

**HAZARD ANALYSIS
Toxic Industrial Chemicals
IDENTIFICATION AND MODELING**

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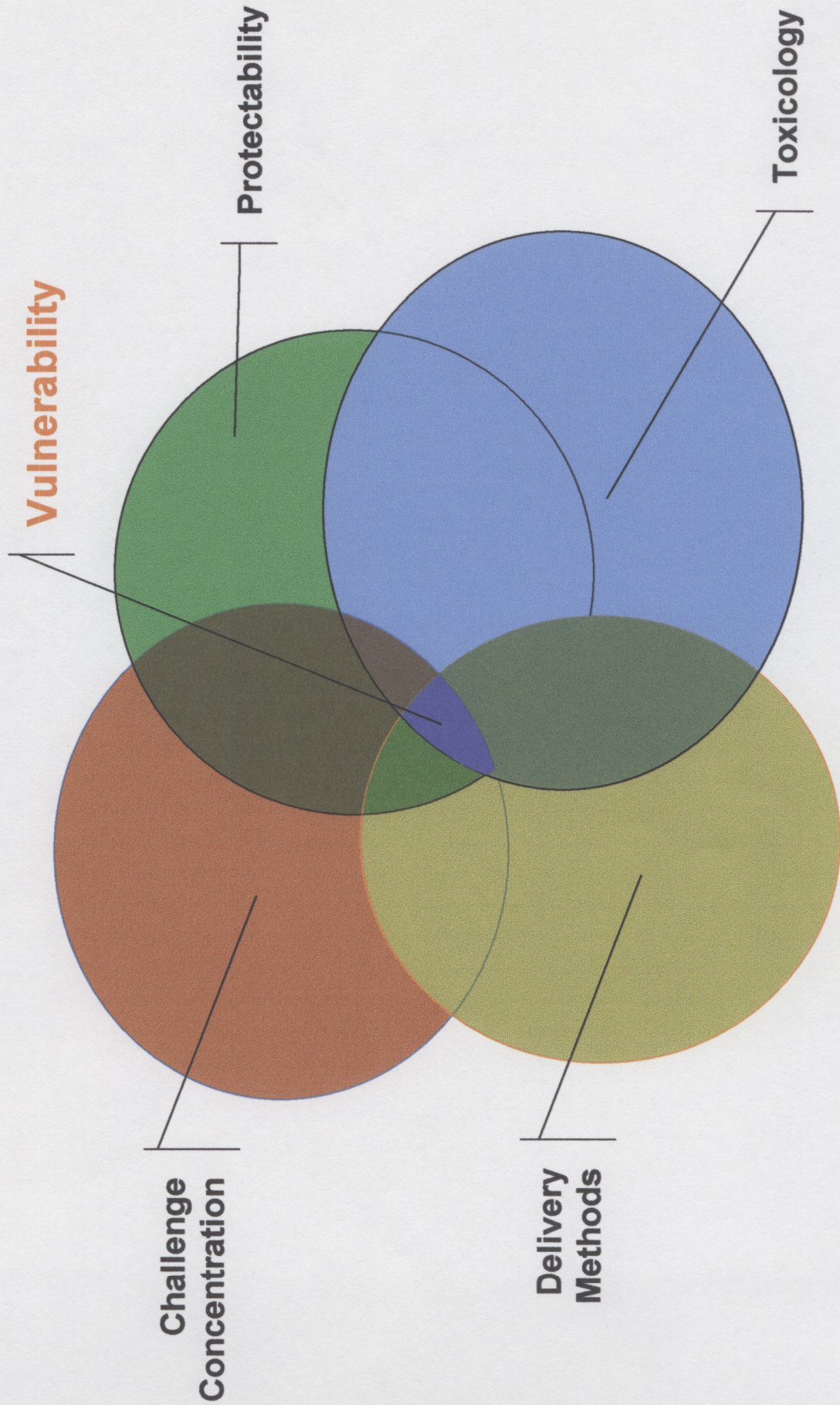
OVERVIEW

