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March 7, 2012

U.S. Nuclear Regulatory Commission
c/o Ted Carter
Mail Stop T8F5
11545 Rockville Pike
Rockville, MD 20852

**RE: Sigma-Aldrich (Sigma) Fort Mims Site Decommissioning
Request for Additional Information, USNRC (NRC) License # 24-16273-01
Mail Control number: 574094
Docket number: 030-10716**

Dear Mr. Carter,

By letter dated August 1, 2011, Paul Michalak of the NRC requested additional information to complete the review of Sigma's request for release of the Fort Mims site for unrestricted use. Sigma's responses to questions contained in the NRC's request for additional information are documented in this letter, and in the attached report, "Final RESRAD Modeling In Support of Release for Unrestricted Use." For ease of review, NRC Comments and Path Forward from each specific area of concern have been duplicated above each Sigma Response.

1. NRC Comment: In the letter dated February 6, 2009, the licensee states, "We expect the area for the highest potential for impacting ground water will be the septic and leachate field." However, it appears the highest concentration was identified elsewhere and the leachate field location has yet to be described. In addition, Phase III FMF Open Land Soil Sampling and Analysis Report attached to Sigma's December 10, 2010, letter states that several samples collected at a depth of two meters have detectable carbon-14 levels which indicate the vertical extent of contamination has not been fully bounded.

Path Forward: Provide a cause or conceptual model which:

- a) Explains the higher level of residual contamination identified in the soil outside of the septic tank and leachate field area. In addition, provide the technical basis that demonstrates the previous sampling depth and areal extent were adequate to identify the horizontal and vertical extent of residual contamination, and therefore potential safety issues, or provide a plan to sample at more locations and/or at a greater depth.
- b) Describes the activities or processes which resulted in the subsurface contamination, including any known spills, uncontrolled releases, and description of all on-site systems or equipment and their conditions that had potential to interact contaminate environment (e.g. septic tank system, leachate field piping, and air effluent stack system).

Sigma Response:

Higher levels of contamination outside the septic tank and leachate area likely resulted from processing activities during licensed activities from 1975 through 2008. No major spill or uncontrolled releases were reported during licensed operations. Over twenty processing fume hoods were in various levels of operation throughout the period. Because the fume hood cabinets sat directly on the concrete floor, area surveys of those surfaces were not possible, and as a result, minor contamination of the floor could have gone undetected. The "hot spots" detected in the soil underneath the concrete slab are believed to have come from the fume hood operations. Other elevated levels in the soils outside the perimeter of the concrete slab are believed to be from stack emissions (and rainwater run-off from the stack and roof) during the course of licensed operations. Supporting evidence is found with elevated levels found near the roof downspout discharge points at the rear of the building (the roof sloped down from front to back). The highest reading (1290 pCi/g C-14) was found in shallow soil samples directly below the stack, above a concrete footing.

2. **NRC Comment:** The leachate field location was not identified.

Path Forward : Provide the believed location of the leachate field and how it relates to previously sampled areas. If the historic leachate field location cannot be identified, provide detailed description of the search conducted to try to locate the field (e.g. blueprints or interviews) and justification that the previous sampling locations encompassed the potential areas containing the leach field. If the previous soil sampling location did not encompass this area, provide a new sampling plan to include areas with the potential to have contained the leachate field.

Sigma Response:

Based on the identified location of the septic tank (near the innermost section of the concrete pad), the leachate field is believed to have been located in the area over which the concrete building slab was constructed during the building expansion in 1986. No blueprints exist that show the location of the septic or leachate lines. Prior to removal of this concrete pad, ground penetrating radar was used to identify the presence of leachate lines, but none were found. Subsequent soil sampling did not indicate any cluster or pattern of elevated activity that might come from leach field lines. Thus, the initial soil sampling that was performed after slab removal, and the most recent sampling event down to bedrock, are considered to represent the area which served as the leachate field during septic operations.

3. **NRC Comment:** More information is needed regarding the septic tank and leachate field and its impact on the environment.

Path Forward: Provide a cause or conceptual model which describes the potential effluent pathways associated with the septic tank and leachate field. Include a description of historical effluent flow: a) quantity and levels of radioactivity, if known; b) how did the effluent flow to the septic tank; and c) how did the effluent flow to the septic leach field. Also, provide a description of the septic system, including the

location and depth of the tank, associated pipes, and leachate field and how the septic tank operates.

Sigma Response:

During licensed operations involving the septic tank, discharge to the sewer from production operations was not permitted. The only isotopes used at the Fort Mims site were carbon-14 and tritium, with carbon-14 representing over 95% of the total activity. Trace amounts of activity to the sewer could have come from final rinsing of pre-cleaned glassware. The finding of no detectable activity below the septic tank and limited detectable activity in surrounding shallow soils strongly suggests that contamination of soil through the septic tank and leachate lines was not a significant factor.

