Appendix 9

Risk Assessment Reports
September 1, 2004 and
March 23, 2005

The following Appendix consists of 2 parts.

Part 1 is entitled “Summary Report Hazard and Risk Assessment National Emerging Infectious Diseases Laboratories (NEIDL)” and was prepared by RWDI West Inc., September 1, 2004.
Part 2 is entitled “Summary Report Hazard and Risk Assessment National Emerging Infectious Diseases Laboratories (NEIDL)” and was prepared by RWDI West Inc., March 23, 2005.

SUMMARY REPORT
HAZARD AND RISK ASSESSMENT
NATIONAL EMERGING INFECTIOUS DISEASES LABORATORIES (NEIDL)
BOSTON UNIVERSITY MEDICAL CAMPUS
BOSTON, MASSACHUSETTS

Project Number: W04-263

Date: September 1, 2004

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1. INTRODUCTION

Boston University Medical Campus (BUMC) retained RWDI West Inc. to conduct a risk assessment for the proposed BSL-4 facility at the new National Emerging Infectious Diseases Laboratories (NEIDL) at the BUMC campus.

This report summarizes the results for a screening-level assessment conducted to provide anthrax spore concentration isopleths under a variety of release conditions. Maximum downwind ground-level anthrax spores concentrations were predicted using dispersion modeling techniques following an accidental laboratory release for three conceivable release scenarios to provide an estimate of the maximum possible risk of exposure to these spore concentrations along the path of the dispersing plume.

The following analysis was prepared to support a BUMC review of the public health risk of a "worst-case scenario" at a proposed BSL-4 laboratory. The worst case scenario was defined to include:

- Complete loss of containment systems in the BSL-4 laboratory despite preventative maintenance, testing and HEPA certification programs.

- Impacts to individuals not associated with the Boston-NBL, including nearby residents, workers, inmates, patients and pedestrians. Worker exposure is not part of the public health risk assessment.

- The maximum exposure potential is through the release of aerosolized anthrax spores.

- The entire release from the facility can be assumed to have elapsed over approximately 30 minutes.

Anthrax was selected because of its resistance to environmental factors such as sunlight and lack of humidity, and ease of airborne dissemination.

The primary risk associated with the inhalation exposure to anthrax spores by humans are initial symptoms resembling a common cold (e.g., sore throat, mild fever, muscle aches and malaise), and if untreated progressing to severe breathing problems, shock and death.

The literature regarding exposure levels reference a range of exposure criteria, including:

- US Defense Department estimate of LD_{50} for humans - between 8,000 and 10,000 spores (Reference 2).

- Meselson et. al. reference from a forensic study of the release at Svardlosk – "the dose causing 2% fatalities ... is nine spores" (Reference 2).

The references used in this assessment, including the one noted above, are listed in Section 6 of this report.

2. ASSUMPTIONS

The following assumptions were used in determining the dispersion modeling results for the Maximum Possible Risk (MPR) scenarios.

Source Characterization Assumptions

- Each 15 cc (cubic centimeter) container of purified anthrax (anthrax vial) contains 10 billion spores of which approximately 400,000 respirable particles are available to become and remain airborne.

- This quantity has been selected to coincide with a range finding study previously conducted within the NIH. The study reviewed a laboratory release of anthrax to determine the number of reparable particles generated that became airborne following a laboratory accident involving 1 gram of dry purified anthrax. Under the worst-case scenario, the full 10 billion spores, approximately 1 gram of dry purified anthrax, was presumed to be manipulated in the laboratory and dropped to the floor prior to tightening the cap, allowing the entire contents of the vial to be released to the environment. Based on the simulations by the NIH, it was determined that of 10 Billion anthrax spores only 400,000 spores would become airborne and respirable.

- The breathing rate corresponds to the rate of inhalation for an active person, 30 liters per minute to provide a conservative upper bound on the potential number of inhaled spores (Reference 2, Reference 7).

- Ventilation flow rates from the exhaust stacks were assumed to correspond with 12 air changes per hour (corresponding to an exhaust flow rate of 14,000 cubic feet per minute) for the building BSL-4 Laboratory Space.

Dispersion Modeling Assumptions

- Dispersion modeling was conducted from the top of the building exhaust stack.

- Dispersion modeling of the spores was performed using SLAB, a U.S. EPA-approved dispersion model developed at Lawrence Livermore Laboratories to determine the hazard associated with different release scenarios. The SLAB model is a general purpose dispersion model with additional algorithms capable of handling the dispersion of a dense vapor cloud. Buoyant and neutrally buoyant releases are handled in a manner similar to other Gaussian dispersion models.

