distribution to major sites of contamination, and to estimate the number of prairie dogs available as prey for bald eagles and other raptors (p. 3-16).

Dates of Study. Summer 1987 and January 1988.

Summary of Study. Visual counts were conducted at 20 locations on RMA in 1987 and at 12 locations on RMA in 1988; the latter included two locations in Section 36 and two in Section 25 near to contaminated areas. The method for selecting count locations was not specified, but appears to have been similar to that used in Study I (above). Sampling design for contaminant analysis specified the collection of 39 carcass samples (18 from two contaminated areas onpost, 13 from a control site onpost, and 8 from a control site offpost). Precise collection locations were not reported and the extent of soil contamination at the collection locations apparently was not assessed; the offpost control site was not identified. Counts of juvenile/adult ratios were reported also by MKE (1989a) and are discussed under Study I (above).

Summary of Results. Contaminant concentrations were reported in Table 4.3-1. High concentrations of dieldrin were measured in most samples from contaminated areas (Section 36 and the Toxic Storage Yard; range 0.064-13.4 ppm, N=19), lower concentrations in a few samples from onpost control areas (BDL-0.346 ppm, N=14); all samples from offpost control areas were BDL (N=18). Population estimates averaged about 20 animals/ha and did not differ significantly between winter and summer, or between contaminated and control areas in winter (Tables 5.3-1 to 5.3-3). However, only one of the four count locations was within the part of Section 36 where prairie dogs were sampled for contamination (Figures 4.3-12 and 5.3-1).

STUDY III (RLSA 1992)

Study conducted by: R.L. Stollar & Associates, Inc. (RLSA 1992), Vol. IV, pp. 1-11.

Purpose of Study.

"[t]o estimate the relative abundance and distribution of prairie dogs on RMA" (p. 1). The studies were undertaken because of the importance of prairie dogs as prey for highly mobile species and their role in contaminant transport (p. 1).

Dates of Study. Fall 1990; results compared with earlier surveys in 1987-1989 (p. 1).

Summary of Study. The extent and distribution of prairie dog colonies was determined by mapping, using aerial photographs and field verification. Relative abundances were determined by visual counts. Two plots were located in "potentially contaminated" areas and four control plots in areas with no known contamination (p. 4); the Figure cited mapped areas of active prairie dog towns but did not indicate the locations of the study plots.

Summary of Results. The area of active prairie dog towns on RMA declined from 1,851 ha in Oct. 1988 to 98 ha in Oct. 1989 as a result of an outbreak of campestral plague. By the time of the 1990 survey it had increased to 230 ha, in part because of reintroduction efforts. Relative abundances (animals counted/ha within towns) also declined between 1988 and 1990. The report stated that "In 1988 and 1990 the relative densities of prairie dogs in uncontaminated and potentially contaminated areas appeared to be similar" (p. 7). However, no statistical analysis was presented and no information on contamination was reported or referenced.

OTHER INFORMATION CITED

The Army also cited information from an annual report (USFWS 1993a) and minutes from a meeting (USFWS 1993b). These reports document the recovery of prairie dog populations following the plague epizootic of 1988-89. The US Fish and Wildlife Service relocated 5,229 prairie dogs to RMA between 1989 and 1991. By 1993, the area occupied by prairie dog towns had increased to 741 ha, with an estimated total population of 29,393 animals. A survey of 27 litters (locations unstated) yielded a mean of 4.44 pups per litter. The Army stated that this value was at the high end of the normal range found in several other studies, citing four published studies (only one in Colorado).

The Army also cited information on tissue concentrations in prairie dogs at RMA, including a number of specimens with concentrations of aldrin/dieldrin or DDE above the MATCs.

EPA's Conclusions:

Status: The studies and reports cited provided good information on the distribution of prairie dogs at RMA and on the effects of the plague epizootic, the reintroduction program, and natural recovery. Although not measures of absolute abundance, the data from visual counts provided useful quantitative information on relative abundance.

Health: The studies cited provided useful information on litter size and the juvenile/adult ratios at several points in time; the value of this information is limited by the small number and unsystematic selection of sample locations for juvenile/adult ratios, and by the lack of location information for the measurements of litter size. The studies document the effect of the epizootic but do not provide any information on possible interactions between contamination and plague.

Impairment: The surveys cited provided no usable information on the possible impairment of the status or health of prairie dogs, because of the lack of information on soil contamination or exposure at the survey locations. The data on tissue concentrations indicate risks to prairie dogs in some areas and risks to their predators over wider areas.

Army's Conclusions:

"Average prairie dog density had no apparent correlation with the general distribution of soil contamination in RMA where prairie dogs occur. There were no statistically significant differences ($p>0.05$) in prairie dog densities between the central colony that included portions of Sections 25 and 36, which are possible sources of contamination, and other colonies at RMA. The percentage of juveniles in the population was significantly lower at RMA in 1987 than in the offpost reference sites, but about the same in 1993. ... Comparison of measured tissue concentrations with whole-body MATC values for prairie dogs indicated that some individuals are likely to be affected by RMA contaminants. However, the effects of campestral plague, which occurs as a well-documented phenomenon in natural populations (RLSA 1992), and the subsequent managed immigration of thousands of prairie dogs, especially between 1988 and 1990, have obscured any potential effects of contamination" (p. C.5-20).

Differences between EPA's and Army's Conclusions. The first conclusion appears to be wrong because contamination levels were not reported, and no analysis of the relation between density and "general distribution of contamination" was reported, either by the original authors or by the Army. The Army's retrospective analysis is unjustified for reasons stated in EPA's comments (see comments on Retrospective Linking, Attachment 4). All the sites at which prairie dog density was measured had soil contamination levels close to or below the CRLs. The Army's second conclusion is unjustified for the same reasons. The Army's third conclusion appears to be incorrect because no information was cited for control sites in 1993.

Relation of this Study to Issues Raised by EPA.

1. Definition of Ecological "Health". This study was not conducted on a regional scale and provides no information on ecological "health" as defined by the Army.
2. Appropriateness of Off-Post Control Areas. Off-post control areas were used in all three studies, but were not described and were stated to have differed in important ecological characteristics from the on-post study-areas.

3. Spatial Scale and Within-RMA Comparisons. Although the Army's conclusions were purportedly based on comparisons among locations within RMA, underlying data were not reported in Study III. For all three studies, the comparisons were informal at best.

4. Relationship of Ecological Characteristics to Contamination Levels. No information was collected, presented, or used on soil contamination levels. Only one study plot (in Study II) was located within an area where contamination levels were measured; even in this case, there is no information on the contamination levels at or near the observation point. The claim that average prairie dog density had no apparent correlation with the "general distribution" of soil contamination was unsupported and conjectural. The Army's retrospective analysis is invalid for reasons stated elsewhere in these comments (Attachment 4).

5. Population characteristics. The studies cited provided useful information on distribution, semi-quantitative information on abundance and total RMA population, and useful information on litter size and juvenile/adult ratios.

6. Treatment of uncertainty. No discussion of uncertainty was presented either in the study reports or in the Army's summary of them, except for the Army's statement that the effects of the epizootic obscured any potential effects of contamination.

Bias, power, and relevance

The Army categorized the information on prairie dogs as "Medium" for each of the factors bias, power, and relevance (Table C.5-2). EPA's categorizations of bias, power, and relevance are as follows:

Categorization		Comments
Bias	HIGH	All studies: Off-post control areas were not described and were stated to have differed ecologically from on-post study-areas. Effects of plague and subsequent recovery may have confounded attempts to identify effects of contamination. I: Study locations were selected because

		they had large numbers of animals. II: Selection of study locations not specified, but apparently similar to that for Study I. III: Locations of study plots not indicated.
Power	MEDIUM (I)	20 study plots and 20 controls in 1987.
	LOW (II)	Only 4 study plots near contaminated areas; only one within sampled area.
	LOW (III)	Only 2 study-plots and 4 controls in 1992.
Relevance	HIGH	The studies could have provided relevant information on effects of contamination on reproduction, distribution and abundance if the problems of design had been overcome and if levels of contamination had been measured at locations of observations.

American Kestrel

The Army cited four successive studies (DeWeese et al. 1982 and unpublished, ESE 1989, RLSA 1990 and 1992, and USFWS 1992a and 1993) in its assessment of the status and health of American kestrels at RMA. These studies will be evaluated sequentially in this section.

STUDY I (DeWeese et al., 1982 and unpublished)

Study conducted by: DeWeese et al. (unpublished, ca. 1983; the report was not paginated, but page numbers have been added starting with the first page of the Abstract). The report by DeWeese et al. (1982) is not available to EPA at the time of this review, but the unpublished report appears to include the results from both years of the study.

Purpose of study:

..."to determine the magnitude of organochlorine pesticide contamination in the terrestrial system on the RMA" (p.3).

Dates of study: Spring-summer, 1982 and 1983.

Summary of study. The RMA study-area included all the land within the RMA boundary; two control study-areas were established 0.5-16 km and 68-95 km away from RMA; each study-area included several zones at different distances and directions from RMA. Habitats differed considerably both among and within RMA and control study-areas. Fifty-three nest boxes were placed in the RMA study-area and 38 in the control study-areas; locations of nest boxes were not described or mapped and spacing between boxes varied widely. Boxes were visited at 10- to 14-day intervals. Methods and criteria for determining clutch size, hatching success, and fledging success were not described. One egg was removed for contaminant analysis from each clutch laid on RMA and from "a portion" of the clutches in the control study-areas.

Summary of Results. Pooling data from the two years, 41 nest attempts were recorded at RMA, 35 in the near-RMA control area and 22 in the distant control area. Hatching success and fledging success were lower on RMA than in the control areas, but the differences were not statistically significant. However, the difference in the proportion of nestlings that died or disappeared (27% at RMA, 14% in controls) approached statistical significance ($P = 0.06$). When nests were stratified according to distance (<1.6 km, 1.6-3.2 km, and > 3.2 km) from contaminated zones (Basin A, Basin F and the chemical manufacturing plant), both nest-box utilization and nest success varied strongly with distance (Table 4). Dieldrin was detected in 25/41 eggs collected on RMA but in only 2/24 eggs from control areas. The authors stated: "When dieldrin concentrations in sample eggs were plotted against the success of nests sampled, no strong negative correlation was detected" (p.9). However, the data supporting this statement were not given, and no formal analysis was presented.

STUDY II (ESE 1989)

Study conducted by: Environment Science and Engineering, Inc. (ESE, 1989). Pages 1-1, 3-21 to 3-24, 4-37 to 4-40, 5-341 to 5-348.

Purpose of study: Part of the Biota Remedial Investigation (Biota RI), whose overall purpose was to present an overall environmental contamination assessment of biota within the RMA Study Area (p. 1-1). Specific objectives of the Biota RI included evaluation of data on contamination, provision of specific information on the migration and accumulation of contaminants in regional food webs, and assessment of environmental effects of RMA contamination (pp. 1-8, 1-12). Objectives of the kestrel study were to determine organochlorine concentrations in and nesting success of American kestrels and to compare current findings with the 1982 and 1983 results and with data on concurrent controls as an indication of trends in terrestrial contamination at RMA (p. 3-20).

Dates of study. Spring-summer, 1986.

Summary of study. "About" forty-five nest boxes were placed on RMA and on each of two control areas north of RMA, a near-zone within 10 miles and a control zone more than 40 miles away. Control areas were not described. The basis for selecting nest box locations was not stated; the distribution of boxes on RMA appears to have been haphazard, with only 7 or 8 boxes located near the more contaminated areas (Figure 3.2-3). Methods and criteria for determining clutch size, hatching success and fledging success were not described. One egg was removed for contaminant analysis from each active nest box in each of the three study-areas in each year. A "representative sample" of young kestrels was also collected prior to fledging from each area (p. 3-21).

Summary of Results. Contaminant concentrations were reported in Figures 4.3-3 and 4.3-4. Dieldrin was detected in 17/33 eggs collected on RMA, compared to 0/11 from control areas. High concentrations of dieldrin (1.01-3.63 ppm) were reported in eggs and/or nestlings from five nest boxes on RMA, including 4/8 boxes near the more contaminated areas and one in a remote area near the RMA boundary. Productivity of kestrels on RMA in 1986 was 2.24 fledged/nest attempt, higher than on RMA in 1982 and 1983, but still lower than in control areas in 1986 (2.78 fledged/nest attempt) (Table 5.3-6). Most nest failures were in boxes along First Creek; 2/5 of the failures in this area and 1/4 elsewhere were associated with high dieldrin levels. However, the report did not analyze the relationship between reproductive success and contamination levels.

STUDY III (RLSA 1992)

Study conducted by: R.L. Stollar & Associates, Inc. (RLSA 1992), Vol. IV, pp. 13-15. The Army also cited RLSA (1990), but the 1992 report appears to include all the information on American kestrels for both survey years except the contamination data for 1988.

Purpose of Study. Not stated (p. 14).

Dates of Study. May-July 1988 and 1990; results compared with earlier surveys in 1982-1986 (p. 14).

Summary of Study. Fifty nest boxes were observed at RMA in each year, including the 45 used in Study II plus five new boxes installed in 1988; 23 off-site boxes (locations unstated) were observed in each year. "Eggs and nestlings were selected from among the occupied boxes most correlated with the RMA BSAs and appropriate control areas. Data on nest occupancy and success were collected incidentally to this sampling program." Methods and criteria for determining clutch size, hatching success and fledging success were not described.

Summary of Results. Results are presented in Table 6.3-1. On RMA, 17/50 nest boxes were occupied in 1988 and 21/50 in 1990; off-site, 5/23 were occupied in 1988 and 7/23 in 1990. Locations of occupied boxes were not described or mapped. Mean productivity was lower on RMA than in the off-site nests in each year (1.14 vs 1.20 in 1988, 1.52 vs 2.11 in 1990), but the differences were not statistically significant (p. 15). Contaminant concentrations are reported in Table 4.1-2 and 5.1-4. Dieldrin was detected in most kestrel samples from RMA and in few samples from off-site locations. Locations of collection sites were not described or mapped. No analysis was presented of the relationship between reproductive data and contaminant concentrations.

STUDY IV (USFWS 1992a, 1993)

Study conducted by: U.S. Fish and Wildlife Service (USFWS, 1992a) Pages D-7 to D-14. The Army also cited USFWS (1993) in its introductory paragraph, but did not summarize the data in the text.

Purpose of Study. Not stated.

Dates of Study. May-July 1991 (p. D-7); 1992 (pp. 27-28).

Summary of Study. This study was a continuation of Studies I-III (see above). In 1991, 46 nest boxes were monitored at RMA and 19 at four off-post control sties. In 1992, 24 breeding pairs were monitored at RMA and 11 at two off-post control sites, but only five of the off-post pairs laid eggs. No contaminant analyses were conducted in either year.

Summary of Results. In 1991, the proportion of occupied boxes was 27/46 at RMA and 12/19 at control sites. The average productivity was 3.31 fledglings/nest attempt at RMA and 3.58 at control sites. Although the occupied boxes at RMA were mapped (Figure 2) and productivity data were listed by box (Table 1), the data were not analyzed in relation to location. In 1992, the average productivity was 2.1 fledglings/pair at RMA (N=24) and 2.0 at control sites (N=5).

EPA's Conclusions:

Status: The studies provided good information on the numbers and trends of American kestrels nesting at RMA during a 10-year period, and moderately good (incomplete) information on the pattern of occupation of next boxes.

Health: The studies provided useful information on several components of reproductive success in American kestrels at RMA, and on the temporal trends in these components since 1982. Although methods and criteria for measuring these parameters were not stated in any of the studies, this information is probably reasonably reliable.

Impairment: None of the cited studies listed investigation of possible impairment among the stated objectives. Nevertheless, the studies provided some information on the possible impairment of the status and health of American kestrels at RMA. The data suggest reduced productivity on RMA relative to offsite controls, and lower occupancy and productivity in core areas of RMA versus peripheral areas, especially in 1982 and 1983. These findings are inconclusive, however, for the following reasons: poorly matched off-site controls; unsystematic placement of nest boxes; small number of nest boxes in contaminated areas, and low occupancy of these boxes; limited analysis of the relationship of reproductive success to location; inadequate information and lack of analysis of the relationship of reproductive success to contaminant levels.

Army's Conclusions: "The trends over time for on-post/off-post comparisons are not consistent. ... The information associated with tissue contaminant data from RMA and off-post control areas (Attachment C.5-2) does not allow identification of possible contributing factors that are related to habitat .... The concentrations of dieldrin found in kestrel tissue and the reduced reproductive success in the core area are consistent with exposure pathways and possible adverse effects of contamination and suggest that there was risk associated with dieldrin, particularly in the early 1980s. However, no trend between nest success and contaminant concentrations were observed in 1988 and 1990 data for dieldrin. The statistically significant correlation between nestling mortality and DDE concentration in eggs may be spurious; it was not generally associated with higher DDE concentrations in eggs or juveniles at RMA (p. C.5-35).

Differences between EPA's and Army's Conclusions: The Army's first sentence is questionable. The most important measure of reproductive success, number of chicks fledged per nesting attempt, was lower at RMA than in the off-post areas in six of the seven years of study. The Army's claim that trends were "inconsistent" appears to be based on results for other reproductive endpoints. The Army's last two sentences are based on its retrospective analysis, which is invalid for reasons stated elsewhere in EPA's comments (see comments on Retrospective Linking, Attachment 4).

Relation of these Studies to Issues Raised by EPA:

1. Definition of Ecological "Health". This study was not conducted on a regional scale and provides no information on ecological "health" as defined by the Army.

2. Appropriateness of Off-Post Control Areas. Off-post control areas were used in each study, but the locations of the areas and the placement of nest boxes were not described precisely in any report. Habitats and other ecological information for the control areas were not reported in any study except Study I, which indicated substantial differences in habitat within and among control areas and between the control areas and RMA.

3. Spatial Scale and Within-RMA Comparisons. Study I reported a comparison of reproductive success among three zones based on increasing distance from areas thought to be highly contaminated. Study II reported an informal interpretation of the geographical pattern of nest failures. Studies III and IV did not make any within-RMA comparisons.

4. Relationship of Ecological Characteristics to Contamination Levels. Although information on contamination of eggs and fledglings was collected in Studies I, II and III, the results were not analyzed in relation to reproductive success in the original reports. The Army's retrospective analysis of this relationship is invalid for reasons stated elsewhere in these comments (see Attachment 4). The assumption in Studies I and II (and in the Army's assessment) that location within RMA is a reliable index of exposure in questionable, because Study II reported low contaminant levels in several samples collected near the core areas and a high level in one sample collected near the RMA boundary.

5. Population characteristics. The studies provided good information on the total breeding population of RMA and on reproductive success over a 10-year period. Although lethal poisoning is a known effect of dieldrin in American kestrels, no information was collected on survival of adult kestrels at RMA, either within or between breeding seasons. Although lack of occupation of nest boxes might reflect mortality, occupancy was considered as a dependent variable only in Study I.

6. Treatment of uncertainty. No discussion of uncertainty was presented either in the study reports or in the Army's summary of them, except in the Army's statement about the unknown role of habitat differences between RMA and control areas.

Bias, power and relevance. The Army categorized the information on American kestrels as "Low" for bias, "Medium" for power, and "High" for relevance (Table C.5-2). EPA's categorizations of bias, power, and relevance are as follows:

	Categorization	Comments
Bias	HIGH	Off-post control areas were not described in Studies II-IV and were stated in Study I to have differed in habitat from on-post study-areas. Nest boxes were not systematically placed and very few were placed near core areas. Variable occupancy of nest boxes was not analyzed as a dependent variable except in Study I, where large differences were reported related to location. Contaminant levels were not closely correlated with location; contaminant levels in eggs and juveniles were not correlated with ESC.
Power	MEDIUM	For RMA-offpost comparisons, offpost samples were rather small; a two-fold difference in chick loss in Study I was not statistically significant.
	LOW	For within-RMA comparisons, very few nest boxes were placed near core areas and few of these were occupied.
Relevance	HIGH	The studies could have yielded useful information on the relationship between reproductive success and contamination levels if the problems of design had been overcome and if the relationship had been analyzed in a systematic way. The results would have been more relevant if survival of adults had been measured as well as reproductive success.

Burrowing Owls

Study Conducted by: David L. Plumpton, December 10, 1991, in USFWS FY 91 Annual Progress Report.

Purpose of Study.

.....[t]o (1) determine burrowing owl abundance on the RMA, (2) locate areas on the RMA used by burrowing owls, and to quantify habitat variables in selected and non-occupied habitats, (3) determine the behaviors, productivity, morphology, and food habits of burrowing owls breeding on the RMA, (4) determine differences in behavior, productivity and density between owl populations subjected to various management treatments.

Dates of Study: 1990, 1991.

Summary of Study: Abundance was determined by vehicular and foot surveys. Physical and vegetative attributes were measured at equal numbers of nesting burrows and "control" burrows (control burrows were burrows within prairie dog towns that were not selected for nesting). Behavior, productivity, morphology, and food habit data were collected from mated pairs.

Summary of Results : A summary of results is presented on Tables 2.1, 2.2, and 3.1 through 3.9 and discussed in the text. Forty seven nesting burrows and 47 unused burrows were studied. Each year, one nest was located in a "contaminated area" (location not specified, and no soil measurements taken), but no study measurements were taken at these sites (reason not given). In both years, two burrows were in areas that were mowed. Results indicated that burrowing owls select burrows with greater nearest-perch distances than control burrows (P=0.004), as well as burrows with shorter mean grass height than controls (P=0.02). For both years combined, mean productivity was 4.38 chicks per nesting territory (range = 2 to 10).

EPA 's Conclusions:

Status: The study provided useful quantitative information on burrowing owl abundance and productivity at RMA, as well as on physical and vegetative variables associated with nest site selection.

Health: The study did not provide information on the relative "health" of burrowing owls at RMA at the individual, population, or community level, in that no offsite control sites containing nesting burrowing owls were part of the study.

Impairment: The study did not provide usable information on the possible impairment of the status or health of burrowing owls at RMA, in that there was no attempt to measure or estimate potential contaminant exposure to the burrowing owls in this study.

Army's Conclusions:

"Thus, while known diet and limited data on tissue levels

indicate contaminant exposure for some individuals, population reproductive, fledgling, and breeding return data do not reveal adverse effects on the population at RMA".

Differences between EPA's and Army's Conclusions: The Army's conclusion is inappropriate with regard to the central issue of whether contaminants at RMA are affecting individual burrowing owls or burrowing owl populations at RMA. This is because the Army considers the "population" of burrowing owls to be that occupying the entire site. See comments on appropriate scale for investigation of population impairments (Attachment 2). As pointed out in EPA's comments on retrospective linking (Attachment 4), almost all of the burrowing owls included in the Army's retrospective analysis were in uncontaminated areas. The Army's analysis, therefore, gives no information on whether burrowing owls are prevented from occupying more contaminated areas, whether those that attempt to do so are impaired, and whether the total population is reduced because of these local effects. In addition, EPA's review of the paper entitled "Movements, Activity Patterns, and Habitat Use of Burrowing Owls in Saskatchewan", by Haug and Oliphant (J. Wildl. Manage 54(1):27-35) indicates that the appropriate exposure range for burrowing owls has a radius of 600 m (approximately 1968 ft), not 2874 feet. The Army's retrospective analysis is invalid for these, as well as for other reasons (see Attachment 4).

Relation of this Study to Issues Raised by EPA:

1. Definition of Ecological "Health". This study was not conducted on a regional scale and provides no information on ecological "health" as defined by the Army.
2. Appropriateness of Offpost Control Areas. There were no offpost control areas in the burrowing owl study.
3. Spatial Scale and Within-RMA Comparisons. The primary comparison in this study was between used and unused burrows within RMA prairie dog towns. Although one nest each year was located within the "contaminated" area, no measurements of contamination were taken, and no study variables were measured at these nests. Second, nesting birds were compared for various behavior, productivity, morphology, and food habit variables, but these comparisons were all within RMA, and unrelated to contamination.
4. Relationship of Ecological Characteristics to Contamination Levels. No information was collected, presented, or used in the original study regarding soil contamination levels. The Army's retrospective analysis is invalid for reasons stated elsewhere (see Attachment 4)
5. Population Characteristics. Repeated searches conducted throughout the summer suggest that most of the burrowing owls on RMA were identified and included in this study. This gives an accurate representation of population abundance of burrowing owl on the Arsenal.
6. Treatment of Uncertainty. No discussion of uncertainty was presented either in the study report, or in the Army's summary of it.

Bias, power, and relevance:

The Army apparently included this study in the group of Avian reproductive success studies, which it categorized as low, medium, and high for the factors bias, power, and relevance, respectively (Table C.5-2). EPA's categorizations of bias, power, and relevance are as follows:

	Categorization	Comments
Bias	LOW	The original study has low bias, in that adequate data were collected to measure abundance and productivity of burrowing owls on RMA; within-RMA comparisons can be made with low potential for bias.
Power	HIGH	Because most of the population of burrowing owls at RMA were identified and included in the study, the power of the study to accomplish the stated objectives is high.
Relevance	LOW	Because most or all of the burrowing owl nests were in areas with low soil contamination, there is no a priori hypothesis that reproduction would have been impaired. The study would have been more relevant if owls had been nesting in more contaminated areas (but in that case the power to detect effects would have been low).

Fortuitous Observations, Incidences of Mortality, and Morbidity Studies.

Studies conducted by: ESE 1989; USFWS; and others.

Purpose of study: Not stated.

