RECLAMATION MONITORING PROGRAM
PROGRAM REPORT - GHS-524-93

Prepared for:

DEPARTMENT OF ENERGY
ROCKY FLATS OPERATIONS
GOLDEN, COLORADO

Prepared by:

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ENVIRONMENTAL PROTECTION MANAGEMENT
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Introduction

The purpose of the Reclamation Monitoring Program is to monitor the progress and success of reclamation activities on disturbed or otherwise ecologically modified areas on the Rocky Flats Plant (RFP). The overarching purpose of this report is to stress the need for a coherent reclamation program which develops reclamation standards, guides reclamation activities, and develops a plan for monitoring reclamation success.

In the past, reclamation activities at the RFP have been done separately for each project by personnel with varying levels of competence and experience. The persons responsible for designing and implementing reclamation and revegetation plans have worked independently and without guidance or a consistent framework. This has resulted in plans that were insufficient or unable to succeed. In light of the RFP's new mission to clean up the plantsite, reclamation activities can only become more common. A set of procedures, guidelines for defining successful revegetation, and guidelines for monitoring revegetation success will facilitate revegetation activities. EG&G's Ecology and National Environmental Policy Act Division (END) contains a cadre of ecologists capable of designing aand implementing reclamation and revegetation activities on the RFP. Members of END's Ecology Group are:

Stephen M. Nesta	END Manager
Dr. Fred A. Harrington	technical lead, ecologist
Dr. Juli K. Armstrong	plant ecologist, database manager
Dr. Mark E. Bakeman	soil ecologist
Bruce J. Bevirt	field ecologist
Dr. Thomas M. Ivory	aquatic ecologist
Jeff D. Krause	wetlands ecologist
Alison Deans	plant ecologist, mammal ecologist
Marcia B. Murdock	field ecologist
Dr. Frank A. Vertucci	aquatic ecologist
Dr. Lawrence E. Woods	soil ecologist

The terms reclamation, remediation, and revegetation are often used interchangably although their connotations are quite different. Reclamation is converting a disturbed site to a condition that conforms to a predesignated purpose (e.g., livestock grazing or wildlife use). This purpose may include erosion control, dust suppression and surface stabilization. Remediation, on the other hand, generally refers to the removal of contaminants and reduction of risks posed by contamination. Revegetation refers to the process of replacing or augmenting plant life on a disturbed site. It has a connotation of anthropogenically induced regrowth (through seeding, fertilizing or other processes), but may also refer to natural recolonization. Throughout this report, "revegetation" will carry the meaning of anthropogenically induced and, in some cases, maintained regrowth, from selection of the seedmix, to preparation of the seedbed (if necessary) and the spreading of the seed. Revegetation is an important aspect of reclamation and in many cases, is important for the recovery of sites disturbed during remedial activities.

Outlined below are the objectives of the Reclamation Monitoring Program as well as a description of the areas that have already been reclaimed and areas for which reclamation is projected. These disturbed areas will usually require revegetation and subsequent monitoring

of the revegetation efforts.

Objectives

The primary objective of END's reclamation monitoring plan is to establish the degree of success of revegetation activities following a remedial or reclamation action. If revegetation is not successful, the plan outlines steps to correct the condition.

All Remedial Actions or Interim Remedial Actions that ultimately result in a revegetated landscape need to have the final success of the actions evaluated. This is done by reclamation monitoring every 5 years for 30 years under CERCLA (Comprehensive Environmental Response, Compensation, and Liability Act) guidance. This monitoring includes analyses of the media for reappearance of contaminants and evaluation of the reestablished ecosystem.

Additionally, reclamation monitoring can evaluate compliance with wetland policies by comparing vegetation establishment with standards outlined in a wetland mitigation plan.

A secondary objective of reclamation monitoring is to aid in delineating natural resource injuries caused by remedial actions or residual contamination. Residual injury could manifest itself in vegetation, mammals, soil or any other ecosystem component.

Another role for reclamation monitoring is to provide input into technology selection during the Feasibility Study (FS) portion of CERCLA compliance (or Remedy Selection under the Resource Conservation and Recovery Act [RCRA]). Nine criteria must be evaluated for this selection. Two of these are short-term and long-term effectiveness. Prudence suggests that the same ecological monitoring process used to evaluate the success of an action ought to be used to decide which actions to take and which technologies to employ.