- The SLAB model provides concentration versus time information for short duration releases (less than 1 hour). Many other dispersion models regularly used for air quality impact studies operate on a 1 hour time frame; as a result, the information required to estimate the impacts of a short duration transient release are not as readily available. The SLAB model results are used to obtain concentration information for transient releases that does not require modifications to the model itself, since it involves post-processing of the results once the model is run.

- Dispersion modeling was conducted using a range of weather conditions that may be encountered, from sunny, summer windy conditions to calm clear, winter nights (Table 1 summarizes the different weather conditions used in the analyses).

- Dispersion modeling assumed that the spores did not contribute to the plume buoyancy.

- The plume was modeled as room temperature air with trace amounts of contaminant.

- In each release scenario, under the specific meteorological conditions modeled, all of the spores are assumed to travel downwind in the same direction to provide an upper bound or maximum value for the estimated ground level concentration.

Table 1: Description of The Meteorological Conditions Used in Modeling Release Scenarios

Stability Class	Wind Speed		Description
	(m/s)	(km/hr)	
B	2	7.2	Bright sunny afternoons in late spring, summer and early fall. Skies are clear or almost clear and winds are light. Temperatures range from warm to hot.
D	2	7.2	Sunny days in early spring and late fall. Overcast days and evenings with light winds at any time of the year. Hours with rain or snow falling.
D	5	18.0	Partly cloudy to overcast days and nights (anytime of year) with moderate winds. Periods with weak sunshine in early spring and late fall.
D	10	36.0	Strong winds at any time of the day or night, regardless of temperature or cloud cover.
E	3	10.8	Nights with some cloud at any time of the year. Daytime conditions on the coldest days in winter.
F	2	7.2	Cold clear nights in winter or cool clear nights in the rest of the year.

3. RELEASE SCENARIOS

In the release events modeled, the number of spores released is expected to vary over time, decaying exponentially (see Figure 3.1), and extending the time of the release event. In these scenarios, the spore cloud mixes with the surrounding air as the fresh air is brought into laboratory space.