Dates of studies: 1989 to present

Summary of studies:

The present IEA/RC (March, 1994) uses information from the fortuitous sample collection program in two sections and one attachment: (1) Section C.5.3.4 (pages C.5-57 and 58) entitled, "Incidences of Mortality," (2) Section C.5.4.2.3 (pages C.5-63 and 64), entitled "Morbidity," and Attachment C.5-3, entitled "Information on Fortuitous Samples Collected by the U.S. Fish and Wildlife Service between 1990 and 1993."

A discussion of animal mortality is provided in Section C.5.3.4 (pages C.5-57 and 58). A number of historic studies of animal mortalities are presented, linking animal deaths to contaminants. The information presented for 1989 and later is primarily derived from periodic reports of necropsy studies of animals found dead or dying on the Arsenal. The data are, at least in part, summarized in Table C.5-13. This chart contains 24 entries consisting of 23 moribund or dead animals (18 birds, three mammals, one fish, and one reptile) and one report of an interview with the "Building 111/112 Dead Bird Patrol". While not so specified in this section, this listing represents a selected grouping of the dead and dying animals found on RMA. Table C.5-3.1 indicates that samples from an additional 10 animals have been sent for analysis but no results are yet available. This table also indicates that an additional 285 samples were submitted for analysis "but the data reported from these samples may have been improperly reported and are under investigation."

Over the past five years, there have been over 240 recorded instances of wildlife mortality at RMA, recorded in a document entitled the Special Purpose Salvage Log (SPSL). This describes animal mortalities and incidents related to morbidity and trauma. The dead or moribund animals are referred to as "fortuitous samples."

Review of the fortuitous samples collected on RMA between 1989 and 1993 indicates that some 190 birds and 50 mammals were found during this period. Table C.5-3.2 indicates that results are available for one mammal, a badger collected in 9/92 and reported to have dieldrin in concentrations of 13 ppm in liver and 75 ppm in fat. These results are qualified, and have been submitted for reanalysis (see Table C.5-3.1).

Summary of results:

The Army has summarized the results of the several studies considered in the Incidences of Mortality section as follows

(page C.5-58):

> Incidents of extensive wildlife mortality have occurred in the past at RMA. The extent and implications of current mortality are not well documented and poorly understood, but it is substantially less than that documented in the 1950s and 1960s (see Appendix A).
>
> The extensive analytical data reported in the Biota RI (1989) and the subsequent Biota CMP (1988-90) shows variable concentrations of organochlorine pesticides in individuals of all taxa sampled. Dieldrin levels were as high as the 56 ppm reported in a mourning dove carcass found on the lawn of Building 111. Thus, potentially lethal concentrations of organochlorine pesticides, chiefly dieldrin, occur in the tissues of some individuals of certain mammal and bird species (Attachment C.5-2). Dieldrin is the contaminant most likely to be detected at injurious levels and occurs in a variety of trophic levels and species.

EPA's conclusions:

For the 1990-1993 period only one analysis result is reported. EPA believes that there are no consistent data to support conclusory statements related to current morbidity or mortality among RMA animal populations based upon the fortuitous sample collection program.

If mortalities were currently being produced in individuals or resident populations as a result of exposure to organochlorine compounds, a wide variety of sub-lethal effects would also be expected.

Army's conclusions:

Despite the contaminant levels detected, current contamination-related mortality is not believed to be causing deleterious effects on the overall abundance or richness of wildlife populations at RMA. Wildlife resources are generally quite abundant at RMA and the species composition is quite diverse for the Rocky Mountain/plains grassland ecotone of eastern Colorado (page C.5-58).

Differences between EPA's and Army's conclusions:

The Army's conclusion regarding the "current contamination-related mortality" has no apparent basis, given that analysis results are available for only one specimen in the recent (1990-93) period.

Bias, power, and relevance:

The Army has categorized the bias, power, and relevance of the fortuitous observations as medium, N.A., and high, and the

morbidity studies as medium, low, and medium. EPA's categorizations of bias, power, and relevance are as follows:

Categorization		Comments
Fortuitous Observations		
Bias	HIGH	The data can neither define nor measure the problem or question being addressed.
Power	NA	The null hypothesis cannot be addressed by these data.
Relevance	LOW	As previously noted, the data were never intended to measure the effects about which the Army draws conclusions.

Morbidity studies:

The morbidity studies categorized by the Army under this section (C.5.4.2.3) are a collection of studies previously discussed in detail elsewhere in both the IEA and reviewed in this document. These studies included deer mortality and general health, bald eagles general health and potential exposure, great horned owl individuals exhibiting symptoms of contamination, fortuitous observations and necropsy reports, and vegetation presence and growth.

Categorization		Comments
Bias	MEDIUM	No clear study design or question addressed. Controls or reference ranges not defined.
Power	LOW	In some cases the null hypothesis cannot be addressed by the information available, in other cases it cannot be rejected with reasonable probability.
Relevance	LOW	The studies used in this section were not designed to address the question as posed by the Army. In no case was there an a priori hypothesis present for the study in question.

Songbirds

Study conducted by: Morrison-Knudsen Environmental Services, Inc, (MKE, 1989a) Pages 1, 25-32, 66-83.

Purpose of Study.

... [t]o (1) document the distribution and relative abundance of [small birds] across the RMA, (2) evaluate [small bird] use at RMA in relation to habitat types and contamination sources, and (3) compare [small bird] use at RMA with selected offsite areas. (p. 1)

Dates of Study. February-March 1986; May-June 1986.

Summary of Study. Winter surveys were conducted along 26 transects on RMA and along 5 transects at each of two control sites. Each transect was 500m long. Only two transects were within core contaminated areas (pp. 26-27).

Breeding birds were counted (spot counts of singing males) in 111 plots on RMA and in 27 plots at each of two control sites. Each plot was 100 x 100 m (1ha). Plots were positioned at regular intervals along roads; although not randomized, they covered all parts of RMA including core contaminated areas. Habitat variables were measured on each plot. Control sites were mapped and were assessed through the habitat variables.

Summary of Results. Results were presented in Tables 4-4 (winter surveys), 4-5 and 4-6 (breeding bird surveys). Only two species (horned lark and western meadowlark) were widespread in open country in winter. Frequencies of encounter varied widely among habitats and among sites. Horned larks were more abundant at one control site than at RMA and meadowlarks were more abundant at the other control site than at RMA; no statistical analyses were presented.

Only four breeding species (horned lark, western meadowlark, grasshopper sparrow, and vesper sparrow) were sufficiently numerous and widespread for statistical analyses. Because of the small size of the sample plots, numbers of birds per plot ranged only from 0 to 3, with means of less than 1 for each species (Tables 4-5 and 4-6). All four species were significantly more frequent at the control sites than at RMA, the differences holding across major habitat divisions. Multivariate analysis of the habitat variables suggested that much of these differences was attributable to habitat differences, specifically to greater structural complexity of the vegetation at the control sites. Within RMA, comparisons within habitat categories showed no significant differences between plots located within Section 36 (presumed to be contaminated) and plots far from presumptively contaminated areas. However, the significance of this finding is limited: (i) sample sizes were very small (e.g., nine birds of two species in eight plots in two habitat types in Section 36); (ii) the comparison was not controlled for the habitat variables found to be important in the between-site comparisons; (iii) all plots were beside roads, so the assumption that those in Section

36 were all contaminated is questionable; (iv) levels of soil contamination were not measured or referenced.

Descriptive information on the occurrence, diversity, and distribution of songbirds on RMA was also presented (pp. 82-83).

EPA's Conclusions:

Status: The study provided useful qualitative information on the occurrence and distribution of songbirds at RMA and extensive quantitative information on their relative abundance and use of different habitats.

Health: The study did not provide information on the "health" of songbirds at RMA at the individual, population, or community level.

Impairment: The study did not provide information on the possible impairment of the status or health of songbirds, except for documenting the presence of a few singing males of two species beside roads within the core contaminated areas.

Army's Conclusions:

"The lower abundance and density of songbirds at RMA relative to control areas have been attributed to differences in habitat" (MKE 1989a) (p. C.5-50). The Army also cited contaminant levels in fortuitously collected samples of songbirds (Attachment C.5-2) and concluded: "there is evidence that individual songbirds are being adversely affected by contaminants at RMA" (p. C.5-51).

Differences between EPA's and Army's Conclusions: Although there is no major difference between the conclusions of EPA and Army about songbirds, the Army's conclusion did not address the within-RMA comparisons that were discussed in the text. The Army quoted without qualification MKE's (1989a) conclusion that "no within-site variation was attributable to trends in contamination" (p. C.5-50).

Relation of this Study to Issues Raised by EPA:

1. Definition of Ecological "Health". This study was not conducted on a regional scale and does not provide information on ecological "health" as defined by the Army.

2. Appropriateness of Off-Post Control Areas. Off-post control areas were used in this study and (in contrast to other studies cited in this report) were thoroughly characterized for habitat variables. The results of this characterization showed major differences in habitat characteristics between the control areas and RMA. Although in this case the multivariate analysis permitted control for these differences, this result illustrates the importance of proper selection and characterization of control areas.

3. Spatial Scale and Within-RMA Comparisons. Although the

conclusions of this study were based on statistical comparisons among zones within RMA, the sample plots were all located beside roads and the assumption that they were representative of contamination zones is questionable.

4. Relationship of Ecological Characteristics to Contamination Levels. No information was collected, presented, or used on contamination levels. The inference that comparison among plots within zones was equivalent to comparison among levels of contamination was unsupported and is questionable in view of the non-random location of the plots.

5. Population characteristics. No information was collected on population characteristics. The spot counts of singing males are crude indices of relative abundance, but the numbers of birds counted per plot were very small and evidence that the birds were breeding successfully was not presented.

6. Treatment of uncertainty. No discussion of uncertainty was presented either in the study report or in the Army's summary of it.

Bias, power, and relevance: The Army categorized the information on songbirds as "Medium" for each of the factors bias, power, and relevance (Table C.5-2). EPA's categorizations of bias, power, and relevance are as follows:

	Categorization	Comments
Bias	HIGH	Although the breeding bird study measured and controlled for differences in habitat variables, the location of plots beside roads meant that the plots were not representative of the zones they were used to characterize. The winter surveys were not controlled for the differences between sites that were measured in the summer survey.
Power	LOW	Winter survey had very small numbers of transects within habitat types and large variance counts. Breeding-bird survey had very small plots (mean count less than 1 bird per species per plot).
Relevance	MEDIUM	Within-RMA comparisons could provide data relevant to an *a priori* hypothesis of population effects of contaminants if original

data could be found and compared with matched data on soil contamination for the same locations.

Small Mammals

Study conducted by: Morrison-Knudsen Environmental Services, Inc. (MKE, 1989a) Pages 1, 21-24, 58-62.

Purpose of Study.

.... [t]o (1) document the distribution and relative abundance of [small mammals] across the RMA, (2) evaluate [small mammal] use at RMA in relation to habitat types and contamination sources, and (3) compare [small mammal] use at RMA with selected offsite areas. (p. 1)

Dates of Study. November 1986 and June 1987 (p. 21).

Summary of Study. Mice, voles and shrews were surveyed by live-trapping. Sixteen locations on RMA were sampled in 1986 and 11 in 1987. Most of the locations were in peripheral areas of RMA with about six locations (1, 2, 13, 21, 22, 27) near to contaminated areas (p. 22). However, information was neither collected nor referenced on contamination and the precise locations of study-areas were not reported. Each location was an area 50m x 300m, positioned well within a distinct habitat type. Eight habitat types were sampled in 1986 and ten in 1987 (only one in both years). Numbers of trap-nights per habitat type ranged from 75 to 720.

"Emphasis was placed on documenting species occurrence and comparing use among different habitat types." "Random, statistically independent samples were not necessary because the objective was species identification, not a quantitative comparison." (pp. 21-24)

Three control sites were located at Buckley Air National Guard Base in November 1986 only. The sites were not described except to "habitat type." Trapping effort was 180 trap-nights at each site.

Summary of Results. Results for RMA were presented in Tables 4-2 and 4-3 (pp. 59-60), results for Buckley were given in summary form in the text. Seven species of small mammals were trapped; trapping frequencies varied by species and habitat from zero to 31.9 animals per 100 trap-nights. "Statistical tests of differences in abundance among locations were not practicable because of the low capture frequencies" (P. 58). Pooling all species and comparing mean capture frequencies (animals/100 trap-nights) indicated that mean abundances were higher at Buckley than RMA in native grasslands (9.4 vs 1.2) and crested wheatgrass (5.6 vs. 2.8), but higher at RMA in cheatgrass (8.6 vs 3.3). "These differences were apparently related to differences in habitat, rather than to contamination per se, because the highest abundances at RMA were in weedy areas near the disposal basins and manufacturing areas" (p. 58). The basis for the last statement is not given in the report, since data are averaged by habitat. The Tables give individual data for only five locations; one of these was not mapped, three were peripheral; only one (no. 27) was near a disposal basin, and none was near a

manufacturing site. No basis was given for the suggestion that habitats differed between Buckley and RMA.

EPA's Conclusions:

Status. The study provided useful qualitative information on the species of small mammals at RMA and semi-quantitative information on their relative abundance and use of different habitats.

Health. The study did not provide information on the "health" of small mammals at RMA at the individual, population, or community level.

Impairment. The study did not provide useful information on the possible impairment of the status or health of small mammals.

Army's Conclusions:

"The highest mean abundances of small mammals at RMA were in areas of weedy forbs/grasses north or east of Basin F (MKE, 1989a); evaluation of trends between small mammal abundance and ESC values showed no indication that small mammal abundance is deleteriously affected by aldrin/dieldrin contamination")p. C.5-28).

Differences Between EPA's and Army's Conclusions: The first part of the Army's conslusory sentence is correct but irrelevant, since there is no specific information on contamination or exposure in the areas referenced. The second part of the conclusion is unjustified for reasons stated in EPA's comments on Retrospective Linking, Attachment 4.

Relation of this Study to Issues Raised by EPA:

1. Definition of Ecological "Health". This study was not conducted on a regional scale and provides no information on ecological "health" as defined by the Army.

2. Appropriateness of Off-Post Control Areas. Off-post control areas were used for only three of the 18 habitat types and for only one of the two years (seasons) of the study. Off-post control areas were not described in any way except by statement of habitat type. The study report invoked assumed differences in habitat between the on-post study-areas and the off-post control areas as an explanation for the differences found. Hence, the control areas, as described, were not suitable for rigorous comparisons.

3. Spatial Scale and Within-RMA Comparisons. Although the conclusions of this study were purportedly based on comparisons among locations within RMA, the comparisons were informal at best and underlying data were not presented.

4. Relationship of Ecological Characteristics to Contamination Levels. No information was collected,

presented, or used on contamination levels at the locations where mammals were trapped. The Army's retrospective attempt to relate abundances to ESC values is invalid for reasons stated elsewhere in these comments (see Attachment 4).

5. Population characteristics. No information was collected on population characteristics. Data on trapping frequencies were used to make inferences about "abundances", although the objective of the study was not to make quantitative comparisons and the data are unsuitable for this purpose.

6. Treatment of uncertainty. No discussion of uncertainty was presented either in the study report or in the Army's summary of it.

Bias, power, and relevance

The Army categorized bias, power, and relevance for this study as medium, medium, and medium, respectively (Table C.5-2). EPA's categorizations of bias, power, and relevance are as follows:

Categorization		Comments
Bias	HIGH	Study design not intended for quantitative comparisons; control areas not described and stated to differ in habitat; within-RMA comparisons not matched for species or habitat
Power	LOW	Study design not intended for quantitative comparisons; statistical tests not practicable
Relevance	MEDIUM	Within-RMA comparisons might have provided some data relevant to an *a priori* hypothesis of population effects of contaminants if co-located data on soil contamination had been collected.

Bald Eagle

The bald eagle differs from other species considered in this report in two important respects. First, it is a winter visitor to RMA, and individual birds range over wide areas. Hence, the composition of the "population" at RMA changes from year to year and even from day to day. In consequence, much of the information on bald eagles at RMA is in the nature of descriptive surveys rather than systematic or controlled studies of sample areas or representative individuals. Second, the bald eagle is an endangered species, so that assessments of risk and potential impairment need to be made on an individual as well as a population basis.

The information available on bald eagles at RMA includes a series of detailed surveys of the ecology and behavior of the wintering birds, and a number of measurements of contaminant concentrations in birds trapped at RMA. Studies through 1990 were described in two major study reports (ESE 1988b, USFWS Final Report on Bald Eagle Study, December 1992, not cited in the IEA/RC); continued studies in 1991 and 1992 were reported in annual reports of the U.S. Fish and Wildlife Service (USFWS 1992a, 1993a). The Army also made conclusory statements about potential exposure to eagles at RMA, but did not cite most of the information on contaminant concentrations in prey, in other raptors that feed on the same prey, and in a bald eagle that was found dead at RMA. This section of EPA's review, therefore, briefly reviews the available information without following the sequence of topics and studies cited by the Army.

NUMBERS, FEEDING HABITS, AND BEHAVIOR

Detailed information on numbers, feeding habits, and behavior of bald eagles at RMA is presented in the four reports cited above (ESE 1988b, USFWS Final Report 1992a, 1993a). Bald eagles occur at RMA from late October to March, with peak numbers in late December or January. Peak one-night counts at the roost increased steadily to 38 in 1990-91, but declined to 30 in 1991 to 1992. The proportion of subadult birds declined from 78% in 1986-1987 to between 50% and 60% in recent years. Individual birds studies by telemetry regularly moved on and off the site. The primary food items on RMA are prairie dogs (70-80% by frequency) and rabbits (15-25% by frequency). Eagles commonly obtain prey by stealing from other raptors, especially ferruginous hawks.

CONDITION AND TISSUE LEVELS OF CONTAMINANTS

The Army stated: "The majority of bald eagles captured at RMA have been within normal ranges for size, weight, and condition for their age and the time of year when they were captured (personal communication from M. Lockhart to Michael Macrander of Shell, 1993)." The information on which this statement is based, including reference ranges, apparently is not available for review.

Between 1987 and 1990, blood was taken from 90 bald eagles captured at RMA and was analyzed for organochlorine contaminants and certain metals. Dieldrin was found above detection limits in 20 samples (22%), ranging up to 70 ppb. DDE was found above detection limits in 34 samples (38%), ranging up to 280 ppb. PCBs were found above detection limits in 9 samples (10%), ranging up to 710 ppb. Mercury, lead, selenium, and arsenic were also found in many blood samples (USFWS 1992b, 1993a). The Army, citing USFWS (1992b), stated that none of the detected concentrations exceeds the lower limits of concern (p. C.5-39). The basis for this statement is unclear. Additionally, most of the birds were trapped relatively early in the winter seasons, before they would have had time to accumulate organochlorine contaminants in their tissues to steady state levels that would reflect their average exposure at RMA.

Fat samples were taken by biopsy from 11 eagles trapped in the winters of 1991-92 and 1991-92 and were analyzed for organochlorine contaminants. All the samples contained a variety of organochlorine compounds; for example, dieldrin ranged from 0.13 to 1.6 ppm, DDE from 0.58 to 20 ppm, and PCBs from 1.2 to 28 ppm; the highest concentrations of these and other analytes were found in the same individual. Endrin was detected in one sample at 0.18 ppm. The Army, again citing USFWS (1992b), stated that none of the detected concentrations exceeds the lower limits of concern (p. C.5-39). The basis for this statement is unclear, however: assuming that fat would comprise 20% of the total body mass, the individual with the highest concentration would have had a whole-body concentrations of DDE higher than the MATC, and a whole-body concentration of dieldrin approaching the MATC.

One eagle found dead on RMA and analyzed for COCs contained 0.276 ppm dieldrin and 1.70 ppm DDE in its muscle tissue, with corresponding concentrations in liver (0.11 ppm dieldrin, 0.40 ppm DDE) and brain (0.11 ppm dieldrin, 0.40 ppm DDE) (Attachment C.5-2, Tables 5.1-4 and 5.1-7). Based on the expected partitioning of these chemicals between muscle, liver, and whole body, this eagle may well have exceeded the MATCs for both dieldrin and DDE.

CONTAMINANT CONCENTRATIONS IN PREY AND IN OTHER RAPTORS

Attachment C.5.2 to Appendix C.5 of the IEA/RC lists high concentrations of dieldrin in many samples of prairie dogs and cottontails from several Sections of RMA (not limited to Section 36). Page C.5-46 and Attachment C.5.2 list high concentrations of dieldrin in several birds of prey, including lethal concentrations in the brains of single great horned owls, red-tailed hawks, and ferruginous hawks. Attachment C.5.2 (Figures 4-14 to 4-16) shows numerous sightings of raptors, including red-tailed hawks, rough-legged hawks, ferruginous hawks, and bald eagles, around and even within the more contaminated areas of RMA. Based on the known diets of bald eagles at RMA and their habit of stealing food from ferruginous hawks and other raptors, this information indicates that bald eagles at RMA are at risk of exposure to prey containing high concentrations of dieldrin.

EPA's Conclusions:

Status: The surveys cited provide good information on the numbers of bald eagles at RMA since the roost was discovered in 1986, and on their roosting behavior, foraging behavior, flight range, and diets.

Health: The information reviewed does not provide significant information on the "health" of individual eagles or that of the "population" of eagles using RMA.

Impairment: The information reviewed does not provide information on actual impairment of survival, reproduction, or other functions of eagles at RMA. Based on the contaminant levels found in eagles, their prey, and other consumers of eagle prey, bald eagles at RMA are potentially exposed to hazardous concentrations of contaminants in their prey.

Army's Conclusions:

"The current general health of bald eagles at RMA does not reveal any adverse effects of RMA contamination, and bald eagles are unlikely to be significantly exposed to contaminants while wintering at RMA. These two considerations do not suggest that eagles are likely to be adversely affected by contamination at RMA." (p. C.5-39).

Differences between EPA's and Army's Conclusions: EPA considers the Army's conclusions to be unwarranted.

1. There is no information on the "general health" of bald eagles at RMA. The Army cited a personal communication that the "majority" of bald eagles captured at RMA have been within "normal ranges" for size, weight and condition for their age and the time of year when they were captured. However, size, weight, and condition convey little useful information about potential toxic effects of RMA contaminants because these contaminants generally do not affect size, weight, or condition, except in the terminal phase of lethal poisoning by dieldrin and endrin.

2. The Army's claim that bald eagles are "unlikely to be significantly ...exposed to contaminants while wintering at RMA" is inconsistent with the information cited above on the concentrations of dieldrin in their prey, the sightings of bald eagles and other raptors in contaminated areas, and the deaths of other raptors (including a ferruginous hawk) with lethal concentrations of dieldrin in their tissues.

3. The Army's conclusions do not reflect consideration of the data on concentrations of organochlorines in the fat of eagles captured at RMA, and in the tissues of the eagle found dead at RMA.

4. "Likelihood" of exposure and blood chemistry data from captured birds, even if correctly cited and interpreted, would provide information only about potential adverse effects of contamination. It is

inappropriate to argue from this information that adverse effects are not revealed.

Relation of Bald Eagle Studies to Issues Raised by EPA: In its comments dated September 20, 1993, EPA presented eight specific issues raised by the Army's draft of Appendix C.5. One of these eight issues was specific to the bald eagle, and is addressed in detail in this section of the report.

Bias, power, and relevance: The Army categorized the information on abundance of bald eagles as "medium" on each of the factors, bias, power, and relevance. The Army categorized the information from "Morbidity Studies" (sic) of bald eagles as Medium, Low, and Medium, respectively, on these factors (Table C.5-2). EPA considers it difficult to categorize these surveys according to "bias" and "power", because they were generally in the nature of descriptive surveys rather than systematic studies testing specific hypotheses about status, health, or impairment. EPA would rank most of the information as of "High" relevance -- including the information on numbers, trends, behavior, foraging habits, diet, contaminant levels in prey, and contaminant levels in other raptors that feed on the same prey. However, the information on contaminants in blood and fat of captured eagles is of "low" relevance, because most of the eagles were captured early in the season and reference ranges are not available. The information on size, weight, and condition of captured eagles would be of "Low" relevance to assess contaminant effects, because the RMA contaminants generally do not affect size, weight, or condition except in the terminal phase of poisoning by dieldrin and endrin.

Table C.3-1 EPA's Characterization of Bias, Power, and Relevance Ratings of RMA Studies Selected to Evaluate Ecological Endpoints Relevant to Risk Characterization

Study	Bias[1]	Power[2]	Relevance[3]
Aquatic snail population density and biomass	High	Low	Low
Grasshopper abundance	High	Medium	Medium
Earthworm population density	High	Low	Low
AChE inhibition in mammals and birds	High	Low	Low
Eggshell thinning	High	Low to Med	Low
Prairie dog population density and age ratios			
I. distribution/abundance/ habitat use	High	Medium	High
II. contamination assessment	High	Low	High
III. distribution/abundance/use	High	Low	High
Avian reproductive success			
American kestrel			
(RMA-offpost comparison)	High	Medium	High
(Within RMA Comparison)	High	Low	High
Burrowing owl	Low	High	Low
Fortuitous observations and incidences of mortality	High	NA	Low
Other abundance studies			
songbird distribution/ abundance/use	High	Low	Medium
Small mammal distribution/ abundance/use	High	Low	Medium
Morbidity studies	Medium	Low	Low
Bald Eagle			
ecology/behavior	NA	NA	High
contamination	NA	NA	Low
size, weight, condition	NA	NA	Low

[1] Bias is the magnitude and direction of the tendency to measure something other than what was intended. Criteria for evaluation are:

1. Study design fully documented and sufficient such that samples or observations are representative of intended object of study; and

2a. Control areas fully described and characterized, and matched to study areas in terms of all factors likely to affect the characteristic being measured except levels of exposure; or (in case comparisons are made among samples with different levels of contamination)

2b. Samples matched in terms of all factors likely to affect the characteristic being measured except levels of exposure; levels of exposure measured in comparable ways among samples.

