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ROCKY MOUNTAIN ARSENAL
BIOTA ASSESSMENT

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DRAFT FINAL PHASE II TECHNICAL PLAN
AUGUST 1986
CONTRACT NUMBER DAAK11-84-D-0016
TASK NUMBER 9

ENVIRONMENTAL SCIENCE AND ENGINEERING, INC.

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ROCKY MOUNTAIN ARSENAL

19950227 022

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. AGENCY USE ONLY *(Leave blank)*

2. REPORT DATE
08/00/86

3. REPORT TYPE AND DATES COVERED

4. TITLE AND SUBTITLE
BIOTA ASSESSMENT, PHASE II, TASK 9, DRAFT FINAL TECHNICAL PLAN

5. FUNDING NUMBERS
DAAK11 84 D 0016

6. AUTHOR(S)

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
ENVIRONMENTAL SCIENCE AND ENGINEERING
DENVER, CO

8. PERFORMING ORGANIZATION REPORT NUMBER
86251R01

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
ROCKY MOUNTAIN ARSENAL (CO.). PMRMA
COMMERCE CITY, CO

10. SPONSORING/MONITORING AGENCY REPORT NUMBER

11. SUPPLEMENTARY NOTES

12a. DISTRIBUTION/AVAILABILITY STATEMENT
APPROVED FOR PUBLIC RELEASE; DISTRIBUTION IS UNLIMITED

12b. DISTRIBUTION CODE

13. ABSTRACT *(Maximum 200 words)*

THE OVERALL OBJECTIVE OF THE TASK 9 BIOTA ASSESSMENT IS TO PROVIDE INFORMATION NECESSARY FOR THE EVALUATION OF CURRENT AND PAST HAZARDOUS WASTE EFFECTS ON BIOLOGICAL RESOURCES ON AND RELATED TO RMA. PHASE I RESULTS AND ADDITIONAL REGULATORY GUIDANCE INDICATE A NEED FOR ADDITIONAL FIELD STUDIES. THE ACTIVITIES DESCRIBED IN THIS TECHNICAL PLAN ARE DESIGNED TO OBTAIN PERTINENT INFORMATION ON THE DISTRIBUTION, CONCENTRATION, AND EFFECTS OF CONTAMINANTS.

SECTIONS DETAIL INFORMATION ON THE FOLLOWING PROGRAMS:
1. EVALUATION OF EXISTING INFORMATION
2. SAMPLING
3. CHEMICAL ANALYSIS
4. QUALITY ASSURANCE
5. SAFETY.

OTHER INFORMATION IN THE PLAN INCLUDES:
1. CONTAMINATION SITES AND SOURCES

14. SUBJECT TERMS
CONTAMINATION SOURCES, VEGETATION, SAMPLING, CHEMICAL ANALYSIS

15. NUMBER OF PAGES

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT
UNCLASSIFIED

18. SECURITY CLASSIFICATION OF THIS PAGE

19. SECURITY CLASSIFICATION OF ABSTRACT

20. LIMITATION OF ABSTRACT

LITIGATION TECHNICAL SUPPORT AND SERVICES

Rocky Mountain Arsenal

Biota Assessment

Draft Final Phase II Technical Plan
August 1986
Contract Number DAAK11-84-D-0016
Task Number 9

PREPARED BY

ENVIRONMENTAL SCIENCE AND ENGINEERING, INC.

PREPARED FOR

U.S. ARMY PROGRAM MANAGER'S OFFICE FOR
ROCKY MOUNTAIN ARSENAL

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1.0 INTRODUCTION

1.1 LOCATION AND HISTORY

Rocky Mountain Arsenal (RMA) occupies about 27 square miles of Adams County, Colorado and is located about 10 miles northeast of the city of Denver (Figure 1.1-1). RMA was established in 1942 and has been used for the manufacture of chemical and incendiary munitions as well as chemical munitions demilitarization. Industrial chemicals were manufactured at RMA from 1947 to 1982 (U.S. Army Toxic and Hazardous Materials Agency, 1984).

A number of changes have occurred since RMA's establishment. Over 1,000 acres were altered for industrial, commercial, and residential purposes. During the 1940's a portion of RMA was leased for agricultural uses, and crops such as wheat and corn were planted for game habitat improvement. A large area in the northern part of RMA was planted with wheat for the production of biological agents during the 1960's. Approximately 2,800 acres were leased for cattle grazing in the late 1960's. Over time, large areas have been planted with crested wheatgrass. In addition, trees and shrubs have been planted around buildings and along roadsides.

During the period of 1942 to 1950, RMA distilled stocks of Levinstein mustard, demilitarized several million rounds of mustard-filled shells, and test-fired 10.7 centimeter (cm) mortar rounds filled with smoke and high explosives. During this period many types of obsolete World War II (WWII) ordnance were destroyed by detonation or burning.

In 1947, portions of RMA were leased to Colorado Fuel and Iron Corporation (CFI) and Julius Hyman and Company (Hyman). CFI manufactured chlorinated benzenes and dichlorodiphenyltrichloroethane (DDT). Hyman produced a variety of pesticides, including insecticides and herbicides. Hyman assumed the CFI lease in 1950. In 1951, Shell Chemical Company (Shell) assumed the Hyman lease. Manufacturing by Shell ceased in 1982, and the Shell lease expires in 1987.

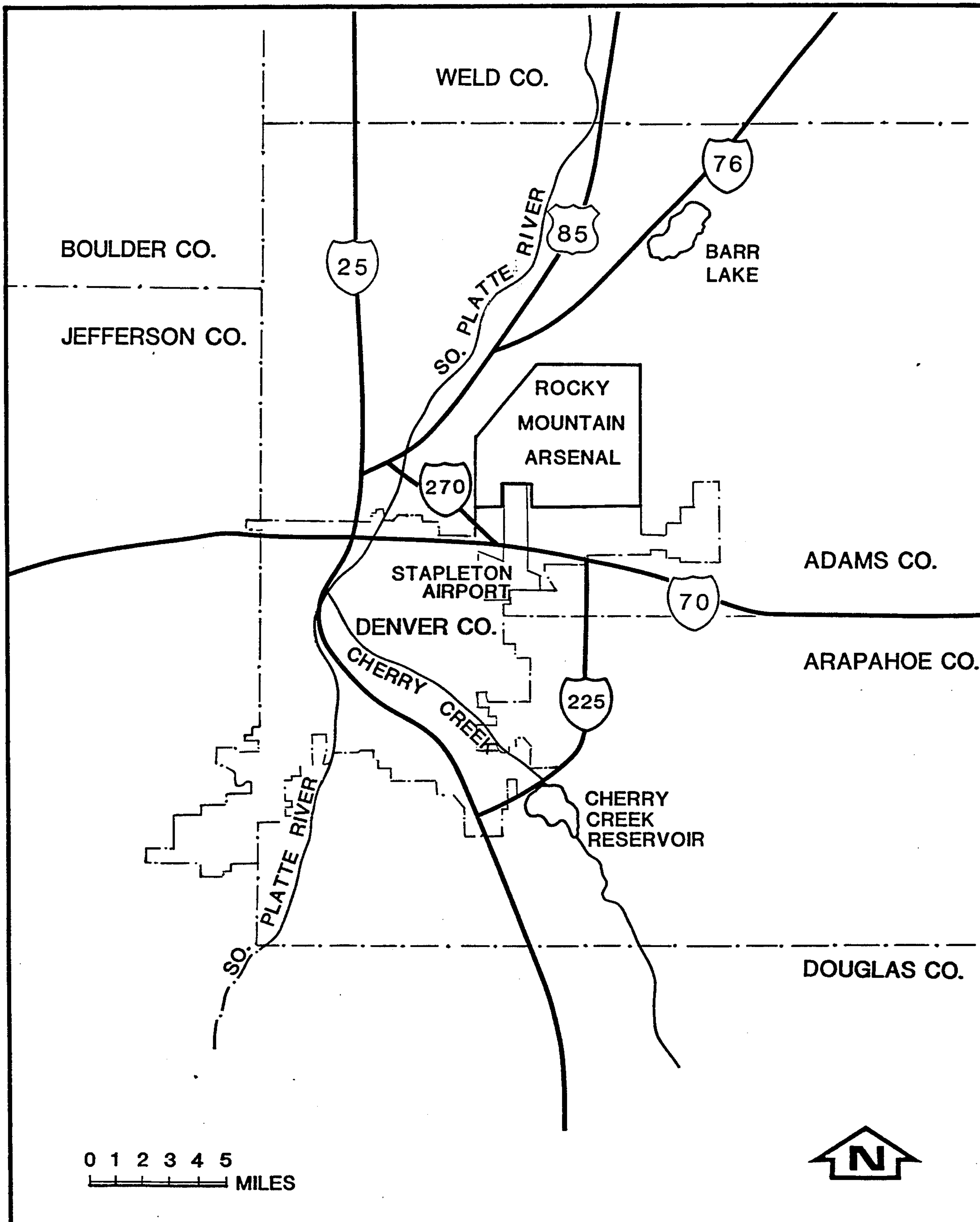


Figure 1.1-1
ROCKY MOUNTAIN ARSENAL
LOCATION MAP

Prepared for:
U.S. Army Program Manager's Office
For Rocky Mountain Arsenal
Aberdeen Proving Ground, Maryland

Construction of facilities for the production of GB nerve agent began in 1950 and was completed in 1953. Manufacture of GB was continued until 1957 and GB munitions filling operations continued until late 1969 (U.S. Army Toxic and Hazardous Materials Agency, 1984).

Basin A, located within Section 36, was the original disposal area for waters and waste waters resulting from all RMA and industrial operations. Basin A was selected because it was part of a natural depression. In 1952, the impoundment dike was raised 5 feet (ft) to handle additional waste generated after the GB plant went into operation. During the period from 1943 to 1956, Basin A was the primary receptor of liquid waste. Overflows went through the open drainage to Basins B, C, D, and E, constructed in 1952. Basin F was completed in 1957 to contain all waste waters, and liquids in Basin A were transferred to it by 1958.

During the period from 1965 to 1969 demilitarization of phosgene and cyanogen chloride munitions was performed at RMA. Disposal of mustard munitions occurred from 1972 to 1974, and demilitarization of GB munitions was performed from 1973 to 1976.

Disposal practices at RMA have included routine discharge of industrial waste effluents to unlined evaporation basins and burial of solid wastes at various locations. In addition to these practices, unintentional spills of raw materials, process intermediates, and final products have occurred within the manufacturing complexes at RMA. Many of these compounds are mobile in surface and ground waters as well as air.

1.2 ENVIRONMENTAL SETTING

RMA occupies over 17,000 acres (27 square miles) of low, rolling terrain with grassland, wetland, and aquatic habitats which support a number of plant and wildlife species. The South Platte River flows parallel to the northwest boundary and is less than two miles from RMA. The area surrounding RMA is largely ranch/farmland, rural and urban residential, and industrial (Kolmer and Anderson, 1977).

The adjacent land north of RMA consists mostly of rangeland (grassland) and dryland agriculture. Rural residential developments are scattered north and northwest of RMA. Urban developments include Commerce City (west) and Montbello (south). The north runways of Denver's Stapleton International Airport extend into the southwestern corner of RMA.

Cropland and range habitat north and east of RMA provide habitat for game species such as cottontails, ringneck pheasants, and mourning dove. Lake and wetland areas at Barr Lake, five miles to the northeast and downstream from RMA, provide staging, breeding, and resting areas for waterfowl; habitat for edible fish species; and winter habitat for the the bald eagle, an endangered species.

1.2.1 TOPOGRAPHY

The topography of RMA consists of stream-valley lowlands separated by gently rolling uplands. The maximum local topographic relief in the area is about 300 ft; the elevation above mean sea level (msl) ranges from about 5,330 ft at the southeastern boundary of RMA to about 5,029 ft at the northwestern boundary of RMA. The average elevation across RMA is 5,250 ft msl.

Tributaries from RMA to the South Platte River drain to the northwest, while the overall surface drainage in the region is toward the northeast, and all of RMA is drained by the South Platte River and its tributaries. The South Platte River originates in the Rocky Mountains southwest of Denver, and then flows in a general north-northeast direction to the vicinity of Greeley, where it swings toward the east.

RMA contains parts of five different drainage basins as shown in Figure 1.2-1. Proceeding from southwest to northeast, these basins are Sand Creek, Irondale Gulch, Basin A, First Creek, and Second Creek. All these areas are sub-basins in the South Platte River drainage. The South Platte River flows northeasterly at a distance of approximately 4.8 km from the RMA northwest boundary.

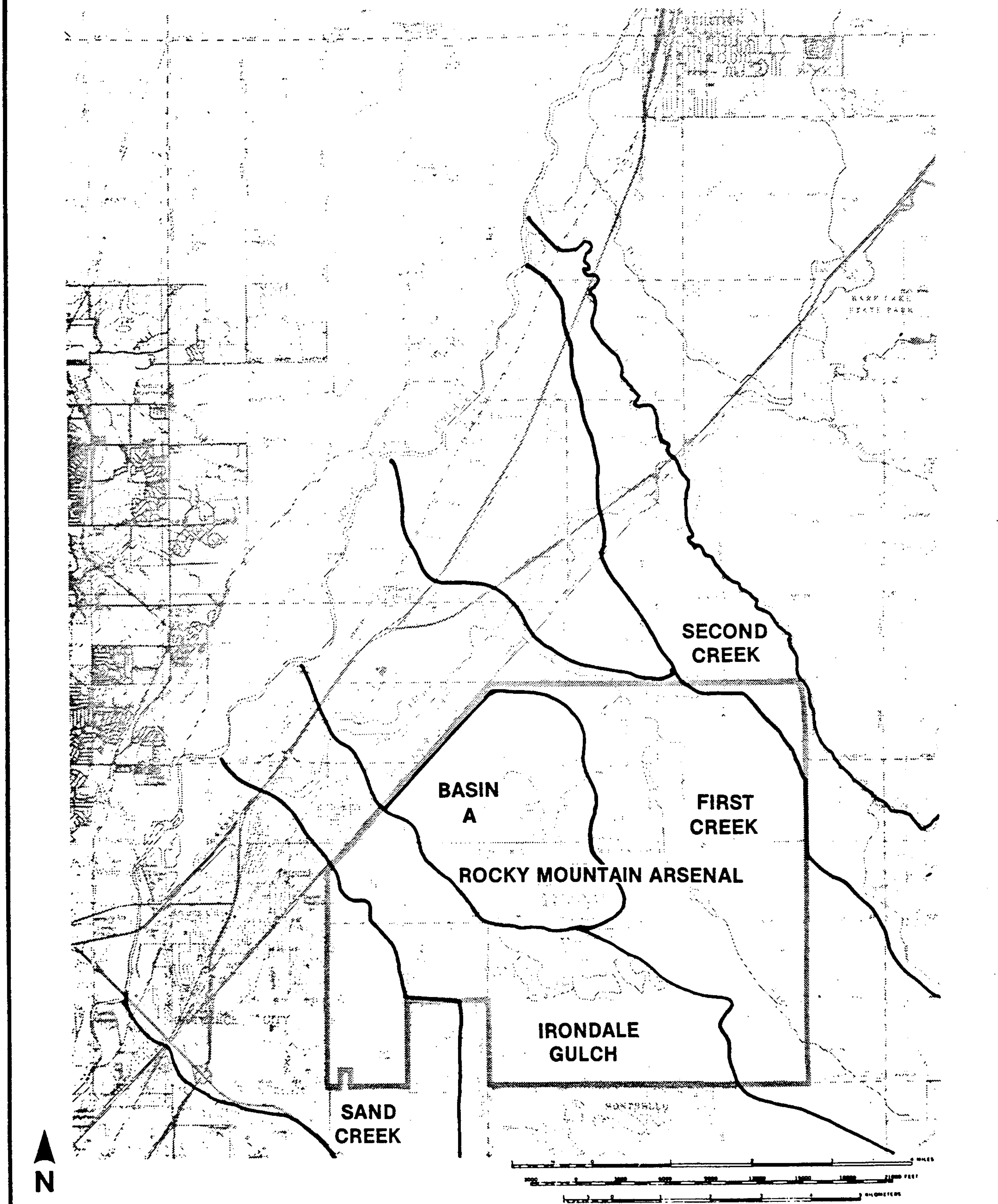


Figure 1.2-1
DRAINAGE BASINS

Source: Resource Consultants, 1981

Prepared for:
U.S. Army Program Manager's Office
For Rocky Mountain Arsenal
Aberdeen Proving Ground, Maryland

Two major irrigation canals, O'Brian Canal and Burlington Ditch, and several smaller ditches run southwest to northeast between RMA and the South Platte River. O'Brian Canal and Burlington Ditch receive drainage from RMA by interception of First and Second Creeks. These flows are either stored in the reservoir at Barr Lake State Park or distributed into one or more of many irrigation ditches downstream, depending on the season and the quantity of water available.

1.2.2 GEOLOGY

RMA is located in the northwestern portion of the Denver Basin, an oval shaped structural depression, 120 miles long and 70 miles wide. Sediments within the basin are composed of limestone, sandstone, shale and conglomerate up to 15,000 ft thick. These are overlain by a relatively thin veneer of recent alluvial and aeolian deposits. The major units at RMA include the recent alluvial and aeolian deposits and the underlying Denver Formation. The alluvial and aeolian deposits, often referred to simply as alluvium, consist of Quaternary age interbedded unconsolidated sands, silts, clays, and gravels. These deposits generally range from 10 to 20 ft thick over most of RMA, however thicknesses up to 130 ft have been encountered along buried channels that traverse RMA in a generally northwest direction.

The Denver Formation underlies the surficial materials at RMA. The Denver Formation consists of 400 to 600 ft of clay shale and lenticular bodies of sand and thin zones of silt, clay, lignite, coal, siltstone, sandstone, and volcanoclastic sediments. The clay shale is a hard, bentonitic unit that varies from blocky to laminated in appearance. The sand lenses are composed predominantly of poorly cemented sandstone which grades laterally and vertically into silts and clay shales.

There are two aquifers of primary concern at RMA, the alluvial aquifer and the Denver aquifer. The alluvial aquifer, also termed the upper aquifer, consists of interbedded sands, silts, clays and gravels of alluvial and aeolian origin. The contact between these deposits and the underlying Denver Formation is often marked by a zone of weathered bedrock. Where present, this zone is considered to be part of the alluvial aquifer system.

The Denver aquifer, also referred to as the lower aquifer, bedrock aquifer or Denver sands, is composed primarily of lenses of weakly cemented sandstone or compact fine to medium grained sands. These sand lenses are discontinuous, grading laterally and vertically into relatively impermeable silts and clay shales.

1.2.3 CLIMATE

A sunny, semi-arid climate prevails over much of the central Rocky Mountain region, without the extremely cold mornings of the high elevations and restricted mountain valleys during the cold part of the year, or the hot afternoons of summer at lower altitudes. Extremely warm or cold weather is usually of short duration. Air masses from at least four different sources influence the area weather: arctic air from Canada and Alaska, warm moist air from the Gulf of Mexico, warm dry air from Mexico and the southwest, and Pacific air modified by its passage over coastal ranges and other mountains to the west.

Spring is the wettest, cloudiest, and windiest season. Approximately 37 percent of the total annual precipitation (normal = 15.53 inches) occurs in spring. Much of this moisture falls as snow during the colder, earlier period of the season.

Summer precipitation (31 percent of the annual total), particularly in July and August, comes mainly from scattered local thunderstorms during the afternoons and evenings. In autumn, there is less cloudiness and a greater percentage of sunshine than at any other time of the year. Precipitation amounts to about 19 percent of the annual total.

Winter has the least precipitation accumulation, only approximately 13 percent of the annual total, and almost all of it is snow. Precipitation frequency, however, is higher than in autumn. There is more cloudiness, and the relative humidity averages higher than in the autumn.

Temperature and precipitation normals, means, and extremes are summarized in Table 1.2-1 (Fairbanks and Kolmer, 1976; Kolmer and Anderson, 1977). These data were collected at the Weather Bureau Office at Stapleton International Airport which borders a part of the RMA south boundary.

1.2.4 BIOTA

Several distinct vegetation types occur on RMA and are classified into three major ecosystem types: terrestrial, wetland, and aquatic. Over 200 plant species have been documented on RMA. Disturbed shortgrass prairie, mixed grasslands, and crested wheatgrass predominate on much of the northern portions while lakes, wetlands, and small patches of woodland occur within the southern section. Indigenous and introduced plants on and near RMA are mostly common species found throughout the region. Figure 1.2-2 shows the distribution of vegetation types on RMA based on aerial photography, existing maps, limited ground-truthing, and reference to the draft vegetation map provided by Morrison-Knudson Engineers, Inc.

Overall, non-native herbaceous plants are the most widely distributed vegetation. This vegetation cover type occurs on approximately 65 percent of the land area at RMA, and reflects past disturbance. Some of the more abundant species are cheatgrass, prickly lettuce, tumble-mustard, kochia, Russian thistle, bindweed, western ragweed, prairie sunflower, and horseweed (Kolmer and Anderson, 1977).

Second in relative abundance and covering approximately 15 percent of the area is crested wheatgrass, an Asiatic species planted for soil stabilization. This species often forms pure stands. However, in some areas, red threeawn, sand dropseed or cheatgrass may occur as co-dominants. Hairy golden-aster and western ragweed are common forbs.

Table 1.2-1. Temperature and Precipitation Normals, Means, and Extremes Recorded at Stapleton International Airport

Month	Temperatures °F				Precipitation in Inches		
	Normal Daily Maximum	Normal Daily Minimum	Record Highest	Record Lowest	Normal Monthly	Maximum Monthly	Mean Monthly Snow
January	43.5	16.2	69	-25	0.61	1.44	8.2
February	46.2	19.4	76	-18	0.67	1.66	7.9
March	50.1	23.8	84	- 4	1.21	2.89	12.7
April	61.0	33.90	84	- 2	1.93	4.17	9.9
May	70.3	43.6	93	26	2.64	7.31	1.6
June	80.1	51.9	98	36	1.93	4.69	Trace
July	87.4	58.6	103	43	1.78	6.41	0.0
August	85.8	57.4	100	41	1.29	4.47	0.0
September	77.7	47.8	97	20	1.13	4.67	1.8
October	66.8	37.2	87	3	1.13	4.17	3.7
November	53.3	25.4	78	- 2	0.76	2.97	7.9
December	46.2	18.9	73	-18	0.43	2.84	6.4
YEAR	64.0	36.2	103	-25	15.51/yr	7.31	60.1/yr

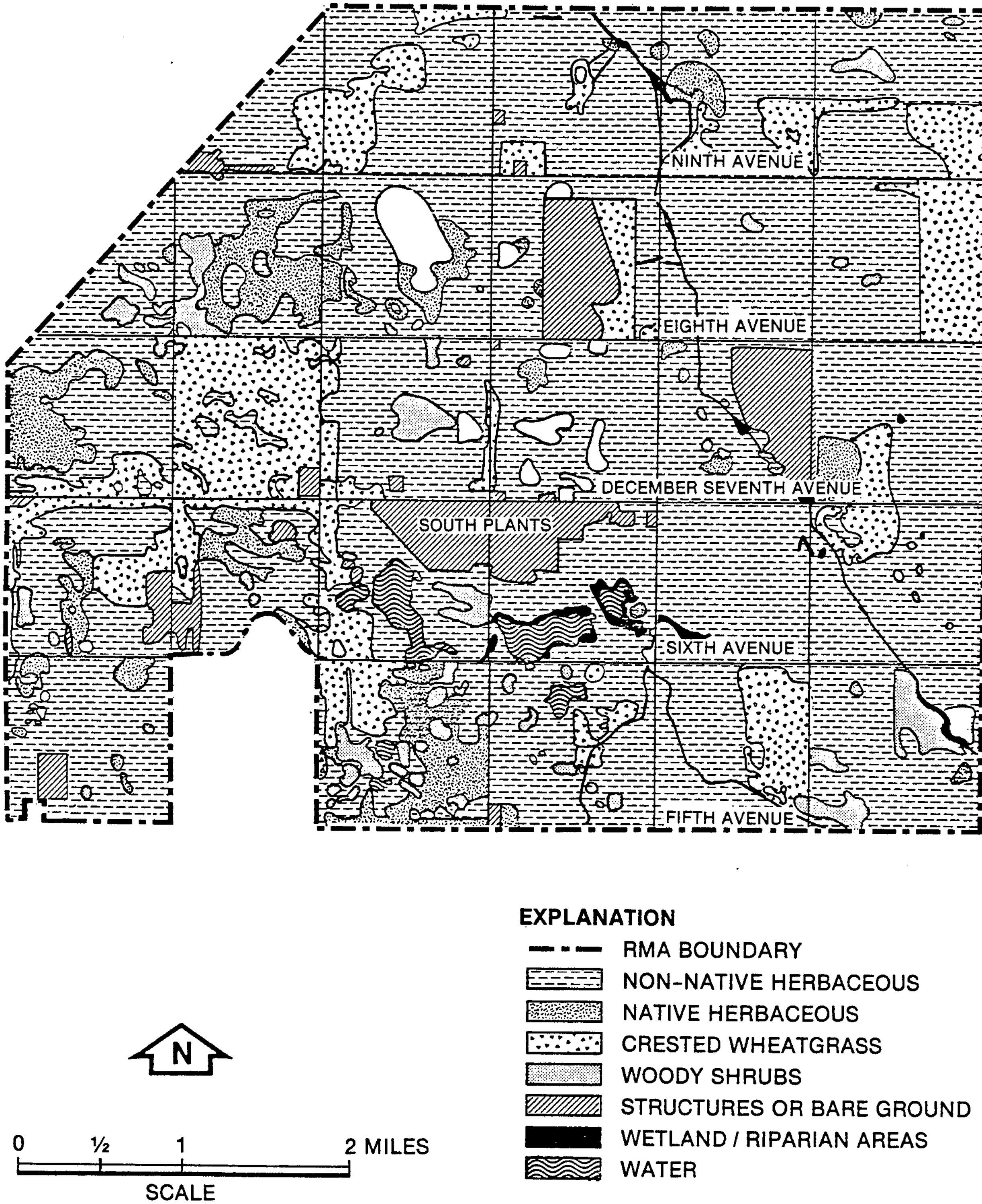


Figure 1.2-2
PRELIMINARY VEGETATION MAP OF ROCKY MOUNTAIN ARSENAL

SOURCE: ESE, 1986

Prepared for:
U.S. Army Program Manager's Office For Rocky Mountain Arsenal
Aberdeen Proving Ground, Maryland

The native herbaceous plant group is present on about 7 percent of the area. Blue grama is the most abundant species, often forming a dense sod with such mid-grasses as squirreltail, sand dropseed, or red threeawn as co-dominants. Common forbs include copper-mallow, prairie sunflower, and sand lily.

Upland shrubs and scattered woodlands constitute about 4 percent of RMA property. Dense, nearly impenetrable, pure stands of black locust dot the plains at RMA. These thickets developed from black locusts planted by the early settlers. Most are from 5 to 20 ft in height, with a low diversity of understory vegetation. Dense willow thickets are scattered along water courses at RMA. The small woodlands consist of scattered trees around old farmsteads, along roads, windbreaks, and in riparian areas. These woodlands contain a variety of trees including Chinese elm, plains cottonwood, white poplar, Rocky Mountain juniper, ponderosa pine, and box elder (Fairbanks and Kolmer, 1976).

Wetland and riparian vegetation comprises less than 2 percent of the surface area at RMA. It is found in patches along First Creek, some of the canals, the lakes and ponds, and other low-lying moist areas. Cattails are abundant in shallow water or very wet areas. Smartweed, sedges, and American bulrush are locally common in these areas. On moist areas alkali salt-grass or squirreltail may form a dense cover. Lakes and ponds containing aquatic vegetation represent about one percent of the area and are concentrated in the southern portion of RMA (Kolmer and Anderson, 1977).

Approximately 7 percent of the land area at RMA has been developed or is otherwise devoid of vegetation. This includes the large, industrial complexes as well as small, commercial and residential areas. Waste disposal areas lacking vegetation are also included.

The great variety of vegetation present on RMA provides cover, food, and reproductive habitat for many wildlife species. Four hundred and seventy-one vertebrate species potentially occur on RMA property (Appendix A).

These include 25 fish, 7 amphibian, 23 reptile, 361 bird, and 55 mammal species. Migratory as well as resident wildlife are represented. In addition, a diversity of invertebrate species are represented from collections at RMA.

Populations of game fish including largemouth bass, black bullhead, channel catfish, and bluegill inhabit the lakes and ponds in the southern part of RMA. Most of these have been stocked or have been introduced via irrigation canals (Kolmer and Anderson, 1977).

RMA supports a variety of amphibians and reptiles. Of the 30 species listed, population levels are considered at least fairly common for 24 species and uncommon or unknown for six species (Colorado Division of Wildlife, 1981). The bullsnake may be the most abundant reptile throughout RMA, while the lesser earless lizard is common in exposed sandy areas and the plains garter snake is common in marsh or moist habitats. The prairie rattlesnake inhabits grassland areas.

Populations of bullfrogs are found around the permanent lakes of RMA. Other common amphibians include the chorus frog, plains spadefoot, northern leopard frog, and tiger salamander.

A great diversity of bird life, including songbirds, shorebirds, water birds, upland gamebirds, and raptors are found on RMA. The most abundant breeding birds of the prairie habitats of RMA include the western meadowlark, lark bunting, horned lark, mourning dove, Brewer's sparrow, and ring-necked pheasant (Colorado Division of Wildlife, 1982A). The lark bunting and horned lark are primarily restricted to shortgrass vegetation, such as the blue grama and red threeawn vegetation cover types, while the Brewer's sparrow is common only in areas with scattered shrubs. During winter, the western meadowlark, horned lark, common redpoll, lapland longspur, and ring-necked pheasant are among the dominant prairie species.

The scattered trees, thickets, and woodlands of RMA provide nesting habitat for black-billed magpies, eastern and western kingbirds, house wrens, starlings, northern orioles, common grackles, and many others. The tree sparrow, white-crowned sparrow, dark-eyed junco, starling and black-billed magpie are common wintering birds of the woodland habitat.

