Plum Brook Reactor Facility

Final Status Survey Report

Attachment 6

Revision 1

Waste Handling Building
(Building 1133)

FINAL STATUS SURVEY REPORT
ROUTING AND APPROVAL SHEET

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Section 2.4 was edited to clarify the configuration of the WHB for the FSS and the disposition of materials following building demolition in May 2010.

Section 3.1 was edited to add WHB demolition to the Chronology.

In response to an NRC comment, a note was added to Table 2 and an explanatory paragraph added to Section 4.4 to explain the use of the DCGL, instead of the $DCGL_{EMC}$, as the scan investigation-action level in Class 1 survey units.

Table 5 notes were edited in response to NRC comments to clarify the explanation of the adjustments made in the designs of the DCGLs for the presence of embedded piping (EP) and for deselected insignificant radionuclides.

In response to an NRC comment, Section 5.1 was edited to clarify how scan investigations of areas of elevated activity were initiated.

The introductory paragraph of Section 5.2 was edited to clarify the evaluations presented in Table 9.

Table 9 and Table 9 notes are revised in response to NRC comment as follows:

- Survey units are identified for which the DCGL is adjusted to account for 1 mrem dose from EP.
- Survey units are identified for which the DCGL is adjusted to account for the 2.5 mrem dose contribution from "insignificant radionuclides".

Table 9 was also modified by the addition of a column to show that a check was performed to verify that the total dose was less than 25 mrem/y considering the dose contributions from residual contamination, embedded piping and insignificant radionuclides.

Minor typographical, formatting and punctuation errors in the text and tables were corrected.

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LIST OF ACRONYMS & SYMBOLS

A	Sensitive area of detector, also area of elevated activity
α	alpha; denotes alpha radiation, also type I error probability in hypothesis testing
AEC	Atomic Energy Commission
ALARA	As Low as Reasonable Achievable
AF	Area Factor
β	beta; denotes beta radiation, also type II error probability in hypothesis testing
b_i	background counts in observation interval
B_R	Background count rate
BPL	Byproduct License
BSI	Babcock Services, Inc.
CFR	Code of Federal Regulations
cm	centimeters
cm^2	square Centimeters
cpm	counts per Minute
Δ	delta, $DCGL_W$ – LBGR
Δ/σ	Relative shift
d'	Scan surveyor sensitivity index
DAW	dry active waste
DCGL	Derived Concentration Guideline Level
$DCGL_{EMC}$	DCGL for small areas of elevated activity, used with the Elevated Measurement Comparison test (EMC)
$DCGL_W$	DCGL for average concentrations over a survey unit, used with statistical tests (the "W" suffix denotes "Wilcoxon)."
dpm	disintegrations per minute
E_i	Detector, or instrument efficiency
E_s	Surface efficiency
E_t	Total efficiency (also shown as T_{tot})
EMC	Elevated Measurement Comparison
EPA	US Environmental Protection Agency
F	Fahrenheit
FH	Fan House, Building 1132
FSS	Final Status Survey
FSSP	Final Status Survey Plan
FSSR	Final Status Survey Report
γ	gamma, denotes gamma radiation
g	gram
HTD	Hard To Detect
HEPA	High Efficiency Particulate Air – generic term for high-efficiency air filter
HRA	Hot Retention Area, Building 1155
HVAC	Heating, ventilation and air conditioning
i	observation counting interval during scan surveys
in.	inch
LMI	Ludlum Measurements, Inc.
LBGR	Lower Bound of the Gray Region
m^2	square meters
MARSSIM	Multi-Agency Radiation Survey and Site Investigation Manual

LIST OF ACRONYMS & SYMBOLS, Continued

MDC	Minimum Detectable Concentration
MDC_{scan}	Minimum Detectable Concentration for scanning surveys
MDC_{static}	Minimum Detectable Concentration for static surface activity measurements
MDCR	Minimum Detectable Count Rate
MOTA	MOTA Corp (now Siepelkamp, Inc.)
MOU	Memorandum of Understanding
mrem	millirem
MW	Megawatt
MWH	Montgomery Watson Harza, Inc.
NASA	National Aeronautics and Space Administration
N	Number of FSS measurements or samples established in a survey design
NA	Not Applicable
NRC	US Nuclear Regulatory Commission
PBRF	Plum Brook Reactor Facility
PNL	Pacific Northwest Laboratory
Φ	Standard normal distribution function
p	surveyor efficiency for scan surveys
pCi/g	picocuries per gram
%	percent
QC	Quality Control
Rad/h	Rads per hour, absorbed radiation dose, equal to 100 ergs per gram per hour
Rem/h	Rem per hour, Roentgen equivalent man, unit of absorbed dose that includes weighing factors that indicate biological effectiveness
RESRAD	RESidual RADioactive – a pathway analysis computer code developed by Argonne National Laboratory for assessment of radiation doses. It is used to derive cleanup guideline values for soils contaminated with radioactive materials
RESRAD-BUILD	A companion code to RESRAD for evaluating indoor building contamination and developing site-specific DCGLs
s	seconds
σ	generic symbol for standard deviation of a population
SAIC	Science Applications International Corporation
SNL	Sandia National Laboratory
SR	Survey Request
t_b	background count time
t_s	sample count time
TBD	Technical Basis Document
μ	Mean activity concentration, also prefix for micro (one millionth)
μCi/ml	microCuries per milliliter
UCM	Unusual Condition Measurement
UL	Upper limit of the confidence interval about the mean
VSP	Visual Sample Plan
WEMS	Water Effluent Monitoring System
WHB	Waste Handling Building, Building 1133
$Z_{1-\alpha}$	Proportion of standard normal distribution values less than $1-\alpha$
$Z_{1-\beta}$	Proportion of standard normal distribution values less than $1-\beta$
∞	Mathematical symbol for infinity

1.0 Introduction

This report presents the results of the final status radiological survey of the Plum Brook Reactor Facility (PBRF) Waste Handling Building (WHB, Building 1133). It is Attachment 6 of the PBRF Final Status Survey Report (FSSR) [1]. This attachment describes the WHB, its operational history and final condition for the final status survey (FSS). It describes the methods used in the FSS and presents the results of the survey measurements.

As stated in the PBRF Final Status Survey Plan (FSSP) [NASA 2007], the goal of the decommissioning project is to release the facility for unrestricted use in compliance with the requirements of US NRC 10CFR20 Subpart E. The principal requirement is that the dose to future site occupants will be less than 25 mrem/y. Subpart E also requires that residual contamination be reduced to levels as low as reasonably achievable (ALARA). A Derived Concentration Guideline Level (DCGL) for residual surface contamination has been established for the WHB. Considering the radionuclide mixture established for the WHB, the gross beta DCGL is 40,051 dpm/100-cm^2. [2]

The survey measurement results and supporting information presented herein demonstrate that residual contamination levels in each survey unit of the WHB are well below the DCGL. Additionally, it is shown that residual contamination has been reduced to levels that are consistent with the ALARA requirement. Therefore, the WHB meets the criteria for unrestricted release.

Section 2.0 of the report provides a description of the WHB. This includes the building layout, its relation to other PBRF buildings and facilities, design and materials of construction, building contents and use, systems and services, building modifications, final configuration for the FSS and scope of the FSS for this building.

A brief history of operations is presented in Section 3.0. A chronology of significant milestones is followed by history of operations with radioactive materials. Post shutdown and decommissioning activities are summarized. Results of radiological characterization surveys in support of decommissioning are presented.

Section 4.0 presents the FSS design for the WHB. This section includes applicable FSS Plan requirements, breakdown into survey units and assignment of MARSSIM classifications. The survey design approach, instrumentation and measurement sensitivities are described.

Survey results are presented in Section 5.0. This section includes a summary of the FSS measurements performed in the WHB survey units, comparison to the DCGL, tests performed and an evaluation of residual contamination levels relative to the ALARA criterion.

Supporting information is contained in Appendices. Appendix A contains photos and schematics to supplement the text. Survey design maps, tables of coordinates and total surface beta measurement results for each survey unit are provided in Appendix B.

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[1] The PBRF Final Status Survey Report comprises the report main body and several attachments. The attachments present survey results for individual buildings and open land areas. The entire final report will provide the basis for requesting termination of NRC Licenses TR-3 and R-93 in accordance with 10CFR50.82 (b) (6).

[2] This is the primary DCGL. The DCGLs for the building exterior and for soil are discussed in Section 4.1.

2.0 WHB Description

The PBRF included a building designed for handling and processing radioactive material, designated as the Waste Handling Building. It was located immediately south of and directly connected to the Fan House (FH, Building 1132). The building comprised a main floor on the 0 ft. elevation, a partial mezzanine at the 9 ft. elevation and a partial basement at the – 13 ft. elevation. The main floor footprint was 4700 square ft. of dimensions 95 ft. (north-south) by 60 ft. (east-west, north end) and 45 ft. (east-west, south end). The WHB is shown on the PBRF site map in Figure 1. Views of the building exterior are shown in Exhibits 1 and 2 of Appendix A.

The building contained equipment for processing contaminated water, protective clothing, miscellaneous contaminated trash, or dry active waste (DAW), equipment and experiment hardware. Waste processing activities spanned decontamination, waste shipment and recycling. The WHB included laundry facilities for decontaminating protective clothing. It contained operating areas for processing and packaging radioactive waste for offsite shipment, an evaporator facility for processing high-solids contaminated waste water and work areas for decontaminating reusable equipment and for packaging radioactive waste for storage and shipment. The WHB was designed for operation in close conjunction with the FH and Hot Retention Area (HRA) for processing PBRF radioactive wastes.

The WHB also housed an office area, a laboratory, boiler room, change room, clean and contaminated rest rooms, and a storage area for clean clothing and other items. The WHB connected directly to the Fan House through a basement tunnel and a corridor connection on the first floor. Health Safety contractor personnel routinely manned the laundry facility and waste preparation areas in the WHB. Roving NASA operators normally attended to evaporator and boiler room operations, including back-shift maintenance.

2.1 Building Construction and Layout

The WHB was of steel frame and poured concrete construction. The first floor was constructed with concrete floors and exterior walls of fluted metal panels. Interior walls were constructed of 6 in. concrete block or 3 in. insulated metal panels. Basement walls, floors and ceiling were poured concrete. The ceiling over the north section of the first floor was constructed of concrete and served as the floor for the mezzanine area. The south high bay area and mezzanine ceilings were constructed of 1 ½ in. metal decking overlaid with a vapor barrier, 1 in. insulation and built up roofing materials – tar and gravel. The roof contained two roof drains and 6 vents or flues in the south roof section and 12 vents or flues, one boiler stack and two roof drains over the north mezzanine section.

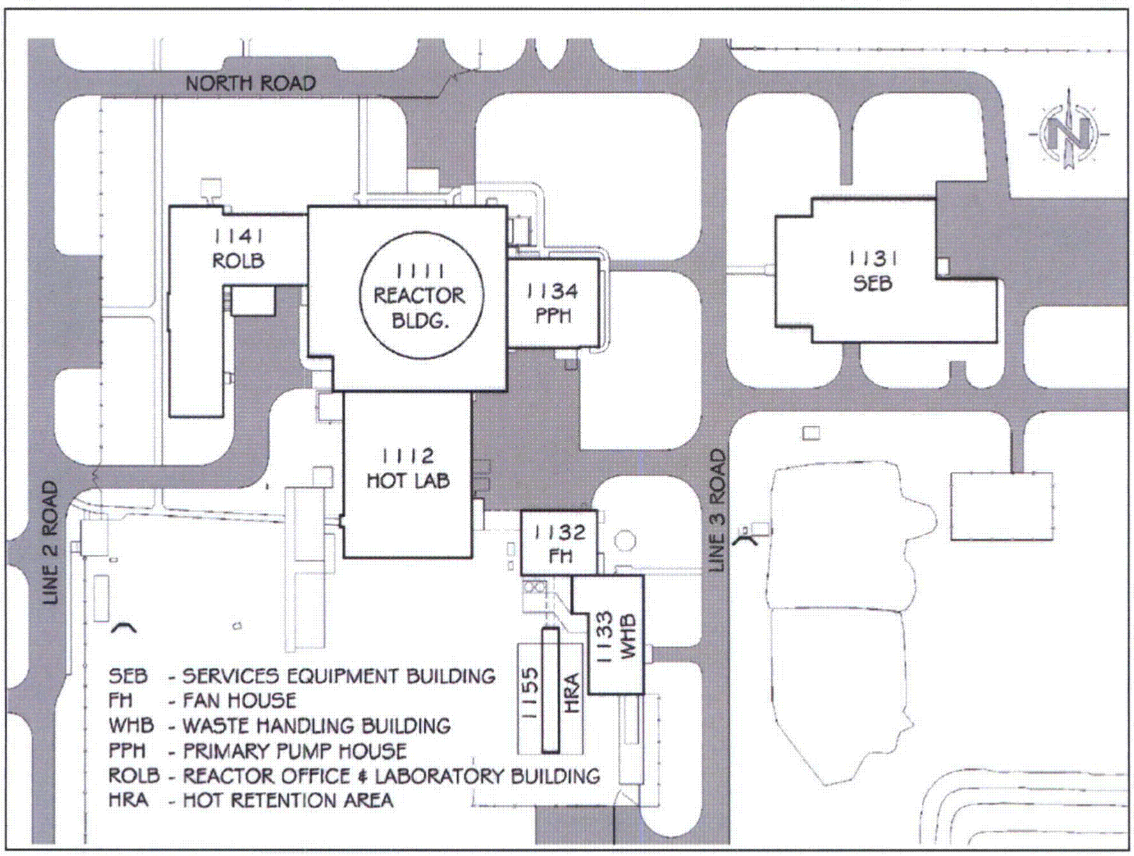
The WHB first floor served as the main operating area containing the laboratory, office, restrooms, laundry facility and storage area. A stairwell located in the center of the building connected the first floor and the basement area. A 13'x10' opening in the west-central section contained evaporator equipment and piping which extended from the basement. A 10'x10 1/2' hatchway located in the east-central area of the operating floor provided access for hoisting items to and from the basement. The southeast corner of the first floor high bay area contained a separate walled in area for decontaminating materials and packaging items for shipment. This room was served by an overhead gantry crane.

The northwest section of the first floor contained a boiler room that supplied steam to the evaporator and a corridor to the FH. The central north section housed the laundry room (washer, extractor and dryer), a clean clothes storage room, a contaminated and clean toilet and shower area, and a janitor's closet. The northeast section housed office, laboratory and storage rooms plus corridors.

The basement southeast corner contained the preparation room with an overhead monorail crane, plus a sand hopper on the east side. The southwest corner housed the evaporator room and hot sump. The north side of the basement was a large work area. It contained the laundry sump and sewage sump along the center west wall and the storm drain sump along the northeast wall. A tunnel in the northwest corner connected the WHB basement to the FH basement.

There were several entrances to the WHB first floor in addition to the FH corridor - a personnel door on the west center side north of an adjacent roll-up truck door, a double personnel door on the northeast side, a roll-up truck door on the south side of the boiler room and a large roll-up truck door on the south side of the decontamination room.

Figure 1, PBRF NW Area Showing Reactor Building, WHB and Other Support Buildings



2.2 Building Systems and Services

Building services included a gas fired boiler that provided 100 psi (lb/in.^{2}) process steam to the waste evaporator and a gas fired water heater that supplied domestic hot water to the WHB. Building space heat was provided by 5 unit heaters (four 80,000 BTU/h and one 60,000 BTU/h). Heating and cooling air was distributed by an HVAC ducting system. Electric service was provided via the FH basement from a transformer located on the east side of the Hot Laboratory Building to a distribution panel located in the WHB basement.

The non-condensable fraction of waste evaporator air exhaust was routed through a header to the Fan House absolute high efficiency particulate air (HEPA) filter train. It was then exhausted through the Fan House Stack. Air exhaust from the laundry extractor, dryer and laboratory hood were routed through individual HEPA units located on the mezzanine before exhausting through WHB roof vents.

Waste water from cold sinks and the clean restroom was collected by the sanitary sump. This waste water was pumped to the main sewer line west of Line 2 Road (radioactive waste water processing is discussed in Section 3.3). The WHB roof drains emptied directly into the storm drain system; the building footer drains emptied into the cold sump and were pumped to the Lateral C storm drain system.

Three cranes serviced WHB operations. Two 10 ton cranes were located on the operating floor: an overhead rail crane in the high bay and a gantry crane on rails that extended to the loading dock located outside the south rollup door. A two ton monorail crane was located in the basement for support of bulk waste handling and evaporator operations.

2.3 Building Modifications

The WHB was operated as designed and built, with only minor modifications after initial startup. The contaminated laundry operation was moved from the Fan House and installed in the WHB in 1964 as part of the WHB process equipment.

2.4 Final Configuration and Scope

Configuration of the WHB for the FSS and the period until license termination is controlled by PBRF decommissioning and FSS procedures. The first floor and mezzanine structure was intact, but stripped and vacant for the FSS with utilities and services limited to temporary lighting and power. All equipment was removed. Exhibits 4 through 9 (also Exhibits 11 and 12) of Appendix A show the condition and configuration of the WHB structure at the time of the Final Status Survey.

The WHB above ground structure excepting the exterior sheet metal walls and the roof was covered by the FSS in its entirety. The wall sheet metal and roof covering has been removed and disposed of under PBRF decommissioning and radiation protection procedures. This material has been segregated for "free release" survey under PBRF radiological control procedures (no detectable activity per Procedure RP-008).

The scope of FSS results reported in this attachment includes building interior surfaces and exterior concrete surfaces. It includes surface attachments, temporary safety covers and small embedded fixtures, for example, pipe and conduit stubs. It does not include piping embedded in WHB concrete or piping buried beneath or adjacent to the building. These results are reported in separate attachments of the FSS Report.

Embedded piping was removed from the WHB basement floor on grade portion south of the basement stairs. Photos in Exhibit 6, of Appendix A show the configuration of this area at the time of the FSS. The evaporator pit (and sump) and surrounding concrete was removed and disposed of as radioactive waste prior to the FSS of the basement. Views of the evaporator pit area prior to and after concrete removal are shown in Exhibit 7 of Appendix A.

The FSS of the WHB was conducted in two phases. The FSS of interior and exterior above grade structures was performed in 2009. After completion of FSS measurements of the above grade structures, the roof, steel siding and above grade structure were removed.[3] The remaining above grade structure was demolished in May 2010. The basement FSS measurements were then performed. Views of the WHB demolition in May 2010 are shown in Exhibit 10 of Appendix A.

3.0 History of Operations

A chronology of major milestones is given below. This is followed by a discussion of building operations, post-shutdown and decommissioning activities. Emphasis is on operations with radioactive materials that could affect the final building condition and final status survey.[4]

3.1 Chronology

Major PBRF and WHB milestones are listed below:

1956 – September, groundbreaking for PBRF.

1961 – June, 60 MW Test Reactor critical.

1962-1964 WHB Construction

1963 – 60 MW Test Reactor Full Power Operation

[3] Demolition of the WHB, including removal of the above-ground steel structure was performed by Clauss Construction under an approved Work Execution Package. Steel structural support members and sheet metal were segregated for survey under PBRF Radiological Control Procedure RP-008, Radiological Release of Equipment, Material and Vehicles. Under this procedure, material with detectable surface activity cannot be released; any such material from the WHB is disposed of as radioactive waste. Materials removed from the WHB that meet the RP-008 criterion of no detectable activity are disposed of as industrial waste, or recycled.

[4] Information sources for the history and pre-decommissioning period include, construction photos, construction drawings, PBRF operating cycle reports, Radiochemistry periodic reports, PBRF Annual Reports, Unusual Occurrence Files, memoranda and other historical files maintained by PBRF Document Control.

1964 - WHB operational

1973- January 5th, Reactor shutdown.

1973 – June 30, PBRF facilities placed in "standby condition

1985 – Initial radiological characterization, Teledyne Isotopes Inc.

1989 – Follow-up radiological characterization, GTS-Duratek.

2002 – Decommissioning Plan approved.

2003-2004 - Equipment removal and initial building decontamination.

2006- 2009- Remediation of contaminated areas and preparation for FSS.

2010 – FSS measurements completed.

2010 – WHB demolished.

3.2 Startup and Operations

Construction of the WHB was completed in 1964 after initiation of full power reactor operations in 1963. Upon completion, WHB support systems were immediately incorporated as part of routine reactor operations and utilized throughout the period, 1964-1973. The laundry and decontamination facilities were usually staffed as needed to ensure availability of clean protective clothing and processing of radioactive waste shipments in a timely manner. The evaporator and boiler were operated on an as needed basis for cleaning up contaminated HRA water and laundry water containing high solids.

Operations in the WHB generated liquid, solid and gaseous radioactive waste. The WHB hot sump collected water from all WHB floor drains; the hot sump pumped to the HRA tanks for waste cleanup and/or controlled disposal. Laundry waste drained to the laundry sump and was pumped to the underground storage tanks 9 through 12 or to HRA tanks 1 and 2 that collected low radioactivity water. The waste evaporator received water from HRA tanks 7 and 8 that collected high solids water. These two HRA high solids tanks were pumped through the WHB hot sump filter to the WHB hot sump.

The hot sump was pumped to the evaporator residue tank. The recycle pump then pumped water from the residue tank to the evaporator. The water was then distributed to the inner steam heated tank wall. The vapors produced passed from the evaporator through a separator to a condenser. The condensed vapor, or condensate, was pumped to the WHB laundry sump where it was returned to the HRA tanks 1, 2 or 9-12 for disposal. Uncondensed gasses were processed through a monitored-controlled ventilation system prior to release. The un-evaporated water and residue were pumped to a residue tank and continuously re-circulated through a filter. The residue filter was periodically changed out and the material processed as solid radioactive waste.

3.3 Radioactive Materials in the WHB

The US Atomic Energy Commission (AEC) authorized operations and use of radioactive materials at the PBRF under several licenses.[5] License No.TR-3 (Docket 50-30) authorized the 60 MW test reactor. The 100 KW mock-up reactor was licensed under License No.R-93. A broad byproduct license (BPL) No. 34-06706-03, authorized possession and use of radioactive materials (byproduct material) produced by the Plum Brook 60MW and Mockup reactors and other radioactive materials. Radioactive materials in the WHB were those originating from PBRF operations and contained in waste water, contaminated equipment and DAW [PBRF 2009].

Gross beta-gamma activity levels seen in the WHB waste water systems ranged from about $1x10^{-6}$ to $1x10^{-2}$ μCi/ml. The highest-water contamination levels occurred during periods of reactor operations with leaking reactor fuel elements. Radioactive material inventories for decontamination and/or waste shipment varied widely in type of material and activity level. Solid components irradiated in the reactor and irradiated experiment components were often greater than 1 Rem/h (on contact).

Operations and support personnel in the WHB were exposed to direct radiation levels that were much higher than background. These exposures were controlled by procedures and safe work permits and met the facility guidelines and AEC regulations. Other activities such as maintenance on pumps and valves and filter material change out also involved similar direct radiation and contamination levels. During operations, the evaporator solids, de-ionizer resins and reactor and experimental hardware often had direct readings up to 5 Rem/h (on contact) or higher when preparing them for shipment offsite. Surface contamination levels on equipment and nearby floors were often in excess of 10,000 dpm/100 cm^2 total surface beta activity [NASA 2009].

The Health Safety Operations Office reported unplanned incidents in the Operations Cycle Reports for PBRF related activities. Two events involving WHB activities were recorded:

- Cycle 57 - 12/6/1966. The Water Effluent Monitoring System (WEMS) gate was closed due to high activity level. The origin of the high activity was found to be from rain water washing radioactive contamination off a leaking shipping container onto the WHB storage pad. The rain caused runoff to flow to the nearby effluent ditch. Radiation levels up to 60 Rad/hr were noted on the top of the drum. The drum was sealed and the waste handling pad decontaminated (except for a 10x15 ft. area which was resistant to further surface decontamination efforts).

- Cycle 90 - 4/1/1969. Barrels in the WHB containing spent resins were found to be leaking water onto the floor. The barrels were tested and found to be defective. The barrels were secured-watertight and sufficient absorbent material was added to completely absorb the liquid. Procedures were modified to ensure that incoming waste drums are inspected and leak-tested if visual inspections so indicate.

[5] Authority for the PBRF reactor and radioactive materials licenses was assumed by the US Nuclear Regulatory Commission in 1975.