- Objectives and Purpose
- Warm Zone Strategy
- Proposed Assessment Methodology
- Model Estimations
- Data Needs
- Discussion
- Conclusions

OVERVIEW

- Purpose
- Vulnerability Assessment
- Chemicals of Interest
- Scenarios
- Hot Zone Modeling
- Vapor Concentration-Time Profiles
- Conclusions

Vulnerability Assessment



TOXICOLOGY

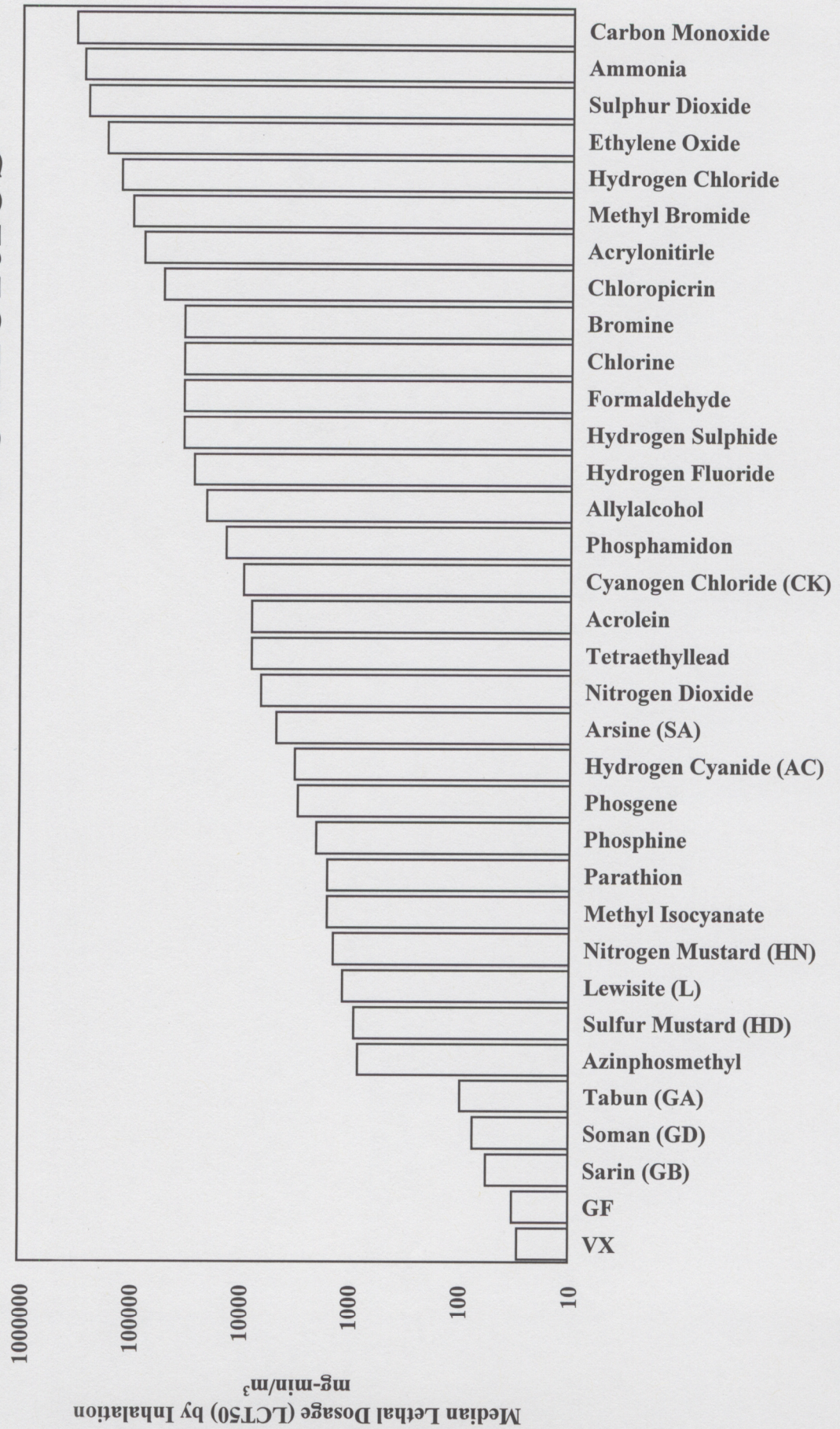
What is it?