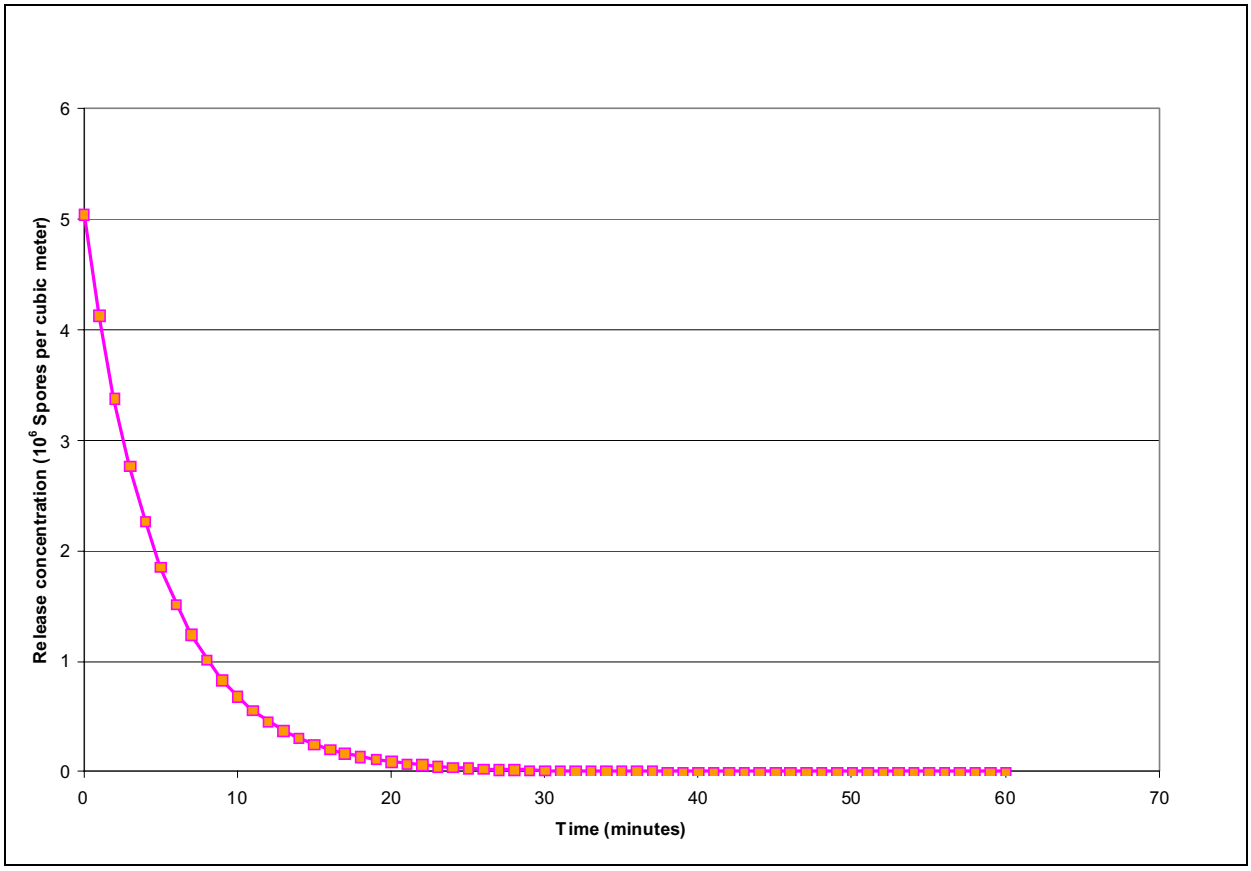

Figure 3.1: The concentration of spores released, varying with time, for a ventilation rate of 12 air changes per hour (corresponding to a ventilation rate of 14,000 cubic feet per minute for the BSL-4 laboratory space).

3.1 Accidental Laboratory Release Scenario - Two HEPA Filters

This scenario simulates an accidental laboratory release where the entire contents of an anthrax vial are released within the BSL-4 Laboratory space in a cloud of spores. Figure 3.2 shows the spore concentration varying with time at a distance downwind of the release where the maximum ground level concentration occurs. The results are considered over the range of weather conditions noted in Table 1.

The calculated maximum number of spores that may be inhaled by an individual standing on the plume centerline at a given downwind distance from the release in this scenario occurs under B stability (wind speed of 2 m/s). For an individual breathing at a rate of 30 litres per minute (the

breathing rate of an active person) for the duration of the release event, the calculated maximum number of spores that may be inhaled is 0.00000000021 spores. Since the release and inhalation of a partial spore is not feasible, this number may be practically considered as zero.

