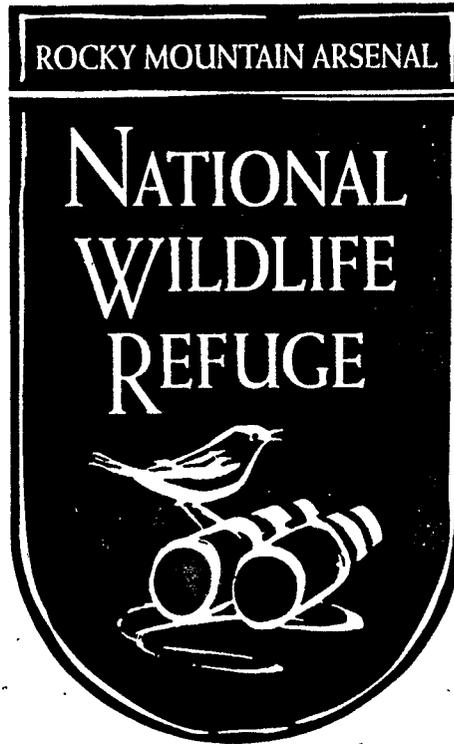


# ROCKY MOUNTAIN ARSENAL NATIONAL WILDLIFE REFUGE



## HABITAT RESTORATION PLAN

AUGUST 1999



U.S. FISH & WILDLIFE SERVICE  
DEPARTMENT OF INTERIOR



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**HABITAT RESTORATION PLAN**

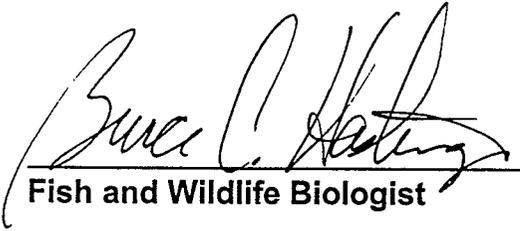
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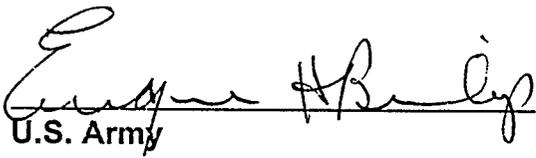
**ROCKY MOUNTAIN ARSENAL NATIONAL WILDLIFE REFUGE**

**U.S. FISH AND WILDLIFE SERVICE  
ROCKY MOUNTAIN ARSENAL NATIONAL WILDLIFE REFUGE  
BUILDING 111  
COMMERCE CITY, COLORADO 80022-1748**

**AUGUST 1999**

**HABITAT RESTORATION PLAN**  
**FOR**  
**ROCKY MOUNTAIN ARSENAL NATIONAL WILDLIFE REFUGE**

Prepared by:  8-30-99  
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## SUMMARY

The U.S. Fish and Wildlife Service is mandated to conserve and enhance the land and water of Rocky Mountain Arsenal National Wildlife Refuge in a manner that will conserve and enhance the natural diversity of fish, wildlife, plants, and their habitats. However, the Refuge is undergoing significant remediation activities to contain and remove contaminants remaining from years of producing chemical weapons and pesticides. This cleanup effort will result in the loss of considerable wildlife habitat. The Service proposes to mitigate these losses by restoring much of the Refuge to native plant communities. Additional restoration will be conducted using other sources of funding and labor as appropriate.

Mitigation will be conducted at a 2:1 ratio of replacement units (e.g., acres) to disturbed/destroyed units for most situations. However, most disturbances in human health exceedance areas will be mitigated at a 1:1 ratio and trees greater than 6 inches in diameter will be replaced at a 5:1 ratio.

The Service will work closely with the Remediation Venture Office and the Program Management Contractor to design the location and schedule of most restoration projects based on numerous factors, including the need for revegetation and logistics of irrigation. A map of needed restoration sites will be updated continuously.

Revegetation will be conducted using a variety of seeding and transplanting techniques. The Service will attempt to acquire seed and other plant materials from sources as close to the Refuge as possible, as well as producing seed and plants from the Refuge. The Service and the Program Management Contractor will work together to irrigate as many areas as possible, especially during crucial establishment periods. Some plants will be protected from wildlife depredation during establishment. Some short-term loss of wildlife benefits may be required to meet long-term goals.

Most restoration sites will require maintenance, particularly during establishment. The majority of maintenance activities will involve weed control.

Alternative restoration techniques and sites will be investigated in the future, as funding allows. Virtually all restoration sites will be monitored to determine success and future action.

Restoration may continue for decades, although the majority of large projects will likely be initiated during the 10 years and be funded through mitigation sources. The Service and RVO anticipate seeding approximately 700 acres per year for at least the next 9 years (2000 - 2008). Monitoring, maintenance and volunteer activities will likely dominate restoration activities after approximately 2010.

# HABITAT RESTORATION PLAN

## CHAPTER 1: INTRODUCTION

### PURPOSE AND AUTHORITY

The first Cooperative Agreement for Conservation and Management of Fish and Wildlife Resources at Rocky Mountain Arsenal (U.S. Government 1989) defined a variety of U.S. Fish and Wildlife Service (Service) responsibilities related to land use at Rocky Mountain Arsenal. This agreement, which was revised in 1991, 1993, 1994, and 1997 (U.S. Government 1991, 1993, 1994, 1997), includes Service responsibilities to "propose habitat or other mitigation plans to offset the impact of Arsenal contamination or cleanup efforts on fish and wildlife by: **a)** proposing such actions as a part of the Annual Plan, or as amendments thereto, or through other procedures as appropriate," **b)** "implementing approved actions through oversight of Service and other personnel and equipment," **c)** "maintaining a complete record, including a photographic record of impacts to fish and wildlife resources and habitats and of mitigation responses to the same," **d)** "coordinating with the Program Manager to integrate fish and wildlife mitigation plans into other Arsenal activities," **e)** "providing input for the responsibilities described above into Service Fish and Wildlife Resource Management Plans, Budgets, and Reports," and **f)** "providing supervision for identified staff of the Program Manager who will assist with habitat mitigation efforts" (Pages 12-13 of U.S. Government 1994). The Rocky Mountain Arsenal National Wildlife Refuge Act of 1992 (Public Law 102-402, 102d Congress) established the purposes of the site, which include **a)** "To conserve and enhance populations of fish, wildlife, and plants within the refuge...", **b)** "To conserve and enhance the land and water of the refuge in a manner that will conserve and enhance the natural diversity of fish, wildlife, plants and their habitats," and **c)** "To protect and enhance the quality of aquatic habitat within the refuge." These documents clearly authorize and promote habitat restoration at Rocky Mountain Arsenal National Wildlife Refuge (Refuge).

In addition, the cleanup of the site is being conducted in accordance with the Comprehensive Environmental Response Compensation and Liability Act of 1990 (CERCLA, 42 USC 9601-9657). Properly implemented, CERCLA cleanup procedures are intended to fully comply with or meet criteria of other environmental laws. CERCLA does not specifically discuss "mitigation," but CERCLA-related damages can either be mitigated in the same time period as the damage or treated as natural resources damages and compensated later through some form of injury analysis. The parties have agreed to mitigate at the time of the impact or immediately before or after the impact rather than waiting because: 1) inflation increases the cost of mitigation, 2) funding for the entire mitigation at one time is more difficult to acquire than funding spread over 10-15 years, 3) waiting to revegetate is more expensive because weed

seeds have time to dominate the seed bank, and 4) revegetation is necessary anyway to ensure that soil is not left bare and therefore subject to erosion. In addition, the Refuge Act requires that response actions under CERCLA, including revegetation/mitigation, must be consistent with the purposes for which the Refuge is established.

## ARMY REGULATIONS

Army Regulations 200-3 states that Army's natural resource goal is to systematically conserve biological diversity on Army lands within the context of its mission, and that habitat management is the key to effective conservation of biological diversity. It also states that habitat management efforts will be accomplished in a manner to conserve and enhance existing flora and fauna consistent with above goal. To this point, the Regulations recognize that conserving and restoring biological diversity minimizes the number of species that must be protected as threatened and endangered. The Regulations direct installations to maintain viable populations of the nation's native plants and animals; maintain natural genetic variability within and among populations of native species; maintain functioning representative examples of the full spectrum of ecosystems, biological communities, habitats, and their ecological processes; implement management solutions which integrate human activities with the conservation of biological diversity; increase scientific understanding of biological diversity and conservation; increase public awareness and understanding of biological diversity; and encourage private sector development and application of innovative approaches to the conservation of biological diversity. Mission requirements for the land are to avoid or minimize adverse effects and restore or enhance environmental quality. Emphasis will be placed on the maintenance and restoration of habitat favorable to the production of indigenous fish and wildlife, particularly (but not limited to) federally listed species protected under the Endangered Species Act. Actions will be carried out in accordance with Army regulations and other applicable federal, state, and local laws and regulations.

## MITIGATION POLICY

Where applicable, the National Environmental Policy Act (NEPA) requires federal agencies to assess and fully disclose impacts of their actions on the environment. NEPA also directs agencies to evaluate alternatives to the proposed actions, as well as appropriate mitigation measures, to avoid or reduce the severity of impacts on the environment. NEPA established the Council on Environmental Quality (CEQ), which published regulations to implement the provisions of NEPA. Section 1508.20 of these regulations defines mitigation as a five-step process with the following preferred sequence:

- (1) Avoiding the impact altogether by not taking a certain action or part(s) of the action;

(2) Minimizing impacts by limiting the degree or magnitude of the action and its implementation;

(3) Rectifying the impact by repairing, rehabilitating, or restoring the affected environment;

(4) Reducing or eliminating the impact over time by preservation and maintenance operations during the life of the action; and

(5) Compensating for the impact by replacing or providing substitute resources or environments.

Most of the Habitat Restoration Program is guided by the Service's Mitigation Policy, which is recorded in Volume 46, No. 15 of the Federal Register (U.S. Government 1981). This policy was developed to complement the CEQ mitigation guidelines and directs the Service to classify fish and wildlife habitats into one of four resource categories based on their relative value and scarcity. Each resource category has a specific mitigation planning goal, as follows:

<u>Resource Category</u>	<u>Designation Criteria</u>	<u>Mitigation Planning Goal</u>
1	High value for wildlife; unique and irreplaceable.	No loss of existing habitat value.
2	High value for wildlife; scarce or becoming scarce.	No net loss of in-kind habitat value.
3	High to medium value for wildlife; abundant.	No net loss of habitat value; minimize loss of in-kind habitat value.
4	Medium to low value for wildlife.	Minimize loss of habitat value.

## RECORD OF DECISION AND REMEDIATION VENTURE OFFICE

The Record of Decision (ROD) for the remediation of contamination was signed during June 1996. Following this signing, the U.S. Army (Army), Shell Oil Company (Shell), and the Service formed a joint venture named the Remediation Venture Office (RVO). The RVO provides a partnership in the remediation decisions within the scope of the ROD. The RVO's mission is to "implement the safe, efficient and cost effective remediation of the Arsenal and complete the transition of the site to the Rocky Mountain Arsenal National Wildlife Refuge.

Included within the RVO partnership is a department to deal with mitigation issues (Appendix A, Figure 1). The Service provides the lead on all mitigation. Because of this responsibility, the Service will conduct all final habitat restoration on the Refuge, including on remediation and borrow sites.

## FISH AND WILDLIFE COORDINATION ACT

Another authority for conducting some restoration activities on the Refuge is the Fish and Wildlife Coordination Act (Public Law 85-624), which provides for mandatory consultation with the Fish and Wildlife Service whenever federally-related projects modify streams or bodies of water (e.g., remediation of Lower Derby Lake). The law provides for on-site and/or off-site mitigation for unavoidable impacts related to the projects.

## GENERAL

This restoration plan outlines a general strategy for replacing habitat in some portions of the Refuge and improving habitat in others. Most of the plan concerns manipulation of vegetation, although management of water and construction of structures are also considered. The plan serves as a step-down document from the Refuge's Comprehensive Management Plan and as an "umbrella" plan to guide specific habitat restoration projects.

The plan is designed to be flexible. For example, the plan discusses the most promising revegetation methods and seed mixes. However, these will change somewhat due to different site and climatic conditions and, more importantly, due to new technology and information. Rather than revising the entire document annually to provide for these changes, amendments may be attached to the plan, as needed.

## SITE DESCRIPTION AND HISTORY

Rocky Mountain Arsenal National Wildlife Refuge is located approximately 10 miles northeast of downtown Denver, Colorado (Figure 2). The Refuge currently spans approximately 17,000 acres, a minimum of 815 of which will be sold in accordance with the provisions of the Refuge Act. Most of the site was intensively farmed (both dryland and irrigated) during the late 1800's and early 1900's. Farming removed most of the native vegetation, although areas that were only grazed retained some of the native vegetation components. These farms were acquired by the U.S. Army in 1942, whereupon factories (South Plants) were built in the interior area for production of chemical weapons. Portions of South Plants were leased later to chemical companies, particularly Shell Chemical Company, for the production of pesticides. A second factory complex (North Plants) was constructed and managed by Army during the 1950's for the production of nerve gas. Portions of by-products from both factory complexes were discharged into both natural and artificial basins. The manufacturing and disposal

practices left considerable contamination in the central portions of the Refuge; however, most of the buffer zone surrounding production and disposal areas remained relatively uncontaminated and has been used extensively by wildlife.

Ten major soil types exist on the Refuge (Figure 3). The soils in the southwestern half of the Refuge are primarily sandy (Bresser sandy loam, Ascalon sandy loam, Truckton loamy sand, and Bresser-Satanta sandy loam). Much of the soil in the northeastern half of the Refuge has a higher clay content (Weld loam, Satanta loam, and Nunn clay loam). Many of the wetter areas, in particular the First Creek riparian corridor, are dominated by aquic haplustolls.

The Refuge lies within the shortgrass prairie zone of the Great Plains of North America. Before intensive agriculture, however, other prairie types also existed within the broad shortgrass prairie zone wherever conditions allowed. Sandy soils were often dominated by sandhill prairie species, some riparian areas had pockets of tallgrass communities (*albeit* reduced in height due to lower soil moisture), and transition zones of mixed-grass prairie often lay between standard shortgrass prairies and other grassland types. The Service suspects that much of the northeastern portion of the site was originally typical shortgrass prairie, most of the southwestern area was sandhills prairie, and many other sites were more of a mixed-grass community. Some sites along First Creek and a few other locations were probably dominated by riparian vegetation (including some tallgrass and woody species) and wetland communities. Shrubland probably existed in many soil types.

Thirteen major vegetation types (Figure 4) and eight major habitat types (Figure 5) are currently identified at the Refuge. The species composition of most of this vegetation is probably a result of agriculture (and to a lesser extent, Army land management) rather than soil types or presettlement native plant communities. A few remnants of the prairie still exist where sites were grazed but not tilled.

Almost sixty percent of the Refuge is dominated by nonnative weedy forbs and/or weedy grasses. Approximately one quarter (24%) of the Refuge has been classified as native perennial grassland, although most of these areas have a significant weedy component. The shrubland/succulent habitat is the next most prevalent class, covering six percent of the site. Each of the other five habitat classes (disturbed, wetlands, riverine/riparian, upland trees, lacustrine) account for less than three percent of the total Refuge acreage (Morrison Knudsen Environmental Services, unpubl. data).

The Service has been conducting habitat restoration projects since 1989. The first project was the Bald Eagle Management Area Habitat Manipulation Project, conducted in conjunction with Army, Shell, and Shell's contractor, Morrison Knudsen Corporation (MK). This project consisted of mostly grassland seeding sub-projects in 20 sites (Figure 6), and provided conservation measures to offset loss of wildlife habitat anticipated due to the loss of 293 acres in Section 9 leased to Denver for use as a commuter airplane runway. More than 100 additional sites and subsites have been

used as habitat restoration/mitigation areas (Figure 7), consisting mostly of prairie seeding sites, shrub restoration, and habitat protection projects (e.g., fencing). These projects have met with varying degrees of success, often depending on the amount of summer precipitation during establishment.

## TERMS

Several terms and abbreviations are mentioned repeatedly through this document that may be confusing to some readers. Therefore, definitions are provided below.

Arsenal	Rocky Mountain Arsenal; Rocky Mountain Arsenal National Wildlife Refuge.
Balance sheet	An accounting list showing disturbance projects and the restoration projects that mitigate for those disturbance projects.
BEMA	Bald Eagle Management Area.
CEQ	Council on Environmental Quality.
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act.
CFS	Cubic Feet per Second.
CGS	Contracting and General Services (The Service's contracting office).
CMP	Comprehensive Management Plan (The Service's umbrella plan for the Refuge).
CSU	Colorado State University.
DBH	Diameter at Breast Height. If tree splits above the ground but below breast height, the diameter of all stems are added to calculate DBH.
Desirable species	Native species
Disturbance	Any action that leads to either damage or destruction of a site or its vegetation.
Drip line	The area under the canopy of a woody plant.

EPA	Environmental Protection Agency.
HRP	This Habitat Restoration Plan.
In-kind mitigation	Mitigation that replaces damaged or destroyed habitat with a very similar habitat. Example: replacing habitat dominated by shrubs with similar shrub species.
Interim vegetation	Vegetation, such as crested wheatgrass ( <i>Agropyron cristatum</i> ) or slender wheatgrass ( <i>Agropyron trachycaulum</i> ), that is to be planted in areas that will be redisturbed but not for at least one year following planting.
IPM	Integrated Pest Management. A program that uses as many techniques as available to control pests. Most IPM work on the Refuge involves weed control using mechanical, cultural, chemical, and biological methods, often in conjunction with each other.
IRA	Interim Response Action. A remedial action initiated before the Record of Decision was signed.
Live cover	The percent of ground surface covered by a living plant or one that was alive during the current growing season.
Mitigation	The act of avoiding, minimizing, rectifying, reducing or eliminating over time, or compensating (by replacement) for impacts. These impacts usually result from remediation-related activities. While all forms will be used at Rocky Mountain Arsenal, this document usually refers to mitigation as a form of compensation through replacement of vegetation.
NEPA	National Environmental Protection Act.
Off-post	Outside the borders of Rocky Mountain Arsenal.
Off-site	Off the specific site that was damaged or destroyed but within the borders of Rocky Mountain Arsenal.
On-post	Within the borders of Rocky Mountain Arsenal.
On-site	On the specific site that was damaged or destroyed.

Out-of-kind mitigation	Mitigation that replaces damaged or destroyed habitat with a different type of habitat. Example: replacing habitat dominated by cheatgrass with habitat dominated by native shortgrass prairie species.
Percent relative live cover	The sum of live cover for a species or group of species (e.g., “desirable” species) divided by the sum of cover for all species multiplied by 100. This is in contrast to the total cover, which could also include litter, rocks, etc. For example, 30% relative live cover of desirable species means that 30% of the sample points that hit live vegetation were of desirable species (as opposed to 30% of all sample points regardless of what they hit).
Permanent vegetation	Native vegetation that will be planted where no further disturbance is anticipated.
PIT	Program Integration Team. A group of RVO managers that represents the second line of authority at the Arsenal.
PLS	Pure Live Seed.
PMC	Program Management Contractor. The main contractor chosen to carry out the 31+ post-ROD remediation projects.
Refuge	Rocky Mountain Arsenal National Wildlife Refuge.
Restoration	Revegetation of native species in an attempt to simulate communities that are assumed to have existed in the area before white settlement. Out of convenience, however, this “Habitat Restoration Plan” includes all revegetation, including that of non-native species.  Restoration here is not to be confused with another use of the term, i.e., any restitution resulting from natural resource injury analyses for production related damages.
Revegetation	Any type of vegetation planting. This includes seeding and live planting of either native or exotic species.
ROD	Record of Decision. Signed on June 11, 1996, this document provides the framework for post-ROD remediation.

RVO	Remediation Venture Office. An organizational joint venture of the U.S. Army, Shell Oil Company, and the U.S. Fish and Wildlife Service whereby teams are formed from representatives of each party to jointly resolve problems related to remediation of the Arsenal and transition of the site into a national wildlife refuge. The RVO and RVO Support are made up of approximately 60 individuals forming about 20 teams.
SHPO	State Historic Preservation Office or State Historic Preservation Officer
Shrubland	Area dominated by either shrubs or succulents (e.g., cactus, yucca).
Sweeping	A weed control technique whereby a blade plow or cultivator moves blades just under the soil surface to kill weeds by cutting roots. This process causes minimal disturbance to the soil surface.
TBD	To Be Determined.
Temporary vegetation	Annual vegetation, such as winter wheat ( <i>Triticum aestivum</i> ), that is to be planted in areas that will be redisturbed in less than one year following planting.
VMAD	Vegetation Monitoring Analysis and Database system.
Wetlands	Those areas that are inundated by surface or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. (Federal Clean Water Act, 40 CFR Part 232.2(r).
Woody vegetation	Trees and/or shrubs.

## CHAPTER 2: GOALS AND OBJECTIVES

The Comprehensive Management Plan (CMP) for the Refuge was completed in March 1996 (U.S. Fish and Wildlife Service 1996a). This document provides the framework for further planning of refuge activities. The CMP (Page 46) listed six goals to help guide planning and management:

- “1. Manage wildlife and habitat to contribute to ecosystem management using strategies that recognize the Refuge’s different resource types and the varying purposes specified in the enabling legislation.
2. Interact with communities and organizations through outreach and cooperative agreements to create mutually beneficial partnerships.
3. Develop environmental education and outreach programs for urban communities to nurture an appreciation of nature which ultimately results in fostering an environmental consciousness which promotes conservation of our natural resources.
4. Provide opportunities for wildlife-oriented recreational activities.
5. Utilize the Refuge for research opportunities compatible with Refuge management.
6. Develop a program support system to provide facilities, funding, and resources necessary to accomplish Refuge purposes.”

This Habitat Restoration Plan is part of a step-down process based on these CMP goals. CMP Goal No. 1 provides the framework for most habitat restoration at the Refuge. Nevertheless, the Habitat Restoration Program also is partially guided by each of the other five CMP goals, particularly when working with Public Participation personnel on projects related to CMP Goals 2 and 3.

Of particular importance to the Habitat Restoration Program is 1) avoidance or minimization of wildlife habitat damaged during cleanup, 2) replacement of wildlife habitat damaged during production and cleanup, 3) restoration of native plant communities, 4) development of stable vegetation communities for specific native wildlife, 5) restoration of the First Creek corridor, 6) maintenance of existing plant communities that are critical for existing wildlife communities, and 7) improvement of methods for restoring and enhancing wildlife habitat in the Northern Great Plains. Therefore, the Service has identified each of these items as Habitat Restoration Plan (HRP) goals, although these goals are interrelated and methods to obtain one goal may be similar for another goal. In addition, many of these goals reflect specific CMP objectives. The Service would conduct all work unless otherwise stated.

**HRP GOAL 1.** Wherever possible, avoid or minimize the loss of wildlife habitat.

*Objective A.* Provide Service representation at all possible meetings and tours related to design of remediation or supporting operations. Recommend appropriate changes to designs to avoid loss of wildlife habitat. Wherever avoidance is impossible, recommend appropriate changes to minimize loss of wildlife habitat.

*Objective B.* Review all appropriate documents of remediation or operational design. Recommend appropriate changes to designs to avoid loss of wildlife habitat. Wherever avoidance is impossible, recommend appropriate changes to minimize loss of wildlife habitat.

*Objective C.* Provide all possible support (e.g., telephone, E:Mail) for other questions regarding design of remediation or supporting operations. Recommend appropriate changes to designs to avoid loss of wildlife habitat. Wherever avoidance is impossible, recommend appropriate changes to minimize loss of wildlife habitat.

**HRP GOAL 2.** Compensate for the loss of habitat which has been or will be destroyed or significantly disturbed by the U.S. Army, Shell Oil Company, and/or their contractors as a result of production and/or cleanup of chemical contaminants.

*Objective A* Revegetate approximately 7700 acres of Rocky Mountain Arsenal (minus area already revegetated).

This estimate is based on mitigating approximately 3,650 acres at a 2:1 ratio and approximately 400 acres at a 1:1 ratio of habitat that has been or will be disturbed as a direct or indirect result of remediation activities (Appendix B, Table 1). These activities include Pre-ROD projects (e.g., Interim Response Actions), the 31+ post-ROD remediation projects, and all post-ROD borrow sites. The acreages include mostly grassland, but also some shrubland, woodland, wetland, and aquatic areas.

*Objective B* Replace damaged habitat using a 1:1 ratio (e.g., 1 acre planted for 1 acre damaged or destroyed) in Human Health Exceedance and Principle Threat Areas and usually a 2:1 ratio (e.g., 2 acres planted for 1 acre damaged or destroyed) in other areas. The precise number of units (e.g., acres, trees) to be replaced is dynamic because future cleanup activities will damage only an estimated amount of additional habitat.

The exceptions to these ratios are as follows:

- (1) Wetland and riparian woody vegetation (i.e. trees and shrubs) will be mitigated based on a 5:1 ratio, regardless of plant size or proximity to contaminated soils of lost trees. Trees that are 6 inches or more in Diameter at Breast Height (DBH) will be mitigated based on individual trees; replacements will be saplings. Shrubs and trees less than 6 inches in DBH will usually be mitigated based on area occupied within drip line rather than by individual plants.
- (2) Upland trees that are 6 inches or more in DBH will be mitigated using a 5:1 ratio, regardless of proximity to contaminated soils. These trees will be mitigated based on individual trees lost; replacements will be saplings.
- (3) Russian olive (*Elaeagnus angustifolia*) and salt cedar (*Tamarix ramosissima*) will not require any mitigation.

Ratios of 2:1 are justified because of the temporal loss of habitat and the difficulty of reaching the restoration goals. Ratios of 5:1 are justified by the exceptionally high value for wildlife of these plant communities in this area and their relatively low survivability following planting; replacement trees will almost always be in the form of saplings. Russian olives and salt cedars will not require mitigation because they are considered to be noxious plants; however, their removal must be coordinated with the Service.

Replaced habitat can be on-site (i.e., on the site damaged) and/or off-site (i.e., elsewhere on the Refuge). Most on-site mitigation will occur in the central core of the Arsenal as specific remediation activities are completed. Most off-site mitigation will occur in clean peripheral sites that have relatively low wildlife habitat value for most wildlife species (e.g., in crested wheatgrass stands) or are considered unstable (e.g., patches of annual weeds).

Replacement habitat may be in-kind (same as) or out-of-kind (different from) from the habitat which was destroyed. However, the replacement habitat must be native to the area and appropriate for the site specific soil and moisture conditions. For example, sandy soils should receive a sandhills prairie mix, while most soils with higher clay contents should receive a shortgrass prairie mix. These are the main two prairie types to be planted. Other site-specific objectives, such as the desired wildlife use, also will be

factored into the choosing of a seed mix, within the confines of the soil and moisture conditions.

**HRP GOAL 3.**

Restore important components of the native plant communities thought to have existed prior to European settlement. When appropriate, organize this restoration based upon four types of revegetation locations: 1) soil covers with biota barriers, 2) soil covers without biota barriers, 3) remedy and borrow areas without soil covers but where the topsoil has been removed, and 4) areas inside and outside the remedy where topsoil still exists.

*Objective A*

Establish approximately 517 acres of appropriate native plant communities in remediation areas that have soil covers with biota barriers. The species composition of the desired plant communities will vary with site-specific soil conditions and wildlife management objectives. The main two prairie seed mixes in remediation areas will be variations of a sandhills prairie mix for sandy soils and a shortgrass prairie mix for Weld loam and Nunn clay loam soils. However, the plant communities should consist of 70-100% grasses and 0-30% forbs and shallow-rooted shrubs. Grass compositions may vary where certain wildlife species are particularly desired or discouraged. While most final plantings will be native, occasionally exotic species (e.g., crested wheatgrass) may be used to hold the soil until cleanup is complete.

Revegetation efforts will be initiated during or prior to the first growing season that cleanup covers are complete and, with maintenance operations will aim to establish each desired plant community within five years of planting. Additional maintenance after five years will be necessary to control the invasion of undesirable species and maintain established prairie vegetation. This project will retard erosion, and discourage use of these areas by certain wildlife.

*Objective B*

Establish approximately 693 acres of appropriate native plant communities in remediation areas that have soil covers without biota barriers. The species composition of the desired plant communities will vary with site-specific soil conditions and wildlife management objectives. The main two prairie seed mixes in remediation areas will be a sandhills prairie mix for sandy soils and a shortgrass prairie mix for Weld loam and Nunn clay loam soils. The resulting plant communities should consist of 70-90% grasses and 10-30% forbs and shrubs as measured by cover within five years of seeding. Note that shrubs, including deep-rooted shrubs, are included in these communities. In addition, replacement of

trees that have been destroyed would make up a fraction of a percent of this mitigation. However, mitigation costs for woody species should not be overlooked or underestimated.

