



Risk Management Series

Primer

to Design Safe School Projects in Case of Terrorist Attacks

December 2003



FEMA

RISK MANAGEMENT SERIES

Primer *to*
Design Safe School Projects
in Case of Terrorist Attacks

PROVIDING PROTECTION TO PEOPLE AND BUILDINGS



FEMA

www.fema.gov

Any opinions, findings, conclusions, or recommendations expressed in this publication do not necessarily reflect the views of FEMA. Additionally, neither FEMA or any of its employees makes any warrantee, expressed or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, product, or process included in this publication. Users of information from this publication assume all liability arising from such use.

The creation of the Department of Homeland Security (DHS) is one of the most significant transformations in the Federal Government in decades, establishing a department whose first priority is to protect the nation against terrorist attack. Within the DHS, the Directorate of Emergency Preparedness and Response (EP&R) is focused on ensuring that our nation is prepared for catastrophes, including both natural disasters and terrorist assaults.

This Primer for Protection of Schools Against Terrorist Attacks provides guidance to protect students, faculty, staff, and their school buildings from terrorist attacks. It also provides guidance to the building science community of architects and engineers working for local institutions on school projects.

This document is intended for use by schools who feel that they are at risk to terrorist attacks. It provides necessary guidance to those who desire to increase the performance of their school and related infrastructure. Not all schools are at risk of terrorist attacks. The decision-makers in each school district should use current and available threat information from the proper sources to make this determination. The use of experts to apply the methodologies contained in this document is encouraged.

This primer references several sources for additional information, including publications completed by other government agencies. The reader is encouraged to obtain additional guidance.

This document was prepared by the Building Sciences and Technology Branch of the Mitigation Division, part of EP&R. DHS would like to thank the following agencies for their contribution and input to this publication:

- General Services Administration
 - Naval Facilities Engineering Service Center
 - Naval Facilities Command (NAVFAC) Criteria Office
-

- USACE Protective Design Center
- Department of Veterans Affairs
- Centers for Disease Control and Prevention/National Institute for Occupational Safety and Health
- Department of Justice, Office of Domestic Preparedness (DHS - Border and Transportation Security)
- United States Air Force - Civil Engineer Support Agency



FOREWORD AND ACKNOWLEDGMENTS

BACKGROUND

The purpose of this primer is to provide the design community and school administrators with the basic principles and techniques to make a school that is safe from terrorist attacks and at the same time is functional, aesthetically pleasing, and meets the needs of the students, staff, administration, and general public. Protecting a school building and grounds from physical attack is a significant challenge because the ability to design, construct, renovate, operate, and maintain the facility is spread across numerous building users, infrastructure systems, and many building design codes.

There is a strong interest in the United States (U.S.) in ensuring the safety of students, faculty, and staff in our schools. Schools are integral parts of their communities. On any given weekday, nearly 53 million young people aged 5 to 17 attend more than 117,000 public and private schools where 6 million adults work as teachers or staff (counting students,



An American high school

faculty, and staff, this constitutes more than one-fifth of the U.S. population). Additionally, schools are resources for their communities. Many schools are used as shelters, command centers, or meeting places in times of crisis. Schools are also used widely for polling and voting functions. In some communities, schools are places of health care delivery.

Schools may or may not be the targets of terrorism, but they are certain to be affected by terrorism, whether directly or indirectly.

On September 11, 2001, four elementary schools and three high schools located within 6 blocks of the World Trade Center were just beginning classes when the first plane hit the north tower. Thousands of children were exposed to the dust clouds from the collapsing buildings. Even those children not in the immediate vicinity experienced a great deal of anxiety. Children in at least three states (New York, New Jersey, and Connecticut) had parents working in or around the World Trade Center that day. In the Washington, DC, area, schools faced similar situations after the Pentagon was attacked.¹

Many Americans feel that schools should be the safest place our children can be, perhaps at times even safer than the homes in which they live. Security is not a standalone capability; it is a critical design consideration that should be constantly reviewed and scrutinized from the design phase through construction or rehabilitation and onto building use.

The focus of this primer will be on the threats posed by potential physical attacks on a school by terrorists. Attacking schools and school children could be a highly emotional and high profile event. At the time of publication of this primer, there have been no direct terrorist threats against a school known to the public; however, schools could be indirectly threatened by collateral damage from a terrorist attack directed at nearby facilities. Protecting a school against terrorist attack is a challenging task. A school may have considerable vulnerabilities, because of its well defined periods of use, designated access points, storage of sensitive personal information, minimal security forces, and numerous avenues of penetration and escape for attackers.