Regulatory Drivers

DOE Order 5400.1 requires an ecological monitoring program to be initiated at all DOE facilities, but does not specify what that program should contain. Rocky Flats has initiated such a monitoring program. This program will characterize unimpacted areas that are under DOE's responsibility. This program will provide baseline data and a set of consistent procedures that can be used to monitor reclamation, remediation and revegetation activities.

As mentioned above, CERCLA and RCRA remedial actions performed under the Interagency Agreement (IAG) could benefit from ecological monitoring. CERCLA and RCRA actions have already resulted in disturbances at the 881 Hillside and in the Walnut Creek Drainage which have been revegetated. More remedial actions will no doubt be implemented as the IAG work proceeds.

In order to comply with the Clean Water Act (CWA), management of dams and waterways will be required. These actions will require occasional stabilization of surface soils including revegetation. These activities will require monitoring to establish their efficacy and the

likelihood of permanent establishment.

Natural Resource Damage Assessment (NRDA) regulations constitute an optional rule under CERCLA and the CWA. These regulations allow the trustees of natural resources to collect damages for residual injuries that remain after a CERCLA or CWA release has been remediated. They also allow damages to be collected for the loss of services of the natural resources that resulted from the contaminant release and subsequent remedial activities. Very large damage suits are now in litigation for two DOE sites. This is potentially a very important set of regulations with long term implications. Monitoring remediation success must consider establishing the levels of residual injury, or the lack of injury, that is potentially assessable under NRDA regulations.

Four regulations can be grouped together as "Biological Statutes": the Endangered Species Act (ESA), the Fish and Wildlife Coordination Act (FWCA), the Eagle Protection Act (EPA), and the Migratory Bird Treaty Act (MBTA). All these biological statutes imply that reclamation is not complete until all pre-disturbance conditions of the ecosystem, including the presence of wildlife, have been restored. The Ecology and National Environmental Policy Act Division (END) is currently monitoring ongoing activities with consideration for these requirements.

The Wetland Protection Regulations require that jurisdictional wetlands be selected by the Army Corps of Engineers. These selections are based on vegetation communities, soil characteristics and the presence of water. Any destruction of wetlands may require the creation of new wetlands. Monitoring is one feasible method of assessing if wetlands were indeed lost, and if the newly-created wetlands are functioning and persisting.

There exist a series of county, state and federal Noxious Weed Control regulations that require the control of weeds on federal property. The existence, severity and spread of weeds can best be documented by an ongoing, consistent vegetation monitoring program. Activities that require manipulation of the vegetation community to remove weed populations will also require monitoring to determine their effectiveness. Monitoring will also enable technically feasible alternatives to be suggested in the event that weed control activities are not successful.

Need for Technical Assistance

Compliance with all of the above regulatory requirements requires specific expertise. This expertise currently resides in the Ecology and NEPA Division of EG&G Rocky Flats. In addition to the specific subject matter knowledge outlined below, general ecological expertise is required to put all of the individual subjects into an ecosystem framework. This type of framework places all of the components in relation to each other. It avoids undue emphasis on individual types of measurements, and emphasizes those that are critical to understanding whether or not compliance has been attained.

Probably the most important skills relevant to general remediation monitoring are in vegetation sampling and evaluation. The primary producers (vegetation) constitute the largest amount of biomass in nearly every ecosystem. It might be suggested that if the vegetation is satisfactory, everything else will follow. While that may not be strictly true and does not

necessarily meet the specific requirements of individual regulations, healthy vegetation is certainly an essential part of successful reclamation.

A closely allied and equally important skill is soil science expertise. In order to establish satisfactory vegetation, satisfactory soil conditions must exist. In addition, NRDA regulations specifically call for measurements of soil respiration, microbial biomass, and microbial nitrogen transformations. END currently has experts in soils and soil ecology, an allied skill that ties together vegetation and soils expertise is weed control expertise. END currently has more expertise in these areas than any other division at Rocky Flats.

Additional important adjunct skills lie in small and large mammal, bird, insect, and aquatic biota assessments. These measurements are not normally associated with monitoring reclamation success, however, they may be very important in view of the status of a population of *Zapus hudsonius preblei* (Preble's meadow jumping mouse) in the Buffer Zone. Successful reclamation may provide habitat for this "species of special concern" for the state of Colorado. The Preble's meadow jumping mouse is also a candidate species for listing on the EPA's endangered species list.

