ENVIRONMENTAL EVALUATION WORK PLAN

FOR

OPERABLE UNIT 5
WOMAN CREEK DRAINAGE

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Submitted to:

EG&G, ROCKY FLATS, INC.
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9.1 INTRODUCTION

The objective of this Environmental Evaluation Plan is to provide a framework for addressing risks to the environment from potential exposure to contaminants resulting from IHSSs within the Woman Creek Drainage, OU5. This plan is prepared in conformance with the requirements of current applicable legislation, including the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA), as amended by the Superfund Amendments and Reauthorization Act (SARA), and follows the guidance for such studies as provided in the National Contingency Plan (NCP) and Environmental Protection Agency (EPA) documents for the conduct of Resource Conservation and Recovery Act (RCRA) Facility Investigation/ Remedial Investigation (RFI/RI) activities. Specifically, the EPA guidance provided in Risk Assessment Guidance for Superfund, Vol. II, Environmental Evaluation Manual (1989c) is followed.

The goal of the environmental evaluation is to determine the nature and extent of potential impacts of contamination from OU5 to biota (plants, animals and microorganisms). Determination of the effects on biota will be performed in conjunction with the human health risk assessment for Woman Creek Drainage. Where appropriate, criteria necessary for performing the environmental evaluation will be developed in accordance with human health risk assessments and environmental evaluations for all Rocky Flats Plant OUs. Determination of ecological effects will be limited to those contaminants whose effects on biota are adequately documented in the scientific literature. Information from the environmental evaluation will assist in determining the form, feasibility, and extent of remediation necessary for Woman Creek Drainage in accordance with CERCLA.

9.1.1 Approach

This plan presents a three-stage approach for conducting the environmental evaluation at Woman Creek Drainage. While some tasks within the stages will be sequential, these stages will overlap in time (see Schedule, Section 9.9). This phased and comprehensive approach is designed to ensure that all procedures to be performed are appropriate, necessary and sufficient to adequately characterize the nature and extent of environmental effects to biota under the "no action" scenario. As is recommended by EPA, this environmental evaluation is not intended to be or to develop into a research-oriented project. The plan presented herein is designed to provide a focused investigation of potential contaminant effects on biota.

Each stage of the environmental evaluation activities will be coordinated with sitewide RFI/RI activities in order to avoid unnecessary duplication of effort and resources. Environmental evaluation planning is currently underway at two operable units in close proximity to OU5: OU1 (881 Hillside) and OU2 (903 Pad, Mound, and East Trenches Area). Several other Operable Units have IHSSs which are in the Woman Creek Drainage. These include OU12 (400/ 800 Area), OU9 (Original Process Waste Line), OU10 (Other Outside Closures; IHSSs 177, 182, 205, 207, 208, and 213), OU16 (Low Priority Sites; IHSS 196), OU15 (Inside Building Closures; IHSSs 178, 204, 211, and 217) and OU14 (Radioactive Sites). The program developed for OU5 is designed to be consistent with the OU1 and OU2 EEPs. Locations of the IHSSs for OU5 are shown on Figure 9-1.

Stage I of the environmental evaluation will focus on planning, review and integration of available data and conduct of an ecological field investigation. Data quality objectives (DQOs) will be defined according to EPA guidance (EPA 1990), and procedures for monitoring and controlling data quality will be specified. Preliminary field surveys and an ecological inventory will be conducted in Stage I to characterize the Woman Creek Drainage biota and note the locations of obvious zones of chemical contamination and ecological effects. Site history, chemical data, results from the RFI/RI fate and transport models, and existing ecological data will be reviewed and evaluated. Stage I activities will include a preliminary assessment of population, community or ecosystem-level impacts (endpoints) to be measured. Stage I activities will provide a preliminary determination of the contaminants of concern and their potential adverse effects to key receptor species at Woman Creek Drainage and will allow a conceptual ecological model of the site to be prepared.

Stage II will entail development of a site-specific pathways model based on the ecological field investigation and inventory. This exposure-receptor pathways model will be used to evaluate the transport of contaminants from sources in the Woman Creek Drainage to biological receptors. The pathways model prepared in Stage II is based on a conceptual pathways approach (Fordham and Reagan, 1991) and will provide an initial determination of the movement and distribution of contaminants, likely interactions among ecosystem components and expected ecological effects. It is anticipated that this approach will be coordinated with the efforts of investigators working in other operable units so that comparable data are collected and so that risk assessment approaches are consistent.

Scoping and design of the Stage III investigation will be determined by the outcome of the preliminary Stage II analyses and pathways model. During Stage III, tissues will be analyzed from selected species to document current levels of specific target analytes. The primary endpoint for Stage III is the detection of chemicals of concern in target species, calibration of the site-specific pathways model and final determination of contaminant effects to biota and ecosystems. Selection of the target analytes, species and tissues will be based on the Stage II determination as to which contaminants are likely to be present in sufficient concentrations, quantities and locations as to be detected in biota. The need

for measuring additional endpoints in Stage III through reproductive success, enzyme inhibition, or other toxicological-type studies will be evaluated based on results from Stage I and Stage II analyses as well as appropriate acceptance criteria. The actual or potential effects of contamination on ecological *endpoints* (e.g., species diversity, food web structure, productivity) will also be addressed. All necessary federal and state permits will be obtained prior to any destructive sampling or collecting.

9.1.2 OU5 Contamination

Contamination of soil, groundwater, surface water, and sediment occurs in the Woman Creek Drainage, although the exact extent is difficult to assess, given the uncertainties in much of the data. Based on the data available in this Phase I RI, it appears that numerous chemicals (organics, metals, and radionuclides) are present above detection levels at OU5. Which, if any, of these levels are above background, however, is currently under investigation. The following list of chemicals suspected to be present in the soils and surface water at OU5 is summarized from information presented in Section 2.0 of this RFI/RI. Groundwater data are not considered in this initial assessment, although groundwater contamination to a depth of 20 feet (maximum depth of burrowing animals and plant root penetration) will be considered in the exposure pathways analysis.

ORIGINAL LANDFILL (IHSS 115)

Soil:

Organics: petroleum distillates, 1,1,1-trichloroethane, dichloromethane, benzene, carbon-tetrachloride and trichloroethane

Metals: beryllium, lead and chromium

Radionuclides: uranium

ASH PITS, INCINERATOR AND CONCRETE WASH PAD (IHSSs 133.1-133.6)

Soil:

Radionuclides: uranium

Ponds C-1 AND C-2 (IHSSs 142.10 and 142.11)

Surface Water:

Organics: phenol

Metals: iron, magnesium, manganese, zinc, aluminum, mercury, strontium, calcium and sodium

Radionuclides: americium-241, cesium-137, gross alpha, gross beta, plutonium-239, strontium-90, tritium, uranium-233/234, uranium 235, uranium-238 and radium-226

Anions: sulfide, potassium, carbonate, chloride, sulfate and nitrate/nitrite

Indicator: total dissolved solids

Sediments:

data on metals, organics and anions are not yet available

Radionuclides: plutonium

WOMAN CREEK DRAINAGE

Surface Water:

Organics: data not yet available

Metals: aluminum, calcium, iron, magnesium and sodium, strontium, manganese, barium, lead, lithium, zinc, mercury, molybdenum, chromium, copper, tin, arsenic, beryllium, cobalt and nickel

Radionuclides: americium- 241, cesium-137, gross alpha, gross beta, plutonium-239, strontium-90, uranium-233/234, uranium-235, uranium-238, tritium and radium-226

Anions: potassium, sulfate, carbonate, hydrogen, chloride and nitrate/nitrite

Indicator: total dissolved solids

Sediments:

data not yet available

Data on the contaminants present at OU5 are not yet available as this is a Phase I investigation. Based on what information is available, including that from OU1 and OU2, many of the contaminants are likely to impact biota at OU5 if present at sufficient concentrations. Several of the metal contaminants found at OU5 can be taken up by plants through their roots or stomates or deposited on plant leaves and stems. In addition, they can be inhaled and ingested by animals. These metals have various effects on biological organisms. When ingested, antimony, arsenic, beryllium, cadmium, chromium, lead, mercury, selenium and tin can be toxic. Arsenic, cadmium, lead and mercury function as cumulative

poisons, while beryllium, chromium, nickel and arsenic are carcinogenic. Cadmium and lead cause neurological disruption, while copper, mercury, cobalt and nickel act as biocides at low concentrations to certain species. Some metals such as arsenic are thought to be essential trace metals in mammalian species.

Many of the metal contaminants are known to bioaccumulate, bioconcentrate or biomagnify. Bioaccumulation is the process by which chemicals are taken up by organisms directly or through consumption of food containing the chemicals. Arsenic, cadmium, chromium, cobalt, copper, lead, mercury, nickel and selenium are concentrated by a number of biological organisms potentially present in the Woman Creek Drainage.

Bioconcentration is the process by which there is a net accumulation of a chemical directly from a medium, such as water, into organisms resulting from simultaneous uptake (e.g., by gill or epithelial tissue in aquatic habitats) and elimination (Rand and Petrocelli, 1985). Partitioning is the dominant process governing bioconcentration of chemicals in algae, fish and invertebrates.

Biomagnification includes bioconcentration and bioaccumulation and is the process in which tissue concentrations of bioaccumulated chemicals increase as the chemical passes up through two or more trophic levels. The term implies an efficient transfer of chemical from food to consumer, so that residue concentration increase systematically from one trophic level to the next (Rand and Petrocelli, 1985). In terrestrial habitats, biomagnification occurs from soil to plants for beryllium, cadmium, lead, mercury, nickel and selenium. In herbivores, an increase occurs for antimony, arsenic, cadmium, chromium, copper, lead, mercury and selenium. Only mercury and cadmium biomagnify in terrestrial carnivores. In aquatic habitats, biomagnification has been found in algae for antimony, arsenic, cadmium, copper, chromium, cobalt, lead, mercury, nickel and selenium. In aquatic herbivores, an increase occurs for antimony, arsenic, cadmium and mercury; in carnivores, an increase occurs for cadmium and mercury.

Several of the volatile organic compounds found at Woman Creek Drainage, such as trichloroethylene, are on the EPA Priority Toxic Pollutants List and are known to have acute and chronic toxic effects on aquatic life depending on their concentrations. The elevated levels found in groundwater samples warrant evaluation where there is potential interaction with surface water and the subsequent potential for exposure to receptor organisms.

High nitrate levels were found in the groundwater, surface water and sediments. Nitrates are relatively nontoxic to organisms although they can cause eutrophication problems. Under reduced oxygen conditions, nitrites and ammonia are especially toxic to aquatic organisms.

According to the Radioecology and Airborne Pathway Summary Report (Rockwell, 1986), plutonium is not considered to pose an ecological hazard to biota unless extremely high levels (>1 mCi/m^2) occur.

The reason for this is thought to be the extremely low biological mobility of the common forms of the element. These findings and other studies on the ecological effects of radionuclides will be reviewed for their applicability to the Woman Creek Drainage environmental evaluation.

9.1.3 Protected Wildlife, Vegetation and Habitats

9.1.3.1 Wildlife

The U.S. Fish & Wildlife Service has identified several listed endangered or threatened wildlife species which could possibly occur in the Rocky Flats Plant area. However, none is expected to occur because of lack of habitat. These species include the bald eagle (endangered), peregrine falcon (threatened), whooping crane (endangered) and black-footed ferret (endangered).

The bald eagle (Haliaeetus leucocephalus) is primarily a winter resident around rivers and lakes, and the closest known nesting pairs are found at Barr Lake, 25 miles to the east of Rocky Flats. The whooping crane (Grus americana) passes through Colorado during its spring and fall migrations. Whooping cranes, blown off their migration course, could use the Rocky Flats area as a night roost. These birds prefer large marshes and wetlands in broad open river bottoms and prairies. Such habitat is not present at Rocky Flats.

Two subspecies of peregrine falcon (Falco peregrinus tundris and F. p. anatum) may occasionally occur in the Rocky Flats area as they hunt for prey. Nesting preferences are high cliff sides and river gorges, both of which are absent at Rocky Flats. However, nesting sites have been recorded to the west about 4 to 5 miles from the site.

The historical geographic range of the black-footed ferret (Mustela nigripes) coincides with that of prairie dogs, a principal prey species. Although black-footed ferret populations are now extinct in the wild, large prairie dog towns (>80 acres for black-tailed prairie dogs) sufficient to support a black-footed ferret population would be surveyed at Rocky Flats by approved methods (U.S. Fish and Wildlife, 1986).

Several additional species are of special interest to the State of Colorado because they are endangered in the state, are game species, have small and/or declining populations or are pest/nuisance species (Colorado Division of Wildlife 1981, 1982a, 1982b and 1985). These species will be identified and investigated during Stage I and will be considered in the development of onsite food webs.

9.1.3.2 Vegetation

Ten federally-listed or proposed plant species occur in Colorado, all of which are western slope species. None of these is known or expected to occur on or near Rocky Flats. A number of candidate species for federal listing are known to occur in Jefferson and Boulder Counties but have not been identified at Rocky Flats.

9.1.3.3 Wetlands

Numerous regulations and acts have been promulgated to protect water-related resources, including wetlands. Wetlands play an important role in ecosystem processing and in providing habitat to a variety of plant and animal species. An assessment of Rocky Flats wetlands was completed in 1989 (EG&G, 1990); these wetlands currently fall under the jurisdiction of the U.S. Army Corps of Engineers. Wetlands occur along Woman Creek, portions of the South Interceptor Ditch and Ponds C-1 and C-2. DOE activities with a potential to impact wetlands must follow regulations designed for their protection.

