Attachment V

Final Status Survey Report #24 Documentation

(UNDER SEPARATE COVER)

FSSR # 24

28m2

FINAL

COLUMBUS CLOSURE PROJECT CHARACTERIZATION AND FINAL STATUS SURVEY REPORT FOR THE AREAS SURROUNDING AND INCLUDING THE ACTIVE MIDDLE FILTER BED

Revision 2
June 16, 2006

Prepared by

ECC & E2 Closure Services
1425 State Route 142 East
West Jefferson, OH 43162

FSSR# 24

Contract Number: DE-AC24-04OH20171

Final Characterization and Final Status Report for the Areas Surrounding and Including the Active Middle Filter Bed

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Contract Number: DE-AC24-04OH20171

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1.0 Introduction

This report contains the final status surveys (FSS) for the Areas Surrounding and Including the Active Middle Filter Bed (AMFB) located at the Columbus Closure Project (CCP), 1425 Plain City/Georgesville Road State Route 142 East, West Jefferson, OH 43162. Final status surveys were conducted according to the guidance presented in the *Manual for Conducting Surveys in Support of License Termination*, NUREG/CR-5849, and the *Radiological Characterization and Final Status Plan for Battelle Columbus Laboratories Decommissioning Project, West Jefferson Site*, DD-97-02 (Final Status Plan) (Battelle, 2000). The final status surveys were conducted in November of 2005 and performed under Work Instruction 2806 (Closure Services, 2004).

The intent of this final status survey report is to provide a complete and unambiguous record of the radiological status of the AMFB excavation. Sufficient information and data is provided to enable an independent re-creation and evaluation at some future date of both the survey activities and the reported results for the excavation. Information in this report is also available in referenced technical basis documents, final status survey plans, technical procedures, the *Battelle Memorial Institute Columbus Operations, Decommissioning Plan*, DD-93-19 (BMI Decommissioning Plan), and other reporting and quality assurance procedures.

To the extent practicable, this final status survey report is presented with minimal information incorporated by reference. This final status survey report has been generated following the comprehensive, annotated outline presented in Chapter 9 of NUREG-5849 (ORAU, 1992).

1.1 Background

On April 16, 1943, the Battelle Memorial Institute (BMI), acting through what is now its Battelle Columbus Operations (BCO), entered into Contract No. W-7405-ENG-92 with the Manhattan Engineering District (MED) to perform atomic energy research and development (R&D) activities. BCO performed nuclear materials research and development at privately-owned facilities for the MED and its successor agencies: the Atomic Energy Commission (AEC), the Energy Research and Development Agency (ERDA), and the Department of Energy (DOE). Research and development continued until 1988 (Battelle, 2003a).

The BCO facilities at the King Avenue Site, Columbus, Ohio, and the West Jefferson North (WJN) and South (WJS) Sites, West Jefferson, Ohio, became partially radiologically contaminated as a result of the R&D activities. Decontamination of the King Avenue and WJS Sites has been completed and activities continue at the WJN site. The DOE, as the successor to the AEC and the Government's earlier work, is the agreed party with predominant liability and responsibility for decontamination and decommissioning (D&D) of the BCO facilities (Battelle, 2003a). The Assistant Secretary for Nuclear Energy of the DOE accepted the D&D of the WJN into the DOE's Surplus

Facilities Management Program as a major project (DOE, 1986). The DOE is the agency funding and managing the cleanup of the WJN (Battelle, 2003a). However, the site is not a DOE-owned facility.

BMI holds U.S. Nuclear Regulatory Commission (NRC) license number SNM-7. BMI has continually operated and conducted D&D activities in full compliance with this NRC license and according to the BMI Decommissioning Plan. The BMI Decommissioning Plan for the WJN site does not serve as a declaration to terminate SNM-7, but establish the criteria for performing D&D activities. The end goal of the BMI Decommissioning Plan is to reach unrestricted use conditions for the site (Battelle, 2003a).

The DOE has contracted ECC&E2 Closure Services, LLC (Closure Services) to safely remove DOE radioactive materials and contamination from the WJN site. Removal of radioactive material will be to levels allowing future use of the site without radiological restrictions, as described in the BMI Decommissioning Plan. Closure Services has conducted characterization and final status surveys for the areas surrounding and including the AMFB excavation. The results of the surveys demonstrate that these areas have been remediated to levels allowing future use without radiological restrictions.

2.0 Site Description

The Battelle Columbus Decommissioning Project (BCLDP) was implemented in 1984 to address the decommissioning activities of nine buildings at the King Avenue site and five at the WJN site. The DOE has subsequently transitioned the BCLDP to the Columbus Closure Project (CCP). Closure Services is implementing and completing the CCP under contract to the DOE.

The WJN Site is west of Columbus, Ohio. The site is bounded by the Big Darby Creek, a national scenic and state protected river on the east, and farm lands to the west, south, and north. Immediately east of the Big Darby Creek are a Girl Scout camp and several residential neighborhoods, all within ½ mile of the site. The CCP consists of the decontamination and decommissioning of the WJN site. Buildings JN-1, JN-2, and JN-3 were the three radiological contaminated buildings located within approximately 11.7 acres of the site. The filter bed area covers approximately 2.6 acres. The buildings previously contained a reactor, a plutonium test facility and radioactive analysis laboratory, three large hot cells, and a 50 foot deep fuel pool contaminated with nuclear fuel residuals. Additionally, extensive sanitary sewer systems of 4,000 linear feet of contaminated underground piping and filter beds have been remediated. **Figure 1** shows the location of the WJN site and the AMFB area.

2.1 Area Description

The filter bed area lies atop a sloped field located to the east of the Lake Battelle Dam and to the west of the Big Darby Creek. The area includes the:

- Abandoned North Filter Bed(s).
- Active North Filter Bed,
- Abandoned Middle Filter Bed, and
- Active Middle Filter Bed.

The filter bed area covers close to 2.6 acres of land. The area has been divided into roughly 107, 10-meter by 10-meter grids, with a total surface area of 10,700 square meters (m^2). Figure 2 details the AMFB area. The Active Middle Filter Bed is a surface sand filter sanitary system which currently serves the Battelle Middle site and is not radioactively contaminated.

Figure 2 illustrates the location and perimeter of the excavation surrounding and including the AMFB area. Contamination resulting from the Abandoned North Filter Bed (AbNFB) encroached upon the AMFB. As such, the area surrounding and including the AMFB excavation is considered to be affected.

Two classifications of areas are used in NUREG-5849 and are termed **affected** or **unaffected.** These classifications are defined as (NRC, 1992):

> **Affected Areas:** Areas that have potential radioactive contamination (based on plant operating history) or known radioactive contamination (based on past or preliminary radiological surveillance). This would normally include areas where radioactive materials were used and stored, where records indicate spills or other unusual occurrences that could have resulted in spread of contamination, and where radioactive materials were buried. Areas immediately surrounding or adjacent to locations where radioactive materials were used, stored, or buried are included in this classification because of the potential for inadvertent spread of contamination.
>
> **Unaffected Areas:** All areas not classified as affected. These areas are not expected to contain residual radioactivity, based on knowledge of site history and previous information.

The areas surrounding and including the AMFB excavation are considered to be affected.

In 1980, portions of the AbNFB were removed, packaged as low level radioactive waste, and disposed off-site. Analysis of samples taken from the remaining filter media were submitted to the NRC by BMI. BMI was then authorized by the NRC to backfill the beds with clean sand, blend the sand with the remaining filter bed media, and cover the blended material with three feet of soil. BMI completed this action in 1982. (DOE, 1990).

In 2005, Closure Services began the demolition and removal of the Filter Bed Area, including the AbNFB. The excavation of the AbNFB was halted due to encroachment upon the AMFB. Further excavation of the AbNFB required the AMFB to be shut down and the sanitary waste re-routed to a separate system. The initial excavation of the AbNFB took place in October of 2004. The second excavation of the AbNFB focused on an area commonly referred to as the Well Injection Deep Extraction (WIDE) system. This excavation and FSS is detailed in the *Characterization and Final Status Report for the Filter Bed Affected Areas and WIDE System* and is not included in this report.

