Common Mistakes
Application of a Risk Matrix

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- Principal EHS Professional & System Safety Engineer
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- Nearly 20-yrs experience as an EHS professional including performing and guiding hazards analyses that adhere to the principles in the Redbook
- Primary responsibilities and areas of expertise are centered around the identification of workplace hazards and development of consequence analysis associated with hazard analysis, safety assessments, primary hazard screens, readiness reviews, and compliance auditing techniques for a variety of clients including the DOE, commercial, industrial, and private industry clients.
- National Director for the Alliance of Hazardous Materials Professionals, Past-President for the New Mexico Chapter of the American Society of Safety Professionals, Past-President and Director at Large for the New Mexico Society of Hazardous Materials Managers, and historically served two consecutive mayoral appointed terms on the Albuquerque-Bernalillo County Joint Air Quality Control Board.

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- Partner at Parvati Consulting LLC & Parvati Government Services Inc
- Principal EHS Professional & System Safety Engineer
- B.S., Biology and B.S. Chemistry from the New Mexico Institute of Mining and Technology (NM Tech)
- Over 35-years of experience as an EHS professional including performing and guiding hazards analyses that adhere to the principles in the “Redbook.”
- Primary responsibilities and areas of expertise are centered around establishing the framework for clients in Hazard Analysis within a diverse set of industrial facilities including nuclear facilities, accelerators, semiconductor facilities, R&D laboratories, and dynamic energetic materials testing facilities.
- Respected for his ability to create highly functional teams and solve diverse, complex problems.
- Provides direct input to Line/Executive Management and Regulators to ensure solutions for continued organizational success.
- Active officer/board member ~ NMSHMM, NM ASSP, & ISSS

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Quick Overview

- Risk Matrixes are in the HA practitioner's toolbox to help make risk-based decisions to assign resources
  - Proper use of the risk matrix is a powerful tool
    - Helps to make "risk-based" decisions to assign resources
    - Helps to understand loss events and control strategies
  - Misuse of the risk matrix is dangerous
    - Yields a hollow promise of safety
    - Waste resources
- Understand development of risk matrices to support use
- Reflect lessons learned to aid the HA practitioner with addressing unmitigated risk, mitigated risk, and adequacy of safeguards

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Hazard Analysis Fundamentals

HI + HE (+ QRA) = HA

Hazard Identification + Hazard Evaluation
(+ Qualitative Risk Analysis) = Hazard Analysis

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What Is A Qualitative Risk Matrix?

- **Qualitative Risk Analysis**

✓Process of grading **risk** in terms of likelihood and consequence using a predefined ranking system.

- **Qualitative Risk Matrix**

✓Effective Tool to Make Risk Based Decisions

✓Visual Aid in Assigning Risk

✓Unmitigated Risk

✓Visual Aid in Deriving Control Adequacy

✓Mitigated Risk

Potential Screening Mechanism

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QRA Purpose

- Need Method to Rank Consequence ~ Focus Analysis
  - ✓Unmitigated Consequence
  - ✓Simple Consequence Ranking
  - ✓Qualitative Assignment of Consequence

Potential Unmitigated Consequence Screen

- Need Method to Derive Controls
  - ✓Unmitigated Likelihood
  - ✓Unmitigated Risk