*Objective C*

Establish approximately 2156 acres of appropriate native plant communities in remediation areas that have no soil covers nor topsoil. The species composition of the desired plant communities will vary with site-specific soil conditions and wildlife management objectives. The main two prairie seed mixes in remediation areas will be a sandhills prairie mix for sandy soils and a shortgrass prairie mix for Weld loam and Nunn clay loam soils. However, three additional seed mixes will be used to seed into the following soil types: 1) Satanta and Bresser-Satanta loams, 2) petrocalcic paleustolls, and 3) typic and aquic haplustolls. The resulting plant communities should consist of 70-90% grasses and 10-30% forbs and shrubs as measured by cover within five years of seeding.

*Objective D*

Establish approximately 4334 acres of appropriate native plant communities inside and outside remediation areas where there are no soil covers and the topsoil still exists. The species composition of the desired plant communities will vary with site-specific soil conditions and wildlife management objectives. The main two prairie seed mixes in remediation areas will be a sandhills prairie mix for sandy soils and a shortgrass prairie mix for Weld loam and Nunn clay loam soils. However, three additional seed mixes will be used to seed into the following soil types: 1) Satanta and Bresser-Satanta loams, 2) petrocalcic paleustolls, and 3) typic and aquic haplustolls. The resulting plant communities should consist of 70-90% grasses and 10-30% forbs and shrubs as measured by cover within five years of seeding. Note that shrubs, including deep-rooted shrubs, are included in these communities.

Note for GOAL 3: Replacement of trees that have been destroyed would make up a fraction of a percent of this mitigation. However, mitigation costs for woody species should not be overlooked or underestimated.

Revegetation efforts have already begun and will continue at the Refuge for 10-15 years. Work will aim to establish each desired plant community within five years of planting. Additional maintenance after five years may be necessary to control the invasion of undesirable species. Meeting this objective will retard erosion and discourage use of these areas by certain wildlife.

**HRP GOAL 4.**

Develop stable vegetation communities for native wildlife species, including small mammals, grassland birds, those species

emphasized in the “Goals and Objectives” section of the Comprehensive Management Plan (i.e., black-tailed prairie dog (*Cynomys ludovicianus*), deer (*Odocoileus* spp.), bison (*Bison bison*), pronghorn (*Antilocapra americana*), and prairie grouse (*Tympanuchus* spp.)). In addition, many additional important species or groups of species (e.g., raptors) will benefit from developing or enhancing habitat for the species above, particularly prairie dogs and deer.

- Objective A* Establish all sites such that small mammals and grassland birds appropriate to shortgrass or sandhills prairies will benefit within 10 years of seeding.
- Objective B* Establish new grasslands such that a total 3,500 to 5,000 acres of appropriate native vegetation are available as stable prairie dog habitat within five years of cleanup completion.
- Objective C* Ensure that enough browse (i.e., forbs and shrubs) is available to maintain a pre-determined number of mule deer (*O. hemionus*) and white-tailed deer (*O. virginianus*).
- Objective D* Ensure that adequate (TBD) grassland is available for 10 - 100 bison within five years of the completion of cleanup.
- Objective E* Develop enough (TBD) habitat to sustain a herd of 15 - 30 pronghorn antelope within five years of the completions of cleanup.
- Objective F* Establish appropriate habitats for a self-sustaining population of either greater prairie chickens (*T. cupido*) or Plains sharp-tailed grouse (*T. phasianellus*) within five years of completion of cleanup. This habitat will include an appropriate mixture of both shrubland and grassland.
- Objective G* Develop and maintain the habitat listed in the objectives above in conjunction with each other such that one wildlife species does not destroy the habitat of another (e.g., bison removing the habitat of deer).
- HRP GOAL 5.** Restore important features of First Creek believed to have existed prior to European settlement within five years of cleanup completion.
- Objective* Redesign and reconstruct First Creek to:

- (1) restore stream meandering where appropriate, particularly in reaches within Sections 19, 24, 30, and possibly 5;
- (2) protect known bald eagle habitats, particularly the eagle roost in Section 5, probably with construction of a flood channel to divert flows greater than 300 cfs west of the roost;
- (3) control increased flows and related erosion by helping to design a potential detention facility in Section 8, constructing one to four grade control structures in Section 5, and installing biotechnical bank protection potentially in all sections;
- (4) restore functions and values of wetlands by crushing underground tile, guiding borrow activities adjacent to First Creek, and planting appropriate wetland species particularly in Sections 24, 30, and 31;
- (5) restore riparian vegetation by planting clusters of native woody and grassland communities throughout the stream corridor;
- (6) control 90-100% of the Russian olive plants through both mechanical and chemical means, while leaving many dead mature olive trees in place for perches; and
- (7) control other weedy or nuisance species (e.g., 100% of salt cedar, 75-100% of Canada thistle (*Cirsium arvense*, 10-25% of cattails (*Typha* spp.).

Meeting each part of this objective would increase diversity of both plant and animal life in the First Creek corridor, but would be particularly helpful to preserving existing bald eagle habitat and providing additional food and cover for neotropical migratory bird species. Planning for the work in the form of Title I (conceptual design) and Title II (construction design) was accomplished by the Service, engineering and wetland firms under contract with the Service, and Army and Shell/MK personnel. Most fieldwork will be conducted by the Service.

**HRP GOAL 6.** Maintain certain specific plant communities, especially those defined by native, woody or succulent vegetation, that serve particularly significant wildlife communities.

*Objective A*

Maintain all existing native plant communities (e.g., native grassland, sand sagebrush shrubland, yucca stands, cactus stands) by protecting them from disturbance wherever possible and monitoring and controlling weedy species where appropriate. Maintenance of existing native plant communities has already been initiated and should continue in perpetuity throughout the Refuge provided that changes would not benefit the site (e.g., change from early to later seral stages). Meeting this objective will maintain existing diversity of both the plants and animals that populate these areas and will provide a local source of genetic material for recolonization of other Refuge sites and dispersal of small animals into contiguous sites.

*Objective B*

Maintain woodlands by replacing dead trees with living ones, usually by transplanting with native species whenever appropriate. If habitat value cannot be approximated by replacement with native plant species, then some exotic plants may be used unless the species is considered noxious (e.g., Russian olive). Dead trees usually will be left in place for nesting and perching value. Monitoring this type of vegetation should begin immediately and should continue in perpetuity. Objective B is particularly relevant to the Southern Zone of the Refuge, where additional water has been available to establish considerable woody vegetation important to numerous species of birds and mammals; however, this objective also applies to other places on the Refuge (e.g., most of the First Creek corridor and some homesteads in the Northern Zone). Meeting Objective B can maintain the existing diversity of wildlife species.

**HRP GOAL 7.**

Improve methods for reestablishing native wildlife habitat.

*Objective A*

Evaluate potential methods used to establish native plant communities from seed. These evaluations should include 1) comparisons of different irrigation strategies, 2) the use of sucrose applications to control annual weeds, 3) the use of cover crops (e.g., sorghum (*Sorghum vulgare*)) versus a native grass hay mulch (at 2 tons/ac), and 4) the use of drill seeding versus broadcast seeding. The Service currently supports research by Colorado State University that will help make these evaluations. This research will require one more field season (i.e., 1999), but is already identifying additional research projects that would provide vital answers to additional questions regarding restoration of shortgrass and sandhills prairie. Current research is confined mostly to southwestern Section 3, but other sites throughout the Refuge might be appropriate, depending on specific future

research questions. The results of this type of research will help the Service produce better stands of self-sustaining native vegetation with minimal expenditures of time and money. Responsible parties (Army and Shell) will benefit from this research by 1) reducing the time and money needed to revegetate sites and 2) receiving mitigation credit from acreage revegetated during research.

*Objective B*

Evaluate the effectiveness of different restoration methods used in the past, present and future by the Service, Morrison Knudsen Corporation, Army and their respective contractors. Evaluation of vegetation response to restoration has already been initiated and should be continued as long as restoration continues at the Refuge. Revegetation should be evaluated at least during the third and fifth years following planting of a native seed mix and at least once every five years afterwards. Determination of vegetative success will be made on the fifth season (see the Research and Monitoring chapter). These evaluations should be conducted on all restoration projects regardless of location within the Refuge. In addition, response of small mammals, grassland birds, and site-specific wildlife objectives will be monitored. The results of this type of monitoring will help the Service identify the best methods to use, problems not immediately evident, opportunities for improving methods, both short-term gains and long-term trends, and ultimately ways to save time and money in future restoration projects.

*Objective C*

Evaluate methods that do not involve planting (e.g., prescribed fire, herbicides, mowing, haying, grazing) to establish and maintain native seedlings and control weedy species. Evaluation has already been initiated and should be continued as long as restoration continues at the Refuge. These projects usually should be evaluated at least every third and fifth years following planting and at least once every five years afterwards. Evaluations should be conducted on all of these projects regardless of location within the Refuge. The results of this type of monitoring will help the Service identify the best methods to use, problems not immediately evident, opportunities for improving methods, both short-term gains and long-term trends, and ultimately ways to save time and money in future restoration projects.

## CHAPTER 3: METHODS

### GENERAL APPROACH

#### HISTORY AND ORGANIZATION

Two significant components of the Habitat Restoration Program are Mitigation and Operational Assistance. These components are not mutually exclusive but complement one another. The mitigation program documents specific disturbances caused directly or indirectly by environmental cleanup and related actions, while operational assistance projects usually are designed to avoid or minimize impacts to vegetation or wildlife. Mitigation requirements have been calculated not only for habitat disturbances in cleanup sites but also for construction of roads, buildings, and borrow sites in clean areas to support cleanup. By January 1999, mitigation encompassed 1125 acres in various phases of revegetation with native grasses, forbs, shrubs, and a few trees. More than half of the projects initiated two or more years ago appear to be successful for the limited amount of time since seeding, although several additional years using specific vegetative monitoring techniques will be required to determine objectively how successful the sites become. However, native plant species have not become established on several sites, most notably Bald Eagle Management Area (BEMA) Sites 1C and 4B (Figure 6), which were seeded in 1992 and 1991, respectively. The Service was never able to control competition from weeds in these sites; both sites have been or will be reseeded after appropriate methods (e.g., mowing, disking) control the weeds.

Many operational assistance projects involve barriers of various types. For example, smooth wire fences and signs were installed to minimize inadvertent destruction of remnant vegetative communities, such as a sand prairie area in Section 4 and a cobble soil community in Section 35 (Figure 4). Unnecessary roads also have been closed and revegetated as operational assistance projects. Other types of projects are designed to exclude prairie dogs from boundary containment systems or contaminated areas. These projects include vegetative and/or physical visual barriers, since prairie dogs prefer an unobstructed field of view.

Additional components of the habitat restoration program may include revegetation as a result of a future natural resources injury analysis and the use of volunteer labor. Both of these programs have the potential to become significant aspects of the habitat restoration program in the future. The Service does not know at this time how much additional restoration, if any, will be identified from a damage assessment. However, the Service is confident that the volunteer program will increase in significance to eventually serve a prominent role in the overall restoration program, particularly in high-visibility areas. Habitat restoration projects are more likely to succeed if they are maintained for at least the first three to five years. Weed control is labor intensive but very important for establishment of native plant communities. The volunteer program is rapidly increasing in significance and may eventually become the dominant form of

restoration maintenance in public use areas, but the Service must provide maintenance of other sites to ensure overall success.

Pursuant to the Mitigation Policy, the Service organized the Morrison Knudsen vegetation communities at the Refuge (Figure 4, Table 2) into eight distinct functional habitat types (Figure 5, Table 3), and assigned each habitat type to one of the four resource categories (Figure 8, Table 4) based on regional scarcity and relative value for wildlife. No Resource Category 1 habitats were identified on the Refuge.

Resource Category 2 is considered to have high value for evaluation species and is relatively scarce or becoming scarce on a national basis or in an ecoregion. The mitigation goal is no net loss of in-kind habitat value. Approximately 37 percent of the Refuge has been classified as Resource Category 2 (Table 4). As with all mitigation, the first preference is to avoid impacts to these habitats. Where impacts cannot be avoided, the Mitigation Policy requires that lost habitat be replaced with the same habitat type (i.e., in-kind).

Resource Category 3 has high to medium value for evaluation species and is relatively abundant on a national basis. The mitigation goal is no net loss of habitat value while minimizing loss of in-kind habitat value. This is the most common category found on the Refuge, with slightly more than 10,000 acres (59%). Due to its dominance at the Refuge and its somewhat lower value than Resource Category 2 habitats, most off-site compensation will take place in Resource Category 3 habitats. Because the Mitigation Policy does not require that Resource Category 3 habitat losses be replaced in-kind, the Service will emphasize conversion of nonnative weedy plant communities to more stable native communities.

Resource Category 4 has medium to low value for evaluation species. The mitigation goal is to minimize loss of habitat value. Less than three percent of the Refuge has been classified as Resource Category 4. Much of this 458-acre area falls within the Human Health Exceedance areas (Figure 9). It is important to realize that these areas still possess some habitat value whose loss must be mitigated. Even buildings provide some benefit for certain species, such as thermal cover for mule deer and nesting habitat for barn owls (*Tyto alba*). In some cases, these structures can be an attractive nuisance, potentially exposing wildlife to contaminants, entrapment, and other hazards; therefore, most should be removed, but their habitat value should be replaced in appropriate sites, frequently by planting woody species.

## ACCOUNTING

To date, most mitigation has resulted from 837 acres of pre-ROD disturbances (Table 1), particularly the Interim Response Actions (e.g., construction and maintenance of boundary containment systems). Most current and future mitigation will compensate for an estimated 1738 acres of disturbance resulting from the 31+ post-ROD remediation

projects and 1474 acres expected to be disturbed by borrow projects supporting the post-ROD remediation.

In upland areas, mitigation will be guided by a requirement of one unit (e.g., acre) of mitigation for one unit of disturbance to grasslands or shrublands in the Principal Threat and Human Health Exceedance areas (Table 5, Figure 9) and two units of mitigation for each unit disturbed in any other grassland or shrubland area. A 1:1 ratio is used in highly contaminated areas because existing wildlife habitat value is relatively low and is more easily approximated than less contaminated or clean areas. A 2:1 ratio is used for these sites because it is often difficult to replace habitat adequately, especially within several years of the impact. Temporal loss of habitat following impact and during years of revegetation is a significant problem for wildlife and must be mitigated. Some small mammals require 10-15 years to recover populations.

Also in upland areas, a 5:1 ratio is required for loss of trees that are 6 inches or larger in DBH (considered to be mature trees), regardless of proximity to contaminated soils. Only a 2:1 ratio will be required for a loss of an upland tree smaller than 6 inches DBH. Trees will be replaced with saplings, not mature trees.

In wetland and riparian areas, a 5:1 ratio is used for loss of any woody vegetation (trees or shrubs) and a 2:1 ratio for loss of non-woody vegetation, regardless of plant size or proximity to contaminated soils. Wetlands are defined by the Corps of Engineers using specific vegetative, hydrologic, and soil characteristics. Riparian areas are located adjacent to or near wetlands, streams, and other bodies of water and are considered to be existent because of associated groundwater. The Service will make the call on a case-by-case basis as to whether specific sites or vegetation types are riparian.

All ratios have been developed to be ecologically sound and cost effective. Experience in this semi-arid region indicates that a 2:1 ratio, with monitoring to help compensate for the impact of significant climatic variations, should result in a 1:1 replacement of lost vegetation over time. Ratios of 5:1 are justified by the difficulty and extended time required for replacement, low survivability, and high value to numerous wildlife species, especially in wetlands or riparian areas. Experience also demonstrates that 5:1 ratios on mature trees (without further monitoring and replacement) should lead eventually to a 1:1 replacement of lost trees; only one in five saplings is expected to reach maturity. Contamination is not a consideration in establishing ratios for riparian/wetland areas because of the high value for wildlife regardless of contamination levels.

Trees that are 6 inches or more in DBH will be mitigated based on individual trees. Mitigation of shrubs and trees less than 6 inches in DBH will usually be mitigated based on area occupied within the drip line rather than by individual plants, although the latter may be used as the basis under certain circumstances.

Russian olives are considered noxious and therefore do not require replacement. However, removal of Russian olives must be coordinated with the Service.

Disturbed vegetation must be replaced with vegetation of equal or greater value (as determined by the Service) as long as the replacement species are native to the site.

Impacts and related mitigation are tracked on a "Summary Balance Sheet" (Appendix C). The Balance Sheet is a dynamic document that provides up-to-date accounting for disturbances and their respective revegetation projects. Almost all disturbance projects relate to pre-ROD disturbances (e.g., IRA's), the 31+ post-ROD remediation projects, and the post-ROD borrow sites. This Balance Sheet is updated on a regular basis.

A combination of 1:1 and 2:1 ratios for grassland disturbances has resulted in a need for approximately 7,700 acres of grassland restoration (Table 1). However, many of the remediation sites that will need to be restored eventually to native vegetation may require other interim or temporary types of revegetation. To improve efficiency and allow specialization in revegetation, the Service will conduct all permanent revegetation unless particular circumstances require contractor support (Table 6). Temporary and interim revegetation will be conducted by a seeding contractor working for the Program Management Contractor.

The estimated costs of permanent habitat restoration vary widely, depending mostly on type of habitat (Table 7). Grassland restoration is expected to cost an average of almost \$1,800/acre during 1999. Shrubland restoration can run almost \$90,000/acre and trees can run \$843 each if live plant material and full landscaping methods are employed. Wetland restoration, based on Aquatic Wetland Consultants' recommendations, can run up to \$444,095/acres. While some of the costs can be reduced after certain equipment and irrigation materials are purchased, it is obviously in the best interest of the government and Shell to direct their remediation and support contractors to avoid and minimize loss of existing habitat, especially trees, wetlands, and shrubs. It will also be in the best interest of cost savings to emphasize a "best value" approach to restoration; this philosophy may result in high early costs (e.g., for irrigation) that will save money over the extent of mitigation.

#### RELATIONSHIP OF HABITAT RESTORATION PROGRAM WITH WILDLIFE MANAGEMENT AND PUBLIC USE

Habitat restoration will be conducted in conjunction with the goals and objectives of wildlife management and public use of the Refuge. Potential conflicts will be resolved before impacting any of the three programs.

Wildlife Management: The product of restoration efforts should improve habitat for key wildlife species and, more importantly, functional biotic communities. The Refuge Act emphasized conservation and enhancement of not only wildlife but also the vegetation itself, not necessarily as just a means to support wildlife. Fortunately, revegetation can significantly enhance habitat for wildlife, including key species such as bald eagles (*Haliaeetus leucocephalus*), while also restoring native plant communities. In addition,

the needs of several other existing (e.g., prairie dogs) and reintroductions (e.g., pronghorn) species are currently being evaluated to help guide future plantings.

Conflicts between habitat restoration and wildlife management are most likely to occur when the work required to restore native habitats threatens the well-being of wildlife species at the Refuge or when depredation by wildlife hinders the desired plants from becoming established. Whenever possible, such conflicts would be resolved best by 1) choosing restoration sites where current habitat value is relatively low, 2) scheduling field activities at times when most wildlife species would be impacted the least, 3) using techniques that minimize impacts to wildlife and promote recovery of wildlife populations, 4) coordinating activities with others to minimize unforeseen conflicts, and 5) managing wildlife to protect developing restoration projects. Nevertheless, some short-term impacts to wildlife undoubtedly will result to meet long-term habitat restoration goals.

Another potential source of conflict is planting native versus exotic species. Many exotic species do have some value as forage and/or cover for wildlife. However, the grassland and shrubland species that evolved in this portion of Colorado generally are better adapted to the local climatic conditions and have more extensive soil-binding root systems than most early successional exotics. Therefore, well-established native plant communities should better tolerate black-tailed prairie dog grazing and drought conditions than most exotic plants, resulting in more ecological stability, less soil erosion and better wildlife habitat under adverse circumstances. In the absence of competition from some exotics, native plants will produce as much or more food and cover at the Refuge as the exotics that they replace. Thus, the Service will strive to use native species wherever possible during habitat restoration. However, a few exotics may be planted, particularly in the Southern Zone of the Refuge (Figure 10), if their habitat value cannot be compensated by native species and the exotics are not aggressive colonizers.

Public Use: Both the product of habitat restoration and the process of achieving it can provide excellent opportunities for interpretation and environmental education at the Refuge. The aesthetics and value of healthy grasslands, shrublands, wetlands, and riparian areas, and the numerous wildlife species that they support, can provide the opportunities for the public to become more aware of how the area may have looked before agriculture. The restoration process itself may provide even better opportunities to interpret the ultimate objective of habitat restoration, as well as the impacts of habitat destruction and the difficulty and expense of repairing damaged habitats. One of the greatest assets of Rocky Mountain Arsenal National Wildlife Refuge is its proximity to a major metropolitan area and the opportunities it provides to educate large numbers of people who may not otherwise have positive contact with nature. Potential conflicts between habitat restoration and public use can be minimized through close coordination. In addition, Habitat Restoration personnel will work side by side with Public Participation personnel to combine small restoration projects with environmental education programs.

## RELATIONSHIP OF HABITAT RESTORATION PROGRAM WITH REMEDIATION VENTURE OFFICE AND PROGRAM MANAGEMENT CONTRACTOR

Remediation Venture Office: Mitigation and restoration are represented by their own department (Figure 1) within the Remediation Venture Office infrastructure. While plans are written by Service employees, they are done so with the aid of this department and other members of the RVO.

Program Management Contractor: The Remediation Venture Office has contracted with Foster Wheeler Environmental to be the Program Management Contractor (PMC) to conduct the 31+ post-ROD remediation projects. The Service's habitat restoration staff will interact with the PMC on a regular basis, often through a PMC liaison section called the Refuge Transition Team. This interaction is expected to result in timely scheduling and completion of revegetation-related activities from both parties. The PMC is expected to be responsible for most temporary and interim revegetation in remediation and borrow sites (Appendix D). The PMC also will create soils to specifications on caps and borrow sites, bring these sites to grade, and mix any soil amendments appropriately. They will also be responsible for planning, constructing, and testing irrigation systems. The Service will harrow the sites, if necessary, and conduct appropriate seeding of permanent vegetation, irrigation, and maintenance activities on the covers and borrow sites. Again, Foster Wheeler and the Service will work together such that both organizations' responsibilities will be fulfilled.

More importantly, the Service and RVO Mitigation Section will work closely with key PMC and RVO personnel to draft and update long-range plans for most restoration work. The PMC has been given the task of providing functional irrigation systems to predetermined grassland restoration sites by June 1 of each year. This responsibility requires close coordination with the Service and RVO for choosing locations, schedules, and irrigation systems.

### PLANNING AND APPROVAL

This Habitat Restoration Plan is a step-down plan from the Refuge's Comprehensive Management Plan. It also serves as a general or "umbrella" plan from which brief annual restoration plans can be derived. One annual plan will be written each year for all projects to be conducted the following fiscal year (Figure 11). This annual plan will summarize individual projects in or two paragraphs each and be included in the Service's Annual Management Plan. Review and concurrence of this brief annual plan would be sought from one Program Integration Member of Army, Shell, and the Service. (At the time of this plan, Charles Scharmann (Army), Roger Shakely (Shell), and Ronel Finley (Service) serve in this capacity.) This process will be conducted early enough each year to become an integral part of the RVO's annual budgetary process. This streamlined review process is made possible by the teaming effort between the Service, Foster Wheeler, and the RVO for planning projects based on irrigation needs; much of

the project planning and review is built into the system before it reaches the key PIT members.

At a later date, internal Service plans will be written for each project (Figure 11). These plans will usually be 5-12 pages long. They will be technical in nature, often describing in detail the specific techniques to be used in the field. Also, conflicts regarding sensitive wildlife, health and safety, cultural resources, and utilities will be identified and reviewed here. Therefore, these site-specific plans will only require concurrence from the Mitigation Section of the RVO. Project plans will be written using a "best value" approach that will frequently require expensive initial techniques (e.g., irrigation) to promote quicker, more successful efforts which will be less expensive for the overall program.

Teaming with Foster Wheeler to plan restoration locations and schedules occurred during late FY 1998. This change was made mostly because the Service and RVO agreed that most restoration projects should be irrigated to increase success on the first attempt. The PMC was already evaluating water capabilities for remediation purposes and some of its cleanup projects blocked access to restoration irrigation. Therefore, the PMC was officially tasked with providing water to irrigate revegetation sites without interrupting remediation water needs.

Approximately 4050 acres of the Refuge have been or are expected to be impacted by various remediation-related activities (Table 1). Approximately 3650 of these acres are located outside Human Health Exceedance or Principal Threat Exceedance Areas. Therefore, 7700 acres of restoration are needed to mitigate for these disturbances. The PMC, RVO, and Service has developed jointly a terrestrial revegetation map (Figure 12) to display which areas on the Refuge are most appropriate for grassland revegetation, potential alternate sites, and areas least likely to be revegetated. Factors considered in setting these priorities include 1) the locations of cleanup and borrow activities needing on-site restoration, 2) proximity to cleanup and borrow activities for efficient off-site restoration, 3) the number of acres needed for restoration based on mitigation criteria, 4) logistics of water availability, 5) sensitive wildlife issues such as the presence of active prairie dog towns, 6) the three landscape zones described in the Comprehensive Management Plan for the Refuge (Figure 10), and 7) the value of existing vegetation in potential off-site locations.

Obviously, on-site revegetation must be conducted on virtually all remediation and borrow sites (Figure 12). More off-site revegetation with native species is proposed for the Northern Zone partially because of efficiency of irrigation, but also because the Comprehensive Management Plan calls for planting less water-dependent vegetation in the north (following one year of irrigation to establish these prairie communities). Areas currently dominated by weedy forbs and grasses are preferred for off-site revegetation with native species, while areas already dominated by native perennial grasslands, wetlands, or shrublands would not be targeted for revegetation. However, Figure 12 may be altered as new information becomes available. For example, acreage from an

area identified in green (highest priority) could be replaced by acreage in yellow (second priority) if the original green area were unexpectedly found to be dominated by native plants. Also, a die-off of prairie dogs in an area that is currently designated as second priority could lead to its elevation to first priority to revegetate the area before prairie dogs return. However, such projects must be planned to avoid significant impacts on other key wildlife species, such as burrowing owls (*Athene cunicularia*).

Some sites totaling more than 600 acres that have already been revegetated will require some maintenance in the future. A significant portion of this acreage is in large shrubland restoration areas in the boundary containment systems. Because crested wheatgrass is needed to deter prairie dogs from colonizing these sites, shrubs are being added to help discourage prairie dogs while improving habitat for non-burrowing wildlife (e.g., deer, songbirds).

Several smaller sites, including shrubland restoration sites and wildlife guzzlers (Figure 7), also will require maintenance but are too small to identify on Figure 12; they are located in Sections 2, 4, 5, 8, 19, 20, 27, 29, 32, and 34. More than 100 acres of wetlands will continue to be actively managed. More than 1200 acres of the Refuge is not considered appropriate for mitigation and left as “unclassified” because it will be sold or lost as rights-of-way.

## **RESTORATION TECHNIQUES**

As mentioned in the Goals and Objectives, different restoration objectives will accompany four different types of revegetation locations: 1) soil covers with biota barriers, 2) soil covers without biota barriers, 3) remedy areas without soil covers but where the topsoil has been removed, and 4) areas inside and outside the remedy where topsoil still exists. All four types of areas will eventually require native revegetation. The first three categories, however, will also require construction of soil by mixing organic amendments with parent material. Many of the methods described below pertain to most of these four revegetation situations and therefore will be discussed simultaneously.

A variety of revegetation techniques will be employed to establish, maintain, and monitor the desired plant communities on the Refuge. Six general techniques are reconnaissance, soil building, seeding, transplanting, construction, and research and monitoring, although methodology varies between types of revegetation location.

Almost all revegetation sites are expected eventually to grow native plant species. However, many of the remediation sites that will need to be restored eventually to native vegetation may require other interim or temporary types of revegetation. In general, permanent revegetation with native seed mixes will occur only when the disturbance at the site is complete (Figure 13). Interim revegetation with perennial grass species (e.g., crested wheatgrass, slender wheatgrass) will occur when the site is

expected to be redisturbed, but not for at least one year. Crested wheatgrass may be desired if prairie dog immigration is a concern because of its tall, unpalatable status. Temporary revegetation should be conducted when the site is to be redisturbed in less than a year but with enough time to establish an annual plant species (e.g., winter wheat) for preventing erosion and perhaps providing temporary wildlife habitat. A more precise definition of when to conduct each type of revegetation is determined by when the site is available for revegetation; frequently, a site will need to be planted with a temporary seeding until the timing is appropriate for an interim or permanent one (Figures 14-16).

To improve efficiency and allow specialization in revegetation, the Service will conduct all permanent revegetation unless particular circumstances require contractor support (Table 6). Temporary and interim revegetation will be conducted by a seeding subcontractor working for the Program Management Contractor. Seedbed preparation for interim and temporary revegetation are described in Appendix D and will not be repeated here.

## RECONNAISSANCE

Reconnaissance includes study of existing information on the site to be revegetated, mostly by viewing maps regarding soils, vegetation, contamination, and other projects in the area. This information should be available from the PMC for all remedy areas, including when the disturbed area will be available for revegetation, regardless of biota barrier or topsoil status. Information gathering is followed by site visits. If all obstructions to revegetation of the site are removed, then the boundaries of the site are marked and, if necessary, the soil is sampled for specific data to identify which amendments and changes in the seed mix would be most appropriate.