In September of 2005, DOE and BMI agreed to shut down the AMFB to allow the excavation of contamination from under and around the system to proceed (including the areas from Oct. 2004 that were halted due to encroachment on the active middle filter bed system). The contaminated materials were then excavated to the point where the excavation samples and surveys indicate the excavation is eligible for unrestricted release under the DP.

Excavation activities exposed the east end of two (2) vitrified clay pipes during the removal of materials from the south end of the area. Samples collected of soil from the outside of the pipes indicated contamination levels greater than the release criteria.

Figure 3 details the location of pipes exposed during the excavation of the area surrounding and including the AMFB.

Excavation proceeded roughly 6 feet to the west along the run of the pipes. Characterization Technicians then obtained samples of material from the interior of and around the outside of the pipes. A scanning survey of the interior of the pipes was also performed using a two (2) inch by two (2) inch Sodium Iodide (NaI) detector connected by a 12-foot long cord to a scaler/ratemeter. The detector was gently pushed toward of west along the interior run of the pipe to a distance 12 feet from the pipe outlet. Readings obtained from the survey were at background levels of less than 17,000 counts per minute. Sample results indicated soil activity concentrations well below the screening criteria for unrestricted release. **Table 1** presents the analytical results of samples obtained from the interior and exterior of the clay pipes.

Multiple areas of elevated contamination were encountered during the excavation of the AMFB. Characterization Technicians directed removal of each location identified by the walkover scan and verified by sample results. Final status survey proceeded once post-remediaiton samples indicated compliance to the modified screening criteria of 11 pCi/g for Cs-137.

Figure 2 details the location of the excavation of the northern half of Grids 34 and 43 was performed during October of 2004. The excavation was halted due to the encroachment on the AMFB system. Final status survey data for excavation of the northern half of Grids 34 and 43 has been included in this report for the areas surrounding and including the AMFB, and presented in **Tables 4, 5, 6,** and **7**.

3.0 Decommissioning Activities

3.1 Decommissioning Objective

The objective of the final status survey performed of the areas surrounding and including the AMFB excavation is to demonstrate that the remediation of the area will allow for future use without radiological restriction. Remediated areas of the CCP may be determined to be free of residual radioactive contamination when remaining soil contamination levels are below those presented DD-93-03, Rev. 0, "Volumetric Release Criteria Technical Basis Document for Battelle Columbus Laboratory Decommissioning Project", *hereinafter* referred to as DD-93-03, Rev. 0. (Battelle, 1993). **Table 2** presents the volumetric release criteria as presented in DD-93-03, Rev. 0.

4.0 Final Status Survey Procedures

Planning and implementation of the final status survey of the areas surrounding and including the AMFB excavation adhered to the requirements of the Final Status Plan (Battelle, 2000) and Work Instruction 2806 (CS, 2004)

4.1 Sampling Parameters

Final status soil samples of the areas surrounding and including the AMFB excavation were obtained from survey grids. Survey grids were each ten by ten meters, with each grid divided into equal sized quadrants. Final status soil samples were then obtained from each of the grid quadrants. Localized areas of elevated radiological concentration were sampled separately. Analyses of soils samples by gamma spectroscopy were performed by the On-Site Radioanalytical Laboratory (RAL).

4.2 Major Contaminants Identified

The characterization of the AMFB excavation identified Cesium-137 (Cs-137) as the primary radiological contaminant of concern (RCOC). Other RCOCs included Cobalt-60 (Co-60), Europium-152 (Eu-152) and 154, Americium-241 (Am-241), Strontium-90 (Sr-90), Plutonium-238 (Pu-238), and Pu-239. Cs-137 is used as a surrogate for the other RCOCs present in the soils as it typically accounts for 64 percent of the total isotopic activity. Further, the release criteria set for Cs-137 is considered conservative for the decommissioning activities. The surrogate relationship of Cs-137 to other RCOCs was calculated using data presented in **Table 3**. **Table 3** presents the isotopic quantity and activity concentrations of samples collected from the filter bed area by BMI from March through September 2000. These data are not associated with the AMFB excavation. Average activities for the multiple samples were calculated for each RCOC prior to setting the ratios against Cs-137.[1] For each RCOC, the average activity concentration was set as a ratio against the average Cs-137 activity concentration as obtained from previous actions at the filter beds. Cs-137 activity ratios for each RCOC utilized to calculate the RCOCs for the AMFB excavation are presented at the lower portion of **Table 3**.

4.2.1 Guidelines Established

Table 2 presents the guidelines for residual radioactivity concentrations for soil and solid volumes as applied to the excavation. Criteria for residual radioactivity concentrations in soil are defined in a number of references. DOE Order 5400.5, Section IV.a.2 provides

[1] Battelle, *Radiological Status of Abandoned Filter Bed Presentation*, http://www.ohio.doe.gov/ccp_seb/, Posted 7/15/2003. Presentation provided by DOE to the CCP website. Page titled "Radioactive Inventory of the Abandoned North Filter Beds & Limit Fractions" contains sampling data obtained from March through September 2000 from the filter beds. Average Cs-137 ratios were utilized to calculate the activity concentrations of the isotopes of concern.

generic guidelines for residual concentrations of Ra-226, Ra-228, Th-230, and Th-232. NRC Guidance has been received by the CCP which contains soil radioactivity concentration guidelines for Co-60, Sr-90, Cs-137, Ra-226, and Ra-228. NRC guidance for soil radioactivity concentration guidelines for natural, enriched and depleted uranium are also utilized. **Table 2** compiles soil residual radioactivity concentration guidelines to be utilized by the CCP. **Table 2** values have been generated primarily from the various reference technical documents and from soil guidelines generated from computer pathway analyses. Pu-241 is calculated by applying a ratio to sum of Pu-238 and Pu-239 (obtained from ORIGEN 2.1 derived values, Battelle, 2003c), resulting in a Cs-137 to Pu-241 ratio of 2.8. Using the ratios from **Table 3** and the Cs-137 to Pu-241 ratio of 2.8, the sum of ratios of radionuclides will meet unity at Cs-137 concentrations of 11 pCi/g. This provides modified screening criteria for Cs-137 of 11 pCi/g.

Exposure rates were compared to the 5 microRoentgen per hour (μR/hr) above mean background limit listed in DD-97-02, Rev. 0 (Battelle, 2000). Survey measurements are those 1-meter above the ground surface. The calculated mean background exposure rate and the 95 percent confidence intervals used for the CCP open area grounds is 8 ● 2 μR/hr. Compliance to the limit is met when the exposure rate survey is less then or equal to the limits of DD-97-02, Rev. 2 (Battelle, 2000). Initial compliance screening is met if individual exposure rates are less than or equal to 13 μR/hr. Further assessment of compliance allows for exposure rates to be averaged of a 100 m^2 gird area to meet the limit of less than or equal to 5 μR/hr above background at 1-meter above the ground surface. Additionally, exposure rates over any discreet area may not exceed 5 μR/hr above background.

Data collected from trench-like culverts located on Battelle property unassociated with site operations indicate a geometry effect, increasing the background exposure rates inside the trenches by 3 to 5 μR/hr. Trench exposure rate measurements must be less than or equal to 18 μR/hr. The same compliance assessment is applied to these measurements as stated above.

5.0 Equipment and Procedures

5.1 Equipment

Survey instruments sensitive to gamma radiation are used to monitor grounds and excavation surfaces for residual radioactive materials. Ludlum Model 44-10 two-inch by two-inch sodium iodide detectors with Eberline ESP-2 meters were used to scan the grounds and excavation. Ludlum Model 19 exposure rate meters were used to obtain µr/hr measurements.