END also has collected and is currently interpreting data on the biotic background of unimpacted sites at Rocky Flats. These data are critical for interpreting data collected in conjunction with monitoring for reclamation success. The same procedures must be used and the same data quality objectives followed in order to compare reclaimed with undisturbed sites. In addition, these data will eventually show the overall trends in biotic changes and the ranges that exist naturally in the Rocky Flats ecosystem. Understanding these trends may prevent attempting impossible undertakings and indicate how much manipulation is enough (and when further disturbance is just making things worse).

Current Activities

OU 1 French Drain Revegetation Activities

An example of just how fractured revegetation activities have been is the 881 Hillside French Drain revegetation. In this case, a construction subcontractor engaged another firm to revegetate the area after the construction activities were complete. The initial plan called for irrigation and reseeding with lawn or fairway grasses (*Poa pratensis*). These grasses are not the natural grasses that thrive under the soil and climatic conditions found at the RFP. They would have been expensive to establish and maintain. An alternative revegetation plan (see Appendix 1) was prepared by Remediation Programs Division staff with previous experience in revegetation of mined lands. At that time, there was no established protocol for revegetation and no standards for successful revegetation. This is still true. The professional ecologists of the Ecology and NEPA Division judge that this lack of standard methods for revegetation and for evaluating the success of a revegetation activity could lead to very expensive and questionable practices being implemented in the future.

Installation of the 881 Hillside French Drain was an Interim Remedial Action (IRA) undertaken for CERCLA compliance on a schedule that was part of the Interagency Agreement (IAG). This

installation left roughly 6 acres of highly disturbed surface. Revegetation activities were performed following the completion of the French Drain Installation.

After completion of the construction activities and regrading the surface to approximately the original contours, the site was prepared. Site preparation consisted of ripping to 12 inches, applying 60 pounds of N and P_2O_5 per acre, and disking the surface.

Topsoil that had been previously stockpiled was returned to most of the surface. Because there was insufficient topsoil to cover the entire area, commercial compost was applied to areas that were not covered with the reserved topsoil. The compost appeared to be thick in some places and may not have been well distributed. We do not know how much compost was applied.

Spring barley (*Hordeum vulgare*, Otis variety) was planted for erosion control with a rangeland drill on May 12 and 13, 1992. A "hydroseeder" was used to apply a spray on mulch on May 13, 1992. This mulch contained no tackifier because of concerns about organic compounds from tackifier potentially appearing in subsequent soil or water samples. This concern originated from previous suspicions that "Coherex" used in other places had caused measurable phthalate concentrations at other Rocky Flats locations.

A seed mix containing native grass, forb and shrub seeds was planted on November 17, 1992. The mix was seeded into the standing barley stubble with a no-till drill. Soil temperatures were 10°C or less to prevent premature germination. Eighteen lb/acre of the mix were applied.

END staff recognized the need for an assessment of the revegetation efforts, and conducted assessment fieldwork activities in September, 1993. All methods were developed by END staff, with the aim of ensuring complete data collection consistent with already existing vegetation programs. Twenty-five cover and belt transects were established for the assessment. Mean plant cover was 4.68% and 78% of the site was bare ground. Perennials comprised less than 1% of cover. Yellow sweet clover, an annual forb, constituted 43% of the plant cover detected. More than 80 species are present. A data summary is presented in Appendix 2. Ten transects on and adjacent to the French Drain prior to construction yielded mean plant cover of 29.2% ± 3.3% ($p<0.1$). Mean bare ground values in this community are typically less than 2%.

END staff recommend that a heavy broadcast overseeding of western wheatgrass (*Agropyron smithii*) be applied by hand-held spreaders both in the late fall (soil temperature below 10°C) and again in the spring.

881 French Drain Wetland Reestablishment

The wetland reestablishment provides another example of the inconsistency of reclamation activities at the RFP. None of the personnel involved in the wetland reestablishment were the same as those involved in the French Drain revegetation. The subcontractors, regulator representatives, and EG&G representatives were all different from those conducting the French Drain revegetation activities. A pre-disturbance discription of the site did not exist for comparison. Reclamation guidelines were determined by the regulators and implemented by END staff.

In constructing the 881 French Drain, a small area of cattails and cottonwood trees was removed. This "wetland" was created by the outfall from the perimeter drain of the 881 Building. The regulators (EPA and the Fish and Wildlife Service of DOI) required this to be replaced by another created wetland.

