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October 22, 2008

George M. McCann
U.S. NRC Region III
2443 Warrenville Road
Suite 210
Lisle, Illinois 60532-4352

RE: NRC License 24-16273-01

Dear Mr. McCann,

In fulfillment of the timely notification requirement of CFR 30.36(d), this letter serves to officially notify the NRC that normal manufacturing and processing activities licensed at our Fort Mims Facility have ceased, effective September 30, 2008.

Sigma-Aldrich Company intends to decommission the Fort Mims facility under a Decommissioning Plan (DP), with final release of the building and property for unrestricted use. Sigma has a contractual agreement with Philotechnics, Ltd, a company licensed to perform decommissioning activities, to complete the scope of work defined in the DP under Purchase Order 4100240836.

The attached DP and Facility Management and Oversight Agreement, detail the policies and procedures that will be used to meet all regulatory requirements for decommissioning under NUREG 1757.

Please don't hesitate to contact me regarding any questions or concerns you have in this matter.

Sincerely,

10-22-08

Thomas K Spencer / Manager, RSO
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Attachments
-Decontamination and Decommissioning Plan
-Open Land Soil Sampling and Analysis Plan
-Facility Management and Oversight Agreement
-Health Physics Operations Procedures (HPOP) – Table of Contents
-Decommissioning Plan Checklist

Sigma-Aldrich
Fort Mims Facility
Maryland Heights, MO
Decontamination and Decommissioning Plan

Sigma-Aldrich Company
PO Box 14508
St. Louis, MO 63178

U.S. Nuclear Regulatory Commission
Radioactive Materials License No. 24-16273-01

October 20, 2008

Prepared by:
Philotechnics, Ltd.
25 Mall Road, Suite 301
Burlington, MA 01803

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Attachments

ACRONYM LIST

ALARA	As Low As Reasonably Achievable
CFR	Code of Federal Regulations
D&D	Decontamination and Decommissioning
$DCGL_W$	Derived Concentration Guideline Level – Wilcoxon Rank Sum
DQO	Data Quality Objective
DSV	Default Screening Value
HSA	Historical Site Assessment
HVAC	Heating , Ventilation, Air Conditioning
MARSSIM	Multi-Agency Radiation Survey and Site Investigation Manual
MDC	Minimum Detectable Concentration
NMSS	Nuclear Materials Safety and Safeguards
NRC	U.S. Nuclear Regulatory Commission
NUREG	Nuclear Regulatory Commission Guidance Document
QAPP	Quality Assurance Project Plan
RAM	Radioactive Materials
RSO	Radiation Safety Officer
RSC	Radiation Safety Committee
TEDE	Total Effective Dose Equivalent

Executive Summary

Sigma-Aldrich Chemical Co. (Sigma-Aldrich) is planning to perform a radiological decontamination and decommissioning (D&D) of their Fort Mims Facility located at 11542 Fort Mims Drive, Maryland Heights, MO. The two-story building consists of laboratory and office space. Sigma Aldrich has determined that the site meets the definition of a Decommissioning Group 3 site.

The goal of decommissioning is to achieve unrestricted release of the site. Sigma-Aldrich has contracted Philotechnics Ltd. to perform the decommissioning activities including characterization, remediation, final status surveys and development of a final report. All onsite activities will be performed under a reciprocity agreement with the NRC using Philotechnics' Massachusetts Radioactive Materials License No. 56-0543. The preparation phase of this decommissioning began on September 24, 2008 with a proposed completion date of March 31, 2009. In the event of any significant changes or newly discovered conditions that would change the direction of this D&D, an amendment will be submitted with an additional plan for the NRC to review.

Radioactive materials used at the Fort Mims facility consisted of Carbon-14 (C-14) and Tritium (H-3).

This plan was developed using the guidance provided in NUREG 1757, "Consolidated NMSS Decommissioning Guidance" Volumes 1-3 and NUREG 1575, "Multi-Agency Radiation Survey and Site Investigation Manual" (MARSSIM). It provides the approach, methods, and techniques for the radiological D&D of impacted areas of the facility. Final status surveys are designed to implement the protocols and guidance provided in MARSSIM to demonstrate compliance with the default screening values specified in NUREG 1757, Volume 2, Appendix H. These methods ensure technically defensible data is generated to aid in determining whether or not these facilities meet the release criteria for unrestricted use specified in 10 CFR 20 Subpart E, 25 mrem/yr.

Sigma-Aldrich has selected has established an administrative goal of 10 mrem/yr for the Surface and Structure release criteria.

Soil Analysis and Sampling is not addressed in this plan. A separate document discussing the methodology and sampling requirements has been prepared and will be submitted separately from this document.

1.0 General Facility Description

The Sigma-Aldrich property in Maryland Heights, Missouri consists of a two-story building of approximately 1,858 square meters. The building is constructed on a concrete slab. The building exterior walls are a combination of cinder block, sheet metal and wood. The building roof is sheet metal and foam. Interior floors are a combination of carpeted concrete, tile over concrete and painted concrete. Interior walls are primarily painted drywall with a few painted cinder block walls. The facility is located on approximately 1 acre parcel in a commercial/light industrial park. Radioactive materials were used in specific areas within this building since 1975. Actual production activities were suspended at the facility on September 30, 2008.

2.0 Historical Site Assessment

The purpose of the historical site assessment (HSA) is to determine the current status of the site including potential, likely, or known sources of radioactive contamination by gathering data from various sources. This data includes physical characteristics and location of the site as well as information found in site operating records.

Philotechnics conducted extensive reviews of facility records on August 5-6, 2008. The records review included: radioactive materials licenses, license applications, amendment requests, radiological surveys, radionuclide receipt and distribution records, incident reports and blueprint plans.

2.1 Radioactive Materials License

The Fort Mims Facility currently operates under U.S. Nuclear Regulatory Commission Radioactive Materials License Number 24-16273-01, Amendment #16, with an expiration date of March 31, 2012. Since the last license renewal, approved on March 13, 2002, the license was amended once. An amendment application dated June 20, 2006 was submitted to change the Radiation Safety Officer. This amendment was approved on August 24, 2006 as Amendment #16.

Radioactive materials usage at the site consisted of research and development activities as defined in 10 CFR 30.4 and storage, processing and use in the production of labeled compounds for distribution to authorized recipients. Current possession limits are provided in Table 2.1.

Table 2.1 –Current License Possession Limits

Isotope	Physical Form	Possession Limit
Hydrogen-3	Any	1000 curies (Ci)
Carbon-14	Any	800 curies (Ci)

2.2 Potential Contaminants

Based on the HSA, the only radionuclides used in unsealed form at the Fort Mims Facility are provided in Table 2.2.

Table 2.2 – Radionuclides Used in Unsealed Form

Isotope	Half-Life	Last Use
C-14	5730 years	Presently Used
H-3	12.3 years	Presently Used
Cl-36	3.01E5 years	Never Used
P-32	14.29 days	Never Used
P-33	25.3 days	Never Used
S-35	87.39 days	Never Used
Se-75	119.78 days	Never Used

The maximum amounts of each radionuclide on site were 12 Ci of H-3 in 1998 and 570 Ci of C-14 in 1991. The inventory of each radionuclide has declined steadily each year since these respective maximums. By the end of 2007, there were 1.7 Ci of H-3 and 21 Ci of C-14 present at the site. The most current radionuclide inventory as of July 31, 2008 is 2.2 Ci of H-3 and 21 Ci of C-14.

Chlorine-36 (Cl-36), Phosphourus-32 (P-32) Phosphourus-33 (P-33), Selenium-75 (Se-75) and Sulfur-35 (S-35) were previously listed on the license. An amendment application dated February 27, 1991 was submitted with a request to remove Cl-36, P-33 and Se-75 from the license due to lack of use. These nuclides were removed and the license was approved as Amendment #11. On August 24, 2001, a license renewal application was submitted with a request to remove P-32 and S-35 from the license due to lack of use. These nuclides were removed from the license as Amendment # 15.

Cl-36, P-32, P-33, S-35 and Se-75 were never used at the site prior to their removal from the license; therefore these radionuclides were eliminated as nuclides of concern for the purposes of this Decommissioning Plan.

2.3 Spills/Incidents

Minor spills were documented during the site's operational history and in all cases decontamination activities were successful in reducing levels of contamination below 2,200 dpm/100cm^2 removable. Numerous areas of elevated non-removable activity exist and have been documented during surveys performed by Philotechnics in 2003 and 2007, which are on file with the Radiation Safety Officer (RSO).

There is no history of decommissioning activities in the facility other than routine cleanup activities of minor spills.

3.0 Release Criteria

The areas being released under this decommissioning effort will be surveyed in accordance with the guidance contained in MARSSIM to demonstrate compliance with the criteria specified in 10CFR20.1402, Radiological Criteria for Unrestricted Use. The 10CFR20.1402 criteria specifies that the TEDE received by an average member of the critical group from residual radioactivity does not exceed 25 mrem per year and that the residual radioactivity has been reduced to levels that are as low as reasonably achievable (ALARA). However, an administrative limit of 10 mrem/yr, selected by Sigma-Aldrich for unrestricted use, will be used as the basis for determining the site release criteria for decontamination and decommissioning the building.

3.1 Default Screening Values

The NRC has published default screening values in NUREG 1757, Volume 2, Appendix H for commonly used radionuclides. Sigma-Aldrich has selected a lower release criterion, 10 mrem/yr. The nuclides of concern screening values for surfaces under default conditions from NUREG 1757 and Sigma-Aldrich's administrative limits are provided in Table 3.1 and Table 3.2.

Table 3.1 NUREG 1757 Default Screening Values based on 25 mrem/yr

Isotope	Half-life	Radiation Type	Total Activity (dpm/100cm^2) Note 1	Removable Activity (dpm/100cm^2)
H-3	12.3 years	Beta	1.2E8	1.2E7
C-14	5730 years	Beta	3.7E6	3.7E5

[1] The screening values are determined from the NRC DandD Ver.2.1 model and the default parameters for removable fraction are set to 0.1.

Table 3.2 Sigma-Aldrich Administrative Limits based on 10 mrem/yr

Isotope	Half-life	Radiation Type	Total Activity (dpm/100cm^2) Note 1	Removable Activity (dpm/100cm^2)
H-3	12.3 years	Beta	4.8E7	4.8E6
C-14	5730 years	Beta	1.48E6	1.48E5

[1] The screening values are determined from the NRC DandD Ver.2.1 model and the default parameters for removable fraction are set to 0.1.

3.2 Project Release Criteria

The default screening values are the basis for developing the derived concentration guideline levels (DCGLs) or release criteria for the project. The $DCGL_W$ is the radionuclide specific surface area concentration that could result in a dose equal to the release criterion. $DCGL_W$ is the concentration limit if the residual activity is essentially evenly distributed over a large area. For the purposes of this plan, the default screening values are used as the project DCGLs.

Sigma-Aldrich does not plan to develop area factors and utilize the elevated measurement comparison. All residual activity will be remediated to levels below the $DCGL_W$.

Additionally, a reasonable effort shall be made to decontaminate any detectable contamination in compliance with the ALARA principle.

3.3 ALARA Analysis

Due to the extremely low doses associated with the release criteria used for this D&D project, a quantitative ALARA analysis is not required. Default screening values are being used to establish DCGLs.

NUREG 1757 Vol 2, Appendix N states in part: "In light of the conservatism in the building surface and surface and soil generic screening levels developed by the NRC staff, the staff presumes, absent information to the contrary, that licensees or responsible parties that remediate building surfaces or soil to the generic screening levels do not need to demonstrate that these levels are ALARA. However, licensees or responsible parties should remediate their facility below these levels through practices such as good housekeeping. In addition, licensees or responsible parties should provide a description in the final status survey report of how these practices were employed to achieve the final activity levels."

4.0 Radiological Status of the Facility

The primary restricted area of the facility includes Laboratories 1-4, the QC Laboratory, the airlocks entering the lab areas. These areas are located on the first floor of the facility and require protective clothing for entry. Lesser restricted areas include the shipping and receiving area, the count room and the second floor mechanical spaces. Unrestricted areas include offices and restrooms on the first floor, a break room on the second floor and the stairwell at the front entrance.

4.1 Restricted Laboratory Areas

Floors in the restricted laboratory areas are generally contaminated from ~10,000 dpm/100 cm^2 to 52,000 dpm/100 cm^2 total activity. There are numerous localized areas of high contamination levels on the floors that range from 200,000 dpm/100cm^2 to 36,000,000 dpm/100 cm^2 total activity. Removable H-3 contamination levels range from <1000 dpm/100cm^2 to 105,000 dpm/100 cm^2. Removable C-14 contamination levels range from <1000 dpm/100 cm^2 to 1,376,000 dpm/100 cm^2.

Lower wall surfaces are generally contaminated from 10,000 dpm/100 cm^2 to 100,000 dpm/100 cm^2 total activity. Localized areas of high contamination levels range from 200,000 dpm/100cm^2 to 98,000,000 dpm/100 cm^2 total activity. Removable H-3 contamination levels range from <1000 dpm/100cm^2 to 26,400 dpm/100 cm^2. Removable C-14 contamination levels range from <1000 dpm/100 cm^2 to 32,600 dpm/100 cm^2.

The bench tops and casework interior and exterior surfaces are generally contaminated from 10,000 dpm/100cm^2 to 60,000 dpm/100 cm^2 total activity. Localized areas of high contamination levels range from 200,000 dpm/100cm^2 to 61,700,000 dpm/100 cm^2 total activity. Removable H-3 contamination levels range from <1000 dpm/100cm^2 to 1,200,000 dpm/100 cm^2. Removable C-14 contamination levels range from <1000 dpm/100 cm^2 to 1,478,000 dpm/100 cm^2.

The upper wall and ceiling surfaces are generally contaminated from 10,000 dpm/100cm^2 to 60,000 dpm/100 cm^2 total activity. Localized areas of high contamination levels range from 200,000 dpm/100cm^2 to 2,301,000 dpm/100 cm^2 total activity. Removable H-3 contamination levels range from <1000 dpm/100cm^2 to 15,400 dpm/100 cm^2.

Removable C-14 contamination levels range from <1000 dpm/100 cm^2 to 64,900 dpm/100 cm^2.

4.2 Restricted Areas Outside of the Laboratories

These areas consist of the clean counting lab, the shipping and receiving area and the second floor mechanical space above the restricted laboratories. These areas have not been fully characterized at the time this plan was developed. Based on previous history, it is expected that some incidental contamination will be detected on floor surfaces and equipment.

4.3 Non-Restricted Areas

These areas include the offices, hallways, restrooms and break room outside of the restricted areas. A few locations of elevated activity were detected on the floors in some of the 1st floor office areas. The total activity at these locations range from 42,000 dpm/100 cm^2 to 145,000 dpm/100 cm^2. Removable activity for H-3 and C-14 at these locations is <500 dpm/100 cm^2. There is one location detected on the men's restroom floor that was 3,482,000 dpm/100 cm^2 total activity. The removable C-14 at this location was 1,588 dpm/100 cm^2.

4.4 Open Land Areas

Initially the outside soil areas to the north and west of the building have been classified as impacted. This is based on samples collected by a contractor hired by Sigma Aldrich in 2003 and samples collected by the NRC in October 2007 and January 2008. Both sample sets indicated C-14 levels in the surface soils greater than of 12 pCi/g as listed in NUREG 1757, Volume 2, Appendix B Table B.2, Screening Values of Common Radionuclides for Soil Surface Contamination Levels. The samples collected in 2003 contained concentrations of C-14 ranging from 13 to 140 pCi/g. The NRC samples from 2007 and 2008 had concentrations of C-14 ranging from 2 to 137 pCi/g.

5.0 Project Management and Organization

Philotechnics will perform the project under the direction of a Project Manager (PM). The onsite project team will consist of, in addition to the PM, a Senior Health Physicist, a Health Physics Technicians (HP Techs), Waste Technicians and administrative support. All project team members will report to the PM. In addition, the project team will have full support of the corporate expertise available from Philotechnics corporate offices. These include the Corporate Radiation Safety Officer (a Certified Health Physicist, the Corporate Health and Safety Officer, the Corporate Quality Assurance Manager, and a Certified Industrial Hygienist.

5.1 Responsibilities and Authorities

Project Manager

The Project Manager will be in charge of all aspects of the project and will be the point of contact with the designated client representative and Philotechnics management. The Project Manager will also function as the Health and Safety Officer and shall ensure that a project health and safety program is followed. Specific aspects of project management include:

- Ensuring safety and quality performance on the project
- Daily project coordination and direction
- Meeting client and Philotechnics requirements
- Meeting scope, schedule and budget requirements
- Keeping management informed of project progress
- Control of project equipment and inventories
- Establishing performance measures and progress reporting
- Developing and implementing the Project Management Plan.
- Defining items to be coordinated between Philotechnics and the client.
- Providing effective leadership in direction, coordination, planning and control of cost, schedules and resources through continuous communications with project team members and the client

The Project Manager's principal job is to accomplish the assigned tasks through the active support of others. The Project Manager is responsible for the success of the project. The ultimate goal is to leave behind a satisfied client, deliver a quality project on schedule and within budget.

Certified Health Physicist
A CHP will be available to support the project planning and execution. The CHP will provide corporate-level oversight and support for this project. The CHP will ensure that work control documents and procedures are consistent with regulatory requirements; review project plans and reports for technical accuracy and completeness; advise project personnel in matters of instrument selection, ALARA considerations, waste characterization, and performance of surveys; and provide technical oversight for the entire radiation protection program.

Senior Health Physicist
The Senior Health Physics Technician reports directly to the Project Manager; responsible for overall site radiological controls, industrial safety and industrial hygiene; supervises Health Physics Technician(s); reviews all radiological surveys and sample results; maintains radiation dosimetry program (as needed); maintains the survey database; ensures that a project health and safety program is prepared and is followed; performs pre-field activity safety walk downs; ensures that all Philotechnics and Sigma Aldrich safety requirements are met; stops work as necessary when safety issues warrants; functions as the site project manager in the absence of the Project Manager. Performs pre-field activity safety walk downs; ensures that all Philotechnics and Sigma-Aldrich safety requirements are met; and stops work as necessary when safety issues warrant. The Sr HP will be responsible for overseeing and directing the HP Techs in providing job coverage and performance of surveys in support of the D&D activities.

HP Technicians
Reports to the Senior Health Physics Technician; monitors all radiological work to ensure it is performed safely and in compliance with Radiation Work Plans,

Philotechnics' Health Physics Operations Procedures; performs and documents all radiation surveys; maintains and performs other duties as assigned by the Senior Health Physics Technician.

Waste Technicians

Performs disassembly, remediation, and waste packaging in compliance with the project specific Radiation Work Permit (RWP). This includes the removal and packaging of contaminated components, operation of remote demolition equipment, and size reduction of large components. Ensure that wastes are property segregated to minimize the generation of LLRW and verify the wastes meet the designated processor waste acceptance criteria (WAC).

6.0 Health Physics Programs During Decommissioning: Radiation Safety Controls and Monitoring For Workers

All D&D activities will be conducted under Philotechnics Massachusetts Radioactive Materials 56-0543 license under reciprocity with the NRC. Specifically, the scope of activities will be performed under Philotechnics Radiation Protection Program for Massachusetts Licensed Activities and Philotechnics Health Physics Operations Procedures.

6.1 Radiation Work Permits

Specific Radiation Work Permit(s) (RWPs) will be developed for the project activities in accordance with Philotechnics' Health Physics Operations Procedures Manual. The RWP will contain at least the following:

- Location of work
- Job description
- Unique RWP number
- Expected radiological conditions
- Effective dates/times of work
- PPE and dosimetry requirements
- Limiting conditions
- Special instructions

6.2 Air Sampling Program

Air sampling will be conducted in accordance with Philotechnics Health Physics Operations Procedures Manual. Air sampling is required to measure the radioactivity to which workers are exposed if worker intakes are expected to result in a committed effective dose of 100 mrem or more. Air samples are also required if respiratory protection is worn to reduce workers intakes of radioactive materials, and to verify the effectiveness of engineering controls.

