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# TECHNICAL MEMORANDUM
# INDUSTRIAL AREA
# ENVIRONMENTAL EVALUATION

ROCKY FLATS PLANT
INDUSTRIAL AREA
OPERABLE UNIT NOS 8, 9, 10, 12, 13 and 14

US DEPARTMENT OF ENERGY
Rocky Flats Plant
Golden, Colorado

ENVIRONMENTAL MANAGEMENT PROGRAM

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## EXECUTIVE SUMMARY

The purpose of this Rocky Flats Plant (RFP) Industrial Area (IA) Environmental Evaluation (EE) Technical Memorandum (TM) is to discuss, evaluate, and summarize all data gathered in all three phases of the IAEE. Phase I addressed the field activities and results of the ecological investigation, Phase II described the results of the existing ecological and abiotic environmental media data review, and Phase III consisted of selecting and summarizing the data reviewed into a format useable for the characterization of potential risk to biotic species.

The IAEE was conducted under seven major tasks: Preliminary Planning; Data Collection/Evaluation and Conceptual Model Development (Phase I); Ecological Field Investigation (Phase I); Toxicity Assessment (Phase II); Exposure Assessment and Pathways Model Development (Phase II); Preliminary Contamination Characterization (Phase III); and Uncertainty Analysis (Phase III). Each task was planned and executed to provide data to the next task.

A conceptual food web and pathway-receptor model was developed based on the ecological field investigations conducted during July, October and November 1993, and ecological data gathered in past studies of RFP.

As part of the exposure assessment, and related to the generalized food web, sink food webs were developed for key raptor or predator species. A sink food web illustrates major contaminant pathways through the food chain from soils (water and sediments) to higher order consumers at the top of a food chain. These sink food webs provided the structure for the conceptualization of contaminant transport and calculation of bioaccumulation, bioconcentration and biomagnification factors used in an ecological risk assessment.

The pathways proposed are not complete in the sense of including all potential pathways existing for each species at the top of the food chain. For example, insects, reptiles and carrion are not included in these pathways for those species which are omnivores or which switch food items on a seasonal basis. However, these pathways are intended to best illustrate major routes of contaminant movement from source to biotic receptors.

A bioaccumulation model was used to evaluate the terrestrial pathway using the following assumptions for bioconcentration factors (BCFs):

- The chemical concentration in the soil is in equilibrium with the chemical concentration in vegetation tissue. In other words, vegetation tissue concentration equals chemical soil concentration and each have a BCF of 1.

- The first order consumers (cottontail rabbit, bird, and deer mouse) each have a BCF of 2. A BCF of 2 was also assumed for the feral cat, kestrel and great-horned owl at the third level of the food chain. A BCF of 1.5 was assumed for the great-horned owl at the forth level.

Nine of the 19 COCs identified were qualitatively characterized for risk. The biomagnification factor (BMF) for strontium of 52.37 mg/kg is the only BMF falling within the range of concentrations detected at OU4. Hence, strontium appears to present a risk to biota in the IA. No risk characterization could be conducted for chromium, mercury, all the radionuclides and 1,1,2,2-tetrachloroethane because of the lack of data applicable to the biota from the IA. Toxicity profile data indicate that there is a potential for injury to species from release of these contaminants.

The absence of site-specific information required conservative assumptions regarding data inputs to the analysis. Assumptions were made with respect to COCs, toxicities, and risk characterization. The result is conservative estimates of risk parameters, and an overly conservative risk estimate.

# 1.0 INTRODUCTION

The purpose of this Rocky Flats Plant (RFP) Industrial Area (IA) Environmental Evaluation (EE) Technical Memorandum (TM) is to discuss, evaluate, and summarize all data gathered in all three phases of the IAEE. The following is a brief description of each phase of the IAEE.

The Phase I Data Summary (DOE, 1993b) addressed the field activities and results of the ecological investigation as outlined in the IAEE Field Sampling Plan (DOE, 1993a). The objectives, approach, and detailed methodologies used to conduct the field investigations are referenced in the IAEE Field Sampling Plan and EG&G Rocky Flats Plant (EG&G) Environmental Management Operating Procedures Manual.

The Phase II Data Summary (DOE, 1993c) described the results of the existing ecological and abiotic environmental media data review. The review addressed a listing of species recorded during past surveys, and those observed during the July and October through November 1993 field surveys. Habitat and species distribution and dominance were also noted. Abiotic environmental media data were also reviewed, summarized and evaluated with respect to suitability for inclusion as potential contaminants of Concern (COCs). Potential COCs were selected and the chemicals were evaluated for toxicity to biota based on a data search and literature review of toxicological data. A generalized foodweb for the IA ecosystem was constructed. The foodweb provides data for the selection of key receptor species and the construction of a sink foodweb to illustrate pathway-receptor models for contaminant transport from source to biotic receptor.

The Phase III Data Summary (DOE, 1993d) consisted of selecting and summarizing the data reviewed into a format useable in the discussion of potential risk to biotic species. Tables were constructed to present toxicity data, Applicable or Relevant and Appropriate Requirements (ARARs), health classification and chemical concentrations ranges for the IA. Information on target taxa were also prepared with respect to ingestion rates, body weights and food items for each taxon group. Based on the food web model potential transport pathways were identified and evaluated with the pathway-receptor model, and factors for bioaccumulation, bioconcentration and biomagnification were estimated using literature values. From these data a preliminary assessment of risks were discussed.

## 2.0 SCOPE OF INVESTIGATION

The scope of the ecological risk assessment was conducted under seven major task activities as briefly summarized below. Each task was planned and executed to provide data to the next task in order to maintain the flow of information throughout the assessment process.

Task 1 - Preliminary Planning

The planning and coordination of the IAEE included development of a staffing plan and schedule of activities, and the preparation of DQO's to guide the data collection and analysis. In addition, a Field Sampling Plan (DOE, 1993a) was also prepared for guidance in the ecological field survey. The objectives of the planning for ecological risk assessment were:

- Qualitatively describe the ecological setting of the IA;
- Identify COCs and key species;
- Construct a conceptual site release and transport model;
- Determine toxicity effects and exposures from easily accessible literature values and existing data for COCs; and
- Summarize assumptions and uncertainties associated with the evaluation and characterization of ecological risk.

Task 2 - Data Collection/Evaluation and Conceptual Model Development (Phase I)

This task included a review, evaluation and data summary of available RFP chemical and ecological data pertinent to the IA. Generally, the data were expected to reflect species present, their distribution and habitat requirements, and potential COCs. This data review helped identify data gaps, and assist in the construction of the food web model and preliminary exposure pathways. COCs identified in this task for RFP narrowed the scope of toxicity assessment to those chemicals which occurred at elevated levels and are known to cause harm to biota. Toxicity literature pertaining to COCs was obtained from databases available for search at the EPA Region VIII library. This information was used in the conceptual model development and evaluation, and supported the historical and field data evaluation specific to the IA.

Task 3 - Ecological Field Investigation (Phase I)

The ecological field investigation consisted of qualitative observations and quantitative assessments of plant and animal populations within the IA areas. Sampling methodologies and procedures followed those approved in the SOP manual. Results of this field investigation provided information to describe the existing biological system in terms of habitat type and quality, species presence, trophic relationships, and potential contaminant source uptake by key (receptor) species.

The habitat surveys provided qualitative assessments of habitat type, extent and quality, including plant and animal species present. No threatened or endangered species, or protected habitats were identified. Quantitative vegetation sampling included cover and composition. Live trapping of small mammals was conducted along established transects with Sherman live traps over a three day period. Relative abundance estimates were calculated from the trapping data. Bird survey data was gathered along established transects to record and identify bird species, their numbers and use of the area. Sightings of larger mammal included qualitative assessments of presence identified by sign, vocalizations of sightings.

Task 4 - Toxicity Assessment (Phase II)

Phase II activities consisted of toxicity and exposure assessments. The objective of the toxicity assessment was to evaluate the COCs identified in Task 2 relative to their potential to cause harm to biota identified as key species. This was accomplished by review and evaluation of the toxicity data gathered from the literature in Task 2, and the comparison of these data with established criteria indicating potential harm to IA species. The criteria are the lowest tissue concentrations in key species which indicate a potential adverse effect, determined through easily accessible literature. These data will be compared to existing RFP tissue analysis data when these data are available.

Task 5 - Exposure Assessment and Pathways Model Development (Phase II)

A site-specific generalized food web and sink food webs (exposure pathways-receptor models) were developed, based on the ecological field survey results, to evaluate transport of contaminants to bio-receptors. Each sink foodweb was developed from the generalized food web model produced during Task 2 with data gathered during Task 3 and 4. In order to evaluate identified pathways, they need to be complete, that is, data should exist to support the presence of a source, a release mechanism, a transport mechanism, an exposure route, and an affected ecological receptor. With the lack of site-specific data, we made assumptions about complete pathways, source concentrations and bioaccumulation factors. Instead we relied on easily accessible literature values.

Site specific needs identified in the data review were for contaminant concentrations of IA source materials (soil, water, air), intermediate food chain items (vegetation, prey species) and target species (raptor/predator).

Task 6 - Preliminary Contamination Characterization (Phase III)

Phase III included the preliminary contamination characterization. Threat or risk to receptor populations and habitats were evaluated based on direct observations in the field and literature data, since no site-specific toxicological data were available. Data generated from literature information were used to compute bioconcentration, bioaccumulation and biomagnification factors for key species. In addition, using toxicological data from the literature, first-cut evaluations of potential risk were computed for COCs. Very conservative factors were computed and used to estimate maximum allowable tissue concentrations in bio-receptors.

Task 7 - Uncertainty Analysis (Phase III)

The uncertainty analysis addressed uncertainty in the toxicity and exposure assessment and uncertainty in the risk characterization. The assumptions of exposure, bioconcentration factors, and lack of site-specific data, all increase the uncertainty of any conclusions of potential harm to biota from site releases. Uncertainty in the exposure assessment is related to the accuracy with which exposure pathways correctly predict receptor contact with contaminated media and corresponding model inputs of contaminant concentrations. Risk characterization uncertainty is also influenced by the assumptions regarding exposures and toxicities which are affected by the sampling and analysis programs, and the literature data used in the model. Uncertainty was described qualitatively.

# 3.0 SITE DESCRIPTION

Rocky Flats Plant (RFP) and environs is composed of a wide variety of habitat types. The IA of the RFP, although the most disturbed and limited in terms of areal extent, also has diverse habitats. Habitat diversity in turn influences the distribution and abundance of plants and animals because of the differences in topography, aspect, soil type, previous and continuous disturbance, and microclimatic across these habitats. An understanding of present vegetative communities and wildlife habitat characteristics and usage provides important information to remediation efforts and restoration planning.

The extent of the habitats in the IA is limited to relatively undisturbed or reclaimed sites and total about 25 acres or, 6 percent of the IA. These habitats are fragmented and small with roads and disturbed surfaces interspersed throughout. Other habitats in associated Operable Units (OUs) 1, 2, 4, 6, and 7 that are adjacent to and in the IA, and not included in these field surveys, occupy about another 30 acres. Figure 1 illustrates the Industrial Hazardous Substance Sites associated with the IA.

The IA was traversed on foot by two ecologists to characterize and map the different habitat types. The characterization of the IA habitats was conducted following EG&G SOP EE.11 (EG&G, 1992a and 1992b). Topographic features, such as aspect and slope, were noted. Plant species lists were made to better understand ecological relationships of the area. Dominant species were recorded along with their spatial foliar dominance to a particular habitat type.

Habitat types identified in the IA area include disturbed (annual/forb), mesic grass (mixed grassland), xeric grass (short grass), short marsh, tall marsh, deciduous woodland (woodland), reclaimed grassland, and ornamental plantings. Specific habitats were mapped in five different study areas illustrated in Figures 2 through 6.

The disturbed (annual/forb) habitat type was found throughout the IA. All study areas had this habitat type, including the East Drainage, North Pond and Seep, the Northwest Drainage, the

West Railroad, and the West Area. These areas have had previous or frequent surficial soil disturbance due to road building and maintenance, mowing, earthmoving, and storage of cargo facilities.

The mesic grassland (mixed grassland) habitat type occurs in the Northwest Drainage and the West Area. These areas of about 10 to 15 acres are remnants of the original prairie. Several prairie habitat types come together to compose the mesic grassland and they include tall grass prairie, northern mid-grass prairie, and southern mid-grass prairie. This habitat type was the most diverse with upwards of eighty species identified.

There were several small areas of xeric grassland (short grass) habitat located at the Northwest Drainage and at the West area. Although small, the xeric grassland habitat type was also very diverse with approximately 60 species identified. The xeric grassland habitat type was found on more gravelly outcrops with bare ground and rock, and exposed to harsh wind and weather conditions.

Due to a number of seeps, ditches, and diverted water sources, the short marsh habitat type may occur throughout the IA wherever these conditions exist. Short marsh was found at the East Drainage, North Pond and Seep, West Railroad, and West Area.

The water levels vary seasonally along the ditches and sloughs where the tall marsh habitat occurs. Cattails dominate areas with receding and stagnant water levels up to two feet deep, or where the subsurface soils remain saturated. Therefore, in many areas of the IA, tall marsh has infiltrated portions of canals and roadside ditches, become established below seeps, and maintained its dominance in shallow creeks which run through the Protected Area.

Deciduous woodland (woodland habitat) areas were encountered at the East Drainage, Northwest Drainage, and in the West Area. Since creeks and streams are small and flow intermittently at Rocky Flats, large areas of riparian woodland development have been minor. Creeks and streams are sparsely populated with single individuals or small pockets of mature trees.

