N60200.AR.002969
NAS CECIL FIELD, FL
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DEVELOPMENT OF ECOLOGICALLY-BASED REMEDIATION GOALS FOR LEAD AND POLYCYCLIC AROMATIC HYDROCARBONS IN SOIL AT SITE 15 BLUE 10 ORDNANCE DISPOSAL AREA NAS CECIL FIELD FL

6/1/2001

TETRA TECH NUS INC

Development of Ecologically-Based Remediation Goals for Lead and PAHs in Soil

Site 15, Blue 10 Ordnance Disposal Area

Naval Air Station Cecil Field

Jacksonville, Florida

Southern Division
Naval Facilities Engineering Command

Contract Number N62467-94-D-0888

Contract Task Order 0078

June 2001

DEVELOPMENT OF ECOLOGICALLY-BASED REMEDIATION GOALS FOR LEAD AND PAHs IN SOILS

FOR

SITE 15, BLUE 10 ORDNANCE DISPOSAL AREA
NAVAL AIR STATION CECIL FIELD
JACKSONVILLE, FLORIDA

COMPREHENSIVE LONG-TERM
ENVIRONMENTAL ACTION NAVY (CLEAN) CONTRACT

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CONTRACT NUMBER N62467-94-D-0888
CONTRACT TASK ORDER 0078

JUNE 2001

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TABLE OF CONTENTS

SECTION **PAGE NO.**

1.0 INTRODUCTION 1

2.0 THE CONCEPTUAL SITE MODEL 1
2.1 HABITAT TYPES AND ECOLOGICAL RECEPTORS 1
2.2 CONTAMINANT SOURCES 3
2.3 MIGRATION PATHWAYS 3
2.4 EXPOSURE PATHWAYS 3
2.4.1 Lead 3
2.4.2 PAHs 6

3.0 ASSESSMENT AND MEASUREMENT ENDPOINTS 6
3.1 LEAD 6
3.1.1 Assessment Endpoints 6
3.1.2 Risk Questions 7
3.1.3 Measurement Endpoints 7
3.1.3.1 Survival of Soil Invertebrates 7
3.1.3.2 Diversity and Abundance of Soil Invertebrates 9
3.1.3.3 Impacts to Birds and Small Mammals 10
3.1 PAHS 11
3.2.1 Assessment Endpoints 11
3.2.2 Risk Questions 11
3.2.3 Measurement Endpoints 11
3.2.3.1 Survival of Soil Invertebrates 11
3.2.3.2 Diversity and Abundance of Soil Invertebrates 12

DEVELOPMENT OF PRGs 12
4.1 LEAD PRG DEVELOPMENT FOR SOIL INVERTEBRATES 12
4.1.1 Toxicity Tests 12
4.1.2 Diversity and Abundance of Soil Invertebrates 13
4.2 LEAD PRG DEVELOPMENT FOR BIRDS AND SMALL MAMMALS 13
4.3 PRG DEVELOPMENT FOR PAHs 17

5.0 SUMMARY 17

REFERENCES R-1

APPENDIX
A **PHASE VIII SAMPLING AND ANALYSIS WORK PLAN**

TABLES

NUMBER		PAGE NO.
1	Food Ingestion Rates in Herbivorous and Omnivorous Mammals	19
2	Exposure Parameters for Representative Ecological Receptors	20

FIGURES

NUMBER		PAGE NO.
1	Site 15 Habitat Map	21
2	Contaminant Pathways at Site 15	22
3	Isoconcentration Contours for Lead in Soil	23
4	Site 15 and Reference Site Location	24
5	Isoconcentration Contours for PAHs in Soil	25

DEVELOPMENT OF ECOLOGICALLY-BASED REMEDIATION GOALS FOR LEAD AND PAHs IN SOIL SITE 15, BLUE 10 ORDINANCE DISPOSAL AREA NAVAL AIR STATION CECIL FIELD JACKSONVILLE, FLORIDA

1.0 INTRODUCTION

Previous sampling of media at Site 15 conducted in support of an ecological risk assessment has shown that lead and polycyclic aromatic hydrocarbons (PAHs) in surface soil in some portions of the site may pose risk to ecological receptors (ABB, 1997). Additional sampling at Site 15 has further characterized locations of elevated lead and PAHs in soil at the site. Site-specific preliminary remediation goals (PRGs) for soil at Site 15 are needed so that risk managers can evaluate remedial options.

This report describes how ecologically-based PRGs will be developed for lead and PAHs at Site 15. The methodologies described herein have been approved by representatives of the Navy, the U.S. Environmental Protection Agency (EPA) Region IV, and the Florida Department of Environmental Protection in a teleconference on May 11, 2001.

The development of PRGs requires the creation of a conceptual site model that addresses the physical characteristics and ecological receptors at the site, complete exposure pathways that will be evaluated, assessment endpoints, risk questions, and measurement endpoints. Each of these topics is discussed herein.

2.0 THE CONCEPTUAL SITE MODEL

This section describes the conceptual site model for Site 15 and begins with a description of the habitats and ecological receptors at the site.

2.1 Habitat Types and Ecological Receptors

Site 15 covers approximately 85 acres in the northern portion of NAS Cecil Field. The majority of the site consists of pine flatwoods (Figure 1). This habitat type is characterized by flat topography, acidic, sandy soil, an overstory of pines, an extensive low shrub stratum, and a variable but often sparse herbaceous layer (Abrahamson and Hartnett, 1990). Planted slash pine (*Pinus elliottii*) is the dominant tree species at the site. The understory in some portions of this habitat is a thick layer of shrubs dominated by saw palmetto (*Serenoa repens*) and gallberry (*Ilex glabra*), while in other areas the understory is sparsely vegetated. A 1 to 5 inch layer of decaying organic matter (i.e., detritus, duff) covers the surface throughout most of the pine flatwoods habitat. Trees were harvested from an area at the eastern portion of the site in 1997. A large portion of the pine flatwoods south and west of the paved entrance road was

burned by a forest fire in 1999; this area was subsequently clear-cut, is now largely devoid of trees and shrubs, and consists mostly of logging debris.

Other habitats at the site include mesic pine/hardwoods, a narrow strip of floodplain forest, and a depressional area that was formerly a cypress dome swamp (Figure 1). The floodplain forest is located along a wet-weather stream that drains the southern portion of the site, and is dominated by oaks (*Quercus spp*.), red bay (*Persea borbonia*), red maple (*Acer rubrum*), sweetgum (*Liquidambar styraciflua*), and blackgum (*Nyssa sylvatica*). Major understory species here include saw palmetto, gallberry, *Vaccinium spp*., and wild grape (*Vitis rotundifolia*). The mesic pine/hardwoods habitat occurs where the floodplain forest merges with the pine flatwoods, and is composed of plants typically found in the latter two habitats. A shallow circular depression covering approximately ¾ acre is located in the eastern portion of the site. This area appears to have been a cypress dome swamp in the past, but now consists of bare ground except for a few scattered bald cypress (*Taxodium distichum*) trees. Yellow jessamine (*Gelsemium sempervirens*), myrtle-leaf holly (*Ilex myrtifolia*), and saw palmetto are scattered around the edge of the depression. The depression has been dry during site visits by Tetra Tech NUS biologists. Drainage ditches north and northwest of the site have apparently altered the hydrology, so that appreciable surface water runoff into this area no longer occurs, and the depression presumably rarely (if ever) contains surface water.

Based on several site visits by Tetra Tech NUS biologists, Site 15 appears to be typical of other pine flatwoods habitats in northern peninsular Florida. As such, the site provides habitat for several species of vertebrate receptors. Numerous bird species such as the brown-headed nuthatch (*Sitta pusilla*), prairie warbler (*Dendroica discolor*), pine warbler (*Dendroica pinus*), rufous-sided towhee (*Pipilo erythrophthalmus*), mockingbird (*Mimus polyglottus*), and red-bellied woodpecker (*Melanerpes carolinus*) have been observed on the site. Mammals such as the white-tailed deer (*Odocoileus virginianus*), gray fox (*Urocyon cinereoargenteus*), raccoon (*Procyon lotor*), gray squirrel (Sciurus carolinensis), nine-banded armadillo *(Dasypus novemcinctus*), Eastern cottontail (Sylvilagus floridanus), and Eastern mole (*Scalopus aquaticus*) are known to utilize the site. Based on current habitat and known geographic range, mammals such as the cotton mouse (*Peromyscus gossypinus*), cotton rat (*Sigmodon hispidus*), Southern short-tailed shrew (*Blarina carolinensis*), Southeastern shrew (*Sorex longirostris*), and least shrew (*Cryptotis parva*) are expected to be present. Amphibians and reptiles such as the oak toad (*Bufo quercicus*), box turtle (*Terrapene carolina*), and black racer (*Coluber constrictor*) probably occur on the site.

Previous observations at Site 15 and at nearby reference locations indicate that invertebrates are scarce in soils deeper than one to three inches below the top of the mineral horizon, presumably due to the typically low organic mater content of the sandy soils in pine flatwoods (Abrahamson and Hartnett, 1990).

However, a variety of invertebrates (e.g. beetles, spiders, centipedes, millipedes, and termites) have been observed at Site 15 in the organic duff layer and at the interface between the duff layer and mineral soil. (Note: The remaining text uses the term “soil invertebrates” to include invertebrates in the mineral soil as well as those in the organic duff layer).

2.2 Contaminant Sources

Site 15 was used as a trap and skeet range during the 1940s and 1950s. A second shooting area possibly existed south of the access road (ABB, 1997). Lead shot from the trap and skeet range is the primary source of lead contamination in soils at the site. Soil concentrations of lead are elevated in some portions of the site, with a maximum concentration of approximately 65,000 mg/kg.

A metal chamber near the center of Site 15 was used to incinerate ordnance from the mid 1960s through 1977. Ash resulting from the burned ordnance was presumably deposited in various areas in the vicinity of the burn chamber (ABB, 1997). Soil concentrations of PAHs are elevated in some portions of the site, with a maximum concentration of approximately 12,000 mg/kg. The source of elevated PAHs at the site is assumed to be the disposal of ash from the burn chamber and/or fragments of “clay pigeons” used as targets on the former trap and skeet range. A study at one trap and skeet range showed that clay pigeons were comprised of 32 percent petroleum pitch, which consisted of several PAHs (Baer et al, 1995).

2.3 Migration Pathways

Surface soil is considered to be the only significant exposure medium for ecological receptors at Site 15. Previous sampling and analyses have shown that infiltration of contaminants into groundwater and subsequent discharge of groundwater contaminants into surface water is negligible at the site (ABB, 1997). Overland flow and surface runoff are minor due to the overall flat character of the site. Furthermore, the forest cover and duff layer throughout most of the site minimizes erosion as a migration pathway. In addition, aquatic habitat at the site is negligible. A wet-weather stream is located in the southern portion of the site, and a second wet-weather stream is in the extreme western portion of the site. However, these two streams are dry except after recent rain events, and permanent aquatic habitats have not become established therein. For the above reasons, site-related contaminants are relatively stationary in soil, and soil is the only significant exposure medium.

2.4 Exposure Pathways

2.4.1 Lead

Soil invertebrates are directly exposed to lead in soil at Site 15. Terrestrial animals can be exposed to site-related lead contamination through ingestion of contaminated food items. Animals can also incidentally ingest lead in soil while grooming fur, preening feathers, digging, grazing close to the soil, or

feeding on items to which soil has adhered. Absorption of lead from the gastrointestinal tract is the primary pathway of intake for terrestrial receptors, and chronic exposure to lead can produce adverse neurological, gastrointestinal, respiratory, immunological, and reproductive (fetal and maternal) effects (Eisler, 1988).

