Plum Brook Reactor Facility

Final Status Survey Report

Attachment 2

Revision 0

Service Equipment Building
(Building 1131)

FINAL STATUS SURVEY REPORT
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LIST OF ACRONYMS & SYMBOLS

α	alpha
A	Area
A_{EMC}	Area corresponding to the area factor calculated using the scan MDC
AEC	Atomic Energy Commission
ALARA	As Low As Reasonable Achievable
AF	Area Factor
β	beta
CFR	Code of Federal Regulations
CoC	Chain-of-Custody
cm	centimeters
cm^2	square Centimeters
cpm	counts per Minute
CPT	Cold Pipe Tunnel
δ	delta, the average residual activity in the survey unit
Δ	delta, DCGLw - LGBR
DCGL	Derived Concentration Guideline Level
$DCGL_{EMC}$	DCGL for small areas of elevated activity, used with the Elevated Measurement Comparison test (EMC)
$DCGL_{ES}$	Effective Surface DCGL
$DCGL_{G}$	Gross activity DCGL
$DCGL_{GB}$	Gross beta activity DCGL
$DCGL_{sur}$	Surrogate activity DCGL
$DCGL_{W}$	DCGL for average concentrations over a large area, used with statistical tests
dpm	disintegrations per minute
DQA	Data Quality Assessment
DQO	Data Quality Objective
EMC	Elevated Measurement Comparison
EPA	Environmental Protection Agency
FSS	Final Status Survey
FSSP	Final Status Survey Plan
FSSR	Final Status Survey Report
ft	feet
γ	gamma
g	gram
HTD	Hard To Detect
L	Grid dimension
LMI	Ludlum Measurements, Inc.
LBGR	Lower Bound of the Gray Region
m^2	square meters
μCi	microCurie
MARSSIM	Multi-Agency Radiation Survey and Site Investigation Manual
MDC	Minimum Detectable Concentration

LIST OF ACRONYMS, Continued

MDC_{scan}	Minimum Detectable Concentration for scanning surveys
MDC_{static}	Minimum Detectable Concentration for static surface activity measurements
MDCR	Minimum Detectable Count Rate
ml	milliliter
mrem	millirem
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
NaI	Sodium Iodide
N_{EMC}	number of measurements or samples determined using the elevated measurement comparison test
NRC	Nuclear Regulatory Commission
PBRF	Plum Brook Reactor Facility
pCi/g	picocuries per Gram
QA	Quality Assurance
QC	Quality Control
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
ROLB	Reactor Office and Laboratory Building, Building 1141
RPD	Relative Percent Difference
σ	generic symbol for standard deviation of a population
σ_b	standard deviation of background measurements
σ_n	standard deviation of net activity measurements
σ_t	total estimated standard deviation of surface activity measurements
SEB	Reactor Service Equipment Building, Building 1131
TBD	Technical Basis Document
WEMS	Water Effluent Monitoring Station
VSP	Visual Sample Plan
WRS	Wilcoxon Rank Sum Test

1.0 Introduction

This report presents the results of the final status radiological survey of the Plum Brook Reactor Facility (PBRF) Service Equipment Building (SEB). This is Attachment 2 of the PBRF Final Status Survey Report (FSSR). This document describes the SEB, 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[1].

As stated in the Plum Brook Reactor Facility 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 criteria in US NRC 10CFR20 Subpart E. The principal criterion is that the dose to future site occupants will be less than 25 mrem/y. In addition, levels of residual contamination will be reduced to achieve doses as low as reasonably achievable (ALARA) below 25 mrem/y. A Derived Concentration Guideline Level (DCGL) for residual surface contamination has been established for the SEB. Considering the radionuclide mixture established for the SEB, the gross beta DCGL is 27,166 dpm/100-cm^2. However, the DCGL for the entire length of the Cold Pipe Tunnel is 11,000 dpm/100-cm^2.

The survey measurement results and supporting information presented herein demonstrate that residual contamination levels in each survey unit of the SEB 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 SEB meets the criteria for unrestricted release.

Section 2.0 of the report provides a description of the SEB. 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 of the SEB 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.

Section 4.0 presents the FSS design for the SEB. This includes FSS Plan requirements applicable to the SEB, breakdown into survey units and assignment of MARSSIM classification to each, the survey design approach, and instrumentation used for the FSS and measurement sensitivities.

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

[1] The report of Final Status Survey results for the PBRF, including the SEB, will provide the basis for requesting termination of NRC Licenses TR-3 and R-93 in accordance with 10CFR50.82(b)(6).

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

2.0 SEB Description

The SEB is a three-story structure consisting of a basement, main floor, and mezzanine elevation. There is an addition attached to the east side of the building, with a high bay and three offices on the mezzanine. The SEB housed water processing equipment, air compressors, electrical control equipment, diesel generators for emergency electrical power, and the health physics radiochemistry/analytical laboratory. The CPT was located at the -15 foot level and extended east to the cooling tower and overhead water storage tanks area and west to the Primary Pump House and the Reactor Building. It contained the piping associated with all the water, gas, service and auxiliary air, steam and other ancillary support systems.

The SEB was designed to treat Lake Erie water using process equipment to clarify and de-ionize the lake water; provide emergency diesel electric power; supply service and instrument air for facility and experiment use; deliver steam to the entire facility; and provide a backup control console with capability to safely shutdown the 60 MW nuclear test reactor. It also housed personnel offices, an environmental radiological counting laboratory and a chemical test laboratory for water treatment analysis. Initial construction began in 1957 and the building was completed in about 1960, prior to reactor startup in 1961.

There also were a number of ancillary facilities connected to the SEB. These included the main electrical substation, the water treatment precipitator, two utility air intakes, two diesel fuel oil tanks, a waste oil tank, and the above utility tunnel.

The SEB, identified as Building 1131, is shown on the PBRF site map in Figure 1. A recent (2009) photograph of the SEB is provided in Exhibits 1, 2 and 3 of Appendix A.

2.1 Building Construction

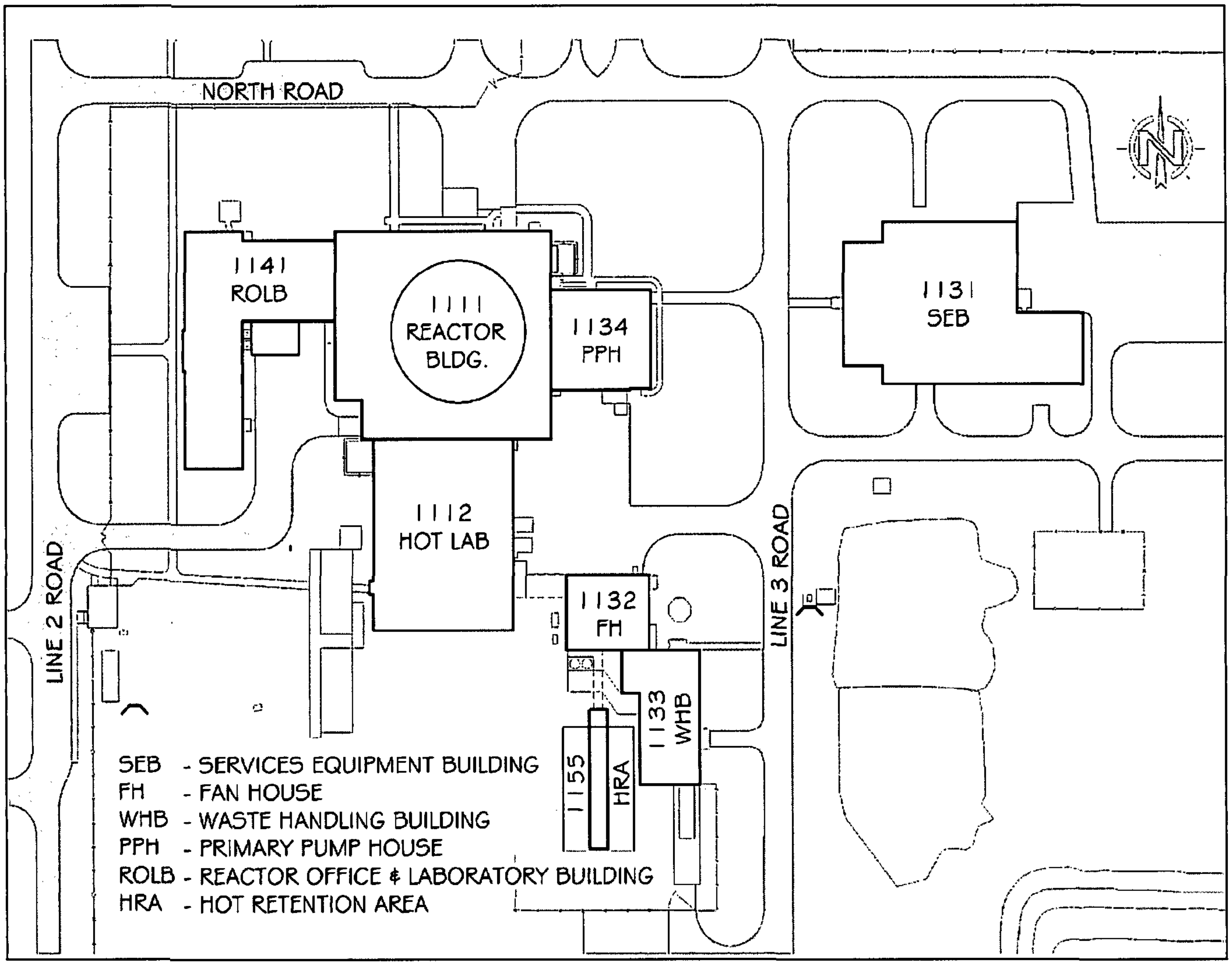
The SEB was principally constructed in the 1958 –1960 time frame. Later, facility modifications occurred several times to improve operations.

The basement of the SEB consisted of three main excavated areas totaling roughly 6,300 square feet. The south side contained approximately 1400 square feet of excavated area that included an electrical room with batteries, a stairwell to the Equipment Control Room, a pit area off the east side of the electrical room and trenches for two large utility air receiver tanks and associated piping. The area between the south side of the basement and the north side was 1900 square feet of utility tunnel. The north portion of the basement contained an excavated area of approximately 3000 square feet that housed an auxiliary equipment room, a water treatment pump room and a large clear-well for processed water (part of the water treatment plant).

The first floor of the SEB contains about 15,700 square feet of total space. A low roofed one-story section on the west side included two offices, rest rooms, a janitors closet, a chemical test laboratory, a counting room and an equipment control room with reactor shutdown capability. The exterior front section was concrete and the remainder of the building was two stories of fluted metal siding; all windows were steel sash “Solex”. The high bay area contained the water treatment area with a chlorine room, sand filters, pumps, a clear well storage tank and de-ionizers; a large room with two boilers; a storage area; and a locker room on the north side. The south side contained an engine room with two associated plumbing plus a general shop and equipment area. The two-story Annex, located in the southeast corner of the building, contained a shop and equipment area.

The second floor (mezzanine) consisted of about 2,100 square feet of chemical storage (lime, alum, etc.) and the upper parts of the chemical feeders for water treatment. In addition, the SEB Annex second floor contained about 800 square feet for two offices and a shop area.

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



2.2 Building Systems and Services

The principal operational activities at that time were the startup and testing of all the reactor facility support systems contained in the SEB, i.e., the water treatment plant, the diesel systems, the boilers, utility air systems, electrical power feed and control systems, etc.

During the reactor operations period of 1961 through early 1973, the SEB services were operated continuously to fulfill their support role. Three personnel were normally for continuous three shift manning of the SEB during reactor operations – a water treatment operator, a roving electrician and an Equipment Control Room operator.

During the day shift, there was a large number of other support personnel (electricians, mechanics, supervisors, lab technicians, etc.) assigned to support operations, perform corrective and preventative maintenance and make system modifications facility-wide. The SEB staff also supported implementing facility changes and system upgrades to improve the effectiveness and efficiency of reactor operations.

2.3 Building Modifications

Facility modifications occurred several times to improve operations such as the addition of a 2,200 square foot Annex in the 1964-1965 time frame, replacement of four small diesels generators with two larger units, and remodeling to create a separate radioactivity counting room.

Until modifications, made in 1965, the Chemical Test Laboratory, Room 1, was used to perform analysis on PBRF water systems, such as: raw water, process water, de-ionized water, cooling tower water, domestic water, boiler water and condensate, effluent water (WEMS), along with Plum Brook Station stream and sewage water. It was also used to perform routine and special radiometric analysis on facility and environmental air, charcoal, water, smears, vegetation, soils and silts, atmospheric fall out, aquatic biota and selected biological samples (milk, animals, etc.). Modifications in 1965 converted an adjacent office area, Room 2, into a counting room. All radiometric work was then done in this room until shutdown, in 1973.

In addition, a fume hood was installed in Room 1, which brought the total of fume hoods to two. Both hood exhausts were tied together and vented through the roof. The hood sink drains were connected to the building sanitary system, which emptied into the sewage sump in the basement. Natural gas, deionized water, hot domestic water, service air and a localized vacuum system were supplied to the hoods for sample preparation and chemical analysis work.

Between termination of reactor operations on January 5, 1973 and June 30, 1973, the SEB services were placed in a standby status similar to the rest of PBRF. The PBRF end condition statements governed the status of each system for the protected safe shutdown mode. General building conditions such that areas were left clean and void of miscellaneous equipment, materials and supplies governed the status of the SEB itself. Desks, tables, filing cabinets, bookcases, etc. were cleaned out and left. Rest rooms were taken out of service. Water fountains were deactivated and drained. The four large fans were removed from the top of the wooden cooling tower and were stored in the SEB Annex. The building was closed and locked.

2.4 Final Configuration and Scope

Configuration of the SEB for the FSS and the period until license termination is controlled by PBRF decommissioning and FSS procedures. The structure remains intact with utilities and services limited to temporary lighting. All furniture, furnishings and equipment have been removed. Most floor coverings, wall coverings and false ceilings have been removed. Electrical conduit, drains, HVAC ducts, hood ventilation ducts and plumbing fixtures have been removed. All piping was drained and removed and all sumps deactivated, except for the north sump which is maintained active to control groundwater intrusion. See Exhibits 8 and 9 of Appendix A.

The scope of FSS measurement results reported in this attachment includes building interior and exterior surfaces. It includes surface attachments, temporary safety covers and small embedded fixtures, for example pipe and conduit stubs such as shown in bottom photograph of Appendix A, Exhibit 10. It does not include FSS measurement results for piping embedded in SEB concrete buried beneath or adjacent to the building, as shown in upper photograph in Appendix A, Exhibit 10. The results for these commodities are reported in separate attachments to the FSS Report.

3.0 SEB History and Operations with Radioactive Materials

A chronology of SEB milestones is given below. This is followed by a discussion of the significant phases of SEB construction, operation and post-shutdown activities. Emphasis is on information pertaining to radiological operations that could affect the final building condition and final status survey.[2]

3.1 Chronology

1956 – September, groundbreaking for PBRF

1957 – SEB construction initiated

1959 – Jan-Feb. Initial SEB occupancy

1961 – June, 60 Mw Test Reactor critical

1963 — April, 60 Mw Test Reactor reaches full power

1973 — January 5th, Reactor shutdown

1973 – June 30, SEB vacated and placed in "standby condition". New Reactor Fuel and radioactive sources removed

1986 – New roof installed on SEB

[2] 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.

1987 – The Teledyne Isotopes Characterization survey reported that the SEB was not surveyed because it was a clean area "previously verified to be in an uncontaminated condition". It should be noted that no survey data was presented to document this "uncontaminated condition".

1998 — Additional roofing work on SEB

1998 – GTS Duratek Confirmatory Survey showed no loose contamination. Fixed beta/gamma activity ranged from 260 to 485 dpm/100 cm^2 in the SEB addition. There is no evidence of fixed alpha surveys being performed.

2001 – The Historical Site Assessment, conducted in 2001, identified evidence that indicated the presence of radioactive contamination in structures classified as non-impacted (e.g., Service Equipment Building 1131).

2002 – PBRF Decommissioning Plan approved. Equipment and cabinets removed; initial building decontamination.

2003 – In January, 2003 MWH characterization package D1131 401C1 was written for loose equipment and material. The highest fixed plus removable contamination levels were 109 dpm/100 cm^2, alpha, and 74,891 dpm/100 cm^2, beta.

2003- 2005 – Temporary storage of contaminated equipment in SEB during D&D of the PBRF. Two pieces of stored equipment were identified as containing fixed radioactive contamination.

2004 – MWH characterization package for the basement of the SEB identified activity, by direct measurement, to a maximum level of 16 dpm/100 cm^2, alpha, and 1,021 dpm/100 cm^2, beta. As a result of this survey, the area was re-classified from non-impacted to Impacted Class 2.

2006 – The SEB basement was surveyed under Survey Request (SR) 32. All smears were <MDA for both alpha and beta activity and the highest fixed activity, of the 26 measurements taken, was 7,708 dpm/100 cm^2, beta. The average of the other 25 measurements was 438 dpm/100 cm^2.

2006 – During performance of work for SR 32, it was determined that Sump #4, located in the Cold Pipe Tunnel portion of the SEB basement, accumulates water from the entire SEB and the entire Cold Pipe Tunnel, a decision was made to re-classify it as Impacted Class 1.