9.1.4 Scope of Work

In order to accomplish the plan objectives, a number of activities will be prepared and executed. These are briefly described below:

Stage I

- Project Preparation - This activity includes project planning, identification of DQOs, and refinement of the ecological inventory field sampling plan. Also included is continued review and analysis of existing information, identification of data gaps, and a preliminary determination of the contaminants of concern and their documented ecological effects on key receptor species and/or other ecological endpoints.

- Ecological Field Investigation - This activity represents the field surveys, inventory and food habit studies necessary to characterize the biota and trophic relationships in the Woman Creek Drainage. Brief field surveys will be conducted in the spring, summer, fall and winter in the study area to obtain information on the occurrence, distribution, variability and general abundance of key plant and animal species. A field inventory will be conducted in late spring and mid-summer to obtain quantitative data on community composition in terrestrial and aquatic habitats. Samples collected as part of the activity will be saved for tissue analyses where contaminants of concern have been

identified and sampling protocol are in place. Toxicity tests using Ceriodaphnia and fathead minnows will be conducted on surface water samples. As part of these activities, all collected field data will be reduced, evaluated, compared with and integrated into the existing data bank to update knowledge of site conditions.

Stage II

- Contamination Assessment - This activity includes the toxicity assessment, exposure assessment, development of the site-specific food web pathways model and characterization of impacts to biota posed by exposures to contaminants in the Woman Creek Drainage.

Stage III

- Biological Contamination Studies - This activity includes the field and laboratory analyses of contaminant levels in select plant and/or animal species. Samples collected in Stage I will be used wherever possible (e.g., when contaminants of concern have been identified and sampling protocol are in place); new samples will be collected if necessary. Stage III may include additional investigations of adverse effects such as reproductive success or enzyme inhibition studies. Before selecting such methodologies, data quality objectives to be achieved by such sampling will be defined according to EPA guidance (EPA, 1990). Such testing will only be performed where the acceptance criteria for demonstrating injury to a biological resource will be satisfied in accordance with regulations under the Natural Resource Damage Assessment Rule [40 CFR Subtitle A Section 11.62 (f)].

- Remediation Criteria - Statutes require the selection of remedial actions *sufficient to protect the environment.* This activity entails consideration of federal and Colorado laws and regulations pertaining to preservation and protection of natural resources that are Applicable or Relevant and Appropriate Requirements (ARARs). Information from ARARs, toxicological assessments and implementation of the pathways model will be used to develop criteria that address biological resource protection.

- Environmental Evaluation Report - This activity represents the preparation of the report which addresses the scope of the investigation, site environmental characteristics and

contaminants, characterization of effects, remediation criteria, conclusions, uncertainty analysis and limitations of the assessment.

Elements of the Scope of Work are described in the following sections. Stage I preliminary planning is presented in Subsection 9.2. The Stage I field investigation is described in Subsection 9.3. Subsection 9.4 presents the Stage II contamination assessment. Subsection 9.5 describes the Stage III contamination studies. Remediation criteria are discussed in Subsection 9.6. A suggested outline for the environmental evaluation report is presented in Subsection 9.7. The field sampling plan presented in Subsection 9.8 includes both the Stage I ecological investigation and the Stage III contamination studies. A tentative outline for performing the environmental evaluation is presented in Subsection 9.9.

9.2 PROJECT PREPARATION (Stage I)

An environmental evaluation at OU5 is necessary for Rocky Flats Plant to meet the requirements of Sections 121(b)(1) and (d) of CERCLA. An environmental evaluation, in conjunction with the human health risk assessment, is required to ensure that remedial actions are protective of human health and the environment. Guidelines for conducting this evaluation, which is also called an ecological assessment, are provided by EPA in Risk Assessment Guidance for Superfund, Volume II, Environmental Evaluation Manual (EPA, 1989c). Additional guidance is derived from EPA's Ecological Assessments of Hazardous Waste Sites: A Field and Laboratory Reference Document (EPA, 1989b) and other guidance documents (see the list of documents in Table 9-1).

The environmental evaluation is both a qualitative and quantitative appraisal of the actual or potential injury to biota other than humans and domesticated species due to contamination at OU5. The environmental evaluation is intended to reduce the inevitable uncertainty associated with understanding the environmental effects of contaminants present in Woman Creek Drainage and to give more definitive boundaries to that uncertainty during remediation.

The following plan for OU5 provides a framework for the review of existing data, the conduct of subsequent field investigations and the preparation of the contamination assessment. The staged approach presented in this plan begins with the activities described in the following subsections on preliminary planning, DQO development, support documentation and review of existing information. The field investigation and inventory, which is also part of Stage I, is described in Subsection 9.3.

9.2.1 Preliminary Planning

This task includes an initial determination of the scope of the environmental evaluation, identification of DQOs and a plan for obtaining the information required for each stage of the environmental evaluation. Types of information required in Stage I of the evaluation include the following:

- Species present at OU5, community structure and food webs;
- Obvious signs of adverse ecological effects;
- Contaminant inventory;
- Contaminant sources and locations, chemical and radionuclide analyses of soil and water and background levels;
- Sediment composition and quality, grain sizes and total organic carbon;
- Toxicity data to provide a preliminary determination of potential effects of contaminated media on receptor species; and
- Preliminary toxicity testing data on aquatic organisms.

As an integral part of the RFI/RI process, Stage I of the environmental evaluation will focus on accumulating and analyzing pertinent information on three major areas:

- Species, populations and food web interrelationships;
- Types, distribution and concentrations of contaminants in the abiotic environment (e.g., soil, surface water, groundwater and air); and
- Potential exposure pathways and the effects of contaminants on various biological components in the affected ecosystems. (This step includes the conceptual pathways model.)

Data from past studies and preliminary data from current environmental studies will be used to better define the present distribution of contaminants in the abiotic environment. Based on this information, a defined scope of work for Stage II and Stage III studies will be developed. As part of this effort, a food-web model will be developed to provide a preliminary identification of potential exposure pathways or combinations of pathways and receptor species at risk.

In addition, aquatic toxicity tests using Ceriodaphnia and fathead minnows will be conducted to provide an initial evaluation of toxic conditions in Woman Creek, the South Interceptor Ditch and Ponds C-1 and C-2. Monthly aquatic toxicity testing is currently being conducted at other locations on Rocky Flats (outlet works from the Sewage Treatment Plant, Pond B-3) as part of the National Pollutant Discharge Elimination System (NPDES) permitting program. Standardized acute and chronic testing methods will

be used at OU5 with quality control procedures to conform to EPA requirements for NPDES toxicity testing (EPA 1985a and 1985b).

Information that will be developed from Stage I of the environmental evaluation includes the following:

- Criteria for selection of contaminants of concern, key receptor species and reference areas. These criteria will be applicable to environmental evaluations at all OUs. Examples of such screening criteria include the following:
  - Concentrations detected onsite above background level,
  - Frequency of detection,
  - Historical disposal information (type and quantity),
  - Mobility in environmental media,
  - Persistence,
  - Bioaccumulation,
  - Bioavailability,
  - Background/ reference area concentrations,
  - Biochemistry (essential nutrient, inhibitor, etc.), and
  - Toxicity.
- Species inventory - Plant and animal species known to occur within OU5 or to potentially contact contaminants at OU5.
- Population characteristics - General information on the abundance of key species.
- Food habit studies - Available information from literature sources to supplement field observations and gut content analysis on key species.
- Field surveys - Inventory of Woman Creek Drainage biota and locations of obvious zones of chemical contamination and ecological effects.
- Initial toxicity test data - Preliminary data on the toxicity of potentially complex chemical mixtures in Woman Creek Drainage surface waters.
- Chemical inventory - Existing information including that obtained on chemical contaminants from other investigations at Rocky Flats and other DOE facilities will be used in the development of a preliminary list of contaminants of concern.

This information will provide the basis for the Stage II contamination assessment (Subsection 9.4). In the contamination assessment, food webs and contaminant exposure pathways will be developed for Woman Creek Drainage. Information on these food webs will be used to relate quantitative data on contaminants in the abiotic environment to adverse effects in biota and to evaluate potential impacts to biota due to contaminant exposure.

Field studies for contamination will be conducted in Stage III for both aquatic and terrestrial systems. Tissue analyses will be conducted on selected species from Woman Creek Drainage and reference areas to document current levels of specific target analytes. Preliminary information from the Stage I field survey and the Stage II contamination assessment will determine the species and contaminants to be tested and the methods to be used. Selection of the target analytes, species and tissues will depend on an initial Stage I/ Stage II determination as to which contaminants are likely to adversely impact biota and which contaminants are likely to be present in concentrations sufficient for detection.

The need for measuring additional endpoints in Stage III through community or population studies, enzyme analyses, reproductive success studies or other identified endpoints will be evaluated based on the Stage II pathways analysis and published information on direct toxic effects. Use of the toxicity-based methods may involve the measurement of a biological effect associated with exposure to complex mixtures. For this method, the selection of toxicological endpoints for indicator or target species will be based on a review of available scientific literature providing quantitative data for the species of concern. Analysis of population, habitat or ecosystem changes will be based on species or habitats that represent broad components of the ecosystem or are especially sensitive to the contaminants. Selection of an appropriate methodology will be based on the following acceptance criteria:

- Measurement endpoint corresponds to or is predictive of the assessment endpoint;
- Methodology is capable of demonstrating a measurable biological response distinguishable from other environmental factors such as weather or physical site disturbance;
- Measurement is practical to perform and produces scientifically valid results;
- Methodology and measurement endpoint are appropriate to the exposure pathway; and
- A standard acceptable protocol exists for the methodology.

Determination of impacts will be based on establishment of a statistically significant difference in the biological response between samples from populations at OU5 and the reference areas. The

determination as to what constitutes a statistically significant difference will be consistent with DQOs and quality assurance provisions of the Quality Assurance Project Plan (QAPjP).

9.2.2 Data Quality Objectives

The DQO development process will be initiated during State I preliminary planning. Development of DQOs will follow the three steps recommended by EPA (1990). Step I of the DQO process involves preparing definitions and concise DQOs. Examples of Step I program DQOs for this environmental evaluation include the following:

- Identify appropriate site-specific receptor species and contaminants of concern to determine if there is a potential for adverse effects to occur as a result of potential contaminant release. This step includes determination of relevant contaminant concentrations in biological tissues;
- Evaluate the potential for impacts to occur to biological resources outside the boundaries of OU5 or Rocky Flats Plant; and
- Evaluate the need for remediation to protect the environment.

Steps II and III of the DQO process include identification of data uses and needs and design of the data collection program. Products of Step II include proposed statements of the type and quality of environmental data required to support the DQOs, along with other technical constraints on the data collection program. The objective of Step III is to develop data collection plans that will meet the criteria and constraints established in Steps I and II. Step III results in the specification of methods by which data of acceptable quality and quantity will be obtained. The DQO development process will continue as scoping of the environmental evaluation becomes more refined. Additional Step I decision-type DQOs may be needed or data collection-type DQOs may be modified based on results of the State I preliminary planning process and subsequent refinement of the field sampling plan.

9.2.3 Support Documentation

In addition to the work plan, proper conduct of this environmental evaluation will depend upon revision and refinement of the field sampling plan. The purpose of the field sampling plan is to ensure that field data collection activities will be comparable to and compatible with previous data collection activities performed at the site while providing a mechanism for planning and approving new field activities. The field sampling plan provides guidance for all field work by defining in detail the sampling and data-gathering methods to be used on the project. The preliminary field sampling plan for this environmental evaluation is presented in Subsection 9.8.

Guidance for the selection and definition of field methods and sampling procedures was acquired from the Compendium of Superfund Field Operations Methods, a compilation of demonstrated field techniques that have been used during remedial response activities at hazardous waste sites (EPA, 1987). To the extent possible, procedures from the Compendium are incorporated by reference. Additional methods for detecting injury to biological resources are provided in the Type B Technical Information Document: Injury to Fish and Wildlife Species (U.S. Department of the Interior, 1987).

9.2.4 Review of Existing Information

As an essential part of the environmental evaluation at OU5, a review of available documents, aerial photographs, and data relevant to the site will be completed. This will allow compilation of a data base from which to determine data gaps and to provide evidence for a defensible field sampling program. Prior studies by DOE and the RFP operating contractors will be reviewed and evaluated. Information to be reviewed will include the following:

- Project files maintained by Rockwell International and EG&G;
- Project reports and documents on file at Front Range Community College Library and the Colorado Department of Health;
- DOE documents and DOE orders;
- The Phase I RI database;
- The Rocky Flats EIS database;
- Data from ongoing environmental monitoring and NPDES programs;
- Studies conducted at Rocky Flats on radionuclide uptake, retention and effects on plant and animal populations;
- Scientific literature, including ecological and risk assessment reports, from other DOE facilities (ORNL, Los Alamos, Hanford, Savannah River).

If available and applicable, historical data will be used. Where the same methods are not used in the collection of new data, use of historical data will depend on the demonstrated comparability of the data collection methods.

