Appendix H

Engineering Design File for the Calibration of Field Instrumentation

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Engineering Design File

OU 5-12 Phase II Soil Removal – Global Positioning Radiometric Scanner System Calibration for Use at ARA-23

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4. Title: OU 5-12 Phase II Soil Removal – Global Positioning Radiometric Scanner System Calibration for Use at ARA-23

5. Summary:

A field study was conducted at the ARA-23 CERCLA site to calibrate the INEEL Global Positioning Radiometric Scanner System (GPRS). The field study resulted in the development of a calibration equation to convert net count rate data from the GPRS to Cs-137 concentrations at the ARA-23 site. Additionally, a lower limit of detection (referred to as the scan MDC) for Cs-137 for the GPRS was calculated at a value of 1.01 pCi/g. An evaluation of the GPRS accuracy with respect to the ISO-CART system shows that the GPRS is within 25% of the reported ISO-CART values. The linear calibration function and the lower limit of detection show that the GPRS is a suitable technology for the rapid field screening of Cs-137 contaminated soils at the ARA-23 site. It is cautioned that the data presented in this EDF are site specific for the ARA-23 site, and should not be arbitrarily applied to other radiologically contaminated sites; however, the method presented herein could be used to develop a site specific calibration provided that the site meets certain criteria. It is also recommended that the GPRS background be reevaluated just prior to deployment for the OU 5-12 soil removal.

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7. Review (R) and Approval (A) Signatures: (Minimum reviews and approvals are listed. Additional reviews/approvals may be added as necessary.)

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ACRONYMS

ARA	Auxiliary Reactor Area
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
DOE-ID	Department of Energy Idaho Operations Office
EDF	Engineering Design File
EML	Environmental Measurements Laboratory
GPRS	Global Positioning Radiometric Scanner System
INEEL	Idaho National Engineering and Environmental Laboratory
MDC	minimum detectable concentration
MDCR	minimum detectable count rate
NRC	Nuclear Regulatory Commission
OU	operable unit

OU 5-12 Phase II Soil Removal – Global Positioning Radiometric Scanner System Calibration for Use at ARA-23

1. INTRODUCTION

This engineering design file (EDF) presents the radiation measurements and data analysis in support of a site specific field calibration of the Idaho National Engineering and Environmental Laboratory (INEEL) Global Positioning Radiometric Scanner System (GPRS) using the ORTEC ISO CART system. The primary basis for performing the equipment measurements and calibration is to demonstrate the utility of in-situ real-time measurement systems, and benchmark their use in remedial activities at a large contaminated soil area site at the INEEL. The OU 5-12 Phase II Work Plan (DOE-ID 2000a), OU 5-12 Phase II Field Sampling Plan (DOE-ID 2000b), and the OU 5-12 Soil Volume minimization strategy (INEEL 2000) detail the use of in-situ radiological measurement systems during the cleanup of Auxiliary Reactor Area (ARA)-23 Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) site.

1.1 Source, Nature and Extent of Contamination

The ARA-23 site is a large, roughly oval-shaped windblown contamination site encompassing the SL-1 Burial Ground and the remnants of the ARA-I and ARA-II facilities (see Figure 1). The long axis of the site is consistent with the generally southwest to northeast winds common on the INEEL. Soils were radiologically contaminated by the 1961 SL-1 accident and subsequent cleanup. Minor amounts of contamination may have been added by other ARA operations. Over time, winds dispersed the contamination over an area roughly 240 acres in size.

A Track 1 investigation was initiated for ARA-23 in 1993 but was not finalized because the site was reassigned to OU 10-06 for evaluation. The OU 10-06 evaluation, which excluded the areas within the ARA-I and ARA-II facility fences, was only partially completed before ARA-23 was reassigned to WAG 5 for final disposition. The data gaps identified in the WAG 5 Work Plan (DOE-ID 1997b) comprised the horizontal and vertical extent of Cs-137 in the windblown soil area and in the presence of uranium isotopes and other radionuclides such as Co-60, Eu-152, Eu-154, Sr-90. Based on the sampling and analytical results combined with the surface gamma-radiation survey conducted using the GPRS, a risk assessment was performed. Cesium-137 was identified as the primary contributor to the estimated total risk for all pathways. Cesium-137 was also the only gamma-emitting contaminant identified at the ARA-23 site, which is a key factor in using the GPRS to make quantitative measurements of the contamination. Figure 1 also provides the results of the in situ gamma survey of ARA-23.