Other instrumentation was used in the RAL to support the final status survey includes:

- A VMS based Canberra Procount data acquisition system in conjunction with high purity germanium detectors for gamma spectroscopy of soil samples.
- A Tennelec Model LB5100 Simultaneous Alpha and Beta Gas Proportional Counter to count smear samples

5.2 Scanning Minimum Detectable Activities

Scanning minimum detectable concentrations (MDC_{scan}) is determined to demonstrate that the MDC_{scan} is less than the modified Cs-137 screening criteria. The MDC_{scan} is calculated utilizing the methodology described in NUREG-1507 and the background count rate and a default detector response to Cs-137 (NRC, 1998). The equation used to calculate the MDC_{scab} for the walkover surveys incorporates a d' of 1.38 and a surveyor efficiency of 0.5. The ambient background in the area was 12.276 counts per minute (cpm). The following is the calculation of the MDC_{scan}:

b_i = (12.276 cpm) x (1 sec) x (1 min/60 sec) = 204.6 counts

MDCR = (1.38) x ($\sqrt{204.6}\ counts$) x (60 sec/1min) = 1184 cpm

$MDCR_{surveyor}$ = 1184 cpm/$\sqrt{0.5}$ = 1674 cpm

MDER = 1674 cpm/(900 cpm/µR/hr) = 1.86 µR/hr

$$MDC_{scan} = (5\,pCi/g) * \frac{1.86\,\mu R/hr}{1.307\,\mu R/hr} = 7.11\ pCi/g$$

5.3 Procedures

The Characterization Team was formally trained and qualified to applicable procedures prior to the initiation of the characterization and final status surveys. Documentation of training is maintained by CCP Project Records.

The following plans and procedures were utilized for the surveys:

DD-93-19, Rev. 5	Decommissioning Plan, Battelle Memorial Institute Columbus Operations
DD-97-02, Rev. 0	Radiological Characterization and Final Status Plan for BCLDP West Jefferson Site
SC-OP-002, Rev. 0	Facility Post-Decontamination Final Status Survey for Baseline Areas
SC-SP-004.2, Rev. 3	Manual and Mechanical Collection of Surface and Subsurface Soil Samples in Support of Site Characterization
HP-OP-100, Rev. 4	Operation and Calibration of the Eberline Model ESP-2 Survey Meter
WI-2806	Excavation and Trench Sampling and Surveys

6.0 Survey Findings

6.1 Exposure Rate Surveys

The calculated mean background exposure rate and the 95 percent confidence intervals used for the CCP grounds are 8 ± 2 μR/hr. The exposure rate readings for the areas surrounding and including the AMFB excavation are presented in **Table 4**. Exposure rate surveys are also presented in **Table 7**.

The exposure rate readings were individually compared to the mean background value of 8 ± 2 μR/hr in order to show compliance with the 5 μR /hr above background release criterion. Grounds exposure rate surveys must be less than or equal to13 μR/hr to be compliant: trenches must be less than or equal to18 μR/hr. The average one meter measurement was 9.8 μR/hr. the minimum measurement was 6 μR/hr and the maximum measurement was 13 μR/hr.

6.2 Grounds and Excavation Sampling

Final status soil samples of the areas surrounding and including the AMFB excavation were taken from each of the survey grids. Samples were obtained from each grid quadrant as required by Section 6.3.3 of DD-97-02, Rev. 0. Samples were also obtained from localized areas of elevated radiological concentrations. **Table 5** presents the reported Cs-137 result for each final status soil sample location. Final status soil sample analytical results are also presented in **Table 7**. Anomalies presented in **Figure 4 and 5** are discussed in Section 6.5 for this report.

6.3 Scanning Measurements

Scanning measurements were performed with a two inch by two inch sodium iodide detector in accordance with section 6.3.1 of DD-97-02. **Table 6** presents the surface scanning results for the AMFB excavation. Scanning measurements are also presented in **Table 7**.

6.4 Radioanalytical Reporting Limits

Table 5 presents the reported analytical results for Cs-137 in each final status survey soil sample. In general, soils samples exhibited low concentrations Cs-137 activity. Utilizing the ratio of Cs-137 to other radionuclides, low concentrations of Cs-137 would indicate even lower concentrations of other gamma emitting radionuclides of concern. As such, gamma emitting radionuclides of concern other than Cs-137 would be less than corresponding Minimum Detectable Activity (MDA). **Table 8** presents the typical MDAs for the gamma-emitting radionuclides of concern.

Cesium-137 is utilized as a surrogate for determining compliance to the cleanup criteria presented in **Table 1**. The CCP has consistently utilized Cs-137 as a surrogate for other

radionuclides of concern as it is the predominate radionuclide present throughout the site and the buildings. Additionally, Cs-137 exhibits the lowest cleanup criteria of 15 pCi/g. The calculation of the Cs-137 surrogate value is performed utilizing sample results obtained prior to remediation of the area in question. **Table 3** presents the results of the pre-remediation samples of the filter bed and are not associated with the AMFB. The ratio of Pu-241 to Cs-137 is calculated by applying the ORIGEN 2.1 derived value with a resulting value of 2.8. **Table 3** summarizes the method of developing the Cs-137 ratios. Use of the Cs-137 ratio has been reviewed by the BMI and accepted by the NRC.

Results for Co-60, Cs-137, Sr-90, EU-152 and 154, Pu-239, 240 and 241, and Am-241 are then compared to the respective release criteria, with a "fraction of limit" then calculated. The "fraction of limit" is determined by summing the ratios of each isotopic concentration to the respective release limit. The sum of ratios must be less than one to meet release criteria.

The modified screening criteria of 11 pCi/g for Cs-137 is used to evaluate initial compliance to the cleanup levels. Further remediation is typically conducted if reported Cs-137 activity concentrations approach or exceed the modified screening criteria of 11 pCi/g. The "fraction of limit" calculation is applied to reported analytical results of samples with Cs-137 activity concentrations greater than 4 pCi/g.

Six samples were collected from locations that exceeded the DLV for the gamma walkover surveys. These six samples exceeded the 4 pCi/g for Cs-137 limit. **Table 9** presents the results of the "fraction of limit" calculation for each of the six samples. Each location met the cleanup criteria as the "fraction of limit" was less than 1.0.

6.5 Elevated Areas of Activity

Characterization Technicians performing the final status survey located two (2) areas of elevated activity within the AMFB excavation. These areas have been evaluated individually according to the guidance presented in Section 8.5.2 of NUREG/CR-5849. The following details the method applied for the evaluation of the elevated areas of activity.

According to NUREG/CR-5849, Section 8.5.2, *Elevated Areas of Activity*:

> "The limit for soil activity at any location is three times the average guideline value...Areas of elevated activity between one and three times the guideline value are then tested to assure that the average concentration is less than $(100/A)^{1/2}$ times the guideline value, where A is the area of the elevated activity in m^2."

The *Elevated Areas of Activity* Section of NUREG/CR-5849 requires the user to satisfy two conditions. The first condition is that no sample can exceed three times the release criteria. The second condition is that the area of elevated activity is less than $(100/A)^{1/2}$ times the guideline value. Closure Services has evaluated each area in the excavation in accordance with these two conditions. The results of the evaluations follow.

The first location is a one foot by seven feet area located on the floor of the northeast quadrant of Grid 47. **Figure 4** shows the location of the area of elevated activity. Cs-137 results from samples from the area are 20.0 and 20.4 pCi/g. Each sample from the area is less than three times the modified screening criteria, and using the equation presented above with an area of 7 ft^2 = 0.65 m^2,

$\sqrt{\frac{100}{0.65}}$ = 12.4 times the modified screening criteria = 136 pCi/g.

The average Cs-137 concentration of the 10 by 10 meter grid is 1.30 pCi/g. This location satisfies both criteria for elevated area of activity presented in NUREG/CR-5849.

The second location of elevated activity is located on the wall of Grid 36 in the Southwest quadrant. The area is two foot by six inches, with a Cs-137 concentration of 12.2 pCi/g. **Figure 4** shows the location of the area of elevated activity. The Cs-137 concentration from the sample is less than three times the modified screening criteria, and using the equation presented above with an area of 6 ft^2 = 0.56 m^2,

$\sqrt{\frac{100}{0.56}}$ = 13.4 times the modified screening criteria = 147 pCi/g.

The average Cs-137 concentration of the 10 by 10 meter grid is 2.17 pCi/g. This location satisfies both criteria for elevated area of activity presented in NUREG/CR-5849.

