DRAFT FINAL

IOWA ARMY AMMUNITION PLANT SCOPING SURVEY PLAN FOR FIRING SITES 6 AND 12

MARCH 2001

U.S. Army Corps of Engineers
St. Louis District Office
Formerly Utilized Sites Remedial Action Program

TABLE OF CONTENTS

LIST OF APPENDICES

LIST OF FIGURES

ACRONYMS, ABBREVIATIONS

µR/hr	microroentgen per hour
AEC	Atomic Energy Commission
AHA	activity hazard analyses
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
cm	centimeters
cpm	counts per minute
DCGL	derived concentration guideline level
DOT	Department of Transportation
DU	Depleted Uranium
FS	Firing Sites
ft/s	feet per second
FUSRAP	Formerly Utilized Sites Remedial Action Program
GIS	geographic information systems
GPS	global positioning system
HSA	Historical Site Assessment
HSWP	health and safety work permits
IAAAP	Iowa Army Ammunition Plant
LAP	load, assemble, and pack
LiF	lithium fluoride
m/sec	meters per second
MARSSIM	Multi-Agency Radiation Survey and Site Investigation Manual
MDC	minimum detectable concentration
mm	millimeter
mrem/hr	millirem per hour
mrem/yr	millirem per year
NRC	Nuclear Regulatory Commission
OSHA	Occupational Safety and Health Administration
pCi/g	picocuries per gram
PPE	personal protective equipment
PRG	preliminary remediation goal
RMSA	Radioactive Material Storage Areas
RSO	Radiation Safety Officer
SAIC	Science Applications International Corporation
SSHO	Site Safety and Health Officer
TLD	thermo-luminescent dosimeters
USACE	United States Army Corps of Engineers
UXO	Unexploded Ordnance

1.0 INTRODUCTION

Science Applications International Corporation (SAIC) has prepared this Scoping Survey Plan for the St. Louis District United States Army Corps of Engineers (USACE) to describe the initial radiological investigation survey activities (hereafter referred to as the scoping survey) at the Iowa Army Ammunition Plant (IAAAP) in Burlington, Iowa (Figure 1). Specifically, this plan is being prepared to investigate Firing Sites (FS) 6 and 12 (Figure 2) for the presence of Depleted Uranium (DU) contamination. Historical records indicate that FS 6 and 12 are potentially contaminated with DU fines incorporated into the soil and that FS 12 is potentially contaminated with visible fragments of DU.

This preliminary scoping survey is being conducted to augment past and future Historical Site Assessments (HSA) by locating areas and media impacted by the spread of contamination and to determine the magnitude of the contamination present on FS 6 and 12. Additionally, the scoping survey will verify that all contaminated areas are contained and controlled and that all identifiable fragments of DU have been containerized for future disposition. Other objectives of the survey include:

1. providing data to complete a preliminary risk assessment and/or to complete the CERCLA Preliminary Assessment/Site Investigation process;
2. providing input for the design of any future characterization surveys (if necessary);
3. supporting the classification of the firing sites as impacted or non impacted and further classification of impacted areas as Class 1, 2, or 3 areas in accordance with the Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM);
4. obtaining an estimate of the variability in the residual radioactivity concentration for the site; and
5. identifying non-impacted areas that may be appropriate for obtaining reference areas samples to be used to estimate the background soil concentration for uranium at the site.

2.0 SITE BACKGROUND

IAAAP is a government facility, owned by the United States Army and operated by a private contractor, American Ordnance Company. It is located in the southeastern part of Iowa, near the town of Middletown, approximately 10 miles west of the Mississippi River. The IAAAP is a secured facility covering 19,127 acres in a rural setting. Approximately 7,751 acres are leased for agricultural use, 7,500 acres are forested land, and the remaining area is used for administrative and industrial purposes.

According to the *Remedial Investigation/Risk Assessment, Iowa Army Ammunition Plant, Middletown Iowa* (USACE, 1996), IAAAP was initially developed in 1941, and has undergone modernization and expansion since that time. Production of ammunition and explosives for World War II began at the facility in September 1941 and ended in August 1945. Production was resumed in 1949 and has continued to the present.

