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Cañon de Valle Terrestrial Ecological Risk Assessment Pilot Steps Four and Five: Study Design and Implementation Plan

Introduction

The ecological risk assessment pilot for Cañon de Valle is being conducted in accordance with USEPA, Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments, (ERAGS) (EPA 1997, 59370). Steps one through three have been completed. These steps are screening level problem formulation, screening level exposure estimates and risk calculations, and baseline risk assessment problem formulation. A companion to this document addresses the aquatic resources in Cañon de Valle. That document is called "Cañon de Valle Aquatic Ecological Risk Assessment Pilot Steps Four and Five: Study Design and Implementation Plan."

Key information needs, derived from the screening assessment results, are empirical evidence that contaminants of potential ecological concern (COPECs) are impacting small mammal populations and not impacting top carnivores. The wildlife exposure models in "Screening Level Ecological Risk Assessment Methods," (LANL 1999, 64783) have sufficient uncertainties to prevent resolution of these questions without data from biota sampling. The top carnivore question is particularly relevant to Cañon de Valle because the Mexican spotted owl, a threatened species, is a top carnivore in that canyon system.

Cañon de Valle Conceptual Model

Effluent discharges from Technical Area 16, including the 260 outfall (PRS 16-021(c)-99), silver outfall (PRS 16-020), steam plant, roof drains, and parking lot runoff all served to augment the surface flow in Cañon de Valle and to transport contaminants into the natural systems of the canyon. Data from media samples collected in the canyon show high explosives and metals, especially barium, to be present in surface water, alluvial groundwater, soils and sediments.

With the elimination of discharges from the 260 outfall and the steam plant, the aquatic regime of the canyon is receding to pre-laboratory conditions. During the drought of year 2000 Burning Ground Spring continued to flow but the rest of the canyon was mostly dry.

The problem formulation phase of the ecological risk assessment pilot for Cañon de Valle identified potential adverse impacts to aquatic, riparian and terrestrial systems in the canyon. The results of that analysis are summarized in Table 1. The aquatic resources are addressed in "Cañon de Valle Aquatic Ecological Risk Assessment Pilot Steps Four and Five: Study Design and Implementation Plan."

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Table 1. Summary of Step 3: Problem Formulation
COPECs and Receptors, by Media
Unfiltered Water Data Used for Assessment
Guild suffixes: h - herbivore; o - omnivore; i - insectivore; f - flesh

COPEC	Surface Water	Springs	Alluvial Water	Sediment	Soil
Inorganics					
Aluminum	aquatic community	aquatic community	aquatic community, shrew, deer mouse, bat, fox		
Barium	aquatic community[1]	aquatic community	aquatic community	Bkgnd	cottontail, kestrel, plant, fox, kestrel-f
Cadmium	aquatic community	aquatic community	aquatic community		
Cobalt	aquatic community	aquatic community	aquatic community	Bkgnd	
Copper				aquatic community	Bkgnd, plant
Lead				aquatic community	robin-h, robin-o
Manganese	aquatic community	aquatic community	aquatic community		
Silver		aquatic community	aquatic community	aquatic community, swallow	plant, robin-h, robin-o, robin-i
Thallium				bat	
Vanadium				Bkgnd	
Organics					
Di-n-butyl phthalate				swallow	
HMX				bat	deer mouse, cottontail, shrew
RDX				bat	deer mouse

[1] Generic aquatic community, "Final Water Quality Guidance for the Great Lakes System; Final Rule," or from New Mexico water quality standards.

A geomorphic survey and map has been completed for 2500 m of the canyon from the Silver Outfall (16-020) to below MDA-P. Soil samples collected as part of the geomorphic investigation were analyzed for contaminants and the data were used to support the problem formulation assessment. The results indicate a potential for adverse effects to ten of the eleven terrestrial screening receptor species. The results are summarized in Table 1. The potentially effected receptor species range in trophic position in the food web from primary producer to top carnivore.

The distinction between soil and sediment in this work is a matter of location. Sediment refers to the active channel of the canyon. Soil is used to encompass the channel and floodplain sediment deposits as well as the terraces, fans, and colluvial slopes. The canyon bottom averages 23 m in width over the mapped reach. The overbanks that are influenced by contaminant transport and deposition average 6 m in width. The overbanks consist of sorted fine material. The highest COPEC concentrations are in the c3 and c2 units. These are packages that have been deposited since LANL commenced operations. The active channel is poorly sorted; indicating that transport in the system tends to occur under higher energy and short duration events. These events do not provide conditions that sort the transported material into deposits with different particle sizes. The balance of the canyon bottom area, nominally 75 percent, is made up of Quaternary terraces. These features are abandoned by channel incision and no longer experience flood flows. The distribution of contaminant concentrations across the geomorphic feature types is presented in Figure 1.

Problem Formulation Results Summary for Riparian and Terrestrial Systems.

The ERAGS step three results identified several COPECs in overbank soils that exceed the screening criteria. The COPECs are barium, silver, lead, copper, HMX, and RDX. Summary information for hazard quotients with minimum, maximum and the 95% upper confidence limit on the median are provided in Table 2. This table shows that copper and lead have a full complement of eleven screening values, barium and silver are missing the invertebrate endpoint, RDX is missing six endpoints and HMX is missing seven endpoints. Endpoints are missing because toxicology studies have not been included in the Ecorisk database for these contaminants. In some cases, such as avian endpoints for HMX and RDX, extensive searches of the literature have yet to identify relevant studies. This is consistent with Talmage, et al. (1999, 63021) which states that no subchronic or chronic feeding studies of high explosives compounds were found for avian species. The table also shows great variability in the extent to which the COPECs exceed screening values. A single screening endpoint value is exceeded by the maximum RDX concentration. All available screening endpoint values were exceeded by the maximum barium concentration and four of those endpoint values were exceeded by the minimum barium concentration.