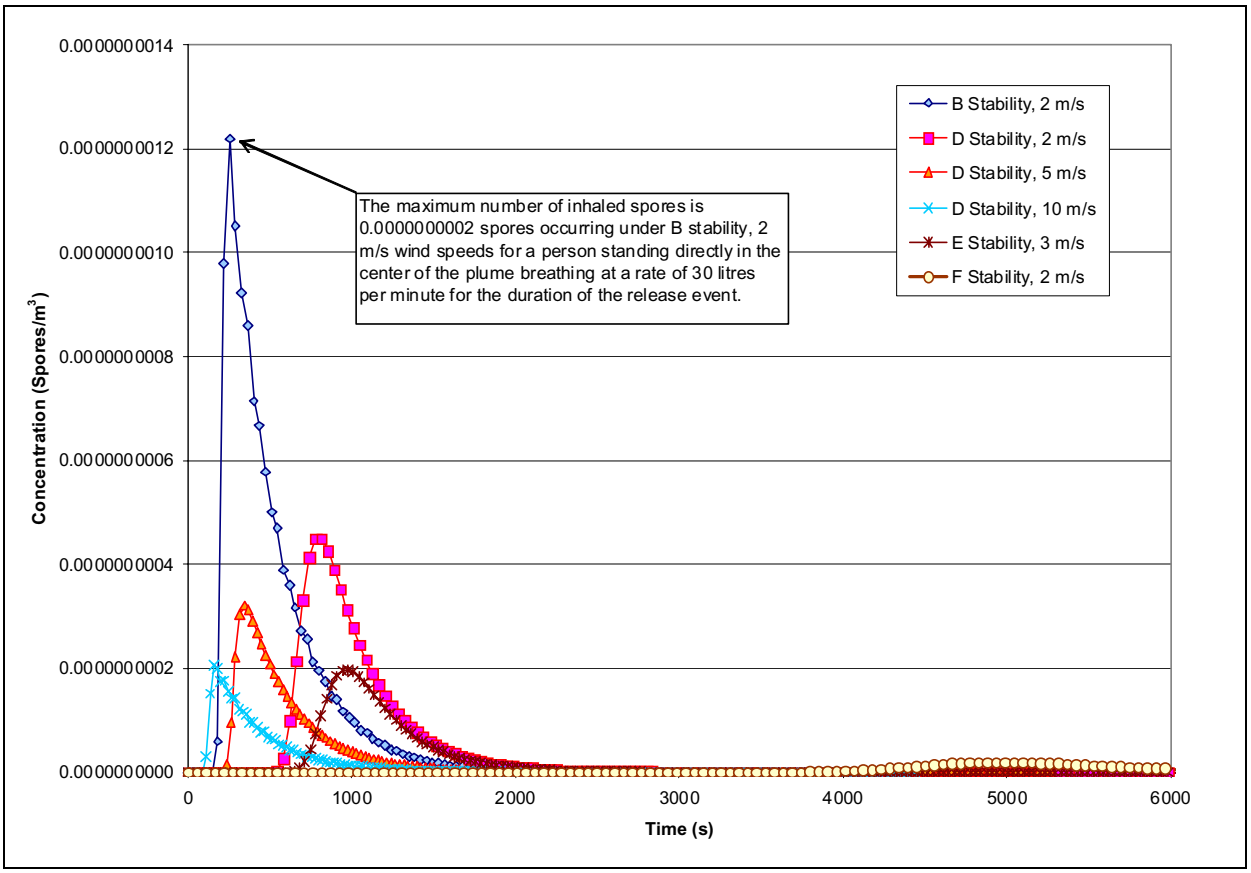

Figure 3.2: Accidental Laboratory Release Scenario: *Maximum* predicted ground-level concentration of spores occurring downwind of a release (with two HEPA Filters in place) shown at the maximum point of impingement for the range of meteorological conditions considered.

3.2 Accidental Laboratory Release Scenario – Single HEPA Filter Malfunction

This scenario simulates an accidental laboratory release where the entire contents of an anthrax vial are released within the BSL-4 Laboratory space in a cloud of spores when only one of the HEPA filters is not functioning. Figure 3.3 shows the spore concentration varying with time at

a distance downwind of the release where the maximum ground level concentration occurs. The results are considered over the range of weather conditions as noted in Table 1.

The calculated maximum number of spores that may be inhaled by an individual standing on the plume centerline at a given downwind distance from the release in this scenario occurs under B stability (wind speed of 2 m/s). For an individual breathing at a rate of 30 litres per minute (the breathing rate of an active person) for the duration of the release event, the calculated maximum number of spores that may be inhaled is 0.0000007 spores. Since the release and inhalation of a partial spore is not feasible, this number may be practically considered as zero.