3.4 Disposition of Materials in the Post-Shutdown Period

In the period following termination of reactor operations in January 1973 and June 30th of 1973, the WHB was placed in standby status similar to the rest of the PBRF. End condition statements were prepared which governed the status of each system for the protected safe shutdown mode. The WHB was left as a radiological white zone, except for the specific areas that could not be effectively decontaminated.[6] All filters (air and water) were removed from filter housings; water systems drained and air systems depressurized and drained. The evaporator and boiler were shutdown. All process piping, tanks and pumps were cleaned and drained. The hot floor drains were sealed closed. The hot sump and laundry sump were deactivated, cleaned and flushed with clean water, dried and sealed. Electric power to pump motors was disconnected, except for the cold sump. This sump was left active to collect footer and storm drainage; the sump was monitored with alarms for high water level. Gas-fired unit heaters were left operational to maintain the building interior at 50 degree F. during cold weather.

The WHB was generally decontaminated; any remaining contaminated areas were clearly identified and properly posted. General building conditions were such that areas were left clean and void of miscellaneous equipment, waste and other materials and supplies. The restroom was taken out of service. Water fountains were deactivated and drained. The building was closed and locked.

The radiological status of the WHB has been investigated on several occasions since the PBRF was shutdown in January 1973. The first of these evaluations was performed by Teledyne Isotopes, Inc. during 1984-86. The results were reported in a 1987 Report [TELE 1987]. The Teledyne Isotopes study reported that with the exception of the waste evaporator area, most of the WHB structure would require only minor decontamination once the contaminated equipment is removed. Direct radiation levels in the WHB ranged from < 0.01 to 5.0 mR/h. Total surface beta contamination levels on building surfaces ranged from 25 to 5,000 dpm/100-cm^2. Removable beta surface contamination levels ranged from non-detectable to 12,000 dpm/100-cm^2. Total surface alpha contamination levels ranged from non-detectable to 63 dpm/100-cm^2. It was reported that no significant removable alpha activity was detected. [7]

In 1998, a confirmatory survey that included the WHB structure was performed by GTS-Duratek. The GTS-Duratek survey generally confirmed the results of the Teledyne Isotopes 1985 survey. It reported wide spread low-level surface contamination with total surface beta ranging from < 100 to 4850 dpm/100-cm^2. Removable surface beta levels ranged from < MDA (12.6 dpm/100-cm^2) to 550 dpm/100-cm^2. Removable surface alpha measurements were all < MDA (8.8 dpm/100-cm^2) [GTS 1998].

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[6] White zone criteria were as follows: area dose rates such that no individual could be exposed to greater than 5 mrem (whole body) in one hour or greater than 100 mrem in any 40 hour work-week; total and removable beta-gamma and alpha surface contamination levels – not greater than 2 times instrument background.

[7] It is noted that the maximum measured removable surface beta contamination level reported is higher than the reported maximum total surface beta contamination level. This is likely because the two types of measurements were not taken in the same locations.

3.5 Decommissioning

All equipment housed in the WHB was removed and disposed of as contaminated waste or recyclable materials by Montgomery-Watson during 2003 and 2004. All tanks, piping (except embedded piping), pumps, fans, electrical cabinets, instrumentation panels, metal gratings, etc. were shipped for disposal. Subsequently, the WHB was characterized to identify remediation requirements for the remaining structure. Also, as noted in Section 2.4, the WHB metal roof was removed, surveyed and disposed of in accordance with PBRF radiological control procedures.

In August of 2006, characterization surveys were performed under SR-29. Areas with contamination levels above the DCGL were identified on the floor and walls of the first floor. Highest measured levels were 77,000 dpm/100-cm^2 total and 807 dpm/100-cm^2 removable beta activity. Surveys in the basement showed total surface beta activity on the floor of up to 670,000 dpm/100-cm^2 and up to 110,000 dpm/100-cm^2 removable. Core bore samples were also taken under this SR, which showed activity generally in the top 1" of the floor surfaces, with one core taken on a crack on the 0' elevation showing activity throughout the core.

Decontamination of drain piping beneath the WHB basement floor was performed in 2006 and 2007 by Babcock Services, Inc. (BSI). Surveys for compliance with applicable FSS DCGL's were performed following the decontamination of the piping. The results of these surveys led to the decision to remove the floor drain system during decommissioning. This piping was removed in 2009 by Clauss Construction. Sanitary drain piping, located in Rooms 11, 12, and 6, was surveyed to the structural DCGL and met the release criteria (Survey Unit WH-SANS).

During 2007 and early 2008, MOTA Corporation performed remediation by sponge blasting the walls and ceilings of both elevations, and performing floor shaving. Additionally, extensive remediation was performed in the evaporator pit area. Post-remediation surveys of the evaporator pit showed areas of activity still above the DCGL. Final remediation was not performed at this time.

In the summer of 2008, SAIC performed remediation of areas in the WHB. The crane rails embedded in the first floor by the south roll-up door were removed, as were the rails in the floor on -13 ft. elevation by the evaporator pit. Block walls that were suspected of harboring contamination in the concrete beneath the wall were removed. Additional core bore samples were taken to characterize activity in floor cracks on the first floor (SR-103). Core bores and surveys on the floor/wall seam showed activity above the DCGL which required further remediation.

In January thru April of 2009, Clauss Construction continued remediation efforts by removing floor sections of the first floor to remove the drain piping that was above the Embedded Pipe DCGL, to remove the concrete floor of the evaporator pit, and to remove the sections of the basement floor/wall seam with activity above the DCGL. The Cold Sump, (also called the Storm Drain Sump) located in the north east area of the basement was also removed. It was determined that volumetric contamination in the south end of the basement was extensive and could not be removed without compromising the structural integrity of the building. The south end of the – 13 ft. elevation of the WHB was removed, including the Evaporator Sump, as part of building demolition in 2010 and segregated for survey and release or disposal as radioactive waste as appropriate (all material found to have detectable contamination was separated from material designated for use as backfill). With removal of the contaminated concrete, FSS of remaining basement floor and lower wall structures was completed in August, 2010. See Exhibits 11 and 12 of Appendix A for views of these areas at the time of the FSS.

4.0 Survey Design and Implementation for the WHB

This section describes the method for determination of the number of fixed measurements and samples for the FSS of the WHB. Applicable requirements of the FSS Plan are summarized. These include the $DCGL_W$[8], the gross activity DCGL, scan survey coverage and action-investigation levels, classification of areas and breakdown of the survey units. The radiological instrumentation and their detection sensitivities are discussed.

4.1 FSS Plan Requirements

The DCGLs for individual radionuclides were obtained for PBRF structures considering exposure to future site occupants from two potential pathways. Single radionuclide DCGLs were calculated using RESRAD-BUILD Version 3.22 for a building reuse scenario. Single radionuclide volumetric DCGLs were calculated for subsurface structures using RESRAD Version 6.21 for a resident farmer scenario.[9] The volumetric DCGLs (in pCi/g) were converted to "effective surface" DCGLs (in dpm/100-cm^2) using surface-to-volume ratios for the assumed volume of contaminated subsurface concrete. The DCGL calculations are described in the FSSP, Attachment B. To obtain the DCGLs for PBRF structures, the smaller of the two DCGLs calculated for each of the radionuclides of concern were selected.

A gross activity DCGL is used for structural surfaces in the PBRF, where multiple radionuclides are potentially present in residual contamination. The gross activity DCGL accounts for the presence of multiple radionuclides, including beta-gamma and alpha emitters. The gross activity DCGL can also account for so-called hard-to-detect (HTD) radionuclides. The latter are not detected, or detected with very low efficiency, by the beta detectors selected for the FSS of structures.

The gross activity DCGL for the WHB is calculated using equations in the FSSP for gross beta, gross alpha and surrogate DCGLs, based on the radionuclide mixture in residual contamination. Activity fractions and the gross activity DCGLs for the WHB are shown in Table 1.

[8] The convention used in the MARSSIM is to identify the DCGL used as the benchmark for evaluating survey unit measurement results, as the $DCGL_W$. The "W" subscript denotes "Wilcoxon", regardless of the particular test used (Wilcoxon Rank Sum Test, or Sign Test).

[9] Potential exposure to future occupants from subsurface structures could occur from contaminated concrete rubble placed as fill and from contaminated intact structures such as the below-grade portion of the Reactor Bioshield.

Table 1, WHB Radionuclide Activity Fractions and Gross Activity DCGLs for Structures

Location	Radionuclides								$DCGL_W$ (dpm/100-cm^2)
	H-3	Co-60	Sr-90	I-129	Cs-137	Eu-154	U-234	U-235	
	Activity Fractions Assigned to WHB (1)								
Interior surfaces	0.0052	0.0016	0.0260	0	0.9634	0	0.0036	0.0002	40,051
Exterior surfaces (2)	0.2707	0.0965	0.0788	0.0142	0.4671	0.0012	0.0698	0.0017	27,166

Table 1 Notes:

1. Activity profiles and gross activity DCGLs for structures are reported in the Technical Basis Document PBRF-TBD-07-001 [PBRF 2007]. A DCGL for soil is described in Section 4.3.
2. In Survey Design 29A, the default radionuclide mixture and DCGL reported in TBD-07-001 were applied to WHB exterior surfaces.

Survey designs incorporate requirements for scan coverage and investigation levels derived from the MARSSIM classification of survey units. The values applicable to the WHB are shown in Table 2.

Table 2, Class-Based Survey Scan Coverage and Action Level Requirements

Classification	Scan Survey Coverage	Scan Investigation Levels	Static Measurement or Sample Result Investigation Levels
Class 1	100%	$>DCGL_{EMC}$	$>DCGL_{EMC}$
Class 2	10 to 100%	$>DCGL_W$ or $>MDC_{scan}$ if MDC_{scan} is $>DCGL_W$	$>DCGL_W$
Class 3	Minimum of 10%	$>DCGL_W$ or $>MDC_{scan}$ if MDC_{scan} is $>DCGL_W$	$\geq$50% of the $DCGL_W$

Table 2 Note:

1. The scan investigation levels shown above are as listed in the FSS Plan. However, as described in Section 4.4, the scan investigation level was set to be equal to the $DCGL_W$ for Class 1 survey units.

4.2 Area Classification and Survey Unit Breakdown

The WHB was divided into 23 initial areas for classification and final status survey planning as shown in Table 2-1 of the FSS Plan. All except two areas, the building roof and exterior walls, were classified as MARSSIM Class 1 in the FSS Plan. These were classified as Class 2. As part of the FSS implementation process, individual survey units were identified and their final MARSSIM classification established. The WHB was divided into 29 Class 1 survey units for the FSS. These are identified in Table 3. Table 4 summarizes the survey unit breakdown by major elevation.[10]

[10] The calculations performed in preparation of this report are documented in a memorandum to the PBRF Decommissioning Project File [PBRF 2010].

Table 3, WHB Survey Units for FSS

Survey Unit (1)	Class	Description	FSSP Classification (2)
WH-1-1	1	Operating Room Floor Section 1	1
WH-1-2	1	Operating Room Trench Sides & Penetrations	1
WH-1-3	1	Operating Room Floor Section 2	1
WH-1-4	1	Operating Room Floor Section 3	1
WH-1-5	1	Rooms 3 – 7 Floor	1
WH-1-6	1	Rooms 8 – 13 Floor	1
WH-1-7	1	Room 14 Floor	1
WH-1-8	1	Wall Section 1 – Operating Room and Corridor Room	1
WH-1-9	1	Wall Section 2 – Rooms 3/4 and Hallway Room 8	1
WH-1-10	1	Wall Section 3 – Rooms 5 through 7	1
WH-1-11	1	Wall Section 4 – Room 11/12	1
WH-1-12	1	Wall Section 5 – Rooms 9, 10 and 14	1
WH-2-1	1	Mezzanine Floor – Section 1	1
WH-2-2	1	Mezzanine Floor – Section 2	1
WH-2-3	1	Mezzanine Concrete Wall	1
WH-3-1	1	WHB Basement Trench - Soil	1
WH-3-2	1	WHB Basement Trench – Concrete Edges	1
WH-3-3	1	WHB Basement Ceiling – Section 1	1
WH-3-4	1	WHB Basement Ceiling – Section 2	1
WH-3-5	1	WHB Basement Ceiling – Section 3	1
WH-3-6	1	WHB Basement Ceiling – Section 4 – Hallway to FH	1
WH-3-7	1	WHB Basement Stairway & Stairway Block Walls	1
WH-3-8	1	WHB Basement Upper Walls – West Walls, Tunnel	1
WH-3-9	1	WHB Basement Upper Walls - North, East, & South	1
WH-3-10	1	WHB Basement Lower Walls	1
WH-3-11	1	WHB Basement Floor - Section 1	1
WH-3-12	1	WHB Basement Floor - Section 2	1
WH-3-13	1	WHB Basement Floor Section 3 & Sumps	1
WH-4-1(3)	1	WHB Exterior Concrete Wall	2

Table 3 Notes:

1. The FSSP Table 2-1 identified 23 WHB survey areas. For the FSS, the WHB areas were re-defined to meet FSS Plan classification-based size limits for individual survey units. This resulted in 29 survey units – all designated as Class 1.
2. The FSS Plan classification was based on area history and available characterization data at the time the FSSP was prepared.
3. The WHB roof and walls were identified as Class 2 areas in the FSSP. As described in Section 2.4, the roof was removed during D&D and is not included in the FSS. The classification of WH-4-1 was changed to Class 1 in the survey design process as described in Survey Design 29A (rather than prepare a separate design for a Class 2, it was included in the Class 1design and surveyed as Class 1 for efficiency).

Table 4, WHB Survey Unit Breakdown by Major Elevation

Floor	No. Survey Units	Surface Area (m^2)	% of Survey Units	% of Area
First	12	801.0	41.4	45.4
Mezzanine	3	148.6	10.3	8.4
Basement	13	794.6	44.8	45.1
Exterior	1	18.5	3.4	1.0
Total	29	1762.7	100	100

4.3 Number of Measurements and Samples

The number of measurements and samples for each survey unit was determined using the MARSSIM statistical hypothesis testing framework as outlined in the FSS Plan. The Sign Test is selected because background count rates of instruments to be used are equivalent to a small fraction of the applicable $DCGL_W$.[11] Decision error probabilities for the Sign Test are set at $\alpha = 0.05$ (Type I error) and $\beta = 0.10$ (Type II error) in accordance with the FSSP.

The Visual Sample Plan (VSP) software was used to determine the number of FSS measurements in the WHB.[12] When the Sign Test is selected, the VSP software uses MARSSIM Equation 5-2 to calculate the number of measurements. Equation 5-2 is shown below:

$$N = 1.2\frac{\left(Z_{1-\alpha} + Z_{1-\beta}\right)^2}{4\left[\Phi\left(\frac{\Delta}{\sigma}\right) - 0.5\right]^2}$$ **(Equation 1)**

Where:

1.2 = adjustment factor to add 20% to the calculated number of samples, per a MARSSIM requirement to provide a margin for measurement sufficiency,
N = Number of measurements or samples,
α = the type I error probability,
β = the type II error probability,
$Z_{1-\alpha}$ = proportion of standard normal distribution < $1 - \alpha$ (1.6449 for σ = 0.05),
$Z_{1-\beta}$ = proportion of standard normal distribution < $1 - \beta$ (1.2816 for β = 0.1),

[11] Background count rates for the LMI 44-116 detector, the instrument of choice for FSS surface beta activity measurements on structures, are in the range of 300 cpm or less for most materials. This is equivalent to about 2500 dpm/100-cm^2; less than 10% of PBRF structure DCGLs (this assumes a detection efficiency of ~ 12%).

[12] The FSS Plan (Section 5.2.4) states that a qualified software product, such as Visual Sample Plan© [PNL 2010], may be used in the survey design process.

Φ (Δ/σ) = value of cumulative standard normal distribution over the interval -∞, Δ/σ,
Δ = the "relative shift", defined as the DCGL – the Lower Bound of the Gray Region (LBGR), and
σ = the standard deviation of residual contamination in the area to be surveyed (or a similar area). This may include the variation in measured "ambient" background plus the material background (for total surface beta measurements).

The MARSSIM module of VSP requires user inputs for the following parameters: α, β, LBGR, the $DCGL_W$ and σ. The numbers of measurements were calculated for the 29 WHB survey units using the parameters established in three survey designs. Table 5 summarizes the WHB survey design calculations and lists the values of the key VSP input parameters.

Table 5, WHB Survey Design Summary

Design No. (1)	Survey Units	Class	$DCGL_W$ (2)	LBGR (2)	Δ (2)	σ (2)	Δ/σ	N
29A	WH-1-1 thru 1-12, WH-2-1, 2-2 WH-3-3 thru 3-7	1	36,045 (3)	33,678	2,367	909	2.6	11
29A	WH-4-1	1	24,449 (4)	21,722	2,727	909	3.0	11
29C (5)	WH-1-3	1	36,045 (3)	33,318	2,727	909	3.0	11
29B	WH-3-1	1	12.88 (6)	6.44	6	2.57	2.5	11
29B	WH-3-2	1	34,443 (7)	33,642	801	267	3.0	11
49A	WH-3-8 & 3-9	1	34,044 (7)	32,637	1,407	469	3.0	11
49B	WH-3-10 thru 3-13	1	34,044 (7)	32,637	1,407	469	3.0	11

Table 5 Notes:

1. The data reported in this table is obtained from the Survey Design reports listed. They are maintained in the PBRF Document Control System.
2. Units are dpm/100-cm^2, except for Survey Unit WH-3-1, Survey Design 29B, which are pCi/g, soil.
3. The $DCGL_W$ is obtained by adjusting the original DCGL (40,051 dpm/100-cm^2) by a factor of 22.5/25 to account for the potential dose contribution of 2.5 mrem/y from deselected-insignificant radionuclides.
4. The $DCGL_W$ for the WHB exterior concrete walls is obtained from the facility default DCGL for structures, 27,166 dpm/100-cm^2, published in TBD-07-001 [PBRF 2007] and adjusting it by a factor of 22.5/25 to account for the potential dose contribution of 2.5 mrem/y from deselected-insignificant radionuclides.
5. Design 29C prepared for re-survey of WH-1-3 after failure of initial FSS.
6. The $DCGL_W$ value used to evaluate soil sample results for WH-3-1 soil was obtained in Survey Design 29B by adjusting the Cs-137 Surrogate DCGL for soil, 13.7 pCi/g, by a factor of 23.5/25 to account for 0.5 mrem/y contribution from deselected-insignificant radionuclides and one mrem/y contribution from embedded pipe in the nearby concrete.
7. The $DCGL_W$ in these survey designs for structures is obtained by adjusting the original DCGL (40,051 dpm/100-cm^2) by a factor of 21.5/25 to account for the potential dose contribution of 2.5 mrem/y from deselected-insignificant radionuclides and one mrem/y contribution from embedded piping. It is noted that not all the survey units in these designs contain embedded piping. The survey units with embedded piping are identified and the survey unit doses evaluated in Section 5.2 and Table 9.

Selection of design input parameters followed guidance in the FSS Plan. The Plan states that "the LBGR is initially set at 0.5 times the $DCGL_W$, but may be adjusted to obtain a value for the relative shift (Δ/σ) between 1 and 3." It is seen in Table 5 that a relative shift value of 3.0 was used in the final calculations for determining N.

The VSP software automatically performs an analysis to examine the sensitivity of N, the number of samples, to critical input parameter values. The following is an example obtained from the VSP report for survey unit WH-1-4. The sensitivity of N was explored by varying the following parameters: standard deviation, lower bound of gray region (as % of DCGL), beta, probability of mistakenly concluding that the survey unit mean concentration, μ, is greater than the DCGL and alpha, probability of mistakenly concluding that the survey unit mean concentration, μ, is less than the DCGL. Table 6 summarizes this analysis. The region of interest is for $\alpha = 0.05$ (required to be fixed), $\beta = 0.10$ (may be adjusted) and the LBGR at 80% to 90% of the DCGL. With the LBGR at 90%, doubling σ only increases N slightly, from 11 to 12. With the LBGR set to 80%, doubling σ causes no increase in N. The sensitivity of N to an incorrect conclusion that the survey unit will pass (regulator's risk) is quite low; increasing α from 0.05 to 0.10 and 0.15 and holding σ constant at 909 dpm/100-cm^2, shows that the number of measurements is 12 or fewer in all cases. These results show that N = 11 represents a reasonably conservative design.

Table 6, Sensitivity Analysis for WHB FSS Design

Number of Samples							
DCGL=36,045 (1)		α=0.05 (2)		α=0.10		α=0.15	
		σ= 1818 (1) (3)	σ= 909	σ= 1818	σ= 909	σ= 1818	σ= 909
LBGR=90% (1) (4)	β=0.05(5)	15	14	12	11	10	10
	β=0.10	12	11	10	9	8	8
	β=0.15	10	10	8	8	6	6
LBGR=80%	β=0.05	14	14	11	11	10	10
	β=0.10	11	11	9	9	8	8
	β=0.15	10	10	8	8	6	6
LBGR=70%	β=0.05	14	14	11	11	10	10
	β=0.10	11	11	9	9	8	8
	β=0.15	10	10	8	8	6	6

Table 6 Notes:

1. Units of DCGL, σ and LBGR are dpm/100-cm^2.
2. α = alpha, probability of mistakenly concluding that $\mu <$ DCGL.
3. σ = Standard Deviation.
4. LBGR = Lower Bound of Gray Region (as % of DCGL).
5. β = beta, probability of mistakenly concluding that $\mu >$ DCGL.

Visual Sample Plan was also used to determine the grid size, the random starting location coordinates and to display the measurement locations on survey unit maps drawn to scale. Refer to Appendix B for location coordinate tables and scale VSP maps showing measurement locations for each WHB survey unit.

The survey designs also specify scan survey coverage and action levels based on the MARSSIM classification listed in Table 2 (establishment of scan investigation-action levels for Class 1 survey units are discussed further in Section 4.4). If the scan sensitivity of the detectors used in Class 1 survey units is below the $DCGL_W$, the number of measurements in each survey unit is determined solely by the Sign Test. If the scan sensitivity is not below the $DCGL_W$, the number of measurements is increased as determined by the Elevated Measurement Comparison (EMC). As discussed in the next section, the scan sensitivities of instruments used in the FSS of the WHB are below the $DCGL_W$, therefore no increase in the number of measurements above the value calculated using the Sign Test was required.

4.4 Instrumentation and Measurement Sensitivity

Instruments to be used in the FSS of each survey unit are selected in each survey design. Their detection sensitivities must be sufficient to meet the required action levels for the MARSSIM class of each survey unit. Minimum detection sensitivities for static alpha and beta measurements are calculated using the following equation:

$$MDCstatic = \frac{3 + 3.29\sqrt{B_R t_s (1 + \frac{t_s}{t_b})}}{t_s E_{tot} \frac{A}{100}}, \qquad \textbf{(Equation 2)}$$

where:

MDC_{static} = Minimum Detectable Concentration (dpm/100-cm^2),

B_R = Background Count Rate (cpm),

t_b = Background Count Time (min),

t_s = Sample Count Time (min),

A = Detector Open Area (cm^2) and

E_{tot} = Total Detection Efficiency (counts per disintegration). The total efficiency equals the product of Detector Efficiency, E_i and Surface Efficiency, E_s.

Scan sensitivities for detectors which measure alpha and beta surface activity are determined using the following equation:

$$MDCscan = \frac{d'\sqrt{b_i}\,\frac{60}{i}}{E_i E_s \sqrt{p}\,\frac{A}{100}}, \qquad \textbf{(Equation 3)}$$

Where:

MDC_{scan} = Minimum Detectable Concentration (dpm/100-cm^2),

d' = Index of sensitivity related to the detection decision error rate of the surveyor, from Table 6.5 of MARSSIM [USNRC 2000],

i = observation counting interval, detector width (cm) / scan speed (s),

b_i = background counts per observation interval,

E_i = Detector Efficiency (counts per disintegration),

Es = Surface Efficiency, typically 25% for alpha and 50% for beta per ISO 7503-1, Table 2 [ISO 1988],

p = Surveyor efficiency (typically 50%) and

A = Detector Open Area (cm^2).