The lakes, ponds, and marshes of RMA support many species of aquatic and marsh birds. Common breeding birds include several species of waterfowl, red-winged and yellow-headed blackbirds, and common yellowthroats. Many species of waterfowl, including large numbers of Canada geese, as well as other birds, utilize these habitats during the winter.

In addition to supporting the typical breeding birds of eastern Colorado, RMA supports breeding populations of several species which breed only locally or rarely on the eastern plains. The short-eared owl, tree swallow, mockingbird, sage thrasher, orchard oriole, grasshopper sparrow, and Brewer's sparrow, as well as other species, are in this category.

Another unique characteristic of RMA is the density of raptors present on the installation. The abundance of prey, the distribution and abundance of suitable nesting and perching habitat, and the relative lack of human disturbance favor high population densities of hawks and owls. Previous winter surveys showed that hawk densities averaged approximately five to six individuals per square mile (Kolmer and Anderson, 1977). Rough-legged hawks are most abundant during the winter, although ferruginous, red-tailed, and marsh hawks are also common. Golden eagles and prairie falcons are present in smaller numbers. Wintering owls include long-eared, short-eared, barn, and great-horned. During the summer, red-tailed, ferruginous, Swainson's and marsh hawks, and American kestrels are common. The latter three species are the dominant breeders. Great-horned, long-eared, short-eared, and burrowing owls are also common breeders.

Several groups of mammals are represented at RMA. Rodents (25 species) and carnivores (13 species) are the most diverse groups. Although some species are rare or uncommon, most are fairly common (Colorado Division of Wildlife, 1982B).

Previous small mammal trapping has indicated that large densities of certain species may be present in some areas. Among the most abundant are deer mice, prairie and meadow moles, and Ord's kangaroo rat. The larger, more conspicuous rodents include the black-tailed prairie dog, thirteen-lined ground squirrel, and fox squirrel. RMA contains large prairie dog towns. Twelve separate towns together cover over 1,000 acres (Kolmer and Anderson, 1977). Another abundant rodent, the plains pocket gopher, is conspicuous due to the mounds of soil it produces at the surface when it excavates its underground tunnels. The densities of this small mammal are highest in areas with sandy soils.

Lagomorphs are conspicuous and abundant on RMA. Black-tailed jackrabbits are widespread, being especially common in areas with tall grass, forbs, or shrubs. Cottontail rabbits are common in and around woodlands, thickets, brush piles, and prairie dog towns.

The mule deer is the most common big game mammal on RMA. Over the past several years, the population has averaged between 50 and 100 animals. In addition, several white-tailed deer are generally present (Fairbanks and Kolmer, 1976).

The most abundant predatory mammals on RMA are the coyote, badger, and long-tailed weasel. Coyotes are frequently observed, especially in winter.

Several rare, threatened, and endangered birds and mammals and species of special status have been observed on or near the vicinity of RMA including the peregrine falcon, prairie falcon, spotted owl, bald eagle, ferruginous hawk, and western burrowing owl. The black-footed ferret is probably the only threatened or endangered mammal which might have occurred on RMA, though no confirmed sightings in the RMA vicinity have occurred since 1914, and nocturnal spotlight searches in 1975 found no ferrets (Kolmer and Anderson, 1977).

Although systematic studies have not been made, regional and site literature indicate that a diversity of invertebrate species exists at

RMA. Representatives of 48 insect families have been collected at RMA since 1975 and species from 11 other families of invertebrates have been identified.

Grasshoppers (Orthoptera) are a major food source for many of the birds and mammals found on RMA (Martin et al., 1951). They are abundant throughout summer and occasionally become so dense that they do considerable damage to the vegetation.

Other common invertebrate residents of the prairie of RMA are the harvester ants. They denude the vegetation in circles up to 20 ft or more in diameter around their mounds. They collect and store large quantities of seeds and are used as food items by many amphibians, reptiles, birds, mammals, and other insects.

Beetles (Coleoptera); moths and butterflies (Lepidoptera); bees, wasps, and ants (Hymenoptera); and other invertebrates are abundant and important organisms in the natural environment at RMA. They are important in the decomposition of organic matter, as food sources for other animals, for the pollination of many plants, and for aeration of soil (Kolmer and Anderson, 1977).

1.3 PROBLEM DESCRIPTION

There are numerous sites on RMA where hazardous wastes have been intentionally deposited or that have become accidentally contaminated due to past Army and lessee activities. Industrial waste effluents generated at RMA were routinely discharged to unlined evaporation basins. Solid wastes have been buried at various locations throughout RMA. Unintentional spills of raw materials, intermediate and final products have occurred within the manufacturing complexes at RMA. Contaminants from these sites have occasionally entered mobile media (ground water, surface water, air, or animals) and may have been transported off RMA limits.

Deaths and abnormal behavior have been recorded for several waterfowl species in the lower lakes on RMA (Jensen, 1955). Subsequent observations and testing indicated that ducks found dead, dying, or displaying unusual behavior (e.g., flying into buildings) contained high levels of dieldrin and other organochlorine compounds. Since that time, high levels of organochlorines have also been found in fish from the lower lakes, in raptors collected on and near the RMA, and in the flesh of other game animals including ringneck pheasant, mourning dove, and cottontail rabbits.

Chemical analyses of fish and wildlife have been conducted on an annual basis from the early 1970s to the present. These studies have revealed that at least some of the waterfowl, fish, and other fauna from RMA contain levels of pesticides and metals (e.g., mercury) in their flesh which pose a potential health hazard to humans who consume them. These contaminant levels could adversely affect wildlife by lowering reproductive success, decreasing hatching success of waterfowl, and causing the premature death of young individuals.

In 1954 and 1955 farmers to the northwest of RMA reported severe crop losses due to use of well water for irrigation. In 1974, two contaminants, diisopropylmethylphosphonate (DIMP), which is a by-product of manufacture of GB nerve agent, and dicyclopentadiene (DCPD), a chemical used in insecticide production, were detected in offpost ground water. Since 1974, offpost migration of dibromochloropropane (DBCP), a nematocide which had been shipped from RMA by rail from 1970 to 1975, has been observed in ground water.

Shallow ground water contamination exists in areas north and west of RMA, in part, as a result of onpost activities. Well water in contaminated offpost areas is used to water vegetable crops which are grown for local sale and consumption. Livestock are watered from some of these wells, and are also fed crops raised in the area. Ground water contamination thus poses a potential hazard to livestock and humans as well as wildlife in the offpost area.

Past investigations have documented a variety of injuries to the biota at RMA. This plan provides the comprehensive assessment needed to determine the species affected, chemicals and areas of concern, and the extent and nature of past and current injuries to biota resources and to the services provided by these resources for purposes of the remedial investigation/feasibility study.

1.4 OBJECTIVES AND REGULATORY REQUIREMENTS

1.4.1 GENERAL OBJECTIVES

The overall objective of the biota assessment is to provide information necessary for the evaluation of current and past hazardous waste effects on biological resources on and related to RMA. This information is to be obtained from existing documents, contacts with regional experts and other knowledgeable individuals, and from sampling programs instituted to acquire data not already available from other sources.

The activities of this task will be used to:

- o Fulfill the U. S. Environmental Protection Agency (EPA) Remedial Investigation/Feasibility Study (RI/FS) requirements for biota studies of hazardous waste sites under the National Contingency Plan (NCP);
- o Provide specific information on the migration and accumulation of contaminants through regional food webs; and
- o Provide information for the injury determination phase of the Natural Resource Damage requirements of CERCLA.

The regulatory requirements for biological studies at RMA in relation to hazardous waste assessment are described in the following sections.

1.4.2 NATIONAL CONTINGENCY PLAN

A Remedial Investigation/Feasibility Study (RI/FS) is required by the National Oil and Hazardous Substances Pollution Contingency Plan (NCP), Final Rule 50 Federal Register 479112 (November 20, 1985). This study is to be undertaken by the lead agency conducting the remedial action in order to determine the nature and extent of the threat presented by the contamination and to evaluate possible remedies. The study design includes appropriate sampling, monitoring, and exposure assessment as necessary, and requires the gathering of sufficient information to determine the necessity for and proposed extent of remedial action. The

NCP also requires an analysis of food chain contamination and bioaccumulation. While extensive statistically valid ecological monitoring is not required, it is necessary to examine potential food chain contamination and to estimate the extent of any food chain contamination problem (50 Federal Register 47925).

1.4.3 NATURAL RESOURCE DAMAGE ASSESSMENT REGULATIONS

CERCLA § 301(c), 42 U.S.C § 9651(c), provides for the issuance of regulations for the assessment of damages for injury or destruction of, or loss of natural resources resulting from a release of a hazardous substance. Accordingly, Natural Resource Damage Assessment (NRDA) regulations were promulgated, 50 Federal Register 27674 (August 1, 1986), to provide a cost-effective means of assessing any compensatory damages which may be warranted for injuries residual to those injuries that may be ameliorated in the response action. In essence, these regulations provide for the initiation of the NRDA process upon the lead agency's notification of each Federal or State agency authorized to act as trustee(s) of the potential existence of natural resource injury, with a preassessment screen occurring thereafter. In the event that a type B NRDA is then found to be warranted, this would involve a three-phase process:

1. Establishing that the injury occurred and that the injury resulted from the discharge or release;
2. Quantifying the effects of the discharge or release on the services provided by the injured resource; and
3. Determining the damage.

During the post-assessment phase, procedures would be implemented for the issuance of the Report of Assessment, to provide a demand for a sum certain to a responsible party, and for the establishment of a restoration account.

Although the Army has not initiated the formal NRDA process as of this time, this "Biota Assessment Phase II Technical Plan" contemplates utilizing data gathered during the biota assessment for purposes of the NRDA whenever appropriate. Thus, it is intended that this NCP biota assessment will also be consistent with the NRDA process to the maximum extent possible.

1.4.4 STUDY COORDINATION

The major participants in the biota assessment portion of RI/FS studies at RMA include the U.S. Army, as lead agency of the site and its contractor, ESE, Inc.; Shell Oil Company and its environmental contractor, Morrison-Knudsen Engineers, Inc.; the U.S. Fish and Wildlife Service and the State of Colorado represented by the Department of Health and the Division of Wildlife. Procedures for the regular exchange of data, coordination of environmental studies, and review of study plans are part of a Memorandum of Agreement (MOA) among these parties. A Biota Assessment Committee has been established to facilitate the process and serves as an official subcommittee of the MOA group.

2.0 EVALUATION OF EXISTING INFORMATION

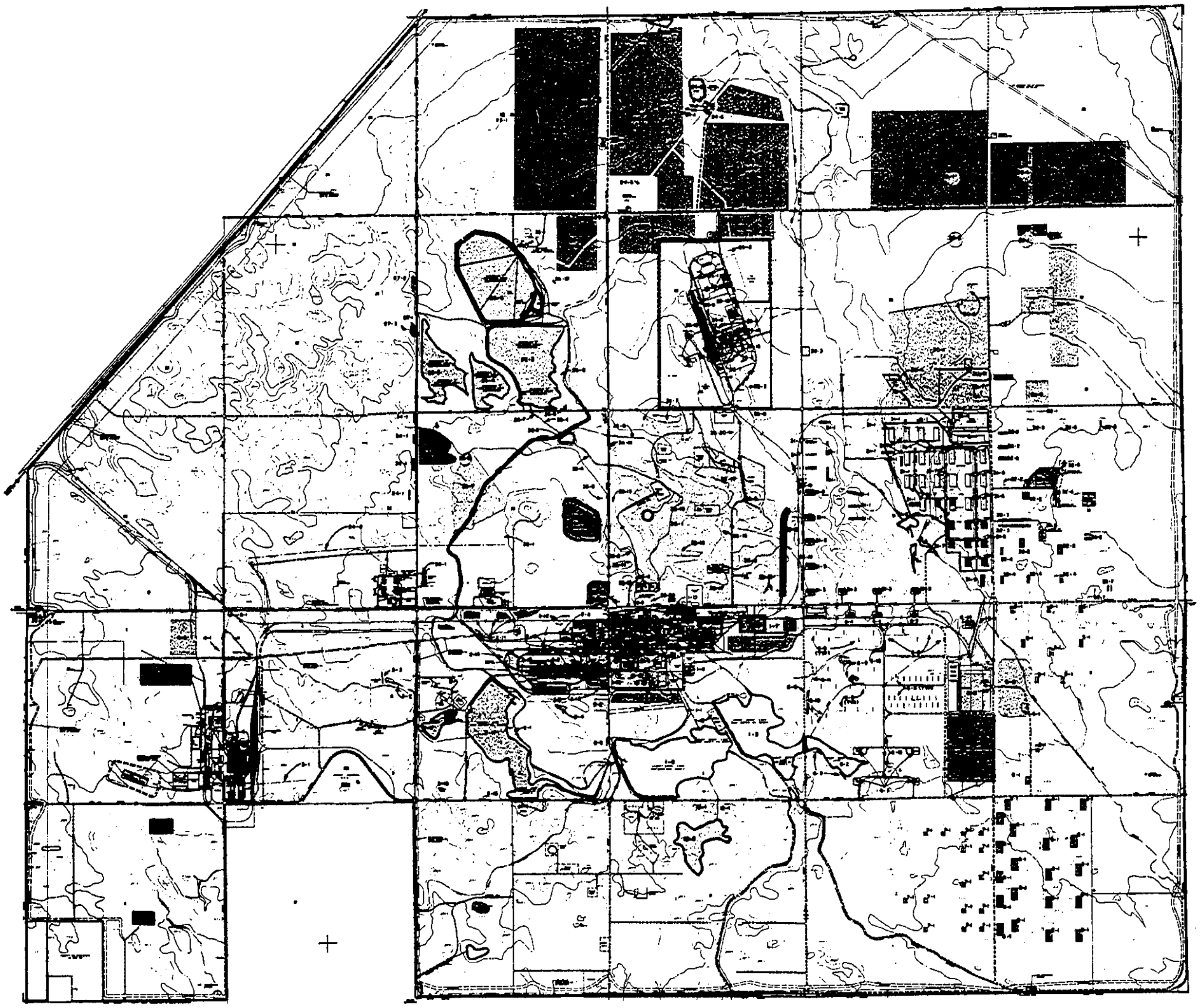
2.1 CONTAMINATION SITES AND SOURCES

Numerous studies have been conducted in relation to particular contamination problems in the three decades since the discovery of chemical contamination in the environment on and near RMA. Recent summary documents have provided an overview of the history of contamination at RMA. Potential sites of contamination have been identified on RMA (U. S. Army Toxic and Hazardous Materials Agency, 1984). Additional investigations have been performed in relation to the known and potential migration of chemical contaminants from RMA by means of ground water (U. S. Army Toxic and Hazardous Materials Agency, 1983). Data provided in these documents was the result of investigations conducted at different locations, different times, and involving the analysis of different groups of chemicals. The results of these studies identified more than 100 discrete sites of potential contamination and/or contaminant migration on RMA (Figures 2.1-1 and 2.1-2).

Comprehensive investigations of contaminant distribution are presently underway which are aimed at identifying the locations, types, and concentrations of contaminants in the environment on and near RMA. When completed, the first phase of data collection for surface water, ground water, and soil will provide an overview of contamination in these media. Additional assessment studies of contamination in air and in the biota are presently under way. When completed, these will provide a comprehensive evaluation of the nature and extent of environmental contamination resulting from activities associated with the RMA.

2.1.1 SITE IDENTIFICATION

Potential sites of contamination which affect or have affected biota were selected on the basis of existing information. The description of sites of potential contamination and potential contaminant migration were reviewed to determine the known or probable chemical contaminants associated with each location. Data on the amount, toxicity, and persistence of these chemicals were examined for each site. These data are discussed further in Section 2.2.



ROCKY MOUNTAIN ARSENAL

EXPLANATION

- Sites Likely to Contain Contaminated Materials
- Contaminated Sites Addressed Under Baseline Actions
- Balance of Areas Investigated

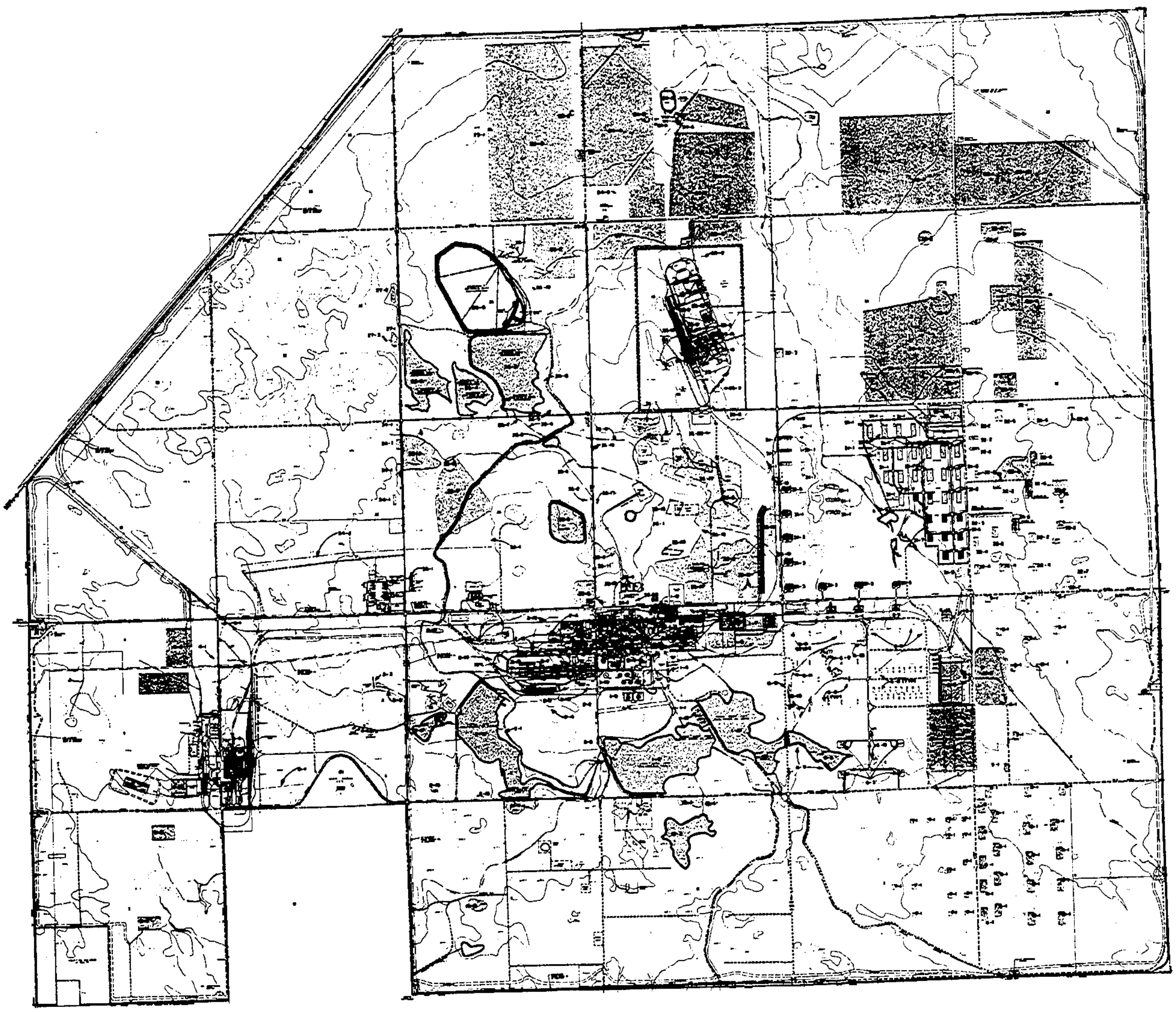
N

0 ½ 1 2 MILES

SCALE

Figure 2.1-1
AREAS INVESTGATED AS POTENTIAL CONTAMINATION SITES ON RMA

Prepared for:
U.S. Army Toxic and Hazardous Materials Agency
Aberdeen Proving Ground, Maryland



ROCKY MOUNTAIN ARSENAL

EXPLANATION

- Primary Migration Source
- Potential Migration Source
- Balance of Areas Investigated

N

0 ½ 1 2 MILES

SCALE

Figure 2.1-2
AREAS INVESTIGATED AS
MIGRATION SOURCES ON RMA

Prepared for:
U.S. Army Toxic and Hazardous Materials Agency
Aberdeen Proving Ground, Maryland

Additional information examined in order to select potential areas of contamination came from the numerous documents on observed biological impacts associated with particular sites on RMA (U.S. Army, Dugway Proving Ground, 1973 and 1975a and b; U.S. Fish and Wildlife Service, 1965 and 1982; Rosenlund et al., 1986) and from documents containing information on contaminants in tissues from animals collected on and near RMA (Thorne, 1986a and b; U.S. Army Dugway Proving Ground 1975a and 1975b). Information on the distribution of contaminants in biota at RMA are presented in Sections 2.3 and 2.4.

Presence in the physical environment at a particular site was not sufficient to designate a particular site as a potential contamination source for biota. In many instances contamination studies indicated that the chemical contamination was confined to underground aquifers, well below soil layers inhabited by most biota. In most cases, the precise distribution, concentration, and chemical composition of contaminants was not identified and the sites could not be completely eliminated from consideration.

Final determination of sites of contamination with respect to biota are being identified on the basis of information contained in the aforementioned documents produced by the U. S. Army Toxic and Hazardous Materials Agency (1983 and 1984), documents describing contaminant effects on biota which can be associated with a particular site or sites of contamination (e.g., lower lakes, Basin F, etc.), and documents summarizing data being collected at sites throughout RMA and the offpost study area (Figure 2.1-3). Data from current studies is presently being reviewed by the Army and will be used to update the list of sites of potential contamination to biota.

2.1.2 SITES OF CONTAMINATION

Present information from the current Phase I assessment studies is being compiled in a series on source reports for the various areas on and off RMA. Surveys conducted as a basis for these reports included surface water, ground water, and soil surveys throughout RMA and the offpost study area. These surveys were conducted not only to determine the

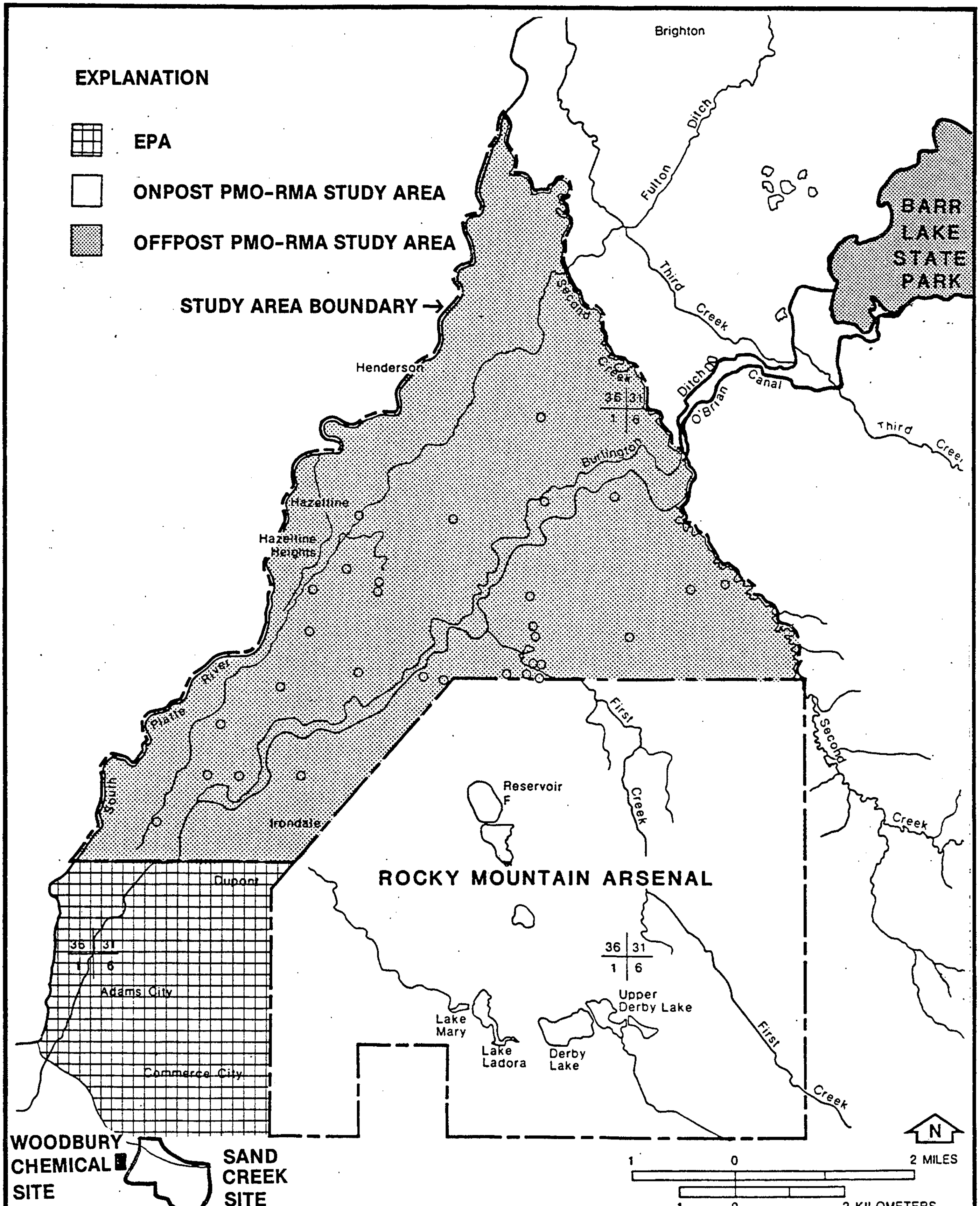


Figure 2.1-3
PHASE I STUDY AREA BOUNDARIES

SOURCE: ESE, 1984

Prepared for:
U.S. Army Program Manager's Office For Rocky Mountain Arsenal
Aberdeen Proving Ground, Maryland

nature and extent of contamination at potential sites of contamination and contaminant migration, but also to determine if additional sites might exist. Preliminary indications suggest that the number of sites of concern may be smaller than the list of potential sites. These changes may be the result of incomplete or erroneous past documentation and/or the result of the dissipation of contamination over the past three decades. This would be particularly true of chemicals which can easily migrate through physical media or which are not persistent in the environment.

Assessment of contamination at RMA must therefore rely on documentation of past distribution of chemicals and effects on biota as well as a comprehensive knowledge of the present distribution of these chemicals in the environment. Because Phase I surveys of contaminants in surface water, ground water, and soil are not yet finished, it is not possible to determine all sites of contamination and sources of contaminant migration of RMA contaminants. However, major sites of contamination can be identified, based on information from a variety of sources (Thorne, 1986a and 1986b; RIC#81341R02; Environmental Hygiene Agency, 1973; Jensen, 1955 and many others). The descriptions which follow include only major sites of contamination which have been identified in connection with known and potential effects on biota. Additional information from current Phase I investigations and future studies of contamination in biota will be incorporated into subsequent versions of this report.

2.1.2.1 South Plants Area and Basin A

In 1942, the Armed Forces of the United States had a critical need for chemical filled munitions, as well as an urgent requirement for incendiary munitions. Manufacture and filling of these munitions in the South Plants Area (Sections 1 and 2) resulted in discharge of liquid waste into the Basin A lime settling ponds and Basin A pool, located in Section 36, north of the South Plants Area. Other industrial operations in the area included the production, munition filling and storage of mustard gas, lewisite, phosgene, white phosphorous, chlorine, incendiary mixtures, and explosive button bombs. Julius Hyman Company and Shell have leased South Plants buildings for the manufacture of chlordane, DDT, dieldrin, aldrin, and other pesticides. (PMCDIR, 1977, Volume 2, Appendix E, p. 7). Facilities completed in 1953 in the North Plants Area which produced GB agent also utilized Basin A for liquid waste disposal.

Historical and current data provide evidence which identifies the South Plants Area as containing the most heavily contaminated ground water on RMA. The following are representative of the problems known to have occurred in this area:

- A major spill of benzene in 1948; benzene is currently present and migrating from the area;
- The surface disposal of waste in disposal ponds and burial pits;
- Spills of pesticides into the environment through surface ditches impacting Lower Lakes: Upper Derby, Lower Derby and Ladora;
- Plumes of contaminants with high migration potential indicated by ground water sampling and analysis;
- Infiltration and exfiltration of contaminants from sewers provide current active pathways for contaminant drainage from the source areas; and
- Buildings with contaminated water in basements and sumps.

Because of these problems, Basin A and the South Plants Area has contributed to past and current migration of contaminants in the direction of RMA boundaries.

2.1.2.2 Lower Lakes

The Lower Lakes consist of four water filled depressions. Lake Ladora is a natural lake clearly visible in its present configuration on 1937 aerial photographs. The remaining "lakes" are impoundments constructed in natural depressions following the creation of RMA and are interconnected by drainages. Lake Mary was completed in 1960. The Rod and Gun Club Pond was created by high water overflow from Lower Derby Lake several years after the southern lakes were dredged (RIC#81342R06, RIC#83326R01).

The lake system has been used as a source of process cooling water for the various industrial operations on RMA. Water was pumped from Lake Ladora via the pumping station, Building 371, and returned to Upper Derby Lake. The water flows by gravity into Lower Derby Lake and then to Lake Ladora (EBASCO, 1985). Lake Mary is not included as part of the process water system by any of the reviewed reports. There is no indication that waste was disposed of in Lake Ladora or Lake Mary. The lake system reportedly has received contaminants from the following (EBASCO, 1985):

- Recirculated process cooling water containing contaminants from defective equipment;
- Underground flow of contaminants from an acetylene waste disposal basin; and
- Shell operations in 1964 contributed pesticides, aldrin, and dieldrin contamination.

In 1964, Upper and Lower Derby Lakes and Lake Ladora were drained, and sediment was excavated. The sediment was placed in the north-central parts of Sections 11 and 12. Recovered sediments reported contained 25 to 50 ppm of dieldrin. Sediment samples were take from Lake Ladora and Lake Mary as part of a 1983 study (EBASCO, 1985). Samples were analyzed for 81 priority contaminants. Chemicals that were above detection limits are mercury, aldrin, dieldrin, endrin, p,p-DDT, methylene chloride, diethylphthalate, phenanthrene, dibutylphthalate, and butylbenzylphthalate.