During preparation of this work plan, several documents were reviewed in addition to those listed in Table 9-1 as part of an assessment of available information. These included the Final EIS, Rocky Flats Plant (DOE, 1980); Wetlands Assessment (EG&G, 1990); Draft Environmental Evaluation Work Plan for OU2 (in RFI/RI Work Plan, DOE, 1991); and the Final Phase III RFI/RI Work Plan, 881 Hillside Area (DOE, 1990c) among others. Literature reviews will continue throughout the environmental evaluation. Review of this Draft Phase I RFI/RI Work Plan for OU5 and the Environmental Evaluation Work Plans for OU1 (DOE, 1990c) and OU2 (DOE, 1991) formed the basis for the establishment of the initial sampling locations discussed in the OU5 Field Sampling Plan (Subsection 9.8).

9.3 FIELD INVESTIGATION (Stage I)

The following field investigation consists of three separate programs. The air program will entail emissions estimation and modeling. The soils, surface water and groundwater programs will be conducted as part of the Phase I RFI/RI activities. The terrestrial and aquatic biota sampling program will be conducted as part of this environmental evaluation.

9.3.1 Air Quality

It is necessary to model ambient air concentrations to estimate environmental risk that results from airborne transport of Woman Creek Drainage contaminants to potential receptors. Emission estimates will be calculated for surface wind erosion and from the diffusion of volatiles and semivolatiles existing below the surface through the top layer of soil. Wind erosion emissions will be estimated for total particulates, metals and radionuclides while soil diffusion emissions will be estimated for volatiles and semivolatiles detected below the surface, as determined from groundwater and soil sampling results. Air quality dispersion modeling using a Chi/Q approach, which assumes a unit emission rate, will be performed. Compound-specific emission rates will then be multiplied by the modeled impacts to produce compound-specific ambient concentration estimates, since predicted concentrations are directly proportional to the emission rate.

Based on the dispersion modeling results, 24-hour and annual compound-specific ambient concentrations will be estimated at a set of receptor points on and downwind of the actual Woman Creek Drainage area. Pathways will then be defined using these receptors and risks calculated as necessary. These ambient concentrations will then be used to perform a baseline risk assessment for each chemical of concern detected above background levels in the soil and groundwater.

TABLE 9-1

EXAMPLES OF EPA AND DOE GUIDANCE DOCUMENTS AND REFERENCES FOR CONDUCTING ENVIRONMENTAL EVALUATIONS

Barnthouse, L.W., G.W. Suter, S.M. Bartell, J.J. Beauchamp, R.H. Gardener, E. Linder, R.V. O'Neill and A.E. Rosen. 1986. User's Manual for Ecological Risk Assessment. Environmental Sciences Division. Publication No. 2679, ORNL-6251.

U.S. DOE. 1988a. Comprehensive Environmental Response, Compensation, and Liability Act Requirements. DOE Order 5400.YY. Draft, September 1988.

U.S. DOE. 1988b. Radiation Effluent Monitoring and Environmental Surveillance. DOE Order 5400.XY, Draft, September 1988.

U.S. DOE. 1990a. Radiation Protection of the Public and the Environment. DOE Order 5400.5.

U.S. EPA. 1988a. Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA. Interim Final. Office of Emergency and Remedial Response, Washington D.C., EPA/540/g-89/004.

U.S. EPA. 1988b. Superfund Exposure Assessment Manual. Office of Emergency and Remedial Response. Washington, D.C. EPA/540/1-88/001.

U.S. EPA. 1988c. Guidance on Remedial Actions for Contaminated Groundwater at Superfund Sites. Office of Emergency and Remedial Response. Washington, D.C. EPA/540/2-88/003.

U.S. EPA. 1988d. Technological Approaches to the Cleanup of Radiologically Contaminated Superfund Sites. Office of Research and Development, Washington, D.C. EPA/540/2-88/002.

U.S. EPA. 1989a. Exposure Factors Handbook. Office of Health and Environmental Assessment. Washington, D.C. EPA/600/8-89/043.

U.S. EPA. 1989b. Ecological Assessments of Hazardous Waste Sites: A Field and Laboratory Reference Document. Office of Research and Development. EPA/600/3-89/013.

U.S. EPA. 1989c. Risk Assessment Guidance for Superfund Volume II Environmental Evaluation Manual. Interim Final. Office of Emergency and Remedial Response. Washington, D.C. EPA/540/1-89/001.

U.S. EPA. 1990. Guidance for Data Useability in Risk Assessment. Office of Emergency and Remedial Response. Washington, D.C. EPA/540/G-90/008.

9.3.2 Soils

Very little data currently exist on contaminants present in surficial materials in the Woman Creek drainage. Groundwater monitoring wells have been installed at several locations within the drainages, but all wells are outside OU5 IHSS boundaries. Soil samples from various depths in these wells were analyzed. These data have not been validated and there is some uncertainty in the unvalidated data.

The purpose of the Phase I RFI/RI sampling and analysis program is to provide data for characterizing the IHSSs and for confirming the presence or absence of contamination. The Phase I RFI/RI Work Plan proposes to collect soil samples from each of the IHSSs at OU5. Soil samples will be collected from the surface (< 2 inches deep) in the Ash Pits, the Original Landfill and the Surface Disturbances areas. Surface soils samples will be analyzed for radionuclides and metals in the Ash Pits and proximal to the Original Landfill, and additionally for organics in the Surface Disturbance Areas. Soil samples will be collected from IHSS 115, Original Landfill only where there are radiation hotspots or high soil gas readings. The list of soil analysis parameters is presented in Table 7-5 and the planned analytical program is presented in Table 7-6. The range of substances to be tested (Hazardous Substance List) is also considered sufficient for the environmental evaluation.

Near-surface soil samples (<2 inches deep) will be of prime importance for determining source contaminants for biota. This uppermost layer is a major source of nutrients and contaminant uptake for the vegetation under study and is also a potential source of contaminant ingestion to wildlife. Soil samples from all depths are related to surface water and groundwater regimes. Fluids moving through the soils can act to leach contaminants, transport them through available flow paths and deposit them in downgradient environments. Contamination in soil and groundwater at a depth of greater than 20 feet (maximum depth of burrowing animals and plant root penetration) will not be considered as affecting biota.

The sampling and analysis programs under the Phase I RFI/RI field investigations will be reviewed and modified as necessary to ensure that sampling intervals and methods are appropriate to collect surficial soil samples in the required locations. Data from the Phase III OU1 RFI/RI program and the Phase II OU2 RFI/RI Program will also be evaluated for use in characterizing the nature and areal extent of surface soil contamination in the vicinity of OU5. The information will be used to help identify exposure pathways for the environmental assessment.

9.3.3 Surface Water

Surface water and sediment samples are collected on a regular basis as part of ongoing site-wide investigations. These investigations will continue. This Phase I RFI/RI Work Plan proposes extensive sampling along Woman Creek, the South Interceptor Ditch and in Ponds C-1 and C-2. In addition,

samples will be collected upstream of the Rocky Flats Plant to provide background data. Samples will be analyzed for metals, radionuclides, inorganics, and organics.

Surface water sampling and analytical results presented in the Final Phase III OU1 RFI/RI Work Plan for OU1 and the Draft Final RFI/RI for OU2 will be evaluated with respect to this environmental evaluation plan. Sampling locations presented in this work plan were integrated with OU1 and OU2 sampling locations. All seeps and springs on the Woman Creek Drainage will be sampled as part of these programs. Chemical results from the OU1 and OU2 surface sampling locations will be reviewed and incorporated into the OU5 environmental evaluation.

9.3.4 Groundwater

Groundwater monitoring wells upgradient and downgradient of some of the IHSSs provide limited information on groundwater conditions in Woman Creek Drainage. This Phase I RFI/RI proposes to install monitoring wells downgradient of the Original Landfill, Ash Pits and Ponds C-1 and C-2. The laboratory analytical results will be used to assess the presence or absence of groundwater contamination and to assess the exposure pathway, if present.

Data from the Phase III OU1 RFI/RI Program and the Phase II OU2 RFI/RI Program will also aid in characterizing the nature and areal extent of groundwater contamination in the vicinity of the site. The hydrogeologic information and laboratory analytical results from these planned boring and well installation programs will likewise be incorporated in this environmental evaluation where applicable. The information will be used to assist in determining the nature and extent of contamination in shallow groundwater and help identify exposure pathways for the environmental assessment.

9.3.5 Terrestrial and Aquatic Biota

Terrestrial and aquatic species in the Rocky Flats Plant area have been described by several researchers (Weber et al., 1974; Clark, 1977; Clark et al., 1980; Quick, 1964; Winsor, 1975; CDOW, 1981; CDOW, 1982a, 1982b); most of these reports are summarized in the Final EIS (DOE, 1980). In addition, terrestrial and aquatic radioecology studies conducted by CSU and DOE (Rockwell International, 1986; Paine, 1980; Johnson et al., 1974; Little, 1976; Hiatt, 1977) along with annual monitoring programs at Rocky Flats Plant have provided information on the plants and animals in the area and their relative distribution.

Limited field surveys will be necessary to characterize current biological site conditions in terms of species presence, habitat characteristics and/or community organization. The emphasis will be to describe the structure of the biological communities at OU5 in order to identify potential contaminant pathways, biotic receptors and key species.

9.3.5.1 Vegetation

The objectives of the vegetation sampling program are to provide data for: (1) the description of site vegetation characteristics; (2) identification of potential exposure pathways from contaminant releases to higher trophic-level receptors; (3) selection of key species for contaminant analysis to determine background conditions for the Woman Creek Drainage; and (4) identification of any protected vegetation species or habitats. The selection of key species is a subjective decision based on species dominance or judged importance in the food chain. Development of site-wide criteria for the selection of key species will be a coordinated between the Operable Units.

9.3.5.1.1 Terrestrial Vegetation

Approximately seven habitat types are expected to be found in the Woman Creek Drainage area (Clark et al., 1980). Grasses characteristic of the short grass plains are abundant. Representative species include Junegrass (Koeleria cristata), dropseed (Sporobolus spp.), slender wheatgrass (Agropyron trachycaulum) and green needlegrass (Stipa viridula), which are interspersed with other grasses, shrubs, and a variety of annual flowering plants. Transects will be established at each of the IHSSs, along the South Interceptor Ditch, and along Woman Creek Drainage to collect phytosociological data on density, cover, frequency and species presence.

9.3.5.1.2 Wetland Vegetation

Wetlands have been identified along Woman Creek (EG&G, 1990). These occur as linear wetlands that support hydrophytic vegetation species including sandbar willow (Salix exigua), american watercress (Barbarea orthoceras), and plains cottonwood (Populus sargentii). Other species associated with these wetlands include broad-leaf cattail (Typha latifolia), baltic rush (Juncus articus), cordgrass (Spartina pectinata), silver sedge (Carex praegracilis) and various bulrushes (Scirpus spp.). Transects will be established in wetland vegetation habitats along the South Interceptor Ditch and Woman Creek and around Ponds C-1 and C-2 to collect phytosociological data on density, cover, frequency and species presence.

9.3.5.1.3 Periphyton

The periphyton community is a closely-adhering group of organisms that form mat-like communities on rocks, other solid objects or the stream bottom. The community is composed of algae, bacteria, fungi, detritus and other macroscopic heterotrophic organisms. Because of the large surface-to-volume ratio of its constituents, periphyton have been found to be an excellent indicator community for accumulation of contaminants. Periphyton samples will be collected at designated locations on the South Interceptor Ditch, along Woman Creek and at Ponds C-1 and C-2.

Periphyton communities provide a sensitive mechanism to detect changes in aquatic environments that result from the introduction of contaminants. Taxonomic composition and relative abundance of periphyton can be measured on natural substrates as well as standardized artificial substrates. On hard artificial substrates, data on algal abundance, biomass and species composition will be obtained by removing the substrate and by scraping or brushing the flora from a measured area into a container.

9.3.5.2 Wildlife

A field survey will be conducted to gather data on animal communities at Woman Creek Drainage. The objective of the animal life survey is to: (1) describe the existing animal community at Woman Creek Drainage; (2) identify potential contaminant pathways through trophic levels; (3) develop food web models including contribution from vegetation; (4) identify key species for potential collection and tissue analysis; and (5) identify any protected species.

9.3.5.2.1 Terrestrial Species

The field survey will document the presence of terrestrial species and allow for a general description of the community. Some species (e.g., songbirds, larger mammals, reptiles and raptors) may use the area daily, seasonally or sporadically, or wander through as vagrants. Survey timing and techniques will consider these uses.

9.3.5.2.2 Aquatic Species

Benthic macroinvertebrates may exist in rocky/ gravelly substrates or as soft bottom communities along portions of Woman Creek, the South Interceptor Ditch and Ponds C-1 and C-2. The soft-bottom benthos are those macroscopic invertebrates inhabiting mud or silt substrates, whereas the immature stages of insects inhabit rock surfaces, rooted stems, and leaves or gravelly substrates. Because these communities are essentially stationary, they are good indicators of past and present habitat contamination. Additionally, their feeding methods (filtering microscopic organisms and fine materials, preying on smaller invertebrates and grazing periphyton), suggest that benthic species are ingesting other organisms that are potentially concentrating contaminants. Designated locations in the South Interceptor Ditch, Woman Creek and Ponds C-1 and C-2 will be sampled for benthic organisms. Fish species represent both herbivores and carnivores and may demonstrate biomagnification of contaminants within the creek or pond ecosystem. The aquatic survey will document species present and their trophic relationships.