Potential Unmitigated Risk Screen

Consequence x Likelihood = Risk

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Anatomy of Loss Event

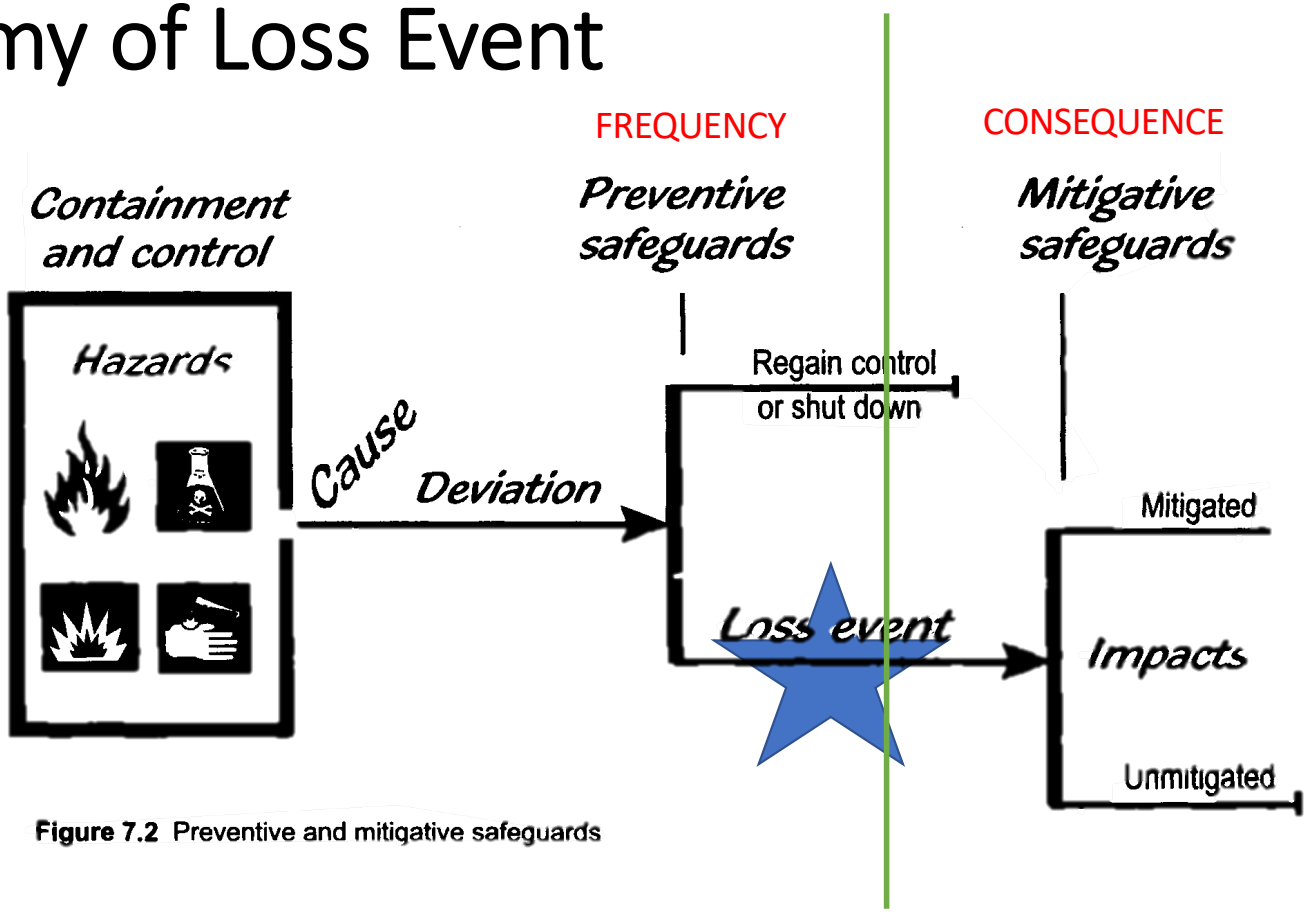