A summary of the a priori detection sensitivities of instruments used in the FSS of the WHB is provided in Table 7. [13]

Table 7, Typical Detection Sensitivities of Field Instruments

Detector Model	Detector Efficiency (c/d) (1)	MDC_{scan} (dpm/100-cm^2) (2)	Net cpm Equivalent to $DCGL_W$	MDC_{static} (dpm/100-cm^2) (2)
LMI 44-116	0.140	2,587(3)	4213	589(4)
LMI 43-37	0.125	889(5)	4506	NA
LMI 44-9	0.142	9,919(6)	614	3,229(7)

Table 7 Notes:

1. The detector efficiencies listed are total efficiency, i. e., $E_t = E_i + E_s$.
2. A priori scan sensitivities are calculated using Equation 3 and static sensitivities are calculated using Equation 2.
3. The scan MDC for the LMI 44-116 is reported in Design No. 29A for background count rate = 125 cpm; scan speed =15.2 cm/s and E_s = 0.5. An efficiency correction factor = 0.8349 is applied to compensate for concrete roughness (the detector-to-surface distance is 0.5 in.).
4. The static MDC for the LMI 44-116 detector is reported in Design No. 29A for background count rate = 125 cpm, E_s = 0.5 and the detector-to-surface distance = 0.5 in. (one minute count times are assumed for both the background and sample counts).
5. The scan MDC for the LMI 43-37 is from Survey Design No.29A. The background count rate is 500 cpm; the scan speed is 27 cm/s, E_s = 0.5 and the detector-to-surface distance is 0.5 in.
6. The scan MDC for the LMI 44-9 is obtained from Survey Design No. 29A. The background count rate is 125 cpm with a scan speed of 4.4 cm/s and the detector in contact with the surface.
7. The static MDC for the LMI 44-9 is obtained from Survey Design No. 29A. The background count rate is 125 cpm and the detector in contact with the surface (one minute count times are assumed for both the background and sample counts).

The scan investigation level for Class 1 survey units listed in Table 2 is the $DCGL_{EMC}$, as specified in the FSS Plan Section 8.1. However, the scan investigation level is actually set at the $DCGL_w$ established in the survey design for each structure survey unit. This practice was established in early survey designs for conservatism and was continued in subsequent designs.

[13] Table 7 addresses detection sensitivities of instrumentation for FSS of structure survey units. The WHB also contains a soil survey unit, WH-3-1 where the LMI-44-10 NaI detector is used for the scan survey. In accordance with Survey Design 29B and Survey Request SR-173, the scan investigation level was set at 310 net cpm (ncpm). At a nominal background count rate of 200 cpm, this corresponds to an MDC scan of ~ 9.5 pCi/g Cs-137 in surface soil.

It is also noted the FSS Plan states that technicians are to respond to indications of increased count rates even though scan count rates may not be above the investigation level specified in survey instructions. [14]

Modifications to survey instructions are adjusted to account for unusual measurement conditions. Modified detection sensitivities may be applied taking into account adjustments in detector efficiency. Scan speeds may be reduced to ensure that required scan sensitivities are achieved. The bases for adjustments due to non-standard conditions are provided in PBRF Technical Basis Documents.[15] Examples of areas or locations in WHB survey units where special measurement conditions apply are shown in Exhibits 13 through 15 of Appendix A.

5.0 WHB Survey Results

Results of the WHB FSS are presented in this section. This includes scan survey frequencies (% of areas covered) for each survey unit and occurrence of events where scan investigation levels were exceeded. Investigations performed and the results are summarized. Fixed measurement results for each survey unit and the results of comparison tests of survey unit maximum and average values with the $DCGL_W$ are reported. As discussed below, no statistical tests were required. It is shown that levels of residual contamination have been reduced to levels that are ALARA. This section closes with a summary which concludes that applicable criteria for release of the WHB for unrestricted use are satisfied and all FSS Plan requirements are met.

5.1 Surveys and Investigations

Scan survey results were reviewed to confirm that the scan coverage requirement (as % of survey unit area) was satisfied for all survey units. The results of QC replicate scan surveys were also reviewed to confirm that the minimum coverage requirement of 5% was satisfied. Results of the WHB scan surveys are compiled in Table 8. The table shows that scan coverage requirements were satisfied for all survey units. The table also shows that investigations were performed in three survey units (all WHB survey units are Class 1).

In survey unit WH-1-3, WHB Operating Room Floor, floor Section 3, elevated counts were observed while scanning along a crack and at several small penetrations in the floor concrete. An investigation revealed that several cracks contained contamination at depth at levels above the surface activity $DCGL_W$. The decision was made to "fail" the survey unit and perform

[14] From FSS Plan Section 7.1.1: "Technicians will respond to indications of elevated areas while surveying. Upon detecting an increase in visual or audible response, the technician will reduce the scan speed or pause and attempt to isolate the elevated area. If the elevated activity is verified to exceed the established investigation level, the area is bounded (e.g., marked and measured to obtain an estimated affected surface area). Representative static measurements are obtained as determined by the FSS/Characterization Engineer. The collected data is documented on a Radiological Survey Form."

[15] The PBRF-TBD-07-004 [PBRF 2007a] presents efficiency correction factors developed for the LMI 44-116 detector. The correction factors are presented as a function of detector-to-surface distance. Application of the factors requires empirical measurements of the effective detector-to-surface distance for areas with non-standard surface conditions as part of the survey unit inspection process.

additional characterization and remediation of the impacted floor area. The contaminated cracks were removed by over-coring.

A new survey design (Design 29C) and survey instructions were prepared for WH-1-3. The FSS re-survey was conducted. In preparation for the FSS re-survey of WH-1-3, three additional cracks were observed. An evaluation was performed and the cracks were remediated. [16] Two remaining areas of elevated activity associated with these cracks were identified and evaluated as part of the FSS. Scan investigation levels were not exceeded, but increases in scan count rates were observed in areas that had been previously remediated. These included an elevated area of < 100 cm^2 detected along the crack identified as Crack #2, located adjacent to the Evaporator Pit hatch. Surface beta activity of 23,000 dpm/100-cm^2 was measured. This is below the $DCGL_W$ and no further action was required. In a second elevated area on the floor, adjacent to Crack # 2, about 300 cm^2 in area, surface beta activity of 53,200 dpm/100-cm^2 was measured. As reported in the WH-1-3 release record, the elevated measurement test was performed and the calculated unity value found to be 0.094, hence the EMT was successful.

The scan investigation level was exceeded in two small areas of elevated activity, located on the west wall of the operating floor area in survey unit WH-1-8, and investigated. A static surface beta measurement on the first, reported as 30,900 dpm/100-cm^2, was below the $DCGL_W$. The second was measured to be 74,400 dpm/100-cm^2 in an area less than the detector area (126 cm^2). The elevated measurement test was performed and as reported in the WH-1-3 release record, the calculated unity value was 0.061. Hence the EMT was satisfied.

While performing a scan survey of the concrete block wall in survey unit WH-1-9, the west wall sections of Rooms 3 and 4, the scan investigation level was exceeded. An area of elevated activity was confirmed and an investigation performed. The surface beta activity was reported to be 7290 dpm/100-cm^2, on a very small area, less than the area of the LMI-44-9 pancake detector (12 cm^2) used to obtain the measurement. Since this is < the $DCGL_W$, no further action was required.

Table 8, Scan Survey Results

Survey Unit	Class	Scan Survey Coverage (%) (1) (2)	Survey Request No.	Investigation Performed (3)	QC Replicate Scan Coverage (%) (1) (4) (5)
WH-1-1	1	100	183	No	15.3
WH-1-2	1	100	183	No	9.4
WH-1-3	1	100	183	Yes	7.5
WH-1-4	1	100	183	No	12.3
WH-1-5	1	100	183	No	8.1
WH-1-6	1	100	183	No	8.9
WH-1-7	1	100	183	No	10.3
WH-1-8	1	100	184	Yes	6.7

[16] As discussed in Survey Design 29C (Attachment 6), the cracks were evaluated prior to the new FSS Design for Survey Unit WH-3-1. This evaluation included collection and analysis of multiple core bores along each crack, the determination of the volumetric activity in the crack and surrounding concrete. The volumetric activity measurements were also converted to surface activity. Portions of the cracks which exceeded either the volumetric DCGLs for subsurface structures or the surface activity DCGL were removed by over coring.

Table 8, Scan Survey Results

Survey Unit	Class	Scan Survey Coverage (%) [(1) (2)]	Survey Request No.	Investigation Performed [(3)]	QC Replicate Scan Coverage (%) [(1) (4) (5)]
WH-1-9	1	100	184	Yes	5.2
WH-1-10	1	100	184	No	6.0
WH-1-11	1	100	184	No	6.0
WH-1-12	1	100	184	No	5.1
WH-2-1	1	100	185	No	12.8
WH-2-2	1	100	185	No	12.8
WH-2-3	1	100	185	No	12.8
WH-3-1	1	100	173	No	8.1
WH-3-2	1	100	174	No	8.1
WH-3-3	1	100	186	No	5.6
WH-3-4	1	100	186	No	5.6
WH-3-5	1	100	186	No	5.6
WH-3-6	1	100	186	No	5.6
WH-3-7	1	100	187	No	5.6
WH-3-8	1	100	252	No	8.4
WH-3-9	1	100	252	No	8.4
WH-3-10	1	100	265	No	5.4
WH-3-11	1	100	265	No	5.4
WH-3-12	1	100	265	No	5.4
WH-3-13	1	100	265	No	5.4
WH-4-1 [(6)]	1	100	188	No	10.6

Table 8 Notes:

1. Scan % coverage values are rounded to the nearest whole per cent. Values reported with the first decimal as 5, e. g., 5.5, are rounded downward.
2. One hundred percent of the accessible surface area was scanned. A fraction of the surface area of the survey unit is inaccessible for scanning. In most such survey units, it is less than a few percent of the total surface area. In all cases it is less than 10%.
3. Investigation performed when the investigation-action level was exceeded during a scan survey. The scan investigation level, in gross cpm, was set to be equivalent to the DCGL plus nominal background cpm.
4. The % scan coverage is given as the % of the area scanned in the initial survey.
5. Replicate QC scan results are reported for multiple survey units in some Survey Requests. For these, the QC scan percentages are reported as % of the scanned area of the survey units combined. So the same % coverage value is assigned to all of the survey units reported in a Survey Request.
6. Designated a Class 1 survey unit in Survey Design 29A – it was originally designated Class 2 in the FSSP (see Table 3 Note 3).

5.2 Fixed Measurements and Tests

Results of the assessment of WHB FSS total surface beta measurements are presented in Table 9 (individual measurements in each survey unit are reported in Appendix B). Table 9 compares the maximum activity measured in each survey unit to the DCGL. The mean activity of each survey unit is also compared to the DCGL, and as expected, are all less than the DCGL. The DCGL values used for these comparisons are identified as "adjusted DCGLs". As explained in the Table 9 Notes, the adjusted DCGLs are calculated for each survey unit to allow for the dose contribution from deselected radionuclides (2.5 mrem/y) and embedded piping (1 mrem/y) as applicable. The last column of Table 9 shows the results of an additional check. This check is to ensure that the dose from residual surface contamination in each survey unit plus the doses allocated for embedded piping and deselected radionuclides is below 25 mrem/y.

The evaluations summarized in Table 9 show that the total dose from each WHB survey unit is well below the 25 mrem/y dose criterion.[17] The average of 316 systematic total surface beta measurements reported in the WHB release records is: 548 ± 230 dpm/100-cm^2 (one standard deviation) [PBRF 2010].[18]

Removable surface activity measurements were also performed at each fixed activity measurement location and counted for gross alpha and gross beta activity. A review of the WHB Release records was conducted to ensure that all smear counting results were less than 10% of the gross activity DCGL. The requirement for PBRF laboratory smear counting instruments is that the MDAs be < 10% of the applicable gross activity DCGL[19]. Gross beta and gross alpha counts for all WHB smears were less than MDA.

The survey unit, WH-3-1, covered surface soil beneath the basement where soil was exposed by concrete excavation to remove embedded drains. It was designated as Class 1. Eleven surface soil samples were collected and analyzed by gamma spectroscopy by the PBRF laboratory. All of the Co-60 results were < MDA (average MDA = 0.11 ± 0.01 pCi/g). Three of the 11 samples were positive for Cs-137 (> MDA). They were: 0.214, 0.228 and 0.567 pCi/g. Hence, all Cs-137 and Co-60 sample results are < their respective soil DCGLs. The soil

[17] The average estimated dose from residual activity in the WHB survey units is 0.45 mrem/y and the maximum dose is 1.71 mrem/y. Included in this average are the estimated doses from each survey unit obtained from the systematic total surface beta activity measurements and any contributions from activity measured in localized areas of elevated activity that exceeded the DCGL. For the systematic measurements, the estimated dose is obtained as the ratio of the survey unit average residual surface beta activity (from the systematic measurements only) to the adjusted DCGL times the dose equivalent to the adjusted DCGL. The dose contributions from localized areas of elevated activity in two WHB survey units are described in Table 9, Note 6.

[18] It is noted that in converting total surface activity measurements in cpm to dpm/100-cm^2, the detector background response from surface materials is not subtracted. As a result, the total surface activity measurement results are biased high.

[19] Typical MDAs for PBRF low background smear counting instruments are 14 dpm for alpha and 18 dpm for beta. Smears cover 100 cm^2, so these MDA values are equivalent to dpm/100-cm^2.

DCGL for Cs-137 listed in the FSS Plan is 14.7 pCi/g and for Co-60 is 3.8 pCi/g. Activity fractions used in the survey design for WH-3-1 are: Cs-137, 0.9721; Co-60, 0.0016 and Sr-90, 0.0262. Cesium-137 is used as the surrogate for Sr-90. With the surrogate DCGL of 12.88 pCi/g, for soil sample evaluation and the Sr-90: Cs-137 activity ratio equal to 0.027, it is determined that based on the maximum measured Cs-137 concentration, Sr-90 is also < DCGL.

Table 9, WHB Total Surface Beta Activity Measurement Summary and Test Results

Survey Unit ID	$DCGL_W$ (1) (4)	Adjusted DCGL (2) (4)	N (3)	Maximum (4)	Test Result Maximum < Adj. DCGL	Average (4)	Test Result Average < Adj. DCGL	Total Dose < 25 mrem/y (5)
WH-1-1	40051	36046	11	822	YES	629	YES	YES
WH-1-2	40051	36046	11	897	YES	538	YES	YES
WH-1-3 (6)	40051	36046	11	993	YES	714	YES	YES
WH-1-4	40051	36046	11	1120	YES	594	YES	YES
WH-1-5	40051	36046	11	943	YES	633	YES	YES
WH-1-6	40051	36046	11	781	YES	602	YES	YES
WH-1-7	40051	36046	11	795	YES	579	YES	YES
WH-1-8 (6)	40051	36046	11	836	YES	373	YES	YES
WH-1-9	40051	36046	11	500	YES	357	YES	YES
WH-1-10	40051	36046	11	528	YES	304	YES	YES
WH-1-11	40051	36046	14	678	YES	364	YES	YES
WH-1-12	40051	36046	11	603	YES	325	YES	YES
WH-2-1	40051	36046	12	943	YES	598	YES	YES
WH-2-2	40051	36046	12	863	YES	574	YES	YES
WH-2-3	40051	36046	13	754	YES	368	YES	YES
WH-3-2 (7)	40051	34444	11	805	YES	478	YES	YES
WH-3-3	40051	36046	11	795	YES	683	YES	YES
WH-3-4	40051	36046	11	1240	YES	695	YES	YES
WH-3-5	40051	36046	12	877	YES	658	YES	YES
WH-3-6	40051	36046	11	890	YES	621	YES	YES
WH-3-7	40051	36046	11	813	YES	448	YES	YES
WH-3-8	40051	36046	11	984	YES	703	YES	YES
WH-3-9	40051	36046	11	1140	YES	730	YES	YES
WH-3-10	40051	36046	11	950	YES	704	YES	YES
WH-3-11 (7)	40051	34444	11	669	YES	454	YES	YES
WH-3-12 (7)	40051	34444	11	1150	YES	491	YES	YES
WH-3-13 (7)	40051	34444	11	773	YES	505	YES	YES
WH-4-1	27166	24449	11	1290	YES	705	YES	YES

Table 9 Notes:

1. The $DCGL_W$ as specified in Table 1 and Table 1 Notes.
2. The $DCGL_W$ is adjusted by a factor of 21.5/25 to account for one mrem/y dose contribution from embedded piping and 2.5 mrem/y from deselected radionuclides. If no embedded piping is associated with the survey unit, the $DCGL_W$ is adjusted by a factor of 22.5/25 to account for the dose contribution from deselected radionuclides only.
3. N = number of measurements. Where the number of measurements is greater than the default design value of 11, it is due to the VSP method of fitting the calculated systematic grid pattern into the survey unit. On occasion, this adds additional measurement locations.
4. Units are dpm/100-cm^2.

5. This column shows the results of a check performed on each survey unit to confirm that the building structure surface activity measured from the systematic measurements plus any activity in localized areas of elevated activity is less than the adjusted DCGL. This is an additional check to ensure that the total dose from all contributors associated with each survey unit is less than 25 mrem/y.
6. The dose estimated for survey units WH-1-3 & WH-1-8 include contributions from localized small areas of elevated activity with measured activity above the DCGL. The estimated dose contribution from the small area sources are 1.26 & 1.38 mrem/y for WH-1-3 & WH-1-8, respectively. These doses were estimated by applying the EMC unity value factor calculated in accordance with the FSS Plan Section 8.3.
7. Embedded piping is associated with WHB basement floor survey units, WH-3-2, 3-11, 3-12 & 3-13.

5.3 ALARA Evaluation

It is shown that residual contamination in the WHB has been reduced to levels that are ALARA, using a method acceptable to the NRC. The NRC guidance on determining that residual contamination levels are ALARA includes the following:

> "In light of the conservatism in the building surface and surface soil generic screening levels developed by the NRC, NRC staff presumes, absent information to the contrary, that licensees who remediate building surfaces or soil to the generic screening levels do not need to provide analyses to demonstrate that these screening levels are ALARA. In addition, if residual radioactivity cannot be detected, it may be presumed that it had been reduced to levels that are ALARA. Therefore the licensee may not need to conduct an explicit analysis to meet the ALARA requirement."[20]

Screening level values published by the NRC, as dpm/100-cm^2 values for individual radionuclides, are shown in Table 10. In contrast, the FSS of PBRF structures comprise gross beta activity measurements. Thus a direct comparison of WHB residual contamination levels to individual radionuclide screening level values is not possible. However, a comparison can be made to an appropriate screening level-equivalent gross activity DCGL for the mix of radionuclides potentially present in the WHB. A screening level value that is equivalent to the gross activity DCGL was calculated using the equations in Section 3.6 of the FSS Plan.[21] The activity fractions listed in Table 1 (also shown in Table 10) were used in the calculation. The screening level equivalent DCGL for the WHB interior is calculated to be 12,591 dpm/100-cm^2. [22]

[20] This guidance was initially published in Draft Regulatory Guide DG-4006, but has been reissued in NUREG-1757 Volume 2, Appendix N.

[21] The equivalent screening level gross activity DCGL is calculated using an EXCEL template [PBRF 2010]. This template incorporates the equations in section 5.3 of the FSS Plan [NASA 2007].

[22] The screening level equivalent gross activity DCGL was also calculated for the default radionuclide mixture applied to the WHB exterior surfaces. This was calculated to be 1182 dpm/100-cm^2. The upper confidence limit of the FSS measurements on the WHB exterior surfaces is 858 dpm/100-cm^2, also less than the associated screening level equivalent DCGL value.

The average total surface beta activity measured in the FSS of the WHB interior surfaces is 543 ± 227 dpm/100-cm^2 (one standard deviation). The upper limit of the 95$^{th\ \%}$ confidence interval of this mean value is 568 dpm/100-cm^2.[23] This value is well below the screening level gross activity DCGL of 12,591 dpm/100-cm^2.

Soil activity concentrations measured in survey unit WH-3-1 are compared to NRC surface soil screening level values in Table 11. As shown in the table, all soil activity concentrations are well below their respective screening level values. From these comparisons, it is concluded that the ALARA criterion is satisfied.

Table 10, NRC Structure Screening Level Values for WHB and Activity Fractions

Radionuclide	Screening Level Value (dpm/100-cm^2)	WHB Activity Fraction (%) $^{(1)}$
H-3	1.2 E+08 $^{(2)}$	0.52
Co-60	7.1E+03 $^{(2)}$	0.16
Sr-90	8.7E+03 $^{(2)}$	2.6
I-129	3.5E+04$^{(2)}$	0
Cs-137	2.8E+04 $^{(2)}$	96.34
Eu-154	1.2E+04$^{(3)}$	0
U-234	9.1E+01 $^{(3)}$	0.36
U-235	9.8E+01$^{(3)}$	0.02

Table 10 Notes:

1. Activity fractions used to develop the $DCGL_W$ for WHB interior surfaces.
2. Values from NUREG-1757 Vol. 2, Table H.1 [USNRC 2006].
3. Values from NUREG/CR-5512, Vol. 3, Table 5.19 [SNL 1999]. These are 90th percentile values of residual surface activity corresponding to 25 mrem/y to a future building occupant.

Table 11, NRC Soil Screening Level ALARA Comparison

Radionuclide	NRC Screening Level (pCi/g)	Maximum Measured Concentration (pCi/g)
Co-60	3.8	< MDA $^{(1)}$
Cs-137	11	0.57 $^{(2)}$
Sr-90	1.7	< 0.01 $^{(3)}$

Table 11 Notes:

1. The average Co-60 MDA for 11 samples is 0.11 ± 0.01 pCi/g.
2. The maximum of three of 11 samples with measured concentration > MDA.
3. Maximum Sr-90 concentration inferred from measured Cs-137 concentration and Sr-90: Cs-137 activity ratio of 0.027.

5.4 Comparison with EPA Trigger Levels

The PBRF license termination process includes a review of residual contamination levels in groundwater and soil, as applicable, in accordance with the October 2002 Memorandum of

[23] The upper limit of the confidence interval, 95th percentile value, is calculated as: UL = mean + 1.96 $\sigma/\sqrt{n}$, where n = 305 measurements.

Understanding (MOU) between the US NRC and the US Environmental Protection Agency (EPA) [USEPA 2002]. Concentrations of individual radionuclides, identified as "trigger levels" for further review and consultation between the agencies, are published in the MOU. Maximum activity concentrations of radionuclides of concern measured in the WHB FSS are compared to EPA trigger levels. This comparison is shown in Table 12. The table shows that the measured soil activity concentrations are well below EPA trigger levels. It is noted that groundwater is not within the scope of the WHB FSS.

Table 12, Comparison of Soil Sample Results with EPA Trigger Levels

Radionuclide	EPA Trigger Level (pCi/g)	Maximum Measured Concentration (pCi/g)
Co-60	4	< MDA (1)
Cs-137 (4)	6	0.57 (2)
Sr-90 (4)	23	< 0.01 (3)

Table 12 Notes:
1. The average Co-60 MDA for 11 samples is 0.11 ± 0.01 pCi/g.
2. The maximum of the three (of 11 samples) with measured concentration < MDA.
3. Maximum Sr-90 concentration inferred from measured Cs-137 concentration and SR-90: Cs-137 activity ratio of 0.027.
4. Specified in the MOU as including daughter activity [USEPA 2002].

5.5 Conclusions

The results presented above demonstrate that the WHB satisfies all FSS Plan commitments and meets the release criteria in 10CFR20 Subpart E. The principal conclusions are:

- Scan surveys were performed in 100 % of the accessible surfaces of all 29 WHB survey units – all were surveyed as Class 1.
- Residual surface contamination levels requiring investigation were observed in three survey units. One survey unit was determined to have activity in excess of the $DCGL_W$. It was remediated and a new FSS was performed. In two of the survey units, levels above the $DCGL_W$ were measured in small localized areas; both passed the elevated measurement test.
- All randomly selected fixed total surface activity measurements are less than the applicable $DCGL_W$.
- All survey unit mean fixed measurement results (total surface beta activity) are below the $DCGL_W$, hence no statistical tests were required.
- All removable surface activity measurements are less than 10% of the $DCGL_W$.
- In the single soil survey unit, radionuclide concentrations of Cs-137, Co-60 and Sr-90 were all well below their respective DCGLs (unity value < 0.05 for the highest activity sample).
- Residual surface activity concentration measurement results are shown to be less than NRC screening level values - demonstrating that the ALARA criterion is satisfied.

- Only minor changes from what was proposed in the FSS Plan were made – the WHB was divided into 29 survey units, whereas the FSS Plan had identified 23 survey areas, not divided in to survey units. One area classified as Class 2 in the FSSP was changed to Class 1 in the FSS design review process (this was done for administrative reasons – not as a result of new information on contamination levels).
- There were no changes from initial assumptions (in the FSS Plan) regarding the extent of residual activity in the WHB. No reclassification of survey units was required as a result of FSS measurements and investigations.