Breathing zone and general area air samples will be collected during aggressive remediation and dismantlement activities of highly contaminated equipment and structures. The samples will be analyzed by liquid scintillation counting and compared to the C-14 Derived Air Concentration (DAC) value of 1 x 10-6 μCi/ml. The results will be forwarded to Philotechnics Corporate Radiation Safety Officer for review and determination if continued sampling is required or if respiratory protection is required.

It is evident from the characterization surveys performed by Philotechnics that the vast majority of residual contamination is C-14. Personnel exposures from H-3 are expected to be significantly less and will be evaluated based on the bioassay results.

6.3 Respiratory Protection Program

Philotechnics has developed a corporate respiratory protection program which describes training, fit tests, selection, use, and maintenance of respiratory protection devices. Certain activities during the decommissioning will require individuals to wear respiratory protection. These activities include aggressive decontamination and demolition of highly contaminated surfaces and structures. Prescribed respirators are powered air purifying respiratory (PAPR) hoods providing a protection factor (PF) of 1000 for particulate airborne radioactivity. Respirators are assumed to provide no protection (PF=1) against H-3 in any form.

6.4 Internal Exposure Determination

Internal exposure may result from ingestion or inhalation of C-14 or H-3. Because the chemical form of C-14 present is not always known, Philotechnics will default to the most conservative DAC value of 1 E-6 uCi/ml. The DAC for H-3 is 2 E-5 uCi/ml, a factor of 20 higher than that of C-14. Approximately two-thirds of the contamination present at the site is C-14.

In accordance with Philotechnics Health Physics Operations Procedures Manual internal exposure to radionuclides will be measured by urine bioassay and supplemented with air sampling. Initially, bioassays will be collected every 14 days and sent to an independent laboratory for analysis. Additional bioassays will be ordered in the event of respirator failure, unexpected airborne radioactivity in excess of 1 DAC where respirators are not worn, or facial contamination. Intakes will be determined using the guidance contained in NUREG 4884 and internal dose will be determined using the guidance in Federal Guidance Report 11.

Air sampling is performed to supplement the bioassay program, verify the effectiveness of engineered and administrative controls, and to provide guidance for use of respiratory protection. Air sampling will consist of a combination of general area and breathing zone samplers for particulate radioactive material. Air samples that are representative of the breathing zone will be collected whenever respiratory protection is used for limiting internal radiation exposure.

6.5 External Exposure Determination

Because the only radionuclides known to be present at the site are H-3 and C-14, the likelihood of individuals receiving external radiation exposure at the site is very small. Regardless, individuals having unescorted access to the restricted area will be monitored for external radiation exposure with whole-body thermoluminescent dosimeter (TLD). TLDs will be worn on the front portion of the trunk of the body, between the waist and neck. Visitors will be issued self-reading dosimeters and escorted in the restricted area.

6.6 Summation of Internal and External Exposures

In accordance with 10 CFR 20.1202, internal and external doses are summed such that the total effective dose equivalent is equal to the sum of the deep dose equivalent and the committed effective dose equivalent.

6.7 Contamination Control Program

All work activities are performed under the guidance of a radiological work permit. Many of the contamination control measures are discussed elsewhere in this document; however, a description of the methods used follows.

Removable contamination in areas accessible to personnel – such as high traffic areas and ingress/egress routes – is controlled by decontamination where practicable. In the event decontamination is not practicable, contamination is controlled through a combination of anti-contamination clothing and covering of surfaces, as appropriate. Anti-contamination clothing will be worn as specified in the RWP when working in contamination areas.

Aggressive decontamination techniques such as scabbling will be done with negative ventilation attached to the tool. Ventilation will be drawn through a HEPA-filtered vacuum cleaner. Discharge will be to the building ventilation system where possible. If not possible discharge will be inside the building and a general area air sampler will be placed in the vicinity of the discharge.

Ductwork, fume hoods, gloveboxes, and other highly contaminated components will be sprayed with a fixative agent prior to disassembly.

Work areas and components will be monitored for contamination frequently during work activities to ensure radiological controls are adequate for the conditions.

Individuals exiting contamination areas are required to proceed to the nearest frisking station and monitor themselves for contamination. Contaminated individuals shall not exit the restricted area.

7.0 Planned Decommissioning Activities

7.1 Contaminated Structures

Remediation activities in all laboratories will include the removal of loose equipment, flame cabinets, drawer contents, drum compactor, fume hoods and ceiling tiles that are contaminated above the licensee's release criteria. Floor tiles and drywall will be removed where established contamination limits are exceeded. Concrete walls and floors will be remediated, as required, using scabbling, scarifying or breaking equipment. All contaminated materials will be treated as Low-Level Radioactive Waste (LLRW). Additional remediation activities that will be used include simple decontamination (i.e. wet wiping with a mild detergent) and removal of contaminated material. If it is likely that radioactive materials have migrated to inaccessible areas, such as under casework, dismantlement will be required to assess the activity levels in these areas.

7.2 Contaminated Systems and Equipment

Contaminated ventilation, drain and vacuum system components will be removed and managed as LLRW. In limited cases, such as short runs of ventilation ducts, decontamination of system internals may be performed. Administrative and engineering controls, as discussed above, will be put in place to prevent the spread of contamination during any removal operations.

7.3 Subsurface Structure

Prior to expansion of the facility in 1980, the primary sewers from the facility led to a septic tank that was abandoned as the facility switched to city sewers. It is believed that the tank was filled with a concrete grout and abandoned in place. The location of this septic tank is believed to be below what is now Laboratory #2 (Survey Unit FMF-05). As part of the decommissioning activities, this septic tank will be characterized to determine if contamination is present above the site's decommissioning criteria. This will require coring through the existing concrete slab or possibly complete excavation. Based on the results of this evaluation it may be necessary to perform sampling of the leach lines and adjacent soils.

8.0 Project Schedule

A detailed schedule of the D&D activities are described in the Proposed Gantt Chart provided in Attachment B. The activities in this Gantt Chart are contingent upon the NRC's approval of this D&D. In the event of any changes that would significantly alter the schedule, an updated schedule will be submitted to the NRC. If the D&D is not completed within the timeframe pursuant to 10 CFR 30.36(h)(1), a request for an alternative schedule to complete the D&D will be submitted.

9.0 Effluent Control Program

The facilities HEPA filtered local exhaust systems will continue to operate during the decommissioning activities to maintain negative pressure within the restricted areas. Effluent monitoring on the exhaust stacks will continue to be performed by Sigma-Aldrich throughout the project activities until it become necessary to remove the fans from operation. All removal and decontamination activities will be conducted to ensure that contamination is not spread by applying strict contamination and engineering controls. These include the use of fixative agents and portable HEPA ventilation units.

10.0 Radioactive Waste Management

All waste will be packaged in appropriate DOT compliant shipping containers, where required, for shipment to licensed processors or disposal facilities. Some waste may require sizing for packaging in the appropriate shipping containers. All waste will be stored in approved storage areas at the facility until shipment off-site. Radioactive waste will be subdivided into categories based on types of material and processing methods. Radioactive subdivisions include metals, DAW/Combustible, asbestos containing, and mixed wastes. All radioactive waste will be transported via DOT compliant carriers and manifested by qualified waste shippers and/or brokers to licensed waste processors and/or disposal sites as appropriate.

It is estimated that there will be approximately 78,000 lbs of dry active waste and approximately 3,000 lbs of radioactive ACM waste that will require disposed. The LLRW will be packaged and shipped to Toxco Inc. in Oak Ridge, TN for processing and eventual disposal at Energy Solutions facility in Clive, Utah.

The remaining contaminated chemical stocks, labeled compounds and mixed wastes are currently being inventoried and packaged for shipment to Perma-Fix Northwest in Richland, WA; Diversified Scientific Services Inc (DSSI) in Kingston, TN; and Materials & Energy Corp (M&EC) in Oak Ridge, TN.

11.0 Survey Instrumentation

11.1 Instrument Calibration

Laboratory and portable field instruments will be calibrated at least annually with National Institute of Standards and Technology (NIST) traceable sources, where feasible, and to radiation emission types and energies that will provide detection capabilities similar to the nuclides of concern.

11.2 Functional Checks

Functional checks will be performed at least daily when in use. The background, source check, and field measurement count times for radiation detection instrumentation will be specified by procedure to ensure measurements are statistically valid. Background readings will be taken as part of the daily instrument check and compared with the acceptance range for instrument and site conditions. If an instrument fails a functional check, all data obtained with the instrument since the last satisfactory check will be invalidated.

11.3 Determination of Counting Times and Minimum Detectable Concentrations

Minimum counting times for background determinations and counting times for measurement of total and removable contamination will be chosen to provide minimum detectable concentrations (MDC) that meet the data quality objectives (DQOs) specified in this plan. MARSSIM equations relative to building surfaces have been modified to convert to units of dpm/100cm^2. Count times and scanning rates are determined using the following equations:

11.3.1 Static Counting

Static counting Minimum Detectable Concentration at a 95% confidence level is calculated using the following equation, which is an expansion of NUREG 1507, "Minimum Detectable Concentrations with Typical Radiation Survey Instruments for Various Contaminants and Field Conditions", Table 3.1 (Strom & Stansbury, 1992):

$$MDC_{static} = \frac{3 + 3.29\sqrt{B_r \cdot t_s \cdot (1 + \frac{t_s}{t_b})}}{t_s \cdot E_{tot} \cdot \frac{A}{100cm^2}}$$

Where:

MDC_{static} = minimum detectable concentration level in dpm/100cm^2
B_r = background count rate in counts per minute
t_b = background count time in minutes
t_s = sample count time in minutes
E_{tot} = total detector efficiency for radionuclide emission of interest (includes combination of instrument efficiency and 0.25 surface efficiency for beta emitters <400 keV max)
A = detector probe area in cm^2

11.3.2 Ratemeter Scanning

Scanning Minimum Detectable Concentration at a 95% confidence level is calculated using the following equation which is a combination of MARSSIM equations 6-8, 6-9, and 6-10:

$$MDC_{scan} = \frac{d'\sqrt{b_i}\left(\frac{60}{i}\right)}{\sqrt{p} \cdot E_{tot} \cdot \frac{A}{100cm^2}}$$

Where:

MDC_{scan} = minimum detectable concentration level in dpm/100 cm^2
d' = desired performance variable (1.38)
b_i = background counts during the residence interval
i = residence interval
p = surveyor efficiency (0.5)
E_{tot} = total detector efficiency for radionuclide emission of interest (includes combination of instrument efficiency and 0.25 surface efficiency for beta emitters <400 keV max)
A = detector probe area in cm^2

11.3.3 Smear Counting

Smear counting Minimum Detectable Concentration at a 95% confidence level is calculated using the following equation, which is NUREG 1507, "Minimum Detectable Concentrations with Typical Radiation Survey Instruments for Various Contaminants and Field Conditions", Table 3.1 (Strom & Stansbury, 1992):

$$MDC_{smear} = \frac{3 + 3.29\sqrt{B_r \cdot t_s \cdot (1 + \frac{t_s}{t_b})}}{t_s \cdot E}$$

Where:

MDC_{smear}	=	minimum detectable concentration level in dpm/smear
B_r	=	background count rate in counts per minute
t_b	=	background count time in minutes
t_s	=	sample count time in minutes
E	=	instrument efficiency for radionuclide emission of interest

11.4 Counting Uncertainty

The counting uncertainty for both total and removable measurements will be calculated using equation 6-15 from MARSSIM:

$$\sigma_R = \sqrt{\frac{C_{s+b}}{T_{s+b}^2} + \frac{C_b}{T_b^2}}$$

Where:

σ_R	=	uncertainty
1.96	=	multiplier to achieve 95% confidence level
C_{s+b}	=	gross counts of the sample (cpm)
T_{s+b}	=	Sample time (minutes)
C_b	=	Gross background counts (cpm)
T_b	=	Background count time (minutes)

11.5 Uncertainty Propagation and Confidence Interval

Because calculations to determine the final static measurement results are based on dividing the net count rate by total efficiency, the uncertainty propagation formula to be used is as follows (MARSSIM Section 6.8.3):

$$\sigma_A = u\sqrt{\left(\frac{\sigma_{R_b}}{R_b}\right)^2 + \left(\frac{\sigma_E}{E}\right)^2}$$

Where:

σ_A	=	Measurement propagated error or total uncertainty
u	=	Final result in dpm/100 cm^2
σ_{R_b}	=	Standard deviation or statistical counting uncertainty of the net count rate
R_b	=	Net count rate

σ_E = Standard deviation of the instrument efficiency

E = Instrument efficiency

Referring to MARSSIM Table 6.9, a k value of ±1.96 represents a confidence interval equal to 95 percent about the mean of a normal distribution. All total activity measurements will be presented as the final result in dpm/100 cm^2 $\pm 1.96\,\sigma_A$.

11.6 Instrumentation Specifications

The instrumentation used for facility decommissioning surveys is summarized in the following tables. Table 10.1 lists the standard features of each instrument such as probe size and efficiency. Table 10.2 lists the typical operational parameters such as scan rate, count time, and the associated Minimum Detectable Concentrations (MDC). Alternate or additional instrumentation with similar detection capabilities may be utilized as needed for survey requirements with RSO approval.

Table 11.1 – Instrumentation Specifications

Detector Model	Detector Type	Detector Area	Meter Model	Window Thickness	Typical Total Efficiency
NE IBP19DD	Beta Scintillation	100 cm^2	Ludlum 2350-1	0.9 mg/cm^2	5 % (C-14)
Ludlum 43-37 Floor Monitor	Gas Flow Proportional	582 cm^2	Ludlum 2221	0.8 mg/cm^2	7% (C-14)
Packard	Liquid Scintillation	N/A	N/A	N/A	40% (H-3) 80% (C-14)

Table 11.2 – Typical Instrument Operating Parameters and Sensitivities

Measurement Type	Detector Model	Meter Model	Scan Rate	Count Time	Background (cpm)	MDC (dpm/100cm^2)
Surface Scans	NE IBP19DD	Ludlum 2350-1	2 in./sec.	N/A	350	3,843 (C-14)
Surface Scans	Ludlum 43-37 Floor Monitor	Ludlum 2221	4 in./sec.	N/A	1000	1,855 (C-14)
Total Surface Activity	NE IBP19DD	Ludlum 2350-1	N/A	60 sec.	350	1,801 (C-14)
Removable Beta Activity	Packard	N/A	N/A	60 sec.	25 (H-3) 15 (C-14)	41 (H-3) 25 (C-14)

12.0 Characterization Surveys

For this plan, characterization survey activities will involve detailed assessment of building surfaces and structures, surface and subsurface soil. This characterization survey is designed to determine the extent of contamination, estimate remediation alternatives, identify the classification of each survey unit described in Section 13.3 and determine site specific DCGLs.

The survey protocol for building surfaces and structures will include surface scanning, surface activity (static) measurements, exposure rate measurements and sample collection (smears). The purpose of scanning is to identify locations of elevated activity. Where elevated activity is identified, a static measurement and smear will be taken at the location of highest activity identified during the scan. Where elevated activity is identified, the boundary of the elevated area will be marked to aid in locating the area for remedial actions. Based on contamination potential, at least twenty locations in each survey unit will be judgmentally selected to perform static measurements and removable contamination measurements. Judgmental static measurements and smears shall also be taken on vertical surfaces as part of final status survey protocols described in Section 14.6.

The survey protocol for building system surveys will consist of performing contamination measurements of internal surfaces of ventilation and drain and vacuum systems. The percentage of systems surveyed will be consistent with the Section 13.8 of this plan.

For areas that are partially contaminated, the characterization survey data can be used as part of the final status survey measurements provided the data used is only from areas with contamination levels below the release criteria, and decontamination work is controlled such that the survey location could not have become cross-contaminated.

Each survey unit will have an independent survey package that has specific survey instructions. The survey package will contain, at a minimum:

- Survey Unit number (e.g., Building and Room Number, System Number, etc.)
- Percentage of surface requiring scan surveys
- Number of total and removable contamination measurements
- Instrumentation to be used with static count times and scan rates
- Any additional specific survey instruction
- Maps of the survey unit surfaces

If the initial characterization survey results indicate that contamination is not present in excess of the release criteria, then data from the survey may be used as part of the final status survey.

13.0 Remedial Action Surveys

Remediation will be conducted in such a manner to control the spread of contamination and keep personnel exposures ALARA. Remedial action surveys are conducted in support of remediation activities to help determine when the area is ready for a final status survey and to provide updated estimates for final status survey planning. Remedial action surveys serve to monitor the effectiveness of decontamination efforts and ensure that surrounding areas are not cross-contaminated from remediation actions.

Remedial action surveys will consist of scan surveys, direct measurements and removable contamination measurements. These will be conducted following remediation activities to establish the success or failure of the efforts to decontaminate the applicable survey area. Results of the survey will be the decision basis for continued remediation or conduct of final status surveys. The survey documentation resulting from remedial action surveys will be maintained with the original characterization survey package.

Remedial action surveys will be designed to meet the objectives of the final status surveys. To the extent allowed by MARSSIM, the results of the remedial action surveys will be used to supplement the final status survey.

14.0 Design and Performance of Final Status Surveys

Final status surveys are performed to demonstrate that residual radioactivity in each survey unit satisfies the predetermined criteria for release for unrestricted use. The final status survey will be conducted using the Data Quality Objective (DQO) process. Characterization and remedial action survey data will be used as final status survey data to the maximum extent possible in order to minimize overall project costs.

Final status surveys will be conducted by performing required scan surveys, total direct surveys, removable contamination measurements and solid sampling as discussed further in this section. All survey data shall be documented on survey maps and associated data information sheets.

14.1 Background Determination

The use of reference background areas or paired background comparisons is not necessary for the purposes of this plan due to the high release criteria. An ambient background measurement taken at waist level in the center of each survey unit will be used. The ambient background value will be subtracted from the applicable FSS gross measurement count rates (in cpm) to determined the net measurement count rate.

14.2 Data Quality Objectives (DQO)

The Data Quality Objective Process as described in MARSSIM is used throughout the design and implementation of survey design. The following is a list of the major DQOs for the survey design described in this plan:

- Static measurements will be taken to achieve an MDC_{static} of less than 10% of the DCGLs.
- Scanning will be conducted at a rate to achieve an MDC_{scan} of less than 50% of the DCGLs.
- Individual measurements will be made to a 95% confidence interval.
- Decision error probability rates will initially be set at 0.05 for both α and β decision errors.
- The null hypothesis (H_0) and alternate null hypothesis (H_A) are that of NUREG 1505 scenario A:

  H_0 is that the survey unit does not meet the release criteria

  H_A is that the survey unit meets the release criteria

- Characterization and remedial action support surveys will be conducted under the same quality assurance criteria as final status surveys such that the data may be used as final status survey data to the maximum extent possible.

14.3 Area Classifications

Based on the results of the historical site assessment and previous survey results, facility areas have been classified as impacted areas or non-impacted areas.

14.3.1 Non-Impacted Area

Non-impacted areas are areas without residual radioactivity from licensed activities and are not surveyed during final status surveys. For the purpose of this plan, the following are initially classified as non-impacted:

- Surfaces above a two meter height in Class 2 and Class 3 survey units
- Building exterior walls
- Surface and subsurface soils of outside grounds
- Inaccessible surfaces in renovated areas

Based on historical operations, a potential exists for residual contamination from spills or tracking on surfaces less than two meters in height. Thorough surveys of building entrances/exits and ventilation exhausts will be conducted during characterization and will provide adequate assurance that any residual contamination is contained within the building structure.

14.3.2 Impacted Areas

Impacted areas are those areas that have potential residual radioactivity from licensed activities. Impacted areas are subdivided into Class 1, Class 2 or Class 3 areas. Class 1 areas have the greatest potential for contamination and therefore receive the highest degree of survey effort for the final status survey using a graded approach, followed by Class 2, and then by Class 3. Impacted sub-classifications are defined, for the purposes of this plan, as follows:

14.3.2.1 Class 1 Area

Areas with the highest potential for contamination, and meet the following criteria: (1) impacted; (2) potential for delivering a dose above the release criterion; (3) potential for small areas of elevated activity; and (4) insufficient evidence to support classification as Class 2 or Class 3.