2006 – 2007 Remediation was performed on the contaminated areas of SEB and preparation for FSS.

2008 – FSS measurements completed in SEB interior.

2009 – Roof covering removed.

2009 - FSS measurements of SEB roof and exterior walls completed.

3.2 Operations with Radioactive Material

A review of the Health-Safety Operations Office input to the reactor cycle reports showed the de-ionized water to the SEB laboratory was contaminated during at least 4 reactor cycles (39, 76, 82 and 136) from 1965 to 1971. The maximum contamination level noted was 0.002 μCi/ml. This water was used to wash and polish glassware and for sample preparation. Thus, there was a potential impact on the sanitary drains and sewage sump because of the waste from use of the contaminated de-ionized water.

During reactor cycle 82, on 11-7-68, draining of the de-ionized water header in the CPT inadvertently resulted in a large quantity of contaminated water flowing from the floor to the SEB -15' floor area. Transferable contamination levels of 100,000 dpm/100 cm^2 were noted in areas contacted by the water. The cold drains in the CPT were also affected by this spill. These drains were connected to the SEB cold sump, which then pumped to the storm drain system.

Radiometric samples were prepared in the fume hoods such as water, vegetation, soils and silts, atmospheric fall out, aquatic biota and biological samples and then dried. The samples would then be passed to the counting room and counted in one of two low-level background counters. Occasionally, higher activity radioactive samples would be encountered; such as smears, air (particulate) and water samples.

Sealed radioactive calibration sources were used to calibrate the counters, for example, Pb-210, U-238, Sr-90, Cs-137 and Ra-226. The sources were either disposed of or transferred to Bldg 7143 at PBS at shutdown. Both low level counters were transferred to Bldg. 7143 after shutdown.

There were no hot drains or sumps or related systems located in the SEB because it was intended that no unsealed radioactive materials would be processed there.

Subsequent to July 1, 1973, the SEB was controlled according to Nuclear Regulatory Commission Licenses TR-3, R-93 and Broad By-Product Material License BPL No. 34-06706-03. The annual reports to the NRC provide the details of significant events or changes in status during the period between 1973 and the approval of the PBRF Decommissioning Plan in 2001. In 1995, the original 4 ply roofing materials of the SEB were removed and a layer of foamed polyurethane material was replaced to prevent significant water leakage into the SEB. Also, in 1983-1984, the wooden cooling tower and the above grade portions of the concrete basin were removed.

3.3 Disposition of Material in the Post-Shutdown Period

Notification was received on January 5, 1973 that NASA was terminating all nuclear related operations at PBRF due to budget constraints. The test reactor, mock-up reactor, hot laboratory and all associated operations were to be placed in standby condition by June 30, 1973. This included termination of the reactor facility operations staff.

Following notification, the test reactor (60 MW) was immediately shutdown on January 5th. A Master Plan was developed to address the activities associated with terminating the operating licenses for PBRF and placing the facility in a standby status. End condition statements were developed. These specified the final conditions for all buildings, structures and equipment on the PBRF site as of June 30, 1973. Both the initial Master Plan and the End Condition Statements were subject to revision as activities progressed or conditions changed.

Services to the building were terminated with the exception of electricity and the operation of one sump in the basement. Sanitary systems and water were cut off, the heating system was secured, and laboratory hoods were tagged and the access doors cabled shut to prevent entry.

All source (i.e., natural uranium) and special nuclear material were removed from the facility; except for calibration sources covered by general licenses per 10CFR70 and 10CFR40.

During the period between mid-1973 and the start of decommissioning in 2002, activities at PBRF were controlled according to modified AEC/NRC licenses TR-3, R-93 and BPL No. 34-060706-03. SNM-605 was apparently terminated in 1973; the by-product license No. 34-060706-03 was terminated in May, 1982. Licenses TR-3 and R-93 then controlled and authorized possession only of the remaining radioactive materials on-site, i.e., no facility operations were permitted. During 1973 to 2002, selected equipment, materials, and waste (both low-level radioactive and non-radioactive) were removed to other locations or discarded as the projected long-term considerations for the facility changed from possible restart to standby to decommissioning. For a brief history of the activities during this period, see the NASA PBRF Decommissioning Plan, Section 1.2.1 Decommissioning Historical Overview [NASA 2007a].

3.4 Decommissioning

In addition to removal of bulk equipment and furnishings, D&D activities focused on decontamination of known contaminated areas identified in the initial decommissioning characterization surveys. Also, surface coverings and fixtures that could mask contamination or physically interfere with surface activity measurements were removed. This included removal of floor tiles, ceiling acoustic tile and wall coverings. Hazardous materials and many building features, except structural components, have been removed from the building to facilitate the Final Status Survey. Recyclable items were segregated where possible.

Characterization, decommissioning support and post remediation radiological surveys were performed throughout the decommissioning process. The objective of the final post-remediation survey was to ensure that the SEB was ready for the FSS and could satisfy the release criteria with a high probability of success.

A summary of the areas in the SEB where contamination was measured and remediated during D&D is provided in Table 1. Note that these results do not include surveys of contaminated equipment or bulk contaminated items that were removed and disposed of as radioactive waste.

Table 1, Contaminated Areas Identified in SEB Decommissioning Surveys

Room No. or Location	Contamination levels	Radionuclides Measured	Results, Survey ID and Date
Roof and Building Exterior	Up to 699 dpm/100-cm^2 beta total surface activity	No sample analysis reported	MWH D1131 405C1, 4/2004
Cold Pipe Tunnel	Up to 16 dpm/100-cm^2 alpha and up to 92,897 dpm/100-cm^2 beta fixed activity	No sample analysis reported	MWH D1131 406C1, 4/2004, Tunnel Remediated (1)
Cold Pipe Tunnel sediment sample from drainage trench	5,941 dpm/100-cm^2 beta total surface activity	66 pCi/g Co-60 and 0.9 pCi/g Cs-137	MWH D1131 406C1, 4/2004, Trench Remediated (1)
Mezzanine Room 19A on floor	Hot particle discovered 92,158 dpm/100-cm2 beta and 23 dpm/100-cm2 alpha	Gamma spec sample results on hot particle were 17,507 pCi of Cs-137	MWH D1131 404C1, 4/2004, Smears all < MDA for alpha and beta.

Table 1 Note:

1. Remediation goals varied somewhat through the decommissioning period, but were generally lowered to < 5,500 dpm/100-cm^2 total surface beta activity and < 20 dpm/100-cm^2 total surface alpha activity during final post-remediation surveys.

4.0 Survey Design and Implementation for the SEB

This section describes the method for determination of the number of fixed measurements and samples for the FSS of the SEB. Requirements of the FSS Plan applicable to the SEB are summarized. These include the $DCGL_W$[3], the gross activity DCGL that applies to the SEB, scan

[3] The convention in 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.

survey coverage and action-investigation levels, classification of areas and breakdown of the SEB 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.[4] 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.

For structural surfaces in the PBRF, where multiple radionuclides are potentially present in residual contamination, the DCGL for FSS design and implementation is a gross activity DCGL. The gross activity DCGL accounts for the presence of multiple radionuclides, including beta-gamma and alpha emitters. The gross activity DCGL can also include 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 DCGLs were calculated for PBRF structures using the best available information on radionuclides identified and their activity ratios. Activity fractions and gross activity DCGLs for the SEB are shown in Table 2. The default DCGL for PBRF structures, 27,166 dpm/100-cm^2, is applied to the SEB. However, the DCGL for the entire length of the Cold Pipe Tunnel is 11,000 dpm/100-cm^2. [5]

[4] 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.

[5] Data from smear samples and concrete samples collected in multiple characterization-sampling surveys in the period from approximately 2002 though 2007 were evaluated to develop activity profiles for the various PBRF structures. Activity profiles and gross activity DCGLs for structures are reported in the Technical Basis Document PBRF-TBD-07-001 [PBRF 2007]. Since only a small fraction of characterization smear and material samples from the ROLB and SEB showed detectable activity, the SEB was assigned the default radionuclide mixture and DCGL for the PBRF structures. For the SEB, only the Cold Pipe Tunnel was assigned a location-specific radionuclide mixture and DCGL.

Table 2, SEB Radionuclide Activity Fractions and Gross Activity DCGLs

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 SEB(1)								
Areas Outside the CPT	0.2707	0.0965	0.0788	0.0142	0.4671	0.0012	0.0698	0.0017	27,166
CPT (entire length)	0	1.000	0	0	0	0	0	0	11,000

Table 2 Note:

1. Activity profiles and gross activity DCGLs for structures are reported in the Technical Basis Document PBRF-TBD-07-001 [PBRF 2007]. Only a small fraction of characterization smear and material samples from the ROLB and Service Equipment Building (SEB) showed detectable activity. Thus, the ROLB and SEB were assigned the default radionuclide mixture. The default activity fractions were obtained as the averages of the radionuclide activity fractions in 18 characterization samples.

Survey designs must incorporate requirements for scan coverage and investigation levels derived from the MARSSIM classification of survey units. The values applicable to the SEB are shown in Table 3.

Table 3, 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 >$DCGL_W$	≥50% of the $DCGL_W$

4.2 SEB Area Classification and Survey Unit Breakdown

The SEB was divided into 39 areas for division into potential survey units and assigned initial MARSSIM classifications in the FSS Plan. This breakdown is shown in Table 2-1 of the FSS Plan. As part of the FSS implementation process, individual survey units are identified and their final MARSSIM classification established. The SEB was divided into 52 survey units for the FSS. Table 4 lists the individual survey units and their classification for the FSS. The table compares final classification of the survey units with FSS Plan Table 2-1 classifications. Table 5 summarizes the survey unit breakdown by major elevation. Table 6 shows the survey unit breakdown by MARSSIM classification.

Table 4 was reviewed to ensure that no areas were classified "downward" from classifications assigned in the FSS Plan. It is seen from examination of the table that upward classification of two survey units did occur. The two survey units that were identified as having the FSS classification change upward were survey units SE-3-32 and SE-3-34. These two survey units were identified in the FSSP as being class 3 areas. However, due to leaks in the CPT that eventually accumulated in the sump, located in SE-3-34, it was necessary to raise the classification for SE-3-34 to class 1. Due to the proximity of survey unit SE-3-32 to SE-3-34 (now a class 1 area), it was also necessary to raise SE-3-32 to a class 2 area.

Recent photographs, taken during survey unit inspections, are provided in Exhibits 8 -29 of Appendix A.

Table 4, SEB Survey Units for FSS

Survey Unit (1)	Class	Description (Rm=Room; Fl=Floor; Lw=Lower wall; Uw=Upper wall; Wl=Window ledges)	FSSP Classification (2)
SE-1-1	1	Shop and Equipment Room Fl	1
SE-1-2	1	Shop and Equipment Room Fl	1
SE-1-3	1	Shop and Equipment Room Fl	1
SE-1-4	1	Shop and Equipment Building North and East Lw	1
SE-1-5	1	Shop and Equipment Building South and West Lw	1
SE-1-6	1	Shop and Equipment Building Steel below 2m Lw	1
SE-1-7	2	North Class 2 Floors Fl	2
SE-1-8	2	South Class 2 Floors Fl	2
SE-1-9	2	Class 2 Lower Walls Lw	2
SE-1-10	2	Class 2 Steel below 2m Lw	2
SE-1-11	3	Class 3 Upper Walls and Ceiling Uw, Ceiling	3
SE-1-12	3	Class 3 Steel Beams Uw, Ceiling	3
SE-2-1	1	Rm 19A, Chemical Storage Fl	1
SE-2-2	1	Rm 19A, Chemical Storage Lw	1
SE-2-3	2	Mezzanine Class 2 areas, Fl, Lw, Uw, Ceiling	2
SE-2-4	3	Mezzanine Class 3 areas, Fl, Lw, Uw, Ceiling	3
SE-3-1	1	Cold Pipe Tunnel – Floor Section 1 Fl	1
SE-3-2	1	Cold Pipe Tunnel – Floor Section 2 Fl	1
SE-3-3	1	Cold Pipe Tunnel – Floor Section 3 Fl	1
SE-3-4	1	Cold Pipe Tunnel – Floor Section 4 Fl	1
SE-3-5	1	Cold Pipe Tunnel – Floor Section 5 Fl	1
SE-3-6	1	Cold Pipe Tunnel – Floor Section 6 Fl	1
SE-3-7	1	Cold Pipe Tunnel – Floor Section 7 Fl	1
SE-3-8	1	Cold Pipe Tunnel – Floor Section 8 Fl	1
SE-3-9	1	Cold Pipe Tunnel – North Wall Section 1 Lw, Uw	1
SE-3-10	1	Cold Pipe Tunnel – North Wall Section 2 Lw, Uw	1
SE-3-11	1	Cold Pipe Tunnel – North Wall Section 3 Lw, Uw	1
SE-3-12	1	Cold Pipe Tunnel – North Wall Section 4 Lw, Uw	1
SE-3-13	1	Cold Pipe Tunnel – North Wall Section 5 Lw, Uw	1

Table 4, SEB Survey Units for FSS

Survey Unit (1)	Class	Description (Rm=Room; Fl=Floor; Lw=Lower wall; Uw=Upper wall; Wl=Window ledges)	FSSP Classification (2)
SE-3-14	1	Cold Pipe Tunnel – South Wall Section 1 Lw, Uw	1
SE-3-15	1	Cold Pipe Tunnel – South Wall Section 2 Lw, Uw	1
SE-3-16	1	Cold Pipe Tunnel – South Wall Section 3 Lw, Uw	1
SE-3-17	1	Cold Pipe Tunnel – South Wall Section 4 Lw, Uw	1
SE-3-18	1	Cold Pipe Tunnel – South Wall Section 5 Lw, Uw	1
SE-3-19	1	Cold Pipe Tunnel – Ceiling Section 1Ceiling	1
SE-3-20	1	Cold Pipe Tunnel – Ceiling Section 2 Ceiling	1
SE-3-21	1	Cold Pipe Tunnel – Ceiling Section 3 Ceiling	1
SE-3-22	1	Cold Pipe Tunnel – Ceiling Section 4 Ceiling	1
SE-3-23	1	Cold Pipe Tunnel – Ceiling Section 5 Ceiling	1
SE-3-24	1	Cold Pipe Tunnel – Ceiling Section 6 Ceiling	1
SE-3-25	1	Cold Pipe Tunnel – Ceiling Section 7 Ceiling	1
SE-3-26	1	Cold Pipe Tunnel – Cooling Tower Basin Tunnel Floor Fl	1
SE-3-27	1	Cold Pipe Tunnel – Cooling Tower Basin Tunnel South and West Walls Lw, Uw	1
SE-3-28	1	Cold Pipe Tunnel – Cooling Tower Basin Tunnel North and East Walls Lw, Uw	1
SE-3-29	1	Cold Pipe Tunnel – Cooling Tower Basin Tunnel Ceiling Ceiling	1
SE-3-30	1	Cold Pipe Tunnel – Connecting Tunnel C Floor and Ceiling Fl, Ceiling	1
SE-3-31	1	Cold Pipe Tunnel – Connecting Tunnel C Walls Lw, Uw	1
SE-3-32	2	Basement Class 2 Areas Fl, Lw	3
SE-3-33	3	Basement Class 3 Areas Fl, Lw, Uw, Ceiling	3
SE-3-34	1	Rm 20/21 Sump #4	3
SE-4-1	2	Roof	2
SE-4-2	3	Exterior Walls	3

Table 4 Notes:

1. The increase from 39 areas identified in Table 2-1 of the FSS Plan to 52 survey units was primarily due to the redistribution of the 6 Cold Pipe Tunnel areas into 31 class 1 survey units (Survey Unit classification-based size limits were maintained in accordance with FSS Plan).
2. The FSS Plan classifications were based on area history and available characterization data.

Table 5, SEB Survey Unit Breakdown

Major Elevation or Area	No. of Survey Units	Surface Area (m^2)	% of Survey Units	% of Surface Area
Shop and Equipment Rm	6	419	11.5	2.4
Ground Floor Elevation	6	8,358	11.5	47.4
Mezzanine(s)	4	1273	7.7	7.2
Basement	3	2168	5.8	12.3
CPT	31	2548	59.6	14.4
OW&R	2	2877	3.9	16.3
Total	52	17643	100	100

Table 5 Notes:
1. Rm – Room
2. OW&R – Outside Walls and Roof.

Table 6, SEB Survey Unit Breakdown by MARSSIM Classification

Class	No. Survey Units	Surface Area (m^2)	% of Survey Units	% of Surface Area	Average Area of Survey Units (m^2)
1	39	3073	75	17.4	78.8
2	6	5155	11.5	29.2	859.2
3	7	9415	13.5	53.4	1345.0
Total	52	17643	100	100	

4.3 Number of Measurements and Samples

The number of measurements and samples for each SEB 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 $DCGL_W$.[6] 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.

[6] 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 or less than 10% of PBRF structure DCGLs (this assumes a detection efficiency of ~ 12%).