How Much is there?

How long are you exposed?

What routes of entry?

Relative Inhalation Toxicities



CWA Physical Properties

Chemical Name	Mole Wt. (g/mole)	VP (mm Hg @ 20 °C)	Volatility (g/m ³)
Sarin (GB)	140.1	2.1	16
Soman (GD)	182.18	0.40	3.9
Sulfur Mustard (HD)	159.08	0.072	0.63
Cyanogen Chloride (CK)	61.47	~880	~2945

NIOSH List of Respirable TIC

- Ammonia
- Cyclohexane
- Carbon Tetrachloride
- Cyanogen Chloride
- Ethylene Oxide
- Formaldehyde
- Hydrogen Cyanide
- Hydrogen Sulfide
- Nitrogen Dioxide
- Phosgene
- Phosphine
- Sulfur Dioxide

Physical Properties

Chemical Name	Mole Wt. (g/mole)	VP (mm Hg @ 21.1 °C)	Volatility (g/m ³)
Ammonia	17.03	6660.8	6200
Cyclohexane	84.16	~100	~458
Carbon Tetrachloride	153.82	~95	~796
Cyanogen Chloride	61.47	~880	~2945
Ethylene Oxide	44.05	~1100	~2640
Formaldehyde	30.03	>760	>1250

Physical Properties

Chemical Name	Mole Wt. (g/mole)	VP (mm Hg @ 21.1 °C)	Volatility (g/m ³)
Hydrogen Cyanide	27.03	~650	~1000
Hydrogen Sulfide	34.08	13792	25688
Nitrogen Dioxide	46.01	760	1810
Phosgene	98.92	1313	6568
Phosphine	34	~30650	57000
Sulfur Dioxide	64.07	2539	8515

DELIVERY METHODS

Spill

Spray

Explosive

Pressurized Cylinders

Challenge Concentration

Venue

Location of Casualties

Amount and type of Hazard

Venues Considered

- Large Meeting Room
- Auditorium/Theater
- Office Building
- Airport Concourse
- Shopping Mall Store
- Shopping Mall Food Court

TIC ASSUMPTIONS

- Mass function of container size and type
- Rate of Mass release – dependent on method of dissemination
- Compressed gas discharge rates dependent on TIC, pressure, temperature, valve size, etc.

TIC ASSUMPTIONS

- Choke Flow Equations
- Ventilation kinetics
drastically influence vapor
TIC concentrations
- Heavy gas not factored in
these initial calculations.

INDOOR SCENARIO COMPLEXITIES

- Building Structure
- Compartmentalization
- Ventilation Characteristics
- Source Type and Location
- Remediation Techniques

VENUES

INDOOR (Reference)	IDENTIFICATION	INCIDENT SITE L-W-H (ft ³)	VENTILATION NEEDS	TOTAL VOLUME (ft ³)	HVAC SERVICED ROOMS
1	Meeting room 1 (MR1)	51-68-11	15% OA* 3500 cfm	38,148	1
	Meeting room 2 (MR2)	51-68-11	15% OA 25,000 cfm total	160,000	4
2	Auditorium/theater 1 (A1)	130-84-40	15% OA 3640 cfm	436,800	1
3	Office Building 1 (OB1)	50-6-8.5 (Hallway)	15% OA 63,500 cfm total	75,000	12 different room sizes
5	Office Building 2 (OB2)	10-10-10	20%OA 120 cfm	20,000	20
4	Airport Concourse (AC)	160-128-33	5% OA 9,100 cfm	389,120 HVAC off	1
5	Shopping Mall Store1 (SM1)	30-100-10	25% OA 3000 cfm	30,000	1
2	Shopping Mall Food Court (SMFC)	100-50-20	25%OA 3300 cfm	100,000	1