Grid	Location	Highest Sample (pCi/g)	< 3 Times Criteria	Area of Elevated Activity (m^2)	Grid Average (pCi/g)
47	NE	20.4	Yes	0.65	1.30
36	SW	12.2	Yes	0.56	2.17

7.0 Conclusions

The characterization and final status survey results demonstrate that the radiological endpoint criteria objectives of the NRC-approved Decommissioning Plan have been met for the AMFB excavation addressed by this effort. (Battelle, 2003) Reported analytical results for media samples obtained from the excavation are below the residual radioactivity concentrations for soil and solid volumes as presented in **Table 2** with the exception of two areas within the excavation. These areas have been evaluated using the guidance supplied in NUREG/CR-4859, Section 8.5.2, *Elevated Areas of Activity*. Both locations were found to meet the criteria and are therefore within release criteria.

Remaining soil contamination levels are below those presented in DD-93-03, Rev. 0, "Volumetric Release Criteria Technical Basis Document for Battelle Columbus Laboratory Decommissioning Project" (Battelle, 1993). The decommissioning objective has been satisfied. The final status survey performed in the AMFB excavation, statistically demonstrates that the remediation of the area was successful and that the excavations are free from residual radioactive contamination making them suitable for unrestricted release.

8.0 References

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Figures

Figure 1
Site Map

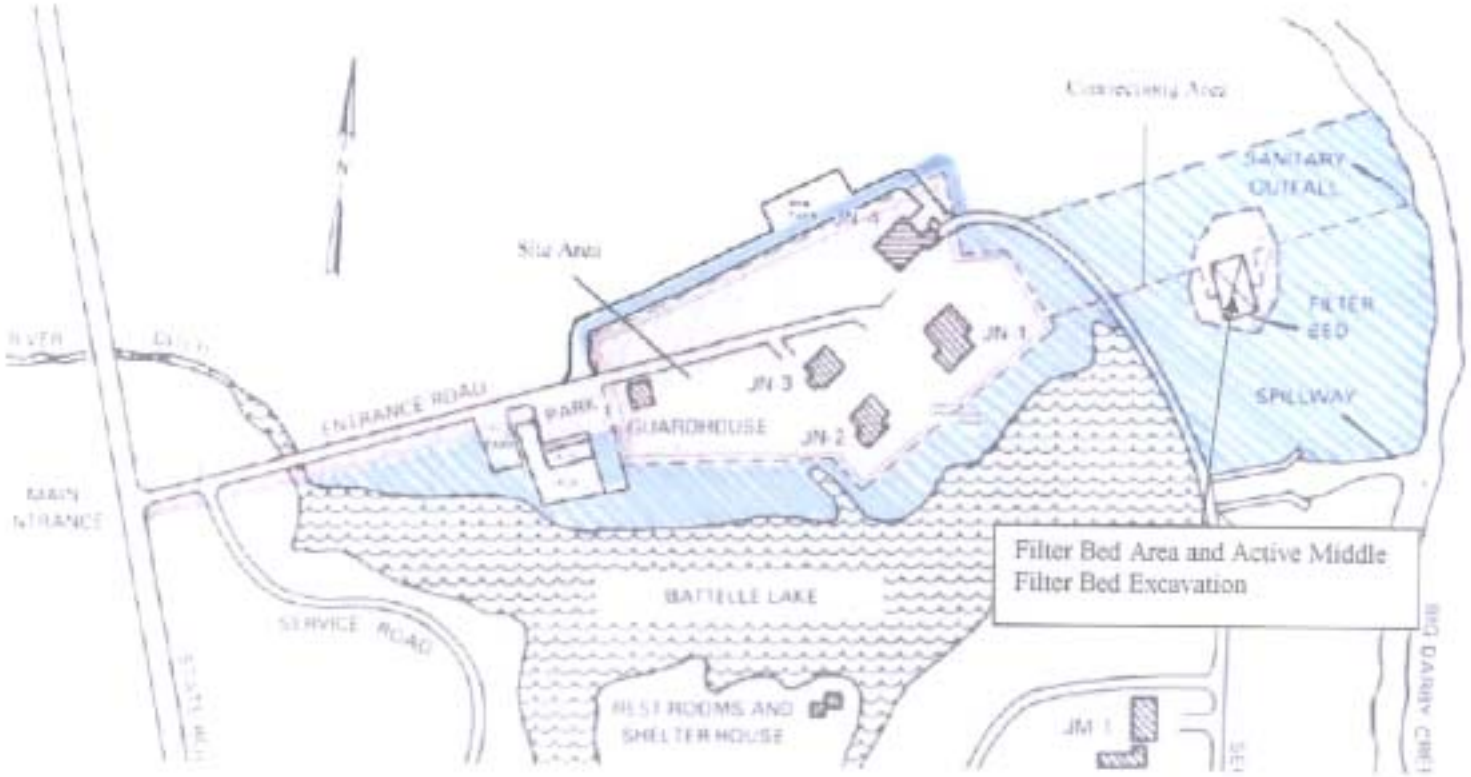


Figure 2
Areas Surrounding and Including the AMFB Map

Figure 3
Abandoned Pipes Adjacent to Excavation

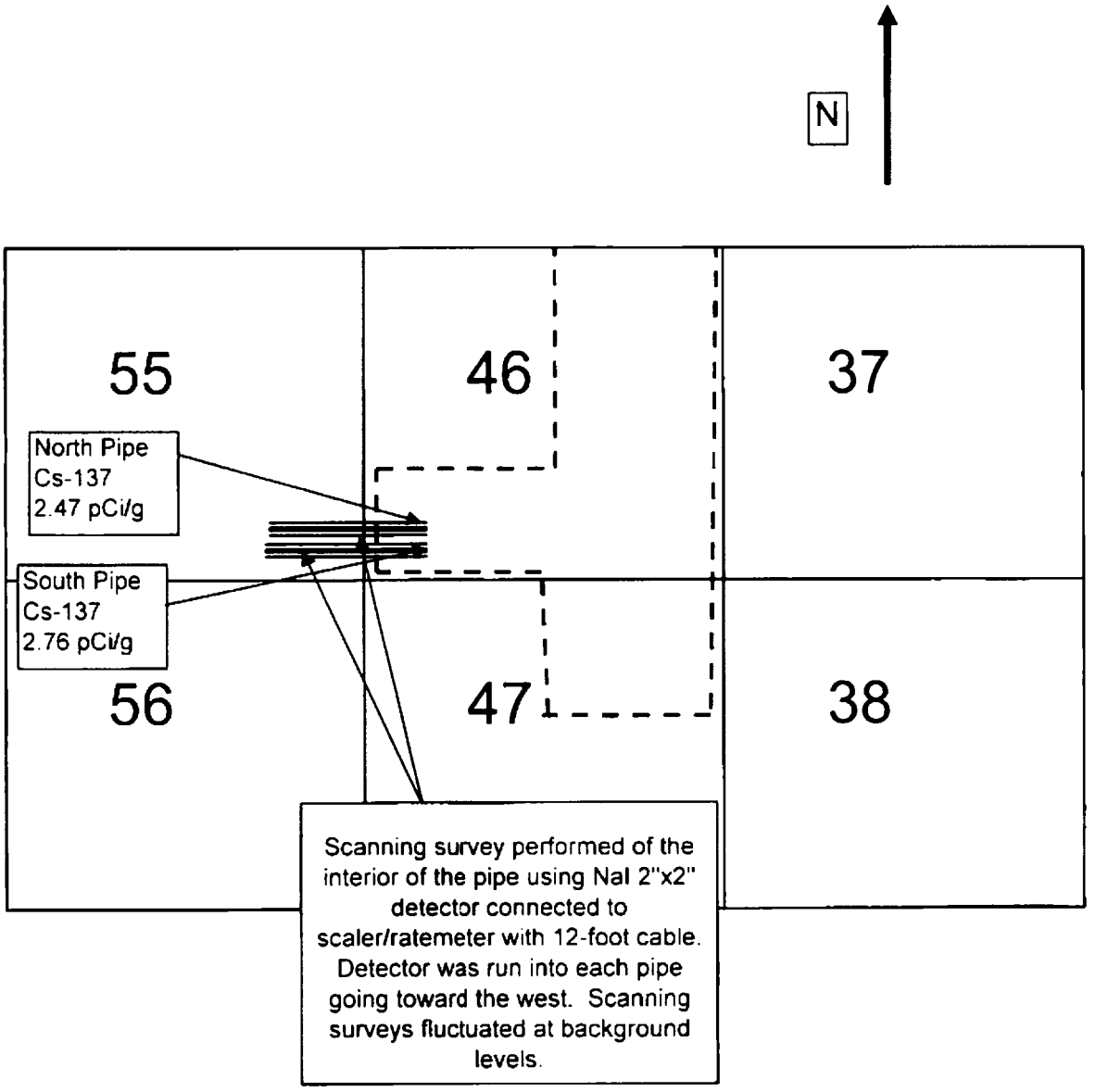


Figure 4
Surface Areas and General Location of Anomalies on Excavation Floor

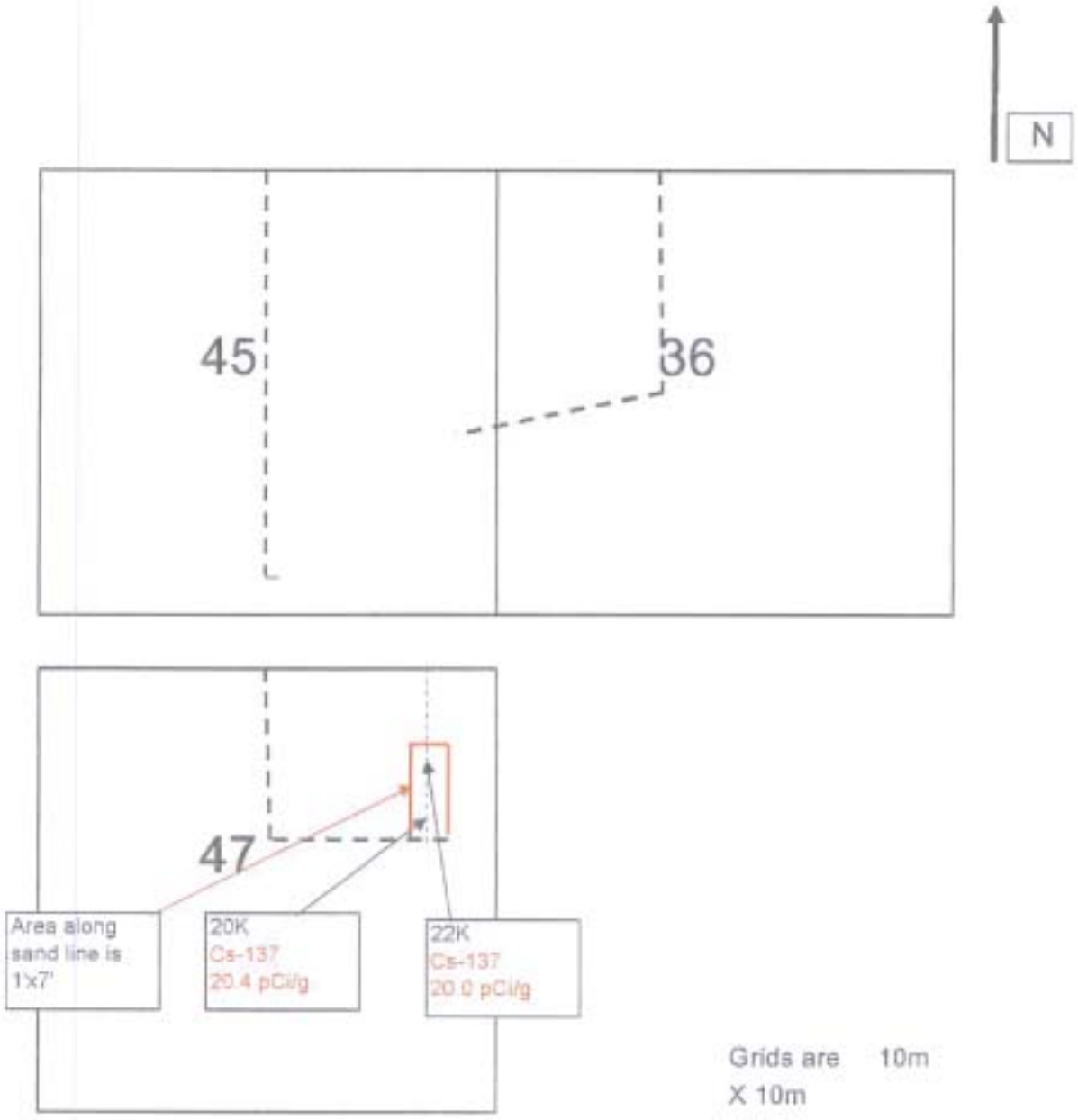
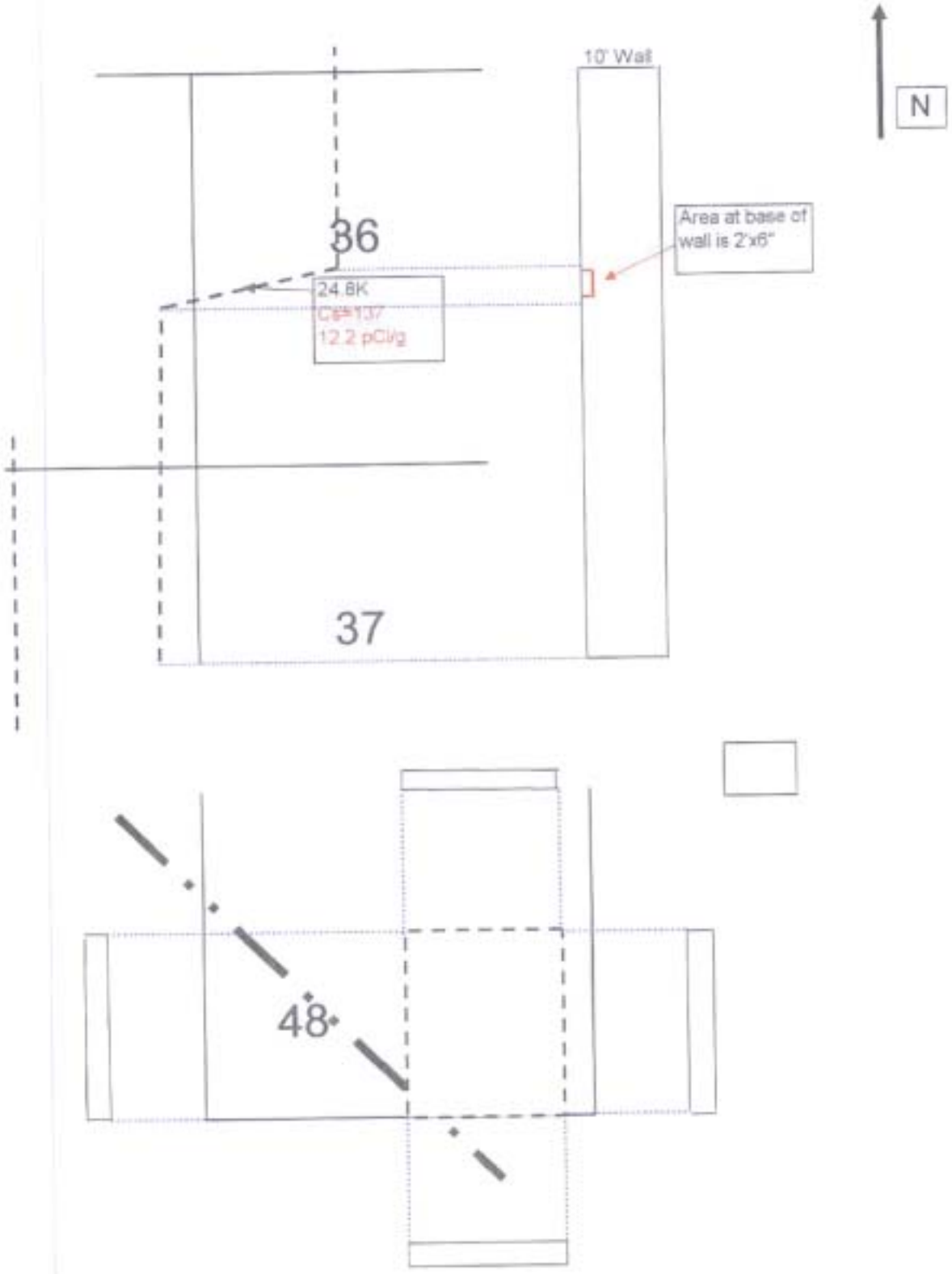