Reclaimed grassland was found at all study sites, except the West Area. Disturbed areas are reclaimed with aggressive species in order to revegetate a site as quickly and as thoroughly as possible. Generally, native species take a longer time to reestablish in disturbed sites, so introduced species are used instead. Some hybridized native grass species also are used for reclamation because they quickly establish on disturbed soils. Some native species have been hybridized to have more aggressive characteristics, such as faster establishment. Since the IA has largely been disturbed much of the area is composed of reclaimed grassland.

Ornamental plantings were observed throughout the IA. These ornamental plantings are not well maintained, but the understories are groomed and mowed at least once annually. These areas seemed to be major grouping sites for wildlife, such as deer and cottontail rabbits. Evidence of herbivory was noticed on the trees and grasses in and around ornamental plantings.

Small mammal surveys conducted during July and October-November 1993 revealed that the IA provides habitat for a small number of species. The largest herbivore is the mule deer that moves in and out of the IA, particularly in the west area. The cottontail rabbit appears to be common throughout the IA, but mainly in the annual grass/weedy forb and xeric grassland habitat types. The deer mouse, prairie vole and harvest mouse were the common small herbivorous mammals. These species were most abundant in the reclaimed grassland habitat near sources of water and tall grass cover. The prairie vole and harvest mouse are considered herbivorous but probably include some insects in their diets, while the deer mouse is omnivorous. A small population of pocket gophers exists in the reclaimed/mesic grassland along the northwest drainage.

Because of migratory patterns in songbirds, the IA supports year round residents, spring nesting species and winter visitors. Common year round residents include the house sparrow, house finch and European starling, while the black-eyed juncos and rosey finches winter in the IA drainages. Common nesting species observed within the IA were the American robin, Say's phoebe, house sparrow, house finch, European starling, barn swallow and cliff swallow.

Many of the above small mammal and bird species form the prey base for raptors, and feline and canine predators.

Feral cats were observed in the East Drainage, North Pond and Seep, Northwest Drainage and West Area study areas. Although drainage structures may provide canine predators access to the IA from the buffer zone, this was not confirmed. Scat found within the IA were not analyzed in detail and could have been from feral cats or smaller canids.

Two owl casts were found within the IA, and probably were from the great-horned owl. This raptor hunts for small mammals and will also take cottontail rabbits and feral cats. No carcasses of either were found within the IA. The American kestrel was commonly observed perched on fence and telephone poles. Within the IA this species will also feed on small mammals, insects and an occasional bird.

Based on the results of the existing data review and ecological field survey, a generalized foodweb was constructed for the IA and is illustrated in Figure 7. This figure indicates that the great-horned owl and American kestral are at the top of the foodweb in the IA. However, because these species have large home ranges, the IA prey base probably contributes to a relatively small proportion of their diet. The feral cat, on the other hand, appears to hunt exclusively in the IA, therefore a large proportion of feral cat food items are from the IA. One exception to this are songbirds that may move in and out of the IA on a seasonal basis.

## 4.0 CONTAMINANTS OF CONCERN AND TARGET TAXA

The IA RCRA Facility Investigation/Remedial Investigation is just beginning, hense a review of the data was not possible. However, potential COCs were selected by reviewing the following sources: *Reconstruction of Historical Rocky Flats Operations & Identification of Release Points* (ChemRisk, 1992); OU4 Draft Summary Table of Contaminants of Concern in Surficial Soil and Vadose Soil, Phase I IM/IRA-EA; and *State of Colorado's Health Studies on Rocky Flats* (CDH, 1993). A list of potential COCs is provided in Table 4-1 along with toxicological information and concentration ranges in OU4 environmental media. The following chemicals are potential COCs:

Inorganics
- Beryllium
- Cadmium
- Chromium
- Mercury
- Nickel
- Silicon
- Strontium

Radionuclides
- Americium-241
- Plutonium-230/240
- Thorium
- Tritium
- Uranium-233/234
- Uranium-235
- Uranium-238

Volatile Organics
- Carbon Tetrachloride
- Chloroform
- Methylene Chloride
- Tetrachloroethylene
- 1,1,1-Trichloroethane
- 1,1,2,2-Tetrachloroethane

Existing data not part of an ongoing RFI/RI suggest that the nature and extent of contamination within the IA is not well understood and is based on waste stream identification, ground water and surface water monitoring, previous site uses, or knowledge of how materials were stored or disposed. Validated environmental media data are not yet available for review.

Over 100 vegetation species were identified within the IA from a variety of habitat types. The most common species were the reclamation grasses used for restoration of disturbed areas, and weedy species that have invaded these disturbed areas. Weedy species, particularly kochia, annual sunflower and yellow and white sweetclover, provide a food source to many seed-eating birds. In a similar matter, the grasses also provide cover and food to birds and small mammals. Based on the ecological field investigation, the following species are probably important receptor species for the ecological risk assessment:

Vegetation
- Smooth brome
- Slender wheatgrass
- Crested wheatgrass
- Buffalo grass
- Blue grama
- Annual sunflower
- Kochia
- Yellow and white sweetclover

Small Mammals
- Prairie vole
- Deer mouse
- Harvest mouse
- Cottontail rabbit

Raptors/Predators
- American Kestrel
- Feral Cat
- Great-horned owl

# 5.0 EXPOSURE ASSESSMENT AND RISK CHARACTERIZATION

The following sections address the development of a conceptual food web and pathway-receptor model, assumptions for the pathway-receptor model, calculation of bio-factors, and risk characterization.

## 5.1 DEVELOPMENT OF A CONCEPTUAL FOOD WEB AND PATHWAY-RECEPTOR MODEL

Much of the data provided in the toxicological profiles (Section 3.0 of the Phase III Data Summary, 1993d) have been gathered from studies on laboratory mice and rats. To the extent practical, these data were included in the exposure assessment. However, the attempt was to structure a contamination characterization as close as possible to existing ecological conditions at the IA. The approach was to construct a conceptual model of the IA food web based on the ecological field investigations conducted during July, October and November 1993, and ecological data gathered in past studies of the RFP. This resulted in the conceptual food web model for the IA as shown in Figure 7 developed to represent existing ecological conditions.

As a part of the exposure assessment, and related to the generalized food web, sink food webs were developed for key raptor or predator species as shown in Figures 8 through 11. A sink food web illustrates major contaminant pathways through the food chain from soils (water or sediments) to higher order consumers at the top of a food chain. These sink food webs provide the structure for the conceptualization of contaminant transport and calculation of bioaccumulation, bioconcentration and biomagnification factors used in a ecological risk assessment.

Based on the generalized food web for the IA shown in Figure 7, the following pathways were identified for evaluation:

Pathway #1: Soil → Plants → Bird → Feral Cat → Great-horned Owl

Pathway #2: Soil → Plants → Deer Mouse → Feral Cat → Great-horned Owl

Pathway #3: Soil →Plants → Cottontail Rabbit → Feral Cat → Great-horned Owl

Pathway #4: Soil → Plants → Deer Mouse → Great-horned Owl

Pathway #5: Soil → Plants → Cottontail Rabbit → Great-horned Owl

Pathway #6: Soil → Plants → Bird → Great-horned Owl

Pathway #7: Soil → Plants → Deer Mouse → American Kestrel

Pathway #8: Soil → Plants → Bird → American Kestrel

Pathway #9: Soil → Plants → Bird → Feral Cat

Pathway #10: Soil → Plants → Deer Mouse → Feral Cat

Pathway #11: Soil → Plants → Cottontail Rabbit → Feral Cat

These pathways do not include pathways for insects, reptiles or carrion, and are not complete. However, these pathways best illustrate major routes of contaminant movement from source to biotic receptors.

## 5.2 ASSUMPTIONS FOR THE PATHWAYS MODEL

The bioaccumulation model proposed by Thomann (1981) and modified by Fordham and Reagan (1991) was used to evaluate the pathways identified for the IA. This model includes multiple food chains and can link chemical concentrations in soil, sediment or water to tissue concentrations in biota by estimating exposures to COCs. The original use of this model was to evaluate chemical transfer through an aquatic food chain. For the IA the model was modified to only evaluate the terrestrial pathway since no significant aquatic systems occur within the IA. Several assumptions were made for bioconcentration factors (BCFs):

- The chemical concentration in the soil is in equilibrium with the chemical concentration in vegetation tissue. In other words, vegetation tissue concentration equals chemical soil concentration and each have a BCF of 1.

- The first order consumers (cottontail rabbit, bird, and deer mouse) each have a BCF of 2. Bioconcentration is uptake of a chemical from water. It is generally accepted that terrestrial species have negligible uptake from water. Small mammals generally receive most of their water from food items and not from direct water ingestion. A BCF of 2 was also assumed for the feral cat, kestrel and great-horned owl at the third level of the food chain. A BCF of 1.5 was assumed for the great-horned owl at the forth level. These BCFs are very conservative.

- The same BCFs were used for each COCs because databases located at EPA Region VIII contained little or no data on BCFs.

## 5.3 CALCULATION OF BIOACCUMULATION AND BIOMAGNIFICATION FACTORS

Bioaccumulation factors (BAFs) apply to second, third, and fourth order consumers. BAFs were calculated in the following manner:

Food Chain Level 1) $C_{soil} = C_{vegetation}$ ; $BCF_{vegetation} = 1$

Food Chain Level 2) $BAF_2 = BCF_2 + f_2BCF_1$

Food Chain Level 3) $BAF_3 = BCF_3 + f_3BCF_2 + f_3f_2BCF_1$

Food Chain Level 4) $BAF_4 = BCF_4 + f_4BCF_3 + f_4f_3BCF_2 + f_4f_3f_2BCF_1$

where: C = chemical concentration
BAF = bioaccumulation factor
BCF = bioconcentration factor
$f_i$ = the food term.

$f_i$, the food term is calculated as follows:

$$f_i = \frac{A \times D \times I}{L}$$

where: A = assimilation efficiency, <u>weight absorbed</u>
D = daily food intake
I = percent of food item in daily diet
L = loss rate, a fraction/day.

To be conservative, an assimilation efficiency of 0.9 was used. This value indicates that for every 10 mg of chemical ingested, 9 mg are assimilated. Spacie and Hamelink (1985) used this value for PCBs and DDT. Loss rate, or depuration, is the loss of the chemical due to growth, dilution, excretion and metabolism. For avian species the value of 0.36 was used, and for mammals, 0.4 (ESE, 1988).

Table 6-1 was constructed to present data on animal weights, food ingestion rates, animal diet items. Table 3 presents data on water and soil ingestion for selected species. These data provide input for calculations to estimate BAFs.

A food term was calculated for each key species using the above food term formula. These food terms were then substituted into the appropriate food chain level formula (Levels 1,2,3 and 4) and BAFs were calculated for each key species in each pathway #1 through #11). Each food chain level represents a BAF calculation for a key species. For example, Level 2 represents the level for the bird, cottontail rabbit and the deer mouse, while Level 4 only includes the great-horned owl. Therefore, each species in that level has a BAF. These data are summarized in Table 6-3.

Biomagnification results in an increase of chemical tissue concentration as the chemical is passed up the food chain. This is a result of bioconcentration and bioaccumulation at each level of the food chain. Whereas BAF values are for single food chains, BMF values represent overall accumulation in the identified food web. A total BMF was calculated for each predator/raptor by the following general formula:

$$BMF_i = BCF_i + \text{sum of } f_i BAF_{i-1}$$

The total BMFs were calculated with the following results:

$\text{Total } BMF_{\text{feral cat}} = 7.16$

$\text{Total } BMF_{\text{kestrel}} = 20.42$

$\text{Total } BMF_{\text{great-horned owl}} = 23.14.$

Total BMFs were used to evaluate maximum allowable concentrations of a chemical in soil, water or sediment by relating environmental media concentrations to maximum acceptable tissue concentrations (MATC) in target species:

$$\frac{MATC}{\text{Total BMF}} = C_{\text{water,soil or tissue}} \quad (\text{"no effects" level})$$

This value can be compared to existing chemical concentrations in environmental media as a first approximation of a water, soil or sediment criterion. For example, strontium has a rat NOAEL of 375 mg/kg/day as shown in Table 4-1, and we assume that the feral cat also has an identical NOAEL, which adjusted for its weight (1250 g) is 468 mg/kg/day. An assumption at 468 mg/kg as the MATC, results in:

$$\frac{468 \text{ mg/kg}}{7.16 \quad (BMF_{\text{feral cat}})} = 65.36 \text{ mg/kg}$$

Comparing 65.36 mg/kg with the range of strontium concentrations (22 through 510 mg/kg) from Table 4-1 would suggest that 65.36 mg/kg strontium in the soil may cause harm to the feral cat. In this calculation, no factor for uncertainty was used. Accepted practice is to multiply certain estimated values by an "uncertainty factor". The higher the factor, the higher the associated uncertainty. Uncertainty factors can be used to convert effects to a chronic NOEL range from 5 through 1,000, and a factor of 5 can be used for species interspecific variation. Total uncertainty factors then range from 5 to 5,000.

Table 6-4 summarizes soil and water criteria estimated from BMFs for a feral cat. It lists NOEL/LOAEL used as MATC and divided by the calculated BMF for the feral cat to estimate a soil concentration assumed to represent a "no effects" level. The table lists NOEL/LOAEL, estimated "no effects", and estimated daily doses of the chemical from published ingestion rates of soil or water. These data suggest that ingestion of soil or water is a negligible route of chemical entry into the food chain.