A small basin at the top of the French Drain construction area was enlarged. The bottom of the depression was lined with bentonite and cattails (*Typha* spp.), coyote willow (*Salix exigua*) and two species of rushes were planted as required by EPA specifications.

The initial planting was photographed for documentation. The progress of the planted species has been monitored periodically. The extent of the newly-created wetland was surveyed to establish a baseline size for the wetland. After the wetland was planted with nursery-raised seedlings, END staff compiled a species inventory for the flora within the wetland boundaries. Additionally, emergent insect traps were used to document aquatic invertebrate colonization in the wetland. Monitoring the site will continue.

Weed Control Activities under the Watershed Management Plan

No effective weed control program existed at Rocky Flats Plant after 1988 (or 1989). Prior to that time, weeds were routinely sprayed through RFP maintenance activities which were handled by Plant Services. In 1988 (or 1989), atrazine was detected in Walnut Creek water. This persistent, broadleaf herbicide had been used extensively to suppress weeds, especially in the buffer strip between the fences surrounding the protected area (PA). A decision was made to ban all herbicide use at the RFP. No chemical controls were used thereafter. At this point, Surface Water Division assumed responsibility for weed control.

During the 1970s biological controls for St. Johnswort (*Hypericum perforatum*) and musk thistle (*Carduus nutans*) were instituted. These consisted of species-specific insects. Although no more releases of insects were made, there are thriving populations of all three species of insects. St. Johnswort and musk thistle were inspected during the 1993 growing season. The insects were found to be effectively controlling seed production of these species. The Surface Water Division released additional musk-thistle-specific control insects in the summer of 1993.

END staff monitored baseline conditions in August 1993 on three test plots slated for further weed control experiments. After treatments are applied in subsequent years, the same procedures used to establish baseline conditions will be used to track changes, trends, and progress on the test plots. Data are presented in Appendix 3.

Potential Reclamation Activities

Revegetation will be necessary at several locations around the Buffer Zone. Many of the following activities have already begun, others are ongoing or projected for upcoming years. They are controlled by different groups or Divisions, follow different guidelines (if any), and have different goals. Ideally, they should all be handled consistently and take the same route to completion.

- Landfill: The current landfill (OU7) generally employs no revegetation. Permitting natural recolonization of weeds has been the primary soil stabilization activity utilized at the landfill. Soil Conservation Service guidelines are followed when revegetation is required. Revegetation is anticipated upon closure of the landfill which is projected to occur in the next 2 years.

- Road Closures: Several miles of roads are projected for closure in the coming years. Reclamation for these areas will require revegetation and no reclamation plan currently exists. This activity presents the opportunity to start at the beginning: set a goal and standards, design a reclamation plan, effect the plan, initiate a monitoring program, collect the data and analyze them.

- OU Remedial Activities: Revegetation at OUs is generally required following implementation of the IM/IRA. As discussed earlier, OU1 has been revegetated and monitoring the success of that revegetation occurred in the summer of 1993 and will continue. OU4 has also been revegetated but may require another seeding treatment. OU4 has not been rigorously monitored.

- Flume Construction: EG&G's Surface Water Division plans to construct flumes in various drainages throughout the Buffer Zone. Flume construction will destroy riparian vegetation and its replacement is currently planned.

- Dam Maintenance: Dam repair and maintenance is an ongoing activity at the RFP and revegetation is often necessary following repair. The Surface Water Division currently mows the dams once a year for inspection and reseeds when necessary using the seed mixes presented in the Watershed Management Plan.

- Weed Control: Weeds are controlled throughout plantsite by a variety of methods including biological controls and mowing. These activities are part of the Surface Water Division's Watershed Management Plan which calls for monitoring the success of weed control activities.

Projected Program Activities

Database Development

An extensive database with ties to the Rocky Flats Environmental Data System (RFEDS) has been developed for the EcMP. Not only can the experience gained during database development be applied to developing a database for reclamation activities, but it is a tremendous resource for vegetation information. The species lists for RFP terrestrial communities reside in the EcMP database where they may be easily accessed.