Figure 5
Surface Areas and General Location of Anomalies on Excavation Walls



Tables

Table 1
Characterization Data of Vitrified Clay Pipes

Sample ID	Grid ID	Date	Field Screening (cpm)	Cs-137 Activity (pCi/g)
Pre-Remediation Samples				
RL05-3660-3544	Grid 46 NE Floor Sample 4	10/21/2005	10000	6.52
RL05-3661-3545	Grid 46 SE Floor Sample 5	10/21/2005	9670	3.62
RL05-3662-3546	Grid 46 SE Floor Sample 6	10/21/2005	9400	3.12
RL05-3663-3547	Grid 46 NE Floor Sample 7	10/21/2005	13400	9.91
Post-Remediation Samples				
RL05-3652-3554	Grid 46 North Pipe	10/21/2005	8390	2.47
RL05-3653-3555	Grid 46 South Pipe	10/21/2005	8510	2.76

Table 2
BCLDP GUIDELINES FOR RESIDUAL
RADIOACTIVITY CONCENTRATIONS FOR SOIL AND SOLID VOLUMES

Radionuclide[a]	King Avenue Concentration (pCi/g)[b]	West Jefferson Concentration (pCi/g)[b]
Natural Uranium	10[1]	na[c]
Enriched Uranium	30[1]	30[1]
Depleted Uranium	35[1]	35[1]
Ac-227	19	19
Am-241	na[c]	30[4]
Am-243	na	30[4]
Ce-144	na	2,100
Cm-243	na	0.79
Cm-244	na	1.0
Co-60	8[2]	8[2]
Cs-134	na	33
Cs-137	15[2]	15[2]
C-14	940	940
Eu-152	na	36
Eu-154	na	32
Eu-155	na	1,800
Fe-55	na	2.7E+07
H-3[d]	41,000	38,000
I-129	na	13
Mn-54	na	61
Ni-59	na	1.3E+07
Ni-63	na	4.9E+06
Np-237	na	0.58
Pa-231	18	18
Pb-210	140	na
Pu-238	na	25[4]
Pu-239	na	25[4]
Pu-240	na	25[4]
Pu-241	na	25[4]
Pu-242	na	25[4]
Ra-226 (0-15 cm of soil)	5[2,3]	na

Radionuclide[a]	King Avenue Concentration (pCi/g)[b]	West Jefferson Concentration (pCi/g)[b]
Ra-226 (>15 cm of soil)	15[2,3]	na
Ra-228	5[2,3]	na
Ru-106	na	180
Sb-125	na	118
Sm-151	na	6.700
Sr-90	5[2]	5[2]
Th-228	29	na
Th-230	5[3]	na
Th-232	5[3]	na

Notes and References

Notes:

a. Activity concentrations above natural background concentrations. Where more than one radionuclide is present, the sum of the ratios of the individual radionuclide concentrations to their respective concentration limits shall not exceed 1.

b. Concentrations for which no specific reference is cited have been derived from RESRAD calculations and are the more restrictive values calculated for soil deposition at a depth of 5 meters.

c. Indicates that this radionuclide is not expected to be found at the indicated site.

d. Difference in tritium activity concentrations are due to the difference in depths of the water tables at two sites. The water table depth at King Avenue is deeper than that at West Jefferson.

References:

1. Options 1 and 2 of the Branch Technical Position, "Disposal or Onsite Storage of Thorium or Uranium Wastes from Past Operations" (46 FR 52061, October 23, 1981).

2. NRC Memorandum, "Acceptable Cleanup Criteria and Practices for Decontamination and Decommissioning (License No. SNM-7)" dated April 17, 1992, to Harley L. Toy, License Coordinator and Manager, Nuclear Sciences, Battelle Memorial Institute from J.W.N. Hickey, Chief, Fuel Cycle Safety Branch, Division of Industrial and Medical Nuclear Safety, Office of Nuclear Material Safety and Safeguards.

3. DOE Order 5400.5, "Radiation Protection of the Public and the Environment".

4. NRC Policy and Guidance Directive FC83-23, "Termination of Byproduct, Source, and Special Nuclear Material Licenses".

Table 3
Cesium-137 Surrogate Analysis Data & Modified Cs-137 Screening Criteria

Sample ID (a,b)	Cs-137 Activity (pCi/g)	Co 60 Activity (pCi/g)	Eu 152 Activity (pCi/g)	Eu-154 Activity (pCi/g)	Am-241 Activity (b) (pCi/g)	Sr 90 Activity (pCi/g)	Pu-238 Activity (pCi/g)	Pu-239 Activity (pCi/g)
16741	40 1	0 05	<0 096	<0 053	1 30 g	<0.172	<0 009	0 053
16746	21 6	0 04	<0 079	<0 051	1 29 a	<0 184	0 026	0 9
16747	26 1	0 06	<0 077	<0 046	0 89 g	<0 175	<0 011	0 116
16751	8	<0 024	<0 068	<0 047	0 93g	<0.151	0.021	0 496
16752	39 1	0.06	<0 086	<0 046	10 74 a	<0 167	0.131	5 822
16607	74 2	0 28	7 26	0 65	1 18 a	0 59	0 0213	0 629
16608	18 7	0 07	4 03	0.26	0 47 a	<0 180	0.016	0 287
16668	41 6	0 08	<0 098	<0 061	2 59 a	NA	0.036	1 846
16686	38 1	0 07	<0 050	<0 031	4 71 a	NA	0.135	3 84
19079	11 7	0 17	8 02	0 64	0 018	4 39	<0 016	0 034
19080	32 4	<0 016	0 562	<0 053	<0 016	0 21	<0 019	<0 017
Average	*31 99*	*0 084*	*1 857*	*0 176*	*2 2*	*0 691*	*0 04*	*1 276*

Calculated Cs-137 Surrogate Ratio (c)	
Cs-137/Co-60	381
Cs-137/Eu-152	17
Cs-137/Eu-154	182
Cs-137Am 241	15
Cs 137/Sr-90	46
Cs-137/Pu-238	800
Cs-137/Pu-239	25
Cs-137/Pu-241 (d)	2.8

Modified Cs-137 Screening Criteria			
Cleanup Criteria (pCi/g)		*Surrogate Activity (pCi/g)*	*Summed Ratio*
Cs-137	15	11	0.73
Co-60	8	0.028884026	0.00
Eu-152	36	0.638543295	0.02
Eu-154	32	0.060518912	0.00
Am-241	30	0.756486402	0 03
Sr-90	5	0 237605502	0.05
Pu-238	25	0 013754298	0.00
Pu-239	25	0.438762113	0.02
Pu-241	25	3.928571429	0.16
		Unity Rule (e)	*1 00*

Notes:

(a) Battelle reported analytical results of samples obtained from the filter bed area between March and September 2000

(b) Reported data obtained from gamma spectroscopy analysis

(c) Surrogate ratio calculated by dividing average Cs-137 activity by average activity of isotope of concern

(d) Pu-241 is calculated by applying a ratio to sum of Pu-238 and Pu-239 (obtained from ORIGEN 2 1 derived values, Battelle, 2003c), resulting in a Cs-137 to Pu-241 ratio of 2.8.