All actively commissioned laboratories will be considered impacted Class 1 survey units. Because these areas have the greatest potential for contamination, surfaces above two (2) meters in height above all Class 1 survey units will also be considered impacted but classified as a Class 2 survey unit.

14.3.2.2 Class 2 Area

Areas that meet the following criteria: (1) impacted; (2) low potential for delivering a dose above the release criterion; and (3) little or no potential for small areas of elevated activity.

The LSC room, north and south stairwells, the plenum, equipment deck and storage room will be considered impacted Class 2 survey units.

14.3.2.3 Class 3 Area

Areas that meet the following criteria: (1) impacted; (2) little or no potential for delivering a dose above the release criterion; and (3) little or no potential for small areas of elevated activity.

All office areas and associated corridors, restrooms, lunchroom and unrestricted areas will be considered impacted Class 3 areas.

14.4 Survey Units

A survey unit is a geographical area of specified size and shape for which a separate decision will be made whether or not that area meets the release criteria. A survey unit is normally a portion of a building or site that is surveyed, evaluated, and released as a single unit. For the purposes of this plan, areas of similar construction and composition will be grouped together as survey units and tested individually against the DCGLs and the null hypothesis to show compliance with the release criteria. Survey units will be homogeneous in construction, contamination potential, and contamination distribution.

The number of discrete sampling locations needed to determine if a uniform level of residual radioactivity exists within a survey unit does not depend on the survey unit size. However, the sampling density should reflect the potential for small elevated areas of residual radioactivity. Survey units will be sized according to the potential for small elevated areas of residual radioactivity. Recommended maximum survey unit sizes for from MARSSIM are provided in Table 14.1.

Table 14.1 – Recommended Maximum Survey Unit Size Limits

Type of Survey Unit	Class 1	Class 2	Class 3
Structures	Up to 100 m^2	100 m^2 to 1,000 m^2	No Limit
Open Land	Up to 2000 m^2	2,000 m^2 to 10,000 m^2	No Limit

Initial Survey units for the Fort Mims Facility are summarized in Table 14.2.

Table 14.2: Fort Mims Facility Area Summary

Restricted Area	Isotope Usage	Classification	Period of Use
FMF-01 (Laboratory 1) Surfaces <2 meters in height	^{3}H, ^{14}C	1	1975-2004
FMF-02 (Laboratory 1) Surfaces >2 meters in height	^{3}H, ^{14}C	2	1975-2004
FMF-03 (Laboratory 4) Surfaces <2 meters in height	^{3}H, ^{14}C	1	1980-2004
FMF-04 (Laboratory 4) Surfaces >2 meters in height	^{3}H, ^{14}C	1	1980-2004
FMF-05 (Laboratory 2) Surfaces <2 meters in height	^{3}H, ^{14}C	1	1980-2004
FMF-06 (Laboratory 2) Surfaces >2 meters in height	^{3}H, ^{14}C	2	1980-2004
FMF-07 (QC Laboratory) Surfaces <2 meters in height	^{3}H, ^{14}C	1	1986-9/30/2008
FMF-08 (QC Laboratory) Surfaces >2 meters in height	^{3}H, ^{14}C	2	1986-9/30/2008
FMF-09 (QC Laboratory) Surfaces <2 meters in height	^{3}H, ^{14}C	1	1986-9/30/2008
FMF-10 (QC Laboratory) Surfaces >2 meters in height	^{3}H, ^{14}C	2	1986-9/30/2008
FMF-11 (QC Laboratory) Surfaces <2 meters in height	^{3}H, ^{14}C	1	1986-9/30/2008
FMF-12 (QC Laboratory) Surfaces >2 meters in height	^{3}H, ^{14}C	2	1986-9/30/2008
FMF-13 (Laboratory 3) Surfaces <2 meters in height	^{3}H, ^{14}C	1	1986-9/30/2008
FMF-14 (Laboratory 3) Surfaces >2 meters in height	^{3}H, ^{14}C	2	1986-9/30/2008
FMF-15 (LSC Room) Surfaces <2 meters in height	^{3}H, ^{14}C	2	1986-2008
FMF-19 (Storage Area) Surfaces <2 meters in height	^{3}H, ^{14}C	2	1986-2008
FMF-30 (Caged Vacuum Pump/Ventilation Area) Surfaces <2 & >2 meters in height	^{3}H, ^{14}C	1	1986-2008
FMF-32 (Loading Dock Area) Surfaces <2 meters in height)	^{3}H, ^{14}C	3	1975-2008

Non-restricted Area	Potentially Impacted Isotopes	Classification	Period of Use
FMF-16 (North Stairwell) Surfaces <2 meters in height	^{3}H, ^{14}C	3	1980-9/30/2008
FMF-17 (South Stairwell) Surfaces <2 meters in height	^{3}H, ^{14}C	3	1986-9/30/2008
FMF-18 (Office Areas) Surfaces <2 meters in height	^{3}H, ^{14}C	3	1975-9/30/2008
FMF-20 (Plenum Area) Surfaces <2 meters in height	^{3}H, ^{14}C	2	1975-9/30/2008
FMF-21 (Equipment Deck) Surfaces <2 meters in height	^{3}H, ^{14}C	2	1975-9/30/2008
FMF-22 (Roof-1) All Surfaces	^{3}H, ^{14}C	3	1975-9/30/2008
FMF-23 (Lunch Room) Surfaces <2 meters in height	^{3}H, ^{14}C	3	1980-9/30/2008
FMF-24 (North Exterior Concrete Sidewalk)	^{3}H, ^{14}C	2	1975-9/30/2008
FMF-25 (South Exterior Concrete Sidewalk)	^{3}H, ^{14}C	2	1975-9/30/2008
FMF-26 (East Exterior Concrete Parking Lot)	^{3}H, ^{14}C	2	1975-9/30/2008
FMF-27 (East Exterior Concrete Parking Lot)	^{3}H, ^{14}C	2	1975-9/30/2008
FMF-31 (Office Areas)	^{3}H, ^{14}C	3	1975-9/30/2008
FMF-33 (Office Areas)	^{3}H, ^{14}C	3	1975-9/30/2008
FMF-34 (Roof-2) All Surfaces	^{3}H, ^{14}C	3	1975-9/30/2008

14.5 Surface Scans

Scanning is used to identify locations within the survey unit that exceed the investigation level. These locations are marked and receive additional investigations to determine the concentration, area, and extent of the contamination. Scanning surveys are designed to detect small areas of elevated activity that are not detected by the measurements using the systematic pattern. For this reason, the measurement locations and the number of total surface activity measurements may need to be adjusted based on the sensitivity of the scanning technique. Table 14.3 summarizes the percentage of accessible building structural surfaces to be scanned based on classification.

Table 14.3 – Scan Survey Coverage by Classification

Classification	Recommended Scan Coverage	Plan Coverage
1	100%	100%
2	10-100% (Judgmental)	50%
3	Judgmental	20%

For the purposes of the FSS, Class 1 survey units will receive a 100% scan survey of all accessible surfaces. Class 2 survey units will receive a minimum scan survey of 50% of all accessible surfaces. Class 3 survey units will receive a minimum scan survey of 20% of all accessible surfaces.

For Class 2 and Class 3 survey units, the sensitivity for scanning techniques is not tied to the area between measurement locations as they are for Class 1 areas. The scanning techniques selected will represent the best reasonable effort based on the survey data quality objectives

The percentage of survey area scan surveyed may be increased based on suspected elevated activity. For all classes, the surfaces to be scan surveyed will be those with the highest potential to contain residual contamination.

Floor areas near building entrances and exits will receive a 100% scan survey regardless of the area classification. These surveys will provide indications of potential migration of residual contamination to the outside grounds.

If elevated activity is detected during the scan surveys, then the location shall be marked and total and removable surface activity measurements will be taken to quantify the activity. However, these total surface activity measurements are in addition to the static measurements required for the statistical test.

14.6 Total Surface Activity Measurements

Direct surveys (static measurements) will be taken on building surfaces and system internals to the extent practical in impacted areas utilizing instrumentation of the best geometry based on the surface at the survey location. Additionally, locations of elevated activity identified and marked during the scan survey will also require total activity measurements.

Total surface activity measurements shall be taken at each determined sample location. Scaler count times will be determined based on the MDC_{static} of the applicable survey instrument.

14.6.1 Determining the Number of Samples

A minimum number of samples are needed to obtain sufficient statistical confidence that the conclusions drawn from the samples are correct. The number of samples will depend on the relative shift (the ratio of the concentration to be measured relative to the statistical variability of the contaminant concentration). Initial calculations have been performed to determine an estimated standard deviation and Lower Bound of the Gray Region (LBGR) for determination of the relative shift. These calculations were based on the characterization survey performed by Duratek, Inc. Specific data was selected from areas that appear to meet the release criteria using the assumption that remedial actions will remove locations greater than the $DCGL_W$.

The survey design for surfaces and structures will be based on the Sign test. The minimum number of samples is obtained from MARSSIM tables or calculated using MARSSIM Equation 5-2.

14.6.1.1 Determination of the Relative Shift

The number of required samples will depend on the ratio involving the activity level to be measured relative to the variability in the concentration. The ratio to be used is called the Relative Shift, Δ/σ_S and is defined in MARSSIM as:

$$\Delta / \sigma_S = \frac{DCGL - LBGR}{\sigma_S}$$

Where:

DCGL = derived concentration guideline level

LBGR = concentration at the lower bound of the gray region. The LBGR is the average concentration to which the survey unit should be cleaned in order to have an acceptable probability of passing the test

σ_S = an estimate of the standard deviation of the residual radioactivity in the survey unit

For the purpose of this plan, an estimated standard deviation will be pre-determined based on the expected total activity levels at the time of the FSS. The LBGR will initially be set at one-half of the C-14 $DCGL_W$.

14.6.1.2 Determination of Acceptable Decision Errors

A decision error is the probability of making an error in the decision on a survey unit by failing a unit that should pass (β decision error) or passing a unit that should fail (α decision error). MARSSIM uses the terminology α and β decision errors; this is the same as the more common terminology of Type I and Type II errors, respectively. The decision errors are 0.05 for Type I errors and 0.05 for Type II errors.

14.6.1.3 Determination of Number of Data Points (Sign Test)

The number of direct measurements for a particular survey unit, employing the Sign Test, is determined from MARSSIM Table 5.5, which is based on the following equation (MARSSIM equation 5-2):

$$N = \frac{(Z_{1-\alpha} + Z_{1-\beta})^2}{4(SignP - 0.5)^2}$$

Where:

N	=	number of samples needed in the survey unit
$Z_{1-\alpha}$	=	percentile represented by the decision error α
$Z_{1-\beta}$	=	percentile represented by the decision error β
SignP	=	estimated probability that a random measurement will be less than the DCGL when the survey unit median is actually at the LBGR

Note: SignP is determined from MARSSIM Table 5.4

MARSSIM recommends increasing the calculated number of measurements by 20% to ensure sufficient power of the statistical tests and to allow for possible data losses. MARSSIM Table 5.5 values include an increase of 20% of the calculated value.

14.6.2 Determination of Sample Locations

Determination of Class 1 survey unit sample locations is accomplished by first determining sample spacing and then systematically plotting the sample locations from a randomly generated start location. The random starting point of the grid provides an unbiased method for obtaining measurement locations to be used in the statistical tests.

Similar systematic spacing methods are used for Class 2 survey units because there is still some probability of small areas of elevated activity. The use of a systematic grid allows the decision-maker to draw conclusions about the size of the potential areas of elevated activity based on the area between measurement locations.

Class 3 survey locations are determined from computer-selected randomly generated x and y coordinates. Survey protocols for all areas are summarized in Table 14.4

Table 14.4 – Survey Sample Placement Overview

Survey Unit Classification		$DCGL_w$ Comparison	Elevated Measurement Comparison	Measurement Locations
Impacted	Class 1	Yes	N/A	Systematic random
	Class 2	Yes	N/A	Systematic random
	Class 3	Yes	N/A	Judgmental
Non-Impacted		None	None	None

Additional total surface activity measurements will be collected at each area of elevated activity identified during the scan surveys. These are in addition to the systematic measurements.

14.6.2.1 Determining Class 1 Sample Locations

In Class 1 survey units, the sampling locations are established in a unique pattern beginning with the random start location and the determined sample spacing. After determining the number of samples needed in the survey unit, sample spacing is determined from MARSSIM equation 5-8:

$$L = \sqrt{\frac{A}{N}} \text{ for a square grid}$$

Where:

L = sample spacing interval
A = the survey unit area
N = number of samples needed in the survey unit

Maps will be generated of the survey unit's permanent surfaces included in the statistical tests (floors, walls, ceilings, fixed cabinetry, etc.) and folded out in a 2-dimensional view. A random starting point is determined using computer-generated random numbers coinciding with the x and y coordinates of the total survey unit. A grid is plotted across the survey unit surfaces based on the random start point and the determined sample spacing. A measurement location is plotted at each intersection of the grid plot.

14.6.2.2 Determining Class 2 and Class 3 Sample Locations

Class 1 survey units generally consist of one or two rooms or laboratories. Class 2 and Class 3 survey units generally consist of many rooms. All Class 1 rooms will be a scale drawing in a "fold-out" view to show all surfaces presents, while Class 2 and Class 3 drawings will not display a "fold-out" view. The process to identify, map and locate measurement coordinates in survey units with many rooms is complicated due to the noncontiguous nature of the survey unit once walls are "folded-out".

Determining Class 2 Sample Locations
In Class 2 survey units, the sampling locations are established in a unique pattern beginning with the random start location and the determined sample spacing. After determining the number of samples needed in the survey unit, sample spacing is determined from MARSSIM equation 5-8:

$$L = \sqrt{\frac{A}{N}} \text{ for a square grid}$$

Where:

L = sample spacing interval
A = the survey unit floor area
N = number of samples needed in the survey unit

Maps will be generated of the survey unit's permanent surfaces included in the statistical tests. Only horizontal surfaces (e.g., floors, countertops, etc.) are included in the statistical tests. A random starting point is determined using computer-generated random numbers coinciding with the x and y coordinates of the total survey unit. A grid is plotted across the survey unit surfaces based on the random start point and the determined sample spacing. A measurement location is plotted at each intersection of the grid plot.

Determining Class 3 Sample Locations
For Class 3 areas, maps will be generated of the survey unit floor surfaces and applicable permanent equipment and/or furnishings. Sample locations will be chosen on floor, lower wall (<2m) and permanent equipment surfaces at the discretion of the survey technician. Measurement locations will be biased towards areas with the highest potential of residual contamination. Each chosen location will be plotted on the applicable survey map.

14.7 Removable Contamination Measurements

Removable contamination measurements (smears) will be collected on building surfaces and structures at each total activity sample location to determine the potential removable contamination. H-3 contamination levels will be evaluated using removable contamination measurements only (wipe test). This approach assumes that the removable portion is 10% of the total fixed contamination levels of H-3. Additionally, removable contamination measurements will be collected for building system internals. An area of approximately $100cm^2$ shall be wiped if possible. If an area of less than $100cm^2$ is wiped, a comment shall be added to the survey data sheet estimating the surface area wiped to allow for area correction of the results. Swabs may be used when system or component access points are not large enough to allow for a wipe of a $100\ cm^2$ surface area.

14.8 Surveys of Building Mechanical System Internals

Surveys of various building system components will need to be performed. Survey design for these systems is out of the scope of MARSSIM. For the purposes of identifying potential residual contamination within these systems, a survey protocol has been established and is presented in the following sections.

14.8.1 Ventilation Systems

Surveys of building ventilation and fume hood ventilation will consist of scan surveys, total activity measurements and removable contamination measurements of accessible ventilation exhaust points and at locations of potential collection buildup. The frequency of the survey effort will depend on the classification of the surrounding area. Ventilation system initial survey requirements are summarized in Table 14.5.

Table 14.5 – Ventilation System Survey Requirements

Component(s)	Classification of Area in Which Components Exist	Survey Requirements		
		Scan Surveys	Static (Total Activity) Measurements	Removable Contamination Measurements
General ventilation and fume hood exhaust ducts	Class 1	100% scan survey of accessible[1] internal surfaces of all existing exhaust ducts	At least one static measurement taken on the internal surfaces of 100% of existing exhaust duct openings	One smear taken at each static measurement location
	Class 2	100% scan survey of accessible[1] internal surfaces of at least 50% of existing exhaust ducts	At least one static measurement taken on the internal surfaces 50% of existing exhaust duct openings	One smear taken at each static measurement location
	Class 3	100% scan survey of accessible[1] internal surfaces of at least 10% of the existing exhaust ducts	At least one static measurement taken on the internal surfaces of 10% of the existing exhaust duct openings	One smear taken at each static measurement location
Collection points within ventilation fan units	All	100% scan survey of accessible[1] internal surfaces of all applicable ventilation fan units	At least one static measurement taken on each internal surface of each accessible[1] opening on the units	One smear taken at each static measurement location

[1] Within reach of duct or component opening

Components will be de-energized prior to access. Lock-out/Tag-out procedures will be initiated prior to any access to mechanical or electrical components.

14.8.2 Vacuum System

Surveys of building vacuum system internals will consist of removable contamination measurements of accessible vacuum inlet points. Scan surveys and static measurements are not practical due to the small geometry of the vacuum inlet points. Additionally, surveys of potential collection points will be performed. The frequency of the survey effort will be dependent on the classification of the surrounding area. Vacuum system initial survey requirements are summarized in Table 14.6 .

Table 14.6 – Vacuum System Survey Requirements

Component(s)	Classification of Area in Which Components Exist	Survey Requirements	
		Scan Surveys and Static (Total Activity) Measurements	Removable Contamination Measurements
Vacuum system inlets	Class 1	N/A[1]	At least one smear on the internal surfaces of 100% of the existing vacuum inlet points[2]
	Class 2	N/A[1]	At least one smear on the internal surfaces of 50% of the existing vacuum inlet points[2]
	Class 3	N/A[1]	At least one smear on the internal surfaces of 10% of the existing vacuum inlet points[2]
Collection points within vacuum system moisture accumulators and/or filtration components	All	N/A[1]	At least one smear on the internal surfaces of all accessible locations within the vacuum system moisture accumulator(s) and filtration points[2].

14.8.3 Drain Systems

Surveys of building drain system internals will consist of surveys of accessible sink drains, sink drain traps, floor drains and collection points such as sumps and outfalls. Removable contamination surveys of sink drains sink drain traps and floor drains will be collected, since scan surveys and static measurements are not practical due to their small geometry. The frequency of the survey effort will be dependent on the classification of the surrounding area. Drain system initial survey requirements are summarized in Table 14.7.

Table 14.7 – Drain System Survey Requirements

Component(s)	Classification of Area in Which Components Exist	Survey Requirements	
		Scan Surveys and Static (Total Activity) Measurements	Removable Contamination Measurements
Drain system inlets	Class 1	N/A[1]	At least one smear on the internal surfaces of 100% of the existing sink drains, sink drain traps and floor drains[2].
	Class 2	N/A[1]	At least one smear on the internal surfaces of 50% of the existing sink drains, sink drain traps and floor drains[2].
	Class 3	N/A[1]	At least one smear on the internal surfaces of 10% of the existing sink drains, sink drain traps and floor drains[2].
Drain system collection points such as accumulator tanks, sumps and outfalls	All	Scan surveys, total surface activity measurements and removable contamination measurements will be collected in sumps and at drain system outfalls as applicable. Sediment samples will be collected at these locations, if possible.	

[1] Scan surveys and static measurements are not practical for these locations due to the small geometry of the drain system components.
[2] Some disassembly of system components may be necessary to complete these surveys.