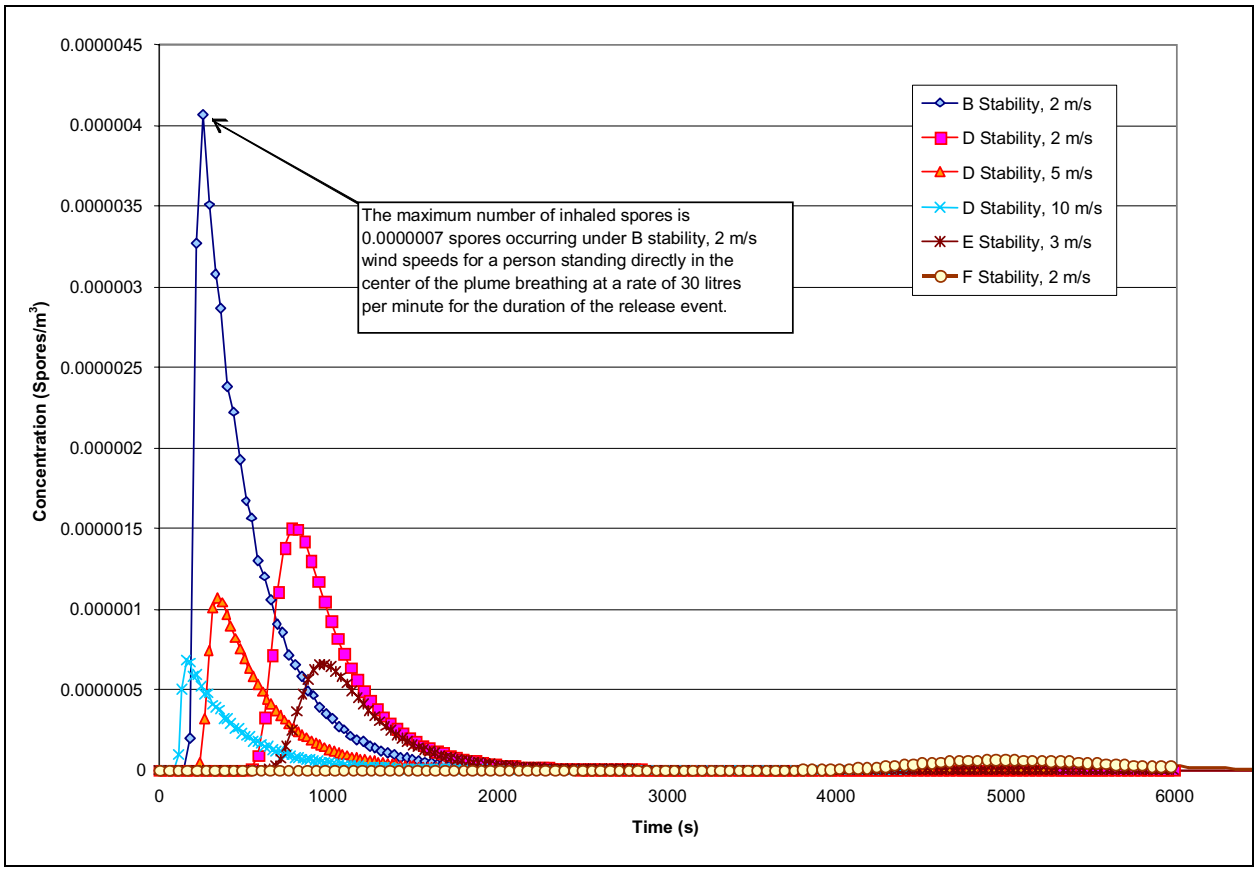

Figure 3.3: Accidental Laboratory Release Scenario – Single HEPA Filter Malfunction: *Maximum* predicted ground-level concentration of spores occurring downwind of a release shown at the maximum point of impingement for the range of meteorological conditions considered.

3.3 Accidental Laboratory Release Scenario – No HEPA Filters

This scenario simulates an accidental laboratory release where the entire contents of an anthrax vial are released within the BSL-4 Laboratory Space in a cloud of spores with neither of the HEPA filters in operation. Figure 3.4 shows the spore concentration varying with time at a distance downwind of the release where the maximum ground level concentration occurs. The results are considered over the range of weather conditions noted in Table 1.

The calculated maximum number of spores that may be inhaled by an individual standing on the plume centerline at a given downwind distance from the release in this scenario occurs under B stability (wind speed of 2 m/s). For an individual breathing at a rate of 30 litres per minute (the breathing rate of an active person) for the duration of the release event, the calculated maximum number of spores that may be inhaled is 0.0024 spores. Since the release and inhalation of a partial spore is not feasible, this number may be practically considered as zero.