High: One or other of the criteria are not met (e.g., samples not representative, control areas not described or characterized, areas not appropriately matched, or samples no appropriately matched).

Medium: One or other of the criteria not fully met (e.g., control areas inadequately characterized, or areas or samples incompletely matched).

Low: All of the criteria are met.

[2] Power is the probability of rejecting the null hypothesis when in fact it is false and the alternative hypothesis is correct. Criteria for evaluating power are:

1. Close correspondence between the quantities that are measured and the biological characteristics that are under investigation; and

2. ability of the study design to capture the major sources of variance in the quantities that are measured; and

3. (statistical power) ability of the study design to detect an ecologically meaningful difference in the biological characteristics that are measured if such a difference in fact exists and is related to levels of contamination.

High: All of the criteria are met.

Medium: Uncertainty about one or more of the above criteria.

Low: One or more of the above three criteria are not met.

[3] Relevance is pertinence to the matter at hand. Criteria for evaluating relevance are:

1. The study involves a measurement endpoint related to an a priori hypothesis that the endpoint would be affected by one of the contaminants present at RMA; and

2. the measurement endpoint reflects some aspect of "status" or "health" as outlined above; and

3. the a priori hypothesis is consistent with the predictions of the ecological risk characterization; and

4. the study is carried out on a scale appropriate to this prediction.

High: All of the criteria are met.

Medium: Uncertainty about one or more of the above criteria.

Low: One or more of the above criteria is not met.

In all cases, professional judgement is needed to interpret and apply these criteria, including the words "related", "consistent", and "appropriate".

ATTACHMENT 4

Retrospective linking of data on measurement endpoints to soil concentrations.

In this version of the IEA/RC, the Army has added five sections in which data on measurement endpoints are linked to estimates of exposure soil concentrations (ESC). These sections appear on p. C5-25 (prairie dog), C.5-27 to C5.28 (small mammals), C.5-32 to C.5-34 (American Kestrel), C.5-40 to C.5-41 (great horned owl) and C.5-43 (burrowing owl). EPA cannot support the material presented in these new sections and the conclusions drawn therein, for the following reasons:

1. In none of the five cases was the analysis of the endpoint in relation to exposure soil concentration part of the original study design or even the original study objectives. The analyses are retrospective attempts to relate the endpoints measured in the original field studies with values of ESC that were derived later for different purposes. It is inappropriate to present these retrospective analyses under the headings "study findings," as is done in these new sections. The analyses should be presented, if at all, under a separate heading making clear the retrospective nature of the investigations and discussing the limitation of this approach.

2. None of the original studies included a precise map or other precise information on the location of study plots. Only in the case of the American kestrel could the locations of the study sites (nest boxes) be determined retrospectively with any precision; however, the text of Appendix C.5 is silent about methods used to determine nest box location and their precision. It is unclear that the locations of study plots vaguely described or vaguely mapped in old reports can be determined retrospectively with sufficient precision for the purposes for which they are now used. In the section on prairie dogs (p. C5-25), for example, one sample site is located as "in the northwest quarter of the southwest quarter of Section 31" -- i.e., somewhere within a square 400 m x 400 m. After pursuing the maps in this report (MKE 1989a), EPA believes that this is about the maximum precision that can be achieved.

3. In earlier comments, EPA has objected to the derivation of ESC and to the use of ESC as a measure of exposure. EPA reiterates its previous opinion that ESC is not an acceptable measure of exposure for any species. In particular, values of ESC are not correlated with values of TC, the concentrations of contaminants measured in the tissues of prey species sampled at RMA. This finding is reinforced by a lack of correlation between ESC and tissue concentrations in the predatory species for which data are presented in the current draft of the IEA/RC (Tables C.5-7 and C.5-11). Accordingly, EPA considers that ESC is not an acceptable measure of the exposure of the species for which these retrospective analyses are conducted. In general, therefore, analysis of the relationship between measurement endpoints and ESC is not an acceptable way to investigate potential effects of contamination.

4. With one exception (American kestrel), the analyses of the relationship between measurement endpoints and ESC are informal and not rigorous.

In addition to these general objections to the retrospective analyses, EPA has the following comments on specific cases:

Prairie Dogs (p.C5-25). Although not clearly stated, the data appear to be derived from the study by MKE (1989a). As stated (p.C5-25), nineteen of the twenty study sites were located in areas where dieldrin levels were below the "detection limit" (presumably meaning the CRL). [This reflects and illustrates EPA's general comments, that most biota studies cited in Appendix C.5 were focused on areas of low contamination.] The twentieth site was located "in the northwest quarter of the southwest quarter of Section 31." In this area of 400 m x 400 m, only five soil samples were analyzed for aldrin and dieldrin; four of these samples were BCRL for both analytes, and the combined concentration was 0.30 ppm in the fifth. It is not clear how the Army's procedures yielded on ESC value of 1.195 ppm for this location. This illustrates EPA's contention that ESC is not a valid measure of exposure. Comparison between the percentage of juvenile prairie dogs and ESC values is meaningless and no conclusions about effects of contamination can be drawn.

Small mammals (pp. C.5-27 to C.5-28). The data are derived from the study by MKE (1989a). The "analysis" presented on p. C.5-27 is informal and makes no attempt to analyze data on individual species or to control for habitat differences. As stated on p. C.5-27, most of the ESC values were driven by BCRL replacement values [another illustration of EPA's general comment that most biota studies cited in Appendix C.5 were focused on areas of low contamination]. The analysis ignores key qualifying statements in the original report by MKE: "Random, statistically independent samples were not necessary because the objective was species identification, not a quantitative comparison" (p. 24). "Statistical tests of differences in abundance among locations were not practicable because of the low capture frequencies" (p. 58). In light of these comments, the Army's retrospective analysis of these data is unjustified.

American kestrel (pp. C.5-32 to C.5-34). The data set for the retrospective comparison is presented in Table C.5-7. Both the data set and the methods of analysis present many problems:

(i) The Army pooled both RMA and offpost data. As pointed out in EPA's comments, offpost ("control") locations in this study were not identified or described, but in the 1982 study (DeWeese et al. no date) the "control" sites differed considerably in habitat, both among themselves and from the RMA study sites.

(ii) No soil concentrations or ESC values were available for the offpost sites. The dieldrin concentrations in eggs and juveniles at the offpost sites were all below or close to the CRLs, as were the DDE values in 6/9 nests.

(iii) For DDE, 3/5 egg concentrations and 5/10 of the

juvenile tissue concentrations were BCRLs; none of the positive values approached the concentrations at which adverse effects of DDE have been reported in wild or captive birds.

(iv) The ESC values for dieldrin at the onpost sites all fell within a narrow range (0.018 to 0.14 ppm) and apparently were driven largely by BCRL replacements. The ESC values for DDE all fell within a narrow range (0.006 to 0.043 ppm) and apparently were determined entirely by BCRL replacements. [This reflects and illustrates EPA's general comments, that most biota studies cited in Appendix C.5 were focused on areas of low contamination.]

(v) Within the small onpost samples, there was no correlation between ESC and either the egg or juvenile tissue concentrations, for either dieldrin or DDE. This further demonstrates the invalidity of using ESC as a measure of exposure.

(vi) The Army pooled 1988 and 1990 data, without testing for inhomogeneity or independence. In fact, 3/10 on-post nests and 4/8 off-post nests were studied in both years. In one of the on-post nests and two of the off-post nests, there were major divergences in the success variables between years. Egg concentrations were measured only in 1988, whereas concentrations in juveniles were measured in both years. For unexplained reasons, concentrations in juveniles were 1-2 orders of magnitude lower in 1990 than in 1988, including data from one nest box from which juveniles were sampled in both years.

(vii) The Army did not consider occupation of nest boxes as a dependent variable, despite the fact that DeWeese et al. (no date) reported that occupation was significantly related to distance from the core contaminated area, and despite the fact that lethal poisoning is a documented effect of dieldrin in American kestrels.

For these reasons, the data set is unsuitable for statistical analysis. The concentrations of dieldrin and DDE in all soil samples and in most tissue samples were so low that no measurable effects would have been predicted (a consequence of experimental design), so that no analysis could be justified. In consequence, the analysis performed by the Army is inappropriate.

Great horned owl (pp. C.5-40 to C.5-41). The data are presented in Table C.5-8. This table pools data from three successive years, although it is likely that some of the same birds or pairs were included in different years. Only data on ESC were available. From the "sample size" of 29 nests, ESC values were below 0.16 ppm in 27 locations; presumably these values were driven largely or entirely by BCRL replacements. [This illustrates EPA's general comment that most biota studies cited in Appendix C.5 were focused on areas of low contamination.] The informal "analysis" of the data that is presented is not appropriate.

Burrowing owl (p. C.5-43). No consensus value is available for the home range of this species.. EPA cannot support the home

range radius of 2,874 feet (home range area of 300 ha) used by the Army in calculating ESC values for this species. In spite of this inflated value used for home range radius, 92% of the nests were at locations where the computed values of ESC were less than 0.125 ppm; presumably, these values were driven largely or entirely by BCRL values. [This illustrates EPA's general comment, that most biota studies cited in Appendix C.5 were focused on areas of low contamination.] Table C.5-11 shows that at 4 of the 8 locations where ESC exceeded 1.0 ppm, the concentrations of aldrin/dieldrin in juvenile burrowing owls were low (below the MATC for great horned owl); at the only location where the concentrations of aldrin/dieldrin in a juvenile burrowing owl was above the MATC for great horned owl, the value of ESC was very low. In view of these facts, analysis of breeding success in relation to ESC would yield meaningless results; the informal "analysis" of the data that is presented is not appropriate.

Based on the foregoing facts, EPA concludes that the retrospective analyses presented in this version of the IEA/RC are unjustified. EPA requests that all these analyses be deleted and replaced by a clear statement that available data are insufficient to analyze the ecological data on any species in relation to contamination levels.

ATTACHMENT C.5-5

U.S. FISH AND WILDLIFE SERVICE'S POSITION
ON HEALTH AND DIVERSITY

As directed by the RMA Council the U.S. Fish and Wildlife Service (Service) is providing this response to the "Ecological Status and Health" Appendix (Appendix C.5) of the Integrated Endangerment Assessment/Risk Characterization for the Rocky Mountain Arsenal On-Post Operable Unit. The Service has been involved with both the implementation of several of the studies cited in the Appendix and the development of the Appendix itself. Results of the studies conducted or sponsored by the Service may be found in our Annual Progress Reports to the Army (1989-1993) and in various Master's Theses available at the Rocky Mountain Arsenal Technical Information Center. The Service has previously commented (February 2, 1994) that the findings of the Appendix accurately reflect the body of knowledge developed at the Arsenal and are scientifically defensible. Nevertheless, critiques of this Appendix have attempted to discredit the findings of these studies through misinterpretation of the biological design of the studies and the meaning of the results. These critiques use three basic arguments to misrepresent the facts:

1) The studies were not designed to address the potential effects of contaminants to individuals, populations, or communities of biota at the Arsenal.

2) The studies were not designed to measure biological endpoints relative to contaminant exposures at the Arsenal.

3) The studies were not designed as a part of the Ecological Risk Assessment for the Arsenal.

First, the argument that the studies did not address potential effects of contaminants to various levels of biological organization is not true. The referenced studies were designed to address the known effects to wildlife caused by Arsenal contaminants. These effects include changes in abundance, reproductive success, survivability, morbidity, species richness, age and sex ratios, and other biological endpoints appropriate for evaluating the actual, not theoretical, effects of Arsenal contaminants on Arsenal biota. The Service has documented over 225 birds species, 34 mammal species, 19 reptile and amphibian species and 14 fish species using the Arsenal during at least part of the year. From all of these studies of biota at the Arsenal, the Service has not been able to identify a single population of animals that is declining in number, which would be the ultimate indication of adverse effects caused by Arsenal contaminants. In fact, all animal populations at the Arsenal that have been evaluated are either self-sustaining, at a minimum, or growing rapidly. The Service has demonstrated that raptors, prairie dogs, and deer at the site reproduce at or above values cited in the literature. The Service has documented longevity in deer, coyotes, prairie dogs, burrowing owls, eagles, red-tailed and Swainson's hawks. The Service agrees and points out that an occasional individual animal may succumb from exposure to contaminants in the "core area" of the Arsenal, but this minor level of mortality has not had an effect on overall wildlife populations across the area. The answer to this problem is not continued study or manipulation of existing data, but to clean up the obvious areas of contamination and start alleviating the problem.

Second the argument that the studies did not compare results between areas of high contamination and low contamination would suggest that contaminant concentration and distribution is so heterogeneous that none of the populations studied (including those studied in the core area) can be assumed to be exposed to chemical stressors. This argument ignores a large and detailed data base developed specifically to characterize contaminant distribution across the Arsenal. This argument also ignores three simple biological facts:

A) all animals do not exist everywhere in the environment for the simple reason that appropriate habitats may not be available in all areas so this comparison cannot always be made and must be interpreted carefully,

B) the Service specifically manages some species (i.e. prairie dogs) out of some areas (i.e. Basin A) for very obvious reasons, again this comparison cannot be made for some species in some areas, and

C) most animals range over areas greater than the distribution of contaminants at the Arsenal making the comparison difficult to interpret.

Again, the Service is evaluating the effects of contaminants at the end result, effects to populations. The Service has not identified a population that is in decline at the Arsenal.

Third the argument that the studies were not designed as a part of an Ecological Risk Assessment assumes that Ecological Risk Assessment methodologies are the only appropriate way to evaluate wildlife at Superfund sites, is incorrect. The referenced studies were designed, implemented, evaluated and reported by professional, on-site fishery and wildlife biologists using standard, up-to-date techniques to establish the status and monitor trends in fish and wildlife populations no matter where they exist. Ecological Risk Assessment methodologies are undergoing intense scrutiny in the scientific community to determine if they are capable of producing the desired results or not.

Finally, it has been concluded that, since the referenced studies supposedly did not measure up to the intense "re-interpretation" leveled on them by the Risk Assessment process, that they are of little or no value to the Risk Assessment and should not be used in concert with the predictions of the Risk Assessment. The Service believes that the quantitative risk assessment is highly theoretical, uses unrealistic biological assumptions as a substitute for a lack of knowledge, and is unproven in its ability to predict biota tissue concentrations or risk to wildlife from contaminants. The Service and Appendix C.5 has approached the topic of evaluating wildlife health from a simple biological tenant; if you want to know what is happening with wildlife, instead of asking a statistician or computer to predict a result, evaluate wildlife at the population, community or ecosystem level. If an adverse effect cannot be identified at these levels of organization, any significant adverse effect does not likely exist.

ATTACHMENT C.5-6

ARMY COMMENT ON EPA'S ECOLOGICAL
STATUS AND HEALTH POSITION

ARMY COMMENT
ON
EPA's ECOLOGICAL STATUS AND HEALTH POSITION
Included in the IEA/RC

The preceeding pages of EPA position on Ecological Status and Health at RMA do not represent the scientific judgement of the other three signatories to the Federal Facilities Agreement, which is presented in Appendix C.5 of this document. EPA Region VIII's position is included in resolution of EPA Region VIII's dispute of the presence and content of Appendix C.5. The Army strongly disagrees with the opinions presented in EPA Region VIII's position because they:

- are inconsistent with EPA's own national guidance,
- are inconsistent with the opinion of an expert panel convened by EPA in a Risk Assessment Forum, which considered data from RMA and other sites,
- contradict EPA Region VIII's own previous statement regarding biota at RMA,
- criticize the appendix but do not provide alternative interpretations or evidence,
- ignore and then dispute the considerable text changes that have been made in good faith response to EPA Region VIII's prior comments.
- minimize the importance and relevance that 9 years of substantial biological information on the potential effects of contamination at RMA provide,
- present misstatements, distortions, and quotes out of context from Appendix C.5,
- fail to consider professional opinions and conclusions of numerous field biologists who have spent considerable time studying RMA biota. and

- do not appear to focus on environmental protection of RMA biota.

EPA Region VIII's position document ignores current and past EPA national guidance on what types of data should be collected and how results should be evaluated in an assessment of the effects of site contamination on biota. Note the following EPA guidance statements:

> "Risk characterization uses the results of the exposure and ecological effects analyses to evaluate the likelihood of adverse ecological effects associated with exposure to a (chemical) stressor." (EPA 1992).
>
> "It is important to recognize that environmental evaluations are not research projects: they are not intended to provide absolute proof of damage..." (EPA 1989).
>
> "The purpose of this document is to provide a scientific framework for designing studies, at the appropriate level of effort, that will evaluate pertinent ecological aspects of a site for the Remedial and Removal processes." (EPA 1989).
>
> "Ecological assessment seeks to determine the nature, magnitude, and transience or permanence of observed or expected effects." (EPA 1989).
>
> "Observational field studies provide environmental realism that laboratory studies lack." (EPA 1992).

EPA guidance, therefore, encourages the use of field studies for the characterization of risk and ecological effects analysis. The studies presented in the Ecological Status and Health section of the IEA/RC do this with the appropriate qualifying statements. EPA Region VIII repeatedly ignores this guidance in their position statement.

Similarly, the standard espoused by EPA Region VIII requires that absolute proof of the lack of damage be provided before such evidence can be considered relevant. Absolute proof of a negative is unlikely and continued speculative seeking of effects is neither in the interest of the public nor of the environment. For example, if there is no indication of exposure at any American kestrel nest boxes, which vary in their location relative to areas of contamination, and there is no evidence of eggshell

thinning, these two pieces of information are mutually corroborative; the first doesn't make the second irrelevant. Further, if no population impairment has been identified, it is not reasonable to require identification of a cause for population impairment or to determine its implications.

In the February 9, 1994 meeting of the EA Technical Subcommittee, EPA Region VIII stated that their concern with the Ecological Status and Health section was that it would counterbalance the exposure modeling portion of the ecological endangerment assessment, which EPA Region VIII also has in dispute. Yet the inclusion of information from both exposure modeling and effects measurements in the characterization of risk is explicitly recommended in current EPA guidance. Explicit language has been added in the IEA/RC stating that neither exposure modeling or effects measurement data is meant to discount the other, but both types of information are provided for consideration during decisions on remediation of RMA.

In their review of the ecological risk assessment approach used at RMA, an expert panel selected by EPA to participate in a Risk Assessment Forum was favorably impressed with the RMA studies. They stated:

> "A diversity of endpoints is used at a number of ecological levels, including tissue concentrations, biomarkers, and population surveys. This wide diversity of endpoints provides a holistic examination of the ecosystem, lending greater confidence in risk estimates." (EPA 1993).

Thus, EPA's own expert panel recognizes the appropriateness and utility of the RMA studies. EPA Region VIII has pointedly ignored this statement and continues to attack the RMA studies and their use.

It should also be noted that considerable additional work has been done, primarily by the U.S. Fish and Wildlife Service, since the studies reviewed and published by the Risk Assessment Forum.

EPA Region VIII has recently contradicted their own past statement on ecological considerations at RMA. For example, throughout the Biota RI process, EPA Region VIII deferred to the U.S. Fish and Wildlife Service for expertise on ecological effects. The U.S. Fish and Wildlife Service played an active role in designing and implementing ecological assessment studies at RMA (e.g., the kestrel studies), selecting and/or approving off-

post control sites (e.g., waterfowl, upland game birds, and others), and in analysis of study results. Formal documentation of EPA Region VIII's deferral is contained in their letter of comment on the Biota RI dated March 13, 1989 in which EPA Region VIII states:

> "As in the past, in regard to matters specific to the RMA biota, we defer to the concerns of the USFWS."

EPA Region VIII has provided no justification for its change in position with respect to the U.S. Fish and Wildlife Service.

The EPA Region VIII position statement criticizes the appendix but does not provide alternative evidence or interpretations of data from Biota RI and U.S. Fish and Wildlife studies they helped to design. For example, since Appendix C.5 addresses ecological health, it is logical that a definition be presented in the document. EPA Region VIII disagreed with the definition presented and accepted the opportunity to provide their own. They failed to provide a definition and continued to criticize the Army definition in written comments provided in early February 1994, Further, EPA Region VIII's written statements totally fail to acknowledge the verbal discussions and agreements that had been made and not honored.

EPA Region VIII has in the past made numerous comments and suggestions for revisions that have been addressed in Appendix C.5. For example, at the 24 June 1993 EA Technical Subcommittee meeting, EPA Region VIII suggested that explicit rankings of bias, power and relevance be added, that perspective on the scale addressed be provided, that ecological health be defined early in the appendix, and that conclusory language be added. Each of these and other requested items was added to Appendix C.5. The Army has been responsive to comments at every step along the way, yet met with increasing resistance from EPA Region VIII.

Substantial information has been collected on biota at RMA since 1985, yet EPA Region VIII states:

> "EPA requests that all these analyses be deleted and replaced by a clear statement that available data are insufficient to analyze the ecological data on any species in relation to contamination levels."

Many of the studies do interpret effects in relation to contamination levels.

EPA Region VIII acknowledges this earlier in their position document (e.g., grasshoppers, earthworms). Studies presented by the Army in the IEA/RC are consistent with the "weight of evidence approach" recommended in EPA guidance, which encourages the use of field studies for the characterization of risk and ecological effects analysis. Please note Tables C.5-1 through C.5-4 in Appendix C.5. EPA Region VIII's insistence on rejecting all studies not performed specifically for the assessment of contaminant risks is counter to EPA's general position on data usability and rational scientific approaches to assessing ecological risk.

Endpoint selection and experimental design are major issues in EPA Region VIII's attack on the ecological health section of the IEA/RC. However, U.S. Fish and Wildlife Service and Colorado Division of Wildlife personnel were closely involved in control site selection and study design, and the appropriate trustee concerns were, therefore, appropriately addressed.

The EPA Region VIII position misstates the experimental design and distorts the interpretation of studies that have been conducted to address contaminant effects. It sets up new definitions for what is said in Appendix C.5 and then states that Appendix C.5 doesn't meet the new definitions. For example, EPA Region VIII established artificial and unrealistic standards for defining bias, power, and relevance and then arbitrarily state: "As a result, most of the studies cited actually have high potential for bias and low power; many also have low relevance as explained below." Designation of levels of bias, power, and relevance were made on the basis of guidance from EPA Region VIII and other involved parties' experts. Differences with specific definitions appear to be the result of EPA Region VIII's treating these studies as academic investigations rather than appropriate studies as part of a "weight of evidence approach suggested by EPA guidance (EPA 1992). Further, EPA Region VIII continues to use words like conclusively...yet their guidance says absolute proof of damage not intended.

EPA Region VIII has established standards of information relevance, data quality, and burden of proof that are unrealistic (given the intricacies of the RMA system) and suggest a remediation strategy that is potentially detrimental to the environment because it would delay cleanup actions and use conservative standards that would result in physical destruction of extensive habitats and individuals. By suggesting the need for explicit studies of dispersal, immigration, emigration, trophic diversity, nutrient

cycling, primary productivity, and further quantitative evaluation of the diet in prey consumed by the predator species, EPA Region VIII is insisting upon an investigative program that is not necessary at a superfund site. The appropriate question is: "Do the available studies indicate unacceptable risk?", not "Is this the best and most detailed approach that could be achieved with unlimited time and money". EPA Region VIII has declined to include any information regarding how long it might take to collect the type of data they desire and has ignored the fact that the studies were designed well and with their participation.

EPA Region VIII's position fails to consider professional opinions and conclusions of numerous field biologists who have spent considerable time studying RMA biota. Yet EPA Region VIII has chosen to reject the investigative findings and professional judgement of dozens of biologists who have spent extensive time assessing the health and diversity of the biota at RMA. Fish and Wildlife personnel alone have collectively spent more than 85 biologist staff years studying biota on RMA. Appendix C.5, as presented, has been developed as a joint effort of all of the parties that have contributed to these investigations. As such, the appendix represents a consensus opinion of these parties. EPA Region VIII, on the other hand, has no record of field participation in the RMA studies. For example, the degree of EPA Region VIII's focus on human rather than ecological perspectives was evidenced by their misunderstanding of the way in which the term "population" was being used in Appendix C.5.

EPA Region VIII's position does not appear to focus on protection of RMA biota. All EPA Region VIII actions should be directed toward the remediation of RMA in a manner that is timely, cost effective, and protective of RMA biota. By arbitrarily rejecting the evidence represented by the current status and health appendix, which is consistent with the results of the quantitative risk assessment, EPA Region VIII is, in effect, delaying timely remediation of RMA. This poses a potential risk to the resources that EPA claims to protect. If indeed population-level effects exist, they would be expected to be greatest within the area already delineated for remediation by concurrence of all parties. Likewise, the rejection of relevant information and insistence upon unwarranted remediation potentially would result in the unnecessary destruction of environmental resources by disturbing areas and species not shown to be affected. This would also result in significant unwarranted costs to the responsible parties and, ultimately, the public.

References Cited

EPA (U.S. Environmental Protection Agency), Risk Assessment Forum. 1992. Framework for Ecological Risk Assessment. EPA/630/R-92/001.

EPA 1989. Risk Assessment Guidance for Superfund II, Environmental Evaluation Manual. Interim Final. EPA/540/1-89/001.

EPA, Risk Assessment Forum. 1993. A Review of Ecological Assessment Case Studies from a Risk Assessment Perspective. EPA/630/R-92/005.