The Visual Sample Plan (VSP) software was used to determine the number of FSS measurements in the SEB. [7] 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:

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

(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 – α (1.6449 for σ = 0.05),
$Z_{1-\beta}$ = proportion of standard normal distribution < 1 - β (1.2816 for β = 0.1),
Φ (Δ/σ_t) = 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 (LGBR), and
σ_t = 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, Δ, σ and the $DCGL_W$. The number of measurements, N, for the 52 SEB survey units were calculated in 11 survey designs. Table 7 summarizes the SEB survey design calculations and lists the values of the key VSP input parameters.

Appendix B provides VSP maps of all sample measurement locations for each of the 52 survey units within the SEB.

[7] 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.

Table 7, SEB Survey Design Summary

Design No.(1)	Survey Units	Class	DCGL(2)	LGBR(2)	□(2)	□(2)(3)	□□	N
11	SE-1-1 through SE-1-6	1	27,166	26,137	1,029	343	3.0	11
12	SE-1-7 through SE-1-10	2	27,166	26,137	1,029	343	3.0	11
13	SE-1-11 through SE-1-12	3	27,166	26,054	1,112	371	3.0	11
14	SE-2-1 through SE-2-2	1	27,166	23,341	3,825	1,275	3.0	11
15	SE-2-3	2	27,166	23,341	3,825	1,275	3.0	11
16	SE-2-4	3	27,166	23,341	3,825	1,275	3.0	11
10	SE-3-1 through SE-3-31	1	11,000	7,660	3,340	1,113	3.0	11
17	SE-3-32	2	27,166	21,718	5,448	1,454	3.7	11
18	SE-3-33	3	27,166	21,718	5,448	1,454	3.7	11
21	SE-3-34	1	10,560	6,199	4,361	1,454	3.0	11
36(4)	SE-4-1 & SE-4-2	2,3	24449	12,225	12,224	4,890	2.5	11

Table 7 Notes:

1. The data reported in Table 7 is taken from the Survey Design reports listed. They are maintained in the PBRF Document Control System.
2. Units are dpm/100-cm^2.
3. Survey design inputs for the SEB Basement Sump #4 (Design No.21, SE-3-34) were derived from DCGLs for the Cold Pipe Tunnel (CPT) since it was determined that Sump #4 was a collection point for CPT floor drains. The Design No. 21 $DCGL_W$, 10,560 dpm/100-cm^2, was obtained by adjusting CPT DCGL, 11,000 dpm/100-cm^2, by a factor of 24/25 to account for embedded piping.
4. In Survey Design No. 36, survey units SE-4-1 and SE-4-2 (building exterior surfaces), the $DCGL_W$, 24,449 dpm/100-cm^2, was obtained by adjusting the default value, 27,166 dpm/100-cm^2, by a factor of 22.5/25 to account for deselected "insignificant" radionuclides.

Selection of design input parameters followed guidance in the FSS Plan. The Plan states that "the LGBR 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 7, that in the majority of SEB designs, 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 parameters. The following is an example obtained from the VSP report for survey unit SE-2-1 in Design No. 14. The sensitivity the of number of samples 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 8 summarizes this analysis. The region of critical sensitivity is for α = 0.05 (required), β = 0.10 (optional) and the LGBR set equal to 90% of the DCGL. In this region, N is only moderately sensitive to an increase of 100% in the value of σ. In this case N changes from 11 to 12. 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 shows that the number of measurements is 11 or fewer in all cases except one. These results show that N = 11 represents a conservative design.

Table 8, VSP Sensitivity Analysis Results for Survey Unit SE-2-1 Design

		Number of Samples					
DCGL=27166		α=0.05(2)		α =0.10		α =0.15	
		σ=1452(1)(3)	σ=726	σ=1452	σ=726	σ=1452	σ=726
LBGR=90%(1)(4)	β=0.05(5)	16	14	12	11	11	10
	β=0.10	12	11	10	9	9	8
	β=0.15	11	10	9	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=0.5	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 8 Notes:
1. Units of DCGL, σ and LBGR are dpm/100 –cm^2.
2. α = Alpha (%), Probability of mistakenly concluding that μ < DCGL.
3. σ = Standard Deviation.
4. LBGR = Lower Bound of Gray Region (as % of DCGL).
5. β = Beta (%), Probability of mistakenly concluding that μ > DCGL

Visual Sample Plan was also used to determine the grid size, the random starting location coordinates (for Class 1 and 2 survey units) 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 SEB survey unit.

The survey designs also specify scan survey coverage and action levels based on the MARSSIM classification listed in Table 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 Test. As discussed in the next section, the scan sensitivities of instruments used in the FSS of the SEB are below the $DCGL_W$, and no increase in the number of measurements calculated using the Sign Test was required. One exception would be the LMI 44-9. As observed in Table 9, the scan sensitivity for the LMI 44-9 is 22,659 dpm/100-cm^2, which is greater than the DCGL for the CPT (11,000 dpm/100-cm^2). However, the primary use for the LMI 44-9 was to determine the activity in "hard-to-reach" places where the LMI 44-116 was not able to be measure.

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 (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 SEB is provided in Table 9.

Table 9, Detection Sensitivities of Field Instruments

Detector Model	Detector Efficiency (c/d) (1)	MDC_{scan} (dpm/100-cm^2) (2) (3)	Net cpm Equivalent to $DCGL_w$	MDC_{static} (dpm/100-cm^2)
LMI 44-116 (3) (4)	0.12	2402	172	452
LMI 43-37 (5)	0.145	798	352	NA
LMI 44-9(6)	0.0925	22,659	151	4,745

Table 9 Notes:

1. The detector efficiencies listed are total efficiency, i. e., $E_t = E_i + E_s$.
2. A' priori scan sensitivities for the LMI 44-116 & LMI 43-37 detectors are calculated using Equation 3.
3. The static MDC for the LMI 44-116 detector is calculated using Equation 2 with background count rate = 196 cpm, $E_i = 0.242$ and $E_s = 0.5$ (detector-to-surface distance = 0.5 in.)
4. The scan MDC for the LMI 44-116 is from Survey Design No.11 Att. 5-2. The background count rate is 196 cpm; scan speed is 10 cm/s, $E_i = 0.242$, $E_s = 0.5$, efficiency correction factor = 0.8349 to compensate for concrete roughness (detector-to-surface distance 0.5 in.)
5. The scan MDC for the LMI 43-37 is from Survey Design No.11, Att. 5-3. The background count rate is 483 cpm; scan speed is 30 cm/s, $E_i = 0.29$, $E_s = 0.5$, detector-to-surface distance 0.5 in.
6. The static MDC for the LMI 44-9 detector is calculated using Equation 2 with background count rate = 200 cpm, $E_i = 0.185$ and $E_s = 0.5$ (detector-to-surface distance = 0.5 in.)

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. Examples of areas or locations in SEB survey units where special measurement conditions apply are shown in Exhibits 26 and 27 of Appendix A.

5.0 SEB Survey Results

Results of the SEB 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 SEB 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 surveys were also reviewed to confirm that the minimum coverage requirement of 5% was satisfied. Results of the SEB scan surveys are compiled in Table 10. The table shows that scan coverage requirements were satisfied for all survey units. The table also shows that scan investigation levels were exceeded in three survey units (all Class 1). The results of the investigations are summarized below.

Table 10, Scan Survey Results

Survey Unit	Class	Scan Survey Coverage (%) (1)	QC Replicate Scan Coverage (%) (1) (2) (3)	Investigation Level Exceeded
SE-1-1	1	100	7	No
SE-1-2	1	100	7	No
SE-1-3	1	100	7	No
SE-1-4	1	100	7	No
SE-1-5	1	100	7	No
SE-1-6	1	100	7	No
SE-1-7	2	52	9	No
SE-1-8	2	52	9	No
SE-1-9	2	51	9	No
SE-1-10	2	57	12	No
SE-1-11	3	11	1	No
SE-1-12	3	11	1	No
SE-2-1	1	100	10	No
SE-2-2	1	100	10	No
SE-2-3	2	60	3	No
SE-2-4	3	13	1	No
SE-3-1	1	100	33	Yes
SE-3-2	1	100	33	Yes
SE-3-3	1	100	33	No
SE-3-4	1	100	33	No
SE-3-5	1	100	33	No
SE-3-6	1	100	33	No
SE-3-7	1	100	11	No
SE-3-8	1	100	17	No
SE-3-9	1	100	7	No
SE-3-10	1	100	7	No
SE-3-11	1	100	7	No
SE-3-12	1	100	7	No
SE-3-13	1	100	7	No
SE-3-14	1	100	7	No
SE-3-15	1	100	7	No
SE-3-16	1	100	7	No
SE-3-17	1	100	7	No
SE-3-18	1	100	7	No

Table 10, Scan Survey Results

Survey Unit	Class	Scan Survey Coverage (%) (1)	QC Replicate Scan Coverage (%) (1) (2) (3)	Investigation Level Exceeded
SE-3-19	1	100	6	Yes
SE-3-20	1	100	6	No
SE-3-21	1	100	6	No
SE-3-22	1	100	6	No
SE-3-23	1	100	6	No
SE-3-24	1	100	6	No
SE-3-25	1	100	7	No
SE-3-26	1	100	7	No
SE-3-27	1	100	7	No
SE-3-28	1	100	7	No
SE-3-29	1	100	7	No
SE-3-30	1	100	7	No
SE-3-31	1	100	7	No
SE-3-32	2	53	6	No
SE-3-33	3	10	10	No
SE-3-34	1	100	5	No
SE-4-1	2	51	6	No
SE-4-2	3	10	7	No

Table 10 Notes:

1. Scan coverage % results are rounded to the nearest whole per cent. Values reported with the first decimal as 5, e. g., 5.5, are rounded downward.
2. The % scan coverage is given as the % of the area scanned in the initial survey.
3. Replicate QC scan results are reported for multiple survey units in some survey request close-out reports. The QC scan percentages are reported as % of the scanned area of the survey units combined. So the same % scanned is assigned to all of the survey units.

Review of SEB release records indicates that during the FSS of the SEB, investigations were performed in three survey units.

In survey unit SE-3-1, Cold Pipe Tunnel, a class 1 survey unit, three localized areas were identified that were observed to have activity above background during the scan survey. The areas were bounded and investigations performed of each. The three locations were found to contain fixed activity with measured gross surface activity of 8,320, 8,480 and 4,050 dpm/100-cm^2 respectively. These values are all below the DCGLw (11,000 dpm/100-cm^2), and no further action was required.

In survey unit SE-3-2, Cold Pipe Tunnel, a class 1 survey unit, one small localized area was identified that was observed to have activity above background during the scan survey. The area was bounded and an investigation was performed. The location was observed to be approximately 4 cm^2 and the measured activity was 21,574 dpm/100-cm^2. An evaluation was conducted and it was determined that this area would not contribute significantly to the annual dose of the survey unit based on the following:

- The measured activity is < $DCGL_{EMC}$ (29,015 dpm/100-cm^2) listed in Survey Design 10, Table 6.
- The measured activity is less than the investigational $DCGL_{EMC}$ of 442,200 dpm/100-cm^2 which was derived by using Table 3-5 of the FSSP and applying an area factor of 40.2.
- The elevated measurement test was performed using the following equation, in accordance with procedure CS-09, Section 4.6. The calculated unity value was 0.113.

$$\frac{\delta}{DCGL_W} + \frac{(average\ \text{concentration in elevated area - } \delta)}{(Area\ \text{Factor})(DCGL_W)} \leq 1.0$$

δ = the average residual activity in the survey unit

In survey unit SE-3-19, Cold Pipe Tunnel, a class 1 survey unit, one small localized area was identified that was observed to have activity above background during the scan survey. The area was bounded and an investigation was performed. The location was observed to be approximately 125 cm^2 and the measured activity was 12,709 dpm/100-cm^2. An evaluation was conducted and it was determined that this area would not contribute significantly to the annual dose of the survey unit based on the following:

- The measured activity is < $DCGL_{EMC}$ (24,338 dpm/100-cm^2) listed in Survey Design 10, Table 6.
- The measured activity is less than the investigational $DCGL_{EMC}$ of 442,200 dpm/100-cm^2 which was derived by using Table 3-5 of the FSSP and applying an area factor of 40.2.
- The elevated measurement test was performed using the following equation, in accordance with procedure CS-09, Section 4.6. The calculated unity value was 0.08.

$$\frac{\delta}{DCGL_W} + \frac{(average\ \text{concentration in elevated area - } \delta)}{(Area\ \text{Factor})(DCGL_W)} \leq 1.0$$

δ = the average residual activity in the survey unit

As all three of these survey units were class 1, no reclassification was required as a result of these investigations.

5.2 Fixed Measurements and Tests

Results of the assessment of SEB FSS measurements are presented in Table 11 (individual measurements in each survey unit are reported in Appendix B). Table 11 compares the maximum activity measured in each survey unit to the $DCGL_W$. It is demonstrated that all measured activity values are less than the $DCGL_W$, thus all survey units meet the 25 mrem/y release criterion. The mean activity of each survey unit is also compared to the $DCGL_W$, and as expected, are all less than the $DCGL_W$. The average of 579 total surface beta measurements reported in the SEB release records is: 494 ± 258 dpm/100-cm^2 (one standard deviation).[8]

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 SEB 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[9]. Gross beta and gross alpha counts for all SEB smears were less than MDA.

Table 11, SEB Total Surface Beta Activity Measurement Summary and Test Results

Survey Unit ID	No. of Measurements	Maximum (dpm/100-cm^2)	Test Result Maximum < $DCGL_W$ (1)	Average (dpm/100-cm^2)	Test Result Average < $DCGL_W$ (1)
SE-1-1	11	757	Yes	547	Yes
SE-1-2	11	951	Yes	624	Yes
SE-1-3	11	826	Yes	657	Yes
SE-1-4	11	174	Yes	36	Yes
SE-1-5	11	285	Yes	68	Yes
SE-1-6	11	194	Yes	24	Yes
SE-1-7	11	719	Yes	493	Yes
SE-1-8	11	934	Yes	686	Yes
SE-1-9	13(3)	566	Yes	201	Yes
SE-1-10	11	230	Yes	77	Yes
SE-1-11	11	444	Yes	42	Yes
SE-1-12	11	221	Yes	36	Yes

Table 11 is continued on the following page.

8 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. This suggests that given the results reported for the SEB, average residual activity levels are indistinguishable from background.

9 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.

Table 11, SEB Total Surface Beta Activity Measurement Summary and Test Results

Survey Unit ID	No. of Measurements	Maximum (dpm/100-cm^2)	Test Result Maximum < $DCGL_W$ (1)	Average (dpm/100-cm^2)	Test Result Average < $DCGL_W$ (1)
SE-2-1	12(3)	867	Yes	704	Yes
SE-2-2	11	371	Yes	41	Yes
SE-2-3	11	534	Yes	171	Yes
SE-2-4	11	669	Yes	248	Yes
SE-3-1	11	2688	Yes(2)	1186	Yes
SE-3-2	11	1115	Yes(2)	726	Yes
SE-3-3	11	777	Yes(2)	540	Yes
SE-3-4	11	1210	Yes(2)	784	Yes
SE-3-5	11	796	Yes(2)	593	Yes
SE-3-6	11	921	Yes(2)	753	Yes
SE-3-7	11	742	Yes(2)	458	Yes
SE-3-8	13(3)	808	Yes(2)	634	Yes
SE-3-9	11	859	Yes(2)	587	Yes
SE-3-10	11	834	Yes(2)	553	Yes
SE-3-11	11	1060	Yes(2)	582	Yes
SE-3-12	13(3)	893	Yes(2)	590	Yes
SE-3-13	11	819	Yes(2)	623	Yes
SE-3-14	11	711	Yes(2)	479	Yes
SE-3-15	11	861	Yes(2)	648	Yes
SE-3-16	11	1060	Yes(2)	659	Yes
SE-3-17	11	881	Yes(2)	558	Yes
SE-3-18	11	636	Yes(2)	456	Yes
SE-3-19	11	782	Yes(2)	529	Yes
SE-3-20	11	1415	Yes(2)	628	Yes
SE-3-21	11	796	Yes(2)	600	Yes
SE-3-22	11	676	Yes(2)	484	Yes
SE-3-23	11	634	Yes(2)	364	Yes
SE-3-24	11	715	Yes(2)	513	Yes
SE-3-25	11	841	Yes(2)	587	Yes
SE-3-26	11	991	Yes(2)	718	Yes
SE-3-27	11	1000	Yes(2)	673	Yes
SE-3-28	11	1106	Yes(2)	738	Yes
SE-3-29	11	1188	Yes(2)	946	Yes
SE-3-30	11	1097	Yes(2)	671	Yes
SE-3-31	11	958	Yes(2)	565	Yes
SE-3-32	11	1177	Yes(2)	665	Yes
SE-3-33	11	538	Yes(2)	393	Yes
SE-3-34	11	369	Yes(2)	80	Yes
SE-4-1	11	642	Yes	159	Yes
SE-4-2	11	842	Yes	323	Yes

Table 11 Notes: 1.DCGL for SEB is 27,166 dpm/100 cm^2 unless otherwise noted.
2. DCGL for Cold Pipe Tunnel (CPT) is 11,000 dpm/100 cm^2.
3. No. of measurements > 11 is due to VSP determination of sample locations.