6.0 References

GTS 1998 GTS-Duratek, Inc., *NASA/Lewis Plum Brook Facility 1998 Confirmation Survey, Volume 1 - Survey Packages and Survey Results*, November 1998.

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NASA 2006 NASA Safety and Mission Assurance Directorate, Plum Brook Reactor Facility, *Decommissioning Project Quality Assurance Plan,* QA-01, Revision 2, February 2006.

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PBRF 2009 Plum Brook Reactor Facility, Memorandum to Project File, J. L. Crooks, Don Young, *Final FSS Report Background –Waste Handling Building (1133),* December 17, 2009.

PBRF 2010 Plum Brook Reactor Facility Decommissioning Project Office, Memorandum to Project File, *Engineering Record for Final Status Survey Report Calculation – WHB Update.* August 12, 2010.

PNL 2010 Battelle Pacific Northwest Laboratories (PNL), *Visual sample Plan*, Version 5.9, 2010.

SNL 1999 Sandia National Laboratories (SNL), for US Nuclear Regulatory Commission, *Residual Radioactive Contamination From Decommissioning, Parameter Analysis,* NUREG/CR-5512, Vol.3, Oct. 1999.

TELE 1987 Teledyne Isotopes, *An Evaluation of the Plum Brook Reactor Facility and Documentation of Existing Conditions*, Prepared for NASA Lewis Research Center, December 1987.

USEPA 2002 Memorandum of Understanding, US Environmental Protection Agency and US Nuclear Regulatory Commission, *Consultation and Finality on Decommissioning and Decontamination of Contaminated Sites*, October 9, 2002.

USNRC 2000 US Nuclear Regulatory Commission, *Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM)*, NUREG-1575, Rev.1, August 2000.

USNRC 2006 US Nuclear Regulatory Commission, *Consolidated Decommissioning Guidance, Characterization, Survey and Determination of Radiological Criteria*, NUREG 1757, Vol. 2, Rev.1, September 2006.

7.0 Appendices

Appendix A – Exhibits

Appendix B – Survey Unit Maps and Tables Showing Measurement Locations and Results

Final Status Survey Report

Attachment 6

Waste Handling Building
(Building 1133)

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Appendix A

Exhibits

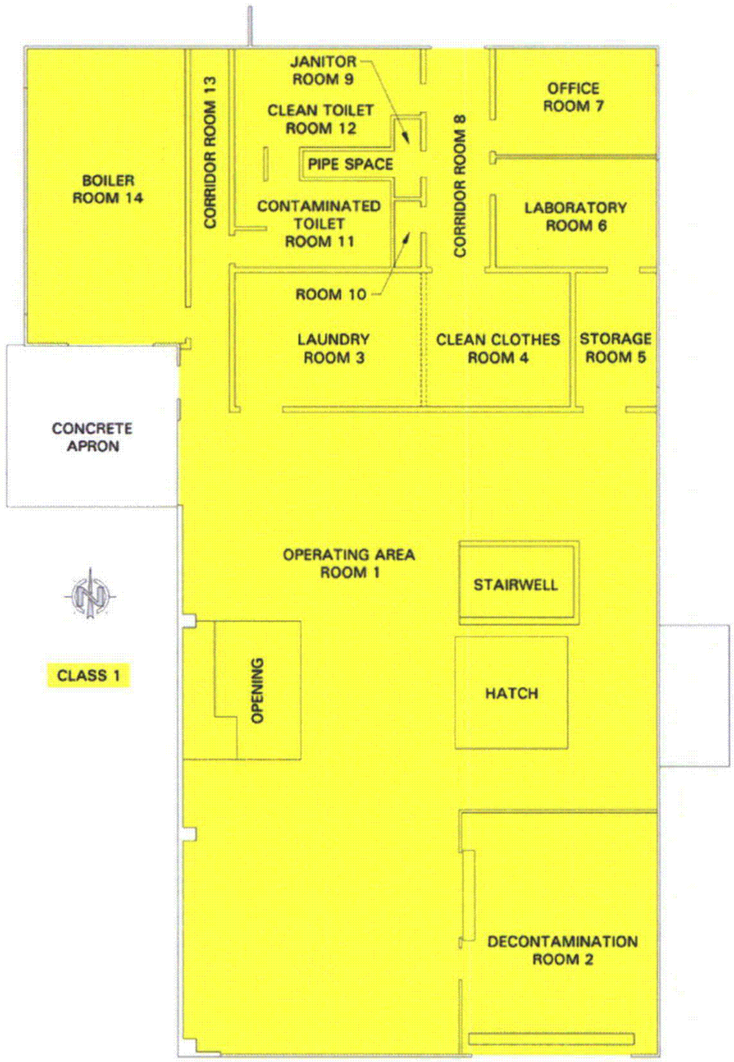
List of Exhibits

Exhibit 1, Views of WHB Exterior

Waste Handling Building Viewed from the South

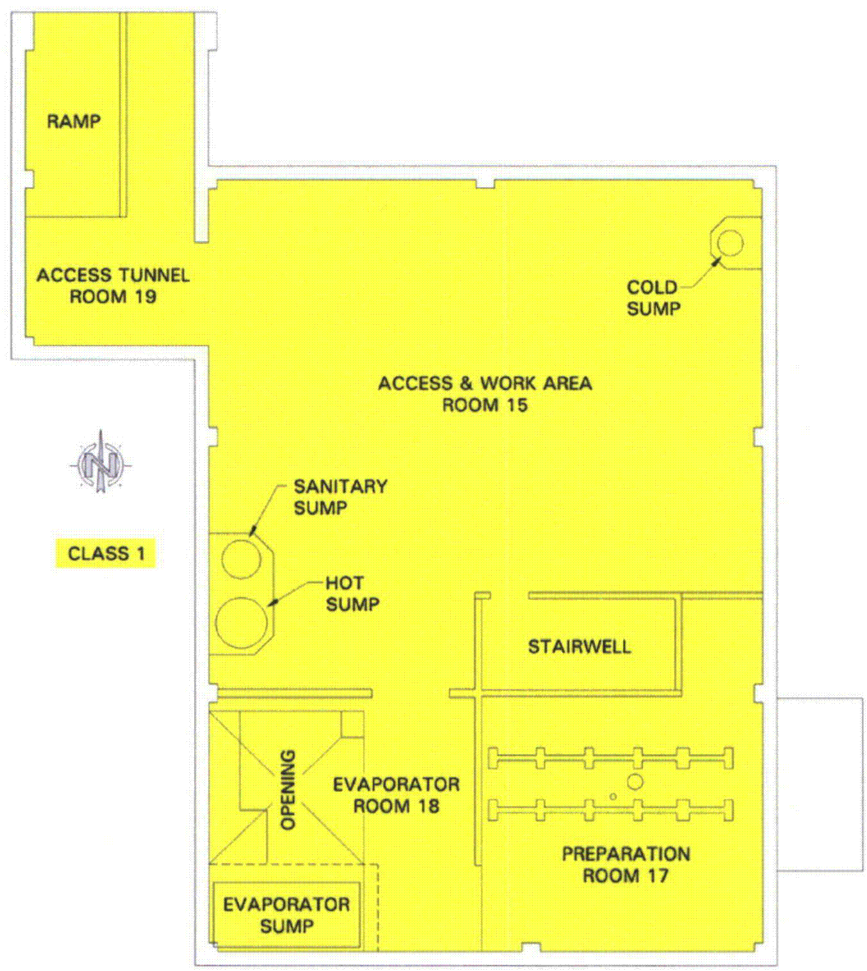
View of WHB from the NE Showing North and East Walls

Exhibit 2, WHB First Floor Layout and Survey Unit Identification



Survey Unit	Class	Description
WH-1-1	1	Operating Room Floor Section 1
WH-1-2	1	Operating Room Trench Sides & Penetrations
WH-1-3	1	Operating Room Floor Section 2
WH-1-4	1	Operating Room Floor Section 3
WH-1-5	1	Rooms 3 – 7 Floor
WH-1-6	1	Rooms 8 – 13 Floor
WH-1-7	1	Room 14 Floor
WH-1-8	1	Wall Section 1 – Operating Room and Corridor Room 13
WH-1-9	1	Wall Section 2 – Rooms 3/4 and Hallway Room 8
WH-1-10	1	Wall Section 3 – Rooms 5 through 7
WH-1-11	1	Wall Section 4 – Room 11/12
WH-1-12	1	Wall Section 5 – Rooms 9, 10 and 14

Exhibit 3, WHB Basement Layout and Survey Unit Identification



Survey Unit #	Class	Description)
WH-3-1	1	WHB Basement Trench - Soil
WH-3-2	1	WHB Basement Trench – Concrete Edges
WH-3-3	1	WHB Basement Ceiling – Section 1
WH-3-4	1	WHB Basement Ceiling – Section 2
WH-3-5	1	WHB Basement Ceiling – Section 3
WH-3-6	1	WHB Basement Ceiling – Section 4 – Hallway to FH
WH-3-7	1	WHB Basement Stairway & Stairway Block Walls
WH-3-8	1	WHB Basement Upper Walls – West Walls, Tunnel Walls
WH-3-9	1	WHB Basement Upper Walls - North, East, & South Walls
WH-3-10	1	WHB Basement Lower Walls
WH-3-11	1	WHB Basement Floor - Section 1
WH-3-12	1	WHB Basement Floor - Section 2
WH-3-13	1	WHB Basement Floor Section 3 & Sumps

Exhibit 4, WHB Operating Floor (First Floor)

View from Operating Floor Looking Northeast with Mezzanine in Background

View from Operating Floor Looking Northwest with Mezzanine in Background

Exhibit 5, Views of WHB Mezzanine

Survey Unit WH-2-1 Looking East to West

Survey Unit WH-2-2 Looking West to East

Exhibit 6, Basement Floor Areas

View from Main Work Area Looking East, Showing Floor Drain Excavations

Central Work Area Looking South, Showing Floor Drain Excavations

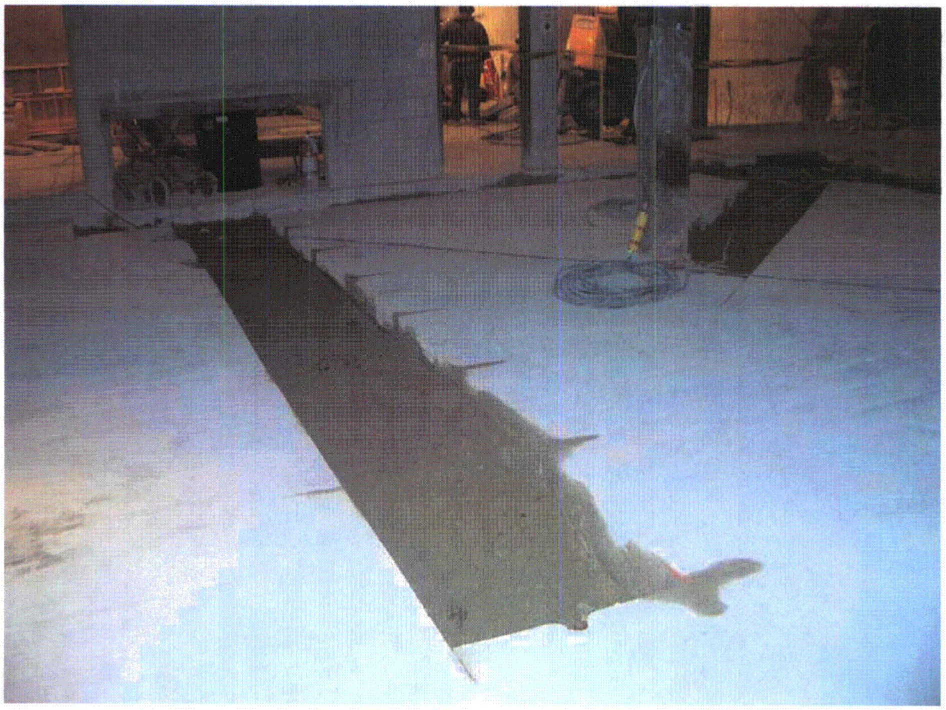
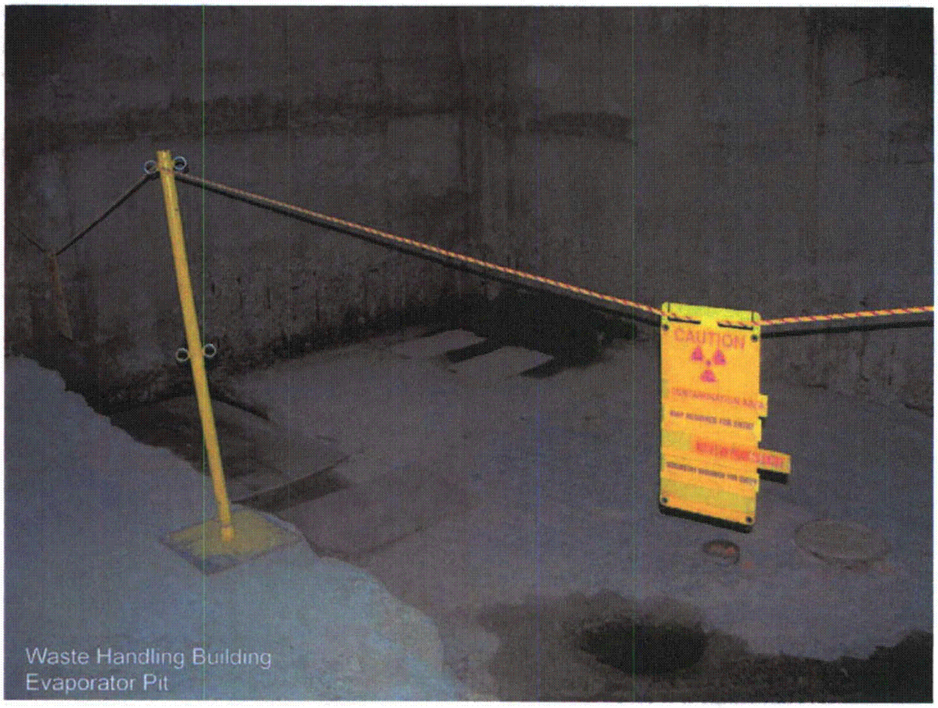


Exhibit 7, WHB Evaporator Pit and Excavated Area

Evaporator Pit



Basement Area Adjacent to Evaporator Pit Where Concrete and Soil Were Removed

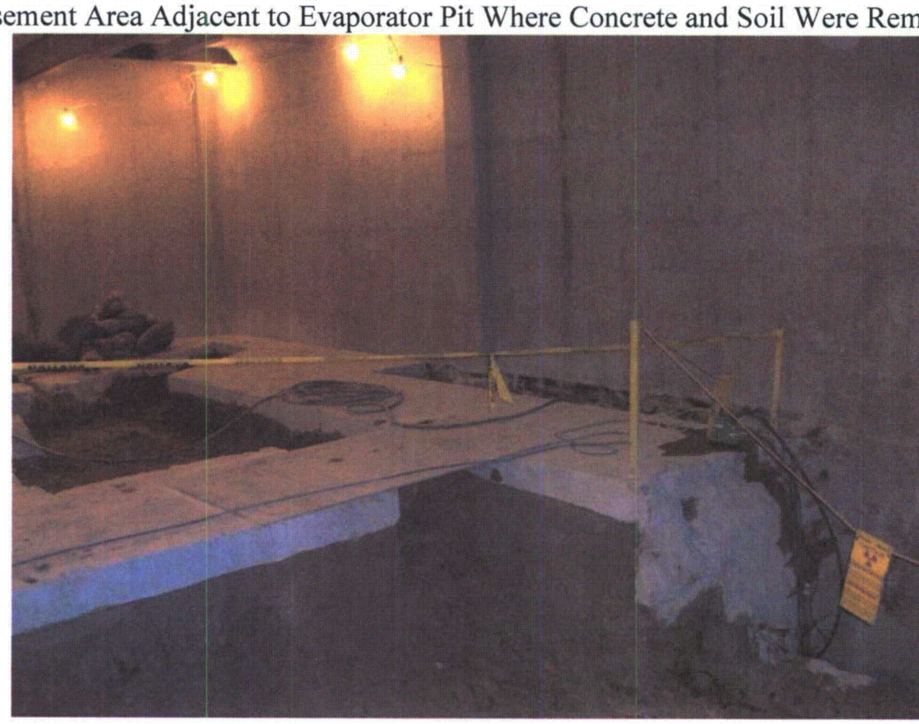


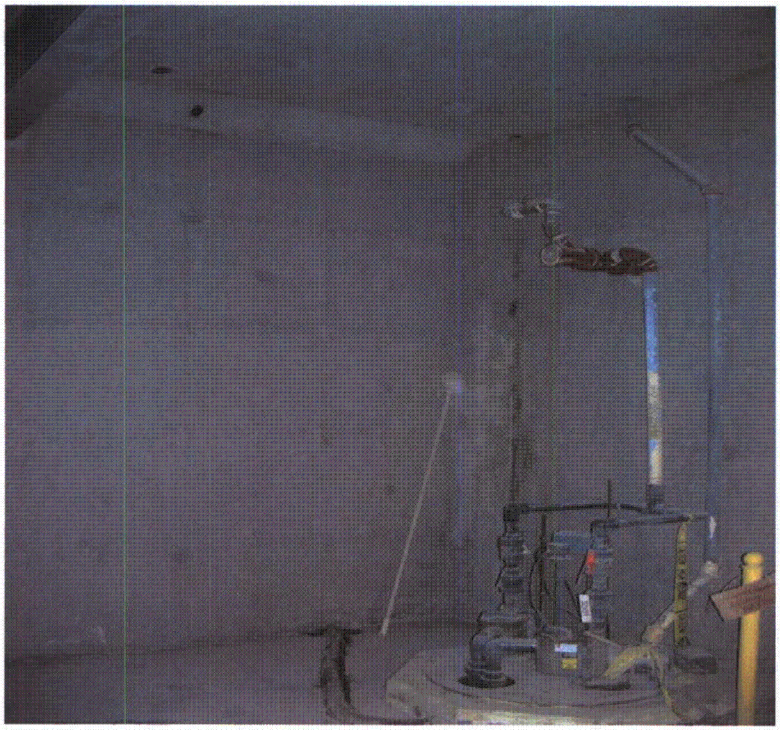
Exhibit 8, Basement Passage to Fan House

View of Floor and Walls Looking North

View of Ceiling Looking North

Exhibit 9, Basement Walls and Ceiling

Basement NE Sump Area Showing Walls, Ceiling and Cold Sump



Ceiling Center Section, View from East Looking West, Survey Unit WH-3-4

Exhibit 10, WHB Demolition

Demolition of Above Grade Structure

WHB Basement after Removal of Structure

Exhibit 11, WHB Basement Survey Units
Survey Unit WH-3-10 North and East Lower Walls

Survey Unit WH-3-11 NW Floor Area

Exhibit 12, WHB Basement Survey Units, Continued

Survey Unit WH-3-12 NE Floor Area Looking from West to East

Survey Unit WH-3-13 SW Floor Area Showing Sanitary and Hot Sumps

Exhibit 13, WHB Unusual Condition Measurement Areas

Crevasse in Concrete Trench in WHB Floor, Survey Unit WH-1-2

Voids in Concrete Block Wall from Aggressive Decontamination, Survey Unit WH-1-12

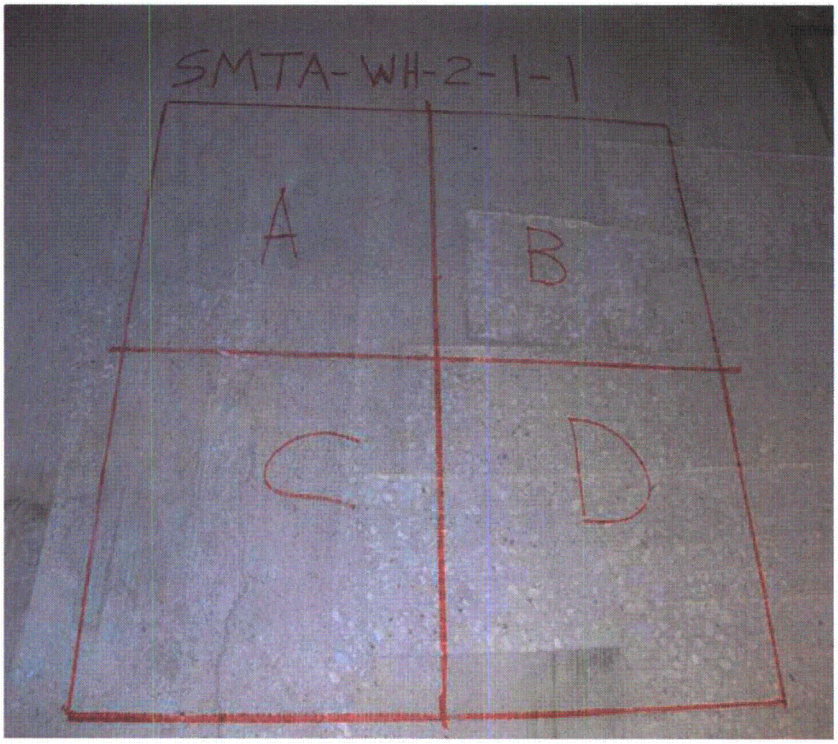
Exhibit 14, WHB Unusual Condition Measurement Areas, Continued

Inaccessible Areas at Base of Column, Survey Unit WH-2-2

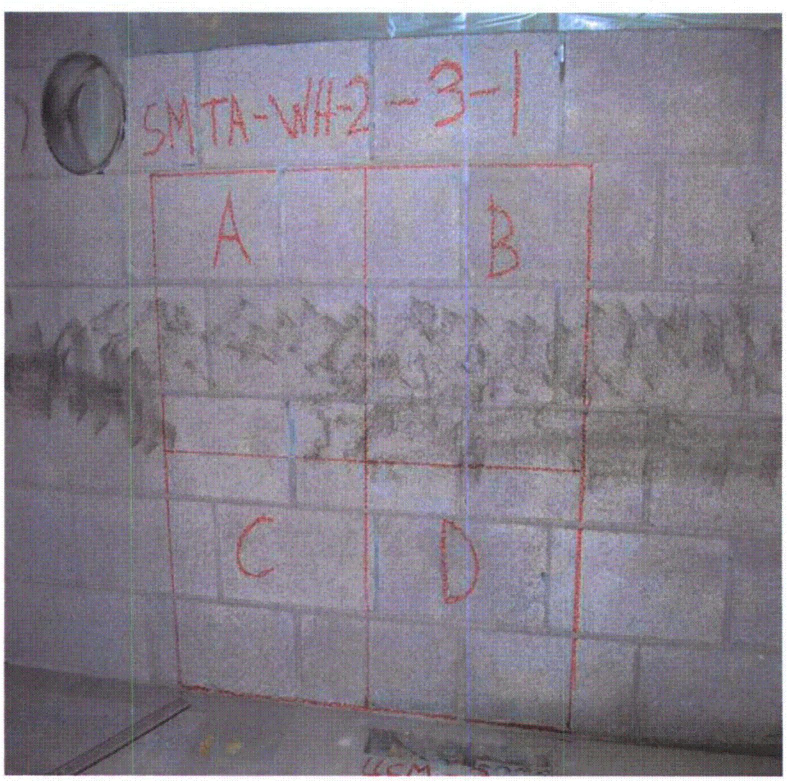
Penetrations in Floor with Perforated Metal Base, Survey Unit WH-2-1