Ingestion of lead shot can be acutely toxic to birds, but previous studies at Site 15 indicate that relatively few lead pellets remain in the soil. Specifically, 36 soil samples were collected and sieved through a No. 20 sieve to remove pelletized lead shot (ABB, 1997). Each of the samples was analyzed for lead before and after sieving. Lead concentrations in the sieved samples were within 16 percent (average difference) of the lead concentrations in the unsieved samples. The authors concluded that most of the lead shot had oxidized (ABB, 1997). Based on the ABB study, and since no pelletized lead shot has been observed by Tetra Tech NUS biologists during previous site visits, lead shot is assumed to be largely absent from surficial soils. Therefore, exposure to lead in soil at Site 15 is considered to be primarily chronic, rather than acute.

Soil invertebrates at the site undoubtedly serve as food items for vermivorous, insectivorous, and omnivorous mammals and birds that are known or expected to occur at Site 15. These mammals include the Eastern mole, nine-banded armadillo, Southern short-tailed shrew, Southeastern shrew, least shrew, cotton mouse, and others. (Note: "vermivorous" refers to worm-eating organisms. However, most animals that consume worms also consume adult and larval insects and other arthropods, and no animals at Site 15 are strictly vermivorous. Thus, the term "vermivorous/insectivorous" will be used herein to denote animals whose primary prey is a combination of worms, insects, and other arthropods). Numerous species of birds prey upon soil invertebrates at the site; examples include the bobwhite quail (*Colinus virginianus)*, mockingbird, American robin (*Turdus migratorius*), and rufous-sided towhee. Invertebrates in lead-contaminated soils are known to accumulate lead (Eisler, 1988), and the exposure pathway of soil to invertebrates to animals that prey on invertebrates is assumed to be the primary pathway of exposure to lead at Site 15 (Figure 2). This pathway includes toxicity to soil invertebrates and toxicity to birds and mammals that prey upon soil invertebrates.

The contaminant pathway at Site 15 is admittedly more complex than the simplified pathway shown in Figure 2. For example, lead in soil can reduce plant growth and photosynthesis. Lead in soil can also be taken up via plant roots, transported through the vascular system, and deposited in foliage; the foliage can then provide lead exposure to herbivorous mammals as well as to insects and subsequently to insectivorous birds and mammals. Senescent foliage on the ground is colonized by fungi, which are foraged upon by mites and other tiny arthropods; these are preyed upon by larger arthropods such as nematodes and spiders, which are consumed by birds and mammals. Reptiles and amphibians can be exposed to lead through activities such as consuming lead-contaminated insects and other organisms.

Upper level carnivores such as hawks, owls, foxes, and weasels can ingest lead through the consumption of lead-contaminated prey items (e.g., reptiles, amphibians, vermivorous/insectivorous birds and mammals). As EPA (1997) points out, however, it is frequently possible to reduce the number of exposure pathways that need to be evaluated to one or a few critical exposure pathways. Furthermore, it is not practical or necessary to directly evaluate risks to all of the individual components of the ecosystem (EPA, 1997). The exposure pathway of soil to invertebrates to animals that prey on invertebrates represents a sensitive and ecologically important pathway. It is sensitive because soil invertebrates are in constant contact with the contaminated medium (*i.e.*, soil), and invertebrates are known to be vulnerable to lead toxicity. This pathway is ecologically important because site-related lead toxicity can adversely impact not only the invertebrate community, but can also adversely impact populations of vermivorous/insectivorous birds and mammals. Reduced populations of vermivorous/insectivorous birds and mammals would result in fewer prey items for carnivorous animals that consume the vermivorous/insectivorous animals, and thus, populations of carnivorous animals might be reduced as an indirect result of impacts to the invertebrate community.

The pathway of soil to vegetation to herbivorous animals is likely complete, but lead ingestion for invertebrate-eating mammals and birds will be higher than lead ingestion for herbivorous and omnivorous mammals. At least two factors are responsible for this. First, lead accumulation in plants is usually less than accumulation in invertebrates (Sample et al, 1998a; ORNL, 1998). Second, food ingestion rates of insectivorous/vermivorous mammals such as shrews and moles are greater than food ingestion rates of herbivorous and omnivorous mammals (Table 1). Moles and shrews have high metabolic rates (Brown, 1997), so their food ingestion rates are greater than food ingestion rates of herbivorous and omnivorous rodents. Therefore, the soil-to-herbivore pathway will not be investigated because the remediation goals will be developed using the more highly exposed receptors.

Lead usually does not biomagnify in food chains (Eisler, 1988), and lead concentrations in prey items of vermivorous/insectivorous mammals and birds will be greater than in prey items of large carnivores. For example, mean and median soil-to-earthworm uptake factors for lead were 3.342 and 0.266, respectively, in a review of several published literature studies (Sample et al, 1998a), while mean and median soil-to-small mammal uptake factors for lead were 0.1615 and 0.1054, respectively, in a review of several published literature studies (Sample et al, 1998b). Ingestion of food containing biologically incorporated lead is unlikely to cause clinical signs of toxicity in birds of prey (Eisler, 1988; Custer *et al*, 1984; Henny *et al*, 1994). Lead tends to be deposited in bones, but bones are not digested by owls, and are only partially digested by hawks and falcons before being regurgitated in pellets (Henny *et al*, 1994). In summary, the soil-to-carnivore pathway will not be investigated because the remediation goals will be developed using more highly exposed and sensitive receptors.

2.4.2 PAHs

PAHs show little tendency to biomagnify in the food web (Eisler, 1987). U.S. EPA Region IV considers the potential toxicity of PAHs via the terrestrial food web to be generally negligible unless PAHs are present at extremely high concentrations (i.e., percent levels: 10,000 mg/kg) in soil. Risks to human health from carcinogenic PAHs at Site 15 have been evaluated, and preliminary human-health remediation goals have been generated; the maximum concentration of total PAHs expected at Site 15 after human health-based remediation of carcinogenic PAHs is 746 mg/kg. Because this value is well below percent levels, toxicity to upper level receptors is not expected and will not be further evaluated.

Some PAHs are toxic to soil invertebrates at concentrations that will remain after the human health remediation. For example, in a toxicity study of fluorene, a concentration of 170 mg/kg was lethal to 50 percent of the earthworms used in the test (Neuhauser *et al*, 1986). Since soil invertebrates are primary prey items for a variety of birds and mammals, reduced populations of soil invertebrates could impact populations of upper level receptors by decreasing their food supply. The soil-to-invertebrate pathway is assumed to be the primary pathway of exposure to PAHs at Site 15 (Figure 2). Adverse impacts to plants from PAHs are rare (Eisler, 1987) and risks to plants from PAHs will not be evaluated.

3.0 ASSESSMENT AND MEASUREMENT ENDPOINTS

An assessment endpoint is “an explicit expression of the environmental value that is to be protected”, while a measurement endpoint is “a measurable ecological characteristic that is related to the valued characteristic chosen as the assessment endpoint” (EPA, 1997). Measurement endpoints represent the assessment endpoints chosen for a site, and are measures of biological effects (EPA, 1997). The appropriate selection of assessment and measurement endpoints is critical for the evaluation of ecological risks and the establishment of remediation goals. A discussion of assessment endpoints, risk questions, and measurement endpoints for lead is presented below, and is followed by a similar discussion for PAHs.

3.1 <u>Lead</u>

3.1.1 Assessment Endpoints

Based on the conceptual model for Site 15, assessment endpoints for lead have been developed for soil invertebrates, birds, and mammals. Soil invertebrates serve as prey for rodents, shrews, moles, and birds, which are preyed upon by carnivores such as hawks, owls, foxes, weasels, and bobcats. Thus, soil invertebrates are vital components of the ecosystem at Site 15. With this in mind, the first assessment endpoint for lead at Site 15 is as follows:

- Survival of soil invertebrate populations typical in pine flatwoods habitat.

As mentioned above, birds and small mammals serve as prey items for carnivores such as hawks, owls, foxes, weasels, and bobcats. Thus, contaminant-related reduced populations of birds and small mammals could result in reduced populations of receptors higher in the food chain. With this in mind, the two remaining assessment endpoints for lead at Site 15 are as follows:

- Growth and reproduction of residential and migratory avian populations typical in pine flatwoods habitat.
- Growth and reproduction of mammalian populations typical in pine flatwoods habitat.

An important distinction pertaining to the latter two assessment endpoints above is that lead in soil could potentially cause adverse impacts to predators *directly* through ingestion of contaminated prey and *indirectly* through a reduced food supply (which could result from a toxicity-related decline in prey populations).

3.1.2 Risk Questions

Ecological risk questions are based on assessment endpoints and provide a basis for developing the study design (EPA, 1997). Based on the conceptual model and the assessment endpoints, the primary risk questions involving lead contamination at Site 15 are as follows:

- At what soil concentration does lead at Site 15 cause (or potentially cause) reduced survival of soil invertebrates?
- At what soil concentration does lead at Site 15 cause (or potentially cause) reduced diversity and abundance of soil invertebrates?
- At what soil concentration does the ingestion of lead at Site 15 cause (or potentially cause) adverse effects to avian and mammalian receptors?

3.1.3 Measurement Endpoints

The measurement endpoint for each of the lead-associated risk questions is provided below.

3.1.3.1 Survival of Soil Invertebrates

The measurement endpoint for the first risk question in Section 3.1.2 will be the survival of earthworms in 14-day laboratory toxicity tests using soil samples collected from Site 15 and a reference area. The purpose of the toxicity tests will be to determine if lead concentrations in site soil samples are correlated with mortality of the organisms associated with this assessment endpoint (i.e., soil invertebrates). The survival of laboratory-reared earthworms (*Eisenia fetida*) in site soil samples will be evaluated following standardized methods (ASTM, 1998). Survival will be measured at 14 days, since this is the typical duration of toxicity tests using *Eisenia fetida* when mortality is the endpoint (ASTM, 1998). Although

laboratory toxicity tests do not reflect actual field conditions, their use allows the control of factors such as temperature, moisture, predation, etc. that could confound conclusions regarding site-related contaminants.

Earthworms will be used to represent other soil invertebrates that occur on the site, since toxicity test methodologies using earthworms have been standardized, whereas toxicity tests using other invertebrates have not. Unfortunately, there are no data in the literature on the comparability of earthworms versus other terrestrial invertebrates regarding lead toxicity. However, earthworms are generally considered to be representative of soil invertebrates in ecological risk assessments (Sample *et al*, 1997). Earthworms have been shown to be more sensitive than insects to chemicals such as cadmium and PCBs (Parmelee *et al*, 1997), and many researchers have proposed that conclusions derived from earthworms should apply at least somewhat to other soil invertebrates (Beyer and Stafford, 1993). The uncertainty resulting from the lack of data on the comparability between earthworms and insects will be partially mitigated by the measurement endpoint discussed in Section 3.1.3.2.

Twelve samples will be collected from Site 15 for toxicity tests. This number of samples is expected to be sufficient to determine if lead concentrations in site soils are correlated with survival of earthworms in the toxicity tests, and will provide sufficient data for the measurement endpoint discussed in Section 3.1.3.2. Lead chemistry data from previous sampling events at Site 15 were used to identify a gradient of lead concentrations in surface soil represented by four intervals: 197 to 499 mg/kg, 500 to 999 mg/kg, 1,000 to 4,999 mg/kg, and >5,000 mg/kg. The 197 mg/kg value is the concentration indicative of background soil concentrations of lead at NAS Cecil Field (NAS Cecil Field Inorganic Background Data Set; HLA, 1998). The remaining interval boundaries were selected based on lead toxicity data in the literature. Existing PAH data were evaluated to select sampling locations with minimal expected PAH concentrations in order to minimize the possibility that PAHs would confound any conclusions regarding lead toxicity. Three soil samples in each lead concentration interval and three samples from the reference area will be collected for a total of 15 soil samples (Figure 3).