2.1.2.3 Basin F

The need for expanded waste storage facilities as a result of the manufacture of Agent GB from 1953 to 1957 resulted in the construction of Basin F. Basin F encompasses approximately 93 acres and was completed in 1957 with an asphalt-lined bottom protected with a 12 in thick sand overburden.

Problems associated with the storage of liquid wastes in Basin F were encountered early in its operation and were caused by wave action against the shoreline that, at the time, had not been protected by riprap. In 1957, tears in the asphalt liner were found. The Basin F contents were pumped into Basin C, an unlined facility, while repairs were made to the Basin F liner and riprap was installed.

Historical and current studies of Basin F have identified problems with the site. Parts of the liner which are torn are being exposed to the impounded liquid. Fluctuating liquid levels cause cyclical exposures of the liner to sunlight and weather conditions. Also, evidence of ground water contamination has been determined by the chemical analysis of monitoring wells immediately adjacent to the Basin.

Recent sampling and analysis of subsoil by WES/RMA show that the original liner, generally, is in good condition, with some leaching noted, particularly in the southeast corner of the Basin known as "Little F". Contamination has migrated through the liner in several sample locations and is present in the shallow depths beneath the basin.

2.1.2.4 Basins C, D, E

Basin C, an unlined evaporation pond, stored overflow from Basins A and B, large quantities of freshwater from Sand Creek Lateral, and temporarily held approximately 100 million gallons of liquid wastes while Basin F underwent lining repairs in 1957. Basins D and E, also unlined, received overflow from Basin A from 1953 until the construction of Basin F in 1956. These four basins overlie several contamination plumes originating in the Basin A area, making it difficult to assess whether they are true sources. Chemical analyses of soil samples from the basins found traces of DIMP, PCPMS, PCPMSO, and $PCPMSO_2$ in solvent extracts. Water extracts of soil samples resulted in below detectable limits for all parameters except PCPMSO.

2.1.2.5 North Bog

A small body of surface water called North Bog is located on the northern boundary of RMA in Section 24. This pond receives surface water from the North Boundary System and is believed to have a subsurface connection with shallow aquifers which may be contaminated. Several species of ducks from this pond show levels of contamination in their tissue (see Section 4.0) which may have come from surface water or sediments in this pond. Surface water testing is planned and sediment testing is contemplated for the summer of 1986 which would provide data necessary for implicating North Bog as a source of contamination of concern to biota.

2.1.2.6 Offpost Biota

Domesticated Crops and Animals

Damage to domesticated biota in the area adjacent to RMA was first documented in the summer of 1954 when several farmers complained that ground water used for irrigation had damaged their crops (U.S. Army Toxic and Hazardous Materials Agency, 1984). In May 1974, two compounds directly related to operations at RMA were detected in surface water drainage from a man-made pond on the northern boundary of RMA.

Offsite contaminant migration in the early 1970's prompted the Colorado Department of Health to issue a series of administrative orders that led to the establishment of the Contamination Control Program by the U.S. Army. Several pollution abatement efforts have been implemented since that time however, contaminants are still present in shallow aquifer and some surface water areas within the offpost study area (Figure 2.1-3).

Recent surveys indicate that shallow ground water is still used for irrigation of vegetable crops and livestock watering within the areas of known and suspected contaminated ground water plumes. Offpost investigations on the types, concentrations, and distribution of ground water plumes are presently being performed. Data developed from these studies will be available in the near future which can be used to determine potential for contamination of domestic biota in the offpost study area.

Offpost Ecosystems

Potential exists for the migration of RMA contaminants into natural ecosystems in the offpost study area. Ground water distribution to surface water along the O'Brian Canal could lead to the contamination of surface waters and sediments in the canal and in Barr Lake (Figure 2.1-3). Sediment and surface water sampling in the canal and at Barr Lake will be conducted on a quarterly basis. Results of these studies can be used to evaluate the potential for contamination of biological resources in these areas (see Section 5.0 for evaluation methods).

2.2 CONTAMINANTS OF CONCERN

A list of potential contaminants was derived by first listing all compounds found in biota (compiled through a review of all notes and literature on RMA biological studies). The initial list also included compounds included in current ground water and/or soil screening programs, and all compounds known to be associated with operations at RMA (Geraghty & Miller, 1986). For each potential contaminant categories of information were added to form a matrix of available data for each compound. Compounds finally listed as "Potential Contaminants" were those found in biota sampled at RMA, and those which satisfied the following criteria:

- Present in RMA environment above ambient concentrations: Many chemicals were not included in tests during RMA environmental screening processes, and records did not indicate that these had contaminated the environment. There was therefore no evidence that these chemicals occur in the RMA environment. This group includes chemical used in laboratory or production processes, or which are intermediate or degradation products of these processes (Geraghty & Miller, 1986);
- Rated at least "Moderately Toxic" on the Merck Index: With two exceptions, only compounds rated "Moderately Toxic" or "Severely Toxic" were included for consideration; and
- Volume of disposal and/or persistence data available: Information on volume of disposal and/or persistence (half-life) (Geraghty and Miller, 1986) was considered important because it provided some indication of the compounds continued presence at RMA. Compounds of low or unknown disposal volume and low or unknown persistence may be more difficult to detect or sample than compounds of high disposal volume and/or high persistence.

DMMP was included because it is associated with DIMP, and because it was disposed of in relatively high volumes. Methylphosphonic acid (MPA), though of low toxicity, was included because it is toxic to plants, mobile in ground water, and highly persistent in the environment (Geraghty & Miller, 1986).

The list of potential contaminants that resulted from the above matrix construction is shown in Table 2.2-1.

Source reports completed for the South Plants (Task 2) and the Lower Lakes (Task 7) by EBASCO (March 1986) and by Environmental Science and Engineering, Inc. (February 1986) for sites in Section 36 indicate that fewer chemicals than previously thought have been detected in the RMA environment. Four organochlorines (aldrin, dieldrin, endrin, isodrin), arsenic, and mercury are prevalent throughout most sampling sites. Present less frequently are DBCP and DCPD. Three organosulfur compounds (PCPMS, PCPMSO, $PCPMSO_2$) are found infrequently. As they become available, these source reports will be used to update or refine biota contaminant studies.

2.3 CONTAMINANTS IN BIOTA

Observations of contaminants in and contaminant effects on biota have been documented by various agencies and personnel on RMA for more than three decades. These studies have been undertaken both as response actions to specific incidents and as monitoring activities at selected sites of known contamination. Examination of data from these investigations indicates that some effects on biota may have resulted from specific spills, but that others have resulted from persistent contamination problems in diverse species throughout this time period.

Although numerous studies relating contaminants in the physical environment to contaminant levels in selected species of biota have been conducted, quantitative data are generally lacking. In addition, each study involved analysis for a particular suite of chemicals, was usually associated with a particular site or group of sites, and most were conducted at different times over a span of thirty years. Because all

Table 2.2-1. Matrix of Criteria Used to Determine Potential Contaminants* (Page 1 of 3)

	Found In Biota Sampled at RMA	In RMA Environment	On "Potential for Migration" List	On Soil "Hit List"	Volume	Persistence (Half-life)	Toxicity
Aldrin	X	X	X	X	M,S	H	H*
Allyl chloride		X		X	L,S	L	H*
Arsenic	X	X	X	X	–	H	H*
Atrazine		X	–	X	–	M	M*
Azodrin		X		X	M,S	L	M*
Cadmium	X	X	X	X	–	–	H*
Chlordane	X	X	–	X	–	H	H*
p-cpm sulfide	X	X	X	X	M	M	M-L
p-cpm sulfone	X	X	X	X	M	H	H-M
p-cpm sulfoxide	X	X	X	X	L	H	M
Chlorobenzene		X	X	X	–	M	M-L
Chloroform		X	X	X	H	H	H*
Copper	X	X	X	X	–	H	H
Dibromochloropropane (DBCP)	X	X	X	X	M,S	M	H*
p,p^1 - DDT	X	X	X	X	–	H	H*
p,p^1 - DDE	X	X	X	X	–	H	M-L
Dicyclopentadiene (DCPD)		X	X	X	HP,M,S	M	H-M
Dieldrin	X	X	X	X	HP,H	H	H*
DIMP	X	X	X	X	MP	H	M-L
DMMP			X	X	H	–	L
Dithiane	X	X	X	X	–	–	M-L
Endrin	X	X	X	X	M	H	H*
Ethylbenzene		X	X	X	–	L	M-L*
Heptachlor		X				H	H*
Heptachlorepoxide (HE)	X	X				H	H*
Isodrin	X	X	X	X	M	H	H
Malathion		X		X	–	–	H*
Mercury	X	X	X	X	S	H	H

Table 2.2-1. Matrix of Criteria Used to Determine Potential Contaminants* (Continued, Page 2 of 3)

	Found In Biota Sampled at RMA	In RMA Environment	On "Potential for Migration" List	On Soil "Hit List"	Volume	Persistence (Half-life)	Toxicity
Methyl parathion		X		X	M	L	H-M*
Methylphosphonic Acid		X		X	M	H	L
Mustard		X		X	NR	H	H*
Nitrosodimethylamine		X		X	–	–	H*
1,4-Oxathiane	X	X	X	X	–	–	M
Oxychlordane	X					H	–
Parathion	X	X		X	–	–	H*
PCB	X	–	–	–	–	H	–
Toluene		X	X	X	H,S	M	H*
Trichloroethylene		X	X	X	–	H	H*
Xylene		X	X	X	M,S	L	M*

*Volume

H = High waste disposal	HP = High production
M = Moderate waste disposal	MP = Moderate production
L = Low waste disposal	LP = Low production
S = Spills, volume not rated	NR = Not able to rate

volume < 48,049 lbs. = Low production volume

48,049 ≤ volume ≤ 396,850 lbs. = Moderate production volume

volume > 396,850 lbs. = High production volume

volume < 45,000 lbs. = Low disposal volume

45,000 ≤ volume ≤ 720,000 = Moderate disposal volume

volume > 720,000 = High disposal volume

Table 2.2-1. Matrix of Criteria Used to Determine Potential Contaminants* (Continued, Page 3 of 3)

Persistence/Half Life Data

H = High persistence
M = Moderate persistence
L = Low persistence

half-life < 60 days = Low persistence

60 ≤ half-life ≤ 365 days = Moderate persistence

half-life < 365 days = High persistence

Toxicity Rating

Toxicity Rating for chemicals on the core lists are from these sources:

1. Sax, N. Irving, 1984. Dangerous Properties of Industrial Materials. Van Nostrand Reinhold Company.

2. Rosenblatt, David H., 1985, April 25. HCIC Report: Literature reviews on 13 RMA on-post contaminants. 1985, May 2. Literature reviews on 12 RMA on-post contaminants.

3. The Merck Index, 1983, Tenth Edition, Merck and Company, Inc.

H = Severely toxic
M = Moderately toxic
L = Slightly toxic
NR = No toxicity rating assigned
* = Toxic Hazard Review availabe in Chemical Index

potential contaminants have not been systematically surveyed in biota, a completely quantitative evaluation of contaminants in biota and potential contaminant effects based on existing information is not possible at this time. Some of the incidences which have occurred in the past have been followed by cleanup measures, hence quantification of injury to biota must rely on data collected in the past as current studies are not possible in these instances.

An assessment of contamination in biota involves two types of information. The contaminant levels in different species of biota must be documented at levels above regional background, and these levels must be associated with demonstrated effects. Information on contaminant levels observed in species from RMA and observations of contaminant effects associated with these chemicals are provided below.

2.3.1 CONTAMINATION LEVELS IN BIOTA

Most data indicating contamination in the tissues of plants and animals at RMA are associated with identified major sources of known or potential contamination. These sources have been identified and discussed in Section 2.1 and the chemicals of potential concern have been considered in Section 2.2. Tables 2.3-1 through 2.3-5 summarize existing information on species of biota at RMA in which chemical contamination has been documented during the past three decades. Due to the quantity of existing information, ranges of contamination in species are presented and reference is made to pertinent documents as sources of additional information.

Examination of these tables shows that a variety of key wildlife species contain RMA contaminants. Plant tissues have not been examined as thoroughly, but evidence of adverse effects has also been noted. In spite of the fact that a comprehensive survey has not been conducted, these studies which were conducted over a period of more than thirty years demonstrate that a wide range of species in aquatic, wetland, and terrestrial ecosystems contain or contained contaminants with known adverse effects on biota. The distribution of these contaminants in

Table 2.3-1. Contaminants Recorded From Biota From the Lower Lakes (Lake Mary, Lake Ladora, Lower Derby, and Upper Derby) (Page 1 of 4)

Section	Species Represented	Contaminant	Amount Range ppm (parts per million)	Reference
01	Algae	Aldrin	3.0 - 73.0 ppm	RZA 001 2217, RFA 003 0659-0661, RFA 003 1262F
02	Algae	Aldrin	1.2 ppm	RFA 003 0659-0661
01	Blue-Winged Teal	Aldrin	0.1 - 0.17 ppm	RMA 046 2040
01	Mallard	Aldrin	0.03 - 0.20 ppm	RMA 162 0821F, RMA 045 1751, RMA 046 2040
01	Aquatic snails	Aldrin	9.0 -38.0 ppm	RFA 003 0659-0661
01	Redhead	Aldrin	1.0 ppm	RFA 003 0659-0661
01	Black Bullhead	Aldrin	0.03 - 0.28 ppm	RMA 045 1786
02	Black Bullhead	Aldrin	0.01 ppm	RFA 001 0338
02	Leech	Aldrin	0.1 ppm	RIC#84296R04
02	Bluegill	Aldrin	0.01 ppm	RFA 001 0338
01	Largemouth Bass	Aldrin	0.03 ppm	RMA 045 1786, RIC#84296R02
02	Largemouth Bass	Aldrin	0.08 - 0.1 ppm	RMA 045 1786, RIC#84296R02
02	Rainbow Trout	Aldrin	0.18 ppm	RMA 036 1575
02	Mourning Dove	Aldrin	0.05 ppm	RMA046 2040
02	Largemouth Bass	Arsenic	2.0 - 2.20 ppm	RMA045 1786
02	Shoveler	Chlordane	15.0 ppm	RSH 855 1544F
02	Mallard	Chlordane	4.8 - 20.0 ppm	RSH 855 1544F
02	Mallard	CPM Sulfoxide	0.25 - 0.26 ppm	RMA 045 1797
02	Mallard	CPM Sulfide	0.04 ppm	RMA 045 1797
02	Mourning Dove	CPM Sulfone	0.22 ppm	RMA 045 1751F
01	Mallard	Copper	16.8 - 31.5 ppm	RMA 162 0821F
02	Mallard	Copper	8.6 - 9.4 ppm	RMA 162 0821F
01	Blue Winged Teal	DBCP	0.36 ppm	RMA 046 2040
01	Mallard	DBCP	0.03 - 0.51 ppm	RMA 046 2040
01	Algae	Dieldrin	2.7 - 45.0 ppm	RFA 003 0659-0661, RFA 003 1262F
02	Algae	Dieldrin	23.0 - 39.0 ppm	RFA 003 0659-0661, RFA 003 1262F
01	Tiger Salamander	Dieldrin	117.0 ppm	RFA 003 0659-0661
01	Pintail	Dieldrin	5.0 - 36.0 ppm	RFA 003 0659-0661, RFA 003 1262F
02	Pintail	Dieldrin	5.0 - 36.0 ppm	RSH 855 1544F
02	Shoveler	Dieldrin	10.0 - 44.0 ppm	RZA 001 2217, RFA 003 0659-0661, RSH 855 1544F
02	Green-Winged Teal	Dieldrin	9.0 - 58.0 ppm	RZA 001 2217, RFA 003 0659-0661, RSH 855 1544F
01	Blue-Winged Teal	Dieldrin	0.12 - 39.0 ppm	RFA 003 0659-0661, RMA 046 2040, RMA 045 1797
02	Blue-Winged Teal	Dieldrin	39.0 ppm	RSH 855 1544F
01	Mallard	Dieldrin	0.52 - 48.0 ppm	RFA 003 0659-0661, RMA 046 2040, RMA 162 0821F, RMA 045 1751F
02	Mallard	Dieldrin	0.08 - 81.0 ppm	RMA 162 0821F, RMA 045 1751F, RDA 002 1865, RMA 031 0751F

Table 2.3-1. Contaminants Recorded From Biota From the Lower Lakes (Lake Mary, Lake Ladora, Lower Derby, and Upper Derby) (Continued, Page 2 of 4)

Section	Species Represented	Contaminant	Amount Range ppm (parts per million)	Reference
01	Gadwall	Dieldrin	3.4 ppm	RFA 003 1262F
01	Aquatic snails	Dieldrin	32.0 - 77.0 ppm	
02	Aquatic snails	Dieldrin	22.0 - 28.0 ppm	RSH 855 1544F
01	Redhead	Dieldrin	12.0 ppm	RFA 003 0659-0661
02	Redhead	Dieldrin	10.0 ppm	RFA 003 0659-0661
01	Ring-Neck Duck	Dieldrin	4.0 ppm	RFA 003 0659-0661
01	Canada Goose	Dieldrin	2.1 - 3.0 ppm	RSH 855 1544F
02	Goldeneye	Dieldrin	8.8 ppm	RSH 855 1544F
01	Northern Pike	Dieldrin	0.03 - 0.12 ppm	RMA 045 1786, RMA 031 0751F, RIC#85115R01 RMA 117 1364-1374, RMA 045 1769F
02	Northern Pike	Dieldrin	0.03 - 0.12 ppm	RMA 031 0751F, RIC#85115R01, RMA 117 1364-1374, RMA 045 1769F
01	American Coot	Dieldrin	1.43 - 5.0 ppm	RSH 855 1544F, RDA 002 1865
02	Channel Catfish	Dieldrin	0.16 ppm - 0.22 ppm	RMA 045 1786, RMA 031 0751F, RIC#85115R01, RMA 117 1364-1374
01	Black Bullhead	Dieldrin	0.05 ppm - 0.44 ppm	RMA 045 1786, RMA 031 0751F, RIC#85115R01, RMA 117 1364-1374, RMA 045 1769F
02	Black Bullhead	Dieldrin	0.03 - 0.40 ppm	RMA 045 1786, RMA 031 0751F, RIC#85115R01, RMA 117 1364-1374, RMA 045 1769F
02	Leech	Dieldrin	83.0 ppm	RSH 855 1544F
02	Bluegill	Dieldrin	0.03 - 3.05 ppm	RFA 001 0338, RMA 045 1786, RMA 031 0751F, RIC#85115R01, RMA 117 1364-1374
01	Common Merganser	Dieldrin	6.6 ppm	RSH 855 1544F
02	Common Merganser	Dieldrin	6.6 - 14.0 ppm	RSH 855 1544F
01	Largemouth Bass	Dieldrin	0.03 - 0.46 ppm	RMA 045 1786, RMA 031 0751F, RMA 045 1769F
02	Largemouth Bass	Dieldrin	0.03 - 3.94 ppm	RFA 001 0338, RMA 045 1786, RIC#84296R03, RMA 031 0751F, RIC#85115R01, RMA 045 1769F
01	Pheasant	Dieldrin	0.04 - 0.16 ppm	RMA 045 1751F
02	Pheasant	Dieldrin	0.04 - 14.4 ppm	RSH 855 1544F, RMA 045 1797
02	Rainbow Trout	Dieldrin	2.0 ppm	RMA 036 1575
01	Desert Cottontail	Dieldrin	0.03 - 0.59 ppm	RMA 045 1751F, RMA 045 1797, RMA 031 0751F, RIC#85115R01, RMA 117 1364-1374
02	Robin	Dieldrin	2.3 ppm	RZA 001 2217
02	Cattails	Dieldrin	5.0 ppm	RFA 003 0659-0661
02	Mourning Dove	Dieldrin	0.03 - 0.61 ppm	RMA 046 2040, RMA 045 1751F, RIC#85115R01, RMA 117 1364-1374
01	Blue-Winged Teal	Endrin	0.1 - 0.11 ppm	RMA 046 2040
01	Mallard	Endrin	0.04 - 0.18 ppm	RMA 046 2040, RMA 045 1751F
02	Mallard	Endrin	0.03 - 0.24 ppm	RMA 162 0821F, RMA 045 1751F
01	Northern Pike	Endrin	0.03 - 0.04 ppm	RMA 045 1786, RMA 031 0751F, RMA 045 1769F
02	Channel Catfish	Endrin	0.03 ppm	RMA 031 0751F
01	Black Bullhead	Endrin	0.03 - 0.14 ppm	RMA 045 1786, RMA 031 0751F, RMA 045 1769F

Table 2.3-1. Contaminants Recorded From Biota From the Lower Lakes (Lake Mary, Lake Ladora, Lower Derby, and Upper Derby) (Continued, Page 3 of 4)

Section	Species Represented	Contaminant	Amount Range ppm (parts per million)	Reference
02	Black Bullhead	Endrin	0.03 ppm	RMA 045 1786, RMA 031 0751F
01	Northern Bluegill	Endrin	0.03 ppm	RMA 045 1786
01	Largemouth Bass	Endrin	0.03 - 0.04 ppm	RMA 045 1786, RMA 031 0751F
01	Aquatic snails	Endrin	1.41 ppm	RMA 076 0736
02	Aquatic snails	Endrin	1.41 ppm	RMA 076 0736
02	Rainbow Trout	Endrin	0.29 ppm	RMA 036 1575
02	Mourning Dove	Endrin	0.03 - 0.42 ppm	RMA 046 2040, RMA 045 1751F
02	Rainbow Trout	Heptachlor epoxide	0.01 ppm	RMA 036 1575
01	Mallard	Isodrin	0.13 ppm	RMA 162 0821F
01	Black Bullhead	Isodrin	0.02 - 0.03 ppm	RMA 045 1786
02	Mourning Dove	Isodrin	0.13 - 0.16 ppm	RMA 046 2040
01	Blue Winged Teal	Mercury	2.1 - 5.3 ppm	RMA 046 2040
01	Mallard	Mercury	0.29 - 3.8	RMA 046 2040
01	Northern Pike	Mercury	0.28 - 1.60 ppm	RMA 045 1786, RMA 031 0751F, RIC#85115R01, RMA 117 1364-1374, RMA 045 1769F
02	Northern Pike	Mercury	0.21 - 4.5 ppm	RMA 031 0751F, RIC#85115R01, RMA 117 1364-1374, RMA 045 1769F
02	Channel Catfish	Mercury	0.35 - 0.50 ppm	RMA 045 1786, RIC#85115R01, RMA 117 1364-1374
01	Black Bullhead	Mercury	0.16 - 9.0 ppm	RMA 045 1786, RMA 031 0751F, RIC#85115R01, RMA 117 1364-1374, RMA 045 1769F
02	Black Bullhead	Mercury	0.20 - 0.94 ppm	RMA 045 1786, RMA 031 0751F, RIC#85115R01, RMA 117 1364-1374, RMA 045 1769F
01	Northern Bluegill	Mercury	0.36 ppm	RMA 045 1786
02	Northern Bluegill	Mercury	0.14 - 1.80 ppm	RMA 045 1786, RMA 031 0751F, RIC#85115R01, RMA 117 1364-1374
01	Largemouth Bass	Mercury	0.40 - 0.44 ppm	RMA 045 1786, RMA 031 0751F, RMA 045 1769F
02	Largemouth Bass	Mercury	0.19 - 15.3 ppm	RMA 045 1786, RIC#85115R01, RMA 117 1364-1374, RMA 045 1769F
01	Pheasant	Mercury	0.23 - 1.2 ppm	RMA 045 1751F
01	Desert Cottontail	Mercury	0.2 ppm	RMA 045 1751F
02	Shoveler	P,p-DDE	0.1 ppm-1.8 ppm	RSH 855 1544F
01	Blue-Winged Teal	P,p-DDE	0.07 ppm	RMA 046 2040
01	Mallard	P,p-DDE	0.23 - 0.47 ppm	RMA 162 0821F
02	Mallard	P,p-DDE	0.1 - 0.39 ppm	RMA 162 0821F, RMA 045 1751F
02	Aquatic snails	P,p-DDE	1.0 ppm	RSH 855 1544F
01	Canada Goose	P,p-DDE	0.04 - 7.0 ppm	RSH 855 1544F
02	Goldeneye	P,p-DDE	1.4 ppm	RSH 855 1544F
01	Northern Pike	P,p-DDE	0.03 - 0.21 ppm	RMA 031 0751F, RIC#85115R01, RMA 117 1364-1374
02	Northern Pike	P,p-DDE	0.03 - 0.14 ppm	RMA 031 0751F, RIC#85115R01, RMA 117 1364-1374 RMA 045 1769F
02	Channel Catfish	P,p-DDE	0.05 - 0.09 ppm	RMA 031 0751F, RIC#85115R01, RMA 117 1364-1374

Table 2.3-1. Contaminants Recorded From Biota From the Lower Lakes (Lake Mary, Lake Ladora, Lower Derby, and Upper Derby) (Continued, Page 4 of 4)

Section	Species Represented	Contaminant	Amount Range ppm (parts per million)	Reference
01	Black Bullhead	P,p-DDE	0.03 - 0.12 ppm	RMA 045 1786, RMA 031 0751F, RIC#85115R01, RMA 117 1364-1374, RMA 045 1769F
02	Black Bullhead	P,p-DDE	0.03 - 0.43 ppm	RFA 001 0338, RMA 031 0751F, RIC#85115R01, RMA 117 1364-1374, RMA 045 1769F
02	Leech	P,p-DDE	4.5 ppm	RSH 855 1544F
01	Northern Bluegill	P,p-DDE	0.37 ppm	RMA 045 1786
02	Northern Bluegill	P,p-DDE	0.03 - 0.10 ppm	RFA 001 0338, RMA 031 0751F, RIC#85115R01
01	Common Merganser	P,p-DDE	1.4 ppm	RSH 855 1544F
02	Common Merganser	P,p-DDE	1.3 ppm	RSH 855 1544F
01	Largemouth Bass	P,p-DDE	0.05 - 0.08 ppm	RMA 031 0751F, RMA 045 1769F
02	Largemouth Bass	P,p-DDE	0.03 - 0.30 ppm	RFA 001 0338, RMA 162 0821F
02	Pheasant	P,p-DDE	0.03 - 1.4 ppm	RSH 855 1544F, RMA 045 1797
02	Rainbow Trout	P,p-DDE	0.23 ppm	RMA 036 1575
02	Mourning Dove	P,p-DDE	0.02 - 0.53 ppm	RMA 046 2040, RIC#85115R01, RMA 117 1364-1374
01	Blue-Winged Teal	P,p-DDT	0.19 ppm	RMA 046 2040
01	Mallard	P,p-DDT	0.02 - 0.96 ppm	RMA 046 2040, RMA 162 0821F, RMA 045 1751F
02	Mallard	P,p-DDT	0.03 - 0.10 ppm	RMA 162 0821F, RMA 045 1751F
02	Aquatic snails	P,p-DDT	0.1 ppm	RIC#84296R04
01	Northern Pike	P,p-DDT	0.04 - 0.09 ppm	RMA 031 0751F, RIC#85115R01, RMA 117 1364-1374
02	Northern Pike	P,p-DDT	0.03 - 0.09 ppm	RIC#85115R01, RMA 117 1364-1374
01	Black Bullhead	P,p-DDT	0.02 - 0.04 ppm	RMA 045 1786
02	Black Bullhead	P,p-DDT	0.03 - 0.11 ppm	RFA 001 0338, RMA 031 0751F, RIC#85115R01, RMA 117 1364-1374
02	Leech	P,p-DDT	0.7 ppm	RIC#84296R04
02	Northern Bluegill	P,p-DDT	0.01 - 0.03 ppm	RFA 001 0338, RIC#85115R01, RMA 117 1364-1374
01	Largemouth Bass	P,p-DDT	0.07 - 0.1 ppm	RMA 045 1786, RMA 031 0751F
02	Largemouth Bass	P,p-DDT	0.02 - 0.09 ppm	RMA 031 0751F
02	Mourning Dove	P,p-DDT	0.08 ppm	RMA 046 2040
02	Rainbow Trout	Parathion	0.30 ppm	

Table 2.3-2. Contaminants Recorded From Biota in Section 36 (Page 1 of 2)

Species Represented	Contaminants	Amount Range ppm (parts per million)	Reference
Prairie Dog	Oxathiane	0.12 ppm	RMA 076 0736
Earthworms	Aldrin	0.02 ppm	RMA 076 0736
Grasshoppers	Aldrin	0.705 ppm	RMA 076 0736
Earthworms	Cadmium	3.63 ppm	RMA 076 0736
Prairie Dog	CPM Sulfone	0.12 - 0.22 ppm	RMA 076 0736
Grasshoppers	CPM Sulfone	0.11 - 0.95 ppm	RMA 076 0736
Grasshoppers	CPM Sulfoxide	0.27 - 1.11 ppm	RMA 076 0736
Prairie Dog	Copper	8.50 ppm	RMA 076 0736
Earthworms	Copper	46.0 ppm	RMA 076 0736
Grasshoppers	Copper	17.6 ppm	RMA 076 0736
Deer Mouse	Copper	5.30 ppm	RMA 076 0736
Pheasant	Copper	8.10 ppm	RMA 076 0736
Western Meadowlark	Copper	25.3 ppm	RMA 076 0736
Desert Cottontail	Copper	14.1 ppm	RMA 076 0736
Mourning Dove	Copper	6.3 ppm	RMA 076 0736
Prairie Dog	Dieldrin	0.04 - 0.57 ppm	RMA 076 0736
Earthworms	Dieldrin	6.57 ppm	RMA 076 0736
Grasshoppers	Dieldrin	0.078 - 1.38 ppm	RMA 076 0736
Deer Mouse	Dieldrin	0.02 - 0.49 ppm	RMA 076 0736
Pheasant	Dieldrin	0.2 ppm	RMA 076 0736
Western Meadowlark	Dieldrin	0.99 ppm	RMA 076 0736
Desert Cottontail	Dieldrin	0.21 ppm	RMA 076 0736
Mourning Dove	Dieldrin	0.53 - 1.81 ppm	RMA 076 0736, RMA 045 1797