Assessment Endpoints

The environmental values, or assessment endpoints, to be protected for Cañon de Valle consist of features of the canyon relative to the surrounding landscape and the resident

Figure 1. COPEC Concentrations by Geomorphic Feature
Samples Sizes:c2=10; c3=12; f1=6; lowc3=2

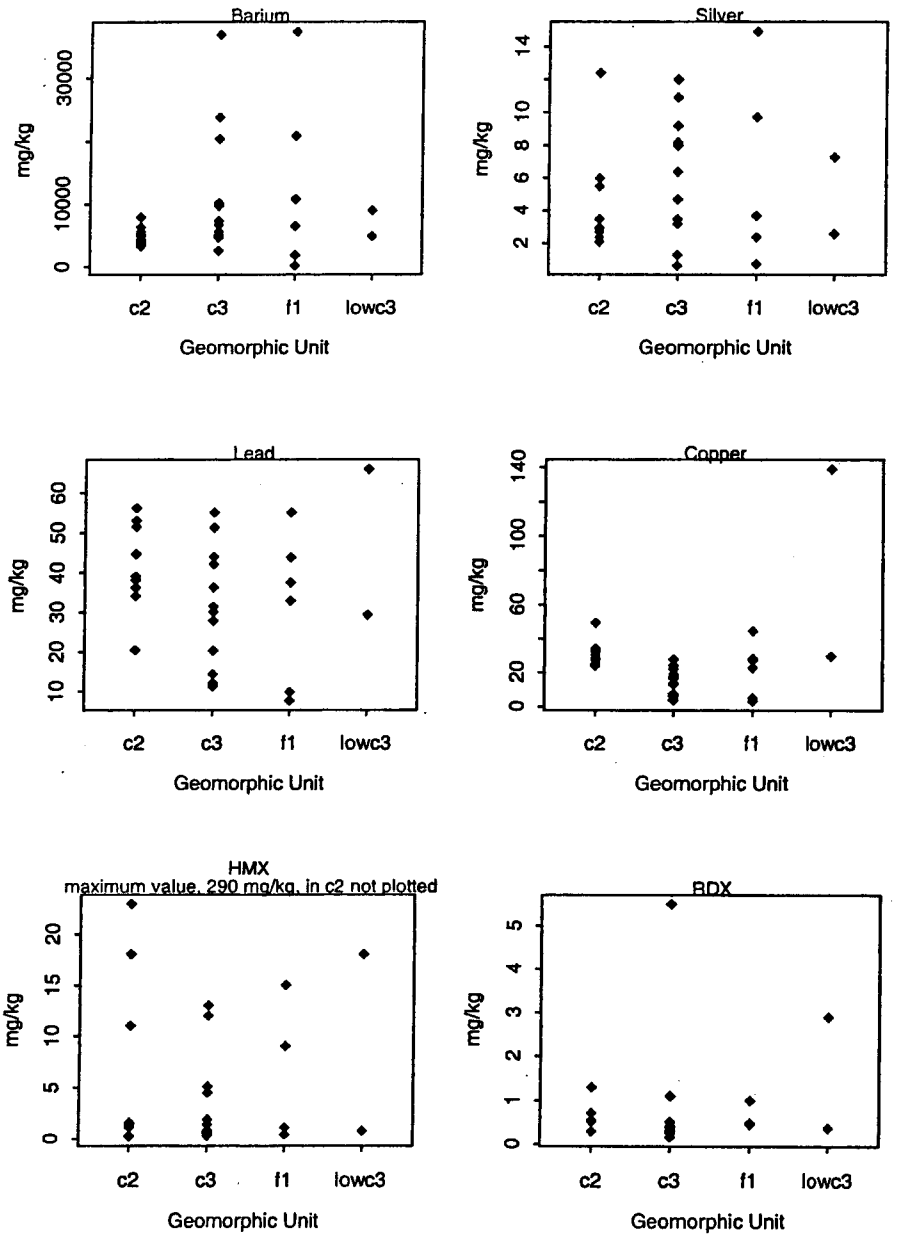

Table 2. Summaries of Soil Hazard Quotients for COPECs That Exceed One or More Screening Values

Bolded values exceed criteria; NA – Criteria Not Available

Diet suffixes on receptor names: i – invertebrate; p – plant; f - flesh

Barium
Soil HQ Summary

	Minimum	Maximum	MedUCL
Plant	0.18	**37.**	**7.9**
Invert	NA	NA	NA
Robini	**3.4**	**690.**	**150.**
Robinip	**2.1**	**420.**	**90.**
Robinp	0.80	**160.**	**34.**
Kestrel	0.46	**93.**	**20.**
Kestrelf	0.018	**3.7**	0.79
Cottontail	0.59	**120.**	**26.**
Mouse	**4.4**	**890.**	**190.**
Shrew	**8.0**	**1600.**	**340.**
Fox	0.050	**10.**	**2.1**

Silver
Soil HQ Summary

	Minimum	Maximum	MedUCL
Plant	**3.2**	**74.**	**36.**
Invert	NA	NA	NA
Robini	0.22	**5.3**	**2.6**
Robinip	0.48	**11.**	**5.6**
Robinp	0.71	**17.**	**8.2**
Kestrel	0.027	0.65	0.32
Kestrelf	0.0048	0.11	0.056
Cottontail	0.0035	0.083	0.041
Mouse	0.0048	0.11	0.056
Shrew	0.0025	0.060	0.029
Fox	0.000057	0.0014	0.00074

Copper
Soil HQ Summary

	Minimum	Maximum	MedUCL
Plant	0.033	**1.4**	0.28
Invert	0.25	**11.**	**2.2**
Robini	0.0087	0.37	0.074
Robinip	0.016	0.66	0.13
Robinp	0.024	0.99	0.20
Kestrel	0.001	0.043	0.0088
Kestrelf	0.00021	0.0087	0.0018
Cottontail	0.022	0.93	0.19
Mouse	0.033	**1.4**	0.28
Shrew	0.021	0.87	0.18
Fox	0.00049	0.02	0.0042

HMX
Soil HQ Summary

	Minimum	Maximum	MedUCL
Plant	NA	NA	NA
Invert	NA	NA	NA
Robini	NA	NA	NA
Robinip	NA	NA	NA
Robinp	NA	NA	NA
Kestrel	NA	NA	NA
Kestrelf	NA	NA	NA
Cottontail	0.17	**260.**	**11.**
Mouse	0.19	**290.**	**12.**
Shrew	0.019	**29.**	1.2
Fox	0.000086	0.13	0.0055

Lead
Soil HQ Summary

	Minimum	Maximum	MedUCL
Plant	0.38	**3.3**	**2.2**
Invert	0.076	0.66	0.44
Robini	0.097	0.84	0.56
Robinip	0.12	**1.0**	0.66
Robinp	0.13	**1.2**	0.77
Kestrel	0.0078	0.068	0.045
Kestrelf	0.0040	0.035	0.023
Cottontail	0.010	0.088	0.058
Mouse	0.016	0.14	0.093
Shrew	0.027	0.24	0.16
Fox	0.0013	0.011	0.0074