Soil samples collected for toxicity tests at Site 15 and at the reference location will consist of the first three inches of mineral soil plus the overlying duff layer atop the mineral horizon, since this is the predominant stratum in which soil invertebrates exist at the site. Each soil sample will consist of five composites from throughout 15 ft x 15 ft quadrats. The five composites will be homogenized in the field and split into sub-samples for chemical analyses and toxicity tests. Soil samples will be subjected to a quick laboratory turnaround (7 days maximum) for lead and total PAH analyses. Toxicity tests using Site 15 samples will be analyzed only when lead concentrations exceed 197 mg/kg (NAS Cecil background).

As explained above, the 12 locations from which samples will be collected for toxicity tests at Site 15 (Figure 3) are based on lead data from previous sampling events. However, most existing soil lead data from Site 15 are based on samples that were composites of 0 to 12 inches below the surface, while samples in the current study will consist of the upper 3 inches of soil plus the overlying duff layer. Therefore, the lead concentrations in the samples to be collected for toxicity tests could be greater or less than concentrations suggested by existing lead data. Because of this uncertainty, and since samples are desired from a gradient of lead concentrations, field-portable x-ray fluorescence (XRF) equipment will be utilized to select the sampling locations. Thus, the locations shown in Figure 3 can be considered as provisional.

The three reference samples will be collected from a forested area approximately 2,000 feet east of Site 15 (Figure 4). Existing soil types, vegetation, and habitats in this area are similar to those at Site 15. The XRF will be used to select three sample locations where lead concentrations are at or below 197 mg/kg (NAS Cecil background).

As explained above, the 12 soil samples collected for toxicity tests and chemical analyses at Site 15 will consist of the first three inches of mineral soil plus the overlying duff layer. At each of the 12 sampling locations, one additional soil sample will be collected and archived for possible future analyses of lead. These additional samples will consist of mineral soil only (no overlying duff) and will be composites of 0 to 12 inches below the surface.

3.1.3.2 Diversity and Abundance of Soil Invertebrates

The diversity and abundance of soil invertebrates will be evaluated by collecting soil invertebrates from a gradient of lead concentrations at Site 15 and from three locations at a reference area. The soil invertebrates will be collected simultaneously with, and from the same soil/duff stratum at the same 15 locations, as the soil samples that are collected for the soil toxicity tests (Section 3.1.3.1). After removing overlying leaves, limbs, and debris from the surface, invertebrates in the duff layer atop the mineral horizon will be collected by hand during a careful examination of surface litter from the 15 ft x 15 ft sampling quadrats. Invertebrate species that are not normally in close contact with soil and/or duff (e.g., butterflies, dragonflies, ticks) will not be collected.

Invertebrates will be classified to the genus level to the maximum practical extent. When this level of classification becomes excessively problematic for a qualified entomologist/taxonomist, classification to family level will be acceptable. Earthworms, however, will be classified simply as “earthworms”. The number of invertebrates within each genus or family will be recorded at each 15 x 15 ft quadrat. Ants will not be enumerated; however, their presence will be noted and the number of mounds or colonies within each quadrat will be recorded. Habitat characteristics such as soil type, duff thickness, plant species

composition, and percent coverage of overstory, midstory, and understory layers of trees, shrubs, etc. will be recorded. Attempts will be made to select sampling locations such that habitat characteristics are similar among stations.

Many factors other than chemistry can affect the diversity and abundance of soil invertebrates. These factors include vegetation species and abundance in the vicinity, soil litter characteristics, amount of sunlight, weather events, and soil characteristics such as moisture, acidity, and organic matter content of the soil. In addition, since invertebrate populations vary seasonally, soil invertebrate surveys are frequently conducted throughout one full year, and often for two years. Surface crawling invertebrates are generally collected in pitfall traps made from buried cups, cans, jars, or troughs. Pitfall traps are usually checked once or twice each day, since less frequent collection allows samples to be preyed upon by organisms such as birds, small mammals, and fire ants. Invertebrates are often sorted into trophic groups such as fungivores, bacterivores, herbivores, omnivores, and predators. The invertebrate collection proposed for Site 15 is not intended to be such an exhaustive investment of time and resources. Instead, the diversity and abundance data will provide a “snapshot” of conditions during the approximately 10-day period in which sampling activities are conducted.

3.1.3.3 Impacts to Birds and Small Mammals

The measurement endpoint for determining the soil concentration at which the ingestion of lead causes adverse effects to avian and mammalian receptors will be concentrations of lead in soil and in soil invertebrates collected from the site. The purpose of the invertebrate tissue analyses is to measure lead concentrations in prey items consumed by the species associated with the assessment endpoints. This will allow the development of soil-to-invertebrate bioaccumulation factors (BAFs) for Site 15 with which soil remedial goals can be calculated (Section 4.1).

Lead concentrations will be measured in soil invertebrates and in co-located soil samples. The soil samples will be sub-samples of those collected for the soil toxicity tests (see Section 3.1.3.1), and the invertebrate samples will be those collected and described in Section 3.1.3.2. Thus, 15 soil and 15 invertebrate samples will be collected. The analytical laboratory selected for tissue analyses indicates that approximately 1.3 grams (g) of tissue will be required for lead analyses. Invertebrate tissues from Site 15 samples will be analyzed only when lead concentrations in co-located soil samples from Site 15 exceed 197 mg/kg (NAS Cecil background).

As mentioned in Section 3.1.3.1, soil samples will be collected from the top three inches of mineral soil and the duff atop the mineral soil. Since invertebrates are scarce in Site 15 soil at depths greater than approximately three inches below the surface, lead at deeper depths poses negligible risk to soil invertebrates and organisms that consume these invertebrates.

3.2 PAHs

3.2.1 Assessment Endpoints

As discussed in Section 2.4.2, the soil-to-invertebrate pathway is assumed to be the primary pathway of exposure to PAHs at Site 15. Invertebrates in soil serve as prey items for birds and many small mammals. Therefore, even though PAH-related toxicity to upper level receptors via the terrestrial food web is negligible, PAH-related toxicity to soil invertebrates could result in reduced populations of vermivorous/insectivorous birds and mammals at the site, which could result in reduced populations of carnivorous birds and mammals. For this reason, the assessment endpoint for PAHs at Site 15 is as follows:

- Survival of soil invertebrate populations typical in pine flatwoods habitat.

3.2.2 Risk Questions

Based on the conceptual model and the above assessment endpoints, the primary risk questions involving PAH contamination at Site 15 are as follows:

- At what soil concentrations do PAHs at Site 15 cause (or potentially cause) reduced survival of soil invertebrates?
- At what soil concentration do PAHs at Site 15 cause (or potentially cause) reduced diversity and abundance of soil invertebrates?

3.2.3 Measurement Endpoints

The measurement endpoint for each of the lead-associated risk questions is provided below.

3.2.3.1 Survival of Soil Invertebrates

The measurement endpoint for the first risk question in Section 3.2.2 will be the survival of earthworms in 14-day laboratory toxicity tests using soil samples collected from Site 15 and a reference area. The purpose of the soil toxicity tests will be to determine if PAH concentrations in site soil samples are correlated with mortality of the species associated with the assessment endpoint.

Fourteen-day survival of laboratory-reared earthworms (*Eisenia fetida*) in site soil samples will be evaluated following standardized methods (ASTM, 1998). The appropriateness of laboratory toxicity tests, and of using earthworms to represent other soil invertebrates, was discussed in Section 3.1.3.1.

Twelve samples will be collected from areas of elevated PAHs for toxicity tests. This number of samples is expected to be sufficient to determine if PAH concentrations in site soils are correlated with survival of earthworms in the toxicity tests. PAH data from previous sampling events were used to generate a

gradient of total PAH concentrations in surface soil represented by four intervals: 20,000 to 49,999 µg/kg, 50,000 to 499,999 µg/kg, and > 500,000 µg/kg.

Three soil samples in each PAH concentration interval and three samples from the previously mentioned reference area will be collected for a total of 15 soil samples (Figure 5). Existing lead data were evaluated to select locations with minimal expected lead concentrations so as to minimize the possibility that lead would confound any conclusions regarding PAH toxicity. Soil samples will be subjected to a quick laboratory turnaround (7 days maximum) for analyses of total PAHs and lead.

Soil samples will consist of the first three inches of mineral soil plus the duff layer atop the mineral horizon. Soil samples will consist of five composites from throughout 15 ft x 15 ft quadrats, and will be homogenized in the field and split into sub-samples for chemical analyses and toxicity tests.

3.2.3.2 Diversity and Abundance of Soil Invertebrates

The diversity and abundance of soil invertebrates will be measured by collecting soil invertebrates from a gradient of PAH concentrations at Site 15 and from three locations at a reference area. The diversity and abundance of invertebrates in the samples from Site 15 will then be compared to the results from the reference area. The methodology to be employed for data collection and evaluation will be the same as that discussed in Section 3.1.3.2.

4.0 DEVELOPMENT OF PRGs

If lead concentrations in all soil samples collected for this study are less than 197 mg/kg (NAS Cecil background value; HLA, 1998) further evaluation of lead and concomitant calculation of remediation goals will be considered unnecessary. The section below describes how PRGs will be developed for lead, and is followed by a description of how PRGs will be developed for PAHs.

4.1 Lead PRG Development for Soil Invertebrates

4.1.1 Toxicity Tests

The toxicity test data will be statistically analyzed to determine whether there are significant differences between survival in the Site 15 soil samples versus survival in the reference samples. The survival data will be analyzed using a commercial computer program, the details of which will be provided by the laboratory selected for the toxicity tests. All statistical analyses will be performed at the 0.05 probability level. Backward elimination stepwise regression analyses will be used to determine which parameters account for the variability in survival between samples. Independent variables included in the regression analyses will be lead concentrations, PAH concentrations, soil pH, soil cation exchange capacity (CEC), soil total organic carbon (TOC), and soil grain size.

If the lead concentrations are correlated with earthworm mortality in the toxicity tests, protective concentrations within the exposure-response curve can be identified. Specifically, the protective concentration is bounded by the no-observed-effect-concentration (NOEC) and the lowest-observed-effect-concentration (LOEC) from the toxicity tests. Therefore, remedial goals for consideration by the risk managers will consist of the NOEC and LOEC. If lead concentrations are not correlated with earthworm survival, remedial goals associated with the assessment endpoint for invertebrates will be evaluated using all available data in a lines of evidence approach.

4.1.2 Diversity and Abundance of Soil Invertebrates

The data collection methods for invertebrate diversity and abundance at the site are not designed for definitive statistical analyses. Instead, the analyses of diversity and abundance data will be qualitative only. Differences among locations along lead gradients, PAH gradients, and at reference locations will be evaluated by visually examining bar graphs of the data. If the diversity or abundance differs among sampling locations, all available data for the samples in question (*e.g.*, soil lead concentration, habitat characteristics) will be evaluated in a "lines of evidence" approach to assess the likelihood that site-related lead toxicity is occurring. No "decision point" will be generated by this qualitative analysis. Instead, the data will assist the risk managers in their evaluation of remedial options for Site 15.