Figure 7.2 Preventive and mitigative safeguards

See Page 218

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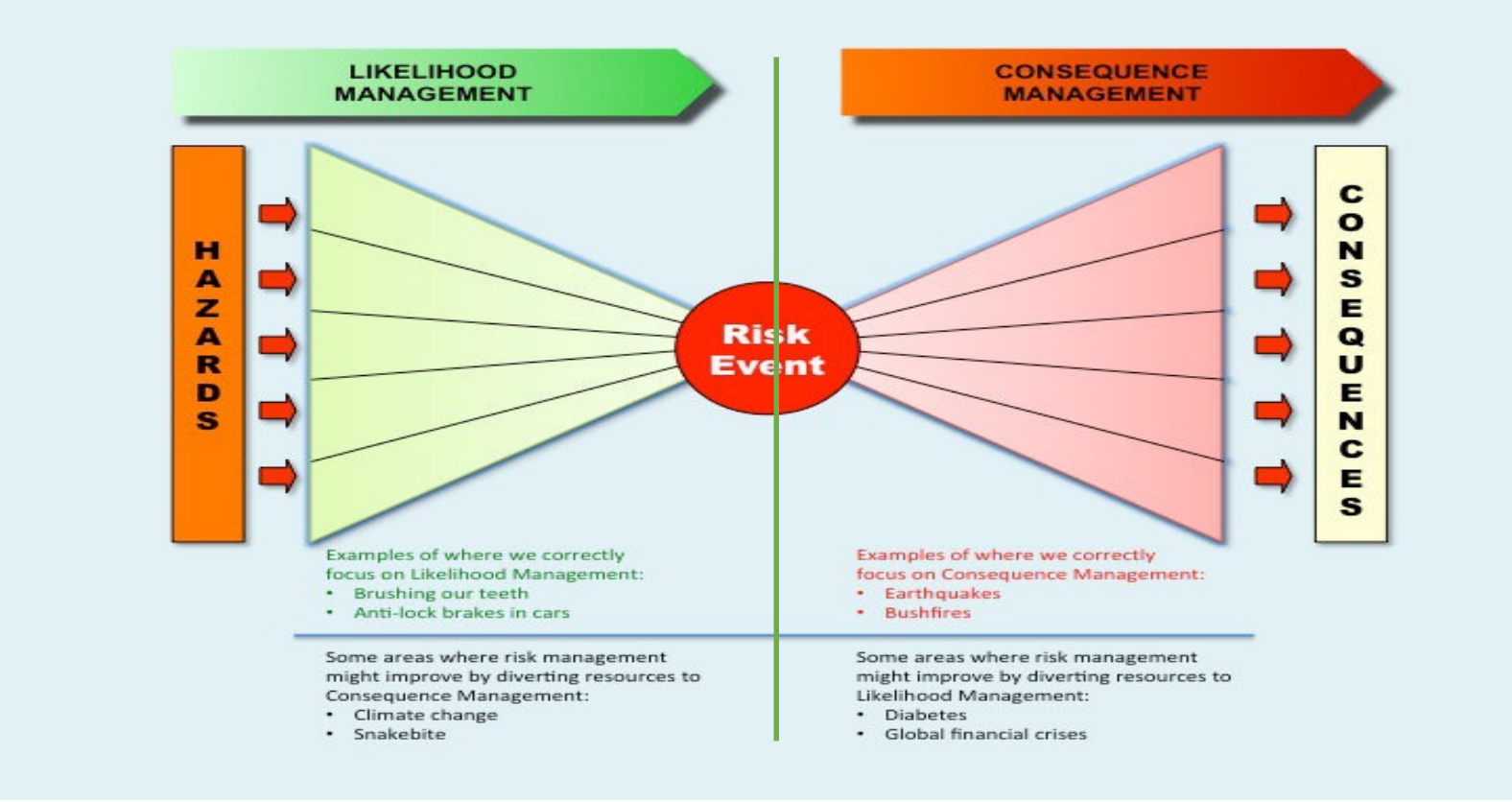
Likelihood & Consequence