9.3.6 Reference Areas

Reference areas will be identified for terrestrial, wetland and aquatic species to the west or north of RFP away from potential effects associated with releases from either RFP or Woman Creek Drainage. To the extent practicable, selection and sampling of these areas will be coordinated among related operable units. Sampling rationale, methodologies and procedures for both terrestrial and aquatic sampling are presented in Subsection 9.8, the Field Sampling Plan.

Reference areas will be selected when current and historical data are not available to assess impacts from Woman Creek Drainage contaminants. One or more reference areas will be selected based upon their similarity to OU5 and their lack of exposure to contamination from Rocky Flats or other sources. Data collected at the reference area will be compared where possible to values reported in the scientific literature to demonstrate that the data represent a normal range of conditions. Methods used to collect data at the reference area will be comparable to those used at OU5.

The selection of reference areas will be made to meet Step I DQOs and the selected assessment and measurement endpoints. Criteria for the selection of reference areas will be developed during Stage I preliminary planning.

Two basic criteria will be employed in the selection and establishment of reference areas:

1. The reference areas will be similar to Woman Creek Drainage in terms of soil series, topography, aspect, vegetation, habitat types and plant and animal assemblages.

2. The reference areas, including vegetation and wildlife, have not been impacted by releases from Woman Creek Drainage or other RFP Operable Units.

9.4 CONTAMINATION ASSESSMENT (Stage II)

The two major objectives of the contamination assessment are to:

- Obtain quantitative information on the types, concentrations, and distribution of contaminants in selected species; and

- Evaluate the effects of contamination in the abiotic environment on ecological systems.

Conducting a contamination assessment requires an evaluation of chemical and radiological exposures and the subsequent toxicological effects on key species. Of specific importance in the contamination assessment are the identification of exposure points, the measurement of contaminant concentrations

at those points and the determination of potential impacts or injury. Impacts may result from movement of contaminants through ecological systems or from direct exposure (inhalation, ingestion, or deposition).

The Stage II Contamination Assessment for Woman Creek Drainage will be based on existing environmental criteria, published toxicological literature and existing, site-specific environmental evaluations. The program design will be integrated with other ongoing RFI/RI studies so that concentrations of contaminants in abiotic media can be related to contaminant levels and effects in biota.

The contamination assessment process is divided into the following five tasks:

- Site characterization,
- Contaminant identification,
- Exposure assessment,
- Toxicity assessment, and
- Impact Evaluation.

The objectives and description of work for each of these tasks is described below.

9.4.1 Site Characterization

Environmental resources at the site will be characterized based on data reviews from existing literature and reports, including results from the Phase I RFI/RI investigation, other Operable Unit RFI/RI investigations and the environmental evaluation field studies. The description of the site will be presented in terms of the following distinct resource areas:

- Meteorology/ Air Quality,
- Soils and Geology,
- Surface and Groundwater Hydrology,
- Terrestrial Ecology,
- Aquatic Ecology, and
- Protected/ Important Species and Habitats.

The purpose of the site characterization is to describe resource conditions as they exist without remediation. The narrative with supporting data will include descriptions of each resource, with attendant tables and figures, as appropriate, to depict, in a concise and clear fashion, site conditions, particularly as they influence contaminant fate and transport.

Included in this task is the development of a community food web model (Reagan and Fordham, 1991) to describe the feeding relationships of organisms at Rocky Flats Plant. Food web construction begins with gathering information to evaluate the food habits of species or species groups (e.g., grasshoppers) found or potentially occurring on site. Standard computer searches will be augmented with searches of local university libraries to locate any regionally pertinent studies on food habits. The preliminary list of important species, compiled from background information, will be completed based on observations of presence and abundance made during the ecological site surveys and on trophic level data obtained from the food web model. Based on the model, a modified list of species will be made using toxicological information (toxicity assessment) to determine which species or species groups might be most affected or most sensitive to the chemical(s) of interest.

9.4.2 Contaminant Identification

Because there is a variety of individual contaminants associated with Woman Creek Drainage, it is critical to narrow the list of chemicals to a manageable number. Chemical and species-specific criteria (e.g., likelihood of exposure) will be used for selecting those contaminants which are of particular concern from an ecological perspective at Woman Creek Drainage. Although the selection process will parallel that for the Human Health Risk Assessment, the lists may differ somewhat based on contaminant fate and transport characteristics and species-specific toxicities. Selection of the contaminants of concern will be evaluated in accordance with EPA guidance (EPA, 1989c).

9.4.3 Exposure Assessment

This task will identify the exposure or migration pathways of the contaminants, taking into account environmental fate and transport through both physical and biological means. Each pathway will be described in terms of the chemical(s) and media involved and the potential ecological receptors. The exposure assessment process will include the following four subtasks:

- Identify exposure pathways,
- Identify key receptor species,
- Determine exposure points and concentrations, and
- Estimate chemical intake for receptors.

Each of these subtasks is described below.

9.4.3.1 Exposure Pathways

The purpose of this subtask is to qualitatively identify the actual or potential pathways by which various biological receptors at or near Woman Creek Drainage might be exposed to site-related chemicals or radionuclides. The exposure pathway analysis will address the following four elements:

- A chemical/ radionuclide source and mechanism of release to the environment,
- An environmental transport medium (e.g., soil, water, air) for the released chemical/ radionuclide,
- A point of potential biological contact with the contaminated medium, and
- A biological uptake mechanism at the point of exposure.

All four elements must be present for an exposure pathway to be complete and for exposure to occur.

Exposure pathways will be evaluated and modeled, where possible, in this Stage II contamination assessment. Toxicity tests may eventually be used based on model results or the need to conduct a direct effects-related investigation.

9.4.3.2 Identification of Key Receptor Species

Key receptor species are those species which are or may be sensitive to the particular contaminants of concern. Species that need to be considered in the contamination assessment include threatened and protected species, game species and species at higher trophic levels in food webs in which contaminants are expected to bioaccumulate.

Criteria for the selection of key receptor species will be based on a preliminary analysis of exposure routes and food web relationships as well as the known toxicological effects of the contaminants of concern (see Section 9.4.1). This analysis will include an evaluation of the species in relation to potential contaminant exposure through both direct contaminant accumulation from the abiotic environment and bioaccumulation through the food chain.

Key receptor species may include game species such as mule deer (Odocoileus hemionus) which is mobile and has a large home range; or an organism that is sedentary or has a more restricted movement such as plants, some invertebrates, and some small vertebrates. For contaminants that bioaccumulate, the effects are usually most severe for organisms at the top of the food chain (e.g., top

predators). Examination of contaminant effects on these more mobile species may necessitate the integration of data from different OUs.

9.4.3.3 Determination of Exposure Points and Concentrations

The identified exposure points are those locations where key ecological receptor species may contact the contaminants of concern. Determination of exposure points entails an analysis of key receptor species, locations and food habits in relation to potential contaminant exposure through both direct contaminant accumulation or deposition from the abiotic environment and through indirect bioaccumulation.

A determination of the nature and extent of contamination in the abiotic media (air, soils, surface water and groundwater) is presented in this Phase I RFI/RI Work Plan for Woman Creek Drainage. Phase I data, where available, will be summarized and used to characterize source areas and release characteristics at the site. The exact exposure points can be expected to vary depending on both the contaminant and the key receptor species under consideration.

Concentrations of chemicals that are likely to have the greatest impact (based on concentration in the environment, toxicity values, and biological uptake) will be determined by environmental fate and transport modeling or actual environmental media sampling for each exposure point. Fate, transport and endpoint contamination levels will be modeled using environmental multi-media risk assessment models. Such models can provide the potential maximum concentrations of chemicals at the exposure points by which to evaluate the "worst-case" scenario.

9.4.3.4 Estimation of Chemical Intake by Key Receptor Species

This step includes an evaluation of key receptor species' contaminant uptake by direct routes (i.e., inhalation, ingestion, dermal contact) and indirect routes (bioconcentration, bioaccumulation, biomagnification). The amounts of chemical and radiological uptake will be estimated in the Stage II contamination assessment using appropriate conservative assumptions, site-specific analytical data, and guidance from EPA's Wildlife Exposure Factors Handbook (to be published in 1991). A pathways analysis model (Reagan and Fordham, 1991; Thomann, 1981) will be used to establish relationships between concentrations of a chemical in different media with concentrations known to cause adverse effects.

Direct measurement of contaminant uptake through tissue analyses will be conducted during Stage III of the environmental evaluation. Such site-specific data and field observations will be used to reduce uncertainty in the pathways model and strengthen interpretation of the overall study.

9.4.4 Toxicity Assessment

This assessment will include a summary of the types of adverse effects on biota associated with exposure to site-related chemicals, relationships between magnitude of exposures and adverse effects and related uncertainties for contaminant toxicity, particularly with respect to wildlife. Ecological receptor health effects will be characterized using EPA-derived critical toxicity values when available in addition to selected literature pertaining to site- and receptor-specific parameters.

Tissue contaminant analyses will be performed on samples of key species in Stage III. These measurement endpoints will be chosen based on the predicted concentrations and the known toxicological effects of single contaminants on receptor species. The species, contaminants and tissues to be sampled will be evaluated during Stage I preliminary planning.

Comparison of on-site concentrations to criteria or toxicity values may not be sufficient to assess the potential impacts of all the contaminants of concern at OU5. Also, the pathways approach may not account for the potential synergistic, antagonistic, or additive effects of complex mixtures and may not adequately reflect the bioavailability of the contaminants. For this reason, an initial toxicity testing program limited to aquatic organisms will be conducted in Stage I (see Subsections 9.5.2 and 9.8.5).

9.4.5 Evaluation of Adverse Effects

Impact evaluation entails the integration of exposure concentrations and reasonable worst-case assumptions with the information developed during the exposure and toxicity assessments to characterize the current and potential adverse effects to the environment posed by Woman Creek Drainage. The potential impacts from all exposure routes (inhalation, ingestion and dermal contact) and all media (air, soil, groundwater and surface water/ sediment) will be included in the impact evaluation as appropriate.

Characterization of ecological impacts on receptor species is generally more qualitative in nature than characterizing human risks. This is because the toxicological effects of most chemicals have not been well documented for most ecological species. Where specific information is available in the published literature, a more quantitative evaluation of effects will be made using the site-specific pathways model. This approach is in agreement with EPA guidance (EPA, 1989c).

9.4.5.1 Ecological Effects Criteria

Criteria that are usable and applicable for the evaluation of ecological effects are generally limited. EPA Ambient Water Quality Criteria (AWQC) and Maximum Allowable Tissue Concentrations (MATC) are the most readily available criteria. Criteria found in federal and Colorado state laws and regulations

pertaining to the preservation and protection of natural resources can also be used. Criteria may also be derived from information developed for use under other environmental statutes, such as the Toxic Substances Control Act or the Federal Insecticide, Fungicide and Rodenticide Act.

General information on the toxicity and environmental behavior of chemical contaminants in relation to biological resources will be compiled. The development of ecological effects criteria will be based on results of the pathways models as well as available data which document potential adverse effects from contaminant of concerns on biological resources. Selection of these criteria will be coordinated with other OU RFI/RI studies and environmental evaluations.

9.4.5.2 Uncertainty Analysis

The process of assessing ecological effects is one of estimation under conditions of uncertainty. To address uncertainties, the environmental evaluation for Woman Creek Drainage will present each conclusion, along with the issues that support and fail to support the conclusion, and the uncertainty accompanying the conclusion. Factors that limit or prevent development of definitive conclusions will also be discussed. In summarizing the assessment data, the following sources of uncertainty and limitations will be specified:

- Variance estimates for all statistics,
- Assumptions and the range of conditions underlying use of statistics and models, and
- Narrative explanations of other sources of potential error.

Validation and calibration of the pathways model will also be used where practicable.

9.5 CONTAMINATION STUDIES (Stage III)

Stage III will include the tissue analysis studies and any additional toxicity studies used to determine impacts from the contaminants of concern on receptor species. An initial design for the Stage III program will be completed in Stage I after contaminants of concern and key receptor species have been selected. Species to be sampled for tissue analyses will be designated to the extent possible prior to implementation of the Stage I field inventory in order to avoid a duplication of sampling effort.

In order to demonstrate an impact due to contamination, the biological response under consideration and the proposed methodology should satisfy program DQOs as well as the following more specific criteria:

- The biological response is a well-defined, easily identifiable and a documented response to the contaminant;

- Exposure to the contaminant is known to cause the biological response in laboratory experiments or experiments with free-ranging organisms;

- The biological response can be measured using a published standardized laboratory or field testing methodology;

- The biological response measurement is practical to perform and produces scientifically valid results; and

- The determination of impact will be based on the establishment of a statistically significant difference in the biological response between samples from populations in the reference areas and in Woman Creek Drainage.

9.5.1 Tissue Analysis

Tissue analyses will be conducted to measure the total concentration of specific chemical compounds in key receptor species. Because individuals and species accumulate contaminants differentially in their tissues, environmental concentrations and general uptake rates will not necessarily predict biotic concentrations or adverse effects. Analysis of tissue contaminant concentrations will provide data to evaluate the predicted relationship, if any, between environmental concentrations and the amount of contaminants accumulated in receptor species. Selection of the species and specific tissues for analysis will be based on a preliminary evaluation of site-specific food webs, potential contaminant transport pathways and potential for bioaccumulation, bioconcentration and biomagnification. Calibration and validation of the pathways model(s) will be conducted during this phase to reduce uncertainty and make the model site-specific.