## 5.4 RISK CHARACTERIZATION

Only one set of formulae was used in the calculation of bio-factors. This assumes that all chemicals behave identically. This is not the case, but in the absence of site-specific data on bioaccumulation or bioconcentration data, and literature values, conservative assumptions were made to perform qualitative risk characterization. From these values a BMF was also estimated and used to calculate a first order "no effects" level representing a soil concentration at which "no effect" results to biota. Next, using water and soil estimated ingestion rates, daily doses to biota were also estimated. These data indicated that the water and soil ingestion routes contribute negligible chemical amounts to biota. Data are needed on the concentrations of chemicals in site biota tissues to compare with estimated factors, criteria and ingestion rates to quantitatively characterize risk to biota from site contaminants. These data are potentially available from the radioecological investigations already conducted at Rocky Flats (Whicker and Ibrahim, 1993).

Nine of the 19 COCs identified were qualitatively characterized for risk. Table 6-4 presents soil and water criteria estimated from BMFs for a Feral Cat. The BMF for Strontium of 52.37 mg/kg is the only BMF falling within the range of concentrations detected at OU4. Hence, Strontium appears to present a risk to biota in the IA. No risk characterization could be conducted for chromium, mercury, all the radionuclides and 1,1,2,2-tetrachloroethane because of the lack of data applicable to the biota from the IA. Toxicity profile data indicate that there is a potential for injury to species from releases of these contaminants.

# 6.0 UNCERTAINTY ANALYSIS

The absence of site-specific information required conservation assumptions regarding data inputs to the analysis. Assumptions were made with respect to COCs, toxicities, and risk characterization. The result is conservative estimates of risk parameters, and an overly conservative risk estimate. Most of the data used to evaluate potential risk to the biota were based on the literature values except the identification of receptor species, or target taxa, and chemical concentrations found in OU4 soils and water.

The absence of site-specific data, required that all values characterizing bioaccumulation, bioconcentration and biomagnification be computed from literature data for similar or related species, or for species data gathered at other locations. For example, data on animal weights were gathered from about four different sources. However, weights of the mice were from species collected at the IA during the ecological survey. These literature values for ingestion rates, diet food items and body weights were used to calculate food terms in the bioaccumulation formula.

There was little information on BAFs, BCFs or BMFs from the literature reviewed, so conservative estimates were made in the calculation of these terms. Because there was little information, all assumptions for BAFs, BCFs, and BMFs were identical. Therefore, only one food term for each species was calculated. In other words, whether evaluating cadmium or strontium, the BAFs, BCFs and BMFs were identical for each species. This resulted in only one total BMF per key species instead of a BMF for each chemical evaluated. Although these values were calculated to be conservative, it is possible that in reality, one or more of these chemicals accumulates in tissues far greater than estimated. Loss rates, or depuration, and assimilation efficiency data also were not site-specific, so literature values were used from a study on turkeys and rats. These rates were used in the food term formula for the key species of small mammals, the feral cat and the two raptors. The other assumption was that soil chemical concentrations were in equilibrium with vegetation tissues, such that a soil chemical concentration of 5 mg/kg was also the vegetation tissue chemical concentration. Each of these parameters and assumptions had a level of uncertainty attached to them, such that the final estimate of biomagnification could over- estimate risk.

Two other parameters, the NOEL and LOAEL (No Observed Effects Level and Lowest Observed Effects Level) were used to estimate a soil/water criterion and a "no effects" level. The value generally used in this calculation is the MATC (Maximum acceptable tissue concentration). No MATCs were found in the databases located at EPA Region VIII for the COCs evaluated, so the NOEL or LOAEL were used as substitutes. Generally, an uncertainty factor ranging from 5 to 5000 can be applied when using these values for soil or water criteria.

Because of the lack of site-specific data, it was not possible to validate any of the calculated factors or parameters. Thus, it is not possible to know how close or how far off are estimates of bioaccumulation and transfer through the food chain. It was also assumed in this assessment that dermal and inhalation exposures routes were insignificant in chemical accumulation n tissues. The values calculated from NOEL/LOAELs to estimate daily doses from water or soil ingestion suggested this was the case.

The conclusions of the risk assessment based on the assumptions used are that strontium concentrations in the soils are a potential risk to biota. However, even though the assumptions used were thought to be conservative, they may not be conservative enough. To better evaluate the potential risk to biota from IA contamination, site-specific chemical concentration data should be gathered and evaluated through the pathway-receptor model used in this study.

The uncertainty analysis addressed uncertainty in the toxicity and exposure assessment and uncertainty in the risk characterization. The assumptions of exposure, bioconcentration factors, and lack of site-specific data, all increase the uncertainty of any conclusions of potential harm to biota from site releases. Uncertainty in the exposure assessment is related to the accuracy with which exposure pathways correctly predict receptor contact with contaminated media and corresponding model inputs of contaminant concentrations. Risk characterization uncertainty is also influenced by the assumptions regarding exposures and toxicities which are affected by the sampling and analysis programs, and the literature data used in the model. Uncertainty was described qualitatively.

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# TABLES

## TABLE 3-1
## VEGETATION SPECIES BY HABITAT

| HABITAT | VEGETATION SPECIES |
|---|---|
| Disturbed (annual/forb) | Sunflower, Russian-Thistle, Klamath Weed, Curlycup Gumweed, Western Ragweed, Burning Bush, Diffuse Knapweed, Cheat-grass, Japanese Brome, Canada Thistle, Musk Thistle, Bull Thistle |
| Mesic Grassland (mixed grassland) | Needle-and-Threadgrass, Prairie Junegrass, Big Bluestem, Canada Bluegrass, Kentucky Bluegrass, Sideoats Grama, Blue Grama, Mountain Muhly |
| Xeric Grassland (short grass) | Red Three-Awn, Fendler Three-Awn, Buffalo Grass, Hairy Grama, Ring Muhly, Aster, Mountain Bladder-Pod, Prairie Sage, Golden Aster, Filaree, Green Milkweed, Goldenrod, Winged Eriogonum, Sego-Lily, Sagewort, Broom Snakeweed, Spanish Bayonet, Prickly Pear |
| Short Marsh | Spike Rush, Rush, Baltic Rush, Soft Rush, Redtop Bentgrass, Timothy, Meadow Fescue, Nebraska Sedge, Foxtail Barley, Water Cress, Cress, Horseweed, Common Evening-Primrose, Violet, Lady's Thumb |
| Tall Marsh | Common Cattail, Common Evening Primrose, Catnip, Field Mint, Foxtail, Houndstongue, Plains Cottonwood, Russian-Olive, Peach-Leaved Willow |
| Deciduous Woodland (Woodland) | Plains Cottonwood, Russian-Olive, Peach-Leaved Willow, Creek Willow, Choke Cherry, Coyote Willow, Leadplant, Sandbar Willow |
| Reclaimed Grassland | Smooth Brome, Crested Wheatgrass, Intermediate Wheatgrass, Hybrid Native Side-Oats Grama, Alfalfa, White Sweet Clover, Yellow Sweet Clover, Wild Licorice |
| Ornamental Plantings | Ponderosa Pine, Russian-Olive, Plains Cottonwood, Juniper, Sheep Fescue |

## TABLE 3-2
## RESULTS OF SMALL MAMMAL LIVE TRAPPING AT THE EAST DRAINAGE STUDY AREA, OCTOBER 14 THROUGH 16, 1993

**Small Mammal Species**

**White-footed deer mouse (*Peromyscus maniculatus*)**

| Number Caught: | Oct 14 | Oct 15 | Oct 16 |
|---|---|---|---|
| Males | 3 | 2 | 3 |
| Females | 0 | 0 | 0 |
| Number of Age Classes: | | | |
| Juveniles | 8 | 8 | 8 |
| Number of Reproductives: | 0 | 0 | 0 |
| Number of Recaptures: | - | 1 | 1 |

**Western harvest mouse (*Reithrodontomys megalotis*)**

| Number Caught: | Oct 14 | Oct 15 | Oct 16 |
|---|---|---|---|
| Males | 0 | 2 | 0 |
| Females | 0 | 1 | 1 |
| Number of Age Classes: | | | |
| Subadults | 2 | 2 | 2 |
| Juveniles | 2 | 2 | 2 |
| Number of Reproductives: | 0 | 0 | 1 |
| Number of Recaptures: | - | 0 | 0 |

**Prairie vole (*Microtus ochrogaster*)**

| Number Caught: | Oct 14 | Oct 15 | Oct 16 |
|---|---|---|---|
| Males | 1 | 3 | 0 |
| Females | 0 | 0 | 1 |
| Number of Age Classes: | | | |
| Adults | 4 | 4 | 4 |
| Juveniles | 1 | 1 | 1 |
| Number of Reproductives: | 0 | 0 | 0 |
| Number of Recaptures: | - | 1 | 0 |

## TABLE 3-3
## RESULTS OF SMALL MAMMAL LIVE TRAPPING AT THE NORTH POND AND SEEP STUDY AREA, OCTOBER 14 THROUGH 16, 1993

**Small Mammal Species**

**White-footed deer mouse (*Peromyscus maniculatus*)**

| Number Caught: | Oct 14 | Oct 15 | Oct 16 |
|---|---|---|---|
| Males | 0 | 0 | 1 |
| Females | 0 | 0 | 0 |
| Number of Age Classes: | | | |
| Subadults | 1 | 1 | 1 |
| Number of Reproductives: | 0 | 0 | 1 |
| Number of Recaptures: | - | 0 | 0 |

**Western harvest mouse (*Reithrodontomys megalotis*)**

| Number Caught: | Oct 14 | Oct 15 | Oct 16 |
|---|---|---|---|
| Males | 1 | 0 | 0 |
| Females | 0 | 0 | 0 |
| Number of Age Classes: | | | |
| Adults | 1 | 1 | 1 |
| Number of Reproductives: | 0 | 0 | 0 |
| Number of Recaptures: | - | 0 | 0 |

**Prairie vole (*Microtus ochrogaster*)**

| Number Caught: | Oct 14 | Oct 15 | Oct 16 |
|---|---|---|---|
| Males | 0 | 0 | 0 |
| Females | 0 | 2 | 2 |
| Number of Age Classes: | | | |
| Adults | 3 | 3 | 3 |
| Subadults | 1 | 1 | 1 |
| Number of Reproductives: | - | 0 | 0 |
| Number of Recaptures: | - | 0 | 0 |

## TABLE 3-4
## RESULTS OF SMALL MAMMAL LIVE TRAPPING AT THE NORTHWEST DRAINAGE STUDY AREA, OCTOBER 14 THROUGH 16, 1993

**Small Mammal Species**

**White-footed deer mouse (*Peromyscus maniculatus*)**

| Number Caught: | Oct 14 | Oct 15 | Oct 16 |
|---|---|---|---|
| Males | 1 | 1 | 0 |
| Females | 2 | 1 | 0 |
| Number of Age Classes: | | | |
| Adults | 2 | 2 | 2 |
| Juveniles | 2 | 2 | 2 |
| Number of Reproductives: | 0 | 0 | 0 |
| Number of Recaptures: | - | 1 | 0 |

**Western harvest mouse (*Reithrodontomys megalotis*)**

| Number Caught: | Oct 14 | Oct 15 | Oct 16 |
|---|---|---|---|
| Males | 0 | 1 | 0 |
| Females | 0 | 0 | 1 |
| Number of Age Classes: | | | |
| Juveniles | 2 | 2 | 2 |
| Number of Reproductives: | 0 | 0 | 0 |
| Number of Recaptures: | - | 0 | 0 |

**Prairie vole (*Microtus ochrogaster*)**

| Number Caught: | Oct 14 | Oct 15 | Oct 16 |
|---|---|---|---|
| Males | 0 | 0 | 1 |
| Females | 0 | 2 | 1 |
| Number of Age Classes: | | | |
| Adults | 2 | 2 | 2 |
| Subadults: | 2 | 2 | 2 |
| Number of Reproductives: | 0 | 1 | 0 |
| Number of Recaptures: | - | 0 | 0 |

## TABLE 3-5
## RESULTS OF SMALL MAMMAL LIVE TRAPPING AT THE WEST RAILROAD STUDY AREA, OCTOBER 14 THROUGH 16, 1993

**Small Mammal Species**

**White-footed deer mouse (*Peromyscus maniculatus*)**

| Number Caught: | Oct 14 | Oct 15 | Oct 16 |
|---|---|---|---|
| Males | 0 | 0 | 0 |
| Females | 0 | 0 | 0 |

Number of Age Classes: None

Number of Reproductives: None

Number of Recaptures: None

**Western harvest mouse (*Reithrodontomys megalotis*)**

| Number Caught: | Oct 14 | Oct 15 | Oct 16 |
|---|---|---|---|
| Males | 0 | 0 | 0 |
| Females | 0 | 0 | 1 |
| Number of Age Classes: | | | |
| Juveniles | 0 | 1 | 0 |
| Number of Reproductives: | 0 | 0 | 0 |
| Number of Recaptures: | - | 0 | 0 |

**Prairie vole (*Microtus ochrogaster*)**

| Number Caught: | Oct 14 | Oct 15 | Oct 16 |
|---|---|---|---|
| Males | 0 | 0 | 0 |
| Females | 0 | 0 | 0 |