4. **NRC Comment:** Phase I FMF Open Land Sampling and Analysis Report, attached to Sigma's December 10, 2010, letter shows samples from the septic tank area were taken from 0.05 to 1 m below the surface. However, the bottom of the septic tank sludge was located approximately 2 m below the surface. Information is needed to determine the concentration of residual radioactive material below the septic tank.

Path Forward: Provide soil sample results below and near the septic tank location at depths greater than the bottom of the septic tank, with the vertical extent of impacted soil fully defined.

Sigma response:

See Attached report, "Final RESRAD Modeling In Support of Release for Unrestricted Use."

This report documents the additional soil testing and characterization from a core drilled directly underneath the previous location of the septic tank. Samples were collected at depths of 3, 4, 5, 8 and 12 meters below grade. No activity was detected at any of the depths sampled.

Description of the conceptual model of the site including the source term, physical features important to modeling the transport pathways, and the critical group

5. **NRC Comment:** Final RESRAD modeling report dated November 11, 2010, states, "Available documentation indicates an aquifer is at least 140 feet (47 meters) below the ground surface." The provided information contained in the EDR GeoCheck Report only contains information on three wells, where only one of the wells report water depth, which was at 31 feet. This does not provide adequate justification to describe the depth of the aquifer.

Path Forward: Provide further justification to support aquifer depth and that the water located 10-20 m (30 to 60 feet) below ground surface is not a sustainable aquifer.

Sigma Response:

See Attached report, "Final RESRAD Modeling In Support of Release for Unrestricted Use."

This report documents that contamination of soil at the site was not detected at a depth greater than 4 meters (approximately 12 feet) below

grade. Distance to bedrock was found to be approximately 10 meters (33 feet) below grade, and groundwater was not detected at any of the core locations down to bedrock. These findings, along with other conservative assumptions in the dose model, make accurate determination of the aquifer depth and flow characteristics unimportant in determining dose to the public.

6. NRC Comment: The unsaturated zone is a critical component of the RESRAD model and needs to be adequately characterized. No technical basis was provided for the statement in the final RESRAD modeling report dated November 11, 2010, "Surface and subsurface soils are a combination of silty clay and sandy clay." No technical basis was given for not using parameter values associated with the unsaturated bedrock (St. Louis Limestone).

Path Forward: Information is needed on the geologic characteristics of the site and the region around the site, a description of the subsurface geologic characteristics of the site and its vicinity, a description of the unsaturated zone, and the physical parameters. Provide documentation, survey results, or technical bases justifying the unsaturated zone RESRAD inputs. For example, rationale for assuming the non-conservative distribution coefficient value for sand although the sediments were basically described as clays.

Sigma Response:

See Attachment E within Attached report, "Final RESRAD Modeling In Support of Release for Unrestricted Use."

Sigma contracted with Schreiber, Yonley & Associates, an environmental engineering firm, to characterize the soil at intervals from 3 meters to bedrock depth. The soil types found at each interval were used to determine a conservative value for the distribution coefficient.

7. NRC Comment: No information is provided regarding St. Louis Limestone and other formations through which the groundwater flows. The unconsolidated material is reported to extend to a depth of 40 to 50 ft below the land surface, and the limestone formation is underlain below. The nature of aquifer in the vicinity of the facility is not provided.

Path Forward: Information is needed on the saturated zone, descriptions of subsurface materials observed in borings and monitoring wells, a description of ground water flow directions and velocities, and physical parameters. Provide documentation or survey results justifying the saturated zone RESRAD inputs. Provide a conceptual model on the hydrogeology and the residual radioactive material transport, including information on how fast pathways to and through the limestone can be excluded.

Sigma response:

See Attached report, "Final RESRAD Modeling In Support of Release for Unrestricted Use."

See response to NRC Comment 5.

8. NRC Comment: Response to the request for information in Sigma's letter dated February 6, 2011, states that the Soil Sampling and Analysis Plan will be used as a starting point to identify any substantial areas of contamination which could serve as a source to impact either surface or ground water. If significant levels of contamination are identified that have the potential for impacting water at the site, a specific groundwater monitoring plan will be assembled to address the site specific issues identified. During the three phases of soil sampling at the site, residual radioactive material was identified in surface and subsurface soil and in the septic tank, but no groundwater monitoring has been reported.

Path Forward: Provide groundwater monitoring data demonstrating the ground water beneath the facility has not been impacted or justification that the residual radioactive material identified at the site, would not lead to a potential for significantly impacting the ground water at the site.

Sigma response:

See Attached report, "Final RESRAD Modeling In Support of Release for Unrestricted Use," and response to NRC Comment 5.