To the extent possible, tissue samples will be collected simultaneously with environmental media samples. This will allow for a determination of site-specific bioconcentration factors (BCFs). These BCFs will be incorporated into the final exposure assessment and pathways analysis model. Where BCFs cannot be determined, published or predicted BCF values will be used in the pathways model to assess potential impacts.

Prior to conducting the State III tissue analysis studies, the field sampling plan will be refined and more specific DQOs will be formulated. The field sampling plan will address the following:

- The number and types of analyses to be run;
- The species, locations, and tissues to be sampled;
- The number of samples to be taken;
- The detection limits for contaminants; and
- The acceptable margin of error in analyzing results.

9.5.2 Toxicity Tests

Toxicity tests may include either in-situ (in-field) or laboratory toxicity tests. In-situ methods usually involve exposing animals in the field to existing aquatic or soil conditions. Laboratory toxicity tests can be used to evaluate the lethal or sublethal effects of chemicals as they occur in environmental media. Both approaches can be used to test for toxicity of mixtures as they actually occur in the environment. Selection of a particular methodology is generally based on the capability of the method to demonstrate a measurable biological response to the selected contaminant(s) of concern.

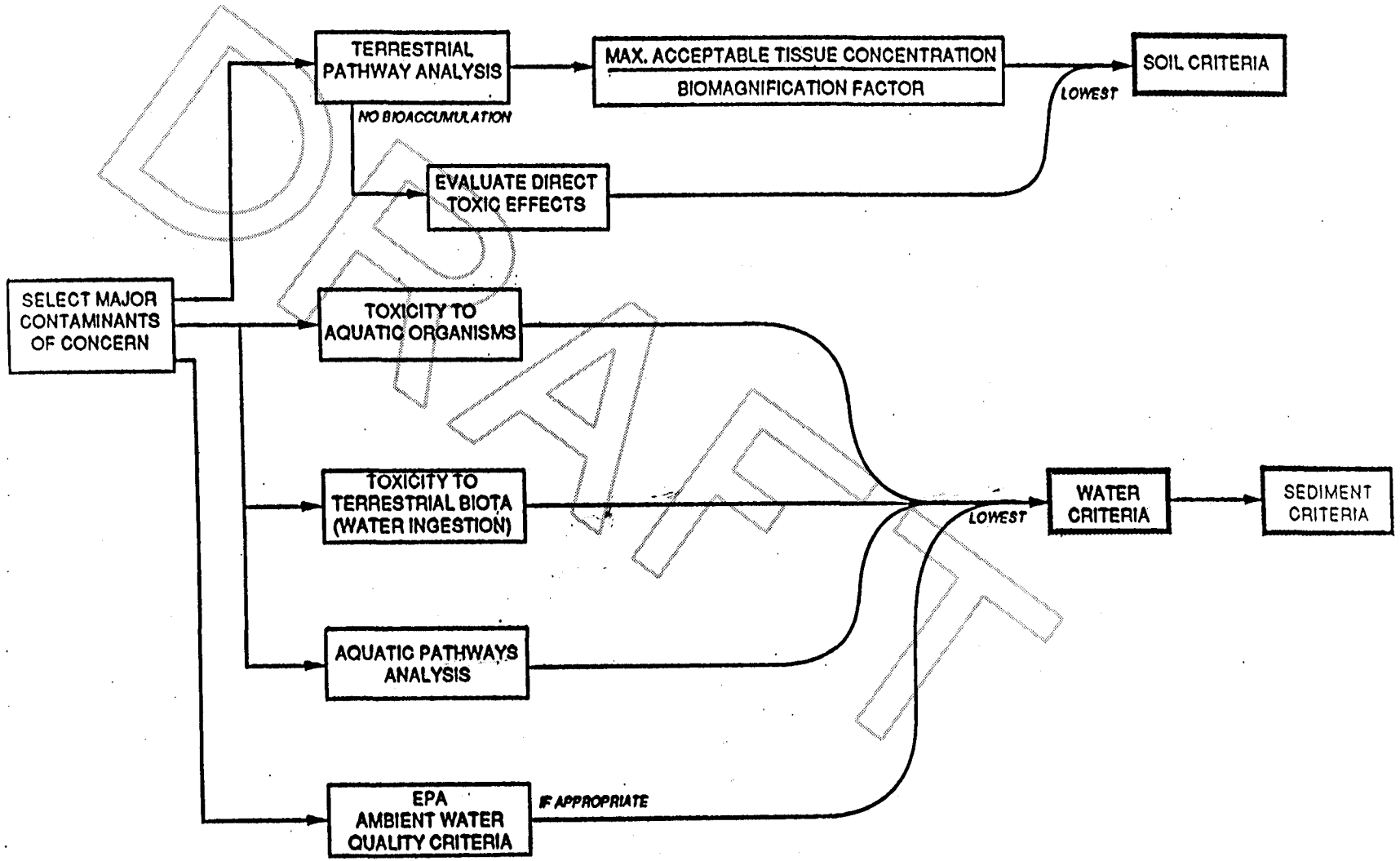
Acute and chronic aquatic toxicity tests using fathead minnows and Ceriodaphnia are proposed for Stage I of this evaluation. These simple screening tests will provide an initial determination of the toxicity of potentially complex chemical mixtures in Woman Creek, the South Interceptor Ditch and Ponds C-1 and C-2. If toxicity is observed in either the acute or chronic tests at any one station, then a supplemental toxicity testing program in conjunction with physical and chemical analyses of the water and sediment may be designed for that location to determine the potential extent of the toxicant(s).

Toxicity testing methods are available for terrestrial ecosystems using microbes, earthworms, crickets, and grasshoppers (EPA, 1989c). The need for such tests will be evaluated as part of the Stage II contamination assessment.

9.6 REMEDIATION CRITERIA

Remediation criteria protective of site-specific plants and animals for the contaminants of concern can be developed based on detailed food-web analyses using the pathways model calibrated and validated in Stage III. These ecological effects criteria are determined by tracing the biomagnification of contaminant residues from organisms at the top of the food web back through intermediate trophic levels to the abiotic environment. The "no effects" criteria levels for abiotic media are then derived from contaminant concentrations known to produce sublethal effects in the most sensitive (usually highest trophic level) organisms. The process for establishing ecological criteria is shown in Figure 9-2.

The acceptable (no-effects) criteria levels will be used in conjunction with ARARs to evaluate potential adverse effects on biota as appropriate for the environmental evaluation portion of the Phase I RFI/RI.



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Prepared by: L.H.P.
Date: 2/18/91

Figure 9-2

OUTLINE OF THE METHODOLOGY FOR DETERMINING CRITERIA FOR MAJOR CONTAMINANTS OF CONCERN

SOURCE: REAGAN AND FORDHAM, 1991

This approach will be integrated with the Human Health Risk Assessment process and will assist in the development of potential remediation criteria.

9.7 ENVIRONMENTAL EVALUATION REPORT

An Environmental Evaluation Report will be prepared in a clear and concise manner to present study results and interpretation. All relevant data from the environmental evaluation in addition to relevant Phase I RFI/RI data will be integrated and evaluated in the characterization of potential environmental impacts. The following topics will be covered in the report:

- Objectives,
- Scope of Investigation,
- Site Description,
- Contaminants of Concern and Key Receptor Species,
- Contaminant Sources and Releases,
- Exposure Characterization,
- Impact Characterization,
- Remediation Criteria, and
- Conclusions and Limitations.

A proposed, detailed outline of the report is shown in following Table 9-2.

9.8 FIELD SAMPLING PLAN

The environmental evaluation of Woman Creek Drainage is planned in three stages as described in Subsection 9.1.5. Field sampling activities will be conducted in Stage I and Stage III of the environmental evaluation. Stage I will include brief field surveys, an ecological inventory of biota present at OU5 and initial aquatic toxicity testing. The field surveys will be conducted to obtain information on the occurrence, distribution and general abundance of biota in Woman Creek Drainage. Data obtained in the field inventory will be used to identify sensitive species and develop a detailed food web model of OU5 and to provide input to the Stage II pathways analysis. Planning for the Stage III tissue analysis program will begin in Stage I so that samples collected in the Stage I field inventory may be used for Stage III tissue analysis wherever possible (i.e., where the contaminants of concern have been defined and the field sampling protocol have been developed. The need for further contaminant studies (e.g., reproductive success or enzyme analyses) in Stage III, in addition to the tissue analyses, will be determined based on Stage I and Stage II findings.

The following field sampling plan is provisional and will be periodically revised as appropriate. The Stage I sampling plan is largely complete but may be altered in order to better coordinate with the

TABLE 9-2

DRAFT ENVIRONMENTAL EVALUATION REPORT OUTLINE
WOMAN CREEK DRAINAGE

EXECUTIVE SUMMARY

1.0 INTRODUCTION

- 1.1 OBJECTIVES
- 1.2 SITE HISTORY
- 1.3 SCOPE OF EVALUATION

2.0 SITE DESCRIPTION

- 2.1 PHYSICAL ENVIRONMENT
  - 2.1.1 Air Quality/Meteorology
  - 2.1.2 Soils
  - 2.1.3 Surface Water
  - 2.1.4 Groundwater
- 2.2 BIOTIC COMMUNITY
  - 2.2.1 Freshwater Community
  - 2.2.2 Terrestrial Community
  - 2.2.3 Protected/Important Species and Habitats

3.0 CONTAMINANT SOURCES AND RELEASES

- 3.1 SOURCES
- 3.2 RELEASES

4.0 CONTAMINANTS OF CONCERN

- 4.1 CRITERIA DEVELOPMENT FOR SELECTION OF CONTAMINANTS OF CONCERN
- 4.2 DEFINITION OF CONTAMINANTS

5.0 TOXICITY ASSESSMENT

- 5.1 TOXICITY ASSESSMENTS OF CONTAMINANTS OF CONCERN
- 5.2 CONTAMINANT EFFECTS
  - 5.2.1 Terrestrial Ecosystems
  - 5.2.2 Aquatic Ecosystems

6.0 EXPOSURE ASSESSMENT

TABLE 9-2
(Continued)

6.1 CONTAMINANT PATHWAYS AND ACCEPTABLE CRITERIA DEVELOPMENT

- 6.1.1 General Methodology for Pathway Analysis
- 6.1.2 Selection of Key Receptor Species

6.2 EXPOSURE POINT IDENTIFICATION

- 6.2.1 Soil
- 6.2.2 Water
- 6.2.3 Vegetation

6.3 CHEMICAL FATE AND TRANSPORT

6.4 EXPOSURE POINT CONCENTRATIONS

- 6.4.1 Soil and Sediment Concentrations
- 6.4.2 Surface Water Concentrations
- 6.4.3 Groundwater Concentrations
- 6.4.4 Vegetation Concentrations

6.5 EXPOSURE PATHWAYS

- 6.5.1 Terrestrial Pathway
- 6.5.2 Freshwater Pathway

7.0 IMPACT CHARACTERIZATION

7.1 DEVELOPMENT OF ECOLOGICAL EFFECTS CRITERIA

- 7.1.1 Air Criteria
- 7.1.2 Soil and Sediment Criteria
- 7.1.3 Freshwater Criteria
- 7.1.4 Vegetation Criteria

7.2 EFFECTS CHARACTERIZATION

- 7.2.1 Terrestrial Pathway
  - 7.2.1.1 Air
  - 7.2.1.2 Soil
  - 7.2.1.3 Vegetation
- 7.2.2 Freshwater Pathway
  - 7.2.2.1 Air
  - 7.2.2.2 Surface Runoff
  - 7.2.2.3 Seeps and Springs

8.0 ASSUMPTIONS AND UNCERTAINTIES

TABLE 9-2
(Concluded)

9.0 RECOMMENDATIONS AND CONCLUSIONS

10.0 REFERENCES

surface water and soil sampling programs for OU5 or other Operable Units. The Stage III field sampling plan will be designed in greater detail after contaminants of concern and key receptor species have been identified and a preliminary determination of food webs and contaminant source-receptor pathwayshas been developed. This information will allow determination as to which contaminants of concern are likely to be present in sufficient concentrations to be detected in biota and which biota are most practical and suitable for sampling.

9.8.1 Sampling Objectives

The Stage I sampling program for OU5 has four broad objectives:

1. Conduct brief field surveys and an ecological inventory to describe the existing ecological setting in terms of habitats, vegetation, wildlife and aquatic species. Observations for obvious signs or zones of contamination or injury to biota and their habitats will be made. The inventory will be accomplished through the use of established ecological field methodologies (e.g., Mueller-Dombois and Ellenberg, 1974; Southwood, 1978; Krebs, 1989).

2. From the above data, identify key food web species which represent the major flow of energy and nutrients and thus the major pathways for contaminant transfer from physical environmental media to higher trophic-level ecological receptors.

3. Identify the presence or absence of protected or other important species and habitats.

4. Provide site-specific information for determining objectives, measurement endpoints and methodologies for Stage III field/ laboratory contamination studies. Conduct initial aquatic toxicity testing using Ceriodaphnia and fathead minnows.