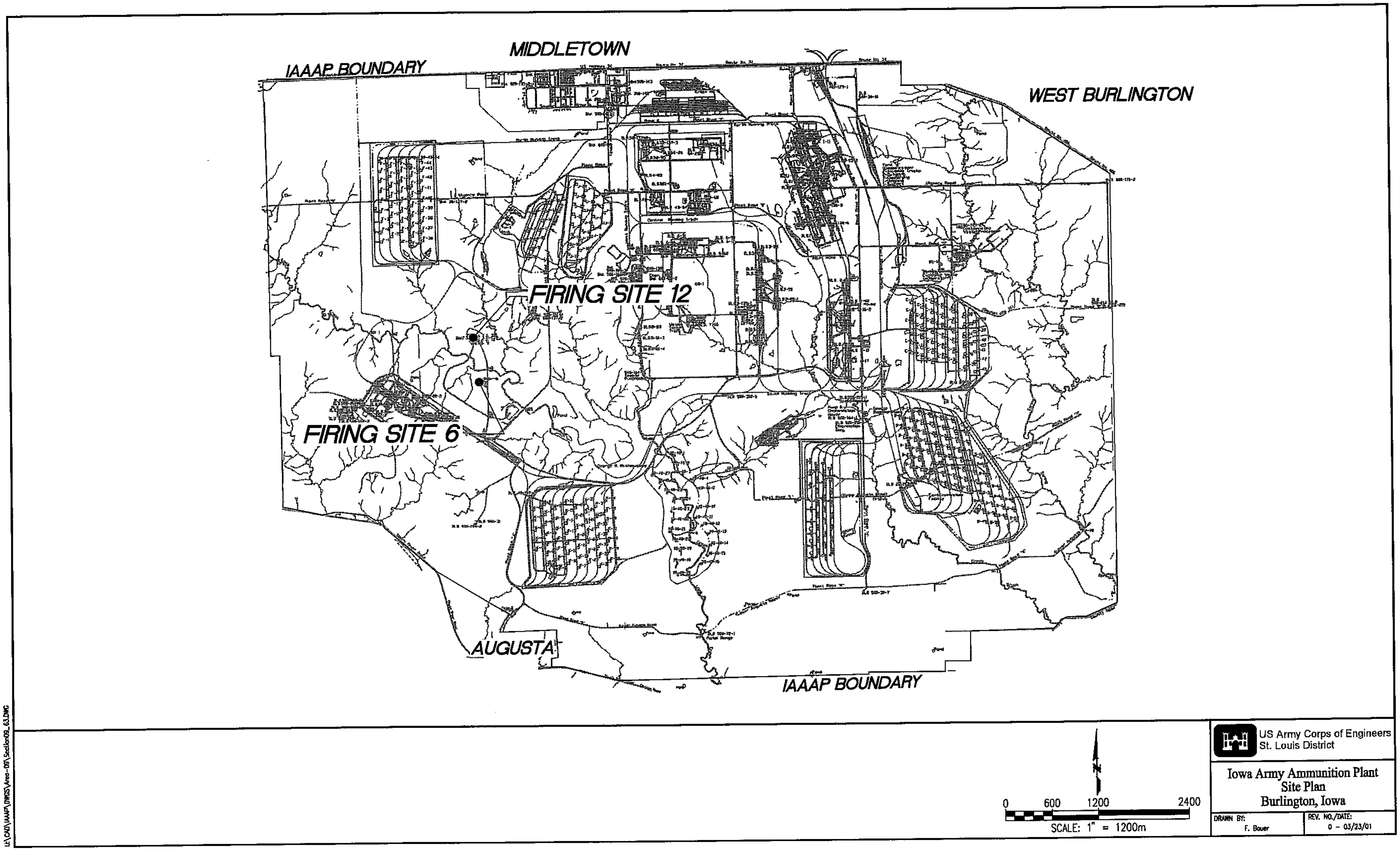

Figure 1. Site Plan of IAAAP

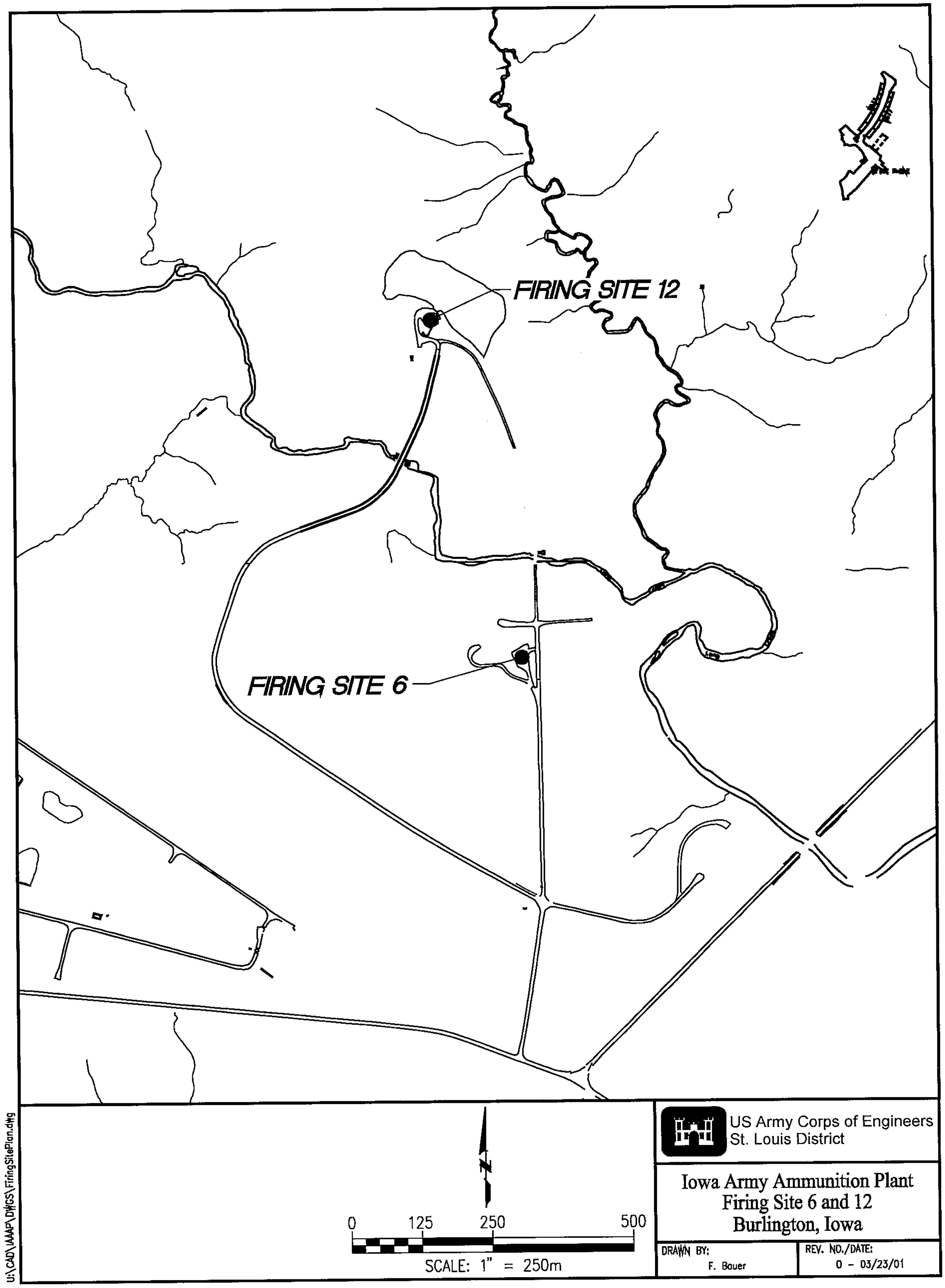

Figure 2. Firing Sites 6 and 12 Area

IAAAP is currently operated to load, assemble, and pack (LAP) ammunition items, including projectiles, mortar rounds, warheads, demolition charges, anti-tank mines, anti-personnel mines, and the components of these munitions, including primers, detonators, fuses, and boosters. The LAP operations use explosive material and lead-based initiating compounds. Only a few of the existing production lines are in operation.

Line 1 was modified and operated by the Army for the U. S. Atomic Energy Commission (AEC) from 1947 to 1975. Line 1 is located in the northeastern portion of IAAAP, encompasses 190 acres, contains 22 buildings, and currently functions as a cartridge, missile, warhead, and grenade loading and packing facility. Due to the nature of the AEC operations, little information is available on the activities conducted at Line 1 during the AEC presence. However, it is known that various components were assembled into a finished nuclear weapon. Radioactive materials used at the line were "received in a sealed configuration" and were swipe tested for leaks before use. Known radioactive materials include depleted uranium, enriched uranium, plutonium, tritium, and polonium-210. The AEC released and returned control of these buildings to the Army in July 1975.

FS 6 and 12 are located in the western portion of IAAAP, approximately 1 mile from the nearest plant boundary, near the point where the west and north branches of Long Creek converge and flow into Mathes Lake. These firing sites have been in use since the 1940s and it is known that FS 12 was used for AEC activities between 1965 and 1974. FS 6 and 12 make up just a small portion of the entire firing site area, which covers approximately 1.85 million square meters. A security fence is placed around the entire firing site area.

The firing sites are routinely used for the static testing of explosives produced at IAAAP. During the period of December 1965 through December 1973, FS 12 was used for the destructive testing of 701 hydrodynamic shots (hydro-shots) of D-38 (depleted uranium 238) and high explosives. Less is known about the AEC activities at FS 6. Interviews with site personnel indicate that test firing of DU spheres were conducted at FS 6. The spheres consisted of an outer and inner shell of explosives with 1/16-inch of DU between the shells. The number of test firings is unknown.

Historical records indicate that at the conclusion of AEC activities at FS 12, residual DU soil contamination as high as 1746 pCi/g existed at the site. Decontamination activities were subsequently conducted by the Silas Mason Company consisting of the removal of soil at ground zero to a depth of 15 feet; the removal of the top 1-2 inches of soil at an approximate radius of 30-50 feet around ground zero; and the plowing of the remaining FS-12 area. A letter from the Silas Mason Company dated September 20, 1974 shows the results of 12 post-remedial action samples taken from FS-12. This data set ranged from 2.4 to 335 pCi/g with a mean of 79 pCi/g and a standard deviation of 107 pCi/g. This letter indicates that these 12 samples are "additional" post-remedial action samples; however, it is not clear if documentation of the other data has been located. Site investigations at FS-12 as late as November 2000 revealed the presence of DU fragments up to a distance of 100 meters from ground zero.

3.0 ORGANIZATION AND RESPONSIBILITIES

Overall coordination and implementation of the scoping survey described in this plan is the responsibility of the SAIC project manager/survey supervisor. The scoping survey team will consist of eight personnel to include a project manager/survey supervisor, a sample manager/geographic information systems (GIS) analyst, four health physics technicians, and two Unexploded Ordnance Center of Excellence (UXO) specialists. The roles and responsibilities of key personnel for this scoping survey are listed in Table 3-1.

Table 3-1. Roles and Responsibilities

Role	Person	Phone	Responsibility
PM/Survey Supervisor	Jim Moos	(314) 581-6081	Assures all sample/survey activities are performed in accordance with this plan and that all project quality, compliance, and health and safety requirements are followed.
Sample Manager/GIS Analyst	Rodney Alderson	(314) 581-6082	Assures samples are handled in accordance with the project sampling and analysis guide and that all GIS data is collected and analyzed in a defensible manner.
UXO Safety	Nick Heleg-Greza	(309) 782-1486	Implementation of the UXO safety plan developed for these scoping survey activities.
IAAAP Safety	Robert Haines	(319) 753-7859	Provides safety and occupational oversight for the hazards presented by the IAAAP.
USACE Health Physicist	Dennis Chambers	(314) 260-3917	Provides the overall technical oversight, direction, and coordination for the implementation of this plan.