Table 2.3-2. Contaminants Recorded From Biota in Section 36 (Continued, Page 2 of 2)

Species Represented	Contaminants	Amount Range ppm (parts per million)	Reference
Prairie Dog	DIMP	0.20 - 1.52 ppm	RMA 076 0736
Grasshoppers	DIMP	0.17 - 0.71 ppm	RMA 076 0736
Deer Mouse	DIMP	0.06 - 0.09 ppm	RMA 076 0736
Prairie Dog	Dithiane	0.13 ppm	RMA 076 0736
Earthworms	Endrin	0.76 ppm	RMA 076 0736
Pheasant	Endrin	0.37 ppm	RMA 076 0736
Mourning Dove	Endrin	0.03 - 0.05 ppm	RMA 045 1797
Earthworms	Isodrin	0.02 ppm	RMA 076 0736
Grasshoppers	Isodrin	0.167 ppm	RMA 076 0736
Pheasant	Mercury	0.2 ppm	RMA 076 0736
Western Meadowlark	Mercury	0.33 ppm	RMA 076 0736
Prairie Dog	P,p-DDE	0.02 - 0.13 ppm	RMA 076 0736
Grasshoppers	P,p-DDE	0.021 - 0.03 ppm	RMA 076 0736
Deer Mouse	P,p-DDE	0.02 - 0.05 ppm	RMA 076 0736
Pheasant	P,p-DDE	0.22 ppm	RMA 076 0736
Mourning Dove	P,p-DDE	0.04 ppm	RMA 076 0736
Earthworms	P,p-DDT	0.18 ppm	RMA 076 0736
Pheasant	P,p-DDT	0.11 ppm	RMA 076 0736
Mourning Dove	P,p-DDT	0.05 ppm	RMA 045 1797

Table 2.3-3. Contaminants From Biota in Section 24 (Page 1 of 2)

Species Represented	Contaminants	Amount Range ppm (parts per million)	Reference
Mallard	Oxathiane	0.20 ppm	RMA 045 1797
Aquatic snails	Oxathiane	0.36 ppm	RMA 076 0736
Mallard	Aldrin	0.02 ppm	RMA 045 1751F
Aquatic snails	Aldrin	0.03 - 0.33 ppm	RMA 076 0736
Mourning Dove	Aldrin	0.04 - 0.05 ppm	RMA 046 2040
Earthworms	Cadmium	2.45 ppm	RMA 076 0736
Mallard	CPM Sulfoxide	0.20 - 0.24 ppm	RMA 045 1797
Mourning Dove	CPM Sulfide	0.2 ppm	RMA 046 2040
Aquatic snails	Copper	13.4 ppm	RMA 076 0736
Earthworms	Copper	2.6 ppm	RMA 076 0736
Deer Mouse	Copper	5.50 ppm	RMA 076 0736
Pheasant	Copper	12.9 ppm	RMA 076 0736
Meadowlark	Copper	25.9 ppm	RMA 076 0736
Mourning Dove	Copper	18.5 ppm	RMA 076 0736
Canadian Thistle	Copper	3.0 - 120.0 ppm	RMA 037 0170-0185
Musk Thistle	Copper	5.0 - 9.0 ppm	RMA 037 0170-0185
Cheatgrass	Copper	5.0 - 8.0 ppm	RMA 037 0170-0185
Pheasant	DBCP	0.03 ppm	RMA 046 2040
Cheatgrass	Dieldrin	0.06 ppm	RMA 037 0170-0185
Kochia	Dieldrin	0.09 ppm	RMA 037 0170-0185
Blue-Winged Teal	Dieldrin	0.16 ppm	RMA 031 0751F
Mallard	Dieldrin	0.08 - 3.58 ppm	RMA 046 2040, RMA 045 1751F, RMA 045 1797, RMA 031 0751F, RIC#85115R01, RMA 117 1364-1374
Aquatic snails	Dieldrin	2.2 - 3.9 ppm	RMA 076 0736
Earthworms	Dieldrin	1.27 ppm	RMA 076 0736
Deer Mouse	Dieldrin	0.08 ppm	RMA 076 0736
Pheasant	Dieldrin	0.04 - 0.15 ppm	RMA 076 0736, RMA 046 2040, RMA 045 1797
Meadowlark	Dieldrin	0.05 ppm	RMA 076 0736
Mourning Dove	Dieldrin	0.02 - 1.23 ppm	RMA 076 0736, RMA 046 2040, RIC#85115R01, RMA 117 1364-1374
Aquatic snails	DIMP	0.19 ppm	RMA 076 0736
Cheatgrass	DIMP	0.12 - 6.01 ppm	RMA 037 0170-0185
Musk thistle	DIMP	0.35 ppm	RMA 037 0170-0185
Canadian thistle	DIMP	0.32 ppm	RMA 037 0170-0185
Kochia	DIMP	0.29 - 12.11	RMA 037 0170-0185
Mallard	Endrin	0.02 - 0.07 ppm	RMA 046 2040, RMA 045 1751F RMA 031 0751F

Table 2.3-3. Contaminants From Biota in Section 24 (Continued, Page 2 of 2)

Species Represented	Contaminants	Amount Range ppm (parts per million)	Reference
Aquatic snails	Endrin	2.34 ppm	RMA 076 0736
Earthworms	Endrin	0.84 ppm	RMA 076 0736
Mourning Dove	Endrin	0.03 - 0.1 ppm	RMA 076 0736
Cheatgrass	Endrin	0.04 ppm	RMA 037 0170-0185
Aquatic snails	Isodrin	0.05 ppm	RMA 076 0736
Mourning Dove	Isodrin	0.14 ppm	RMA 046 2040
Mallard	Mercury	0.29 - 2.40 ppm	RMA 046 2040, RMA 045 1751F, RIC#85115R01, RMA 117 1364-1374
Pheasant	Mercury	0.26 - 0.38 ppm	RMA 076 0736, RMA 045 1751F
Meadowlark	Mercury	0.37 ppm	RMA 076 0736
Musk thistle	Mercury	0.25 - 0.42 ppm	RMA 037 0170-0185
Mallard	p,p`-DDE	0.09 - 0.16 ppm	RMA 031 0751F, RIC#85115R01, RMA 117 1364-1374
Aquatic snails	p,p`-DDE	0.16 ppm	RMA 076 0736
Earthworms	p,p`-DDE	0.15 ppm	RMA 076 0736
Deer Mouse	p,p`-DDE	0.05 ppm	RMA 076 0736
Pheasant	p,p`-DDE	0.04 ppm	RMA 076 0736
Meadowlark	p,p`-DDE	0.04 ppm	RMA 076 0736
Mourning Dove	p,p`-DDE	0.03 - 0.15 ppm	RMA 076 0736, RMA 046 2040
Canadian thistle	p,p`-DDE	0.17 - 0.22 ppm	RMA 037 0170-0185
Mallard	p,p`-DDT	0.02 - 0.03 ppm	RMA 045 1751F, RIC#85115R01, RMA 117 1364-1374
Pheasant	p,p`-DDT	0.07 ppm	RMA 045 1797

Addendum: Contaminants Recorded from Biota from the North Bog in Section 24

Mallard	Dieldrin	0.09 ppm (edible portion)	RIC#86091R02
	Dieldrin	1.00 ppm (liver)	RIC#86091R02
	DIMP	0.06 ppm (liver)	RIC#86091R02
	Endrin	0.07 ppm (liver)	RIC#86091R02
	p,p`-DDE	0.40 ppm (edible portion)	RIC#86091R02
	p,p`-DDT	0.08 ppm (liver)	RIC#86091R02
	1,4-Oxathiane	0.22 ppm (liver)	RIC#86091R02
Blue-Winged Teal	Dieldrin	0.46 ppm (edible portion)	RIC#86091R02
	Dieldrin	3.3 ppm (liver)	RIC#86091R02
	p,p`-DDE	0.3 ppm (edible portion)	RIC#86091R02
	p,p`-DDE	0.08 ppm (liver)	RIC#86091R02
	Endrin	0.22 ppm (liver)	RIC#86091R02
	1,4-Oxathiane	0.30 ppm (liver)	RIC#86091R02

Table 2.3-4. Contaminants Recorded From Biota in Section 26 (Page 1 of 2)

Species Represented	Contaminants	Amount Range ppb (parts per billion) ppm (parts per million)	Reference
Pintail	Aldrin	0.06 ppb	RDA 002 1865
Mallard	Aldrin	5 ppb	RDA 002 1865
Earthworms	Aldrin	0.03 ppm	RMA 076 0736
Grasshoppers	Aldrin	0.169 - 0.39 ppm	RMA 076 0736
Plains Spadefoot	Aldrin	3-100 ppb	RDA 002 1865
Cheatgrass	Aldrin	0.5 - 0.13 ppm	RMA 037 0170-0185
Rush Skelton weed	Aldrin	0.14 ppm	RMA 037 0170-0185
Earthworms	Cadmium	2.57 ppm	RMA 076 0736
Cheatgrass	Cadmium	1.0 ppm	RMA 037 0170-0185
Prickly lettuce	Cadmium	1.0 ppm	RMA 037 0170-0185
Grasshoppers	CPM Sulfoxide	0.36 - 0.51 ppm	RMA 076 0736
Cheatgrass	CPM Sulfoxide	2.07 - 4.78 ppm	RMA 037 0170-0185
Rush Skelton weed	CPM Sulfoxide	1.48 - 19.5 ppm	RMA 037 0170-0185
Kochia	CPM Sulfoxide	6.00 - 12.12 ppm	RMA 037 0170-0185
Pheasant	CPM Sulfone	0.36 - 1.9 ppm	RMA 046 2040, RMA 045 1751F, RMA 031 0751F, RIC#85115R01, RMA 117 1364-1374
Desert Cottontail	CPM Sulfone	0.27 - 0.46 ppm	RMA 031 0751F, RIC#85115R01, RMA 117 1364-1374
Mourning Dove	CPM Sulfone	0.53 - 2.53 ppm	RMA 045 1751F, RIC#85115R01, RMA 117 1364-1374
Prickley lettuce	CPM Sulfide	2.62 ppm	RMA 037 0170-0185
Prickley lettuce	Copper	5.0 - 9.4 ppm	RMA 037 0170-0185
Prairie Dog	Copper	5.40 ppm	RMA 076 0736
Earthworms	Copper	31.0 ppm	RMA 076 0736
Grasshoppers	Copper	7.1 - 37.6 ppm	RMA 076 0736
Deer Mouse	Copper	6.8 ppm	RMA 076 0736
Pheasant	Copper	5.70 ppm	RMA 076 0736
Western Meadowlark	Copper	29.8 ppm	RMA 076 0736
Desert Cottontail	Copper	13.5 ppm	RMA 076 0736
Mourning Dove	Copper	14.2 ppm	RMA 076 0736
Cheat grass	Copper	5.8 - 15.0 ppm	RMA 037 0170-0185
Kochia	Copper	8.0 - 9.0 ppm	RMA 037 0170-0185
Pintail	Dieldrin	1.3 ppm	RDA 002 1865
Shoveler	Dieldrin	340 ppb	RDA 002 1865
Mallard	Dieldrin	900 ppb	RMA 045 1751F, RSH 855 1544F, RDA 002 1865
		0.11 - 0.84 ppm	RMA 045 1751F, RDA 002 1865, RMA 117 1364-1374

Table 2.3-4. Contaminants Recorded From Biota in Section 26 (Continued, Page 2 of 2)

Species Represented	Contaminants	Amount Range ppb (parts per billion) ppm (parts per million)	Reference
Earthworms	Dieldrin	7.0 ppm	RMA 076 0736
Grasshoppers	Dieldrin	0.54 - 5.38 ppm	RMA 076 0736
Deer Mouse	Dieldrin	4.10 ppm	RMA 076 0736
Pheasant	Dieldrin	0.02 - 2.83 ppm	RMA 046 2040, RMA 045 1751F, RMA 031 0751F, RIC#85115R01, RMA 117 1364-1374
Plains Spadefoot	Dieldrin	300-875 ppb	RDA 002 1865
		2.7 ppm	RDA 002 1865
Western Meadowlark	Dieldrin	2.44 ppm	RMA 076 0736
Desert Cottontail	Dieldrin	0.04 - 1.87 ppm	RMA 076 0736, RMA 045 1751F, RMA 031 0751F, RIC#85115R01, RMA 117 1364-1374
Mourning Dove	Dieldrin	0.03 - 9.96 ppm	RMA 076 0736, RMA 045 1751F, RMA 031 0751F, RIC#85115R01, RMA 117 1364-1374
Cheatgrass	Dieldrin	0.07 - 0.45 ppm	RMA 037 0170-0185
Rush skeleton weed	Dieldrin	0.48 - 0.57	RMA 037 0170-0185
Prickly lettuce	Dieldrin	0.11 - 0.33 ppm	RMA 037 0170-0185
Kochia	Dieldrin	0.24 - 0.33 ppm	RMA 037 0170-0185
Tumble pigweed	Dieldrin	0.58 - 0.63 ppm	RMA 037 0170-0185
Grasshoppers	DIMP	0.17 - 0.36 ppm	RMA 076 0736
Pheasant	DIMP	0.10 - 1.54 ppm	RMA 046 2040, RMA 045 1751F
Deer Mouse	Dithiane	0.17 ppm	RMA 076 0736
Earthworms	Endrin	0.98 ppm	RMA 076 0736
Grasshoppers	Endrin	0.05 - 0.07 ppm	RMA 076 0736
Pheasant	Endrin	0.03 - 0.32 ppm	RMA 076 0736, RMA 045 1751F, RIC#85115R01, RMA 117 1364-1374
Western Meadowlark	Endrin	0.02 ppm	RMA 076 0736
Mourning Dove	Endrin	0.09 - 1.21 ppm	RMA 076 0736, RMA 045 1751F, RIC#85115R01, RMA 117 1364-1374
Earthworms	Isodrin	0.32 ppm	RMA 076 0736
Grasshoppers	Isodrin	0.09 ppm	RMA 076 0736
Prickly Lettuce	Mercury	0.36 ppm	RMA 037 0170-0185
Mallard	Mercury	0.29 - 1.79 ppm	RIC#85115R01, RMA 117 1364-1374
Pheasant	Mercury	0.2 - 0.50 ppm	RMA 076 0736, RIC#85115R01, RMA 117 1364-1374
Western Meadowlark	Mercury	0.26 ppm	RMA 076 0736
Desert Cottontail	Mercury	1.56 ppm	RIC#85115R01; RMA 117 1364-1374
Cheatgrass	Mercury	0.40 ppm	RMA 037 0170-0185
Mallard	p,p`-DDE	0.05 ppm	RIC#85115R01, RMA 117 1364-1374
Pheasant	p,p`-DDE	0.19 - 0.32 ppm	RMA 076 0736, RMA 046 2040
Mourning Dove	p,p`-DDE	0.11 ppm	RIC#85115R01, RMA 117 1364-1374
Pheasant	p,p`-DDT	0.08 - 0.09 ppm	RMA 076 0736, RMA 046 2040

Table 2.3-5. Contaminants in Biota From Sections 6, 7, 11, 12, 19, 23, 30, and 35 (Page 1 of 3)

Section	Species Represented	Contaminant	Amount Range ppm (parts per million)	Reference
06	Pheasant	CPM Sulfone	14.5 ppm	RMA 045 1769F
06	Pheasant	Dieldrin	0.02 - 0.54 ppm	RMA 046 2040
06	Pheasant	Endrin	0.02 ppm	RMA 045 1751F
06	Pheasant	Mercury	0.32 ppm	RMA 045 1751F
06	Pheasant	p,p`-DDE	0.02 ppm	RMA 045 1797
07	Desert Cottontail	Dieldrin	0.04 ppm	RMA 045 1797
07	Pheasant	p,p`-DDE	0.27 ppm	RMA 046 2040
07	Pheasant	p,p`-DDT	0.03 ppm	RMA 046 2040
09	Mourning Dove	Aldrin	0.03 - 0.09 ppm	RMA 046 2040, RMA 045 1769F
09	Mourning Dove	CPM Sulfide	0.75 - 1.46 ppm	RMA 046 2040, RMA 045 1769F
09	Mourning Dove	Endrin	0.14 - 0.19 ppm	RMA 046 2040, RMA 045 1769F
09	Mourning Dove	Isodrin	0.02 - 0.14 ppm	RMA 046 2040
09	Mourning Dove	p,p`-DDE	0.04 - 0.62 ppm	RMA 046 2040
09	Mourning Dove	p,p`-DDT	0.04 ppm	RMA 045 1797
11	Mallard	Dieldrin	0.03 - 0.57 ppm	RMA 045 1751F, RMA 031 0751F, RIC#85115R01, RMA 117 1364-1374
11	Mallard	Endrin	0.03 ppm	RMA 045 1751F
11	Mallard	Mercury	0.22 - 1.0 ppm	RMA 045 1751F
11	Mallard	p,p`-DDE	0.03 ppm	RMA 045 1751F
11	Mallard	p,p`-DDT	0.02 ppm	RMA 045 1751F
12	Blue-Winged Teal	Aldrin	0.16 ppm	RMA 046 2040
12	Mallard	Aldrin	0.05 ppm	RMA 046 2040
12	Mourning Dove	Aldrin	0.07 ppm	RMA 046 2040
12	Mourning Dove	CPM Sulfide	0.2 ppm	RMA 046 2040
12	Mallard	Copper	9.6 - 14.4 ppm	RMA 162 0821F
12	Blue-Winged Teal	Dieldrin	0.41 ppm	RMA 046 2040
12	Mallard	Dieldrin	0.06 - 0.97 ppm	RMA 046 2040, RMA 162 0821F, RMA 045 1751F
12	Mourning Dove	Dieldrin	0.07 - 0.27 ppm	RMA 046 2040
12	Blue-Winged Teal	Endrin	0.23 ppm	RMA 046 2040
12	Mallard	Endrin	0.03 - 0.17 ppm	RMA 046 2040, RMA 162 0821F, RMA 045 1751F
12	Mourning Dove	Endrin	0.1 - 0.2 ppm	RMA 046 2040
12	Mourning Dove	Isodrin	0.11 - 0.22 ppm	RMA 046 2040
12	Blue-Winged Teal	Mercury	8.9 ppm	RMA 046 2040
12	Mallard	Mercury	0.51 - 21.8 ppm	RMA 046 2040, RMA 162 0821F, RIC#85115R01
12	Mallard	p,p`-DDE	0.04 - 0.30 ppm	RMA 162 0821F, RMA 045 1751F, RIC#85115R01
12	Mourning Dove	p,p`-DDE	0.03 - 0.24 ppm	RMA 046 2040, RMA 045 1751F
12	Blue-Winged Teal	p,p`-DDT	0.12 ppm	RMA 046 2040
12	Mallard	p,p`-DDT	0.02 - 0.03 ppm	RMA 045 1751F

Table 2.3-5. Contaminants in Biota From Sections 6, 7, 11, 12, 19, 23, 30, and 35 (Continued, Page 2 of 3)

Section	Species Represented	Contaminant	Amount Range ppm (parts per million)	Reference
19	Muskrat	p,p`-DDE	0.15 ppm	RFA 003 0659-0661
23	Mourning Dove	Aldrin	0.03 ppm	RMA 046 2040
23	Cheatgrass	Aldrin	0.05 ppm	RMA 037 0170-0185
23	Kochia	Copper	5.0 - 8.0 ppm	RMA 037 0170-0185
23	Prickly Lettuce	Copper	1.0 - 13.0 ppm	RMA 037 0170-0185
23	Canadian thistle	Copper	7.0 - 17.0 ppm	RMA 037 0170-0185
23	Cheatgrass	Copper	1.0 - 11.0 ppm	RMA 037 0170-0185
23	Mourning Dove	CPM Sulfide	0.3 ppm	RMA 046 2040
23	Canadian thistle	CPM Sulfone	1.0 - 2.84 ppm	RMA 037 0170-0185
23	Kochia	CPM Sulfone	1.47 - 2.28 ppm	RMA 037 0170-0185
23	Cheatgrass	CPM Sulfone	2.16 - 3.68 ppm	RMA 037 0170-0185
23	Cheatgrass	CPM Sulfoxide	0.27 - 0.64 ppm	RMA 037 0170-0185
23	Pheasant	DBCP	0.03 ppm	RMA 046 2040
23	Desert Cottontail	Dieldrin	0.05 - 0.06 ppm	RMA 045 1751F
23	Kochia	Dieldrin	0.22 - 0.28	RMA 037 0170-0185
23	Canadian Thistle	Dieldrin	0.10 - 0.68	RMA 037 0170-0185
23	Cheatgrass	Dieldrin	0.04 - 0.08	RMA 037 0170-0185
23	Canadian Thistle	DIMP	0.50 - 14.88 ppm	RMA 037 0170-0185
23	Mourning Dove	DIMP	0.1 ppm	RMA 046 2040
23	Prickly Lettuce	DIMP	1.88 - 14.64 ppm	RMA 037 0170-0185
23	Cheatgrass	DIMP	0.10 - 0.15 ppm	RMA 037 0170-0185
23	Kochia	DIMP	0.22 - 18.15 ppm	RMA 037 0170-0185
23	Mourning Dove	Endrin	0.2 - 0.25 ppm	RMA 046 2040
23	Mourning Dove	p,p`-DDE	0.13 - 0.24 ppm	RMA 046 2040
23	Canadian Thistle	p,p`-DDE	0.18 - 0.21 ppm	RMA 037 0170-0185
23	Mourning Dove	p,p`-DDT	0.1 ppm	RMA 046 2040
23	Cheatgrass	Mercury	0.24 ppm	RMA 037 0170-0185
30	Pheasant	Dieldrin	0.06 ppm	RMA 046 2040
30	Mourning Dove	Dieldrin	0.17 - 0.51 ppm	RIC#85115R01
30	Pheasant	Endrin	0.04 ppm	RMA 046 2040
30	Mourning Dove	Endrin	0.02 0.04 ppm	RIC#85115R01
30	Pheasant	p,p`-DDE	0.08 - 0.10 ppm	RMA 046 2040
35	Mourning Dove	CPM Sulfone	0.22 ppm	RMA 045 1751F

Table 2.3-5. Contaminants in Biota From Sections 6, 7, 11, 12, 19, 23, 30, and 35 (Continued, Page 3 of 3)

Section	Species Represented	Contaminant	Amount Range ppm (parts per million)	Reference
00	Lizards/Bullsnakes	Aldrin	0.06 - 0.07 μg/g	RMA 076 0751
		Copper	2.0 μg/g	RMA 076 0751
		Dieldrin	0.06 - 3.78 μg/g	RMA 076 0751
		DIMP	0.31 μg/g	RMA 076 0751
		Endrin	0.12 μg/g	RMA 076 0751
		p,p`-DDT	0.09 μg/g	RMA 076 0751
00	Beetles/Grasshoppers	Aldrin	0.17 - 0.70 μg/g	RMA 076 0753
		Copper	20.4 - 37/6 μg/g	RMA 076 0753
		Dieldrin	0.08 - 5.38 μg/g	RMA 076 0753
		DIMP	0.17 - 0.71 μg/g	RMA 076 0753
		Dithiane	0.35 μg/g	RMA 076 0753
		Endrin	0.05 - 0.07 μg/g	RMA 076 0753
		Isodrin	0.09 - 0.17 μg/g	RMA 076 0753
		$PCPMSO_2$	0.11 - 2.94 μg/g	RMA 076 0753
		PCPMSO	0.27 - 1.11 μg/g	RMA 076 0753
		p,p`-DDE	0.06 - 0.08 μg/g	RMA 076 0753

biota in relation to potential pathways of contamination for major animal communities on RMA are discussed in Section 2.4.

2.3.2 CONTAMINANT EFFECTS ON BIOTA

Most chemical analyses of plant and animal tissues for contamination have been conducted on species associated with potential major sources of contamination. Several were associated with observed effects on species. Some of these effects are within the definition of injury to biological resources as defined in the NRDA. According to 43 CFR Section 11.62(f), an injury to a biological resource has resulted from a chemical contaminant if the concentration of the substance is sufficient to:

1) Cause the biological resource or its offspring to have undergone at least one of the following adverse changes in viability: death, disease, behavioral abnormalities, cancer, genetic mutations, physiological malfunctions, or physical deformations; or
2) Exceeds action or tolerance levels established under Section 402 of the Food, Drug, and Cosmetic Act, 21 U.S.C. 342 in edible portions of organisms; or
3) Exceeds levels for which an appropriate State health agency has issued directives to limit or ban consumption of such organisms.

Of the seven manifestations of injury described in the injury definition, one (genetic mutation) currently has no methods of determination which meet the criteria of acceptance under the NRDA regulations, and two others (cancer and disease) have only single limited methods of determination each which meet these proposed acceptance criteria. Each of the four remaining manifestations of injury have been documented in relation to chemical contamination associated with particular sites/ sources of contamination on RMA. Observed incidents of wildlife injury on RMA associated with contaminants and contaminant sources are summarized in Table 2.3-6 together with references to supporting documentation for these observed effects.

Table 2.3-6. Wildlife Injury Incidents, Miscellaneous or Unknown Locations (1949 to 1982) (Page 1 of 3)

Date	Species	Location	Injury Category	Apparent Cause of Death	Reference
1949-1959	Ducks	Lower Lakes (and Basin F)	Death (20,000 minimum)	Unknown	RFA 003-0107F
1952	Ducks	Lower Lakes	Behavior Abnormality and Death (Test vs Control Areas As Well)	Unknown	RSH 855 1544F RMA 036 1495F
1955	Duck	Lower Lakes	Death	High level of Dieldrin	RSH 855 1544F RMA 036 1495F
1959-1960	Leopard Frog Chorus Frog (Tadpoles)	Lower Lakes	Dead	Aldrin, dieldrin, in water, mud, snails, algae	RSH 855 1544F
03/28/62	Ducks	Lower Lakes	Death (>100)	High dieldrin levels	RSH 855 1544F
01/66-05/66	Waterfowl	Lower Lakes	Death (163)		RFA 003 0039
05/16/73	Large Mouth Bass Bluegill Catfish	Lower Lakes	Fish Kill/Death	Aldrin released into lakes prior to fish kill	RDA 002 1865 RIC#84131R02 RMA 036 1495
06/09/82	Great Blue Heron	Lower Lakes	Found Dead	Dieldrin, endrin, DDE, Heptachlor Epoxide Polychlorinated biphenyls	RFA 003 1673;
06/09/82	Muskrat	Lower Lakes	Found Dead		RFA 003 0301
05/05/82	Eared Grebe	Lower lakes	Found Dead		RFA 003 0301
05/14/82	Magpie	Lower Lakes	Found Dead		RFA 003 0301
04/73	Ducks	Basin C	Death (136)	Dieldrin in mud, water, tissue	RIC#84131R02
04/73-05/73	Ducks	Basin F	Death (Large Numbers)	Aldrin, dieldrin in tissue	RDA 002 1865
05/73	Toads	Basin D	Death, Physical Deformity	Dieldrin in tissue	RIC#84131R02; RDA 002 1865
1974	Ducks	Basin F	Death	"Detergents" Wet Feathers-Caused loss of body heat	RMA 046 0975F

Table 2.3-6. Wildlife Injury Incidents, Miscellaneous or Unknown Locations (1949 to 1982) (Continued, Page 2 of 3)

Date	Species	Location	Injury Category	Apparent Cause of Death	Reference
06/24/75	Western Grebe (2)	Basin F	Death	High Aldrin, Dieldrin Levels	RFA 002 0262F
	Ruddy Duck (1)	Basin F	Death		RFA 002 0262F
	Coot (1)	Basin F	Death		RFA 002 0262F
05/01/75-05/02/75	Grebe	Basin F	Death (291 Birds Total)		RSH 855 1544F
	Coot	Basin F	Death		RSH 855 1544F
	Merganser	Basin F	Death		RSH 855 1544F
	Ducks	Basin F	Death		RSH 855 1544F
	Buteo Hawks	Basin F	Death		RSH 855 1544F
	Burrowing Owl	Basin F	Death		RSH 855 1544F
	Pheasants	Basin F	Death		RSH 855 1544F
	Songbirds	Basin F	Death		RSH 855 1544F
	Shorebirds	Basin F	Death		RSH 855 1544F
	Loon	Basin F	Death		RSH 855 1544F
06/80	Migratory Birds	Basin F	Death (375)		RDA 005 1726
10/80-12/80	Waterforwl	Basin F	Death (49)		RDA 005 1726
05/25/82	Bullock Oriole	Basin F	Death		RFA 003 0301
04/06/82	Gadwall	Basin F	Death		RFA 003 0301
05/25/82	Brewer's Blackbird	Headquarters	Death		RFA 003 0301
05/14/82	Starling	Headquarters	Death		RFA 003 0301
06/23/82	Pheasant	North Bog	Death		RFA 003 0301
03/01/82	Red Tail Hawk	Section 6	Death		RFA 003 0301
03/29/82	Red Tail Hawk	Section 36	Death	Dieldrin, endrin, DDE Heptachlor Epoxide Polychlorinated biphenyls	RFA 003 0301
1982	Kestrel	RMA	Physiologic Malfunction Eggshell Thinning	High dieldrin levels in eggshell	RMA 134 0649; RFA 002 0061 RFA 003 0290

Table 2.3-6. Wildlife Injury Incidents, Miscellaneous or Unknown Locations (1949 to 1982) (Continued, Page 3 of 3)

Date	Species	Location	Injury Category	Apparent Cause of Death	Reference
Fall 1981	Mallard (1)	Unknown	Behavior Abnormality and Death	Dieldrin, DDE, Endrin, PCB	RFA 003 0704F
06/76	Starlings	Unknown	Death	High dieldrin levels in tissues	RIC#83020R03
06/76	Red Tail Hawk	Unknown	Death	High dieldrin levels in tissues	RIC#83020R03
11/03/76	Great Horned Owl	Unknown	Death*	Pesticides, unknown	RMA 153 2150F
12/08/76	Coyote	Unknown	Death*		RMA 153 2150F
03/07/77	Starling	Unknown	Death*		RMA 153 2150F
03/18/77	Ferruginous Hawk	Unknown	Death*		RMA 153 2150F
04/12/77	Starling	Unknown	Death*		RMA 153 2150F
04/18/77	Rainbow Trout	Unknown	Death*		RMA 153 2150F
12/08/77	Ferruginous Hawk	Unknown	Death*		RMA 153 2150F
04/05/78	Marsh Hawk	Unknown	Death*		RMA 153 2150F
01/29/79	Ferruginous Hawk	Unknown	Death*		RMA 153 2150F
02/27/79	Rough Leg Hawk	Unknown	Death*	Significant concentrations of CPM sulfone in tissue	RMA 153 2150F
03/30/81	Canada Goose	Unknown	Death*	Pesticides, unknown	RMA 153 2150F

* Significant concentrations of pesticides found in animal.