4.2 <u>Lead PRG Development for Birds and Small Mammals</u>

The equation below describes potential risks to birds and mammals that prey upon soil invertebrates. The equation combines the hazard from the incidental ingestion of soil and the hazard from ingestion of contaminated prey.

$$HQ = [(C_S \times AUF \times SA_S \times AF \times F)/(TRV \times WR \times CF)] + [(C_{prey} \times FA \times AUF \times AF \times F)/(TRV \times WR \times CF)] \quad (1)$$

where:

HQ	=	hazard quotient
C_S	=	lead concentration in soil (mg/kg)
AUF	=	area use factor (portion of home range that overlaps impacted area)
SA_S	=	soil as a portion of diet
AF	=	absorption faction (unitless)
F	=	total amount of food plus soil consumed (mg/day)
TRV	=	toxicity reference value for lead (mg/kg/day)
WR	=	weight of receptor (kg)
CF	=	conversion factor (kg to mg)
FA	=	portion of diet consisting of invertebrates (1.0 minus soil portion of diet)
C_{prey}	=	lead concentration in invertebrates (mg/kg)

Equation # 1 will be used to calculate soil concentrations (i.e., soil PRGs) that pose acceptable risk to birds and mammals that prey upon soil invertebrates at Site 15. To do this, the lead concentration in invertebrates (C_{prey} in equation # 1) must be expressed as a function of the lead concentration in soil. Thus, C_{prey} is rewritten as C_S x BAF, where BAF is the soil-to-invertebrate bioaccumulation factor. By rearranging equation # 1 to solve for C_s, and setting the hazard quotient equal to 1.0, remediation goals will be calculated as follows:

$$C_S = \frac{TRV \times WR \times CF}{(AUF \times AF \times F) \times (SA_S + BAF \times FA)} \qquad (2)$$

The least shrew will be used to represent mammals that prey upon soil invertebrates at Site 15, and the northern mockingbird will be used to represent birds that prey upon soil invertebrates. These two species have a high probability of exposure to lead in soil at the site based on their diet and habitat preferences.

The northern mockingbird is a familiar songbird known to be present at Site 15. Mockingbirds in Florida are non-migratory and highly territorial throughout the year. Body mass averages 49 g (Derrickson and Breitwisch, 1992). The diet of adult mockingbirds is about 50 percent invertebrates (especially beetles, ants, bees, grasshoppers), and 50 percent fruit. The proportion of animal prey in the diet increases to approximately 85 percent during the breeding season and decreases in winter to approximately 13 percent (Derrickson and Breitwisch, 1992). Using Nagy's (1987) equation for passerine birds (commonly known as "song birds"), the expected food consumption for a mockingbird is 10.9 g dry mass/day. This equates to 37.6 g fresh mass/day based on 71 percent moisture content in food items. Average territory sizes of mockingbirds in south-central Florida varied from 0.31 ha (0.8 acres) in winter to 1.27 ha (3.1 acres) during the May and June breeding season (Derrickson and Breitwisch 1992).

The least shrew inhabits pine flatwoods and other habitats in Florida (Abrahamson and Hartnett, 1990; Brown, 1997), and is expected to be present at Site 15. It weighs about 3.5 to 6.5 g (Choate et al, 1994). This species uses runways and burrows of other animals, but also makes its own tunnels in loose, soft soils. Least shrews consume large numbers of insects and other invertebrates, and are food items for predators such as owls, hawks, weasels, and skunks (Brown, 1997). Using Nagy's (1987) equation for mammals, the expected food consumption of the least shrew is 0.954 g dry mass/day. This equates to 3.3 g fresh mass/day based on 71 percent moisture content in food items. The 71 percent moisture value is the average of moisture contents in earthworms (84 percent), crickets and grasshoppers (69 percent) and adult beetles (61 percent) (EPA, 1993). Home ranges for the least shrew usually vary from approximately 0.4-1.4 ha (1-3.5 acres) (Choate and Fleharty, 1973) but home ranges in some studies have been reported to be as small as 0.5 acre (Choate et al, 1994).

The BAF term in equation # 2, expressed as mg lead/kg tissue ÷ mg lead/kg soil, will be derived from lead concentrations in the 12 soil and corresponding invertebrate samples described in Section 3.1.3.3. Regression analyses will be used to derive the BAF. It is possible, however, that the correlation of soil and invertebrate lead concentrations will be poor. This could result from variable invertebrate composition among samples, or from other factors. If the correlation of soil and invertebrate lead concentrations is poor, the BAF used in equation # 2 will be represented by the mean of the BAFs derived from the 12 individual soil and corresponding invertebrate samples. The maximum BAF from the 12-sample data set will also be used to derive a worst case PRG.

Exposure parameters for the WR and F terms to be used in the above equation for the least shrew and mockingbird are summarized in Table 2.

An accurate SA_s term in equation # 2 is difficult to determine for the shrew. EPA (2000) estimates that three percent of a shrew's diet is soil. This value is the 90th percentile of data from analyses of gastrointestinal (GI) tracts of short-tailed shrews (*Blarina spp.*) collected in an area where earthworms were plentiful (EPA 2000; Sample, 2001), and thus, the shrews probably fed heavily on earthworms. Wildlife species whose diets consist largely of earthworms generally have high soil ingestion rates (EPA, 1993), since earthworms are typically 20-30 percent soil by weight (Beyer *et al*, 1994). Based on previous site visits, arthropods such as beetles, centipedes and millipedes probably comprise a considerably greater portion of the diets of small mammals than do earthworms. Soil ingestion rates for shrews at Site 15 cannot be quantified with existing data, but are probably less than the literature values for shrews. A value of 0.015 will be used as the SA_s term for the shrew; this value is approximately the mean (0.0156) of data for the short tailed shrew in EPA (2000), and appears to be a reasonable approximation based on the factors discussed above.

For similar reasons, an accurate soil ingestion rate for mockingbirds at Site 15 cannot be quantified with existing data. The soil ingestion rate in Table 2 for the mockingbird is based on GI tract data for the American woodcock (*Scolopax minor*), whose diet consists largely of earthworms and was 99 percent earthworms in one study (Beyer *et al*, 1994; EPA, 1993). The SA_s term in equation # 2 for the mockingbird will be assigned two values. In one scenario, a value of 0.02 will be used as the SA_s term for the mockingbird, and is derived following the approach of Sample and Suter (1994). Specifically, if the diet of the woodcock is 99 percent earthworms and 10.4 percent of the woodcock diet is soil (Beyer *et al*, 1994), then a mockingbird consuming 20 percent earthworms (a conservative upper estimate for Site 15), will consume 2 percent soil. In the second scenario, a value of 0.093 (9.3 percent) will be used as the SA_s term for the mockingbird. This value is the soil ingestion rate for the wild turkey (*Meleagris gallopavo*) based on data presented by Beyer *et al* (1994). Although the wild turkey is much larger than the

mockingbird, prey items for these two species are similar, and both species forage by visually locating prey in the soil litter.

The area use factor in equation # 2, calculated as the portion of the representative receptor's home range that overlaps the impacted area, will be assigned a value of 1.0 for the shrew and mockingbird. This assumes that the receptors spend 100 percent of their life on the site. This is a valid assumption for the least shrew, since its home range is 3.5 acres or less. Unfortunately, home range data for the mockingbird were not available. As discussed above, average territory sizes for this bird range from 0.8 to 3.1 acres. The term "territory" refers to the area occupied by an animal or group of animals that is forcibly defended against by intruders of the same species. The home range is the area within which an animal normally spends all, or most, of its time in the course of a season (Dasmann, 1981), and home ranges of birds are usually larger than their territories. For this evaluation, it will be conservatively assumed that Site 15 encompasses the home range of the mockingbird.

No-observed-adverse-effect-levels (NOAELs) and lowest-observed-adverse-effect-levels (LOAELs) that could be used as TRVs in equation # 2 cover a wide range of values. Screening level ecological risk assessments often use NOAELs to identify contaminants of concern for ecological receptors. NOAELs are conservative because they represent the lowest dose that produces "no effect" in a toxicity study, or in a database of several toxicity studies. The use of a NOAEL as a threshold toxicity value estimates a point below which effects are unlikely, and above which effects are uncertain. Hence their value in screening-level risk assessments. The uncertainty associated with site-related doses that lie between the NOAEL and LOAEL is often not acceptable for setting PRGs, because of the expense and habitat disruption that is often involved in remediation to these PRGs. In order to avoid unnecessary remediation, LOAELs are often used to set PRGs. LOAELs, when used as threshold toxicity values, estimate points above which effects are likely, and below which effects are uncertain. LOAELs reflect the most sensitive species and the most sensitive appropriate endpoints available, and therefore a measure of conservativeness is retained. The results of a literature search for lead TRVs have previously been presented to the NAS Cecil Field Partnering Team. Based on the results of the literature search, the NAS Cecil Field Partnering Team has approved the following values as TRVs for lead. A LOAEL of 11.3 mg/kg/day will be used as the avian TRV. This value is based on reduced egg hatching in a reproduction study in which Japanese quail (a laboratory surrogate for avian species at Site 15) were exposed to lead in their diet for 12 weeks (Edens et al., 1976). A LOAEL of 80 mg/kg/day will be used as the mammal TRV. This value is based on reduced offspring weights and kidney damage in offspring and was derived from a one-year reproduction study in which three generations of rats were exposed to lead in their diet (Azar et al., 1973).

The bioavailability of ingested lead (i.e., the absorption fraction [AF] in equation # 2) refers to the portion of lead that is absorbed from the gastrointestinal tract. An AF of 1.0 (100 percent) will be used in the most conservative PRG scenario. The actual bioavailability of lead after ingestion depends upon a variety of factors, including the chemical form of lead, the species of organism, and the age, sex, and nutritional status of the individual (Eisler, 1988). Most toxicity studies of dietary lead exposure (including the two cited for the LOAEL values) used lead acetate as a test substance. Lead acetate is considered to be 100 percent bioavailable (Wilson and Davies, 1993). Lead in oyster meat was 69-75% percent bioavailable relative to lead acetate when mixed in a standard bird diet and fed to Japanese quail (Stone *et al*, 1981). Absorption rates for lead in other food items of birds and small mammals were not available, but are probably less than 100 percent. Thus, using an AF of 1.0 in equation # 2 will overestimate the potential risks of lead ingestion under field conditions. A less conservative value of 72 percent (the average of values in the Stone et al [1981] study) will be used to represent the AF in equation # 2 for each of the representative receptors. This will result in a range of PRGs for consideration by the risk managers.

The total food consumption (F) used in equation # 2 for the mockingbird will be assigned two values. In the most conservative scenario, the non-soil portion of the mockingbird's diet will be assumed to consist of 100 percent invertebrates. However, the average diet of adult mockingbirds is about 50 percent invertebrates and 50 percent fruit. Therefore, a second PRG will be generated by assuming that the non-soil portion of the mockingbird's diet consists of 50 percent invertebrates and 50 percent fruit. In this scenario, lead will be assumed to be absent in the fruit portion of the diet. Within above-ground tissues, concentrations of lead in plants are higher in stems than in leaves, and are higher in leaves than in reproductive tissues. Lead is rarely transferred to reproductive organs in plants (Morel, 1997). Edible portions of vegetables (*e.g.*, green beans, corn, tomatoes) grown in sandy soils amended with four sewage sludges showed negligible accumulation of lead, while leaves of the same plants accumulated lead at concentrations considered to be toxic to humans (Keefer *et al*, 1986). Therefore, based on available data, the contribution of lead in berries and seeds appears to be insignificant, and the collection and analyses of berries and seeds at the site does not appear to be warranted.

4.3 PRG Development for PAHs

Since soil invertebrates are the primary receptors at risk from PAHs at the site, the development of an associated remedial goal follows the procedure described for lead in Section 4.1. The only difference is that an NOEC and LOEC for PAHs (rather than lead) will be generated.