(e) Unity Rule applied to surrogate calculated activity resulting in modified Cs-137 screening level of 11 pCi/g

Table 4

AMFB Area Exposure Rate Survey (µR/hr)

Table 5

AMFB Area Soil Samples, Cs-137 Activity (pCi/g)

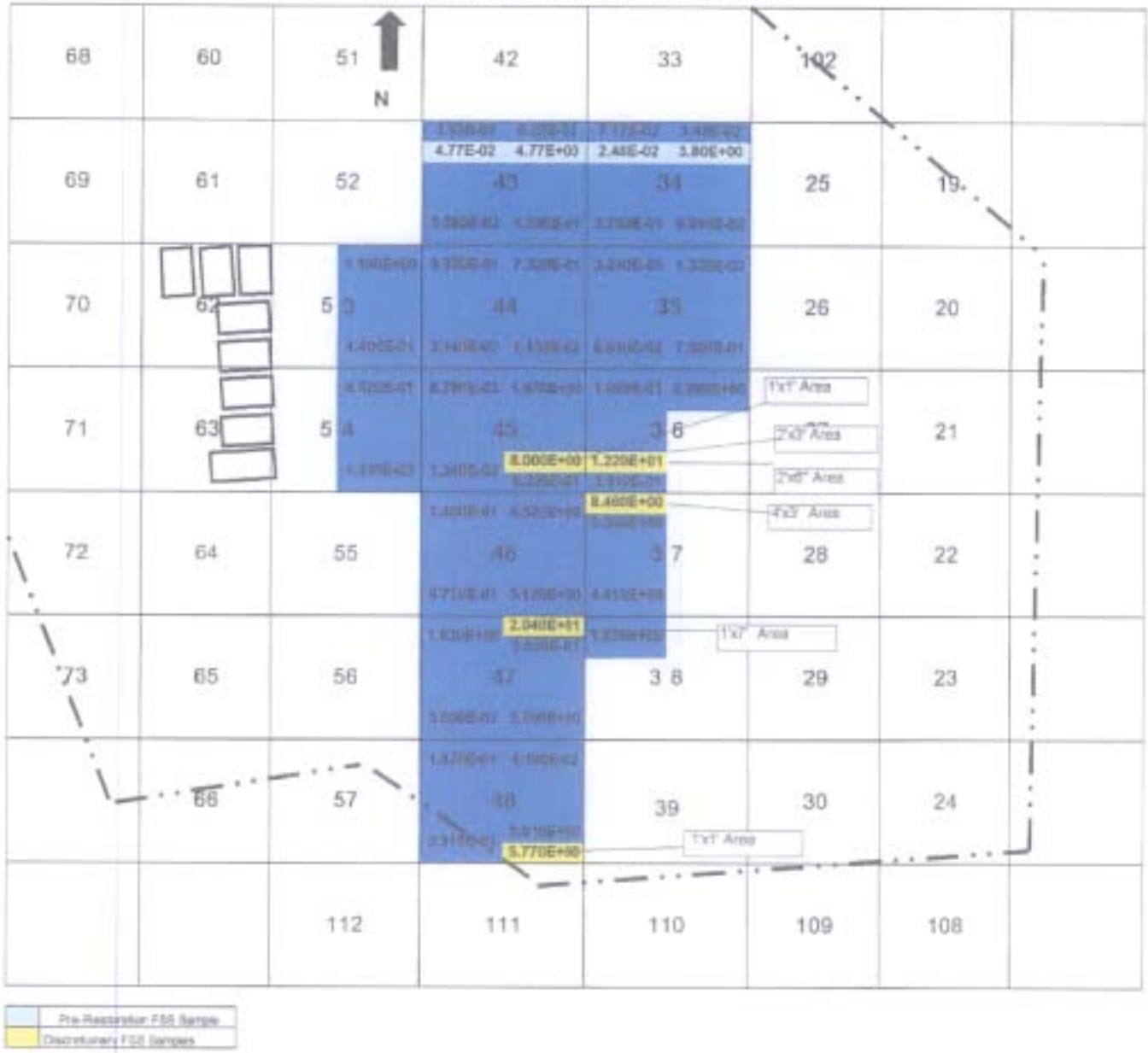


Table 6

AMFB Area Walkover Survey (cpm)