2. OBJECTIVES

The primary objective for performing the GPRS calibration is to provide a method to convert the gross count rate information to a Cs-137 concentration at the ARA-23 site. The calibration will provide the basis that these types of systems can use to demonstrate the effectiveness of remedial actions. Additionally, the equipment calibration measurements will provide the GPRS calibration with a scan or moving minimum detectable concentration (i.e. scan MDC). This MDC should be a factor of two below the remedial action goal of 23 pCi/g as identified in the OU 5-12 record of decision (ROD) (DOE-ID 2000c) if the GPRS is to be used effectively in identifying Cs-137 contamination. The secondary

objective of the calibration is to present a method that could be used to calibrate the GPRS or similar real-time data and position acquisition systems for use at other radiologically contaminated soil sites.

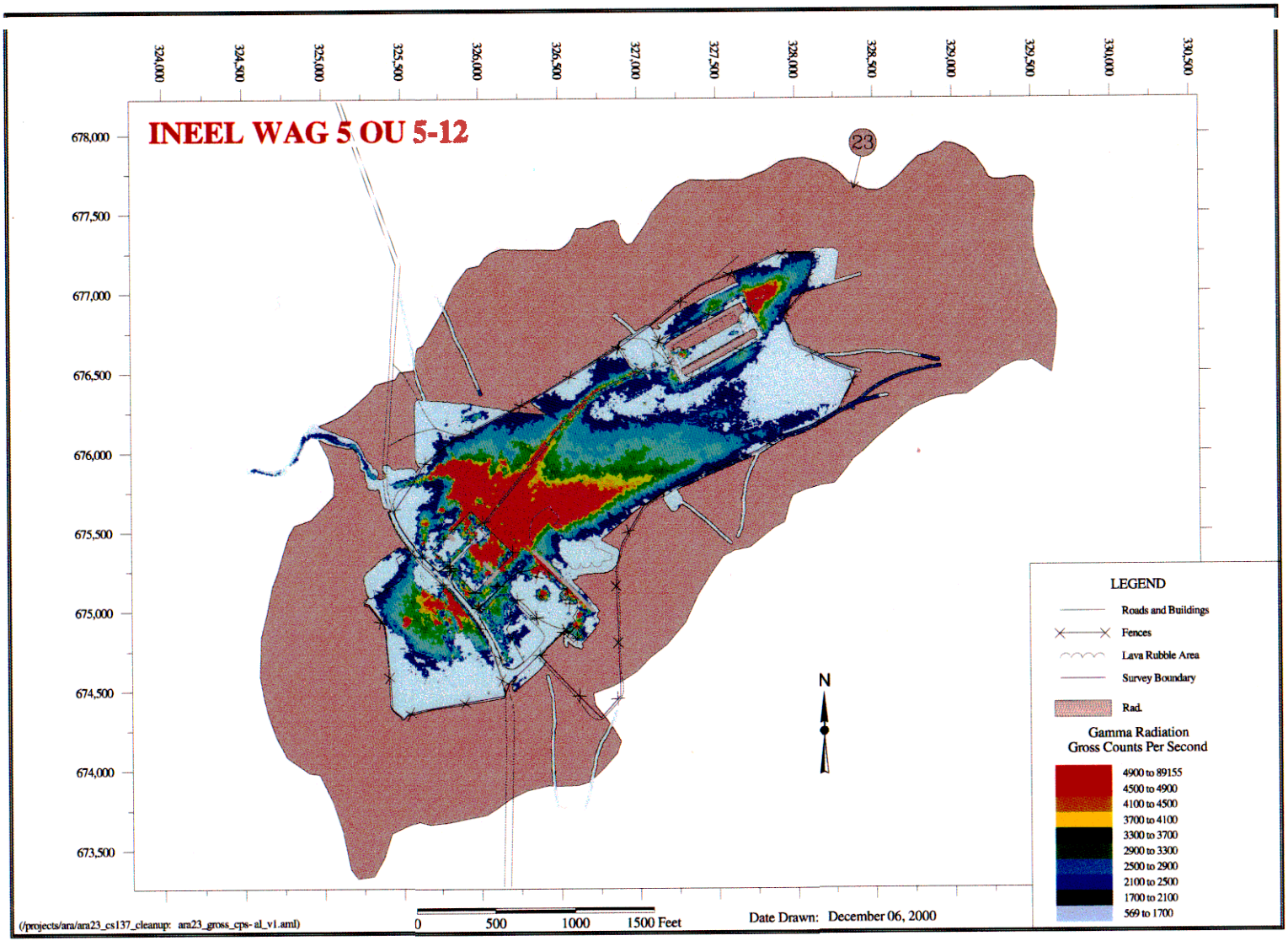

Figure 1. ARA-23 CERCLA site and gamma survey results.

3. METHODS AND MATERIALS

The basic method followed in the calibration of the GPRS is detailed in an EDF prepared in support of the *In-situ Gamma Radiation Survey at ARA-23 and ARA-24* (Josten 1997). The following sections describe the equipment and methodology used to collect and analyze the data.

3.1 INEEL Global Positioning Radiometric Scanner System

The INEEL GPRS is a mobile field survey system designed to rapidly characterize the areal extent of gamma-emitting radionuclide contamination of surficial soils. The GPRS consists of two large area plastic scintillation radiation detectors mounted to the front of a Humvee all-terrain vehicle that is equipped with global positioning system (GPS) navigation instruments. The detector height is fixed at a height of 3.3 ft. At this height, the detector has an approximate field of view diameter of 25 ft. The GPRS integrates the radiological data with the GPS data to provide information regarding the spatial distribution of gamma emitting contamination, in terms of gross counts per second, in the form of an area map.

3.2 ORTEC ISO-CART

The INEEL field based gamma spectrometry system measures radionuclide concentrations at areas where soils are contaminated with anthropogenic isotopes and that contain the usual naturally occurring nuclides. The system employs a standard coaxial germanium detector positioned at 1 m (3.3 ft) above ground and connected to an ORTEC Dart multichannel analyzer. The multichannel analyzer is connected to a field computer