## SOIL BUILDING

On-site mitigation will require construction of new soils wherever cover or borrow sites have permanently lost their topsoil. An RVO/Regulators team has been working on this problem to resolve issues regarding volume, storage, soil chemistry, timing, costs, delivery, availability, and incorporation of amendments. At present, a variety of organic amendments are available to build soils, although biosolids may be the most economic. The chosen product must have a carbon to nitrogen ratio of approximately 30:1; high nitrogen levels may be reduced by mixing organic amendments with wood chips or sawdust. Product choice should also consider presence and degree of weed seed contamination. If compacted, sites with exposed parent material will be chiseled or ripped before soil amendments are spread over the top at a rate of 40 tons/acre and incorporated by rototilling or disking.

Soil building will rarely, if ever, be necessary for sites that still have topsoil. Thus, off-site mitigation areas and remedy/borrow sites with intact topsoil will go directly to soil preparation and seeding.

## SEEDING

Two types of seeding (broadcast and drill seeding) will be used to revegetate the vast majority of the acreage. Grasses, forbs, shrubs, and some succulents can all be planted using these seeding techniques. Broadcast seeding frequently is preferred for native plantings in areas that have undergone extensive seedbed preparation. Drill seeding will be used for planting cover crops and interseeding native seed mixes into existing vegetation or litter. Either technique can be used regardless of revegetation location and will be chosen on a case-by-case basis.

Seed Mixes: Five basic native seed mixes suitable for nine soil types found on the Refuge have been developed to approximate plant communities that probably existed here historically (Tables 8-12). Each of these are appropriate for any site without a biota barrier. A variety of factors were used to create these mixes (Figure 17), including examination of existing prairie communities on and near the Arsenal, literature review, and testing of mixes. These mixes are intended to provide a start to the planting process, but easily can be altered to meet specific site objectives (e.g., prairie dog habitat) or conditions (e.g., different degrees of moisture, slope and aspect).

Two additional mixes (Tables 13-14) have been developed for remediation covers with biota barriers; they approximate other mixes for sandy and loamy soils, but do not include species that might compromise the integrity of the covers. They also include more than one variety of some particularly important species to ensure that various climatic changes will not result in failure of the covers. These mixes were developed by the Vegetation and Erosion Group, a team of RVO and Foster Wheeler personnel and EPA and the Colorado Department of Public Health and Environment consultants; as with any mixes, they are subject to change based on future information.

All species listed in Tables 8-14 are considered native or, in one or two cases, near the fringe of their pre-settlement ranges. However, these seed mixes do not list all species that may have existed here in the past, and therefore the mixes may be altered or supplemented with additional species. Changes will usually include desirable forbs as they become available, or exclude one or more species that are either already established on the site, unusually expensive, or difficult to establish from seed.

Two additional seed mixes have been developed for specific needs. One mix (Table 15) is designed to discourage burrowing mammals, especially prairie dogs, from colonizing certain areas (e.g., boundary containment systems). Another (Table 16) is appropriate for preventing erosion in and adjacent to drainage ditches. In the future, rare plants may be seeded or otherwise established in suitable habitat on the Refuge, but would be planted in such a manner as to not interfere with remediation.

The species and the amount of seed per acre can (and often should) be manipulated to achieve site-specific objectives and conditions. In many cases, the seed mix should be recalculated based on the percentage of grass desired. The Service normally uses a

standard of 50 pure live seeds per square foot for drill seeding. In the past, the Service doubled that rate for broadcast seeding because broadcast seed is incorporated into various depths of the soil, including the surface where it may be eaten or blown away. However, the Service recently increased the percent of forbs and shrubs in the mix and discontinued doubling rates for broadcast seeds. The following is a very simplified demonstration of how seed rates can be calculated for:

<u>Species</u>	<u>% of Community</u>	<u>Seeds/sq. ft.</u>	<u>Seeds/acre</u>	<u>Seeds/lb</u>	<u>Lbs PLS/ac</u>
A (grass)	50	25.0	1,089,000	110,000	9.90
B (grass)	25	12.5	544,500	220,000	2.48
C (grass)	20	10.0	435,600	825,000	0.53
D (forb)	3	1.5	65,340	570,000	0.11
E (shrub)	2	1.0	43,560	65,000	<u>0.67</u>
				TOTAL	13.69

One key to developing an appropriate seed mix is to arrive at an appropriate “% of Community” figure for each species. The Service commonly assumes that approximately 90-95% of the pure live seeds should be grasses and 5-10% be forbs/shrubs to approximate the desired grassland community, although this figure can be easily adjusted. Manipulation of the % of Community should be followed by over- or under-representation of each species in the seed mix. This manipulation may be done to meet site-specific factors (e.g., anticipated colonization by prairie dogs), but more frequently to adjust for factors such as the ability or inability of a plant species to become established after germination, or to out-compete other plants within the seed mix or already established on the site. One PLS pound of Species A may have a very similar germination rate as one PLS pound of Species B, but be very different in rate of establishment. Manipulations of % of Community will be important for all revegetation locations, but may be particularly significant on covers with biobarriers. Species (and subspecies) and their desired percentages will be picked to minimize the probability of compromising the covers barriers while also ensuring erosion control in a variety of climatic conditions over hundreds of years.

Seed from most species can be purchased from local and regional seed companies. Nevertheless, the Service intends to collect seed from several species on the Refuge to obtain genotypes best suited for local climatic and soil conditions. Some species most likely to be collected and planted are blue grama (*Bouteloua gracilis*), needle-and-thread (*Stipa comata*), Canada wildrye (*Elymus canadensis*), rubber rabbitbrush (*Chrysothamnus nauseosus*), sand sagebrush (*Artemisia filifolia*), and yucca (*Yucca glauca*). Seeds from other species will be collected opportunistically. Collection techniques will vary but usually will involve either mechanized seed collection equipment or volunteers using hand labor. In addition, the Service recently has collected native grass and forb seed of other species at Ft. Carson and expects to expand this effort at that military installation and other suitable governmental and private properties near the Refuge. Currently, the Service is initiating a partnership with

Foster Wheeler and the City and County of Denver to have seed of at least 80 species (mostly forbs) collected, propagated, and planted into new propagation sites.

The Service also is developing its own on-post seed and living material production facilities to provide the desired genotypes of several commonly planted species and to cut costs in the future. Two sites currently being developed as production facilities are the ballpark area (approximately 1.5 acres) in the southeastern corner of Section 34 and another site in southwestern Section 3. The ballpark site had an existing underground irrigation system, and the Section 3 site has recently been equipped with a solid set system, which will be invaluable for producing native seed rapidly. However, prairie dogs must be excluded from such facilities. Additional propagation sites, including a nursery and greenhouse, may be located south of Rattlesnake Hill adjacent to a future environmental education center, in southeastern Section 34 with access to an existing irrigation system, or in the Western Zone in conjunction with future Service infrastructure (e.g., Visitor Center, maintenance center). The Service currently is discussing a separate partnership with Denver for the potential construction and sharing of a 5-acre greenhouse and 8-acre nursery on the Refuge.

Plot Size: This discussion is significantly affected by location of revegetation; that is, whether the site is in a disturbed area, such as a remedy or borrow site. For on-site areas, availability of disturbed sites large enough for efficient seeding and irrigation is a crucial determining point. Aqua Engineering, an irrigation subcontractor for the PMC, is designing irrigation systems for almost all revegetation on the Arsenal, regardless of whether the restoration project is located on or off the site of disturbance; Figure 18 demonstrates an early version of this draft design.

For off-site areas, the size of restoration plots will vary depending mostly on efficiency of irrigation but also on existing vegetation, wildlife needs, and availability of funding. In addition to irrigation concerns, larger areas are more effective in controlling weeds and concentrating restoration efforts, while smaller areas are more quickly recolonized by small mammals, other wildlife, and invertebrates. Where appropriate, the Service will leave existing habitat islands within a revegetation site as refugia for small mammals. The size and number of such islands will be determined by subjectively evaluating existing vegetation and wildlife. Shrub clusters and pockets of native vegetation already are being preserved. Preserving islands of some weedy species, such as woolly mullein (*Verbascum thapsus*), would be less detrimental to the restoration efforts than preserving other more aggressive species, such as Canada thistle.

Seedbed Preparation: Seedbed preparation techniques will vary depending on the soil type, existing vegetation, current and former use by prairie dogs, anticipated future wildlife use, time since last being prepared, availability of water and equipment for irrigation, etc.

*Weedy sites with irrigation.* Most remedy and borrow sites will not have many weed problems, although some interim and temporary species might require controlling to

ensure success of permanent plant communities. Many off-site areas have not been tilled in several decades and are currently dominated by highly competitive weedy species. The Service frequently will follow a sequence similar to the following scenario in highly weedy sites when irrigation is available:

- Mow (to facilitate plowing).
- Chisel (to facilitate plowing in some clayey soils).
- Plow 9-14 inches (to bury weeds and weed seed).
- Disc 4-6 inches (to break up soil).
- Harrow (to level the soil surface).
- Seed native mix (usually broadcast fluffy seeds and drill others).
- Harrow (to lightly bury seeds or erase row effect from drill seeder).
- Irrigate for one growing season.

*Weedy sites with irrigation and a significant native component.* Sites that are weedy but have a native component worth saving may be approached in the following manner:

- Spot-spray weedy areas with glyphosate or other approved herbicide in spring.
- Interseed by drill seeding native mix into untilled soil in late spring.
- Irrigate for one growing season.

*Weedy sites with no irrigation.* For those sites that are highly weedy but no irrigation is available, the Service will probably conduct one of the multi-year strategies outlined below:

- Mow, sweep, or spot-spray weedy areas with approved herbicide during growing season prior to restoration to control weeds and weed seeds.
- Mow (to facilitate plowing) in spring.
- Chisel (to facilitate plowing in some clayey soils).
- Plow 9-14 inches (to bury weeds and weed seed).
- Disc 4-6 inches (to break up soil).
- Harrow (to level the soil surface).
- Seed native mix (usually broadcast fluffy seeds and drill others).
- Harrow (to lightly bury seeds or erase row effect from drill seeder).

or:

- Mow (to facilitate plowing).
- Chisel (to facilitate plowing in some clayey soils).
- Plow 9-14 inches (to bury weeds and weed seed).
- Disc 4-6 inches (to break up soil).
- Harrow (to level the soil surface).
- Seed summer cover crop (usually drilled) in late May.
- "Sweep" site with blade plow or cultivator (or spray with glyphosate) as needed.

Interseed winter cover crop (drilled) in late August.  
Repeat summer cover crop if necessary.  
Disk 4-6 inches to kill weeds in early spring.  
Harrow.  
Seed native mix (either drilled or broadcast).  
Harrow (to lightly bury seeds or erase row effect from drill seeder).

The summer cover crop may be sorghum and the winter crop may be winter wheat, although the Service is investigating additional species that may be able to fill this role. Cover crops should out-compete weeds, provide interim wildlife habitat (cover and perhaps food), and prevent erosion. Their main purpose, though, is to allow time for (1) the survival of annual weed seeds to diminish and (2) the Service to control weeds that germinate on-site before planting an expensive native seed mix.

Sweeping is a process that involves moving a blade plow or cultivator just under the soil surface to kill weeds by cutting roots with minimal soil disturbance. Interseeding (also called overseeding) uses drill seeding equipment to seed a site without tilling the area again.

*General.* The timing of these soil preparation steps can vary. In general, seed mixes can be planted in the fall, winter, or early spring unless the particular strategy used specifies a particular time for planting. Warm season grasses, which dominate most of the native seed mixes, are more easily established when planted in the spring. If moisture is certain to be adequate (i.e., from irrigation), the timing of planting becomes less significant and can be delayed until late spring. Sweeping usually would take place the spring following planting of a cover crop and immediately before interseeding. However, flexibility in both timing and methods is crucial because numerous unpredictable factors (particularly climatic conditions) greatly affect the outcome of the project. Approximately 40 percent of the Refuge lies within the Bald Eagle Management Area. Access to the BEMA is closely regulated for six months of the year (October 15 through April 14), which can significantly influence the timing of some habitat restoration projects.

Fertilizer may not be necessary for converting weedy sites to native vegetation, although the soil at each site should be analyzed to determine inadequacies. Nitrogen in particular appears to hinder more than help native prairie plantings because many native species require relatively little nitrogen, while many annual weeds readily use excess nitrogen fertilizer to quickly out-compete the natives. Techniques that actually reduce availability of soil nitrogen are being tested as a means of providing a competitive advantage to native plantings.

Considerable flexibility must be used in restoration seeding to respond to daily or seasonal conditions or new, innovative methods. For example, hand broadcasting of cottonwood seeds could be used in association with reconstruction of First Creek when

soil is exposed, although traditional plantings of saplings and seedlings probably will dominate tree planting efforts.

At a later date, the process could be followed by weed control, if necessary. Various techniques are presented under Maintenance of Seeded Areas below.

Irrigation of Seeded Areas: Water may be the most significant factor in establishing native prairie from seed. The Refuge averages only 12-15 inches of precipitation per year, although some years (e.g., 1994) may receive much less. The timing and frequency of that precipitation often determines success or failure of revegetation efforts. Therefore, the Service is supplementing natural, unpredictable precipitation with irrigation of seeding projects wherever possible. Summer irrigation should significantly increase the success of grassland restoration projects, particularly for warm-season species, and provide opportunities to interseed additional sites instead of tilling and seeding them. Most irrigation will be limited to one growing season; however, the Service will irrigate some sites for longer periods, such as the demonstration plots at the Visitor Center in Section 2 and various propagation sites, partially because of their high visibility, utility for producing seed for other sites, and proximity to sources of water.

One of several different irrigation systems will be used depending on site-specific conditions. Linear move or similar systems that spray the ground underneath them will be used in many long, uniform sites where slopes are 6% or less and no obstacles (e.g., trees, electric poles) are present. Sideroll systems will be used in similar sites, although plots will not have to be quite as large, flat, uniform, or obstacle-free. Above-ground solid set systems (i.e., line systems) and possibly water guns will be used where the terrain is even less uniform, large, or obstacle-free. Above and below-ground solid set systems will be used in small, intensively managed areas, such as research plots, demonstration plots, and seed production facilities. Wherever possible, solid set systems will be automated to turn on and off at predesignated times, particularly at night when competition for water is reduced.

Restoration sites will be irrigated for only one growing season unless drought, logistical delays in initiating irrigation, or similar conditions warrant further watering. Normal irrigation will require 2 inches of water per month for June through August. Under ideal circumstances, a grassland restoration project will be watered at 1/4 inch twice per week for the first two weeks of June, 1/2 inch per week for the last two weeks of June, 1 inch every other week for the next 6 weeks, and 1/2 inch every other week for the last two weeks of August (Table 17). The frequent early waterings will help germination. As the seedling becomes larger, irrigation will remain at 2 inches per month but will become less frequent. This technique should force plant roots to "chase" the moisture deeper into the ground. Irrigation will be reduced in late August to help the plant to "harden off" and be ready for cooler weather. The method described above will be used whenever, conditions allow; however, if workloads exceed labor capacity, the

Service reserves the right to omit the 1/4 inch applications and go straight to 1/2 inch irrigations.

In general, large remediation and borrow sites will be irrigated mostly by linear move systems or similar large, partially automated systems. However, parts of these sites may be irrigated by other systems, as conditions require. Relatively small sites on the outskirts of bigger irrigated projects may not be irrigated at all. Similarly, small remediation sites located far away from irrigation sources may be seeded and mulched in the fall without any irrigation applied the following summer. These decisions will be made on a case-by-case basis by the Terrestrial Revegetation Committee.

**Maintenance of Seeded Areas: Prairie restoration is a process; there are no recipes for instant success!** Each restoration site will require at least 3-5 years of somewhat intensive management to become established, mostly due to relatively slow growth of most native perennial species, competition from weeds, and low or erratic natural precipitation. Fortunately, recent improvements in how irrigation is planned, weeds controlled, seedbeds prepared, and seed planted make success much more probable on the first attempt. Nevertheless, each prairie type will require some level of management, the degree of which will depend on a variety of factors such as location, competition from weedy species, presence of certain native plant species, the potential impact of different management strategies on key wildlife species, etc. Some weeds are more detrimental to prairie restoration than others and would require more work to control. Some native plant species are considered more valuable or more susceptible to competition from weeds, for which a more aggressive form of management may be needed. Sites where management might impact certain wildlife species (e.g., bald eagles) might receive less attention than others, unless management would directly benefit the wildlife species of concern and could be accomplished without creating an unacceptable impact to those species.

Conversely, some sites will receive more attention than others. Prairie sites located near human-use areas and especially those serving as demonstration plots will be more micro-managed than others. The Visitor Center demonstration plots, for example, will require more "hands on" work to reach later seral stages quickly. This type of project will involve considerable labor from groups such as the Youth Conservation Corps, National Civilian Community Corps, environmental education programs, scouts, and special event participants. In particular, the Service has created a partnership with the Denver Botanic Gardens (DBG) and Shell Oil Company, whereby DBG interns and volunteers will take responsibility for these demonstration plots for 3-5 years. Similar work is being initiated along the Rattlesnake Hill Trails. Maintenance can be accomplished at these sites by hand-pulling weeds, raking seed into the soil where needed, transplanting grasses, forbs and shrubs from elsewhere on the Refuge, or irrigating all or portions of the areas.

The type of management also would vary, but usually would involve one or more forms of weed control. Weeds, along with normally limited and unpredictable precipitation,

constitute serious obstacles to revegetation success at the Refuge. Weed control is conducted under the Integrated Pest Management Plan (U.S. Fish and Wildlife Service 1996b). The IPM program can include mechanical, cultural, chemical, and biological means, often in conjunction with each other, to control undesirable plant species.

Historically, the Service has tried to avoid use of herbicides, fire, grazing, and fallowing on the Refuge. However, the Service recently (spring of 1996) reintroduced fire as a management tool; fire could be used to control some weeds, as well as reduce litter and stimulate growth of native communities in many restoration areas. Some of the shrubland/succulent areas would not be burned or would be burned very carefully using a slow, cool fire. The Fire Management Plan (1999) will guide these efforts.

Some sites are mowed to control undesirable species, such as annual rye (*Secale cereale*). Weedy species in other sites may be killed by "sweeping" just under the soil surface with a blade plow or cultivator or other form of mechanical treatment. Some areas could be irrigated to stimulate the desired species, which would successfully compete with weedy species. Others could have sucrose (or similar but less expensive product) applied to reduce competition from annual weeds; sucrose is used as a carbon source by soil microbes which also reduce availability of nitrogen in the soil and provide a competitive advantage to native plants. Use of biological controls could be expanded (*albeit* cautiously) to more easily and efficiently treat some weedy species with species-specific parasitic organisms (e.g., insects or nematodes) in areas where instant eradication is not required; current candidates for such treatment are Russian knapweed (*Centaurea repens*), Canada thistle, and field bindweed in selected locations. Grazers, such as native bison or exotic Cashmere goats also could be used to control weeds and stimulate growth of natives in temporarily fenced areas, especially if they would not be used until completion of remedy or if they would remain on the Refuge if used before completion of remedy. The Service will use approved herbicides (e.g., glyphosate) in conjunction with other weed control techniques as a last method of controlling noxious weeds. The Service proposes to eliminate Russian olive through a combination of girdling larger trees and leaving snags in place as perches, cutting and pulling smaller plants and, if necessary, injecting an appropriate herbicide into medium to large plants to eliminate sprouting; Russian olives in riparian areas will receive a higher priority for control than in other sites.

Some sensitive habitats may need to be fenced until there is no longer any danger of their being destroyed accidentally. The cobble soil vegetation on Rattlesnake Hill and the sandhills prairie remnant near Quebec Street are good examples of the effectiveness of only a single strand of smooth wire fence and some signs. Fencing and installing signs should be used to limit entry by people or wildlife (e.g., deer, prairie dogs) in particularly sensitive areas or during the establishment of plantings (at least three and preferably five years for most plantings). More aesthetic alternatives to fencing should be sought to exclude prairie dogs from highly visible areas, such as small prairie vegetation demonstration plots at a visitor center; some devices that

generate high-frequency vibrations in the soil have proven successful elsewhere on other burrowing mammals.

## PLANTING AND TRANSPLANTING LIVING PLANT MATERIALS

Some habitat restoration will be accelerated by planting materials other than seed. Transplanting will be the most common form of planting living material; in the past, this operation has usually involved shrubs. Shrub plantings will continue in the future, but wildflowers, plugs of grass, and succulents also may be planted. As with seeding, some rare plants may be transplanted to the Refuge, subject to availability and resolution of potential interference with cleanup and other activities.

The Service purchases much of its living material from commercial sources, although the Denver Botanic Gardens has provided several thousand small shrubs that were unavailable commercially. The Service now is attempting to construct a greenhouse and nursery, possibly in a cooperative effort with the City and County of Denver, to produce numerous species of forbs, shrubs, trees, and other species. The products of this effort will be mostly species that are difficult to find (at least in local genotypes), difficult to germinate and establish under normal field conditions, or prohibitively expensive. The resulting plants would be planted both within restoration sites and specially designated propagation areas, depending upon the species.

Planting Shrubs: Thousands of shrubs already have been planted on the Refuge (Figure 7), with varying degrees of survival. Five-gallon containerized plants have been planted in nine sections; containerized shrubs are much more expensive than bare root or seedling shrubs but usually have the highest survival rate, which is very useful when quick success is imperative and water is relatively easy to apply (e.g., at the Visitor Center, along trails, beside BEMA gates). Thousands of bareroot and seedling shrubs have been planted in 12 sections of the Refuge. These plants are inexpensive but have a much lower probability of survival than larger shrubs with better developed root systems. Weed barrier material has been installed over most of these shrubs to retain soil moisture and inhibit competition from weeds. While many shrubs have been planted in rows to maximize use of water along ditches and between underground lines in boundary containment systems, most shrubs in the future will be planted in clusters to simulate natural conditions, enhance use by songbirds and small mammals, and increase efficiency of both irrigation and protection from excessive depredation by wildlife. Species resistant to deer browsing will be used more frequently than in the past; however, other species will be planted and protected from over-browsing until a thicket is formed. Although fences are not aesthetically pleasing, they should not be removed before the plants are able to sustain browsing and antler damage. Fencing excludes deer (and only deer) from very little cumulative area.

The Service currently is attempting to produce shrubland from seed to produce more natural and less expensive mitigation projects. Early attempts at this process failed, but further information available from the literature, RMA revegetation research, and RMA

field experience suggests that certain species can be seeded. Other species will continue to be planted.

Sites possessing remediation covers with biobarriers are least likely to be planted with living material because trees and most shrubs will be inappropriate on these sites. Any area without biobarriers would be a candidate site.

The Service will continue to plant shrubs in appropriate places as defined by soil and moisture conditions and their intended future use on the Refuge. The most common species are listed in Table 18. All of these species are considered native or on the fringe of their presettlement ranges. Information concerning appropriate soil types and other conditions identified in Tables 8-18 will help determine the most appropriate locations for planting.

Several of these species (e.g., sand sagebrush, rubber rabbitbrush), a few subshrubs (e.g., fringed sage (*Artemisia frigida*)), and a few succulents (e.g., *Yucca glauca*, *Opuntia* spp.) will be transplanted from areas of the Refuge that might be destroyed during cleanup (e.g., borrow sites), sold at auction (e.g., Section 9 and western portions Sections 4 and 33), lost to rights-of-way expansion, or where they are already abundant. Shovels and tree spades (usually a tractor or loader attachment) will be the two major tools used to collect these plants, depending on their size. The Service has successfully propagated some plants (e.g., western snowberry (*Symphoricarpus occidentalis*)) from Refuge sources through cuttings and will continue this method as well. As mentioned above, the Service anticipates constructing its own plant production facility on the Refuge, located adjacent to both a seed production facility and an environmental education center.

Nevertheless, it is unrealistic to assume that all shrubs can be produced from Refuge sources in the near future, particularly when large numbers of shrubs are needed. The Service will attempt to use plants from the most appropriate commercial source when its own stock is insufficient to meet project requirements.

Planting Trees: Although rarely abundant, four species of trees were probably native to the vicinity of the Refuge: plains cottonwood (*Populus deltoides*), peachleaf willow (*Salix amygdaloides*), hackberry (*Celtis occidentalis*), and box elder (*Acer negundo*). Plains cottonwood will be the most common native tree planted on the Refuge and usually will be planted in moist soils along First Creek and around the lakes.

Trees at some homesteads will be replaced when lost. The Service will replace these trees with native species whenever appropriate. Some of the most common exotic trees currently found on the Refuge are Siberian elm (*Ulmus pumila*), Russian olive, green ash (*Fraxinus pennsylvanicus*), and white poplar (*Populus alba*). Russian olive will not be planted anywhere on the Refuge and eventually will be eradicated.

The Service will employ three major types of tree stock: commercial ball & burlap, poles, and transplanted material originating elsewhere on the Refuge. The most frequently used materials and techniques may involve planting poles in holes augered to the water table, especially in association with the enhancement of First Creek. Poles and transplanted material could be taken from even-age stands elsewhere on the Refuge, such as exists in Section 3 near Lake Mary and C Street. Commercial sources would be sought near the Refuge, if necessary.

Planting Forbs: More species of forbs will be planted as live material than any other group. Many of these species will be derived from local commercial sources in conjunction with special events (e.g., Earth Day, Trails Day). Transplanting forbs from the wild will be somewhat opportunistic, often from the same areas from which shrubs and succulents are removed before being destroyed. However, the Service anticipates that many of the species grown in greenhouse situations will be forbs. Initially, many species of these wildflowers will be planted in demonstration areas, such as the prairie plots at the Visitor Center and along trails. However, additional plants will be used in propagation areas and other restoration sites.

Planting Grasses: Grasses will also be transplanted rather than seeded in a few instances. The most common species of transplanted grasses probably will be derived from western wheatgrass, blue grama, sand dropseed (*Sporobolus cryptandrus*), sand bluestem (*Andropogon hallii*), prairie sandreed (*Calamovilfa longifolia*), needle-and-thread, and Canada wildrye. Material for transplanting usually will be from sources on the Refuge. Transplanting will be accomplished using bulb planters, regular shovels, sharpshooter spades, tree spades, transplanting bars, and a sod cutter. They will be transplanted using appropriately sized containers, such as planting pots. As with forbs, grasses will usually be transplanted to high-visibility sites, such as demonstration plots, or to seed production facilities.

Irrigation of Living Materials: Watering will be required for virtually all live plants, except poles buried into the water table, until they become established. The establishment period may be only the first month following planting for some hardy plants. More often, live plants will need water augmentation during the first one to four growing seasons. Permanent irrigation may be used in the most visible sites (e.g., demonstration plots at the Visitor Center).

Methods for applying water also will vary, depending on site visibility, species planted, proximity to a permanent water source, funding, and availability of labor. The most common techniques will be drip irrigation systems, sprinkler systems, and hand watering. Drip systems are more costly to install and maintain, but they are far more efficient in conserving water by reducing competition from undesirable species directing water to the desired plants. Shrubs in low profile areas will be watered as necessary, usually with truck and trailer mounted water tanks; weed barriers will help reduce the need for watering in these areas.

Maintenance of Living Materials: Maintenance of established plants also will depend somewhat on location and species. Materials planted in high profile areas may be maintained much more aggressively than those planted elsewhere in the field.

Most maintenance, other than irrigation in some areas, will consist of maintaining fences around thickets until they have fully formed, applying wildlife repellent or replacing plastic mesh protectors on some highly palatable species, and weeding.

## WETLAND RESTORATION

The Service has constructed five wetlands in the southeastern portion of the Refuge (Figure 7), two of which historically were wetlands. These wetlands were developed partially as pre-mitigation for unavoidable future disturbance of wetlands during remediation. Future wetland construction may be limited to restoration of previously existing wetlands (Figure 19), except for watering holes and deep borrow pits, which might function as wetlands with appropriate engineering and additional enhancement and management.

Most existing wetlands are located in the First Creek corridor, around the lakes, and in other portions of the southern tier. Most wetland restoration projects would take the form of enhancement of these areas. Other possibilities include restoration of seep-related wetlands in Sections 12, 24, and 31, enhancement of the Rod and Gun Club Pond and Havana Ponds, and expansion of Wetland 2 westward. Several prehistoric playas have been identified in Section 34, but are unlikely to be restored because of current excessive depth of playa bottoms and growth of native upland vegetation on the sites.

The Service has been working with water engineers and wetland consultants to restore First Creek to its "natural" state, at least as much as practicable. The conceptual design was completed in 1994 (McLaughlin Water Engineers 1994), and the final design with construction drawings and contract documents was completed in 1998 (Sellards and Grigg, Inc. and Aquatic Wetland Consultants 1998). As a result of the design work, the Service anticipates that: 1) meanders will be restored in a few straightened portions of this intermittent stream; 2) the bald eagle roost will continue to be protected with additional flood control (e.g., floodwater bypass, drop structures); 3) several existing wetlands will be enhanced by controlling noxious weeds, and planting wetland vegetation; 4) cottonwoods and numerous shrub species will be planted and protected in appropriate locations; 5) other riparian vegetation will be planted near the stream; 6) any borrow site(s) created adjacent to First Creek may be constructed with wetland values and functions as additional objectives; and 7) if the Refuge is required to house a water detention facility on First Creek, the Service will provide specifications for the facility to minimize its aesthetic and environmental impact and increase its potential benefits to wildlife.