4.0 SURVEY DESIGN

Radiological measurements and soil sampling will be conducted on FS 6 and 12 to verify contamination boundaries and to determine the magnitude of DU contamination present in surveyed areas. Where possible, the design of this survey will follow MARSSIM and the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) protocols as they relate to a scoping/site investigation type survey. Radiological measurements will include gamma activity measurements at the soil surface using NaI scintillation detectors, general area dose rates at one meter from the soil surface using hand-held detectors and laboratory analysis of soil samples collected at locations of elevated activity.

4.1 PROCESS KNOWLEDGE

The design of the scoping survey for the collection of radiological measurements will take into consideration:

1. All relevant operational history within the facility and previous radiological surveys to identify the radionuclides known or suspected to be present and associated activity levels.
2. The potential radionuclide distribution and/or the presence of multiple isotopes (i.e., U-238, U-234, U-235). DU is signified by the reduction of the U-235 isotope below its natural abundance of 0.7%. The abundance of U-235 in DU is typical on the order of 0.2 – 0.3%. The specific activity of DU is 3.637×10^{-7} Ci/g with an activity abundance of 92.18%, 1.49%, and 6.36% for U-238, U-235, and U-234, respectively.
3. The size, geometry, composition, and physical properties of the surfaces and contaminants to be surveyed (i.e, soil with small DU fragments).
4. Associated radionuclides that result from radioactive decay and progeny ingrowth, if any.
5. The selected instrument's scanning minimum detectable concentration (MDC) for the establishment of an appropriate screening level Derived Concentration Guideline Level (DCGL). The selected screening level DCGL will be used for the purpose of screening impacted areas to determine if further action is warranted.

4.2 INSTRUMENT SELECTION

Survey instruments used for radiological measurements will be:

1. selected based on the survey instrument's detection capability for depleted uranium;
2. capable of measuring radionuclides in outside soils;
3. calibrated in accordance with ANSI N323A, *Radiation Protection Instrumentation Test and Calibration – Portable Survey Instruments* (ANSI, 1997) for the spectrum of radiation energies expected at FS 6 and 12; and
4. operated and maintained by qualified personnel, in accordance with SAIC's Health Physics Program procedures (e.g., duplicate measurements, response/operational checks, etc).

Based on the data quality objectives listed above, the following instrumentation has been selected for use during this scoping survey.

<u>Ludlum Model 44-10; 2" × 2" NaI Gamma Scintillation Detector Coupled with a Global Positioning System (GPS)</u>

Since DU and its short-lived daughters (e.g., Th-234, Pa-234m, Th-231) have associated gamma radiation, which can be used to identify the presence of residual contamination and estimate the concentrations present in soil, surface scans for gross gamma radiation will be the primary method used to identify fragments of DU and/or locations of elevated activity. Scanning results will be recorded in counts per minute (cpm) using real time position and data recording methods (GPS).

Bicron Model G5 FIDLER Scintillation Detector Coupled with a GPS

The G5 FIDLER detector is a large NaI scintillation detector optimized to detect low energy gamma radiation. The 127-millimeter (mm) diameter, 1.6-mm thick crystal is designed to be sensitive to low energy gamma radiation below 100 keV. Its primary effectiveness will be for detecting the 63 and 93 keV gamma emissions from Th-234 which are considered the most abundant low energy gamma radiations emitted by the short lived daughters associated with DU. Results of the FIDLER will be recorded in counts per minute using real time position and data recording methods (GPS).

Ludlum Model 19 NaI Dose Rate Meter

General area dose rate readings will be taken with this instrument at approximately 1 meter above the soil surface to identify above background dose rates that may require action to control personnel exposure. Results from this instrument will be recorded in microrem per hour (μR/hr).

Canberra Gamma Spectroscopy and Alpha Spectroscopy Laboratory Equipment

Collected soil samples will be sent to the USACE Certified Formerly Utilized Sites Remedial Action Program (FUSRAP) Radioanalytical Laboratory located in Berkeley, Missouri and analyzed in accordance with the *FUSRAP St. Louis, Laboratory Quality Assurance Plan and Laboratory Procedures Manual* (SAIC, 1999b).

Samples will be dried, homogenized, and analyzed for the standard FUSRAP library of contaminants (Ac-227, Am-241, Cs-137, K-40, Pa-231, Ra-226, Ra-228, Th-228, Th-230, Th-232, U-235, U-238) using Marinelli beaker geometry and a Canberra gamma spectroscopy system equipped with a 65% N-type HPGe detector. The typical detection sensitivity for U-238 and U-235 is approximately 3 pCi/g and 0.2 pCi/g, respectively.

All background reference area samples and a portion of the investigation soil samples collected for analysis will be processed for alpha spectroscopy analysis to determine the isotopic concentrations of all three uranium isotopes present in DU (U-238, U-235, and U234). Prepared samples will be chemically processed using the Claude Sills method of chemical separation and will be counted on a Canberra alpha spectroscopy system equipped with PIP detectors. The typical detection sensitivity for this analysis is approximately 0.1 pCi/g for each isotope. The St. Louis District USACE Health Physicist will be responsible for determining what samples require isotopic uranium analysis.

All instrumentation will be calibrated in accordance with ANSI N323A, *Radiation Protection Instrumentation Test and Calibration – Portable Survey Instruments* (ANSI, 1997) within the past 12 months. Daily performance checks will be conducted in accordance with the SAIC *St. Louis Health Physics Manual* (SAIC, 1998) procedures. The performance checks will be performed prior to and following daily field activities and at any time the instrument response appears questionable. Only data obtained using instruments that satisfy the performance requirements will be accepted for use in this investigation.

4.3 SCREENING LEVEL DCGL

In order to evaluate the need for future action after reviewing collected data, a preliminary, screening level DCGL should be established. The screening level DCGL in analogous to a preliminary remediation goal (PRG). Such preliminary DCGLs are typically conservative values (i.e., based on residential use scenarios) used by facilities and regulatory agencies as screening tools to determine if the magnitude of residual contamination that exists at a facility requires further action to be taken. If it is determined that further action is warranted, these DCGLs should be adjusted using site specific information.

In many instances, the establishment of a DCGL is limited by the ability to detect the contaminant of concern using reasonable detection methodologies. NUREG 1507, *Minimum Detectable Concentrations with Typical Radiation Survey Instruments for Various Contaminants and Field Conditions* (NRC, 1997) lists the approximate scan detection sensitivity using a 2"x 2" NaI detector for soil contaminated with DU at 56 pCi/g. It has been determined that this level of contamination will be detected at least 95% of the time by the average survey technician walking at a rate of 0.5 meters per second (m/sec). Conservative risk and dose assessment calculations were performed using RESRAD 5.82 to model a residential scenario with DU soil contamination at 56 pCi/g. The resulting risk and dose to the maximum exposed individual from this evaluation is 6 E-5 and 9.1 millirem per year (mrem/yr), respectively. A complete discussion of this risk and dose assessment is provided in Appendix A.

The use of 56 pCi/g as a screening level DCGL for DU would only be appropriate for areas contaminated with very fine particles of DU incorporated into the soil. In this situation, it is expected that the activity per gram of soil is much less than the known specific activity of solid DU (i.e., 3.637 E-7 Ci/g). In the case of solid DU where the specific activity is known, the ability to detect a fragment is based on its size rather than its specific activity. The more important data quality objective is the minimum size DU fragment that is detectable at the ground surface or some depth below the ground surface.