5.0 SUMMARY

Previous sampling of media at Site 15 indicates that lead and PAHs in surface soil in some portions of the site may pose risk to ecological receptors. Site-specific PRGs for lead and PAHs in soil at Site 15 are

needed for risk managers to evaluate remedial options at the site. Based on the toxicological characteristics of lead and PAHs, and on the physical characteristics and ecological receptors at Site 15, a site conceptual model was developed through which ecological assessment endpoints and measurement endpoints were established. The primary receptors at risk from lead are soil invertebrates, and birds and mammals that prey on soil invertebrates. The primary receptors at risk from PAHs are soil invertebrates.

Lead chemistry data previously collected were used to select tentative locations from which further samples will be collected and analyzed for lead. Final locations will be determined using XRF equipment. Composite soil samples will be collected along a gradient of soil lead concentrations, and from a reference location. A sub-sample of each composited soil sample will be analyzed for lead, total PAHs, pH, TOC, CEC, grain size, and moisture content. The remaining sub-sample will be used in standardized toxicity tests in which the survival of laboratory-reared earthworms (*Eisenia fetida*) will be measured. Soil dwelling invertebrates will be collected from co-located soil samples simultaneously with the soil samples. The diversity and abundance of invertebrates in Site 15 samples will be compared to results in reference samples. Results of the toxicity tests and the diversity and abundance data will be used to generate remedial goals for lead that pose acceptable risk to soil invertebrates. The collected soil invertebrates will also be analyzed for lead. Concentrations of lead in soil and invertebrates will be used to estimate ingestion doses for representative avian and mammalian receptors. This will allow the development of soil concentrations (remediation goals) that pose acceptable risk to the selected representative receptors.

PAH chemistry data previously collected were used to select locations from which further samples will be collected and analyzed for total PAHs. Composite soil samples will be collected along a gradient of soil concentrations of total PAHs, and from a reference site. A sub-sample of each composited soil sample will be analyzed for total PAHs, lead, pH, TOC, CEC, grain size, and moisture content. The remaining sub-sample will be used in standardized toxicity tests in which the survival of laboratory-reared earthworms (*Eisenia fetida*) will be measured. Soil dwelling invertebrates will be collected from co-located soil samples simultaneously with the soil samples. The diversity and abundance of invertebrates in Site 15 samples will be compared to results in reference samples. Results of the toxicity tests and the diversity and abundance data will be used to generate remedial goals for PAHs that pose acceptable risk to soil invertebrates.

TABLE 1

FOOD INGESTION RATES IN HERBIVOROUS AND OMNIVOROUS MAMMALS

SITE 15, BLUE 10 ORDINANCE DISPOSAL AREA

NAVAL AIR STATION CECIL FIELD

JACKSONVILLE, FLORIDA

Mammal	Food Ingestion (g/g bw/day) *	Food Habits	Source
mole	~0.5	insectivorous/vermivorous	Gorman and Stone, 1990
short tailed shrew	0.49 – 0.62	insectivorous/vermivorous	EPA, 1993
deer mouse	0.18 – 0.45	omnivorous	EPA, 1993
prairie vole	0.09 – 0.14	largely herbivorous	EPA, 1993
meadow vole	0.30 – 0.35	largely herbivorous	EPA, 1993
muskrat	0.26 – 0.34	herbivorous	EPA, 1993

***** g/g bw/day = food (grams, fresh weight) per gram of body weight per day

TABLE 2

EXPOSURE PARAMETERS FOR REPRESENTATIVE ECOLOGICAL RECEPTORS

SITE 15, BLUE 10 ORDINANCE DISPOSAL AREA

NAVAL AIR STATION CECIL FIELD

JACKSONVILLE, FLORIDA

Receptor	Body Weight (grams)	Food Ingestion[1] (grams/day)	Assumed Diet for Exposure Assessment	Home Range (acres)
Least shrew (*Cryptotis parva*)	5.5[2]	3.3[3]	98.5% invertebrates 1.5% soil[4]	0.5 to 3.5 [5]
Northern mockingbird (*Mimus polyglottus*)	49[6]	37.6[7]	49% invertebrates 49% vegetation 2% soil[8]	Not available[9]

1 Food ingestion values include intended food items plus incidentally ingested soil.

2 Nowak (1991), Cothran et al (1991)

3 Calculated using mammal equation Nagy (1987); converted to fresh weight assuming 71 percent water content in food items.

4 See Section 4.1 of text.

5 Choate and Fleharty (1973), Choate et al (1994).

6 Derrickson and Breitwisch (1992)

7 Calculated using passerine equation Nagy (1987); converted to fresh weight assuming 71 percent water content in food items.

8 Diet from Derrickson and Breitwisch (1992), see Section 4.1 of text for other soil ingestion scenarios.

9 Home range data not available, but based on non-migratory and territorial nature of this species (Derrickson and Breitwisch, 1992), home range is assumed to be contained within Site 15.

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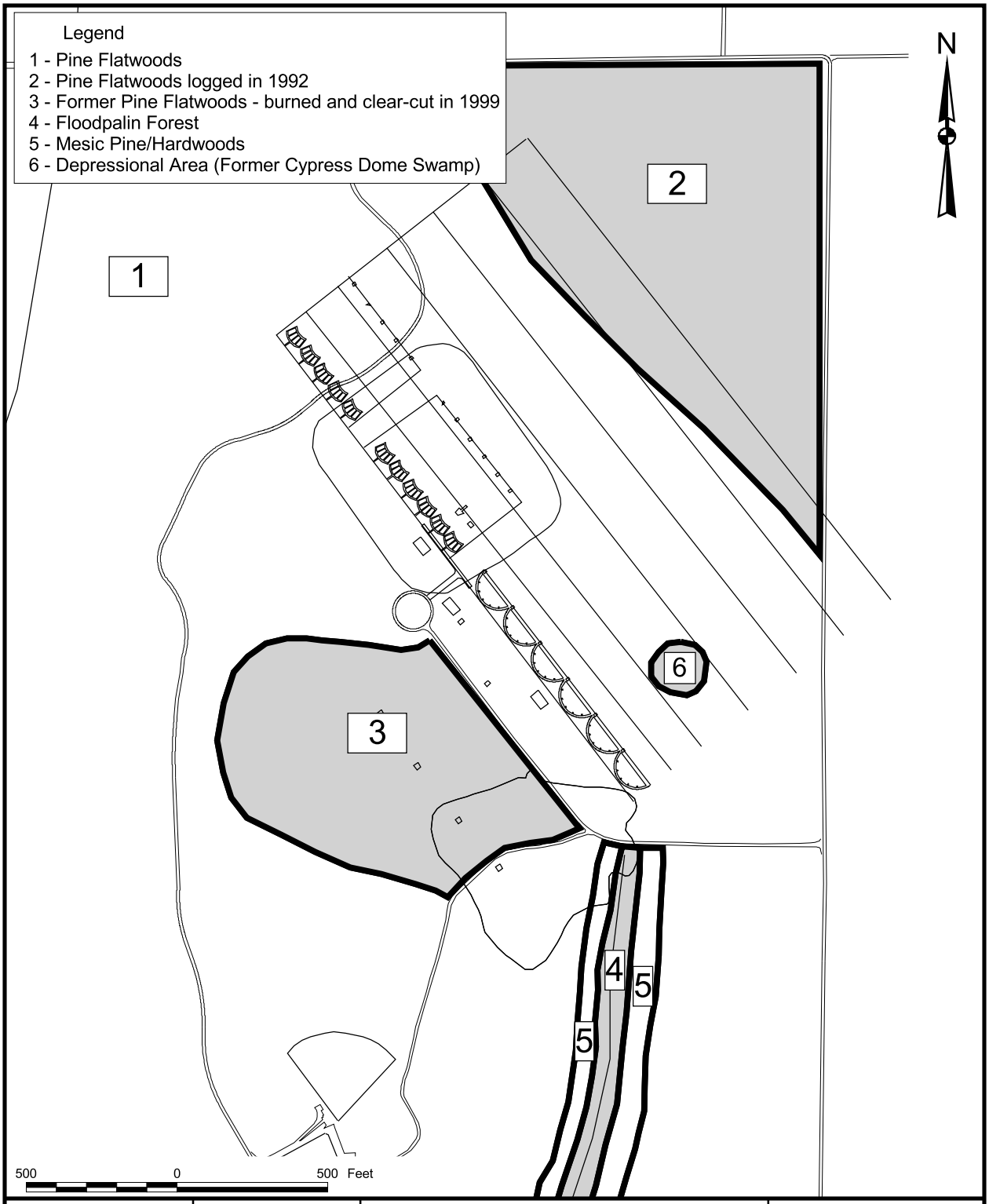

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COST/SCHEDULE-AREA			APPROVED BY — DATE —
SCALE AS NOTED			DRAWING NO. FIGURE 1 / REV 0