2.3.2.1 Death

Laboratory toxicity testing, documented fish kills, and observations of animals found dead on RMA have been conducted in connection with tissue analyses which document this adverse effect on biota. Existing documentation from 1949 to the present indicate that thousands of individuals of fish, waterfowl, and other animal species have died as a result of RMA contamination (Table 2.3-6). Additional investigations of the distribution and extent of this contamination in relation to biological resources are necessary in order to quantify damage to biological resources and to determine existing areas of contamination because the chemicals implicated in the death of these organisms are still present in the RMA environment.

2.3.2.2 Behavioral Abnormalities

Waterfowl which have been observed in the lower lakes area have exhibited clinical signs of abnormal behavior associated with organochlorine contamination (e.g., flying into buildings, attempting to land while several feet above the ground). The observed abnormal behavior was documented in association with high contaminant levels in the tissues of these birds (see references to this observation in Table 2.3-6). Recent observations at Basin F indicate that similar behavioral effects may be associated with chemicals present in the water of this known contaminant source.

2.3.2.3 Physiological Malfunctions

Eggshell thinning and reduced avian reproduction are well documented effects of organochlorine pesticides. These effects have been documented for one bird species, the American kestrel, from RMA (Table 2.3-6). These investigations were conducted as a controlled experiment comparing offpost (control) and onpost (experimental) areas to document the relationship between chemical contaminants in tissues and the observed adverse effects. Pathways analysis (Section 5.0) suggests that other resident breeding species may have been similarly affected, but documentation is lacking.

2.3.2.4 Physical Deformation

Physical deformations have been observed in toads from Basin D (Table 2.3-6). While this animal group is not of primary concern as a key species in animal communities at RMA, it suggests that similar effects may have occurred or may still affect other wildlife species.

2.4 PRELIMINARY PATHWAY IDENTIFICATION

An analysis of the movement of contaminants to and through the biota is necessary in order to identify any resources which have been or may be impacted. Biota may become contaminated through a variety of pathways including air, drinking water, and contact with soil. Once a contaminant has become incorporated into a plant or animal species it may be consumed by an animal species and be transferred to other biota through a complex system of pathways. Consequently, pathway identification for biota requires analytical approaches substantially different from those which apply to physical resources such as soil, air, and water.

The examination of food chain relationships is a logical and accepted mechanism for the analysis of pathways through plant animal communities. Food chain analysis is indicated as an accepted approach in both the NCP and NRDA.

2.4.1 FOOD WEB ANALYSIS

A food chain is a pathway for the movement of energy and nutrients (potentially including contaminants) through a series of organisms by progressive levels of consumption. The sequence where a plant is eaten by one animal which is in turn eaten by another animal, and so on constitutes a food chain (Elton, 1927).

The interconnected food chains in an animal community form a food web which is a representation of the feeding relationships among all organisms in a community. As such, a food web is a model which permits the identification of pathways for the movement and accumulation of contaminants in the biota. Except in instances where one species feeds entirely on another, more than one food chain will be involved. Consequently, food chain determination is best achieved by food web analysis.

Food web analysis as adapted for pathways identification proceeds stepwise from a general and comprehensive level to a systematic evaluation of food chains which can impact general ecosystem function, adversely affect key species within the animal community, or provide a pathway for contaminant transfer to humans. The approach used herein applies standard methods for food web analysis, systematically organized to determine potential pathways of contaminant movement through the biota. Figure 2.4-1 outlines the steps in this food web analysis which are described in the following sections.

2.4.1.1 Definition of Animal Communities

The first step in food web development was to define which animal communities are potentially affected by the contamination. Species lists were compiled for plants and animals known or thought to occur on RMA (Appendix A). Sources consulted for this information included environmental impact assessments (Federal Aviation Administration 1985, Fairbanks and Kolmer 1976), regional wildlife literature (Colorado Division of Wildlife 1981, 1982a, 1982b; Lovell and Choate 1982), data from reports and collections at RMA (Gauthier et al., 1974), and recent onsite observations. Because of their higher visibility and importance to humans, more detailed information (e.g., species) was available for higher plants (e.g., grasses, shrubs, trees) and for vertebrates (e.g., fish, mammals, birds) than for the lower taxonomic categories (e.g., algae, invertebrates, insects).

Species and animal groups were then organized into the three major animal communities indicated above. Species which feed in more than one community (e.g., raptors, amphibians) were included in each food web as appropriate. Because contaminants have been documented as present in the physical environment of the three major regional ecosystems (see Section

PRELIMINARY FOOD WEB ANALYSIS

1. Define Animal Communities
   - List species in each major ecosystem potentially contaminated
   - Include plant base for plant based food webs
   - Based on general and regional literature and limited onsite observation

2. Determine Food Habits
   - Food classified by percent animal and percent plant material
   - Species grouped by general food categories
   - Based on general and regional literature

3. Construct Food Web Database
   - Computerized database developed for each species based on food habits data
   - Food species grouped by taxonomic status (e.g. ducks) or growth form (e.g. shrubs)

4. Analyze Source and Sink Food Webs
   - Develop list of key species
   - Construct source and sink food webs from computerized database
   - Evaluate source and sink food webs
   - Present / prioritize potentially important source and sink food webs and / or food chains for each major animal community

Figure 2.4-1
STEPS IN PRELIMINARY
FOOD WEB ANALYSIS

See text for explanation

Prepared for:
U.S. Army Program Manager's Office
For Rocky Mountain Arsenal
Aberdeen Proving Ground, Maryland

2.1.2), the species and groups in all three community food webs were considered in this analysis.

2.4.1.2 Food Habits Determination

Preliminary definition of the feeding relationships among organisms in each food web was based on published information on the general food habits of species and animal groups (Hammerson, 1982; Bellrose, 1980; Baxter and Simon, 1970; Martin et al., 1951). Supplemental regional sources and direct observation confirmed much of the general information provided by these sources but did not provide data indicating an expansion of potential pathways beyond those indicated in the general references.

Food is classified as percent plant and percent animal material, and species are grouped into general food habits categories (e.g., herbivore, carnivore, omnivore). General data on food habits are sufficient to provide a preliminary determination of potential pathways, in spite of the lack of comprehensive and detailed food habit studies from the site and the adjacent area.

2.4.1.3 Food Web Database Construction

The information on food habits was then organized according to the broad feeding categories of herbivores (plant eaters), carnivores (animal eaters), omnivores (animals which consume plant and animal material), and detritivores (animals which consume decomposed organic material). Parasites were not specifically addressed because adverse effects on this group as a result of contamination would be difficult to demonstrate. Within these broad categories, species which potentially occur on RMA were grouped according to taxonomic classification (e.g., lagomorphs, rodents, etc.) or by growth form (e.g., trees, shrubs, forbs, etc.).

A computerized food web data base was then created which indicated broad categories and food groups consumed by each species or animal group on the comprehensive species list. The percent of each category consumed by each species was also indicated. In instances where these percent estimates varied seasonally, the seasonal percents were averaged to provide a rough estimate of the annual percent consumed.

Once the comprehensive food habits database was developed, it was used to determine potential pathways (e.g., food chains) for the movement of contaminants through regional food webs. This was accomplished by manipulating the database to determine possible feeding relationships among species based on general food habits information.

2.4.1.4 Source and Sink Food Web Analyses

The interactions of all species and groups within an animal community constitutes the community food web. Tracing all possible pathways for contaminant movement through community food webs which include more than a few species, such as those at RMA, would be complex and time consuming. A more manageable approach is to first examine the trophic (feeding) relationships for key species in each community food web. For purposes of the preliminary pathway determination, key species are defined as:

- Species listed as rare, threatened, or endangered either federally or by the state of Colorado;
- Species of economic importance (e.g., game animals, furbearers, pests, etc.) including those species consumed by humans (e.g., ringneck pheasant, cottontails, waterfowl, and mule deer);
- Abundant or common in the respective animal communities;
- Prominant species at each trophic level in regional food webs which may be affected by RMA contaminants; and
- Species which are known to contain RMA contaminants.

In instances where a number of animals occupy the same trophic level, have the same feeding habits, and meet the same criteria of key species (e.g., dabbling ducks), one species was selected as representative of the group. The species selected for analysis and the rationale for their selection are presented in Table 2.4-1. The abundance estimates for each species on this table are based on regional publications and in some cases may not be representative of populations on RMA. Limited field

Table 2.4-1. Species Selected for Preliminary Food Web Analysis from Computer Database

Common Name	Criteria for Selection[1]
AQUATIC FOOD WEB	
Bluegill	game, small carnivore, common
Black Bullhead	game, bottom feeder/omnivore, common
Largemouth Bass	game, large carnivore, common
Northern Pike	game, top carnivore, common
Tiger Salamander	Feeds in aquatic and wetland communities, common
WETLAND FOOD WEB	
American Coot	omnivore, abundant
Canada Goose	game, grazer/surface feeder, abundant
Mallard	game, dabbling duck, abundant
Redhead	game, diving duck, fairly common
Great Blue Heron	carnivore, fairly common
Black-crowned Night Heron	carnivore, fairly common
Redwing Blackbird	omnivore, abundant
GRASSLAND FOOD WEB	
Magpie	omnivore/scavenger, abundant
Mourning Dove	game, herbivore, abundant
Ringneck Pheasant	game, herbivore, abundant
Western Kingbird	aerial insectivore, common
Western Meadowlark	terrestrial insectivore/omnivore, common
American Kestrel	carnivore, fairly common
Redtailed Hawk	top carnivore, common
Badger	terrestrial carnivore, common
Desert Cottontail	game, herbivore (grazer), abundant
Mule Deer	game, herbivore (browzer), abundant
Pocket Gopher	fossorial herbivore, common
Bullsnake	poikilothermic carnivore, fairly common

[1] Information sources are provided in Appendix A

observations conducted as part of the Biota Assessment have confirmed the presence of some species, but no quantitative population estimates have been made. Because it is based on existing documents and limited field observation it contains some species whose occurrence at RMA is of low probability.

Once key species were selected, source and sink food webs were developed for each species. A "sink" food web is a subset of a community food web which includes all of the kinds of organisms that the designated "sink" species eats, the food of these organisms, and so on to the lowest level of the food web (Cohen 1978). A "source" food web includes a designated "source" species plus all of the organisms that consume the source, plus all of the organisms that eat those species, and so on to the highest trophic level involved (Cohen 1978).

Visual inspection of these levels for each species is then conducted to determine important and/or representative food chains. Identification of food chains involving more than one key species were evaluated to determine the potential importance of these species at a particular level within a chain in terms of the transfer and/or bioaccumulation of chemical contaminants. While key species and important food chains can be identified by other methods, this systematic analysis ensures that all possible interrelationships have been examined in the context of the potential for RMA contamination.

2.4.2 CONTAMINATION PATHWAYS AT ROCKY MOUNTAIN ARSENAL

Chemical contaminants were first identified as present in the tissues of plants and animals from RMA during the mid-1950's. Since that time numerous studies have been conducted on selected plant and animal species to determine the occurrence of specific chemicals in selected species, usually in reference to specific contamination problems at a few locations on RMA. The types of chemicals targeted for analysis, species analyzed, and location in past studies were sampled in relation to specific problems. In the three decades of contamination studies at RMA there have been no comprehensive investigations of contamination distribution or effects on biota. While there is abundant information documenting the presence of chemical contamination in RMA biota (which in many cases can be related to adverse effects on selected sites and species), there is no overall assessment of the chemicals harmful to biota, distribution of contaminants in ecosystems, and sites of contaminant transfer to biota. Studies documenting current information on contaminant distribution in biota are summarized in Section 2.3.

2.4.2.1 Food Web Analyses

Food web analyses as described in Section 2.4.1 provide a comprehensive, systematic, and objective approach for evaluating pathways of movement of contaminants through the plant and animal communities (biota) in ecosystems potentially affected by contamination. This approach is useful in evaluating potential contamination, particularly if environmental contamination has just occurred and chemical analyses verifying contamination in biological resources is unavailable. Most situations of this type would involve a single ecosystem involving species in a single animal community, thus simplifying the determination of potential pathways.

Food Web Database Studies

Circumstances of environmental contamination at RMA differ substantially from the typical situation described above. Varying levels of contamination have occurred at numerous potential locations on RMA since RMA was developed by the U.S. Department of Army (U.S. Army Toxic and Hazardous Materials Agency, 1983). More than 50 target chemicals have been identified from a list of over 700 potential RMA contaminants. As previously mentioned, numerous studies have been conducted on selected sites and species for some target chemicals over the past three decades. In addition, the sites of known and potential contamination occur in three major ecosystems: grassland, wetland, and aquatic. The evaluation of contamination impacts on biota at RMA is therefore extremely complicated in comparison to most hazardous waste sites. RMA is a conglomeration of many sites with different amounts and concentrations of chemicals added to the environment at different times, and involving different combinations of plant and animal species. For these reasons, a routine food web analysis is of limited usefulness.

Because of the number of key species potentially affected by RMA contaminants and the complexity of probable feeding interactions, food web analyses described in Section 2.4.1 indicated that most species in all trophic levels of each of the three major food webs were potentially exposed to chemical contaminants. Examination of the food web analyses provided for the northern pike in Appendix B illustrate this complexity.

The northern pike occupies a relatively high trophic level in the aquatic food web. Inspection of the sink food web shows that contaminants in the algae, part of the plant base of this food web, can be passed to invertebrates, through small fish, and on into the northern pike. Chemicals such as organochlorine pesticides (e.g., dieldrin) can bioaccumulate through these successive trophic levels, reaching the pike through a variety of prey species rather than along a single food chain and becoming concentrated in the tissues of the northern pike. Examination of the source food web further indicates that key species in terrestrial ecosystems (e.g., bald eagle) can feed on northern pike, further concentrate the chemical contaminants, and carry the contaminant into the food web of other animal communities. The northern pike, like many of the key species identified on RMA is also a game species and hence serves as a potential exposure pathway of RMA contamination to humans.

Results similar to those described for the northern pike were obtained by examination of the computerized food web for key species listed in Table 2.4-1. These species were selected on the basis of criteria listed in Section 2.4.1.4. All of the species are known or expected to be common or abundant components of regional ecosystems, and many are of economic importance. In general terms, the higher the trophic level occupied by a species, the more likely it is to occur on an exposure pathway, and in instances where the chemical bioaccumulates, the more likely the species is to suffer injury. Recent work on chemical contamination in aquatic ecosystems on RMA conducted by the U.S. Fish and Wildlife Service (1986) provides a discussion and suggested approach for estimating rates of bioaccumulation of contaminants in the aquatic environment. Other methods for estimating the transfer and/or bioaccumulation of selected contaminants are discussed in Lyman et al. (1982). These approaches were not employed in this preliminary assessment of contamination in biotic resources at RMA. Use of these formulas is inappropriate because of the absence of quantitative data on contaminant levels in some key species; the lack of correspondence in chemicals analyzed among species, sites, and years; and the lack of equivalent data on chemical and species for all similar sites.

The abundant data on contaminants in RMA biota obtained during previous investigations were used to determine if the general conclusion regarding the pervasive distribution of contaminants in major food webs could be verified. Information on contamination occurrence in species which is summarized in Tables 2.3-1 through 2.3-5 was used to evaluate potential movement along pathways indicated in source and sink food webs developed for key species. In all cases these data supported the possibility predicted in these model food webs that chemical contamination occurs at all trophic levels sampled in each of the three major food webs. Table 2.4-2 presents a summary of the species in which contaminants have been found in relation to the trophic structure of regional food webs.

Aquatic Ecosystem Studies

Recent work on contaminants in RMA aquatic systems done by the U.S. Fish and Wildlife Service (1986) focused on levels of aldrin, dieldrin, endrin, and mercury. Of 173 samples analyzed in this study the results can be summarized as follows:

- Aldrin:

  One sample exceeded FDA guidelines (0.3 ppm)
  Range = bdl to 0.33 ppm
  Water, dragonflies, damselflies, and snails were bdl in all lakes. Aldrin levels were highest in Lower Derby Lake where it bioaccumulated in viscera of predator fish (mean levels for largemouth bass = 0.300ppm).

- Dieldrin:

  16 samples exceeded FDA guidleines (0.3 ppm)
  Range = bdl (water and damselflies) to 6.5 ppm (bass viscera).

Table 2.4-2. Biota Containing Contaminants on Rocky Mountain Arsenal in the Trophic Levels of Major Ecosystems

Trophic Levels	Major Ecosystems: Aquatic	Wetland	Grassland
Plant (producer)	algae	cattails	grasses, forbs
Invertebrate	snails	snails	grasshoppers, beetles
herbivore	-	-	
carnivore	-	-	beetles
detritivore	-	-	earthworms
parasite	leech	leech	-
Vertebrate herbivore[1]	plains spadefoot toad, chorus frog, leopard frog	Canada goose, gadwall, green-winged teal, muskrat	mourning dove, ringneck pheasant, desert cottontail, black-tailed prairie dog, deer mouse
carnivore/ omnivore	black bullhead, channel catfish, rainbow trout, bluegill, tiger salamander	redhead, blue-winged golden eye, mallard, American coot, shoveler, pintail, ringneck duck, common merganser	ringneck pheasant (young), robin, western meadowlark
higher carnivore	largemouth bass, northern pike	great blue heron	red-tailed hawk, American kestrel, rough-legged hawk, great horned owl, starling, bullsnake, lizard

1 Frogs and toads as tadpoles; waterfowl with plants as 90% or more of diet

Dieldrin levels from Lower Derby Lake suggest the extent to which dieldrin is bioaccumulated in the viscera of predator fish species:

5.387 ppm - bass viscera
1.043 ppm - pike viscera
0.216 ppm - plankton

- Endrin:

  17 samples exceeded FDA guidlelines (0.3 ppm)
  Range = bdl (water, aquatic insects) to 0.21 ppm (bass viscera).
  As with dieldrin, endrin appears to bioaccumulate through trophic levels, to a high in bass viscera.

- Mercury:

  15 samples exceeded FDA guidelines (1.0 ppm)
  Range = bdl (water) to 3.45 ppm (pike fillets)
  Mercury appears to accumulate to the greatest extent in fillets.

Of the 26 Lower Lakes species in which contaminants have been found, six have a completely carnivorous diet. Two of the species discovered with contaminants are plants (Table 2.4-2). The remaining 18 species have diets composed of between 24 and 100 percent plant.

Aquatic plants are able to bioaccumulate mercury to 100 percent of the levels reported in sediments, and to almost one-half of the 1.0 ppm FDA mercury guideline levels for fish (USFWS, 1986). The continued documented presence of mercury within the primary trophic levels of the ecosystem suggest that its spread to higher trophic levels will continue.

2.4.2.2 Other Pathways of Contamination

As previously stated, food chains are the principal route for the contamination of most animal species. Potential pathways exist for the movement of contaminants from the physical environment into both plant and animal species on and near RMA. These pathways have been implicated in the initial incorporation of contaminants into biota, and then to other species by means of feeding interactions within community food webs. The principal routes of contaminant movement from the physical environment to biota are discussed below in relation to major animal communities and key species which have been documented as containing chemical contaminants.

Air

Past investigations of contaminants in air at and near RMA suggest that this pathway is of little potential importance in the contamination of biota. Documented spills and disposal of volatile chemicals have occurred on RMA in the past and have been investigated with respect to potential risk to humans. Although it is possible that some individuals have been harmed by inhalation of chemicals, large scale injuries were not observed, and it is unlikely that injury to plants or animals via the air route were substantial.

Non-volatile substances which are toxic and/or carcinogenic may have been incorporated into biota and produced harmful effects as a result of the suspension of small particles in the air during periods when contaminated areas of bare ground were subjected to surface winds. These injuries, if any, were not observed in the past. If injuries due to the air route did occur, it is likely that the effects were slight, and that the resulting injuries were localized. Most of the potential injury which may have occurred by this route would have taken place when disposal sites and spills were fresh. The length of time intervening between most spills and disposal activities in the 1950's and 1960's and the present would have allowed all but the most persistent and abundant chemical contaminants to have dissipated into other compartments of the environment or to have degraded into non-hazardous substances.

Soil/Sediments

Biota contamination through soil and/or sediments is potentially important. Investigations of the Lower Lakes, connecting waterways, and North Bog indicate that biota in these areas have incorporated contaminants into their tissues and have exhibited several types of injury (Section 3.0). The contaminants in these species of plants and animals were also present in the sediments. Some of these chemicals such as dieldrin are present in high concentrations in sediments, are persistent in the environment (Section 2.0) and are known to bioaccumulate. Initial findings of EBASCO's Phase I studies and recent studies (U.S. Fish and Wildlife Service, 1986) indicate that sediments and biota in the Lower Lakes are still contaminated, and provide a discussion of the routes of this contamination from the sediments through the components of the food web of the aquatic ecosystem.

Incorporation of contaminants into plants occurs through direct exposure. Animals may become contaminated through direct exposure and incorporation of contaminants through the skin or by ingestion of contaminants in sediments. The latter route is particularly important for bottom-feeding species such as bullheads and catfish.

Ingestion of soil is a standard route of exposure for terrestrial organisms, particularly grazing species (e.g., prairie dogs). Direct exposure and ingestion are potential contaminant exposure routes which may affect burrowing species such as pocket gophers and prairie dogs. Pocket gophers which feed on underground plant parts (e.g., roots) and spend nearly all of their lives in burrows may be particularly at risk from this contamination route.

Water

Biota contamination by means of water can occur by a variety of routes. Exposure of aquatic species is direct through tissues which are permeable to contaminants. This exposure includes direct bio-concentration through the exposed tissues. Bioaccumulation of selected contaminants is also likely. Organochlorine compounds (pesticides) have been documented in the sediments and several trophic levels in the aquatic food web (Section 3.0). Although direct exposure to sediments is implicated in contaminant uptake by biota, the role of water may be involved to some extent.

Terrestrial species including waterfowl, gamebirds, small game mammals, and large game (e.g., mule deer) regularly drink surface water. In areas contaminated with chemicals, uptake of chemicals from the drinking water and from associated sediments may provide an important pathway for incorporating these contaminants into the terrestrial food web.

3.0 PHASE II SAMPLING PROGRAM

Phase I results and additional regulatory guidance since the initiation of the Biota Assessment task indicate a need for additional field studies of biota in relation to contamination at RMA. Data from Phase I investigations of other resources (e.g. soil, ground water, surface water) have better defined areas of contamination at RMA and have been used in the development of the sampling program presented in this section.

The subtasks described below are designed to obtain pertinent information on the distribution, concentration, and effects of contaminants on biota on and near the RMA. Procedures were selected in order to obtain information necessary for appropriate remediation of contamination sites and assuming that restoration/replacement will be used as the basis for damage determination rather than diminution of use values. Cost-effectiveness and reasonable cost criteria have been used in development of this program.

3.1 SITE CHARACTERIZATION

Studies will be done to assess current background biota conditions for each major contamination site, and for their corresponding control sites. Because historical data for RMA and vicinity are sparse, control areas will be used to establish baseline conditions, in accordance with the guidelines outlined in the NRDA. Control sites will provide a natural baseline against which variables affecting biotic systems on RMA may be measured. The goals of site characterization should include:

- o To measure the extent to which injury demonstrated has occurred in the assessment area;
- o To measure the extent to which the injured resource differs from baseline (control) to determine the change attributable to contamination; and
- o To provide estimated numbers of affected individuals, or percent area of total resource affected.

Major sites of contamination identified with known and potential effects on biota have been identified and discussed in Section 2.0. These contamination sites (South Plants/Basin A, the Lower Lakes, Basin F, Basins C, D, and E, and the North Bog) will be discussed in succeeding sections in terms of biota assessments proposed for them. Source reports (ESE, EBASCO) will be used to delineate the most likely contaminant locations, and direction and means of contaminant migration.

Control areas will be selected on the basis of their similarity to contaminated areas and their lack of exposure to contaminants. Their comparability will be demonstrated on a site by site basis. Control areas for invertebrate and plant studies will be matched to contaminated areas by exact soil type wherever possible. Soil types will be those described by county soil survey reports published by the Soil Conservation Service and the Colorado Agricultural Experiment Station.

3.1.1 SOIL-ASSOCIATED INVERTEBRATES

Invertebrate species such as earthworms, whose life medium is the soil, are good bio-indicators of soil contamination. Earthworms will be sampled in contaminated areas (on-site) and uncontaminated areas (on and off-site) to provide information on population levels. Because earthworms are so closely associated with the soil environment, standard texture analyses (including pH and organic matter content) will be done for all earthworm sampling grids. This detailed micro-habitat assessments will allow sampling grids between contaminated and uncontaminated areas to be more finely matched, so that variables affecting worm population levels may be minimized.

Transects will be located in association with previous soil study areas, so that information already obtained may be used to assess the results of soil invertebrate studies. Invertebrate population sampling is discussed in Section 3.6.

Transect locations will be chosen within appropriate areas on the basis of the results from texture and organic matter analyses, and pH tests that will be completed for all earthworm sampling areas associated with contamination sites.

3.1.2 VEGETATION

Vegetation sampling techniques will conform as closely as possible to those proposed by Morrison-Knudsen Engineers, Inc. (MKE) so that opportunities for data comparison will be maximized. Transects will be located in association with contamination sites in order to sample any effects specifically related to types or degrees of contamination. This transect location strategy may differ from the apparently random one proposed by MKE, whose transects man not be necessarily associated with contamination sites. The MKE random sampling strategy may be insufficient to detect vegetation differences between contaminated and uncontaminated areas. The MKE transect location maps will be reviewed when available to determine if enough transects are located in proximity to designated contamination sites.

The vegetation sampling scheme is designed with ten 100 m transects in each major soil/vegetation type associated with the major sources of contamination described in Section 2.1 (closely associated pairs of 50 m transects may be used instead of single 100 m transects). SCS soils maps were superimposed on the vegetation map in order to determine areas where major soil and vegetation types occurred in relation to contamination sites.

Control areas were selected both onpost and offpost. Onpost control areas were determined through a review of information available in the ESE and EBASCO source reports. The same soils and vegetation types used for contaminated areas will be used for onpost control areas. Thus, a sunflower-dominated vegetation community occurring on a Tructon loam near a contamination source will have an onpost control area of sunflowers on a Tructon loam. Offpost control areas will be selected on the basis of the same soil types. Areas such as Wellington Wildlife Refuge will be used, where grazing has not occurred for many years. Table 3.1-1 presents the proposed scheme for onpost sampling sites and control areas.

Table 3.1-1. Vegetation Sampling Scheme for Site Characterization.

Location	Soil Type	Vegetation Type	Minimum Number of 100 m Transects
Basin A	2	1	10
Basin C	1	1	5
Basin D	1	1	5
Basin E	1	1	5
Basin F	2	1	10
Lower Lakes	1	1	10
Onpost Controls	2	1	20
Offpost Controls	2	1	20

Onpost transects, in most cases, will be located within sight of ground water wells and soil boring locations. There are several reasons for the frequent association of transects with well and boring locations:

- o Ease of location on maps, and in field, because all wells and borings have surveyed coordinates;
- o Randomness, because wells and borings were randomly placed using a grid system; and
- o Use of data derived from well water and soils analyses, which can be associated with transects placed near them.

Randomness of transect location will be further insured by the use of random numbers to obtain compass bearings for transect direction. Transect locations will be adjusted whenever necessary to avoid bare or severely distrubed areas, or to bypass areas thought to be unsafe.

The number of samples required is intended to incorporate vegetation sample data obtained by Morrison-Knudsen Engineers, Inc. (MKE) in order to avoid duplication of effort and facilitate data exchange. Agreement has been reached between MKE and ESE for this effort. Additional site characterization data such as animal species present, abundance, and behavior will be obtained for all areas sampled.

Parameters to be measured on all vegetation transects include the number of individuals, cover (litter, bare ground, rock, plant species), height, and frequency. These measurements are useful for assessing vegetation changes due to the passage of time, change in location, or chemical treatments. In addition to these measurements, any signs of physiological abnormalities (etiolation, necrosis of leaves, stems, or roots, or chlorosis of leaves) will be noted for use in assessment of habitat injury. Observable phytotoxic changes between plans from contaminated and control areas will be considered significant above the 20 percent level (RIC#81266R08). If significant phytotoxic changes are observed, secondary testing will be done to test for factors other than phytotoxins that may be responsible for plant effects.

A previous survey of RMA for phytotoxic substances tested plant growth in soils from the major contamination sites (RIC#81341R02). Phytotoxins were identified in connection with the major contamination sites in Sections 26 and 36. A small amount of evidence was obtained for the presence of phytotoxins in Sections 9, 22, and 24, though the evidence appears to be limited to one site, and to be restricted to a narrow layer in the soil profile. Soil samples from Sections 5, 6, 8, and 23 appeared to be more or less free of phytotoxins (RIC#81341R02).

3.1.3 FAUNA

Population data for key faunal species, part of a larger body of data gathered by MKE, will be used to help characterize experimental areas in terms of fauna. Additional population data will be collected by ESE for prairie dogs and/or pocket gophers. Census areas will be located on and adjacent to the major contamination sites, so that any effects between contaminated and uncontaminated areas will be demonstrated. A literature review will be done to establish the normal range and variability in prairie dog and/or pocket gopher populations. These animals will also be watched for signs of odd or unusual behavior.