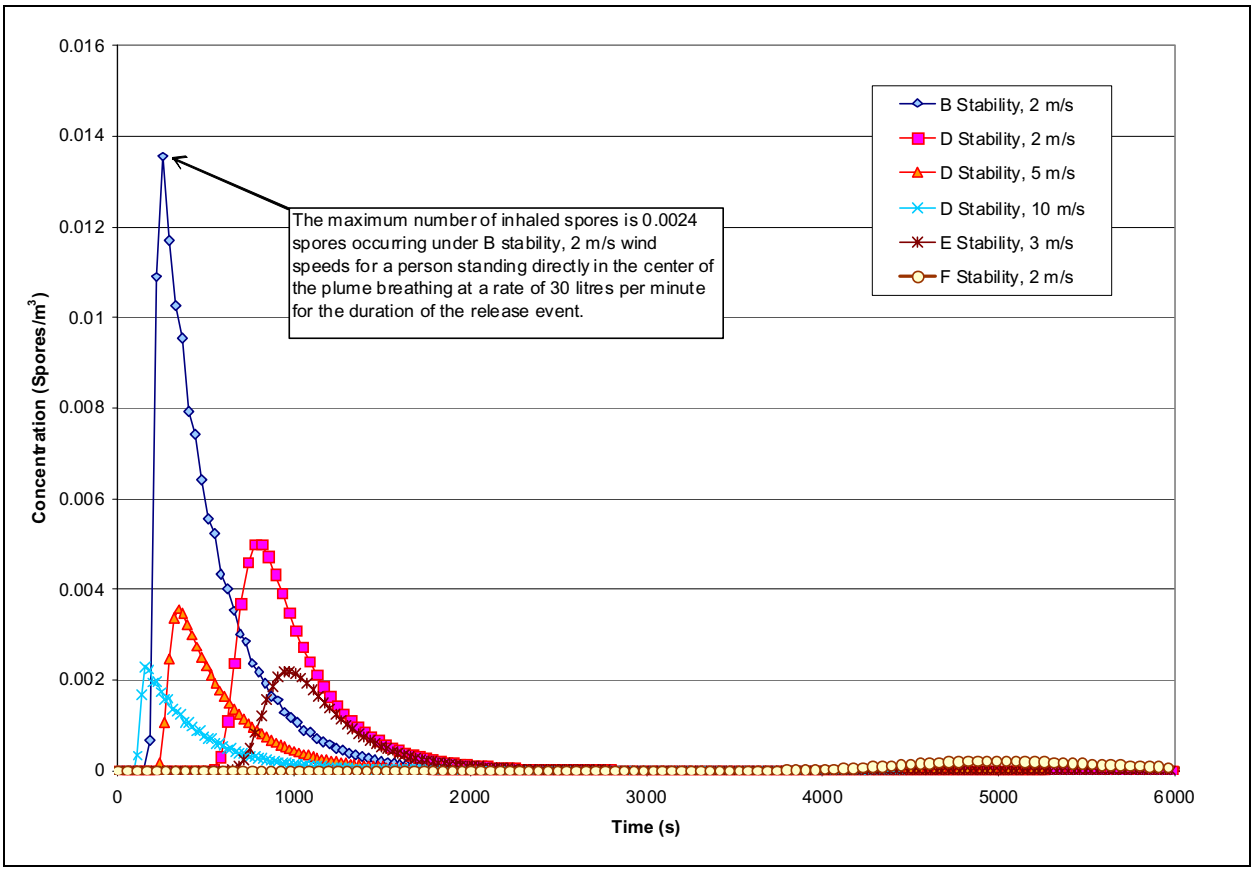

Figure 3.4: Accidental Laboratory Release Scenario – No HEPA Filters: *Maximum* predicted ground-level concentration of spores occurring downwind of a release shown at the maximum point of impingement for the range of meteorological conditions considered.

4. SUMMARY

The results presented in this report summarize preliminary dispersion modeling results describing the maximum downwind ground-level anthrax spore concentrations predicted for three release scenarios. In each case, the calculated maximum number of spores that may be inhaled by an individual standing on the plume centerline downwind from the release is less than a single spore. Since the release and inhalation of a partial spore is not feasible, this number may be practically considered as zero.

5. REFERENCES

1. Emergency response to Anthrax Attack (Lawrence M. Wein, David L. Craft, and Edward H. Kaplan), PNAS, Vol.100, No.7.

2. The Sverdlovsk Anthrax Outbreak of 1979 (M. Meselson et al.), Science, 1994, Vol. 266.

3. Simulation Modeling of Anthrax Spore Dispersion in a Bioterrorism Incident (V. Reshetin and J. Regens), Risk Analysis, Vol. 23, No. 6.

4. Airborne dispersion modeling for outbreak detection (W.Hogan), RODS Conference Presentation.

5. NIH Building 33 Risk Assessment – Executive Summary (NIH Community Liaison Council, November 20, 2003).

6. "User's Manual for SLAB: An Atmospheric Dispersion Model for Denser-Than-Air Releases" (Donald L. Ermak) available through the National Technical Information Services (NTIS).

7. Handbook of Respiration. (D.S. Ditmer and R.M. Grebe, Eds.), Saunders: Philadelphia, 1958. As cited in M. Meselson et.al., Science, 1994, Vol. 266.

SUMMARY REPORT

HAZARD AND RISK ASSESSMENT

NATIONAL EMERGING INFECTIOUS DISEASES LABORATORIES (NEIDL)

BOSTON UNIVERSITY MEDICAL CAMPUS

BOSTON, MASSACHUSETTS

Project Number: W04-263

Date: March 23, 2005

Submitted By: RWDI West Inc.

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APPENDIX A - Wind Tunnel Model

1. INTRODUCTION

Boston University Medical Campus (BUMC) retained RWDI AIR Inc. to conduct a risk assessment for the proposed high-containment laboratory facilities at the new National Emerging Infectious Diseases Laboratories (NEIDL) at the BUMC campus.

This report summarizes the results for a second screening-level assessment conducted to provide estimates of the potential maximum number of inhaled anthrax spores under a variety of release conditions. The second screening-level assessment involved the use of more inclusive dispersion modeling techniques that accounted for building downwash. Maximum downwind anthrax spores concentrations were predicted in order to estimate the maximum possible risk of exposure following an accidental laboratory release to these spore concentrations along the path of the dispersing plume from one of the high-containment laboratory exhausts (BSL-3 and BSL-4). The concentrations were predicted using two different dispersion modeling techniques: numerical dispersion modeling using the U.S. EPA ISC-Prime model; and wind tunnel tests on a scale model of the NEIDL and its surroundings.

The following analysis was prepared to support a BUMC review of the public health risk of a "worst-case scenario" at one of the proposed high-containment laboratories within the NEIDL. The worst case scenario was defined to include:

- complete loss of containment systems in one of the high-containment laboratories despite preventative maintenance, testing and HEPA certification programs;

- impacts to individuals not associated with the Boston-NBL, including nearby residents, workers, inmates, patients and pedestrians; worker exposure is not part of the public health risk assessment;

- the maximum exposure potential is through the release of aerosolized anthrax spores;

- the entire release from the facility can be assumed to have elapsed over approximately 30 minutes; and

- the individuals in the path of the plume (the receptors) were assumed to remain in their locations for the duration of the release; no benefit from shelter-in-place or evacuation was included in the analysis.