RDX
Soil HQ Summary

	Minimum	Maximum	MedUCL
Plant	0.0016	0.055	0.0072
Invert	NA	NA	NA
Robini	NA	NA	NA
Robinip	NA	NA	NA
Robinp	NA	NA	NA
Kestrel	NA	NA	NA
Kestrelf	NA	NA	NA
Cottontail	0.026	0.90	0.12
Mouse	0.031	**1.1**	0.14
Shrew	0.007	0.24	0.031
Fox	0.000031	0.0011	0.00014

threatened species. Cañon de Valle is one of many canyons incised into the Pajarito Plateau. This canyon has two perennial springs and an alluvial seep in the vicinity of the TA-16 facilities. The presence of water in the canyon is ecologically important to the viability of many species in this semi-arid environment. Additionally, the canyon supports a multi-leveled overstory of mixed conifer, aspen and oak with grasses and forbs on overbanks and terraces. The combination of perennial water and diverse vegetation make the canyon a relatively attractive location for endemic fauna. The Mexican spotted owl has a nesting site down canyon from the outfall and is likely to hunt in the canyon.

ERAGS Step Four: Study Design and Data Quality Objectives

Given that an unacceptable potential ecological risk persists through the evaluations in step three, the ERAGS process continues with a study design and data quality objectives. Step four generates field sampling design that will produce the data needed to determine whether the potential risk is evident at the site.

Comparisons to Preliminary Remediation Goals

Some Department of Energy sites have calculated preliminary remediation goals (PRGs) as an alternative to conducting a baseline ecological risk assessment. PRGs are concentrations of COPECs that are considered protective against population level effects. As an example, Sandia National Laboratories published, "Predictive Ecological Risk Assessment Methodology." (SNL 1998, 72727) which provides an approach for developing preliminary remediation goals. A factor of ten is multiplied times the screening levels and compared to the upper confidence limit on the mean COPEC value. The factor of ten is an assumed difference in contaminant concentration between the "no observed adverse effects level" (NOAEL) and the "lowest observed adverse effects level" (LOAEL) for a chemical when one or the other is not available from a toxicity study. The Sandia approach then is to screen at the NOAEL level for the maximum sample contaminant value and to propose remediation goals at the LOAEL level compared to the upper 95th percentile on the mean for the contaminant data. A similar approach has been documented for the Oak Ridge Reservation, Oak Ridge, Tennessee in, "Preliminary Remediation Goals for Ecological Endpoints," (Efroymson, et al. 1996).

There are two difficulties with applying PRGs to Cañon de Valle. Screening values are not available for all species endpoints across the six COPECs in Table 2, and one species of concern for the site is the Mexican spotted owl. As a threatened species, individual effects to the owl must be evaluated. PRGs are intended to assess population level effects. Consequently, data collection to support a baseline risk assessment is the preferred path forward.

Comparing site data to nominal PRGs does provide a context for the potential severity of contaminant effects in Cañon de Valle, where screening levels are available. The 95th percentile upper confidence limits (UCL) on the medians are provided in Table 2 for this purpose. The upper bound on the median is given instead of the upper bound on the mean because the data are not normally distributed. If the values in the third columns for

each of the contaminants are divided by ten to approximate a PRG ratio, then the values for copper, lead, and RDX are less than one for all available endpoints. Silver and HMX have values slightly exceeding one and the barium PRG ratios range from 0.079 to thirty-four.

Evaluating the same information from the perspective of the screening endpoints shows that the screening values for kestrel, as a flesh eater, is only exceeded by the maximum barium value. All of the median UCL values for kestrel are below the screening criteria and well below the PRGs. This endpoint is the closest surrogate for the Mexican spotted owl of the eleven endpoints used. Both the screening values and the PRGs for barium exceed the mouse and shrew endpoints. These are omnivore and insectivore endpoints. The robin endpoints show results similar to the small mammal endpoints. The avian PRG ratios are problematic for decision making because screening criteria are not available for HMX and RDX.

Field Investigation Conceptual Design

The screening receptors that are potentially effected by the contaminants are generic plant, cottontail, robin as an herbivore, robin as an omnivore, robin as an insectivore, deer mouse, shrew, kestrel as an omnivore, kestrel as a carnivore, and fox. In all cases the potential for effects is dependent upon the transfer of contaminants from soil to the effected species. In most cases there are multiple inferred transfers of contaminants from soils to the receptor species. An example is kestrel, as carnivore, which might consume an herbivore an omnivore, or an insectivore. Each of these prey groups has its own set of transport pathways from soil. The number of transfers and whether contaminant concentrations increase, stay the same, or diminish with each transfer determine the dose to the kestrel. This is all to say that estimating the intake of a contaminant by an endpoint species based upon soil concentrations is difficult and imprecise.

There is a limit in the extent to which screening results can be resolved by modifying exposure models and qualifying toxicological data. Multiple contaminants effecting multiple receptors through multiple food chain transfers results in a model where the outcome is largely driven by the modeling assumptions. The results of the calculations are essentially qualitative because of the uncertainties associated with each of the transfers. A more straightforward approach is to analyze biota collected at the site to determine to what extent adverse impacts are indeed occurring.

Options for Biota Sampling

The potentially effected endpoints for Cañon de Valle soils span trophic levels from producer to top carnivore. Uncertainty in the screening values increases up the food chain because the uncertainty for each food chain step is compounded with the subsequent steps. The higher up the food chain that biota sampling is conducted, the better able we are to evaluate the impacts of the site contaminants and concentrations on the ecological system in the canyon. The contradicting consideration is that higher trophic level organisms tend to have larger home ranges. The interpretation of biota sampling results

is most straightforward with species that are likely to reside in the effected area of the canyon for the duration of their life histories.

The relevant reach of canyon bottom in Cañon de Valle is nominally 23 meters wide and 2500 meters long. The overbanks with elevated COPEC concentrations average 6 meters in width. Good candidates for assessing the body burdens of contaminants are species with home ranges and habitat requirements that can reasonably be expected to be contained within the canyon and contaminated areas. Species that range over areas larger than the canyon or that have habitat requirements not met within the contaminated portion of the canyon will provide ambiguous information about body burdens because the extent of their activity within the canyon will be unknown. Additionally, the optimal species would reside in the canyon year-around and the population density would allow for collecting several individuals to support a population estimate of the contaminant body burdens. This last point is important because we are interested in population level effects. For threatened or endangered species, such as the Mexican spotted owl, biota sampling will be conducted on their prey species. A population level estimate of body burdens in the prey species can be used to estimate the contaminant dose to the owl.