This primer should be used in conjunction with the Federal Emergency Management Agency (FEMA) 426, *Reference Manual to Mitigate Potential Terrorist Attacks Against Buildings*, and FEMA 427, *Primer for Design of Commercial Buildings to Mitigate Terrorist Attacks*.

¹ National Advisory Committee on Children and Terrorism (NACCT)

SCOPE

This primer presents an approach to protecting schools at risk from terrorist attacks. The information presented is intended primarily for architects and engineers, or school administrators with a technical background. This publication is designed to meet the needs of all schools, including those with serious security concerns. Because security concerns of individual schools vary greatly, some users with modest security concerns may feel beleaguered by the amount of information and technical approach presented. They should feel free to select the methods and measures that best meet their individual situations while gaining a general appreciation of security concerns and risk management.

Several design philosophies and techniques have been incorporated into this primer, including the Department of Defense (DoD) Minimum Antiterrorism Standards, the Army and Air Force Security Engineering Manual, the General Services Administration (GSA) Public Building Standards, the Department of Veterans Affairs (VA) Building Vulnerability Assessment Checklist, and the Centers for Disease Control and Prevention (CDC)/National Institute for Occupational Safety and Health (NIOSH) Guidelines for Airborne Contaminants.

ORGANIZATION AND CONTENT OF THE PRIMER

This publication contains many how-to aspects based upon current information contained in FEMA, Department of Commerce (DOC), DoD (including Army, Navy, and Air Force), Department of Justice (DOJ), GSA, VA, CDC/NIOSH, and other publications. It is intended to provide an understanding of the current methodologies for assessing threat/hazard, vulnerability, and risk, and the design considerations needed to improve protection of new and existing buildings and the people occupying them. As needed, this primer should be supplemented with more extensive technical resources, as well as the use of experts when necessary.

- Chapter 1 presents a methodology for architects, engineers, and school administrators to analyze the safety of students, teachers, and staff for vulnerabilities to various terrorist threats. The methodology presented will assist schools in performing risk management by helping them to identify the best and most cost-effective terrorism mitigation measures for their unique security needs.
- Chapters 2 and 3 discuss site and layout, and building design guidance and safety plans, respectively, and mitigation measures or comprehensive architectural and engineering design considerations to provide an acceptable level of protection. Specifically, Chapter 2 discusses comprehensive architectural and engineering design considerations for the school site, from the property line to the school building. Chapter 3 presents design considerations for the building envelope.
- Chapter 4 is a brief discussion of explosive blast theory. Chapter 5 presents chemical, biological, and radiological (CBR) measures that can be taken to mitigate school vulnerabilities and reduce associated risk for these terrorist tactics or technological hazards.
- Chapter 6 is a standalone description of the concept of safe rooms within schools that will resist CBR and blast threats intended to provide school board members and decision-makers with the basic components of a protective system.
- Appendices A, B, and C contain acronyms, general definitions, and chemical and biological agent characteristics, respectively. Appendix B is an extensive glossary with terminology used in the report.
- Appendices D and E present a comprehensive bibliography of publications (including information for obtaining the publications), and the associations and organizations capturing the building security guidance needed by the building sciences community (including web sites), respectively.
- Appendix F contains the Building Vulnerability Assessment Checklist.

ACKNOWLEDGEMENTS

Principal Authors:

Michael Chipley, UTD, Inc.

Wesley Lyon, UTD, Inc.

Robert Smilowitz, Weidlinger Associates, Inc.

Pax Williams, Battelle Memorial Institute

Contributors:

Milagros Kennett, FEMA, Project Officer, Risk Management Series Publications

Eric Letvin, Greenhorne & O'Mara, Inc., Consultant
Project Manager

Michael Kaminskas, UTD, Inc.

Christopher Arnold, Building Systems Development, Inc.

Shawn Fenn, FEMA

Randall Hoffman, UTD, Inc.

Damian Kolbay, UTD, Inc.

Eve Hinman, ATC/Hinman Consulting Engineers, Inc.

Robert Burns, UTD, Inc.

Curt Betts, U.S. Army Engineer District, Omaha

Connie Deshpande, Department of Education

Bill Modzeleski, Department of Education

Randy Haslam, Jordan, Utah, School District

Deb Daly, Greenhorne & O'Mara, Inc.

Wanda Rizer, Greenhorne & O'Mara, Inc.

Julie Liptak, Greenhorne & O'Mara, Inc.

Bob Pendley, Greenhorne & O'Mara, Inc.