Exhibit 15, WHB Surface Measurement Test Areas

Shaved Concrete Area on Mezzanine Floor, Survey Unit WH-2-1



Aggressive Decontamination of Mezzanine Concrete Block Wall, Survey Unity WH-2-3



Plum Brook Reactor Facility

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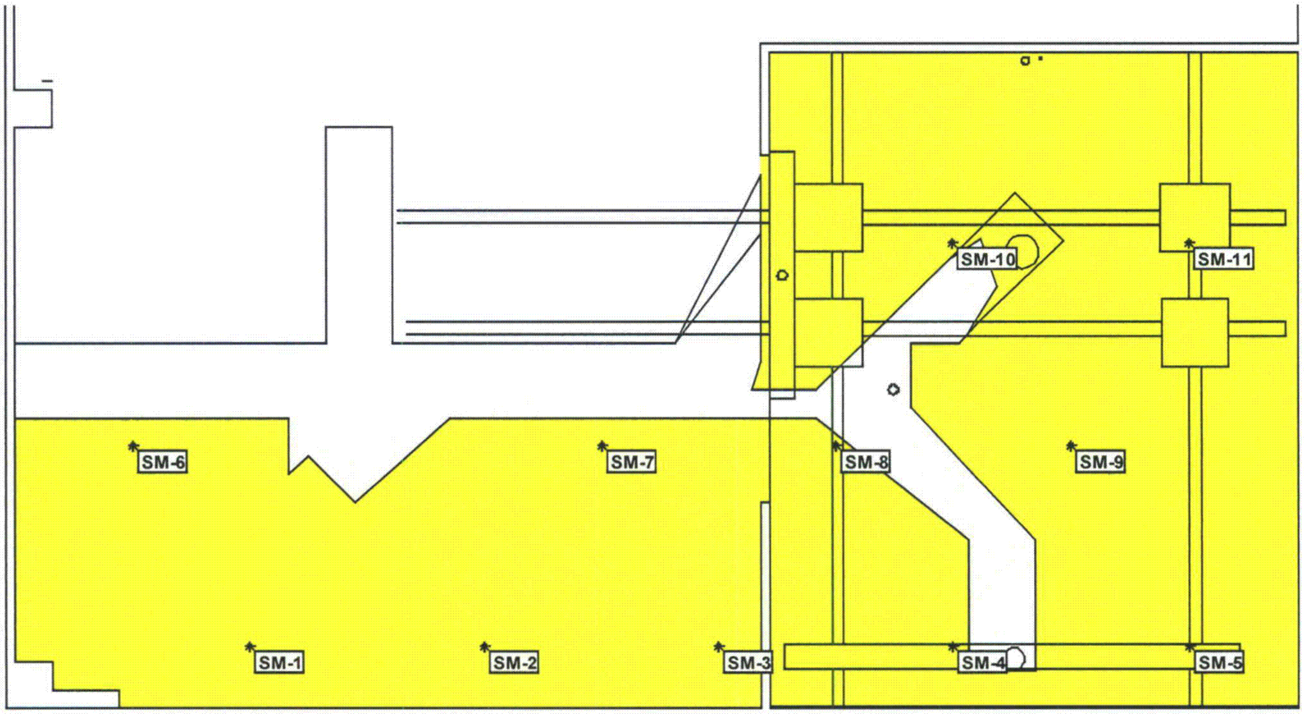
Appendix B

Survey Unit Maps and Tables Showing Measurement Locations and Results

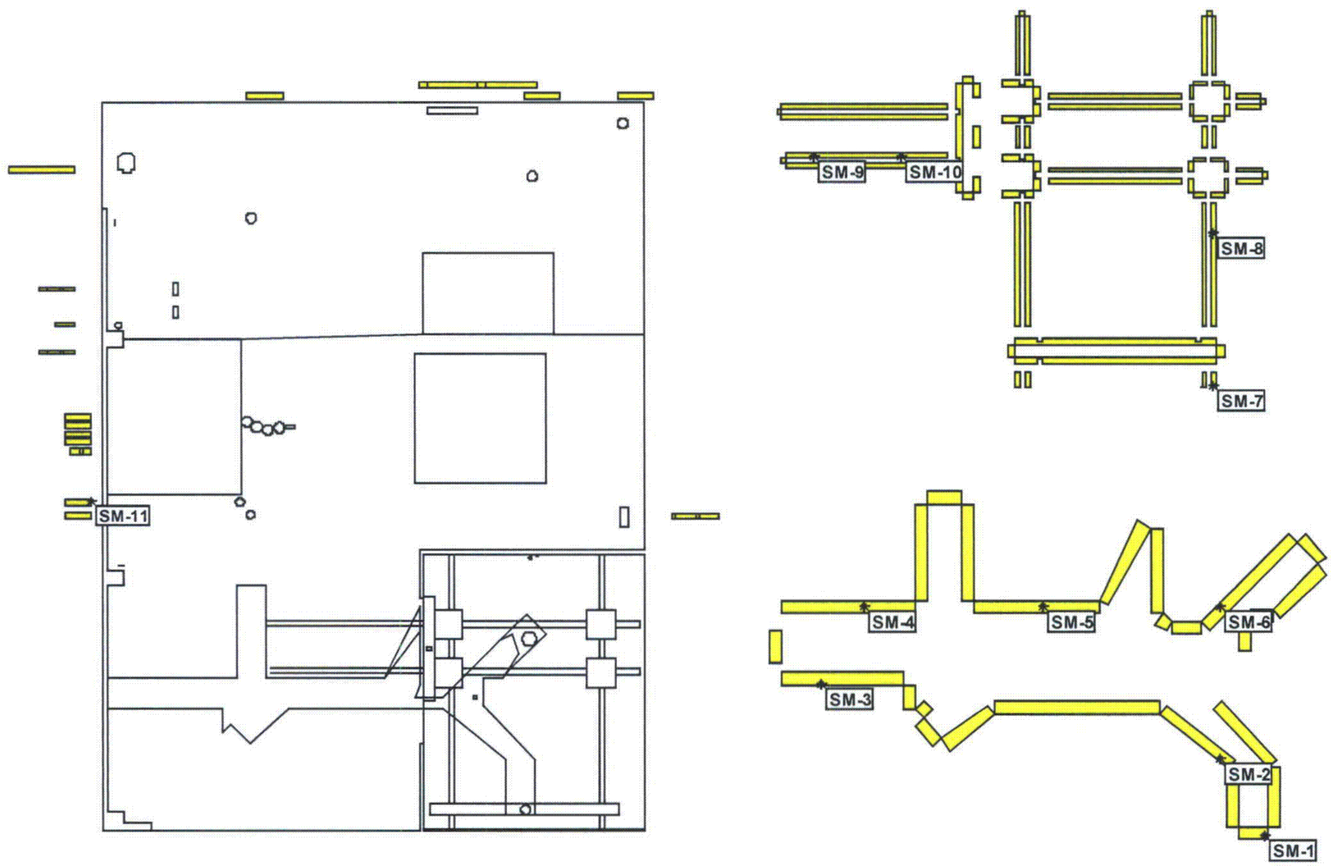
Index of WHB Survey Unit Maps and Tables of Coordinates

Survey Unit WH-1-1
WHB - 1st Floor - Floor Section 1



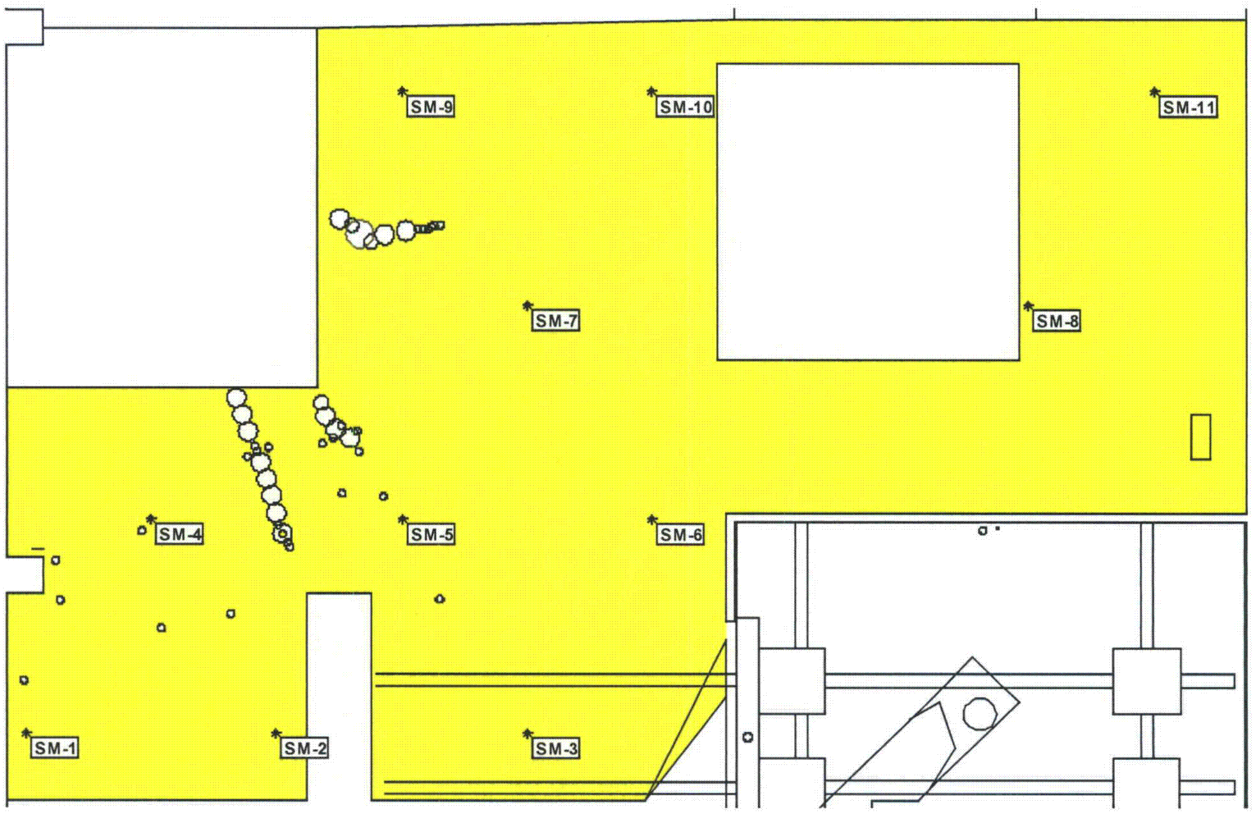
WH-1-1 AREA: Waste Handling Building Floor, Section 1 Measurement Locations and results					
X Co-ord (m)	Y Co-ord (m)	Location / dpm/100cm^2		Type	Notes
1.4	0.7	SM-1	822	Systematic	N/A
3.9	0.7	SM-2	692	Systematic	N/A
6.4	0.7	SM-3	541	Systematic	N/A
8.8	0.7	SM-4	630	Systematic	N/A
11.3	0.7	SM-5	767	Systematic	N/A
0.1	2.8	SM-6	719	Systematic	N/A
5.1	2.8	SM-7	479	Systematic	N/A
7.6	2.8	SM-8	534	Systematic	N/A
10.1	2.8	SM-9	418	Systematic	N/A
8.8	5.0	SM-10	541	Systematic	N/A
11.3	5.0	SM-11	781	Systematic	N/A
All of the sample coordinates are measured from the southwest corner of the survey unit.					

Survey Unit WH-1-2
WHB - 1st Floor - Floor Section 2



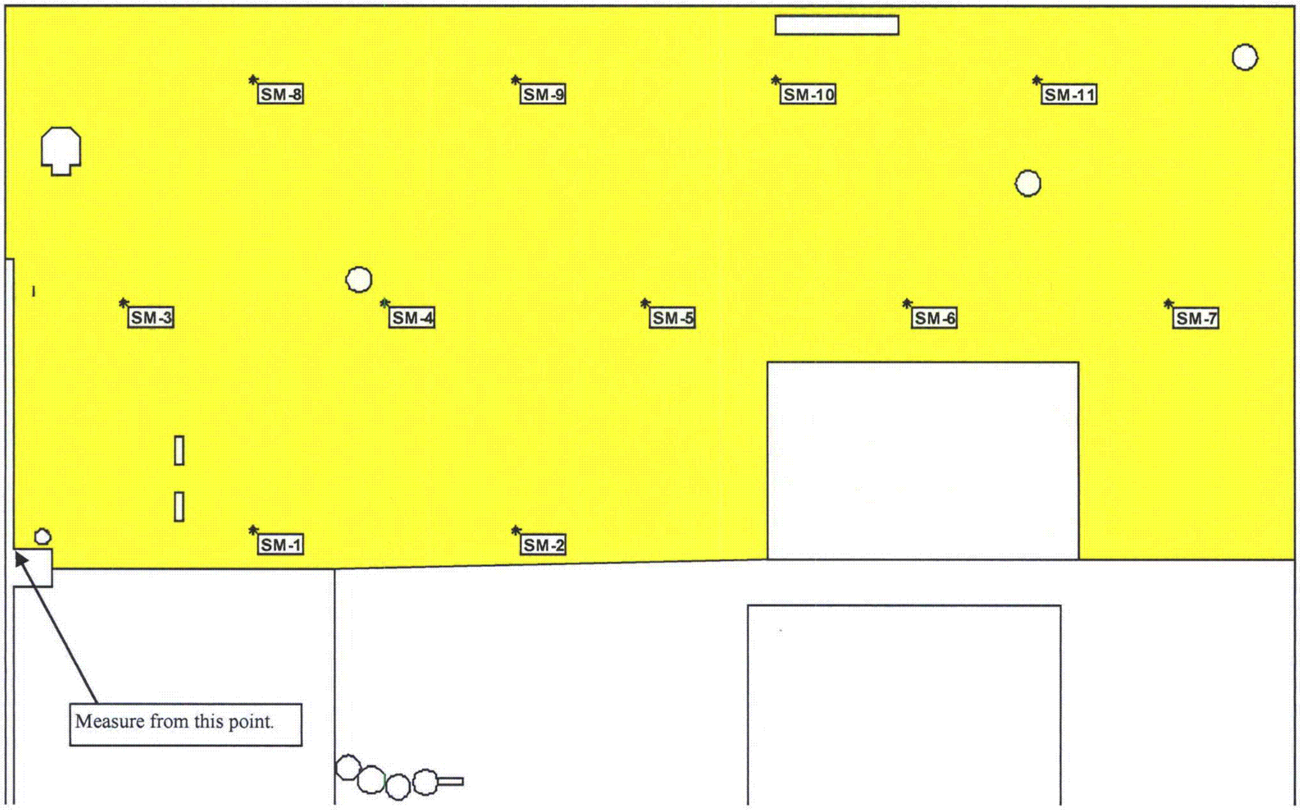
WH-1-2 AREA: Waste Handling Building Trenches and Penetration Edges Measurement Locations and results					
X Co-ord (m)	Y Co-ord (m)	Location / dpm/100cm^2		Type	Notes
0.1	0.2	SM-1	718	Systematic	N/A
0.2	0.2	SM-2	470	Systematic	N/A
2.0	0.2	SM-3	718	Systematic	N/A
2.0	0.2	SM-4	556	Systematic	N/A
1.6	0.2	SM-5	214	Systematic	N/A
0.6	0.2	SM-6	530	Systematic	N/A
0.3	0.05	SM-7	444	Systematic	N/A
0.7	0.05	SM-8	504	Systematic	N/A
0.7	0.05	SM-9	368	Systematic	N/A
2.8	0.05	SM-10	496	Systematic	N/A
0.6	0.1	SM-11	897	Systematic	N/A
All of the sample coordinates are measured from the lower left corner of the surface on which they rest.					

Survey Unit WH-1-3
WHB - 1st Floor - Floor Section 3



WH-1-3 AREA: Waste Handling Building 0' - Floor Section 2 Measurement Locations and results					
X Co-ord (m)	Y Co-ord (m)	Location / dpm/100cm^2		Type	Notes
0.2	0.8	SM-1	993	Systematic	N/A
3.0	0.8	SM-2	637	Systematic	N/A
5.7	0.8	SM-3	548	Systematic	N/A
1.6	3.2	SM-4	568	Systematic	N/A
4.3	3.2	SM-5	952	Systematic	N/A
7.1	3.2	SM-6	555	Systematic	N/A
5.7	5.6	SM-7	774	Systematic	N/A
11.2	5.6	SM-8	534	Systematic	N/A
4.3	8.0	SM-9	808	Systematic	N/A
7.1	8.0	SM-10	767	Systematic	N/A
12.6	8.0	SM-11	719	Systematic	N/A
All of the sample coordinates are measured from the southwest corner of the survey unit.					

Survey Unit WH-1-4
WHB - 1st Floor - Floor Section 4

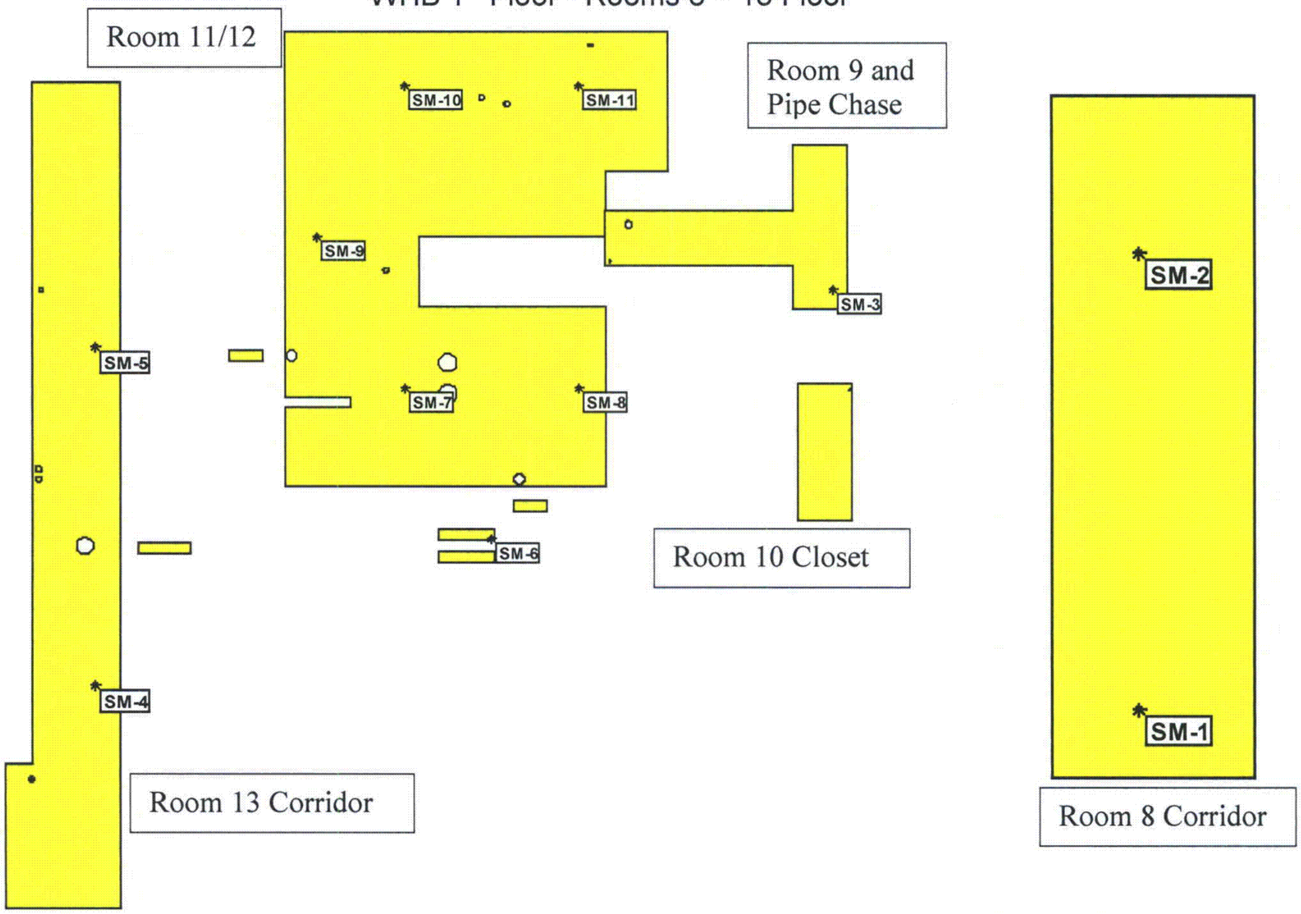


WH-1-4 AREA: Waste Handling Building 0' - Floor Section 3 Measurement Locations and results					
X Co-ord (m)	Y Co-ord (m)	Location / dpm/100cm^2		Type	Notes
2.5	0.2	SM-1	1120	Systematic	N/A
5.3	0.2	SM-2	479	Systematic	N/A
1.2	2.6	SM-3	260	Systematic	N/A
3.9	2.6	SM-4	473	Systematic	N/A
6.7	2.6	SM-5	692	Systematic	N/A
9.5	2.6	SM-6	527	Systematic	N/A
12.3	2.6	SM-7	322	Systematic	N/A
2.5	5.0	SM-8	500	Systematic	N/A
5.3	5.0	SM-9	644	Systematic	N/A
8.1	5.0	SM-10	788	Systematic	N/A
10.9	5.0	SM-11	726	Systematic	N/A
All of the sample Coordinates are measured from the location shown on the map.					

Survey Unit WH-1-5
WHB - 1st Floor - Floor Section 5

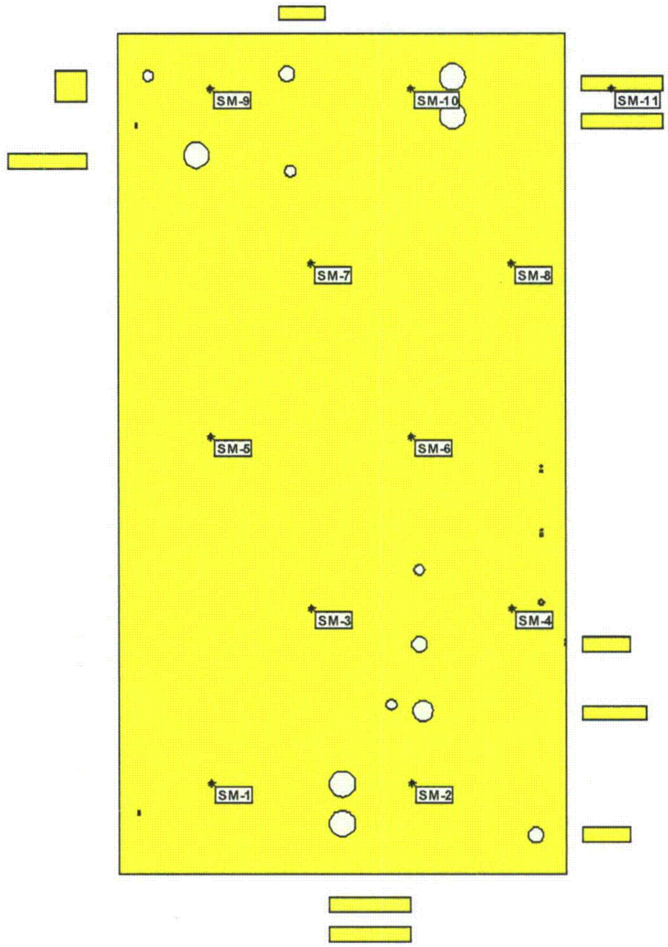
WH-1- 5 AREA: Waste Handling Building 0' - Rooms 3-7 Floor Measurement Locations and results					
X Co-ord (m)	Y Co-ord (m)	Location / dpm/100cm^2		Type	Notes
0.7	1.1	SM-1	935	Systematic	N/A
3.5	1.1	SM-2	431	Systematic	N/A
2.0	0.9	SM-3	691	Systematic	N/A
4.8	0.9	SM-4	520	Systematic	N/A
7.6	0.9	SM-5	715	Systematic	N/A
0.6	3.3	SM-6	504	Systematic	N/A
3.4	3.3	SM-7	618	Systematic	N/A
6.2	3.3	SM-8	390	Systematic	N/A
9.0	3.3	SM-9	553	Systematic	N/A
0.7	1.6	SM-10	943	Systematic	N/A
2.5	1.6	SM-11	667	Systematic	N/A
All of the sample coordinates are measured from the southwest corner of the room.					

Survey Unit WH-1-6
WHB 1st Floor - Rooms 8 – 13 Floor



WH-1- 6 AREA: Waste Handling Building 0' – Rooms 8 – 13 Floor Measurement Locations and results					
X Co-ord (m)	Y Co-ord (m)	Location / dpm/100cm^2		Type	Notes
0.8	0.7	SM-1	781	Systematic	N/A
0.8	4.9	SM-2	651	Systematic	N/A
0.6	0.3	SM-3	705	Systematic	N/A
1.2	2.8	SM-4	500	Systematic	N/A
1.2	7.0	SM-5	671	Systematic	N/A
0.7	0.1	SM-6	438	Systematic	N/A
1.7	1.4	SM-7	616	Systematic	N/A
4.1	1.4	SM-8	644	Systematic	N/A
0.4	3.5	SM-9	521	Systematic	N/A
1.7	5.6	SM-10	630	Systematic	N/A
4.1	5.6	SM-11	281	Systematic	N/A
All of the sample coordinates are measured from the southwest corner of the room in which they lie except SM-6, which is measured from the lower left corner of the surface on which it rests .					