The typical home ranges for the screening endpoint species are provided in Table 3 along with the relative size of these home ranges to the nominal size of the Cañon de Valle bottom. The relevant reach of the canyon is from the 260 Outfall downstream to Southward bend of the canyon, for a total length of 2500 m. The average width of the canyon bottom for this reach is 23 m, resulting in an area of 5.75 ha.

Table 3. Endpoint Species, Home Ranges
And Home Ranges Relative to the Size of Cañon de Valle

Endpoint species	Home range, ha.[1]	Relative to Cañon de Valle canyon bottom, 5.75 ha.
Deer Mouse	0.1 – 0.4	58 – 14
Dusky Shrew	0.06 – 0.5	96 – 12
Mountain Cottontail	0.4 – 6	14 – 1
Gray Fox	100 – 130	0.06 – 0.04
Kestrel	10 – 500	0.6 – 0.01
Robin	0.1 – 0.9	58 – 6.4

[1] from Fire Effects Information System (http://www.fs.fed.us/database/feis/)

The six endpoint species have home ranges from a 0.06 ha minimum for the dusky shrew to 500 ha maximum for the kestrel. The kestrel and gray fox are poor choices for contaminant body burden estimations because their home ranges far exceed the size of the relevant area of Cañon de Valle. The robin is a reasonable candidate from the perspective of home range size and it is a permanent resident of Los Alamos County. Two aspects of it natural history make the robin less desirable for our purposes. Robins are elevational migrants, moving to upper elevations in the spring and lower elevations in

the fall. This behavior would interrupt the contaminant exposure pathways for part of the year. Additionally, robins are not a dominant prey species for carnivores on the Cañon de Valle system. This is especially important because Cañon de Valle is habitat for the threatened Mexican Spotted Owl. Biota sampling should address potential contaminant uptake for the owl.

The three remaining candidates from the endpoint species list are the deer mouse, dusky shrew, and the mountain cottontail. Deer mouse and dusky shrew have home ranges that are suitable to the purposes for biota sampling in the canyon. Mountain cottontail is marginal at the upper bound of its typical home range. Information on general food habits for the Mexican spotted owl documented in "Biota Information System of New Mexico," (BISON-M, http://nmnhp.unm.edu/bisonm/bisonquery.php) indicates:

> "Mammals accounted for 73-96% of total prey and 91 - 99% of prey biomass. Owls consumed prey ranging in mass from beetles (Coleoptera) and moths (Lepidoptera) (ca 1 g) to adult cottontail rabbits (Sylvilagus spp.; ca 650 g). Mean prey mass ranged from 63 - 118 g in various regions. Woodrats, white-footed mice (Peromyscus spp.), and voles (Microtus spp.) accounted for 61 - 83% of the total prey and 59 - 88% of total biomass in various regions. Cottontails and pocket gophers (Thomomys spp.) accounted for another 3 - 14% of total prey and 7 - 36% of total biomass. Birds and reptiles contributed little to prey numbers or biomass except in Southeast Arizona. Insects were relatively common in the diet (3 - 16% of total prey) but contributed little to prey biomass. Diurnally active mammals such as squirrels and chipmunks (Sciuridae) accounted for <3% of total prey or biomass (Ganey, 1992)"

Small mammal populations were surveyed at outfalls and in the canyons at LANL and reported in Raymer and Biggs (1994, 56038). Generally, small mammals captured in canyons with natural surface water flow included long-tailed vole, montane vole, western harvest mouse, dusky shrew, water shrew, deer mouse and brush mouse. Dry canyons were populated by deer mouse and brush mouse. These results suggest that dusky shrew and deer mouse are likely to be present in Cañon de Valle and are viable candidates as measurement endpoint species.

Cañon de Valle is a mosaic of habitat types. It is likely that during wet periods the areas around the springs and the drainage channel will be populated by the species listed for canyons with naturally flowing waters. The dry site species are likely to inhabit the terraces and colluvial slopes of the canyon. During dry periods the flow in the canyon recedes to the vicinity of the springs. Under these conditions the canyon is still likely to support wet-site and dry-site species, with changes in relative abundance. These species typically average four litters per year. This means that population responses to changing environmental conditions can be very rapid.

Small mammals are a viable option for biota sampling in Cañon de Valle. They reside in the canyon year-around and the populations are sufficiently abundant to provide multiple individuals for population estimates of body burdens. Additionally, they are dominant

prey species for the carnivores active in the canyon, including the Mexican spotted owl. Using body burden data from small mammals will provide the information necessary to make direct estimates of contaminant intake by carnivores, obviating most of the assumptions in the contaminant transfer models. Several species are likely to be available that represent the herbivore, omnivore, and insectivore feeding guilds.

The trophic level of a small mammal species generally influences the rate of accumulation of contaminants relative to soil concentrations. Sample, et al. (1998, 72726) found that bioaccumulation is highest in insectivores and lowest in herbivores. These results are corroborated by three other studies cited by Sample, et al. For the three endpoint species under consideration, mountain cottontail is an herbivore, deer mouse is an omnivore and dusky shrew is an insectivore. Based upon home range, potential for bioaccumulation, and prey size preferences of the Mexican spotted owl, the dusky shrew and deer mouse populations are well suited to our purpose for assessing contaminant transfers to top carnivores. Given the propensity for higher body burdens, these species are also likely to reveal population responses to COPECs if those responses are occurring. If necessary, the differences in diet can be used to differentiate body burdens associated with trophic levels. Finally, the reproductive rate of these species is such that individuals removed for analysis will be quickly replaced. Negative consequences to the food chain from sampling are very unlikely.

The Cerro Grande fire impacted Cañon de Valle to varying degrees in the relevant reach of the canyon. Fire effects literature documents multiple studies where the investigators found either intact small mammal populations or rapid colonization after wildfires, (e.g., DeBano, et al. (1998, 72725). Some species, such as deer mouse, show increases in population densities after fires. Evidently, they prefer more open areas caused by fire and are considered a disturbance species. All of this is to say that the impact of the Cerro Grande fire upon small mammal populations in Cañon de Valle is likely to be minimal during 2001.