The EcMP's Terrestrial Vegetation module is broken into three sub-modules in the database according to how the data were collected. The collection methods were point-intercept transect, from which frequency and cover will be calculated; belt transect, from which species richness will be determined; and quadrats, from which cover was estimated. A location dictionary for all

the EcMP sites is also being developed. This location dictionary contains permanent information about each site such as height above the nearest water source and slope angle and aspect of the site. The information stored in the location dictionary can be linked to the vegetation data by site and relevant correlations can be sought. A parallel database could be designed by END personnel; location information is valuable to reclamation success and the data will be collected in a manner very similar to that of the EcMP.

Software specifically designed to measure revegetation success has been ordered and will be evaluated for its appropriateness. This software package, Revegetation Information Monitoring and Analysis (RIMA), was designed to assist with the summarization and interpretation of vegetation data. It has the ability to manage multiple-year data sets or data collected only once. RIMA has been used throughout the west for mined land reclamation.

Revegetation Guideline Development

Revegetation responsibilities currently lie with individual managers or foremen who are often in separate divisions within EG&G which do not always have the ecological expertise needed to design, implement, and monitor revegetation efforts. Such disarticulation can lead to inconsistencies in methodology and implementation. Sitewide revegetation guidelines and recommendations and centralization of monitoring and reporting activities would improve the efficiency of the RFP's reclamation process and ensure that it is done consistently throughout plantsite, and in an ecologically sound manner.

Resources in the form of personnel and expertise to effectively design revegetation procedures lie within END. END conducts the Ecological Monitoring Program (EcMP) which is designed to measure and define natural variation in RFP ecosystems. Lists of plant species in four different terrestrial communities at the RFP have resulted from EcMP surveys. These plant lists may be useful in determining seed mixes for revegetation in a variety of community types. In this way, the introduction of aggressive non-native species through revegetation activities may be avoided and native species best adapted to a particular environment may be used. The native habitat is preserved and the native wildlife is enhanced.

END personnel were responsible for evaluating revegetation activities at OU1. The site was surveyed, the database was developed, and the data were analyzed for the evaluation. Similar monitoring activities will be necessary at other OUs where revegetation is required. Reclamation monitoring is part of END's FY94 Work Package and during the coming year a reclamation program will be developed which will recommend reclamation standards for the RFP. Standards will be based upon a literature and data review of plant community and soil property information collected by other programs (EcMP, Baseline Survey, OU surveys), seed mixes used in implementing the Watershed Management Plan, state and federal mining standards, and standards in place at other DOE facilities.

A draft outline for reclamation monitoring activities is presented below. Its purpose is to develop a compliance based model that indicates the success of a remedial action from ecological measurements accurately, repeatably, and cost effectively.

I. Introduction
- A. Remediation Success - Definition including pre-monitoring baseline
- B. Hierarchies of Ecosystems
- C. Assessments
  1. Populations
  2. Communities
  3. Ecosystems
- D. Needs for Standardization
- E. Regulatory Drivers

II. Materials and Methods
- A. Measurements
  1. Populations
     a. Toxicity Tests
  2. Communities
     a. Richness
     b. Diversity
  3. Ecosystems
     a. Nutrient Export
- B. Models
  1. Populations
  2. Communities
     a. RIMA
  3. Ecosystems

III. Results
- A. Observations Commonly Made
- B. Differences between habitat types
- C. Contaminant Indicators
- D. Models Gamed
  1. Outputs
  2. Sensitivity
  3. Relative Predictions (i.e., Population vs Community Models)

IV. Discussion
- A. Levels of Hierarchy
- B. Technical Adequacy
- C. Strengths and Weaknesses
- D. Cost - Benefit Analysis
- E. Timeliness
- F. Regulatory Compliance

V.References
- A. RIMA
- B. MINTEQ

The above outline will be expanded upon in the upcoming fiscal year. Additionally, a literature review of reclamation activities on the RFP will be conducted as will a more thorough analysis of available software and its applicablility.

Appendix 1
OU1 French Drain Revegetation Plan

ROCKY FLATS REVEGETATION PROGRAM FOR SOIL STABILIZATION
Operable Unit 1 (881 Hillside)

GENERAL DESCRIPTION

Long term soil stabilization can best be achieved by maintaining a productive, diversified plant cover. Soil disturbances that destroy the existing plant cover shall be quickly followed by an effective, aggressive revegetation plan that reestablishes the plant cover. During the period of vegetative reestablishment the surface soils must be protected to prevent further degradation of the site and control resuspension of potential soil contaminants. The Rocky Flats revegetation plan is designed to establish a long lasting vegetative cover of perennial shrubs, grasses and forbs while preventing the resuspension of disturbed surface soils. The following revegetation plan is described in chronological order of occurrence. Revegetation activities shall begin immediately following final grading of the site.