5.3 ALARA Evaluations

It is shown that residual contamination in the SEB 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, those 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."[10]

Screening level values published by the NRC for the mix of radionuclides in structural surface residual contamination potentially present in the SEB are shown in Table 12. Since individual radionuclide activity concentrations are not measured in the FSS of structures, a direct comparison of residual contamination levels to screening level values is not possible. A comparison can be made by converting the nuclide-specific screening level values to an appropriate gross activity DCGL. This is accomplished using activity fractions used in development of the SEB gross activity DCGL. 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 and the activity fractions listed in Table 2 (also shown in Table 12). The screening level equivalent DCGL for the SEB is 1,188 dpm/100-cm^2. This value was determined by using the most conservative screening value based in the two radionuclide mixtures for the SEB reported in Technical Basis Document PBRF-TBD-07-001 [PBRF 2007].

As reported in Section 5.2, the average total surface beta activity measured in the FSS of the SEB is 494 ± 258 dpm/100-cm^2 (one standard deviation). The upper limit of 95^{th} % confidence interval of this mean value is 515 dpm/100-cm^2.[11] This value is well below the screening level gross activity DCGL of 1,188 dpm/100-cm^2.

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

[11] The upper limit of the confidence interval, 95^{th} percentile value, is calculated as: $UL = mean + 1.96\ \sigma/\sqrt{n}$, where n = 579 measurements.

Table 12, Screening Level Values for SEB and Radionuclide Activity Fractions

Radionuclide	Screening Level Value (dpm/100-cm^2)	SEB Activity Fraction (%)	CPT Activity Fraction (%)
H-3	1.2 E+08 [(1)]	27	0
Co-60	7.1E+03 [(1)]	9.7	100
Sr-90	8.7E+03 [(1)]	7.9	0
I-129	3.5E+04[(1)]	1.4	0
Cs-137	2.8E+04 [(1)]	46.7	0
Eu-154	1.2E+04[(2)]	0.1	0
U-234	9.1E+01 [(2)]	7.0	0
U-235	9.8E+01[(2)]	0.2	0

Table 12 Notes:

1. Values from NUREG-1757 Vol. 2, Table H.1 [USNRC 2006].
2. 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.

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 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. The trigger levels applicable to the PBRF are residual soil concentrations in excess of:

- Co-60, 4 pCi/g,
- Sr-90 (+Daughters), 23 pCi/g, and
- Cs-137 (+Daughters), 6 pCi/g.

No soil or groundwater samples were collected or analyzed as part of this Service and Equipment Building Final Status Survey Report.

5.5 Conclusions

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

- Scan surveys were performed in all 52 SEB survey units with scan coverage either equal to (for class 1) or in excess of the percentage requirements (for class 2 and 3) of the survey units.

- Residual surface contamination above investigation levels was detected in only three of 52 survey units. Investigations were performed on the three areas and they were determined to not contribute significantly to the dose for each survey unit.
- Except as noted above, all remaining total surface activity measurements are less than the applicable $DCGL_W$, 11,000 or 27,166 dpm/100-cm^2.
- 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 $DCGL_W$.
- Residual surface activity concentration measurement results were compared to 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 classification of two survey units was increased above what was proposed in the Plan.
- There were no changes from initial assumptions (in the FSS Plan) regarding the extent of residual activity in the SEB. Only two measurements in excess of the DCGL occurred (both in class 1 survey units) and no reclassification of survey units was required as a result of FSS measurements and investigations.

6.0 References

ISO 1988	International Organization for Standardization, *Evaluation of Surface Contamination, Part 1: Beta Emitters and Alpha Emitters,* ISO-7503-1, 1988.
NASA 2006	NASA Safety and Mission Assurance Directorate, Plum Brook Reactor Facility, *Decommissioning Project Quality Assurance Plan,* QA-01, Revision 2, February 2006.
NASA 2007	NASA Safety and Mission Assurance Directorate, *Final Status Survey Plan for the Plum Brook Reactor Facility,* Revision 1, February 2007.
NASA 2007a	NASA Safety and Mission Assurance Directorate, *Decommissioning Plan for the Plum Brook Reactor Facility*, Revision 6, July 2007.
PBRF 2007	Plum Brook Reactor Facility Technical Basis Document, *Adjusted Gross DCGLs for Structural Surfaces,* PBRF-TBD-07-001, June 2007.
PBRF 2007a	Plum Brook Reactor Facility Technical Basis Document, *Efficiency Correction Factor,* PBRF-TBD-07-004, November 2007.
PBRF 2009	Plum Brook Reactor Facility, Memorandum to Project File, J. L. Crooks, Don Young, *FSS Final Report Background Information – SEB, Service Equipment Building (1131),* December 7, 2009.
PBRF 2009a	Plum Brook Reactor Facility Technical Basis Document, *44-10 Detector MDCscan Values for Various Survey Conditions,* PBRF-TBD-09-002, June 2009.
PBRF 2009b	Plum Brook Reactor Facility Technical Basis Document, *An Evaluation of the 2350-1/44-10 NaI Detector Response in Water Covered Areas,* PBRF-TBD-09-006, October 2009.
PBRF 2010	Plum Brook Reactor Facility, Memorandum to Project File, Bruce Mann, *Engineering Record for Final Status Survey Report, Attachment 1 Calculations,* March 25, 2010.
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.
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.

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.

7.0 Appendices

Appendix A – Exhibits

Appendix B – Survey Unit Maps Showing Measurement Locations & Fixed Measurement Data

Final Status Survey Report

Attachment 2

Service Equipment Building

(Building 1131)

Revision 0

Appendix A

Exhibits

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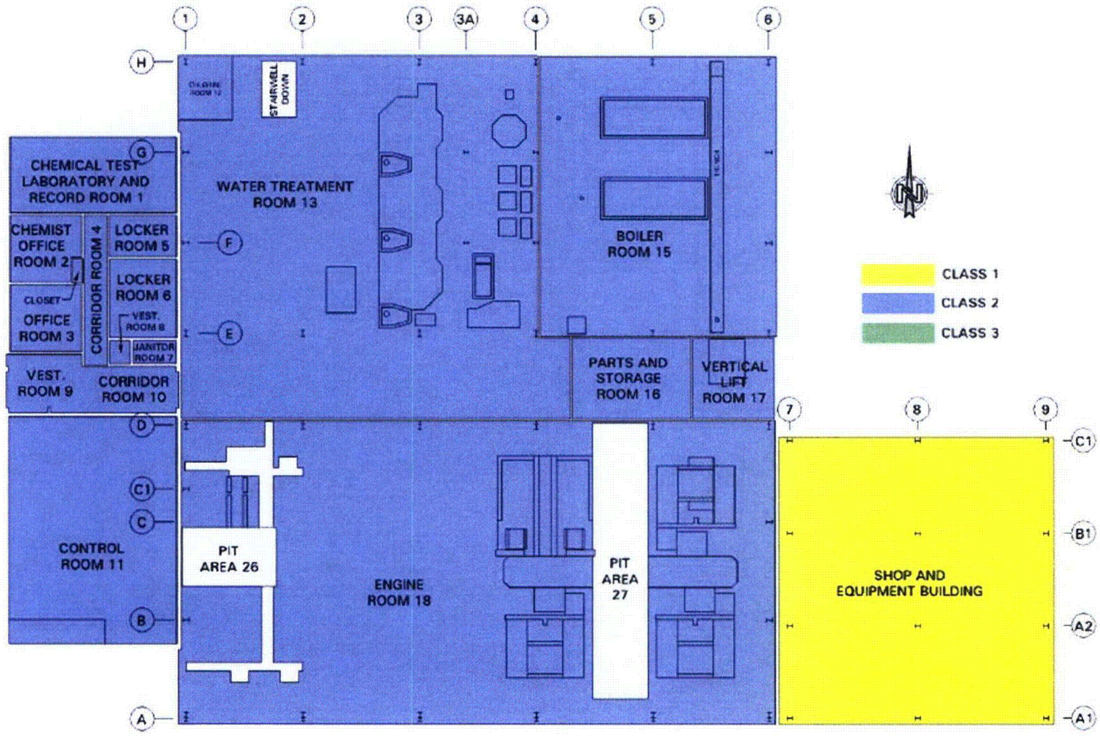
Exhibit 1, Service and Equipment Building Viewed from the North West

Exhibit 2, SEB Viewed from the North East Showing Rollup Doors

Exhibit 3, Close up View of the SEB West Wing

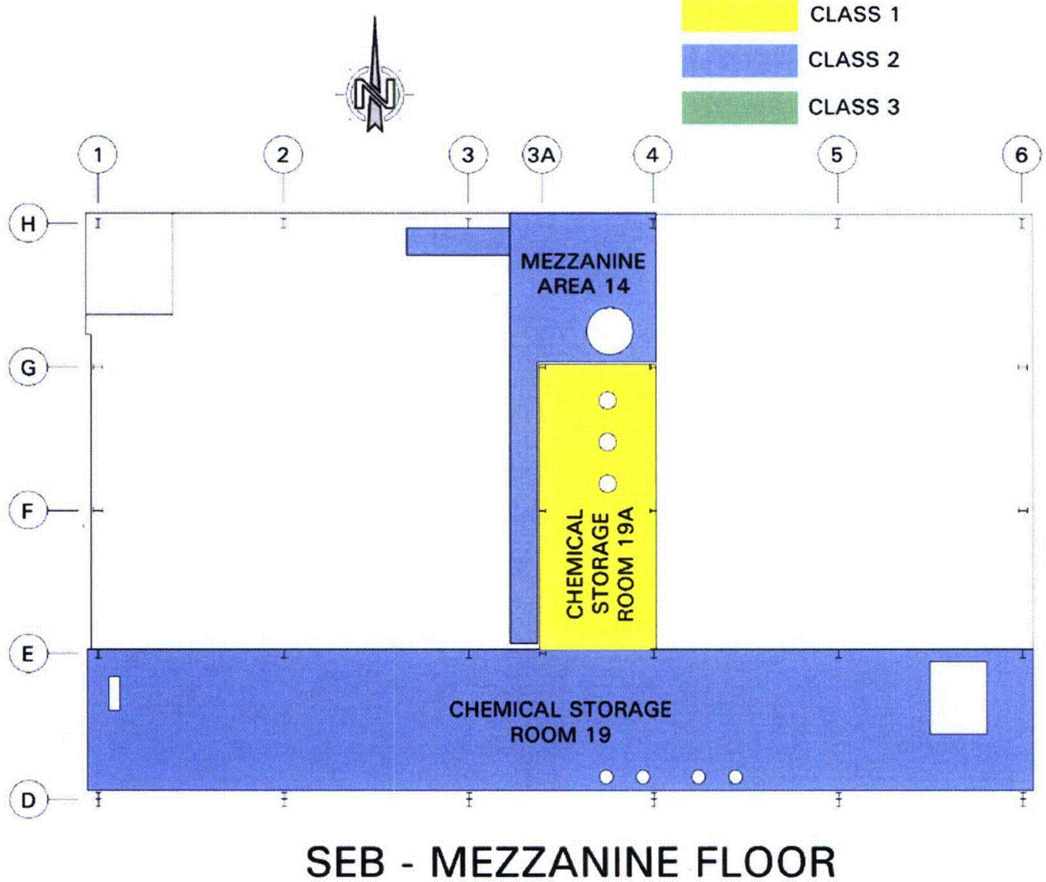
Exhibit 4, SEB First Floor Survey Units



SEB - FIRST FLOOR

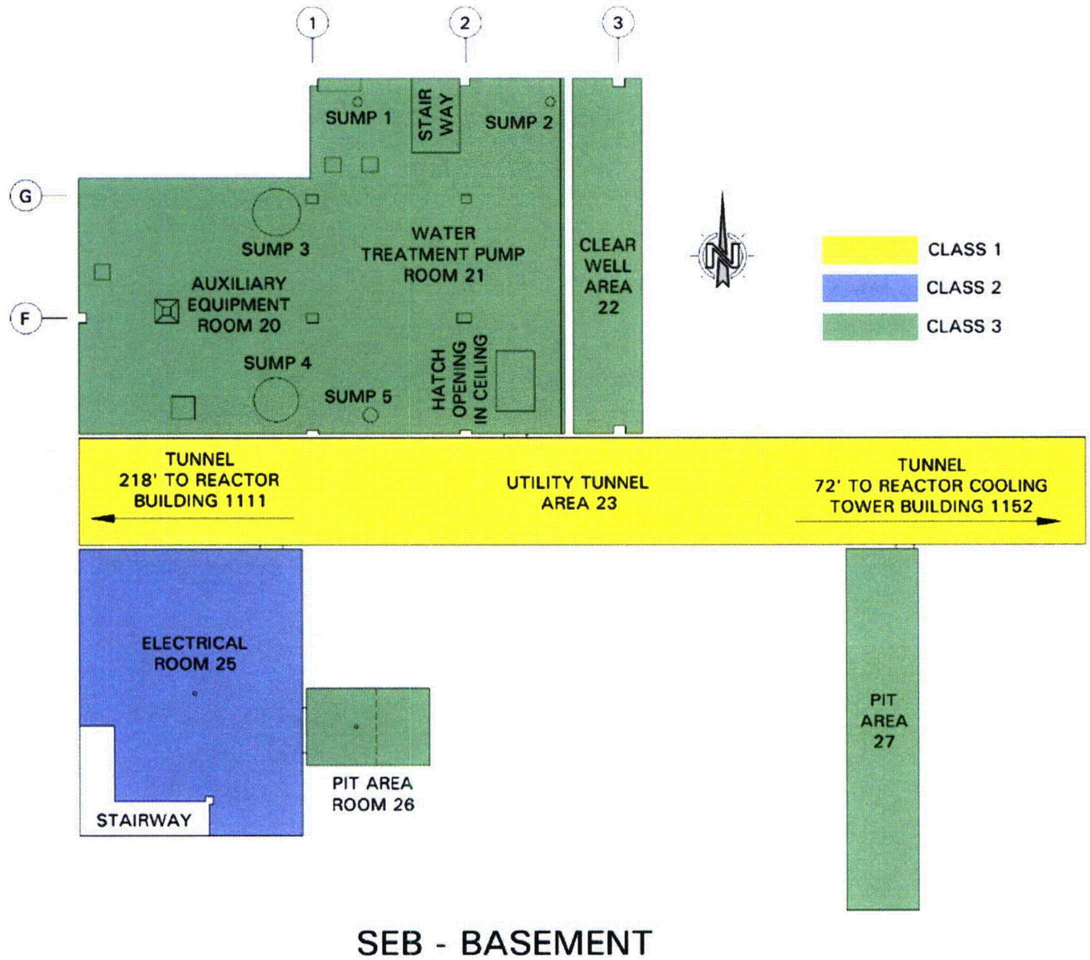
Survey Unit	Class	**Description** (Rm=Room; Fl=Floor; Lw=Lower wall; Uw=Upper wall; Wl=Window ledges)	FSSP Classification
SE-1-1	1	Shop and Equipment Room **Fl**	1
SE-1-2	1	Shop and Equipment Room **Fl**	1
SE-1-3	1	Shop and Equipment Room **Fl**	1
SE-1-4	1	Shop and Equipment Building North and East **Lw**	1
SE-1-5	1	Shop and Equipment Building South and West **Lw**	1
SE-1-6	1	Shop and Equipment Building Steel below 2m **Lw**	1
SE-1-7	2	North Class 2 Floors **Fl**	2
SE-1-8	2	South Class 2 Floors **Fl**	2
SE-1-9	2	Class 2 Lower Walls **Lw**	2
SE-1-10	2	Class 2 Steel below 2m **Lw**	2
SE-1-11	3	Class 3 Upper Walls and Ceiling **Uw, Ceiling**	3
SE-1-12	3	Class 3 Steel Beams **Uw, Ceiling**	3

Exhibit 5, SEB Second Floor Survey Units



Survey Unit	Class	Description (Rm=Room; Fl=Floor; Lw=Lower wall; Uw=Upper wall; Wl=Window ledges)	FSSP Classification
SE-2-1	1	Rm 19A, Chemical Storage **Fl**	1
SE-2-2	1	Rm 19A, Chemical Storage **Lw**	1
SE-2-3	2	Mezzanine Class 2 areas, **Fl, Lw, Uw, Ceiling**	2

Exhibit 6, SEB Basement/Cold Pipe Tunnel Survey Units

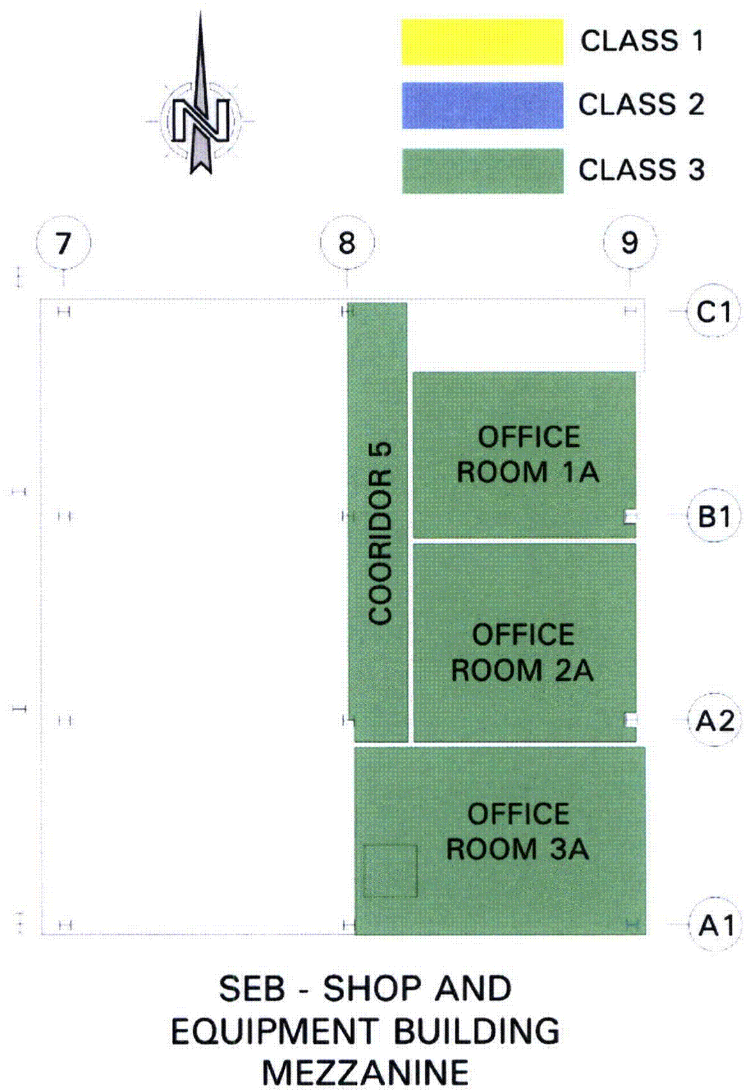


Survey Unit summary for Basement/Cold Pipe Tunnel is continued on the next page.