Anthrax was selected because of its resistance to environmental factors such as sunlight and lack of humidity and ease of airborne dissemination.

The primary risk associated with the inhalation exposure to anthrax spores by humans are initial symptoms resembling a common cold (e.g., sore throat, mild fever, muscle aches and malaise), and if untreated progressing to severe breathing problems, shock and death.

The literature regarding exposure levels reference a range of exposure criteria, including:

- US Defense Department estimate of LD_{50} for humans - between 8,000 and 10,000 spores (Reference 2).

- Meselson et. al. reference from a forensic study of the release at Svardlosk – "the dose causing 2% fatalities ... is nine spores" (Reference 2).

The references used in this assessment, including the one noted above, are listed in Section 5 of this report.

2. ASSUMPTIONS

The following assumptions were used in determining the dispersion modeling results for the Maximum Possible Risk (MPR) scenarios.

Source Characterization Assumptions

- Approximately 400,000 respirable particles are available to be released from the exhaust stack and become airborne.

- The breathing rate corresponds to the rate of inhalation for an active person, 30 liters per minute to provide a conservative upper bound on the potential number of inhaled spores (Reference 2).

- The possible release of anthrax could occur from one of the high-containment laboratories. The wind tunnel tests showed that the highest anthrax concentration would occur for the high-containment laboratory exhaust with the lowest ventilation rate (6,900 cubic feet per minute). This was attributed to the lower exhaust momentum and higher anthrax concentration in the exhaust.

Numerical Dispersion Modeling Assumptions

- Dispersion modeling was conducted from the top of the building exhaust stack.

- Dispersion modeling of the spores was performed using ISC-PRIME, a U.S. EPA recommended dispersion model to determine the downwind concentration (dilution). The use of this model was recommended by the U.S. EPA based on their review of the Draft Environmental Impact Statement for this project in order to account for building downwash.

- Dispersion modeling was conducted using a range of weather conditions that may be encountered, based on historical meteorological data for the Boston area.

- In each release scenario, under the specific meteorological conditions modeled, all of the spores are assumed to travel downwind in the same direction to provide an upper bound or maximum value for the estimated ground level concentration.

Wind Tunnel Modeling Assumptions

- Details regarding wind tunnel modeling approach are provided in Appendix A

Receptors

- Receptor locations were chosen based both on RWDI's experience with exhaust dispersion, and input from BUMC and the building designers for the NEIDL.

- The receptor locations evaluated for this risk assessment included those beyond the NEIDL, specifically air intakes on the existing and future planned BUMC buildings surrounding the NEIDL, and off-site (non-BUMC buildings) such as commercial buildings and residential areas.

- Receptor heights varied from ground-level to rooftop heights for both on-site and off-site locations. One receptor was located on a possible rooftop air intake on a future proposed BUMC building to the east of the NEIDL. This rooftop receptor location on a future proposed building was chosen because of its proximity (both vertical distance and horizontal distance) to the potential NEIDL release point and is expected to result in high anthrax concentrations.

- The highest anthrax concentrations due to emissions from the high-containment laboratory exhaust were predicted to occur at a possible rooftop air intake on a future proposed BUMC laboratory building to the east of the NEIDL. The results presented below present the predicted anthrax spore concentration at this receptor only. Anthrax concentrations at all other receptor locations beyond the NEIDL would be less than those reported herein.

3. RELEASE SCENARIOS

In the release events modeled, the number of spores released is expected to vary over time, decaying exponentially, and extending the time of the release event. In these scenarios, the spore cloud mixes with the surrounding air as the fresh air is brought into laboratory space. To provide a conservative upper bound for the analysis, the individual receptors are assumed to remain in place for the duration of the release.

3.1 Accidental Laboratory Release Scenario - Two HEPA Filters

This scenario simulates an accidental laboratory release where the entire contents of an anthrax vial are released within the high-containment laboratory space (with the lowest ventilation rate) in a cloud of spores.

Using the dispersion model ISC-PRIME, for an individual breathing at a rate of 30 litres per minute (the breathing rate of an active person) for the duration of the release event, the calculated maximum number of spores that may be inhaled is 0.0000000361 spores. Since the release and inhalation of a partial spore is not feasible, this number may be practically considered as zero.

Using the wind tunnel, for an individual breathing at a rate of 30 litres per minute (the breathing rate of an active person) for the duration of the release event, the calculated maximum number of spores that may be inhaled is 0.0000000263 spores. Since the release and inhalation of a partial spore is not feasible, this number may be practically considered as zero.

3.2 Accidental Laboratory Release Scenario – Single HEPA Filter Malfunction

This scenario simulates an accidental laboratory release where the entire contents of an anthrax vial are released within the high-containment laboratory space (with the lowest ventilation rate) in a cloud of spores when one of the two HEPA filters is not functioning.