Most of the site characterization data for faunal populations will be obtained from MKE and CDOW studies (Federal Aid reports), and from published literature. These will include data on carnivorous mammals, deer, rabbits, muskrats, raptors, pheasants, mourning doves, and song birds. Census surveys on prairie dogs or pocket gophers will be done on control areas for comparison with data from contaminated areas. Control areas for prairie dogs and/or pocket gophers will be chosen by their comparability to contaminated areas. Important characteristics in assessing comparability include: similar soil type, soil PH, vegetation communities, and land use history.

3.1.4 VOUCHER SPECIMENS

In accordance with 43 CFR Part 11.72 (k), a reference collection of floral and faunal specimens collected during assessment work will be submitted for expert identification, and for curation. Expert taxonomic assistance will be provided by Dr. Janet Wingate (Denver Botanic Gardens) and Dr. James Halfpenny (University of Colorado, Boulder).

3.2 AVIAN REPRODUCTIVE SUCCESS

Toxic chemical effects on ducks and several other avian species inhabiting the Rocky Mountain Arsenal (RMA) have been observed since 1951 (Jensen 1955). Avian mortality at RMA has continued up to the present time although at a lower level in recent years (McEwen and DeWeese 1984F: W. Adrian, Colorado Division of Wildlife, pers. communication). Waterfowl mortality, before measures were taken to reduce exposure to toxicants, was estimated minimally at 20,000 birds over a 10-year period (Finley, 1959) and many other species of wildlife including birds, mammals, and amphibians died (U.S. Fish and Wildlife Service, 1961). In addition to the known direct losses of wildlife there are other important unanswered questions concerning toxic effects.

The RMA is attractive to migrant birds because it is a large area of relatively undisturbed upland and wetland habitat in the midst of an urbanized, developed region. What are the effects of the organochlorine chemical residues acquired by the thousands of waterfowl, wading birds, songbirds, and raptors that inhabit RMA seasonally and in migration? Do these residues cause later mortality as fat stores are mobilized in migration and breeding? Do they lower reproductive success?

In response to the concern about chemical contaminants in wildlife at RMA, Patuxent WRC initiated a 2-year study in 1982 of American kestrels (sparrowhawks) as indicators of terrestrial contamination. This project was undertaken at the invitation of the Department of the Army. The U.S. Fish and Wildlife Service provided most of the funding for the work. The objectives of the kestrel study were to determine organochlorine chemical concentrations in kestrel eggs and young and to determine toxic chemical effects on kestrel reproduction.

In 1984, a limited survey of waterfowl nesting success at RMA was conducted by USFWS (McEwen and DeWeese, 1985). Fewer nests and broods of young were found than would be expected in the available habitat.

The results of both kestrel terrestrial bioindicators and waterfowl aquatic bioindicators signify continuing environmental contamination at RMA. Follow-up studies in 1986 and future years should establish weather there is a trend in dissipation and degradation of contaminants in these species. The objectives of avian reproductive success studies are:

- o To measure avian breeding populations and reproductive success at RMA in comparison to the same species in similar uncontaminated wetland and terrestrial habitats;
- o To measure concentrations of xenobiotic chemicals in eggs and young of the breeding species, particularly mallards, kestrels and pheasants.

Waterfowl nests will be searched for in all suitable habitat at RMA including the Lower Lakes, Rod and Gun Club Pond, and the North Bog areas using standard survey procedures including rope dragging. Pheasants will be sampled in suitable habitat in the vicinity of the Lower Lakes, within 1/2 mile of Basin F (outside fence), and portions of Section 19, 20, and 29 in the northwestern corner of RMA. One egg will be collected for chemical analysis per nest and each nest will be marked for rechecking to determine the outcome of the remaining eggs.

Nest searches will be done within a 50 m strip of lake shoreline and in nearby areas of herbaceous vegetation. Nest density will be calculated per unit area of shoreline and per ha of herbaceous habitat for statistical tests.

Regular systematic waterfowl brood surveys will be conducted 2 to 3 times a week from June 1 through July 15, 1986 and weekly thereafter though August 31, 1986 to determine brood size and successful fledging. Collected eggs will be marked for identification and refrigerated in the field until processed in the laboratory at CSU. Egg weight, volume, dimensions, and shell thickness will be measured. The state of development of each egg will be recorded and the contents placed in chemically clean jars, weighted to 0.01 gram, and frozen until submitted to the specified ESE chemical laboratory. One young bird per each brood identified will also be collected (by gun, net, or trap) for necropsy and chemical analysis.

Similar waterfowl nest searches, brood surveys, egg collections and sample preparation will be done at a control area in Larimer County, Colorado. The control area for pheasant and waterfowl will be the Wellington Wildlife Area, a 2,300 acre site with several lakes and ponds where human activity is restricted to prevent disturbance of waterfowl during nesting season. Other areas may be selected in order to obtain sufficient samples. Target sample sizes for collection of eggs and young will be 10 or more eggs and 8 or more young per waterfowl species per location (i.e., RMA and Wellington Control Area). Estimated numbers of egg samples are two (mallard, ring-necked pheasant) species x 15 eggs (RMA) = 30 plus 2 species x 10 eggs (control) = 20 for a total of 50 eggs. Numbers of young waterfowl collected will be fewer than the egg samples because of lower numbers available. Estimated numbers of prefledged birds of analysis are 2 species x 10 young x 2 sites = 40 total. Larger numbers of eggs and young birds will probably be available from control areas than from RMA, but sampling will be restricted to the minimum necessary for comparison with a breeding waterfowl at RMA.

Nest boxes for study of kestrel (sparrowhawk) reproduction from the earlier investigation are already in place at RMA and at a control site in Weld County, Colorado. Present utilization and productivity of birds using these boxes needs to be determined. One egg from each nest can be collected for chemical analysis and the hatchability of the remaining eggs, growth, and survival of young to fledging age can be determined. These data will serve as indicators of current terrestrial contamination at RMA.

Estimated kestrel sample sizes are 15 eggs and 8 young from RMA and 10 eggs and 8 young from the control area for a total of 41 samples. To reduce analytical costs, eggs could be composited into two samples per site. Young kestrels form RMA should be analyzed individually to provide data on variation in local terrestrial contamination there. Sample handling, storage, and procedures will be as described for the waterfowl. The areas of RMA where the nest boxes are located include all section except Section 34. Several sections have only one or two nest boxes, usually near the edge of the section.

Samples of eggs and birds for contaminant analysis will be prepared and temporarily stored in the subcontractor's laboratory at CSU in accordance with approved sampling procedures. Samples will be delivered weekly to the ESE chemistry laboratory in Englewood, Colorado during each sampling period. ESE will be responsible for performing contaminant analyses and providing results to Dr. McEwen at least four weeks prior to the submission of the final report for this work.

3.3 TISSUE ANALYSIS FOR CONTAMINANTS

Analysis of biota for RMA contaminants will require the collection of plants and animals from sites of known or potential contamination on RMA, uncontaminated sites on RMA, and from offpost control areas. The selection of key species for analysis is based upon the following criteria:

- Listed as federally threatened or endangered;
- Important components of regional ecosystems (e.g., are abundant prey/predators);
- Are economically important (e.g., game or pest species); and
- Species which represent a trophic level or guild.

Contaminants for tissue analysis were determined on the basis of criteria which were consistent with current and proposed regulatory requirements. Criteria included:

- Contaminants found in elevated levels in biota at RMA based on existing studies;
- Contaminants found in the RMA environment (e.g., soils, surface water) above apparent ambient concentrations;

- Contaminants on the basic inventory list of contaminants at RMA in the environment which are present in high volumes and/or are moderately to highly toxic; and
- Chemicals with a known history of presence in the environment which are known to be persistent.

Selection of species and chemicals for analysis considered cost effectiveness and reasonable cost considerations as evidenced by the criteria listed above.

The species list for contaminant analysis and suite of contaminants to be analyzed in each is based on current information for the major sites of contamination at RMA and for control sites on and offpost. Input for development of both lists was obtained during Biota assessment Committee meetings from the Colorado Division of Wildlife, Colorado Department of Health, Shell, Morrison-Knudsen Engineers, and the U.S. Fish and Wildlife Service. Additional information from other environmental assessment tasks and data forthcoming from this assessment will provide data which may result in modification of this subtask (e.g. additional sites of contamination may be located).

The species, chemical contaminants, and tissues currently proposed for analysis are listed in Table 3.3-1. Detailed information on chemical certification and analysis are provided in Section 4.0.

3.4 CHOLINESTERASE INHIBITION

Chemicals such as organophosphorus and carbonate pesticides are known to inhibit cholinesterase enzymes (ChE) in wildlife species. Inhibition can result in disruption of nerve function and death of the organism. Brain cholinesterase inhibition studies also meet the acceptance criteria for determining biological responses for death injury under the proposed Natural Resource Damage Assessment (NRDA) regulations.

Brain cholinesterase inhibition testing will be conducted on organisms which are found dead in the vicinity of sites of complex contamination (e.g., Basin F) if the cause of death is readily determined. This able 3.3-1. Species and Contaminants for Tissue Analysis

pecies	Locations	Sample Size	Chemicals As	Hg	OCPs	Tissues
lack-tailed Prairie Dog	Basin A	8	x	x	x	whole body
	Control (on)	8	x	x	x	whole body
	Control (off)	8	x	x	x	whole body
esert Cottontail	Basin A	8	x	x	x	carcass
	Control (on)	8	x	x	x	carcass
	Control (off)	8	x	x	x	carcass
ule Deer	Section 26	5	x	x	x	carcass
	Control (off)	5	x	x	x	carcass
allard	Lower Lakes	eggs-8		x	x	eggs
		fledgling-8		x	x	fledgling (WB)
		adult-8		x	x	carcass, organ
	Controls (off)	eggs-8		x	x	eggs
		fledgling-8		x	x	fledgling (WB)
		adult-8		x	x	carcass, organ
ing-necked Pheasant	RMA	eggs-8	x	x	x	eggs
		fledgling-8	x	x	x	fledgling (WB)
		adult-8	x	x	x	carcass, organ
	Control	eggs-8	x	x	x	eggs
		fledgling-8	x	x	x	fledgling (WB)
		adult-8	x	x	x	carcass, organ
merican Kestrel	RMA	eggs-10		x	x	eggs
		fledgling-10		x	x	fledglings (WB)
		adult-10		x	x	carcass, organ
	Control (off)	eggs-10		x	x	eggs
		fledgling-10		x	x	fledglings (WB)
		adult-10		x	x	carcass, organ
arthworm	Basin A	5	x	x	x	composite
	South Plants	5	x	x	x	composite
	Off/On Controls	5/5	x	x	x	composite
rasshopper	Basin A	5	x	x	x	composite
	On/Off Controls	5/5	x	x	x	composite
quatic Macrophytes	North Bog	5		x	x	composite
	Lower Lakes	5		x	x	composite
	Control (off)	5		x	x	composite

testing can be used to differentiate among contaminants which may be present in these systems and to better determine the chemicals implicated in the death of these organisms. This testing will be done in conjunction with tissue analyses for contaminants in order to meet the injury determination requirements under the proposed NRDA regulations.

Testing will be performed in the chemistry laboratory of ESE in Englewood, Colorado. Tissues for testing will be prepared and held in the supercold freezer at a temperature of less than 30°C prior to ChE analysis. It is anticipated that less than 100 samples will be collected and tested.

3.5 FOOD CHAIN DEFINITION

Preliminary contaminant pathways were determined in Phase I through the use of published literature on the general food habits of species and animal groups. Food habit studies are necessary in order to delineate actual contaminant pathways for species of concern at RMA. The results of food habit analyses will contribute to the identification and quantification of actual biological pathways through which potential contaminants have moved to the species being studied. The studies should reveal which foods (whether plant or animal) are being consumed by which animals, in what relative amounts.

Field methods will consist of two broad tasks:

- Observe species in field to determine relative availability of utilized species.
- Collect stomach/crop content samples for comparison with observations.

Sample number will be determined by methods cited in Hanson and Graybill, (1956). Non-lethal sampling will be attempted for any species for which the taking of a "statistical" sample would be potentially decimating population-wise (e.g., mule deer).

Species for food chain studies will be chosen by use of all least the following criteria:

- Species should be on the list of species to be sampled for tissue analysis, so that some connection can be made between body contaminant levels and ingested items. (Species on this tissue list will conform to guidelines outlined in 43 CFR, Part 11, p. 52161). Additional species for which contaminant data already exist may also be used.
- Species should be easy to collect.

Species under consideration for use in food chain studies include the mule deer, ringneck pheasant, mallard, and black-tailed prairie dog. These species are particularly important because of their documented contaminant accumulation tendencies, and because of their different relative positions in regional food webs.

3.6 INVERTEBRATE POPULATION STUDIES

Invertebrates constitute an important portion of the biota in ecosystems on RMA. Species groups were selected for investigation because of their role as herbivores, as prey for key species and because of their potential for demonstrating direct injury from RMA contaminants.

Earthworms can be used as a direct measure of biotic injury or as indicators of injury to soils under the NRDA regulations. This group is also important as a food source for terrestrial organisms. Population and contaminant studies are important for evaluating soil injury, verifying contaminant pathways, and providing an objective basis for determining injury to soil biota.

Grasshoppers are abundant terrestrial invertebrates that constitute a substantial portion of diet of many animals, including immature pheasants. Population/biomass sampling of this group will provide quantitative data on the invertebrate primary consumer level in relation to key predator species. Contaminants have been documented in grasshoppers from RMA (see Section 2.0). Knowledge of contaminant levels in this group can be related to pathways determination, possible bioaccumulation, and injury effects on higher order consumers such as pheasants.

Aquatic snails are a major item in the diet of aquatic and semi-aquatic organisms including game fish and waterfowl. Relatively high contaminant levels have been found in aquatic snails from the lower lakes on RMA. They are particularly important in the diet of waterfowl during nesting season and provide protein and a source of calcium for eggshell production. Determination of population size and contaminant levels is important for pathways confirmation and potential injury determination is aquatic ecosystems.

3.6.1 EARTHWORMS

Ten randomly selected sampling points will be selected within identified sites of contamination, uncontaminated sites onpost (onpost control areas), and in offpost control areas. Some subsampling within contaminated sites (e.g., Basin A) may occur. Sites of contamination which will be sampled include Basins A, C, D, and E and the South Plants Area based on the concentration and distribution of contaminants in the soil.

Earthworm population densities and biomass will be determined by physical excavation of known soil volumes and subsequent hand sorting and removal of worms (Walter and Snider, 1984). Soil samples will be excavated during the same season (late summer and early fall), general weather conditions, and at the same time of day. Areas of soil compaction or recent evidence of surface disturbance will be avoided in selecting random sampling locations.

Each sample will be obtained by excavating a soil plug 25 µm x 25 cm and 20 cm deep (Walter and Snider, 1984). A wire frame will be used to define the surface area, and the plug excavated using a spade. The plug will be placed in a paper sack and into a cooler and removed from the excavation site to a nearby location where the soil can be picked apart and the earthworms removed. The soil will be returned to its original location following sorting. Soil moisture and soil temperature will be recorded for each sample area. Sampling in areas potentially containing agent will be conducted using the appropriate protective clothing and under the supervision of site safety personnel (Section 7.0).

A pilot study will be conducted on RMA prior to implementation of the program in order to determine if changes in sampling techniques, sample size, or type of data recorded are needed. The pilot study should be completed before September 1986 and a report prepared indicating any modifications prior to actual sampling.

To minimize heat stress, field sampling will be conducted during early morning hours (0530 - 0800 hours) in September. A population count and total wet weight of earthworms will be obtained for each sample. A subsample of worms will be retained for identification and voucher purposes. Samples of worms for chemical analysis will be composited from worms collected in the course of population surveys. Control sites will be selected on the basis of similar soil type (using types described by the SCS county soils reports), vegetation cover, and land use history.

3.6.2 GRASSHOPPERS

Grasshopper abundance will be estimated using a standard ocular technique (D. Thompson, personal communication). This method is recommended for grassland habitats because it provides a more precise estimate of the area surveyed than sweep netting techniques and because small plots permit accurate counting of grasshoppers.

Plots of 0.1 square meters will be established at 10 m intervals along 100 m transects randomly located in contamination sites and in on and offpost control areas. Ten points will be established along each transect, and five transects will be sampled at each site. Subsites (e.g. smaller areas of contamination with larger sites) will be surveyed with fewer transects. The plot will be defined by circular plots placed along transects in the field at least two hours before the survey is conducted in order to allow grasshoppers dispersed by plot placement to return to the area. Vegetation height, density, dominant species composition will be recorded as will air temperature, general weather conditions, date, and time of sampling. Sampling will be done at approximately one month intervals in August and September 1986. Grasshoppers collected for contaminant analysis will come from the areas surveyed for population density and will be collected with a sweep net following the last field survey.

Transects which meet the following conditions will be randomly selected within each sample area:

- o All points on each transect will be at least 10 m from the nearest defined boundary and no closer than 10 m to the nearest transect;
- o Transects will be located by using a grid overlay to select one point, then orienting the transect toward (or through) the nearest survey grid marker; and
- o Transects will not include or traverse areas of disturbed and/or compacted ground.

Each transect will be marked at each end with wooden stakes so that the same transects and plots can be surveyed during each of the three survey periods. Sampling will be conducted under generally favorable weather conditions (wind less than 10 mph, no precipitation). Sampling will be coordinated with other sampling activities to avoid periods of disturbance during survey.

3.6.3 AQUATIC SNAILS

A minimum of 10 samples will be collected from each of the lower lakes on RMA (Upper and Lower Derby, Ladora, Mary), Gun Club Pond, and from the North Bog. Equal numbers of samples will be collected from two offpost control areas.

Sample design includes:

- o Determining the perimeter of each body of water;
- o Randomly selecting distances about each lake; and
- o Randomly selecting distance from shore/heavy vegetation (up to 20 ft maximum) in which to sample (sample point should not exceed an 18-in water depth for this study).

A 1 m^2 sample frame will be placed at each sampling point and a $\frac{1}{4}$ m^2 sample plot will be randomly sampled for snails. Water temperature, average depth, pH, and type of substrate (e.g. aquatic plants present or absent) will be recorded for each sample location. All snails and vegetation within the plot will be collected. All vegetation will be weighed for each sample at the ESE laboratory. Snails will be counted and weighed from each sample. All specimens will be preserved in 10 percent formalin and saved for subsequent identification.

A pilot study will be conducted to determine if modifications to this sampling technique are necessary. The study will be completed and a report containing any suggested changes will be filed prior to implementation of field sampling. Sampling in sites of potential contamination will require the use of appropriate safety gear and procedures.

3.7 PHYSICAL MALFORMATIONS

Physical deformation is generally defined as alteration in shape, size, and/or structure of an organism or any part of an organism (U.S. Department of Interior, 1986). Deformaties attributable to chemical contaminants have been reported in embryos, nestlings, and adult birds in the field. Gilberton and Fox (1977) recorded over external deformations related to organochlorine exposure.

Although physical deformations of birds have not been documented from RMA in relation to sites of organochlorine contamination, physical deformation of toads has been noted in Basin D correlated with dieldrin in the tissues of these animals (RIC#84131R02). The areal extent, concentration, persistence, and known biological effects of organochlorine pesticides including aldrin, dieldrin, and endrin on RMA suggest that substantial injury in the form of physical deformation may have occurred and may still be occurring at RMA.

Although other biological responses (e.g., skeletal deformaties, histophathological lesions, internal organ malformations) may also occur, methods of observation and documentation require the sacrifice of large numbers of individuals which would be both unjustifiably expensive and would inflict substantial damage on the animal populations being studied.

Observations of physical deformities in connection with the presence of organochlorine compounds meets the criteria of acceptance for documentation of injury to biological resources. The studies proposed herein would be conducted in conjunction with avian reproductive sampling, would require little additional time for recording observations, and would therefore involve only minor increased costs.

Hatchling and immature birds observed at nests during avian reproductive success studies would be examined for evidence of overt external deformities such as crossed bill, small eyes, reduced mandibles, and foot malformations. Nests would be checked frequently during incubation so that any seriously deformed young, not likely to survive could be noted before these individuals expired and were lost from the population. It is anticipated that these observations would require a minimum of two visits to each nest during the period of late incubation and early hatching for each of the three major bird species; ringneck pheasant, mallard, and American kestrel.

Although other bird species would be observed and deformities noted in the course of avian reproductive success studies, it is not anticipated that deformities in other species would be documented in sufficient numbers to detect statistical differences between contaminant and designated control areas on a per species basis. The frequency of occurrence of overt physical deformities of hatchling and immature birds would be compared between areas of contamination and designated control areas using appropriate parametric and/or nonparametric statistical procedures (Sokal and Rohlf, 1981).

3.8 DOMESTICATED PLANTS AND ANIMALS

Records from RMA, data from growers and vendors in the offpost study area, surveys of well records, and interviews with residents in the offpost study area indicate a potential for contamination of domesticated animals and crops offpost. Potential contamination effects include injury to the biota and implication of contaminated plants and animals as a contamination pathways to humans. References to domestic animal and crop injury are present in records from the 1950s. Regulatory requirements and the need for pertinent data on biota effects indicate the need for investigating this topic.

This subtask will consist of examination of available information on the distribution and concentration of RMA contaminants in the environment inhabited by domestic biota off of RMA. Surface water contamination near RMA and contaminated ground water which is used for irrigating domestic crops and/or watering livestock will be determined. Areas and resources affected (e.g., crops, cattle, sheep, etc.) will be determined form existing information.

Investigations will result in the preparation of a report summarizing the known or potential for this offpost contamination. The report will be used as a basis for determining if offpost sampling and/or surveys are needed to determine the natural and extent of potential injury and/or risk involving domesticated biota.

3.9 SAMPLING AND ANALYSIS SCHEDULE

The schedule for field sampling and chemical analysis is presented in Figure 3.10-1. Additional seasonal sampling and chemical analysis for Domesticated Plants and Animals and implementation of a HEP program may occur as the result of information acquired during the Phase II studies described in this technical plan.

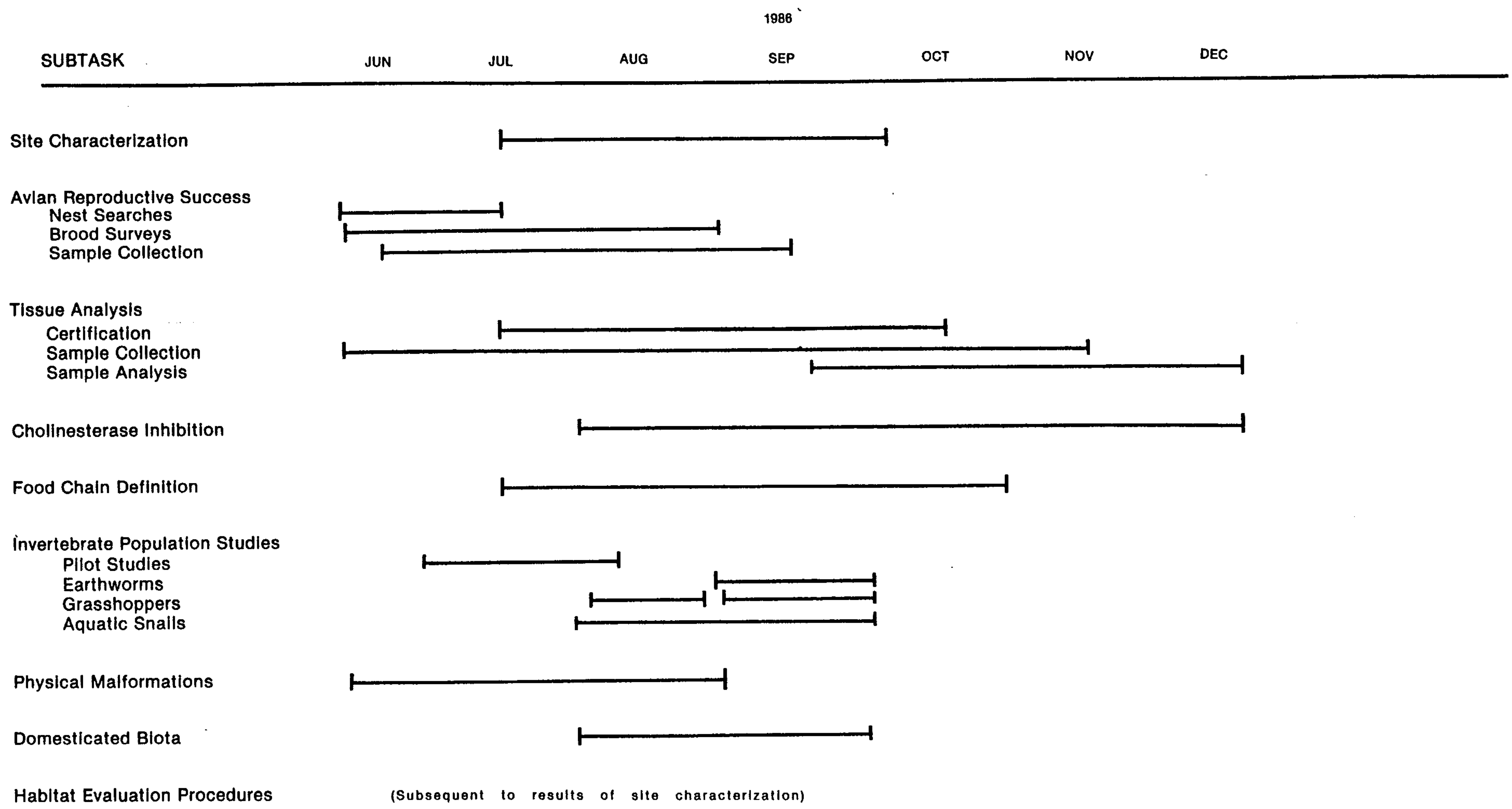


Figure 3.10-1
BIOTA ASSESSMENT PHASE II
FIELD SAMPLING AND
CHEMICAL ANALYSIS SCHEDULE

Prepared for:
U.S. Army Program Manager's Office
For Rocky Mountain Arsenal
Aberdeen Proving Ground, Maryland

4.0 CHEMICAL ANALYSIS

This section currently being developed consistent with the requirements of RMA environmental assessment tasks.

4.1 CERTIFICATION

The certification process will be implemented for the ESE laboratory conducting the analyses of bioilogical samples from RMA and nearby control areas. Laboratory certification will follow the approval of the Methods Development Plan by the Project Manager's Office for Rocky Mountain Arsenal Contamination Cleanup of the U.S. Army.

Three methods will be certified for the following groups of chemical contaminants:

- o Organochlorine pesticides (aldrin, endrin, dieldrin);
- o Mercury; and
- o Arsenic.

Methods will be developed for analysis of different tissue matrices including animal whole body/carcass, animal organ, and plant tissues. Extraction procedures, holding times, and analytical methods will be based on established methods used by other laboratories for purposes similar to the RMA environmental assessment.

4.2 SAMPLE ANALYSIS

Detailed methods for sample analysis will be developed as a result of the certification program. Sample protocol will be consistent with the requirements of RMA environmental assessment tasks, but modified for the matrices being samples.

5.0 QUALITY ASSURANCE

5.1 FIELD LABORATORY QA PROGRAM

Quality Assurance (QA) for Task 9 will be consistent with the Field/Laboratory QA Plan developed for Task 1 activities. The plan is project specific and describes procedures for controlling and monitoring sampling and analysis activities as required. As designed, the Field/Laboratory QA Plan will ensure the production of valid and properly formatted data concerning the precision, accuracy, and sensitivity of each method used for PMO-RMA/USATHAMA April, 1982 QA program requirements as modified by U.S. Army AMCCOM Procurement Directorate and ESE as well as certified analytical methods submitted to and approved by PMO-RMA/USATHAMA. Specific RMA QA/QC requirements for Task 9 are contained in the following sections.

Requirements for this task will be consistent with those provided for other RMA tasks, but modified to fit the needs of the biota assessment program. The following topics are currently being developed and will be addressed in detail in the draft technical plan for Phase II.

5.2 SPECIFIC RMA REQUIREMENTS

5.2.1 RESPONSIBILITIES OF QUALITY ASSURANCE (QA) SUPERVISOR

5.2.2 FIELD PROCEDURES

5.2.3 SAMPLE PREPARATION AND BATCHING

5.2.4 HOLDING TIMES

5.2.5 DETECTION LIMITS, ACCURACY, PRECISION, AND CERTIFICATION

5.2.6 ANALYTICAL CONTROLS

5.2.7 REVIEWING AND REPORTING REQUIREMENTS

6.0 DATA MANAGEMENT PLAN

Data for Task 9 will be handled according to the Data Management Plan in Volume I of the Task 1 Technical Plan Contract Number DAAK11-84-D-0016. sample number assignments, labels, and logsheets will be made in Gainesville and given to the sampling team. Samples shipped to laboratories will follow chain-of-custody procedures described in the Technical Plan. Figure 6.0-1 is an overview of the Data Management procedures for PMO-RMA/USATHAMA analysis.

A map record, field sample monitoring record, and chemical record data file will be created for each subtask. Environmental sampling parameters will be defined and modified according to the requirements of each sampling program. Field data will be entered into the microcomputer LAN system at the ESE Denver office and transmitted to the ESE Gainesville office via telephone. The field data will be transferred to the IR-DMS, put through the data check routine, validated, and put in Level 2.

Samples shipped to laboratories will follow chain-of-custody procedures described in the Technical Plan. Data from lab analyses will be entered into the ESE Prime 750 computer, incorporated with certification and field data, and formatted into files according to the IR-DMS User's Guide. After validation these files will be sent to the Univac using the Tektronix or the microcomputer LAN system, run through the data check routine, and elevated to Level 2.