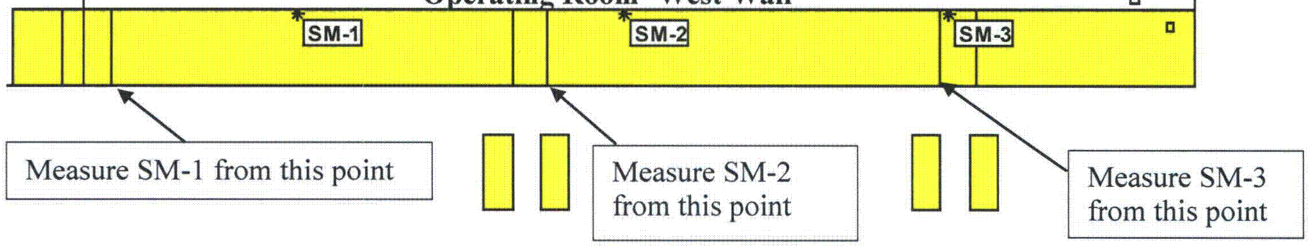
Survey Unit WH-1-7
WHB - Room 14 Floor



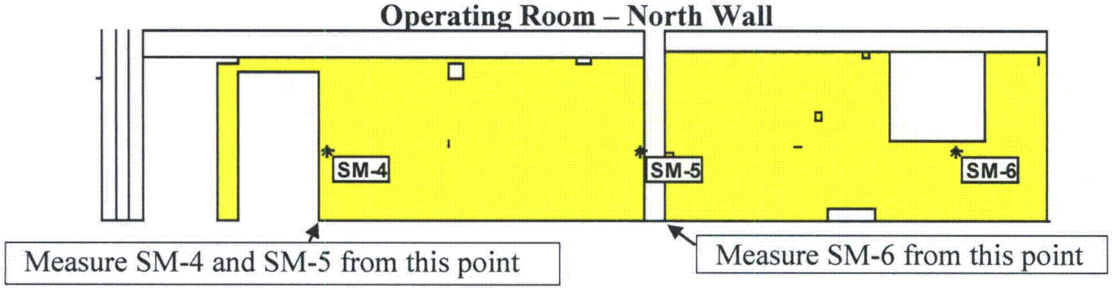
WH-1- 7 AREA: Waste Handling Building 0' – Room 14 Floor Measurement Locations and results					
X Co-ord (m)	Y Co-ord (m)	Location / dpm/100cm^2		Type	Notes
0.9	0.9	SM-1	788	Systematic	N/A
3.0	0.9	SM-2	418	Systematic	N/A
1.9	2.7	SM-3	555	Systematic	N/A
4.0	2.7	SM-4	705	Systematic	N/A
0.9	4.4	SM-5	699	Systematic	N/A
3.0	4.4	SM-6	795	Systematic	N/A
1.9	6.2	SM-7	253	Systematic	N/A
4.0	6.2	SM-8	425	Systematic	N/A
0.9	7.9	SM-9	616	Systematic	N/A
3.0	7.9	SM-10	747	Systematic	N/A
0.3	0.05	SM-11	370	Systematic	N/A
All of the sample coordinates are measured from the southwest corner of the room except SM-11, which is measured from the lower left corner of the surface on which it rests.					

Survey Unit WH-1-8
WHB - 1st Floor, Wall Section 1, Operating Room and Corridor Room 13

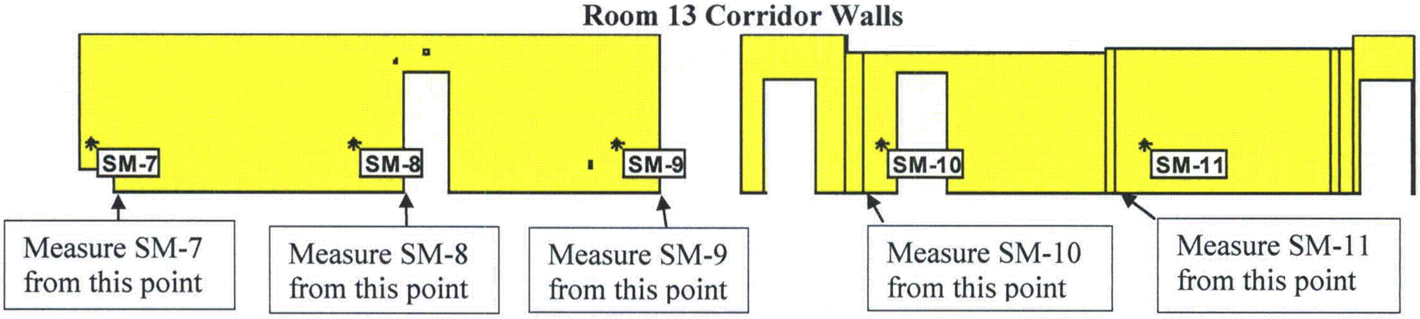
Operating Room- West Wall



Operating Room – North Wall



Room 13 Corridor Walls



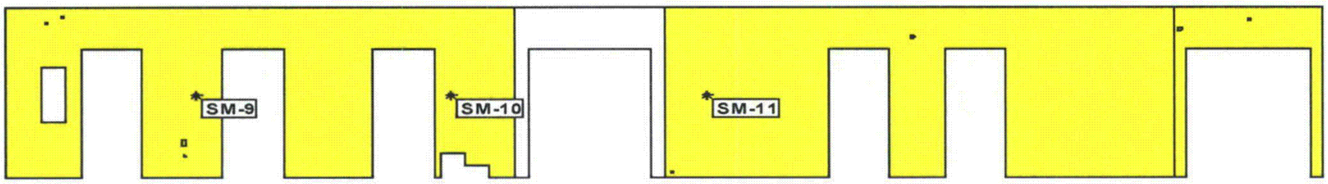
WH-1- 8
AREA: WHB 0' – Wall Section 1 - Operating Room and Corridor Room 13
Measurement Locations and results

X Co-ord (m)	Y Co-ord (m)	Location / dpm/100cm^2		Type	Notes
2.6	1.0	SM-1	836	Systematic	N/A
1.1	1.0	SM-2	596	Systematic	N/A
0.1	1.0	SM-3	459	Systematic	N/A
0.1	1.1	SM-4	233	Systematic	N/A
4.7	1.1	SM-5	315	Systematic	N/A
4.3	1.1	SM-6	-82	Systematic	N/A
0.2	0.5	SM-7	247	Systematic	N/A
- 0.9	0.9	SM-8	582	Systematic	N/A
- 0.8	0.9	SM-9	110	Systematic	N/A
0.3	0.9	SM-10	466	Systematic	N/A
0.5	0.9	SM-11	342	Systematic	N/A

All of the sample coordinates are measured from the points shown on the map.

Survey Unit WH-1-9
WHB - 1st Floor, Wall Section 2 - Rooms 3/4 and Hallway Room 8

North Wall Room -8



North Wall - Rooms 3/4

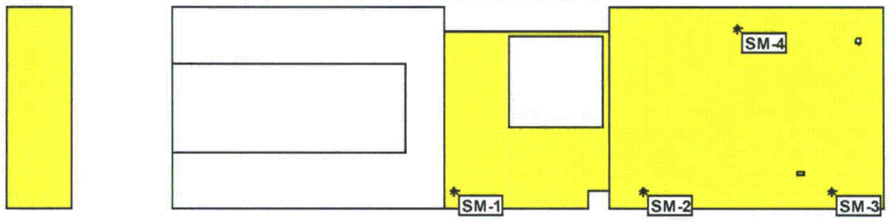
WH-1- 9
AREA: WHB 0' – Wall Section 2 Rooms 3 & 4 and Hallway Room 8
Measurement Locations and results

X Co-ord (m)	Y Co-ord (m)	Location / dpm/100cm^2		Type	Notes
1.6	1.1	SM-1	342	Systematic	N/A
4.8	1.1	SM-2	438	Systematic	N/A
7.9	1.1	SM-3	260	Systematic	N/A
1.5	1.1	SM-4	322	Systematic	N/A
0.8	1.1	SM-5	452	Systematic	N/A
4.0	1.1	SM-6	322	Systematic	N/A
2.9	1.1	SM-7	500	Systematic	N/A
0.8	1.1	SM-8	247	Systematic	N/A
2.3	1.4	SM-9	418	Systematic	N/A
5.5	1.4	SM-10	233	Systematic	N/A
0.5	1.4	SM-11	390	Systematic	N/A

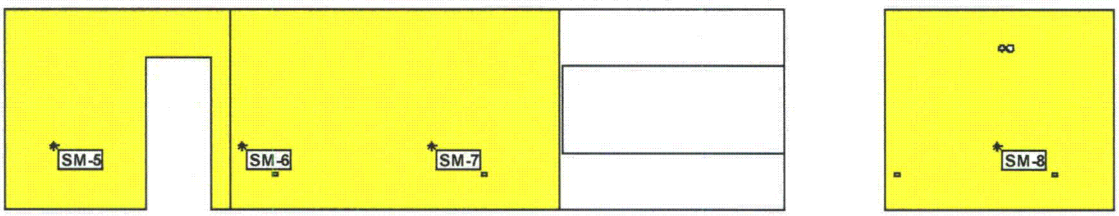
All of the sample coordinates are measured from lower the left corner of the wall surface on which they rest.

Survey Unit WH-1-10
WHB - 1st Floor, Wall Section 3 – Rooms 5 through 7

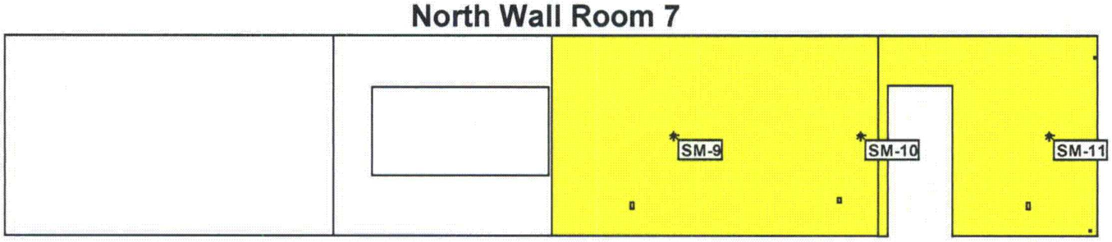
North Wall Room 5



North Wall Room 6



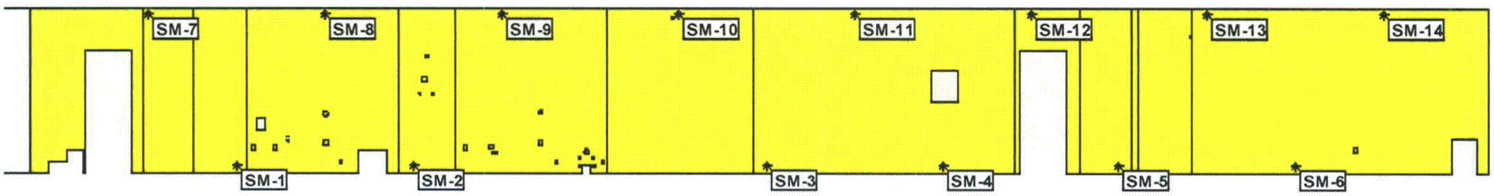
North Wall Room 7



WH-1- 10 AREA: WHB 0' – Wall Section 3 – Rooms 5 through 7 Measurement Locations and results					
X Co-ord (m)	Y Co-ord (m)	Location / dpm/100cm^2		Type	Notes
0.1	0.3	SM-1	333	Systematic	N/A
0.5	0.3	SM-2	301	Systematic	N/A
3.1	0.3	SM-3	512	Systematic	N/A
1.8	2.5	SM-4	358	Systematic	N/A
0.7	0.9	SM-5	398	Systematic	N/A
0.2	0.9	SM-6	220	Systematic	N/A
2.8	0.9	SM-7	154	Systematic	N/A
1.6	0.9	SM-8	138	Systematic	N/A
1.7	1.4	SM-9	528	Systematic	N/A
4.3	1.4	SM-10	244	Systematic	N/A
2.4	1.4	SM-11	154	Systematic	N/A
All of the sample coordinates are measured from the lower left corner of the surface on which they rest.					

Survey Unit WH-1-11
WHB - 1st Floor, Wall Section 4 Rooms 11 and 12

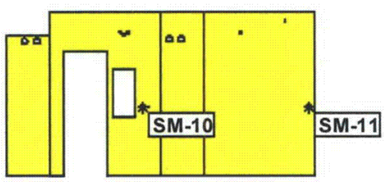
Room 11/12



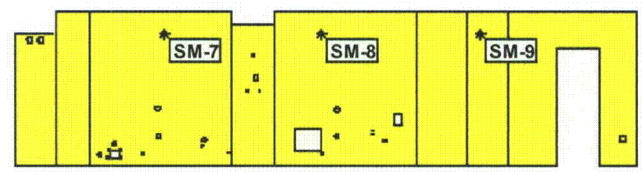
WH-1- 11 AREA: WHB 0' – Wall Section 4 Rooms 11 and 12 Measurement Locations and results					
X Co-ord (m)	Y Co-ord (m)	Location / dpm/100cm^2		Type	Notes
0.7	0.15	SM-1	363	Systematic	N/A
0.3	0.15	SM-2	219	Systematic	N/A
0.2	0.15	SM-3	486	Systematic	N/A
3.2	0.15	SM-4	158	Systematic	N/A
0.7	0.15	SM-5	452	Systematic	N/A
1.8	0.15	SM-6	678	Systematic	N/A
0.1	2.8	SM-7	384	Systematic	N/A
1.3	2.8	SM-8	295	Systematic	N/A
0.8	2.8	SM-9	219	Systematic	N/A
1.2	2.8	SM-10	438	Systematic	N/A
1.7	2.8	SM-11	205	Systematic	N/A
0.3	2.8	SM-12	575	Systematic	N/A
0.3	2.8	SM-13	404	Systematic	N/A
3.3	2.8	SM-14	219	Systematic	N/A
* All of the sample coordinates are measured from the lower left corner of the surface on which they rest.					

Survey Unit WH-1-12
WHB - 1st Floor, Wall Section 5 Rooms 9, 10 and 14

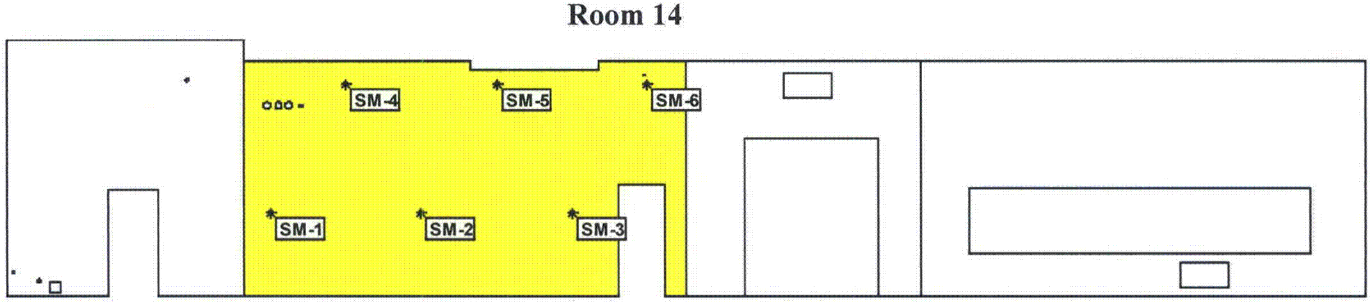
Room 10 Closet



Room 9 and Pipe Chase

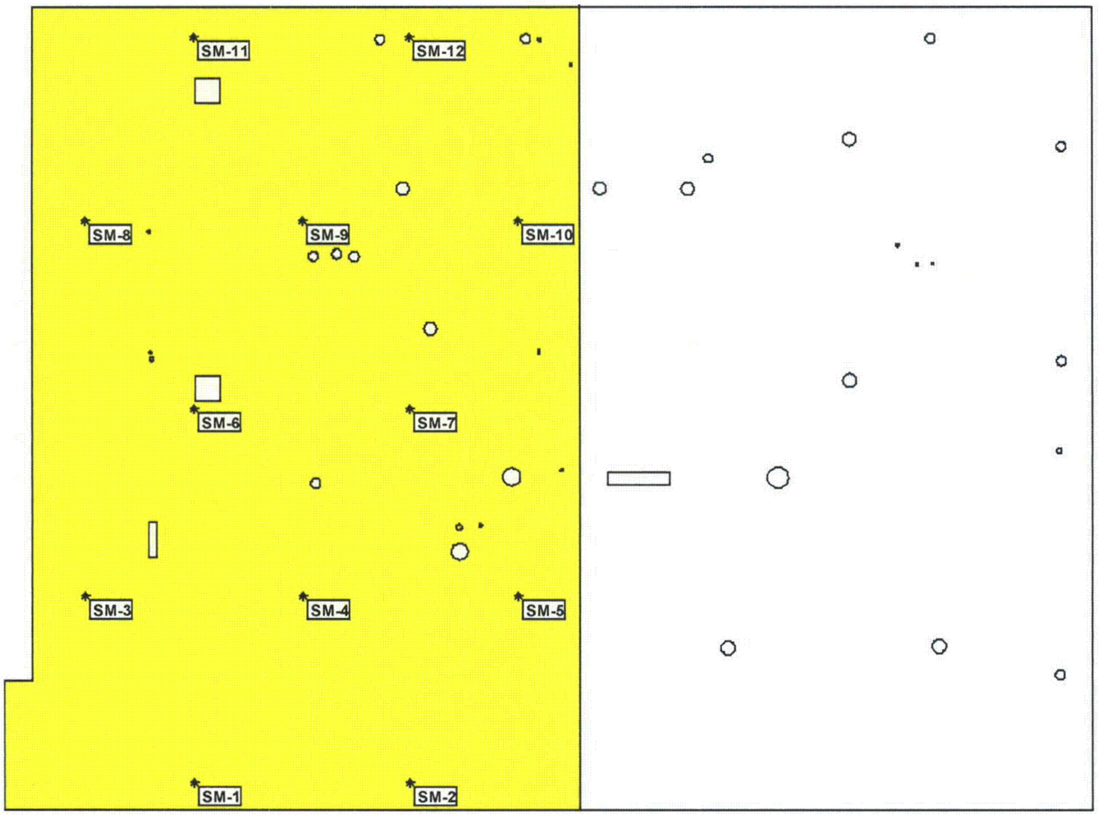


Room 14



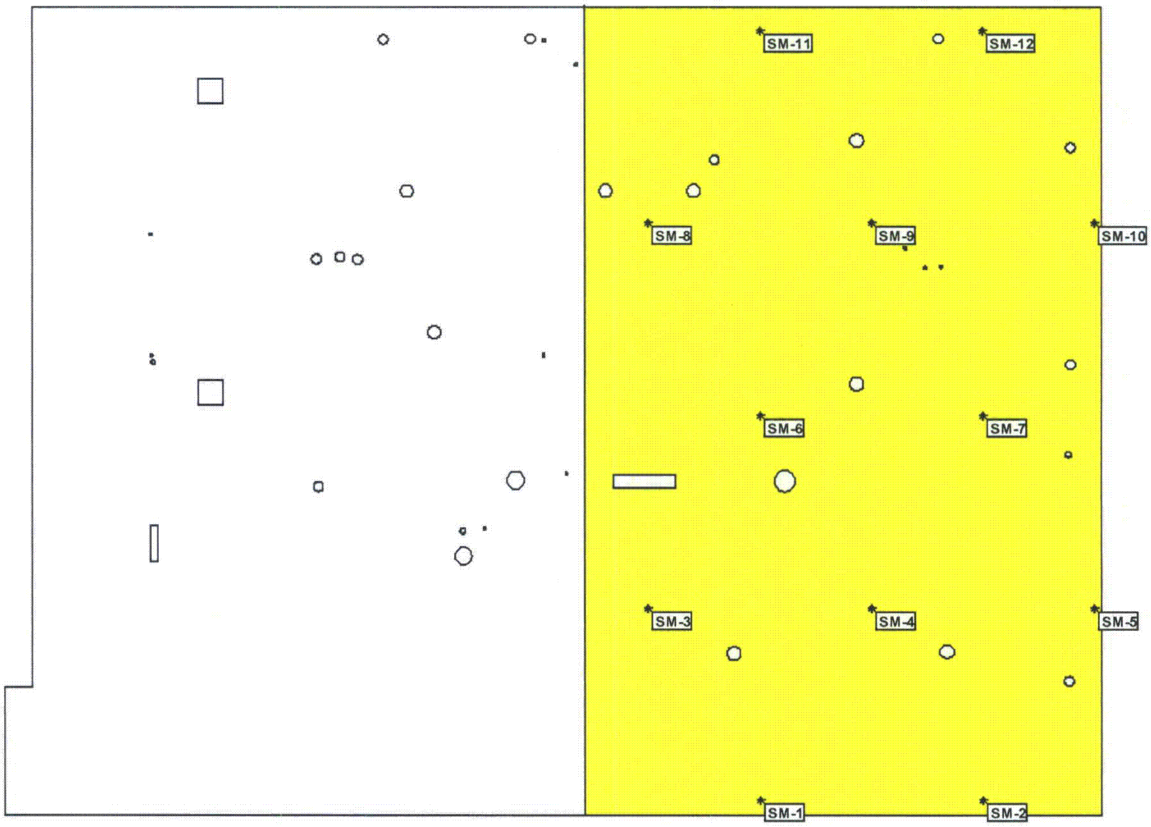
WH-1- 12 AREA: WHB 0' – Wall Section 5 Rooms 9, 10 and 14 Measurement Locations and results					
X Co-ord (m)	Y Co-ord (m)	Location / dpm/100cm^2		Type	Notes
0.5	1.6	SM-1	370	Systematic	N/A
3.4	1.6	SM-2	486	Systematic	N/A
6.3	1.6	SM-3	178	Systematic	N/A
2.0	4.1	SM-4	144	Systematic	N/A
4.9	4.1	SM-5	260	Systematic	N/A
7.7	4.1	SM-6	603	Systematic	N/A
1.4	2.4	SM-7	315	Systematic	N/A
0.9	2.4	SM-8	185	Systematic	N/A
0.2	2.4	SM-9	377	Systematic	N/A
1.6	1.2	SM-10	527	Systematic	N/A
1.8	1.2	SM-11	130	Systematic	N/A
* All of the sample coordinates are measured from the lower left corner of the wall surface on which they rest.					

Survey Unit WH-2-1
WHB - Mezzanine, Floor Section 1



WH-2- 1 AREA: WHB – Mezzanine Floor – Section 1 Measurement Locations and results					
X Co-ord (m)	Y Co-ord (m)	Location / dpm/100cm^2		Type	Notes
2.4	0.3	SM-1	561	Systematic	N/A
5.1	0.3	SM-2	837	Systematic	N/A
1.0	2.7	SM-3	488	Systematic	N/A
3.7	2.7	SM-4	626	Systematic	N/A
6.4	2.7	SM-5	642	Systematic	N/A
2.4	5.0	SM-6	390	Systematic	N/A
5.1	5.0	SM-7	325	Systematic	N/A
1.0	7.4	SM-8	545	Systematic	N/A
3.7	7.4	SM-9	943	Systematic	N/A
6.4	7.4	SM-10	829	Systematic	N/A
2.4	9.8	SM-11	236	Systematic	N/A
5.1	9.8	SM-12	748	Systematic	N/A
* All of the sample coordinates are measured from the southwest corner of the survey unit.					