## STRUCTURES

Habitat restoration may be augmented by constructing or otherwise producing or maintaining various types of structures. These can include vegetation but usually are fabricated from plastic, metal, or wood). Some of these structures are used to improve habitat for some wildlife species, while others are used to exclude one or more species from a particular area.

Nest Boxes and Other Nesting Structures: Some nest boxes already have been installed on the Refuge to provide nesting habitat for barn owls and kestrels (*Falco sparverius*). Five barn owl nest boxes are being monitored by wildlife specialists to determine whether and where more boxes should be installed. The kestrel boxes were erected by Service contaminants specialists as part of the Biomonitoring Program; some of these and other boxes could be used indefinitely for contamination monitoring and/or wildlife management. Nest boxes for additional species (e.g., bluebirds (*Sialia* spp.)) might be deemed appropriate in the future.

Wildlife biologists have placed structures in various locations on the Refuge to provide nesting opportunities for Swainson's hawks (*Buteo swainsoni*). Additional nesting structures for large raptors may be installed at locations determined by monitoring current use patterns. Both installation and monitoring probably would be accomplished by personnel other than the Habitat Restoration staff.

Artificial Watering Sources: The Service has installed five wildlife guzzlers on the Refuge (Figure 7). These guzzlers are located strategically where other water sources are lacking such that most wildlife are within one mile of a source of free water. Currently, deer, songbirds, and coyotes (*Canis latrans*) are known to use the guzzlers. These structures will be maintained, but no additional guzzlers are anticipated.

Additional watering sources may be created by restoring wetlands and constructing watering holes and borrow pits. Watering holes may simply be gouged out of the earth where clean groundwater is close to the surface or another supply of water can be added when necessary, possibly using windmills to pump from existing alluvial wells. Watering holes probably will not be created unless and until the Service reintroduces bison. Borrow pits will be developed to provide gradefill and capping materials for remediation activities. Depending on where these sites are developed and to what depth, they may or may not reach groundwater. The Service will continue to provide input to the RVO on the size, shape, depth, location, and revegetation of these pits.

Prairie Dog Barriers: The Service will continue to use both vegetation and artificial structures as biota barriers (Figure 7), if needed. These barriers are usually employed to keep prairie dogs from entering areas where they might become contaminated or compromise remediation structures (e.g., underground slurry walls in boundary containment systems). The Service may plant vegetation (e.g., crested wheatgrass, pubescent wheatgrass (*Elytrigia intermedia*)) in contaminated areas to discourage

occupation by most wildlife species, but will supplement containment systems with shrubs that will support wildlife (e.g., ungulates, songbirds) other than prairie dogs.

The Service may construct or recommend construction of fences to keep prairie dogs out of highly contaminated areas. These fences would be constructed so that prairie dogs cannot see over, through, or under the material and would be buried deep enough or at an appropriate angle to discourage any wildlife, including badgers (*Taxidea taxus*), from creating holes under the fence that could be used by prairie dogs. In addition, the Service may use non-lethal electric fences to reduce prairie dog emigration.

Fences: Other fences may be used to protect habitat restoration sites from depredation by wildlife during critical establishment periods, at highly visible locations, and where particularly sensitive (e.g., threatened or endangered) species are planted. In many cases, these fences will be left in place until plants can withstand depredation by wildlife. For example, some clusters of highly palatable shrubs planted along First Creek during restoration of the riparian area will require protection until the clusters become thickets and can survive both browsing and antler scraping by deer; this time will vary widely between species but usually will be 4-10 years. Afterwards, ungulates will have a reliable source of browse, while other species (e.g., songbirds, small mammals) will be able to use the plants immediately after planting.

Fences will also continue to be used to protect habitat from inadvertent disturbance by people and equipment. Two single-strand smooth-wire fences were constructed and signed around remnant prairie communities in Sections 4 and 35, although the fence has since been removed from Section 35. Woven-wire fences have been placed around shrub restoration areas beside BEMA gates. These fences have eliminated destruction by deer and discouraged people from driving around the BEMA gates or over the plants.

## CHAPTER 4: RESEARCH AND MONITORING

Research and monitoring will be an integral part of restoration. Research should provide information to guide future restoration activities in a more effective and less expensive manner. Monitoring will provide information that will determine whether the project is going as planned and suggest further activities for improvement to the site and to future efforts on different plots.

Research: Habitat restoration research will vary depending on need and funding. Currently, the Service is working with restoration specialists at Colorado State University (CSU) to: 1) determine if the use of supplemental water can improve overall plant establishment, establishment of warm season species, establishment of woody species from seed, and increase species diversity; 2) determine if the use of supplemental water in combination with sucrose can accelerate the establishment of native prairie by either eliminating or shortening the time that early seral (weedy) species dominate a restored site; 3) compare the effect of mulching with the use of a cover crop on plant establishment and overall species diversity of the established community; 4) determine if seeding technique (drill vs. broadcast) affects shrub establishment and overall species diversity of the established community; 5) clarify the role of nitrogen in treatment responses; and 6) objectively define restoration "success" in the first year and subsequent years following restoration activity. A final report for the 5-year study will be available in spring of 2000. At that time, additional grassland restoration research will be proposed. Anticipated research topics center around successful but cost effective irrigation and weed control.

Research on the constructed wetlands has been conducted by D'Amico and Cooper (1995). Additional research is being considered for determining: 1) what stage the constructed wetlands have reached in plant succession, 2) where natural, restorable wetland basins exist on the Refuge, and 3) competitive relationships between cattail and bulrush (*Scirpus* spp.) along the water table gradient in created wetlands.

Monitoring: Restoration efforts will be monitored in all restoration habitat types (e.g., grasslands, shrublands, woodlands, wetlands). The Service will be interested mostly in determining success of restoration projects, but also in shifts from one vegetation type to another and in outbreaks of particularly noxious weeds (e.g., Russian knapweed). Success will be measured for both vegetative and wildlife responses to restoration efforts. Specific monitoring techniques will receive detailed discussion in a separate restoration monitoring plan that will be finalized during FY 2000. Some vegetative criteria are provided here because of the direct bearing on mitigation and associated funding; wildlife response may take much longer to determine and therefore will likely result in alterations to plant communities that would be funded by other sources.

*Grassland restoration.* Because most of the Service's mitigation efforts are directed toward grassland restoration, the Service will spend most of its monitoring time determining the success of weed control and establishment of desired vegetation

communities for grassland projects. Vegetation monitoring in these areas concentrates on whether each site meets certain success criteria after a given time and whether trends in cover and density are moving in the appropriate direction.

Restoration success of grassland restoration projects will be judged according to criteria for live vegetation cover, total ground cover (i.e., a total of live vegetation, litter, and rock), and a species diversity requirement. These criteria are important indicators of site stability and wildlife habitat conditions. Diversity measures provide useful information about the structural aspect of the restored plant community. The following criteria are recommended for establishing restoration success:

1. A minimum of 30% relative live cover by desirable plant species (seeded species and/or native non-seeded species).
2. A minimum of 70% total ground cover, including live vegetation, standing dead vegetation, litter, cryptogams and rock.
3. A minimum of 50% of the seeded grass species are to be present on the site.
4. No single species contributes more than 45% of the live vegetation cover (except in areas where a single species or dominance by a few species, provides suitable habitat appropriate for long term wildlife management (e.g., western wheatgrass stands for prairie dog colonies)).

These criteria will be used for most restoration sites at the Refuge, including cover areas without biota barriers, borrow sites, and off-site mitigation areas where exotic or weedy species are being replaced with native prairie species. Separate but similar draft criteria have been developed for Basin A (RMA Vegetation and Erosion Group 1998); these criteria will probably be used for most covers with biota barriers. These draft criteria have been established by the Vegetation and Erosion Group, which includes consultants of the EPA and the Colorado Department of Health and the Environment, and are subject to change.

Cover sites with biota barriers will be monitored annually. Other sites will be monitored during the third and fifth growing season following seeding. Monitoring annually and during the third year will help determine the need for maintenance activities. Success will be based on results from the fifth year's data collection. Percentages of both the fifth year's live vegetation cover and undesirable vegetation will determine whether the native revegetation has been successful or will need to be altered or totally revegetated. If during the fifth year, the vegetation cover is affected by severe weather conditions (e.g., drought) and does not meet the vegetation success standard, then data will be collected in the sixth year. Sixth year values will then be used to evaluate success.

The Service will conduct all vegetation monitoring, regardless of whether or not the restoration project is located on covers with biota barriers. However, the covers with biota barriers will be inspected on a regular basis (RMA Vegetation and Erosion Group

1998) by multiple organizations for any signs of problems from vegetation, erosion, or other factors.

*Shrubland restoration.* Shrubland restoration projects will be monitored using simple counts when planted as live material and using area measurements for those planted by seed. Shrubland restoration projects of live plantings will be considered successful when 75% of the shrubs planted are alive three years following planting. This method will allow for some later loss of shrubs while maintaining at least a 1:1 ratio in the distant future.

Shrubs planted from seed will be considered successful when an average shrub density of one shrub per 45 square feet of the shrubland restoration area is alive three years following planting. This method assumes that these plants will reseed the area to a more dense shrubland within a few additional years.

*Woodland restoration.* Loss of trees equal to or more than 6 inches in DBH are mitigated with using a 5:1 ratio. At this ratio, these trees do not require monitoring to determine success; they are considered "successful" upon planting. However, loss of trees that are less than 6 inches in DBH are replaced at only a 2:1 ratio and therefore the replacement trees will be monitored using either simple counts or area measurements.

*Wetland restoration.* Monitoring of wetland restoration will follow the monitoring described above for wetland woody vegetation or follow U.S Army Corps of Engineers guidelines for other wetland vegetation.

*Noxious weeds.* The Service currently monitor the Refuge for noxious weeds mostly by identifying infestations while conducting other activities, although the Service is currently working with a U.S. Geological Survey intern to map the larger patches of weedy species using infrared satellite imagery. Once noxious weeds are sighted, they are mapped and dealt with as time and funding allows.

*General.* Future restoration also should be accompanied by monitoring wildlife response. The Service anticipates that many songbirds and large, mobile mammals will recolonize most restoration areas quickly, while populations of small, relatively immobile mammals will return slowly. Wildlife biologists are implementing specific monitoring techniques at this time.

## **CHAPTER 5: HEALTH AND SAFETY**

Service employees will work in compliance with the Service's Health and Safety Plan. Supervisors and workers also will work with the Service's Health and Safety Officer to ensure that appropriate precautions are taken to protect personnel from work-related hazards. All employees will attend an entry health and safety orientation and tour. Field personnel also will attend appropriate OSHA Hazardous Materials courses and undergo annual physicals if working in any areas that require such training or physicals. Restoration personnel will receive additional safety information in weekly section and staff meetings, and daily tailgate meetings. All employees will report immediately any health and safety concerns, including but not limited to accidents, near misses, or potential hazards. Each Habitat Restoration employee (both field and office personnel) will have health and safety reflected within his or her Performance Evaluation such that every employee will have additional incentive to ensure the safety of himself/herself, employees, co-workers, and volunteers.

## **CHAPTER 6: CULTURAL RESOURCES**

A Programmatic Agreement has recently been signed which provides more on-site review of soil disturbing projects for cultural resource compliance. However, Refuge staff will continue to work with the Service's regional archaeologist and the Remediation Venture Office's Cultural Resource Team to ensure review of appropriate projects by the State Historic Preservation Office (SHPO) prior to ground-breaking.

Field personnel who find cultural resources will stop immediately any activity that could endanger those resources. They will then inform their supervisor, who in turn will seek advice from the Cultural Resources Team and, if appropriate, the regional archaeologist and/or the SHPO before reinitiating any soil disturbing activity within 100 feet of the site. Additional guidance will soon be available from the Cultural Resources Management Plan currently being developed for the Refuge.

## CHAPTER 7: SCHEDULE

Restoration projects are scheduled to match remediation projects as closely as possible. Therefore, the Terrestrial Revegetation Team is planning restoration of approximately 700 grassland acres/year (beginning in FY 2000) such that most mitigation projects would be at least initiated within one year of the completion of remedy in approximately 9 years. An additional 3-5 years would be needed to complete the last restoration projects. This plan assumes adequate funding and consistently successful projects.

Monitoring is expected to continue for at least 5 years following initiation of any given grassland restoration project. This plan is written to include restoration activities that may be appropriate and possible after mitigation is complete; therefore, some restoration activities will probably occur for several decades following completion of cleanup, but may be limited to volunteer assistance and routine vegetation maintenance on areas without biobarriers. Covers with biobarriers will receive frequent monitoring and maintenance to ensure adequate protection from erosion.

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## APPENDICES

## APPENDIX A: FIGURES

# RVO and Support Organization Chart

September 2, 1999

Commander's Representative

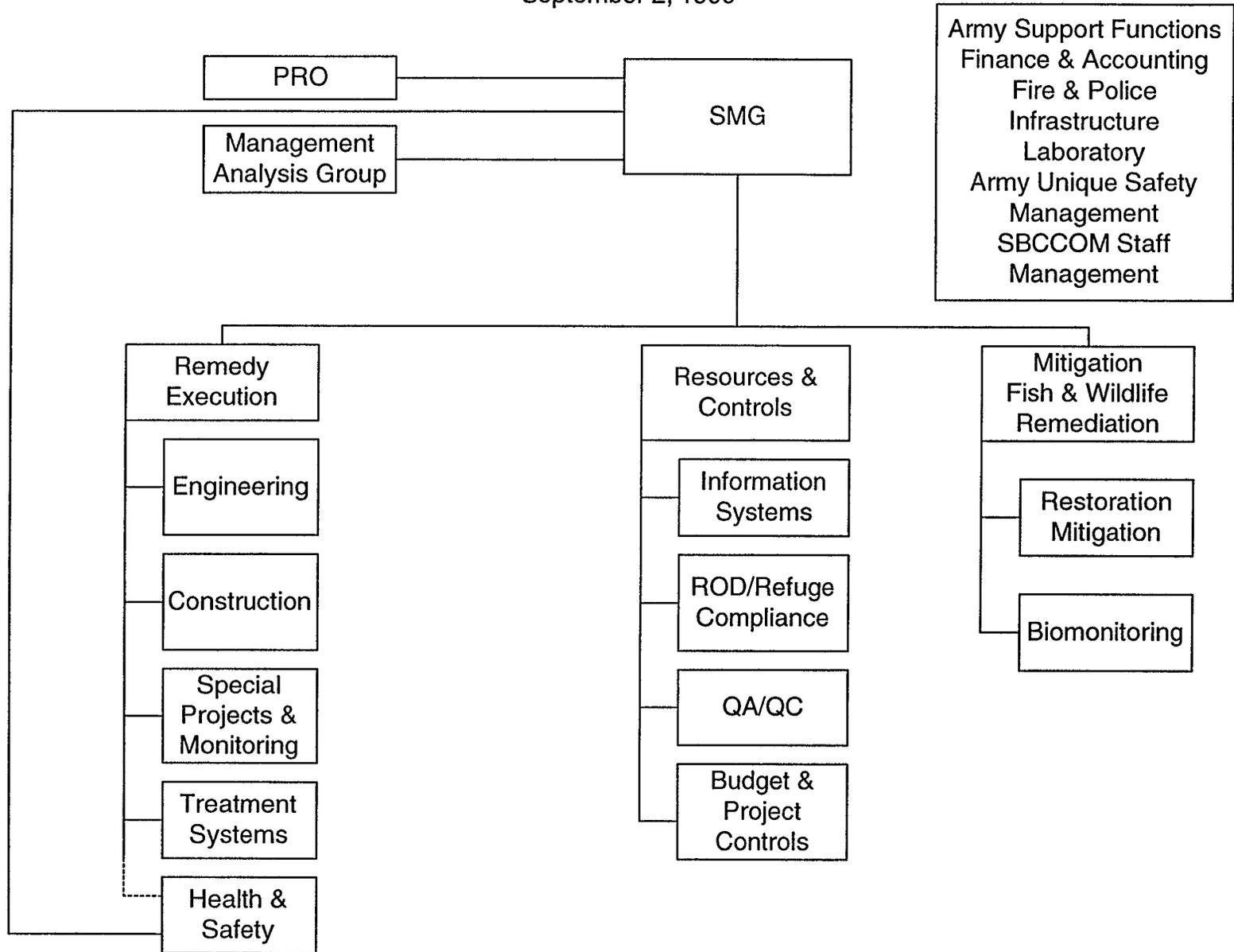
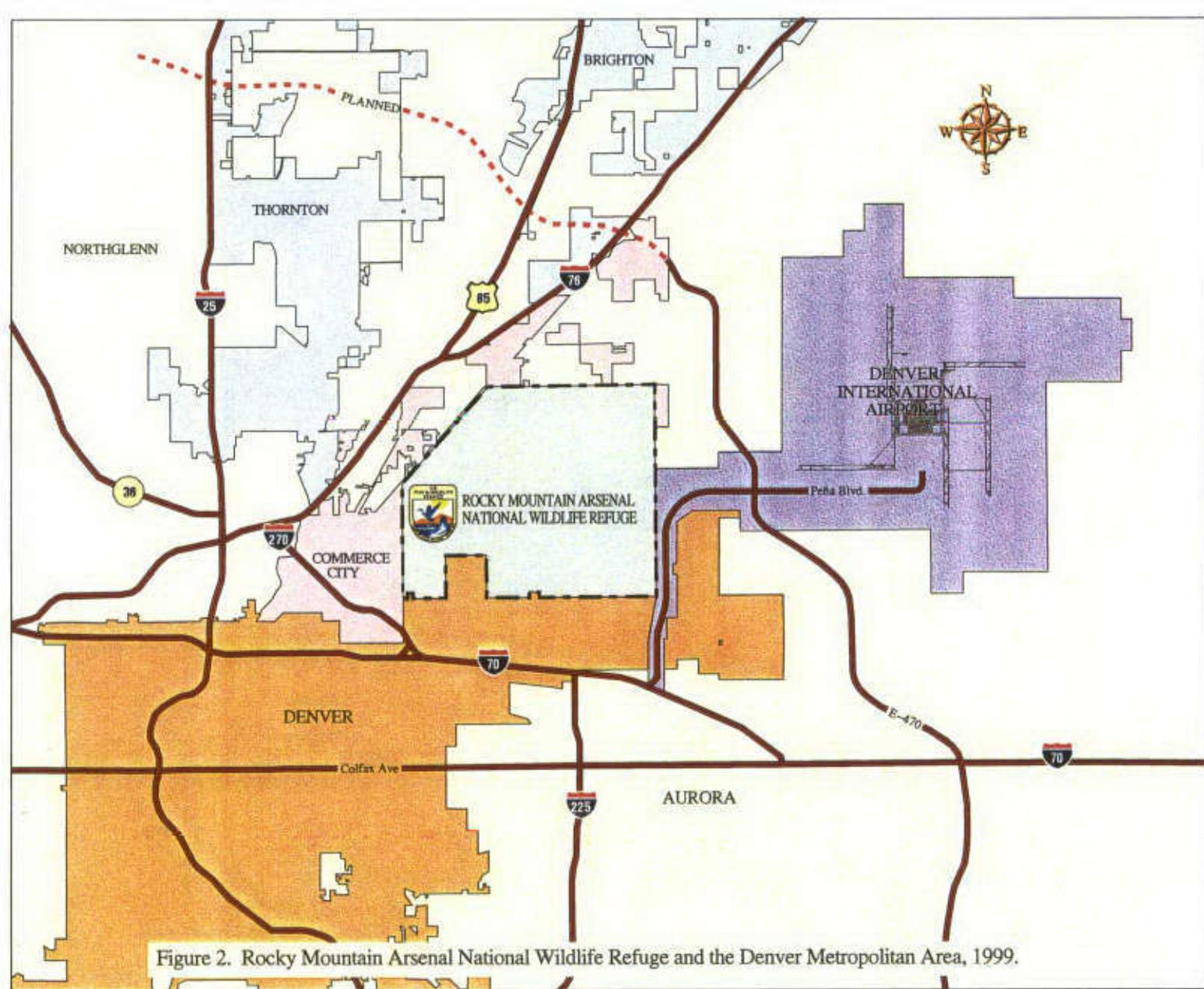
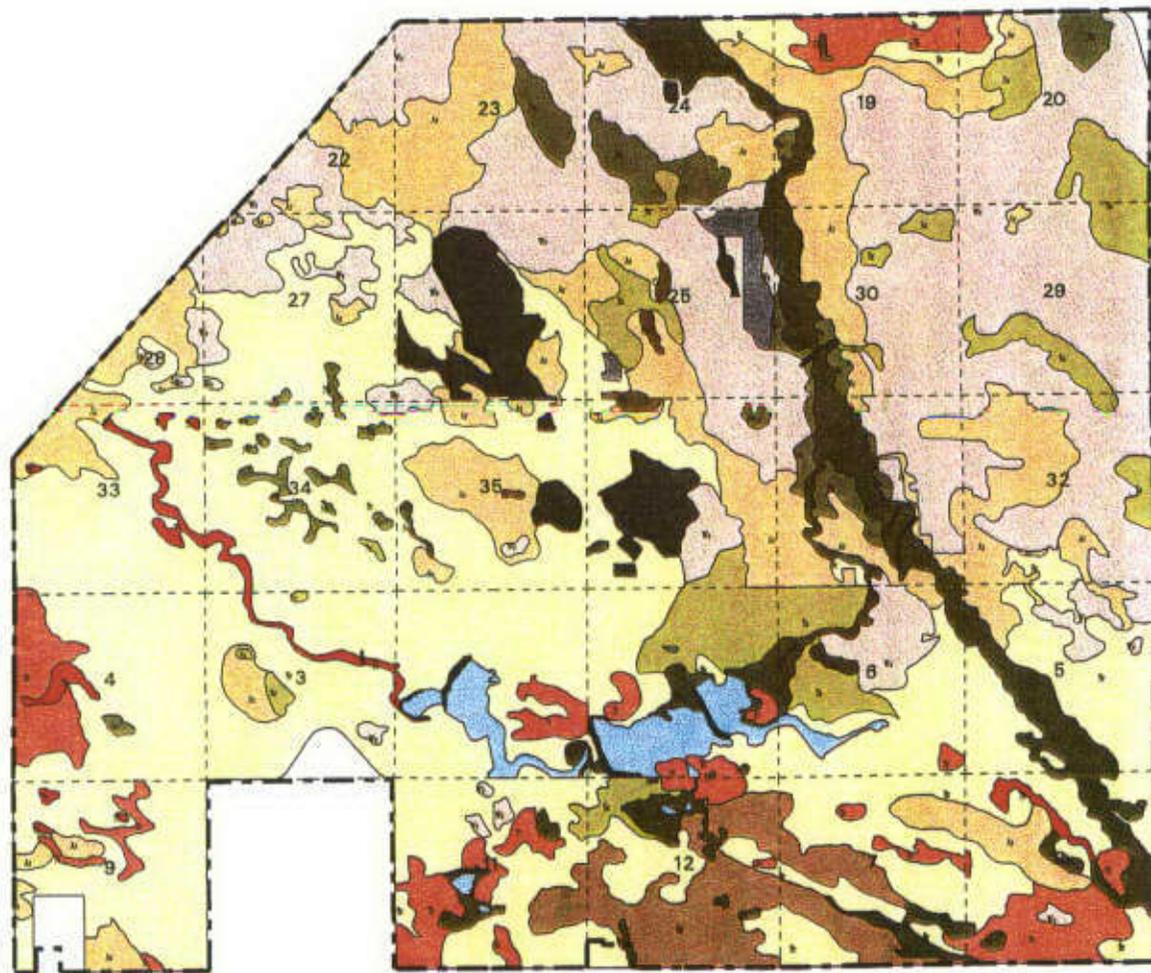


Figure 1. The Remediation Venture Office and RVO Support Structures, Rocky Mountain Arsenal, 1999.



ROCKY MOUNTAIN  
ARSENAL NATIONAL  
WILDLIFE REFUGE  
**1999 SOIL  
CLASSIFICATION**



- Ascalon Sandy Loam (As)
- Bresser Sandy Loam (Br)
- Bresser-Satanta Sandy Loam (Bs)
- Petrocalcic Paleustolls (Ca)
- Aquic Haplustolls (Fa)
- Nunn Clay Loam (Nu)
- Satanta Loam (Sa)
- Typic Haplustolls (Th)
- Truckton Loamy Sand (Tr)
- Weld Loam (We)
- Dam or Dike
- Barrow Pit
- Basin
- Water
- Data Not Available

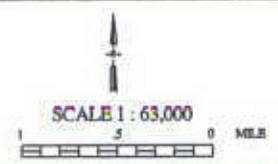
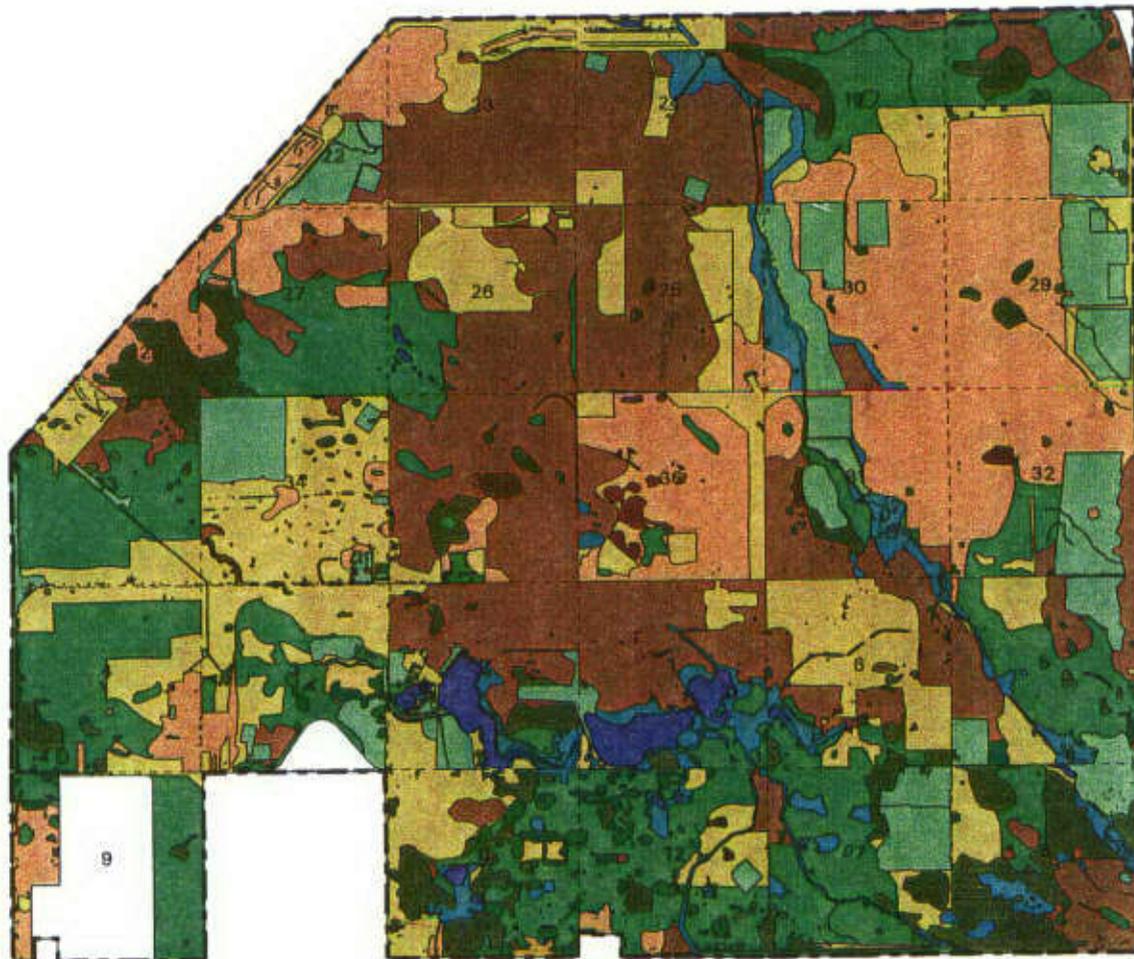


Figure 3. Soil classification for Rocky Mountain Arsenal National Wildlife Refuge, 1999.