running the U. S. Department of Energy (DOE) Environmental Measurements Laboratory (EML) M1 software. This software uses internal efficiency calibration factors, attenuation corrections, and angular flux corrections to calculate and report the individual radionuclide specific activities (pCi/g) and associated uncertainties. The approximate field of view has a radius of 30 ft. with the HPGe detector positioned at a height of 3.3 ft. The system is calibrated on a daily basis prior to field measurements.

3.3 Calibration Measurement Methods

The contaminated portion of the ARA-23 site was completely surveyed by the GPRS, as shown in Figure 1. The initial survey was performed in 1997 in support of the in-situ gamma radiation survey for the OU 5-12 comprehensive remedial investigation/feasibility study (DOE-ID 1999). Data gaps were identified, and additional surveys were performed in 1999 and 2000 to fill the data gaps. The GPRS calibration data was collected during the months of October through November 2000. Data collection with the GPRS occurred first in October followed by the ISO-CART data collection in November. There was a brief period of precipitation between the GPRS and ISO-CART data points measurement; however, due to the radiological control conditions in place at the ARA-23 site, the soil was required to be dry prior to deployment of the ISO-CART. Additionally, during the measurement of the three calibration test points, approximately 1 in. of snow was present. The implications of the snow cover are discussed in Section 4.3. The calibration consisted of four primary steps: 1) GPRS background determination, 2) calibration measurement point selection, 3) calibration measurements, and 4) calibration data reduction.

3.3.1 GPRS Background Data Collection

Prior to calibrating the GPRS, the background response of the system (under field conditions) needs to be determined. The background measurement locations were selected near the ARA-23 site, but at a distance far enough away so that the GPRS detectors were not influenced by the Cs-137

contamination at the ARA-23 site. Two locations were arbitrarily selected based upon their apparent natural state (i.e., there was a considerable amount of sagebrush and grass, and the areas appeared to be previously undisturbed). These two areas are considered representative of the ARA background. The GPRS was driven through the background areas at the normal survey speed of approximately 5-mph, resulting in the collection of 782 background data points.