Fertilization

Prior to distribution of topsoil, the area of disturbance shall be fertilized with 60 pounds per acre of nitrogen and 60 pounds per acre of phosphorus. This addition of fertilizer prior to topsoiling will provide nutrients to the plant root zone

Topsoil

All topsoil stripped and stockpiled prior to excavation will be uniformly distributed over the area of disturbance.

Seeding

The best time for seeding native plants is in late fall for spring germination. As the French Drain construction will be completed in March, the seeding will be done in two parts. Immediately following final contour grading, fertilization and topsoil distribution the area shall be drilled with Spring Barley (Otis) at 50 pounds per acre after April 15th. The resulting short duration vegetative cover will provide soil protection through the spring and summer months. A second seeding shall follow in late fall, after November 1st, with a native perennial seed mix. This seed mix in Table 1 will be drilled with a no-till seeder at a rate of 18 lbs. per acre. Seeding shall occur along the contour where possible.

Mulch

The Spring Barley should provide standing stubble for soil protection during establishment of the native seed mix. If a sufficient stand of barley is not achieved, a supplementary mulch may be required. EG&G-EM personnel shall determine if the barley stand is sufficient. If a supplementary mulch is required, the area will be covered with a native grass hay mulch at 2 tons per acre and held in place with plastic erosion control netting.

Table 1. Recommended seed mix for 881 Hillside, French drain construction site. The seeding mix is given as a seeding rate on a Pure Live Seed per acre basis, species epithet and common name and variety.

COBBLY FOOTHILL AREAS

Species	Common name - variety	Seeding rate (PLS lb/ac)*
Grasses:		
Agropyron smithii	Western wheatgrass - Arriba	8.0
Bouteloua gracilis	Blue gramma - Lovington	6.0
Bouteloua curtipendula	Sideoats grama - Vaughn	5.5
Stipa comata	Needle-and-thread - native	0.5
Andropogon garardii	Big bluestem - native, Kaw or Champ	2.0
Schyzachyrium scoparium	Little bluestem - Blaze, Pastura, Aldous, or Cimmaron	1.0
Panicum virgatum	Switchgrass - Blackwell or Nebraska 28	1.0
Shrubs:		
Ceratoides lanata	Winterfat - native or Hatch	0.3
Chrysothamnus nauseosus	Rabbitbrush - green plume, native	0.1
Atriplex canescens	Fourwing saltbush - native	0.5
Forbs:		
Linum lewisii	Blue flax - Appar	0.2
Penstemon strictus	Rocky Mtn. penstemon - Bandera	0.2
Dalea purpurea	Purple prairie clover - native or Kaneb	0.5

Appendix 2
OU1 Revegetation Summary Data

FRENCH DRAIN BELT TRANSECT STATISTICS, 1993

(FDBLTST3.WK3)

25 Transects 50 x 2m	NUMBER OBSERVATIONS	PERCENT OCCURRENCE
17 August – 17 September 1993		
TREES AND SHRUBS		
Salix exigua	4	16
Atriplex canescens	12	48
CACTI		
None	0	0
GRAMINOIDS		
Agropyron cristatum	1	4
Agropyron intermedium	13	52
Agropyron repens	2	8
Agropyron smithii	14	56
Bromus inermis	13	52
Bromus japonicus	11	44
Bromus tectorum	20	8
Dactylis glomerata	1	4
Echinochloa crusgallii	6	24
Eragrostis cilianensis	1	4
Festuca pratensis	2	8
Hordeum jubatum	6	24
Hordeum, sp.	18	72
Panicum capillare	10	40
Poa compressa	2	8
Setaria viridis	3	12
FORBS		
Alyssum minus	19	76
Ambrosia artemisiifolia	12	48
Ambrosia psilostachya	20	80
Ambrosia trifida	2	8
Asclepias speciosa	1	4
Camelina microcarpa	3	12
Carduus nutans	19	76
Centaurea diffusa	25	100
Chenopodium album	14	56
Chenopodium leptophyllum	16	64
Chenopodium, sp.	3	12
Chrysopsis villosa	1	4
Cirsium arvense	20	80
Cirsium ochrocentrum	3	12
Convolvulus arvensis	22	88
Conyza canadensis	7	28
Cynoglossum officinale	2	8
Dyssodia papposa	5	20
Erigeron divergens	2	8
Eriogonum alatum	1	4
Erodium cicutarium	12	48
Euphorbia serpyllifolia	3	12
Grindelia squarrosa	11	44
Helianthus annuus	24	96