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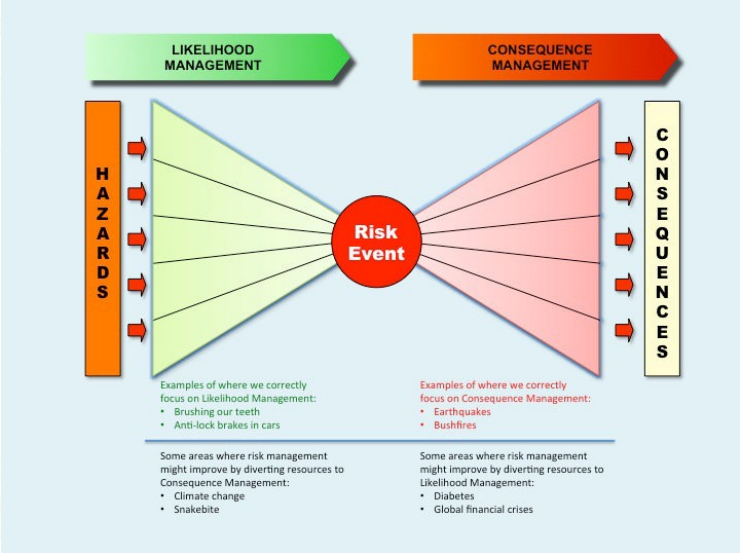
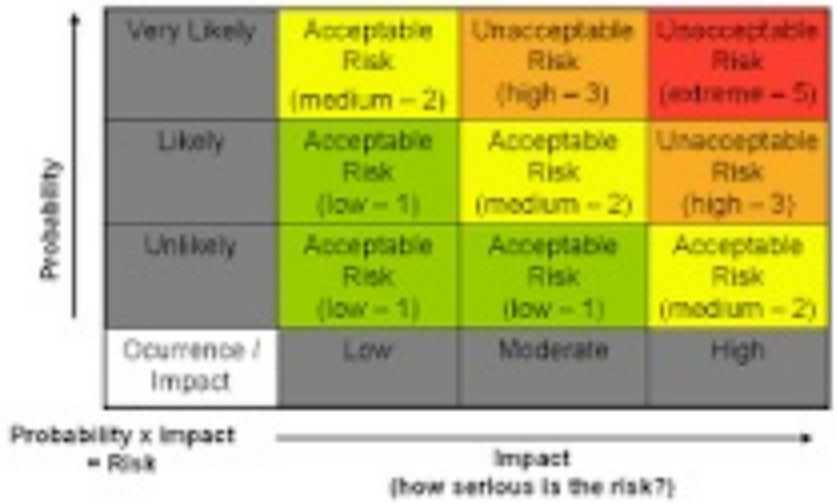
Likelihood & Consequence





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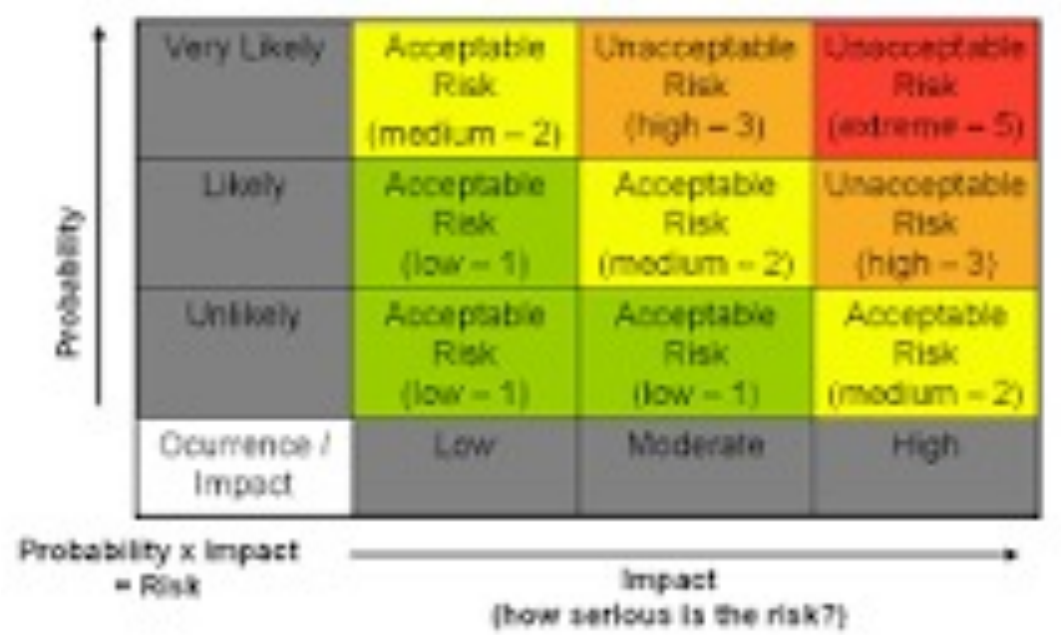
Likelihood & Consequence

Likelihood



Consequence

Unacceptable Risk

Acceptable Risk

Consequence x Likelihood = Risk

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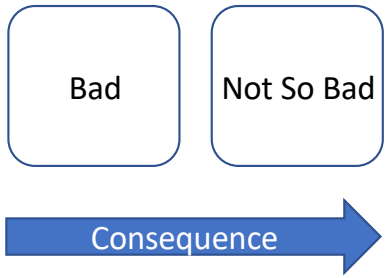
Matrix Development ~ Simple 1 x 2