Using the dispersion model ISC-PRIME, for an individual breathing at a rate of 30 litres per minute (the breathing rate of an active person) for the duration of the release event, the calculated maximum number of spores that may be inhaled is 0.0000526 spores. Since the release and inhalation of a partial spore is not feasible, this number may be practically considered as zero.

Using the wind tunnel, for an individual breathing at a rate of 30 litres per minute (the breathing rate of an active person) for the duration of the release event, the calculated maximum number of spores that may be inhaled is 0.0000877383 spores. Since the release and inhalation of a partial spore is not feasible, this number may be practically considered as zero.

3.3 Accidental Laboratory Release Scenario – No HEPA Filters

This scenario simulates an accidental laboratory release where the entire contents of an anthrax vial are released within the high-containment laboratory space (with the lowest ventilation rate) in a cloud of spores with neither of the HEPA filters in operation.

Using the dispersion model ISC-PRIME, for an individual breathing at a rate of 30 litres per minute (the breathing rate of an active person) for the duration of the release event, the calculated maximum number of spores that may be inhaled is 0.1755 spores. Since the release and inhalation of a partial spore is not feasible, this number may be practically considered as zero.

Using the wind tunnel, for an individual breathing at a rate of 30 litres per minute (the breathing rate of an active person) for the duration of the release event, the calculated maximum number of spores that may be inhaled is 0.2925 spores. Since the release and inhalation of a partial spore is not feasible, this number may be practically considered as zero.

4. SUMMARY

The results presented in this report summarize dispersion modeling and wind tunnel modeling results describing the potential maximum downwind ground-level anthrax spore inhalation predicted for three release scenarios. In each case, the calculated maximum number of spores that may be inhaled by an individual standing on the plume centerline downwind from the release is less than a single spore. Since the release and inhalation of a partial spore is not feasible, this number may be practically considered as zero.

5. REFERENCES

1. Emergency response to Anthrax Attack (Lawrence M. Wein, David L. Craft, and Edward H. Kaplan), PNAS, Vol.100, No.7.

2. The Sverdlovsk Anthrax Outbreak of 1979 (M. Meselson et al.), Science, 1994, Vol. 266.

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6. "User's Manual for SLAB: An Atmospheric Dispersion Model for Denser-Than-Air Releases" (Donald L. Ermak) available through the National Technical Information Services (NTIS).

APPENDIX A

APPENDIX A: Wind Tunnel Model

The larger of RWDI's two wind tunnels was used to measure the impact of emissions from two of the high-containment laboratory exhausts (BSL-3 and BSL-4) on the NEIDL. This tunnel has a cross-section of 16 feet across and 8 feet tall. The wind tunnel was developed to simulate a boundary layer under neutral atmospheric stability. The elements on the floor of the wind tunnel simulate a ground roughness that is designed to represent the buildings and obstructions upwind of the NEIDL. This roughness creates a velocity profile in which the mean wind speeds increase with height until the top of the boundary layer is reached, after which the surface roughness does not play a role. Physical modeling takes into account the effect of building downwash, the complicated building structures, and the layout of the surrounding, and produces what are considered to be the most accurate modeling results available.

A scale model of the proposed NEIDL and surroundings within 800 ft was constructed at a scale of 1:200. This included many Boston University Medical Campus buildings (currently standing and future), and commercial and residential areas. Due to the height of the penitentiary south of the NEIDL, an extension was also added to include this in the model.

The wind tunnel tests were conducted by emitting a tracer gas at a known concentration from a BSL-3 and a BSL-4 exhaust. Each source was tested independently so that the impacts from the different sources could be distinguished. Mean concentrations of tracer gas were measured at receptor locations by drawing samples through flush-mounted tubes leading to a bank of infrared analysers stationed outside the tunnel. Wind tunnel tests were performed over a broad range of wind directions and wind speeds (i.e., up to 24 wind directions in 15° increments and five wind speeds) to ensure that the worst-case (highest) concentrations were captured at the tested receptors. The wind tunnel tests showed that the highest concentrations would occur for the high-containment laboratory exhaust with the lower ventilation rate (6,900 cfm) because of the lower exhaust momentum and higher source concentration of anthrax.

Receptors were installed on the model to represent the NEIDL air intakes, surrounding BUMC building air intakes and pedestrian locations, and off-site locations such as commercial buildings and residential areas. The receptors were chosen based on RWDI's experience with exhaust dispersion, and input from BUMC, and the NEIDL building designers. For the purpose of the risk assessment, only receptors beyond the NEIDL were considered. It was determined that the highest exhaust impacts would occur at a possible rooftop air intake on a future BUMC laboratory building to the east of the NEIDL.

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