Exhibit 6, SEB Basement/Cold Pipe Tunnel Survey Units
(Continued)

Survey Unit (1)	**Class**	**Description** (Rm=Room; Fl=Floor; Lw=Lower wall; Uw=Upper wall; Wl=Window ledges)	**FSSP Classification** (2) (3)
SE-3-1	1	Cold Pipe Tunnel – Floor Section 1 **Fl**	1
SE-3-2	1	Cold Pipe Tunnel – Floor Section 2 **Fl**	1
SE-3-3	1	Cold Pipe Tunnel – Floor Section 3 **Fl**	1
SE-3-4	1	Cold Pipe Tunnel – Floor Section 4 **Fl**	1
SE-3-5	1	Cold Pipe Tunnel – Floor Section 5 **Fl**	1
SE-3-6	1	Cold Pipe Tunnel – Floor Section 6 **Fl**	1
SE-3-7	1	Cold Pipe Tunnel – Floor Section 7 **Fl**	1
SE-3-8	1	Cold Pipe Tunnel – Floor Section 8 **Fl**	1
SE-3-9	1	Cold Pipe Tunnel – North Wall Section 1 **Lw, Uw**	1
SE-3-10	1	Cold Pipe Tunnel – North Wall Section 2 **Lw, Uw**	1
SE-3-11	1	Cold Pipe Tunnel – North Wall Section 3 **Lw, Uw**	1
SE-3-12	1	Cold Pipe Tunnel – North Wall Section 4 **Lw, Uw**	1
SE-3-13	1	Cold Pipe Tunnel – North Wall Section 5 **Lw, Uw**	1
SE-3-14	1	Cold Pipe Tunnel – South Wall Section 1 **Lw, Uw**	1
SE-3-15	1	Cold Pipe Tunnel – South Wall Section 2 **Lw, Uw**	1
SE-3-16	1	Cold Pipe Tunnel – South Wall Section 3 **Lw, Uw**	1
SE-3-17	1	Cold Pipe Tunnel – South Wall Section 4 **Lw, Uw**	1
SE-3-18	1	Cold Pipe Tunnel – South Wall Section 5 **Lw, Uw**	1
SE-3-19	1	Cold Pipe Tunnel – Ceiling Section 1**Ceiling**	1
SE-3-20	1	Cold Pipe Tunnel – Ceiling Section 2 **Ceiling**	1
SE-3-21	1	Cold Pipe Tunnel – Ceiling Section 3 **Ceiling**	1
SE-3-22	1	Cold Pipe Tunnel – Ceiling Section 4 **Ceiling**	1
SE-3-23	1	Cold Pipe Tunnel – Ceiling Section 5 **Ceiling**	1
SE-3-24	1	Cold Pipe Tunnel – Ceiling Section 6 **Ceiling**	1
SE-3-25	1	Cold Pipe Tunnel – Ceiling Section 7 **Ceiling**	1
SE-3-26	1	Cold Pipe Tunnel – Cooling Tower Basin Tunnel Floor **Fl**	1
SE-3-27	1	Cold Pipe Tunnel – Cooling Tower Basin Tunnel South and West Walls **Lw, Uw**	1
SE-3-28	1	Cold Pipe Tunnel – Cooling Tower Basin Tunnel North and East Walls **Lw, Uw**	1
SE-3-29	1	Cold Pipe Tunnel – Cooling Tower Basin Tunnel Ceiling **Ceiling**	1
SE-3-30	1	Cold Pipe Tunnel – Connecting Tunnel C Floor and Ceiling **Fl, Ceiling**	1
SE-3-31	1	Cold Pipe Tunnel – Connecting Tunnel C Walls **Lw, Uw**	1
SE-3-32	2	Basement Class 2 Areas **Fl, Lw**	3
SE-3-33	3	Basement Class 3 Areas **Fl, Lw, Uw, Ceiling**	3
SE-3-34	1	Rm 20/21 Sump #4	3

Exhibit 7, SEB Shop and Equipment Survey Unit



Survey Unit	Class	**Description** (Rm=Room; Fl=Floor; Lw=Lower wall; Uw=Upper wall; Wl=Window ledges)	FSSP Classification
SE-2-4	3	Mezzanine Class 3 areas, **Fl, Lw, Uw, Ceiling**	3

Exhibit 8, SEB Basement Sumps 1 and 2 (Survey Unit SE-3-32)

General Area View of Sump 1

General Area View of Sump 2

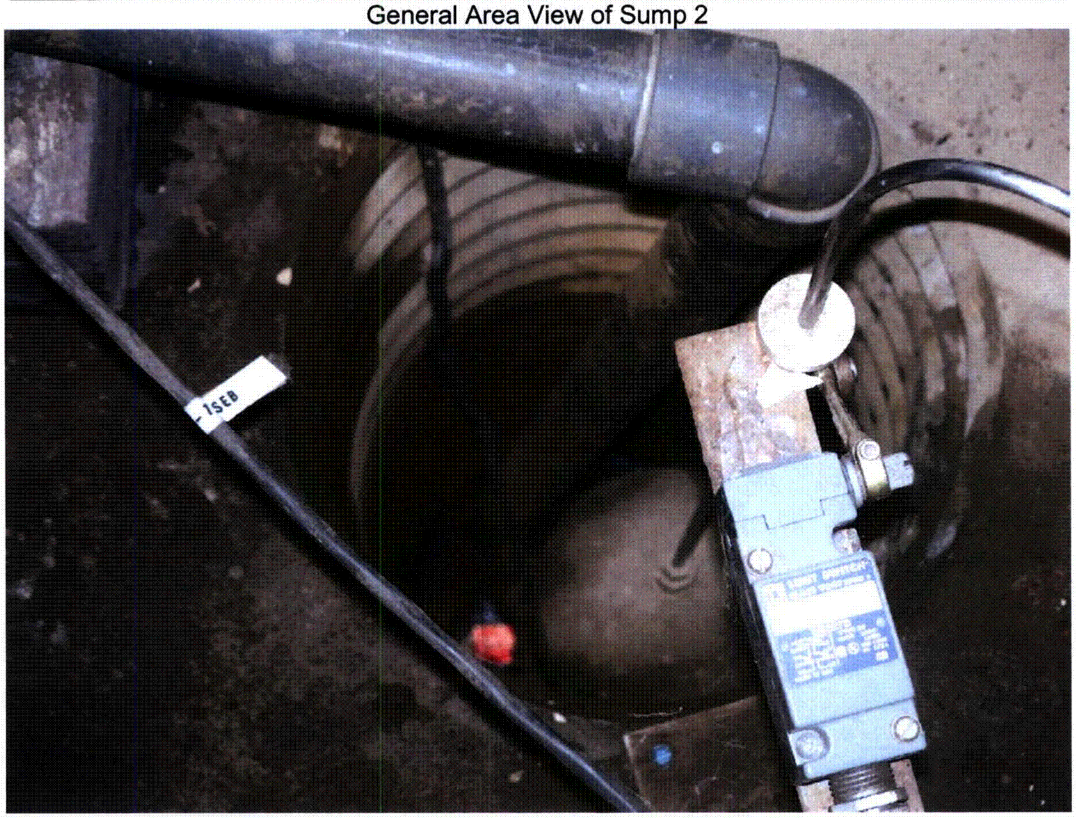


Exhibit 9, SEB Basement Sump 3 (Survey Unit SE-3-32)

General Area View of Sump 3 Looking north

General Area View of Sump 3 Looking West

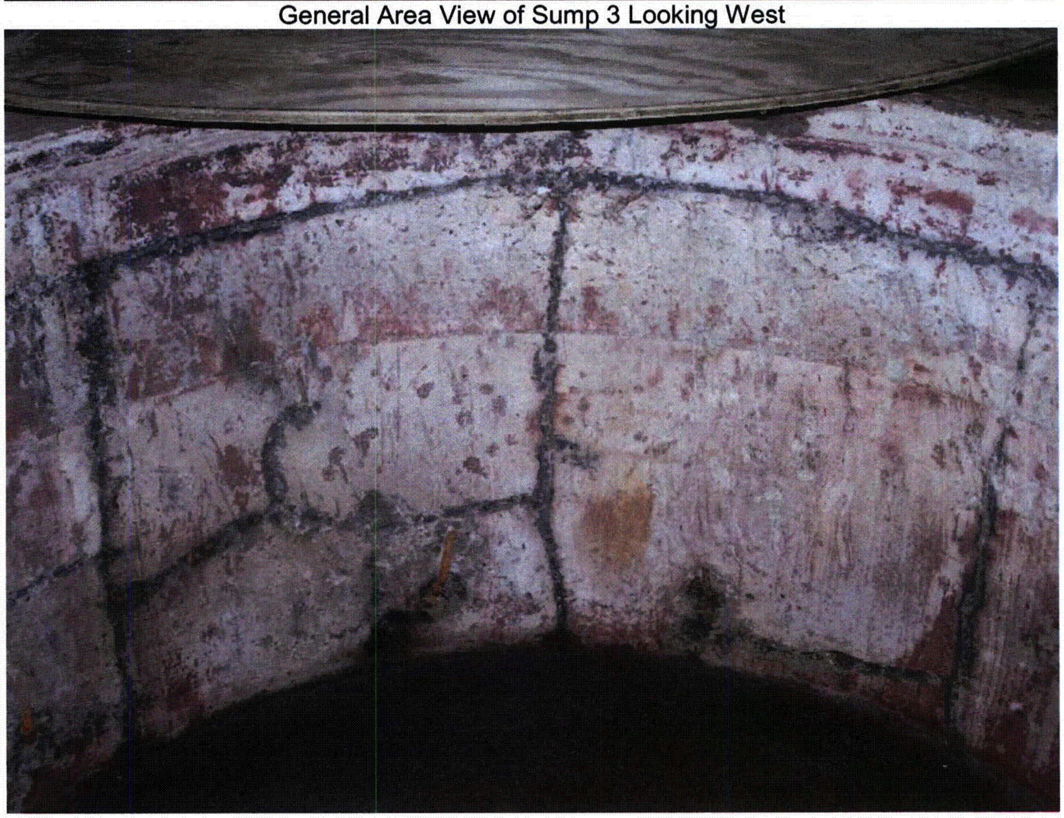
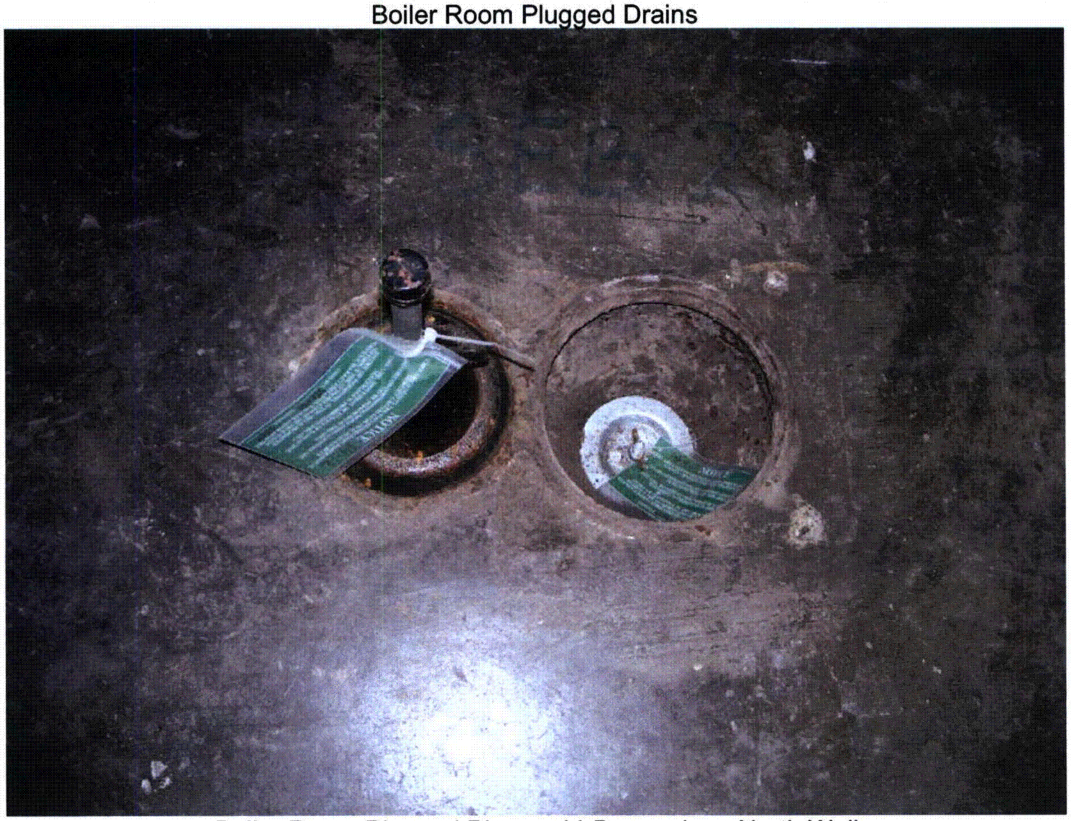


Exhibit 10, Views of SEB Boiler Room Drains and Floor Details (Survey Unit SE-1-7)

Boiler Room Plugged Drains



Boiler Room Plugged Pipe and I-Beam along North Wall

Exhibit 11, Views of SEB Shop and Equipment Room (Survey Unit SE-1-1)