The mechanical system survey frequencies described above are the minimum survey requirements. Additional surveys may be necessary to adequately access internal contamination levels. If additional survey locations are determined to be necessary, the survey package instructions will provide guidance.

If contamination is detected during the previous survey schemes, then additional surveys or removal of components may be required at various locations. This may require disassembly of components downstream of the affected location. Additional instruction will be provided in the survey package instructions.

14.9 Survey Investigation Levels

Investigation levels are used to flag locations that require special attention and further investigation to ensure areas are properly classified and adequate surveys are performed. These locations are marked and receive additional investigations to determine the concentration, area, and extent of the contamination. The survey investigation levels for each type of measurement are listed by classification in Table 14.8.

Table 14.8 – Survey Investigation Levels

Survey Unit Classification	Flag Direct Measurement or Sample Result When:	Flag Scanning Measurement Result When:	Flag Removable Measurement Result When:
Class 1	> 90% of DCGL	> 90% of DCGL	10% of 10mrem/yr Release Criteria
Class 2	> 20% of DCGL	> 20% of DCGL	10% of 10mrem/yr Release Criteria
Class 3	>MDC	>MDC	10% of 10mrem/yr Release Criteria

14.10 Survey Documentation

A survey package will be developed for each survey unit containing the following:

- Survey Instruction Sheets
- General survey requirements
- Instrument requirements with associated MDCs, count times and scan rates
- Survey Maps
- Overview maps detailing survey locations and placement methodology
- Survey sub-unit maps with additional sample location information, as needed
- Survey Data Sheets
- Signature of Data Collector and Reviewer

14.11 Data Validation

Field data will be reviewed and validated to ensure:

- Completeness of forms and that the type of survey has correctly been assigned to the survey unit.
- The MDCs for measurements meet the established data quality objectives; independent calculations will be performed for a representative sample of data sheets and survey areas.
- Instrument calibrations and daily functional checks have been performed accurately and at the required frequency.

14.12 Sample Chain-of-Custody

The sample chain-of-custody maintains the integrity of the sample; that is, there is an accurate record of sample collection, transport, analysis, and disposal. This ensures that samples are neither lost nor tampered with, and that the sample analyzed in the laboratory is actually and verifiably the sample taken from a specific location in the field.

15.0 Data Quality Assessment (DQA) and Interpretation of Survey Results

The statistical guidance contained in Section 8 of MARSSIM will be used to determine if areas are acceptable for unrestricted release, and whether additional surveys or sample measurements are needed.

15.1 Preliminary Data Review

A preliminary data review will be performed for each survey unit to identify any patterns, relationships or potential anomalies. Additionally, measurement data is reviewed and compared with the DCGLs and investigation levels to identify areas of elevated activity and confirm the correct classification of survey units. If an area is misclassified with a less restrictive classification, the area will be upgraded and surveyed accordingly.

The following preliminary data reviews will be performed for each survey unit:

- Calculations of the survey unit mean, median, maximum, minimum, and standard deviation for each type of reading.
- Comparison of the actual standard deviation to the assumed standard deviation used for calculating the number of measurements. If the actual standard deviation is greater than estimated, the minimum number of samples shall be calculated using the actual standard deviation to ensure a sufficient number of samples have been obtained.
- Comparison of survey data with applicable investigation levels.

15.2 Determining Compliance

For Class 1 areas, if it is determined that all total activity results are less than the applicable DCGL, then no further statistical tests are required. If any of the total activity measurements are greater than the $DCGL_W$, then the survey unit fails and the null hypothesis is not rejected. The survey unit is determined to meet the release criterion provided that the application of any unity rules result in values less than 1.

The Sign test is used to determine the minimum number of sample locations. However, the Sign test is not performed in this survey design because the total activity DCGL is used as a maximum. If all measurements are less than the DCGL, performance of the Sign test is not necessary because the survey unit will pass the Sign test by definition.

For Class 2 and Class 3 areas, data results are initially compared to the investigation levels. These investigation levels are provided to help ensure that survey units have been properly classified. If all data results in Class 2 or 3 areas are less than the investigation levels, then the survey unit is determined to meet the release criterion. If these investigation levels are exceeded, then an investigation is performed to verify the initial assumptions for classification and determine the appropriate resolution (e.g., additional scans or survey unit reclassification).

Class 3 survey units, by definition, are not expected to contain residual activity above a small fraction of the DCGL(s). Therefore, if contamination is detected exceeding the

DCGLs, then reclassification is required. However, reclassification of the entire survey unit may or may not be appropriate. The area containing the residual activity may have been an isolated case and reclassification of the entire survey unit would be inappropriate. More appropriately, the affected portion of the survey unit may be separated and only that portion reclassified. The Project Manager will evaluate the survey results, assign additional scan surveys, as appropriate, and determine the appropriate course of action.

Removable contamination measurements will be compared directly to the applicable DCGL. No contingency is established for elevated removable contamination. If any removable contamination is detected which exceeds a removable contamination limit, then the survey unit is determined not to meet the release criterion. However, if all removable contamination measurements are less than the removable contamination DCGL, then compliance shall be determined based on total activity measurements.

Compliance will be determined using a unity calculation of each applicable type of total activity measurement performed in each survey unit (i.e., gross beta total activity measurements). Refer to Table 15.1 below for Data Compliance Overview.

Table 15.1 – Building Surfaces and Structures Data Compliance Overview

Classification	Survey Result	Conclusion
Class 1	• All measurements < $DCGL_W$, and • Results of applicable unity rules ≤ 1	Survey unit meets release criterion
	• Any measurement > $DCGL_W$, or • Result of unity rule >1	Survey unit does not meet release criterion
Class 2	• All measurements < applicable investigation levels, and • Results of applicable unity rules ≤ 1	Survey unit meets release criterion
	• Average > applicable investigation levels, and • All measurements < $DCGL_W$	Survey unit may meet release criterion. Perform evaluation of elevated activity and determine if additional surveys and/or reclassification are warranted.
	• Any measurement > $DCGL_W$, or • Results of applicable unity rule >1	Survey unit does not meet release criterion
Class 3	• All measurements < applicable investigation levels, and • Results of applicable unity rules ≤ 1	Survey unit meets release criterion
	• Average > applicable investigation levels, and • All measurements <$DCGL_W$	Survey unit may meet release criterion. Perform evaluation of elevated activity and determine if additional surveys and/or reclassification are warranted.
	• Any measurement >$DCGL_W$, or • Results of applicable unity rules ≤ 1	Reclassify survey unit or portion of survey unit, if justification for splitting the survey unit is provided. Survey unit does not meet release criterion as it exists

15.3 Mechanical System Survey Data Analysis

If any measurement exceeds the applicable DCGL, then the survey unit does not meet the release criterion and is considered contaminated. Remediation or removal of the affected system components may be required. If all measurements are less than the applicable DCGL, then the system meets the release criterion and is considered releasable. Results of mechanical system surveys will be compared directly with the DCGL. This comparison will consider the applicable DCGL as a maximum value, rather than an average.

If any measurement exceeds the applicable DCGL, then the survey unit does not meet the release criterion and is considered contaminated. Remediation or removal of the affected system components may be required. If all measurements are less than the applicable DCGL, then the system meets the release criterion and is considered releasable.

16.0 Quality Assurance Program

Philotechnics will be required to submit a project-specific Quality Assurance Project Plan (QAPP) to Sigma Aldrich utilizing the guidelines of MARSSIM Section 9. The QAPP will be reviewed and approved by Sigma Aldrich management prior to commencing D&D operations. The QAPP will incorporate at a minimum, the following:

- Description of the Quality Assurance and Quality Control goals, Data Quality Objectives (DQO), procedures, and plans to be implemented for all D&D activities.
- Description of the methodology to ensure that all radiological survey data meet the 95% confidence level.
- Description of the sampling and analysis requirements, and on-site waste packaging and storage location, for each waste stream on site.

The QAPP will be developed and organized with emphasis given to maximizing worker safety, minimizing/eliminating off-site releases and minimizing overall project costs. The quality control program will control all quality documents during the performance of D&D operations. Quality documents include, but are not limited to:

- Training Records
- Survey Records
- Instrument Records
- Work Permits
- Medical Surveillance Records
- Audit Reports
- Shipping Records
- Work Procedures and Plans

17.0 Final Report

A Final Report summarizing D&D activities performed at the facility shall be prepared and submitted to the U.S. Nuclear Regulatory Commission by Sigma Aldrich. The guidance provided in NUREG 1757 will be used to prepare the final report. The Final Report will include, at a minimum:

- An overview of the results of the FSS
- A summary of the screening values for the facility (if screening values are used)
- A discussion of any changes that were made in the FSS from what is proposed in this plan
- A description of the method by which the number of samples was determined for each survey unit
- A summary of the values used to determine the number of samples and a justification for these values
- The survey results for each survey unit including the following:
    - The number of samples taken for the survey unit;
    - A description of the survey unit, including (a) a map or drawing showing the reference system and random start systematic sample locations for Class1 and 2 survey units and reference area, as applicable, the random locations shown for Class 3 survey units and reference areas, (b) discussion of remedial actions and unique features, and (c) areas scanned for Class 3 survey units and reference areas;
    - The measured sample concentrations, in units comparable to the screening values;
    - The statistical evaluation of the measured concentrations;
    - Judgmental and miscellaneous sample data sets reported separately from those samples collected for performing the statistical calculations;
    - A discussion of anomalous data including any areas of elevated activity detected during scan surveys that exceeded the investigation levels or any measurement locations in excess of the screening values; and
    - A statement that a given survey unit satisfies the screening values and the elevated measurement comparison if any sample points exceeded the screening values
- A description of any changes in initial survey unit assumptions relative to the extent of residual activity (e.g., material not accounted for during site characterization)
- A description of how ALARA practices were employed to achieve final activity levels.

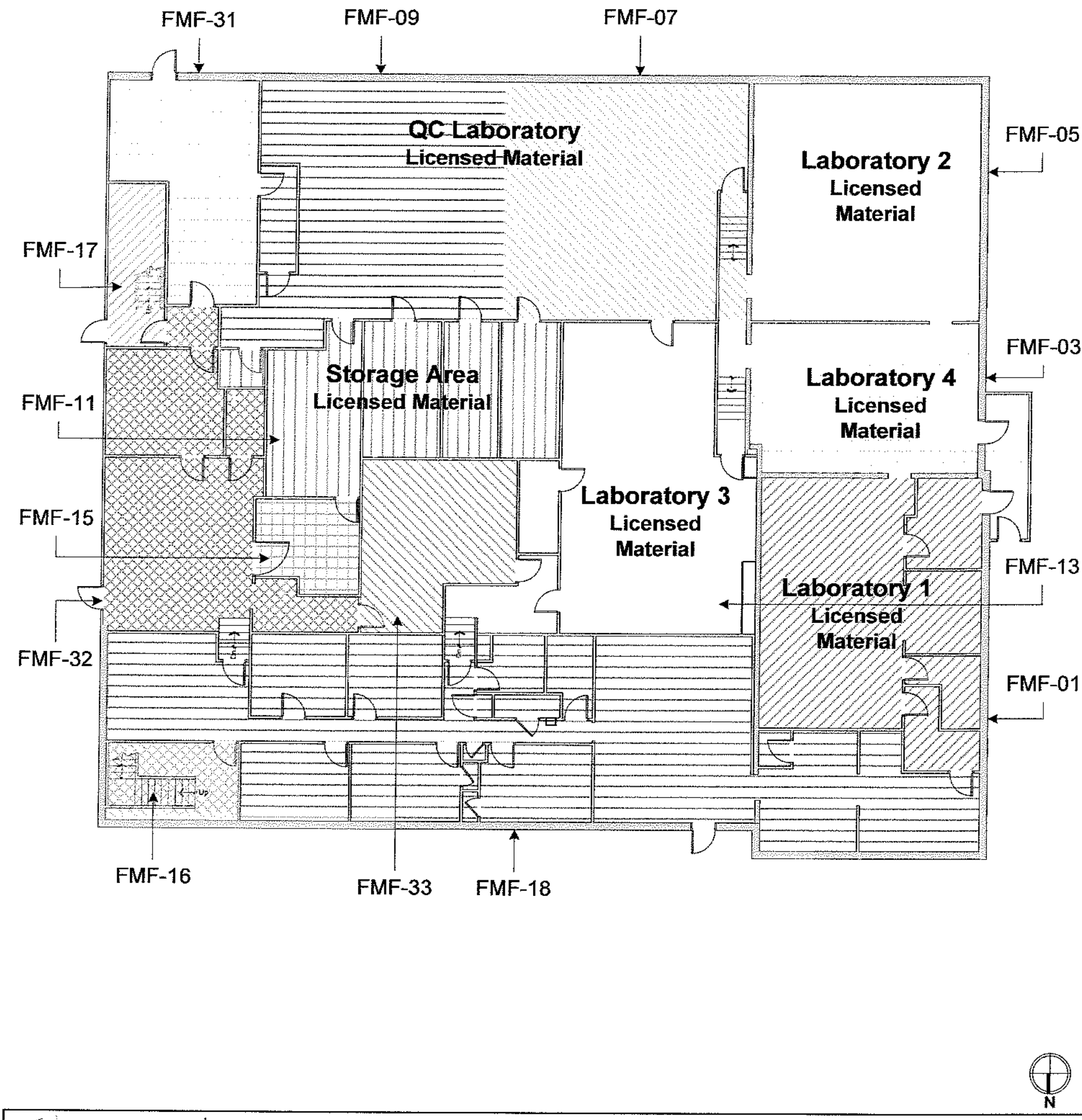
18.0 References

- NRC Regulations 10 CFR 20 Subpart E
- NRC Regulations 10 CFR 30.4
- NUREG-1575, "Multi-Agency Radiation Survey and Site Investigation Manual" (MARSSIM)
- NUREG-1505, "A Nonparametric Statistical Methodology for the Design and Analysis of Final Decommissioning Surveys"
- NUREG 1507, "Minimum Detectable Concentrations with Typical Radiation Survey Instruments for Various Contaminants and Field Conditions"
- NUREG 1727, "NMSS Decommissioning Standard Review Plan," September, 2000.
- NUREG 1757, Volumes 1-3 "Consolidated NMSS Decommissioning Guidance,"

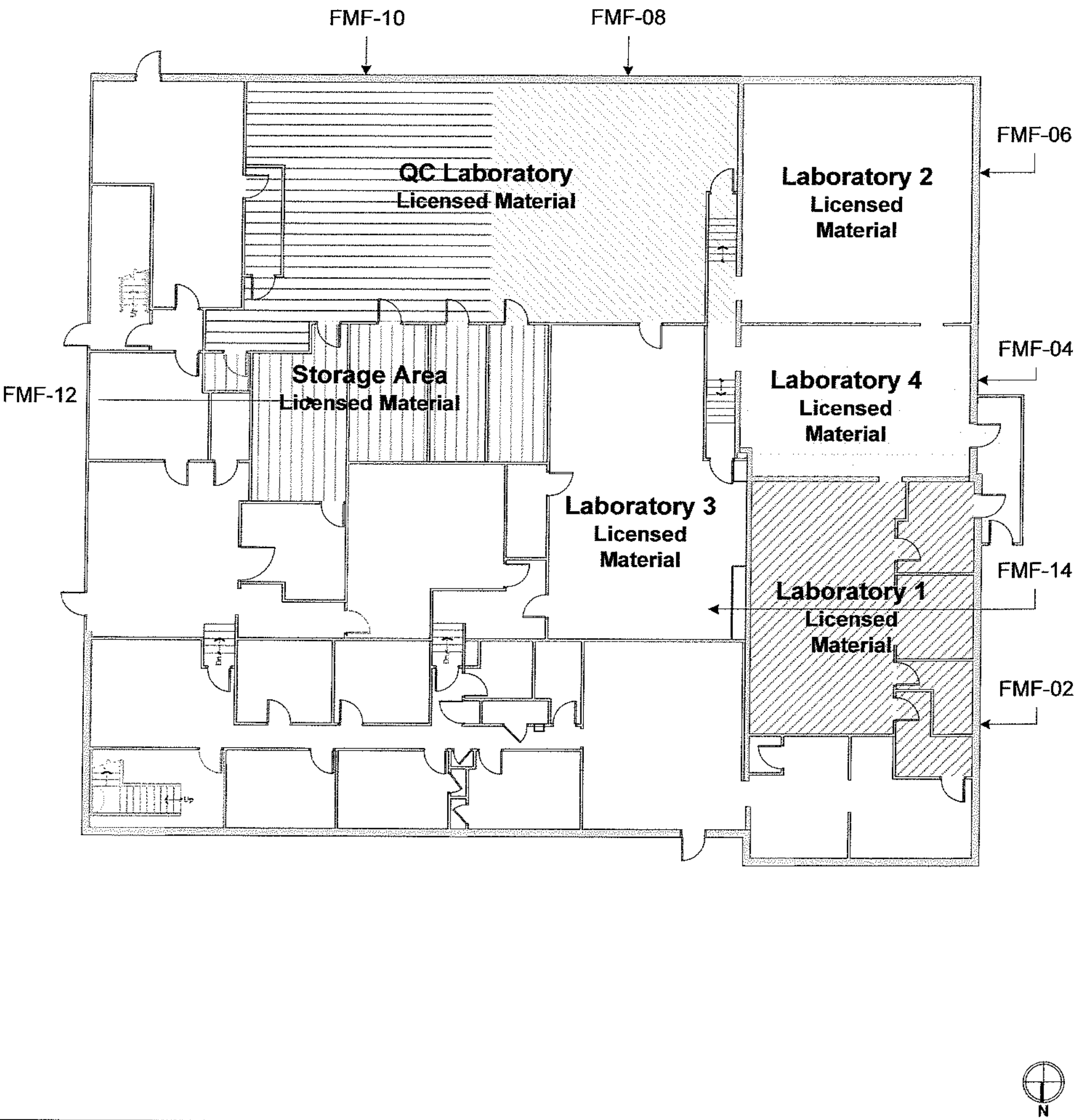
- Sigma-Aldrich Radioactive Materials License Number 24-16273-01, Amendment No. 14
- Sigma-Aldrich Radioactive Materials License Number 24-16273-01, Amendment No. 15.
- Sigma-Aldrich Radioactive Materials License Number 24-16273-01, Amendment No. 16.