Methodologies presented in NUREG 1507 were used to model the smallest size DU fragment that could detected on the ground surface and 5 centimeters (cm) below the ground surface using the 2" x 2" NaI detector. In situations where the detector is located directly above the fragment for the one second duration required for an instrument signal, the smallest fragments that can be detected with confidence on the ground surface and 5 cm below the ground surface are 1.0 cm^3 and 2.0 cm^3, respectively. For a typical scan rate of 0.5 m/sec, the minimum size DU fragment that will produce gamma emissions high enough to be detected with confidence in any 50 cm^2 area surrounding the fragment on the ground surface and 5 cm below the ground surface are 6 cm^3 and 10 cm^3, respectively (50 cm^2 is the area covered by a surveyor in one second moving at a scan rate of 0.5 m/sec). A more detailed discussion of this evaluation is provided in Appendix B.

5.0 SURVEY IMPLEMENTATION

Scoping survey activities will be limited to areas known as FS 6 and 12 at the Iowa Army Ammunition Depot as shown in Figure 2. Prior to conducting the scoping survey, the survey supervisor will review any relevant operational history and any previous radiological surveys at FS 6 and 12 to identify areas of known or potential elevated activity and DU contaminant levels. This information will aid the survey supervisor in determining which areas are likely to contain residual radioactivity, and thus, areas where the scoping survey activities should be concentrated.

5.1 SURFACE AND GENERAL AREA GAMMA MEASUREMENTS

Soil surface scans for gross gamma radiation will be performed for all areas using a 2" x 2" NaI detector to identify locations of elevated activity suggesting possible soil contamination or the presence of DU fragments. The survey team may also perform soil surface scans using a NaI FIDLER detector for up to 20% of the area surveyed focusing on small areas of elevated activity identified with the 2" x 2" NaI detector. Attempts will be made to correlate the responses of both instruments to determine which instrument provides the best detection sensitivity for DU fines and fragments. All instrument response(s) will be continuously monitored during scanning using the instrument's audible signal. Scanning results will be recorded in counts per minute (cpm) using real time position and data recording methods (GPS). In locations where it is not possible to use GPS (e.g., tree cover, next to buildings, etc.), surveys will be hand recorded on survey maps generated in the field.

Screening gamma scans at FS 12 will begin at the historical detonation point referred to as "ground zero" and proceed to a distance of approximately 100 meters in all directions. Figure 3 shows the area to be surveyed at FS 12. The gamma walkover scan of FS 6 will begin at the center of the suspected detonation area to a distance of approximately 30 meters in all directions. Figure 4 shows the area to be surveyed at FS 6. Gamma walkover scans will cover up to 100% of the area to be surveyed as time allows. Survey teams will first focus on those areas most likely to have elevated levels of activity (i.e., land areas not visibly disturbed) then proceed to areas that have most likely been disturbed since historical AEC activities.

The surveyor will advance at a speed of approximately 2 ft/s (0.5 m/sec) while passing the detector at a height of approximately 10 cm over the surface in a serpentine pattern. Audible response of the instrument will be monitored, and locations of elevated audible response will be noted and uniquely marked (i.e., use of uniquely colored pin flags). The ambient background for the site will be determined at the start of the survey and a scanning response which is detectable above the background level (e.g., 2,000 cpm above background) will be set as the investigation level, indicating the presence of a DU fragment or potential soil contamination. As site survey data are collected and evaluated, a correlation of instrument response to radionuclide concentrations and/or the presence of DU fragments may be developed and replace the 2,000 cpm above background action level.