APPENDIX C.6.1

ARMY/EPA JOINT STATEMENT ON DIFFERENCES BETWEEN THE EPA AND ARMY APPROACHES

Section C.1.5 describes three approaches for estimating biomagnification factors (BMFs) for application in risk characterization. The three approaches are referred to as the "Army approach", the "Shell approach" and the "EPA approach". EPA has provided additional description of analyses it has performed in developing its BMF approach, and as well other steps it would like to follow in estimating BMFs by the EPA approach; this is included in the IEA/RC as Appendix C.6.2. Differences among the analytical methods used in the Army, EPA, and Shell approaches are described and discussed in Sections C.1.5 and E.12. This section further describes and discusses the differences between the Army and EPA approaches. This section has been prepared jointly by the Army and EPA and represents a consensus between the two parties on the differences between the two approaches.

1. EPA has prepared an Appendix to the IEA/RC that documents several steps that it would like to follow in estimating BMFs from existing data. These additional steps are collectively referred to as the "full EPA approach." They go beyond the "EPA approach" as implemented in the IEA/RC, although the "EPA approach" was the approach selected by EPA for use under the constraints imposed in the IEA/RC: specifically, the decision to use estimated ESC, as defined in Section C.1.4.1 of the IEA/RC, with which EPA disagrees.

2. Both the Army and EPA would implement BMF estimation differently if more or different data were available.

3. The Army believes that existing data are sufficient to meet the objectives of the IEA/RC; EPA believes that new data should be collected.

4. The Army and EPA agree that the cost of acquiring new data should be balanced against the expected value of those data in improving risk estimates, and against the time that would elapse before improved risk estimates would be developed and risk management actions taken.

5. EPA defines BMF as "the multiplicative factor by which the concentration of a contaminant in the tissues of an organism (TC) exceeds the average concentration (SC) of the contaminant

in the soil to which the organism is exposed (directly or indirectly)."

The Army defines BMF as "an empirical coefficient, calculated by the Army, EPA, or Shell approach, to be used in the model:

$$TC_{pred} = BMF*ESC, \quad (1)$$

where:

TC_{pred} is the predicted population mean tissue concentration at a specific RMA location;

ESC (specifically defined in Appendix C.1.4.1 of the IEA/RC) is the estimated exposure area soil concentration for the location where the population mean tissue concentration is being predicted; and

BMF is an empirical coefficient."

6. EPA and the Army agree that the available data are inadequate as the basis for estimation of BMF, as defined by EPA. EPA and the Army disagree about the adequacy of the data for estimating BMF, as defined by the Army. EPA believes that the limitations of the data for estimating BMF as a biological parameter (as defined by EPA) apply equally to estimating BMF as an empirical modeling coefficient (as defined by the Army). The Army believes that limitations of the data for estimating BMF as a biological parameter are largely inapplicable for estimating BMF as an empirical modeling coefficient.

7. Because EPA regards the empirical values of BMF_{obs} as estimates of biological parameters (concentration ratios in actual organisms), EPA is concerned with obtaining the best possible estimates of the biological parameter consistent with the available data. The Army regards BMF as an empirical coefficient for predicting the population mean tissue concentration from ESC. Therefore, the Army is concerned with obtaining the BMF that, when multiplied by ESCs from across RMA, gives the best possible predictions of the population mean tissue concentrations.

8. The Army and EPA differ in their opinions about the importance of errors in interpolating and averaging the soil contaminant data to obtain estimates of exposure soil concentration. EPA believes that using a different method of interpolating and averaging the IEA/RC soil contaminant data, including taking account of spatial autocorrelation, could significantly reduce systematic error in exposure soil concentration estimates. The Army does not believe that reducing interpolation and averaging errors will significantly improve exposure soil concentration estimates, because other sources of error are large relative to interpolation and averaging errors. These other sources of error include location error (error associated with the assumption that tissue samples were taken at the center of the individual's home range), home range estimation error (error associated with the assumption of uniform utilization of a circular exposure area), and error in the assumption of uniform exposure to contaminants in the 0-1 foot soil profile.

9. EPA is concerned with what it considers to be arbitrary assumptions about the mathematical form of the collocated TC and ESC distributions used by the Army to calculate $BMF_{obs,}$ and about the correlation of the TC and ESC distributions. The Army believes that the quality of the tissue concentration predictions made using its BMFs supports its statistical assumptions.

10. The Army and EPA agree that the IEA/RC tissue concentration predictions are not independent of the tissue concentration observations to which they are compared, because the observations were used to define the BMFs. The Army considers the comparison of dependent tissue concentration predictions and observations to be an appropriate and necessary exercise for both calibrating and evaluating the adequacy of its empirical BMFs. EPA believes that as a calibration exercise, the comparison of dependent tissue concentration predictions and observations is subject to severe data limitations.

11. EPA believes that screening the TC and ESC data from RMA is necessary and that weighting the data is desirable to take account of the widely variable reliability of the data pairs. The Army believes that this problem is reduced by the collocated distributions approach.

12. The Army and EPA agree that linearity, if it does occur, in the relationship between

population mean tissue concentration and the true average exposure soil concentration is only likely to occur over a limited range of soil concentrations. For example, there may be a low dose threshold due to assimilative capacity. In addition, there are statistical problems in precisely estimating average exposure soil concentration and tissue concentration in the low dose region of the dose response curve, which may mask linearity. In the high dose region, non-linearity would be expected to occur because at high values of the true exposure soil concentration, animals could not survive long enough to reach steady-state tissue concentrations. A pharmacokinetics saturation effect could also be responsible for non-linearity in the high dose region of the dose response curve.

EPA believes that the relationship between TC and the estimated exposure soil concentration would be expected to be non-linear because of high and low dose effects such as those described above. EPA believes that non-linearity in this relationship would lead to underestimation of BMFs (using its biological parameter definition of BMF).

The Army believes, on the basis of comparison of mean tissue concentration predictions to individual tissue concentration observations from across RMA, that the empirical model described in equation (1) above, in which TC_{pred} is linearly related to ESC, is adequate for characterizing risks to biota. In other words, the Army believes that equation (1) is an adequate model of the relationship between population mean tissue concentration and ESC, whether or not the underlying relationship is truly linear over the range of exposure soil concentrations present at RMA.

13. The Army and EPA disagree about the relevance of BMF values derived from the literature. EPA believes that there are literature data that allow direct estimation of BMF for biota exposed to relatively uniform concentrations of soil contaminants, and also literature data on bioaccumulation that allow indirect calculation of BMFs. The Army believes that the only estimates that should be used in predicting tissue concentrations through equation (1) are estimates that were derived from or compatible with the existing set of values of ESC, and that there are no such studies reported in the literature.

EPA believes that literature data are relevant and useful for estimating BMFs for at least some combinations of species and contaminants. EPA believes that any biases or other deficiencies in ESC should be addressed by recalculating ESC, rather than by excluding what EPA considers to be relevant (literature) information on BMF. The Army does not consider bias to be a deficiency in ESC, because it is much more cost effective to correct for ESC bias through the use of an empirical BMF than to accurately estimate true exposure soil concentrations.

14. In the "full EPA approach," risk characterization would be effected by multiplying the values of BMF selected by EPA (often literature values) with recalculated estimates of exposure soil concentration:

$$TC_{pred} = BMF^{*}\langle SC\rangle \qquad (2)$$

The Army believes that the resulting tissue concentration predictions would be invalid if the estimate of BMF used in equation (2) is not derived from or compatible with the existing set of values of <SC>.

15. The Army and EPA agree that the relationship between tissue concentration and ESC may be changed by remediating RMA soil contamination, even if the relationship between mean tissue and exposure soil concentration is invariant. The Army and EPA agree that pre-remediation BMFs, when multiplied by post-remediation ESCs, might not accurately predict post-remediation mean biota tissue concentrations. EPA considers this to be a problem that should be solved by improved or additional risk assessment techniques. EPA considers that the "full EPA approach" would yield risk estimates less subject to this problem, and that most steps in the "full EPA approach" (other than the gathering of new data) could be implemented quickly and cost effectively. The Army considers this to be a risk management problem that would be most effectively addressed through biomonitoring before, during, and after site remediation. EPA does not endorse the position that deficiencies in risk assessment can be addressed by biomonitoring. The Army and EPA agree that a risk assessment model designed to predict population mean tissue concentrations under pre-remediation conditions might provide less accurate forecasts of

post-remediation population mean tissue concentrations. The Army does not consider this to be an indication that the risk assessment model is "deficient," because the model is not designed to forecast post-remediation conditions. The Army believes that the pre-remediation data gathering and modeling required to obtain adequate predictions of mean tissue concentrations associated with post-remediation soil concentrations would, at a minimum, take several more years, and would not be a cost effective way to achieve risk management objectives.

APPENDIX C.6.2

EPA'S APPROACH TO ESTIMATING BMFs

Introduction

EPA invoked dispute on this matter in June, 1993. A series of intensive meetings failed to achieve a resolution satisfactory to the RMA parties (Army, Shell, USFWS, EPA, and the State of Colorado). Therefore, the RMA Council resolved that the methodologies for calculating BMF proposed by Army, Shell, and EPA would be presented in the IEA, and that a supplemental field study would be conducted. The purpose of the supplemental study is to determine if biota are exposed to unacceptable levels of contaminants in the areas where the three methods result in different estimates of potential risk. If it is determined that biota are exposed to unacceptable levels of contaminants in these areas, a specific study to improve information on site-specific BMFs would be conducted. The results of these field studies may resolve differences in current risk estimates, but will not address deficiencies of the current data.

This version of the Integrated Endangerment Assessment/Risk Characterization (IEA/RC) presents three alternative methods for calculation of empirical BMFs (BMF_{obs}) derived from RMA field data (TCs and ESCs). The three methods are referred to in Appendix C.1.5.1.2 as the "Army approach", the "Shell approach," and the "EPA approach." The three approaches were developed by the respective parties because of disagreements about the appropriate ways to estimate site-specific BMFs for use in risk assessment, using the IEA/RC food web model. One source of disagreement is the fact that the RMA sampling programs were not originally designed for estimation of BMFs or for calibration of the food web model. The soil sampling program was designed to determine the nature and extent of soil contamination, and focused on areas of known contamination. The tissue sampling program was designed to determine if site-related contaminants are present in biota tissues, and generally focused on areas peripheral to sites of primary contamination. Although these separate sampling programs provide important information regarding their stated goals, they were not designed to be used together to estimate BMF. Because soil sample locations were not specifically co-located with tissue sample locations (different sampling programs at different times), deriving estimates of exposure soil concentrations (ESCs) requires the extrapolation and averaging of soil concentrations measured at various distances from the location of each tissue sample. The parties disagree about the appropriate procedures for deriving ESCs, for deriving estimates of BMF_{obs} from the sets of data

on tissue concentration and ESCs, and for "calibrating" the values of BMF (see Appendix C.6.1).

All three methods for calculating empirical BMFs from field data utilize the same data sets: a set of tissue concentrations (TCs) and a corresponding set of "estimated exposure area soil concentrations" (ESCs). ESCs were calculated in the IEA/RC from estimated soil concentrations for each contaminant in an area surrounding the location where each biota sample was collected. The approaches differ, however, in the manner in which ESC and TC values are used to calculate BMFs. These approaches are described in Appendix C, Section C.1.5.1.2. The three approaches yield different BMFs and, therefore, differing estimates of the spatial extent of risk for ecological receptors.

This Appendix further describes EPA's approach to estimating BMFs for use in risk assessment at RMA. It includes a description of the "EPA approach" or "modified paired data approach" as carried out in the IEA/RC (Appendix C.1.5.1.2), as well as an outline of additional steps that EPA would like to follow in estimating BMFs from existing data. These additional steps are collectively referred to as the "full EPA approach." This Appendix presents the results of implementing one of these additional steps (screening and weighting the field data), carried out by EPA outside the IEA/RC. A separate Appendix (Appendix C.6.1) summarizes differences between the "Army approach" to estimating BMFs and the "full EPA approach", and states differences of opinion between the Army and EPA about these approaches and underlying concepts. Some of these differences of opinion derive from conceptual and definition differences between the Army and EPA, as stated in Appendix C.6.1.

<u>The "full EPA approach"</u>.

The "full EPA approach" to estimating BMFs would include the following steps, each of which is recommended by EPA:

1. Improving statistical methodology for estimating site-specific BMFs (BMF_{obs}) from existing RMA data:
   a. Recalculating values of ESC to take account of spatial structure in the soil

contamination data, e.g., to develop appropriate interpolation distances for calculating ESC;

b. Developing uncertainty estimates for ESC and incorporating these estimates into analysis of uncertainties in estimates of BMF_{obs};

c. Screening and weighting the data to place highest weight on those data pairs (TC/ESC) that yield the most reliable estimates of BMF_{obs}, and to exclude those pairs that yield highly uncertain estimates of BMF_{obs};

d. Developing point estimates of BMF_{obs} from paired values of TC and ESC.

2. Incorporating appropriate literature estimates into the procedure for estimating BMFs:

a. In some cases, estimates of BMF can be derived from literature data directly ($BMF_{liv/dir}$), by dividing tissue concentrations reported in the literature by the corresponding soil concentrations;

b. In other cases, estimates of BMF can be derived through modelling ($BMF_{liv/calc}$), by combining data on bioaccumulation factors at successive trophic levels;

c. Estimates of BMF derived from the literature (where available) should be compared with those derived from field data (where available), and the most appropriate values should be selected based on consideration of the reliability, limitations, and applicability of each.

3. Obtaining new field data to support improved estimates of BMFs.

The rationale for these recommendations may be summarized as follows:

1a. As stated in Appendix C.6.1 (paragraph 8), EPA believes that estimates of BMF could be significantly improved by recalculation of ESCs. EPA has recommended using a different geostatistical technique (e.g., kriging) to take fuller account of spatial autocorrelation in the soil concentration data.

1b. EPA believes that the formal development of uncertainty estimates for ESC would assist in the screening and weighting of the ESC data (see next paragraph) and would lead to improved assessment of uncertainty in estimates of BMF_{obs} (see item 2).

1c. EPA believes that individual values of TC and ESC (and hence pairs of values) differ greatly in reliability because of variability in sampling design and data characteristics. Factors that contribute to this variability include: (a) spatial variability in soil concentrations; (b) variability in sampling density; (c) variable occurrence of BCRL values; (d) variable degree of co-location between tissue and soil samples; and (e) potential non-linearity in the relationship between TC and ESC. As stated in Appendix C.6.1 (paragraph 11), EPA believes that screening the TC and ESC data from RMA is necessary and that weighting the data is desirable to take account of the widely variable reliability of the data pairs. Screening the data would eliminate the least reliable data pairs; weighting the remaining data would place higher weight on the more reliable data pairs.

1d. EPA believes that analyzing paired data (pairing values of TC with values of ESC from the same locations, rather than dissociating the data as in the collocated distributions approaches) would make the best use of the spatial information available in the TC:ESC data set.

2. As stated in Appendix C.6.1 (paragraph 13), EPA believes that literature data are relevant and useful for estimating BMFs for at least some combinations of species and contaminants. EPA believes that there are literature data that allow direct estimation of BMF for biota exposed to relatively uniform concentrations of soil contaminants (item 2b), and also literature data on bioaccumulation that allow indirect calculation of BMFs (item 2c). Literature data on bioaccumulation could also be used as a "reality check" on the ratio between estimates of BMF at successive trophic levels. As stated in Appendix C.6.1 (paragraph 7), EPA regards

the empirical values of BMF_{obs} as estimates of biological parameters (concentration ratios in actual organisms), and hence is concerned with obtaining the best possible estimates of the biological parameter consistent with the available data. Consequently, EPA believes that literature data as well as site-specific data should be used in selecting the values of BMF to be used in risk assessment at RMA (item 2d).

3. For reasons stated later in this Appendix, EPA believes that the field data presently available from RMA are inadequate to derive estimates of BMF_{obs} for many combinations of species and contaminants. Although literature data are available for many of these combinations, EPA believes that better estimates of BMF (and, consequently, better risk estimates) would be obtained if field and literature estimates could be compared (step 2d). For this reason, EPA recommends that additional field data should be collected using a sampling program specifically designed for estimating BMF. EPA believes that such a program could be designed and implemented within one year. In fact, additional field data may be collected in Phase II of the supplemental field study, if this is implemented.

Implementation of the "EPA approach" in the IEA/RC.

Because of time and resource constraints, only part of the "full EPA approach" is implemented in the IEA/RC. The steps that are implemented are steps 1d (analyzing paired data) and part of step 1c (screening the data to exclude areas with low and high average values of ESC). These steps are referred to in the IEA/RC as the "EPA approach." As stated in Appendix C.6.1 (paragraph 1), the "EPA approach" was selected by EPA for use under the constraints imposed in the IEA/RC; specifically, the decision to use the estimated ESC, with which EPA disagrees. EPA regards the values of BMF_{obs} derived using the "EPA approach" as comparable with the values of BMF_{obs} derived using the "Army approach" and the "Shell approach" from the same data sets. However, EPA regards the values of BMF_{obs} derived using the "EPA approach" as interim values only, until other steps in the "full EPA approach" can be implemented.

Procedures used by EPA to further screen and weight biota and soil data.

The remainder of this Appendix describes procedures used by EPA (outside the IEA/RC) to further screen and weight the biota and soil data. This represents an attempt to implement step 1c in the "full EPA approach." EPA reviewed the data pairs individually, examining the original soil contamination data and their spatial variability as well as the values of ESC calculated in the IEA/RC. The objective of the exercise was to identify a subset of the data that could be used for estimating BMF_{obs}, in spite of the limitations imposed by the lack of co-location and other data deficiencies identified earlier in this Appendix.

EPA's three step procedure for screening and weighting the data is described below:

Step 1: Screening of samples with BCRL tissue concentrations.

The first step in screening and weighting the TC/ESC data sets is to address the problems posed by the high prevalence of BCRL values in both data sets. EPA notes initially that each TC/ESC pair consists of a pair of values, a single measured tissue concentration (TC) and an average soil concentration constructed by a process of spatial interpolation (onto a rectangular grid) and spatial averaging (over a circular area surrounding the point of collection and intended to simulate the exposure range of the organism that is sampled). Thus, TC is a single value, whereas ESC is a weighted average of many measured soil concentrations. This structure of the data reflects the biological reality that a single organism is exposed to contaminants at many locations and that the concentration accumulated in tissues integrates its exposure over these locations. Because of this structure, an average soil concentration can be calculated meaningfully even if many of the individual soil concentrations are BCRL. The Army's procedure for calculating ESC assigns numerical values to BCRL samples by a process of weighted averaging over surrounding non-BCRL values. The larger the proportion of replaced values in the set that contributes to the average, the greater the uncertainty in the value of ESC. Accordingly, EPA uses this proportion as a component in the process of weighting described in the next section.

For the tissue concentration, however, a BCRL value is much more problematical. In an

approach that pairs tissue and soil concentrations, a replacement value for a BCRL is largely meaningless, because the point estimate of BMF would be the replacement value for a BCRL tissue concentration divided by ESC (which itself often incorporates replacement values for BCRL soil concentrations). The tissue replacement value may be wrong by orders of magnitude in individual cases. Accordingly, EPA assigns zero weight to all data pairs in which the tissue value is BCRL. Likewise, zero weight is assigned to data pairs in which the ESC is based largely or entirely on BCRL values. EPA assigns variable weight to data pairs in which the tissue value is above the CRL but the ESC is based in part on BCRL values.

The first step in screening the data, therefore, is to identify the data pairs for which the tissue value is BCRL. To effect this screening step, EPA reviewed the complete files of data on tissue concentrations at RMA (files ALDDLDPR.XLS, DDEDDTPR.XLS, ENDRNPR.XLS, and MERCPR.XLS), as provided by the Army. The numbers of positive findings (tissue concentration > CRL) were then compiled for each analyte in each species. Table 1 lists these positive findings. Samples that were not analyzed (concentration listed as 9999.99) or for which data were incomplete (samples with 2- or 3- digit tag identification numbers) are included in the total number of samples but not in the numbers of positive findings.

Combining all species, the total number of biota samples in each file was 752. For dieldrin, the proportion of positive findings was 50% overall, and exceeded 50% in all animal species except for the cottontail (SYAU). Although the proportion of positive findings for aldrin in animals was only 3% (17/516), this is expected because aldrin is metabolized to dieldrin in most animal species. Hence, dieldrin is expected to predominate in most or all animal samples, and the Army's procedures for replacing BCRL values for aldrin will introduce only small uncertainties into the estimates of the combined concentrations (aldrin + dieldrin). For this reason, EPA regards the frequency of positive findings for (aldrin + dieldrin) in animals as numerically sufficient to attempt estimation of BMFs. [Considerations other than numerical sufficiency will be discussed in the next section.]

For plants, the proportion of positive findings was only 25% (60/236) for dieldrin and 2.5%

96/236) for aldrin (Table 1). Because plants accumulate aldrin as well as dieldrin, there is no similar presumption that the true aldrin concentrations in plants would be small compared to the true dieldrin concentrations. Hence, the Army's procedures for replacing BCRL values for aldrin in plants introduce larger uncertainties into the estimates of the combined concentrations (aldrin + dieldrin). For this reason, EPA regards the frequency of positive findings for (aldrin + dieldrin) in plants as too low for reliable estimation of BMFs.

For the other analytes (DDT, DDE, endrin, and mercury), Table 1 shows that the proportions of samples with positive findings ranged from 3% (DDT) to 7% (mercury). Excluding earthworms, the proportions of samples with positive findings ranged only from 2.4% (DDT) to 4.7% (endrin). EPA concludes that these data are inadequate to make any estimates of BMF using RMA field data for DDT+DDE, endrin, or mercury for any species. When the proportions of BCRL values are in the range 93-97%, as they are for these analytes at RMA, estimating replacement values yields results that have very high uncertainty.

Step 2: Further screening and weighting of data for aldrin + dieldrin

In step 2, the paired TC/ESC data are screened and weighted in order to place higher weights on the data pairs which yield more reliable estimates of BMF, and lower or zero weights on the data pairs which yield less reliable estimates of BMF. The weights were assigned to take account of the following factors:

(1) detectability of tissue concentrations (whether one or both analytes were above CRL);

(2) co-location of tissue and soil samples;

(3) measurability of soil concentrations (proportion of soil samples above CRL);

(4) magnitude of average soil concentration (screening out of data pairs with high values of ESC).

These four factors were all utilized in the weighting scheme presented below. EPA originally intended also to take account of the local variability of soil concentrations (placing lower weight on data pairs for which the soil local concentrations were more variable), but was unable to do so, for reasons explained below.

The data were screened using soil concentration maps prepared for this purpose by the Army. The maps were on a scale of 1 inch:300 feet. The collection location for each tissue sample was marked with a colored dot and a list of tissue samples showing the trophic group and Tag ID number for each sample. The Tag ID number was used for sample identification. Reference to the file ALDDLDPR.XLS yielded the trophic group and species, the measurements, if any, of aldrin and dieldrin in the tissue sample, and the estimated value of ESC for the location of collection. The maps also showed the location of each soil sample and the estimated value of ESC. Each soil sample was marked with a symbol showing the number of "hits" (i.e., the number of measurements above CRL for aldrin and/or dieldrin). Triangles indicated 2 "hits", circles indicated one "hit" (plus one BCRL estimation or one not analyzed or NA); squares indicated no "hits" (both BCRL estimations or one BCRL and one NA). Soil sampling locations for which no soil concentration value was posted on the maps (i.e., both values NA) were ignored in all analyses.

For each species, the "home range equivalent radius" (HRER) is defined as the radius of a circle with area equal to the consensus value for the area of the home range. Transparent overlays were prepared with ruled circles of radius equal to the HRER for the various species. Using these overlays, the number of soil samples within the HRER and within half the HRER was determined for each tissue sample. The distance to the nearest soil sample was estimated to the nearest 10 feet. Because of the small scale of the maps, errors of up to 10 feet or more are possible in this measurement, but such errors are smaller than the uncertainty in surveying of the tissue collection locations.

The information collected and used in the analysis is presented on a spreadsheet (Table 2). The spreadsheet is sorted hierarchically in the following order:

Trophic group (alphabetically)

Species (alphabetically)

Tag ID number (alphanumeric, ascending)

The columns in the spreadsheet give the following information:

Column 1: Location number. Location numbers were assigned arbitrarily in order of processing. This was generally in the order of the maps provided, progressing from northwest to southeast within each map. The total number of collection locations was 164.

Columns 2-4: Sample identity. These columns present the Tag ID number, species (4-character code), and trophic group (5-character code), respectively.

Columns 5-7: Co-location. Columns 5 and 6 give the number of soil samples mapped within the HRER and half the HRER, respectively. Column 7 gives the estimated distance (in feet) to the nearest soil collection location.

Columns 8-11: BCRLs in soil. Column 8 gives the proportion of BCRLs among the analyses for soil samples collected within the HRER. (The denominator in this ratio is twice the number of samples, since each sample was analyzed for aldrin and dieldrin and thus contributed two values.) For mourning doves (ZEMA), the number of soil samples collected within the HRER commonly exceeded 35 and ranged up to 200; in such cases, column 8 gives the proportion of BCRLs among the analyses for soil samples collected within the HRER/2. Columns 9-11 give the number of "hits" among the nearest six soil samples to the location of collection, up to a maximum distance of 1,200 feet. In the algorithm used in the IEA/RC for estimating ESC, the mean soil concentration at a grid point is usually estimated from the nearest six soil samples, up to a maximum of 1,200 feet in peripheral areas (see Appendix C.1.4). Although the two-stage procedure used in the IEA/RC for calculating ESC makes it difficult to calculate the contribution of BCRL replacement values to each computed value of ESC, the information in column 8 is expected to reflect this contribution in areas of high sampling density, whereas that in columns

9-11 is expected to reflect this contribution in areas of low sampling density. Columns 9-11, respectively, give the number of soil samples with 2, 1, and 0 "hits" for aldrin and dieldrin.