Study Objectives and Proposed Measurement Endpoints

Biota sampling can serve multiple purposes. First, biota sample data can provide direct estimates of COPEC concentrations that are consumed by the next higher trophic level. As an example, chemical analysis of vegetation can provide estimates of COPEC concentrations consumed by herbivores. This is a more reliable estimate of uptake than modeling transfers from soils to herbivores because site-specific variables such as soil type, chemical form of the COPECs and plant species characteristics have their influences upon the COPEC concentrations in vegetation. Second, biota trap and recapture sampling can be performed to estimate densities of organisms to evaluate COPEC influences on populations. A third purpose for biota sampling is to establish transfer factors from soils to the sampled animal species. This is less definitive for assessing effects because pharmacokenetic models are needed that depend upon knowing chemical forms of COPECs, estimates of assimilation efficiencies, and biological half-lives in order to associate body burdens with soil concentrations. Transfer factors can be

approximated by the ratio of COPEC concentrations in the target species to the COPEC concentrations in the soils or sediments.

There are two objectives for biota sampling in Cañon de Valle. First, the problem formulation results indicate that contaminant transfers to top carnivores are at concentrations below concern, with HQ ratios ranging from 0.023 to 0.79 for the median UCLs. Unfortunately, screening values are not available for the COPECs HMX and RDX. Also, the screening problem formulation results are more appropriate to the protection of populations rather than individuals. With the Mexican spotted owl in the canyon, protection of individuals is a relevant issue. Estimating the COPEC body burdens in dominant prey species for the Mexican spotted owl, gray fox, and kestrel will provide an empirical basis for estimating dose and assessing potential effects to the top carnivores in the canyon system.

The second objective for biota sampling in Cañon de Valle is to characterize the effects of the COPECs upon the small mammal populations in the canyon. The soil hazard summary in Table 2 shows a range of median HQ ratios from 0.029 to 340 for shrew and 0.056 to 190 for deer mouse. These results indicate a need for collecting data to assess impacts at the site. It is quite possible that viable populations occupy the site and that the high screening values result from conservative models for contaminant transfers from soils to small mammals via plants, invertebrates, and direct ingestion.

Small mammal population studies are proposed as the measurement endpoints for assessing the potential adverse effects for all of the screening endpoints below top carnivore. The list of screening endpoints not directly measured includes plant; invertebrate; robin as herbivore, omnivore, and insectivore; and cottontail. Vegetation in the canyon does not show signs of stress. Indeed the overbanks and floodplains in the canyon are heavily vegetated with grasses and forbs. Plants and invertebrates are food sources for the measurement endpoint species. Adverse population effects to plants or invertebrates would in turn influence the populations of small mammals.

As described above, the literature indicates that herbivorous small mammals, such as cottontail, will have lower body burdens than the proposed measurement species. The data base toxicity reference value (TRV) for barium and HMX are 0.55 mg/kg/d and 75 mg/kg/d respectively. These TRVs are used across cottontail, deer mouse and shrew. Hence, dose response associated with trophic level has yet to be differentiated in the toxicology literature reviewed to date. Using omnivorous and insectivorous measurement endpoints assures that higher body burdens are represented in the data. If herbivores dominate the small mammal community in the canyon, then these body burdens will also be estimated because they would represent a substantial component of the owl diet.

The avian endpoints represented by robin as herbivore, omnivore, and insectivore have PRG ratios greater than one for barium and do not have criteria for HMX or RDX. Two factors modify the potential for adverse impacts upon the robin population. First, they are elevational migrants, thereby reducing their potential site exposures to the warm

months of the year. Second, the TRVs for the robin endpoints include a conservative multiplier of ten because the toxicity study was of sub-chronic duration. The basis for the small mammal TRV is a study that determined a NOAEL for chronic exposure. This value does not require a conservative multiplier. Given the migratory behavior of the robin versus the permanent resident status of small mammals and the conservatism built into the avian screening values, it is very likely that field study results for small mammals will be a protective proxy for birds.

Trapping Design Options.

Three general types of small mammal trapping studies can be considered. The simplest is a study designed to determine the presence of species. Trapping arrays are set in different habitat types and individuals are collected and identified. The result of this approach provides a species list for the area and qualitative information about population densities.

The second type of study is a population study. Two general approaches are available. Populations can be estimated through removal trapping or through live trapping and the capture, mark, and re-capture of individuals. In removal trapping the decreasing number of individuals captured for the same effort over time is used to estimate the initial population size. In mark and recapture methods the ratio of total captured individuals to recaptured individuals is used to estimate the population size. With mark and recapture designs, traps are set for successive nights and captured individuals are marked in order for the investigators to recognize re-captured individuals. Statistical methods are available to estimate population densities based upon the area of the trapping array and the rate of recapture of individuals. The individuals collected on the final night of trapping would be sacrificed and used for body burden analysis.

The third type of design is a comparative population study. Either removal trapping or mark and recapture trapping is applied at two or more locations. The purpose is to discern differences in population densities at the different sites. This approach is often used to assess population responses to contamination gradients. While the statistical approach for this work is well developed, assigning causality to differences in populations is not always straightforward. Small mammal populations often go through large changes in densities for reasons that are not apparent to the investigators. Spatial trends in populations over contamination gradients should be confirmed with repeated surveys.

The age structure of small mammal populations is also a useful line of evidence in assessing effects. Viable populations consist of juvenile and sexually mature individuals. The age structure of a population infers the birth rate and loss rate for the species. If the populations consist of a single age class, this may be evidence of non-reproducing assemblages of immigrants from surround areas. The non-viability of the populations could be associated with the COPECs. Age structure information can be collected with any of the three study designs described above. If viable endemic populations become important to decision making, mark and recapture sampling that is conducted over an extended period of time can be used to assess survival.

Trapping Design and Approach

Reconnaissance Sampling for Initial Population Information

Reconnaissance trapping is the most efficient way to get preliminary estimates of the number of species and their relative abundances at the trapping sites to support a final trapping design. This information will be used to identify species that are in common across the trapping locations for body burden analysis. The reconnaissance results will also indicate whether the abundant species are herbivores, omnivores or insectivores. Body burden analyses are best carried out with the same species across the sampled sites to remove confounding factors associated with differences in life histories. It is also desirable to separate body burdens results by trophic level because of differences in transport pathways. At most, three species representing insectivores, omnivores, and herbivores would be analyzed for COPECs. It's possible that only omnivores and herbivores will be common across trapping sites because shrew species (insectivores) are dependent upon water, which is available only intermittently in most of the canyon.