General Area View Floor Looking East

General Area View Floor Looking West

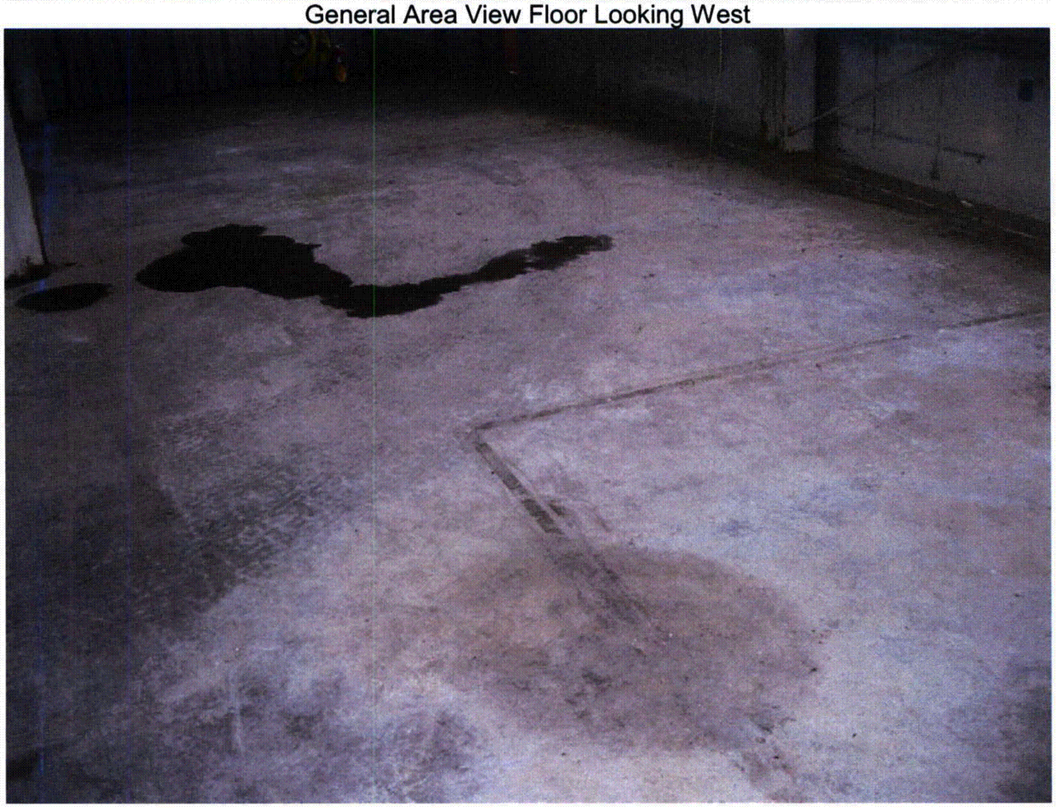
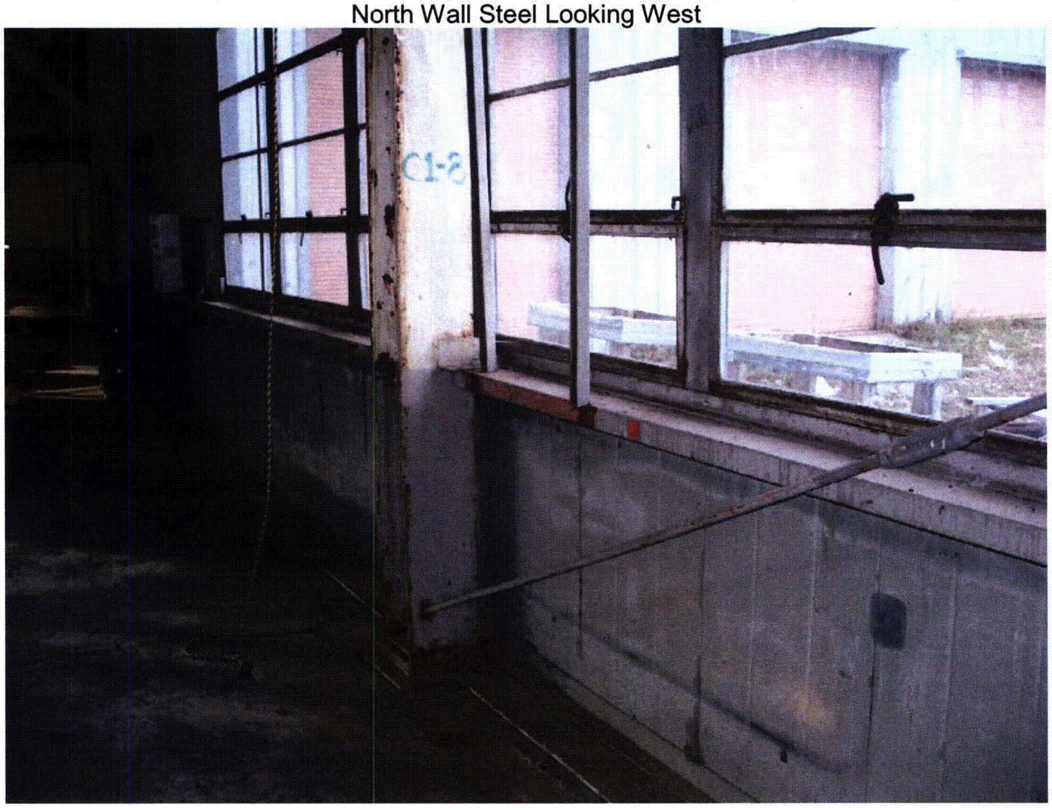


Exhibit 12, Views of SEB Shop Walls and Windows(Survey Unit SE-1-6)

North Wall Steel Looking West



North Wall Steel Looking East

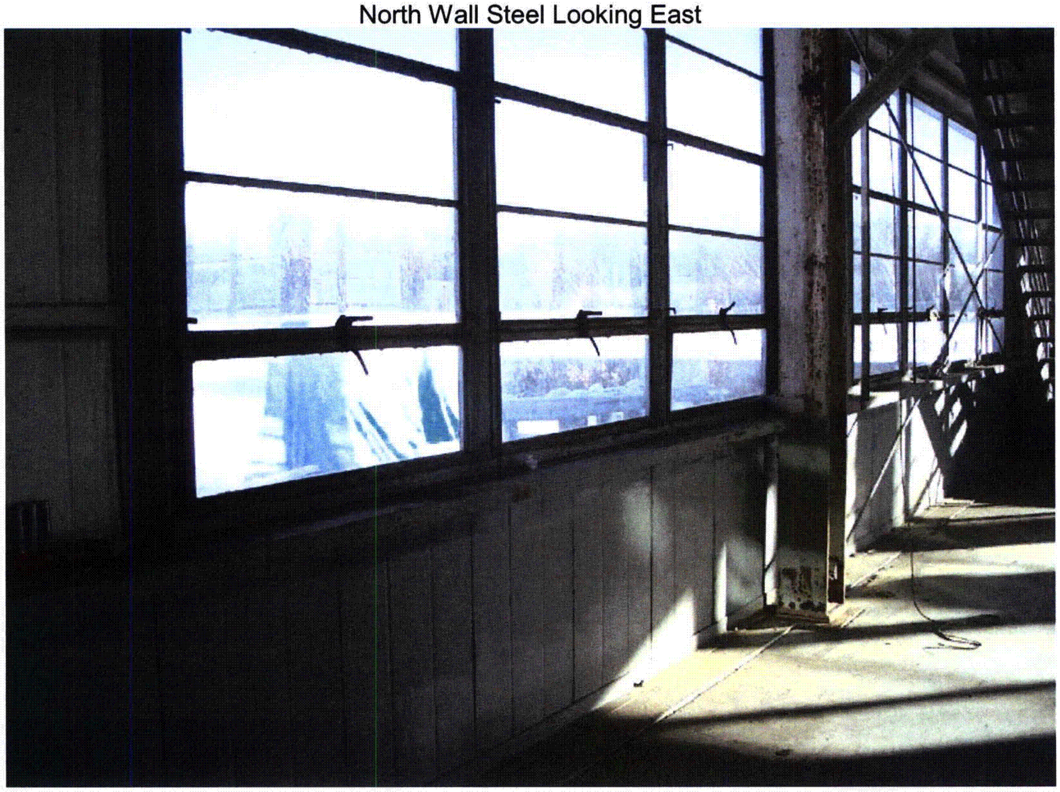


Exhibit 13, Views of SEB First Floor Hallways (Survey Unit SE-1-7)

Main Hallway Looking East

Office Hallway Looking South

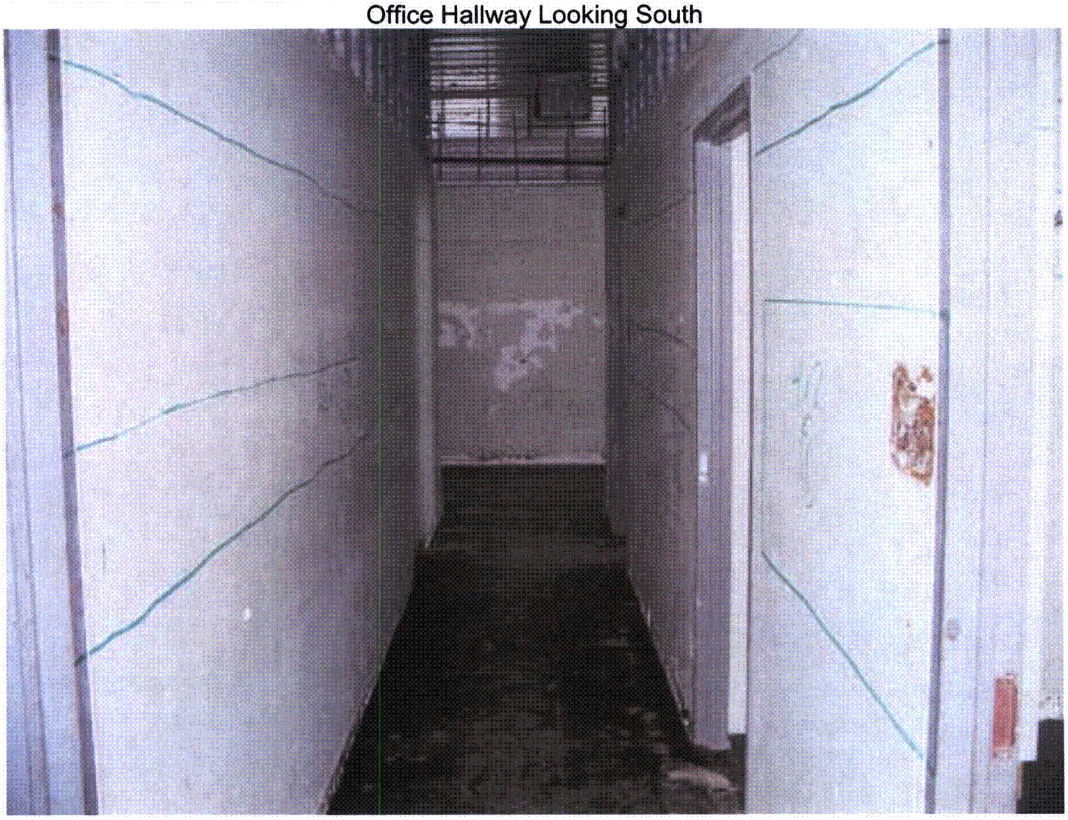


Exhibit 14, SEB Boiler Room Floor Details (Survey Unit SE-1-7)

Boiler Room Trench Looking North

Boiler Room Pedestals Looking North

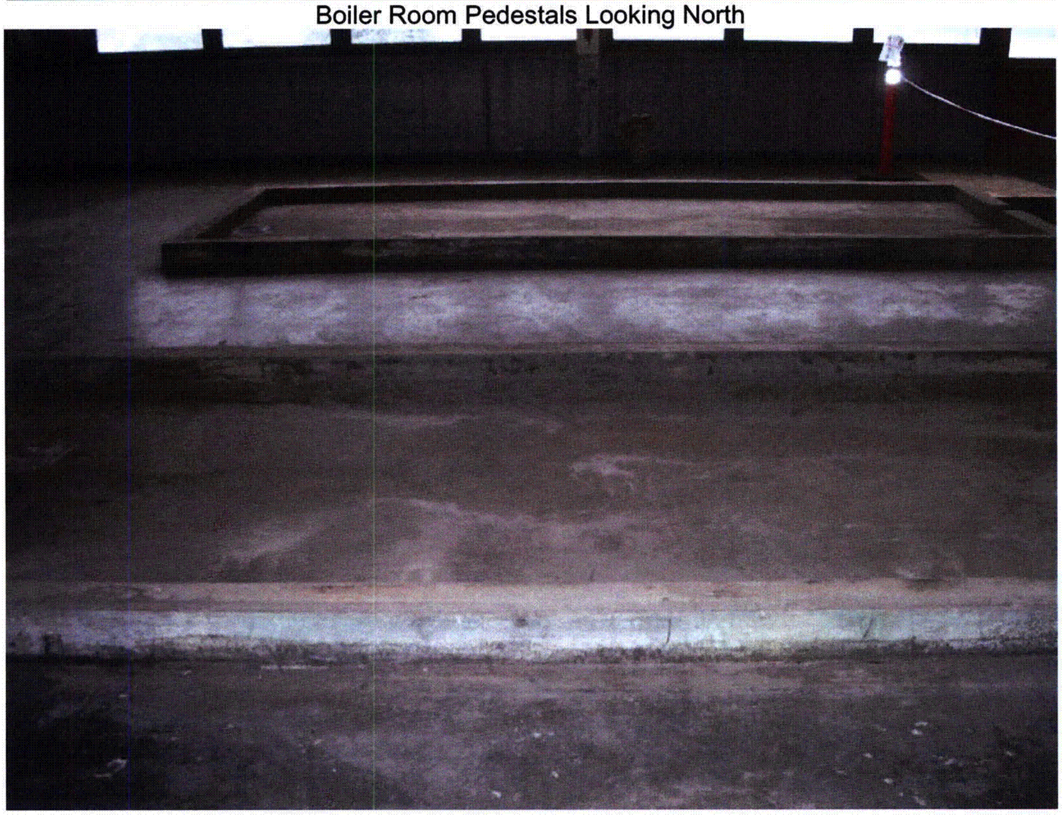
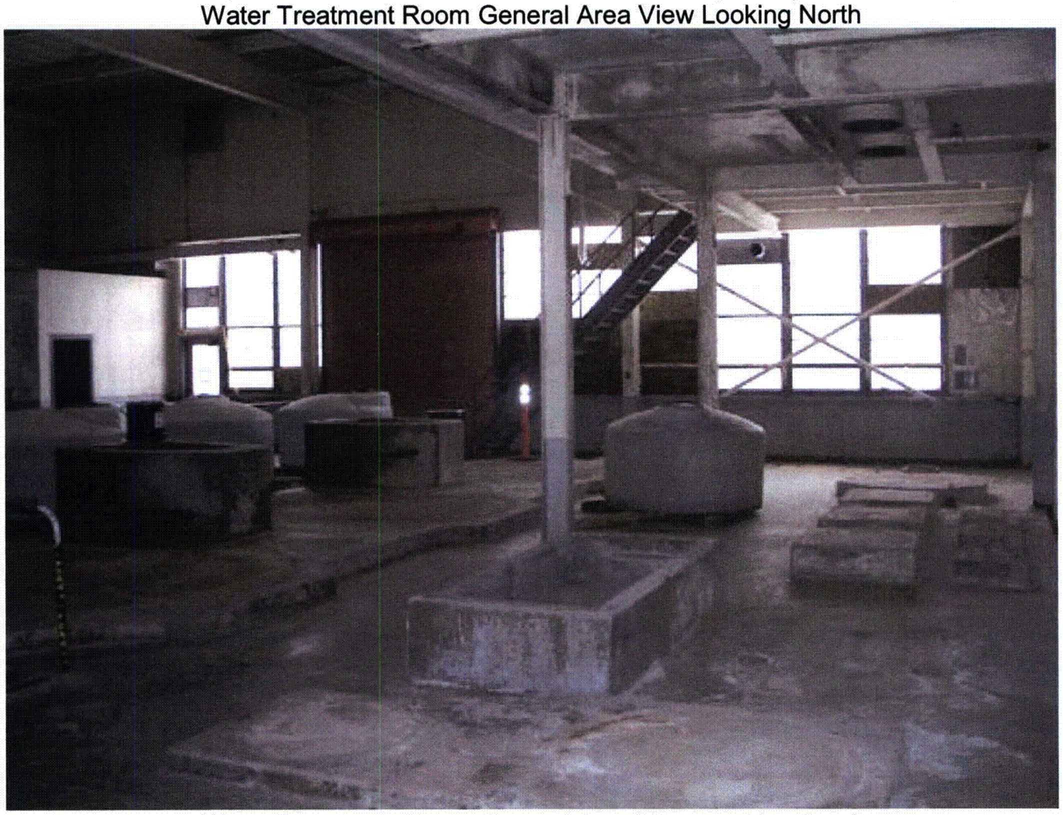


Exhibit 15, Views of SEB Water Treatment Room (Survey Unit SE-1-7)

Water Treatment Room General Area View Looking North



Water Treatment Room General Area View Looking South

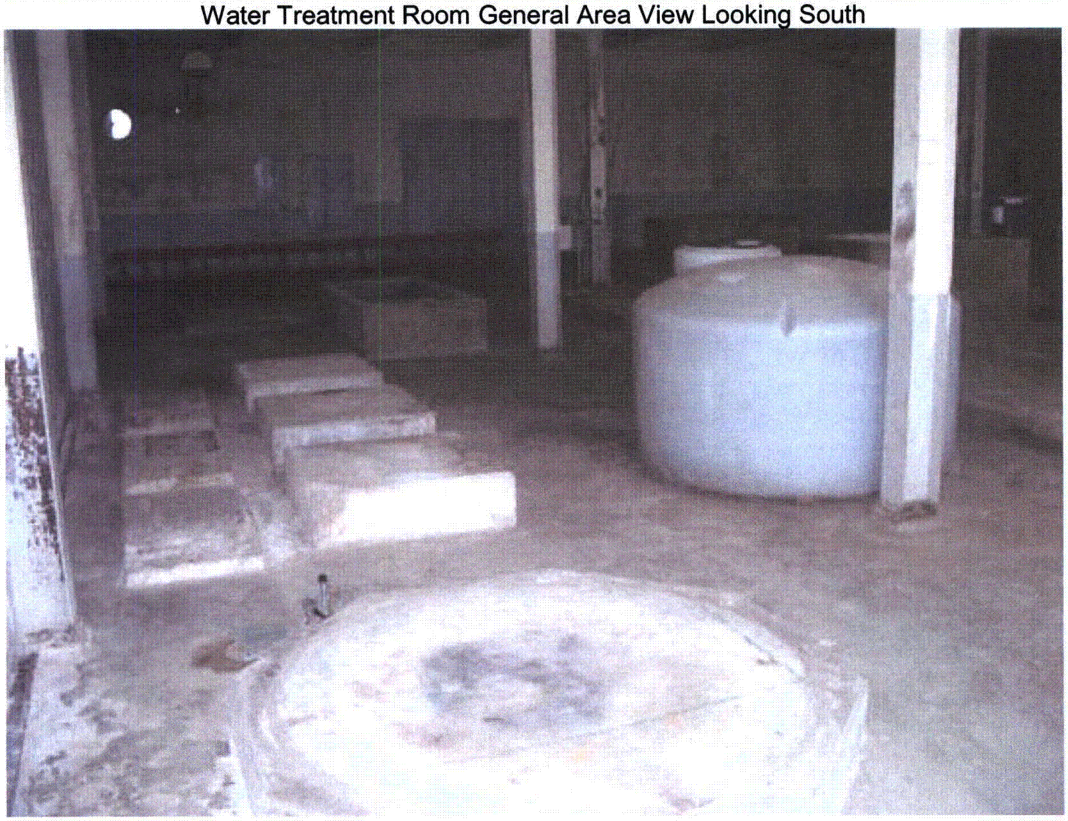


Exhibit 16, General Views of SEB Mezzanine (Survey Unit SE-2-2)