Number of Age Classes: None

Number of Reproductives: None

Number of Recaptures: None

**TABLE 3-6**
**RESULTS OF SMALL MAMMAL LIVE TRAPPING AT THE WEST AREA STUDY AREA, OCTOBER 14 THROUGH 16, 1993**

**Small Mammal Species**

**White-footed deer mouse (*Peromyscus maniculatus*)**

| Number Caught: | Oct 14 | Oct 15 | Oct 16 |
|---|---|---|---|
| Males | 0 | 1 | 0 |
| Females | 0 | 1 | 0 |
| Number of Age Classes: | | | |
| Subadults | 0 | 2 | 0 |
| Number of Reproductives: | 0 | 0 | 0 |
| Number of Recaptures: | - | 0 | 0 |

**Western harvest mouse (*Reithrodontomys megalotis*)**

| Number Caught: | Oct 14 | Oct 15 | Oct 16 |
|---|---|---|---|
| Males | 0 | 0 | 0 |
| Females | 0 | 0 | 0 |

Number of Age Classes: None

Number of Reproductives: None

Number of Recaptures: None

**Prairie vole (*Microtus ochrogaster*)**

| Number Caught: | Oct 14 | Oct 15 | Oct 16 |
|---|---|---|---|
| Males | 0 | 0 | 0 |
| Females | 0 | 0 | 0 |

Number of Age Classes: None

Number of Reproductives: None

Number of Recaptures: None

## TABLE 3-7

## BIRD SPECIES OBSERVED IN THE INDUSTRIAL AREA DURING A THREE DAY SURVEY -- OCTOBER 28 TO NOVEMBER 8, 1993

| SPECIES | EAST DRAINAGE | NO. POND & SEEP | NORTHWEST DRAINAGE | WEST RAILROAD | WEST AREA |
|---|---|---|---|---|---|
| Raven | 4 | 0 | 0 | 0 | 2 |
| Rock Dove | 2 | 3 | 3 | 0 | 0 |
| House Finch | 5 | 0 | 6 | 0 | 0 |
| Cassin's Finch | 0 | 0 | 1 | 0 | 0 |
| Starling | 9 | 4 | 0 | 0 | 20 |
| American Robin | 0 | 0 | 0 | 0 | 2 |
| House Sparrow | 2 | 3 | 0 | 0 | 0 |
| Vesper Sparrow | 0 | 1 | 8 | 0 | 3 |
| Dark-eyed Junco (slate-colored race) | 0 | 0 | 8 | 0 | 3 |
| Rosey Finch (Brown-capped race) | 0 | 0 | 3 | 0 | 0 |
| Unknown Sparrows* | 0 | 0 | 11 | 0 | 0 |
| American Kestrel | 1 | 0 | 0 | 0 | 1 |
| Ferruginous Hawk | 0 | 0 | 1 | 0 | 0 |
| Herring Gull | 1 | 0 | 1 | 0 | 0 |
| **TOTAL BIRDS** | **24** | **11** | **41** | **0** | **30** |
| **TOTAL SPECIES** | **7** | **4** | **9** | **0** | **6** |
| **SPECIES USING HABITAT AND NOT FLYING OVERHEAD** | **3** | **2** | **6** | **0** | **5** |

* These sparrows were deep into the willows and could not be identified with certainty.

# TABLE 4-1
## Rocky Flats Industrial Area Environmental Evaluation
## Potential Contaminants of Concern

| Contaminant of Concern | Toxicity Information | Concentration Ranges from OU4 | Applicable or Relevant and Appropriate Requirements (ARAR) | Carcinogen Classification |
|---|---|---|---|---|
| **INORGANICS** | | | | |
| Beryllium | $LD_{50}$: Intravenous - rat 496 mg/kg<br>NOAEL: 0.95 mg/kg/day | 1.1 - 9.6 mg/kg | 0.2 mg/kg[1] | B2; probable human carcinogen |
| Cadmium | $LD_{50}$: Ingestion - mouse 790 mcmol Cd/kg<br>NOAEL: 0.005 mg/kg/day | 1.1 - 380 mg/kg | 40 mg/kg[1] | B1; probable human carcinogen |
| Chromium | Chronic toxicity studies with rats showed no significant adverse effects | 4.2 - 48.4 mg/kg | 400 mg/kg[1] | A; human carcinogen |
| Mercury | Rats were injected with metallic mercury and observed for their lifetimes, sarcomas were seen only in those tissues that had been in direct contact with the metal | 0.05 - 18 mg/kg | 20 mg/kg[1] | D; not classifiable as to human carcinogenicity |
| Nickel | $LD_{50}$: Ingestion - Rat 2.0 g/kg<br>NOAEL: 5 mg/kg/day | 10 - 180 mg/kg | 2000 mg/kg[1] | EPA has not evaluated for potential human carcinogenicity |
| Silicon | $LD_{50}$: Ingestion - Rat 3160 mg/kg | 463 - 11300 mg/kg | | |
| Strontium | NOAEL: 375 mg/kg/day | 22 - 510 mg/kg | 8 pCi/l[2] | EPA has not evaluated for potential human carcinogenicity |
| **RADIONUCLIDES** | | | | |
| Americium-241 | | 0 - 6.1 pCi/g | 0.05 pCi/l[3] | |
| Plutonium-230/240 | | 0 - 25 pCi/g | 0.05 pCi/l[3] | |
| Thorium | | | 500 pCi/l[3] | |
| Tritium | | 0.11 - 62 pCi/ml | 20,000 pCi/l[2] | |
| Uranium-233/234 | | 0 - 21 pCi/g | | |
| Uranium-235 | | 0 - 0.87 pCi/g | | |
| Uranium-238 | | 0 - 11 pCi/g | 5 pCi/l[3] | |

## TABLE 4-1
## Rocky Flats Industrial Area Environmental Evaluation
## Potential Contaminants of Concern

| Contaminant of Concern | Toxicity Information | Concentration Ranges from OU4 | Applicable or Relevant and Appropriate Requirements (ARAR) | Carcinogen Classification |
|---|---|---|---|---|
| **VOLATILE ORGANICS** | | | | |
| Carbon Tetrachloride | $LD_{50}$: Ingestion - Rat 2350 mg/kg NOAEL: 1 mg/kg/day | 6 - 29 μg/l | 5 mg/kg[1] | B2; probable human carcinogen |
| Chloroform | $LD_{50}$: Ingestion - rat 300 mg/kg LOAEL: 12.9 mg/kg/day | 6 - 29 μg/l | 100 mg/kg[1] | B2; probable human carcinogen |
| Methylene Chloride | NOAEL: 5 mg/kg/day | 0 - 6000 μg/kg | 90 mg/kg[1] | B2; probable human carcinogen |
| Tetrachloroethylene | $LD_{50}$: Ingestion - rat 2629 mg/kg NOEL: 14 mg/kg/day | 6 - 29 μg/kg | 10 mg/kg[1] | The evaluation for this chemical is under review by an EPA inter-office agency work group. |
| 1,1,1-Trichloroethane | $LD_{50}$: Ingestion - human estimation 500 mg/kg | 6 - 29 μg/kg | 200 μg/l[2] | D; not classifiable as to human carcinogenicity |
| 1,1,2,2-Tetrachlorethane | | 6 - 29 μg/kg | 30 mg/kg[1] | C; possible human carcinogen |

$LD_{50}$: Lethal dose to 50% of the population
NOAEL: No observed adverse effect level
LOAEL: Lowest observed adverse effect level
NOEL: No observed effect level
[1] Values from the Corrective Action for Solid Waste Management Units (SWMUs) at Hazardous Waste Management Facilities, Proposed Rule, Vol. 55, No. 145, Friday, July 27, 1990
[2] Maximum Contaminant Level
[3] Colorado Department of Health Standard

# NOTICE:

Table 5 is not missing. See Table of Contents.

The Administrative Record Staff

# TABLE 6-1
# FOOD CONSUMPTION AND FOOD ITEM PERCENTAGES USED TO ESTIMATE BIOACCUMULATION FACTORS

| SPECIES | DAILY FOOD CONSUMPTION (g/kg bw/day)[a] | AVERAGE WEIGHT (grams) | FOOD ITEMS | PERCENT IN DIET |
|---|---|---|---|---|
| Great Horned Owl | 202.5 | 1500[1] | Invertebrates<br>Birds<br>Mammals | 8.1[1]<br>29.7[1]<br>62.1[1] |
| American Kestrel | 30 | 115[1] | Insects<br>Small Birds<br>Reptiles<br>Mammals | 51.8[2]<br>16.4[2]<br>4.5[2]<br>27.3[2] |
| Feral Cat | 50 | 1250 | Insects<br>Mammals | 50[3]<br>50[3] |
| Cottontail Rabbit | 120 | 1450 | Insects<br>Plants | 50[3]<br>50[3] |
| Song Bird | 40 | 40 | Plants<br>Insects<br>Earthworms | 50[4]<br>25[4]<br>25[4] |
| Prairie Vole | 70 | 50[5] | Insects<br>Plants | 50[3]<br>50[3] |
| Harvest Mouse | 20 | 15[5] | Insects<br>Plants | 50[3]<br>50[3] |
| Deer Mouse | 25 | 20[5] | Insects<br>Plants | 50[3]<br>50[3] |

[a] g/kg bw/day = grams/kilogram body weight/day

[1] Craighead and Craighead, 1969
[2] Sherrod, 1978
[3] Jones et. al, 1985
Hall, 1981
[4] ESE, 1988
[5] DOE, 1993b

**TABLE 6-2**
**RATES OF WATER AND SOIL INGESTION**
**FOR SELECTED SPECIES**

| Species | Weight of Animal (grams) | Water (l/kg bw/day)[a] | Soil (g/kg bw/day)[a] |
|---|---|---|---|
| Cotton Rat | 160 | 0.125 | 0.00028 |
| White-footed Mouse | 17.5 | 0.02 | 0.00074 |
| Rabbit | 1450 | 0.165 | 0.0613 |
| Cat | 1250 | 0.05 | 0.0022 |
| Raptor | 1500 | 0.10 | --- |
| Chipmunk | 90 | --- | 0.0016 |

[a] l/kg bw/day = liters/kilogram body weight/day
g/kg bw/day = grams/kilogram body weight/day

**TABLE 6-3**
**SUMMARY OF BIOACCUMULATION FACTORS**
**FOR KEY SPECIES IN INDUSTRIAL AREA FOOD WEB PATHWAYS**

| Pathway[a] | Cottontail Rabbit | Deer Mouse | Bird | Feral Cat | Kestrel | Great Horned Owl |
|---|---|---|---|---|---|---|
| 1 | | | 4.5 | 7.85 | | 13.7 |
| 2 | | 5.05 | | 8.35 | | 28.58 |
| 3 | 2.19 | | | 5.77 | | 16.80 |
| 4 | | 5.05 | | | | 28.58 |
| 5 | 2.19 | | | | | 16.80 |
| 6 | | | 4.5 | | | 13.7 |
| 7 | | 5.05 | | | 24.63 | |
| 8 | | | 4.5 | | 14.52 | |
| 9 | | | 4.5 | 7.85 | | |
| 10 | | 5.05 | | 8.35 | | |
| 11 | 2.19 | | | 5.77 | | |

[a] Pathways include the following:

Pathway #1: Soil → Plants → Bird → Feral Cat → Great-horned Owl
Pathway #2: Soil → Plants → Deer Mouse → Feral Cat → Great-horned Owl
Pathway #3: Soil →Plants → Cottontail Rabbit → Feral Cat → Great-horned Owl
Pathway #4: Soil → Plants → Deer Mouse → Great-horned Owl
Pathway #5: Soil → Plants → Cottontail Rabbit → Great-horned Owl
Pathway #6: Soil → Plants → Bird → Great-horned Owl
Pathway #7: Soil → Plants → Deer Mouse → American Kestrel
Pathway #8: Soil → Plants → Bird → American Kestrel
Pathway #9: Soil → Plants → Bird → Feral Cat
Pathway #10: Soil → Plants → Deer Mouse → Feral Cat
Pathway #11: Soil → Plants → Cottontail Rabbit → Feral Cat

# TABLE 6-4
## SOIL AND WATER CRITERIA ESTIMATED FROM BIOMAGNIFICATION FACTORS FOR FERAL CAT

| Potential COCs | NOEL/LOAEL (mg/kg) | Soil/Water Criteria $\frac{\text{NOEL/LOAEL}}{\text{BMF Cat}}$ mg/kg | Soil Daily Dose to Feral Cat mg/l | Water Daily Dose (Feral Cat) mg/l | Concentration Range at OU4 |
|---|---|---|---|---|---|
| **Beryllium** | 0.95 | 0.133 | $2.9 \times 10^{-4}$ | 0.007 | 1.1 - 9.6 mg/kg |
| **Cadmium** | 0.005 | 0.0007 | $1.5 \times 10^{-6}$ | $3.5 \times 10^{-5}$ | 1.1 - 380 mg/kg |
| **Nickel** | 5.0 | 0.698 | $1.5 \times 10^{-3}$ | 0.035 | 10 - 180 mg/kg |
| **Silicon** | 3160.0 | 441.34 | 0.97 | 22.07 | 463- 11,300mg/kg |
| **Strontium** | 375.0 | 52.37 | 0.115 | 2.62 | 22 - 510 mg/kg |
| **Carbon Tetrachloride** | 1.0 | 0.14 | $3.1 \times 10^{-4}$ µg/l | 0.007 µg/l | 6 - 29 µg/l |
| **Chloroform** | 12.9 | 1.8 | $3.96 \times 10^{-3}$ µ/l | 0.09 µg/l | 6 - 29 µg/l |
| **Methylene Chloride** | 5.0 | 0.698 | $1.5 \times 10^{-6}$ | 0.035 | 0 - 6 mg/kg |
| **Tetrachloroethylene** | 14.0 | 1.96 | $4.3 \times 10^{-3}$ | 0.098 | .006-.029 mg/kg |