Kochia scoparia	10	40
Lactuca serriola	23	92
Linaria dalmatica	2	8
Linum perenne	14	56
Lomatium orientale	1	4
Malva neglecta	1	4
Marrubium vulgare	4	16
Medicago lupulina	1	4
Medicago sativa	1	4
Melilotus alba	1	4
Melilotus officinalis	25	100
Oenothera flava	1	4
Polygonum aviculare	15	60
Polygonum (erectum)	4	16
Polygonum lapathifolium	3	12
Rumex crispus	16	64
Rumex mexicanus	3	12
Salsola iberica	15	60
Scorzonera laciniata	17	68
Sisymbrium altissimum	4	16
Sonchus arvensis	10	40
Taraxacum officinale	4	16
Thlaspi arvense	2	8
Tragopogon dubius	9	36
Verbascum blattaria	3	12
Verbascum thapsus	13	52
Verbena bracteata	17	68
Xanthium strumarium	1	4
Unidentified Forb	1	4
Total Species = 70		
Minimum = 13		
Maximum = 38		
Mean = 24		
Standard Deviation = 5.70		

FRENCH DRAIN COVER TRANSECT STATISTICS, 1993

(FDCVRST3.WK3)

25 TRANSECTS 100 POINTS EACH	NUMBER HITS	MEAN	FREQUENCY OCCURRENCE	% TOTAL PLANT COVER
17 AUGUST-17 SEPTEMBER 93				
TREE CANOPY				
None	0	0.00	0.0%	
Total Tree Canopy				
SHRUB CANOPY				
Salix exigua	4	0.16	4.0%	
Total Shrub Canopy				
GROUND COVER				
(1) Rock	186	7.44	100.0%	
(2) Bare Ground	1959	78.36	100.0%	
(3) Litter	238	9.52	100.0%	
(4) Trees and Shrubs				
None	0	0.00	0.0%	
(5) Cacti				
None	0	0.00	0.0%	
(6) Graminoids				
Agropyron intermedium	3	0.12	12.0%	2.6%
Bromus inermis	1	0.04	4.0%	0.9%
Bromus japonicus	2	0.08	8.0%	1.7%
Bromus tectorum	9	0.36	24.0%	7.7%
Echinochloa crusgallii	2	0.08	8.0%	1.7%
Eragrostis cilianensis	1	0.04	4.0%	0.9%
Hordeum jubatum	1	0.04	4.0%	0.9%
Hordeum, sp.	2	0.08	8.0%	1.7%
(7) Forbs				
Alyssum minus	2	0.08	8.0%	1.7%
Ambrosia psilostachya	4	0.16	16.0%	3.4%
Carduus nutans	3	0.12	12.0%	2.6%
Centaurea diffusa	5	0.20	20.0%	4.3%
Chenopodium leptophyllum	1	0.04	4.0%	0.9%
Cirsium arvense	6	0.24	20.0%	5.1%
Erodium cicutarium	3	0.12	12.0%	2.6%
Helianthus annuus	2	0.08	4.0%	1.7%
Kochia scoparia	1	0.04	4.0%	0.9%
Lactuca serriola	6	0.24	20.0%	5.1%
Linum perenne	1	0.04	4.0%	0.9%
Melilotus officinalis	50	2.00	72.0%	42.7%
Polygonum aviculare	4	0.16	8.0%	3.4%
Salsola iberica	2	0.08	8.0%	1.7%
Scorzonera laciniata	1	0.04	4.0%	0.9%
Sonchus arvensis	1	0.04	4.0%	0.9%
Tragopogon dubius	2	0.08	8.0%	1.7%
Verbena bracteata	1	0.04	4.0%	0.9%
Unid. Forb 1	1	0.04	4.0%	0.9%
Total Plant Ground Cover	117	4.68	100.0%	100.0%

Appendix 3
Weed Control Monitoring Summary Data

These data are awaiting Quality Assurance/Quality Control reviews and will be transmitted at a later time.