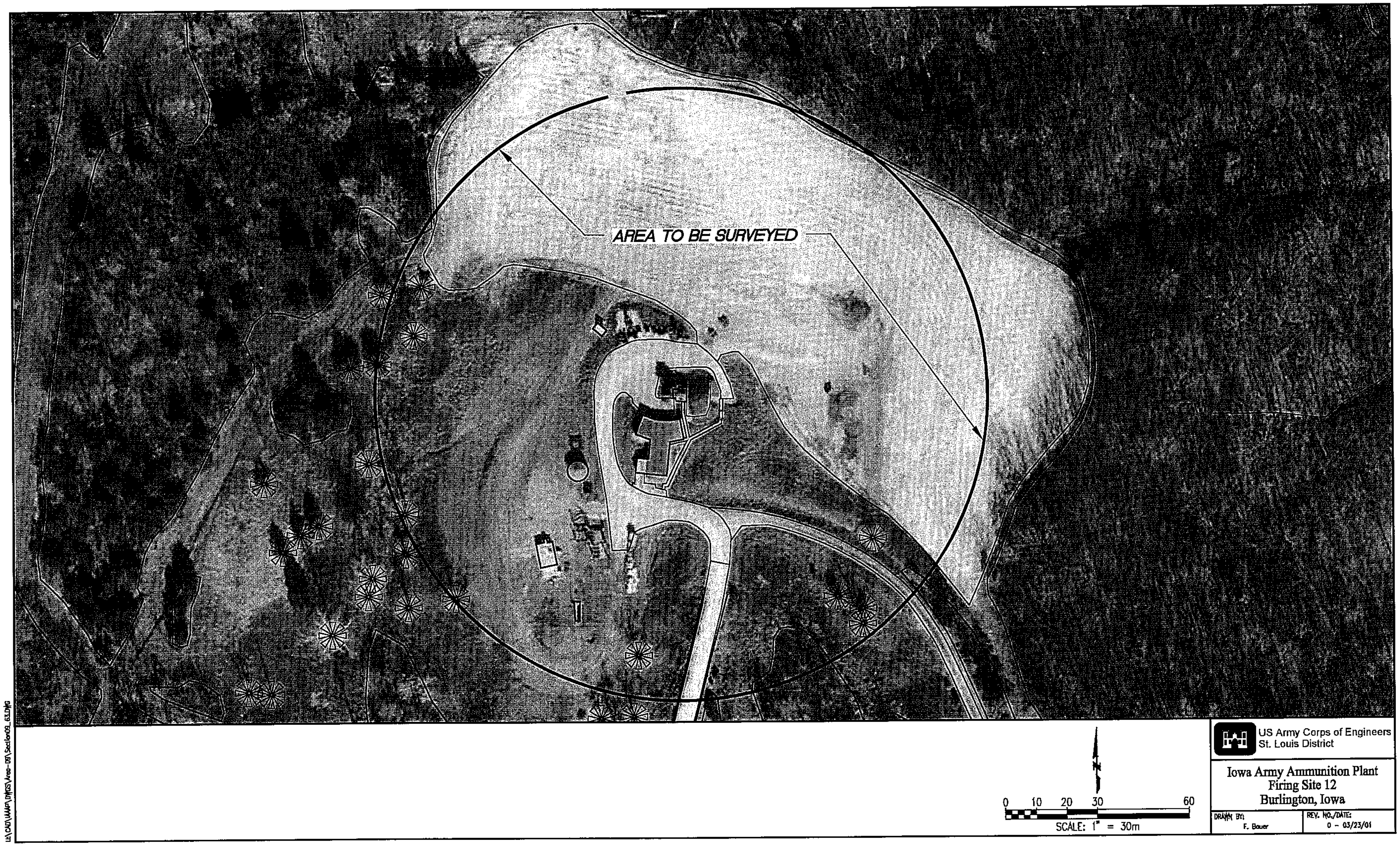

Figure 3. Aerial View of Firing Site 12

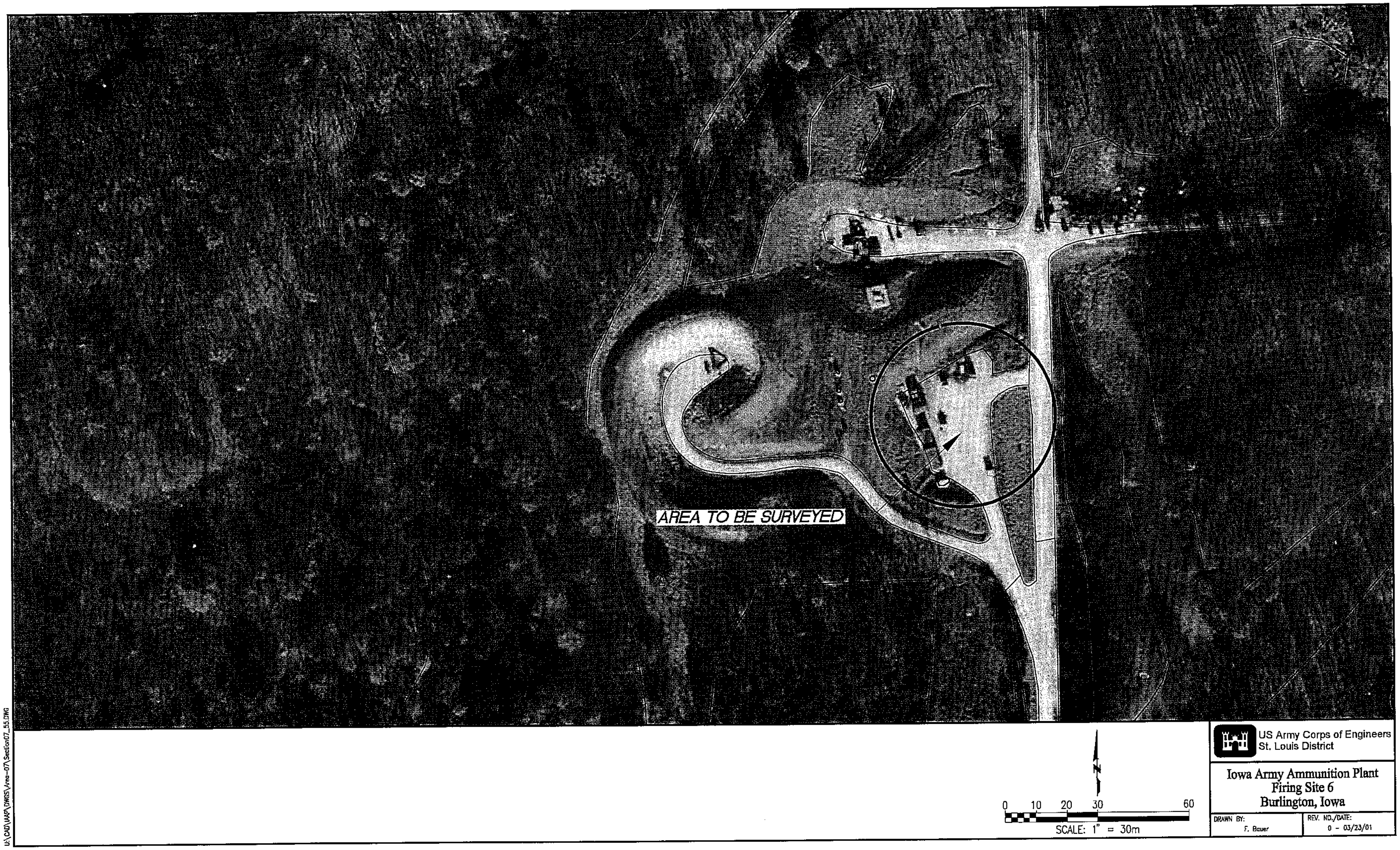

Figure 4. Aerial View of Firing Site 6

An additional evaluation involving the collection of a general area dose rate measurement using the Ludlum Model 19 μR/hr detector at one meter above the ground surface may also be conducted at locations exceeding the investigation level. If appropriate, visible DU fragments will be collected or a soil sample will be obtained for analysis at areas exhibiting elevated activity (see Sections 5.2 and 5.4).

5.2 DEPLETED URANIUM FRAGMENT COLLECTION

Isolated areas of elevated activity where it is readily discernable by the surveyor to be caused by a visible DU fragment will be marked with a unique colored pin flag. Field personnel will proceed to each flag position to locate and collect the DU fragment for placement in an appropriate storage container for future action. The storage container will be closed and stored to prevent infiltration of water or other contaminates and labeled as "Radioactive Material" in accordance with 10 CFR 20 and EM 385-1-80. After the DU fragment has been collected, surveyors may resurvey the area to verify the source of elevated activity has been removed.

5.3 SOIL SAMPLE COLLECTION

Based on historical data and the results of the radiological walkover survey, soil investigation samples will be taken. The survey supervisor will be responsible for evaluating the survey to determine the location of the investigation samples to be collected. Coordinates for all soil sample locations will be surveyed using GPS on NAD 83 or other appropriate coordinate system. All samples will be collected, labeled, logged and analyzed for appropriate radiological constituents in accordance with this plan and the *Sampling and Analysis Guide for the St. Louis Site* (USACE, 2000b).

Up to 7 surface soil samples at FS 6 and 10 surface soil samples at FS 12 will be collected. These samples will be biased to represent areas identified by the walkover survey exhibiting elevated levels of radioactivity. Additional samples from these locations may be collected, at the discretion of the survey supervisor, up to a depth of 2' to 4' below the ground surface if field observations warrant the need for additional information. The survey crew will scan all samples collected from areas of elevated activity with a 2" x 2" NaI detector to determine if the source of the elevated activity is present in the actual sample collected. If samples remain at either firing site after the collection of samples from areas of elevated activity, they will be collected from Class 2 survey unit grid locations projected for each site. Locations will be established assuming 30 samples per Class 2 survey unit would be required. This approach will allow these samples to be used in future final status sampling events conducted at the sites.

An additional 7 surface soil samples will be collected from an appropriate reference area to establish background levels for uranium at the site. The survey supervisor will choose the reference area with the assistance of the IAAAP staff once the survey team has arrived on site. The reference area samples will be collected from an area verified to be non-impacted after a review of all the relevant historical site information and a site "walk-about". A gamma walkover survey will be conducted over the chosen area to confirm that no areas of elevated activity are present.

At one firing site sample location and one reference area location, the survey team will collect Quality Assurance/Quality Control split and duplicate samples for analysis. This will result in a total of 2 split samples and 2 duplicate samples being collected.

5.4 FIELD LOGBOOK ENTRIES

The survey supervisor (or designee) will maintain logbooks to document project information and a daily written record of all survey and sampling activities. Logbooks will be maintained in accordance with the *Sampling and Analysis Guide for the St. Louis Sites* (USACE, 2000b) and SAIC *Field Technical Procedure-1215, Use of Field Logbooks* (SAIC, 1999a). Logbook entries will include, but are not limited to:

- Project personnel;
- Personnel contacts;
- Training activities;
- Daily tailgate meetings;
- Samples collected;
- Sample description;
- Sample IDs;
- Chain of Custody numbers;
- Weather conditions; and
- Nonconformances, issues and concerns.

6.0 SAFETY AND HEALTH

6.1 SITE SAFETY AND HEALTH

Site safety and health requirements for site tasks are based on potential physical, radiological, and chemical hazards. The survey team will follow the general site safety and health requirements documented in SAIC's *Site Safety and Health Plan for the St. Louis* (USACE, 2000a) *FUSRAP Sites, St. Louis Health Physics Manual* (SAIC, 1998), and *St. Louis Environmental Compliance and Health and Safety (EC&HS) Procedures Manual* (SAIC, 1999c). These documents/procedures are written to comply with the Nuclear Regulatory Commission (NRC), Occupational Safety and Health Administration (OSHA), and USACE regulations and have been approved for use by the St. Louis District USACE. The requirements for UXO safety will be in accordance with the UXO plan prepared by the USACE Rock Island District and approved by the USACE UXO Center of Expertise at Huntsville, Alabama.

The survey supervisor is the designated onsite Site Safety and Health Officer/Radiation Safety Officer (SSHO/RSO) for the scoping survey and maintains the responsibility for compliance with these requirements. Specific health and safety requirements will be documented on task specific activity hazard analyses (AHAs) and health and safety work permits (HSWP) for all survey and sampling activities detailed in this plan. The task-specific AHAs will be submitted to the St. Louis USACE for approval prior to the start of field activities.