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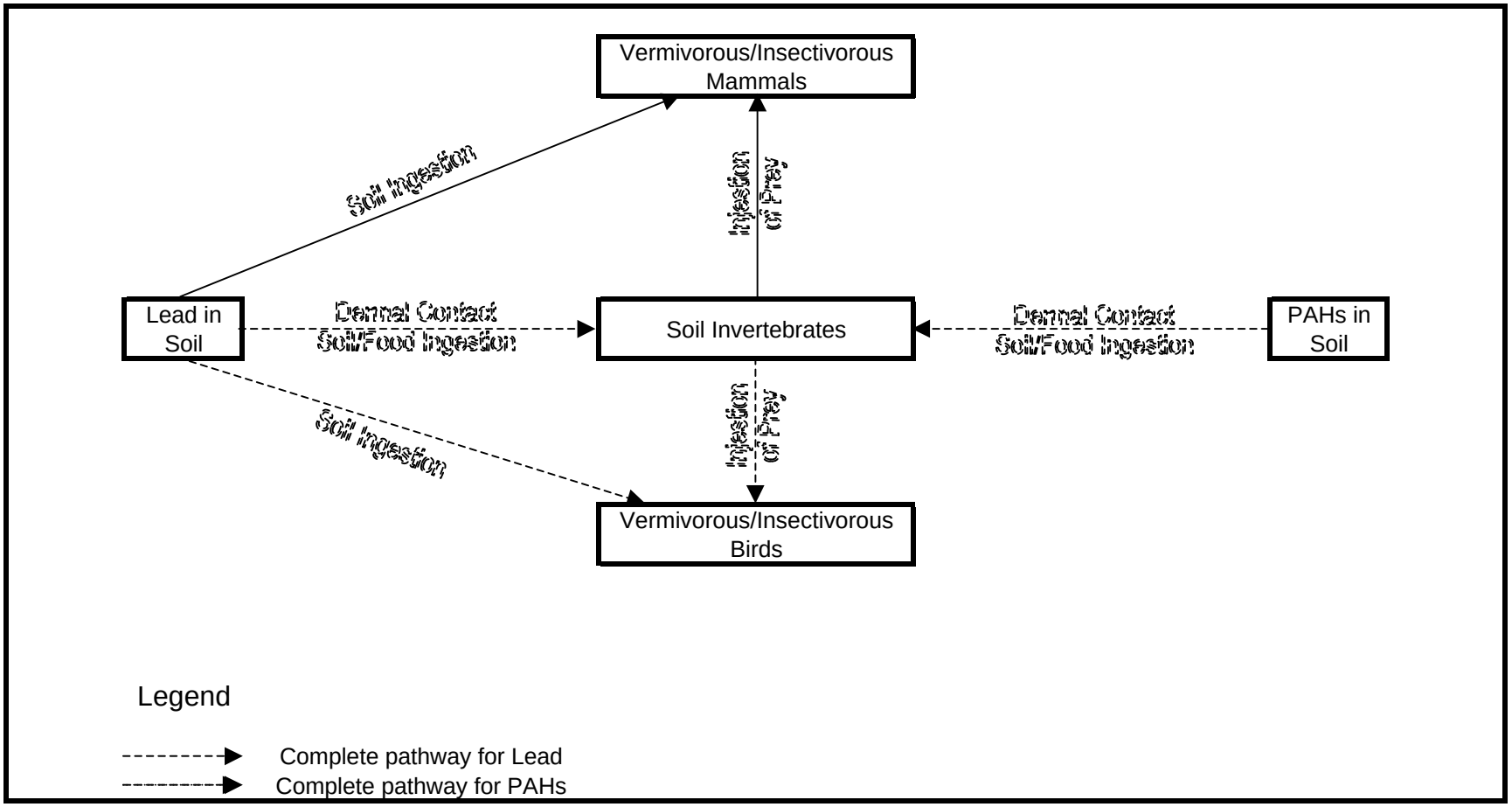
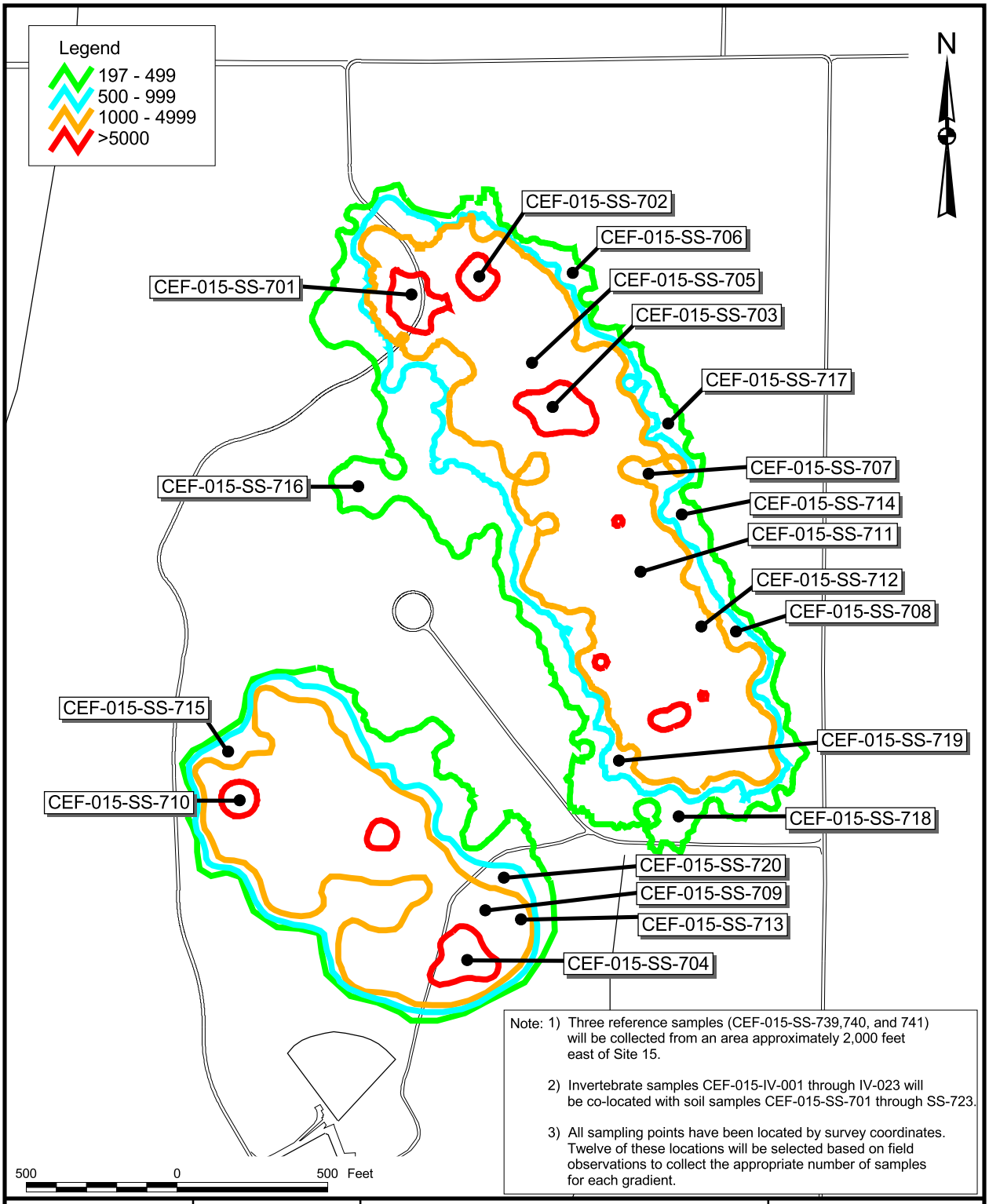


Figure 2

Contaminant Pathways at Site 15
NAS Cecil Field, Jacksonville, Florida



Note: 1) Three reference samples (CEF-015-SS-739,740, and 741) will be collected from an area approximately 2,000 feet east of Site 15.

2) Invertebrate samples CEF-015-IV-001 through IV-023 will be co-located with soil samples CEF-015-SS-701 through SS-723.

3) All sampling points have been located by survey coordinates. Twelve of these locations will be selected based on field observations to collect the appropriate number of samples for each gradient.

DRAWN BY MJJ	DATE 19Dec00	ISOCONCENTRATION CONTOURS FOR LEAD IN SOIL (mg/kg) AND PROPOSED SAMPLE LOCATIONS SITE 15 NAS CECIL FIELD JACKSONVILLE, FLORIDA	CONTRACT NUMBER 7653
CHECKED BY	DATE		APPROVED BY — DATE —
COST/SCHEDULE-AREA			APPROVED BY — DATE —
SCALE AS NOTED			DRAWING NO. FIGURE 3 REV 0

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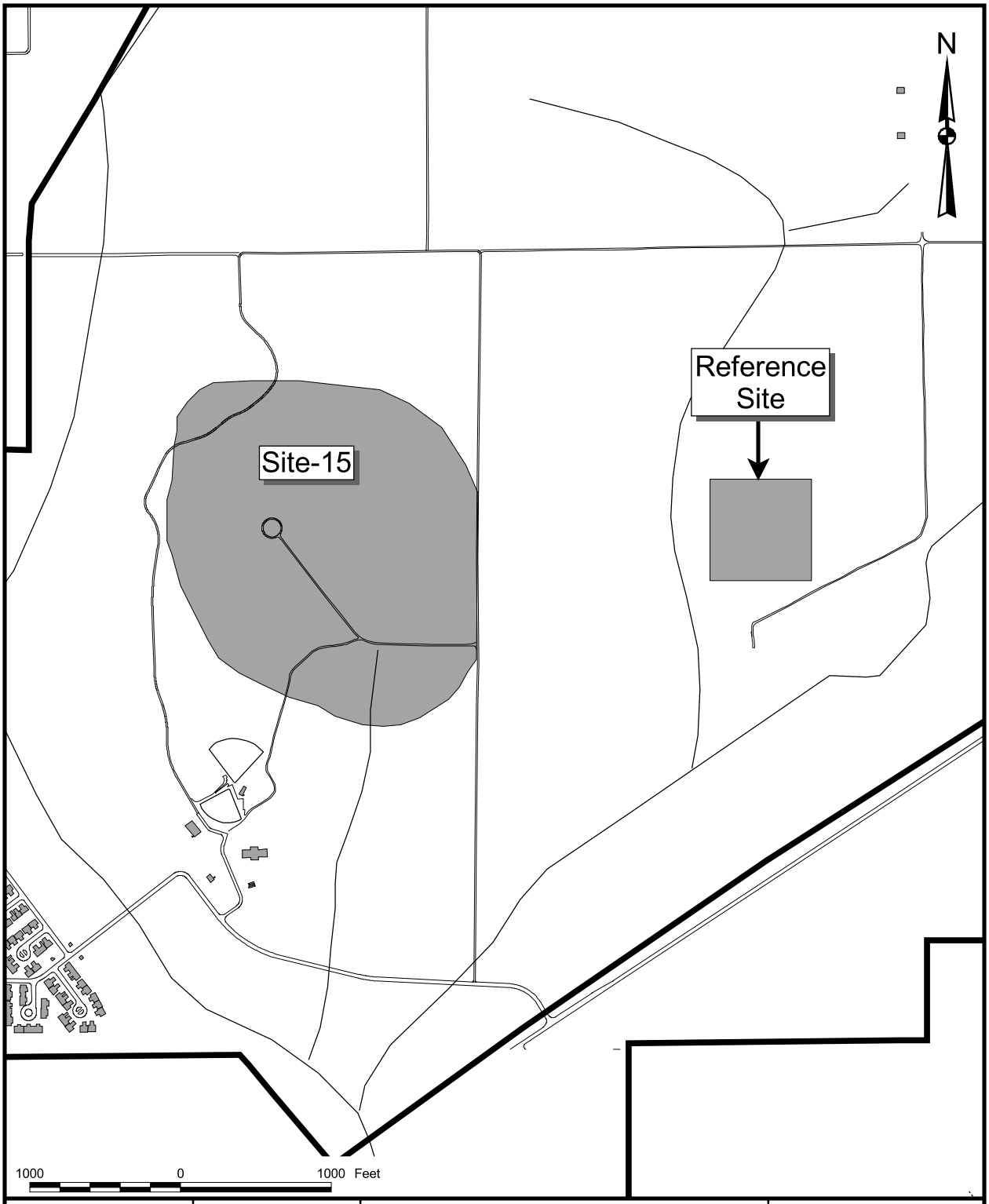

DRAWN BY MJJ	DATE 05Jan01	SITE 15 AND REFERENCE SITE LOCATION SITE 15 NAS CECIL FIELD JACKSONVILLE, FLORIDA	CONTRACT NUMBER 7653
CHECKED BY	DATE		APPROVED BY — DATE —
COST/SCHEDULE-AREA			APPROVED BY — DATE —
SCALE AS NOTED			DRAWING NO. FIGURE 4 / REV 0