This primer was prepared under contract to FEMA. It will be revised periodically, and comments and feedback to improve future editions are welcome. Please send comments and feedback by e-mail to riskmanagementseriespubs@dhs.gov

TABLE OF CONTENTS

FOREWORD AND ACKNOWLEDGMENTS	i
CHAPTER 1 – ASSET VALUE, THREAT/HAZARD, VULNERABILITY, AND RISK	1-1
1.1 Asset Value Assessment	1-2
1.1.1 Identifying School Core Functions.....	1-4
1.1.2 Identifying School Infrastructure	1-4
1.1.3 Quantifying Asset Value.....	1-5
1.2 Threat/Hazard Assessment.....	1-7
1.2.1 Threat Identification	1-9
1.2.2 Threat Definition	1-13
1.2.3 Threat Assessment Products	1-15
1.2.4 Design Basis Threat	1-18
1.3 Vulnerability Assessment	1-20
1.4 Risk Assessment.....	1-23
1.5 The Risk Management Process	1-28
CHAPTER 2 – SITE AND LAYOUT DESIGN GUIDANCE	2-1
2.1 Land Use Considerations	2-2
2.2 Site Planning	2-4
2.2.1 Site Design.....	2-4
2.2.2 Layout and Form.....	2-4
2.2.3 Vehicular and Pedestrian Circulation	2-9
2.2.4 Landscape and Urban Design.....	2-10
2.3 Stand-off Distance	2-14
2.4 Controlled Access Zones	2-16

2.5	Entry Control and Vehicular Access	2-20
2.6	Signage.....	2-21
2.7	Parking.....	2-22
2.8	Loading Docks and Service Access	2-24
2.9	Physical Security Lighting.....	2-25
2.10	Site Utilities	2-26
2.11	Summary of Site Mitigation Measures	2-28
2.12	Crime Prevention Through Environmental Design (CPTED)	2-33
CHAPTER 3 – BUILDING DESIGN GUIDANCE AND SAFETY PLANS.....		3-1
3.1	Architectural.....	3-2
3.2	Building Structural and Non-structural Systems.....	3-5
3.3	Building Envelope.....	3-10
3.3.1	Building Exterior	3-10
3.3.2	Exterior Wall Design.....	3-10
3.3.3	Window Design	3-12
3.3.4	Doors.....	3-17
3.3.5	Roofs	3-18
3.4	Mechanical Systems	3-18
3.5	Electrical Systems	3-24
3.6	Fire Protection Systems.....	3-25
3.7	Communications Systems.....	3-26
3.8	Physical Security Systems	3-27
3.9	Summary of Building Envelope Mitigation Measures	3-29

3.10 Recommendations Based on the Homeland Security Advisory System	3-32
3.11 School Safety Emergency Management Plan.....	3-33
3.12 Emergency Plans and Training	3-36
CHAPTER 4 – EXPLOSIVE BLAST.....	4-1
4.1 Blast Effects.....	4-1
4.1.1 Building Damage	4-3
4.1.2 Casualties and Injuries.....	4-5
4.1.3 Levels of Protection	4-5
4.2 Stand-off Distance and the Effects of Blast	4-10
CHAPTER 5 – CHEMICAL, BIOLOGICAL, AND RADIOLOGICAL MEASURES	5-1
5.1 Evacuation	5-2
5.2 Sheltering in Place	5-3
5.3 Personal Protective Equipment	5-6
5.4 Air Filtration and Pressurization.....	5-8
5.5 Exhausting and Purging	5-8
5.6 CBR Detection.....	5-9
5.7 Indications of CBR Contamination	5-11
CHAPTER 6 – SAFE ROOMS WITHIN SCHOOLS.....	6-1
6.1 Types of CBR Hazards.....	6-2
6.1.1 Toxic Industrial Chemicals.....	6-2
6.1.2 Incapacitating and Tear-producing Agents.....	6-3
6.1.3 Biological Agents.....	6-3
6.1.4 Radiological Agents	6-4
6.2 Most Likely Delivery Methods for CBR Agents.....	6-4

6.2.1	Internal Release	6-5
6.2.2	External Proximate Release	6-5
6.2.3	Remote Release	6-5
6.2.4	Remote Release with Forewarning	6-6
6.3	Vulnerability to Remote CBR Release	6-6
6.4	Vulnerability to Remote CBR Release with Forewarning.....	6-10
6.5	Vulnerability to Internal CBR Release.....	6-11
6.6	Vulnerability to External Proximate CBR Release.....	6-11
6.7	Recommendations for CBR Protection.....	6-16
6.8	Safe Rooms in Response to the Domestic Explosive Threat	6-16
6.9	Locating Safe Rooms to Mitigate Threats	6-20
6.10	Fragment Mitigating Upgrades.....	6-24
6.11	Structural Upgrades.....	6-30