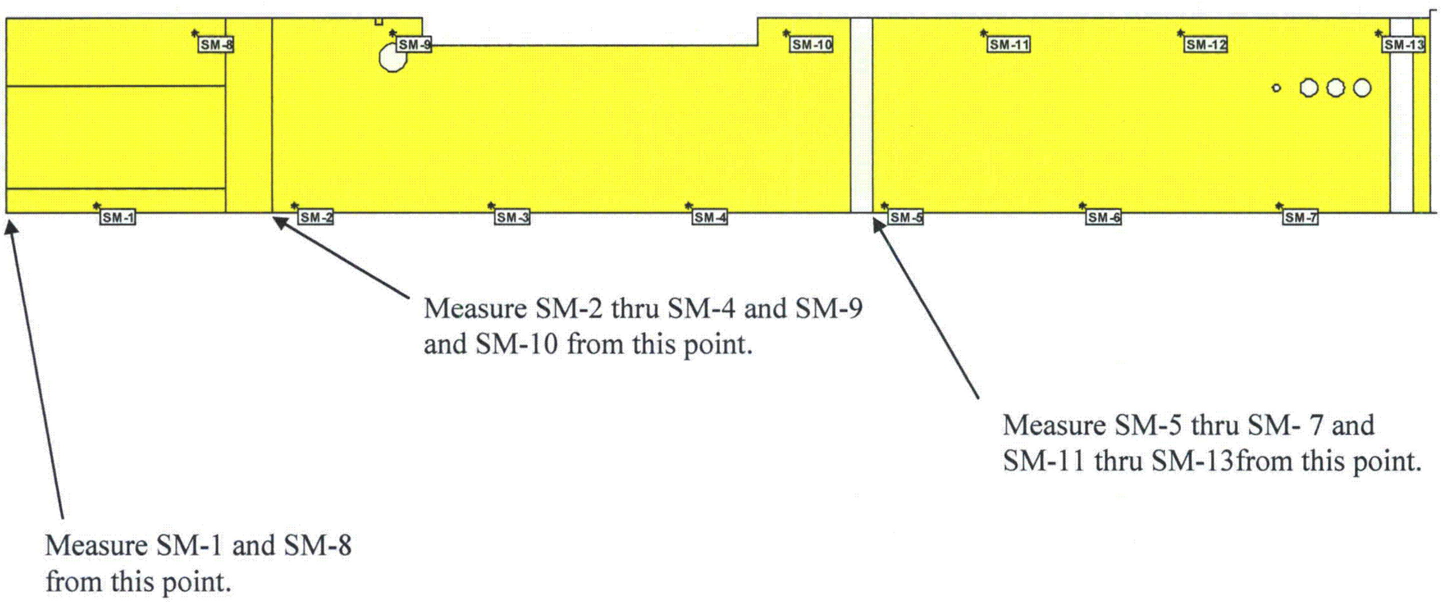
Survey Unit WH-2-2
WHB - Mezzanine, Floor Section 2



WH-2- 2 AREA: WHB – Mezzanine Floor – Section 2 Measurement Locations and results					
X Co-ord (m)	Y Co-ord (m)	Location / dpm/100cm^2		Type	Notes
2.2	0.2	SM-1	863	Systematic	N/A
5.0	0.2	SM-2	445	Systematic	N/A
0.8	2.6	SM-3	836	Systematic	N/A
3.6	2.6	SM-4	651	Systematic	N/A
6.4	2.6	SM-5	555	Systematic	N/A
2.2	5.0	SM-6	62	Systematic	N/A
5.0	5.0	SM-7	384	Systematic	N/A
0.8	7.4	SM-8	479	Systematic	N/A
3.6	7.4	SM-9	671	Systematic	N/A
6.4	7.4	SM-10	596	Systematic	N/A
2.2	9.8	SM-11	685	Systematic	N/A
5.0	9.8	SM-12	664	Systematic	N/A

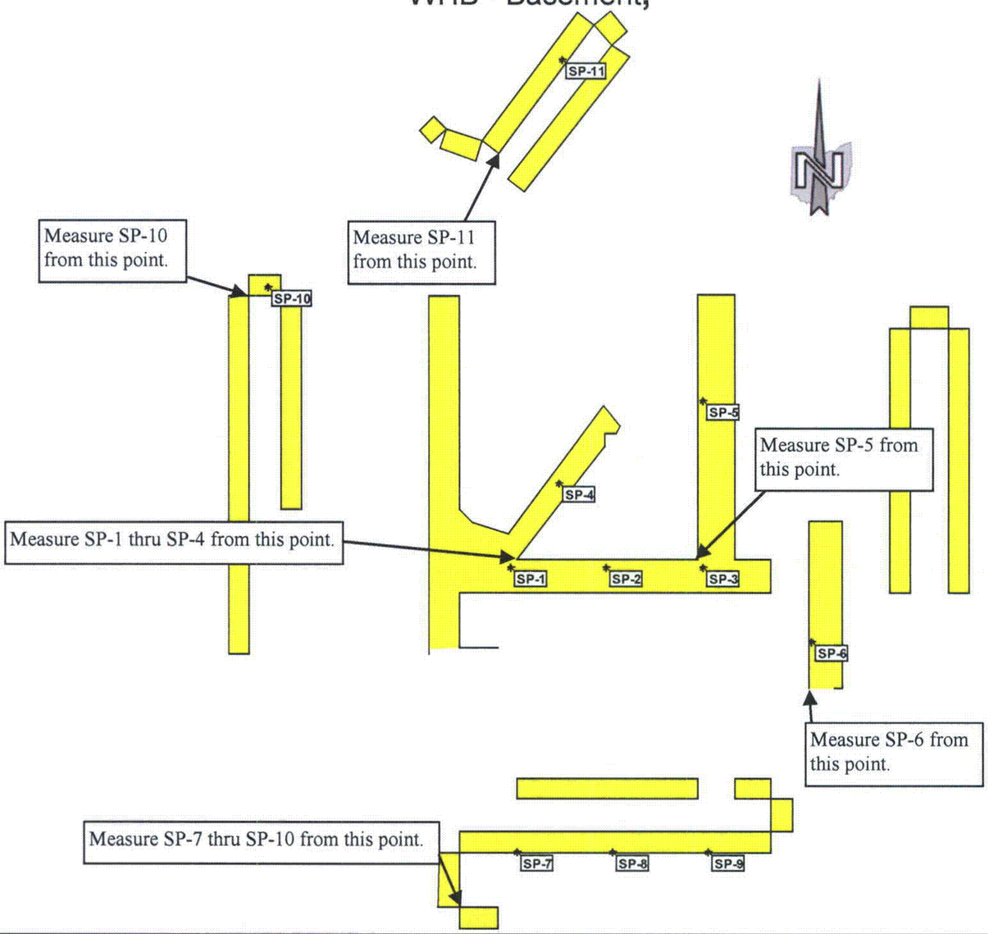
* All of the sample coordinates are measured from the southwest corner of the survey unit.

Survey Unit WH-2-3
WHB - Mezzanine West Wall



WH-2- 3 AREA: WHB 0' – Mezzanine West Wall Measurement Locations and results					
X Co-ord (m)	Y Co-ord (m)	Location / dpm/100cm^2		Type	Notes
0.7	0.1	SM-1	139	Systematic	N/A
0.1	0.1	SM-2	287	Systematic	N/A
1.6	0.1	SM-3	525	Systematic	N/A
3.0	0.1	SM-4	361	Systematic	N/A
0.1	0.1	SM-5	680	Systematic	N/A
1.5	0.1	SM-6	607	Systematic	N/A
3.0	0.1	SM-7	754	Systematic	N/A
1.4	1.3	SM-8	-197	Systematic	N/A
0.8	1.3	SM-9	221	Systematic	N/A
3.7	1.3	SM-10	516	Systematic	N/A
0.8	1.3	SM-11	205	Systematic	N/A
2.3	1.3	SM-12	410	Systematic	N/A
3.7	1.3	SM-13	270	Systematic	N/A
* All of the sample coordinates are measured from the points shown on the map.					

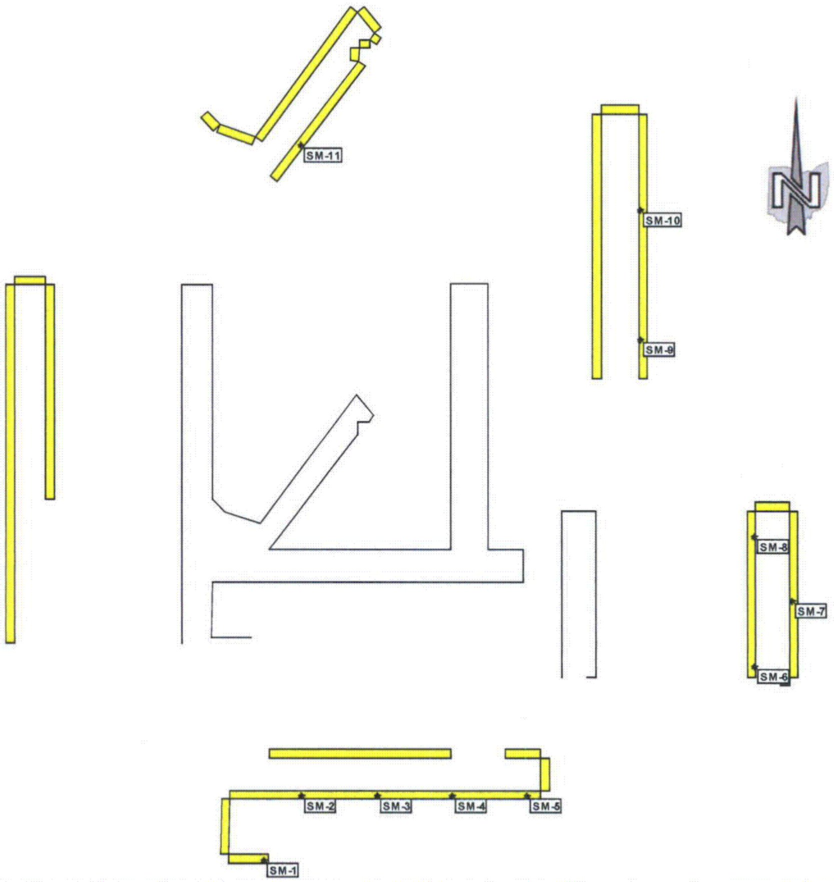
Survey Unit WH-3-1
WHB - Basement,



WH-3-1 AREA: WHB Basement Trench - Soil Measurement Locations and results					
X Co-ord (m)	Y Co-ord (m)	Location / % Unity*		Type	Notes
- 0.15	- 0.15	SM-1	.0714	Systematic	N/A
2.1	- 0.15	SM-2	.0453	Systematic	N/A
4.4	- 0.15	SM-3	.0461	Systematic	N/A
2.02	0.3	SM-4	.0386	Systematic	N/A
0.1	3.8	SM-5	.0419	Systematic	N/A
0.1	1.1	SM-6	.0331	Systematic	N/A
1.3	0.05	SM-7	.0322	Systematic	N/A
3.6	0.05	SM-8	.0313	Systematic	N/A
5.8	0.05	SM-9	.0331	Systematic	N/A
0.45	0.2	SM-10	.0564	Systematic	N/A
2.7	0.15	SM-11	.0342	Systematic	N/A

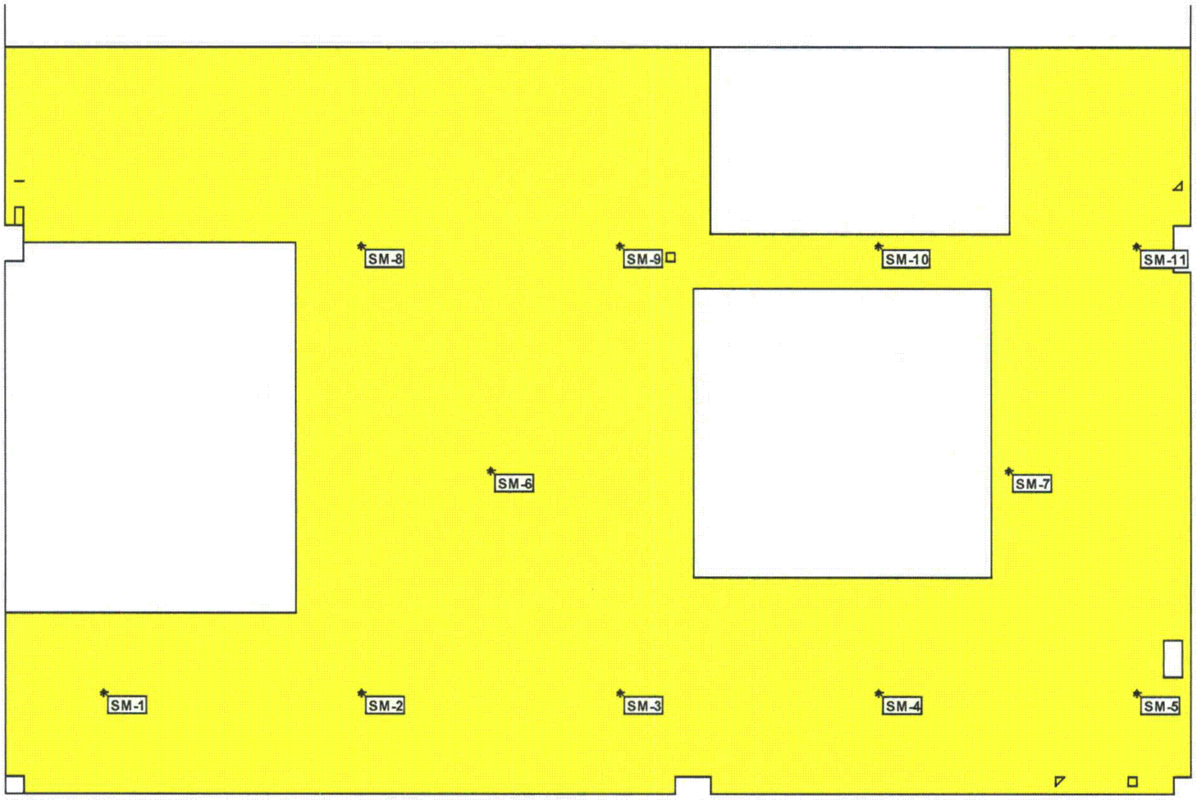
* All of the sample coordinates are measured from the points shown on the map.
This is a soil survey unit – sample results are shown as % unity from unity rule calculation.

Survey Unit WH-3-2
WHB - Basement Trench - Concrete Edges



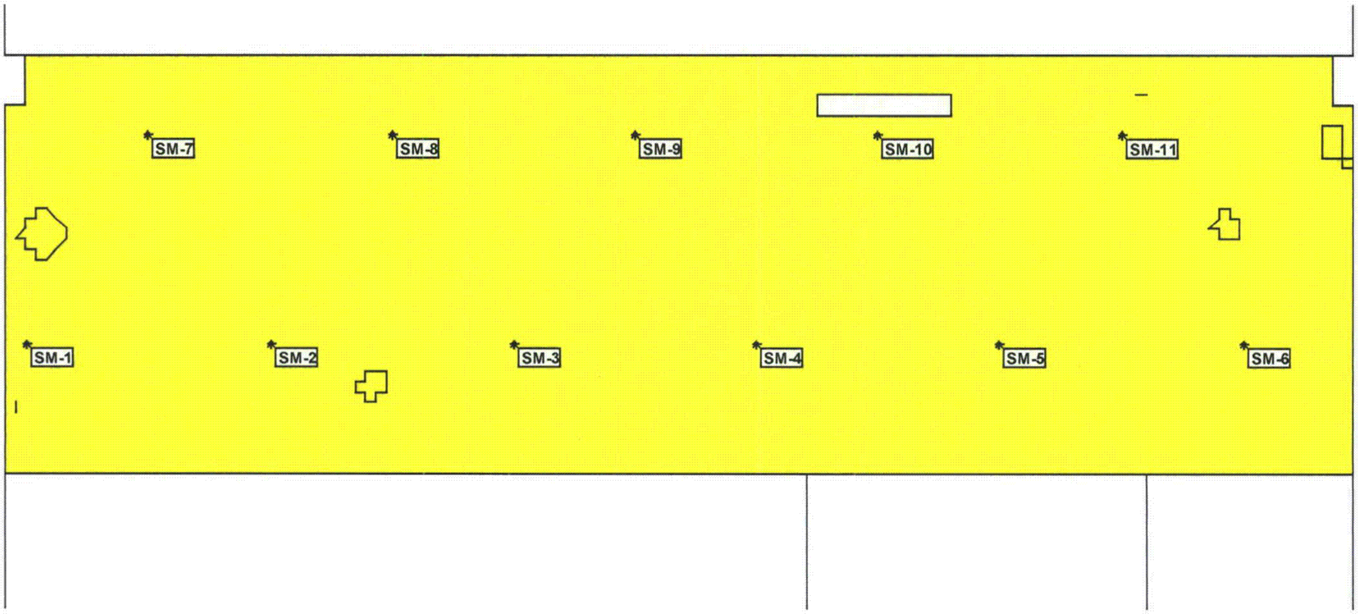
WH-3-2 AREA: WHB Basement Trench – Concrete Edges Measurement Locations and results					
X Co-ord (m)	Y Co-ord (m)	Location / dpm/100cm^2		Type	Notes
0.8	0.15	SM-1	512	Systematic	N/A
1.7	0.08	SM-2	293	Systematic	N/A
3.5	0.08	SM-3	805	Systematic	N/A
5.2	0.08	SM-4	431	Systematic	N/A
7.0	0.08	SM-5	537	Systematic	N/A
0.3	0.05	SM-6	317	Systematic	N/A
2.1	0.05	SM-7	472	Systematic	N/A
3.4	0.05	SM-8	455	Systematic	N/A
5.3	0.05	SM-9	374	Systematic	N/A
2.3	0.05	SM-10	528	Systematic	N/A
2.4	0.1	SM-11	537	Systematic	N/A
* All of the sample coordinates are measured from the lower left corner of the surface on which they rest .					

Survey Unit WH-3-3
WHB - Basement, Ceiling Section 1



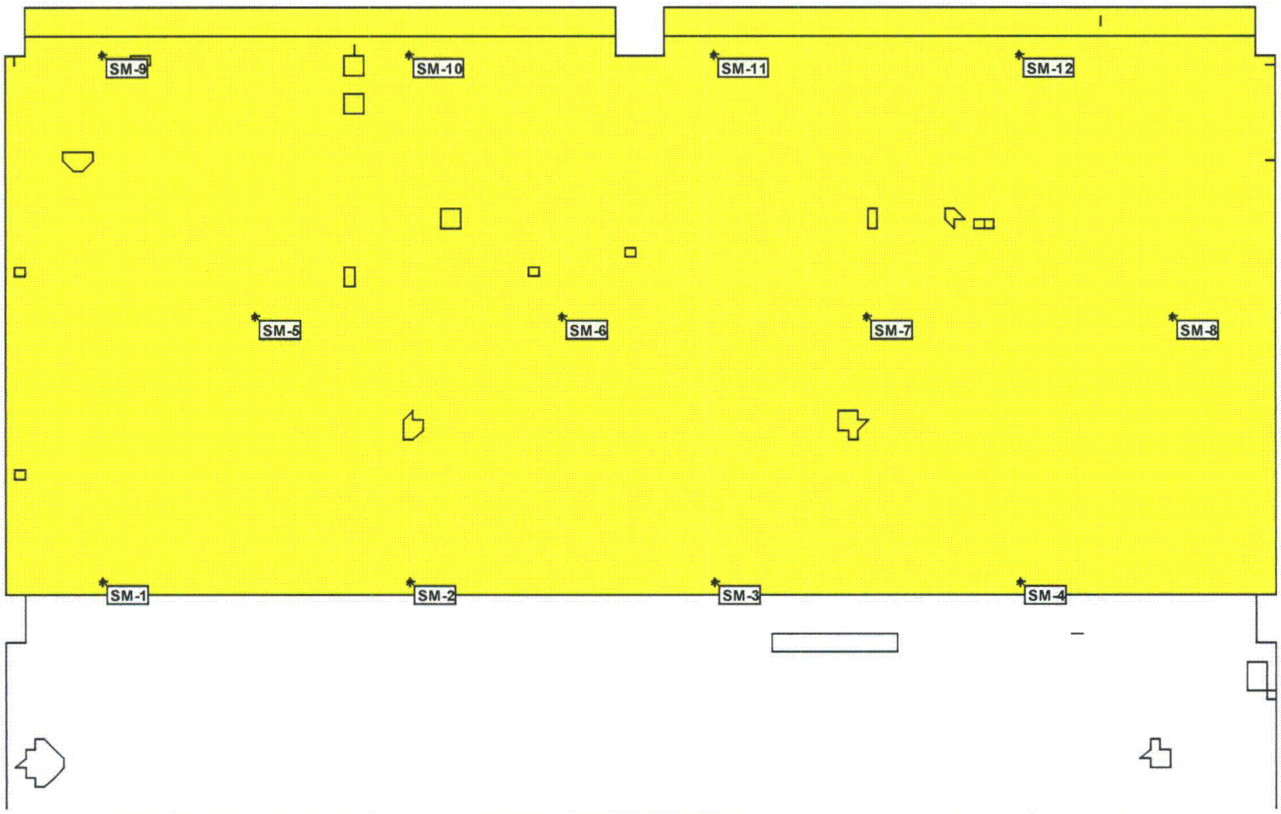
WH-3- 3 AREA: WHB – Basement Ceiling – Section 1 Measurement Locations and results					
X Co-ord (m)	Y Co-ord (m)	Location / dpm/100cm^2		Type	Notes
1.1	1.1	SM-1	500	Systematic	N/A
3.9	1.1	SM-2	795	Systematic	N/A
6.8	1.1	SM-3	685	Systematic	N/A
9.6	1.1	SM-4	760	Systematic	N/A
12.5	1.1	SM-5	411	Systematic	N/A
5.4	3.6	SM-6	699	Systematic	N/A
11.1	3.6	SM-7	774	Systematic	N/A
3.9	6.1	SM-8	740	Systematic	N/A
6.8	6.1	SM-9	747	Systematic	N/A
9.6	6.1	SM-10	610	Systematic	N/A
12.5	6.1	SM-11	788	Systematic	N/A
* All of the sample coordinates are measured from the southwest corner of the survey unit.					

Survey Unit WH-3-4
WHB - Basement, Ceiling Section 2



WH-3- 4 AREA: WHB – Basement Ceiling – Section 2 Measurement Locations and results					
X Co-ord (m)	Y Co-ord (m)	Location / dpm/100cm^2		Type	Notes
0.2	1.3	SM-1	886	Systematic	N/A
2.6	1.3	SM-2	1240	Systematic	N/A
4.9	1.3	SM-3	569	Systematic	N/A
7.3	1.3	SM-4	358	Systematic	N/A
9.7	1.3	SM-5	520	Systematic	N/A
12.0	1.3	SM-6	707	Systematic	N/A
1.4	3.3	SM-7	350	Systematic	N/A
3.8	3.3	SM-8	707	Systematic	N/A
6.1	3.3	SM-9	553	Systematic	N/A
8.5	3.3	SM-10	577	Systematic	N/A
10.9	3.3	SM-11	1180	Systematic	N/A
* All of the sample coordinates are measured from the southwest corner of the survey unit.					

Survey Unit WH-3-5
WHB - Basement, Ceiling Section 3

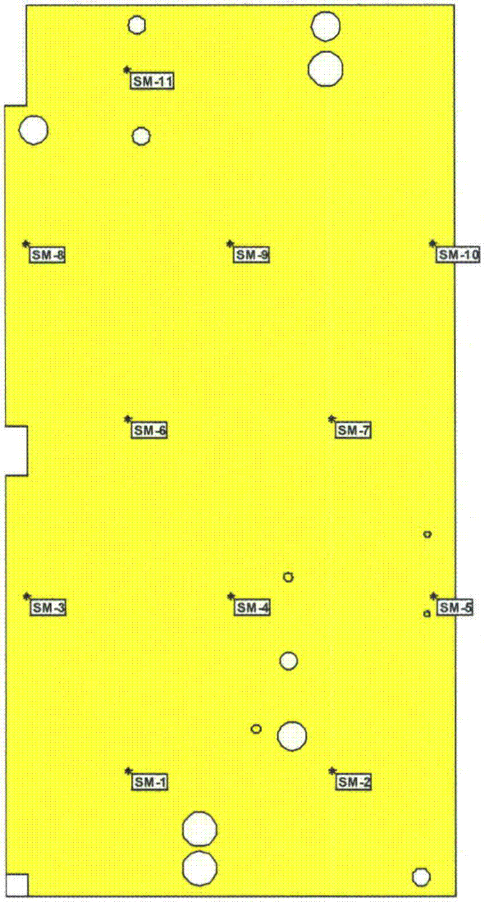


WH-3- 5
AREA: WHB – Basement Ceiling – Section 3
Measurement Locations and results

X Co-ord (m)	Y Co-ord (m)	Location / dpm/100cm^2		Type	Notes
1.0	0.1	SM-1	562	Systematic	N/A
4.2	0.1	SM-2	630	Systematic	N/A
7.3	0.1	SM-3	795	Systematic	N/A
10.5	0.1	SM-4	445	Systematic	N/A
2.6	2.9	SM-5	527	Systematic	N/A
5.7	2.9	SM-6	473	Systematic	N/A
8.9	2.9	SM-7	719	Systematic	N/A
12.0	2.9	SM-8	774	Systematic	N/A
1.0	5.6	SM-9	747	Systematic	N/A
4.2	5.6	SM-10	541	Systematic	N/A
7.3	5.6	SM-11	877	Systematic	N/A
10.5	5.6	SM-12	808	Systematic	N/A

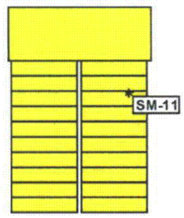
* All of the sample coordinates are measured from the southwest corner of the survey unit.