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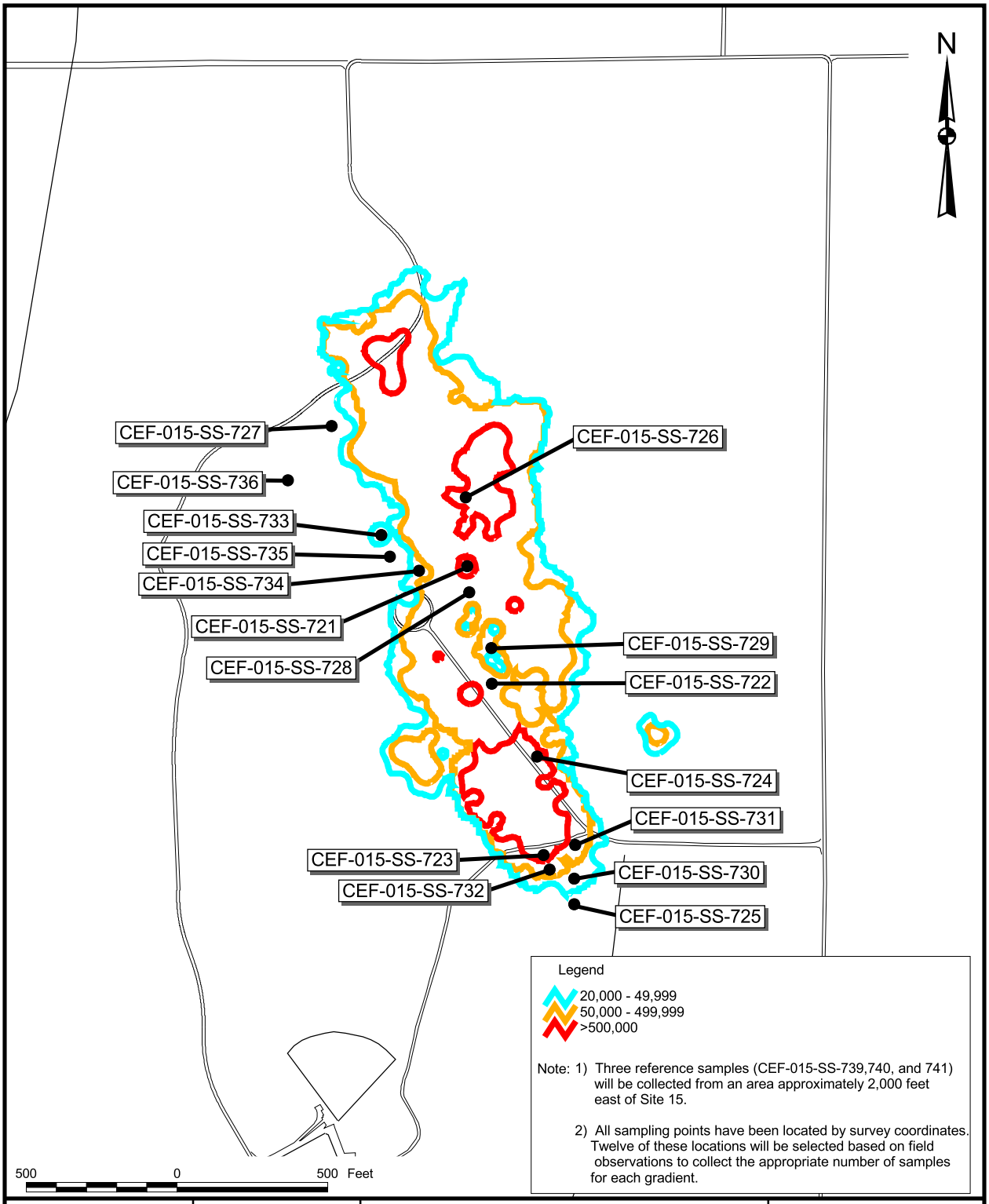

DRAWN BY MJJ	DATE 19Dec00	ISOCONCENTRATION CONTOURS FOR TOTAL PAHs IN SOIL (ug/kg) AND PROPOSED SAMPLE LOCATIONS SITE 15 NAS CECIL FIELD JACKSONVILLE, FLORIDA	CONTRACT NUMBER 7653
CHECKED BY	DATE		APPROVED BY — DATE —
COST/SCHEDULE-AREA			APPROVED BY — DATE —
SCALE AS NOTED			DRAWING NO. FIGURE 5 REV 0

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APPENDIX A

SITE 15, BLUE 10 ORDNANCE DISPOSAL AREA
PHASE VIII SAMPLING AND ANALYSIS WORK PLAN

APPENDIX A

Phase VIII Sampling and Analysis Work Plan
Site 15, Blue 10 Ordnance Disposal Area
Naval Air Station Cecil Field
Jacksonville, Florida

Phase VIII sampling and analysis of surface soil and soil invertebrates are proposed for Site 15 as identified in Figures A-1 and A-2. Sampling and analysis will be conducted to generate remediation goals for lead and polynuclear aromatic hydrocarbons (PAHs) in surface soil at the site. A total of 27 soil samples and 15 invertebrate samples will collected during this sampling event. Soil samples to be collected include 3 samples from each of 4 lead concentration gradients (12 samples), 4 samples from each of 3 PAH concentration gradients (12 samples) and 3 samples from a reference location. Sample locations for the 27 soil samples will be chosen from the 38 potential sampling locations identified on Figures A-1 and A-2 and summarized in Tables A-1 and A-2 based on field observations.

Soil samples will consist of the first three inches of mineral soil and the overlying duff (decaying organic matter) atop the mineral horizon. Invertebrates observed in the soil and duff will be manually collected from co-located soil sample locations, each of which shall consist of an area approximately 15 feet x 15 feet in size. The invertebrates will be collected simultaneously with, and from the same soil/duff stratum, as the soil samples. Soil samples will consist of five composites from throughout the 15 ft x 15 ft areas, and will be homogenized in the field and split into sub-samples for chemical analyses and standardized toxicity tests in which the survival of laboratory-reared earthworms (*Eisenia fetida*) will be measured.

Personnel protection equipment and other waste trash (e.g. disposable trowels) will not be considered hazardous and will be disposed in a municipal landfill. Such trash will be collected in a plastic bag and disposed in a suitable trash receptacle. Removed soil and invertebrates in excess of sampling volume requirements will be placed back on the ground and the ground cover will be replaced.

The sampling activities and procedures described in this Work Plan will be performed in accordance with the U. S. EPA Region IV Environmental Investigation Standard Operating Procedures and Quality Assurance Manual (EISOPQAM) and the Base-Wide Generic Work Plan for Naval Air Station (NAS) Cecil Field. Specifically, the Base-Wide Generic Work Plan includes procedures for management of investigation-derived wastes in Volume I and standard operating procedures in the Project Operations Plan in Volume II.

Surface soil and invertebrate samples will be collected using plastic, disposable trowels. Decontamination of this disposable equipment will not be required. Non-disposable sampling equipment may also be used, and decontamination of this equipment will be conducted in accordance with the EISPOQAM and Base-Wide Generic Work Plan. The proposed samples will be collected at previous sampling locations that will be located by surveying prior to or during the sampling event.

The following laboratories have been subcontracted:

<u>Lead, PAHs, TOC, and CEC in soil</u>:

ACCUTEST SOUTHEAST
4405 Vineland Road, Suite C-15
Orlando, Florida 32881
Attention: Linda Williams
(407) 425-6700
Fax: (407) 425-0707

<u>Grain Size (Soils Geotech Lab)</u>:

Civil Services, Inc.
2394 St. Johns Bluff Road, South
Jacksonville, FL 32246
Attention: Bruce Khosorozadeh
(904) 641-1834

Earthworm Toxicity Lab:

Springborn Laboratories, Inc.
Massachusetts Research Center
790 Main Street
Wareham, MA 02571-1075
Attn: Arthur Putt
(508) 295-2550
Fax: (508) 295-8170

Invertebrate Lead Lab:

Severn Trent Laboratories
4101 Shuffel Drive, NW
North Canton, OH 44720
Attention: Becky Strait
(330) 497-9396

Sample handling requirements, the bottleware required, preservation, and holding time requirements for the analysis proposed for this sampling event are as identified in the following table:

Analysis	Analytical Method	Bottleware	Preservation	Holding Time[1]
SOILS				
By Accutest				
PAHs	SW-846 8310	8-oz. glass jar	Cool to 4°C	14 days to extraction; 40 days to analysis
Lead	SW-846 6010B	8-oz. glass jar	Cool to 4°C	180 days to analysis
TOC	Lloyd Kahn	8-oz. glass jar	Cool to 4°C	28 days to analysis
CEC	SW-846 9081	8-oz. glass jar	Cool to 4°C	28 days to analysis
By Soils Geotech Lab				
Grain Size	ASTM D422	8-oz. glass jar	Cool to 4°C	28 days to analysis
By Earthworm Tox Lab				
Earthworm Toxicity (including pH and % moisture)	ASTM E1676-97; SW-846 9045C; ASTM 2216	To be determined by the lab	Cool to 4°C	14 days to analysis
INVERTEBRATES				
By Invertebrate Lead Lab				
Lead	SW-846 6010B	1.3 g sample mass; botleware to be determined by lab	Cool to 4°C	180 days to analysis

1 Holding times are measured from the date/time of sample collection.

Analytical results for soil samples for ***PAHs and lead*** will be provided on a ***7-day*** turn around basis. All ***other analyses*** are ***21-day*** turnaround.

As agreed upon by the BCT, the collection of rinsate and trip blanks has been eliminated at NAS Cecil Field. In addition, field blanks will not be collected during this sampling program because there will be minimal decontamination of sampling equipment. In accordance with these changes, the following table summarizes the frequency and type of field Quality Assurance/Quality Control (QA/QC) samples to be collected for this sampling program regarding soil samples. Field duplicates are not applicable for invertebrates.

Type of Samples	Frequency	Samples to be Collected
Field Duplicate	1/10 samples (soil)	4 Soil (PAH and lead)
Lab MS/MSD	1/20 samples/matrix	2 Soil (PAH and lead)/ 1 Tissue[1]

1 MS/MSD is a Laboratory QA/QC requirement, separate sample not required, only additional volume.

As agreed upon by the BCT, formal data validation has been eliminated from the installation restoration program at NAS Cecil Field. However, the analytical data packages generated by the analytical laboratory will be reviewed by Tetra Tech NUS personnel to eliminate false positives and false negative results.

Table A-1
Phase VIII Sampling and Analysis
Surface Soil
Site 15, Blue 10 Ordnance Disposal Area

Sample ID CEF-015	Location	PAHs 8310	Lead	Soil Physical Characteristics[1]	14-Day Soil Toxicity
SS-701	Within area of lead concentration >5,000 ppm	X	X	X	X
SS-702	Within area of lead concentration >5,000 ppm	X	X	X	X
SS-703	Within area of lead concentration >5,000 ppm	X	X	X	X
SS-704	Within area of lead concentration >5,000 ppm	X	X	X	X
SS-705	Within lead concentration range of 1,000 to 4,999 ppm	X	X	X	X
SS-706	Within lead concentration range of 197 to 499 ppm	X	X	X	X
SS-707	Within lead concentration range of 500 to 999 ppm	X	X	X	X
SS-708	Within lead concentration range of 500 to 999 ppm	X	X	X	X
SS-709	Within lead concentration range of 1,000 to 9,999 ppm	X	X	X	X
SS-710	Within area of lead concentration >5,000 ppm	X	X	X	X
SS-711	Within lead concentration range of 1,000 to 4,999 ppm	X	X	X	X
SS-712	Within lead concentration range of 1,000 to 4,999 ppm	X	X	X	X
SS-713	Within lead concentration range of 1,000 to 4,999 ppm	X	X	X	X
SS-714	Within lead concentration range of 197 to 499 ppm	X	X	X	X
SS-715	Within lead concentration range of 500 to 999 ppm	X	X	X	X
SS-716	Within lead concentration range of 197 to 499 ppm	X	X	X	X
SS-717	Within lead concentration range of 197 to 499 ppm	X	X	X	X
SS-718	Within lead concentration range of 197 to 499 ppm	X	X	X	X
SS-719	Within lead concentration range of 500 to 999 ppm	X	X	X	X

Table A-1 (continued)
Phase VIII Sampling and Analysis
Surface Soil
Site 15, Blue 10 Ordnance Disposal Area

Sample ID CEF-015	Location	PAHs 8310	Lead	Soil Physical Characteristics[1]	14-Day Soil Toxicity
SS-720	Within lead concentration range of 500 to 999 ppm	X	X	X	X
SS-721	Within area of PAH concentration >500,000 ppb	X	X	X	X
SS-722	Within area of PAH concentration >500,000 ppb	X	X	X	X
SS-723	Within area of PAH concentration >500,000 ppb	X	X	X	X
SS-724	Within area of PAH concentration >500,000 ppb	X	X	X	X
SS-725	Within area of PAH concentration >500,000 ppb	X	X	X	X
SS-726	Within area of PAH concentration >500,000 ppb	X	X	X	X
SS-727	Within total PAH concentration range of 50,000 to 499,999 ppb	X	X	X	X
SS-728	Within total PAH concentration range of 50,000 to 499,999 ppb	X	X	X	X
SS-729	Within total PAH concentration range of 50,000 to 499,999 ppb	X	X	X	X
SS-730	Within total PAH concentration range of 50,000 to 499,999 ppb	X	X	X	X
SS-731	Within total PAH concentration range of 50,000 to 499,999 ppb	X	X	X	X
SS-732	Within total PAH concentration range of 50,000 to 499,999 ppb	X	X	X	X
SS-733	Within total PAH concentration range of 20,000 to 49,999 ppb	X	X	X	X
SS-734	Within total PAH concentration range of 20,000 to 49,999 ppb	X	X	X	X
SS-735	Within total PAH concentration range of 20,000 to 49,999 ppb	X	X	X	X
SS-736	Within total PAH concentration range of 20,000 to 49,999 ppb	X	X	X	X
SS-737	Within total PAH concentration range of 20,000 to 49,999 ppb	X	X	X	X
SS-738	Within total PAH concentration range of 20,000 to 49,999 ppb	X	X	X	X
SS-739*	From reference area approximately 2,000 feet east of Site 15	X	X	X	X
SS-740*	From reference area approximately 2,000 feet east of Site 15	X	X	X	X
SS-741*	From reference area approximately 2,000 feet east of Site 15	X	X	X	X