* = Outside Air

SOURCE DESCRIPTIONS

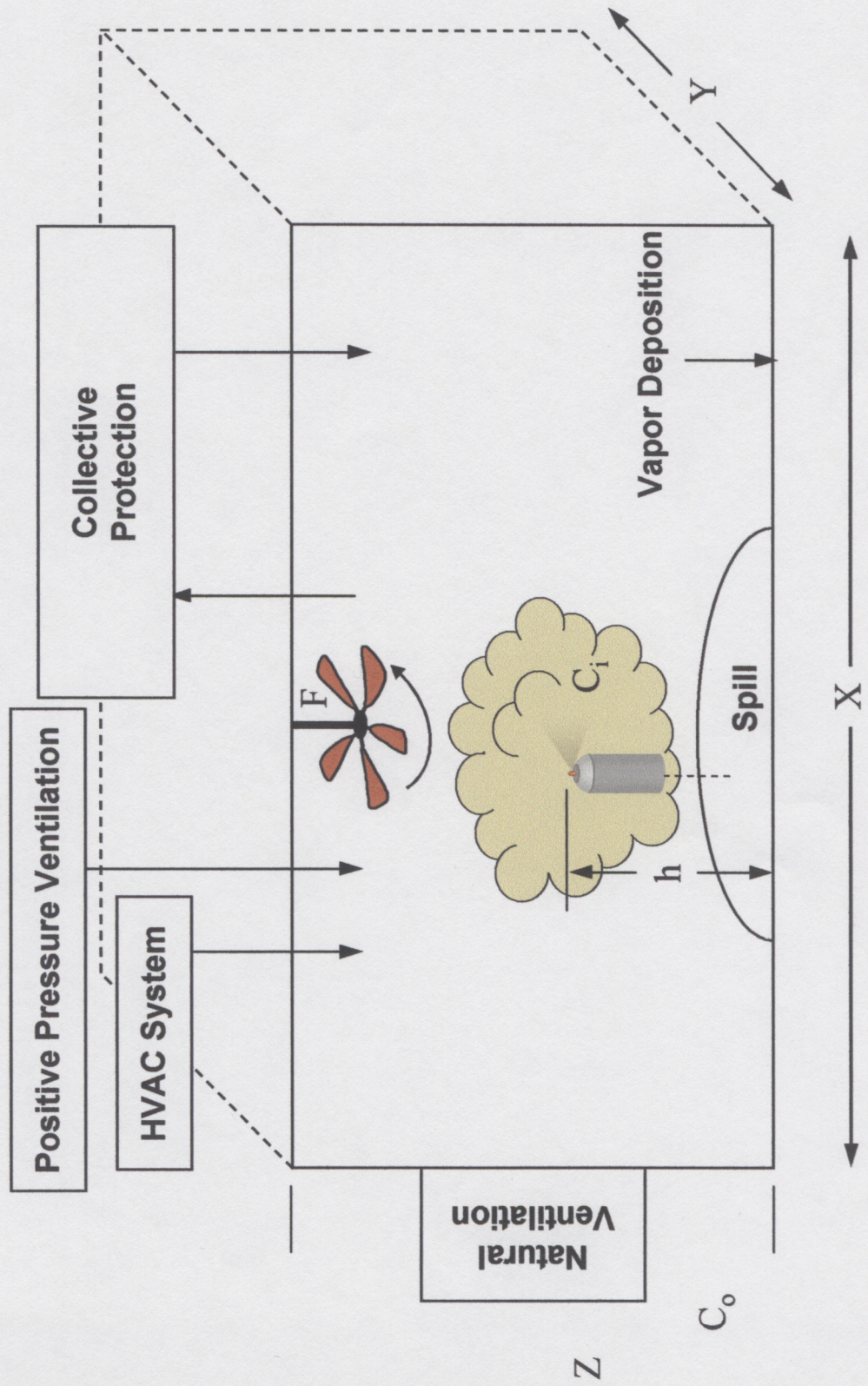
INDOOR VENUE	IDENTIFICATION	AMOUNT	METHOD	RELEASE TIME (SEC)	WHERE	PLACEMENT
MR1	BOTTLE	1 LITER	SPILL	1	FLOOR	CENTER
"	"	1 LITER	EXPLOSIVE	1	FLOOR	CENTER
"	"	1 LITER	SPRAY	120	1 FT-FLOOR	CENTER
MR2	BOTTLE	1 LITER	SPILL	1	HVAC	RM 1 DUCT
"	"	1 LITER	EXPLOSIVE	1	HVAC	RM 1 DUCT
"	"	1 LITER	SPRAY	120	HVAC	RM 1 DUCT
A1	"	1 LITER	SPILL	1	FLOOR	CENTER
"	"	1 LITER	EXPLOSIVE	1	FLOOR	CENTER
"	"	1 LITER	SPRAY	120	HVAC	DUCT
"	"	4 LITERS	EXPLOSIVE	1	FLOOR	CENTER
OB1	BOTTLE	0.5 LITER	SPRAY	3000	CORRIDOR	CENTER
"	"	0.5 LITER	SPRAY	600	CORRIDOR	CENTER
"	"	0.5 LITER	SPRAY	600	HVAC	AHU *