Column 12: Number of tissue "hits". Zero "hits" means both analytes were either BCRL or NA. For plants and earthworms, 1 "hit" means one of the analytes was above CRL, the other BCRL or N/A; 2 "hits" means both analytes were above CRL. For animals other than earthworms, 2 "hits" means dieldrin was above CRL (because most animals metabolize aldrin to dieldrin, a "hit" for dieldrin with BCRL for aldrin is treated as equivalent to 2 "hits" for plants or earthworms).

Column 13: Assigned weight (see next section). EPA also attempted to extract data on variability in soil concentrations around each tissue sampling location. However, with the information available, it was not possible to calculate a useful measure of this variability. This was because of the wide range of soil sampling densities and the high prevalence of BCRL replacements among the soil concentration values. Areas where the mapped soil values were relatively uniform (low variance) were usually those where the soil values were derived largely from BCRL replacements. In the few areas where the proportion of BCRLs was low, the variance in measured soil concentrations was very high, but was difficult to calculate because of irregular sampling designs. Although it would be desirable to analyze the spatial structure of the soil data and to identify areas of high and low variance, this was not possible with the available data.

Assignment of weights. Table 3 shows the weighting scheme developed by EPA. The data pairs are categorized by letter in descending order of assigned weight, such that categories A-C indicate high weight (low uncertainty of estimated BMF), categories D-G indicate low weight (high uncertainty of estimated BMF), and category H indicates zero weight. The data pairs are categorized by letters rather than numerical weights in order to permit exploration of different numerical weighting schemes. The categorizations incorporate information on different factors that lead to uncertainty, using scientific judgement to integrate the various factors as shown in the table.

Data pairs are initially categorized by the number of "hits" in the tissue sample. Samples with two "hits" as defined above follow the categorization in the upper half of Table 3; samples with one "hit" follow the categorization in the lower half of Table 3; samples with zero hits are placed in category H (zero weight). The data pairs are then characterized by the number of soil samples within the HRER: more than 10, 4-9, 1-3, or zero; data pairs with zero soil samples within the HRER are further characterized by the distance to the nearest soil sampling location (greater or less than 100 feet). The data pairs are finally characterized by the percentage of soil samples that are BCRL (>50%, 50-80%, or >80%). This percentage is derived from column 8 in Table 2 if the number of soil samples within the HRER is 4 or more, or from columns 9-11 in Table 2 if the number of soil samples within the HRER is 0-3.

After categorizing all the data pairs following the scheme in Table 3, EPA investigated the linearity of the relationships between TC and ESC. This investigation was limited to the only two species (ZEMA and CYLU) for which a reasonable number (more than 20) of paired samples were assigned non-zero weights based on the scheme presented in Table 3. Plotting TC against ESC within the screened data set for ZEMA indicated that TC increased with ESC up to ESC values of about ppm (combined aldrin/dieldrin concentrations in the 0-12 inch soil profile), but did not increase further above ESC = 1.5 ppm. A scatter plot of unscreened data for deer mice (PEMA), presented in the EPA/ORD report, August 1993, showed a similar nonlinear pattern, with a change in slope at about ESC = 3 ppm. The scatter plot for CYLU showed no clear dependence of TC on ESC, either at low values or high values of ESC (Figure 2). Because of the non-linearity, all data pairs for which ESC was greater than 3 ppm were assigned a zero weight (category H).

Step 3: Further screening and weighting of data on other analytes

For analytes other than aldrin/dieldrin, the screening and weighting procedures described in the previous section were applied only to data pairs for which one or both tissue concentrations were above CRL. For (DDT + DDE), the screening and weighting procedure was the same as that for (aldrin + dieldrin), except that animal samples for which only one analyte was above CRL (either

DDT or DDE being BCRL or NA) were characterized as one "hit" instead of two "hits". For endrin and mercury, only the upper half of Table 3 was used for assigning weights. Non-linearity of the relationship between TC and ESC was not investigated for any of these analytes; i.e., data pairs with high values of ESC were not assigned zero weight for that reason alone.

Results, Discussion, and Conclusions

Table 2 presents the results of the screening and weighting procedure for aldrin + dieldrin. Tables 4, 5 and 6 present the results of the screening and weighting procedure for DDT + DDE, endrin, and mercury, respectively, limited to the data pairs with one or two tissue "hits". Table 7 summarizes the number of data pairs for each analyte that are assigned high weights (categories A-C) and low weights (categories D-G).

A total of 752 biota samples were collected at RMA and analyzed for aldrin, dieldrin, DDE, DDT, endrin, and mercury (database provided by the Army, November 1993). Each was paired with an estimated soil concentration. For aldrin and dieldrin, the total number of pairs of all species assigned non-zero weights was 103, or only 14 percent of all samples collected and analyzed for aldrin and dieldrin. Of these 103 pairs, the majority were assigned low weights, representing high uncertainty and low confidence; 82 of the 103 pairs were assigned low weights, while only 21 (or 3 percent of all samples collected and analyzed for these chemicals) received high weights. Of the 82 pairs receiving low weights, most trophic boxes had a very small number of pairs with non-zero weights (e.g., 1 to 4 per species; see Table 7), with the remaining pairs being assigned zero weights. The only species having more than a few pairs assigned low weights are the grasshopper (ACRI, in 12 of 81 samples analyzed), black-tailed prairie dog (CYLU, in 27 of 128 samples analyzed), and deer mouse (PEMA, in 14 of 90 samples analyzed). Of all the biota samples analyzed for aldrin and dieldrin, birds were the only species assigned high weights, including the mourning dove (ZEMA, in 15 of 68 samples analyzed) and the western meadowlark (STNE, in 6 of 10 samples analyzed) (see Table 7).

For the other analytes, the total numbers of samples assigned non-zero weights are 6 for DDT + DDE, 26 for endrin, and 20 for mercury (Table 7). Only 14 samples (of which 8 are mourning

doves for endrin) are assigned "high" weights. The largest number of samples assigned non-zero weights within any species/analyte combination is 14 (earthworms, mercury, only one assigned "high" weight).

EPA considers that all these sample sizes, after screening and weighting, are inadequate for any meaningful estimation of BMF. The species/analyte combination that would provide the best basis for estimating BMF is the mourning dove for aldrin + dieldrin, with 15 samples given "high" weights and three more given "low" weights. The total of 18 samples with non-zero weights, however, is only 25% of the number of mourning doves collected, raising the possibility of screening biases. Mourning doves tend to receive high weights because they have large home ranges, often incorporating many soil sampling locations. However, for the same reason, estimates of their exposure are highly uncertain, because the home range circles include an extremely wide range of soil concentrations. Finally, mourning doves are relatively large, granivorous birds, and hence are poor models for the small, generally insectivorous nestling birds that form part of the diet of the American kestrel, the only predatory species for which birds are a significant part of the diet. For these reasons, EPA believes that a BMF value calculated from the screened data set for the mourning dove would not be a reliable or meaningful estimate of BMF for small birds for use in risk assessment at RMA. The same comments apply to mourning doves for endrin (N = 14). The western meadowlark (STNE) had six samples assigned "high" weights for aldrin + dieldrin, but this sample size is too small for reliable statistical estimation of BMF, given the high variance in both TC and ESC. Grasshoppers, prairie dogs, and deer mice had modest samples with non-zero weights for aldrin + dieldrin, but all these samples were assigned "low" weights and hence would not serve as a reliable basis for calculation. The same comment applies to the screened sample of worms for mercury (14 with non-zero weights, of which only 1 was assigned a "high" weight). No other species/analyte combination had nearly enough data pairs with non-zero weights to consider estimating a BMF.

Overall, EPA considers the field data from RMA inadequate to serve as the basis for calculating BMF_{obs} for any species/analyte combination. The main reasons why low or zero weights are assigned to so many data pairs are:

o The lack of co-location of tissue and soil samples in the large majority of cases;

o the high frequency of BCRLs in all cases except a few species for dieldrin; and

o the high frequency of sampling locations in which the value of ESC was above the range in which the relationship between TC and ESC appears to be linear.

As stated in Appendix C.6.1 (paragraph 6), the parties disagree about the applicability of this conclusion. The Army believes that it is applicable only to BMF as defined by EPA and estimated by the EPA approach, whereas EPA believes that it is applicable equally to BMF as defined by the Army and estimated by the "collocated distributions" approaches.

Because EPA judges the field data from RMA to be inadequate to serve as the basis for calculating BMF_{obs} for any species/analyte combination, EPA believes that literature data must be the primary source for estimates of BMF for use in the IEA/RC (step 2 in the "full EPA approach"). EPA believes that literature data are available, relevant, and useful for estimating BMFs for at least some combinations of species and contaminants (see Appendix C.6.1, paragraph 13). However, EPA believes that it would be desirable to have site-specific estimates of BMF to compare with the literature values (step 2c in the "full EPA approach"). Accordingly, EPA has recommended that a limited program for collecting additional field data should be conducted for this purpose (step 3 in the "full EPA approach"). To avoid the uncertainties that have resulted from attempts to use the existing data for this purpose, EPA recommends that the program should be designed specifically for estimating BMFs. In particular, the program should select sampling locations within the expected linear range of the TC/ESC relationship, should precisely co-locate tissue and soil samples, should be designed for spatial averaging of soil concentrations, and should use an analytical method sensitive enough to reduce the frequency of BCRLs to low levels. EPA believes that such a program (e.g., Phase II of the supplemental field study) could be carried out within one year and could lead to significant improvement in estimates of BMF and consequent estimates of risks to biota.

TABLE 1

RMA BIOTA SAMPLES: FREQUENCY OF POSITIVE FINDINGS (>CRLs)

Group	Species	No. of Samples	Number of Positive Findings							
			Aldrin	Dieldrin	Both	DDT	DDE	Both	Endrin	Hg
HERPS	AMBY	2	2	2	2	1	0	0	2	2
	PIME	3	0	3	0	0	1	0	0	0
	SCAP	2	0	2	0	0	0	0	0	1
INSCT	ACRI	81	0	41	0	3	0	0	4	0
	COLE	17	5	12	5	1	3	1	5	0
MDMML	CYLU	128	0	74	0	1	2	0	2	1
	SYAU	28	0	8	0	0	0	0	0	1
SHBRD	CHVO	5	0	5	0	3	5	3	2	5
SMBRD	POGR	5	0	3	0	0	0	0	0	0
	STNE	10	0	9	0	0	0	0	0	0
	ZEMA	68	1	45	1	0	2	0	13	0
SMMML	PEMA	90	6	63	6	3	5	1	2	7
	SPTR	3	0	3	0	0	0	0	0	0
TRPLT	BRTE	84	2	28	1	2	1	1	1	0
	COAR	4	0	0	0	0	0	0	0	0
	HEAN	89	3	21	3	1	2	0	2	0
	KOIR	42	1	4	0	1	0	0	1	0
	LASE	17	0	7	0	0	0	0	0	0
WORMS	OLIG	74	3	45	3	8	12	5	11	35
All Samples		752	23	378	21	24	33	11	43	52

TABLE 2. RESULTS OF SCREENING AND WEIGHTING PROCEDURE FOR ALDRIN PLUS DIELDRIN

Loc.	ID No.	Spec.	Group	# of Samples HRER	# of Samples HRER/2	Distance to Nearest Soil Sample (ft)	BCRLs within HR circle	Number of Samples Having Hits w/in Search Radius: 2 hits	1 hit	0 hits	# of Tissue Hits	Rank
18	B0797	AMBY	HERPS	0	0	410	0	4	1	1	2	G
18	B0798	AMBY	HERPS	0	0	410	0	4	1	1	2	G
116	B0486	PIME	HERPS	1	0	270	0/2	1	0	5	2	F
14	B1449	PIME	HERPS	1	0	340	2/2	0	0	5	2	H
80	B1460	PIME	HERPS	5	4	90	8/10	1	0	5	2	D
77	B1458	SCAP	HERPS	0	0	70	0	2	1	3	2	H
79	B1459	SCAP	HERPS	0	0	380	0	2	0	4	2	H
74	B0119	ACRI	INSCT	0	0	70	0	4	1	1	2	H
75	B0120	ACRI	INSCT	0	0	40	0	1	3	2	2	G
122	B0121	ACRI	INSCT	0	0	40	0	3	2	1	2	H
127	B0123	ACRI	INSCT	0	0	225	0	3	0	3	2	H
77	B0131	ACRI	INSCT	0	0	70	0	2	1	3	0	H
148	B0134	ACRI	INSCT	0	0	45	0	0	3	3	0	H
132	B0136	ACRI	INSCT	0	0	870	0	0	0	1	0	H
71	B0147	ACRI	INSCT	0	0	50	0	0	2	4	2	H
68	B0148	ACRI	INSCT	0	0	50	0	1	2	3	2	G
51	B0150	ACRI	INSCT	0	0	60	0	1	5	0	0	H
53	B0152	ACRI	INSCT	0	0	110	0	0	0	6	2	H
99	B0154	ACRI	INSCT	0	0	35	0	2	1	3	2	G
17	B0155	ACRI	INSCT	0	0	100	0	1	0	5	2	H
27	B0157	ACRI	INSCT	0	0	20	0	2	2	2	2	G
28	B0159	ACRI	INSCT	0	0	90	0	1	3	2	2	G
17	B0196	ACRI	INSCT	0	0	100	0	1	0	5	2	H
61	B0197	ACRI	INSCT	0	0	70	0	1	4	1	2	G
119	B0198	ACRI	INSCT	0	0	70	0	2	1	3	2	F
127	B0661	ACRI	INSCT	0	0	225	0	3	0	3	2	H
97	B0662	ACRI	INSCT	0	0	160	0	1	2	3	2	H

TABLE 2. RESULTS OF SCREENING AND WEIGHTING PROCEDURE FOR ALDRIN PLUS DIELDRIN

Loc.	ID No.	Spec.	Group	# of Samples HRER	# of Samples HRER/2	Distance to Nearest Soil Sample (ft)	BCRLs within HR circle	Number of Samples Having Hits w/in Search Radius: 2 hits	1 hit	0 hits	# of Tissue Hits	Rank
79	B0663	ACRI	INSCT	0	0	380	0	2	0	4	0	H
106	B0664	ACRI	INSCT	0	0	110	0	3	0	3	0	H
74	B0680	ACRI	INSCT	0	0	70	0	4	1	1	2	H
31	B0681	ACRI	INSCT	0	0	220	0	2	2	2	0	H
117	B0682	ACRI	INSCT	0	0	80	0	2	2	2	0	H
75	B0683	ACRI	INSCT	0	0	40	0	1	3	2	0	H
27	B0684	ACRI	INSCT	0	0	20	0	2	2	2	2	F
29	B0685	ACRI	INSCT	0	0	190	0	5	1	0	2	G
119	B0686	ACRI	INSCT	0	0	70	0	2	1	3	2	H
104	B0687	ACRI	INSCT	0	0	180	0	1	0	5	2	H
122	B0688	ACRI	INSCT	0	0	40	0	3	2	1	2	H
51	B0689	ACRI	INSCT	0	0	60	0	1	5	0	0	H
71	B0690	ACRI	INSCT	0	0	50	0	0	2	4	2	H
65	B0691	ACRI	INSCT	0	0	30	0	1	4	1	0	H
17	B0692	ACRI	INSCT	0	0	100	0	1	0	5	0	H
53	B0693	ACRI	INSCT	0	0	110	0	0	0	6	0	H
61	B0694	ACRI	INSCT	0	0	70	0	1	4	1	2	H
132	B0704	ACRI	INSCT	0	0	870	0	0	0	1	0	H
77	B0708	ACRI	INSCT	0	0	70	0	2	1	3	0	H
148	B0709	ACRI	INSCT	0	0	45	0	0	3	3	0	H
134	B0744	ACRI	INSCT	0	0	440	0	0	0	1	0	H
133	B0746	ACRI	INSCT	0	0	990	0	0	0	1	0	H
37	B0868	ACRI	INSCT	0	0	450	0	0	0	6	0	H
17	B1368	ACRI	INSCT	0	0	100	0	1	0	5	2	H
31	B1369	ACRI	INSCT	0	0	220	0	2	2	2	2	H
29	B1370	ACRI	INSCT	0	0	190	0	5	1	0	2	G
77	B1373	ACRI	INSCT	0	0	70	0	2	1	3	2	H

TABLE 2. RESULTS OF SCREENING AND WEIGHTING PROCEDURE FOR ALDRIN PLUS DIELDRIN

Loc.	ID No.	Spec.	Group	# of Samples HRER	# of Samples HRER/2	Distance to Nearest Soil Sample (ft)	BCRLs within HR circle	Number of Samples Having Hits w/in Search Radius: 2 hits	1 hit	0 hits	# of Tissue Hits	Rank
27	B1377	ACRI	INSCT	0	0	20	0	2	2	2	2	G
104	B1386	ACRI	INSCT	0	0	180	0	1	0	5	2	H
97	B1387	ACRI	INSCT	0	0	160	0	1	2	3	2	H
122	B1492	ACRI	INSCT	0	0	40	0	3	2	1	2	F
53	B1493	ACRI	INSCT	0	0	110	0	0	0	6	2	H
65	B1494	ACRI	INSCT	0	0	30	0	1	4	1	2	H
71	B1495	ACRI	INSCT	0	0	50	0	0	2	4	2	H
51	B1496	ACRI	INSCT	0	0	60	0	1	5	0	2	H
127	B1498	ACRI	INSCT	0	0	225	0	3	0	3	2	H
106	B1499	ACRI	INSCT	0	0	110	0	3	0	3	2	H
61	B1500	ACRI	INSCT	0	0	70	0	1	4	1	2	H
132	B1504	ACRI	INSCT	0	0	870	0	0	0	1	0	H
34	B1512	ACRI	INSCT	0	0	340	0	0	1	5	0	H
37	B1513	ACRI	INSCT	0	0	450	0	0	0	6	0	H
15	B1514	ACRI	INSCT	0	0	40	0	2	1	3	0	H
16	B1515	ACRI	INSCT	0	0	30	0	0	0	6	0	H
74	B1518	ACRI	INSCT	0	0	70	0	4	1	1	2	H
75	B1519	ACRI	INSCT	0	0	40	0	1	3	2	0	H
117	B1520	ACRI	INSCT	0	0	80	0	2	2	2	0	H
133	B1521	ACRI	INSCT	0	0	990	0	0	0	1	0	H
134	B1522	ACRI	INSCT	0	0	440	0	0	0	1	0	H
119	B1533	ACRI	INSCT	0	0	70	0	2	1	3	2	H
79	B1594	ACRI	INSCT	0	0	380	0	2	0	4	0	H
141	B1595	ACRI	INSCT	0	0	90	0	4	0	2	0	H
148	B1612	ACRI	INSCT	0	0	45	0	0	3	3	0	H
136	B1613	ACRI	INSCT	0	0	180	0	1	0	5	0	H
63	129	ACRI	INSCT	0	0	80	0	4	0	2	0	H

TABLE 2. RESULTS OF SCREENING AND WEIGHTING PROCEDURE FOR ALDRIN PLUS DIELDRIN

Loc.	ID No.	Spec.	Group	# of Samples HRER	# of Samples HRER/2	Distance to Nearest Soil Sample (ft)	BCRLs within HR circle	Number of Samples Having Hits w/in Search Radius: 2 hits	1 hit	0 hits	# of Tissue Hits	Rank
63	418	ACRI	INSCT	0	0	80	0	4	0	2	0	H
63	419	ACRI	INSCT	0	0	80	0	4	0	2	0	H
63	483	ACRI	INSCT	0	0	80	0	4	0	2	0	H
23	488	ACRI	INSCT	0	0	180	0	2	2	2	0	H
22	489	ACRI	INSCT	0	0	290	0	2	3	1	0	H
22	490	ACRI	INSCT	0	0	290	0	2	3	1	0	H
23	491	ACRI	INSCT	0	0	180	0	2	2	2	0	H
97	B0789	COLE	INSCT	0	0	160	0	1	2	3	2	H
128	B0790	COLE	INSCT	0	0	160	0	2	1	3	2	H
61	B0791	COLE	INSCT	0	0	70	0	1	4	1	2	H
134	B0793	COLE	INSCT	0	0	440	0	0	0	1	0	H
5	B0794	COLE	INSCT	0	0	240	0	0	1	5	2	G
17	B0808	COLE	INSCT	0	0	100	0	1	0	5	2	H
65	B0809	COLE	INSCT	0	0	30	0	1	4	1	2	H
130	B0818	COLE	INSCT	0	0	740	0	0	0	4	2	H
29	B0819	COLE	INSCT	0	0	190	0	5	1	0	2	G
141	B0820	COLE	INSCT	0	0	90	0	4	0	2	0	H
51	B1030	COLE	INSCT	0	0	60	0	1	5	0	2	H
17	B1649	COLE	INSCT	0	0	100	0	1	0	5	2	H
5	B1667	COLE	INSCT	0	0	240	0	0	1	5	0	H
61	B1668	COLE	INSCT	0	0	70	0	1	4	1	2	H
51	B1669	COLE	INSCT	0	0	60	0	1	5	0	2	H
97	B1670	COLE	INSCT	0	0	160	0	1	2	3	0	H
51	B0067	CYLU	MDMML	1	0	60	1/2	1	5	0	0	H
53	B0068	CYLU	MDMML	0	0	110	0	0	0	6	2	H
53	B0072	CYLU	MDMML	0	0	110	0	0	0	6	0	H
51	B0073	CYLU	MDMML	1	0	60	1/2	1	5	0	2	H

TABLE 2. RESULTS OF SCREENING AND WEIGHTING PROCEDURE FOR ALDRIN PLUS DIELDRIN

Loc.	ID No.	Spec.	Group	# of Samples HRER	# of Samples HRER/2	Distance to Nearest Soil Sample (ft)	BCRLs within HR circle	Number of Samples Having Hits w/in Search Radius: 2 hits	1 hit	0 hits	# of Tissue Hits	Rank
67	B0074	CYLU	MDMML	2	1	45	3/4	0	5	1	2	H
67	B0075	CYLU	MDMML	2	1	45	3/4	0	5	1	2	H
106	B0076	CYLU	MDMML	0	0	110	0	3	0	3	2	H
108	B0077	CYLU	MDMML	0	0	105	0	3	0	3	0	H
105	B0080	CYLU	MDMML	0	0	210	0	3	0	3	2	H
20	B0101	CYLU	MDMML	0	0	260	0	3	2	1	0	H
96	B0102	CYLU	MDMML	1	1	40	0/2	2	2	2	2	F
95	B0103	CYLU	MDMML	1	0	60	0/2	2	2	2	2	F
59	B0326	CYLU	MDMML	1	1	0	1/2	1	4	1	0	H
59	B0327	CYLU	MDMML	1	1	0	1/2	1	4	1	2	F
58	B0328	CYLU	MDMML	1	1	0	1/2	0	5	1	2	F
57	B0329	CYLU	MDMML	2	1	0	2/4	0	5	1	2	F
57	B0330	CYLU	MDMML	2	1	0	2/4	0	5	1	2	F
13	B0331	CYLU	MDMML	0	0	356	0	0	0	5	2	H
69	B0332	CYLU	MDMML	2	1	30	1/4	2	2	2	2	F
48	B0333	CYLU	MDMML	1	1	0	1/2	0	5	1	2	F
43	B0334	CYLU	MDMML	0	0	150	0	1	1	4	2	H
40	B0335	CYLU	MDMML	4	0	90	8/8	0	1	5	2	G
41	B0336	CYLU	MDMML	2	1	40	4/4	0	2	4	2	H
41	B0337	CYLU	MDMML	2	1	40	4/4	0	2	4	2	H
9	B0338	CYLU	MDMML	0	0	160	0	0	0	6	2	H
88	B0339	CYLU	MDMML	2	1	0	3/4	1	3	2	2	F
47	B0340	CYLU	MDMML	5	4	10	5/10	0	6	0	2	D
84	B0341	CYLU	MDMML	1	1	0	0/2	0	2	4	2	H
54	B0342	CYLU	MDMML	2	1	0	2/4	0	4	2	2	F
94	B0343	CYLU	MDMML	1	1	0	1/2	1	3	2	2	F
104	B0532	CYLU	MDMML	0	0	180	0	1	0	5	2	H