# FIGURES

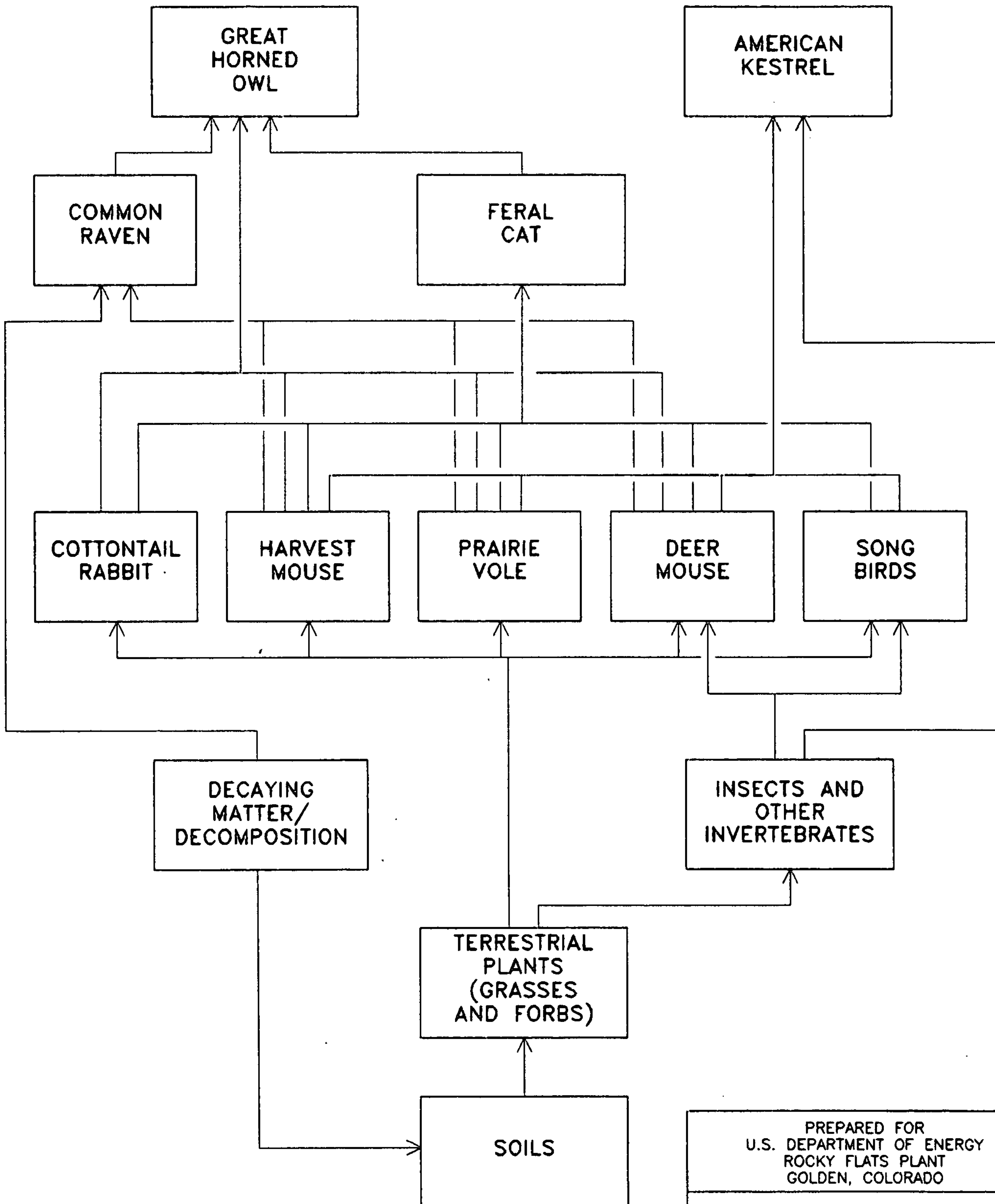


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FIGURE 7
INDUSTRIAL AREA
ENVIRONMENTAL EVALUATION
GENERALIZED FOOD WEB

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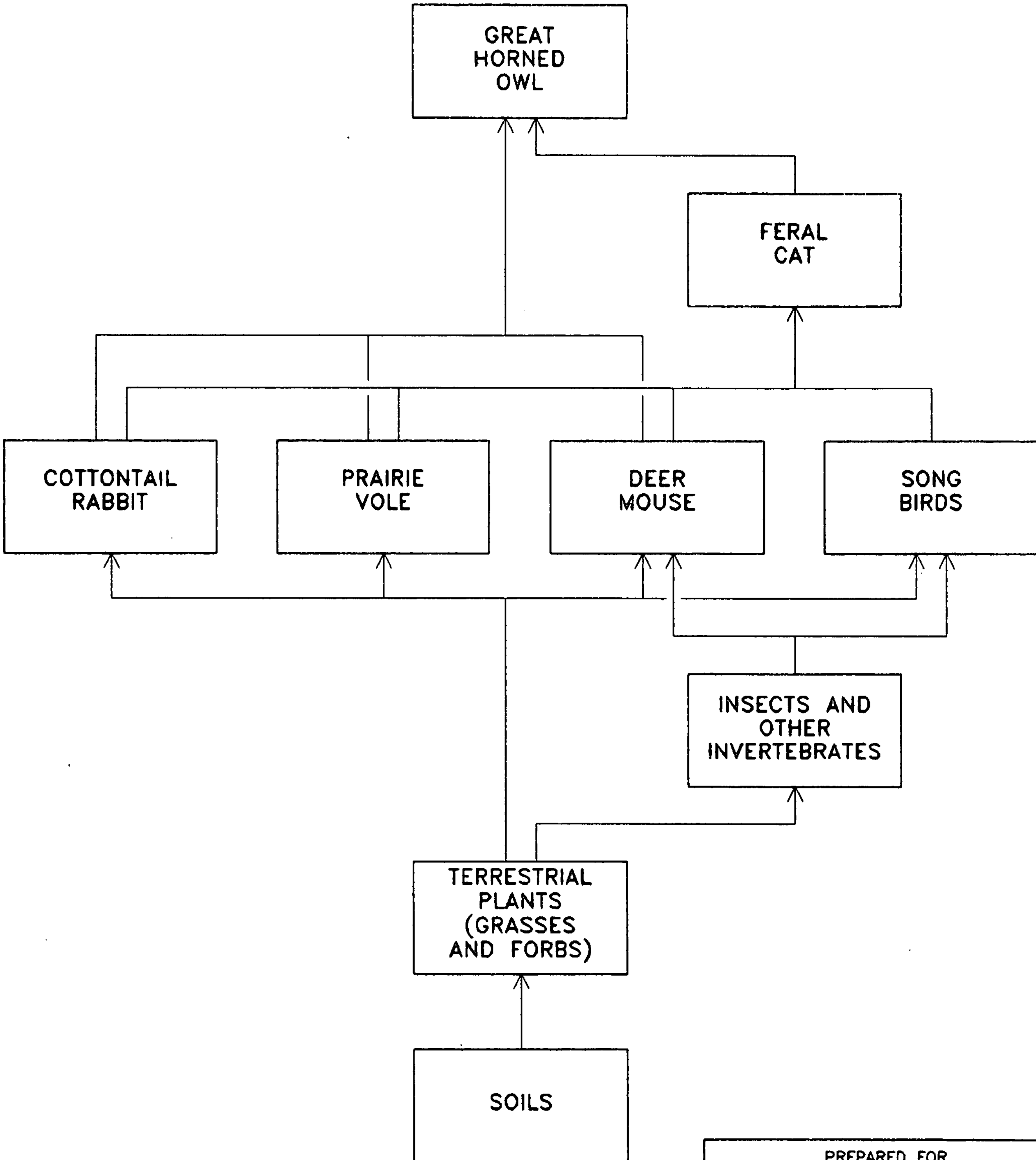


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GOLDEN, COLORADO

FIGURE 8
INDUSTRIAL AREA
ENVIRONMENTAL EVALUATION
SINK FOOD WEB
FOR GREAT HORNED OWL

REVISION NO. 5 | FILE NAME C:\KJS\FWGHOTM | DATE 12/6/93 | DRAWN BY KJS | APPROVED BY | CHECKED BY

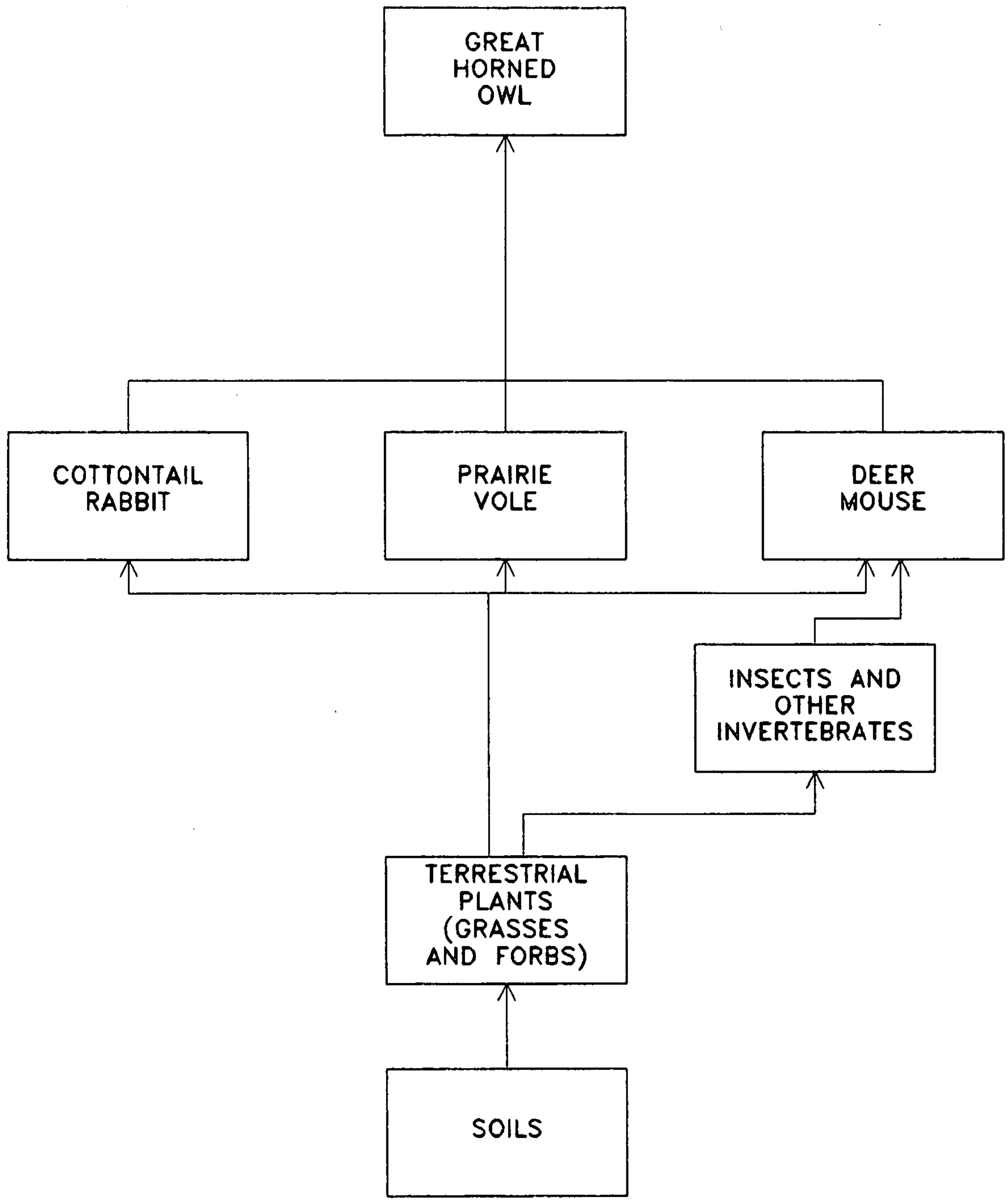


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FIGURE 9
INDUSTRIAL AREA
ENVIRONMENTAL EVALUATION
SINK FOOD WEB
FOR GREAT HORNED OWL
WITHOUT FERAL CAT PATHWAY