OB2	BOTTLE	1 LITER	EXPLOSIVE	1	ROOM 1	CENTER
"	"	1 LITER	SPRAY	600	ROOM 1	CENTER
"	"	"	"	"	1 FT-FLOOR	"
AC	KNAPSACK	25 LBS	EXPLOSIVE	1	FLOOR	CENTER
"	"	25 LBS	SPRAY	600	FLOOR	CENTER
"	PULL LUGGAGE	50 LBS	EXPLOSIVE	1	FLOOR	CENTER
"	LUGGAGE CART	200 LBS	EXPLOSIVE	1	FLOOR	CENTER
SM1	BOTTLE	1 LITER	EXPLOSIVE	1	FLOOR	CENTER
"	"	2 LITERS	EXPLOSIVE	1	FLOOR	CENTER
"	"	5 LITERS	EXPLOSIVE	1	FLOOR	CENTER
"	"	10 LITERS	EXPLOSIVE	1	FLOOR	CENTER
SMFC	BOTTLE	1 LITER	EXPLOSIVE	1	FLOOR	CENTER
"	"	2 LITERS	EXPLOSIVE	1	FLOOR	CENTER
"	"	5 LITERS	EXPLOSIVE	1	FLOOR	CENTER
"	"	10 LITERS	EXPLOSIVE	1	FLOOR	CENTER
"	"	25 LBS	EXPLOSIVE	1	FLOOR	CENTER
"	"	25 LBS	SPRAY	600	FLOOR	CENTER