TABLE 2. RESULTS OF SCREENING AND WEIGHTING PROCEDURE FOR ALDRIN PLUS DIELDRIN

Loc.	ID No.	Spec.	Group	# of Samples HRER	# of Samples HRER/2	Distance to Nearest Soil Sample (ft)	BCRLs within HR circle	Number of Samples Having Hits w/in Search Radius: 2 hits	1 hit	0 hits	# of Tissue Hits	Rank
104	B0533	CYLU	MDMML	0	0	180	0	1	0	5	2	H
97	B0534	CYLU	MDMML	0	0	160	0	1	2	3	0	H
31	B0537	CYLU	MDMML	0	0	220	0	2	2	2	2	H
53	B0538	CYLU	MDMML	0	0	110	0	0	0	6	2	H
53	B0539	CYLU	MDMML	0	0	110	0	0	0	6	2	H
53	B0540	CYLU	MDMML	0	0	110	0	0	0	6	2	H
51	B0582	CYLU	MDMML	1	0	60	1/2	1	5	0	2	H
51	B0583	CYLU	MDMML	1	0	60	1/2	1	5	0	2	H
51	B0584	CYLU	MDMML	1	0	60	1/2	1	5	0	2	H
109	B0585	CYLU	MDMML	0	0	210	0	3	0	3	2	H
101	B0715	CYLU	MDMML	0	0	150	0	3	0	3	0	H
101	B0716	CYLU	MDMML	0	0	150	0	3	0	3	2	H
101	B0717	CYLU	MDMML	0	0	150	0	3	0	3	0	H
101	B0718	CYLU	MDMML	0	0	150	0	3	0	3	2	H
97	B0724	CYLU	MDMML	0	0	160	0	1	2	3	2	H
98	B0727	CYLU	MDMML	0	0	210	0	1	2	3	2	H
31	B0729	CYLU	MDMML	0	0	220	0	2	2	2	2	H
30	B0731	CYLU	MDMML	0	0	110	0	3	3	0	2	G
104	B0732	CYLU	MDMML	0	0	180	0	1	0	5	2	H
160	B0755	CYLU	MDMML	0	0	330	0	1	0	5	2	H
101	B0756	CYLU	MDMML	0	0	150	0	3	0	3	2	H
30	B0757	CYLU	MDMML	0	0	110	0	3	3	0	2	G
103	B0758	CYLU	MDMML	1	1	40	0/2	2	0	4	2	F
161	B0759	CYLU	MDMML	0	0	380	0	0	0	6	2	H
51	B0772	CYLU	MDMML	1	0	60	1/2	1	5	0	2	H
51	B0773	CYLU	MDMML	1	0	60	1/2	1	5	0	2	H
53	B0774	CYLU	MDMML	0	0	110	0	0	0	6	2	H

TABLE 2. RESULTS OF SCREENING AND WEIGHTING PROCEDURE FOR ALDRIN PLUS DIELDRIN

Loc.	ID No.	Spec.	Group	# of Samples HRER	# of Samples HRER/2	Distance to Nearest Soil Sample (ft)	BCRLs within HR circle	Number of Samples Having Hits w/in Search Radius: 2 hits	1 hit	0 hits	# of Tissue Hits	Rank
53	B0775	CYLU	MDMML	0	0	110	0	0	0	6	2	H
162	B0776	CYLU	MDMML	0	0	290	0	0	0	6	2	H
164	B0788	CYLU	MDMML	0	0	300	0	0	1	5	0	H
30	B1312	CYLU	MDMML	0	0	110	0	3	3	0	2	G
30	B1313	CYLU	MDMML	0	0	110	0	3	3	0	2	G
30	B1315	CYLU	MDMML	0	0	110	0	3	3	0	2	G
30	B1318	CYLU	MDMML	0	0	110	0	3	3	0	2	G
97	B1319	CYLU	MDMML	0	0	160	0	1	2	3	0	H
97	B1323	CYLU	MDMML	0	0	160	0	1	2	3	2	H
97	B1324	CYLU	MDMML	0	0	160	0	1	2	3	2	H
32	B1325	CYLU	MDMML	1	0	90	0	2	0	4	2	F
32	B1326	CYLU	MDMML	1	0	90	0	2	0	4	2	F
97	B1329	CYLU	MDMML	0	0	160	0	1	2	3	2	H
104	B1330	CYLU	MDMML	0	0	180	0	1	0	5	2	H
12	B1332	CYLU	MDMML	1	1	30	2/2	1	0	5	0	H
81	B1333	CYLU	MDMML	0	0	240	0	1	0	5	2	H
49	B1335	CYLU	MDMML	0	0	180	0	2	3	1	0	H
100	B1340	CYLU	MDMML	0	0	170	0	5	0	1	2	G
100	B1341	CYLU	MDMML	0	0	170	0	5	0	1	2	G
44	B1342	CYLU	MDMML	0	0	210	0	0	4	2	2	H
46	B1343	CYLU	MDMML	1	0	90	1/2	0	6	0	0	H
100	B1348	CYLU	MDMML	0	0	170	0	5	0	1	2	G
83	B1350	CYLU	MDMML	0	0	310	0	1	0	5	2	H
45	B1351	CYLU	MDMML	0	0	220	0	1	3	2	0	H
86	B1359	CYLU	MDMML	1	1	30	0/2	2	0	4	2	F
82	B1360	CYLU	MDMML	0	0	250	0	1	0	5	2	H
87	B1361	CYLU	MDMML	1	0	80	0/2	0	0	6	2	H

TABLE ... RESULTS OF SCREENING AND WEIGHTING PROCEDURE FOR ALDRIN PLUS DIELDRIN

Loc.	ID No.	Spec.	Group	# of Samples HRER	# of Samples HRER/2	Distance to Nearest Soil Sample (ft)	BCRLs within HR circle	Number of Samples Having Hits w/in Search Radius: 2 hits	1 hit	0 hits	# of Tissue Hits	Rank
85	B1362	CYLU	MDMML	0	0	150	0	2	1	3	2	H
104	B1363	CYLU	MDMML	0	0	180	0	1	0	5	0	H
163	B1364	CYLU	MDMML	0	0	200	0	1	0	5	2	F
11	B1365	CYLU	MDMML	0	0	160	0	2	0	4	0	H
16	B1366	CYLU	MDMML	5	2	30	6/10	0	0	6	0	H
110	B1371	CYLU	MDMML	0	0	290	0	2	0	4	0	H
10	B1378	CYLU	MDMML	0	0	170	0	0	0	6	0	H
111	B1389	CYLU	MDMML	0	0	360	0	2	0	4	0	H
109	B1390	CYLU	MDMML	0	0	210	0	3	0	3	2	H
39	64	CYLU	MDMML	1	0	60	1/2	2	1	3	0	H
39	65	CYLU	MDMML	1	0	60	1/2	2	1	3	0	H
39	120	CYLU	MDMML	1	0	60	1/2	2	1	3	0	H
39	153	CYLU	MDMML	1	0	60	1/2	2	1	3	0	H
39	154	CYLU	MDMML	1	0	60	1/2	2	1	3	0	H
39	155	CYLU	MDMML	1	0	60	1/2	2	1	3	0	H
39	156	CYLU	MDMML	1	0	60	1/2	2	1	3	0	H
39	157	CYLU	MDMML	1	0	60	1/2	2	1	3	0	H
39	158	CYLU	MDMML	1	0	60	1/2	2	1	3	0	H
8	231	CYLU	MDMML	0	0	560	0	0	1	3	0	H
8	232	CYLU	MDMML	0	0	560	0	0	1	3	0	H
4	242	CYLU	MDMML	0	0	340	0	0	1	5	0	H
4	243	CYLU	MDMML	0	0	340	0	0	1	5	0	H
4	244	CYLU	MDMML	0	0	340	0	0	1	5	0	H
8	259	CYLU	MDMML	0	0	560	0	0	1	3	0	H
2	260	CYLU	MDMML	0	0	210	0	0	1	4	0	H
2	261	CYLU	MDMML	0	0	210	0	0	1	4	0	H
8	399	CYLU	MDMML	0	0	560	0	0	1	3	0	H

TABLE 2. RESULTS OF SCREENING AND WEIGHTING PROCEDURE FOR ALDRIN PLUS DIELDRIN

Loc.	ID No.	Spec.	Group	# of Samples HRER	# of Samples HRER/2	Distance to Nearest Soil Sample (ft)	BCRLs within HR circle	Number of Samples Having Hits w/in Search Radius: 2 hits	1 hit	0 hits	# of Tissue Hits	Rank
2	400	CYLU	MDMML	0	0	210	0	0	1	4	0	H
2	401	CYLU	MDMML	0	0	210	0	0	1	4	0	H
2	402	CYLU	MDMML	0	0	210	0	0	1	4	0	H
2	403	CYLU	MDMML	0	0	210	0	0	1	4	0	H
2	404	CYLU	MDMML	0	0	210	0	0	1	4	0	H
35	405	CYLU	MDMML	0	0	290	0	1	1	4	0	H
35	406	CYLU	MDMML	0	0	290	0	1	1	4	0	H
35	407	CYLU	MDMML	0	0	290	0	1	1	4	0	H
35	408	CYLU	MDMML	0	0	290	0	1	1	4	0	H
35	409	CYLU	MDMML	0	0	290	0	1	1	4	0	H
39	410	CYLU	MDMML	1	0	60	1/2	2	1	3	0	H
39	411	CYLU	MDMML	1	0	60	1/2	2	1	3	0	H
39	412	CYLU	MDMML	1	0	60	1/2	2	1	3	0	H
39	413	CYLU	MDMML	1	0	60	1/2	2	1	3	0	H
39	414	CYLU	MDMML	1	0	60	1/2	2	1	3	0	H
70	B0085	SYAU	MDMML	34	6	70	46/68	1	1	4	0	H
60	B0086	SYAU	MDMML	19	5	20	11/38	1	5	0	2	H
123	B0087	SYAU	MDMML	7	3	80	4/14	4	1	1	2	H
66	B0088	SYAU	MDMML	18	4	70	19/36	0	5	1	2	H
24	B0089	SYAU	MDMML	1	0	240	0/2	2	2	2	2	H
157	B0095	SYAU	MDMML	0	0	450	0	0	1	5	2	H
143	B0096	SYAU	MDMML	0	0	470	0	1	0	5	0	H
26	B0097	SYAU	MDMML	2	0	220	0/4	1	2	3	2	F
107	B0098	SYAU	MDMML	2	1	105	2/4	3	0	3	2	H
143	B0099	SYAU	MDMML	0	0	470	0	1	0	5	2	H
144	B0100	SYAU	MDMML	0	0	420	0	2	0	4	0	H
42	B0501	SYAU	MDMML	34	13	0	62/68	0	2	4	0	H

TABLE 2. RESULTS OF SCREENING AND WEIGHTING PROCEDURE FOR ALDRIN PLUS DIELDRIN

Loc.	ID No.	Spec.	Group	# of Samples HRER	# of Samples HRER/2	Distance to Nearest Soil Sample (ft)	BCRLs within HR circle	Number of Samples Having Hits w/in Search Radius: 2 hits	1 hit	0 hits	# of Tissue Hits	Rank
50	B0502	SYAU	MDMML	17	8	10	25/34	0	1	5	0	H
50	B0503	SYAU	MDMML	17	8	10	25/34	0	1	5	0	H
2	128	SYAU	MDMML	0	0	210	0	0	1	4	0	H
2	271	SYAU	MDMML	1	0	210	0/2	0	1	4	0	H
64	274	SYAU	MDMML	8	3	120	2/16	6	0	0	0	H
64	277	SYAU	MDMML	8	3	120	2/16	6	0	0	0	H
64	288	SYAU	MDMML	8	3	120	2/16	6	0	0	0	H
64	291	SYAU	MDMML	8	3	120	2/16	6	0	0	0	H
64	294	SYAU	MDMML	8	3	120	2/16	6	0	0	0	H
64	297	SYAU	MDMML	8	3	120	2/16	6	0	0	0	H
64	300	SYAU	MDMML	8	3	120	2/16	6	0	0	0	H
2	303	SYAU	MDMML	1	0	210	0/2	0	1	4	0	H
140	B1306	CHVO	SHBRD	9	8	40	14/18	1	2	3	2	H
140	B1307	CHVO	SHBRD	9	8	40	14/18	1	2	3	2	H
155	B1309	CHVO	SHBRD	0	0	530	0	1	0	5	2	H
156	B1310	CHVO	SHBRD	0	0	490	0	1	0	5	2	H
156	B1317	CHVO	SHBRD	0	0	490	0	1	0	5	2	H
25	B1327	POGR	SMBRD	0	0	280	0	1	2	3	2	H
126	B1344	POGR	SMBRD	0	0	220	0	1	2	3	2	H
51	B1357	POGR	SMBRD	2	1	60	2/4	1	5	0	2	H
52	B1358	POGR	SMBRD	5	1	60	7/10	0	4	2	0	H
153	B1411	POGR	SMBRD	0	0	340	0	2	0	4	0	H
97	B0719	STNE	SMBRD	22	4	160	28/44	1	2	3	2	C
97	B0720	STNE	SMBRD	22	4	160	28/44	1	2	3	2	C
97	B0721	STNE	SMBRD	22	4	160	28/44	1	2	3	2	C
30	B0736	STNE	SMBRD	6	3	110	3/12	3	3	0	2	B
30	B0742	STNE	SMBRD	6	3	110	3/12	3	3	0	2	B

TABLE 2. RESULTS OF SCREENING AND WEIGHTING PROCEDURE FOR ALDRIN PLUS DIELDRIN

Loc.	ID No.	Spec.	Group	# of Samples HRER	# of Samples HRER/2	Distance to Nearest Soil Sample (ft)	BCRLs within HR circle	Number of Samples Having Hits w/in Search Radius: 2 hits	1 hit	0 hits	# of Tissue Hits	Rank
19	B1382	STNE	SMBRD	2	0	280	0/4	3	2	1	2	F
19	B1383	STNE	SMBRD	2	0	280	0/4	3	2	1	2	F
148	B1388	STNE	SMBRD	17	7	45	26/34	0	3	3	2	C
150	B1408	STNE	SMBRD	1	1	80	2/2	0	2	4	0	H
17	B1409	STNE	SMBRD	6	2	100	10/12	1	0	5	2	H
147	B0637	ZEMA	SMBRD	28	2	130	38/56	0	3	3	0	H
152	B0638	ZEMA	SMBRD	23	17	80	32/46	2	0	4	0	H
151	B0639	ZEMA	SMBRD	25	13	20	38/50	1	0	5	0	H
102	B0640	ZEMA	SMBRD	25	8	50	44/50	0	0	6	2	F
27	B0641	ZEMA	SMBRD	47	9	20	31/94	2	2	2	2	H
16	B0648	ZEMA	SMBRD	48	23	30	33/46	0	0	6	2	C
16	B0649	ZEMA	SMBRD	48	23	30	33/46	0	0	6	2	C
72	B0650	ZEMA	SMBRD	103	36	40	52/72	1	3	2	0	H
74	B0651	ZEMA	SMBRD	132	35	70	43/70	4	1	1	2	H
104	B0652	ZEMA	SMBRD	15	3	180	20/36	1	0	5	2	C
74	B0653	ZEMA	SMBRD	132	35	70	43/70	4	1	1	2	H
122	B0654	ZEMA	SMBRD	35	8	40	27/70	3	2	1	2	H
137	B0730	ZEMA	SMBRD	5	1	330	9/10	1	0	5	2	G
17	B0735	ZEMA	SMBRD	12	7	100	10/24	1	0	5	2	A
17	B0738	ZEMA	SMBRD	12	7	100	10/24	1	0	5	2	A
135	B0739	ZEMA	SMBRD	15	5	225	27/30	0	1	5	0	H
17	B0740	ZEMA	SMBRD	12	7	100	10/24	1	0	5	2	A
17	B0743	ZEMA	SMBRD	12	7	100	10/24	1	0	5	2	A
61	B0768	ZEMA	SMBRD	68	24	70	57/136	1	4	1	2	H
61	B0769	ZEMA	SMBRD	68	24	70	57/136	1	4	1	2	H
61	B0770	ZEMA	SMBRD	68	24	70	57/136	1	4	1	0	H
61	B0771	ZEMA	SMBRD	68	24	70	57/136	1	4	1	2	H

TABLE 2. RESULTS OF SCREENING AND WEIGHTING PROCEDURE FOR ALDRIN PLUS DIELDRIN

Loc.	ID No.	Spec.	Group	# of Samples HRER	# of Samples HRER/2	Distance to Nearest Soil Sample (ft)	BCRLs within HR circle	Number of Samples Having Hits w/in Search Radius: 2 hits	1 hit	0 hits	# of Tissue Hits	Rank
122	B0784	ZEMA	SMBRD	35	8	40	27/70	3	2	1	2	H
76	B0785	ZEMA	SMBRD	79	37	50	41/74	2	0	4	0	H
76	B0786	ZEMA	SMBRD	79	37	50	41/74	2	0	4	2	H
122	B0787	ZEMA	SMBRD	35	8	40	27/70	3	2	1	2	A
75	B0916	ZEMA	SMBRD	107	37	40	43/74	1	3	2	2	C
17	B0917	ZEMA	SMBRD	12	7	100	10/24	1	0	5	2	A
17	B0918	ZEMA	SMBRD	12	7	100	10/24	1	0	5	0	H
75	B0919	ZEMA	SMBRD	107	37	40	43/74	1	3	2	2	H
75	B0920	ZEMA	SMBRD	107	37	40	43/74	1	3	2	0	H
61	B0921	ZEMA	SMBRD	68	24	70	57/136	1	4	1	2	H
61	B0922	ZEMA	SMBRD	68	24	70	57/136	1	4	1	0	H
124	B0940	ZEMA	SMBRD	15	9	150	14/30	4	1	1	2	H
124	B0941	ZEMA	SMBRD	15	9	150	14/30	4	1	1	0	H
91	B1005	ZEMA	SMBRD	85	25	50	44/100	0	2	4	0	H
74	B1006	ZEMA	SMBRD	132	35	70	43/70	4	1	1	2	H
92	B1007	ZEMA	SMBRD	85	25	80	44/50	0	2	4	2	H
27	B1384	ZEMA	SMBRD	47	9	20	31/94	2	2	2	2	H
74	B1396	ZEMA	SMBRD	132	35	70	43/70	4	1	1	2	H
77	B1397	ZEMA	SMBRD	23	14	70	31/46	2	1	3	0	H
146	B1406	ZEMA	SMBRD	14	1	490	19/28	2	0	4	0	H
145	B1407	ZEMA	SMBRD	5	0	450	8/10	2	0	4	0	H
149	B1410	ZEMA	SMBRD	12	2	420	19/24	0	3	3	2	C
74	B1416	ZEMA	SMBRD	132	35	70	43/70	4	1	1	2	H
90	B1417	ZEMA	SMBRD	85	25	35	44/50	0	1	5	0	H
118	B1418	ZEMA	SMBRD	70	10	240	10/20	2	1	3	2	H
118	B1419	ZEMA	SMBRD	70	10	240	10/20	2	1	3	2	H
154	B1420	ZEMA	SMBRD	9	2	160	14/18	1	0	5	2	D

TABLE 2. RESULTS OF SCREENING AND WEIGHTING PROCEDURE FOR ALDRIN PLUS DIELDRIN

Loc.	ID No.	Spec.	Group	# of Samples HRER	# of Samples HRER/2	Distance to Nearest Soil Sample (ft)	BCRLs within HR circle	Number of Samples Having Hits w/in Search Radius: 2 hits	1 hit	0 hits	# of Tissue Hits	Rank
125	B1443	ZEMA	SMBRD	18	2	160	23/36	2	1	3	2	C
21	B1444	ZEMA	SMBRD	23	7	160	14/46	1	4	1	2	H
21	B1445	ZEMA	SMBRD	23	7	160	14/46	1	4	1	2	H
21	B1446	ZEMA	SMBRD	23	7	160	14/46	1	4	1	2	H
21	B1447	ZEMA	SMBRD	23	7	160	14/46	1	4	1	2	H
122	B1448	ZEMA	SMBRD	35	8	40	27/70	3	2	1	0	H
159	B1489	ZEMA	SMBRD	15	2	320	28/30	1	0	5	0	H
62	B1497	ZEMA	SMBRD	69	11	180	75/138	3	1	2	2	C
71	B1501	ZEMA	SMBRD	200	59	50	50/118	0	2	4	2	H
121	B1502	ZEMA	SMBRD	41	8	140	30/82	2	1	3	2	H
109	B1503	ZEMA	SMBRD	9	3	210	7/18	3	0	3	2	B
71	B1505	ZEMA	SMBRD	200	59	50	50/118	0	2	4	2	H
127	B1506	ZEMA	SMBRD	0	0	225	0	3	0	3	0	H
61	B1507	ZEMA	SMBRD	68	24	70	57/136	1	4	1	2	H
71	B1508	ZEMA	SMBRD	200	59	50	50/118	0	2	4	2	A
38	B1509	ZEMA	SMBRD	9	3	10	16/18	0	0	6	0	H
93	B1510	ZEMA	SMBRD	5	0	550	0/10	0	0	6	0	H
33	B1511	ZEMA	SMBRD	9	0	450	17/18	0	1	5	0	H
158	B1516	ZEMA	SMBRD	8	1	270	14/16	1	0	5	0	H
1	B0013	PEMA	SMMML	0	0	820	0	0	1	2	2	H
3	B0015	PEMA	SMMML	0	0	560	0	0	0	3	0	H
127	B0018	PEMA	SMMML	0	0	225	0	3	0	3	2	H
122	B0037	PEMA	SMMML	1	1	40	0/2	3	2	1	2	H
78	B0041	PEMA	SMMML	0	0	140	0	3	0	3	2	H
142	B0042	PEMA	SMMML	2	0	80	2/4	3	0	3	2	H
119	B0047	PEMA	SMMML	1	0	70	1/2	2	1	3	0	H
29	B0052	PEMA	SMMML	0	0	190	0	5	1	0	2	H

TABLE 2. RESULTS OF SCREENING AND WEIGHTING PROCEDURE FOR ALDRIN PLUS DIELDRIN

Loc.	ID No.	Spec.	Group	# of Samples HRER	# of Samples HRER/2	Distance to Nearest Soil Sample (ft)	BCRLs within HR circle	Number of Samples Having Hits w/in Search Radius: 2 hits	1 hit	0 hits	# of Tissue Hits	Rank
97	B0056	PEMA	SMMML	0	0	160	0	1	2	3	2	H
27	B0057	PEMA	SMMML	1	1	20	2/2	2	2	2	2	F
74	B0059	PEMA	SMMML	2	0	70	2/4	4	1	1	2	H
61	B0060	PEMA	SMMML	3	0	70	4/6	1	4	1	2	H
51	B0061	PEMA	SMMML	1	0	60	1/2	1	5	0	2	H
79	B0063	PEMA	SMMML	0	0	380	0	2	0	4	2	H
71	B0064	PEMA	SMMML	3	0	50	6/6	0	2	4	2	H
148	B0066	PEMA	SMMML	2	1	45	1/4	0	3	3	2	F
53	B0070	PEMA	SMMML	0	0	110	0	0	0	6	2	H
77	B0071	PEMA	SMMML	1	0	70	0/2	2	1	3	2	H
17	B0081	PEMA	SMMML	1	0	100	2/2	1	0	5	2	H
5	B0082	PEMA	SMMML	0	0	240	0	0	1	5	0	H
109	B0083	PEMA	SMMML	0	0	210	0	3	0	3	2	H
131	B0084	PEMA	SMMML	0	0	750	0	0	0	1	0	H
128	B0094	PEMA	SMMML	0	0	160	0	2	1	3	0	H
134	B0479	PEMA	SMMML	0	0	440	0	0	0	1	0	H
127	B0528	PEMA	SMMML	0	0	225	0	3	0	3	2	H
122	B0529	PEMA	SMMML	1	1	40	0/2	3	2	1	2	H
141	B0541	PEMA	SMMML	1	0	90	0/2	4	0	2	0	H
77	B0542	PEMA	SMMML	0	0	70	0	2	1	3	2	H
119	B0545	PEMA	SMMML	1	0	70	1/2	2	1	3	2	H
104	B0546	PEMA	SMMML	0	0	180	0	1	0	5	2	H
3	B0547	PEMA	SMMML	0	0	560	0	0	0	3	0	H
97	B0548	PEMA	SMMML	0	0	160	0	1	2	3	2	H
5	B0549	PEMA	SMMML	0	0	240	0	0	1	5	0	H
74	B0551	PEMA	SMMML	2	0	70	2/4	4	1	1	2	H
117	B0556	PEMA	SMMML	1	0	80	1/2	2	2	2	2	H

TABLE 2. RESULTS OF SCREENING AND WEIGHTING PROCEDURE FOR ALDRIN PLUS DIELDRIN

Loc.	ID No.	Spec.	Group	# of Samples HRER	# of Samples HRER/2	Distance to Nearest Soil Sample (ft)	BCRLs within HR circle	Number of Samples Having Hits w/in Search Radius: 2 hits	1 hit	0 hits	# of Tissue Hits	Rank
128	B0557	PEMA	SMMML	0	0	160	0	2	1	3	0	H
75	B0558	PEMA	SMMML	3	1	40	2/6	1	3	2	2	F
109	B0559	PEMA	SMMML	0	0	210	0	3	0	3	2	H
134	B0562	PEMA	SMMML	0	0	440	0	0	0	1	0	H
31	B0565	PEMA	SMMML	0	0	220	0	2	2	2	2	H
27	B0566	PEMA	SMMML	1	1	20	2/2	2	2	2	2	F
79	B0567	PEMA	SMMML	0	0	380	0	2	0	4	2	H
29	B0568	PEMA	SMMML	0	0	190	0	5	1	0	2	H
133	B0569	PEMA	SMMML	0	0	990	0	0	0	1	0	H
61	B0578	PEMA	SMMML	3	0	70	4/6	1	4	1	2	H
71	B0581	PEMA	SMMML	3	0	50	6/6	0	2	4	2	H
65	B0587	PEMA	SMMML	2	1	30	3/4	1	4	1	0	H
130	B0589	PEMA	SMMML	0	0	740	0	0	0	4	0	H
51	B0590	PEMA	SMMML	1	0	60	1/2	1	5	0	2	H
16	B0604	PEMA	SMMML	5	2	30	6/10	0	0	6	2	D
15	B0605	PEMA	SMMML	3	1	40	1/6	2	1	3	0	H
34	B0609	PEMA	SMMML	0	0	340	0	0	1	5	0	H
37	B0611	PEMA	SMMML	0	0	450	0	0	0	6	0	H
36	B0615	PEMA	SMMML	0	0	350	0	4	0	2	0	H
148	B0616	PEMA	SMMML	2	1	45	1/4	0	3	3	2	F
29	B1215	PEMA	SMMML	0	0	190	0	5	1	0	2	H
3	B1216	PEMA	SMMML	0	0	560	0	0	0	3	0	H
17	B1217	PEMA	SMMML	1	0	100	2/2	1	0	5	2	H
109	B1218	PEMA	SMMML	0	0	210	0	3	0	3	2	H
27	B1219	PEMA	SMMML	1	1	20	2/2	2	2	2	2	F
5	B1220	PEMA	SMMML	0	0	240	0	0	1	5	0	H
74	B1221	PEMA	SMMML	2	0	70	2/4	4	1	1	2	H