CHECKED BY WJ | APPROVED BY JEF | DRAWN BY KJS | DATE 12/6/93 | FILE NAME C:\KJS\FWGH3TM | REVISION NO. 2

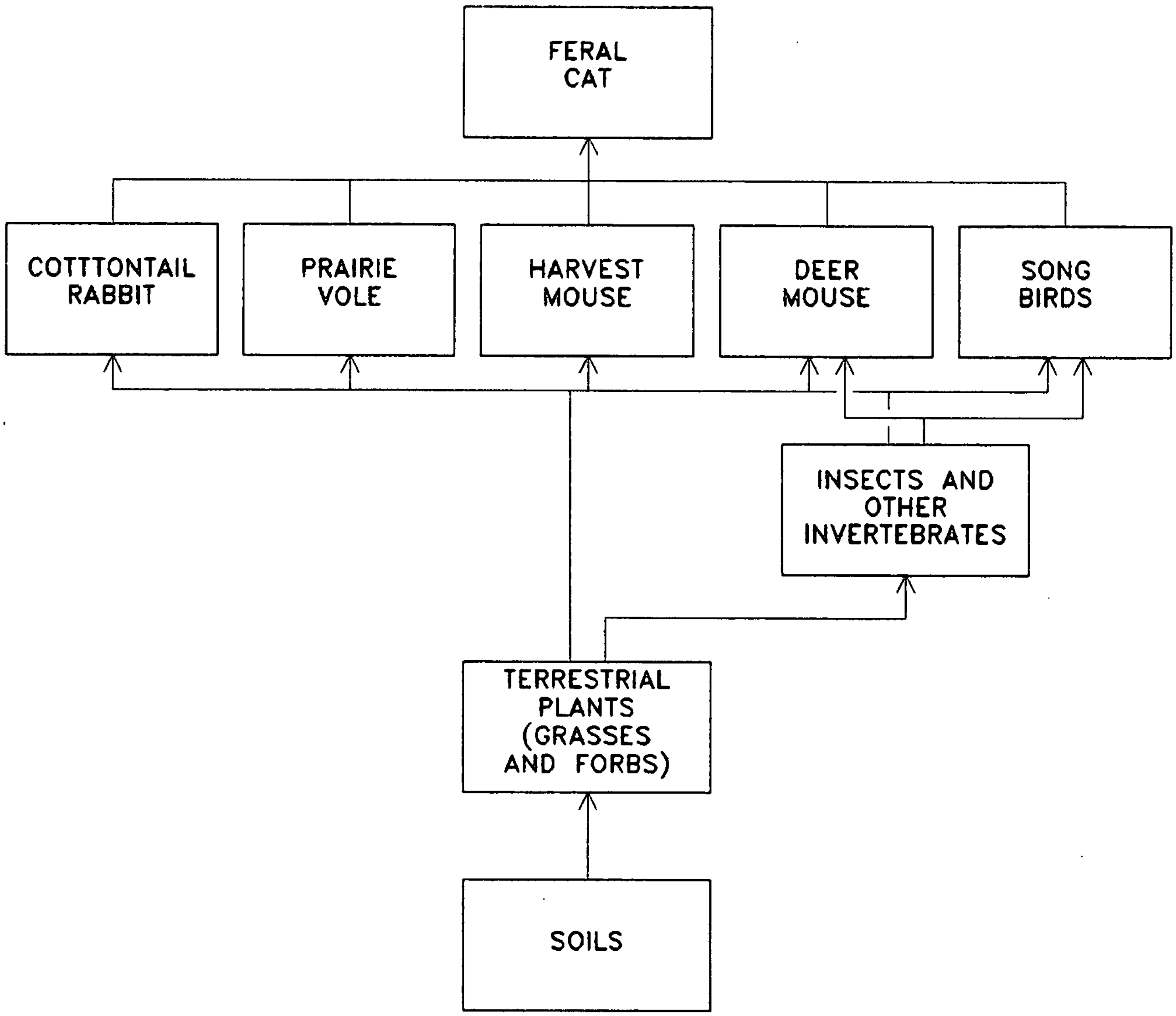


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FIGURE 10
INDUSTRIAL AREA
ENVIRONMENTAL EVALUATION
SINK FOOD WEB
FOR FERAL CAT

REVISION NO. 4
FILE NAME C:\KJS\FWFCTM
DATE 12/6/93
DRAWN BY KJS
APPROVED BY
CHECKED BY

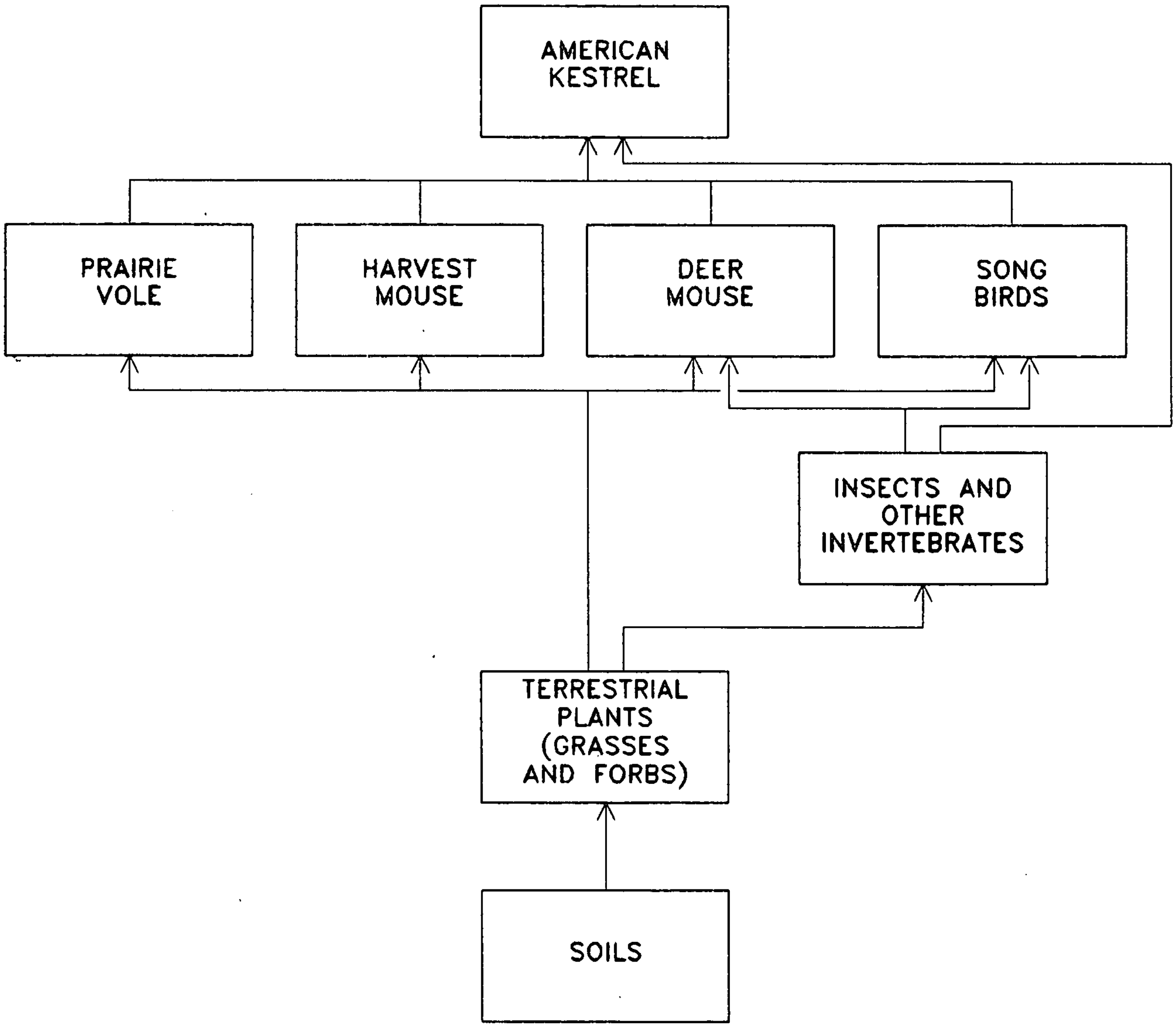


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FIGURE 11
INDUSTRIAL AREA
ENVIRONMENTAL EVALUATION
SINK FOOD WEB
FOR AMERICAN KESTREL

REVISION NO. 4 | FILE NAME C:\KJS\FWAKTM | DATE 12/6/93 | DRAWN BY KJS | APPROVED BY JEF | CHECKED BY

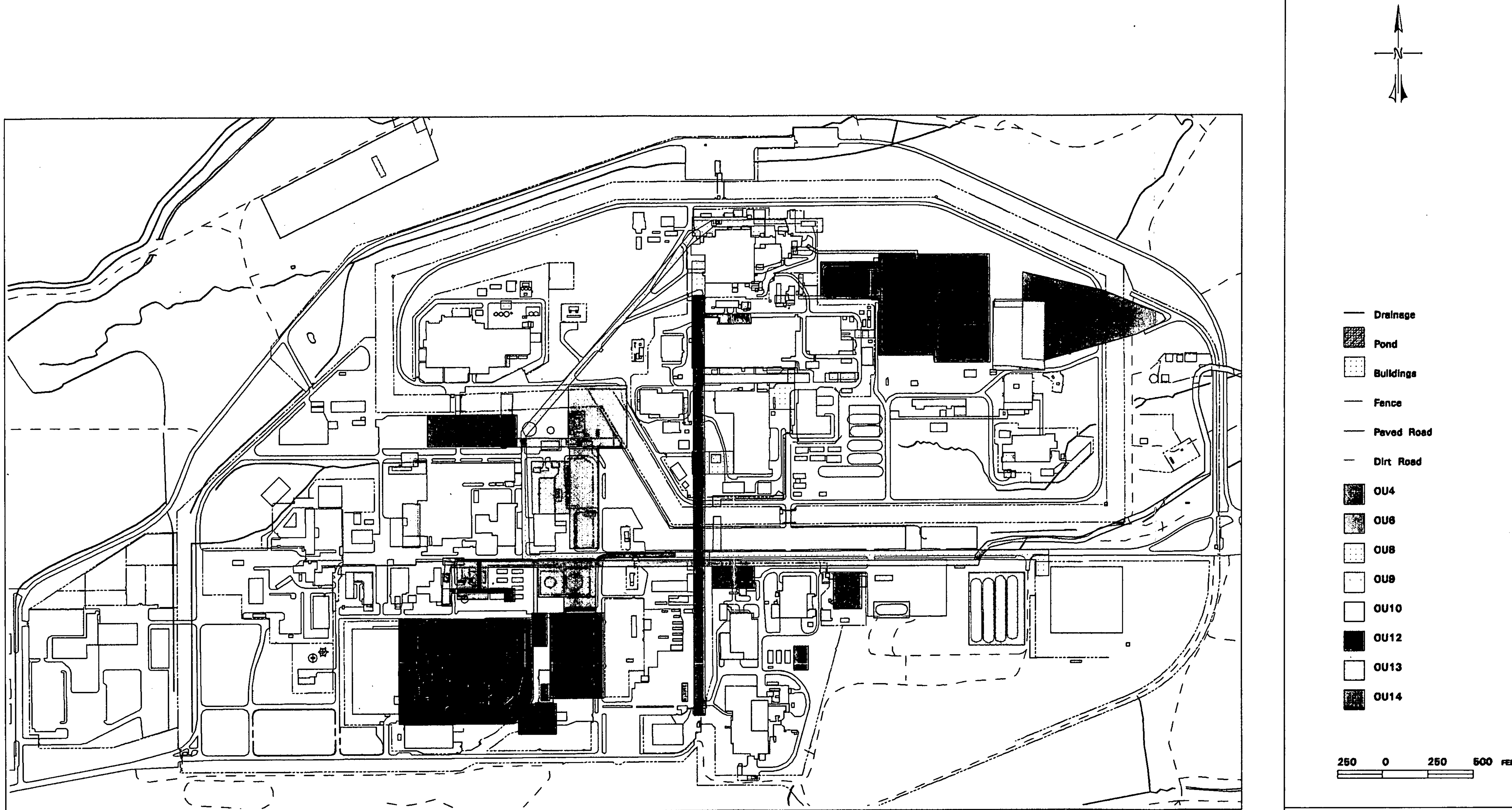


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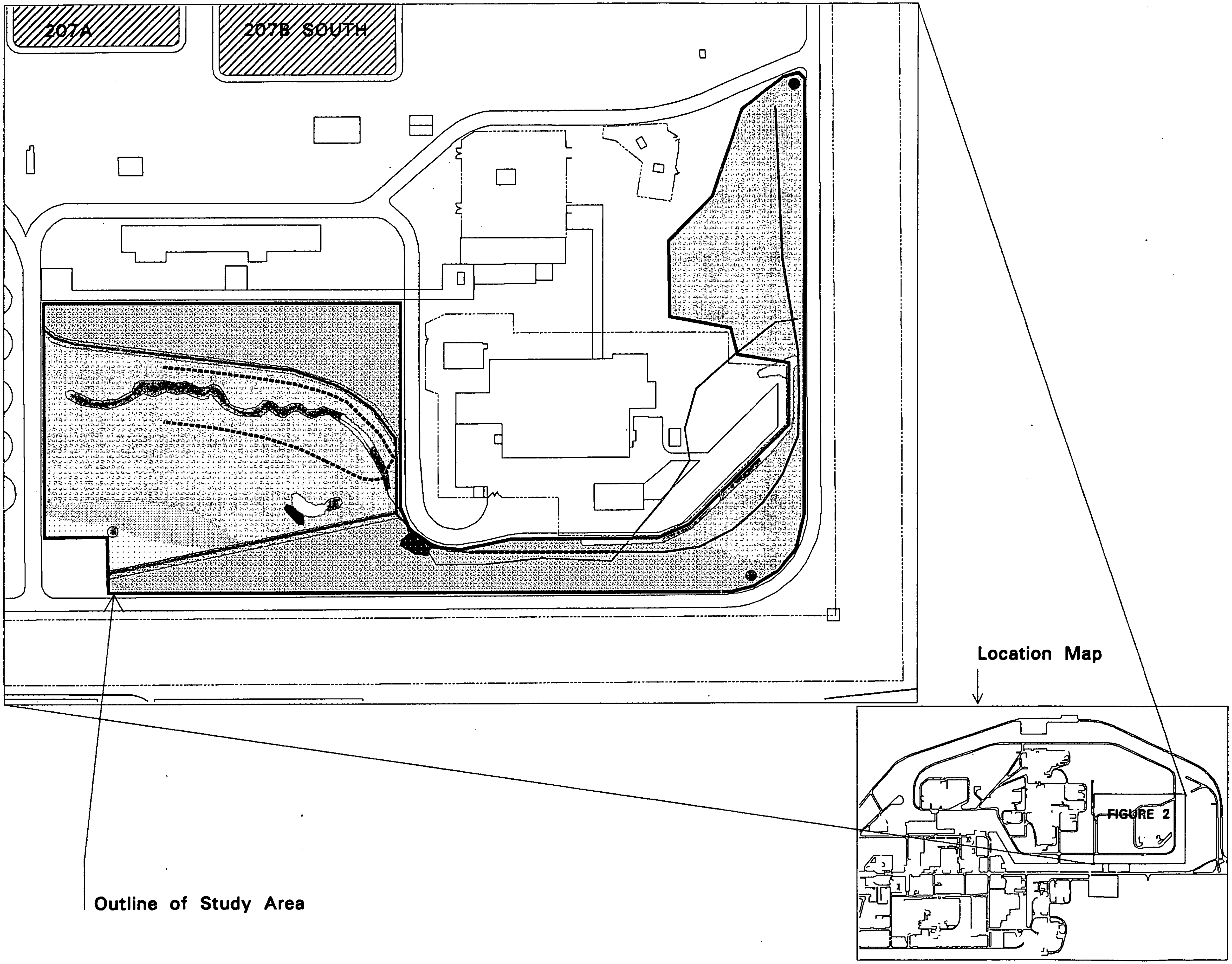
FIGURE 1
**INDUSTRIAL AREA ENVIRONMENTAL EVALUATION INDIVIDUAL HAZARDOUS SUBSTANCE SITES**