Data from the Stage I field survey, inventory and toxicity tests will be summarized, tabulated and accompanied with a narrative description of the following data types:

- Species Present (Diversity),
- Habitat Descriptions/ Mapping Units (Clark et al., 1980),
- Critical/ Protected Habitats,
- Protected Species,
- Terrestrial and Aquatic Food Webs,
- Potential Exposure Pathways,
- Abundance of Key Species,
- Vegetation Cover,

- Vegetation Frequency and Density (shrubs/trees),
- Vegetation Importance (community dominance) Values, and
- Toxicity Test Results.

Appropriate statistical tests will be used to analyze the data so that precision and accuracy of the results can be presented at a stated level of confidence. Depending on the data types being analyzed, within-and-between station differences, within-and-between season differences, and within-and-between species differences will be presented. Means, variances, standard errors, analyses of variance, regression and correlation coefficients will be computed as appropriate. Non-parametric methods will be employed where variances are heteroscedastic and population distribution is non-normal. Where sample sizes are insufficient to detect differences, only descriptive statistics will be prepared.

9.8.2 Sample Location and Frequency

Both Stage I and Stage III field sampling activities for OU5 will be located and timed to the extent possible to coincide with collection of other media samples (soils, surface water and groundwater) as well as sampling activities at other operable units. This integrated sampling approach is consistent with EPA guidance and will provide a synoptic view of potential contaminants in all relevant media at one time.

The field sampling plan for Stage I is based on the assumption that brief field surveys will be conducted in the spring, summer, fall and winter of 1991 and that the ecological field inventory and initial toxicity tests will take place within the May-June and July-August 1991 timeframes. Information from the surveys and initial field inventory will be used to determine sampling parameters for the mid- to late-summer inventory.

9.8.2.1 Locations for Vegetative Sampling

Stage I vegetation inventory and sampling for phytosociological data will be performed at OU5 IHSSs, at the Surface Disturbance south of the Ash Pits, along the South Interceptor Ditch and along Woman Creek. A systematic walk-through of these areas will be conducted during the field surveys and spring field inventory.

A stratified randomization procedure will be utilized to identify sampling locations for the quantitative vegetative description portion of the field inventory. The basis for selecting a random procedure of vegetation transect/plot location is to obtain as unbiased an estimator as possible of true population parameters for herbaceous cover and shrub/tree density and frequency. Stratification is required because several distinct vegetation types appear to be present in the study area, including prairie

grassland, marsh, streambank vegetation, well-vegetated disturbed areas and sparsely vegetated disturbed areas.

The basis for stratification will be a vegetation type map, to be prepared based on the 1975 University of Colorado vegetation map of Rocky Flats and the Clark et al. (1980) report, updated by visual observations during the field surveys. This map will cover Woman Creek Drainage and the nearby areas along Woman Creek and the South Interceptor Ditch.

Sample plots will be located near soil sampling sites (see Subsection 7.2) wherever possible. From each soil sampling point, the centerpoint of a vegetation plot will then be selected based on a random distance (to 10 m) and random direction, using random numbers tables. Plot locations will be selected until an adequate number has been selected for each major vegetation type at each IHSS. Locations will be discarded under several conditions: where the selected location is in a vegetation type for which an adequate number of plots has already been selected (for each IHSS); where the vegetation of the plot is not homogeneous (i.e., located in more than one type or across an ecotone); and where the plot would be located in buildings or paved areas. A similar process will be used for transects along Woman Creek and the South Interceptor Ditch, where the sample locations will be located in the general area of the surface-water/ sediment sampling points. Since vegetation types associated with these features tend to be linear, the randomization process may require limits on direction. In addition, multiple plots will be located near (within 50 meters of) each surface water/ sediment sampling point to provide an adequate sample size.

9.8.2.2 Locations for Periphyton, Macrobenthos and Fish Sampling

Periphyton, macrobenthos and fish samples will be collected at the following surface water sampling locations: SW-26, SW-32, SW-36, SW-39, SW-46, SW-70, SW-126, Pond C-1 and Pond C-2 (Figure 9-1). Should the organisms or proper habitat be absent at a particular location, then the nearest location downstream with suitable habitat will be sampled and located on a map. Sampling at the OU5 sites will be coordinated with OU5 surface water and sediment sampling activities as well as the OU1 and OU2 sampling programs. Both surface water and sediment data will be collected at the same locations as the aquatic biota sampling locations. Sampling locations may be altered to assure these efforts are coordinated. Sampling locations for aquatic biota may also be altered depending on DQOs or required sample size.

9.8.2.3 Locations for Wildlife Sampling

A terrestrial wildlife inventory will be conducted within the Woman Creek Drainage and along the South Interceptor Ditch. Small mammal sampling will be conducted, to the extent possible, at the vegetative

sampling locations. Searches for reptiles will be conducted in the appropriate habitats within the Woman Creek Drainage and along the South Interceptor Ditch.

9.8.2.4 Locations for Initial Toxicity Testing

Locations for initial aquatic toxicity testing will be mostly the same as those for periphyton, macrobenthos and fish sampling: SW-26, SW-32, SW-36, SW-39, SW-126, Pond C-1 and Pond C-2 (Figure 9-1). Toxicity testing activities for OU5 will be coordinated with toxicity testing activities proposed for OU2.

9.8.2.5 Stage III Tissue Sampling Locations

Locations for the collection of Stage III tissue samples (terrestrial vegetation, periphyton, benthos, macrobenthos, fish) will be based on results of the Stage II contamination assessment and contaminant data from surface water, soil and sediment sampling. The intent is to collect tissue samples where existing abiotic media sampling has indicated significant contamination to occur. Development of the OU5 Stage III tissue sampling program will be coordinated with OU1 and OU2 programs.

9.8.2.6 Sample Frequency

Stage I field surveys will be conducted during 1-week periods in the spring, summer, fall and winter of 1991. Special note of transitory species, migratory species, and seasonal breeding habits will be made during these multi-season surveys.

Stage I field inventory sampling will occur during the May-June and July-August 1991 timeframes. Samples collected during the inventory will be saved and used in the Stage III tissue analysis studies where sampling and analysis protocol have been established.

Initial toxicity tests will also be conducted during May-June (high flow) and July-August (low flow). Two acute and two chronic tests will be conducted within 1 to 2 weeks of each other during each season. If toxicity is observed in either acute or chronic tests at any one station, then a supplemental program will be designed for that location to determine if the toxicity is consistent and to determine the potential extent of the toxicant.

9.8.3 Reference Areas

Stage III tissue analysis studies will require the sampling of contaminated and control areas in order to establish a relationship between contaminated conditions and background conditions in areas not exposed to RFP contamination. Selection of reference areas will be based on criteria developed in the

Stage I preliminary planning process. Potential selection criteria include species to be sampled or similarity to Woman Creek Drainage in terms of topography, aspect, soils, vegetation, range type and land use history. Reference areas will be upwind from prevailing air flow patterns through RFP and upstream from drainage off RFP.

The aquatic species reference areas ideally should be located in Rock Creek. A site visit will be made of the proposed aquatic sampling locations for OU5, QU1 and OU2. Habitat characteristics will be noted if not previously recorded in ongoing RFP studies (depth, flow, substrate type, pool/riffle, aquatic/ streamside vegetation, etc.). This process will be repeated at potential reference sites. The reference site locations will be based on DQOs and the measurement endpoints selected in the Stage I and Stage III sampling plans.

9.8.4 Stage I - Field Survey and Inventory Sampling Methods

9.8.4.1 Vegetation

Both qualitative and quantitative methods will be used in to characterize the terrestrial and wetland vegetation at OU5. The following qualitative procedure will be used in the Stage I field surveys:

1. Systematically walk the OU5 IHSSs, the South Interceptor Ditch and Woman Creek Drainage.

2. Record on a vegetation data sheet all vegetation species encountered. Information to be recorded includes:

   - Scientific name,
   - Common name,
   - Life form,
   - Vegetative stage at the time,
   - Qualitative statement on condition, and
   - Qualitative statement on abundance (many, few, solitary).

The following quantitative procedures will be used in the Stage I field inventory to collect structural and compositional data:

- At each plot selected by the process described in Subsection 9.8.2.1, a 10 m- long transect will be laid out in the randomly-selected direction.

- All shrubs which are rooted within 1 m on either side of the transect centerline will be enumerated. Shrubs are defined as woody vegetation over 0.5 m in height and with a stem diameter of less than 2.5 cm at 1.4 m aboveground; smaller woody plants will be counted within the herbaceous stratum and larger ones as trees. For each shrub rooted within the belt transect, the following data will be recorded: species, height, and two cover diameters at right angles (to calculate areal average).

- Herbaceous cover will be visually estimated by species to the nearest percent within a 1 m^2 plot using the Daubenmire cover scale (Mueller-Dumbois and Ellenberg, 1974).

- Trunk diameter, height, canopy diameter, and species of each tree within 5 m on either side of the transect centerline will be recorded.

- Field data will be processed to yield mean cover, density (shrubs and trees), diameter (trees), biomass and frequency by species and/or life form. Each plot/transect will be considered as an observation in calculating the mean and variance. Sample adequacy will be determined for total herbaceous cover using Cochran's formula (1977):

$$N = \frac{(t^2)(s^2)}{[(x)(d)]^2}$$

where: N = the minimum number of samples needed
t = t distribution value for a given level of confidence
s^2 = the variance estimate
x = the mean of the sample
d = the level of accuracy desired

Different quadrat sizes may be used depending on the vegetation type (e.g., a 1/4-m^2 quadrat may be used on dense streambank vegetation). In addition, sample sizes may differ among vegetation types.

9.8.4.2 Terrestrial Wildlife and Invertebrates

The Stage I survey is planned to note the presence or absence of terrestrial/ wetland species and to make note of their food habits. The survey procedure will include a systematic walk-through of the Woman Creek Drainage area, South Interceptor Ditch and Woman Creek Drainage to record ecological features. These will be recorded on a field data sheet and include:

- Species encountered/ observed

- Scientific name
- Common name
- Qualitative statement on:
  - Condition
  - Abundance
  - Habitat requirements
  - Predator/prey species/food habits
  - Regulatory status (to be determined prior to field sampling)
- Species presence will be determined by:
  - Visual observation
  - Vocalization
  - Burrow/den
  - Nest
  - Droppings/scat

Quantitative information on wildlife populations will be obtained in the Stage I field inventory. Inventory sampling will include the following procedures:

- Live trapping of small mammals will take place both on the hillside and along the South Interceptor Ditch and Woman Creek Drainage. Trap lines will consist of 25 stations with traps placed at 15 meter intervals, two to a station and baited with rolled oats or barley. Traps will be set for three to four nights and animals caught will be released alive after recording the following:
  - Scientific name/common name
  - Sex
  - Reproductive condition
  - Weight
  - Life history stage
- Reptile occurrence will be recorded along the same transects used for small mammal trapping in addition to habitat searches. The observer will walk the line of the transect and search the ground for reptiles within three to five meters either side of the transect center line. Data to be recorded include:

- Species encountered
- Activity
- Habitat
- Qualitative statement on abundance

- Medium- and larger-sized mammals will be counted by recording all species along a systematic walk-through of OU5 including the South Interceptor Ditch and Woman Creek Drainage. The counting will occur during the small mammal transect trapping. Species encountered and activity will be recorded.

- Foliage invertebrates will be collected by sweep net and beating. Sweep netting involves 10 - 20 strokes through the entire plant taking care not to destroy or injure the shrub, grass or forb being sampled. Beating involves a shallow net placed under the parts of a shrub or tree sampled. Three to five hard hits on the shrub/tree with a stick knocks the invertebrates to the net below.

- Invertebrates will be placed in a killing jar and returned to the laboratory for processing and identification to Order. Ground arthropods encountered will be identified to Order in the field, if possible. If not, they will be placed in killing jars, returned to the laboratory, processed and identified to Order.

  Data to be recorded will include:
  - Host plant
  - Herbivore
  - Position in food web

9.8.4.3 Periphyton

The following method will be employed at the selected locations along Woman Creek, the South Interceptor Ditch and Ponds C-1 and C-2 in order to characterize the periphyton communities:

- Surface-floating samplers constructed of styrofoam and a submerged rack containing six plexiglass slides will be used to collect periphyton. The upper end of the vertically-suspended slides will be placed about 30 cm below the surface of the water or as deep as possible if the water column is shallower. During low-flow periods, the samplers will be suspended at 45° instead of vertically. To anchor the sampler in place, sufficient weight will be attached at the end of a cord from the bottom of the sampler (cord length varied depending upon the depth at the sampling site). The exposure period in

the field will be 28 ± 1 days. If surface-floating samplers cannot be placed, periphyton will be scraped from substrate (natural).

- The algal growth will be scraped from both sides of the slide and rinsed with distilled water. A portion of the growth from the slides will be used to obtain direct cell counts. The remainder of the sample will be divided into two subsamples: one for analysis of chemical contaminants and the other for determination of radionuclide concentrations. Specific sample preparation requirements will be made by the analytical laboratory and will be added to the procedures once they have been established.

  The sample for cell counts will be diluted (as necessary) and a preservative added. A subsample will be taken and allowed to settle for approximately 12 hours in a sedimentation cylinder. The dilution volume (usually 200 ml to 100 ml) and the volume of the subsample (1 ml to 5 ml) are dependent upon the amount of growth on the slide. Organisms will be identified to genus and enumerated with an inverted microscope at about 320X.