TABLE 2. RESULTS OF SCREENING AND WEIGHTING PROCEDURE FOR ALDRIN PLUS DIELDRIN

Loc.	ID No.	Spec.	Group	# of Samples HRER	# of Samples HRER/2	Distance to Nearest Soil Sample (ft)	BCRLs within HR circle	Number of Samples Having Hits w/in Search Radius: 2 hits	1 hit	0 hits	# of Tissue Hits	Rank
75	B1222	PEMA	SMMML	3	1	40	2/6	1	3	2	2	F
119	B1223	PEMA	SMMML	1	0	70	1/2	2	1	3	2	F
127	B1224	PEMA	SMMML	0	0	225	0	3	0	3	2	H
97	B1225	PEMA	SMMML	0	0	160	0	1	2	3	2	H
122	B1226	PEMA	SMMML	1	1	40	0/2	3	2	1	2	C
141	B1227	PEMA	SMMML	1	0	90	0/2	4	0	2	2	H
117	B1228	PEMA	SMMML	1	0	80	1/2	2	2	2	2	H
77	B1229	PEMA	SMMML	1	0	70	0/2	2	1	3	2	H
79	B1230	PEMA	SMMML	0	0	380	0	2	0	4	2	H
134	B1231	PEMA	SMMML	0	0	440	0	0	0	1	2	H
104	B1235	PEMA	SMMML	0	0	180	0	1	0	5	2	H
136	B1240	PEMA	SMMML	0	0	180	0	1	0	5	2	H
30	B1245	PEMA	SMMML	0	0	110	0	3	3	0	2	G
16	B1253	PEMA	SMMML	5	2	30	6/10	0	0	6	0	H
15	B1254	PEMA	SMMML	3	1	40	1/6	2	1	3	2	F
37	B1289	PEMA	SMMML	0	0	450	0	0	0	6	0	H
51	B1292	PEMA	SMMML	1	0	60	1/2	1	5	0	2	H
36	B1293	PEMA	SMMML	0	0	350	0	4	0	2	0	H
34	B1294	PEMA	SMMML	0	0	340	0	0	1	5	2	H
133	B1295	PEMA	SMMML	0	0	990	0	0	0	1	0	H
61	B1297	PEMA	SMMML	3	0	70	4/6	1	4	1	2	F
71	B1298	PEMA	SMMML	3	0	50	6/6	0	2	4	2	H
130	B1299	PEMA	SMMML	0	0	740	0	0	0	4	0	H
148	B1300	PEMA	SMMML	2	1	45	1/4	0	3	3	2	F
53	B1303	PEMA	SMMML	0	0	110	0	0	0	6	2	H
65	B1328	PEMA	SMMML	2	1	30	3/4	1	4	1	2	F
65	B0478	SPTR	SMMML	2	1	30	3/4	1	4	1	2	H

TABLE 2. RESULTS OF SCREENING AND WEIGHTING PROCEDURE FOR ALDRIN PLUS DIELDRIN

Loc.	ID No.	Spec.	Group	# of Samples HRER	# of Samples HRER/2	Distance to Nearest Soil Sample (ft)	BCRLs within HR circle	Number of Samples Having Hits w/in Search Radius: 2 hits	1 hit	0 hits	# of Tissue Hits	Rank
31	B0480	SPTR	SMMML	0	0	220	0	2	2	2	2	H
58	B0497	SPTR	SMMML	2	1	0	2/4	0	5	1	2	F
132	B0019	BRTE	TRPLT	0	0	870	0	0	0	1	0	H
133	B0020	BRTE	TRPLT	0	0	990	0	0	0	1	0	H
1	B0021	BRTE	TRPLT	0	0	820	0	0	1	2	0	H
3	B0022	BRTE	TRPLT	0	0	560	0	0	0	3	0	H
6	B0023	BRTE	TRPLT	0	0	510	0	0	1	5	0	H
148	B0024	BRTE	TRPLT	0	0	45	0	0	3	3	0	H
141	B0026	BRTE	TRPLT	0	0	90	0	4	0	2	0	H
119	B0027	BRTE	TRPLT	0	0	70	0	2	1	3	1	H
75	B0028	BRTE	TRPLT	0	0	40	0	1	3	2	1	G
122	B0029	BRTE	TRPLT	0	0	40	0	3	2	1	2	F
127	B0030	BRTE	TRPLT	0	0	225	0	3	0	3	1	H
67	B0031	BRTE	TRPLT	0	0	45	0	0	5	1	0	H
61	B0032	BRTE	TRPLT	0	0	70	0	1	4	1	1	H
51	B0033	BRTE	TRPLT	0	0	60	0	1	5	0	1	G
29	B0036	BRTE	TRPLT	0	0	190	0	5	1	0	0	H
5	B0104	BRTE	TRPLT	0	0	240	0	0	1	5	0	H
130	B0105	BRTE	TRPLT	0	0	740	0	0	0	4	0	H
134	B0106	BRTE	TRPLT	0	0	440	0	0	0	1	0	H
17	B0107	BRTE	TRPLT	0	0	100	0	1	0	5	2	H
128	B0109	BRTE	TRPLT	0	0	160	0	2	1	3	0	H
128	B0269	BRTE	TRPLT	0	0	160	0	2	1	3	0	H
148	B0391	BRTE	TRPLT	0	0	45	0	0	3	3	0	H
3	B0570	BRTE	TRPLT	0	0	560	0	0	0	3	0	H
5	B0571	BRTE	TRPLT	0	0	240	0	0	1	5	0	H
130	B0572	BRTE	TRPLT	0	0	740	0	0	0	4	0	H

TABLE 2. RESULTS OF SCREENING AND WEIGHTING PROCEDURE FOR ALDRIN PLUS DIELDRIN

Loc.	ID No.	Spec.	Group	# of Samples HRER	# of Samples HRER/2	Distance to Nearest Soil Sample (ft)	BCRLs within HR circle	Number of Samples Having Hits w/in Search Radius: 2 hits	1 hit	0 hits	# of Tissue Hits	Rank
133	B0573	BRTE	TRPLT	0	0	990	0	0	0	1	0	H
134	B0574	BRTE	TRPLT	0	0	440	0	0	0	1	0	H
79	B0575	BRTE	TRPLT	0	0	380	0	2	0	4	0	H
77	B0576	BRTE	TRPLT	0	0	70	0	2	1	3	1	H
141	B0577	BRTE	TRPLT	0	0	90	0	4	0	2	1	G
128	B0592	BRTE	TRPLT	0	0	160	0	2	1	3	0	H
119	B0593	BRTE	TRPLT	0	0	70	0	2	1	3	1	H
117	B0594	BRTE	TRPLT	0	0	80	0	2	2	2	0	H
75	B0595	BRTE	TRPLT	0	0	40	0	1	3	2	1	H
104	B0596	BRTE	TRPLT	0	0	180	0	1	0	5	0	H
109	B0597	BRTE	TRPLT	0	0	210	0	3	0	3	1	H
127	B0598	BRTE	TRPLT	0	0	225	0	3	0	3	1	H
71	B0621	BRTE	TRPLT	0	0	50	0	0	2	4	1	H
65	B0622	BRTE	TRPLT	0	0	30	0	1	4	1	1	H
51	B0623	BRTE	TRPLT	0	0	60	0	1	5	0	0	H
61	B0624	BRTE	TRPLT	0	0	70	0	1	4	1	1	H
97	B0626	BRTE	TRPLT	0	0	160	0	1	2	3	1	H
31	B0627	BRTE	TRPLT	0	0	220	0	2	2	2	0	H
17	B0628	BRTE	TRPLT	0	0	100	0	1	0	5	0	H
27	B0629	BRTE	TRPLT	0	0	20	0	2	2	2	0	H
29	B0630	BRTE	TRPLT	0	0	190	0	5	1	0	1	H
1	B0631	BRTE	TRPLT	0	0	820	0	0	1	2	0	H
34	B0632	BRTE	TRPLT	0	0	340	0	0	1	5	0	H
36	B0633	BRTE	TRPLT	0	0	350	0	4	0	2	0	H
37	B0634	BRTE	TRPLT	0	0	450	0	0	0	6	0	H
15	B0635	BRTE	TRPLT	0	0	40	0	2	1	3	1	H
16	B0636	BRTE	TRPLT	0	0	30	0	0	0	6	0	H

TABLE 2. RESULTS OF SCREENING AND WEIGHTING PROCEDURE FOR ALDRIN PLUS DIELDRIN

Loc.	ID No.	Spec.	Group	# of Samples HRER	# of Samples HRER/2	Distance to Nearest Soil Sample (ft)	BCRLs within HR circle	Number of Samples Having Hits w/in Search Radius: 2 hits	1 hit	0 hits	# of Tissue Hits	Rank
119	B1232	BRTE	TRPLT	0	0	70	0	2	1	3	1	H
36	B1255	BRTE	TRPLT	0	0	350	0	4	0	2	0	H
134	B1256	BRTE	TRPLT	0	0	440	0	0	0	1	0	H
133	B1257	BRTE	TRPLT	0	0	990	0	0	0	1	0	H
5	B1258	BRTE	TRPLT	0	0	240	0	0	1	5	0	H
34	B1259	BRTE	TRPLT	0	0	340	0	0	1	5	0	H
15	B1260	BRTE	TRPLT	0	0	40	0	2	1	3	0	H
130	B1261	BRTE	TRPLT	0	0	740	0	0	0	4	0	H
3	B1262	BRTE	TRPLT	0	0	560	0	0	0	3	0	H
37	B1263	BRTE	TRPLT	0	0	450	0	0	0	6	0	H
16	B1264	BRTE	TRPLT	0	0	30	0	0	0	6	0	H
117	B1265	BRTE	TRPLT	0	0	80	0	2	2	2	0	H
75	B1266	BRTE	TRPLT	0	0	40	0	1	3	2	0	H
148	B1268	BRTE	TRPLT	0	0	45	0	0	3	3	0	H
141	B1270	BRTE	TRPLT	0	0	90	0	4	0	2	0	H
77	B1271	BRTE	TRPLT	0	0	70	0	2	1	3	0	H
79	B1272	BRTE	TRPLT	0	0	380	0	2	0	4	0	H
61	B1273	BRTE	TRPLT	0	0	70	0	1	4	1	1	H
71	B1274	BRTE	TRPLT	0	0	50	0	0	2	4	1	H
65	B1275	BRTE	TRPLT	0	0	30	0	1	4	1	0	H
51	B1276	BRTE	TRPLT	0	0	60	0	1	5	0	0	H
104	B1278	BRTE	TRPLT	0	0	180	0	1	0	5	0	H
127	B1279	BRTE	TRPLT	0	0	225	0	3	0	3	1	H
17	B1280	BRTE	TRPLT	0	0	100	0	1	0	5	0	H
109	B1281	BRTE	TRPLT	0	0	210	0	3	0	3	0	H
27	B1282	BRTE	TRPLT	0	0	20	0	2	2	2	1	H
30	B1283	BRTE	TRPLT	0	0	110	0	3	3	0	0	H

TABLE 2. RESULTS OF SCREENING AND WEIGHTING PROCEDURE FOR ALDRIN PLUS DIELDRIN

Loc.	ID No.	Spec.	Group	# of Samples HRER	# of Samples HRER/2	Distance to Nearest Soil Sample (ft)	BCRLs within HR circle	Number of Samples Having Hits w/in Search Radius: 2 hits	1 hit	0 hits	# of Tissue Hits	Rank
97	B1284	BRTE	TRPLT	0	0	160	0	1	2	3	1	H
29	B1285	BRTE	TRPLT	0	0	190	0	5	1	0	1	H
122	B1286	BRTE	TRPLT	0	0	40	0	3	2	1	1	G
56	484	COAR	TRPLT	0	0	170	0	1	0	5	0	H
56	485	COAR	TRPLT	0	0	170	0	1	0	5	0	H
56	486	COAR	TRPLT	0	0	170	0	1	0	5	0	H
55	498	COAR	TRPLT	0	0	40	0	1	0	5	0	H
61	B0199	HEAN	TRPLT	0	0	70	0	1	4	1	1	H
51	B0200	HEAN	TRPLT	0	0	60	0	1	5	0	0	H
71	B0201	HEAN	TRPLT	0	0	50	0	0	2	4	1	H
17	B0202	HEAN	TRPLT	0	0	100	0	1	0	5	2	H
31	B0203	HEAN	TRPLT	0	0	220	0	2	2	2	1	H
97	B0204	HEAN	TRPLT	0	0	160	0	1	2	3	1	H
109	B0205	HEAN	TRPLT	0	0	210	0	3	0	3	1	H
122	B0206	HEAN	TRPLT	0	0	40	0	3	2	1	1	G
74	B0207	HEAN	TRPLT	0	0	70	0	4	1	1	1	G
119	B0208	HEAN	TRPLT	0	0	70	0	2	1	3	1	H
128	B0224	HEAN	TRPLT	0	0	160	0	2	1	3	0	H
77	B0225	HEAN	TRPLT	0	0	70	0	2	1	3	0	H
79	B0226	HEAN	TRPLT	0	0	380	0	2	0	4	0	H
6	B0227	HEAN	TRPLT	0	0	510	0	0	1	5	0	H
130	B0228	HEAN	TRPLT	0	0	740	0	0	0	4	0	H
132	B0229	HEAN	TRPLT	0	0	870	0	0	0	1	0	H
133	B0230	HEAN	TRPLT	0	0	990	0	0	0	1	0	H
134	B0231	HEAN	TRPLT	0	0	440	0	0	0	1	0	H
36	B0712	HEAN	TRPLT	0	0	350	0	4	0	2	0	H
37	B0713	HEAN	TRPLT	0	0	450	0	0	0	6	0	H

TABLE 2. RESULTS OF SCREENING AND WEIGHTING PROCEDURE FOR ALDRIN PLUS DIELDRIN

Loc.	ID No.	Spec.	Group	# of Samples HRER	# of Samples HRER/2	Distance to Nearest Soil Sample (ft)	BCRLs within HR circle	Number of Samples Having Hits w/in Search Radius: 2 hits	1 hit	0 hits	# of Tissue Hits	Rank
141	B0800	HEAN	TRPLT	0	0	90	0	4	0	2	0	H
29	B0801	HEAN	TRPLT	0	0	190	0	5	1	0	1	H
17	B0802	HEAN	TRPLT	0	0	100	0	1	0	5	0	H
71	B0803	HEAN	TRPLT	0	0	50	0	0	2	4	1	H
65	B0805	HEAN	TRPLT	0	0	30	0	1	4	1	0	H
51	B0807	HEAN	TRPLT	0	0	60	0	1	5	0	0	H
74	B0812	HEAN	TRPLT	0	0	70	0	4	1	1	1	G
75	B0813	HEAN	TRPLT	0	0	40	0	1	3	2	1	H
117	B0814	HEAN	TRPLT	0	0	80	0	2	2	2	1	H
119	B0816	HEAN	TRPLT	0	0	70	0	2	1	3	1	H
104	B0821	HEAN	TRPLT	0	0	180	0	1	0	5	0	H
127	B0822	HEAN	TRPLT	0	0	225	0	3	0	3	0	H
27	B0823	HEAN	TRPLT	0	0	20	0	2	2	2	0	H
61	B0824	HEAN	TRPLT	0	0	70	0	1	4	1	0	H
109	B0825	HEAN	TRPLT	0	0	210	0	3	0	3	0	H
122	B0826	HEAN	TRPLT	0	0	40	0	3	2	1	0	H
132	B0827	HEAN	TRPLT	0	0	870	0	0	0	1	0	H
31	B0828	HEAN	TRPLT	0	0	220	0	2	2	2	0	H
3	B0829	HEAN	TRPLT	0	0	560	0	0	0	3	0	H
134	B0830	HEAN	TRPLT	0	0	440	0	0	0	1	0	H
5	B0927	HEAN	TRPLT	0	0	240	0	0	1	5	0	H
97	B0928	HEAN	TRPLT	0	0	160	0	1	2	3	0	H
128	B0929	HEAN	TRPLT	0	0	160	0	2	1	3	0	H
148	B0930	HEAN	TRPLT	0	0	45	0	0	3	3	0	H
133	B0931	HEAN	TRPLT	0	0	990	0	0	0	1	0	H
79	B0932	HEAN	TRPLT	0	0	380	0	2	0	4	0	H
104	B1450	HEAN	TRPLT	0	0	180	0	1	0	5	0	H

TABLE 2. RESULTS OF SCREENING AND WEIGHTING PROCEDURE FOR ALDRIN PLUS DIELDRIN

Loc.	ID No.	Spec.	Group	# of Samples HRER	# of Samples HRER/2	Distance to Nearest Soil Sample (ft)	BCRLs within HR circle	Number of Samples Having Hits w/in Search Radius: 2 hits	1 hit	0 hits	# of Tissue Hits	Rank
127	B1451	HEAN	TRPLT	0	0	225	0	3	0	3	1	H
74	B1452	HEAN	TRPLT	0	0	70	0	4	1	1	1	G
117	B1453	HEAN	TRPLT	0	0	80	0	2	2	2	0	H
75	B1454	HEAN	TRPLT	0	0	40	0	1	3	2	0	H
122	B1455	HEAN	TRPLT	0	0	40	0	3	2	1	0	H
119	B1456	HEAN	TRPLT	0	0	70	0	2	1	3	1	H
109	B1457	HEAN	TRPLT	0	0	210	0	3	0	3	0	H
30	B1464	HEAN	TRPLT	0	0	110	0	3	3	0	0	H
97	B1465	HEAN	TRPLT	0	0	160	0	1	2	3	0	H
17	B1466	HEAN	TRPLT	0	0	100	0	1	0	5	0	H
27	B1467	HEAN	TRPLT	0	0	20	0	2	2	2	0	H
29	B1468	HEAN	TRPLT	0	0	190	0	5	1	0	0	H
51	B1469	HEAN	TRPLT	0	0	60	0	1	5	0	0	H
53	B1470	HEAN	TRPLT	0	0	110	0	0	0	6	0	H
71	B1471	HEAN	TRPLT	0	0	50	0	0	2	4	2	H
61	B1472	HEAN	TRPLT	0	0	70	0	1	4	1	1	H
65	B1473	HEAN	TRPLT	0	0	30	0	1	4	1	0	H
3	B1474	HEAN	TRPLT	0	0	560	0	0	0	3	0	H
5	B1475	HEAN	TRPLT	0	0	240	0	0	1	5	0	H
134	B1476	HEAN	TRPLT	0	0	440	0	0	0	1	0	H
132	B1477	HEAN	TRPLT	0	0	870	0	0	0	1	0	H
133	B1478	HEAN	TRPLT	0	0	990	0	0	0	1	0	H
79	B1480	HEAN	TRPLT	0	0	380	0	2	0	4	0	H
141	B1482	HEAN	TRPLT	0	0	90	0	4	0	2	0	H
128	B1483	HEAN	TRPLT	0	0	160	0	2	1	3	0	H
37	B1486	HEAN	TRPLT	0	0	450	0	0	0	6	0	H
16	B1487	HEAN	TRPLT	0	0	30	0	0	0	6	0	H

TABLE 2. RESULTS OF SCREENING AND WEIGHTING PROCEDURE FOR ALDRIN PLUS DIELDRIN

Loc.	ID No.	Spec.	Group	# of Samples HRER	# of Samples HRER/2	Distance to Nearest Soil Sample (ft)	BCRLs within HR circle	Number of Samples Having Hits w/in Search Radius: 2 hits	1 hit	0 hits	# of Tissue Hits	Rank
15	B1488	HEAN	TRPLT	0	0	40	0	2	1	3	0	H
63	415	HEAN	TRPLT	0	0	80	0	4	0	2	0	H
63	416	HEAN	TRPLT	0	0	80	0	4	0	2	0	H
63	417	HEAN	TRPLT	0	0	80	0	4	0	2	0	H
63	420	HEAN	TRPLT	0	0	80	0	4	0	2	0	H
63	496	HEAN	TRPLT	0	0	80	0	4	0	2	0	H
7	503	HEAN	TRPLT	0	0	460	0	0	1	5	0	H
7	504	HEAN	TRPLT	0	0	460	0	0	1	5	0	H
23	505	HEAN	TRPLT	0	0	180	0	2	2	2	0	H
23	506	HEAN	TRPLT	0	0	180	0	2	2	2	0	H
63	576	HEAN	TRPLT	0	0	80	0	4	0	2	0	H
63	577	HEAN	TRPLT	0	0	80	0	4	0	2	0	H
63	578	HEAN	TRPLT	0	0	80	0	4	0	2	0	H
63	579	HEAN	TRPLT	0	0	80	0	4	0	2	0	H
127	B0122	KOIR	TRPLT	0	0	225	0	3	0	3	1	H
109	B0124	KOIR	TRPLT	0	0	210	0	3	0	3	0	H
77	B0130	KOIR	TRPLT	0	0	70	0	2	1	3	0	H
79	B0132	KOIR	TRPLT	0	0	380	0	2	0	4	0	H
148	B0133	KOIR	TRPLT	0	0	45	0	0	3	3	0	H
130	B0135	KOIR	TRPLT	0	0	740	0	0	0	4	0	H
134	B0137	KOIR	TRPLT	0	0	440	0	0	0	1	0	H
1	B0138	KOIR	TRPLT	0	0	820	0	0	1	2	0	H
3	B0139	KOIR	TRPLT	0	0	560	0	0	0	3	0	H
5	B0140	KOIR	TRPLT	0	0	240	0	0	1	5	0	H
51	B0149	KOIR	TRPLT	0	0	60	0	1	5	0	0	H
53	B0151	KOIR	TRPLT	0	0	110	0	0	0	6	0	H
97	B0153	KOIR	TRPLT	0	0	160	0	1	2	3	0	H

TABLE 2. RESULTS OF SCREENING AND WEIGHTING PROCEDURE FOR ALDRIN PLUS DIELDRIN

Loc.	ID No.	Spec.	Group	# of Samples HRER	# of Samples HRER/2	Distance to Nearest Soil Sample (ft)	BCRLs within HR circle	Number of Samples Having Hits w/in Search Radius: 2 hits	1 hit	0 hits	# of Tissue Hits	Rank
17	B0156	KOIR	TRPLT	0	0	100	0	1	0	5	1	H
29	B0158	KOIR	TRPLT	0	0	190	0	5	1	0	0	H
17	B0695	KOIR	TRPLT	0	0	100	0	1	0	5	0	H
65	B0696	KOIR	TRPLT	0	0	30	0	1	4	1	1	H
51	B0697	KOIR	TRPLT	0	0	60	0	1	5	0	1	G
53	B0698	KOIR	TRPLT	0	0	110	0	0	0	6	0	H
148	B0701	KOIR	TRPLT	0	0	45	0	0	3	3	0	H
79	B0702	KOIR	TRPLT	0	0	380	0	2	0	4	0	H
141	B0703	KOIR	TRPLT	0	0	90	0	4	0	2	0	H
134	B0705	KOIR	TRPLT	0	0	440	0	0	0	1	0	H
130	B0706	KOIR	TRPLT	0	0	740	0	0	0	4	0	H
77	B0710	KOIR	TRPLT	0	0	70	0	2	1	3	0	H
34	B0711	KOIR	TRPLT	0	0	340	0	0	1	5	0	H
1	B0747	KOIR	TRPLT	0	0	820	0	0	1	2	0	H
3	B0748	KOIR	TRPLT	0	0	560	0	0	0	3	0	H
5	B0749	KOIR	TRPLT	0	0	240	0	0	1	5	0	H
77	B0750	KOIR	TRPLT	0	0	70	0	2	1	3	0	H
29	B0760	KOIR	TRPLT	0	0	190	0	5	1	0	0	H
97	B0761	KOIR	TRPLT	0	0	160	0	1	2	3	0	H
31	B0762	KOIR	TRPLT	0	0	220	0	2	2	2	0	H
104	B0764	KOIR	TRPLT	0	0	180	0	1	0	5	0	H
109	B0765	KOIR	TRPLT	0	0	210	0	3	0	3	0	H
130	B0799	KOIR	TRPLT	0	0	740	0	0	0	4	0	H
16	B0810	KOIR	TRPLT	0	0	30	0	0	0	6	0	H
15	B0811	KOIR	TRPLT	0	0	40	0	2	1	3	0	H
148	B1479	KOIR	TRPLT	0	0	45	0	0	3	3	0	H
77	B1481	KOIR	TRPLT	0	0	70	0	2	1	3	1	H