REVISION NO: 2
FILENAME: mb9ihss.aml
DATE: December 02, 1993
DRAWN BY: K. Stephens
APPROVED BY:
CHECKED BY:



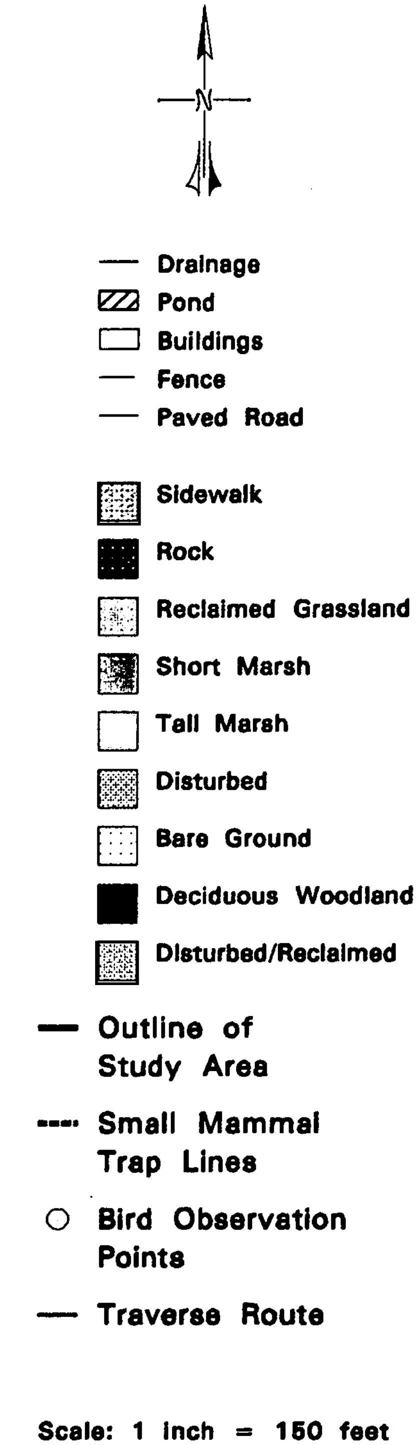




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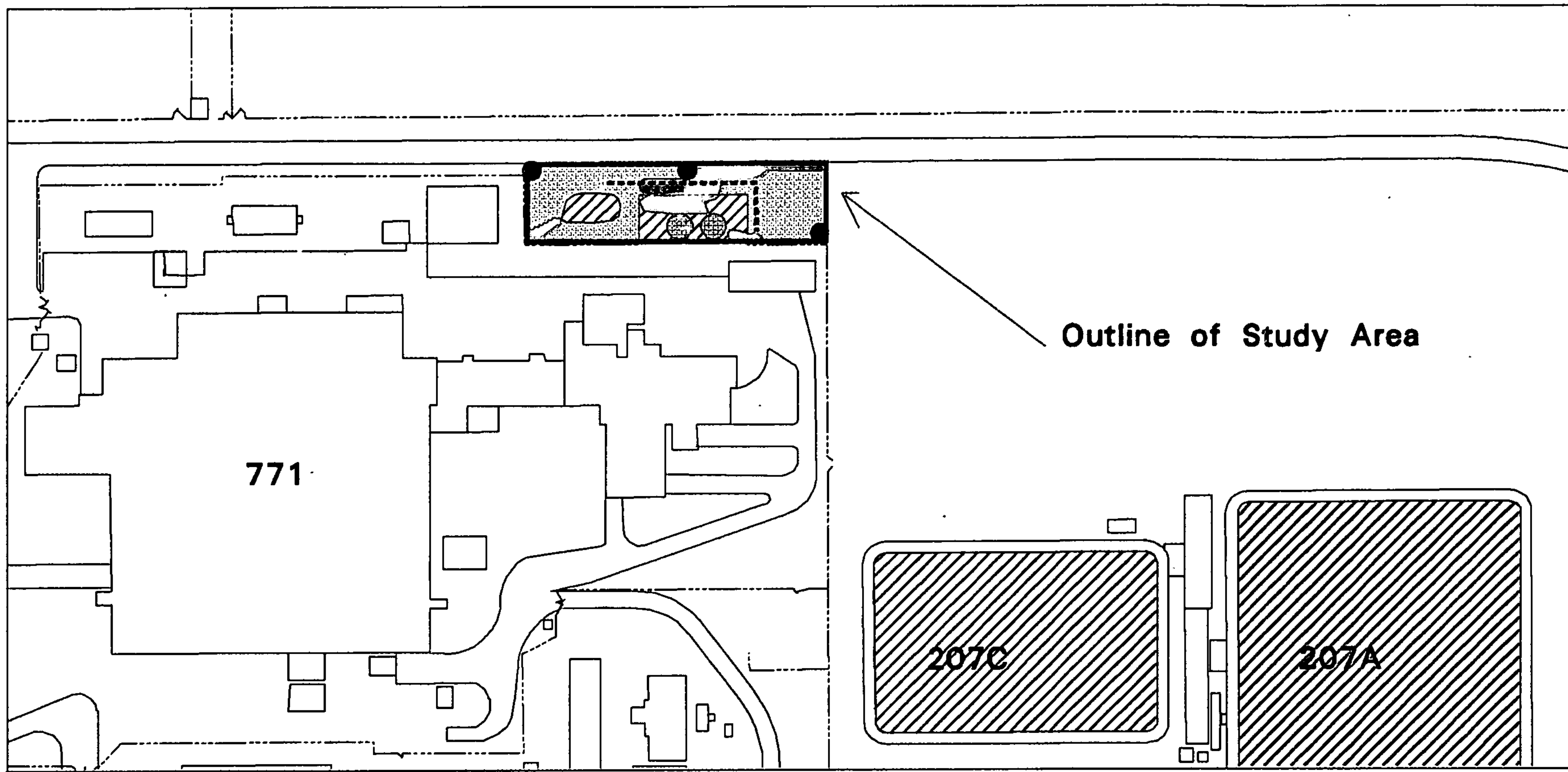
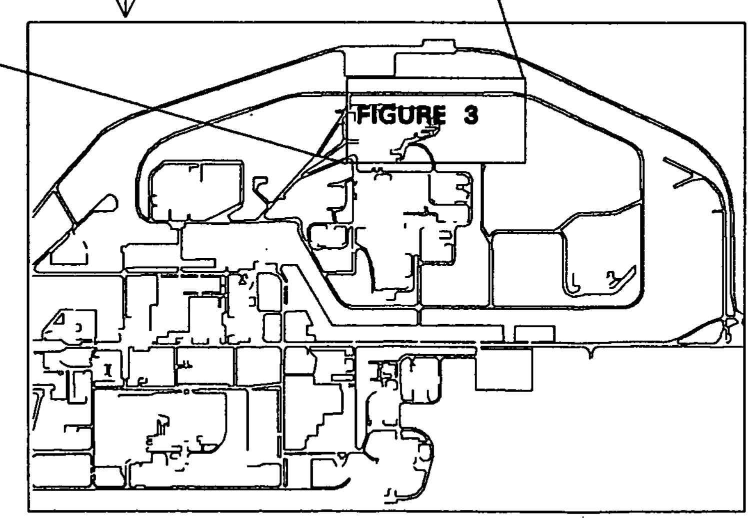
FIGURE 2
INDUSTRIAL AREA
ENVIRONMENTAL EVALUATION
EAST DRAINAGE

REVISION NO: 4
FILENAME: mbconf2.aml
DATE: December 03, 1993
DRAWN BY: K. Stephens
APPROVED BY:
CHECKED BY:




Location Map




N

- Drainage
- Pond
- Buildings
- Fence
- Paved Road
- Tank
- Short Marsh
- Tall Marsh
- Disturbed/Reclaimed
- Outline of Study Area
- Small Mammal Trap Lines
- Bird Observation Points

Scale: 1 inch = 150 feet

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FIGURE 3
INDUSTRIAL AREA
ENVIRONMENTAL EVALUATION
NORTH POND AND SEEP

REVISION NO: 3
FILENAME: mbconf3.aml
DATE: December 03, 1993
DRAWN BY: K. Stephens
APPROVED BY:
CHECKED BY:

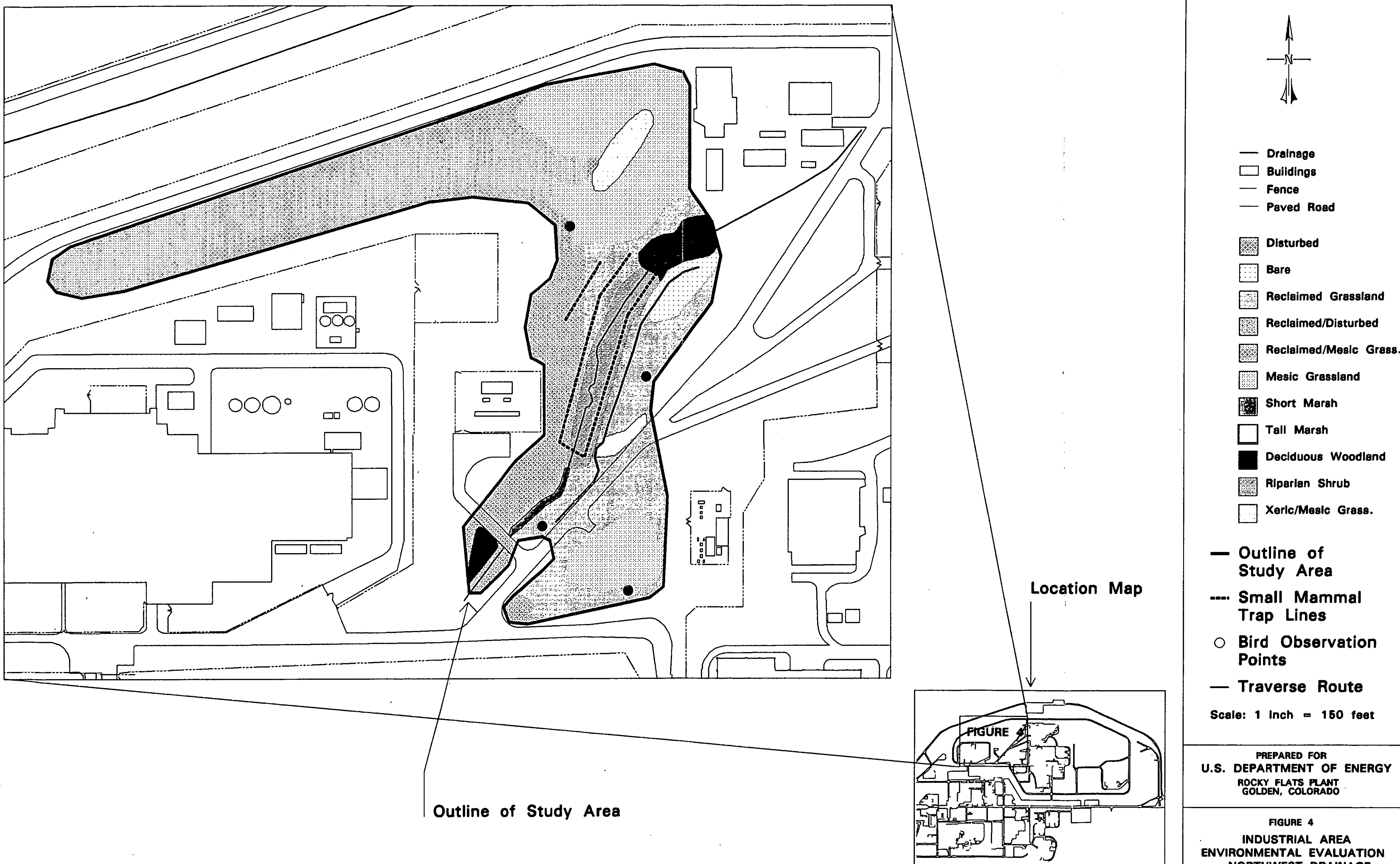


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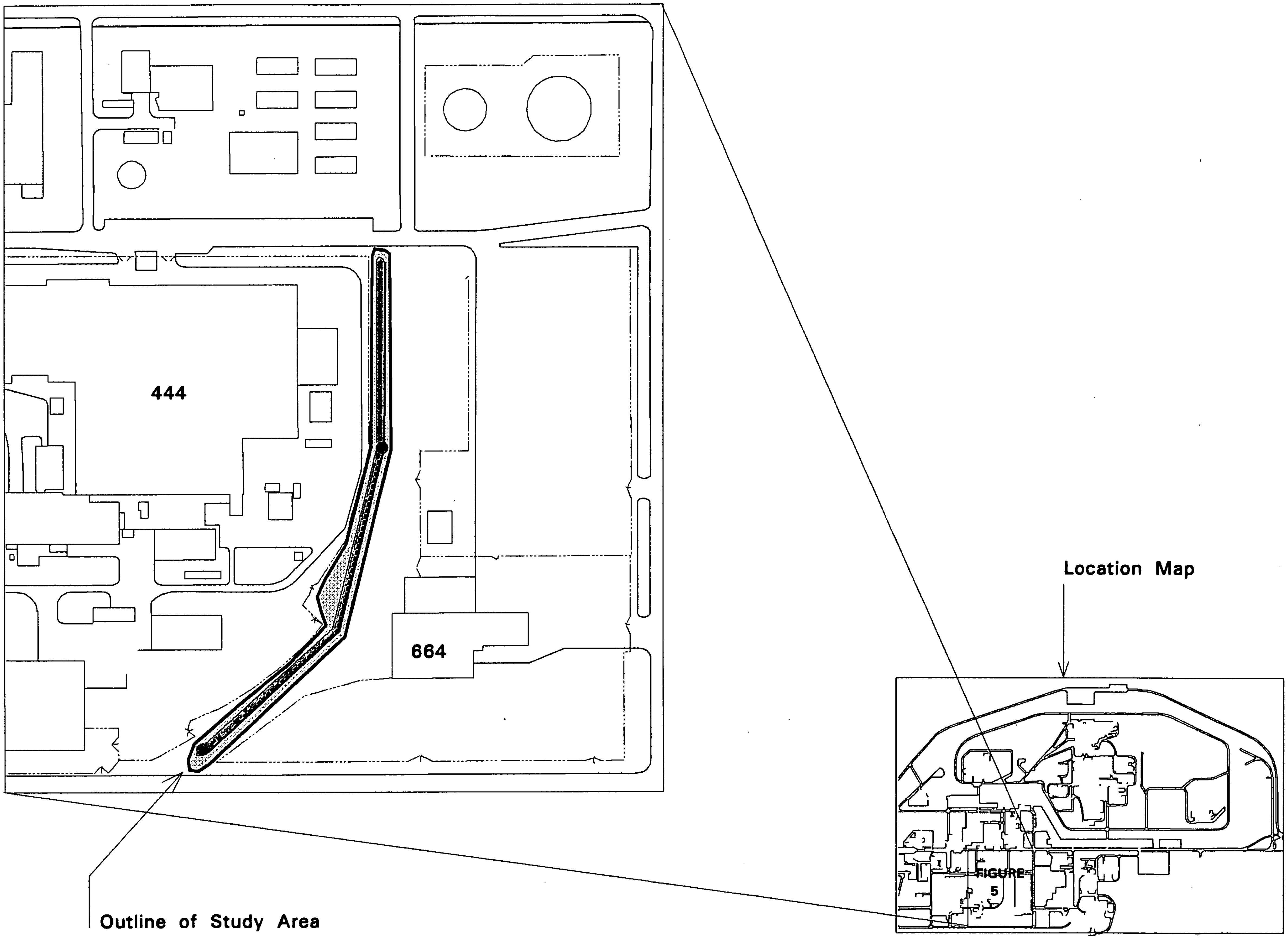
FIGURE 4
INDUSTRIAL AREA
ENVIRONMENTAL EVALUATION
NORTHWEST DRAINAGE

REVISION NO: 3
FILENAME: mbconf4.aml
DATE: December 03, 1993
DRAWN BY: K. Stephens
APPROVED BY: VEF
CHECKED BY: WF




N

Drainage
Buildings
Fence
Paved Road

Short Marsh
Disturbed

Outline of Study Area
Small Mammal Trap Lines
Bird Observation Points
Traverse Route

Scale: 1 inch = 150 feet

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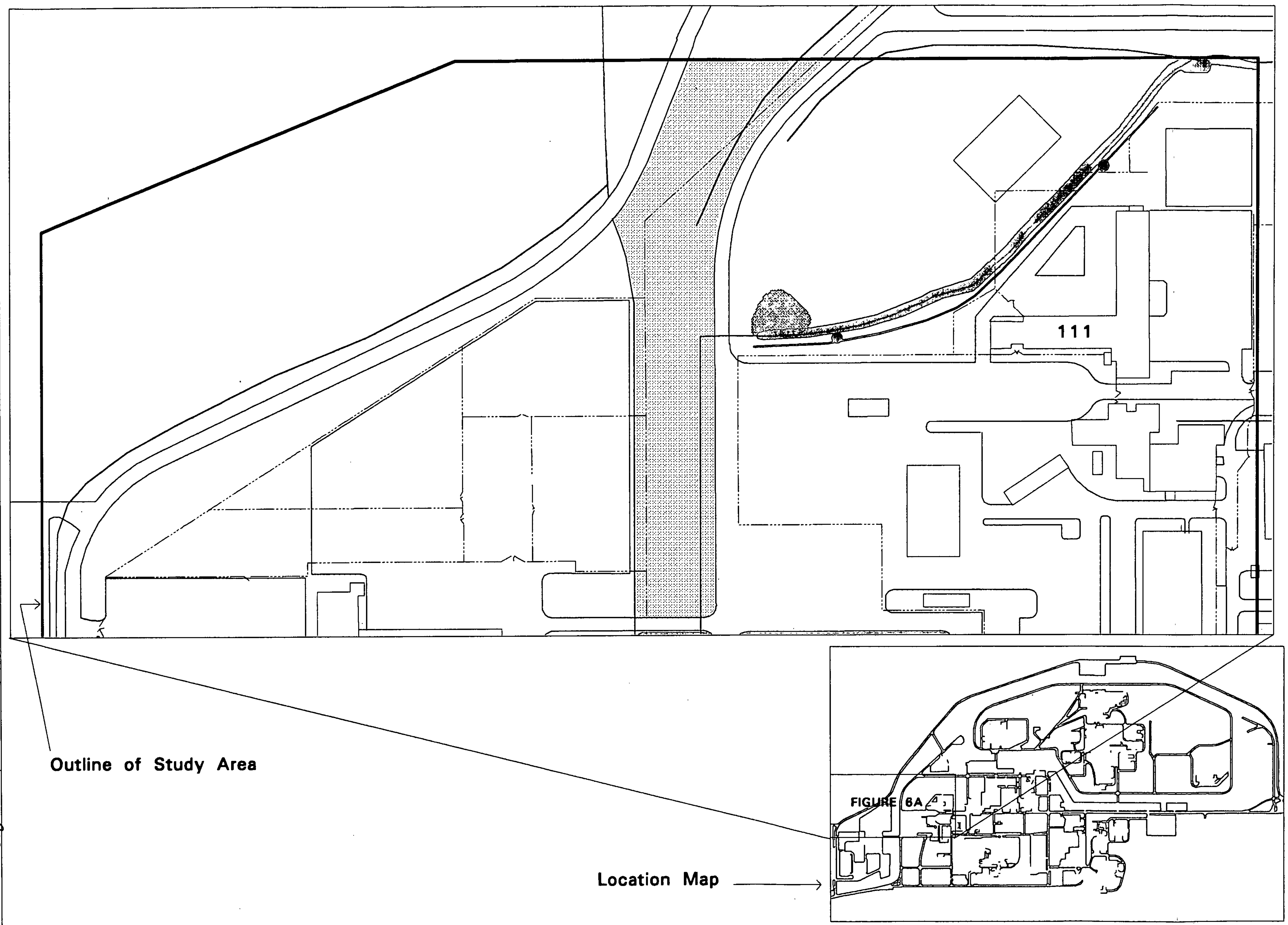
FIGURE 5
INDUSTRIAL AREA
ENVIRONMENTAL EVALUATION
WEST RAILROAD

REVISION NO: 3
FILENAME: mbconf5.aml
DATE: December 03, 1993
DRAWN BY: K. Stephens
APPROVED BY:
CHECKED BY:




N

Drainage
Buildings
Fence
Paved Road

Ornamental Trees
Disturbed/Mesic Grass.
Short Marsh
Tall Marsh

Outline of Study Area
Bird Observation Points
Traverse Route

Scale: 1 inch = 150 feet

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FIGURE 6A
INDUSTRIAL AREA
ENVIRONMENTAL EVALUATION
WEST AREA

CHECKED BY:
APPROVED BY:
DRAWN BY: K. Stephens
DATE: December 03, 1993
FILENAME: mbconf6a.aml
REVISION NO: 3

REVISION NO: 2

FILENAME: mbconf6b.aml

DATE: December 03, 1993

DRAWN BY: K. Stephens

APPROVED BY:

CHECKED BY:

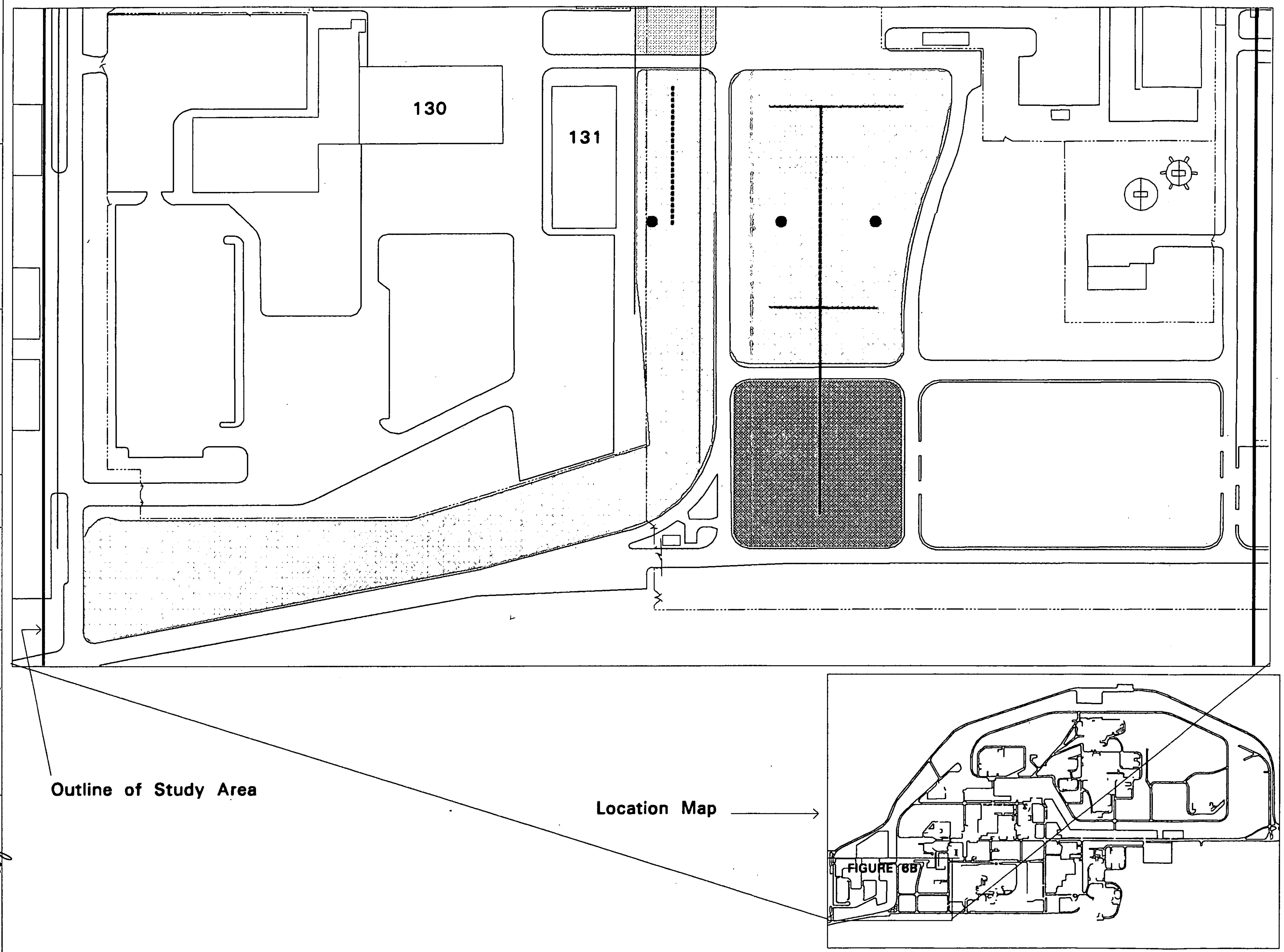


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FIGURE 6B

INDUSTRIAL AREA
ENVIRONMENTAL EVALUATION
WEST AREA