For direct cell counts (identification and enumeration), the algal growth will be scraped from both sides of the slide and rinsed with distilled water. After the sample is diluted (as necessary) and preservative added, a subsample will be taken and allowed to settle for approximately 12 hours in a sedimentation cylinder. The dilution volume (usually 200 ml to 1000 ml) and the volume of the subsample (1 ml to 5 ml) are dependent upon the amount of growth on the slide. Organisms will be identified to genus and enumerated with a microscope at about 320X.

- Biomass determinations will be made by scraping the growth from both sides of the slide into a pre-weighed crucible. The residue is to be dried at 105°C for 12 hours (or until a constant weight is obtained), weighed, and then ashed in a muffle furnace at 600°C for 1 hour and weighed again. The difference between the two weights is the ash-free dry weight or organic weight of the sample.

- To determine the concentrations of chlorophyll-a and phaeophytin-a, both sides of the slides will be scraped and rinsed with a 90 percent acetone solution, resulting in extract volumes of 20 to 50 ml. After the extract is homogenized and steeped for a minimum of 12 hours, it will be clarified by centrifuge tube. The absorbance (optical density) of the extract is to be read at 750 and 630 m in a spectrophotometer. If dilution is necessary, 2 ml of the extract will be added to 10 ml of 90 percent acetone solution.

The amount of phaeophytin-a, a natural degradation product of chlorophyll-a, will be determined by examining the optical density at 633 nm before and after acidification.

- All analyses will be completed within five days of the collection of the slides from the field (EPA, 1987).

9.8.4.4 Macrobenthos

Benthic invertebrates are the most common fauna used in ecological assessments of contaminant releases and are defined as the invertebrates retained by screens of mesh size greater than 0.2 mm. Two types of sample collectors will be used to obtain macrobenthos samples: a Surber sampler with a mesh net and a Ekman grab sampler.

At those stations where shallow riffle habitats dominate the creek, a Surber sampler (0.09 m^2 or 1 square-foot) with a 352-um mesh net will be used. Triplicate samples are to be taken on a transect upstream and within 10 m of the designated sampling location. Samples will be placed in small plastic jars and reference specimens preserved in a 70 percent isopropanol solution. Supplemental data on the time the samples are collected, weather conditions, water temperature, depth and general nature of the substrate for each sample, and width of the creek at the transect will also be recorded.

At creek locations where the water may be shallow and the bottom is soft mud or silt with little current and at Ponds C-1 and C-2, a pole-mounted Ekman grab sampler will be used. The Ekman may also be used with a remote messenger to trigger the sampler. Once the sample is obtained, the entire contents will be placed in a large plastic bag and returned to the field laboratory where the contents will be sieved through a No. 35 mesh (500 μm) sieve and placed in a large white tray. Organisms will be separated from the debris with forceps under a table-mounted magnifier. Specimens will be preserved in vials of 70 percent ethanol solution. Identification and enumerations, generally to genus, will be made using dissecting microscopes.

9.8.4.5 Fish

Fish will be collected in 10 to 25 meter-long collection areas. The section will be fished using a Smith-Root backpack shocker. The anode on the shocker is fitted with a nonconducting collection net, and the operator will be assisted by one person equipped with fine-mesh long-handled dip net for fish capture. A standard effort of approximately 900 shocking-seconds will be used to collect the fish. An alternative method consists of seining the blocked-off creek sections, one person on each side of the seine. The seine is moved along one end to the other with poles on the bottom. At the end of a given length of collection area, the seine is lifted from the creek and fish are collected. Block nets will be set

across the creek at the upstream and downstream end of the section prior to sampling, and one or two electroshocking or seine passes will be made through the area.

In Ponds C-1 and C-2, fish will be sampled from a flat-bottom boat using an electroshocker.

Captured fish will be held in a floating pen or containment area until processed. Fish will be identified to species, counted, and measured for length (mm). Scales will be collected to obtain data on age classes versus size, population structure and survivorship. Weights will be determined by water displacement or by spring balance. Data will be recorded on standardized field sheets. Samples will be taken for laboratory identification/ confirmation.

Analyses will consist of compiling and summarizing the number, size and weight of each species of fish captured at each sampling site. Graphical presentations may include fish length-frequency histograms and plots of catch per effort for each sampling area.

9.8.5 Initial Toxicity Tests

The initial toxicity testing program will be limited to aquatic organisms and will include standardized EPA acute and chronic tests with fathead minnows and Ceriodaphnia. Water samples will be cooled to 4°C and shipped to the laboratory conducting the toxicity tests within 12 to 24 hours. The toxicity tests will be initiated within 36 hours of the field collection time. The duration of the static renewal acute tests will be 48 hours for Ceripdaphnia and 96 hours for fathead minnows. The test water will be renewed daily using dilution water from the sampling station. The static renewal chronic tests will last for 7 days for fathead minnows and until 60 percent of the Ceriodaphnia in the control vessels have three broods. Quality control procedures will conform to the EPA requirements for NPDES toxicity testing currently being used at Rocky Flats.

9.8.6 Stage III - Tissue Analysis Sampling Methods

The methodologies selected for tissue analysis studies will depend on the contaminants of concern and their anticipated effects on the selected key receptor species. Contaminants of concern and key receptor species will be determined as early as possible in the Stage I planning process. It is anticipated that some biota samples collected in the Stage I inventory can be saved and used in the Stage III tissue analysis study. Standardized site protocol for preserving samples for tissue analyses will be followed in those instances where it is anticipated that tissue analyses will be conducted.

Analyses for metals and radionuclides in biota may call for a greater biomass of tissue than is available through standard collection methods. At least 80 grams of material (wet weight) is needed per sample for metals analysis, and 100 grams of material is needed for radionuclides. Obtaining this amount of

sample may be impractical for some species of vegetation, periphyton, benthos and macrobenthos. It is also not the intent of the sampling program to cause unnecessary disturbance or damage to the biota communities in order to collect sufficient samples. Any decrease in sample size, however, would result in a decrease in detection limits. Sampling design should be adequate to ensure statistically valid results. DQOs for the tissue sampling program will be evaluated with respect to this determination prior to the Stage I field inventory and during design of the Stage III field sampling plan.

It is anticipated that tissue samples collected for contaminant analysis will be sent to a laboratory for the following metals and radionuclide analyses:

- Metals determined by ICP: (Ba, Cr^{+6}, Cu and Fe)
- Metals determined by GFAA: (As, Cd, Li, Pb, Se, Sr, Zn)
- Mercury
- Uranium-233, -234, -235, -238
- Americium-241
- Plutonium-239/240

Holding times, preservation methods, sample containers and field and laboratory quality control sample numbers are contained in the Quality Assurance Project Plan (QAPjP) and shown in Table 9-3. Tissue sampling protocol for biota are not necessarily standardized and may vary depending upon the laboratory conducting the analyses. Specific sample preparation requirements will be determined at the time of laboratory selection and will be added to the QAPjP.

9.8.7 Sampling Equipment

The following equipment have been identified for use in the Stage I field surveys and inventory. The following list is partial and does not include the specialized laboratory equipment necessary for toxicological analyses.

Vegetation Sampling

- 30 m and 100 m flexible tape
- Brunton compass
- 1 m rule
- 1 m^2 quadrat frames
- 1/4 m^2 quadrat frames
- Survey stakes or rebar for transect locations
- Small sledge hammer
- Site-wide standardized field forms and recording methods; clipboards

TABLE 9-3

HOLDING TIMES, PRESERVATION METHODS, AND SAMPLE CONTAINERS FOR BIOTA SAMPLES*

	Holding Time From Date Collected	Preservation Method	Container	Approximate Sample Size++
SAMPLES FOR METALS ANALYSES				
TERRESTRIAL VEGETATION				
- Metals Determined by ICP**	6 mos	Freeze & ship w/dry ice	Paper bag inserted into plastic bag and sealed	25 g
- Metals Determined by GFAA+	6 mos.	Freeze & ship w/dry ice	Paper bag inserted into plastic bag and sealed	25 g
- Hexavalent Chromium	24 hours	Freeze & ship w/dry ice	Paper bag inserted into plastic bag and sealed	25 g
- Mercury	28 days	Freeze & ship w/dry ice	Paper bag inserted into plastic bag and sealed	5 g
Periphyton, Benthic Macroinvertebrates, Fish				
- Metals Determined by ICP	6 mos.	Freeze & ship w/dry ice	Plastic	25 g
- Metals Determined by GFAA	6 mos	Freeze & ship w/dry ice	Plastic	25 g
- Hexavalent Chromium	24 hours	Freeze & ship w/dry ice	Plastic	25 g
- Mercury	28 days	Freeze & ship w/dry ice	Plastic	5 g

TABLE 9-3
(Concluded)

	Holding Time From Date Collected	Preservation Method	Container	Approximate Sample Size++
SAMPLES FOR RADIONUCLIDE ANALYSES				
Terrestrial Vegetation				
- Uranium-233, 234, 235, 238 Americium-241 Plutonium-239/240	6 mos	Freeze & ship w/dry ice	Paper bag inserted into plastic bag and sealed	100 g
Periphyton, Benthic Macroinvertebrates, Fish				
- Uranium-233, 234, 245, 238 Americium-241 Plutonium-239/240	6 mos	Freeze & ship w/dry ice	Plastic	100 g

*Source: EPA, 1987.

**ICP = Inductively Coupled Argon Plasma Emission Spectroscopy. Metals to be determined include Ba, Cr, Cu, and Fe.

+GFAA = Graphite Furnace Atomic Absorption Spectroscopy. Metals to be determined include As, Cd, Li, Pg, Se, and Sr.

++ Sample size may vary with specific laboratory requirements.

- Plant press
- Triple beam balance
- Dissecting scope
- Paper collection bags
- Drying oven

Terrestrial Wildlife Sampling

- Binoculars
- Smith live traps
- Sweep nets
- Killing jar
- Absorbent material
- Field forms and clipboard
- Pill boxes

Aquatic Sampling

- Surber sampler
- Ekman grab sampler
- Artificial substrate rack with glass slides
- Styrofoam floats
- No. 35 mesh brass screen
- No. 60 mesh brass screen
- Forceps and glass vials
- 70% ethanol
- Dry ice and sample coolers
- Permanent markers
- One gallon zip-loc plastic bags

The following equipment will be used for collection and preservation of vegetation samples for Stage III tissue analysis:

- 1 m^2 quadrat frames
- Shears for tissue clipping
- Small spade for root collection
- Knife
- One gallon plastic zip-loc bags

- Large paper sacks
- Permanent markers
- Dry ice
- Coolers
- Freezer

9.9 SCHEDULE

The following Table 9-4 presents a proposed schedule for implementation of the OU5 environmental evaluation. The schedule follows the three-stage approach presented in this environmental evaluation. While many of the tasks are sequential, the three stages will overlap in time. The months indicated in the table reflect the timeframe in which the activity will occur and not necessarily the amount of time necessary to complete the task.

The schedule is provisional and likely to change depending on the Phase I OU5 RFI/RI activity schedule as well as schedules from other operable units. A flow chart diagramming the environmental evaluation process will accompany this table. It is currently under preparation to be submitted as a separate deliverable.

TABLE 9-4

ENVIRONMENTAL EVALUATION ACTIVITY SCHEDULE

Project Start: 03/01/1991
Project Finish: 12/1992

Stage I

		Months	Year
TASK 100 -	PRELIMINARY PLANNING		
110	Determine scope	3	91
120	Identify Data Quality Objectives	3	91
130	Develop and reach consensus on site-wide criteria for:		
131	- contaminants of concern	3-4	91
132	- key receptor species	3-4	91
133	- reference areas	3-4	91
140	Coordinate with human health risk assessment efforts	3-4	91
150	Coordinate with other OU environmental evaluations	3-4	91
TASK 200 -	DATA COLLECTION AND EVALUATION		
210	Conduct literature search on Rocky Flats	3-5	91
220	Collect information from other DOE CERCLA sites	3-5	91
230	Review and integrate existing relevant site data	3-5	91
240	Analyze information on contaminant releases	3-6	91
250	Identify RI and background information data gaps	3-6	91
260	Identify preliminary contaminants of concern	3-6	91
270	Identify preliminary target species	3-6	91
280	Identify potential reference areas	3-6	91
TASK 300 -	ECOLOGICAL ASSESSMENT/FIELD INVESTIGATION		
310	Revise/update ecological field sampling plan	5-6	91
320	Conduct ecological field surveys		
321	- spring	5-6	91
322	- summer	7-8	91
323	- fall	11	91
324	- winter 2	92	
330	Conduct initial aquatic toxicity tests	6-8	91
340	Collect food habits data	3-12, 1-6	92
350	Develop food web model	3-9	91
360	Identify key receptor species	3-9	91

TABLE 9-4
(Continued)