TABLE 2. RESULTS OF SCREENING AND WEIGHTING PROCEDURE FOR ALDRIN PLUS DIELDRIN

Loc.	ID No.	Spec.	Group	# of Samples HRER	# of Samples HRER/2	Distance to Nearest Soil Sample (ft)	BCRLs within HR circle	Number of Samples Having Hits w/in Search Radius: 2 hits	1 hit	0 hits	# of Tissue Hits	Rank
34	B1484	KOIR	TRPLT	0	0	340	0	0	1	5	0	H
37	B1485	KOIR	TRPLT	0	0	450	0	0	0	6	0	H
65	B0475	LASE	TRPLT	0	0	30	0	1	4	1	0	H
75	B0476	LASE	TRPLT	0	0	40	0	1	3	2	1	H
119	B0477	LASE	TRPLT	0	0	70	0	2	1	3	1	H
51	B0495	LASE	TRPLT	0	0	60	0	1	5	0	0	H
61	B0496	LASE	TRPLT	0	0	70	0	1	4	1	1	H
61	B0699	LASE	TRPLT	0	0	70	0	1	4	1	0	H
128	B0700	LASE	TRPLT	0	0	160	0	2	1	3	0	H
132	B0707	LASE	TRPLT	0	0	870	0	0	0	1	0	H
133	B0745	LASE	TRPLT	0	0	990	0	0	0	1	0	H
27	B0763	LASE	TRPLT	0	0	20	0	2	2	2	0	H
127	B0766	LASE	TRPLT	0	0	225	0	3	0	3	1	H
122	B0767	LASE	TRPLT	0	0	40	0	3	2	1	1	H
65	B0804	LASE	TRPLT	0	0	30	0	1	4	1	0	H
51	B0806	LASE	TRPLT	0	0	60	0	1	5	0	1	H
117	B0815	LASE	TRPLT	0	0	80	0	2	2	2	0	H
119	B0817	LASE	TRPLT	0	0	70	0	2	1	3	1	H
130	B1032	LASE	TRPLT	0	0	740	0	0	0	4	0	H
1	B0038	OLIG	WORMS	0	0	820	0	0	1	2	0	H
119	B0039	OLIG	WORMS	0	0	70	0	2	1	3	1	H
3	B0040	OLIG	WORMS	0	0	560	0	0	0	3	0	H
142	B0044	OLIG	WORMS	0	0	80	0	3	0	3	1	H
97	B0045	OLIG	WORMS	0	0	160	0	1	2	3	1	H
30	B0046	OLIG	WORMS	0	0	110	0	3	3	0	1	H
29	B0048	OLIG	WORMS	0	0	190	0	5	1	0	2	G
127	B0049	OLIG	WORMS	0	0	225	0	3	0	3	1	H

TABLE 2. RESULTS OF SCREENING AND WEIGHTING PROCEDURE FOR ALDRIN PLUS DIELDRIN

Loc.	ID No.	Spec.	Group	# of Samples HRER	# of Samples HRER/2	Distance to Nearest Soil Sample (ft)	BCRLs within HR circle	Number of Samples Having Hits w/in Search Radius: 2 hits	1 hit	0 hits	# of Tissue Hits	Rank
122	B0050	OLIG	WORMS	0	0	40	0	3	2	1	1	G
106	B0053	OLIG	WORMS	0	0	110	0	3	0	3	1	H
132	B0054	OLIG	WORMS	0	0	870	0	0	0	1	0	H
78	B0055	OLIG	WORMS	0	0	140	0	3	0	3	1	H
77	B0058	OLIG	WORMS	0	0	70	0	2	1	3	1	H
67	B0062	OLIG	WORMS	0	0	45	0	1	2	3	1	H
6	B0065	OLIG	WORMS	0	0	510	0	0	1	5	0	H
79	B0069	OLIG	WORMS	0	0	380	0	2	0	4	0	H
17	B0078	OLIG	WORMS	0	0	100	0	1	0	5	2	H
68	B0079	OLIG	WORMS	0	0	50	0	1	2	3	1	H
3	B0525	OLIG	WORMS	0	0	560	0	0	0	3	0	H
1	B0526	OLIG	WORMS	0	0	820	0	0	1	2	0	H
97	B0527	OLIG	WORMS	0	0	160	0	1	2	3	1	H
141	B0530	OLIG	WORMS	0	0	90	0	4	0	2	1	G
104	B0531	OLIG	WORMS	0	0	180	0	1	0	5	0	H
5	B0535	OLIG	WORMS	0	0	240	0	0	1	5	0	H
77	B0543	OLIG	WORMS	0	0	70	0	2	1	3	1	H
79	B0544	OLIG	WORMS	0	0	380	0	2	0	4	1	H
127	B0550	OLIG	WORMS	0	0	225	0	3	0	3	1	H
130	B0552	OLIG	WORMS	0	0	740	0	0	0	4	0	H
148	B0553	OLIG	WORMS	0	0	45	0	0	3	3	0	H
109	B0554	OLIG	WORMS	0	0	210	0	3	0	3	1	H
128	B0555	OLIG	WORMS	0	0	160	0	2	1	3	1	H
75	B0560	OLIG	WORMS	0	0	40	0	1	3	2	1	H
117	B0561	OLIG	WORMS	0	0	80	0	2	2	2	2	G
134	B0563	OLIG	WORMS	0	0	440	0	0	0	1	0	H
29	B0564	OLIG	WORMS	0	0	190	0	5	1	0	1	H

TABLE . RESULTS OF SCREENING AND WEIGHTING PROCEDURE FOR ALDRIN PLUS DIELDRIN

Loc.	ID No.	Spec.	Group	# of Samples HRER	# of Samples HRER/2	Distance to Nearest Soil Sample (ft)	BCRLs within HR circle	Number of Samples Having Hits w/in Search Radius: 2 hits	1 hit	0 hits	# of Tissue Hits	Rank
65	B0600	OLIG	WORMS	0	0	30	0	1	4	1	1	H
17	B0601	OLIG	WORMS	0	0	100	0	1	0	5	1	H
119	B0602	OLIG	WORMS	0	0	70	0	2	1	3	1	H
89	B0603	OLIG	WORMS	0	0	10	0	0	2	4	1	H
16	B0606	OLIG	WORMS	0	0	30	0	0	0	6	1	H
15	B0607	OLIG	WORMS	0	0	40	0	2	1	3	1	H
37	B0613	OLIG	WORMS	0	0	450	0	0	0	6	1	H
115	B0614	OLIG	WORMS	0	0	160	0	1	1	4	1	H
113	B0617	OLIG	WORMS	0	0	370	0	1	1	4	0	H
112	B0618	OLIG	WORMS	0	0	460	0	1	1	4	0	H
34	B0619	OLIG	WORMS	0	0	340	0	0	1	5	1	H
114	B0620	OLIG	WORMS	0	0	120	0	1	1	4	0	H
75	B1233	OLIG	WORMS	0	0	40	0	1	3	2	1	H
65	B1234	OLIG	WORMS	0	0	30	0	1	4	1	1	H
134	B1236	OLIG	WORMS	0	0	440	0	0	0	1	0	H
148	B1237	OLIG	WORMS	0	0	45	0	0	3	3	1	H
77	B1238	OLIG	WORMS	0	0	70	0	2	1	3	1	H
79	B1239	OLIG	WORMS	0	0	380	0	2	0	4	1	H
141	B1252	OLIG	WORMS	0	0	90	0	4	0	2	1	G
130	B1277	OLIG	WORMS	0	0	740	0	0	0	4	0	H
37	B1288	OLIG	WORMS	0	0	450	0	0	0	6	0	H
34	B1290	OLIG	WORMS	0	0	340	0	0	1	5	1	H
128	B1291	OLIG	WORMS	0	0	160	0	2	1	3	1	H
5	B1296	OLIG	WORMS	0	0	240	0	0	1	5	0	H
120	B1301	OLIG	WORMS	0	0	410	0	1	0	5	0	H
127	B1304	OLIG	WORMS	0	0	225	0	3	0	3	1	H
16	B1305	OLIG	WORMS	0	0	30	0	0	0	6	1	H

TABLE 2. RESULTS OF SCREENING AND WEIGHTING PROCEDURE FOR ALDRIN PLUS DIELDRIN

Loc.	ID No.	Spec.	Group	# of Samples HRER	# of Samples HRER/2	Distance to Nearest Soil Sample (ft)	BCRLs within HR circle	Number of Samples Having Hits w/in Search Radius: 2 hits	1 hit	0 hits	# of Tissue Hits	Rank
112	B1308	OLIG	WORMS	0	0	460	0	1	1	4	1	H
113	B1334	OLIG	WORMS	0	0	370	0	1	1	4	1	H
73	357	OLIG	WORMS	0	0	30	0	0	5	1	0	H
129	358	OLIG	WORMS	0	0	450	0	1	0	3	0	H
129	501	OLIG	WORMS	0	0	450	0	1	0	3	0	H
129	502	OLIG	WORMS	0	0	450	0	1	0	3	0	H
129	543	OLIG	WORMS	0	0	450	0	1	0	3	0	H
129	545	OLIG	WORMS	0	0	450	0	1	0	3	0	H
129	546	OLIG	WORMS	0	0	450	0	1	0	3	0	H
129	567	OLIG	WORMS	0	0	450	0	1	0	3	0	H

TABLE 3. ASSIGNMENT OF WEIGHTS TO TC/ESC DATA PAIRS

Percentage ofSoil Samples BCRL	Number of Soil Samples Within HRER				
	> 10	4-9	1-3	0 nearest soil sample < 100'	0 nearest soil sample > 100'
	Number of tissue 'hits" = 2				
<50%	A	B	C	F	G
50-80%	C	D	F	G	H
>80%	F	G	H	H	H
	Number of tissue "hits" = 1				
<50%	C	D	F	G	H
50-80%	E	F	G	H	H
>80%	G	H	H	H	H

Note: all samples for which the number of tissue hits = 0 are assigned to category H (zero weight)

TABLE 4. RESULTS OF SCREENING AND WEIGHTING PROCEDURE FOR DDE PLUS DDT

Loc.	ID No.	Spec.	Group	# of Samples HRER	# of Samples HRER/2	Distance to Nearest Soil Sample (ft)	BCRLs Within HR Circle	Number of Samples With Hits Within Search Radius			# of Tissue Hits	Rank
								2 hits	1 hit	0 hits		
18	B0798	AMBY	HERPS	0	0	410	0	0	2	4	1	H
14	B1449	PIME	HERPS	1	0	340	0/2	0	0	2	1	H
74	B0680	ACRI	INSCT	0	0	70	0	3	1	2	1	G
31	B0681	ACRI	INSCT	0	0	220	0	0	0	6	1	H
37	B0868	ACRI	INSCT	0	0	450	0	0	0	0	1	H
128	B0790	COLE	INSCT	0	0	160	0	3	0	3	1	H
61	B1668	COLE	INSCT	0	0	70	0	0	1	5	1	H
105	B0080	CYLU	MDMML	0	0	210	0	2	1	3	1	H
57	B0329	CYLU	MDMML	2	1	0	4/4	1	0	5	1	H
104	B0532	CYLU	MDMML	0	0	180	0	1	1	4	1	H
140	B1306	CHVO	SHBRD	9	8	40	16/18	1	1	4	1	H
140	B1307	CHVO	SHBRD	9	8	40	16/18	1	1	4	1	H
155	B1309	CHVO	SHBRD	0	0	530	0	0	1	5	2	H
156	B1310	CHVO	SHBRD	0	0	490	0	0	1	5	2	H
156	B1317	CHVO	SHBRD	0	0	490	0	0	1	5	2	H
16	B0649	ZEMA	SMBRD	48	23	30	71/96	0	1	5	1	E
74	B1006	ZEMA	SMBRD	132	37	70	51/74	3	1	2	1	E
127	B0018	PEMA	SMMML	0	0	225	0	1	0	5	1	H
74	B0551	PEMA	SMMML	2	0	70	3/4	3	1	2	1	C
65	B0587	PEMA	SMMML	2	1	30	4/4	0	2	4	1	H
74	B1221	PEMA	SMMML	2	0	70	3/4	3	1	2	1	C
127	B1224	PEMA	SMMML	0	0	225	0	1	0	5	1	H
71	B1298	PEMA	SMMML	3	0	50	6/6	1	0	5	2	H
141	B0577	BRTE	TRPLT	0	0	90	0	0	2	4	2	H
15	B0635	BRTE	TRPLT	0	0	40	0	0	3	3	1	G
132	B0229	HEAN	TRPLT	0	0	870	0	0	0	0	1	H

TABLE 4. RESULTS OF SCREENING AND WEIGHTING PROCEDURE FOR DDE PLUS DDT

Loc.	ID No.	Spec.	Group	# of Samples HRER	# of Samples HRER/2	Distance to Nearest Soil Sample (ft)	BCRLs Within HR Circle	Number of Samples With Hits Within Search Radius 2 hits	1 hit	0 hits	# of Tissue Hits	Rank
133	B0230	HEAN	TRPLT	0	0	990	0	0	0	0	1	H
71	B0803	HEAN	TRPLT	0	0	50	0	1	0	5	1	H
29	B0760	KOIR	TRPLT	0	0	190	0	1	1	4	1	H
29	B0048	OLIG	WORMS	0	0	190	0	1	1	4	1	H
106	B0053	OLIG	WORMS	0	0	110	0	2	1	3	1	H
128	B0555	OLIG	WORMS	0	0	160	0	3	0	3	2	H
117	B0561	OLIG	WORMS	0	0	80	0	2	0	4	1	H
134	B0563	OLIG	WORMS	0	0	440	0	0	0	0	1	H
65	B0600	OLIG	WORMS	0	0	30	0	0	2	4	1	H
115	B0614	OLIG	WORMS	0	0	160	0	1	0	5	2	H
112	B0618	OLIG	WORMS	0	0	460	0	1	0	5	1	H
114	B0620	OLIG	WORMS	0	0	120	0	1	0	5	2	H
79	B1239	OLIG	WORMS	0	0	380	0	0	2	4	1	H
128	B1291	OLIG	WORMS	0	0	160	0	3	0	3	1	H
120	B1301	OLIG	WORMS	0	0	410	0	1	0	5	2	H
112	B1308	OLIG	WORMS	0	0	460	0	1	0	5	2	H

TABLE 5. RESULTS OF SCREENING AND WEIGHTING PROCEDURE FOR ENDRIN

Loc.	ID No.	Spec.	Group	# of Samples HRER	# of Samples HRER/2	Distance to Nearest Soil Sample (ft)	BCRLs within HR circle	Number of Samples With Hits W/in Search Radius 1hit	Number of Samples With Hits W/in Search Radius 0 hits	# of Tissue Hits	Rank
18	B0797	AMBY	HERPS	0	0	410	0	6	0	1	G
18	B0798	AMBY	HERPS	0	0	410	0	6	0	1	G
75	B0683	ACRI	INSCT	0	0	50	0	0	6	1	H
71	B0690	ACRI	INSCT	0	0	50	0	2	4	1	G
71	B1489	ACRI	INSCT	0	0	50	0	2	4	1	G
61	B0791	COLE	INSCT	0	0	100	0	3	3	1	G
17	B0808	COLE	INSCT	0	0	100	0	1	5	1	H
29	B0819	COLE	INSCT	0	0	190	0	4	2	1	G
61	B1668	COLE	INSCT	0	0	70	0	3	3	1	G
51	B1669	COLE	INSCT	0	0	60	0	2	4	1	F
59	B0327	CYLU	MDMML	0	0	0	0	1	5	1	H
57	B0329	CYLU	MDMML	2	1	0	1/2	3	3	1	F
140	B1306	CHVO	SHBRD	12	3	40	6/12	1	5	1	C
156	B1317	CHVO	SHBRD	0	0	490	0	0	6	1	H
17	B1409	STNE	SMBRD	0	0	100	0	1	5	1	H
102	B0640	ZEMA	SMBRD	13	7	50	12/13	0	6	1	F
27	B0641	ZEMA	SMBRD	42	8	20	16/42	2	4	1	A
16	B0649	ZEMA	SMBRD	41	22	30	37/41	1	5	1	F
74	B0651	ZEMA	SMBRD	122	35	70	105/122	2	4	1	F
104	B0652	ZEMA	SMBRD	14	3	180	11/14	1	5	1	C
17	B0735	ZEMA	SMBRD	12	6	100	5/12	1	5	1	A
17	B0738	ZEMA	SMBRD	12	6	100	5/12	1	5	1	A
17	B0743	ZEMA	SMBRD	12	6	100	5/12	1	5	1	A
61	B0771	ZEMA	SMBRD	70	30	70	34/70	3	3	1	A
17	B0917	ZEMA	SMBRD	12	6	100	5/12	1	5	1	A
71	B1508	ZEMA	SMBRD	145	52	50	112/145	2	4	1	C

TABLE 5. RESULTS OF SCREENING AND WEIGHTING PROCEDURE FOR ENDRIN

Loc.	ID No.	Spec.	Group	# of Samples HRER.	# of Samples HRER/2	Distance to Nearest Soil Sample (ft)	BCRLs within HR circle	Number of Samples With Hits W/in Search Radius 1hit	Number of Samples With Hits W/in Search Radius 0 hits	# of Tissue Hits	Rank
71	B1298	PEMA	SMMML	3	0	50	3/3	2	4	1	F
17	B0202	HEAN	TRPLT	0	0	100	0	1	5	1	H
71	B0803	HEAN	TRPLT	0	0	50	0	2	4	1	G
30	B0046	OLIG	WORMS	0	0	110	0	4	2	1	G
29	B0048	OLIG	WORMS	0	0	190	0	4	2	1	G
127	B0049	OLIG	WORMS	0	0	225	0	1	5	1	H
78	B0055	OLIG	WORMS	0	0	140	0	2	4	1	H
67	B0062	OLIG	WORMS	0	0	45	0	1	5	1	H
17	B0078	OLIG	WORMS	0	0	100	0	1	5	1	H
29	B0564	OLIG	WORMS	0	0	190	0	4	2	1	G
75	B1233	OLIG	WORMS	0	0	40	0	1	5	1	H
65	B1234	OLIG	WORMS	0	0	30	0	1	5	1	H
79	B1239	OLIG	WORMS	0	0	300	0	2	4	1	H
16	B1305	OLIG	WORMS	0	0	30	0	0	6	1	H

TABLE 6. RESULTS OF SCREENING AND WEIGHTING PROCEDURE FOR MERCURY

Loc.	ID No.	Spec.	Group	# of Samples HRER	# of Samples HRER/2	Distance to Nearest Soil Sample (ft)	BCRLs within HR circle	Number of Samples With Hits W/In Search Radius 1hit	Number of Samples With Hits W/In Search Radius 0 hits	# of Tissue Hits	Rank
18	B0797	AMBY	HERPS	0	0	450	0	3	3	1	H
18	B0798	AMBY	HERPS	0	0	450	0	3	3	1	H
79	B1459	SCAP	HERPS	0	0	340	0	2	4	1	H
42	B0501M	SYAU	MDMML	24	8	0	21/24	0	6	1	F
101	B0715	CYLU	MDMML	0	0	210	0	0	6	1	H
140	B1306	CHVO	SHBRD	7	6	50	6/7	0	6	1	G
140	B1307	CHVO	SHBRD	7	6	50	6/7	0	6	1	G
155	B1309	CHVO	SHBRD	0	0	530	0	0	6	1	H
156	B1310	CHVO	SHBRD	0	0	490	0	0	6	1	H
156	B1317	CHVO	SHBRD	0	0	490	0	0	6	1	H
1	B0013	PEMA	SMMML	0	0	710	0	0	6	1	H
142	B0042	PEMA	SMMML	2	0	80	0/2	2	4	1	F
17	B0586	PEMA	SMMML	1	0	90	1/1	0	6	1	H
130	B0589	PEMA	SMMML	0	0	730	0	0	4	1	H
16	B0604	PEMA	SMMML	4	1	40	0/4	5	1	1	B
71	B1298	PEMA	SMMML	4	0	70	1/4	4	2	1	B
1	B0038	OLIG	WORMS	0	0	710	0	0	2	1	H
142	B0044	OLIG	WORMS	0	0	80	0	2	4	1	G
97	B0045	OLIG	WORMS	0	0	130	0	2	4	1	H
29	B0048	OLIG	WORMS	0	0	90	0	2	4	1	G
106	B0053	OLIG	WORMS	0	0	110	0	0	6	1	H
78	B0055	OLIG	WORMS	0	0	130	0	1	5	1	H
67	B0062	OLIG	WORMS	0	0	35	0	4	2	1	F
68	B0079	OLIG	WORMS	0	0	60	0	3	3	1	G
97	B0527	OLIG	WORMS	0	0	130	0	2	4	1	H
141	B0530	OLIG	WORMS	0	0	90	0	2	4	1	G

TABLE 6. RESULTS OF SCREENING AND WEIGHTING PROCEDURE FOR MERCURY

Loc.	ID No.	Spec.	Group	# of Samples HRER	# of Samples HRER/2	Distance to Nearest Soil Sample (ft)	BCRLs within HR circle	Number of Samples With Hits W/in Search Radius 1hit	Number of Samples With Hits W/in Search Radius 0 hits	# of Tissue Hits	Rank
104	B0531	OLIG	WORMS	0	0	330	0	0	6	1	H
77	B0543	OLIG	WORMS	0	0	170	0	3	3	1	H
127	B0550	OLIG	WORMS	0	0	225	0	3	3	1	H
130	B0552	OLIG	WORMS	0	0	730	0	0	4	1	H
128	B0555	OLIG	WORMS	0	0	80	0	1	5	1	H
75	B0560	OLIG	WORMS	0	0	40	0	0	6	1	H
29	B0564	OLIG	WORMS	0	0	90	0	2	4	1	G
65	B0600	OLIG	WORMS	0	0	85	0	3	3	1	G
17	B0601	OLIG	WORMS	0	0	90	0	0	6	1	H
119	B0602	OLIG	WORMS	0	0	60	0	1	5	1	H
89	B0603	OLIG	WORMS	1	0	10	0/1	2	4	1	C
16	B0606	OLIG	WORMS	0	0	40	0	5	1	1	F
15	B0607	OLIG	WORMS	0	0	40	0	2	4	1	G
115	B0614	OLIG	WORMS	0	0	190	0	0	6	1	H
113	B0617	OLIG	WORMS	0	0	370	0	0	6	1	H
112	B0618	OLIG	WORMS	0	0	460	0	0	6	1	H
75	B1233	OLIG	WORMS	0	0	40	0	0	6	1	H
65	B1234	OLIG	WORMS	0	0	35	0	3	3	1	G
148	B1237	OLIG	WORMS	0	0	40	0	2	4	1	G
79	B1239	OLIG	WORMS	0	0	340	0	2	4	1	H
141	B1252	OLIG	WORMS	0	0	90	0	2	4	1	G
34	B1290	OLIG	WORMS	0	0	160	0	0	6	1	H
128	B1291	OLIG	WORMS	0	0	80	0	1	5	1	H
16	B1305	OLIG	WORMS	0	0	40	0	5	1	1	F
113	B1334	OLIG	WORMS	0	0	370	0	0	6	1	H

TABLE 7. NUMBERS OF SAMPLES ASSIGNED NON-ZERO WEIGHT USING EPAS PROCEDURE

Group	Species	No. of Samples	ALDRIN + DIELDRIN		DDE +DDT		ENDRIN		MERCURY	
			high weight	low weight	high weight	low weight	high weight	low weight	high weight	low weight
HERPS	AMBY	2	0	2	0	0	0	2	0	0
	PIME	3	0	2	0	0	0	0	0	0
	SCAP	2	0	0	0	0	0	0	0	0
INSCT	ACRI	81	0	12	0	1	0	2	0	0
	COLE	17	0	2	0	0	0	4	0	0
MDMML	CYLU	128	0	27	0	0	0	1	0	0
	SYAU	28	0	1	0	0	0	0	0	1
SHBRD	CHVO	5	0	0	0	0	1	0	0	2
SMBRD	POGR	5	0	0	0	0	0	0	0	0
	STNE	10	6	2	0	0	0	0	0	0
	ZEMA	68	15	3	0	2	8	3	0	0
SMMML	PEMA	90	0	14	2	0	0	1	2	1
	SPTR	3	0	1	0	0	0	0	0	0
TRPLT	BRTE	84	0	6	0	1	0	0	0	0
	COAR	4	0	0	0	0	0	0	0	0
	HEAN	89	0	4	0	0	0	1	0	0
	KOIR	42	0	1	0	0	0	0	0	0
	LASE	17	0	0	0	0	0	0	0	0
WORMS	OLIG	74	0	5	0	0	0	3	1	13
All samples		752	21	82	2	4	9	17	3	17

APPENDIX C.6.3

STATE'S POSITION ON THE ESTIMATION OF BMF

State's Position on the Estimation of BMF

The State of Colorado has reviewed the three approaches for estimating RMA-specific BMFs and strongly believes that EPA's method is the most scientifically defensible. It is the only approach which tests the fundamental hypothesis that the data collected at RMA can be used to relate measured biota-tissue concentrations to the soil concentrations to which the organisms are exposed. The other two methods impose an assumed correlation between soil and tissue concentrations despite the fact that the data show no such correlation. As explained in detail by the Army and EPA, the data-collection programs for soil and biota were not for the specific purpose of estimating contaminant uptake and therefore did not address the many factors which confound this relationship (for example, physiologic differences and specific knowledge about the organisms' true exposure areas). The second phase of the Supplemental field Program, which at present has not been designed by the parties, would need to specifically address these confounding factors to explain and reduce the current lack of correlation between soil and tissue concentrations.