August 13, 1999

ROCKY MOUNTAIN  
ARSENAL NATIONAL  
WILDLIFE REFUGE

**1999 VEGETATION  
CLASSIFICATION**



Classifications

-  Weedy Forbs
-  Cheatgrass/Weedy Forbs
-  Native Perennial Grassland
-  Crested Wheatgrass Stand
-  Shrubland/Succulents
-  Locust Thicket
-  Wetland
-  Tree Grove
-  Lawn
-  Seeded Area
-  Cereal Rye
-  Cobble Soil Vegetation
-  Alfalfa/Sweetclover
-  Bare Ground
-  Unclassified
-  Water

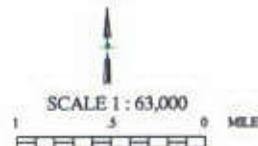
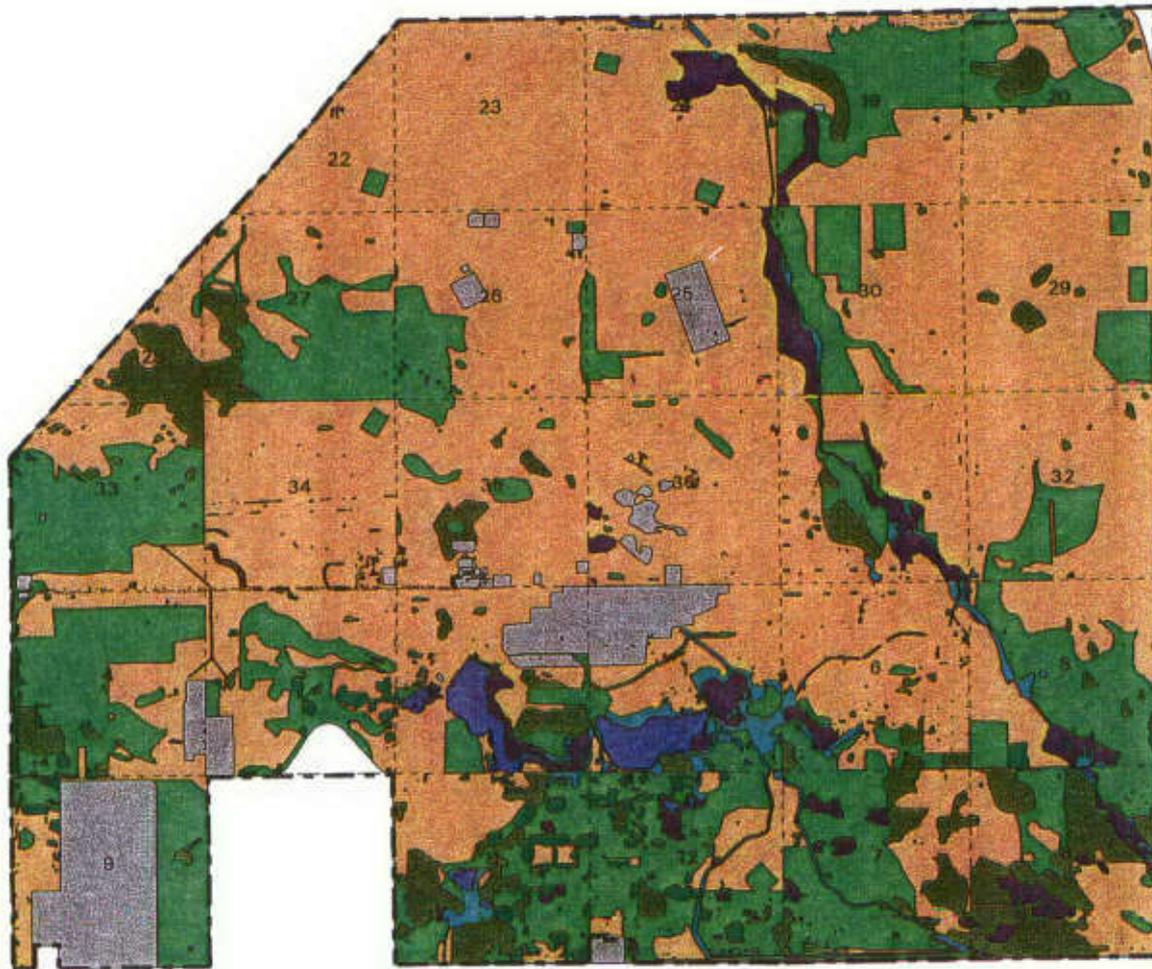


Figure 4. Vegetation classification for Rocky Mountain Arsenal National Wildlife Refuge, 1999.

August 13, 1999

ROCKY MOUNTAIN  
ARSENAL NATIONAL  
WILDLIFE REFUGE  
**Habitat Classification for  
Wildlife Value Assessment  
1999**



- Weedy Forbs/Grasses
- Native Perennial Grasses
- Shrubland/Succulents
- Upland Trees
- Wetlands
- Riverine/Riparian
- Lacustrine
- Disturbed
- Unclassified

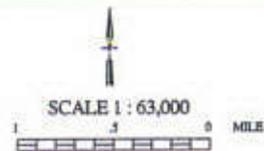


Figure 5. Habitat classification for Rocky Mountain Arsenal National Wildlife Refuge, 1999.

August 13, 1999

ROCKY MOUNTAIN  
ARSENAL NATIONAL  
WILDLIFE REFUGE  
1989- 99 BEMA Habitat  
Manipulation Sites

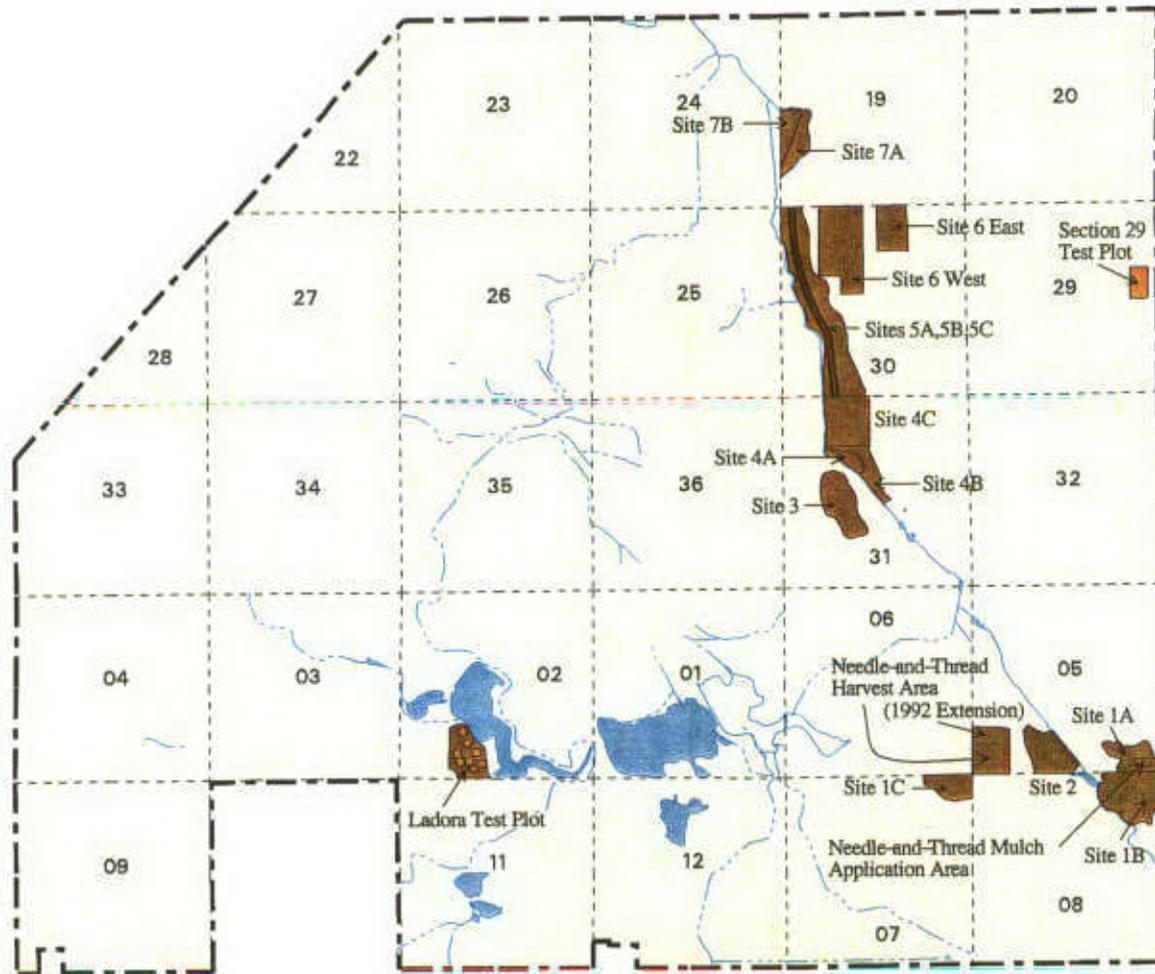
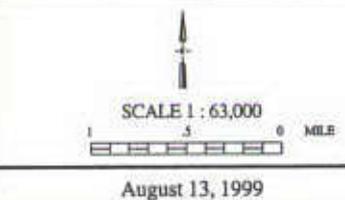


Figure 6. Bald Eagle Management Area (BEMA) habitat manipulation sites for Rocky Mountain Arsenal National Wildlife Refuge, 1989-99.



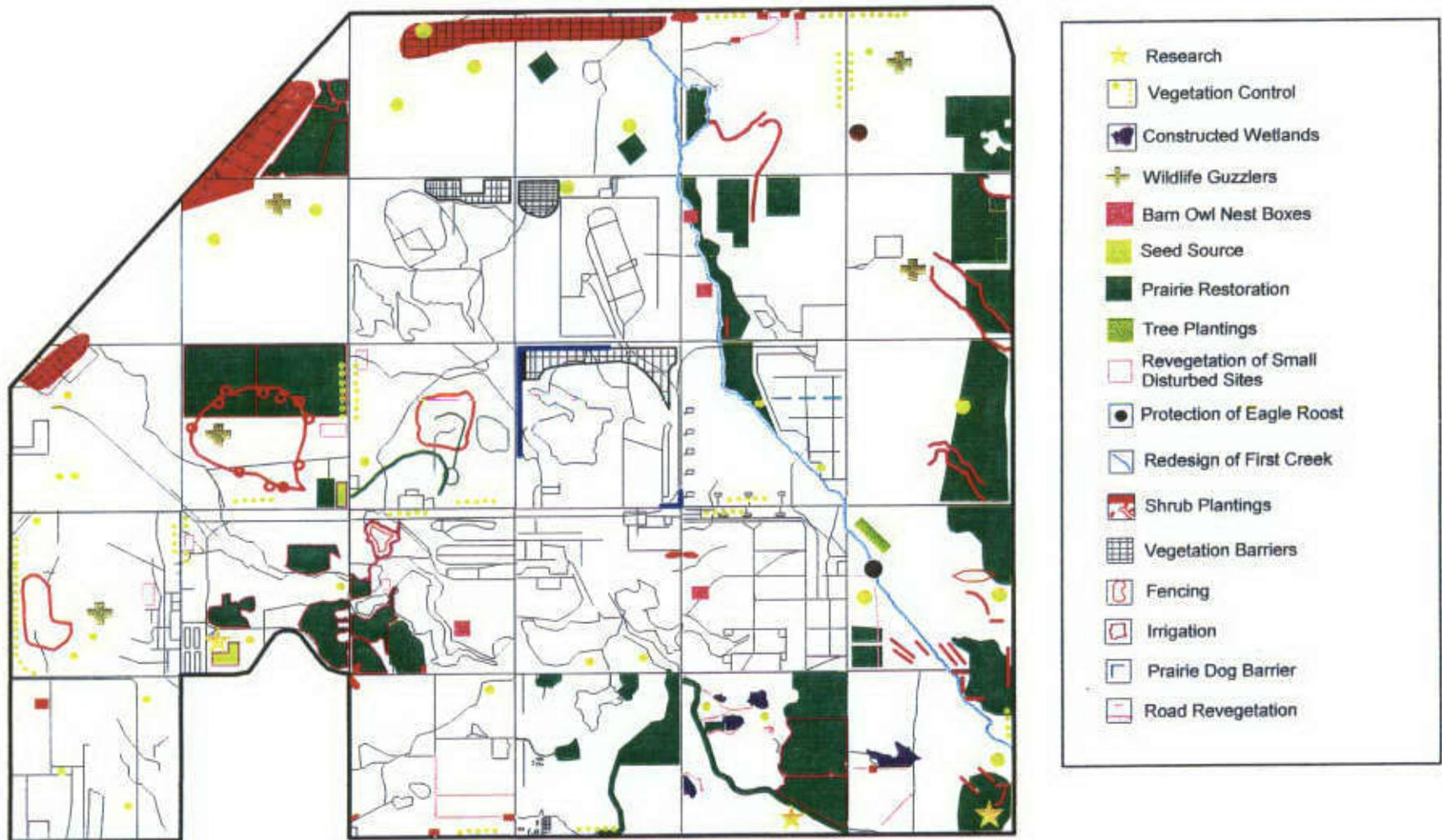
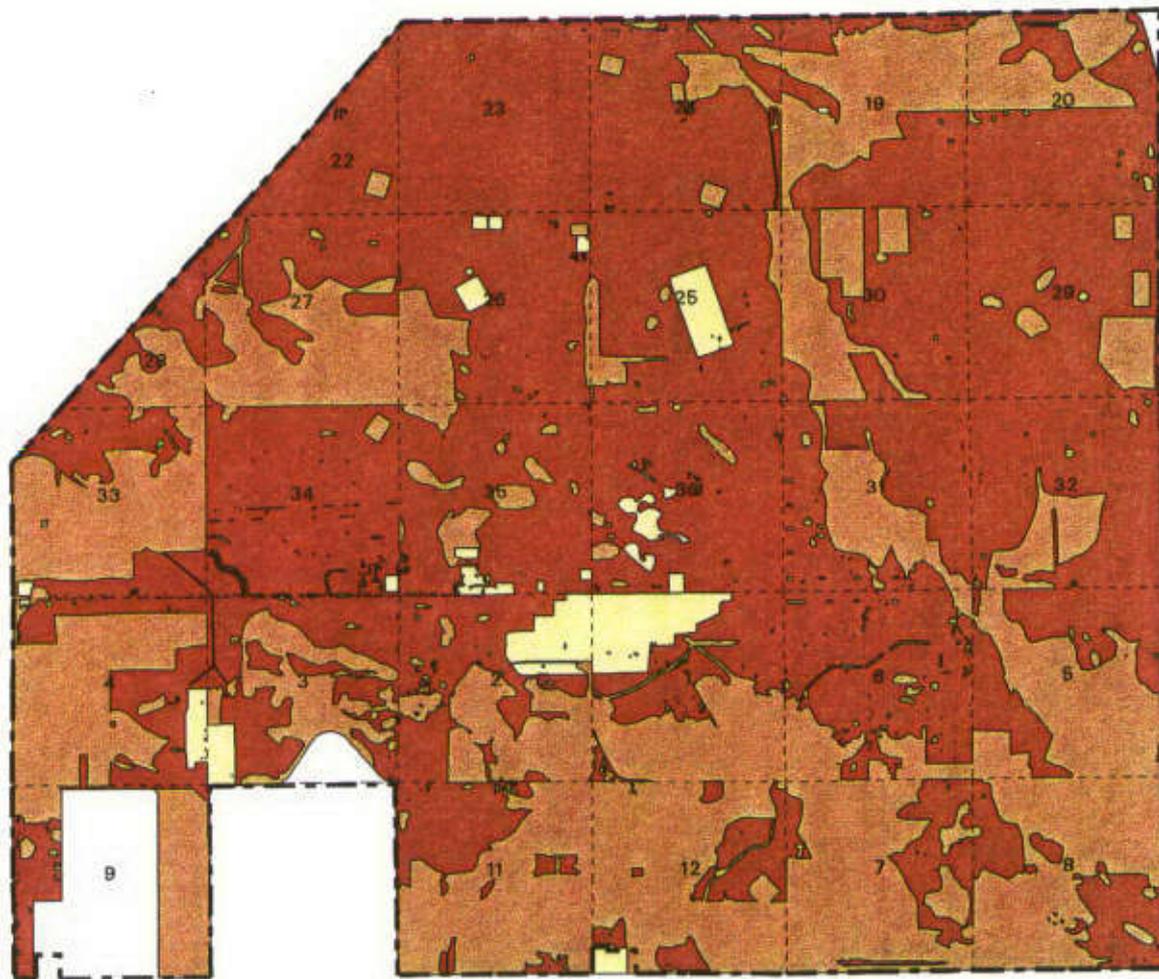


Figure 7. Habitat Restoration Project Locations, Rocky Mountain Arsenal National Wildlife Refuge, 1989 - 1999.

ROCKY MOUNTAIN  
ARSENAL NATIONAL  
WILDLIFE REFUGE

**Resource  
Categories  
1999**

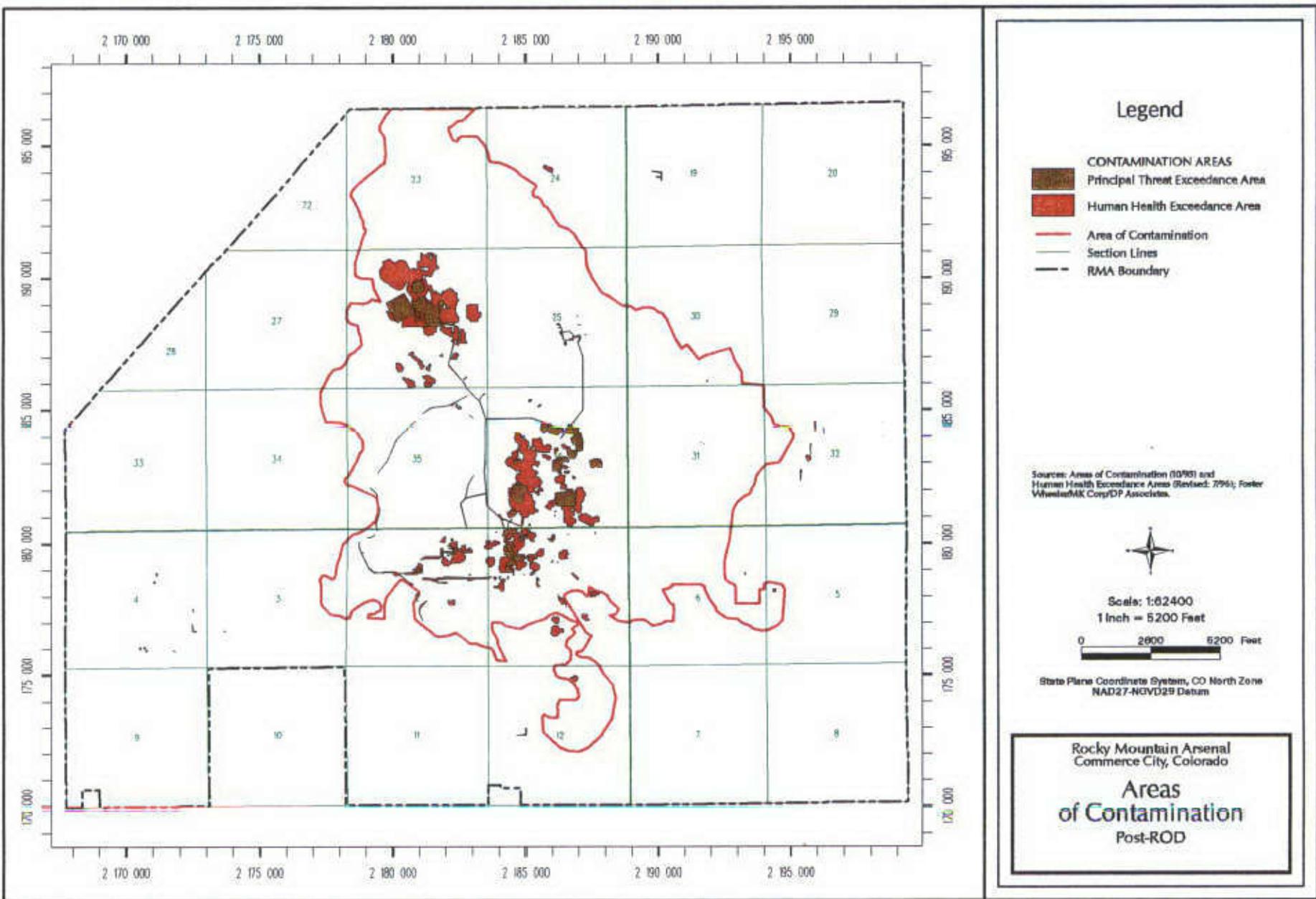


-  Resource Category 2
-  Resource Category 3
-  Resource Category 4
-  Unclassified



Figure 8. Resource categories for Rocky Mountain Arsenal National Wildlife Refuge, 1999.

August 13, 1999

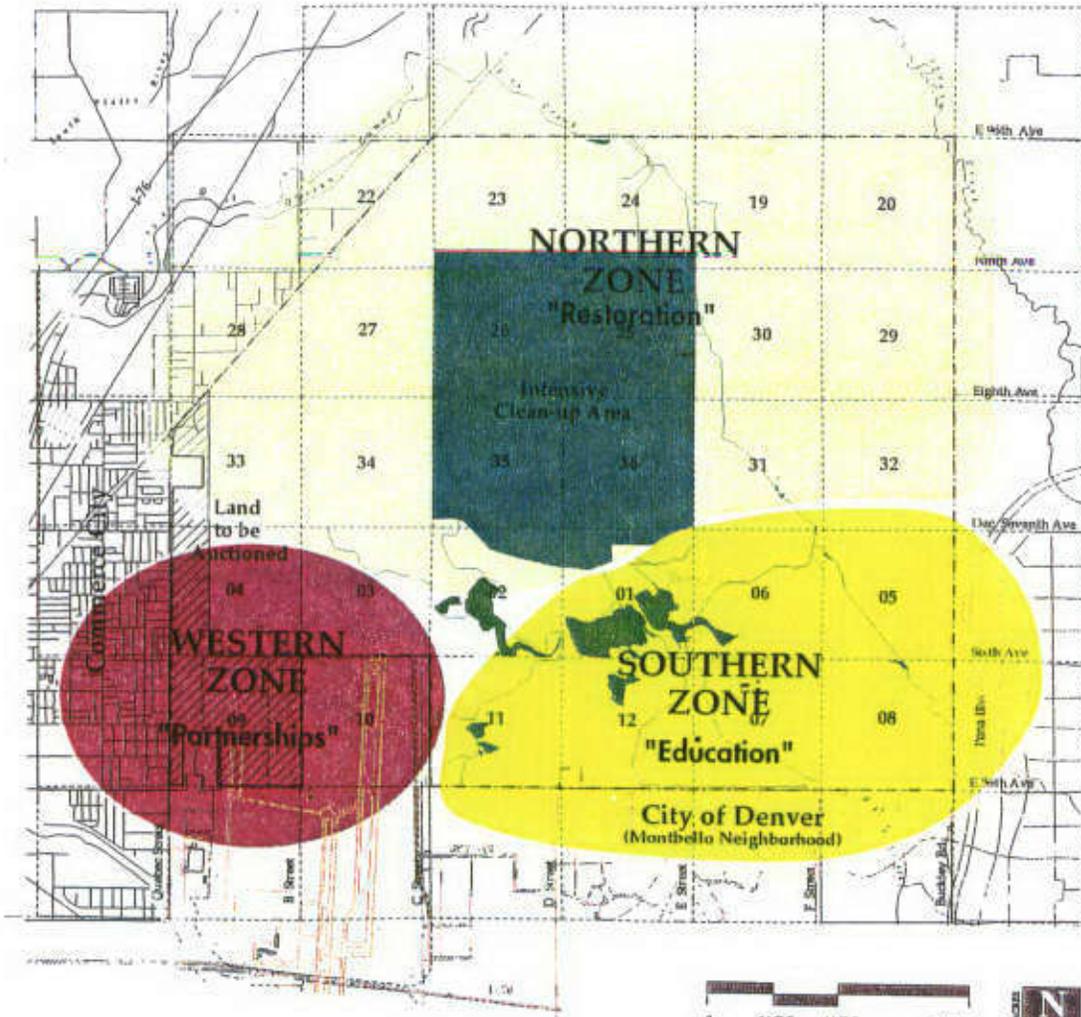


DATE: 08/16/99, AML / disk05/projects/rod/remediation/aml/contam-areas\_99.mxd

Figure 9. Human health and principal threat exceedance areas, Rocky Mountain Arsenal, 1999.

Figure 10. Landscape zones, Rocky Mountain Arsenal National Wildlife Refuge (USFWS 1996a).

**PLANNING ZONES**  
*(Map 1.10)*



0 1/2 MILE 1 MILE 2 MILES

DESIGNWORKSHOP inc.  
 February 1996

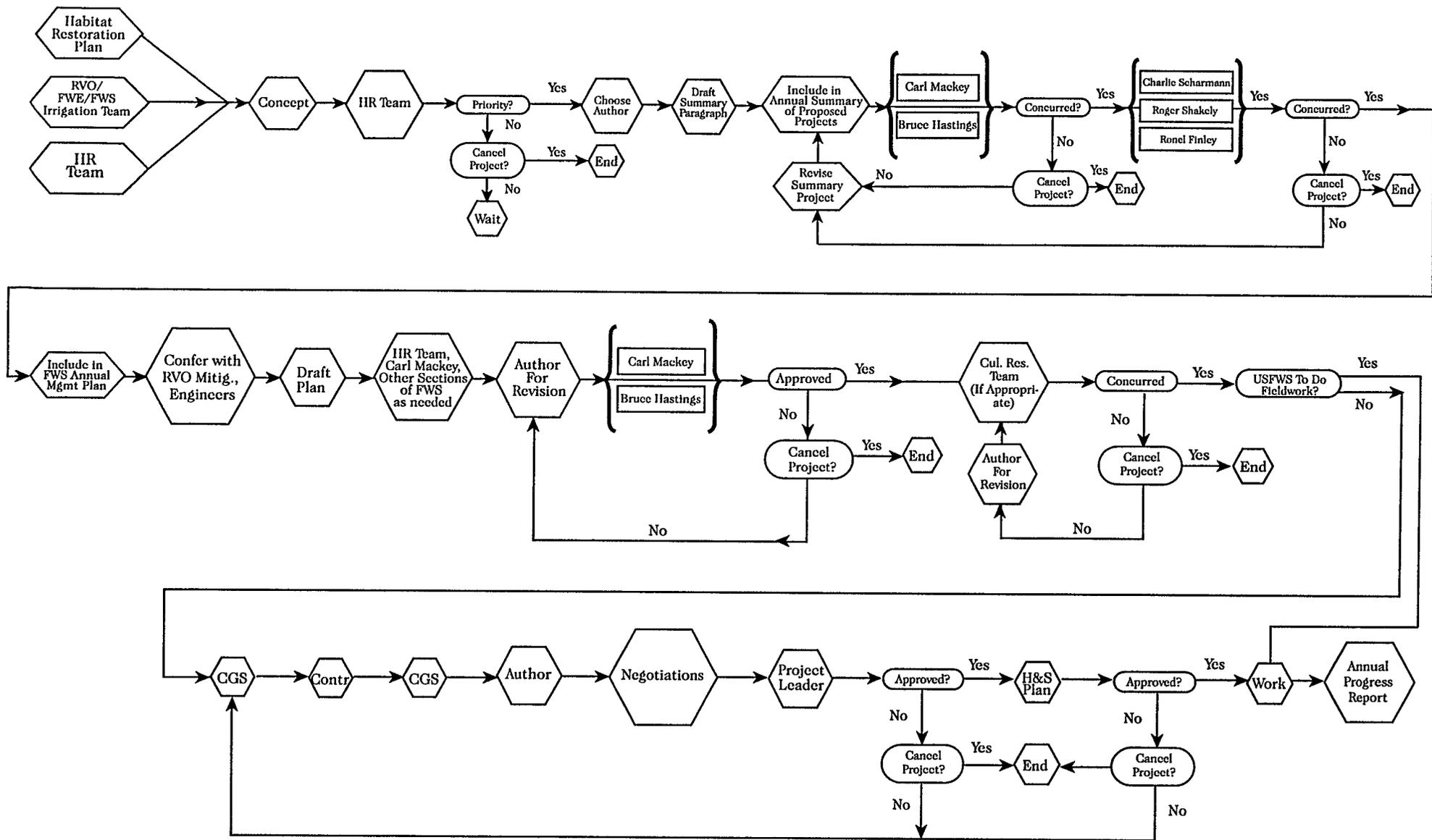
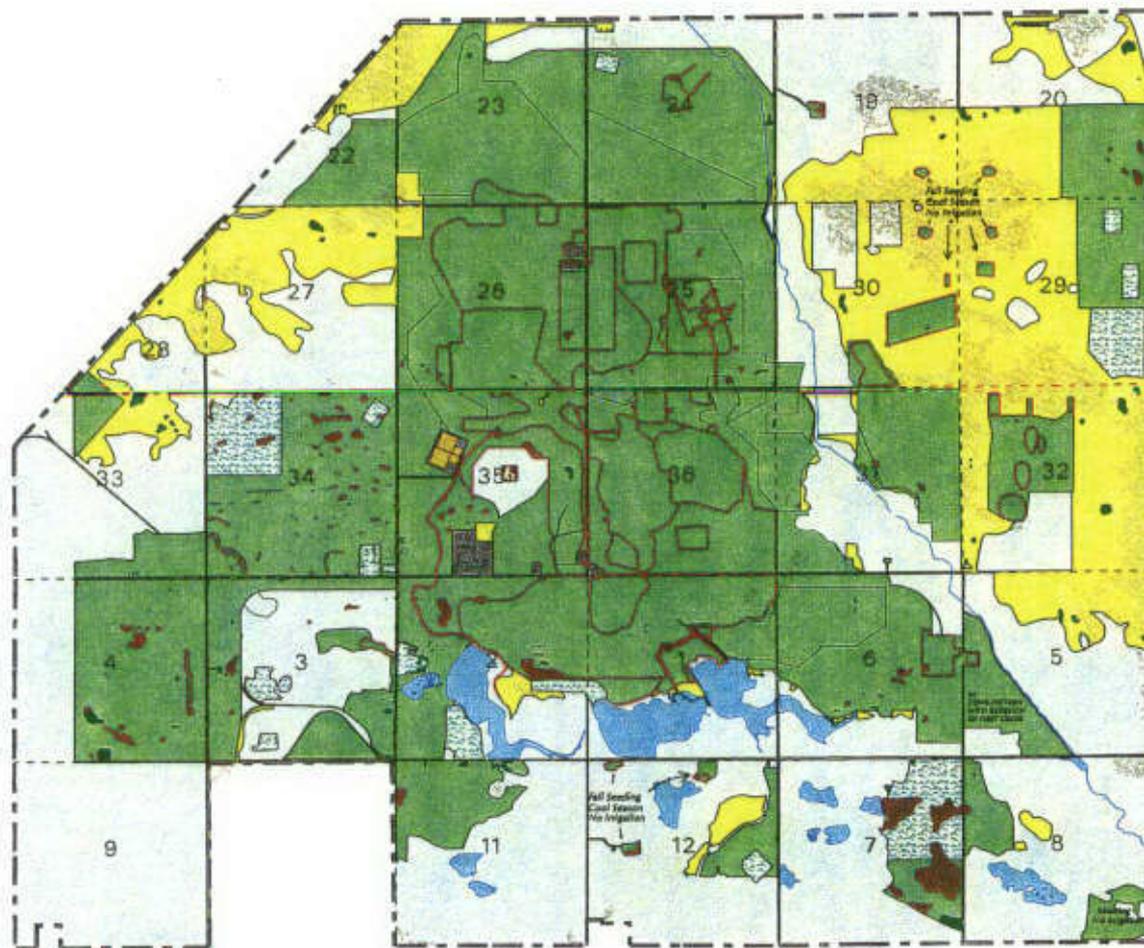


Figure II. Review Process for Typical Habitat Restoration Projects, Rocky Mountain Arsenal National Wildlife Refuge, 1999.