3.3.2 Calibration Measurement Point Selection

It was desired to calibrate the GPRS to a range of Cs-137 soil concentrations that included the 23 pCi/g remedial action goal. As a result, two transects across the windblown contamination footprint were selected for the calibration measurement locations. To provide statistically significant results in the data reduction, 15 individual measurement points were selected along each transect for a total of 30 calibration measurement points. Figure 2 shows the locations of the transects and associated calibration measurement points. The transects were labeled "A" and "B," with the individual calibration points numbered accordingly. Table 1 below provides the coordinates for the calibration measurement points.

Table 1. Calibration measurement point coordinate data[a].

Transect A Point Designation	Easting	Northing	Transect B Point Designation	Easting	Northing
A1	326901.7	675614.2	B1	326628.2	676143.4
A2	326896	675651.0	B2	326636.1	676096.1
A3	326890.1	675687.7	B3	326643.2	676048.7
A4	326884.3	675723.5	B4	326649.8	676000.6
A5	326878.9	675759.9	B5	326656.7	675953.2
A6	326873.1	675796.0	B6	326663.3	675906.3
A7	326866.8	675832.6	B7	326669.9	675859.2
A8	326861.6	675868.8	B8	326677.0	675812.0
A9	326855.3	675905.0	B9	326684.3	675765.4
A10	326849.9	675940.6	B10	326691.0	675719.3
A11	326843.5	675975.4	B11	326697.9	675671.9
A12	326838.5	676012.0	B12	326704.4	675624.6
A13	326832.2	676048.9	B13	326711.2	675576.3
A14	326826.6	676085.6	B14	326718.9	675528.7
A15	326821.6	676121.3	B15	326726.0	675481.3
D1	326307	675911.7			
D2	326447.4	676086.4			
D3	326760.8	676413.3			

a. Coordinates in NAD 27, State Plane.