Data Management Supervisor Responsibilities

The Data Management is responsible for coordinating transmission of all completed data coding forms to PMO-RMA/USATHAMA. The Supervisor's specific responsibilities include:

- Supervise the operation of the ESE data management system;
- Incorporate QC and IR-DMS requirements into the ESE chemical data management system;
- Incorporate onsite meteorological data;

- Review all completed field data coding forms for compliance with IR-DMA requirements;
- Instruct laboratory and field personnel in the proper procedures for recording data;
- Transmit approved Level 1 data on a regular scheduled basis to the PMO-RMA/USATHAMA IR-DMS;
- Transfer Level 1 data to Level 2, after approval/validation; and
- Delete obsolete Level 1 files in accordance with PMO-RMA policy.

To fulfill his/her responsibility to transmit all completed data in IR-DMS upon Site Manager approval, the authorities of the Data Management Supervisor are to:

- Approve or disapprove of laboratory or field data with regard to formatting, as required by the project Data Management Plan.
- Directly communicate with PMO-RMA/USATHAMA data management personnel with regard to data transmittal problem resolution.

7.0 SAFETY PROGRAM

The purpose of this section is to summarize the safety, accident, and fire protection standards and to outline standard operating procedures to ensure the safety of all ESE personnel and its subcontractors performing Task 9 activities. Responsibilities, authorities, and reporting emergency procedures as designated to Task 9 are identical to those designed for Task 1 in Section 7.0 of the Task 1 Technical Plan.

This program addresses all of the requirements of DI-A-5239B and fully complies with requirements of the Occupational Safety and Health Administration (OSHA) and the U.S. Army Material Command (AMC) Regulations 385-100, Army Regulations (AR) 385-10, and Department of Army Pamphlet (DA PAM) 385-1 for all activities to be conducted. The program also complies with the ESE Analytical Laboratory Safety Plan.

7.1 GENERAL SAFETY PROCEDURES

7.1.1 HOTLINE SYSTEMS

Hotlines extend around Section 36, as noted in the Task 1 Technical Plan, Basin C, D, E, and F, and source areas in Sections 19, 20, 22, 23, 24, 25, 27, 28, 29, 30, 31, and 35. Hotlines in the southern half of RMA, mainly those areas south of December 7th Avenue have been established by EBASCO. Work in the southern half of RMA will require the Onsite Safety Officer (OSO) or the field team to consult EBASCO and discuss areas that require personal protection or extra safety precautions. It is not anticipated that any biota work in the southern half of RMA will require an upgrade from Level D to a higher level of protection.

7.1.2 LEVELS OF PERSONAL PROTECTION

Levels of personal protection will be task specific. Personnel will wear a specific level of protection appropriate to the area in which their activities take place. Section 7.2 describes levels of protection and specific procedures for each activity.

7.2 ACTIVITY SPECIFIC SAFETY

All field crews will be made up of at least two people whenever workingin hazardous areas. All crews will carry a radio so that they can be in constant communication with the base station. The field crews will also notify the fire department and emergency personnel as to where they will be working each day. The following section describes safety procedures to be followed for each specific activity taking place under Task 9.

7.2.1 SITE CHARACTERIZATION

Site characterization will take place in Section 36, the Lower Lakes area, South Plants area, and outside the fence at Basin F. Personal protection in Section 36 will consist of modified Level D clothing. This level of protection includes: Tyvek® coveralls, steel toe and shank rubber boots, latex rubber boot covers, 2 pairs of chemical resistant gloves, a full face air purifying respirator, and an escape pack respirator. Respiratory protection will not be required to be worn unless there is airborne visible dust. All decontamination procedures will follow those set forth in the Task 1 Technical Plan.

Activities in the Lower Lakes area, South Plants area, and outside of Basin F will require Level D protection. Steel toe and shank rubber boots, and gloves will be worn by field personnel. If activities require entering the water in the Lower Lakes area, field personnel will don hip waders. A safety rope will also be employed with one person on shore in the event that the person in the water falls or steps unknowingly into a hole or deeper water.

Because of the contaminated sediments in the Lower Lakes, hip waders will need decontamination upon leaving the water. This will be accomplished using two metal wash tubs, an Indian sprayer, and a scrub brush. Waste water will be disposed of at the Section 36 wash pad.

7.2.2 AVIAN REPRODUCTIVE SUCCESS

Avian reproductive success investigations will take place in the Lower Lakes area and in the Basin F area outside the fence. Personal protection will be identical to that described in 7.2.1 for these areas.

7.2.3 TISSUE ANALYSIS FOR CONTAMINANTS

Tissue analysis will require the collection of biota in Section 36, Basin F and its surrounding area, and the Lower Lakes area. Personal protection for work in Section 36 and the Lower Lakes is described in Section 7.3.1. If this activity requires entering Basin F, this will be done wearing Level B protection. This protection consists of a self-contained breathing apparatus (SCBA), Saranex® coveralls, rubber boots with steel toe and shank, two pairs of latex rubber boot covers, and two paris of chemical resistant gloves.

Decontamination procedures for Section 36 and the Lower Lakes are described in Section 7.2.1. Decontamination procedures for Basin F are as follows: personnel will scrub and remove their outer booties and gloves and wash any equipment at the gate. Personnel will then proceed to the wash pad and complete decontamination. SCBA's will remain on until personnel are at the wash pad.

Shooting of animals will be a method of collection for tissue analysis. Before any shooting takes place, field personnel will notify and coordinate with RMA security, the RMA fire department, and all contractors and subcontractors working onpost. It is important that no other field crews are in areas where shooting will be occurring.

7.2.4 CHOLINESTERASE INHIBITION

Cholinesterase inhibition studies will require the collection of animals from the Basin F area. Procedures described in Section 7.2.3 will apply to this activity.

7.2.5 FOOD CHAIN DEFINITION

Food chain definition activities will take place in Section 36 and the Lower Lakes area. Personal protection will be as described in Section 7.2.1. Procedures for shooting are described in Section 7.2.3.

7.2.6 INVERTEBRATE POPULATION STUDIES

Invertebrate population studies will take place in Section 36 and the Lower Lakes area. Procedures are described in Section 7.2.1.

7.2.7 DOMESTICATED PLANTS AND ANIMALS

No field work is anticipated.

7.2.8 PHYSICAL MALFORMATIONS

The investigation for physical malformations will be included with Avian Reproductive Success Investigations described in Section 7.2.2.

7.2.9 HABITAT EVALUATION PROCEDURES

No field work is anticipated.

7.2.10 GENERAL MONITORING AND FIELD COORDINATION

General monitoring and field coordination will take place in the Lower Lakes region. Personal protection and decontamination procedures for this region are described in Section 7.2.1.

7.3 NIGHT WORK AND INCLEMENT WEATHER

Night work may be required for Task 9 activities. If night work is required, field personnel will notify security and the RMA fire department of their specific location. All night work will be accomplished employing the buddy system.

Weather conditions can change rapidly in the RMA area. Strong electrical storms can come in over the mountains with little warning. All field work will immediately cease when lightning is observed. Field personnel will immediately seek cover and remain under cover until the storm or lightning has subsided.

7.4 WOUNDS CAUSED BY ANIMALS

Besides carrying contaminating chemicals in their bodies, animals collected at RMA may also be infested with disease-carrying ticks, fleas, and other parasites. The animals themselves may also be inflicted with or carriers of diseases which could be passed on to humans. Therefore, field personnel handling live or dead animals will at all times wear gloves.

Personnel will check themselves frequently for the presence of fleas and ticks. At lunch and at the end of each day in the field personnel will wash themselves thoroughly after handling animals.

If field personnel are wounded by an animal, whether it be a bite or scratch, the personnel will thoroughly wash the wound and seek immediate medical attention. If it is possible that the animal has rabies, the field personnel should attempt to capture the animal for observation for rabies.

7.5 UNEXPLODED ORDNANCE AND SURETY MATERIAL

It is very likely that field personnel will discover surface UXO or munition fragments. When field personnel do find these objects, they will immediately call the command post and give the trailer monitor a description of the object and its location. The trailer monitor will notify the fire department personnel who will then take over identification and recovery procedures.

It is not expected that field personnel will encounter surety materials. However, if there is an incident involving surety materials, procedures outlined in Section 7.0 of the Task 1 Technical Plan will be followed.

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APPENDIX A

PLANT AND ANIMAL SPECIES WHICH INHABIT OR POTENTIALLY OCCUR ON ROCKY MOUNTAIN ARSENAL

Family	Genus	Species	Common Name	Status*	Source Document**
PLANTS					
Verbenaceae	Abronia	fragrans	Prairie snowball		5
Aceraceae	Acer	negundo	Boxelder		5
Aceraceae	Acer	saccharinum	Silver-leaf maple		5
Gramineae	Agropyron	cristatum	Crested wheatgrass		5
Gramineae	Agropyron	desertorum	Crested wheatgrass		5
Gramineae	Agropyron	elongatum	Tall wheatgrass		5
Gramineae	Agropyron	intermedium	Wheatgrass, intermed.		5
Gramineae	Agropyron	repens	Quack grass		5
Gramineae	Agropyron	smithii	Western wheatgrass		5
Gramineae	Agropyron	trachycaulum	Slender wheatgrass		5
Amaranthaceae	Amaranthus	albus	Tumble pigweed		5
Amaranthaceae	Amaranthus	arenicola	Rope-spike pigweed		5
Amaranthaceae	Amaranthus	retroflexus	Rough pigweed		5
Compositae	Ambrosia	psilostachya	Western ragweed		5
Compositae	Antennaria	rosea	Pussy-toes		5
Apocynaceae	Apocynum	sibiricum	Siberian dogbane		5
Papaveraceae	Argemone	polyanthemos	Prickly poppy		5
Gramineae	Aristida	longiseta	Red three-awn		5
Compositae	Artemisia	filifolia	Sand sagebrush		5
Compositae	Artemisia	frigida	Fringed sagebrush		5
Compositae	Artemisia	ludoviciana	Prairie sage		5
Asclepiadaceae	Asclepias	incarnata	Marsh milkweed		5
Asclepiadaceae	Asclepias	speciosa	Showy milkweed		5
Asparagaceae	Asparagus	officinalis	Asparagus		5
Compositae	Aster	commutatus	White prairie aster		5
Leguminosae	Astragalus	lotiflorus	Lotus milk-vetch		5
Chenopodiaceae	Bassia	hyssopifolia	Bassia		5
Umbelliferae	Berula	erecta	Water parsnip		5
Gramineae	Bouteloua	curtipendula	Side-oats grama		5
Gramineae	Bouteloua	gracilis	Blue grama		5
Gramineae	Bromus	inermis	Smooth brome		5
Gramineae	Bromus	japonicus	Japanese brome		5
Gramineae	Bromus	tectorum	Cheatgrass		5
Gramineae	Buchloe	dactyloides	Buffalo grass		5
Gramineae	Calamovilfa	longifolia	Prairie sand reed		5
Cruciferae	Cardaria	draba	Hoary cress		5
Compositae	Carduus	nutans	Musk thistle		5
Cyperaceae	Carex	spp.	Sedge		5
Leguminosae	Catalpa	speciosa	Catalpa		5
Ulmaceae	Celtis	reticulata	Hackberry		5
Chenopodiaceae	Ceratoides	lanata	Winterfat		5
Euphorbiaceae	Chamaesyce	glyptosperma	Corrugate-seed spurge		5
Euphorbiaceae	Chamaesyce	missurica	Narrow-leave spurge		5
Euphorbiaceae	Chamaesyce	serpyllifolia	Thyme-leaved spurge		5
Chenopodiaceae	Chenopodium	album	Pigweed		5
Chenopodiaceae	Chenopodium	leptophylum	Narrow-leaf gooseft		5

Family	Genus	Species	Common Name	Status*	Source Document**
Compositae	Chrysothamnus	nauseosus	Rabbitbrush		5
Compositae	Cirsium	arvense	Canadian thistle		5
Capparidaceae	Cleome	serrulata	Beeweed		5
Convolvulaceae	Convolvulus	arvensis	Morning glory		5
Compositae	Conyza	canadensis	Horseweed		5
Cactaceae	Coryphantha	vivipara	Ball cactus		5
Euphorbiaceae	Croton	texensis	Croton		5
Boraginaceae	Cryptantha	fendleri	Fendler's cryptantha		5
Cucurbitaceae	Cucurbita	foetidissima	Wild gourd		5
Umbelliferae	Cymopterus	montanus	Biscuit root		5
Leguminosae	Dalea	aurea	Prairie clover		5
Cruciferae	Descurainia	sophia	Tansy mustard		5
Gramineae	Distichlis	stricta	Alkali saltgrass		5
Compositae	Dyssodia	papposa	Fetid marigold		5
Cactaceae	Echinocereus	viridiflorus	Hen and chickens		5
Eleagnaceae	Eleagnus	angustifolia	Russian olive		5
Gramineae	Elymus	canadensis	Canadian wild rye		5
Onagraceae	Epilobium	adenocaulon	Willow-herb		5
Gramineae	Eragrostis	cilianensis	Stinkgrass		5
Polygonaceae	Eriogonum	annuum	Tall eriogonum		5
Compositae	Erigeron	divergens	Spreading fleabane		5
Polygonaceae	Eriogonum	effusum	Bushy eriogonum		5
Compositae	Erigeron	pumilus	Low daisy		5
Geraniaceae	Erodium	cicutarium	Filaree		5
Cruciferae	Erysimum	asperum	Western wallflower		5
Euphorbiaceae	Euphorbia	marginata	Snow-on-the-mountain		5
Compositae	Euthamia	graminifolia	Bushy goldenrod		5
Convolvulaceae	Evolvulus	nuttallianus	Bindweed		5
Oleaceae	Fraxinus	pennsylvanica	Green ash		5
Onagraceae	Gaura	coccinea	Scarlet gaura		5
Onagraceae	Gaura	parviflora	Tall gaura		5
Leguminosae	Gleditsia	triacanthos	Honey locust		5
Compositae	Gnaphalium	chilense	Yellow cudweed		5
Compositae	Grindelia	squarrosa	Gumweed		5
Compositae	Gutierrezia	sarothrae	Snakeweed		5
Caryophyllaceae	Gypsophila	paniculata	Baby's breath		5
Compositae	Haplopappus	spinulosus	Spiny goldenweed		5
Compositae	Helianthus	annuus	Common sunflower		5
Compositae	Helianthus	petiolaris	Prairie sunflower		5
Compositae	Heterotheca	villosa	Hairy golden aster		5
Gramineae	Hordeum	jubatum	Foxtail barley		5
Gramineae	Hordeum	pusillum	Little Barley		5
Polemoniaceae	Ipomopsis	laxiflora	Loose-flowered gilia		5
Convolvulaceae	Ipomoea	leptophylla	Bush morning glory		5
Compositae	Iva	xanthifolia	Tall marsh elder		5
Juncaceae	Juncus	arcticus	Creeping rush		5
Pinaceae	Juniperus	virginiana	Rocky Mt. juniper		5
Chenopodiaceae	Kochia	scoparia	Kochia		5
Compositae	Kuhnia	eupatorioides	False boneset		5

Family	Genus	Species	Common Name	Status*	Source Document**
Compositae	Lactuca	serriola	Prickly lettuce		5
Boraginaceae	Lappula	redowskii	Stickweed		5
Cruciferae	Lepidium	perfoliatum	Peppergrass		5
Polemoniaceae	Leptodactylon	pungens	Prickly gilia		5
Liliaceae	Leucocrinum	montanum	Sand lily		5
Compositae	Liatris	punctata	Blazing star		5
Boraginaceae	Lithospermum	incisum	Narrow-leaf puccoon		5
Leguminosae	Lupinus	argenteus	Lupine		5
Compositae	Lygodesmia	juncea	Rush skeleton weed		5
Compositae	Machaeranthera	linearis	Aster		5
Compositae	Machaeranthera	spp	Aster		5
Leguminosae	Medicago	sativa	Alfalfa		5
Leguminosae	Melilotus	alba	White sweet clover		5
Leguminosae	Melilotus	officinalis	Yellow sweet clover		5
Labiatae	Mentha	arvensis	Field mint		5
Loasaceae	Mentzelia	nuda	Evening star		5
Gramineae	Muhlenbergia	asperifolia	Alkali muhly		5
Gramineae	Muhlenbergia	torreyi	Ring muhly		5
Gramineae	Monroa	squarrosa	False buffalo grass		5
Cruciferae	Nasturtium	officinale	Nasturtium		5
Compositae	Nothocalais	cuspidata	False dandelion		5
Onagraceae	Oenothera	albicaulis	Evening primrose		5
Onagraceae	Oenothera	caespitosa	Stemless primrose		5
Onagraceae	Oenothera	coronopifolia	Cut-leaf primrose		5
Onagraceae	Oenothera	nuttallii	Nuttall's primrose		5
Onagraceae	Oenothera	strigosa	Evening primrose		5
Cactaceae	Opuntia	compressa	Prickly pear		5
Cactaceae	Opuntia	polycantha	Starvation cactus		5
Leguminosae	Oxytropis	lambertii	Colorado loco-weed		5
Nyctaginaceae	Oxybaphus	nyctagineus	Umbrella wort		5
Gramineae	Panicum	capillare	Witch grass		5
Vitaceae	Parthenocissus	inserta	Virginia creeper		5
Scrophulariaceae	Penstemon	albidus	White penstemon		5
Scrophulariaceae	Penstemon	angustifolius	Narrow-lf penstemon		5
Polygonaceae	Persicaria	pennsylvanica	Smartweed		5
Solanaceae	Physalis	virginiana	Ground cherry		5
Pinaceae	Picea	pungens	Colorado blue spruce		5
Pinaceae	Pinus	ponderosa	Ponderosa pine		5
Pinaceae	Pinus	sylvestris	Scotch pine		5
Plantaginaceae	Plantago	purshii	Wooly plantain		5
Gramineae	Poa	agassizensis	Mountain bluegrass		5
Polygonaceae	Polygonum	aviculare	Devil's shoestring		5
Capparidaceae	Polanisia	dodecandra	Clammy weed		5
Gramineae	Polypogon	monspeliensis	Rabbitfoot grass		5
Polygonaceae	Polygonum	ramossissiumum	Bushy knotweed		5
Salicaceae	Populus	alba	White poplar		5
Salicaceae	Populus	sargentii	Plains cottonwood		5
Portulacaceae	Portulaca	oleracea	Common purslane		5
Rosaceae	Prunus	americana	Wild plum		5

Family	Genus	Species	Common Name	Status*	Source Document**
Rosaceae	Prunus	virginiana	Choke cherry		5
Pinaceae	Pseudotsuga	menziesii	Douglas fir		5
Leguminosae	Psoralea	tenuiflora	Slender scurf-pea		5
Gramineae	Puccinellia	nuttalliana	Alkali grass		5
Rosaceae	Pyrus	malus	Apple		5
Saxifragaceae	Ribes	aureum	Golden currant		5
Leguminosae	Robinia	neomexicana	New Mexico locust		5
Leguminosae	Robinia	pseudoacacia	Black locust		5
Cruciferae	Rorippa	sinuata	Yellow-cress		5
Polygonaceae	Rumex	crispus	Curly dock		5
Alismataceae	Sagittaria	spp	Arrowhead		5
Salicaceae	Salix	amygdaloides	Peach-leaved willow		5
Chenopodiaceae	Salsola	collina	Russian thistle		5
Salicaceae	Salix	exigua	Sandbar willow		5
Salicaceae	Salix	interior	Sandbar willow		5
Chenopodiaceae	Salsola	kali	Russian thistle		5
Gramineae	Schedonnardus	paniculatus	Tumble grass		5
Cyperaceae	Scirpus	acutus	Compact bulrush		5
Cyperaceae	Scirpus	americanus	American bulrush		5
Labiatae	Scutellaria	galericulata	Marsh skullcap		5
Compositae	Senecio	spartioides	Butterweed		5
Compositae	Senecio	tridenticulatus	3-toothed butterweed		5
Cruciferae	Sisymbrium	altissimum	Tumble mustard		5
Cruciferae	Sisymbrium	officinale	Hedge mustard		5
Gramineae	Sitanion	longifolium	Squirrel tail		5
Solanaceae	Solanum	rostratum	Buffalo-bur		5
Solanaceae	Solanum	triflorum	Cut-leaf nightshade		5
Compositae	Sonchus	uliginosus	Sow thistle		5
Malvaceae	Sphaeralcea	coccinea	Copper mallow		5
Gramineae	Sporobolus	cryptandrus	Sand dropseed		5
Compositae	Stephanomeria	pauciflora	Wire lettuc		5
Gramineae	Stipa	comata	Needle and thread		5
Caprifoliaceae	Symphoricarpos	occidentalis	Snowberry		5
Tamaricaceae	Tamarix	pentandra	Tamarisk		5
Compositae	Taraxacum	officinale	Dandelion		5
Labiatae	Teucrium	canadense	Germander		5
Compositae	Thelesperma	megapotamicum	Greenthread		5
Cruciferae	Thlaspi	arvense	Penny-cress		5
Tiliaceae	Tilia	spp.	Basswood		5
Compositae	Tragopogon	dubius	Yellow salsify		5
Commelinaceae	Tradescantia	occidentalis	Western spiderwort		5
Zygophyllaceae	Tribulus	terrestris	Puncture vine		5
Typhaceae	Typha	angustifolia	Narrow-leaf cattail		5
Typhaceae	Typha	latifolia	Broad-leaf cattail		5
Ulmaceae	Ulmus	americana	American elm		5
Ulmaceae	Ulmus	parvifolia	Chinese elm		5
Urticaceae	Urtica	dioica	Stinging nettle		5
Scrophulariaceae	Veronica	americana	American Brooklime		5
Scrophulariaceae	Veronica	anagallis	Water Speedwell		5

Family	Genus	Species	Common Name	Status*	Source Document**
Verbenaceae	Verbena	bracteata	Bracted verbena		5
Compositae	Verbesina	encelioides	Crownbeard		5
Scrophulariaceae	Verbascum	thapsus	Great mullein		5
Leguminosae	Vicia	villosa	Vetch		5
Violaceae	Viola	nuttallii	Nuttall's violet		5
Gramineae	Vulpia	octoflora	Six-weeks fescue		5
Liliaceae	Yucca	glauca	Spanish bayonet		5
Gramineae	Zea	mays	Corn		5
Liliaceae	Zygadenus	venenosus	Death camus		5

FISH

Family	Genus	Species	Common Name	Status*	Source Document**
Salmonidae	Salmo	gairdneri	Rainbow Trout	I	1,2
Esocidae	Esox	lucius	Northern Pike	I	1,2
Catostomidae	Catostomus	catostomusi	Longnose Sucker		1,2
Catostomidae	Catostomus	commersoni	White Sucker		1,2
Cyprinidae	Cyprinus	carpio	Carp		1,2
Cyprinidae	Semotilus	atromaculatus	Northern Creek Chub		1
Cyprinidae	Rhinichthys	cattaraceae	Longnose dace		1
Cyprinidae	Notropis	cornutus	Common Shiner		1
Cyprinidae	Notropis	deliciousus	Plains Sand Shiner		1
Cyprinidae	Notropis	dorsalis	Bigmouth Shiner		1
Cyprinidae	Notropis	lutensis	Plains Red Shiner		1,2
Cyprinidae	Hybrognathus	placita	Plains minnow		1
Cyprinidae	Pimephales	promelas	Fathead minnow		1,2
Cyprinidae	Campostoma	anomalum	Plains stoneroller		1
Ameiuridae	Ictalurus	punctatus	Channel catfish	I	1,2
Ameiuridae	Ictalurus	melas	Black Bullhead		1,2
Ameiuridae	Fundulus	kansae	Plains killifish		1,2
Ameiuridae	Fundulus	sciadicus	Plains top minnow		1,2
Centrarchidae	Micropterus	salmoides	Large mouth bass	G,	1,2
Centrarchidae	Lepomis	cyanellus	Green sunfish		1,2
Centrarchidae	Lepomis	gibbosus	Pumpkin seed		1,
Centrarchidae	Lepomis	macrochirus	Northern bluegill		1,2
Centrarchidae	Pomoxis	nigromaculatus	Black crappie		1
Centrarchidae	Lepomis	miggolophys	Red-ear sunfish		1
Percidae	Perca	flavescens	Yellow perch		1,2

AMPHIBIANS

Family	Genus	Species	Common Name	Status*	Source Document**
Pelobatidae	Scaphiopus	bombifrons	Plains spadefoot	B	1,2
Bufonidae	Bufo	w.woodhousei	Woodhouse's toad	B	1,2
Bufonidae	Bufo	cognatus	Great Plains toad	B	1,2
Hylidae	Acris	crepitans	Cricket frog		1
Ranidae	Rana	pipiens	Leopard frog	B	1,2
Ranidae	Rana	catesbeiana	Bullfrog	B	1,2
Ambystomidae	Ambystoma	tigrinum	Tiger salamander	B	1,2

REPTILES

Family	Genus	Species	Common Name	Status*	Source Document**
Chelydridae	Chelydra	s.serpentina	Snapping turtle	b	1,2
Testudinidae	Chrysemys	picta belli	Painted turtle	B	1,2
Testudinidae	Terrapene	o.ornata	Western box turtle	B	1,2
Trionychidae	Trionyx	spiniferus har.	Soft-shelled turtle	b	1,2
Iguanidae	Holbrookia	m.maculata	Earless lizard	B	1,2
Iguanidae	Sceloporus	undulatus eryt.	Fence lizard	B	1,2
Iguanidae	Phyrnosoma	douglassi	Short-horned lizard	B	1,2
Iguanidae	Sceloporus	undulatus garm.	No.prairie lizard	B	2
Scincidae	Eumeces	obsoletus	Great Plains skink		1
Scincidae	Eumeces	m.multivirgatus	Many-lined skink	B	1,2
Teiidae	Cnemidophorus	sexlineatus vi.	Six-lined racerunner	B	1,2
Colubridae	Heterodon	n.nasicus	W. Hognose snake	B	1,2
Colubridae	Coluber	constrictor fl.	Racer	B	1,2
Colubridae	Pituophis	melanoleucus s.	Bullsnake	B	1,2
Colubridae	Lampropeltis	triangulum	Milk snake	B	1,2
Colubridae	Thamnophis	sirtalis parie.	Common garter snake	B	1,2
Colubridae	Thamnophis	radix haydeni	Plains garter snake	B	1,2
Colubridae	Tropidoclonion	l.lineatum	Lined snake	B	1,2
Colubridae	Thamnophis	elegans vagrans	Terrestrial garter	B	2
Colubridae	Masticophis	flagellum test.	Coachwhip	B	2
Colubridae	Nerodia	sipedon sipedon	Northern water snake	B	2
Colubridae	Opheodrys	vernalis blanc.	Smooth green snake	B	2
Viperidae	Crotalus	viridis viridis	Prairie rattlesnake	B	1,2
BIRDS					
Gaviidae	Gavia	immer	Common loon	M	1,2,3
Gaviidae	Gavia	arctica	Arctic loon	M	1,2
Gaviidae	Gavia	stellata	Red-throated loon	M	1,2
Podicipedidae	Podiceps	grisegena	Red-necked grebe	M	1,2
Podicipedidae	Podiceps	auritus	Horned grebe	M	1,2,3
Podicipedidae	Podiceps	nigricollis	Eared grebe	b	1,2,3
Podicipedidae	Aechmophorus	occidentalis	Western grebe	B	1,2,3
Podicipedidae	Podilymbus	podiceps	Pied-billed grebe	R	1,2,3,4
Pelecanidae	Pelecanus	erythrorhynchos	White pelican	n	1,2,3
Phalacrocoracidae	Phalacrocorax	auritus	Dble-cr.cormorant	B	1,2,3
Phalacrocoracidae	Phalacrocorax	olivaceus	Olivaceous cormorant	M	1,2
Anhingidae	Anhinga	anhinga	Anhinga		1
Ardeidae	Ardea	herodias	Great blue heron	R	1,2,3,4
Ardeidae	Butorides	striatus	Green-backed heron	M	1,2,3
Ardeidae	Egretta	caerulea	Little blue heron	M	1,2,
Ardeidae	Bubulcus	ibis	Cattle egret	n	1,2
Ardeidae	Casmerodius	albus	Great egret	n	1,2,3
Ardeidae	Egretta	thula	Snowy egret	B	1,2,3
Ardeidae	Egretta	tricolor	Tri-colored heron	M	1,2
Ardeidae	Nycticorax	nycticorax	Bl.crown night heron	B	1,2,3
Ardeidae	Ncyticorax	violaceus	Yell.cr.night heron	b	1,2,3
Ardeidae	Botaurus	lentiginosus	American bittern	b	1,2,3