* = AIR HANDLING UNIT

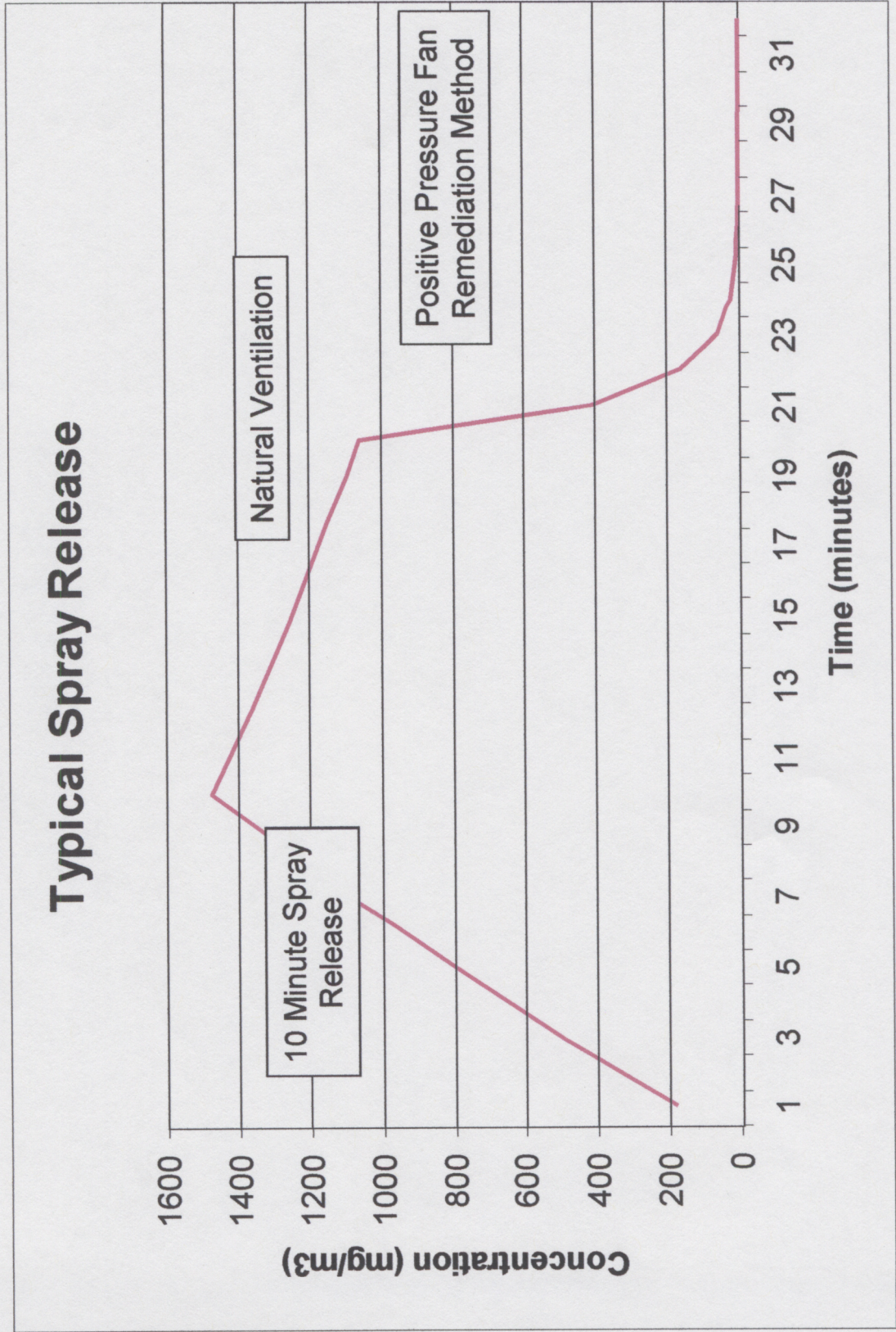
Source Descriptions

<u>Container</u>	<u>Method</u>	<u>Amount</u>
Gas Cylinder	Pressure Valve	150 lbs
Gas Cylinder	Pressure Valve	100 lbs
Gas Cylinder	Pressure Valve	20 lbs
Bottle	Spray	25 lbs
Bottle	Explosive	50 lbs
Bottle	Spill	200 lbs