6.2 SAFETY AND HEALTH TRAINING

All survey team personnel are required to meet the training requirements stated in the *Site Safety and Health Plan for the St. Louis FUSRAP Sites* (USACE, 2000a) to include HAZWOPER (40 hour and current 8 hour refresher), medical surveillance, health and safety orientation and radiation awareness training. Additional training for radiological survey crew personnel will include UXO safety training provided on site by the USACE Rock Island UXO specialists.

Prior to conducting work on site, members of the survey team (including the UXO specialists) will be required to attend the IAAAP safety briefing conducted by the IAAAP Safety Officer. At a minimum, this training will cover site access requirements, installation rules and regulations, and emergency response procedures for on-site personnel. All survey team personnel will follow the emergency response procedures in effect for the IAAAP.

The survey supervisor will verify completion of all training requirements and proof of required training will be maintained on site.

6.3 TASK SPECIFIC PPE

The minimum level of protection that will be used for non-intrusive survey activities at this site is Level D Protective Equipment (safety boots, hard hat, safety glasses). For intrusive activities such as soil sampling and for activities that involve the handling of DU fragments, the minimum level of protection will be Modified Level D Protective Equipment. Modified Level D Protective Equipment is defined as:

- impermeable disposable inner gloves (i.e., nitrile, polyvinyl chloride, or equivalent)
- safety boots (ANSI Z41)
- reusable (rubber) boot covers
- hard hat (ANSI Z89.1)
- safety glasses with side shields (ANSI Z87.1)

Additional personal protective equipment (PPE) such as Tyvek® coveralls or cotton/leather gloves may be required based on conditions encountered during the survey or new information on site contaminants not yet presented. The designated on-site SSHO/RSO has the responsibility for determining if an upgrade in PPE requirements is required once the survey team has mobilized to the site.

6.4 PERSONNAL MONITORING REQUIREMENTS

Monitoring for external exposure during the scoping survey will be conducted as a standard practice for sites with a potential for unknowns. All members of the survey crew will be required to wear whole-body lithium fluoride (LiF) thermo-luminescent dosimeters (TLDs).

Breathing zone air sampling will be conducted during soil sampling activities. At least 1 in 3 personnel performing soil sampling will be required to wear air sampling pumps equipped with cellulose filters set at approximately 3 liters per minute. If more than one group of personnel are soil sampling in different areas of the site, at least one member of each group will be monitored with a breathing zone sampler. All air filters collected will be analyzed and evaluated for the potential for any person to receive greater than 40 DAC-hrs of exposure. Personnel with the potential to exceed 40 DAC-hrs will be required to submit a urine bioassay sample to be analyzed for the presence of uranium.

7.0 RADIOLOGICAL POSTINGS

One of the objectives of this scoping survey is to verify that contaminated areas with the potential to create situations of unacceptable exposure are contained and controlled. Areas exhibiting elevated activity will be evaluated by the survey supervisor to determine if the area should be posted to restrict unauthorized access.

Posting of impacted areas will occur when the following conditions are present:

1. General area dose rate in excess of 2 mrem/hr.
2. General area dose rates such that facility personnel could exceed the public dose limit of 100 mrem/yr during continuous occupancy (e.g., 50 μR/hr assuming continuous occupancy of facility personnel is limited to a maximum of 2000 hours).
3. Soil contamination at a level and form that if an individual comes into contact with the soil would result in detectable contamination on their skin or clothing.

Radiological postings labeled "Caution - Radioactive Material" and yellow/magenta rope (rad-rope) will be placed adjacent to impacted areas of the site to prevent the spread of contamination to non-impacted areas and inadvertent exposure to facility personnel. Postings will be placed conspicuously and at a frequency to provide adequate warning.

8.0 SAMPLE AND WASTE DISPOSITION

Samples will be surveyed, packaged, sealed in strong tight containers and shipped from the IAAAP to the appropriate laboratory through the use of a commercial carrier (i.e., Fed Ex, UPS, etc.). Samples are not expected to exceed the 70 Bq/gm limit that requires the application of Department of Transportation (DOT) requirements for radioactive materials. If the sample manager determines that the sample activity has the potential to exceed 70 Bq/gm, the samples will surveyed, packaged, sealed, and shipped as a Limited Quantity shipment in accordance with SAIC procedure *HP-704, Transportation Requirements for Limited Quantities of Radioactive Material.* All sample containers will be verified free of loose contamination and the dose rate to the outside of the shipping container will be verified as being less than 0.5 mrem/hr.

Collected fragments of DU, as described in Section 5.2 of this plan, and other radioactive waste generated during the scoping survey will be stored in an existing Radioactive Material Storage Areas (RMSA) located at IAAAP, if possible. If necessary, the survey team will set up RMSAs in coordination with IAAAP personnel. All attempts will be made to minimize the amount of radioactive waste generated during the scoping survey. Stored radioactive materials generated during the scoping survey will be transferred at the end of survey activities to IAAAP for dispositioning with other waste materials in the future, as appropriate.

9.0 DOCUMENTATION OF FINDINGS

Survey procedures and results will be documented in a Scoping Survey Summary Report. This report, will at a minimum, contain the following information:

- Facility maps showing scan data, locations of elevated scan levels (if any), and sample locations for each firing site and the reference area;
- Correlation between 2" x 2" NaI , FIDLER and soil contamination levels (if any);
- Tables of radionuclide concentrations for each sample collected from the firing site and reference area to include the result in pCi/g, measurement errors, detection limits, and sample coordinates;
- Summary statistics to include minimum, maximum, mean, standard deviation, and UCL-95 values; and
- Evaluation of how collected data compares to the screening level DCGL and other appropriate risk/dose requirements.

10.0 REFERENCES

10 CFR 20, 1995. U.S. Nuclear Regulatory Commission. "Standards for Protection Against Radiation."

American National Standards Institute (ANSI), 1997. *Radiation Protection Instrumentation Test And Calibration – Portable Survey Instruments*, N323A, New York

EPA, 1977. NUREG-1575, *Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM)*, EPA 402-R-97-016, December.

Nuclear Regulatory Commission (NRC). 1997. *Minimum Detectable Concentrations with Typical Radiation Survey Instruments for Various Contaminants and Field Conditions*. NUREG/CR-1507, Final, NRC, Washington, D.C.

SAIC, 1998. St. Louis Health Physics Manual

SAIC, 1999a. *Field Technical Procedure, Use of Field Logbooks*.

SAIC, 1999b. *FUSRAP St. Louis, Laboratory Quality Assurance Manual and Laboratory Procedures Manual*.

SAIC, 1999c. *St. Louis Environmental Compliance and Health and Safety (EC&HS) Procedures Manual*.

USACE, 1996. *Remedial Investigation/Risk Assessment, Iowa Army Ammunition Plant, Middletown Iowa*. May, Draft Final.

USACE, 1997. Radiation Protection Manual, EM 385-1-80. May.

USACE, 2000a. *Site Safety and Health Plan (SSHP) for Site Activities at the St. Louis Airport Site at St. Louis, Missouri*. January.

USACE, 2000b. *Sampling and Analysis Guide for the St. Louis Sites*. Final, October.

APPENDIX A

IAAAP SCOPING SURVEY
SCREENING LEVEL DCGL RISK/DOSE ASSESSMENT

A.1 IAAAP SCOPING SURVEY SCREENING LEVEL DCGL RISK/DOSE ASSESSMENT

The residual radioactivity dose/risk assessment considers a future residential property at the location of the current Iowa Army Ammunitions Plant firing site area. Although current land use is not residential, the residential scenario is utilized in the dose/risk assessment as it will provide the most conservative assessment to a public receptor and is thus, fully representative of likely future site conditions. The residential property is estimated at 10,000 m^2. This area is equivalent to 2.5 acres, which would equate to a relatively large property in a typical residential subdivision. It should be noted that the residual contamination on the property may cover only a small surface area (which would lower risk estimates); however, the contamination will be assumed to be homogenously mixed throughout the surface of the property for this assessment. The exposure pathways considered for the resident in this assessment include external gamma, inhalation of dust, plant ingestion, meat ingestion, milk ingestion, aquatic food ingestion, drinking water ingestion, and soil/sediment ingestion. RESRAD version 5.82 is used to perform the residual dose/risk assessment.