Reconnaissance trapping will also indicate the relative and absolute abundances of species. The relative abundances of species will help determine how many species need to be analyzed for body burdens. Rare species are unlikely to be common prey for the owl or other top carnivores and therefore would not be included for body burden analysis. Absolute abundance information is necessary in the event that population density estimates are needed for comparing sites with different COPEC soil concentrations. As seen in Table 3, the home ranges of small mammals can vary up to tenfold. Additionally, home ranges for individuals typically overlap. The home range size and the degree of overlap determine the density of a population. The variance of a population estimate goes down in a mark and re-capture study with higher rates of re-capture. An optimal design is large enough to get high recapture rates without being too large and wasting effort for no improvement in the results. The trapping array can be made more efficient with site specific abundance information.

Design Options after Reconnaissance

After reconnaissance trapping, sampling will be conducted according to one of the approaches described below. Preference will be given to insectivores and omnivores for contaminant analysis because they are likely to have the highest body burdens. If herbivores are dominant species in the small mammal community, then herbivore body burdens will also be estimated because of their likely dominance as prey species for owls. All trapping will be conducted at night to coincide with the diel activity pattern of Mexican spotted owls. The number of nights that will be needed to estimate populations will depend upon the rate of recaptures for the trapping grids. The more individuals that are recaptured relative to the total number of captured individuals, the better the population estimate.

The results of the body burden analyses will be influenced by the amount of time individuals spend in contaminated areas, also known as the area use fraction (AUF). The contaminated sediments mapped in the geomorphic survey for the canyon averaged 6-m in combined width for the c1, c2, c3, and f1 sediments. This is one fourth of the average width of the canyon bottom. One option is to record the trap location for each individual in order to determine how cosmopolitan the individual small mammals are within a trapping array. If individuals have small home ranges relative to the trapping array, they are likely to be recaptured in the same or an adjacent trap. For species with small home ranges, choices regarding the compositing of individuals for biota samples can be guided by their trapped locations. The location information would be carried forward as meta data that supports the analytical results.

Up to three trapping arrays will be used for this investigation, depending upon the information that is necessary to support site decisions and available resources. The following descriptions are arranged from simplest to most complex.

Single Trapping Array

The simplest and least expensive approach is a single trapping array in the highest contamination area. Reconnaissance sampling would identify the species present and their relative abundances. The trapped individuals would also provide information on the age structure of the populations. Individuals of the prevalent species representing different trophic levels would be analyzed for COPEC body burdens.

The lines of evidence resulting from this design are body burdens in prey species for top carnivores and age classes as an indicator of population viability. This design will not answer questions about changes in body burdens with changes in soil concentrations, or body burdens at uncontaminated locations.

Two Trapping Arrays

This approach uses two trapping arrays, one at the location of highest COPEC concentrations and one at a reference site. One candidate area for a reference site is Pajarito Canyon. The reconnaissance sampling will identify the species present at each site and their relative abundances. Body burden analysis would be performed on species common to both sites. In the event that a species is a community dominant in the contaminated site but not present in the reference site, that species would also be analyzed for body burdens because it is likely to be a prevalent prey species in the contaminated area. Age structures and sex ratios will also be collected for species in both locations and compared to evaluate sub-lethal effects of the COPECs upon the population dynamics.

The lines of evidence resulting from this design are:

- Comparisons of body burdens of prey species for top carnivores from contaminated and uncontaminated sites. This is useful because the metals COPECs are naturally occurring elements.

- Age structure of the populations as an indication of each population's viability.
- Comparisons of age structure and sex ratio for the species in common. This information might indicate sub-lethal effects from the COPECs.
- If mark and recapture trapping is performed, the population densities of the two sites can be compared. These results should be confirmed with additional trapping at a later date because of the intrinsic variability in small mammal populations.

These data will not provide for an assessment of how body burdens change with soil concentrations in the canyon.

Three Trapping Arrays

Three trapping arrays, with two along a concentration gradient in the canyon and one at a reference site will provide information on the highest body burdens, changes in body burdens with changes in soil concentrations, reference body burdens, and age structure influences associated with COPEC concentrations. If population effects or body burdens are unacceptable then these data will support an assessment of how pervasive the effects are in the canyon.

Lines of evidence from this design are:
- Estimates of the highest COPEC body burdens for prey species.
- Trends in body burdens with changes in soil concentration
- Age structure as an indication of population viability
- Age structure of populations and changes with soil concentrations of COPECs. This is a more robust indicator of sub-lethal effects than the two-site design because effects associated with COPEC should appear as spatial trends.
- If population effects or body burdens are unacceptable, the association of effects with soil concentrations will provide estimates of how pervasive the unacceptable effects are in the canyon.
- If mark and recapture trapping is performed, the population densities across the sites can be compared. These population estimates can be used to relate body burdens at a trapping sites to the relative likelihood of predation based upon the relative population sizes. These results should be confirmed with additional trapping at a later date because of the intrinsic variability in small mammal populations.

While the use of three trapping arrays will support inferences regarding the above lines of evidence, it is important to understand that estimating populations and COPEC influences on those populations can be fraught with confounding factors. Making the transition from inference to defensible statements of causality can be very difficult.

Proposed Trapping Array Locations

The area of highest COPEC concentrations, based upon the geomorphic survey samples, is in the vicinity for Burning Ground Spring from 200 feet above the confluence with the main drainage to 500 feet below that confluence. The second location in Cañon de Valle, for the three-array design, is 3200 feet down canyon from the monitoring well pair 16-

2659 and 16-2660. This is 7800 feet downstream from the 260 outfall in the vicinity of sampling point 16-2674. This location has sediment barium concentrations that are two orders of magnitude below the barium concentrations in the vicinity of the 260 outfall. A geomorphologic survey has not been conducted in this reach of the canyon. Using this reach as part of a three-array design would make the implicit assumption that soil concentration differences are similar to the sediment differences. The proposed reference site is Pajarito Canyon at an elevation that is equivalent to the trapping arrays in Cañon de Valle.

A reference trapping location that is outside of Cañon de Valle is recommended because the metals COPECs have background values and copper is a nutrient. It will be important to establish body burden values for these COPECs independent of the 260 outfall discharge influences in order to provide a context for the results from within the canyon. Pajarito Canyon is an option that is accessible by vehicle and has water.

Sample Preparation and Analysis

Individuals will be analyzed whole in order to estimate the COPEC doses to the owl. Sample size and minimum sample amounts are described in "Step 5, Implementation Plan." Sacrificed individuals will be screened for hanta virus before shipment to the analytical laboratory. Field weights will be recorded for each sample. The samples will be analyzed for metals and high explosives, based upon the COPEC shortlist.