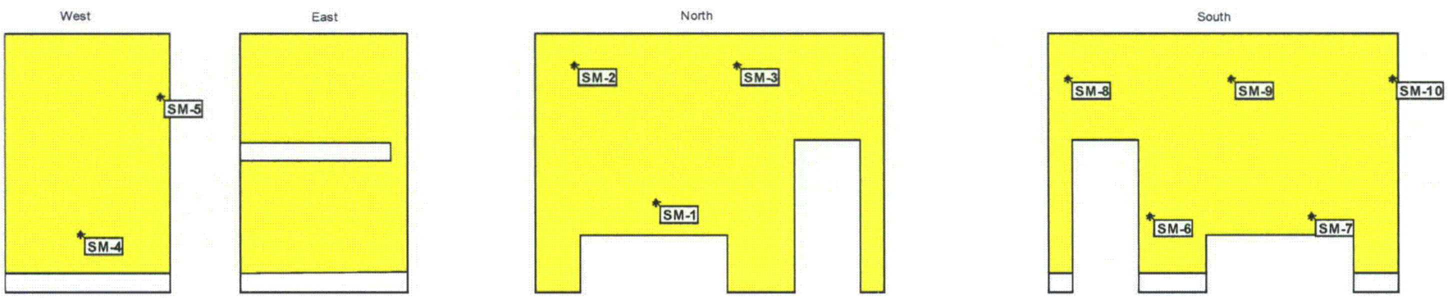
Survey Unit WH-3-6
WHB - Basement, Ceiling Section 4



WH-3- 6 AREA: WHB – Basement Ceiling – Section 4 - Hallway to FH Measurement Locations and results					
X Co-ord (m)	Y Co-ord (m)	Location / dpm/100cm^2		Type	Notes
1.1	1.1	SM-1	678	Systematic	N/A
2.9	1.1	SM-2	692	Systematic	N/A
0.2	2.7	SM-3	781	Systematic	N/A
2.0	2.7	SM-4	890	Systematic	N/A
3.8	2.7	SM-5	568	Systematic	N/A
1.1	4.2	SM-6	459	Systematic	N/A
2.9	4.2	SM-7	747	Systematic	N/A
0.2	5.8	SM-8	575	Systematic	N/A
2.0	5.8	SM-9	555	Systematic	N/A
3.8	5.8	SM-10	390	Systematic	N/A
1.1	7.4	SM-11	500	Systematic	N/A
* All of the sample coordinates are measured from the southwest corner of the survey unit.					

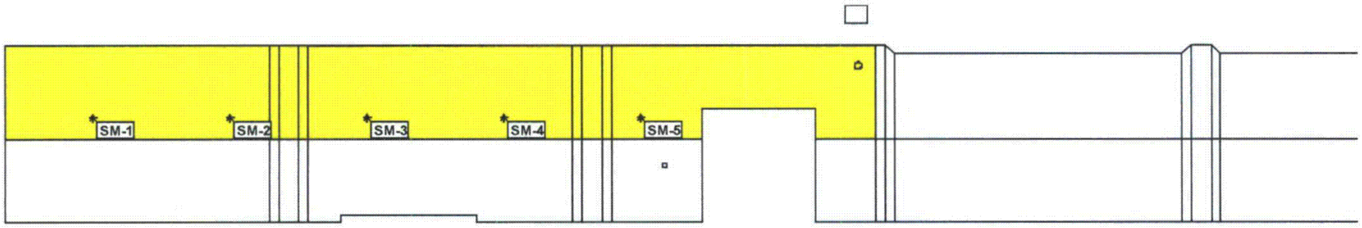
Survey Unit WH-3-7
WHB - Basement, Stairway Walls

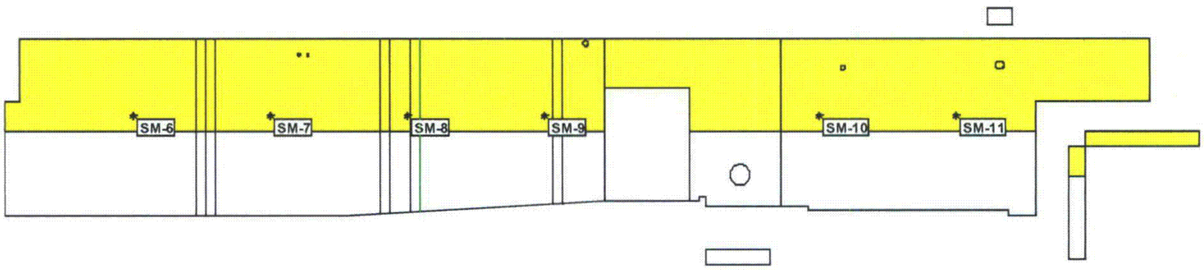




WH-3- 7 AREA: WHB – Stairway Walls Measurement Locations and results					
X Co-ord (m)	Y Co-ord (m)	Location / dpm/100cm^2		Type	Notes
1.7	1.3	SM-1	171	Systematic	N/A
0.5	3.2	SM-2	675	Systematic	N/A
2.7	3.2	SM-3	650	Systematic	N/A
1.0	0.6	SM-4	244	Systematic	N/A
2.1	2.5	SM-5	537	Systematic	N/A
1.4	0.8	SM-6	268	Systematic	N/A
3.6	0.8	SM-7	659	Systematic	N/A
0.3	2.7	SM-8	81	Systematic	N/A
2.5	2.7	SM-9	293	Systematic	N/A
4.7	2.7	SM-10	545	Systematic	N/A
0.6	0.2	SM-11	813	Systematic	N/A
* All of the sample coordinates are measured from the lower left corner of the surface on which they lie.					

Survey Unit WH-3-8
WHB - Basement, Upper Walls



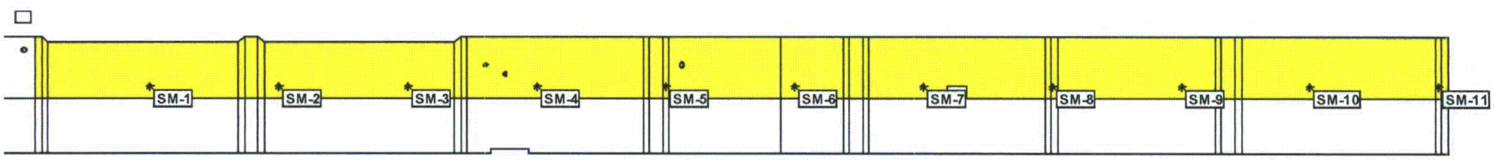


WH-3-8
AREA: Waste Handling Building Basement – Upper Walls
Measurement Locations and results

X Co-ord (m)	Y Co-ord (m)	Location / dpm/100cm^2		Type	Notes
1.9	2.3	SM-1	508	Systematic	N/A
4.8	2.3	SM-2	875	Systematic	N/A
7.7	2.3	SM-3	781	Systematic	N/A
10.7	2.3	SM-4	906	Systematic	N/A
13.6	2.3	SM-5	664	Systematic	N/A
2.8	2.2	SM-6	773	Systematic	N/A
1.2	2.2	SM-7	984	Systematic	N/A
0.4	2.1	SM-8	695	Systematic	N/A
2.7	2.1	SM-9	516	Systematic	N/A
0.8	2.0	SM-10	391	Systematic	N/A
3.8	2.0	SM-11	641	Systematic	N/A

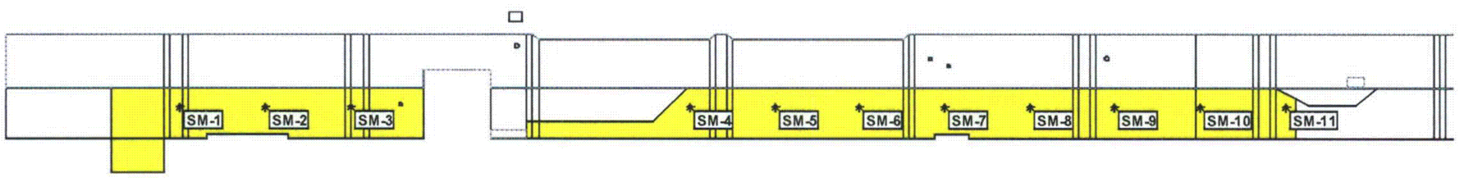
* All of the sample coordinates are measured from the lower left corner of the wall surface on which they lie

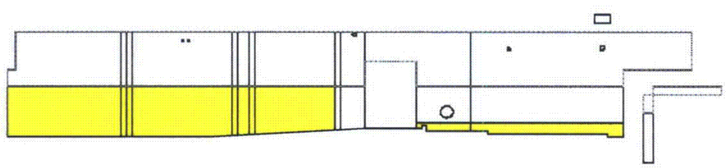
Survey Unit WH-3-9
WHB - Basement, Upper Walls



WH-3-9 AREA: Waste Handling Building Basement – Upper Walls Measurement Locations and results					
X Co-ord (m)	Y Co-ord (m)	Location / dpm/100cm^2		Type	Notes
3.3	2.2	SM-1	625	Systematic	N/A
0.5	2.2	SM-2	766	Systematic	N/A
4.6	2.2	SM-3	1140	Systematic	N/A
2.2	2.2	SM-4	609	Systematic	N/A
0.1	2.2	SM-5	586	Systematic	N/A
4.0	2.2	SM-6	727	Systematic	N/A
1.7	2.2	SM-7	828	Systematic	N/A
0.05	2.2	SM-8	1120	Systematic	N/A
3.9	2.2	SM-9	766	Systematic	N/A
2.2	2.2	SM-10	414	Systematic	N/A
0.1	2.2	SM-11	445	Systematic	N/A
* All of the sample coordinates are measured from the lower left corner of the wall surface on which they lie					

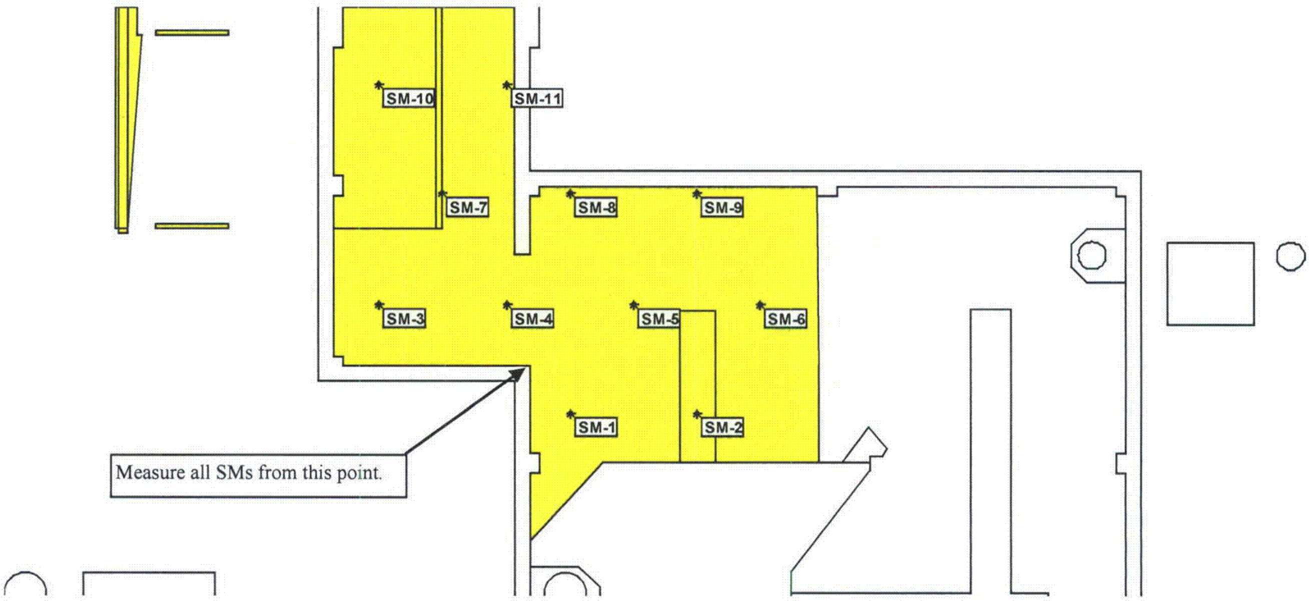
Survey Unit WH-3-10
WHB - Basement, Lower Walls





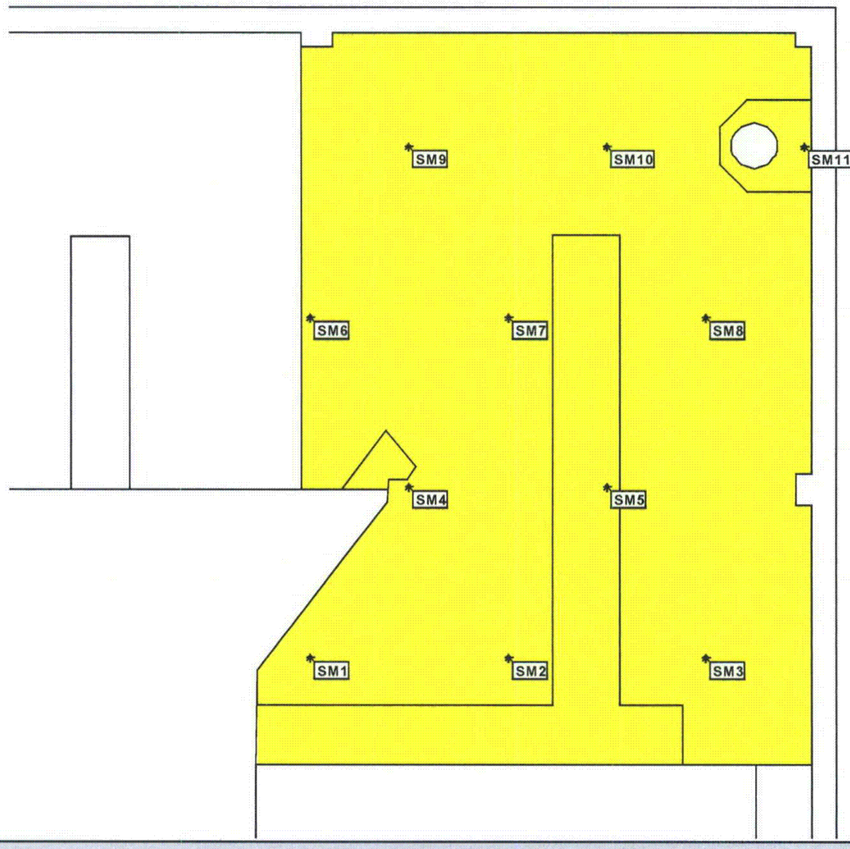
WH-3-10 AREA: Waste Handling Building Basement – Lower Walls Measurement Locations and results					
X Co-ord (m)	Y Co-ord (m)	Location / dpm/100cm^2		Type	Notes
0.3	1.2	SM-1	636	Systematic	N/A
2.8	1.2	SM-2	893	Systematic	N/A
0.15	1.2	SM-3	909	Systematic	N/A
5.4	1.2	SM-4	719	Systematic	N/A
1.5	1.2	SM-5	851	Systematic	N/A
4.6	1.2	SM-6	562	Systematic	N/A
1.1	1.2	SM-7	826	Systematic	N/A
4.1	1.2	SM-8	496	Systematic	N/A
0.7	1.2	SM-9	355	Systematic	N/A
0.2	1.2	SM-10	950	Systematic	N/A
0.3	1.2	SM-11	545	Systematic	N/A
* All of the sample coordinates are measured from the lower left corner of the wall surface on which they rest.					

Survey Unit WH-3-11
WHB - Basement, Floor Section 1



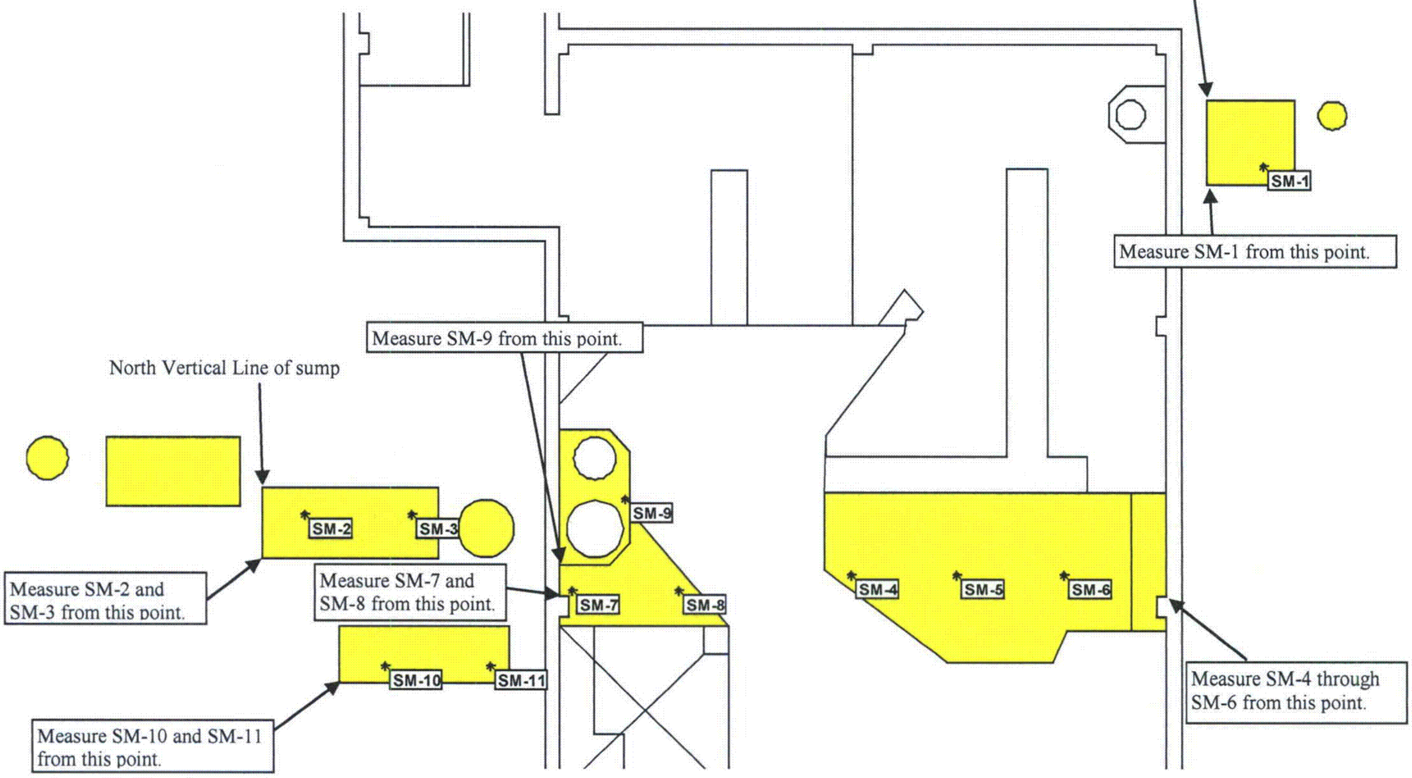
WH-3-11 AREA: Waste Handling Building Basement – Floor Section #1 Measurement Locations and results					
X Co-ord (m)	Y Co-ord (m)	Location / dpm/100cm^2		Type	Notes
0.9	-1.0	SM-1	302	Systematic	N/A
3.7	-1.0	SM-2	367	Systematic	N/A
-3.3	1.4	SM-3	525	Systematic	N/A
-0.5	1.4	SM-4	633	Systematic	N/A
2.3	1.4	SM-5	496	Systematic	N/A
5.1	1.4	SM-6	281	Systematic	N/A
-1.9	3.8	SM-7	590	Systematic	N/A
0.9	3.8	SM-8	554	Systematic	N/A
3.7	3.8	SM-9	50	Systematic	N/A
-3.3	6.2	SM-10	669	Systematic	N/A
-0.5	6.2	SM-11	525	Systematic	N/A
* All of the sample coordinates are measured from the point shown on the map.					

Survey Unit WH-3-12
WHB - Basement, Floor Section 2



WH-3-12 AREA: Waste Handling Building Basement – Floor Section #2 Measurement Locations and results					
X Co-ord (m)	Y Co-ord (m)	Location / dpm/100cm^2		Type	Notes
0.7	1.4	SM-1	625	Systematic	N/A
3.3	1.4	SM-2	353	Systematic	N/A
5.9	1.4	SM-3	1150	Systematic	N/A
2.0	3.7	SM-4	388	Systematic	N/A
4.6	3.7	SM-5	259	Systematic	N/A
0.7	5.9	SM-6	532	Systematic	N/A
3.3	5.9	SM-7	374	Systematic	N/A
5.9	5.9	SM-8	489	Systematic	N/A
2.0	8.2	SM-9	460	Systematic	N/A
4.6	8.2	SM-10	137	Systematic	N/A
7.3	8.2	SM-11	633	Systematic	N/A
* All of the sample coordinates are measured from the southwest corner of the survey unit.					

Survey Unit WH-3-13
WHB - Basement, Floor Section 3 & Sumps

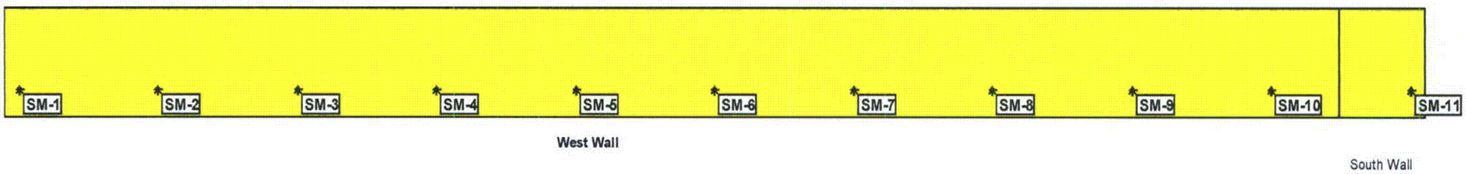


WH-3-13
AREA: Waste Handling Building Basement – Floor Section #3 & Sumps
Measurement Locations and results

X Co-ord (m)	Y Co-ord (m)	Location / dpm/100cm^2		Type	Notes
1.2	0.4	SM-1	258	Systematic	N/A
0.9	0.9	SM-2	648	Systematic	N/A
3.2	0.9	SM-3	594	Systematic	N/A
-6.8	0.5	SM-4	633	Systematic	N/A
-4.5	0.5	SM-5	414	Systematic	N/A
-2.2	0.5	SM-6	414	Systematic	N/A
0.3	0.1	SM-7	172	Systematic	N/A
2.5	0.1	SM-8	773	Systematic	N/A
1.4	1.4	SM-9	469	Systematic	N/A
1.0	-0.8	SM-10	641	Systematic	N/A
3.2	-0.8	SM-11	539	Systematic	N/A

* All of the sample coordinates are measured from the locations shown on the map.

Survey Unit WH-4-1
WHB - Exterior Concrete Wall



WH-4- 1 AREA: WHB – Exterior Concrete Wall Measurement Locations and results					
X Co-ord (m)	Y Co-ord (m)	Location / dpm/100cm^2		Type	Notes
0.2	0.3	SM-1	1290	Systematic	N/A
1.8	0.3	SM-2	699	Systematic	N/A
3.5	0.3	SM-3	634	Systematic	N/A
5.1	0.3	SM-4	715	Systematic	N/A
6.8	0.3	SM-5	699	Systematic	N/A
8.4	0.3	SM-6	626	Systematic	N/A
10.1	0.3	SM-7	740	Systematic	N/A
11.7	0.3	SM-8	593	Systematic	N/A
13.3	0.3	SM-9	203	Systematic	N/A
15.0	0.3	SM-10	626	Systematic	N/A
0.8	0.3	SM-11	927	Systematic	N/A
* All of the sample coordinates are measured from the southwest corner of the survey unit.					