A.2 SCENARIO PARAMETERS

The residential scenario assumes an individual lives onsite for 350 days per year for 30 years, beginning at birth. Each day the resident is assumed to spend 16.4 hours indoors and 2.0 hours outdoors (EPA, 1997). Because child and adult ingestion rates, body weights, and exposure durations vary, exposure to the resident via ingestion of soil/sediment is based on a weighted average of the respective child and adult parameters. The following table summarizes the scenario exposure parameters for this assessment:

Exposure Parameters

Exposure Parameters for Each Medium for Residential Receptor		
Parameter by Media/Pathway	**Units**	**Residential**
Exposure Frequency	days/year	350[a]
Exposure Duration	years	30[a]
Indoor Exposure Frequency	hours/day	16.4[a]
Indoor Fraction	unitless	0.655
Outdoor Exposure Frequency	hours/day	2.0[a]
Outdoor Fraction	unitless	0.0799
Carcinogenic Averaging Time	days	25550
Non-carcinogenic Averaging Time	days	10950
Surface Soil	-	Yes
Subsurface Soil	-	Yes
Ground Water	-	Yes
Surface Water	-	Yes
External Radiation		
Gamma Shielding Factor	unitless	0.4[d]

Exposure Parameters for Each Medium for Residential Receptor (continued)		
Inhalation		
Inhalation Rate	m^3/hour	0.552[a,b]
Exposure Time	hours/day	18.4[a,c]
Ingestion of Plant Foods		
Fruit, Vegetable and Grains Consumption	kg/yr	718.32[a]
Leafy Vegetable Consumption	kg/yr	14[d]
Depth of Roots	meter	0.9[d]
Ingestion of Meat		
Meat and Poultry Consumption	kg/yr	111.7[a]
Livestock Fodder Intake for Meat	kg/day	68[d]
Ingestion of Milk		
Milk Consumption	L/yr	92/person[d]
Livestock Fodder Intake for Milk	kg/day	55[d]
Ingestion of Aquatic Food		
Fish Consumption	kg/yr	15.22[a]
Other Seafood Consumption	kg/yr	0.9[d]
Drinking Water Ingestion		
Ingestion Rate	L/day	2.3[a]
Incidental Ingestion of Soil		
Soil Ingestion Rate		
Adult	mg/day	100[a]
Child	mg/day	200[a]

a EPA 1997, "Exposure Factors Handbook," Volumes I, II, and III, EPA/600/P-95/002Fa-c, EPA, Office of Research and Development, Washington, DC.
b Average of male and female adult values.
c Average time spent at home.
d RESRAD Default Values

A.3 SOIL CONCENTRATION DETERMINATION

For this assessment, a screening level DCGL of 56 pCi/g of depleted uranium was selected and used as the representative concentration for each residential property. This DCGL was selected based upon the field scanning minimum detectable concentration provided for depleted uranium in Table 6.4 of NUREG-1507. In order to assess the dose/risk from the uranium isotopes and short-lived daughters that constitute depleted uranium, the following isotopic activity ratios were utilized:

- 0.9218 U-238
- 0.0636 U-234
- 0.0149 U-235

For the residential scenario, the residual dose/risk assessments are performed assuming the contamination extends 6 inches (0.15 meter) below the surface and there is no cover on the residual soils. The lack of clean cover over the soils provides the most conservative assessment of the radiation dose/risk to the potential residential receptors. Given this information, the following tables summarize the soil parameters used in the assessment.

Hydrological Data

RESRAD default values were used for each of the following hydrological parameters.

Site Data	Contaminated Zone	Saturated Zone	Unsaturated Zone
Thickness (m)	0.15	N/A	4
Density (g/cc)	1.5	1.5	1.5
Erosion Rate (m/yr)	0.00006	0.00006	N/A
Total Porosity	0.4	0.4	0.4
Effective Porosity		0.2	0.2
Soil b Parameter	5.3	5.3	5.3
Hydraulic Conductivity (m/yr)	10	100	10

Initial Soil Concentration

The following table showed the concentrations of each of the three radionuclides.

Name of Radionuclides	Units	Value
U-234	pCi/g	3.562
U-235[1]	pCi/g	0.834
U-238[2]	pCi/g	51.604

[1] RESRAD assumes short lived daughter Th-231 is in secular equilibrium.
[2] RESRAD assumes short lived daughters Th-234 and Pa-234m are in secular equilibrium.

A.4 ASSESSMENT METHODOLOGY

RESRAD Version 5.82 is used to estimate potential radiation dose due to exposure to radiological contaminants in soil and sediment. The RESRAD code uses Federal Guidance Reports 11 and 12 to estimate dose. The exposure parameters used in the assessment were selected to provide a conservative, yet reasonable, estimate of potential dose to each receptor. The parameters discussed above were used to describe site conditions. Parameter values were chosen to provide reasonably conservative estimates of risk or standard default values recommended by the Exposure Factors Handbook (EPA, 1997) were used. The model assumes that contamination is always spread over a large area and is never covered. Thus, the assumption that these measured concentrations are present at the surface provides a conservative estimate of potential radiation dose to each receptor.

Dose/Risk Assessment Results

The following table summarizes the radiological doses and risks to the residential receptor due to the exposure of depleted Uranium at t = 0 and at t = 1000 years.

Summary of Radiological Doses and Risks at t = 0 and t = 1000 years		
Time	**Dose (mrem/yr)**	**Risk**
0	5.7	5 E-05
1000	9.1	6 E-05

The maximum dose due to residential exposure is 9.1 mrem/yr and it occurs at t = 1000 years. The associated risk at this time is 6 E-05. The risk level determined using a residential scenario indicates that the use of the selected remediation goal would provide a risk within the CERCLA target risk range (10^{-4} to 10^{-6}) specified for protection of human health for members of the general public.

A.5 REFERENCES

EPA, 1997. *Exposure Factors Handbook, Volumes I, II, and III*, EPA/600/P-95/002Fa-c, Office of Research and Development, Washington, DC, August.

U.S Nuclear Regulatory Commission. 1998. *NUREG-1507: Minimum Detectable Concentrations with Typical Radiation Survey Instruments for Various Contaminants and Field Conditions*. Washington, D.C.

APPENDIX B

2" X 2" NAI DETECTOR
SCAN DETECTION OF DEPLETED URANIUM FRAGMENTS

B.1 NAI 2-INCH BY 2-INCH SCINTILLATION DETECTOR SCAN DETECTION OF DEPLETED URANIUM FRAGMENTS

NUREG 1507, *Minimum Detectable Concentrations with Typical Radiation Survey Instruments for Various Contaminants and Field Conditions* (NRC 1998), and NUREG 1575, *Multi-Agency Radiation Survey and Site Investigation Manual* (MARSSIM) (DoD 1997) provide examples of typical minimum detectable concentrations (MDCs) for various radionuclides using gamma scan detectors. These documents state that the MDCs provided are examples only and other scan MDC values may be equally justifiable depending on the values chosen for the various input parameters and site specific conditions. The MDC value listed in NUREG 1507 for soil contaminated with depleted uranium is considered justifiable and sufficient. However, the use of this value is not appropriate for the detection of visible, solid DU fragments. Due to the specific activity of a depleted uranium fragment there is little doubt that the typical hotspot siae modeled in NUREG 1507 (0.25-cm radius) could be detected. The question is how small of a fragmented piece of depleted uranium can be detected with confidence.