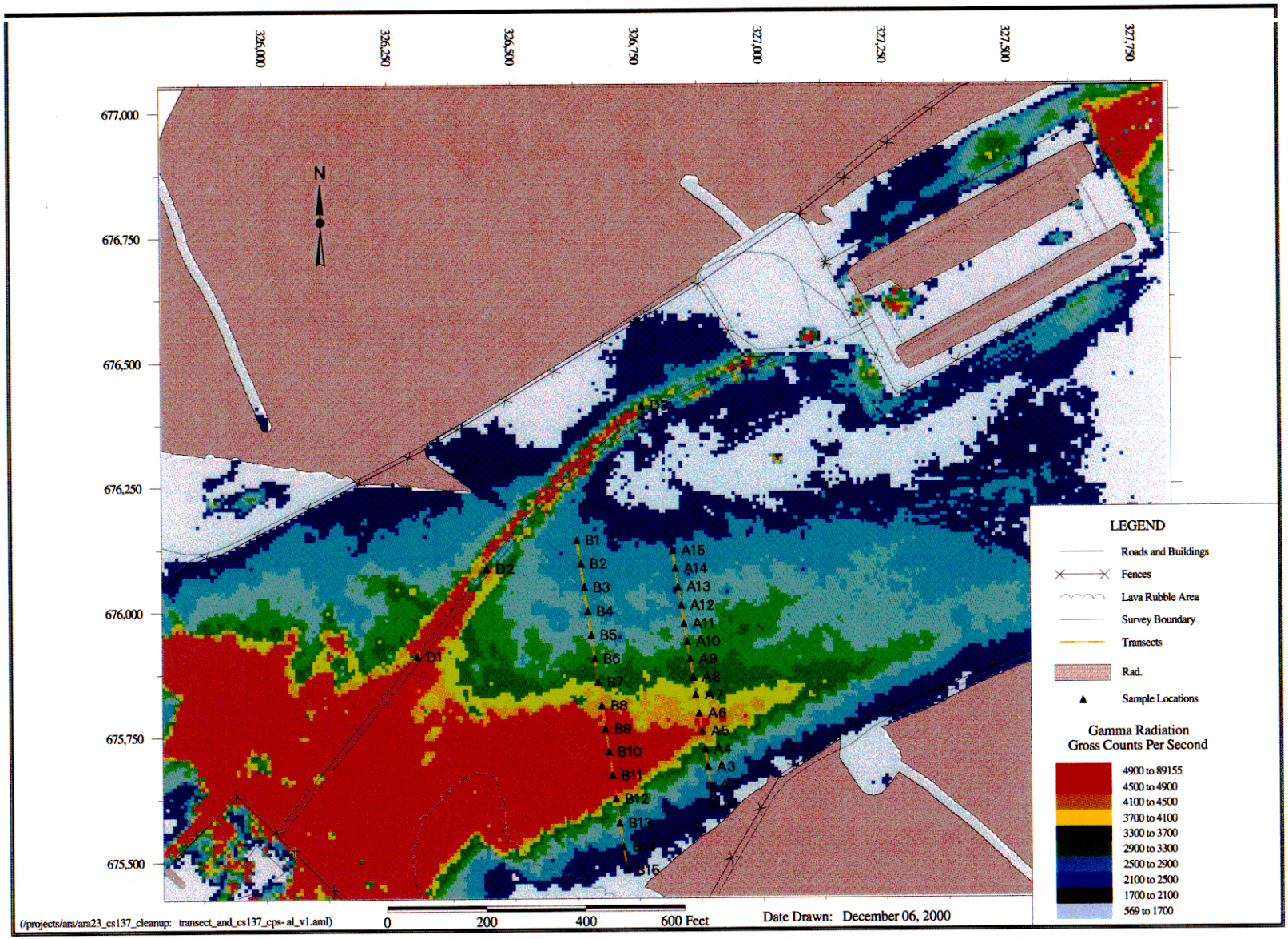

Figure 2. Detail of study area showing calibration measurement point locations.

Three points (designated D1, D2, and D3) located along the haul road were selected as test points to evaluate the accuracy of the GPRS calibration. Table 1 also contains the coordinate data for D-series measurement points.

3.3.3 Calibration Measurements

The calibration measurements were comprised of a series of radiation measurements. These included calibration points A1-A15 and B1-B15 using the GPRS and the ISO-CART system. Initially, the GPRS was used to measure the points along Transects A and B, traveling at a speed of 5-mph. Gross count rate and position data were collected and stored every second along each transect. The GPRS was positioned such that the calibration measurement points were centered beneath the GPRS radiation detectors (i.e., the wheels straddled the transect line). Next, the ISO-CART was used to measure each calibration point individually to quantify the Cs-137 contamination in the area seen by the detector. At this point it is important to note that the fields of view for the GPRS and the ISO-CART are comparable, as discussed in Sections 3.1 and 3.2 above. The ISO-CART system was positioned with the detector "looking" straight down on the measurement point. A count time of 600 seconds was used for the ISO-CART measurements.

GPRS and ISO-CART measurements were also made at points D1, D2, and D3. These points, as noted above, were selected as test points to evaluate the accuracy of the GPRS calibration.

3.4 Data Reduction

Following data collection, detailed data analyses were performed using Microsoft Excel. The data reduction methods employed included statistical analysis of data using the analysis routines in Excel. The GPRS background data were analyzed to determine the average background for the ARA area. In turn, the net count rates (gross counts minus the background) for the GPRS were compared to the reported Cs-137 values from the ISO-CART system. The Cs-137 concentrations reported by the ISO-CART system assume a 1-in. uniform distribution of the contamination in the surficial soils. This allowed for a direct comparison of the Cs-137 concentration of the soils to the observed net count rate from the GPRS. A relationship between Cs-137 and GPRS net count rates was then established. Additionally, it was desirable to identify *a priori*, the minimum detectable count rate or minimum detectable concentration for Cs-137, for the GPRS system to verify that it was below the remedial action goal. The following sections of this EDF present the results of the data analysis and describe the relationship between the GPRS net count rate and Cs-137 soil concentrations at the ARA-23 CERCLA site. The raw data associated with this study are located in the WAG-5 project files.