ROCKY MOUNTAIN  
ARSENAL NATIONAL  
WILDLIFE REFUGE  
**TERRESTRIAL  
REVEGETATION**



Areas for Revegetation

- Area to be Restored
- Prior Mitigation Seeding (Included in Total Revegetation)
- Potential Restoration Area (If Needed)

Other Areas

- Facilities
- Water/Large Wetlands
- No Action
- Prairie Dog Colony
- Existing Shrubs
- Existing Trees
- Implementation Projects
- Borrow Areas



Figure 12. Terrestrial revegetation map, Rocky Mountain Arsenal National Wildlife Refuge, 1999.

August 13, 1999

# Decision Matrix for Type of Revegetation

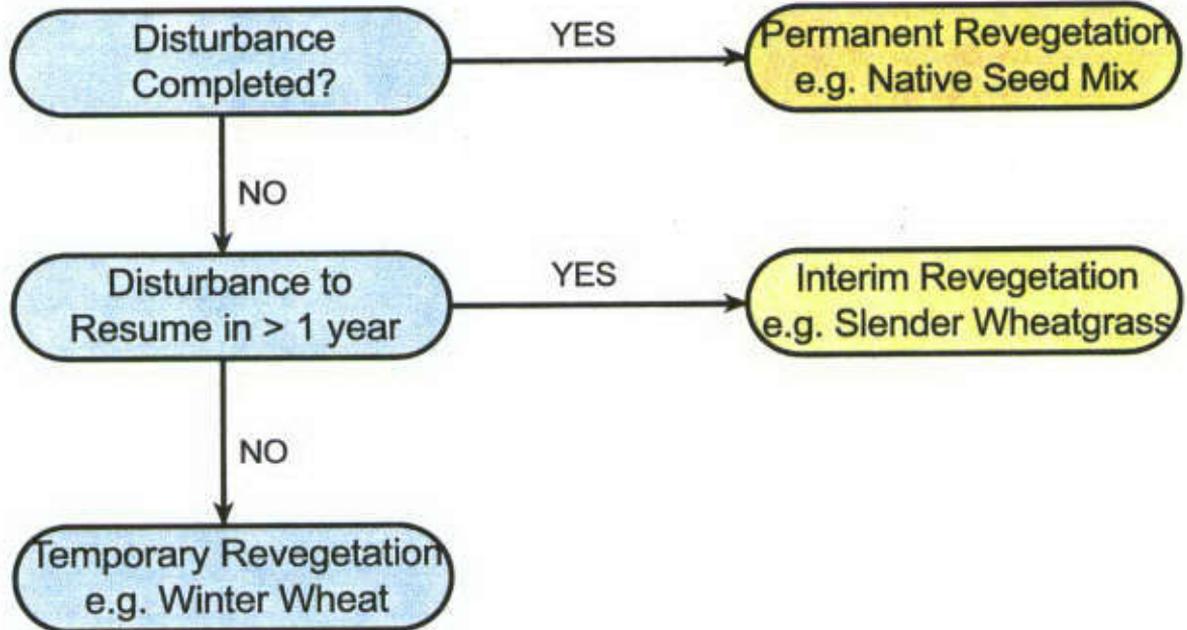


Figure 13. Decision matrix for applying permanent, interim, or temporary revegetation techniques, Rocky Mountain Arsenal, 1999.

# Disturbance Completed Permanent Revegetation

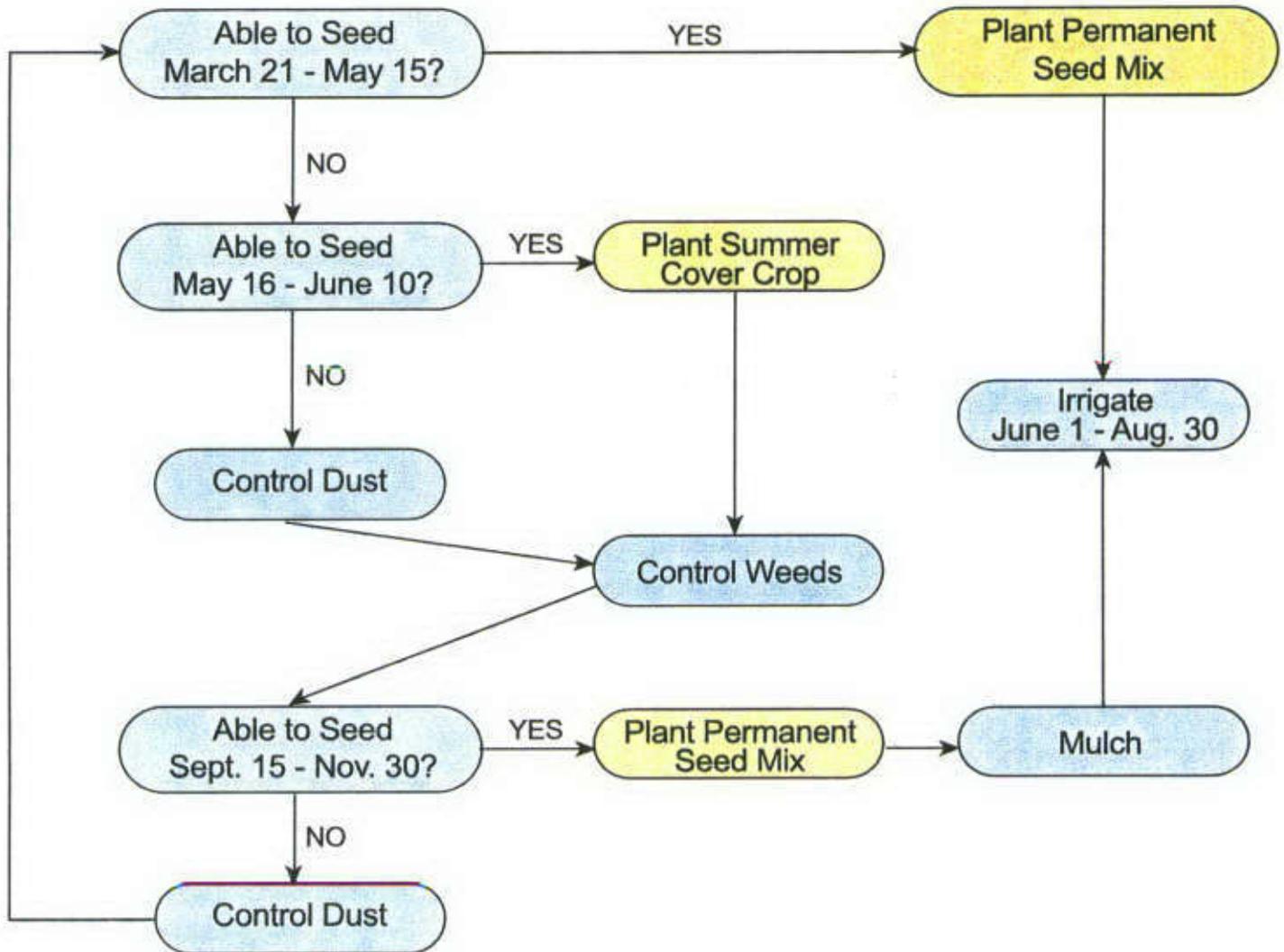


Figure 14. Decision matrix for revegetation after disturbance is completed, Rocky Mountain Arsenal, 1999.

# Disturbance to Resume in Greater Than One Year Interim Revegetation

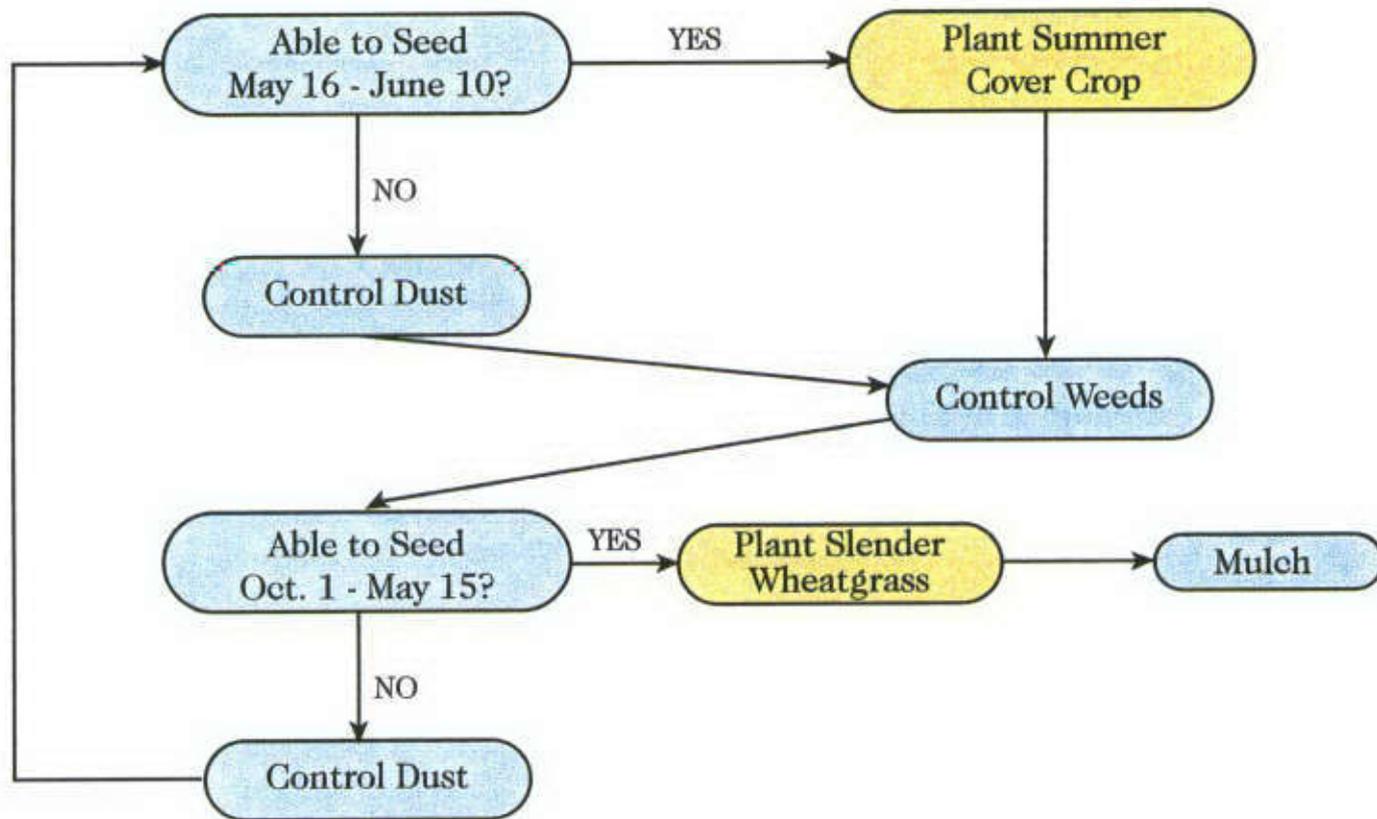


Figure 15. Decision matrix for revegetation when disturbance is expected to resume in greater than one year, Rocky Mountain Arsenal, 1999.

# Disturbance to Resume in Less Than One Year Temporary Revegetation

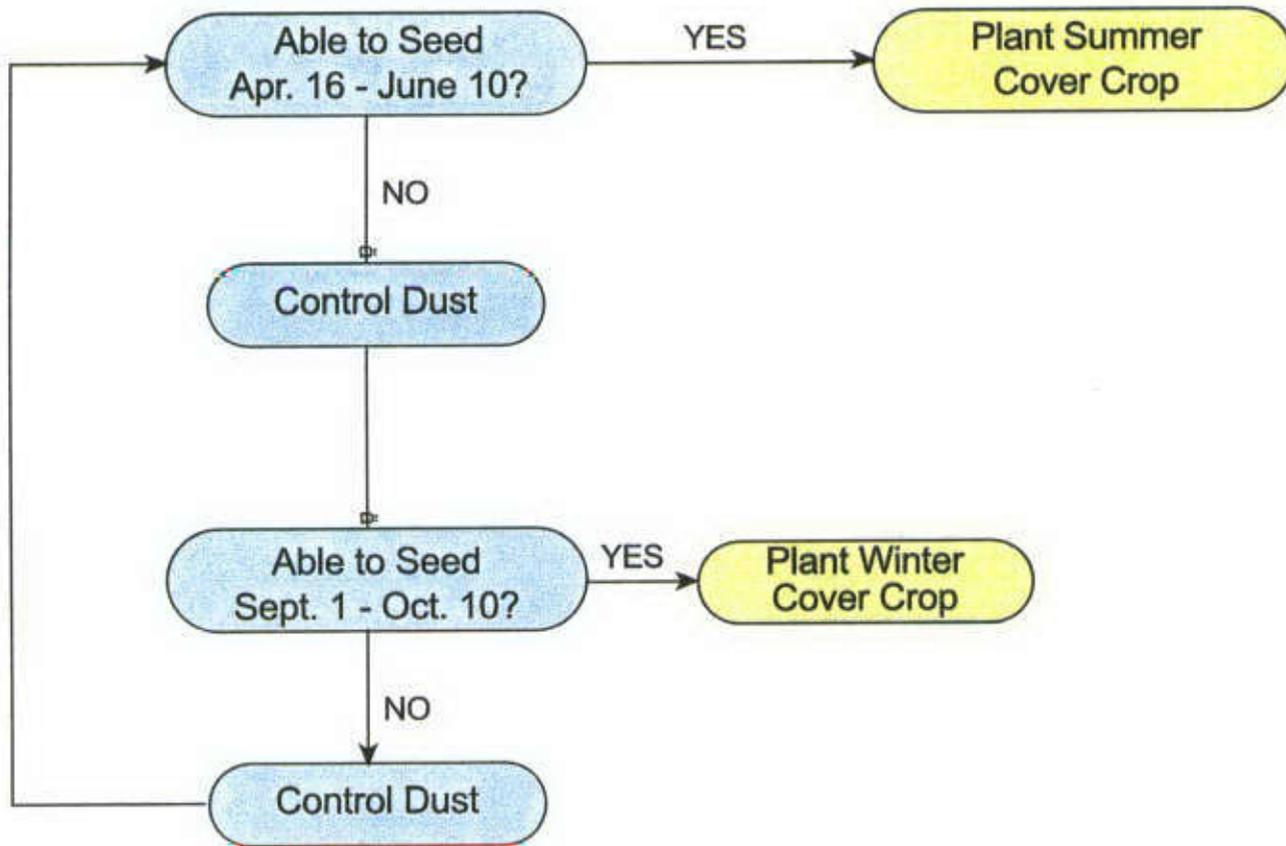


Figure 16. Decision matrix for revegetation when disturbance is expected to resume in less than one year, Rocky Mountain Arsenal, 1999.

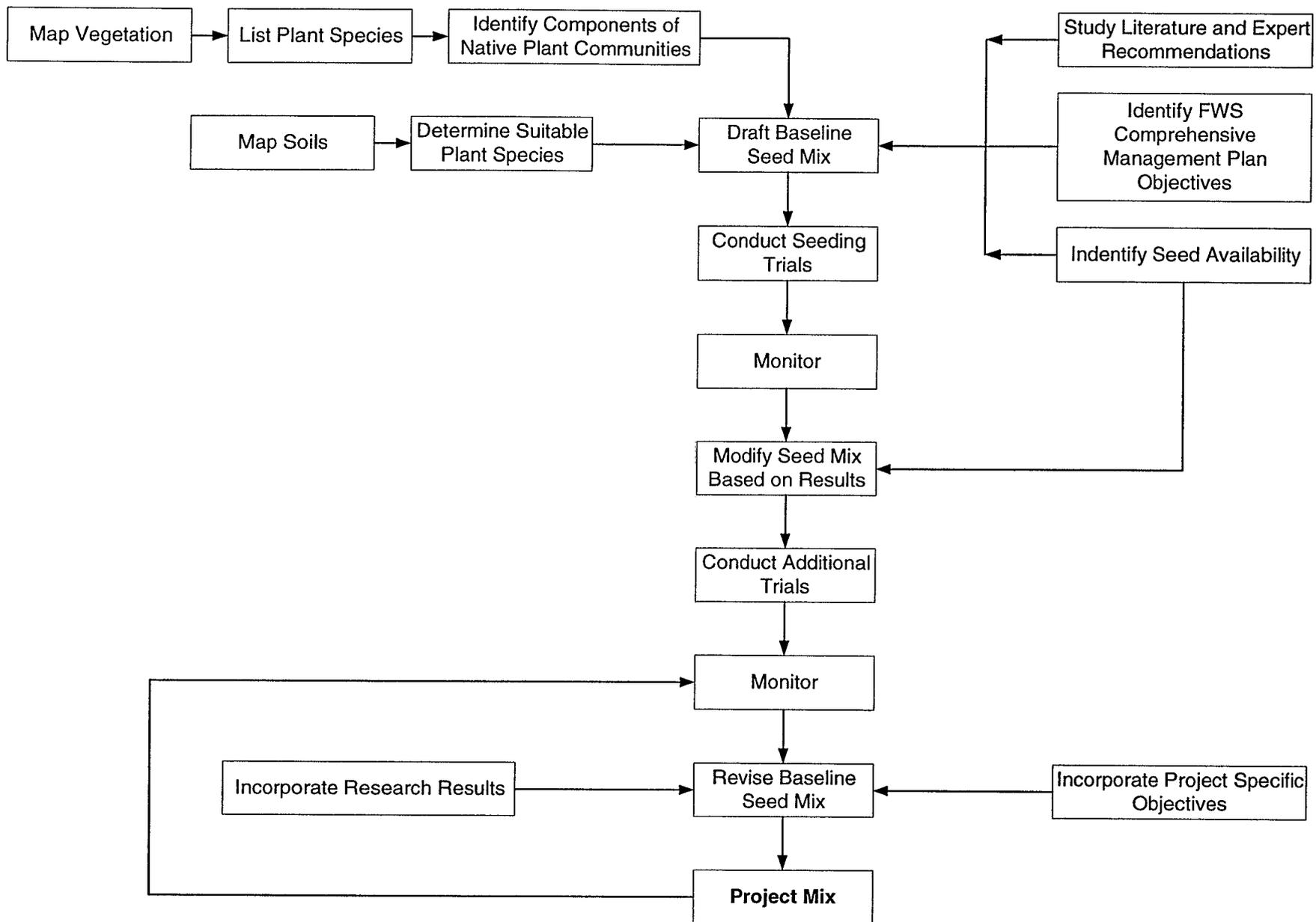
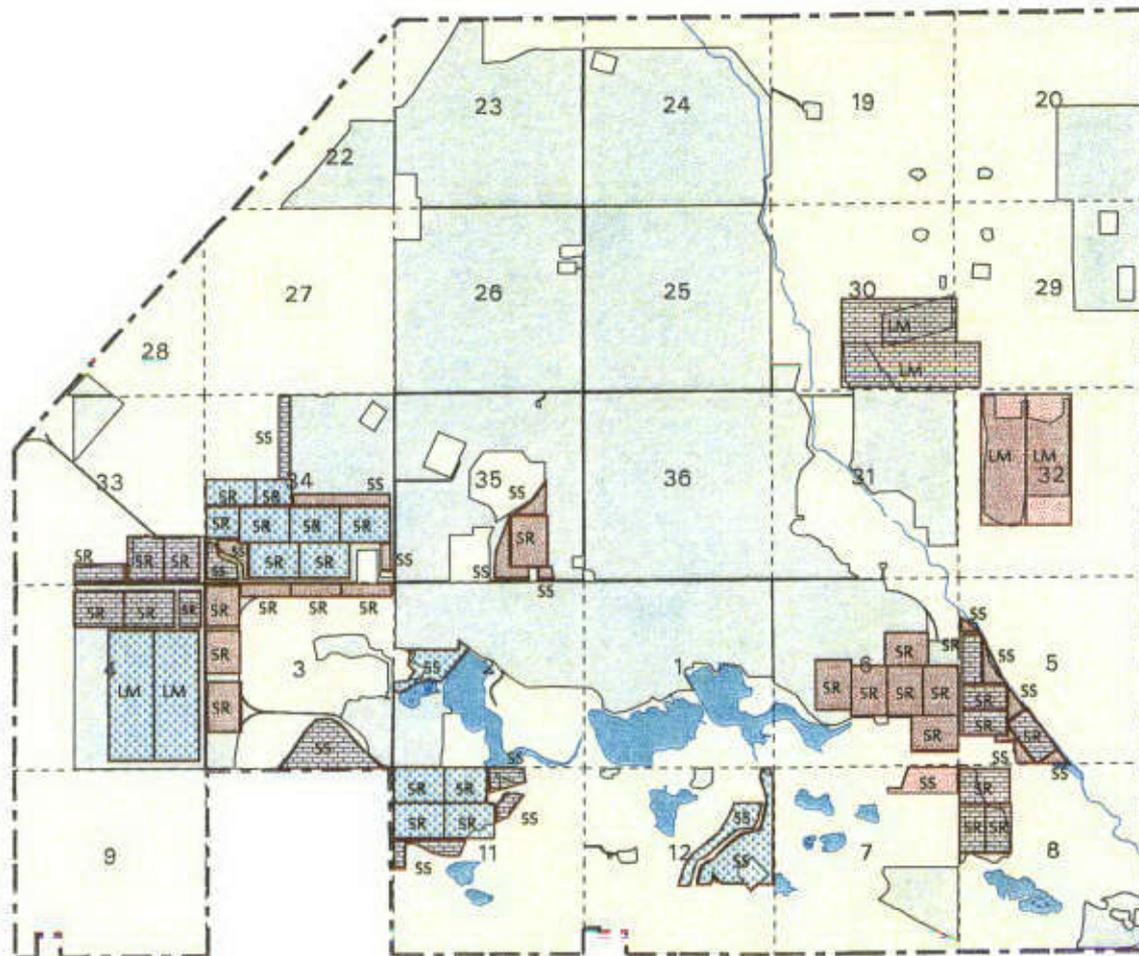


Figure 17. Plant species selection process for habitat restoration projects at Rocky Mountain Arsenal, 1988-1999.

**APPENDIX B: TABLES**

ROCKY MOUNTAIN  
ARSENAL NATIONAL  
WILDLIFE REFUGE

**DRAFT  
IRRIGATION DESIGN**



**Irrigation Plan**

Area to be Restored

Year 2000 Irrigation  
677 Acres

Year 2001 Irrigation  
637 Acres

Year 2002 Irrigation  
657 Acres

LM Linear Move System  
629 Acres

SR Side-Roll System  
985 Acres

SS Solid-Set System  
356 Acres

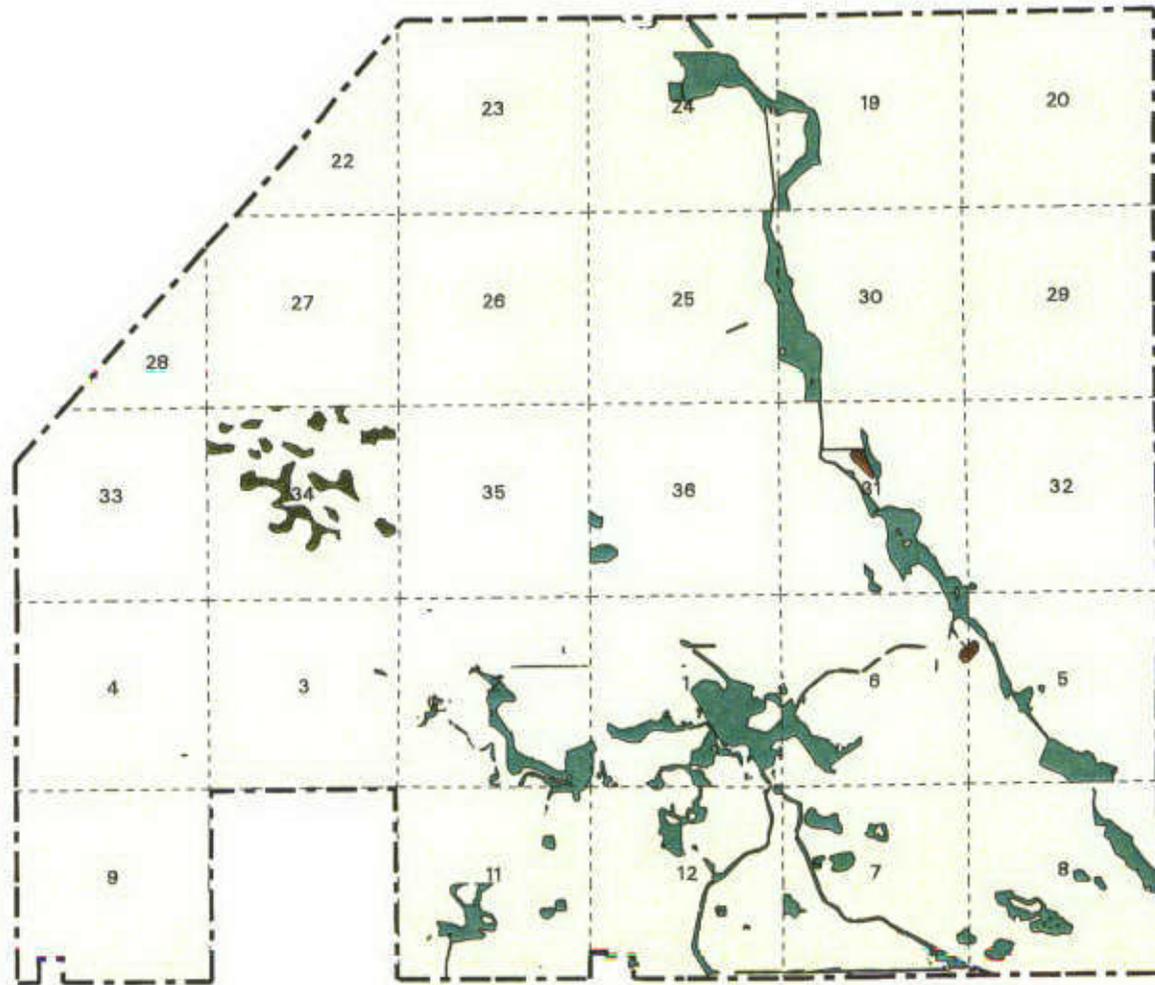
Water/Large Wetlands

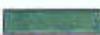


Figure 18. Draft irrigation design for restoration projects,  
Rocky Mountain Arsenal National Wildlife Refuge, FY 2000 – 2002.