Family	Genus	Species	Common Name	Status*	Source Document**
Ciconiidae	Myctaria	americana	Wood stork		1
Threskiorniithidae	Plegadis	chihi	White-faced ibis	M	1,2,3
Anatidae	Olor	columbianus	Whistling swan		1
Anatidae	Branta	bernicla	Brant	M	1,2
Anatidae	Branta	canadensis	Canada goose	R	1,2,3,4
Anatidae	Anser	albifrons	White-fronted goose	M	1,2
Anatidae	Chen	caerulescens	Snow goose	M	1,2,3
Anatidae	Chen	rossii	Ross's goose	M	1,2
Anatidae	Anas	platyrhynchos	Mallard	R	1,2,3,4
Anatidae	Anas	diazi	Mexican duck		1
Anatidae	Anas	rubripes	Black duck	M	1,2
Anatidae	Anas	fulvigula	Mottled duck		1
Anatidae	Anas	strepera	Gadwall	R	1,2,3,4
Anatidae	Anas	acuta	Pintail	R	1,2,3,4
Anatidae	Anas	crecca	Green-winged teal	R	1,2,3
Anatidae	Anas	discors	Blue-winged teal	B	1,2,3,4
Anatidae	Anas	cyanoptera	Cinnamon teal	B	1,2,3,4
Anatidae	Anas	americana	American wigeon	R	1,2,3,4
Anatidae	Anas	clypeata	Northern shoveler	R	1,2,3,4
Anatidae	Aix	sponsa	Wood duck	R	1,2,3
Anatidae	Aythya	americana	Redhead	R	1,2,3,4
Anatidae	Aythya	collaris	Ring-necked duck	W	1,2,3,4
Anatidae	Aythya	valisineria	Canvasback	N	1,2,3
Anatidae	Aythya	marila	Greater scaup	M	1,2,3
Anatidae	Aythya	affinis	Lesser scaup	W	1,2,3
Anatidae	Bucephala	clangula	Common goldeneye	W	1,2,3
Anatidae	Bucephala	islandica	Barrows goldeneye	W	1,2
Anatidae	Bucephala	albeola	Bufflehead	W	1,2,3
Anatidae	Clangula	hyemalis	Oldsquaw	M	1,2,3
Anatidae	Somateria	mollissima	Common eider		1
Anatidae	Melanitta	fusca	White-winged scoter	M	1,2
Anatidae	Melanitta	perspicillata	Surf scoter	M	1,2
Anatidae	Melanitta	nigra	Black scoter	M	1,2
Anatidae	Oxyura	jamaicensis	Ruddy duck	B	1,2,3
Anatidae	Lophodytes	cucullatus	Hooded merganser	W	1,2,3
Anatidae	Mergus	merganser	Common merganser	W	1,2,3
Anatidae	Mergus	serrator	Red-breast merganser	M	1,2,3
Cathartidae	Cathartes	aura	Turkey vulture	B	1,2,3
Accipitridae	Accipiter	gentilis	Goshawk	B	1,2
Accipitridae	Accipiter	striatus	Sharp-shinned hawk	B	1,2,3
Accipitridae	Accipiter	cooperii	Cooper's hawk	B	1,2,3
Accipitridae	Buteo	jamaicensis	Red-tailed hawk	R	1,2,3,4
Accipitridae	Buteo	lineatus	Red-shouldered hawk	M	1,2
Accipitridae	Buteo	platypterus	Broad-winged hawk	M	1,2
Accipitridae	Buteo	swainsoni	Swainson's hawk	B	1,2,3,4
Accipitridae	Buteo	lagopus	Rough-legged hawk	W	1,2,3,4
Accipitridae	Buteo	regalis	Ferruginous hawk	R	1,2,3,4
Accipitridae	Aquila	chrysaetos	Golden eagle	R	1,2,3
Accipitridae	Haliaeetus	leucocephalus	Bald eagle	W	1,2,3

Family	Genus	Species	Common Name	Status*	Source Document**
Accipitridae	Circus	cyaneus	Northern Harrier	R	1,2,3,4
Pandionidae	Pandion	haliaetus	Osprey	M	1,2
Falconidae	Falco	rusticolus	Gyrfalcon	M	1,2
Falconidae	Falco	mexicanus	Prairie falcon	R	1,2,3
Falconidae	Falco	peregrinus	Peregrine falcon	M	1,2,3
Falconidae	Falco	columbarius	Merlin	W	1,2,3
Falconidae	Falco	sparverius	American kestrel	R	1,2,3
Tetraonidae	Tympanuchus	phasianellus	Sharp-tailed grouse	R,E	1,2
Phasianidae	Phasianus	colchicus	Ring-necked pheasant	R	1,2,3,4
Phasianidae	Alectoris	chukar	Chukar	N	1,2
Phasianidae	Colinus	virginianus	Bobwhite	R	1,2
Phasianidae	Callipepla	squamata	Scaled quail	b	2
Gruidae	Grus	canadensis	Sandhill crane	M	1,2,3
Meleagrididae	Meleagris	gallopavo	Wild turkey	R	1,2
Rallidae	Rallus	limicola	Virginia rail	R	1,2,3
Rallidae	Porzana	carolina	Sora	B	1,2,3
Rallidae	Coturnicops	noveboracensis	Yellow rail		1
Rallidae	Laterallus	jamaicensis	Black rail		1
Rallidae	Gallinula	chloropus	Common gallinule		1
Rallidae	Fulica	americana	American coot	R	1,2,3,4
Charadriidae	Charadrius	semipalmatus	Semipalmated plover	M	1,2,3
Charadriidae	Charadrius	melodus	Piping plover	M	1,2,
Charadriidae	Charadrius	alexandrinus	Snowy plover	M	1,2
Charadriidae	Charadrius	vociferus	Killdeer	R	1,2,3
Charadriidae	Charadrius	montanus	Mountain plover	b	1,2
Charadriidae	Pluvialis	dominica	Amer.golden plover	M	1,2
Charadriidae	Pluvialis	squatarola	Black-bellied plover	M	1,2,3
Scolopacidae	Arenaria	interpres	Ruddy turnstone	M	1,2
Scolopacidae	Philohela	minor	American woodcock		1
Scolopacidae	Gallinago	gallinago	Common snipe	R	1,2,3
Scolopacidae	Numenius	americanus	Long-billed curlew	M	1,2,3
Scolopacidae	Numenius	phaeopus	Whimbrel	M	1,2
Scolopacidae	Bartramia	longicauda	Upland sandpiper	b	1,2
Solopacidae	Actitis	macularia	Spotted sandpiper	B	1,2,3
Scolopacidae	Tringa	solitaria	Solitary sandpiper	M	1,2,3
Scolopacidae	Tringa	melanoleuca	Greater yellowlegs	M	1,2,3,4
Scolopacidae	Tringa	flavipes	Lesser yellowlegs	M	1,2,3,4
Scolopacidae	Catoptrophorus	semipalmatus	Willet	M	1,2,3
Scolopacidae	Calidris	canutus	Red knot	M	1,2
Scolopacidae	Calidris	melanotos	Pectoral sandpiper	M	1,2,3
Scolopacidae	Calidris	fuscicollis	Wh.-rump sandpiper	M	1,2
Scolopacidae	Calidris	bairdii	Baird's sandpiper	M	1,2,3
Scolopacidae	Calidris	minutilla	Least sandpiper	M	1,2,3
Scolopacidae	Calidris	alpina	Dunlin	M	1,2
Scolopacidae	Calidris	pusilla	Semipalm.sandpiper	M	1,2,3
Scolopacidae	Calidris	mauri	Western sandpiper	M	1,2,3
Scolopacidae	Calidris	alba	Sanderling	M	1,2,3
Scolopacidae	Limnodromus	griseus	Short-bill dowitcher	M	1,2
Scolopacidae	Limnodromus	scolopaceus	Long-bill dowitcher	M	1,2,3

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Scolopacidae	Calidris	himantopus	Stilt sandpiper	M	1,2,3
Scolopacidae	Tryngites	subruficollis	Buffbreast sandpiper	M	1,2
Scolopacidae	Limosa	haemastica	Hudsonian godwit	M	2
Scolopacidae	Limosa	fedoa	Marbled godwit	M	2
Recurvirostridae	Recurvirostra	americana	American avocet	B	1,2,3,4
Recurvirostridae	Himantopus	mexicanus	Black-necked stilt	M	1,2,3
Phalaropodidae	Phalaropus	fulicaria	Red phalarope	M	1,2,
Phalaropodidae	Phalaropus	lobatus	Northern phalarope	M	1,2
Phalaropodidae	Phalaropus	tricolor	Wilson's phalarope	B	1,2,3
Stercorariidae	Stercorarius	pomarinus	Pomarine jaeger	M	1,2
Stercorariidae	Stercorarius	parasiticus	Parasitic jaeger	M	1,2
Laridae	Larus	minutus	Little gull	M	2
Laridae	Larus	marinus	Gr.black-backed gull	W	2
Laridae	Larus	hyperboreus	Glaucous gull	W	1,2
Laridae	Larus	glaucoides	Iceland gull		1
Laridae	Larus	argentatus	Herring gull	W	1,2,3
Laridae	Larus	thayeri	Thayer's gull	W	1,2
Laridae	Larus	californicus	California gull	N	1,2,3
Laridae	Larus	delawarensis	Ring-billed gull	N	1,2,3
Laridae	Larus	atricilla	Laughing gull	M	1,2
Laridae	Larus	pipixcan	Franklin's gull	M	1,2,3
Laridae	Larus	philadelphia	Bonaparte's gull	M	1,2,3
Laridae	Pagophila	eburnea	Ivory gull		1
Laridae	Rissa	tridactyla	Bl.legged kittiwake	M	1,2
Laridae	Xema	sabini	Sabine's gull	M	1,2
Laridae	Larus	forsteri	Forster's tern	B	1,2,3
Laridae	Sterna	hirundo	Common tern	M	1,2
Laridae	Sterna	paradisaea	Arctic tern		1
Laridae	Sterna	albifrons	Least tern		1
Laridae	Chlidonias	niger	Black tern	B	1,2,3
Alcidae	Synthliboramphus	antiquus	Ancient murrelet		1
Columbidae	Columba	livia	Rock dove	R	2,3
Colmbidae	Zenaida	macroura	Mourning dove	R	1,2,3
Columbidae	Columba	fasciata	Band-tailed pigeon	B	2
Cuculidae	Coccyzus	americanus	Yellow-bill cuckoo	b	1,2
Cuculidae	Coccyzus	erythropthalmus	Black-billed cuckoo	b	1,2
Tytonidae	Tyto	alba	Barn owl	R	1,2
Strigidae	Otus	kennicottii	Western screech owl	R	2
Strigidae	Otus	asio	Screech owl	R	1,2,3
Strigidae	Bubo	virginianus	Great horned owl	R	1,2,3
Strigidae	Nyctea	scandiaca	Snowy owl	W	1,2
Strigidae	Glaucidium	gnoma	Pygmy owl	W	1,2
Strigidae	Athene	cunicularia	Burrowing owl	B	1,2,4
Strigidae	Strix	occidentalis	Spotted owl	M	1,2
Strigidae	Asia	otus	Long-eared owl	R	1,2,3
Strigidae	Asia	flammeus	Short-eared owl	R	1,2
Strigidae	Aegolius	acadicus	Saw-whet owl	R	1,2
Caprimulgidae	Phalaenoptilus	nuttalii	Common poorwill	B	1,2,3
Caprimulgidae	Chordeiles	minor	Common nighthawk	B	1,2,3

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Apodidae	Chaetura	pelagica	Chimney swift	B	1,2
Trochilidae	Archilochus	alexandri	Bl.-chin hummingbird		1
Trochilidae	Selasphorus	platycercus	Br.-tail hummingbird	B	1,2,3
Trochilidae	Selasphorus	rufus	Rufous hummingbird	M	1,2
Trochilidae	Stellula	calliope	Calliope hummingbird	B	2
Alcedinidae	Ceryle	alcyon	Belted kingfisher	R	2
Picidae	Colaptes	auratus	Common flicker	R	1,2
Picidae	Melanerpes	carolinus	Red-belly woodpecker	M	1,2
Picidae	Melanerpes	erythrocephalus	Red-head woodpecker	B	1,2,3
Picidae	Melanerpes	lewis	Lewis's woodpecker	R	1,2
Picidae	Sphyrapicus	varius	Yel.-belly sapsucker	N	1,2
Picidae	Picoides	villosus	Hairy woodpecker	R	1,2,3
Picidae	Picoides	pubescens	Downy woodpecker	R	1,2,3
Tyrannidae	Tyrannus	tyrannus	Eastern kingbird	B	1,2,3
Tyrannidae	Tyrannus	verticalis	Western kingbird	B	1,2,3
Tyrannidae	Tyrannus	vociferans	Cassin's kingbird	b	1,2,3
Tyrannidae	Tyrannus	forficatus	Scis.tail flycatcher	M	1,2
Tyrannidae	Myiarchus	crinitus	Gr-crest flycatcher	M	1,2
Tyrannidae	Myiarchus	cinerascens	Ashthroat flycatcher	M	1,2
Tyrannidae	Sayornis	phoebe	Eastern phoebe	M	1,2
Tyrannidae	Sayornis	saya	Say's phoebe	B	1,2,3
Tyrannidae	Empidonax	traillii	Willow flycatcher	M	1,2,3
Tyrannidae	Empidonax	alnorum	Alder flycatcher		1
Tyrannidae	Empidonax	minimus	Least flycatcher	M	1,2
Tyrannidae	Empidonax	hammondii	Hammond's flycatcher	M	1,2,3
Tyrannidae	Empidonax	oberholseri	Dusky flycatcher	M	1,2,3
Tyrannidae	Empidonax	difficilis	Western flycatcher	M	1,2,3
Tyrannidae	Contopus	virens	Eastern wood pewee		1
Tyrannidae	Contopus	sordidulus	Western wood pewee	B	1,2,3
Tyrannidae	Contopus	borealis	Oliv-sid.flycatcher	M	1,2,3
Tyrannidae	Pyrocephalus	rubinus	Vermill. flycatcher	M	1,2
Alaudidae	Eremophila	alpestris	Horned lark	R	1,2,3
Hirundinidae	Tachycineta	thalassina	Violet-green swallow	M	1,2,3
Hirundinidae	Tachycineta	bicolor	Tree swallow	B	1,2,3
Hiirundinidae	Riparia	riparia	Bank swallow	B	1,2,3
Hirundinidae	Stelgidopteryx	serripennis	Rough-winged swallow	B	1,2,3
Hirundinidae	Hirundo	rustica	Barn swallow	B	1,2,3
Hirundinidae	Hirundo	pyrrhonota	Cliff swallow	B	1,2,3
Corvidae	Cyanocitta	cristata	Blue jay	R	1,2,3
Corvidae	Nucifraga	columbiana	Clark's nutcracker	M	1,2
Corvidae	Corvus	corax	Common raven	W	2
Corvidae	Pica	pica	Black-billed magpie	R	1,2
Corvidae	Corvus	cryptoleucus	Chihuahuan raven	M	1,2
Corvidae	Corvus	brachyrhynchos	Common crow	R	1,2,3
Corvidae	Gymnorthinus	Cyanocephalus	Pinyon jay	M	1,2
Paridae	Parus	atricapillus	Black-cap chickadee	R	1,2,3
Paridae	Parus	gambeli	Mountain chickadee	W	1,2,3
Paridae	Psaltriparus	minimus	Bushtit		1
Sittidae	Sitta	carolinensis	Wh.breasted nuthatch	R	1,2,3

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Sittidae	Sitta	canadensis	Rd-breasted nuthatch	R	1,2,3
Sittidae	Certhia	americana	Brown creeper	R	1,2
Troglodytidae	Troglodytes	aedon	House wren	B	1,2,3
Troglodytes	Troglodytes	troglodytes	Winter wren	W	1,2
Troglodytidae	Thryomanes	bewickii	Bewick's wren	W	1,2
Troglodytidae	Thryothorus	ludovicianus	Carolina wren	M	1,2
Troglodytidae	Telmatodytes	palustris	Long-bill marsh wren		1
Troglodytidae	Salpinctes	obsoletus	Rock wren	b	1,2,3
Troglodytidae	Cistothorus	palustris	Marsh wren	R	2
Mimidae	Mimus	polyglottos	Mockingbird	R	1,2,3
Mimidae	Dumetella	carolinensis	Gray catbird	B	1,2,3
Mimidae	Toxostoma	curvirostre	Curved-bill thrasher		1
Mimidae	Toxostoma	rufum	Brown thrasher	B	1,2,3
Mimidae	Oreoscoptes	montanus	Sage thrasher	B	1,2,3
Turdidae	Turdus	migratorius	American robin	R	1,2
Turdidae	Hylocichla	mustelina	Wood thrush	M	1,2
Turdidae	Catharus	ustulatus	Swainson's thrush	B	1,2,3
Turdidae	Catharus	minimus	Gray-cheeked thrush	M	1,2
Turdidae	Catharus	fuscescens	Veery	B	1,2,3
Turdidae	Sialia	sialis	Eastern bluebird	M	1,2
Turdidae	Sialia	mexicana	Western bluebird	B	1,2,3
Turdidae	Myadestes	townsendii	Townsend's solitaire	W	1,2,3
Turdidae	Sialia	currucoides	Mountain bluebird	B	1,2,3
Cinclidae	Cinclus	mexicanus	Dipper	W	1,2
Sylviidae	Polioptila	caerulea	Bluegray gnatcatcher	M	1,2,3
Sylviidae	Regulus	satrapa	Golden-crown kinglet	W	1,2,3
Sylviidae	Regulus	calendula	Ruby-crowned kinglet	M	1,2,3
Motacillidae	Anthus	spinoletta	Water pipit	M	1,2,3
Motacillidae	Anthus	spragueii	Sprague's pipit	M	1,2
Bombycillidae	Bombycilla	garrulus	Bohemian waxwing	W	1,2
Bombycillidae	Bombycilla	cedrorum	Cedar waxwing	W	1,2
Ptilogonatidae	Phainopepla	nitens	Phainopepla		1
Laniidae	Lanius	excubitor	Northern shrike	W	1,2,3
Laniidae	Lanius	ludovicianus	Loggerhead shrike	B	1,2,3
Sturnidae	Sturnus	vulgaris	Starling	R,I	1,2,3
Vireonidae	Vireo	bellii	Bell's vireo		1
Vireonidae	Vireo	flavifrons	Yellowthroated vireo		1
Vireonidae	Vireo	solitarius	Solitary vireo	B	1,2,3
Vireonidae	Vireo	olivaceus	Red-eyed vireo	B	1,2,3
Vireonidae	Vireo	philadelphicus	Philadelphia vireo	M	1,2
Vireonidae	Vireo	gilvus	Warbling vireo	B	1,2,3
Parulidae	Mniotilta	varia	Bl. & white warbler	M	1,2,3
Parulidae	Protonotaria	citrea	Prothonotary warbler	M	1,2
Parulidae	Vermivora	celata	Orange-crown warbler	M	1,2,3
Parulidae	Vermivora	peregrina	Tennessee warbler	M	1,2,3
Parulidae	Vermivora	chrsoptera	Golden-wing warbler	M	1,2
Parulidae	Vermivora	pinus	Blue-winged warbler	M	1,2
Paruiidae	Vermivora	ruficapilla	Nashville warbler	M	1,2,3
Paruiidae	Vermivora	virginiae	Virginia's warbler	B	1,2,3

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Parulidae	Parula	americana	Northern parula	M	1,2,3,
Parulidae	Dendroica	petchnia	Yellow warbler	B	1,2,3
Parulidae	Dendroica	magnolia	Magnolia warbler	M	1,2
Parulidae	Dendroica	caerulescens	Blackthroat warbler	M	1,2
Paulidae	Dendroica	coronata	Yellowrumped warbler	M	1,2,3
Paulidae	Dendroica	nigrescens	Bl.throat gr.warbler	M	1,2
Parulidae	Dendroica	townsendi	Townsend's warbler	M	1,2,3
Parulidae	Dendroica	virens	Bl.throat green warb	M	1,2,3
Parulidae	Dendroica	cerulea	Cerulean warbler		1
Parulidae	Dendroica	graciae	Grace's warbler		1
Parulidae	Dendroica	fusca	Blackburnian warbler	M	1,2
Parulidae	Dendroica	dominica	Yellowthroat warbler	M	1,2
Parulidae	Dendroica	pensylvanica	Chestnutside warbler	M	1,2,3
Parulidae	Dendroica	castanea	Bay-breasted warbler	B	1,2
Parulidae	Dendroica	striata	Blackpoll warbler	M	1,2,3
Parulidae	Dendroica	pinus	Pine warbler		1
Parulidae	Dendroica	palmarum	Palm warbler	M	1,2
Parulidae	Seiurus	aurocapillus	Ovenbird	B	1,2,3
Parulidae	Seiurus	noveboracensis	Northern waterthrush	M	1,2,3
Parulidae	Oporornis	tolmiei	MacGillivray warbler	M	1,2,3
Parulidae	Geothlypis	trichas	Common yellowthroat	B	1,2,3
Parulidae	Icteria	virens	Yellow-breasted chat	B	1,2,3
Parulidae	Wilsonia	citrina	Hooded warbler	M	1,2
Parulidae	Wilsonia	pusilla	Wilson's warbler	M	1,2,3
Paruiidae	Wilsonia	canadensis	Canada warbler	M	1,2
Parulidae	Setophaga	ruticilla	American redstart	B	1,2,3
Parulidae	Helmitheros	vermivorus	Worm-eating warbler	M	1,2
Passeridae	Passer	domesticus	House sparrow	R,I	1,2,3
Icteridae	Dolichonyx	oryzivorus	Bobolink	B	1,2
Icteridae	Sturnella	neglecta	Western meadowlark	R	1,2,3
Icteridae	Xanthocephalus	xanthocephalus	Yellowhead blackbird	B	1,2,3
Icteridae	Agelaius	phoeniceus	Red-winged blackbird	R	1,2,3
Icteridae	Icterus	spurius	Orchard oriole	B	1,2,3
Icteridae	Icterus	galbula	Northern oriole	B	1,2,3
Parulidae	Euphagus	carolinus	Rusty blackbird	W	1,2
Parulidae	Euphagus	cyanocephalus	Brewer's blackbird	R	1,2,3
Icteridae	Quiscalus	quiscula	Common grackle	B	1,2,3
Icteridae	Molothrus	ater	Brown-headed cowbird	B	1,2,3
Thraupidae	Piranga	ludoviciana	Western tanager	B	1,2
Thraupidae	Piranga	olivacea	Scarlet tanager	M	1,2
Thraupidae	Piranga	rubra	Summer tanager	M	1,2
Fringillidae	Cardinalis	cardinalis	Cardinal	N	1,2
Fringillidae	Pheucticus	ludovicianus	Rose-breast grosbeak	M	1,2,3
Fringillidae	Pheucticus	melanocephalus	Blackheaded grosbeak	B	1,2,3
Fringillidae	Guiraca	caerulea	Blue grosbeak	B	1,2,3
Fringillidae	Passerina	cyanea	Indigo bunting	B	1,2,3
Fringillidae	Passerina	amoena	Lazuli bunting	B	1,2,3
Fringillidae	Passerina	ciris	Painted bunting	M	1,2
Fringillidae	Spiza	americana	Dickcissel	B	1,2

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Fringillidae	Coccothraustes	vespertinus	Evening grosbeak	R	1,2
Fringillidae	Carpodacus	purpureus	Purple finch	W	1,2
Fringillidae	Carpodacus	cassinii	Cassin's finch	W	1,2
Fringillidae	Carpodacus	mexicanus	House finch	R	1,2,3
Fringillidae	Pinicola	enucleator	Pine grosbeak	W	1,2
Fringillidae	Leucosticte	arctoa	Rosy finch	W	2
Fringillidae	Leucosticte	atrata	Black rosy finch		1
Fringillidae	Leucosticte	australis	Brown-cap rosy finch		1
Fringillidae	Carduelis	flammea	Common redpoll	W	1,2,3
Fringillidae	Carduelis	pinus	Pine siskin	R	1,2,3
Fringillidae	Carduelis	tristis	American goldfinch	R	1,2,3
Fringillidae	Carduelis	psaltria	Lesser goldfinch	B	1,2
Fringillidae	Loxia	curvirostra	Red crossbill	R	1,2
Fringillidae	Loxia	leucoptera	White-wing crossbill	W	1,2
Fringillidae	Pipilo	chlorurus	Green-tailed towhee	b	1,2,3
Fringillidae	Pipilo	erythrophthalmus	Rufous-sided towhee	B	1,2,3
Fringillidae	Pipilo	fuscus	Brown towhee		1
Fringillidae	Calamospiza	melanocorys	Lark bunting	B	1,2,3
Fringillidae	Passerculus	sandwichensis	Savannah Sparrow	B	1,2,3
Fringillidae	Ammodramus	savannarum	Grasshopper sparrow	B	1,2
Fringillidae	Ammodramus	bairdii	Baird's sparrow	M	1,2
Fringillidae	Ammodramus	leconteii	Le Conte's sparrow		1
Fringillidae	Pooecetes	gramineus	Vesper sparrow	B	1,2,3
Fringillidae	Chondestes	grammacus	Lark sparrow	B	1,2,3
Fringillidae	Aimophila	ruficeps	Rufous-crown sparrow		1
Fringillidae	Aimophila	cassinii	Cassin's sparrow	b	1,2
Fringillidae	Amphispiza	bilineata	Black-throat sparrow	M	1,2
Fringillidae	Amphispiza	belli	Sage sparrow	M	1,2
Fringillidae	Junco	hyemalis	Dark-eyed junco	W	1,2,3
Fringillidae	Spizella	arborea	Tree sparrow	W	1,2,3
Fringillidae	Spizella	passerina	Chipping sparrow	B	1,2,3
Fringillidae	Spizella	pallida	Clay-colored sparrow	M	1,2,3
Fringillidae	Spizella	breweri	Brewer's sparrow	B	1,2,3
Fringillidae	Spizella	pusilla	Field sparrow	M	1,2
Fringillidae	Passerella	iliaca	Fox sparrow	W	1,2
Fringillidae	Melospiza	melodia	Song sparrow	R	1,2,3
Fringillidae	Melospiza	lincolnii	Lincoln's sparrow	M	1,2,3
Fringillidae	Melospiza	georgiana	Swamp sparrow	W	1,2
Fringillidae	Zonotrichia	leucophrys	White-crown sparrow	W	1,2,3
Fringillidae	Zonotrichia	querula	Harris's sparrow	W	1,2,3
Fringillidae	Calcarius	mccownii	McCown's longspur	M	1,2
Fringillidae	Calcarius	lapponicus	Lapland longspur	W	1,2
Fringillidae	Plectrophenax	nivalis	Snow bunting	W	1,2

MAMMALS

Didelphidae	Didelphis	virginiana	Opossum	b	1,2
Soricidae	Sorex	cinereus	Masked shrew	B	2
Soricidae	Sorex	merriami	Merriam's shrew	B	1,2

Family	Genus	Species	Common Name	Status*	Source Document**
Soricidae	Cryptotis	parva	Least shrew	B	1,2,3
Vespertilionidae	Myotis	lucifugus	Little brown bat		1
Vespertilionidae	Myotis	leibii	Small-footed myotis		1
Vespertilionidae	Lasionycteris	noctivagans	Silver-haired bat		1
Vespertilionidae	Eptesicus	fuscus	Big brown bat		1
Vespertilionidae	Lasiurus	borealis	Red bat		1
Vespertilionidae	Lasiurus	cinereus	Hoary bat		1
Leporidae	Sylvilagus	floridanus	Eastern cottontail	B	1,2,3
Leporidae	Sylvilagus	audubonii	Desert cottontail	B	1,2,3,4
Leporidae	Lepus	townsendii	Whitetail jackrabbit	B	1,2,3
Leporidae	Lepus	californicus	Blacktail jackrabbit	B	1,2,3,4
Sciuridae	Spermophilus	tridecemlineatus	13-lined gr.squirrel	B	1,2,3,4
Sciuridae	Spermophilus	spilosoma	Spotted gr.squirrel	B	1,2,3
Sciuridae	Cynomys	ludovicianus	Black-tail pr.dog	B	1,2,4
Sciuridae	Sciurus	niger	Fox squirrel	B	1,2,3
Sciuridae	Eutamias	minimus	Least chipmunk	B	2
Sciuridae	Spermophilus	variegatus	Rock squirrel	B	2
Geomyidae	Thomomys	talpoides	North.pocket gopher	B	1,2
Geomyidae	Geomys	bursarius	Plains pocket gopher	B	1,2,3
Heteromyidae	Perognathus	fasciatus	Olive-bk pock.mouse	B	1,2
Heteromyidae	Perognathus	flavescens	Plains pocket mouse	B	1,2,3
Heteromyidae	Perognathus	flavus	Silky pocket mouse	B	1,2,3
Heteromyidae	Perognathus	hispidus	Hispid pocket mouse	B	1,2,3
Heteromyidae	Dipodomys	ordii	Ord's kangaroo rat	B	1,2,3,4
Castoridae	Castor	canadensis	Beaver	B	1,2
Cricetidae	Reithrodontomys	montanus	Plains harvest mouse	B	1,2
Cricetidae	Reithrodontomys	megalotis	West. harvest mouse	B	1,2,3
Cricetidae	Peromyscus	maniculatus	Deer mouse	B	1,2,3
Cricetidae	Onychomys	leucogaster	N.grasshopper mouse	B	1,2,3
Cricetidae	Microtus	pennsylvanicus	Meadow vole	B	1,2,3
Cricetidae	Microtus	ochrogaster	Prairie vole	B	1,2,3
Cricetidae	Ondatra	zibethicus	Muskrat	B	1,2,3,4
Muridae	Mus	musculus	House mouse	B,I	1,2
Muridae	Rattus	norvegicus	Norway rat	B,I	1,2
Zapodidae	Zapus	hudsonius	Meadow jumping mouse	B	1,2
Erethizontidae	Erethizon	dorsatum	Porcupine	B	1,2,3
Canidae	Canis	latrans	Coyote	B	1,2,3,4
Canidae	Vulpes	vulpes	Red fox	B	1,2,3
Canidae	Vulpes	velox	Swift fox	B	1,2,3
Canidae	Urocyon	cinereoargenteus	Gray fox	B	1,2,3
Procyonidae	Procyon	lotor	Raccoon	B	1,2,3
Mustelidae	Mustela	erminea	Ermine		1
Mustelidae	Mustela	frenata	Long-tailed weasel	B	1,2,3
Mustelidae	Mustela	nigripes	Black-footed ferret	E	1,2,3
Mustelidae	Mustela	vison	Mink	b	1,2
Mustelidae	Taxidea	taxus	Badger	b	1,2,4
Mustelidae	Mephitis	mephitis	Striped skunk	B	1,2,3
Mustelidae	Spilogale	putorius	Spotted skunk	B	1,2
Felidae	Felis	rufus	Bobcat	B	1,2

Family	Genus	Species	Common Name	Status*	Source Document**
Cervidae	Odocoileus	hemionus	Mule deer	B	1,2,3,4
Cervidae	Odocoileus	virginianus	White-tailed deer	B	1,2,3,4
Antilocapridae	Antilocapra	americana	Pronghorn	B	1,2,3

* Status:B=Definite breeder b=Likely breeder E=Endangered G=Game I=Introduced M=Migrant n=Non-breeder R=Resident W=Winter visitor

**Source Document: 1=EIA.1976.Fairbanks,R.L. & J. Kolmer. 2=Colorado Division of Wildlife Latilong Studies 3=Barr Lake Mammal Checklist 4=Observed on site 5=Information from D.Thorne,PMO,RMA.