Study Design Recommendation

Making risk management decisions for the riparian and terrestrial systems in the canyon can be supported by the two-array design, with one array in the maximally contaminated reach of the canyon and the other array in a reference canyon. This approach will support lines of evidence regarding COPEC impacts to small mammal populations, COPEC doses to top carnivores, including the Mexican spotted owl, reference site body burdens, doses to top carnivores from small mammals in reference areas, and small mammal population characteristics in a non-contaminated canyon.

The single array design leaves open the questions regarding body burdens in non-contaminated areas. This is likely to be significant because four of the six COPECs are naturally occurring and one of them is a nutrient. Without a reference site, information will be lacking on physiologically regulated body burdens of these COPECs in uncontaminated areas.

The three-array design depends upon concentration gradients inferred from the sediment data. Additionally, it is quite possible that small mammal population effects will not be evident in the reach near the 260 outfall. If that is the case, then trapping and analysis in a lesser-contaminated reach is not useful to decision making for Cañon de Valle.

ERAGS Step 5: Implementation Plan

Introduction

This plan includes implementation details for reconnaissance sampling, small mammal population trapping and characterization, and body burden analysis. The final section provides the schedule and personnel.

Reconnaissance Sampling

Trapping arrays will be set up in Cañon de Valle and a reference canyon according to the schedule provided in section 5. The trapping location in Cañon de Valle will be the area of highest soil contaminant concentrations. The reference site in Pajarito Canyon will be selected to have similar topography, elevation, water presence and quantity, vegetation, and burn severity. The reconnaissance trapping will be used to identify small mammal species common to both canyons and to get a qualitative indication of the relative abundance of the captured species. The reconnaissance-trapping period is intended to be one or two nights in duration. The information will be used to assure that there are species in common between the trapping sites in the two canyons and to focus the balance of the field work on those species that are more abundant and therefore likely to be prey species for the Mexican spotted owl. Acceptance of the reference canyon and site will be based upon professional judgement with the primary consideration being that the reference site have the same dominant species as Cañon de Valle. The full trapping array will be installed in Cañon de Valle for the reconnaissance period because that location has been determined. The reference canyon reach will be investigated with a simpler trapping arrangement that can be moved more easily if the results are inconsistent with the Cañon de Valle results.

Small Mammal Population Trapping and Characterization

Population estimates will be supported by data from two sampling grids in each canyon. Rectangular grids are being used to accommodate the narrow canyon floor in Cañon de Valle. The same grid geometry will be used for both canyons. Each grid will consist of a five-by-twenty array with ten-meter spacing, for an array footprint of forty meters by 190 meters, with 100 intersections. Two Sherman live traps will be located at each of 80 (4 X 20) intersections. The line of traps closest to the creek will have a pitfall trap paired with a Sherman live trap at each intersection (1 X 20). The live traps are baited to attract herbivores and omnivores. Insectivores, such as shrews, typically do not respond to bait but are usually caught in pitfall traps. The two grids in each canyon will be separated by a minimum of one hundred meters to prevent trapping competition for individuals.

Each trapping round will consist of live trapping over a minimum of three nights to support a mark and recapture estimate of the small mammal populations. The goal is to recapture at least fifty percent of the marked individuals in order to lower the variance of the population estimates. Data for the small mammals captured with the live-trap grids will be analyzed with methods documented in Seber (1982, 72730) and in White, et al.

(1982, 6053). The pitfall trap results will be analyzed using a software package called DISTANCE, Buckland, et al. (1993, 72729). Two trapping rounds are anticipated, one in the spring after snowmelt and one in the late summer after the monsoon.

Population characteristics

Each animal captured will be weighed, ear tagged, species identified, examined for ectoparasites, sex identified, reproduction status determined (scrotal male, non-scrotal male, lactating female, or juvenile), and any abnormal condition noted. From these data the following information will be determined:

- species inventory,
- relative abundance for each species in Canon de Valle and the reference canyon based upon a comparison of the number of animals captured,
- age structure determined from weight and reproductive status,
- sex ratios,
- breeding phenology from reproductive-age structure, and
- relative health through comparing physical measurements of individuals between Cañon de Valle and the reference canyon.

Body Burden Analysis

On the final night of live trapping, individuals of the relevant species will be sacrificed for body burden analysis. Blood samples will be collected from all specimens and screened for Hanta Virus by the University of New Mexico in accordance with their standard operating procedures for this analysis. Negative Hanta Virus screening results are necessary prior to shipping the whole body samples to the analytical laboratory for body burden analysis. Each sample submitted for chemical analysis of whole body burden will have a live weight of 15 g or more to provide sufficient material for analysis. If individuals of a species weigh less than 15 g, then multiple individuals will be combined to achieve the weight required. The body burden data will be used to compare COPEC concentrations between Cañon de Valle and the reference canyon and to estimate the dose of COPECs to the Mexican spotted owl.

Samples will be submitted to the analytical laboratory for the HEXP and METTAL order codes. These order codes are associated with the high explosives suite and the target analyte list of metals. The order codes also specify the correct analytical methods.

Analytical Quantitation Limits

The required quantitation limits for each of the six COPECs will be related to the toxicity reference values (TRV) for each of the chemicals for avian or mammalian carnivore receptors. The TRV relates a dose of a chemical in mg of chemical in food or water/kg of receptor body weight/day to the "no observed adverse effects level" (NOAEL). The representation of mg of chemical in food / kg of receptor body weight allows the use of scaling equations to convert empirical doses for laboratory studies to wildlife exposures. These TRV values and scaling equations can be used to estimate the concentrations of COPECs in small mammals that are equivalent to NOAEL concentrations for the Mexican spotted owl. The required analytical quantitation limits will be one half of the NOAEL concentrations. This assures that concentrations at or near the NOAEL are measured values and not method detection limits.

Two additional factors are necessary for calculating Mexican spotted owl NOAELs. They are the owl body weight and the owl's rate of food consumption. The Mexican spotted owl's average body weight is 600 g, (pers. comm, David Keller, ESH-20). An estimated daily food consumption rate was developed using two approaches. A daily food consumption rate of 42 g was computed using The Nagy equation (Nagy 1987, 62782) for all birds, as provided in the Wildlife Exposures Handbook, (EPA 1993, 59384) estimates the daily consumption rate for a 600 g bird to be 42 g/d. This value has a food dry weight per live bird body weight basis.