Room Nineteen (19A) General Area North

Room Nineteen (19A) General Area South

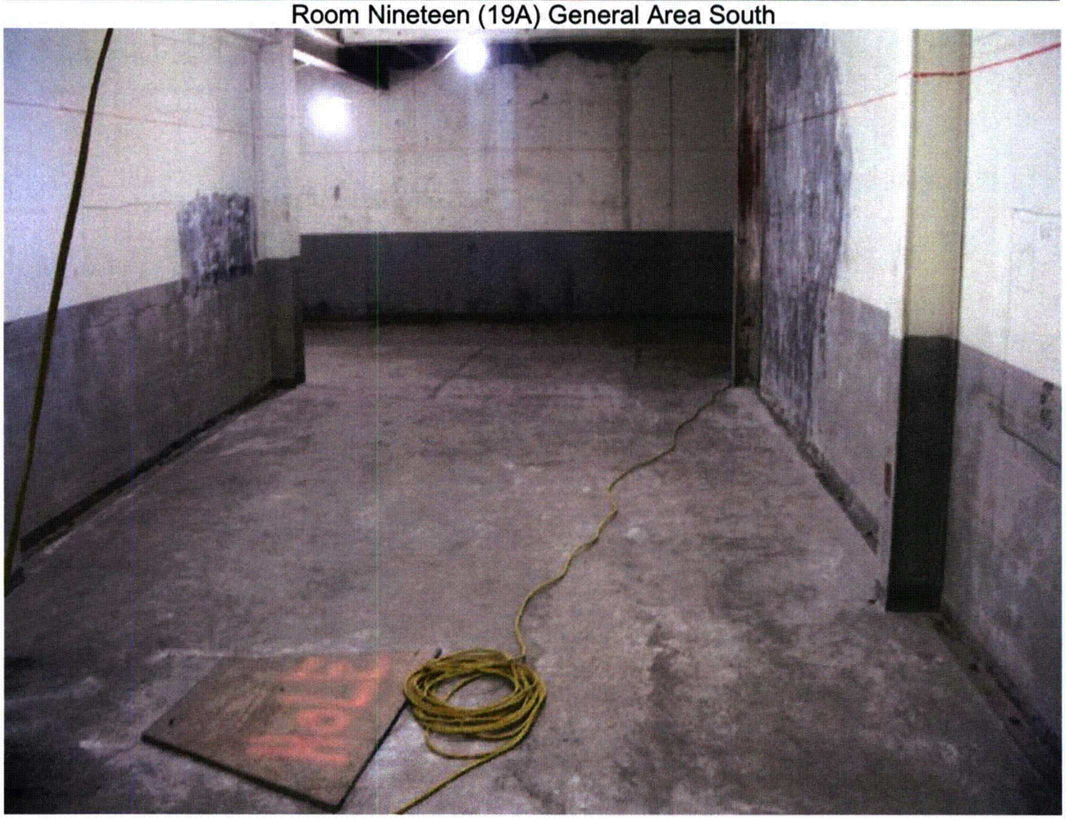


Exhibit 17, SEB Mezzanine Room 14 Landing (Survey Unit SE-2-3)

Room 14 Looking South

Room 14 Landing Looking South

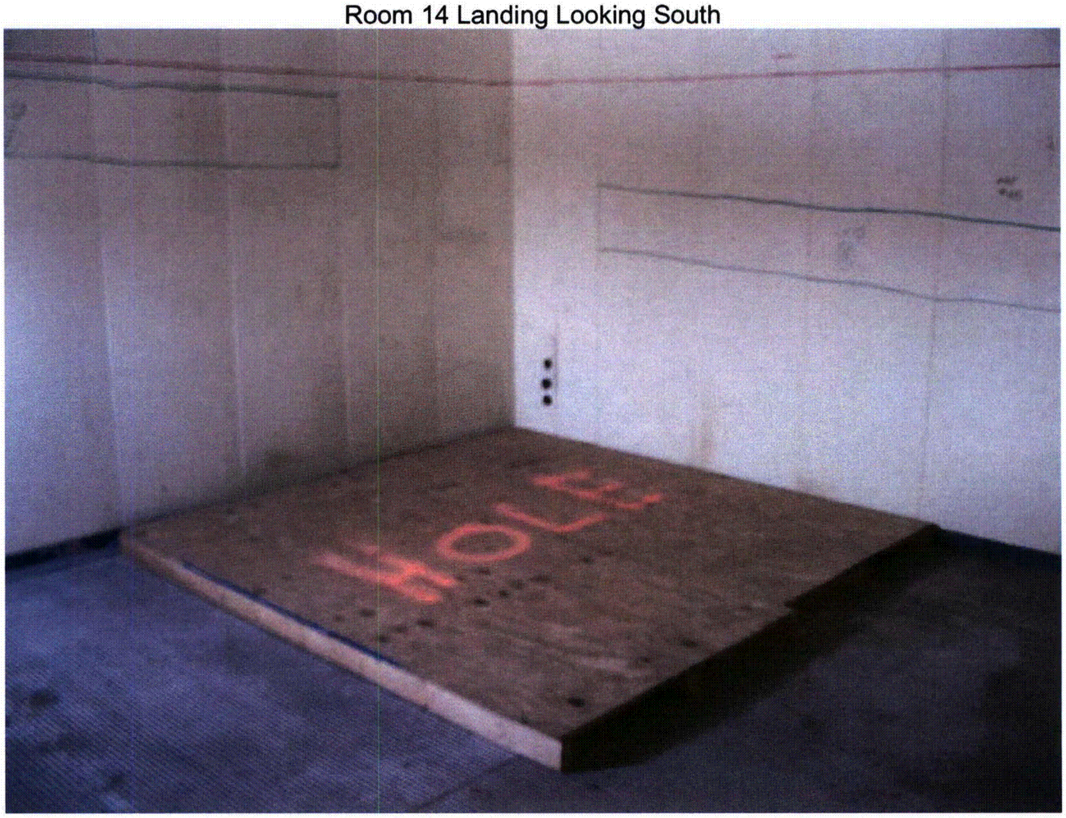


Exhibit 18, SEB Mezzanine (2nd Fl.) Office Rooms (Survey Unit Se-2-4)

Office Room 3 Looking West

Office Room 2 Looking East

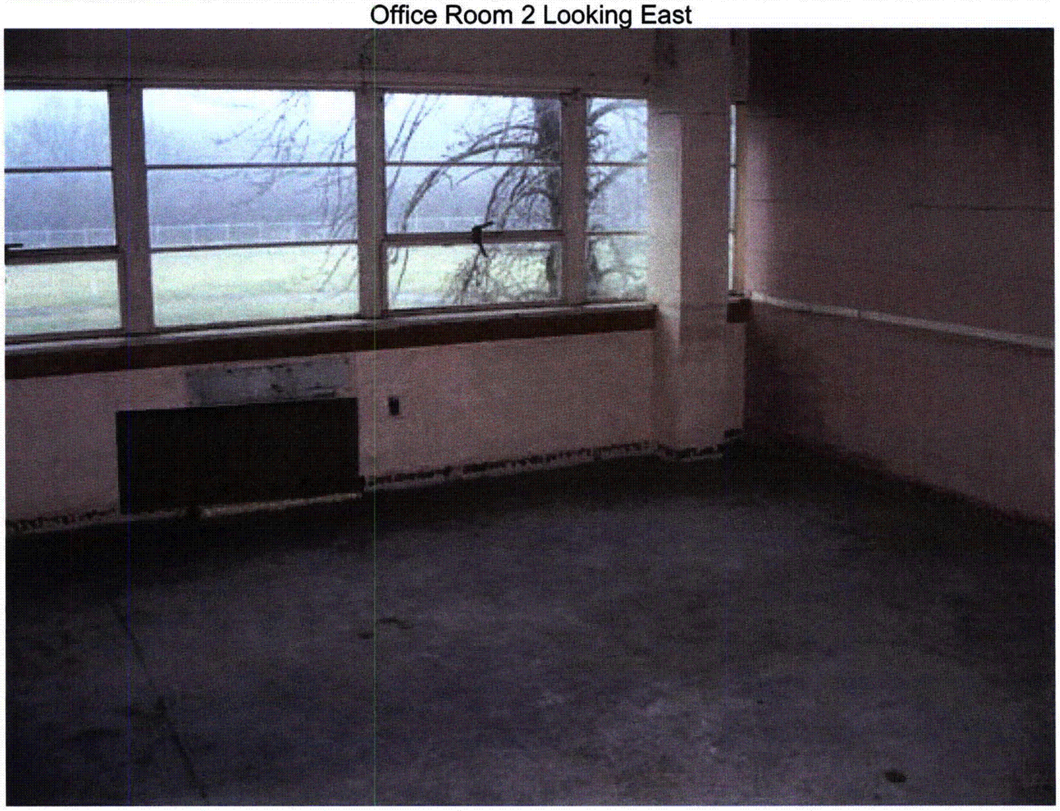


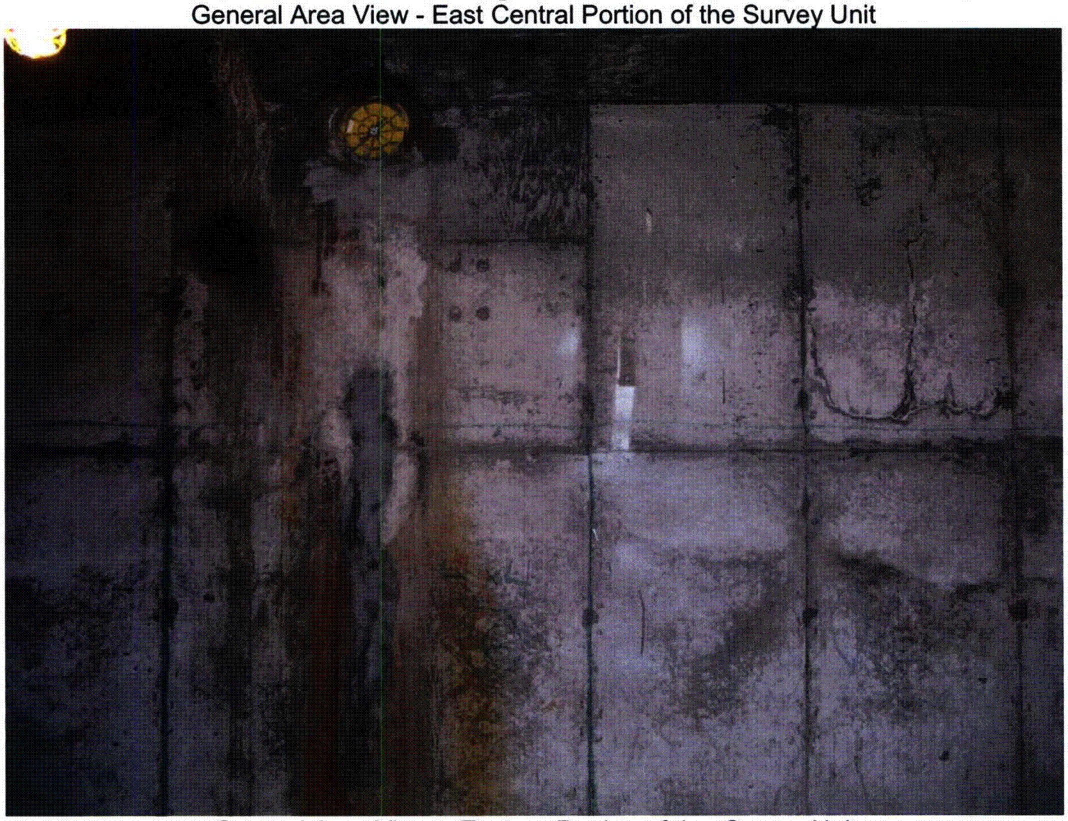
Exhibit 19, SEB Cold Pipe Tunnel Floor (Survey Unit SE-3-8)

General Area View of Floor Surface Looking East.

General Area View of Floor Surface Looking West

Exhibit 20, Views of SEB Cold Pipe Tunnel Walls (Survey Unit SE-3-15)

General Area View - East Central Portion of the Survey Unit



General Area View – Eastern Portion of the Survey Unit

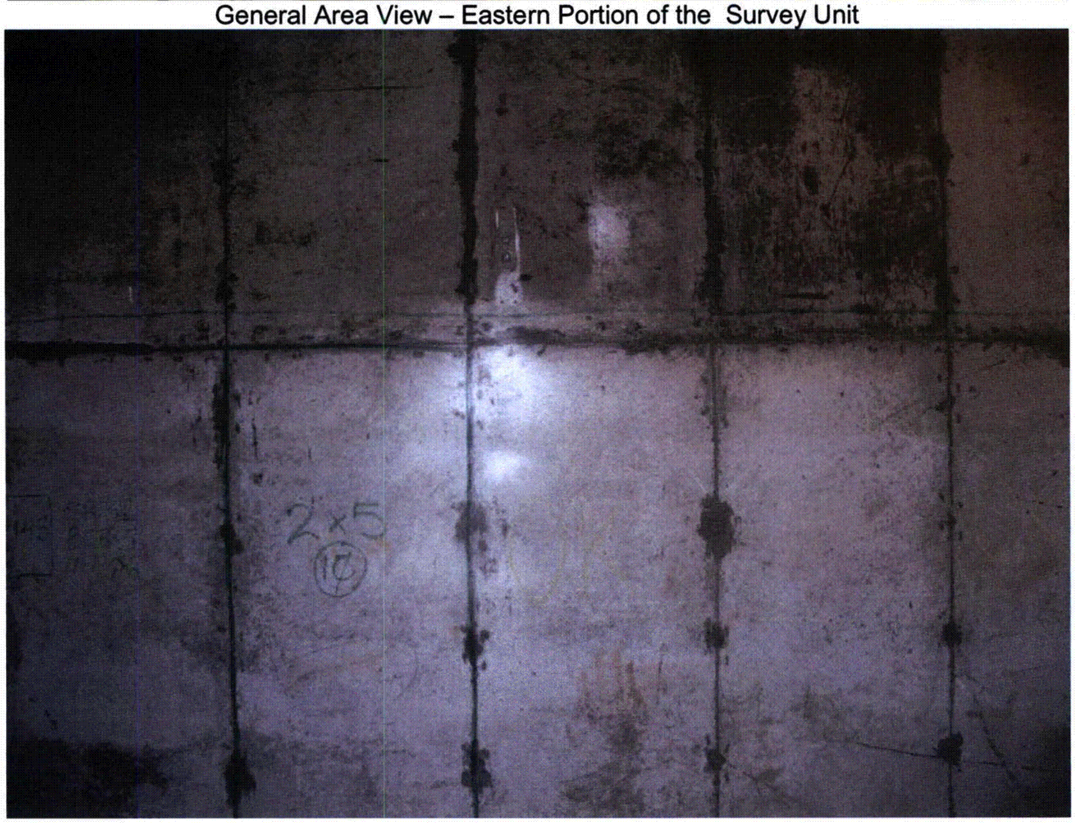
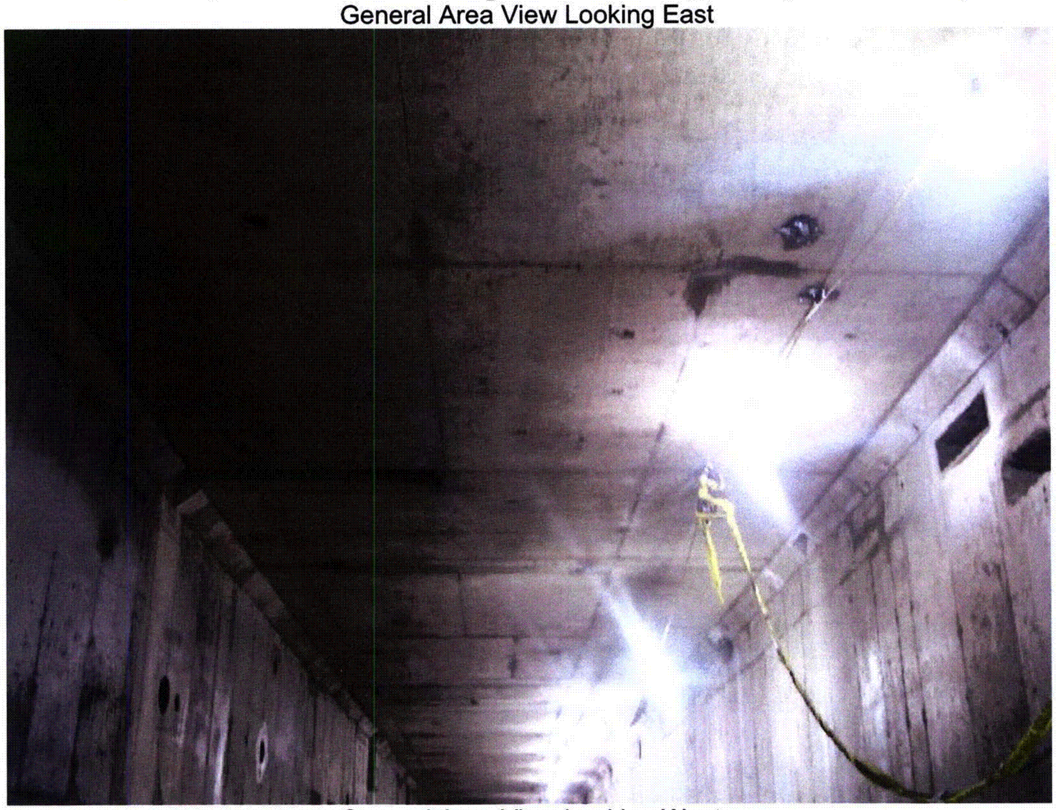