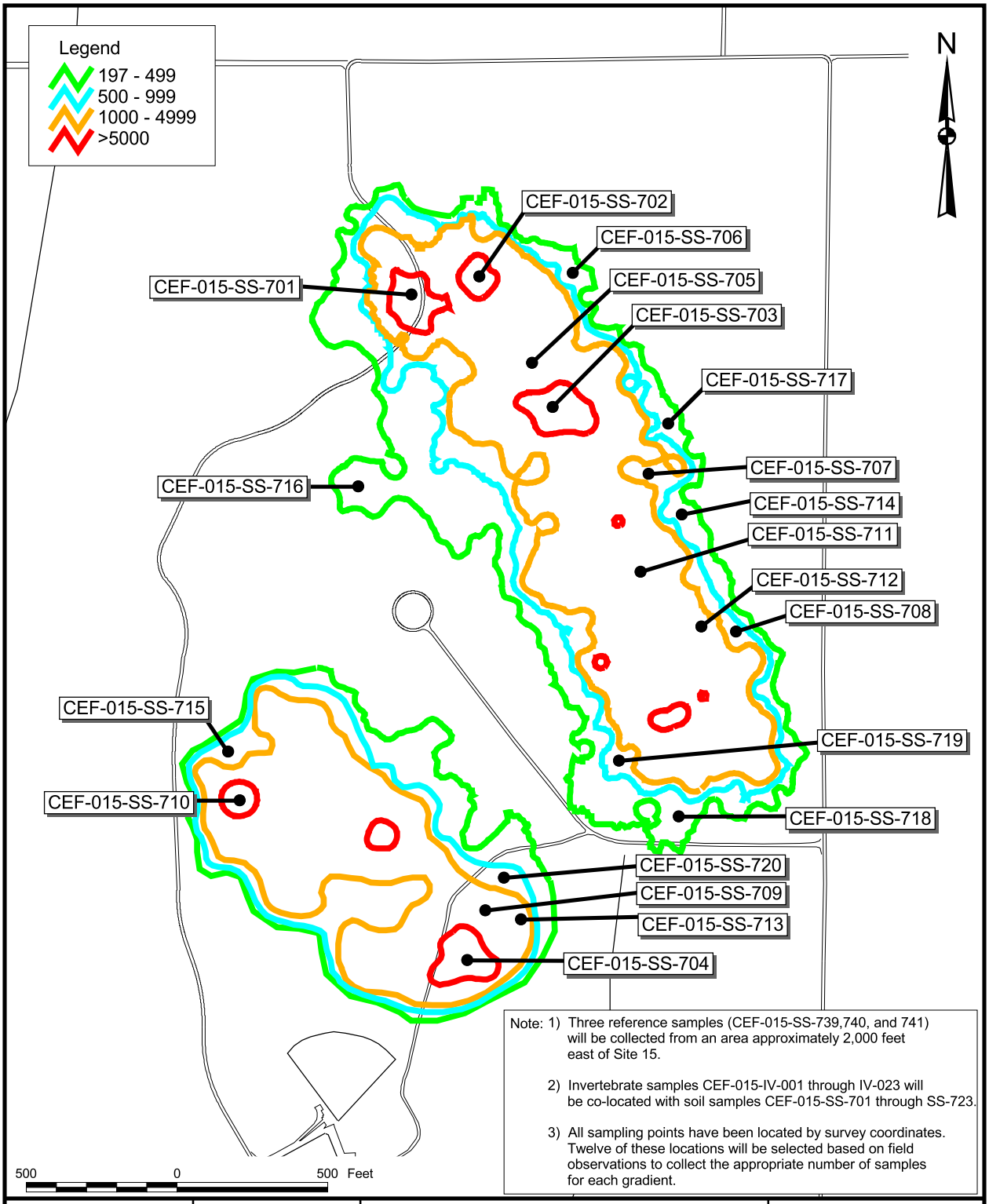
1 Total organic carbon, pH, grain size, and moisture content.
* These samples will be collected from the reference site.
NOTE: Based on field observations, 12 soil samples will be collected from the 20 potential locations determined based on lead gradients, and 12 soil samples will be collected from the 18 potential locations determined based on PAH gradients. Three samples also will be collected from the reference area, resulting in a total of 27 samples.

Table A-2

Phase VIII Sampling and Analysis
Invertebrates
Site 15, Blue 10 Ordnance Disposal Area

Sample ID	Location	Lead
CEF-015-IV-001	At CEF-015-SS-701 location	X
CEF-015-IV-002	At CEF-015-SS-702 location	X
CEF-015-IV-003	At CEF-015-SS-703 location	X
CEF-015-IV-004	At CEF-015-SS-704 location	X
CEF-015-IV-005	At CEF-015-SS-705 location	X
CEF-015-IV-006	At CEF-015-SS-706 location	X
CEF-015-IV-007	At CEF-015-SS-707 location	X
CEF-015-IV-008	At CEF-015-SS-708 location	X
CEF-015-IV-009	At CEF-015-SS-709 location	X
CEF-015-IV-010	At CEF-015-SS-710 location	X
CEF-015-IV-011	At CEF-015-SS-711 location	X
CEF-015-IV-012	At CEF-015-SS-712 location	X
CEF-015-IV-013	At CEF-015-SS-713 location	X
CEF-015-IV-014	At CEF-015-SS-714 location	X
CEF-015-IV-015	At CEF-015-SS-715 location	X
CEF-015-IV-016	At CEF-015-SS-716 location	X
CEF-015-IV-017	At CEF-015-SS-717 location	X
CEF-015-IV-018	At CEF-015-SS-718 location	X
CEF-015-IV-019	At CEF-015-SS-719 location	X
CEF-015-IV-020	At CEF-015-SS-720 location	X

NOTE: A total of 12 samples will be collected corresponding to the locations chosen for soil samples.



Note: 1) Three reference samples (CEF-015-SS-739,740, and 741) will be collected from an area approximately 2,000 feet east of Site 15.

2) Invertebrate samples CEF-015-IV-001 through IV-023 will be co-located with soil samples CEF-015-SS-701 through SS-723.

3) All sampling points have been located by survey coordinates. Twelve of these locations will be selected based on field observations to collect the appropriate number of samples for each gradient.

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CHECKED BY	DATE		APPROVED BY — DATE —
COST/SCHEDULE-AREA			APPROVED BY — DATE —
SCALE AS NOTED			DRAWING NO. FIGURE A-1 REV 0

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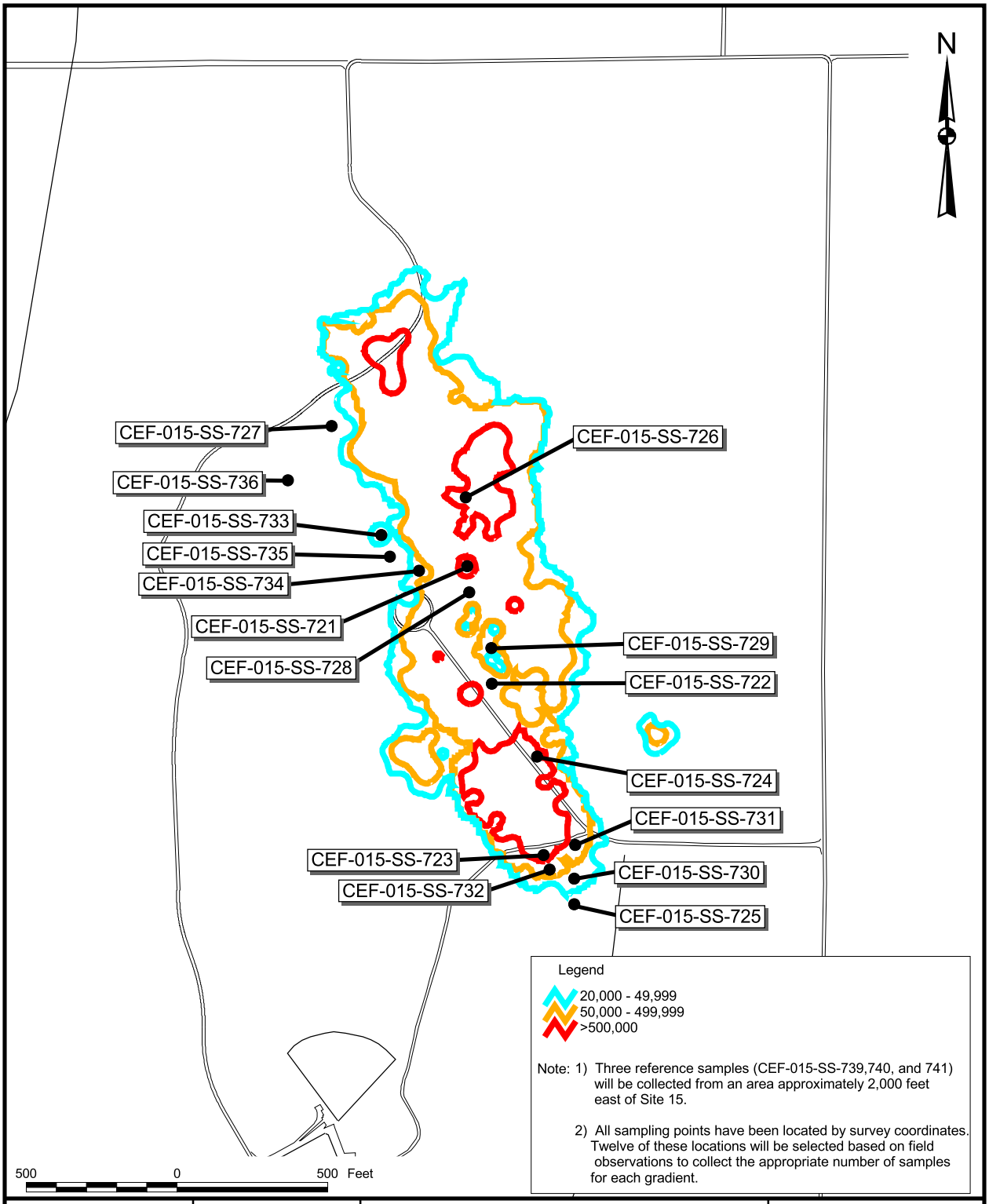

DRAWN BY MJJ	DATE 19Dec00	ISOCONCENTRATION CONTOURS FOR TOTAL PAHs IN SOIL (ug/kg) AND PROPOSED SAMPLE LOCATIONS SITE 15 NAS CECIL FIELD JACKSONVILLE, FLORIDA	CONTRACT NUMBER 7653
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COST/SCHEDULE-AREA			APPROVED BY — DATE —
SCALE AS NOTED			DRAWING NO. FIGURE A-2 REV 0

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