APPENDIX A – ACRONYMS

APPENDIX B – GENERAL GLOSSARY

APPENDIX C – CBR AGENT CHARACTERISTICS

APPENDIX D – BIBLIOGRAPHY

APPENDIX E – ASSOCIATIONS AND ORGANIZATIONS

APPENDIX F – BUILDING VULNERABILITY ASSESSMENT CHECKLIST

TABLES

Chapter 1

Table 1-1	Asset Value Scale.....	1-6
Table 1-2	Nominal High School People and Asset Value Assessment	1-7
Table 1-3	Homeland Security Threat Conditions	1-10
Table 1-4	Event Profiles for Terrorism and Technological Hazards.....	1-15
Table 1-5	Threat Rating Scale	1-16
Table 1-6	Nominal High School Threat Assessment.....	1-17
Table 1-7	Vulnerability Rating Scale.....	1-21
Table 1-8	Nominal High School Vulnerability Assessment	1-22
Table 1-9	Risk Rating System	1-24
Table 1-10	Risk Color Value System.....	1-25
Table 1-11	Nominal School Risk Assessment Matrix.....	1-26

Chapter 2

Table 2-1	Correlation of Mitigation Measures to Threats.....	2-30
-----------	---	------

Chapter 3

Table 3-1	Glazing Protection Levels Based on Fragment Impact Locations.....	3-13
Table 3-2	Correlation of GSA Glazing Performance Conditions and DoD Levels of Protection for New Buildings.....	3-14
Table 3-3	Safety/Security Recommendations.....	3-32

Chapter 4

Table 4-1	DoD Minimum Antiterrorism (AT) Standards for New Buildings	4-6
Table 4-2	Correlation of DoD Level of Protection to Incident Pressure	4-6
Table 4-3	Damage Approximations	4-13

Chapter 5

Table 5-1	Indicators of a Possible Chemical Incident.....	5-13
Table 5-2	Indicators of a Possible Biological Incident	5-15
Table 5-3	Indicators of a Possible Radiological Incident	5-15

Chapter 6

Table 6-1	Pressures Exerted on a School Building Face by Wind.....	6-13
-----------	--	------

FIGURES

Chapter 1

Figure 1-1	The assessment process model.....	1-2
Figure 1-2	Typical building design and construction process	1-19
Figure 1-3	Risk management choices	1-19

Chapter 2

Figure 2-1	Non-redundant critical functions collocated near loading dock	2-6
Figure 2-2	Clustering to enhance surveillance opportunities while minimizing views into buildings.....	2-7
Figure 2-3	Blocking of sight lines.....	2-13

Figure 2-4	Improper building siting and view relationships ...	2-13
Figure 2-5	Clear zone with unobstructed views.....	2-14
Figure 2-6	Concept of stand-off distance.....	2-15
Figure 2-7	Exclusive and non-exclusive zones.....	2-17
Figure 2-8	Sample bollard applications	2-18

Chapter 3

Figure 3-1	Re-entrant corners in a floor plan	3-3
Figure 3-2	Glazed areas oriented perpendicularly away from streets	3-4
Figure 3-3	Offset doors through the foyer	3-5
Figure 3-4	Side view of a test structure illustrating performance conditions of Table 3-2.....	3-13
Figure 3-5	An unprotected window after a large explosion.....	3-15
Figure 3-6	Sacrificial roof.....	3-18
Figure 3-7	Example of protecting outdoor air intakes	3-20
Figure 3-8	Another example of protecting air intakes	3-21
Figure 3-9	Example of elevated air intake	3-21
Figure 3-10	Example of enclosing an existing vulnerable air intake	3-22
Figure 3-11	Considerations for the design of a new security system	3-28
Figure 3-12	Physical security devices.....	3-29

Chapter 4

Figure 4-1	Blast pressure effects on a structure.....	4-4
Figure 4-2	Explosives environments - blast range to effects.....	4-8

Figure 4-3	Blast analysis of a high school for a typical car bomb detonated in the school's parking lot	4-9
Figure 4-4	Blast analysis of a high school for a typical large truck bomb detonated in the school's parking lot.....	4-9
Figure 4-5	Relationship of cost to stand-off distance	4-10
Figure 4-6	Incident overpressure measured in pounds per square inch, as a function of stand-off distance and net explosive weight (pounds-TNT)	4-13

Chapter 5

Figure 5-1	Example of chemical dispersion	5-3
Figure 5-2	Universal-fit escape hood.....	5-7
Figure 5-3	An IMS chemical detector designed for installation in HVAC systems	5-10
Figure 5-4	Placards associated with chemical incidents	5-14
Figure 5-5	Placards associated with biological incidents	5-15
Figure 5-6	Placards associated with radiological incidents.....	5-16