The Wildlife Exposure Factors Handbook provides life history information, include daily food intake rates, for four raptors. They are kestrel, red-tail hawk, osprey, and bald eagle. A regression of consumption rate versus body weight for these species provides an intake estimate of 0.2 body weight per day for the owl. The value of 0.2 is equivalent to a consumption rate of 120 g per day for a 600 g owl. This value has a food fresh weight per live bird body weight basis. The difference between 42 g dry weight and 120 g fresh weight (0.65) closely approximates the typical factor of 0.7 for converting fresh weight to dry weight. The 120 g fresh weight value is used to calculate required quantitation limits because it relates directly to the owl consumption rate.

The quantitation limit calculation is as follows:

Dose, mg for $NOAEL_{owl}$ = TRV x 0.6 kg Owl Body Weight

NOAEL mg/kg $_{owl}$ = (Dose /120 g/d Owl Intake Rate) x 1000 g/kg

Quantitation limit = 0.5 x NOAEL mg/kg $_{owl}$

Table 1 provides the TRVs and quantitation limits for each of the COPECs. The calculated quantitation limit is the extrapolated NOAEL value for the Mexican spotted owl, using a body weight of 0.6 kg and a food intake rate of 120 g per day. The data for HMX and RDX are from mammal studies because bird TRVs are not presently available. The standard quantitation limits quoted by Paragon Analytics for these analyses and for the sample size specified above are as follows: <1 mg/kg for metals COPECs and 2-5

mg/kg for HMX and RDX. The required concentrations for dose estimation to the Mexican spotted owl should be easily supported by these quantitation limits.

Sample Mass and Number of Samples for Body Burden Analysis

The required sample mass is 15 g, either from one animal or two animals combined, for one species, from one trapping array. The sample size estimation was approached in two ways. Both approaches use non-parametric methods because environmental data are rarely normally distributed. The first method, (Helsel 1992, 72723) uses the binomial distribution to determine the rank of the sample result that would represent the upper 95 percent confidence limit on the median concentration ($UCL_{0.95}$). With a sample size less than six, the rank of the $UCL_{0.95}$ value is also the maximum rank of the data. For example, with a sample size of four, the $UCL_{0.95}$ rank is four. This is undesirable because the $UCL_{0.95}$ is not bounded by any of the data values. The actual $UCL_{0.95}$ could be larger than the maximum rank for the data set. With a sample size of six, the $UCL_{0.95}$ rank is five. This means that the second highest value of the data set is the $UCL_{0.95}$ for the median. Describing the data distributions with non-parametric methods is best done with six or more samples.

Table 1. Toxicity Reference Values (TRV) for Top Carnivore Receptors and Quantitation limits for Small Mammal Tissue Associated with Cañon de Valle COPECs

COPEC	TRV, mg/kg-d	Lab Study Organism	Risk Screening Receptor	Mexican Spotted Owl NOAEL, mg/kg	Quantitation limit, mg/kg
Barium	12.6	chicken	Kestrel	63	31
Lead	5.1	kestrel	Kestrel	25	12
Silver	5.4	turkey	Kestrel	27	13
Copper	47	chicken	Kestrel	235	110
HMX	75	mouse	Fox	375	180
RDX	10	rat	Fox	50	25

The second approach to sample size estimation uses a method for comparing a contaminated site and a reference site (EPA 1994, 54952). A statistical method of comparison that is applicable to Cañon de Valle and the reference canyon is the Wilcoxon Rank Sum test. This test has similar efficiency to the t-test when data are normally distributed and has better performance when the data depart from distributional assumptions. A power calculation for the Wilcoxon Rank Sum test was performed using the sample size of six from the median $UCL_{0.95}$ estimation. The minimum detectable difference between the two sites will be a shift of one standard deviation, (α=0.05; β=0.3).

Non-parametric coefficients of variation (CV) for the geomorphic soil sample data were calculated to provide a frame of reference for the shift of one standard deviation. A coefficient of variation is the standard deviation divided by the mean for a data set. The non-parametric approach was to substitute the median absolute difference for the

standard deviation and the median for the mean. For data that are normally distributed, the non-parametric ratio converges on the CV. The soil non-parametric ratios range from 0.34 to 1.2 for the COPECs using detected values. It is likely that ratios calculated for tissue data will be less than for the soil data because small mammal exposures will average over areas much larger than individual soil samples. These results suggest that a statistically significant difference will be detected between the sites when the Cañon de Valle median value is 34 to 120 percent larger than the reference site median. This level of resolution between the sites is very likely to be sufficient to support comparisons of the sites for biologically significant impacts due to the COPECs.

The recommended minimum sample size for body burden analysis is six for each canyon and species combination. Keeping the species separate will avoid confounding factors from differences in life histories, chemical assimilation, and chemical elimination. As an example, if there are two relevant species to be compared between Cañon de Valle and the reference canyon then 24 samples, (6 samples x 2 species x 2 canyons), will be collected.

Field Study Deliverables, Schedule, and Personnel

Deliverables:

The ESH-20 work detailed in this implementation plan will be documented in a Field Report that includes a summary of the mark and recapture data, a density estimate for the populations, by species and canyon, population parameters, and copies of the log sheets and notes. A separate Field Report will be provided for the spring and fall sampling rounds.

Samples for body burden analysis will be transferred under chain of custody to the Sample Management Office for transmittal to the analytical laboratory. The returning data will be managed in accordance with ER Project procedures.

Schedule

Spring Campaign	
Reconnaissance of Sites:	April 24 – May 1
Set up Grids	May 2 – May 4
Run Grids	May 7 - May 11
Take down Grids	May 14 - May 18
Send blood samples to UNM	May 14
Data Analysis	June 1 - June 29
Summary of Capture Results	July 1 - July 15

Fall Campaign

Set up Grids/Lines	September 10 - 14
Run Grids/Lines	September 17 - 21
Take down Grids/Lines	September 24- September 28
Send blood samples to UNM	October 1
Data Analysis	October 1 - October 31
Summary of Capture Results	November 1 - November 15

Personnel:

Personnel Contributing to the Study Design

Mark Tardiff – Technical Lead
Don Hickmott – ER Project Leader
Alison Dorries – ER Analysis and Assessment Focus Area Leader
Lars Soholt – ER Risk Team Leader
Gilbert Gonzales – ESH-20

Woody Woodworth– DOE, Albuquerque
David Gregory – DOE, Los Alamos Office
Eliza Frank – NMED
Kirby Olson – NMED
Ralph Ford-Schmidt - NMED

Field Team:

Kathy Bennett – TSM, also contributed to study design.
David Keller - TSM
Rhonda Robinson - Tech
Sheri Frybarger - Tech

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