Attachment A

Sigma-Aldrich Company
Fort Mims Facility Diagrams

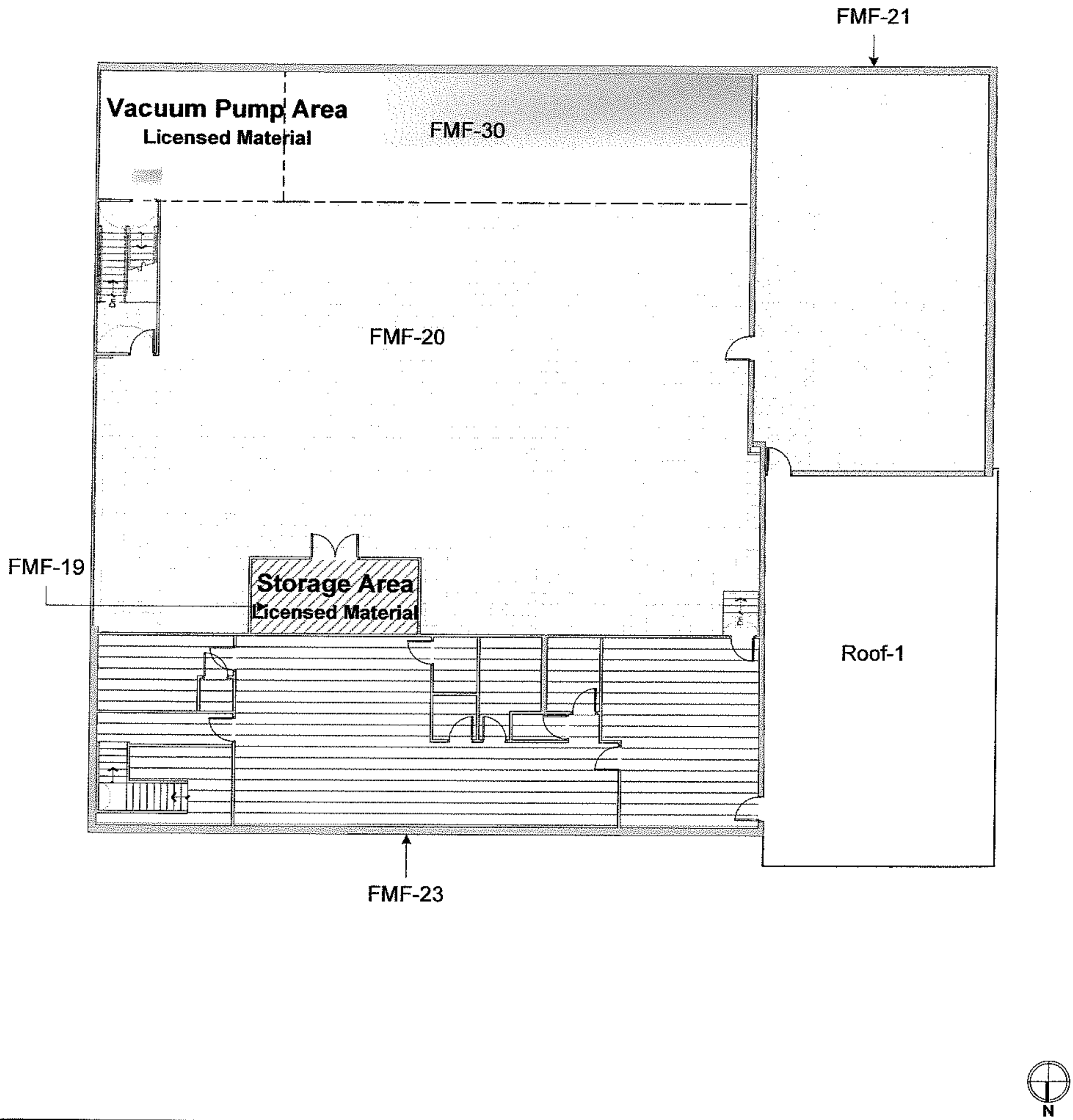


Sigma-Aldrich: Fort Mims Facility First Floor Plan	**Survey Unit:** N/A	**Class:** N/A
Survey Unit Description: Interior Building Surfaces and Structures <2m in Height		



Sigma-Aldrich: Fort Mims Facility First Floor Plan **Survey Unit:** N/A **Class:** N/A

Survey Unit Description: Interior Building Surfaces and Structures >2m in Height

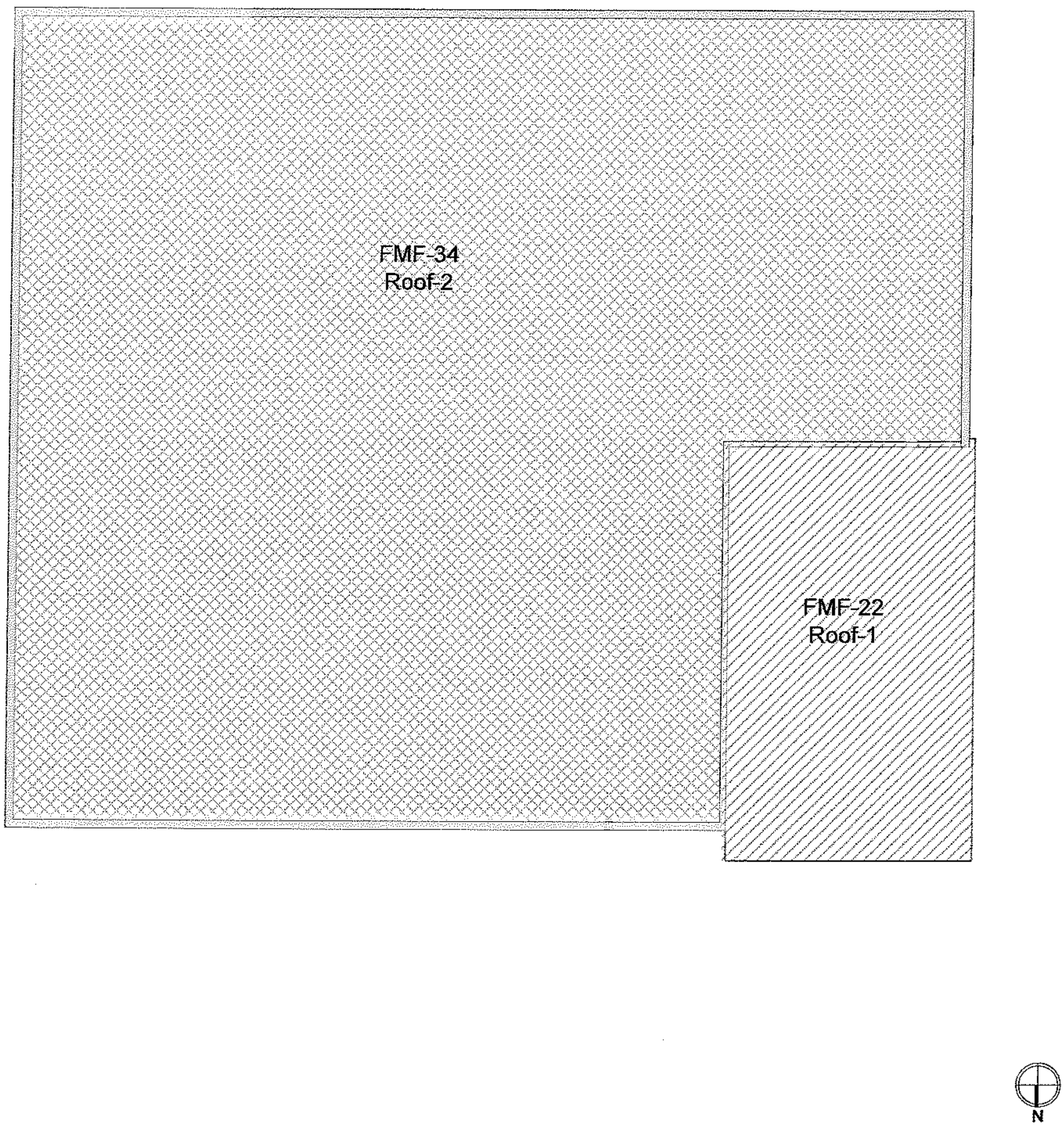


Sigma-Aldrich: Fort Mims Facility Second Floor Plan

Survey Unit: N/A

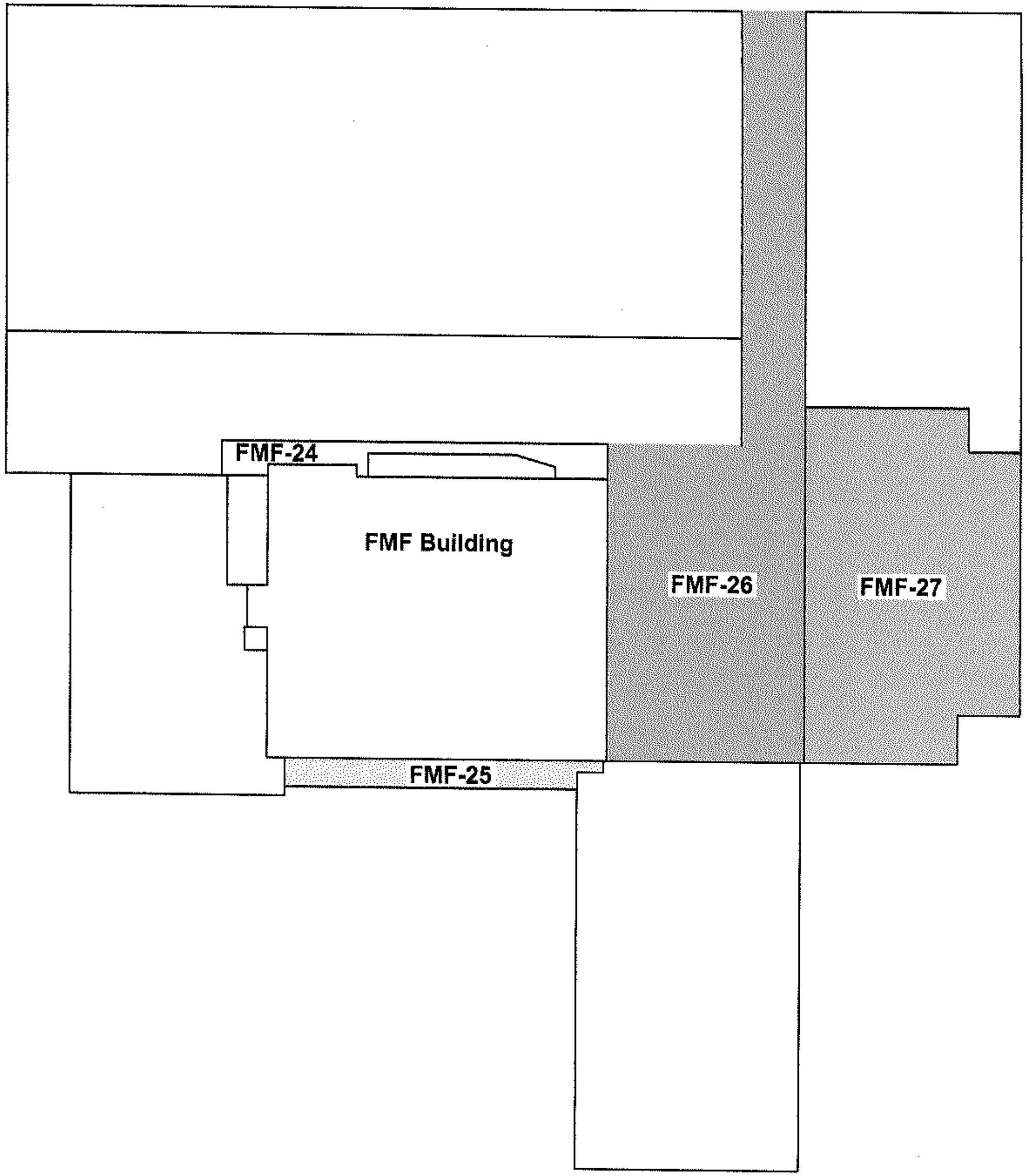
Class: N/A

Survey Unit Description: Interior Building Surfaces and Structures <2m in Height



	Sigma-Aldrich: Fort Mims Facility	**Survey Unit:** N/A	**Class:** N/A
	Survey Unit Description: Exterior Roof Building Surfaces and Structures		

Sigma Aldrich Fort Mims Facility
Exterior Surface and Structure Survey Units

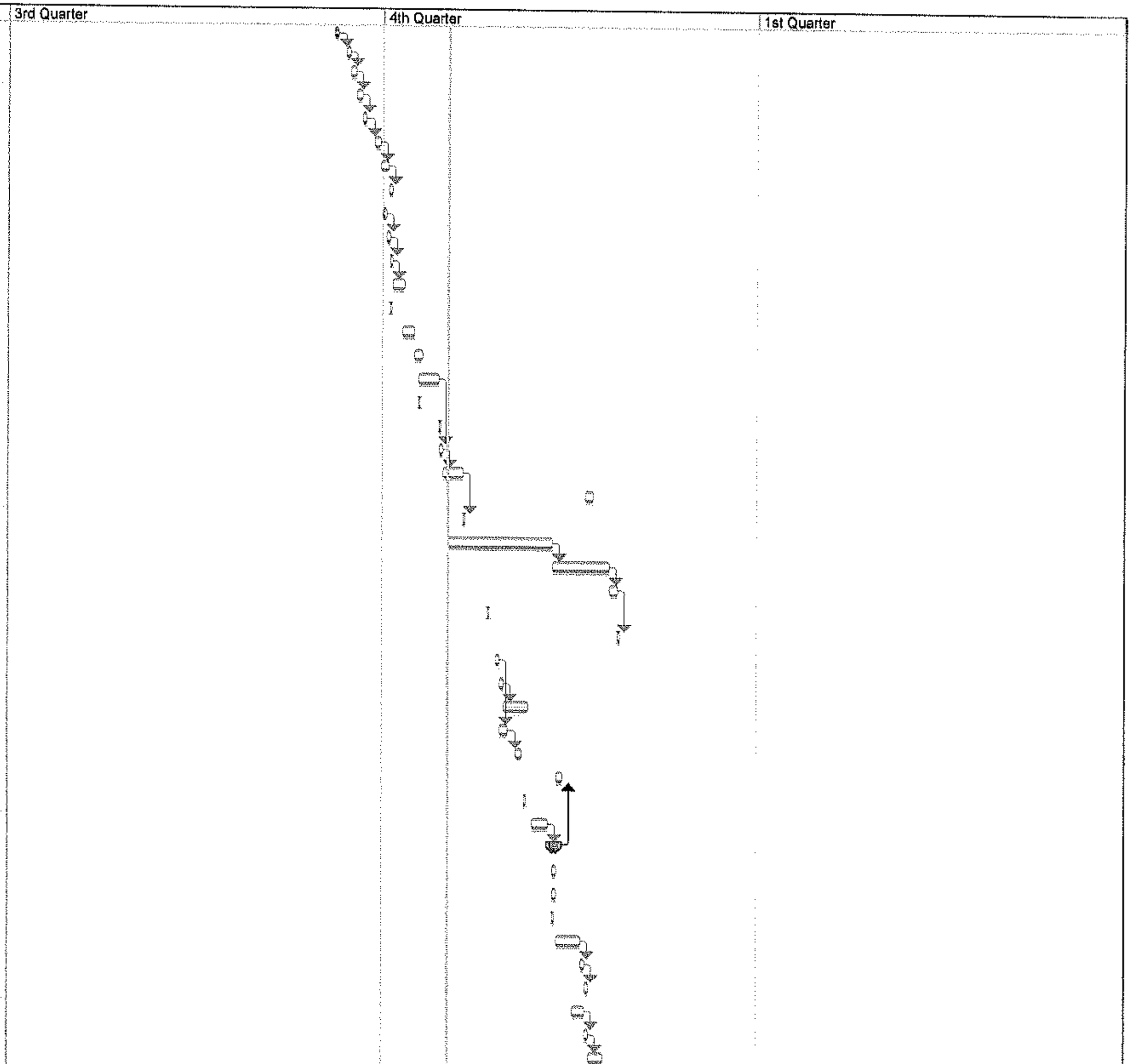


Attachment B

Sigma-Aldrich Company
Proposed D&D Activities Gantt Chart

ID	Task Name
1	Pre Mobilization Survey Team
2	Mobilization Survey Team
3	Laboratory 2 Characterization
4	Lab 4 Characterization
5	Lab 1 Characterization
6	2nd Floor Characterization
7	QC Lab Characterization
8	Laboratory 43 Characterization
9	Pre Mobilization Demo Team
10	Mobilization Demolition Team
11	Safety Training
12	Equipment Set Up
13	Personnel Meeting/Project Plan
14	QC Lab Equipment
15	QC Lab Casework
16	QC Lab Fumehoods
17	QC Lab Ceiling Tiles
18	QC Lab Systems
19	QC Lab Waste Size Reduction
20	QC Lab Brick Scabbling
21	QC Lab Ventilation Removal
22	QC Lab Hercules waste storage set up
23	Laboratory 43 equipment removal
24	Lab 3 Casework Removal
25	Lab 3 Fumehood Removal
26	Lab 3 Ceiling Tile Removal
27	Lab 3 System Removal
28	Lab 3 Drywall Removal
29	Lab 3 Floor Tile Removal
30	Lab 3 Scabble/Needle Gun Walls
31	Lab 3 Scabble Floors
32	Lab 3 Ventilation Removal
33	Lab 3 FSS
34	Waste Shipment
35	Lab 2 Equipment Removal
36	Lab 2 Casework Removal
37	Lab 2 Fumehood Removal
38	Lab 2 Ceiling Tile Removal
39	Lab 2 System Removal
40	Lab 2 Drywall Removal
41	Lab 2 Floor Tile Removal
42	Lab 2 Scabble/Needle Gun Walls
43	Lab 2 Scabble Floors
44	Lab 2 Ventilation Removal
45	Lab 2 FSS

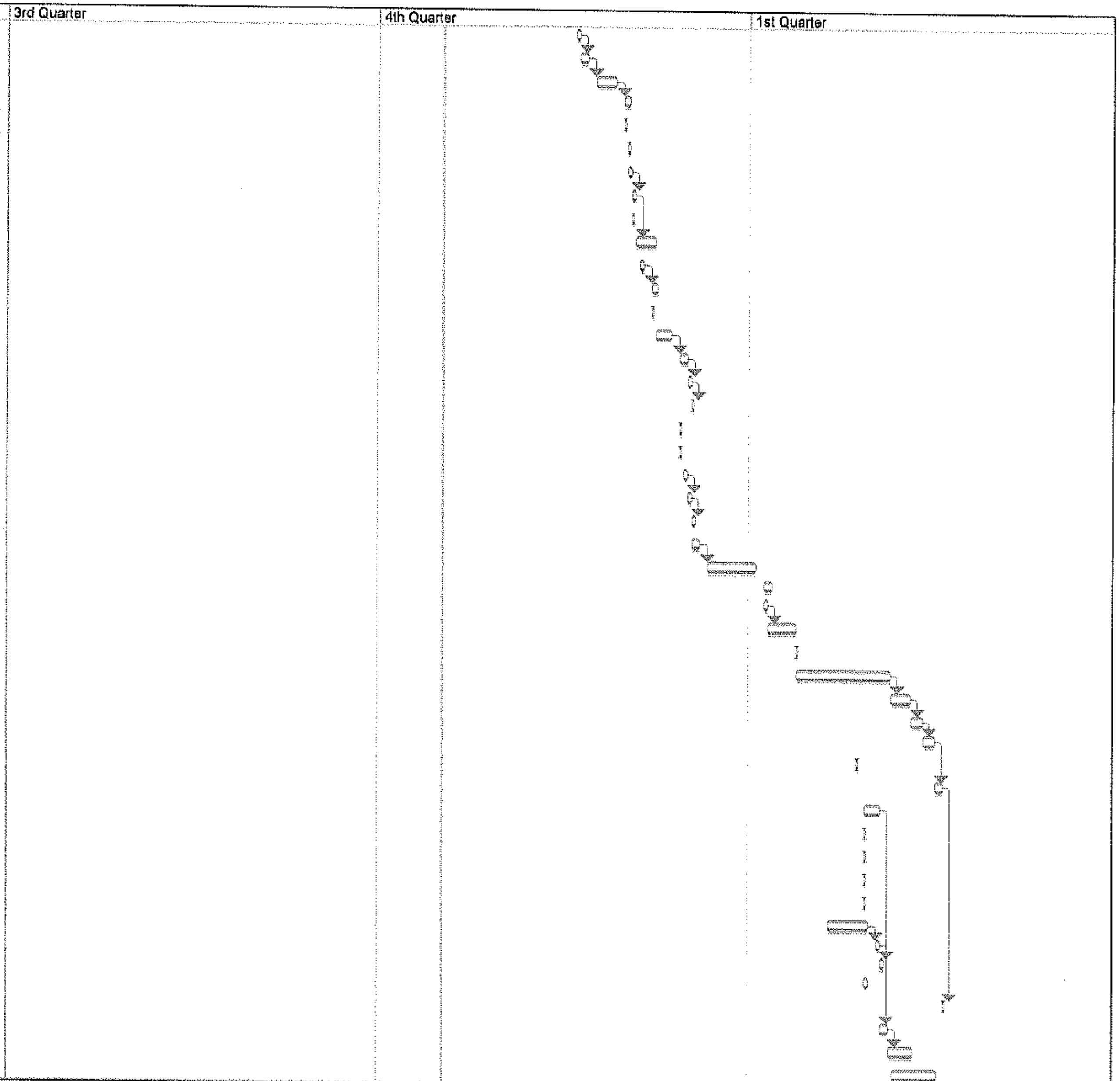
ID		Task Name
1	✓	Pre-Mobilization Survey Team
2		Mobilization Project Team
3		**Laboratory 2 Characterization**
4		**Lab 4 Characterization**
5		**Lab 1 Characterization**
6		**2nd Floor Characterization**
7		**QC Lab Characterization**
8		**Laboratory #3 Characterization**
9		**Pre-Mobilizatioin Demo Team**
10		**Mobilization Demolition Team**
11		**Safety Training**
12		**Equipment Set Up**
13		**Personel Meeting/Project Plan**
14		**QC Lab Equipment**
15		**QC Lab Casework**
16		**QC Lab Fumehoods**
17		**QC Lab Ceiling Tiles**
18		**QC Lab Systems**
19		**QC Lab Walk-In Size Reduction**
20		**QC Lab Brokk Scabbling**
21		**QC Lab Ventilation Removal**
22		**QC Lab Herculite- waste storage set up**
23		**Laboratory #3 equipment removal**
24		**Lab 3 Casework Removal**
25		**Lab 3 Fumehood Removal**
26		**Lab 3 Ceiling Tile Removal**
27		**Lab 3 System Removal**
28		**Lab 3 Drywall Removal**
29		**Lab 3 Floor Tile Removal**
30		**Lab 3 Scabble/Needle Gun Walls**
31		**Lab 3 Scabble Floors**
32		**Lab 3 Ventilation Removal**
33		**Lab 3 FSS**
34		**Waste Shipment**
35		**Lab 2 Equipment Removal**
36		**Lab 2 Casework Removal**
37		**Lab 2 Fumehood Removal**
38		**Lab 2 Ceiling Tile Removal**
39		**Lab 2 System Removal**
40		**Lab 2 Drywall Removal**
41		**Lab 2 Floor Tile Removal**
42		**Lab 2 Scabble/Needle Gun Walls**
43		**Lab 2 Scabble Floors**
44		**Lab 2 Ventilation Removal**
45		**Lab 2 FSS**