Description of the parameters used in the analysis

9. NRC Comment: By letter received on April 12, 2011, Sigma provided a RESRAD model with current septic tank concentration and size as inputs to provide a modeled dose from groundwater pathway. The current radiological status of the aquifer was not considered in the dose modeling.

Path Forward: Provide justification to demonstrate that the RESRAD model is conservative and adequately addresses potential safety concerns regarding water dependent pathways. As stated in the letter dated February 6, 2009, a groundwater monitoring plan was considered to demonstrate the impact site operations had on the groundwater or provide justification that the model's source term input and size conservatively addresses all groundwater contamination pathways.

Sigma response:

See Attached report, "Final RESRAD Modeling In Support of Release for Unrestricted Use," and response to NRC Comment 5.

10. NRC Comment: Rationale needed for each non-default RESRAD parameter, including saturated zone parameter values.

Path Forward: Provide individual rationale for each non-default RESRAD parameter. For example, rationale for using RESRAD saturated zone parameter values based on silt, sand, and clay when the saturated zone is located in limestone.

Sigma response:

See Attached report, "Final RESRAD Modeling In Support of Release for Unrestricted Use."

This report documents that contamination of soil at the site was not detected at a depth greater than 4 meters (approximately 12 feet) below grade. Distance to bedrock was found to be approximately 10 meters (33 feet) below grade. This

finding substantiates that the saturated zone is well above bedrock (limestone). Other non-default RESRAD parameters are substantiated within the report.

11. NRC Comment: Rationale needed for *significant* RESRAD parameters including those left at default.

Path Forward: Provide individual rationale for significant RESRAD parameters including those left at default. For example, rational for leaving RESRAD irrigation rate parameter value at 0.2 m/yr, or the rational for keeping the circular shape factor although the site is not circular.

Sigma response:

See Attached report, "Final RESRAD Modeling In Support of Release for Unrestricted Use."

This report documents that contamination of soil at the site was not detected at a depth greater than 4 meters (approximately 12 feet) below grade. Distance to bedrock was found to be approximately 10 meters (33 feet) below grade. This finding substantiates that the saturated zone is well above bedrock (limestone). Rationale for use of parameters is provided in the report

12. NRC Comment: Clarification needed for RESRAD modeling of the contents of the septic tank.

Path Forward:

- a) Clarify how the "Area of the contaminated zone" and "Length Parallel to Aquifer Flow" RESRAD inputs were obtained;
- b) demonstrate the relative depth of the top of the septic tank, the thickness of the air inside the tank, the water inside the tank, the sludge, and the bottom of the tank through use of a diagram or map.

Sigma Response:

See Attached report, "Final RESRAD Modeling In Support of Release for Unrestricted Use."

See response to NRC Comment 5. The lack of consideration of impact to groundwater, as substantiated in the report, make detailed characterization of the septic dimensions and contents unimportant in determining dose to the public.

Discussion about the effect of uncertainty on the results

12. NRC Comment: Sensitivity analysis is needed to determine significant RESRAD parameters and the rational for default values for significant parameters. The purpose of a sensitivity analysis is to identify the input parameters that are the major contributors to the variation or uncertainty in the calculated dose. Therefore the identification of these key parameters is essential for building a defensible case in support of the assessment. Thus far, the uncertainty analyses provided have not shown which processes or parameters are significant (e.g., infiltration, distribution coefficients, fast pathways through the limestone, dilution, etc.)

Path Forward: Provide a sensitivity analysis of RESRAD parameters and provide a list of the significant RESRAD parameters for each model [NUREG-1757, Vol. 2, App. I, Sec. 7].

Sigma response:

See Attached report, "Final RESRAD Modeling In Support of Release for Unrestricted Use."

A sensitivity analysis is provided attached report.

14. NRC Comment: Clarification needed on the uncertainty analysis on scope and results.

Path Forward: Provide an expanded explanation on the uncertainty analysis to demonstrate the influence of the *key assumptions* on the variability of the estimated dose and the effects of the uncertainty. Provide the justification for the *range of values* used to represent these key parameters in the uncertainty analyses. The *results may be presented* using diagrams, graphs, figures, tables, etc., with explanatory paragraphs to give insight into the important features and processes. For example, providing an explanatory paragraph with a figure in Appendix A of the final RESRAD modeling results presented in letter dated November 30, 2011, would clarify the results greatly. Additionally, diagrams in the appendices of the January 25, 2011, Modeling and Uncertainty Analysis Report could lend to easier interpretation if accompanied with explanatory paragraphs and different scales.

Sigma response:

See Attached report, "Final RESRAD Modeling In Support of Release for Unrestricted Use."

Please contact me if you have any questions or concerns regarding Sigma's responses to your request for additional information.

Sincerely,



Thomas K Spencer
Radiation Safety Officer

ATTACHMENT: Final RESRAD Modeling In Support of Release for Unrestricted Use