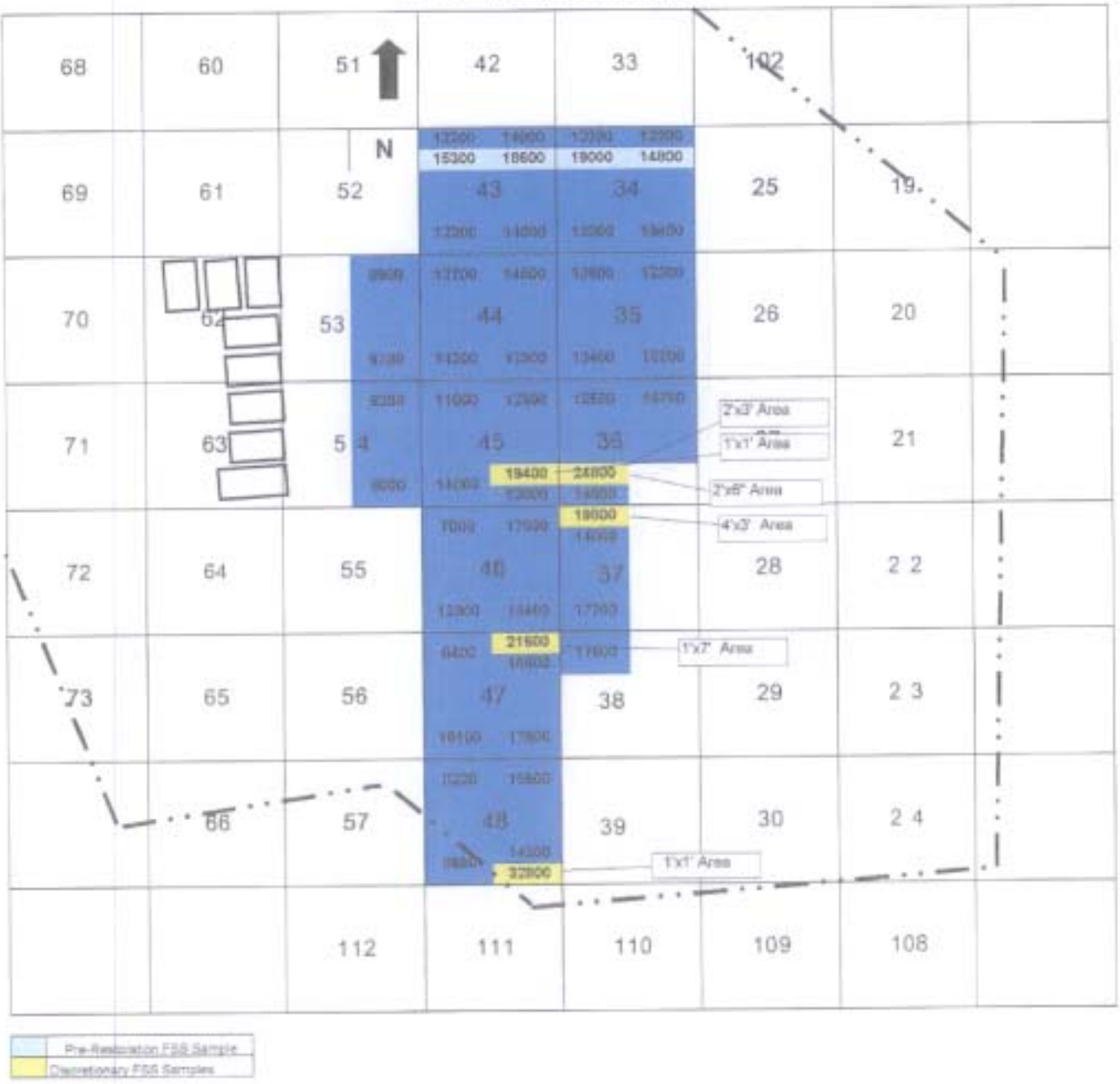


Table 7

AMFB Area Final Status Survey Summary

Sample ID	Location	Collection Date	Field Screen (cpm)	Walkover Scan (NaI) cpm	Exp. Rate µR/hr	Cs-137 Content (Results in pCi/g)
RL05-1861-2239	Grid 34 NW	6/14/2004	11700	12300	8	0.06
RL04-1673-644 Pre-Restoration	Grid 34 NW	11/24/2004	11700	19000	15	0.02
RL05-1862-2240	Grid 34 NE	6/14/2004	11700	12200	8	0.04
RL04-1675-646 Pre-Restoration	Grid 34 NE	11/24/2004	13000	14800	15	3.80
RL05-3744-3621	Grid 34 SW	10/27/2005	8200	12000	8	3.76
RL05-1451-0482	Grid 34 SE	6/14/2005	11600	13400	11	0.06
RL05-3746-3623	Grid 35 NW	10/27/2005	7960	13600	9	3.24
RL05-3959-3813	Grid 35 NE	11/5/2005	7180	12300	10	0.01
RL05-3748-3625	Grid 35 SW	10/27/2005	7280	13400	9	0.07
RL05-3960-3814	Grid 35 SE	11/5/2005	7170	10200	9	0.73
RL05-3769-3653	Grid 36 NW	10/31/2005	7610	12500	13	0.11
RL05-3665-3557	Grid 36 NE	10/24/2005	7570	16700	10	2.28
RL05-3667-3559	2'x3' Area	10/24/2005	9160	21600	N/A	5.90
RL05-3666-3558	2'x6" Area	10/24/2005	11000	24800	N/A	12.20
RL05-3767-3651	Grid 36 SW	10/31/2005	7510	14000	12	0.36
RL05-3782-3666	Grid 37 NW	10/31/2005	8140	14000	12	5.09
RL05-3671-3563	4'x3' Area	10/24/2005	9420	19800	N/A	8.46
RL05-3673-3565	Grid 37 SW	10/24/2005	8510	17700	11	4.41
RL05-3676-3568	Grid 38 NW	10/24/2005	7510	17600	9	1.62
RL05-1857-2235	Grid43 NW	6/14/2004	11700	12200	8	0.07
RL04-1669-648 Pre-Restoration	Grid 43 NW	11/24/2004	11200	15300	14	0.05
RL05-1858-2236	Grid 43 NE	6/14/2004	11300	14000	9	0.05
RL04-1671-650 Pre-Restoration	Grid 43 NE	11/24/2004	13400	18600	14	4.77
RL05-3750-3627	Grid 43 SW	10/27/2005	6790	12300	9	0.01
RL05-1880-2200	Grid 43 SE	6/14/2005	11600	14000	8	0.14
RL05-3754-3631	Grid 44 NW	10/27/2005	7240	12700	9	0.93
RL05-3755-3632	Grid 44 NE	10/27/2005	7300	14500	11	0.73
RL05-3752-3629	Grid 44 SW	10/27/2005	7090	14200	10	0.02
RL05-3753-3630	Grid 44 SE	10/27/2005	7090	12900	10	0.01
RL05-3765-3649	Grid 45 NW	10/31/2005	7500	11000	10	0.01
RL05-3657-3541	Grid 45 NE	10/21/2005	8690	12300	12	1.87
RL05-3766-3650	Grid 45 SW	10/31/2005	7640	14000	9	0.01
RL05-3658-3542	Grid 45 SE	10/21/2005	11400	13000	12	0.62
RL05-4057-3883	1'x1' Area	11/10/2005	10400	19400	N/A	8.00
RL05-3764-3648	Grid 46 NW	10/31/2005	7240	7000	7	0.14
RL05-3660-3544	Grid 46 NE	10/21/2005	10000	17000	11	6.52
RL05-3773-3657	Grid 46 SW	10/31/2005	8010	12800	8	0.67
RL05-3662-3546	Grid 46 SE	10/21/2005	9400	15400	11	3.12
RL05-3676-3568	Grid 47 NW	10/24/2005	7510	6400	8	1.62
RL05-3772-3656	Grid 47 NE	10/31/2005	7070	15600	12	0.36
RL05-3740-3635	1'x7' Area	10/27/2005	15200	21600	N/A	20.00
RL05-3741-3636	1'x7' Area	10/27/2005	13900	21600	N/A	20.40
RL05-3771-3902	Grid 47 SW	10/31/2005	8600	16100	7	0.03
RL05-3771-3900	Grid 47 SE	10/31/2005	8530	17500	11	2.70
RL05-1651-2013	Grid 48 NW	6/24/2005	N/A	8220	8	0.19
RL05-3531-3498	Grid 48 NE	10/13/2005	7380	15500	12	0.04
RL05-1647-2009	Grid 48 SW	6/24/2005	N/A	8680	8	0.29
RL05-3555-3502	Grid 48 SE	10/17/2005	8260	14200	10	1.51
RL05-3945-3800	1'x1' Area	11/4/2005	12900	21000	N/A	5.77
RL05-3949-3803	Grid 53 NE	11/4/2005	7600	8900	8	1.16
RL05-3950-3804	Grid 53 SE	11/4/2005	7250	6700	6	0.44
RL05-3951-3805	Grid 54 NE	11/4/2005	7230	6200	7	0.68
RL05-3952-3806	Grid 54 SE	11/4/2005	6410	8000	6	0.00

Table 8
MDA of Gamma-Emitting Radionuclides of Concern

Cs-137 MDA (pCi/g)	Co-60 MDA (pCi/g)	Eu-152 MDA (pCi/g)	Eu-154 MDA (pCi/g)	Am-241 MDA (pCi/g)
0.024 +/- 0.013	0.022 +/- 0.012	0.067 +/- 0.030	0.055 +/- 0.039	0.451 +/- 0.30

Table 9
Fraction of Limit Calculation

Analytical Parameter	RL05-3667-3559 Result[a] (pCi/g)	Fraction of Limit
Cs-137	5.90	0.39
Co-60	0.02	0.00
Eu-152	0.34	0.01
Eu-154	0.03	0.00
Am-241	0.41	0.01
Sr-90 [b]	0.13	0.03
Pu-238[b]	0.01	0.00
Pu-239[b]	0.24	0.01
Pu-241[c]	2.11	0.08
	Sum Fraction of Limit	**0.54**

Analytical Parameter	RL05-4454-4095 Result[a] (pCi/g)	Fraction of Limit
Cs-137	4.42	0.29
Co-60	0.01	0.00
Eu-152	0.30	0.01
Eu-154	0.03	0.00
Am-241	0.35	0.01
Sr-90	0.11	0.02
Pu-238[b]	0.01	0.00
Pu-239[b]	0.20	0.01
Pu-241[c]	1.82	0.07
	Sum Fraction of Limit	**0.42**

Analytical Parameter	RL05-3671-3563 Result[a] (pCi/g)	Fraction of Limit
Cs-137	8.46	0.56
Co-60	0.02	0.00
Eu-152	0.49	0.01
Eu-154	0.05	0.00
Am-241	0.58	0.02
Sr-90	0.18	0.04
Pu-238[b]	0.01	0.00
Pu-239[b]	0.34	0.01
Pu-241[c]	3.02	0.12
	Sum Fraction of Limit	**0.77**

[a] Activity concentration based on MDA value in absence of positive result

[b] Estimated, based on activity concentration of ratio of isotope to Cs-137

[c] Pu-241 Origin 2.1 derived value

Table 9
Fraction of Limit Calculation

Analytical Parameter	RL05-4057-3883 Result[a] (pCi/g)	Fraction of Limit
Cs-137	8.00	0.53
Co-60	0.02	0.00
Eu-152	0.47	0.01
Eu-154	0.04	0.00
Am-241	0.55	0.02
Sr-90	0.17	0.03
Pu-238[b]	0.01	0.00
Pu-239[b]	0.32	0.01
Pu-241[c]	2.86	0.11
	Sum Fraction of Limit	**0.73**

Analytical Parameter	RL05-3660-3544 Result[a] (pCi/g)	Fraction of Limit
Cs-137	6.52	0.43
Co-60	0.02	0.00
Eu-152	0.38	0.01
Eu-154	0.04	0.00
Am-241	0.45	0.01
Sr-90	0.14	0.03
Pu-238[b]	0.01	0.00
Pu-239[b]	0.26	0.01
Pu-241[c]	2.33	0.09
	Sum Fraction of Limit	**0.60**

Analytical Parameter	RL05-3945-3800 Result[a] (pCi/g)	Fraction of Limit
Cs-137	5.77	0.38
Co-60	0.02	0.00
Eu-152	0.34	0.01
Eu-154	0.03	0.00
Am-241	0.40	0.01
Sr-90	0.12	0.02
Pu-238[b]	0.01	0.00
Pu-239[b]	0.23	0.01
Pu-241[c]	2.06	0.08
	Sum Fraction of Limit	**0.53**

[a] Activity concentration based on MDA value in absence of positive result

[b] Estimated, based on activity concentration of ratio of isotope to Cs-137

[c] Pu-241 Origin 2.1 derived value