Project: Sigma-Aldrich
Date: Fri 10/17/08

Task | Summary | Rolled Up Progress | Project Summary
Progress | Rolled Up Task | Split | Group By Summary
Milestone | Rolled Up Milestone | External Tasks | Deadline

ID	Task Name
46	**Lab 4 Equipment Removal**
47	**Lab 4 Casework/Flame Cab. Removal**
48	Thanksgiving Break
49	**Lab 4 Fumehood Removal**
50	**Lab 4 Ceiling Tile Removal**
51	**Lab 4 System Removal**
52	**Lab 4 Drywall Removal**
53	**Lab 4 Floor Tile Removal**
54	**Lab 4 Drain Removal**
55	**Lab 4 Scabbling**
56	**Lab 4 Ventilation Removal**
57	**Lab 4 FSS**
58	**Waste Shipment**
59	**Lab 1 Equipment Removal**
60	**Lab 1 Casework/Flame Cab. Removal**
61	**Lab 1 Fumehood Removal**
62	**Lab 1 Ceiling tile Removal**
63	**Lab 1 System removal**
64	**Lab 1 Fire Door Removal**
65	**Lab 1 Drywall Removal**
66	**Lab 1 Floor Tile Removal**
67	**Lab 1 Ventilation Removal**
68	**Lab 1 Scabbling**
69	BREAK FOR CHRISTMAS/
70	Lab 1 FSS
71	**2nd Floor Vaccum Pumps Removed**
72	**2nd Floor Scabbling**
73	**Set Up Waste Storage on 2nd Floor**
74	**2nd Floor Ventilation Removal**
75	**Plenum Removal**
76	2nd Floor FSS
77	**Crane Set Up**
78	**Containment Set Up**
79	**Stack Removal**
80	**Size Reduction of Stacks**
81	**Survey Crane and Rigging Equipment**
82	**Electric Motor Removal**
83	**Hand Rails around roof openings**
84	**Cover roof openings**
85	Soil Sampling
86	Laboratory Analysis of Soils
87	Soil Remediation
88	**FSS of Roof Area and Components**
89	**Final Waste Shipment**
90	**Pack Equipment**
91	**Demobilization**
92	Final Report Preperation



Project: Sigma-Alrdrich
Date: Fri 10/17/08

Task | Progress | Milestone | Summary | Rolled Up Task | Rolled Up Milestone | Rolled Up Progress | Split | External Tasks | Project Summary | Group By Summary | Deadline

Sigma-Aldrich
Fort Mims Facility
Maryland Heights, MO
Open Land Soil Sampling and Analysis Plan

Sigma-Aldrich Company
PO Box 14508
St. Louis, MO 63178

U.S. Nuclear Regulatory Commission
Radioactive Materials License No. 24-16273-01

October 20, 2008

Prepared by:
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Table of Contents

Appendices

1.0 Introduction

This document has been written to govern the final status survey (FSS) activities of the soils surrounding the Sigma-Aldrich Fort Mims facility located at 11542 Fort Mims Drive in Maryland Heights, MO to support the unconditional release of the facility and the termination of the facility radioactive materials license. This plan was developed using the guidance provided in NUREG 1757 Volume 2, *Consolidated NMSS Decommissioning Guidance* and NUREG 1575, *Multi-Agency Radiation Survey and Site Investigation Manual* (MARSSIM). It provides the approach, methods, and techniques for the design and performance of final status surveys. FSSs are designed to implement the protocols and guidance provided in NUREG 1757 Volume 2 and MARSSIM to demonstrate compliance with the established release criteria. These methods ensure technically defensible data is generated to aid in determining whether or not the facility meet the release criteria for unrestricted use.

The final status survey will be conducted using the Data Quality Objective (DQO) process. Characterization and remedial action survey data will be used as final status survey data to the maximum extent possible in order to minimize overall project costs.

2.0 Nuclides of Concern

Based on historical data from the facility and the results of samples collected by Nuclear Regulatory Commission (NRC) inspectors in October 2007 and January 2008, the nuclides of concern (NOC) are Tritium (H-3) and Carbon-14 (C-14).

3.0 Determination of Site Specific Soil DCGLs

- Site-specific derived concentration guideline limits (DCGLs) were determined using the NOC screening values for soil surface contamination levels listed in Table B.2 of NUREG – 1757, Vol.1, Rev. 2.

Based on an annual dose limit of 25 mrem per year using the NOC screening values for soil surface contamination levels listed in Table B.2 of NUREG – 1757, Vol.1, Rev. 2 for the isotopes of concern are:

- H-3, 110 pCi/g
- C-14, 12 pCi/g

Fo the purposes of this plan, the default screening values will be used as the DCGLs. The DCGLs for each nuclide individually results in a projected dose of 25 mrem per year. For this reason, the unity rule must be applied such that:

$$\frac{C_{H-3}}{110pCi/g} + \frac{C_{C-14}}{12pCi/g} \leq 1, \text{ where}$$

C_x = the concentration of radionuclide "X" in soil, in pCi/g

4.0 Area Classification and Survey Unit Designation

Based on the results of the historical site assessment and survey results, facility areas are classified as impacted areas or non-impacted areas. Non-impacted areas are areas with no potential residual radioactivity from licensed activities. Non-impacted areas are not surveyed during FSSs. Impacted areas are those areas that have some level of potential residual radioactivity from licensed activities. Impacted areas will be subdivided into Class 1, 2, or 3 areas. Class 1 areas have the greatest potential for contamination and therefore receive the highest degree of survey effort for the FSS, followed by Class 2, and then by Class 3. Impacted sub-classifications are defined, for the purposes of this plan, as follows:

- Class 1 Area

  Areas that have, or had prior to remediation, a potential for radioactive contamination (based on site operating history) or known contamination (based on previous radiation surveys) above the $DCGL_W$.

- Class 2 Area

  Areas that have or had, prior to remediation, a potential for radioactive contamination or known contamination, but are not expected to exceed the $DCGL_W$.

- Class 3 Area

  Any impacted areas that are not expected to contain any residual radioactivity, or are expected to contain levels of residual radioactivity at a small fraction of the $DCGL_W$, based on site operating history and previous radiation surveys.

For the purposes of this plan, open land surfaces near the roof stack (West Open Land Areas) and open land surfaces directly north of the building (North Open Land Areas) are considered as Impacted – Class 1 and Class 2 respectively and are identified in Table 4-1. A diagram of each survey unit is provided in Appendix A.

Table 4-1 – Survey Units

Survey Unit
FMF-28 (North Open Land)
FMF-29 (West Open Land)

A survey unit is a geographical area of specified size and shape for which a separate decision will be made whether or not that area meets the release criteria. A survey unit is normally a portion of a building or site that is surveyed, evaluated, and released as a single unit. For the purposes of this plan, the potentially impacted open land soils surrounding the Fort Mims facility will be divided into two survey units. The area encompassed by these soils is within survey unit size limits recommended by MARSSIM.

Table 4-2 – Recommended Maximum Survey Unit Size Limits

Type of Survey Unit	Class 1	Class 2	Class 3
Open Land	Up to 2,000 m^2	2,000 m^2 to 10,000 m^2	No Limit

The preliminary survey units for the open land soils are provided in Appendix A.

5.0 Data Quality Objectives

The DQO Process as described in MARSSIM is used throughout the design and implementation of the survey design. The following is a list of the major DQOs for the survey design described in this plan:

- Soil sampling will be designed to ensure that a 90% probability of detection a certain sized hot spot is achieved.
- Decision error probability rates will initially be set at 0.05 for both α and β.
- The null hypothesis (H_0) and alternate null hypothesis (H_A) are that of NUREG 1505 scenario A:
  - H_0 is that the survey unit does not meet the release criteria
  - H_A is that the survey unit meets the release criteria
- Characterization and remedial action support surveys will be conducted under the same quality assurance (QA) criteria as FSSs such that the data may be used as FSS data to the maximum extent possible.

6.0 Final Status Survey Design for Soil Areas

Soil samples will be collected in designated outside areas surrounding the facility as part of the FSS. The survey design for these soils will be based on the Sign Test since typical environmental levels of the nuclides of concern are not significant in comparison to the proposed DCGLs. This also eliminates the need for a background reference area that would be difficult to establish at the site. The minimum number of samples would be obtained from MARSSIM tables or calculated using equations in Section 5 of MARSSIM. This approach alone cannot be used to determine the number of samples required due to the inability to perform direct scans of the soils to identify areas of elevated activity. The following sections discuss the methods for determining the number of samples and spacing necessary to statistically provide a 90 percent confidence that a defined survey unit does not exceed the applicable soil screening levels. A multilevel strategy has been assembled to provide a conservative approach to assessing potential soil contamination levels for the facility.

6.1 DETERMINING SAMPLE LOCATIONS

6.1.1 MARSSIM Approach

Determination of Class 1 survey unit sample locations is accomplished by first determining sample spacing and then systematically plotting the sample locations from a randomly generated start location. The random starting point of the grid provides an unbiased method for obtaining measurement locations to be used in the statistical tests. Area factor calculations are completed to determine if the initial sample spacing is acceptable based upon the scan sensitivity of the instrumentation used. Because the primary nuclides at the facility are ^{14}C and ^{3}H, the scan surveys effectiveness using this method is largely diminished. To compensate for this, a Visual Sample Plan approach and specific investigation levels will be used to aid in determining if elevated activity may have been missed. This is discussed in further detail in Section 6.1.2 of this plan.

Similar systematic spacing methods are used for Class 2 survey units because there is still a probability of small areas of elevated activity. The use of a systematic grid allows the decision-maker to draw conclusions about the size of the potential areas of elevated activity based on the area between measurement locations.

Class 3 survey locations are determined from computer-selected randomly generated x and y coordinates at each location. Initially, a Class 1 and a Class 2 survey unit will be established for the soils on the west and north sides of the Fort Mims facility. Survey protocols for all areas are summarized in Table 6-1.

Table 6-1 – Survey Sample Placement Overview

Survey Unit Classification		$DCGL_W$ Comparison	Elevated Measurement Comparison	Measurement Locations
Impacted	Class 1	Yes	Yes	Systematic random
	Class 2	Yes	N/A	Systematic random
Non-Impacted		None	None	None

<u>Class 1 Soil Areas</u>

In Class 1 and 2 survey units, the sampling locations are established in a unique pattern beginning with a random start location and the determined sample spacing. After determining the number of samples needed in the survey unit, sample spacing will be based upon a triangular grid pattern and is determined from MARSSIM Equation 5-7:

$$L = \sqrt{\frac{A}{0.866N}} \text{ for a triangular grid}$$

Where:

L = sample spacing interval

A = the survey unit area

N = number of samples needed in the survey unit

Survey maps will be generated of the survey unit surfaces folded out in a 2-dimensional view. A random starting point is determined using computer-generated random numbers coinciding with the x and y coordinates of the total survey unit. A triangular grid is plotted across the survey unit surfaces based on the random start point and the determined sample spacing. A sample location is collected at each intersection of the grid.

6.1.2 Visual Sample Plan with the Singer and Wickman Hot Spot Approach

The multilevel approach starts with determining the typical number of samples using the standard MARSSIM approach. Because of the inability of direct scan measurements to detect the primary isotopes of concern, Visual Sample Plan (VSP) v5.0 will be used to calculate the number of samples required to detect an area of elevated activity, alternatively referred to as a hot spot. VSP provides the ability to design and modify our sampling approach to obtain a high probability of not missing a defined area of contamination.

VSP, with the Singer and Wickman statistical interval approach, provides additional functionality to assist with a statistical method for determining the number of samples necessary using sampling goals to ensure that most of the area is uncontaminated. This approach uses an upper tolerance limit and an unknown distribution of contamination. A 90 percent probability of not missing a defined hot spot size in excess of the $DCGL_w$ is determined with this method. An example of a VSP report detailing this approach soils survey unit is included as Appendix B.

6.2 DETERMINING THE RELATIVE SHIFT

The number of required samples will depend on the ratio involving the activity level to be measured relative to the variability in the concentration. The ratio to be used is called the relative shift, Δ/σ_S, and is defined in MARSSIM as:

$$\Delta / \sigma_S = \frac{DCGL - LBGR}{\sigma_S}$$

Where:

$DCGL_W$ = derived concentration guideline level

LBGR = concentration at the LBGR. The LBGR is the average concentration to which the survey unit should be cleaned in order to have an acceptable probability of passing the test

σ_S = an estimate of the standard deviation of the residual radioactivity in the survey unit following remediation

6.3 DETERMINING ACCEPTABLE DECISION ERRORS

A decision error is the probability of making an error in the decision on a survey unit by failing a unit that should pass (β decision error) or passing a unit that should fail (α decision error). MARSSIM uses the terminology α and β decision errors; this is the same as the more common terminology of Type I and Type II errors, respectively. The decision errors for the project are 0.05 for Type I errors and 0.05 for Type II errors.

6.4 DETERMINING THE NUMBER OF SAMPLES (SIGN TEST AND VSP/SINGER AND WICKMAN)

Using the combination of the MARSSIM Sign Test approach and the VSP/Singer and Wickman approach our design we will identify the appropriate number of samples necessary for proper evaluation of residual activity in the survey unit. The number of samples required by the MARSSIM design will need to be evaluated and compared to the VSP/Singer and Wickman approach to ensure that too few samples are not selected.

The number of direct measurements for a particular survey unit, employing the Sign Test, is determined from MARSSIM Table 5.5, which is based on the following equation (MARSSIM equation 5-2):

$$N = \frac{(Z_{1-\alpha} + Z_{1-\beta})^2}{4(SignP - 0.5)^2}$$

Where:

N = number of samples needed in the survey unit

$Z_{1-\alpha}$ = percentile represented by the decision error α

$Z_{1-\beta}$ = percentile represented by the decision error β

SignP = estimated probability that a random measurement will be less than the $DCGL_W$ when the survey unit median is actually at the LBGR

Note: SignP is determined from MARSSIM Table 5.4

MARSSIM recommends increasing the calculated number of measurements by 20 percent to ensure sufficient power of the statistical tests and to allow for possible data losses. MARSSIM Table 5.5 values include an increase of 20 percent of the calculated value.

Based on expected contamination levels post remediation, the initial estimated number of soil samples to meet the Sign Test is determined to be 14.

Based upon Survey Unit FMF-29, the VSP/Singer and Wickman approach will add an additional 21 samples to the 14 required using the standard MARSSIM approach in order to obtain a 90 percent confidence that an elliptical hot spot with a length of the semi-major axis of 2.59 meters (8.51 feet) will not be missed from the sampling design. The report produced by VSP for this model is provided in Appendix B.

This conservative approach will require more samples than required by the typical MARSSIM design and provides the statistical confidence necessary to demonstrate that hot spots of the size stated above that exceed soil screening criteria will not be missed.

Additional judgmental samples will be collected at suspect locations. These will be determined by the Project Radiological Engineer or designee.

6.5 INVESTIGATION LEVELS

Investigation levels are used to flag locations that require special attention and further investigation to ensure areas are properly classified and adequate surveys are performed. These locations are marked and receive additional investigations to determine the concentration, area, and extent of the contamination.

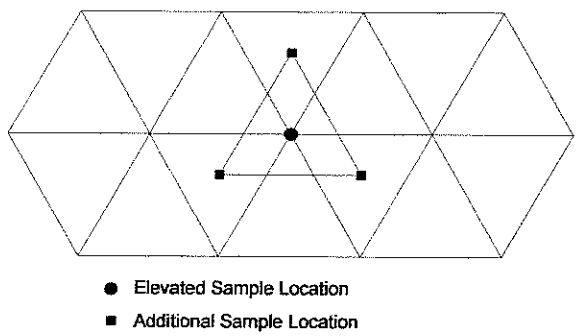
For purposes of this plan, measurements approaching or exceeding a percentage DCGLs are not unexpected. However, a discrete measurement that is much higher than all the other discrete measurements might be considered unusual and warrant further investigation.

As described previously, the inability to scan for the low energy beta emitters undermines the basic MARSSIM survey design. In most cases, the number of samples required for a particular survey unit is based upon the statistical test and the assumption that localized spots of elevated activity can be detected during scan surveys above the $DCGL_{EMC}$ for the bounding area of the samples. VSP software will be used to provide statistical confidence for the number of samples taken for purposes of ultimate site release.

For the purposes of this plan, an investigation levels has been determined that if exceeded could indicate the presence of elevated activity not detected by the random sampling. The Project Health Physics Manager will evaluate each survey unit against the investigation levels and determine if additional samples are required. Additional samples will be obtained at all locations exceeding 75% of any nuclide of concern's DCGL.

Additional samples that are collected for investigation purposes will be collected at locations that support the original random-systematic pattern used in the original survey design. For the purposes of this plan, a triangular grid system has been chosen for open land samples. For any sample location were activity is detected that exceeds the applicable investigation level, an additional (3) three sample will be collected. A triangular grid, using the same sample spacing as the original survey, will be superimposed using the location of the elevated activity as the center. The additional samples will be collected at the corners of the grid and will be analyzed for the specific isotope(s) that exceeded the screening value. An example is provided in Figure 6-1.

Figure 6-1 – Example Open Land Investigative Sample Design



Sub surface samples will be collected at depth intervals of 0-6 inches. Additional sampling intervals may be designated by the Radiological Engineer as required to characterize the vertical extent of contamination.

If the results of the investigative samples are less than the screening values, then the area meets the release criteria and no further action will be required. If any of the results exceed the screening values then additional remediation and sampling may be required.

6.6 ANALYSIS OF SOILS AND VOLUMETRIC SAMPLES

Teledyne Brown Engineering in Knoxville, TN will be used for radiochemical analysis of the samples. Selected analyses for ^{3}H and ^{14}C will be performed on all samples. A health physics technician will be responsible for obtaining, packaging, labeling, and shipping the soil samples. Tritium and ^{14}C analysis will be performed by oxidization to vaporize organics and then analyzed in a liquid scintillation counter. The analytical methods to be used for individual radionuclide analysis are provided in Table 6-2.