The steps utilized for calculating the size of a depleted uranium fragment that can be detected generally follow the approach detailed in NUREG 1507. The steps include:

1. Calculating the minimum detectable count rate (MDCR) by selecting a given level of performance, scan speed, and background level of a 2-inch by 2-inch (or 2"×2") NaI detector,
2. Selecting a surveyor efficiency, and
3. Relating the surveyor's MDCR ($MDCR_{surveyor}$) to a given exposure rate.
4. Modeling the exposure rate of various size fragments.
5. Comparing the MDCR exposure rate to the modeled exposure rates.

The development of this relationship in item three requires two significant steps. In step one, the relationship between the detector's net counting rate to net exposure rate in counts per minute per micro-Roentgen per hour (cpm/μR/hr) is established. In step two, the relationship between the specific activity of depleted uranium and exposure rate is determined. For particular gamma energies, the relationship of the 2"x2" NaI detector's counting rate (in counts per minute or cpm) and exposure rate may be determined analytically. Once this relationship is known, the $MDCR_{surveyor}$ (in cpm) of the NaI detector can be related to the minimum detectable net exposure rate. This minimum rate is used to determine the minimum detectable depleted uranium fragment by modeling a specified postulated fragment.

For determining the MDCR, an average background for the 2×2 NaI detector of 10,000 cpm was selected. The observable background counts is the number of background counts observed within the observation interval. This is commonly referred to as *b'*. The equation used for calculating *b'* is as follows:

$$b' = (\text{background count rate}) \times (\text{observation interval}) \times (1\ \text{min}/60\ \text{sec}) = \text{counts/interval}$$

$$b' = (10{,}000\ \text{cpm}) \times (1\ \text{sec}) \times (1\ \text{min}/60\ \text{sec}) = 166.67\ \text{counts.}$$

The observational interval of 1 second is based on the selected instruments to be used during the GPS assisted gamma walkover. The detector/meter combination will produce a data point or cpm reading every second during operation. This reading will be married to a specific X Y coordinate and recorded in the associated data logger.

The MDCR is defined as the increase above background recognizable during a survey in a given period of time. The variable, *d'*, is the alpha/beta error acceptable for a given survey. Alpha and beta errors of 95% (true positive rate) and 60% (false positive rate), respectively, were selected to be consistent with NUREG 1507. Selection of a high beta error signifies that the surveyor will stop the 1st stage scan at very small increases in detection signal "clicks" in order to conduct a 2nd stage scan. This slows down the survey but provides a higher level of confidence in the results of the survey. The value of 1.38 was obtained from Table 6.1 in NUREG 1507 (Table 6.5 in MARSSIM).

$$MDCR = (d') \times (\text{sq. root of } b') \times (\text{\# of observation/minute}) = \text{cpm}$$

$$MDCR = (1.38) \times (\text{sq. root } 166.67) \times (60 \text{ observations/min}) = 1069 \text{ cpm}$$

The $MDCR_{surveyor}$ or minimum detectable count rate of the surveyor is defined as the increase above background during a survey that will be identified as an increase by the surveyor. Surveyor efficiency was selected to be 50%, consistent with NUREG 1507:

$$MDCR_{surveyor} = (MDCR) / (\text{sq. root of surveyor efficiency})$$

$$MDCR_{surveyor} = (1069) / (\text{sq. root of } 0.5) = 1512 \text{ cpm.}$$

An estimated exposure rate for various sizes of square depleted uranium fragments was obtained by modeling with Microshield Version 5.01. A rectangular volume of depleted uranium with a various lengths and a constant width and thickness of 1.0 cm was selected. The modeled exposure rate was used to calculate the expected increase in count rate above background for the 2"x2" NaI detector. Using the same parameters as above, the same sizes of depleted uranium fragments were modeled with 5 cm (≈2 inches) of soil cover material. The density of the soil was estimated at 1.6 g/cm^3. Table B-1 shows the size of the depleted uranium fragment, associated cpm increase for a sodium iodide 2X2 modeled for a fragment located on the ground surface, and the associated cpm increase for a 2"X2" NaI detector modeled for a fragment covered with 5 cm of soil.

Table B-1. Modeled Count Rate versus DU Fragment Size

DU Fragment Size (cm^3)	Net count rate with DU fragment on ground surface (cpm)[1]	Net count rate with DU fragment beneath 5 cm of soil (cpm)[1]
1.0	2058	1081
2.0	4065	2147
3.0	5976	3186
4.0	7756	4186
5.0	9385	5137
6.0	10853	6032
7.0	12162	6865
8.0	13321	7637
9.0	14337	8347
10.0	15227	8994

[1] Net count rate using a 2"x2" NaI detector.

Since the $MDCR_{surveyor}$ = 1512 cpm a one cubic centimeter depleted uranium fragment located on the surface of the survey area is capable of being detected. However, survey experience has shown that random background fluctuation interferes with recognizing a 1500-cpm increase in count rates. An investigation level of 2000 cpm above relevant background is typically established and used as a field screening value. Setting 2000 cpm above background as the investigation level maintains the size of detectable DU fragments on the ground surface to 1.0 cubic centimeters when the detector is located directly above the fragment for one second. Maintaining the investigation level constant at 2000 cpm above relevant background establishes that a 2 cm^3 depleted uranium fragment buried beneath 5 cm of soil can be detected when the detector is located directly above the fragment for one second. As shown in the table, in both cases, as the size of the fragment increases the modeled count rate increases. The larger the fragment size the easier it becomes to detect.

However, the detection of the above fragments is dependent on the detector being positioned directly above the fragment for the entire 1 second count interval. The typical scan rate employed during gamma walkovers is 0.5 meters per second. This means that the detector will cover approximately 0.5 m^2 or 50 cm^2 in one second. Therefore, during a typical scan survey the detector would only be positioned above the fragment for a fraction of the 1 second count time.

To maintain the required confidence that the fragment would be detected during a normal scan survey the lowest count rate for a specific size depleted uranium fragment obtainable in the 1 second count rate window when normalized to cpm must be > 2000 cpm. The lowest obtainable count rate within the 1 second count rate window when moving at 50 cm per second would occur 25 cm from the fragment.

An estimated exposure rate 25 cm from various sizes of square depleted uranium fragments was obtained by modeling with Microshield Version 5.01. A rectangular volume of depleted uranium with a various lengths and a constant width and thickness of 1.0 cm was selected. The modeled exposure rate was used to calculate the expected increase in count rate above background for the 2"x2" NaI detector. Using the same parameters as above, the same sizes of depleted uranium fragments were modeled with 5 cm (2 inches) of soil cover material. The density of the soil was estimated at 1.6 g/cm^3. Table B-2 shows the size of the depleted uranium fragment, associated cpm increase for a 2"X2" NaI detector modeled for a fragment located on the ground surface, and the associated cpm increase for a 2"X2" NaI detector modeled for a fragment covered with 5 cm of soil.

Table B-2. Modeled Count Rate versus DU Fragment Size at 25 cm

DU Fragment Size (cm^3)	Net count rate at 25 cm with DU fragment on ground surface (cpm)[1]	Net count rate at 25 cm with DU fragment beneath 5 cm of soil (cpm)[1]
5.0	1717	1113
6.0	2047	1326
7.0	2370	1534
8.0	2684	1736
9.0	2990	1932
10.0	3286	2121

Maintaining the investigation level constant at 2000 cpm above relevant background establishes that a 6.0 cm^3 depleted uranium fragment on the surface of the survey area and that 10.0 cm^3 depleted uranium fragment buried beneath 5 cm of soil can be detected with confidence during a normal scan survey. Once again, the larger the fragment the higher the probability of detection.

In summary, the smallest piece of DU located on the surface of the survey area that can be detected is approximately a 1.0 cubic centimeter fragment. The smallest piece of DU that can be detected with confidence during a normal scan survey using conservative assumptions is a 6.0 cubic centimeter fragment. The smallest piece of DU that is covered with 5 cm of soil that can be detected is approximately a 2.0 cubic centimeter fragment. The smallest piece of DU that is covered with 5 cm of soil that can be detected with confidence during a normal scan survey using conservative assumptions is a 10 cubic centimeter fragment.