Exhibit 21, Views of SEB Cold Pipe Tunnel Ceiling(Survey Unit SE-3-23)

General Area View Looking East



General Area View Looking West

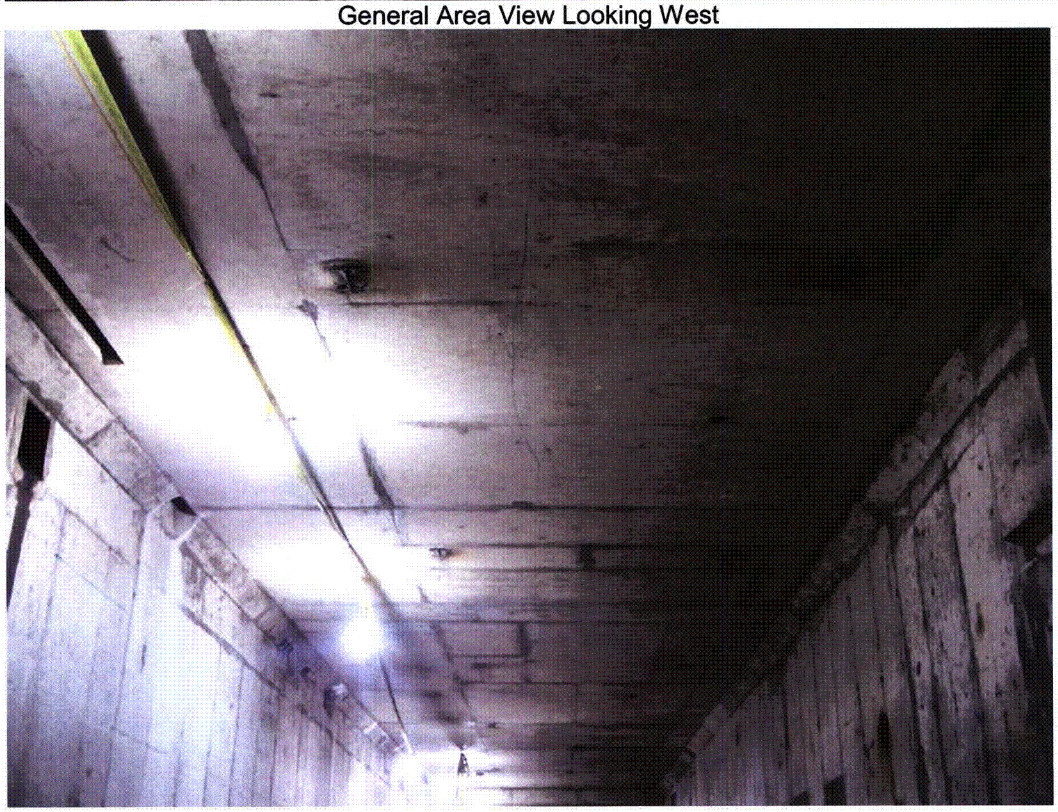
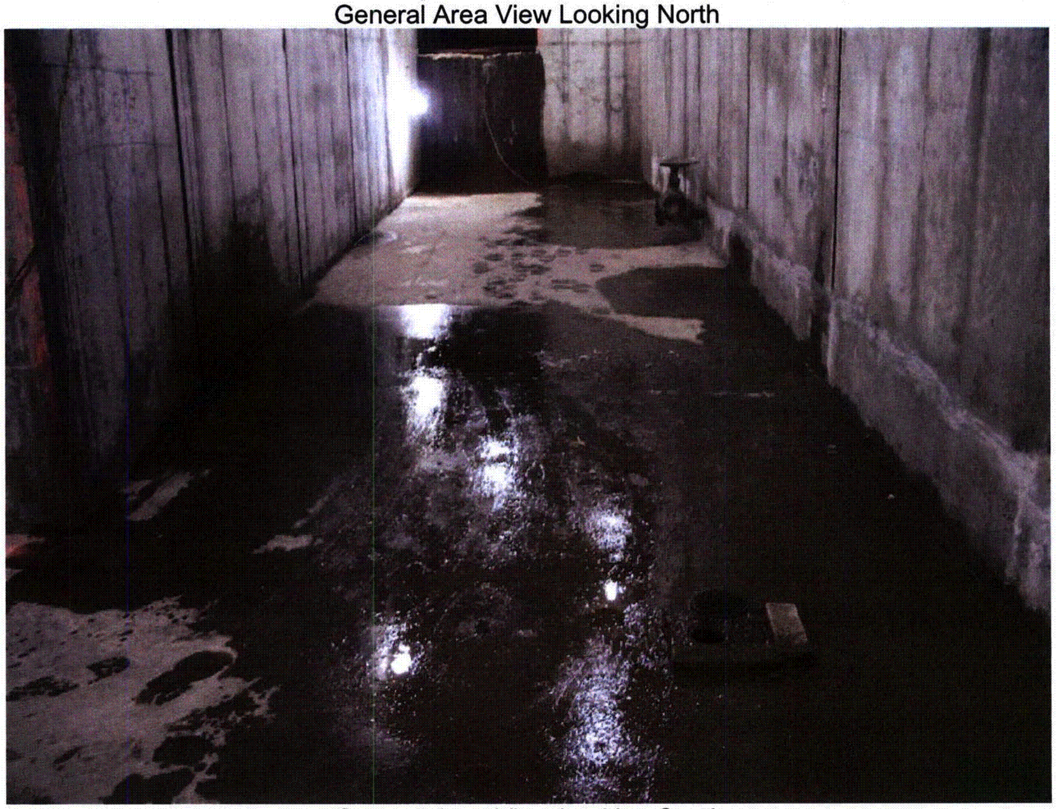


Exhibit 22, Views of SEB Cooling Tower Basin Area of CPT (Survey Unit SE-3-26)

General Area View Looking North



General Area View Looking South

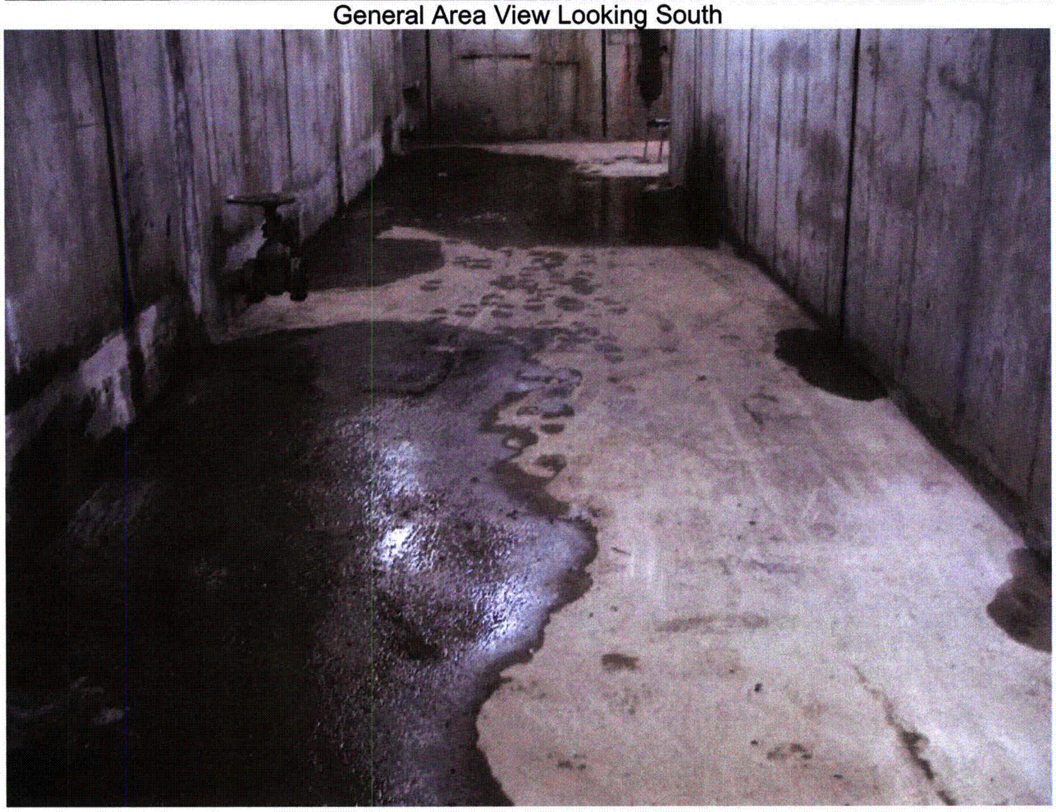


Exhibit 23, Views of SEB Cooling Tower Basin CPT Walls (Survey Unit SE-3-28)

General Area View East Wall Looking North

General Area View East Wall Looking South

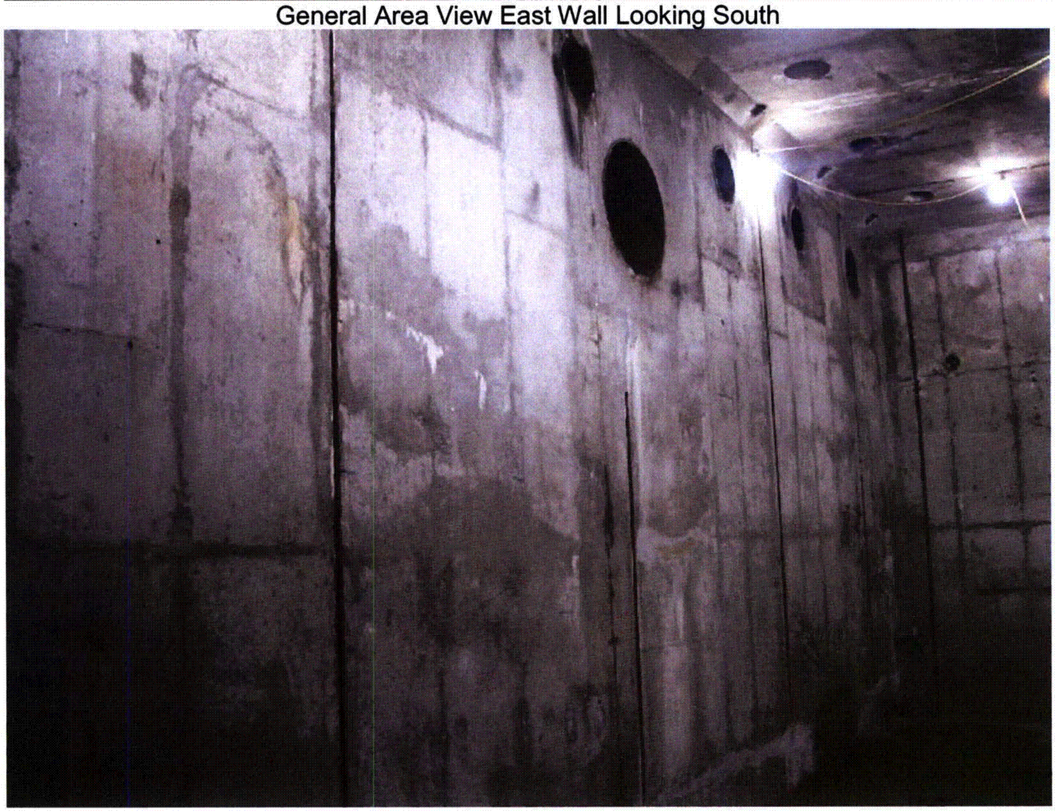


Exhibit 24, Views of SEB CPT Connecting Tunnel (Survey Unit SE-3-30)

North South Hallway - General Area View Looking North

North South Hallway General Area View Looking South

Exhibit 25, Views of SEB Basement (Survey Unit SE-3-32)

Sump Room Floor Looking West

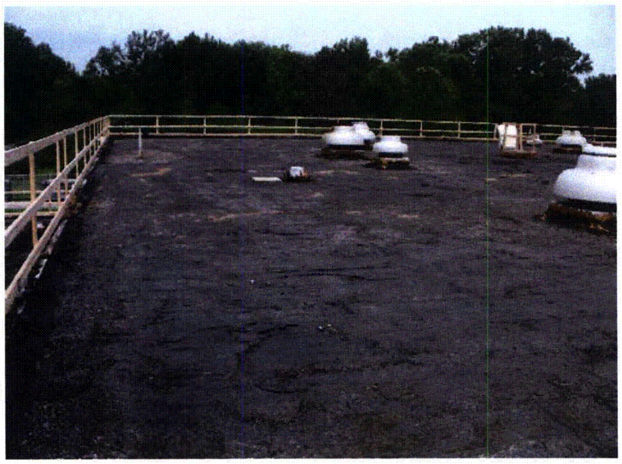
Sump Room Floor, Beams, Looking East

Exhibit 26, SEB Basement Stairwell (Survey Unit SE-3-32)

Electrical Room Bottom of Stairwell Looking South

Exhibit 27, Views of SEB Roof (Survey Unit SE-4-1)

West End – looking North



West End – looking North West

Looking east toward addition

Penetrations with tar and gravel area

Roof drain

Curling tar paper

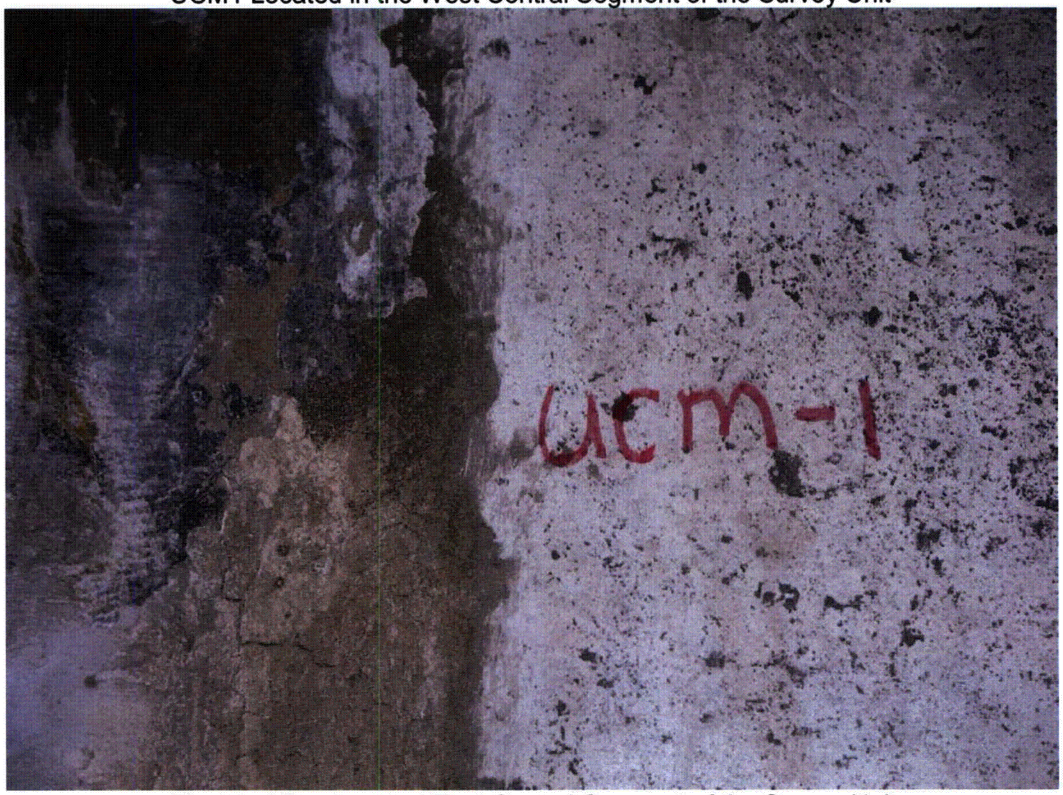
Exhibit 28, Views of Unusual Condition Measurement (UMC) Areas (Survey Unit SE-3-5)

BSI plugged Core Bores

Floor Drains Central Portion of Survey Unit

Exhibit 29, Views of Unusual Condition Measurement (UMC) Areas (Survey Unit SE-3-16)

UCM1 Located in the West Central Segment of the Survey Unit



Electrical Box Located East Central Segment of the Survey Unit