		Month	Year
Stage II			
TASK 400 -	TOXICITY ASSESSMENT		
410	Select major and minor contaminants of concern	6-9	91
420	Compile toxicity literature	3-9	91
430	Assess toxicity of contaminants of concern on key receptor species	5-12	91
TASK 500 -	EXPOSURE ASSESSMENT		
510	Develop source-receptor pathways model	7-12	91
520	Estimate exposure concentrations for pathways	1-6	92
530	Estimate contaminant intakes for pathways	1-6	92
540	Identify potential adverse effects	1-6	92
TASK 600 -	CONTAMINATION CHARACTERIZATION		
610	Develop preliminary determination of biota contamination	1-6	92
620	Characterize potential impacts	1-6	92
630	Evaluate relevance of impacts to "no action" remedial scenario	3-8	92
640	Evaluate uncertainty	3-9	92
650	Summarize information	3-9	92
Stage III			
TASK 700 -	PLANNING		
710	Identify additional Data Quality Objectives	6-9	91
TASK 800 -	TOXICOLOGICAL FIELD INVESTIGATIONS/TOXICITY ASSESSMENT		
810	Revise/update field sampling plan	6-12	91
820	Conduct tissue analyses studies	8/91 to 6/92	
830	Conduct additional investigations	8/91 to 6/92	
840	Data validation	1-6	92
TASK 900 -	CONTAMINATION CHARACTERIZATION		
910	Incorporate site toxicity data into pathways model	10/91 to 4/92	
920	Refine pathways model	10/91 to 4/92	
930	Complete contamination assessment	6-8	92
940	Characterize impacts	1-8	92
950	Evaluate uncertainty	1-8	92
960	Summarize information	1-8	92

TABLE 9-4
(Concluded)

		Month	Year
TASK 1000 -	DRAFT REPORT	5-7	92
TASK 1100 -	DRAFT FINAL REPORT	9-10	92
TASK 1200 -	FINAL REPORT	12	92

9.10 REFERENCES

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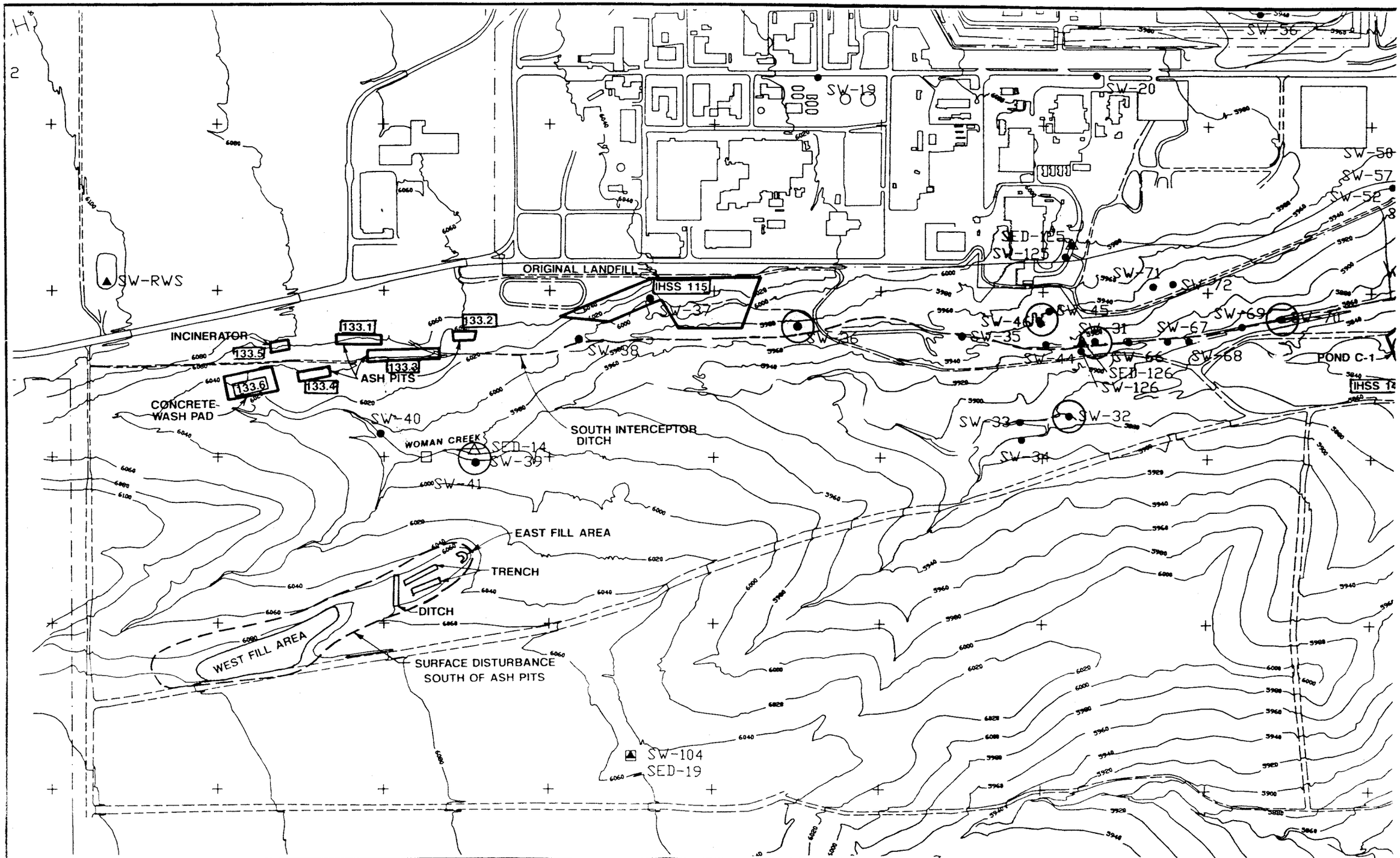
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DITCH
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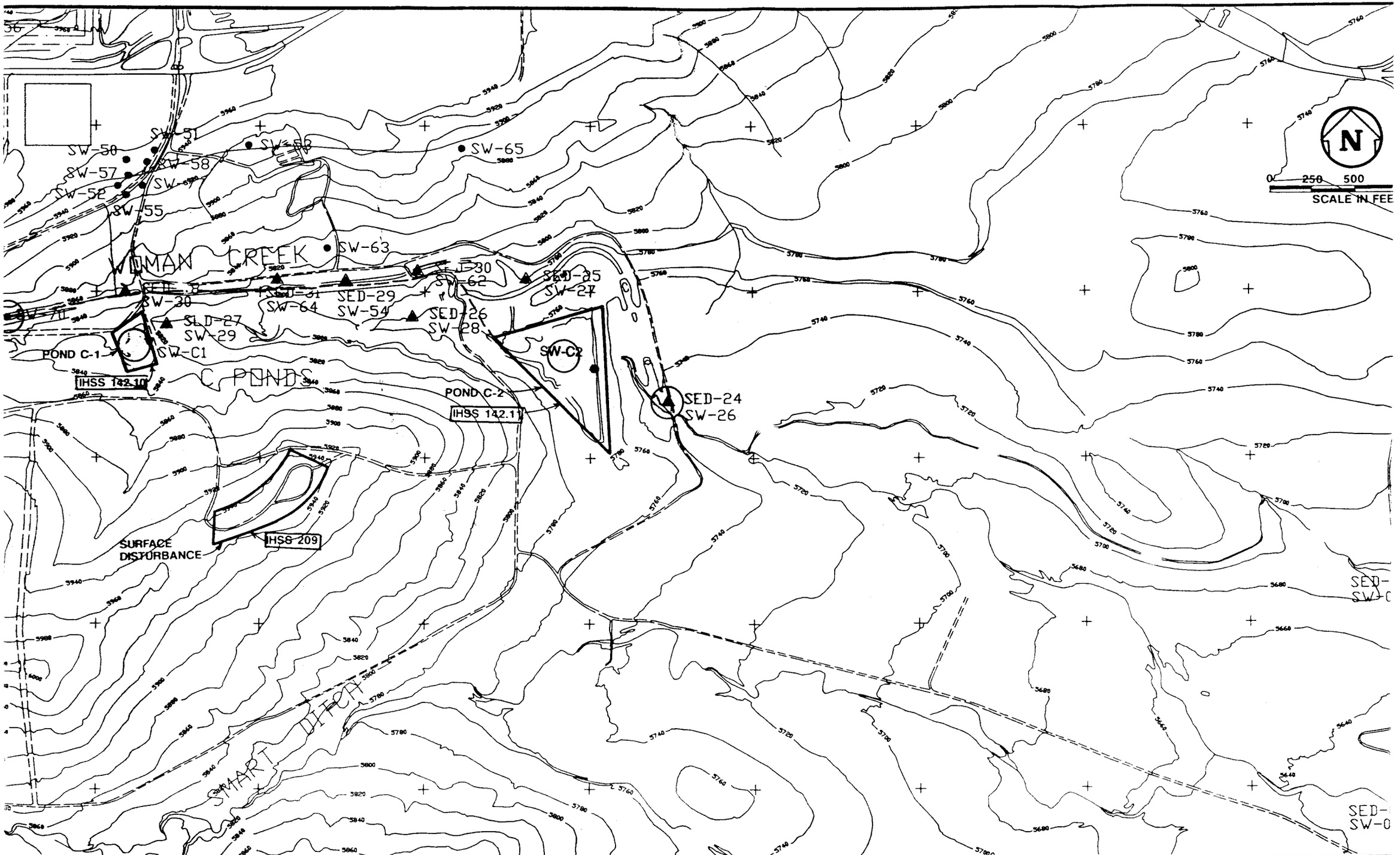
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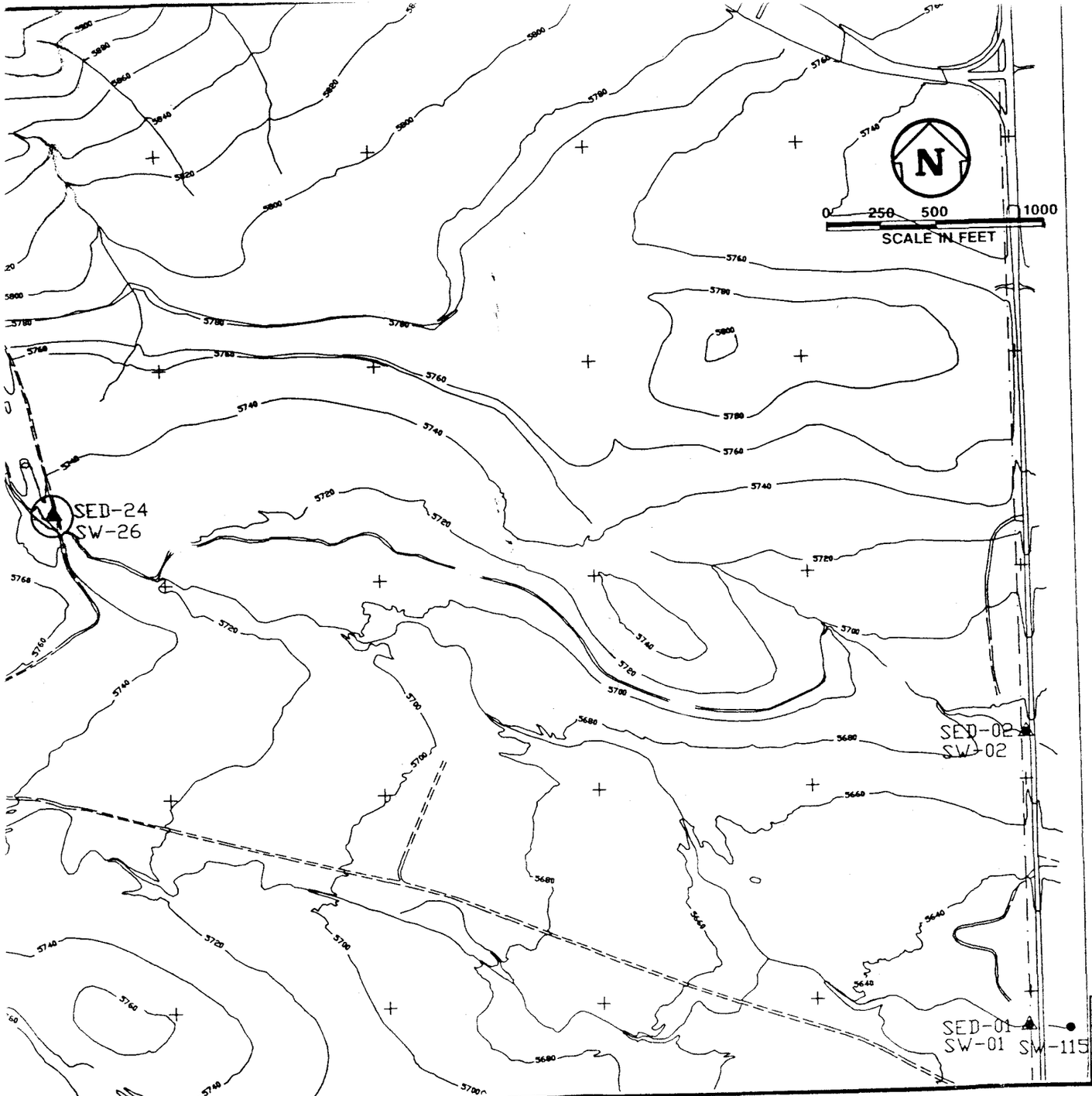

LEGEND

- ● EXISTING SURFACE WATER LOCATION
- △ EXISTING SEDIMENT SAMPLE LOCATION
- ◯ SAMPLING LOCATIONS FOR AQUATIC BIOTA

Job No.: 22506E	Figure 9-1 OPERABLE UNIT 5 AND LOCATION MAP OF THE INDIVIDUAL HAZARDOUS SUBSTANCE SITES AND AQUATIC SAMPLING LOCATIONS
Prepared by: K.A.P.	
Date: 1/30/91	WOMAN CREEK