Table 6-2 – Analytical Method for Soils Analysis

Nuclide	Analytical Method	Method MDC (pCi/g)
^{3}H	EPA 906.0/DOE H3-04-RC	10
^{14}C	EPA EERF C-01-1	1.0

Notes: DOE – Department of Energy, EPA – U.S. Environmental Protection Agency

Sigma Aldrich reserves the right to select alternate laboratories for analysis of the sample as long as equivalent analysis can be performed.

6.7 SCAN SURVEYS

Scan surveys will be performed on exposed soil surfaces using a Sodium Iodide detector to verify there are no unexpected gamma emitters present.

6.8 DOSE RATE SURVEYS

Dose rate surveys will be performed at each soil sample locations using a Sodium Iodide instrument and results will be recorded in units of μR/hr.

6.9 SURVEY DOCUMENTATION

A survey package will be developed containing the following:

- Survey instruction sheets
- General survey requirements
- Instrument requirements with associated MDCs, count times, and scan rates
- Sampling volume requirements
- Survey maps
- Overview maps detailing survey locations and placement methodology
- Survey sub-unit maps with additional sample location information, as needed
- Survey data sheets
- Signatures of data collectors and reviewers

6.10 DATA VALIDATION

Field data will be reviewed and validated to ensure:

- Forms are filled out accurately and completely
- Proper types of surveys are performed for survey unit conditions
- The MDCs for measurements meet the established DQOs, and independent calculations are performed for a representative sample of data sheets and survey areas
- Satisfactory instrument calibrations and daily functional checks are performed as required

6.11 FINAL STATUS SURVEY QUALITY ASSURANCE

QA/QC samples for soil matrices are discussed below. Each type of sample is defined and a preparation procedure is outlined. In addition, the minimum frequency of collection of these QA/QC samples is discussed.

6.11.1 Field Duplicates

Field duplicates are field samples obtained from one location that are homogenized by thorough hand mixing and divided into separate containers. These field duplicates will be treated as separate samples and put through the same sample handling and analytical processes. These samples will be used to assess total error (precision) associated with sample heterogeneity, sample methodology, and analytical procedures. A minimum of 1 field duplicate will be obtained for every 20 soil samples collected. This will ensure adequate data is collected in order for valid statistical analysis to be performed.

6.11.2 Matrix-Spike Samples

Matrix spike and matrix spike duplicate (MS/MSD) samples are environmental samples that are spiked in the laboratory with a known concentration of a target analyte(s) to verify the efficiencies of the laboratory method. MS/MSD samples will be used primarily to check sample matrix interferences. They can also be used to monitor laboratory performance and evaluate errors due to laboratory bias and precision. A minimum of one MS/MSD will be analyzed for every 20 soils samples obtained.

7.0 Soil Sampling Methodology

The soil sampling methodology reflects both the equipment used to collect the sample, as well as how the sample is handled and processed after retrieval of the material. There are two sampling methodologies for collecting soil samples: 1) collection with manual or hand operated devices and 2) collection with powered devices. Simple, manual techniques and equipment, such as hand augers, are usually selected for surface or shallow sub-surface soil sampling. As the depth of the sampling interval increases, some type of powered sampling equipment may be needed to overcome torque induced by soil resistance and depth. A Geoprobe or equivalent may be utilized for subsurface soil sample collection. The Geoprobe relies on a relatively small amount of static weight combined with percussion as the energy for advancement into the sub-surface soil to obtain continuous soil cores or discrete soil samples.

7.1 SURFACE SOIL SAMPLING

Surface soils are generally classified as soils between the ground surface and 6 inches below ground surface. The shallow sub-surface interval may be considered to extend from approximately 6 inches below ground surface to a site-specific depth at which sample collection using manual methods becomes impractical. Surface samples are removed from the ground, placed in bowls and homogenized as described in the sample mixing section.

7.2 SUBSURFACE SOIL SAMPLING

Subsurface samples may be required were elevated activity was detected in the surface samples to determine the depth of the source term. Hand-augering is the most common manual method used to collect subsurface samples. Typically, 4-inch auger-buckets with cutting heads are twisted into the ground and removed as the buckets are filled. The auger holes are advanced one bucket at a time.

When a vertical sampling interval is required, one auger-bucket is used to advance the auger hole to the first desired sampling depth. If the sample is a vertical composite, the sample bucket may be used to advance the hole, as well as to collect subsequent aliquots in the same hole. However, if discrete samples are to be collected, a clean bucket must be place on the end of the auger extension prior to collecting the next samples. The top several inches of the soil should be removed from the bucket to minimize the chances of cross-contamination of the sample from fall-in of material from the upper portions of the hole. The hollow stem auger is also an option for the collection of sub-surface samples due to being able to collect the sample through the center of the digging auger at the desired depth.

A soil core sampler, or push tube, may also be used to collect surface and shallow sub-surface soil samples. This is a thin-walled tube, constructed of stainless steel and has a beveled leading edge. The tube is twisted and pushed or hammered directly into the soil. This type of sampling device is useful for collecting undisturbed samples.

In certain areas, subsurface sampling will be necessary to confirm excavation activities have adequately remediated the impacted soils areas. In cases where the sampling location is not be readily accessible, equipment such as a split spoon sampler attached to the excavation equipment, Geoprobe or hollow stem auger will be used to collect the samples.

7.3 SOIL SAMPLING PROCEDURE

The sampling will be performed as follows:

Sampling personnel will don a new pair of disposable gloves immediately before collecting soil samples at each location.

3.3.1. A hand-auger or push probe will be used to collect soil at accessible locations from 0'' to 6'' below ground surface (bgs).

3.3.2. If the hand auger or push probe is unable to access the sampling location excavating equipment will be used to collect soil samples. A split spoon sampling device capable of collecting a sample interval below the surface of the excavated area will be utilized.

3.3.3. A minimum of 500 grams of material will be collected from each sampling depth before homogenization. In the case of the deep excavation areas multiple samples will be collected in proximity to each other to obtain the necessary sample volume.

3.3.4. Homogenized soil will be placed into sample containers.

3.3.5. A completed sample label will be affixed to each sample container and clear packing tape used to secure the sample label to the container. Note: It may also be practical to write the applicable information directly on the containers.

3.3.6. A custody seal will be affixed over the lid of the sample container.

3.3.7. The sample number, date, time and description of the sample will be recorded on the chain-of-custody (COC) record and in the field logbook. All entries will be written in indelible black or blue ink.

3.3.8. Each sample will be numbered, labeled and packaged in accordance with the Sample Number and Sample Packaging & Shipment sections.

3.3.9. Field documentation, including field logbooks and COC records, will be filled out in accordance with Section 8.0.

3.3.10. The hand-auger, push probe and excavation bucket will be decontaminated in accordance with procedures in the Section 7.8.

7.4 SAMPLE ID

Each sample will be identified as follows:

WWW: Up to 3-character designation of the facility (for example, "FMF")

XX: Up to 2-character designation of the survey unit (for example, "24")

YYYY: Up to 4-character designation of the surface type (for example, "CON" represents concrete, "SOIL" for soils, etc.)

ZZZZ: 4-character designation of the consecutive sample number (for example, 004A)

For example, in the sample identification number FMF-28-SOIL-004, "FMF" represents the facility (Fort Mims Facility), "28" represents the survey unit, "SOIL" represents a soil surface and "004" represents the sample collected at location 4. The sample number will be recorded in the field logbook, on the labels (or containers) and Chain-of-custody record at the time of sample collection. A complete description of the sample and sampling conditions will be recorded in the field logbook and referenced using the unique sample identification number.

7.5 SAMPLE LABELING

Sample labels are necessary to prevent misidentification of samples. Sample labels will be filled out in indelible black or blue ink and affixed to sample containers at the time of sample collection. Each sample container will be labeled with the following, at a minimum:

- Sample identification number
- Sample collection date (month/day/year)
- Time of collection (24-hour clock)
- Sampler's initials

7.6 SAMPLE PACKAGING AND SHIPMENT

Sample packaging and shipment procedures for this project will be in accordance with Department of Transportation (DOT)/International Air Transport Association (IATA) procedures, as applicable for packaging and shipping for samples. Samples for radiological analysis will be packed in an insulated cooler/ice chest with sufficient packing material if samples are transported by a commercial carrier.

7.7 SAMPLE HANDLING AND MIXING

Precautions will be taken to prevent sample contamination. Clean gloves, sampling and mixing equipment will be used for each sample taken and will be decontaminated prior to subsequent use. One member of the sampling team will be responsible for taking the field notes, filling out tags, etc., while the other member(s) collect the samples. When practical, collection activities will proceed progressively from the least suspected contaminated area to the most suspected contaminated area. A minimum of 500 grams of soil will be collected at each soil sampling location.

After collection, all soil samples will be mixed thoroughly to ensure sample uniformity. As the required volume of soil is collected it will be transferred into a stainless steel mixing bowl to be homogenized using stainless steel mixing spoons. Once the material has been properly mixed, samples will be removed and placed into the appropriate containers for analysis. Adequate mixing in the bowls will be completed by breaking down any clumps of material with stainless steel spoons and stirring in a circular fashion, reversing direction and occasionally turning the material over folded from the bottom of the pan into the top of the pan to prevent settling of the finer-grained materials. Any rocks or debris will be removed from the bowl. After mixing is complete, the soil will be divided into two sample sets and placed into the sample containers.

7.8 DECONTAMINATION PROCEDURES

Decontamination of non-disposable sampling equipment will be performed to prevent the introduction of extraneous material into samples and to prevent cross-contamination between samples.

The following steps will be utilized for general decontamination of non-disposable sampling equipment:

a. Clean with appropriate decontamination solution and/or material – This step will remove gross contamination from the equipment.
b. Final wipe and cleaning with dry clean cloth/wipe – This will remove remaining solution and contamination from the equipment.
c. Radiological Screening of equipment – This step will be used to verify effectiveness of decontamination for equipment that is to be taken off site at the completion of work activities. This process will be completed with hand-held survey meters and wipes.

8.0 Field Records, Sample and Document Control

In order to maintain the integrity and traceability of samples, all information pertinent to field sampling will be recorded in a field logbook. All samples will be properly labeled and custody-sealed prior to being transported to the laboratory and will be accompanied by completed COC documentation. All documentation will be recorded in a bound field logbook with indelible blue or black ink.

8.1 CHAIN OF CUSTODY

To establish the documentation necessary to trace sample possession from the time of collection through analysis and disposal, a COC record will be completely filled out and will accompany every sample. Samples will be delivered to the laboratory for analysis as soon as practical. At a minimum, the following items will be recorded on the COC record:

- Project name
- Sample ID
- Sampler Name
- Sampler signature
- Date (of sample collection)
- Sample type (matrix)
- Sample location codes
- Number of sample containers
- Comments
- Transfer signature (to relinquish samples)
    - The sampler will be the first person to relinquish sample possession
- Laboratory representative signature
- Date of custody transfer

8.2 CUSTODY SEALS

Sample custody seals are used to detect unauthorized tampering of samples from the time of sample collection to the time of analysis. The applicable seals will be signed or initialed and dated by the sampler. The seals will be placed on the sample containers and shipping containers in such a way that they must be broken in order to open the containers. Seals will be affixed to containers before the samples leave the custody of the sampling personnel.

8.3 FIELD LOGBOOK

A permanently bound field logbook with consecutively numbered pages, used for sampling activities only, will be assigned to this project. All entries will be recorded in indelible black or blue ink. At the end of each workday, the logbook pages will be signed by the responsible sampler, and any unused portions of the logbook pages will be crossed out, signed and dated. If it is necessary to transfer the logbook to another person, the person relinquishing the logbook will sign and date the last page used, and the person receiving the logbook will sign and date the next page to be used.

At a minimum, the logbook will contain the following information:

- Project name and site location
- Date and time
- Personnel in attendance
- General weather information
- Work performed
- Field observations
- Sampling performed, including specifics such as location, type of sample, type of analyses, and sample identification
- Problems encountered and corrective action taken
- Verbal or written instructions
- Any other events that may affect the samples

8.4 DOCUMENT CORRECTIONS

Changes or corrections on any project document will be made by crossing out the erroneous item with a single line and initialing (by the person performing the correction) and dating the correction. The original item, although erroneous, must remain legible beneath the cross-out line. The new information should be written clearly above the crossed-out item.

9.0 Data Quality Assessment and Interpretation of Survey Results

The statistical guidance contained in Section 8 of MARSSIM will be used to determine if areas are acceptable for unrestricted release and whether additional surveys or sample measurements are needed.

9.1 PRELIMINARY DATA REVIEW

A preliminary data review will be performed to identify any patterns, relationships, or anomalies. Additionally, measurement data is reviewed and compared with the $DCGL_W$(s) and investigation levels to identify areas of elevated activity and to confirm the correct classification of survey units.

The following preliminary data reviews will be performed:

- Calculations of the survey unit mean, median, maximum, minimum, and standard deviation
- Comparison of the survey unit mean and median to the $DCGL_W$
- Identification of each individual measurement that is above the applicable $DCGL_W$
- Comparison of survey data with applicable investigation level

For samples sent to an off-site laboratory, the external analytical laboratories will be required to provide an electronic data validation package for review. As appropriate, this package will include gamma spectrum identification information such as calibration and peak identification measurements, isotopic quantification calculations and, if radiochemical analysis is used, percent sample recovery.

The Radiological Engineer will review the electronic sample data to ensure chain of custody has been preserved; verify all samples taken have corresponding results; the limits of detection are at or below specified criteria; peak identification is correct (i.e., the radionuclides identified are associated with the energy line in the spectrum); calculations for peak quantification are accurate; and no QC problems exist.

If it is determined that all soil samples are less than the applicable investigation levels, then no further statistical tests are required. The survey unit meets the release criterion provided that the sum of fractions is less than one or it can be shown that the peak total effective dose equivalent is less than 25 mrem/yr using site-specific dose modeling.

The sum of fractions method will be used to evaluate situations where multiple radionuclides are present in soil using Equation 2-3 from NUREG 1757 Volume 2 as follows:

$$\sum_{s=1}^{M}\sum_{r=1}^{N}\frac{Conc_{sr}}{Limit_{sr}} \leq 1$$

Where:

$Conc_{sr}$ = the concentration of radionuclide r in source s

$Limit_{sr}$ =the $DGGL_w$ value for radionuclide r in source s

Site-specific dose modeling using Table B.2 of NUREG – 1757, Vol.1, Rev. 2 will be used to determine the peak total effective dose equivalent associated with the survey unit. The Sign Test elevated measurement comparison will be used, if required, to compare the survey unit results with the DCGLs in accordance with MARSSIM section 8.3.1.

9.2 VERIFICATION OF STATISTICAL DESIGN

Although the number of samples is based on the VSP/Singer and Wickman approach, the underlying premise is that the survey is designed using MARSSIM protocols and the Sign Test. Based on the initial a priori calculations using adjusted characterization data, the VSP approach resulted in a significantly higher number of samples than that required by the Sign Test. However, this will be verified using calculation with the actual sample results from the FSS. If the actual (a posteriori) relative shift is lower than the pre-determined (a priori) relative shift, the number of samples required will be re-calculated and additional sampling will be performed. If the actual relative shift is greater than or equal to the pre-determined relative shift, no additional sampling will be necessary.

10.0 Final Report

Following completion of the FSS and determination of compliance with the screening values, a Final Report will be prepared using the guidance of NUREG 1757 Volume 2, Section 4.5. The Final Report will include, at a minimum:

- An overview of the results of the FSS
- A summary of the screening values for the facility (if screening values are used)
- A discussion of any changes that were made in the FSS from what were proposed in this plan
- A description of the method by which the number of samples was determined for each survey unit
- A summary of the values used to determine the number of samples and a justification for these values
- A description of the data quality objectives used in the design and performance of the Final Status Survey
- The survey results for each survey unit including the following:
  - The number of samples taken for the survey unit;
  - A description of the survey unit, including (a) a map or drawing showing the reference system and random start systematic sample locations for Class 1 and Class 2 survey units and reference area as applicable and (b) discussion of remedial actions and unique features
  - The measured sample concentrations in units comparable to the screening values
  - The statistical evaluation of the measured concentrations
  - Judgmental and miscellaneous sample data sets reported separately from those samples collected for performing the statistical calculations
  - A discussion of anomalous data, including any areas of elevated activity detected during scan surveys that exceeded the investigation levels or any measurement locations in excess of the screening values
  - A statement that a given survey unit satisfies the screening values and the elevated measurement comparison if any sample points exceeded the screening values
- A description of any changes in initial survey unit assumptions relative to the extent of residual activity (e.g., material not accounted for during site characterization)
- A description of how As Low As Reasonably Achievable practices were employed to achieve final activity levels.

11.0 References

———. 1995. NUREG 1505. A Nonparametric Statistical Methodology for the Analysis of Final Status Decommissioning Surveys.

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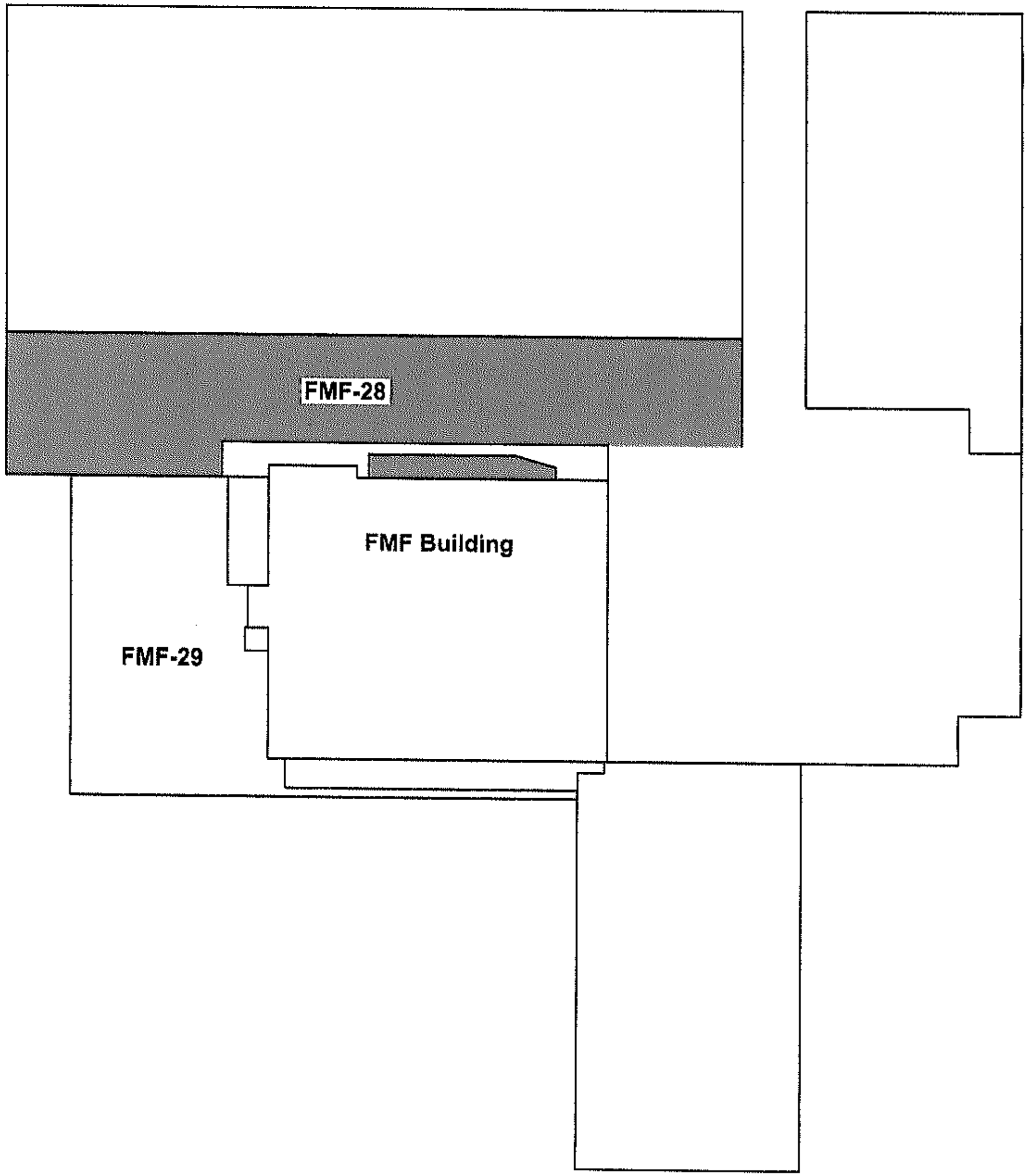
———. 2000. 1727. NMSS Decommissioning Standard Review Plan, Final. September