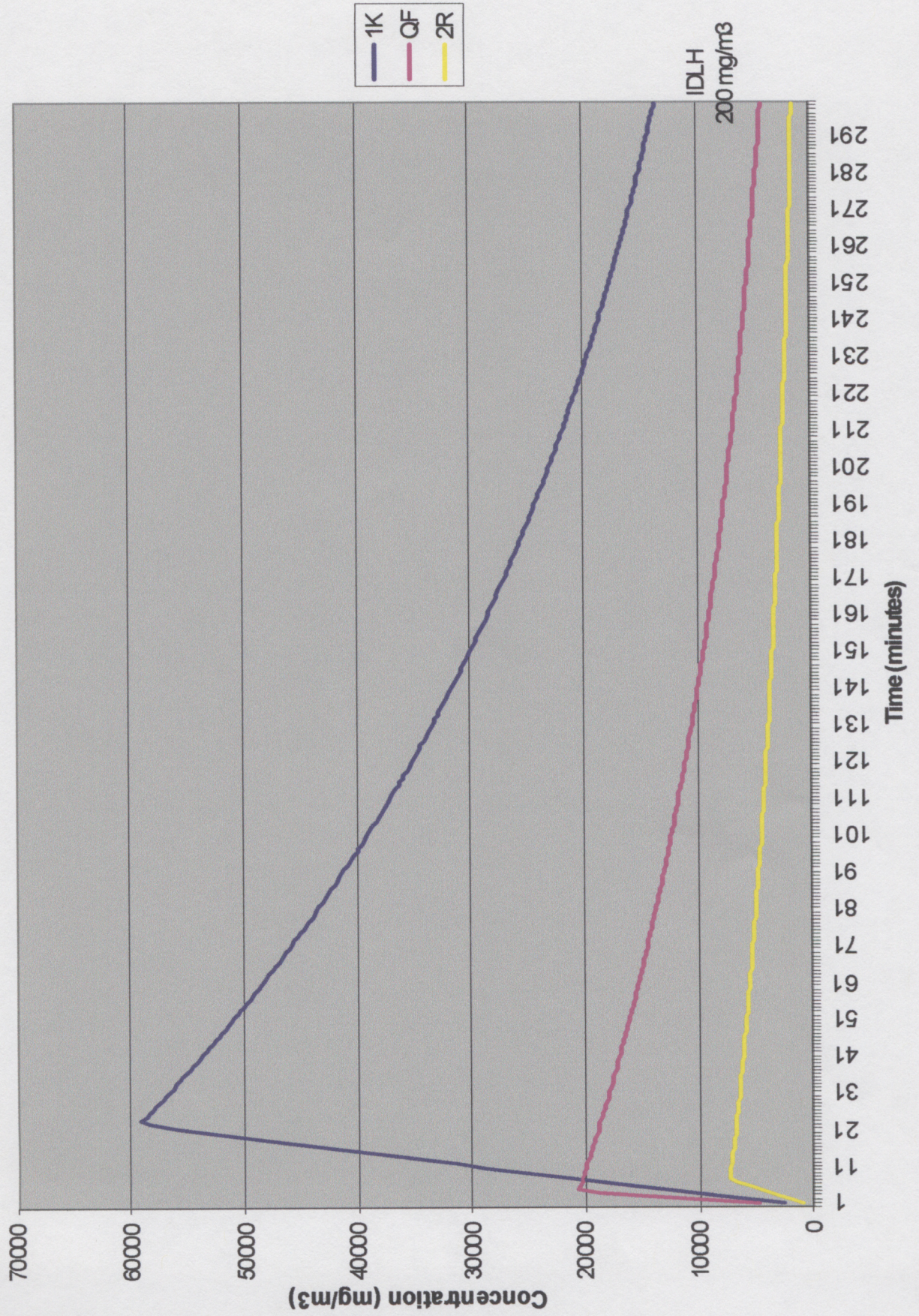
Ventilation Kinetics



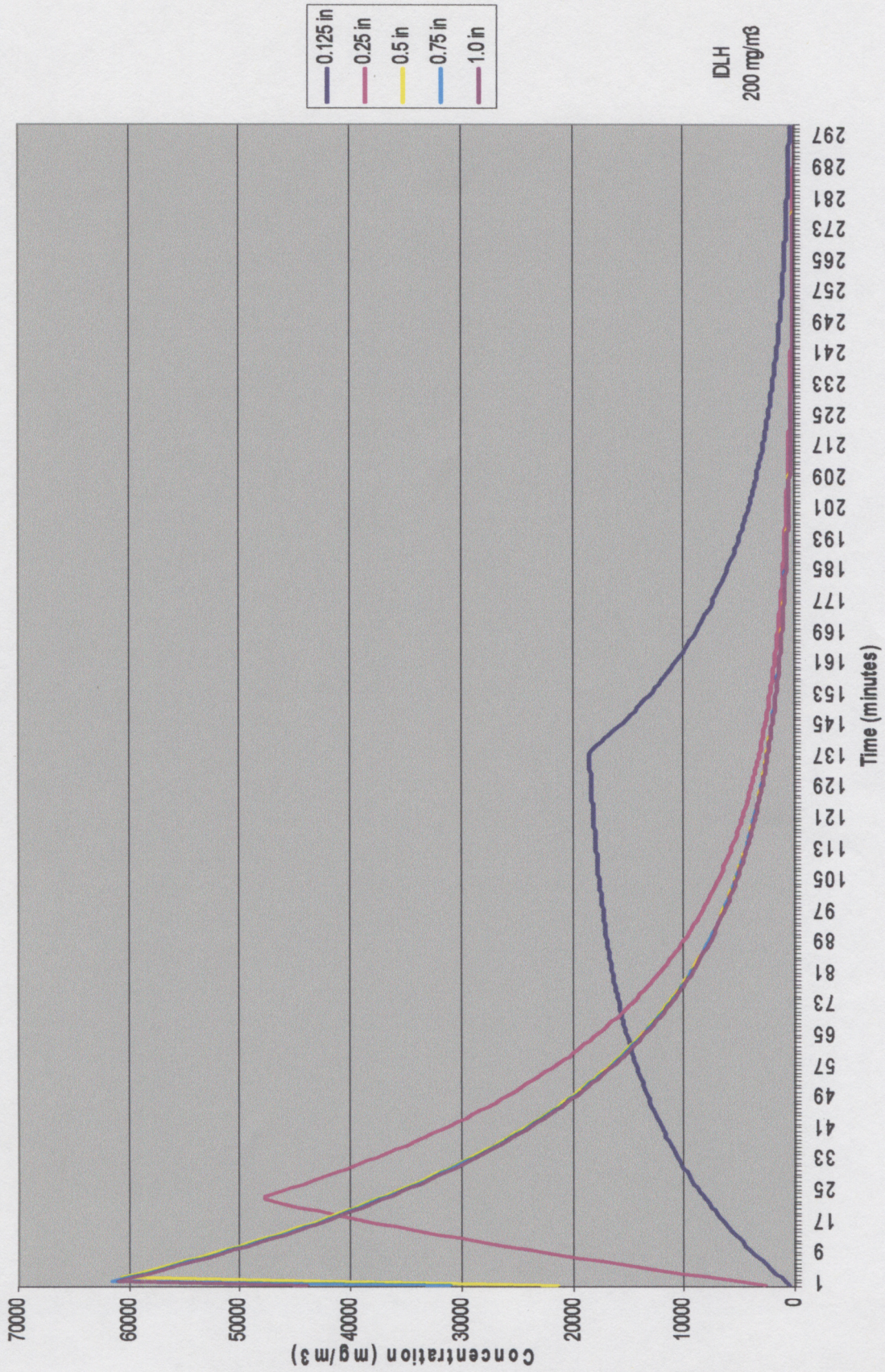
Concentration Profile



Ammonia Gas Cylinder - 0.25 in Opening Meeting Room 1 - no HVAC



Ammonia Gas Cylinder 1K Meeting Room 1



PROTECTABILITY

RESPIRATOR USES

- Escape Hood Respirator (EHR)
 - Atmosphere > IDLH
 - 15 Minute Protection
- Self-Contained Breathing Apparatus (SCBA)
 - Hot Zone, Unknowns, >IDLH
 - Limited to Air Supply Bottle
- Air-Purifying Respirator (APR)
 - Atmosphere < IDLH
 - Lengthy Protection Duration

OPERATIONAL USES

AIR PURIFYING RESPIRATORS

- Protection Zone Security
- Personal Decontamination Corridors
- Transportation of Exposed Personnel
- Medical Services Treatment Centers
- Area Clean-up and Facilities Restoration

CONCLUSIONS

- Vulnerability Assessment Factors Involve:
 - Toxicology
 - Delivery Methods
 - Challenge Concentration
 - Protectability
- Terrorist's Intent Not Prescribed
- Toxicities of TIC and CWA Span Orders of Magnitude in Values
- Challenge Levels are Venue Specific
- Test Standards Dependent on Respirator Uses