August 13, 1999

ROCKY MOUNTAIN  
ARSENAL NATIONAL  
WILDLIFE REFUGE  
**POTENTIAL WETLAND  
RESTORATION  
SITES**



-  Potential Playa Wetland Sites
-  Existing Wetlands Potential Enhancement Sites
-  Potential Historic Wetland Sites

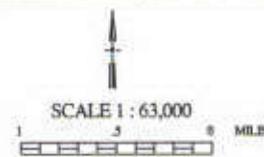


Figure 19. Potential wetland restoration and enhancement sites for Rocky Mountain Arsenal National Wildlife Refuge, 1999.

August 13, 1999

Table 1. Estimated acres needed to mitigate cleanup-related activities, Rocky Mountain Arsenal, 1999.

Disturbance Type	Acres Impacted HHE*	Clean Areas**	Total	Mitigation Acres Needed
31+ post-ROD remediation projects	365	1373	1738	3110
Post-ROD borrow sites	0	1474	1474	2948
Other cleanup-related projects***	28	809	837	1646
<b>TOTAL</b>	<b>393</b>	<b>3656</b>	<b>4049</b>	<b>7704</b>

\* HHE = Human Health Exceedance and Principle Threat areas.

\*\* Clean Areas = Areas that are not HHE areas.

\*\*\* Other cleanup-related projects = Any project other than the 31+ remediation projects or the post-ROD projects.

Table 2. Acreage and percent classified cover types, Rocky Mountain Arsenal National Wildlife Refuge, 1999.

Cover Type	Acres	Percent
Cheatgrass/weedy forbs	3822.1	22.5
Crested wheatgrass	3568.1	21.0
Native perennial grassland	3354.9	19.8
Weedy forbs	2975.4	17.5
Shrubland/succulent	1057.4	6.2
Wetland	692.7	4.1
Seeded native perennial grassland	625.4	3.7
Unclassified (e.g. Section 9 runway)	356.5	2.1
Water	163.1	1.0
Tree groves	151.8	0.1
Locust thickets	88.8	0.5
Bare ground	34.9	0.2
Cobble soil vegetation	27.4	0.2
Alfalfa/sweetclover	22.8	0.1
Lawns	16.2	0.1
Cereal rye	13.7	0.1
<b>TOTAL</b>	<b>16971.2</b>	<b>100.0</b>

Table 3. Acreage and percent of habitat types, Rocky Mountain Arsenal National Wildlife Refuge, 1999.

Habitat Type	Acres	Percent
Weedy forbs/grasses	10002.1	58.9
Native perennial grasses	4032.3	23.8
Shrubland/succulents	1030.5	6.1
Disturbed	458.2	2.7
Wetlands	434.7	2.6
Unclassified (e.g. Section 9 runway)	356.5	2.1
Riverine/riparian	258.5	1.5
Upland trees	240.6	1.4
Lacustrine	157.9	0.9
<b>TOTAL</b>	<b>16971.3</b>	<b>100</b>

Table 4. Acreage and percent of resource categories, Rocky Mountain Arsenal National Wildlife Refuge, 1999.

Resource Category	Acres	Percent
1	0.0	0.0
2	6,154.3	36.3
3	10,002.1	58.9
4	458.2	2.7
Unclassified	356.5	2.1
<b>Total</b>	<b>16971.1</b>	<b>100.0</b>

Table 5. Ratios of mitigation to disturbance for different habitats, Rocky Mountain Arsenal, 1999.

Habitat Restoration	Classification	Mitigation Ratio
Uplands		
Grasslands	Human health exceedance	1:1 (acres)
	Other areas disturbed	2:1 (acres)
Shrublands	Human health exceedance	1:1 (acres)
	Other areas disturbed	2:1 (acres)
Trees*	≥ 6" DBH	5:1 (trees)
	< 6" DBH	2:1 (acres or trees)
Wetlands/Riparian Areas	Woody	5:1 (acres or trees)**
	Non-Woody	2:1 (acres)**

\* The DBH for trees includes the combined DBH of all stems from a common trunk.

\*\* Ratio applies regardless of plant size or proximity to contaminated soils.

Table 6. Revegetation responsibilities by vegetation type, Rocky Mountain Arsenal, 1999.

Type	Definition/Examples	Who Does Fieldwork?
Temporary	Vegetation for < 1 year before next disturbance	Contractor
Interim	Vegetation for >1 year before next disturbance perennial cover crop (e.g. crested wheatgrass)	Contractor
Permanent	Native vegetation for perpetuity	USFWS

Table 7. Potential costs of habitat restoration, Rocky Mountain Arsenal National Wildlife Refuge, 1999.

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Site	Potential Cost	Unit
Grasslands	\$1,798.00	Acre
Shrublands	\$89,382.00	Acre
Trees	\$843.00	Tree
Wetlands*	\$68,511 - \$444,095.00	Acre

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\* From Sellards and Grigg, Inc. and Aquatic Wetland Consultants 1997.

Table 8. Commonly recommended sand prairie plant materials for the Ascalon, Bresser, Bresser-Satanta, and Truckton sandy loam soil types at Rocky Mountain Arsenal National Wildlife Refuge, 1999.

Scientific name	Common name	Variety	Lbs. PLS*/acre	% of mix
Native grass species				
<i>Andropogon hallii</i>	Sand bluestem	Woodward	5.783	30.000
<i>Bouteloua curtipendula</i>	Side-oats grama	Vaughn	0.285	2.500
<i>Bouteloua gracilis</i>	Blue grama	Hachita, Lovington, and Native	0.264	10.000
<i>Calamovilfa longifolia</i>	Prairie sandreed	Goshen	1.995	25.000
<i>Hesperostipa comata</i>	Needle-and-thread		0.947	5.000
<i>Oryzopsis hymenoides</i>	Indian ricegrass	Nezpar	0.386	2.500
<i>Panicum virgatum</i>	Switchgrass	Nebraska 28	0.560	10.000
<i>Pascopyrum smithii</i>	Western wheatgrass	Arriba & native		5.000
		<b>Subtotal</b>	<b>11.210</b>	<b>90.000</b>
Native forbs (wildflowers) or				
<i>Achillea lanulosa</i>	Yarrow		0.004	0.455
<i>Artemisia frigida</i>	Fringed sage		0.003	0.455
<i>Artemisia ludoviciana</i>	Louisiana sagewort		0.003	0.455
<i>Cloeme serrulata</i>	Rocky Mountain bee		0.151	0.455
<i>Coreopsis tinctoria</i>	Plains coreopsis		0.007	0.455
<i>Gaillardia aristata</i>	Blanket flower		0.076	0.455
<i>Helianthus annuus</i>	Annual sunflower		0.170	0.455
<i>Liatrus punctata</i>	Dotted gayfeather**		***	
<i>Linum lewisii</i>	Blue flax		0.034	0.455
<i>Oenothera villosa</i>	Tall evening-primrose		0.007	0.455
<i>Penstemon angustifolius</i>	Narrow-leaf		0.025	0.455
		<b>Subtotal</b>	<b>0.500</b>	<b>5.000</b>
Native shrubs				
<i>Artemisia filifolia</i>	Sand sagebrush		0.011	1.250
<i>Atriplex canescens</i>	Fourwing saltbush		0.524	1.250
<i>Chrysothamnus</i>	Rubber rabbitbrush		0.068	1.250
<i>Yucca glauca</i>	Yucca		1.201	1.250
		<b>Subtotal</b>	<b>1.804</b>	<b>5.000</b>
		<b>Grand total</b>	<b>13.51</b>	<b>100.000</b>

\* PLS = pure live seed

\*\* Hand collected by USFWS staff as available

\*\*\* Rate will vary depending on availability

Table 9. Commonly recommended shortgrass prairie plant materials for the Nunn clay loam soil type at Rocky Mountain Arsenal National Wildlife Refuge, 1999. (Seed mix based on 50 seeds per square foot.)

Scientific name	Common name	Variety	Lbs. PLS*/acre	% of mix
Native grass species				
<i>Bouteloua gracilis</i>	Blue grama	Hachita, Lovington, and native	0.792	30.000
<i>Buchloe dactyloides</i>	Buffalo grass	Sharp's	11.668	30.000
<i>Pascopyrum smithii</i>	Western wheatgrass	Arriba & native	5.940	30.000
<b>Sub-total</b>			<b>18.400</b>	<b>90.000</b>
Native forbs (wildflowers) or semi-shrubs				
<i>Achillea lanulosa</i>	Yarrow		0.005	0.556
<i>Artemisia frigida</i>	Fringed sage		0.003	0.556
<i>Artemisia ludoviciana</i>	Louisiana sagewort		0.003	0.556
<i>Dalea purpurea</i>	Purple prairie-clover		0.058	0.556
<i>Gaillardia aristata</i>	Blanket flower		0.092	0.556
<i>Helianthus annuus</i>	Annual sunflower		0.207	0.556
<i>Linum lewisii</i>	Blue flax		0.042	0.556
<i>Penstemon angustifolius</i>	Narrow-leaf penstemon		0.031	0.556
<i>Sphaeralcea coccinea</i>	Scarlet globemallow		0.025	0.556
<b>Sub-total</b>			<b>0.466</b>	<b>5.000</b>
Native shrubs				
<i>Atriplex canescens</i>	Fourwing saltbush		0.699	1.667
<i>Ceratoides lanata</i>	Winterfat		0.641	1.667
<i>Rhus trilobata</i>	Skunkbrush sumac		1.790	1.667
<b>Sub-total</b>			<b>3.130</b>	<b>5.000</b>
<b>Grand-total</b>			<b>21.996</b>	<b>100.000</b>

\* PLS = pure-live-seed

Table 10. Commonly recommended sand and shortgrass plant material mix for the Satanta Weld loam soil types at Rocky Mountain Arsenal National Wildlife Refuge, 1999. (Seed mix based on 50 seeds per square foot.)

Scientific name	Common name	Variety	Lbs.PLS*/acre	% of mix
Native grass species				
<i>Bouteloua gracilis</i>	Blue grama	Hachita, Lovington, and native	0.264	35.000
<i>Buchloe dactyloides</i>	Buffalo grass	Sharp's	5.834	15.000
<i>Pascopyrum smithii</i>	Western wheatgrass	Arriba & native	4.950	25.000
<i>Sporobolus cryptandrus</i>	Sand dropseed	Native	0.062	15.000
<b>Sub-total</b>			<b>11.770</b>	<b>90.000</b>
Native forbs (wildflowers) or semi-shrubs				
<i>Achillea lanulosa</i>	Yarrow		0.004	0.455
<i>Artemisia frigida</i>	Fringed sage		0.003	0.455
<i>Artemisia ludoviciana</i>	Louisiana sagewort		0.003	0.455
<i>Cloeme serrulata</i>	Rocky Mountain bee plant		0.151	0.455
<i>Gaillardia aristata</i>	Blanket flower		0.076	0.455
<i>Helianthus annuus</i>	Annual sunflower		0.170	0.455
<i>Linum lewisii</i>	Blue flax		0.034	0.455
<i>Penstemon angustifolius</i>	Narrow-leaf penstemon		0.025	0.455
<i>Ratibida columnifera</i>	Prairie coneflower		0.008	0.455
<i>Rudbeckia hirta</i>	Black-eyed susan		0.006	0.455
<i>Sphaeralcea coccinea</i>	Scarlet globemallow		0.020	0.445
<b>Sub-total</b>			<b>0.500</b>	<b>5.000</b>
Native shrubs				
<i>Atriplex canescens</i>	Fourwing saltbush		1.048	2.500
<i>Rhus trilobata</i>	Skunkbrush sumac		2.683	2.500
<b>Sub-total</b>			<b>3.731</b>	<b>5.000</b>
<b>Grand-total</b>			<b>16.001</b>	<b>100.000</b>

\* PLS = pure-live-seed

Table 11. Commonly recommend mixed grass plant materials for the petrocalcic paleustoll type at Rocky Mountain Arsenal National Wildlife Refuge, 1999. (Seed mix based on 50 seeds per square foot.)

Scientific name	Common name	Variety	Lbs.PLS*/acre	% of mix
Native grass species				
<i>Bouteloua curtipendula</i>	Side-oats grama	Vaughn	1.711	15.000
<i>Bouteloua gracilis</i>	Blue grama	Hachita, Lovington, and native	0.792	30.000
<i>Oryzopsis hymenoides</i>	Indian ricegrass	Nezpar	0.773	5.000
<i>Pascopyrum smithii</i>	Western wheatgrass	Arriba & native	0.990	15.000
<i>Poa secunda</i>	Sandberg bluegrass	Native	0.236	10.000
<i>Schizachyrium scoparium</i>	Little bluestem	Pastura	1.257	15.000
<b>Subtotal</b>			<b>7.739</b>	<b>90.000</b>
Native forbs (wildflowers) or semi-shrubs				
<i>Achillea lanulosa</i>	Yarrow		0.005	0.625
<i>Artemisia frigida</i>	Fringed sage		0.003	0.625
<i>Artemisia ludoviciana</i>	Louisiana sagewort		0.003	0.625
<i>Gutierrezia sarothrae</i>	Broom snakeweed		0.019	0.625
<i>Helianthus annuus</i>	Annual sunflower		0.233	0.625
<i>Liatrus punctata</i>	Dotted gayfeather**		***	
<i>Linum lewisii</i>	Blue flax		0.047	0.625
<i>Penstemon angustifolius</i>	Narrow-leaf penstemon		0.034	0.625
<i>Sphaeralcea coccinea</i>	Scarlet globemallow		0.028	0.625
<b>Sub-total</b>			<b>0.372</b>	<b>5.000</b>
Native shrubs				
<i>Atriplex canescens</i>	Fourwing saltbush		0.419	1.000
<i>Chrysothamnus</i>	Rubber rabbitbrush		0.055	1.000
<i>Ceratoides lanata</i>	Winterfat		0.385	1.000
<i>Rhus trilobata</i>	Skunkbrush sumac		1.073	1.000
<i>Yucca glauca</i>	Yucca		0.961	1.000
<b>Sub-total</b>			<b>2.893</b>	<b>5.000</b>
<b>Grand-total</b>			<b>11.004</b>	<b>100.000</b>

\* PLS = pure-live-seed

\*\* Hand collected by USFWS staff as

\*\*\* Rate will vary depending on availability.

Table 12. Commonly recommended tall grass plant materials for the typic and aquic haplustoll soil types at Rocky Mountain Arsenal National Wildlife Refuge, 1999. (Seed mix based on 50 seeds per square foot.)

Scientific name	Common name	Variety	Lbs.PLS*/acre	% of mix
Native grass species				
<i>Andropogon gerardii</i>	Big bluestem	Pawnee	0.838	5
<i>Bouteloua curtipendula</i>	Side-oats grama	Vaughn	1.141	10
<i>Bouteloua gracilis</i>	Blue grama	Hachita, Lovington, and native	0.264	10
<i>Elymus canadensis</i>	Canada wildrye	Native	3.788	20
<i>Elymus trachycaulus</i>	Slender wheatgrass	Revenue	1.370	10
<i>Panicum virgatum</i>	Switchgrass	Nebraska 28	0.840	15
<i>Pascopyrum smithii</i>	Western wheatgrass	Arriba & native	2.970	15
<i>Sorghastrum avenaceum</i>	Yellow Indiangrass	Holt	1.282	10
<b>Sub-total</b>			<b>12.493</b>	<b>95</b>
Native forbs (wildflowers) or semi-shrubs				
<i>Helianthus annuus</i>	Annual sunflower		0.373	1
<i>Dalea purpurea</i>	Purple prairie-clover		0.104	1
<i>Ratibida columnifera</i>	Prairie coneflower		0.018	1
<i>Rosa woodsii</i>	Wood's rose		0.481	1
<i>Rudbeckia hirta</i>	Black-eyed Susan		0.013	1
<b>Sub-total</b>			<b>0.989</b>	<b>5</b>
<b>Grand-total</b>			<b>13.482</b>	<b>5</b>

\* PLS=pure-live-seed

Table 13. Recommended sand prairie plant materials for remediation covers with biota barriers at Rocky Mountain Arsenal, 1999. (Seed mix based on 35 seeds per square foot.)

Scientific name	Common Name	Variety	Lbs.PLS*/acre
Native grass species			
<i>Andropogon hallii</i>	Sand bluestem	Woodward	2.000
<i>Boutelous curtipendula</i>	Side-oats grama	Vaughn	0.400
<i>Bouteloua gracilis</i>	Blue grama	Hachita	0.030
<i>Bouteloua gracilis</i>	Blue grama	Native	0.030
<i>Buchloe dactyloides</i>	Buffalograss	Texoka	0.350
<i>Buchloe dactyloides</i>	Buffalograss	Native	0.350
<i>Calamovilfa longifolia</i>	Prairie sandreed	Goshen	0.800
<i>Elymus trachycaulus</i>	Slender	Primar	1.000
<i>Panicum virgatum</i>	Switchgrass	Nebraska 28	0.200
<i>Pascopyrum smithii</i>	Western	Arriba	2.800
<i>Sporobolus cryptandrus</i>	Sand dropseed	Native	0.010
<i>Stipa comata</i>	Needle-and-thread	Native	1.300
<b>Sub-total</b>			<b>9.270</b>
Native forbs (wildflowers) and succulents			
<i>Abronia fragrans</i>	Sand verbena		0.200
<i>Achillea lanulosa</i>	Yarrow		0.003
<i>Cleome serrulata</i>	Rocky Mountain bee plant		0.100
<i>Coreopsis tinctoria</i>	Plains coreopsis		0.010
<i>Gaillardia aristata</i>	Blanket flower		0.100
<i>Helianthus annuus</i>	Annual sunflower		0.100
<i>Liatrus punctata**</i>	Blazing-star		0.100
<i>Linum lewisii</i>	Blue flax		0.030
<i>Oenothera villosa</i>	Tall evening-primrose		0.010
<i>Opuntia polyacantha</i>	Prickly pear cactus		0.100
<i>Sphaeralcea coccinea</i>	Scarlet globemallow		0.020
<b>Sub-total</b>			<b>0.683</b>
<b>Grand-total</b>			<b>9.953</b>

\* PLS=pure-live-seed

\*\* Hand collected by USFWS staff as available.

\*\*\* Rate will vary based on availability.

Table 14. Recommended loamy soil (Weld and Satanta soil series) plant materials for remediation covers with biota barriers at Rocky Mountain Arsenal National Wildlife Refuge, 1999. (Seed mix based on 35 seeds per square foot.)

Scientific Name	Common Name	Variety	Lbs. PLS/Acre
<b>Native Grass Species</b>			
<i>Buchloe dactyoides</i>	Buffalo grass	Texoka	0.350
<i>Buchloe dactyoides</i>	Buffalo grass	Native	0.350
<i>Bouteloua gracilis</i>	Blue grama	Hachita	0.030
<i>Bouteloua gracilis</i>	Blue grama	Native	0.030
<i>Panicum virgatum</i>	Switchgrass	Nebraska 28	0.600
<i>Bouteloua curtipendula</i>	Side-oats grama	Vaughn	0.800
<i>Sporobolus cryptandrus</i>	Sand dropseed	Native	0.010
<i>Stipa comata</i>	Needle-and-thread	Native	1.300
<i>Pascopyrum smithii</i>	Western wheatgrass	Arriba	4.200
<i>Poa secunda</i>	Sandberg bluegrass	Native	0.100
<i>Elymus trachycaulus</i>	Slender wheatgrass	Primar	0.500
<i>Elymus lanceolatus</i>	Thickspike wheatgrass	Critana	0.500
<b>Subtotal</b>			<b>8.770</b>
<b>Native Forbs (Wildflowers) and succulents</b>			
<i>Erysimum asperum</i>	Wallflower		0.010
<i>Gaillardia aristata</i>	Blanket flower		0.100
<i>Penstemon angustifolia</i>	Narrow-leaf penstemon		0.020
<i>Linum lewisii</i>	Blue flax		0.030
<i>Helianthus annuus</i>	Annual sunflower		0.010
<i>Cleome serrulata</i>	Rocky Mountain bee plant		0.100
<i>Liatris punctata**</i>	Blazing-star		0.100
<i>Oenothera villosa</i>	Tall evening-primrose		0.010
<i>Coreopsis tinctoria</i>	Plains coreopsis		0.010
<i>Opuntia polyacantha</i>	Prickly pear cactus		0.100
<b>Subtotal</b>			<b>0.490</b>
<b>Grand Total</b>			<b>9.260</b>

\* PLS=pure-live-seed

\*\* Hand collected by USFWS staff as available. Rate will vary based on availability.

Table 15. Commonly recommended plant material mix to discourage burrowing wildlife use in specific locations on Rocky Mountain Arsenal National Wildlife Refuge, June 1999. (Seed mix based on 50 seeds per square foot.)

Scientific Name	Common Name	Variety	Lbs. PLS*/Acre	% of mix
Native grass species				
<i>Agropyron cristatum</i>	Crested wheatgrass	Hycrest	6.845	55
<i>Elytrigia intermedia</i>	Pubescent wheatgrass	Luna	8.024	35
<b>Subtotal</b>			<b>14.869</b>	<b>90</b>
Native shrubs				
<i>Atriplex canescens**</i>	Fourwing saltbrush		1.047	10
<b>Subtotal</b>			<b>1.047</b>	<b>10</b>
<b>Grand total</b>			<b>15.916</b>	<b>100</b>

\* PLS = pure-live seed

\*\* This species should be removed from the mix if the site is contaminated or capped.

Table 16. Commonly recommended plant material mix to prevent erosion in and adjacent to drainage ditches at Rocky Mountain Arsenal National Wildlife Refuge, 1999.

Scientific Name	Common Name	Variety	Lbs. PLS*/Acre
<b>Native Grass Species</b>			
<i>Elymus canadensis</i>	Canada wildrye	Native	2.0
<i>Elymus trachycaulus</i>	Slender wheatgrass	Primar	2.5
<i>Panicum virgatum</i>	Switchgrass	Nebraska 28	2.5
<i>Pascopyrum smithii</i>	Western wheatgrass	Arriba	4.0
<b>Subtotal</b>			<b>11.0</b>
<b>Native Forbs (Wildflowers) and Sub-shrubs</b>			
<i>Asclepius tuberosa</i>	Butterfly weed		0.1
<i>Artemisia frigida</i>	Fringed sage		0.1
<i>Helianthus annuus</i>	Annual sunflower		0.1
<i>Pepalostemum purpureum</i>	Purple prairie clover		0.1
<i>Ratibida columnifera</i>	Prairie coneflower		0.1
<i>Rudbeckia hirta</i>	Black-eyed Susan		0.1
<b>Subtotal</b>			<b>0.6</b>
<b>Native Shrubs</b>			
<i>Atriplex canescens</i>	Four-winged saltbush		0.1
<i>Rosa woodsii</i>	Wood's rose		0.1
<b>Subtotal</b>			<b>0.2</b>
<b>Grand Total</b>			<b>11.8</b>

\* PLS=pure-live-seed

Table 17. Irrigation schedule under ideal circumstances, Rocky Mountain Arsenal National Wildlife Refuge, 1999.

Application Period	Application Rate	Total Application
June 1 - June 14	0.25 inches twice per week	1 inch
June 15 - June 28	0.50 inches once per week	1 inch
June 29 - August 17	1.00 inches every other week	3 inches
August 18 - Sept. 1	0.50 inches once per week	1 inch
TOTAL		6 inches

Table 18. Optimal soil type for shrubs recommended for use on Rocky Mountain Arsenal National Wildlife Refuge, 1999.

Common Name	Scientific Name	Habitat	Optimal Soil Type
Fringed sage	<i>Artemisia frigida</i>	Uplands	All but haplustolls
Winterfat	<i>Ceratoides lanata</i>	Uplands	Nunn clay & Weld loams, petroc. pal.
Rubber rabbitbrush	<i>Chrysothamnus nauseosus</i>	Uplands	Ascalon, Bresser, & Truckton sandy loams; petrocalcic paleustolls
Four-wing saltbush	<i>Atriplex canescens</i>	Uplands	All but haplustolls
New Mexico locust	<i>Robinia neomexicana</i>	Uplands	Ascalon, Bresser, & Truckton sandy loams
White snowberry	<i>Symphoricarpos alba</i>	Slopes	Varied
Western snowberry	<i>Symphoricarpos occidentalis</i>	Rocky, shady rip.	Varied
Skunkbrush sumac	<i>Rhus trilobata</i>	Rocks, slopes	All
Sand cherry	<i>Prunus besseyi</i>	Sandy sites	Asc., Bres., & Truckton sandy loams
Sand sagebrush	<i>Artemisia filifolia</i>	Sandy sites	Asc., Bres., & Truckton sandy loams
Golden current	<i>Ribes aureum</i>	Shady riparian	Typic & aquic haplustolls
Silver buffaloberry	<i>Shepherdia argentea</i>	Sunny riparian	Typic & aquic haplustolls
Chokecherry	<i>Prunus virginiana</i>	Moist sites, rip	Typic & aquic haplustolls
American plum	<i>Prunus americana</i>	Moist sites	Satanta & Bresser-Satanta loams
Woods' rose	<i>Rosa woodsii</i>	Moist sites	Typic & aquic haplustolls

**APPENDIX C: SUMMARY OF BALANCE SHEET**

**Mitigation Balance Sheet Summary: Disturbed Acreage Requiring Mitigation and  
Actual Acreage Mitigated, Rocky Mountain Arsenal National Wildlife Refuge, 1999.**

<u>Disturbance Project</u>	<u>Total Acres</u>	<u>H.H.E. Acres</u>	<u>Acres Req. Mit.</u>	<u>Acres Mitigated</u>
<b>Pre-R.O.D. Impacts</b>				
1. Derby Lakes - fluctuations	72.1	3.4	140.8	54.0
2. Lower Derby Dam 1990 trees	0.0	0.0	0.0	0.0
3. Lower Derby Dam 1996 trees	0.0	0.0	0.0	0.0
4. Lower Derby Dam Spillway shrubs	16.1	0.0	32.2	5.7
5. Ladora Spillway rip-rap and dam maintenance (IRA-L-FP) '96 trees	0.0	0.0	0.0	0.0
6. Barracks/Rod & Gun Club	2.5	0.0	5.0	0.5
7. Hydrazine Blending Facility	32.1	0.0	64.2	12.3
8. Hydrazine Facility Dirt Pile NE Sect. 1	20.8	0.0	41.6	0.0
9. Wetlands Haul Roads Sections 7 & 8	1.4	0.0	2.8	1.8
10. Borrow Site EC Sect. 34	2.4	0.0	4.8	1.2
11. North Boundary System	178.1	0.0	356.2	149.5
12. N.W. Boundary System	77.0	0.0	154.0	59.6
13. Irondale System	75.4	0.0	150.8	0.0
14. North Bog	2.9	0.0	5.8	0.0
15. Basin A Neck	15.6	0.1	31.1	0.0
16. Expansion of Roads Sections 4 & 34	2.5	0.0	5.0	3.5
17. Cross-country Road Sect 33	1.0	0.0	2.0	0.1
18. SQI Facility Construction	23.6	0.0	47.2	0.0
19. Borrow Pit and access road in SW Sect 25 to build SQI.	11.7	0.0	23.4	0.0
20. Cleanup of SQI tanks & spoils pile, plus Ponds A & B.	32.8	5.9	59.7	0.0
21. Borrow site in NW Sect 25 to facilitate grading of Ponds A & B	25.4	0.0	50.8	241.5
22. Small areas of soil disturbance in NW 3, SE 4, NW 10, and NW 35, plus various small (<1 acre) soil disturbances.	2.4	0.0	4.8	4.2
23. Basin F Waste Pile Construction	24.6	18.7	30.5	0.0
24. Borrow pits & waterline in Sect 25 for Basin F Pile	89.2	0.0	178.4	0.0
25. Borrow pit in WC 20 for South Plants	1.8	0.0	3.6	0.0
26. Construct Facilities Maintenance and Motor Pool Complex	7.4	0.0	14.8	0.0
27. Construct ARF	1.4	0.0	2.8	0.0
28. Construct Change House	8.4	0.0	16.8	0.0
29. Construct Analytical Lab	5.5	0.0	11.0	0.0
30. Construct CERCLA Facility in SE 35 (IRA-M)	8.0	0.0	16.0	0.0
31. Construct MK-ES Bldg.	4.7	0.0	9.4	0.0
32. Construct Contractor Trailers in Sec 35	7.0	0.0	14.0	0.0
33. Construct Sewage Plant NW 35	25.7	0.0	51.4	0.0



**Phase IV Remediation:**

Project 30: Basin F Waste Pile Remediation	15.6	15.6	15.6	0.0
Project 31: Former Basin F Solidification	19.8	19.8	19.8	0.0
Project 32: Basin F and Basin F Exterior Remediation	342.1	90.8	593.4	0.0
Project 33: Section 36 Lime Basins Soil Remediation	13.2	6.5	19.9	0.0
<b>Other Remediation:</b>				
Additional CAMU Priority 1	125.1	0.0	250.2	30.0

<b>Acreage of 33 Remediation Projects Compared to Required Mitigation Acreage</b>	<b>1737.6</b>	<b>365.0</b>	<b>3110.2</b>	<b>583.6</b>
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**Twelve Borrow Sites**

Borrow Site 1, SE 3	46.0	0.0	92.0	0.0
Borrow Site 2, NW 3	9.4	0.0	18.8	0.0
Borrow Site 3, SW 26, N & E 35	208.0	0.0	416.0	0.0
Borrow Site 4, Section 23	312.8	0.0	625.6	0.0
Borrow Site 5, southern 24	167.1	0.0	334.2	0.0
Borrow Site 6, NE 25	62.4	0.0	124.8	0.0
Borrow Site 7A, southern 25	62.2	0.0	124.4	0.0
Borrow Site 7B, northern 36	31.8	0.0	63.6	0.0
Borrow Site 8, eastern 25	28.9	0.0	57.8	0.0
Borrow Site 9A, SE 25, NE 36, SW 30	56.1	0.0	112.2	0.0
Borrow Site 9C, SW 31	52.1	0.0	104.2	0.0
Borrow Site 10, eastern 31 (TSY)	220.2	0.0	440.4	0.0
Borrow Site 11A, NE 1, NW 6	167.7	0.0	335.4	0.0
Borrow Site 11B, EC 1, NW 6	25.5	0.0	51.0	0.0
Borrow Site 12, NW 25	23.8	0.0	47.6	0.0

<b>Acreage of 12 Borrow Sites Compared to Required Mitigation Acreage</b>	<b>1474.0</b>	<b>0.0</b>	<b>2948</b>	<b>0.0</b>
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<b>Acreage of All pre-R.O.D. Projects, 33 Remediation Projects, &amp; 12 Borrow Sites Compared to Required Mitigation and Actual Acres Mitigated</b>	<b>4031.1</b>	<b>393.1</b>	<b>7669.1</b>	<b>1117.5</b>
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Revised 07/01/99

**APPENDIX D: SECTION 02900 OF REMEDIATION PROJECTS  
(SPECIFICATIONS FOR INTERIM AND TEMPORARY REVEGETATION)**

## SECTION 02900

### REVEGETATION

#### PART 1 GENERAL

##### 1.1 SECTION INCLUDES

- A. Requirements for seeding of vegetation.
- B. Specifications for temporary, interim, and permanent seeding.