APPENDIX A
Fort Mims Facility Sampling Map

Sigma Aldrich Fort Mims Facility
Soil Survey Units



APPENDIX B

Visual Sample Plan/ Singer and Wickman Approach

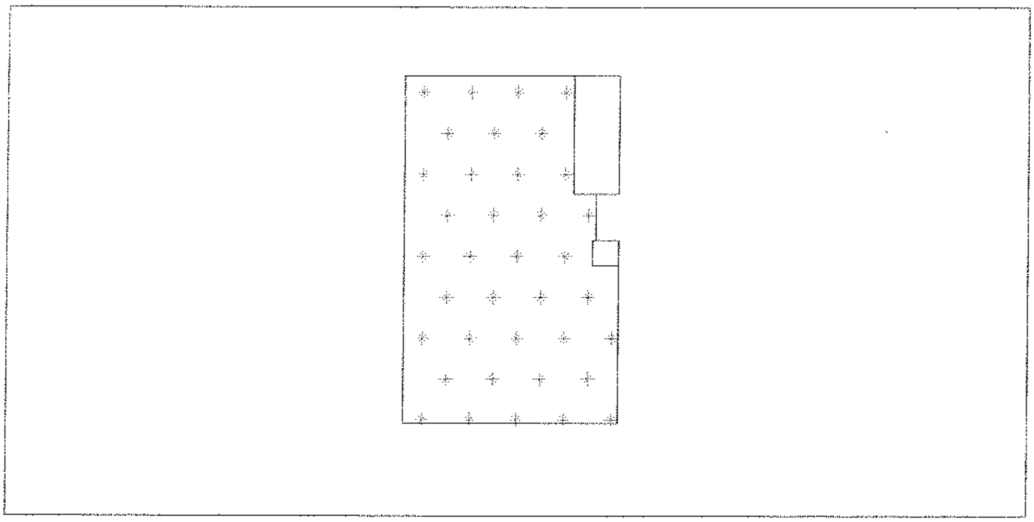
Systematic sampling locations for detecting an area of elevated values (hot spot)

This report summarizes the sampling design used, associated statistical assumptions, as well as general guidelines for conducting post-sampling data analysis. Sampling plan components presented here include how many sampling locations to choose and where within the sampling area to collect those samples. The type of medium to sample (i.e., soil, groundwater, etc.) and how to analyze the samples (in-situ, fixed laboratory, etc.) are addressed in other sections of the sampling plan.

The following table summarizes the sampling design developed. A figure that shows sampling locations in the field and a table that lists sampling location coordinates are also provided below.

SUMMARY OF SAMPLING DESIGN	
Primary Objective of Design	Detect the presence of a hot spot that has a specified size and shape
Type of Sampling Design	Hot spot
Sample Placement (Location) in the Field	Systematic (Hot Spot) with a random start location
Formula for calculating number of sampling locations	Singer and Wickman algorithm
Calculated total number of samples	35
Type of samples	Point Samples
Number of samples on map [a]	37
Number of selected sample areas [b]	1
Specified sampling area [c]	6784.24 ft^2
Grid pattern	Triangular
Size of grid / Area of grid [d]	14.9607 feet / 193.835 ft^2
Total cost of sampling [e]	$5,900.00

[a] This number may differ from the calculated number because of 1) grid edge effects, 2) adding judgment samples, or 3) selecting or unselecting sample areas.
[b] The number of selected sample areas is the number of colored areas on the map of the site. These sample areas contain the locations where samples are collected.
[c] The sampling area is the total surface area of the selected colored sample areas on the map of the site.
[d] Size of grid / Area of grid gives the linear and square dimensions of the grid spacing used to systematically place samples.
[e] Including measurement analyses and fixed overhead costs. See the Cost of Sampling section for an explanation of the costs presented here.



Area: Area 1					
X Coord	Y Coord	Label	Value	Type	Historical
19403.6969	9391.2484		0	Hotspot	
19418.6576	9391.2484		0	Hotspot	
19433.6183	9391.2484		0	Hotspot	
19448.5790	9391.2484		0	Hotspot	
19463.5396	9391.2484		0	Hotspot	
19411.1773	9404.2048		0	Hotspot	
19426.1380	9404.2048		0	Hotspot	
19441.0986	9404.2048		0	Hotspot	
19456.0593	9404.2048		0	Hotspot	
19403.6969	9417.1611		0	Hotspot	
19418.6576	9417.1611		0	Hotspot	
19433.6183	9417.1611		0	Hotspot	
19448.5790	9417.1611		0	Hotspot	
19463.5396	9417.1611		0	Hotspot	
19411.1773	9430.1174		0	Hotspot	
19426.1380	9430.1174		0	Hotspot	
19441.0986	9430.1174		0	Hotspot	
19456.0593	9430.1174		0	Hotspot	
19403.6969	9443.0737		0	Hotspot	
19418.6576	9443.0737		0	Hotspot	
19433.6183	9443.0737		0	Hotspot	
19448.5790	9443.0737		0	Hotspot	
19411.1773	9456.0301		0	Hotspot	
19426.1380	9456.0301		0	Hotspot	
19441.0986	9456.0301		0	Hotspot	

19456.0593	9456.0301		0	Hotspot	
19403.6969	9468.9864		0	Hotspot	
19418.6576	9468.9864		0	Hotspot	
19433.6183	9468.9864		0	Hotspot	
19448.5790	9468.9864		0	Hotspot	
19411.1773	9481.9427		0	Hotspot	
19426.1380	9481.9427		0	Hotspot	
19441.0986	9481.9427		0	Hotspot	
19403.6969	9494.8990		0	Hotspot	
19418.6576	9494.8990		0	Hotspot	
19433.6183	9494.8990		0	Hotspot	
19448.5790	9494.8990		0	Hotspot	

Primary Sampling Objective
The primary purpose of sampling at this site is to detect "hot spots" (local areas of elevated concentration) of a given size and shape with a specified probability, 1-β.

Selected Sampling Approach
This sampling approach requires systematic grid sampling with a random start. If a systematic grid is not used, the probability of detecting a hot spot of a given size and shape will be different than desired or calculated.

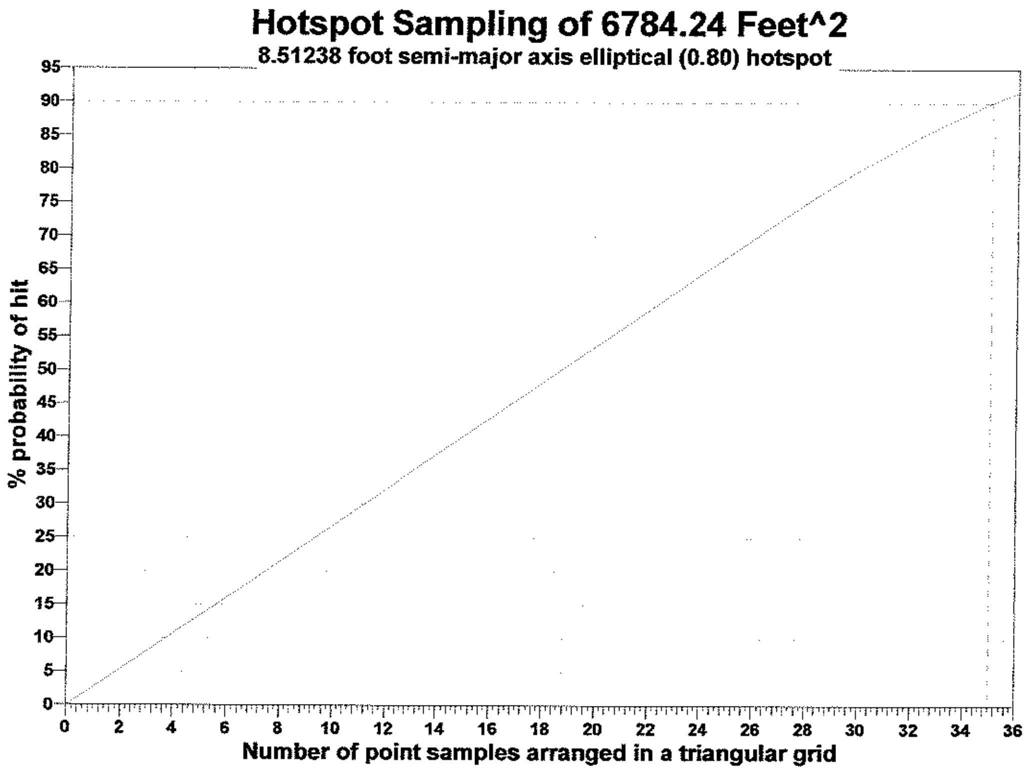
Number of Total Samples: Calculation Equation and Inputs
The algorithm used to calculate the grid size (and hence, the number of samples) is based on work by Singer and Wickman for locating geologic deposits [see Singer and Wickman (1969) and Hassig et al. (2004) for details]. Inputs to the algorithm include the size, shape, and orientation of a hot spot of interest, an acceptable probability of finding a hot spot, the desired type of sampling grid, and the sampling budget. For this design, the smallest hot spot that could be detected was calculated based on the given grid size and other parameters.

The inputs to the algorithm that result in the smallest hot spot that could be detected are:

Parameter	**Description**	**Value**
Inputs		
Samples	Number of samples specified by user	35
1-β	Probability of detection	90%
Grid Type	Grid pattern (Square, Triangular or Rectangular)	Triangular
Grid Size	Spacing between samples	14.9607 feet
Grid Area	Area represented by one grid	193.835 ft^2
Sample Type	Point samples or square cells	Points
Hot Spot Shape	Hot spot height to width ratio	0.8
Angle	Angle of orientation between hot spot and grid	Random
Sampling Area	Total area to sample	6784.24 ft^2
Outputs		
Hot Spot Size	Length of hot spot semi-major axis	8.51238 feet
Hot Spot Area [a]	Area of hot spot ($Length^2$ * Shape * π)	182.113 ft^2

[a] Length of semi-major axis is used by Singer-Wickman algorithm. Hot spot area is provided for informational purposes.

The following graph shows the relationship between the number of samples and the probability of finding the hot spot. The dashed blue line shows the actual number of samples for this design (which may differ from the optimum number of samples because of edge effects).



Assumptions that Underlie the VSP Locating a Hot Spot Design Method

1. The shape of the hot spot of concern is circular or elliptical.
2. The level of contamination that defines a hot spot is well defined.
3. The location of the hot spot is unknown, and if a hot spot is present, all locations within the sampling area are equally likely to contain the hot spot.
4. Samples are taken on a square, rectangular or triangular grid pattern.
5. Each sample is collected, handled, measured or inspected using approved methods that yield unbiased and sufficiently precise measurements.
6. A very small proportion of the surface being studied will be sampled (the sample is much smaller than the hot spot of interest).
7. Sample locations are independent of the measurement process.
8. The systematic grid is placed at a randomly determined starting place to cover the surface area of interest.
9. There are no classification errors (if a hot spot is sampled, it is not mistakenly overlooked or an area is not mistakenly identified as a hot spot).

Sensitivity Analysis

The sensitivity of the calculation of number of samples was explored by varying the probability of hit (%), hot spot shape (height to width ratio) and total sampling area and examining the resulting changes in the number of samples. The following table shows the results of this analysis.

Number of Samples				
		Area=3392.12	**Area=6784.24**	**Area=10176.4**
	Shp=0.7	20	39	58
1-β=85	**Shp=0.8**	17	33	49
	Shp=0.9	15	29	43
1-β=90	**Shp=0.7**	21	42	63

	Shp=0.8	18	35	53
	Shp=0.9	16	31	46
1-β=95	**Shp=0.7**	24	47	70
	Shp=0.8	20	39	58
	Shp=0.9	17	33	50

1-β = Probability of Hit (%)
Shp = Hot Spot Shape (Height to Width Ratio)
Area = Total Sampling Area

Cost of Sampling
The total cost of the completed sampling program depends on several cost inputs, some of which are fixed, and others that are based on the number of samples collected and measured. Based on the numbers of samples determined above, the estimated total cost of sampling and analysis at this site is $5,900.00, which averages out to a per sample cost of $168.57. The following table summarizes the inputs and resulting cost estimates.

COST INFORMATION			
Cost Details	**Per Analysis**	**Per Sample**	**35 Samples**
Field collection costs		$20.00	$700.00
Analytical costs	$120.00	$120.00	$4,200.00
Sum of Field & Analytical costs		**$140.00**	**$4,900.00**
Fixed planning and validation costs			$1,000.00
Total cost			**$5,900.00**

Recommended Data Analysis Activities
Post data collection activities generally follow those outlined in EPA's Guidance for Data Quality Assessment (EPA, 2006). The data analysts will become familiar with the context of the problem and goals for data collection and assessment. The data will be verified and validated before being subjected to statistical or other analyses. Graphical and analytical tools will be used to verify to the extent possible the assumptions of any statistical analyses that are performed as well as to achieve a general understanding of the data. The data will be assessed to determine whether they are adequate in both quality and quantity to support the primary objective of sampling.

A map of the actual sample locations will be generated so that the sampling plan and the field implementation may be compared. Deviations from planned sample locations due to topographic, vegetative, or other features will be noted. Their impacts will be qualitatively assessed. If a hot spot is discovered, additional sampling may be performed to determine its size and shape, in which case, the initial assumptions of the sampling design may then be assessed and/or reconsidered.

References
EPA 2006. *Data Quality Assessment: Statistical Methods for Practitioners EPA QA/G-9S*, EPA/240/B-06/003, U.S. Environmental Protection Agency, Office of Environmental Information, Washington DC.

Gilbert, R.O. 1987. *Statistical Methods for Environmental Pollution Monitoring.* Wiley & Sons, Inc., New York, NY.

Hassig, N.L., J.E. Wilson, R.O. Gilbert and B.A. Pulsipher. 2004. *Visual Sample Plan Version 3.0 User's Guide.* PNNL-14970. Pacific Northwest National Laboratory, Richland, WA, December 2004.

Singer, D.A. and J.E. Wickman. 1969. *Probability Tables for Locating Elliptical Targets with Square, Rectangular, and Hexagonal Point Nets.* Pennsylvania State University, University Park, Pennsylvania. Special Publication 1-69.

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Sigma-Aldrich, Fort Mims Facility
Decontamination and Decommissioning Plan
Facility Management and Oversight Agreement

This Agreement, between Sigma-Aldrich (Sigma), and Philotechnics, Ltd. (Philotechnics), details the responsibilities for management and oversight of the facilities during the decommissioning project. Sigma operates the Fort Mims facility under NRC license number **24-16273-01**. Philotechnics will perform decommissioning activities under reciprocity from state of Massachusetts, radioactive material license number **56-0543**.

Decommissioning Operations and Procedures. The Philotechnics' Health Physics Operations and Procedures (HPOP) will be followed to complete the Decommissioning Plan. These are Philotechnics proprietary procedures. The table of contents page is attached to the Decommissioning Plan. Sigma's RSO, Thomas Spencer, has a copy of the HPOP, which will help guide the project auditing function (below).

Facility oversight and management. Sigma is responsible for oversight and management of the Fort Mims facility and grounds, and will maintain a presence during any significant decommissioning operations.

Security. The facility is currently secured with locked doors, accessible with a key. The main door is controlled with a pass card with pin number. During the decommissioning project, the security system will remain active. Sigma employee access is controlled with pass card privileges. Access to the facility by Philotechnics personnel will be controlled by Sigma. Two key Philotechnics personnel have been granted pass cards with pin numbers. These are Ryan P. Fahey, Project Manager, and Tracie M. Clemons, Senior Health Physicist. Sigma-Aldrich employees or the two key Philotechnics employees may let in other Philotechnics employees.

Separation of different licensed activities
Sigma and Philotechnics will plan and execute operations so that neither party violates the license of the other party. For example, Sigma program personnel operating under the Sigma license will continue to complete activities associated with removal of chemical inventory and chemical waste as it has done under normal operations. These activities will be isolated from ongoing Philotechnics D&D activities. Philotechnics will complete its decommissioning operations in these areas after Sigma completes its activities.

Project decision authority
Sigma will have decision-making authority where questions arise regarding project direction and cost. Sigma's RSO (Thomas Spencer) will represent Sigma management and be responsible for the majority of day-to-day decisions. The RSO has the necessary knowledge of Sigma's financial and regulatory approval authority. Where appropriate, he will get necessary approvals from the Director of Manufacturing (Bob Ringering) and Director of Environmental, Health & Safety (Cheryl Stipsits).

Project auditing

Various aspects of the decommissioning project will be audited periodically to ensure the project is being executed by Philotechnics safely and compliant with the DP and attachments. This auditing will be performed by, or under the direction of the Sigma RSO. Safety and Health aspects will be audited for compliance with Philotechnics Health Physics Operation Procedures (HPOP). Auditing will include, but is not limited to the following:

Activity	Standard	Frequency	Method
Minimal PPE in restricted area	Safety glasses, lab coat, shoe covers.	Daily	Observation
Task PPE	Consistent with requirements of work task PPE	Daily	Observation and review of work task document.
Instrument calibrations	Consistent with DP (Minimum annually. Functional checks daily when in use).	Weekly	Document review
Bioassay/below threshold action values in HPOP	Below threshold action values in HPOP	Bi-Weekly	Document review
Area surveys	Consistent with DP	Weekly	Document review
Safety training	Each employee has current, documented training required for the task	Weekly	Document review
Release of equipment or material for unrestricted use.	Limit (dpm per 100 cm2) for trash: 5000 ave, maximum 15,000 with 1000 removable. For use: Twice background for both removable and total.	Weekly or as needed.	Observation of technique compared to HPOP and document review.
Others deemed appropriate by Sigma RSO	Consistent with DP and attachments	As deemed appropriate	Observation/document review.

Non-Compliance Actions

Sigma's RSO will report the findings of audits to Sigma management and the Philotechnics Project Manager for review. The following table will guide possible actions taken to correct findings.

Severity Level	Description	Examples	Possible Action
1	Minor finding with without significant potential to adversely affect health, safety or compliance.	A few instances of poor documentation; a single instance of incomplete PPE.	Finding noted with expectation for improvement.
2	Findings of that reflect a more significant concern for adversely affecting health, safety or compliance	More frequent instances of level 1 findings, a single instance of not wearing eyeglasses or other important PPE.	Finding noted. An incident report required specifying the circumstances, root cause and corrective action.
3	Findings that clearly have a	Carrying out a	Same actions as above.

	negative impact on health safety and compliance.	dangerous operation without prescribed PPE; a pattern of negligence in documentation.	In addition, Sigma may require disciplinary action on the part of Philotechnics. This could include removal of one or more persons from the decommissioning project.
4	Findings that reflect overall inadequate control of the health safety and compliance aspects of decommissioning.	Repeated level 3 violations or a single act that could severely affect health safety or compliance	Same actions as above. In addition, Sigma may terminate the decommissioning project with Philotechnics

Approval:

Sigma:

Larry M. Hummel 10/21/08
Larry Hummel Date
VP, Saint Louis Operations

Thomas K Spencer 10-21-08
Thomas K Spencer Date
Radiation Safety Officer

Cheryl Stipsits 10/21/08
Cheryl Stipsits Date
Director, Environmental,
Health & Safety

Philotechnics:

10-21-08
Ryan P Fahey Date
Project Manager