##### 1.2 REFERENCES

- A. Federal Seed Act, amended August 1988
- B. Commercial Item Description - CID A-A-1909-Fertilizer
- C. Colorado Noxious Weed Act 35-5.5-101 through 119 C. R. S. (1996 supp.)
- D. Health and Safety Plan for the Program Management Contract
- E. Program Management Contractor Quality Management Plan
- F. Submittal Procedures, Specification Section 01300

##### 1.3 SUBMITTALS

- A. Seeding Plan: Submit a Seeding Plan in accordance with Specification Section 01300 Submittal Procedures, detailing all seeding equipment to be used, fertilizer types, and mulch sources for inspection by the Contractor prior to initiation of work.
- B. Seeds: Certification from the supplier in accordance with Subpart 2.2 of this specification section.
- C. Fertilizer: Formulation certification from supplier.
- D. Daily Quality Control Logs.
- E. Task Specific Health and Safety Plan.

##### 1.4 SUBCONTRACTOR QUALIFICATIONS

- A. Subcontractor must have a minimum of 10 years of experience.
- B. The on-site operator of the equipment must have 3 years of experience in seeding native seed mixes.
- C. Must have or attain proper equipment for the three seeding categories (see seed categories in Subpart 1.7). An equipment list shall be supplied to the Contractor.
- D. Must provide the Contractor with a description of previous experience that includes examples of prior native revegetation work in the Rocky Mountain region or similar ecological region and a minimum of four client references.

## 1.5 SEEDING CATEGORIES

- A. **Temporary cover seeding** is seeding conducted to stabilize soil with an annual cover crop type vegetation for a period of up to 1 year. As an alternative to temporary cover seeding, a crusting agent or dust control plan could be implemented by the Contractor.
- B. **Interim cover seeding** is seeding conducted to stabilize soil with perennial graminoid vegetation for a period of greater than 1 year. Conduct interim seeding in areas that will be redisturbed at a future date or areas that are not ready for permanent seeding.
- C. **Permanent cover seeding** is seeding conducted at areas that are not anticipated to be disturbed by remediation activities at a future date. The U.S. Fish and Wildlife Service has the first right of refusal for the permanent cover seeding work.

## PART 2 PRODUCTS

### 2.1 SEED MIX

- A. Use **temporary cover seeding for summer cover**. Conduct temporary summer cover seeding during the period of May 16 through June 10, unless otherwise specified by the Contractor. Use the following seed for temporary summer cover:

Scientific Name	Common Name	Variety	Ibs PLS/Acre
<i>Sorghum vulgare</i>	Common Sorghum	Bundle King	12

- B. **Temporary cover seeding for winter cover**. Conduct temporary winter cover seeding during the period of September 1 through October 10, unless otherwise specified by the Contractor. Use the following seed mix for temporary winter cover:

Scientific Name	Common Name	Ibs PLS/Acre
<i>Secale cereale</i>	Winter Rye	12

- C. **Interim cover seeding**. Conduct interim seeding only during the period of October 1 through May 15. If interim cover seeding cannot be planted between October 1 and May 15, use the appropriate temporary cover seeding (winter or summer) to stabilize soils until the next interim seeding date, at which time, apply the required interim cover seeding. Use one of the following seed mixes for interim seeding cover:

Scientific Name	Common Name	Variety	Ibs PLS/Acre
<i>Agropyron desertorum</i> or <i>Elymus trachycaulus</i>	Crested Wheatgrass	Nordon	10
	Slender Wheatgrass	Primar	12

- D. **Permanent cover seeding**. Conduct seeding only during the period of March 21 through May 15 or September 15 through November 30. If permanent cover seeding cannot be planted during either period, use the appropriate temporary cover seeding (winter or summer) to stabilize soils until the next permanent seeding date, at which time, apply the required permanent cover seeding. Use a native seed mix for permanent seeding cover based on soil type and area to be seeded.

- 1. Native seed mix for constructed cover areas:
  - a. Seed mix for sites with **loam soil** (see project-specific drawings). Rates are for drill seeding. Double drill seeding rates for broadcast seeding.

**NATIVE GRASS SPECIES**

Scientific Name	Common Name	Variety	lbs PLS/Acre
<i>Buchloe dactyoides</i>	Buffalo Grass	Texoka	0.70
<i>Buchloe dactyoides</i>	Buffalo Grass	Native*	0.70
<i>Bouteloua gracilis</i>	Blue Grama	Hachita	0.05
<i>Bouteloua gracilis</i>	Blue Grama	Native*	0.05
<i>Panicum virgatum</i>	Switchgrass	Nebraska 28	0.60
<i>Bouteloua curtipendula</i>	Side-oats Grama	Vaughn	0.80
<i>Sporobolus cryptandrus</i>	Sand Dropseed	Native*	0.01
<i>Stipa comata</i>	Needle-and-thread	Native*	1.30
<i>Pascopyron smithii</i>	Western Wheatgrass	Arriba	4.20
<i>Poa secunda</i>	Sandberg Bluegrass	Native*	0.10
<i>Elymus trachycaulus</i>	Slender Wheatgrass	Primar	0.50
<i>Elymus lanceolatus</i>	Thichspike Wheatgrass	Critana	<u>0.50</u>
		Subtotal	9.51

\* Native seed varieties shall be from appropriate climatic region. Sources for native seed variety shall be subject to inspection and concurrence by the Contractor before subcontractor is authorized to proceed with seeding.

**NATIVE FORBS (Wild Flowers)**

Scientific Name	Common Name	lbs PLS/Acre
<i>Erysimum asperum</i>	Wallflower	0.01
<i>Gaillardia aristata</i>	Blanket Flower	0.10
<i>Penstemon angustifolia</i>	Narrow-leaf Penstemon	0.02
<i>Linum lewisii</i>	Blue Flax	0.03
<i>Helianthus annuus</i>	Annual Sunflower	0.01
<i>Cleome serrulata</i>	Rocky Mountain Bee Plant	0.10
<i>Liatris punctata</i>	Blazing-star	0.10
<i>Oenothera villosa</i>	Tall Evening-primrose	0.01
<i>Coreopsis tinctoria</i>	Plains Coreopsis	0.01
<i>Oputia polyacantha</i>	Prickly Pear Cactus	<u>0.10</u>
	Subtotal	0.49
	<b>Total</b>	<b>10.00</b>

- b. Seed mix for sites with **sandy loam soil** (see project-specific drawings). Rates are for drill seeding. Double drill seeding rates for broadcast seeding.

**NATIVE GRASS SPECIES**

Scientific Name	Common Name	Variety	lbs PLS/Acre
<i>Elymus trachycaulus</i>	Slender Wheatgrass	Primar	1.00
<i>Stipa comata</i>	Needle-and-thread	Native*	1.30
<i>Pascopyron smithii</i>	Western Wheatgrass	Arriba	2.80
<i>Calamovilfa longifolia</i>	Prairie Seedreed	Goshen	0.80
<i>Bouteloua curtipendula</i>	Side-oats Grama	Vaughn	0.40
<i>Buchloe dactyoides</i>	Buffalo Grass	Texota	0.70
<i>Buchloe dactyoides</i>	Buffalo Grass	Native*	0.70
<i>Sporobolus cryptandrus</i>	Sand Dropseed	Native*	0.01
<i>Andropogon hallii</i>	Sand Bluestem	Woodward	2.00
<i>Panicum virgatum</i>	Switchgrass	Nebraska 28	<u>0.20</u>
		Subtotal	9.91

\* Native seed varieties shall be from similar climatic region. Sources for native seed variety shall be subject to inspection and concurrence by the Contractor before subcontractor is authorized to proceed with seeding.

**NATIVE FORBS (Wild Flowers)**

Scientific Name	Common Name	lbs PLS/Acre
<i>Cleome sarrulata</i>	Rocky Mountain Bee Plant	0.10
<i>Liatris punctata</i>	Blazing-star	0.10
<i>Oenotera villosa</i>	Tall Evening-primrose	0.01
<i>Gaillardia aristata</i>	Blanket Flower	0.10
<i>Linum lweisii</i>	Blue Flax	0.03
<i>Helianthus annuus</i>	Annual Sunflower	0.01
<i>Achillea lanulosa</i>	Yarrow	0.003
<i>Coreopsis tinctoria</i>	Plains coreopsis	0.01
<i>Abronia fragrans</i>	Sand Verbena	0.20
<i>Opuntia polyacantha</i>	Prickly Pear Cactus	0.10
	Subtotal	0.663
	<b>Total</b>	<b>10.573</b>

2. Native seed mix for borrow areas and noncover areas:

- a. Seed mix for sites with Ascalon Sandy Loam, Bresser Sandy Loam, Bresser-Satanta Sandy Loam, Truckton Sandy Loam soil types (see project-specific drawings). Rates are for drill seeding. Double drill seeding rates for broadcast seeding.

**NATIVE GRASS SPECIES**

Scientific Name	Common Name	Variety	lbs PLS/Acre
<i>Andropogon hallii</i>	Sand Bluestem	Woodard	4.1
<i>Bouteloua curtipendula</i>	Side-oats Grama	Vaughn	0.2
<i>Bouteloua gracilis</i>	Blue Grama	Hachita	0.2
<i>Calamovilfa longifolia</i>	Prairie Seedreed	Goshen	1.4
<i>Oryzopsis hymenoides</i>	Indian Ricegrass	Nezpar	0.3
<i>Panicum virgatum</i>	Switchgrass	Nebraska 28	0.4
<i>Pascopyron smithii</i>	Western Wheatgrass	Arriba	0.7
<i>Stipa comata</i>	Needle-and-thread	Native*	0.7
		Subtotal	8.0

**NATIVE FORBS OR SEMI-SHRUBS (Wild Flowers)**

Scientific Name	Common Name	lbs PLS/Acre
<i>Abronia fragrans</i>	Sand Verbena	0.1
<i>Achillea lanulosa</i>	Yarrow	0.001
<i>Artemisia frigida</i>	Fringed Sage	0.001
<i>Artemisia ludoviciana</i>	Louisiana Sangewort	0.001
<i>Cleome serrulata</i>	Rocky Mountain Bee Plant	0.10
<i>Coreopsis tinctoria</i>	Plains coreopsis	0.003
<i>Delphinium virescens</i>	Larkspur	0.02
<i>Gaillardia aristata</i>	Blanket Flower	0.03
<i>Helianthus annuus</i>	Annual Sunflower	0.10
<i>Ipomoea leptophylla</i>	Bush Morning Glory	0.20
<i>Liatris punctata</i>	Blazing-star	0.03
<i>Linum lweisii</i>	Blue Flax	0.02
<i>Oenothera caepitosa</i>	Stemless Evening-primrose	0.01
<i>Oenothera villosa</i>	Tall Evening-primrose	0.003
<i>Oputia polyacantha</i>	Prickly Pear Cactus	0.10
<i>Penstemon angustifolia</i>	Narrow-leaf Penstemon	0.01
<i>Sphaeralcea coccinea</i>	Scarlet Globemallow	<u>0.01</u>
	Subtotal	0.739

**Native shrubs**

Scientific Name	Common Name	lbs PLS/Acre
<i>Artemisia filifolia</i>	Sand Sagebrush	0.01
<i>Atriplex canescens</i>	Fourwing Saltbrush	0.30
<i>Chrysothamnus nauseosus</i>	Rubber Rabbitbrush	0.04
<i>Yucca glauca</i>	Yucca	<u>0.80</u>
	Subtotal	1.15
	<b>Total</b>	<b>9.889</b>

- b. Seed mix for sites with Satanna Loam, and Weld Loam soil types. Rates are for drill seeding. Double drill seeding rates for broadcast seeding.

**NATIVE GRASS SPECIES**

<i>Bouteloua gracilia</i>	Blue Grama	Hachita	0.7
<i>Buchloe dactyloides</i>	Buffalo grass	Sharp's	4.1
<i>Pascopyron smithii</i>	Western Wheatgrass	Arriba	3.5
<i>Sporobolus cryptandrus</i>	Sand Dropseed		<u>0.04</u>
		Subtotal	8.34

**NATIVE FORBS OR SEMI-SHRUBS (Wild Flowers)**

Scientific Name	Common Name	lbs PLS/Acre
<i>Abronia fragrans</i>	Sand Verbena	0.1
<i>Achillea lanulosa</i>	Yarrow	0.001
<i>Antennaria rosia</i>	Pussytoes	0.004
<i>Artemisia frigida</i>	Fringed Sage	0.001
<i>Artemisia Ludoviciana</i>	Louisiana Sagewort	0.001
<i>Astragalus missouriensis</i>	Missouri Milkvetch	0.03
<i>Cleome serrulata</i>	Rocky Mountain Bee Plant	0.10
<i>Delphinium virescens</i>	Larkspur	0.02
<i>Erysimum asperum</i>	Wallflower	0.004
<i>Gailardia aristata</i>	Blanket Flower	0.30
<i>Helianthus annuus</i>	Annual Sunflower	0.01
<i>Linum lewisii</i>	Blue Flax	0.02
<i>Oputia polyacantha</i>	Prickly Pear Cactus	0.10
<i>Penstemon angustifolia</i>	Narrow-leaf Penstemon	0.01
<i>Ratibida columnaris</i>	Prairie Coneflower	0.004
<i>Rudbeckia hirta</i>	Black-eyed Susan	0.003
<i>Sphaeralcea coccinea</i>	Scarlet Globemallow	0.01
<i>Vicia americana</i>	American Vetch	<u>0.10</u>
	Subtotal	0.448

**Native shrubs**

Scientific Name	Common Name	lbs PLS/Acre
<i>Atriplex canescens</i>	Fourwing Saltbrush	0.30
<i>Climatis ligusticifolia</i>	Western Virgin's Bower	0.1
<i>Rhus trilobata</i>	Skunkbrush Sumac	<u>1.3</u>
	Subtotal	1.9
	<b>Total</b>	<b>10.688</b>

2.2 ACCEPTANCE OF SEED

- A. Test seed according to the Association of Official Seed Analysts, International Seed Testing Association, and the Federal Seed Act standards. Tested seed shall be accompanied by a certificate of analysis furnished by a certified testing laboratory. All seed shall be subject to inspection and concurrence by the Contractor before the subcontractor is authorized to proceed with the seeding operation.
- B. Certify as tested the following individual seed types:
  - 1. Purity and Germination: Before seed is used, retest for germination all seed stored over six months from the date of the original acceptance test, and resubmit the results for inspection.
  - 2. Prohibited Noxious Weed Seed: Seed shall contain no federal- or state-listed prohibited noxious weed seed (an amount within the tolerance of zero percent) as determined by a standard purity test.
  - 3. Restricted Noxious Weed Seed: Seed shall contain no more than 40 seeds per pound of any single species, or 150 seeds per pound of all species combined, of restricted noxious weed seed. Restricted noxious weed seed is considered to be a component of other crop and weed seed with limitations specified.
  - 4. Weed Seed: Seed shall contain no more than 1 percent by weight of weed seed of other crops and plant species as determined by standard purity tests.

- C. Furnish the Contractor with certification from the supplier that each lot of seed has been tested by a certified testing laboratory for seed testing within six months of date of delivery. This statement shall include the following:
  - 1. Name and address of laboratory
  - 2. Date of test
  - 3. Lot number of each seed type
  - 4. Results of tests, including name, percentage of purity and germination, percentages of weed content for each kind of seed furnished, hard seed content, and in case of seed mixtures, pure live seed (PLS) proportions of each kind of seed as specified herein.
- D. Information regarding the seed mixture shall be provided by the seed vendor on each standard sealed container label. The labels shall include the following information:
  - 1. Seed mixture name
  - 2. Lot number
  - 3. Total net weight and PLS weight of each seed type
  - 4. Percentages of purity and germination
  - 5. Seed coverage, in acres, on a PLS basis
  - 6. Percentage of maximum weed seed content clearly marked for each seed type.
- E. Seed shall be packaged by the vendor such that the acre coverage of each container is equal for convenience of inventory.

### 2.3 HAY MULCH

Mulch shall consist of native prairie grass hay or weed-free introduced grass hay. Mulch shall not be brittle, molded, or rotted and shall be free of weed seeds classified as "prohibited noxious" and other weeds classified as "troublesome" by the Colorado Weed Management Association (Colorado Noxious weed act). Mulch shall be in air-dry condition and suitable for placing with mulch blower equipment. The mulch will be subject to inspection and concurrence by the Contractor prior to the application of mulch by the subcontractor.

### 2.4 FERTILIZER

- A. Fertilizer shall be commercial-grade, free-flowing, low in salts, and uniform in composition and conforming to CID A-AA-1909. All fertilizer shall be subject to inspection and concurrence by the Contractor before the subcontractor is authorized to proceed with the fertilizer operation.
- B. If the fertilizer is delivered in bulk, a certificate from the manufacturer or supplier indicating labeling required by the Colorado Department of Agriculture shall be submitted to the Contractor for each load.
- C. Granular fertilizer shall consist of nitrogen-phosphorus-potassium, with ratio of 18 parts nitrogen, 46 parts phosphorus, and 0 parts potassium (18-46-0). Fertilizer shall be inspected by the Contractor prior to use.
- D. Fertilizer shall be accompanied by the appropriate material safety data sheet (MSDS).

## 2.5 SOIL AMENDMENTS

- A. Soil layer shall be amended with weed-free organic materials where no topsoil layer is present.
- B. Organic material may consist of the following:
  - 1. Composted biosolids
  - 2. Humic substances
  - 3. Poultry waste
  - 4. Ground bark
  - 5. Sawdust
  - 6. Grass hay
  - 7. Oil seed meal
  - 8. Brewing byproducts
  - 9. Other wood waste material
  - 10. Other organic materials approved by the Contractor
- C. All amendments must be free of stones and sticks, and/or soil or toxic substances harmful to plants.
- D. Amendment gradation: A minimum of 95 percent of the amendment shall pass a No. 4 sieve, and a minimum of 80 percent shall pass a No. 8 sieve.
- E. The carbon to nitrogen ratio (C:N) shall fall within the range of 20:1 to 30:1.

## PART 3 EXECUTION

### 3.1 SEED DELIVERY AND INSPECTION

- A. Pack seeds of the latest season's crop for delivery in suitable rodent-proof bags in accordance with standard commercial practice. If seeds are stored after delivery to the work site, store in a cool, dry, and weatherproof place in a manner that protects the seed from deterioration and permits easy access for inspection.
- B. Deliver seed and seed mixtures in a sealed container. Reject wet, moldy, or otherwise damaged seed packages. Remove unacceptable materials from the job site. All labeling required by law shall be intact and legible.
- C. Deliver fertilizer in waterproof bags or bulk containers and provide all labeling, as required by the Colorado Department of Agriculture, showing weight, grade, chemical analysis, and name of manufacturer.
- D. Prior to planting any seed, the Contractor will inspect seed labels and certification documentation to ensure the seed provided meets the requirements of this specification.
- E. Equipment proposed for use and the methods of seeding shall be subject to inspection and concurrence by the Contractor prior to the commencement of seeding operations. The subcontractor

shall check the equipment for compliance to safety requirements (Contractor HASP) prior to the commencement of seeding operations. Conduct equipment calibration tests in the presence of the Contractor immediately prior to commencement of seeding operations and when the seeding vegetation type changes or when different equipment is used.

### 3.2 ENVIRONMENTAL CONDITIONS

- A. Perform seeding operations only during periods when successful results can be obtained. When drought, excessive moisture, or other unsatisfactory conditions prevail, as determined by the Contractor, the Subcontractor will stop work. When special conditions warrant a variance to the operations, including a work stoppage, submit proposed variances to the Contractor for approval.
- B. Do not conduct seeding operations when soil is frozen or when snow is present.
- C. Do not conduct seedbed preparation, seeding, or mulch application when wind conditions cause the seed/mulch to blow from the intended target area.

### 3.3 AMENDMENTS AND AMENDMENT APPLICATION

- A. The Contractor will direct the Subcontractor regarding the type of soil amendment, chemical fertilizer or biosolids, to be incorporated in specific areas.
- B. For temporary and interim seeding sites, apply fertilizer prior to seedbed preparation by broadcast spreading at a rate of 100 pounds of fertilizer per acre.
- C. For interim and permanent seeding sites, amend the topsoil zone at the time of revegetation with organic materials consisting of composted biosolids (sewage sludge) or other organic materials. The rate of application will be 40 dry weight tons per acre of total organic material with a carbon to nitrogen ratio (C:N) of between 20:1 and 30:1. Evenly spread organic amendments prior to conducting seedbed preparation.

### 3.4 SEEDBED PREPARATION

- A. Maintain existing drainage patterns or as indicated on the project-specific drawings. Retill areas compacted by construction.
- B. Protect finished graded areas from damage by vehicular or pedestrian traffic and erosion.
- C. Use the following criteria to prepare **temporary and interim cover seedbeds when chemical fertilizer will be incorporated:**

Disc to a minimum depth of 6 inches with an offset disc followed by harrowing or other implements until a smooth, reasonably firm but friable seedbed is provided. A smooth seedbed shall be defined as prepared soils containing no particles greater than 1.5 inches in any dimension within 1.5 inches of the top surface of the prepared soil. Should the disc not penetrate the required 6 inches, chisel or rip to a depth of 6 to 8 inches on maximum 16-inch centers prior to discing. Finished seedbed preparation shall be inspected by the Contractor before further seeding operations are implemented.

- D. Use the following criteria to prepare **interim or permanent cover seedbeds when biosolids will be incorporated:**

- 1. Chisel on maximum 16-inch centers to a minimum depth of 18 inches after all backfill and grading activities have been completed and soil amendments have been evenly spread in the area to be seeded.

2. After the area to be seeded has been chiseled, disc with an offset disc or rototill to a depth of 6 to 8 inches so that organic amendments are evenly incorporated into the top 6 to 8 inches of the soil.
  3. After incorporation of organic material is complete, harrow the area to provide a smooth, reasonably firm but friable seedbed. A smooth seedbed shall be defined as prepared soils containing no particles greater than 1.5 inches in any dimension within 1.5 inches of the top surface of the prepared soil. Should the disc not penetrate the required 6 inches, chisel or rip to a depth of 6 to 8 inches on maximum 16-inch centers prior to discing. Finished seedbed preparation shall be inspected by the Contractor before further seeding operations are implemented.
- E. Prior to seeding, rework any previously prepared seedbed areas compacted or damaged by rain, traffic, or other cause to restore the seedbed to previous condition.

### 3.5 SEED TIMING

- A. Fall seeding September 15–November 30 Permanent seeding
- B. September 10–October 10 Temporary seeding
- C. Spring seeding March 1–April 1 Temporary seeding
- D. March 21–May 15 Permanent seeding
- E. Summer seeding May 16–June 10 Temporary seeding
- F. All seasons September 1–May 15 Interim seeding

### 3.6 TEMPORARY AND INTERIM SEEDING

- A. Perform seeding within 10 days of seedbed preparation.
- B. Plant temporary and interim seed by drill seeding.
  1. Sow seed with a seed drill equipped with double coulter furrow openers and depth bands followed by packer wheels.
  2. Plant seed to an average depth of 0.25 inch, but not deeper than 0.50 inch.
  3. Do not exceed 12 inches distance between rows.
  4. Calibrate the seed drill to the specified seeding rates in the presence of the Contractor.

### 3.7 PERMANENT SEEDING

- A. Perform seeding within 10 days of completion of seedbed preparation.
- B. Plant permanent cover by drill seeding or by evenly broadcasting and incorporating the seed into the soil surface by harrowing.
  1. Drill Seeding
    - a. Seed with a rangeland type drill equipped with double coulter furrow openers and depth bands followed by packer wheels. Use a drill capable of evenly seeding the

native seeds mixes over the entire site. Do not exceed 6 inches between drill rows.

- b. Plant seed to an average depth of 0.25 inch but not deeper than 0.50 inch.
- c. Use row markers with drill seeder.
- d. Perform seeding in two directions, 90 degrees from each other, each direction at half the rate specified. Calibrate the seed drill to the specified seeding rate in the presence of the Contractor.

2. Broadcast Seeding

- a. Uniformly broadcast seed at twice the rates specified for drill seeding.
- b. Rake seed into the soil to an average depth of 0.25 inch, but not deeper than 0.50 inch by a harrow device.

3.8 IRRIGATION

- A. Irrigate only permanent seeding sites during the first growing season.
- B. Provide an irrigation system capable of supplying water to the entire job site at a minimum rate of 2 inches per month during the months of June, July, and August. Watering of the seeded areas shall proceed from a frequent low amount of water to an infrequent higher volume of water. For the first 2 weeks after the start of the watering program, the seeded sites shall be watered a minimum of 0.25 inch twice a week to maintain a moist soil condition. The assessment of appropriate soil moisture will be subject to review by the Contractor. Thereafter, the seeded areas will be watered weekly with a total of 0.5 inch of water per week the next 2 weeks. The next 6 weeks of irrigation will apply a total of 1.0 inch of water every other week. The last 4 weeks of irrigation will apply a total of 0.5 inch of water every other week. Watering will be required for a total of 12 weeks after the completion of seeding operations. Application of water may be altered to avoid excess irrigation. Specific irrigation schedules will be based upon plant establishment requirements and soil moisture levels during the vegetation establishment period.

Irrigation Schedule

Date	Application Rate	Total Application
June 1 – June 15	0.25" twice per week	1"
June 16 – July 1	0.5" once per week	1"
July 2 – Aug. 15	1.0" every other week	3"
Aug. 16 – Aug 31	0.5" Every other week	1"

- C. The sources of irrigation water shall be as shown on project-specific drawings.

3.9 HAY MULCHING AND ANCHORING

- A. Spread and anchor grass hay mulch on areas that have been seeded with interim or fall-seeded permanent seed mixes within 24 hours after seeding.
- B. Apply hay mulch in a continuous cover of uniform thickness at a rate of 2 tons per acre.
- C. Anchor hay mulch to the soil by crimping hay into the soil with a crimping disc on approximate

contours 2 to 3 inches deep at no wider than 8-inch spacing. Use V-type-wheel land packers, scalloped-disc land packers, or other suitable equipment. No less than 75 percent of the hay shall remain on the surface after anchoring.

- D. Start mulching on the windward side of relatively flat areas or on the upper part of steep slopes and continue uniformly until the area is covered. Mulch that remains clumped or bunched after application shall be separated and respread.

### 3.10 VEGETATION ESTABLISHMENT

- A. See project-specific drawings for details on areas indicated for temporary, interim, and permanent cover seeding.
- B. Protection: Immediately after seeding, protect seeded areas against traffic or other use by erecting barricades and providing signage as required or directed by the Contractor. Retill, seed, and mulch any areas impacted by traffic as directed by the Contractor.
- C. Repair: Reseed and mulch eroded, damaged, or barren areas that occur prior to completion of the seeding operation as determined by the Contractor. Repair or replace mulch as required.

### 3.11 RESTORATION AND CLEANUP

- A. Restore all areas that have been damaged from the seeding operation to original condition.
- B. Remove excess and waste material from the planting operation area and dispose off- site (e.g., extra mulch, bale twine). Clean adjacent paved areas.

### 3.12 QUALITY ASSURANCE

- A. Cooperate with the Contractor during quality assurance audits and surveillance.
- B. Respond to concerns or findings related to oversight in a specified time frame.

- END OF SECTION -