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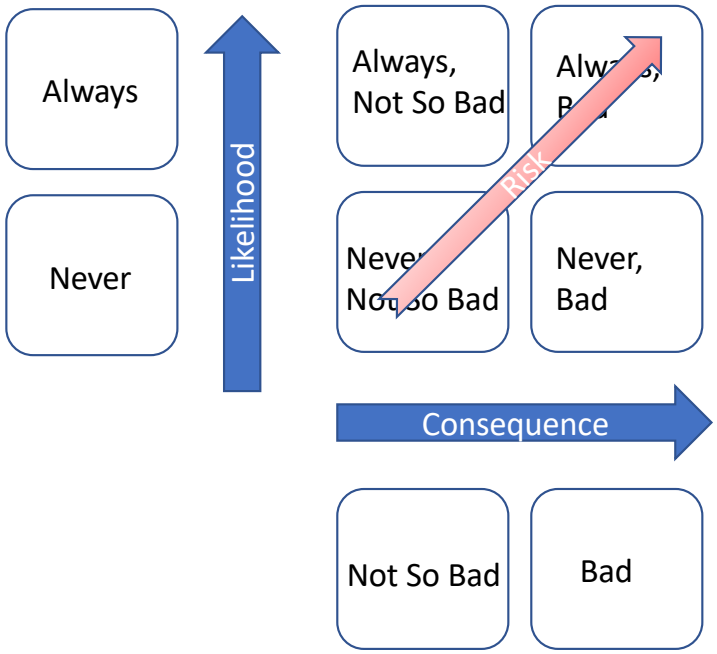
Matrix Development ~ Simple 2 x 2 Increasing Risk



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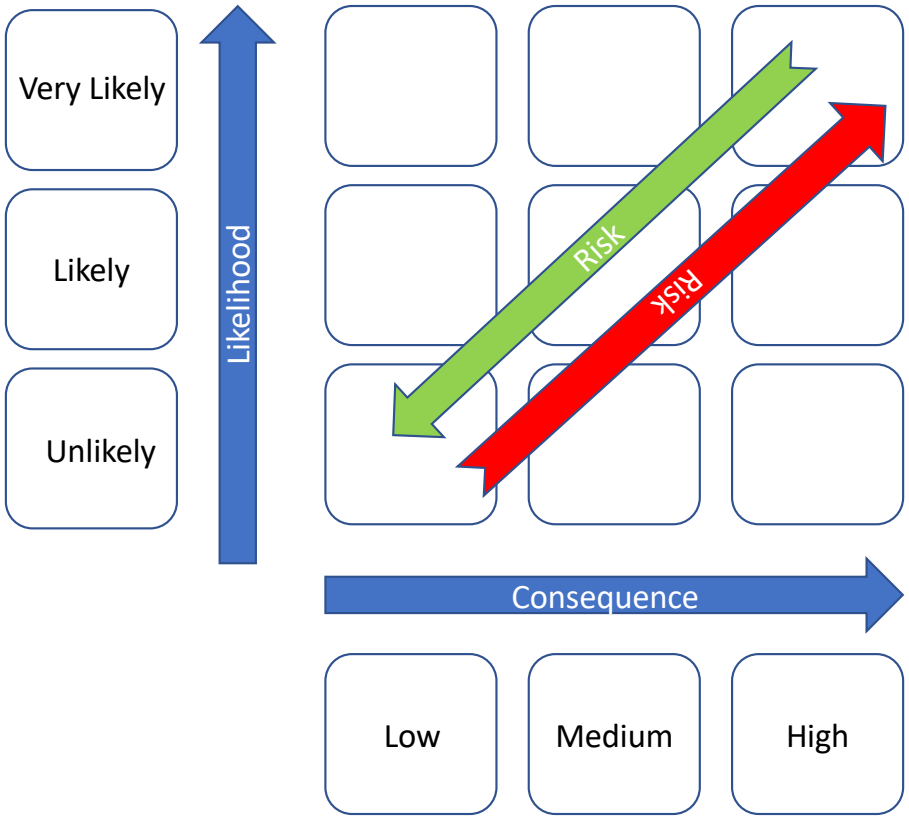
Matrix Development ~ 3 x 3 Reducing Risk



Acceptable Risk
Vs
Unacceptable Risk

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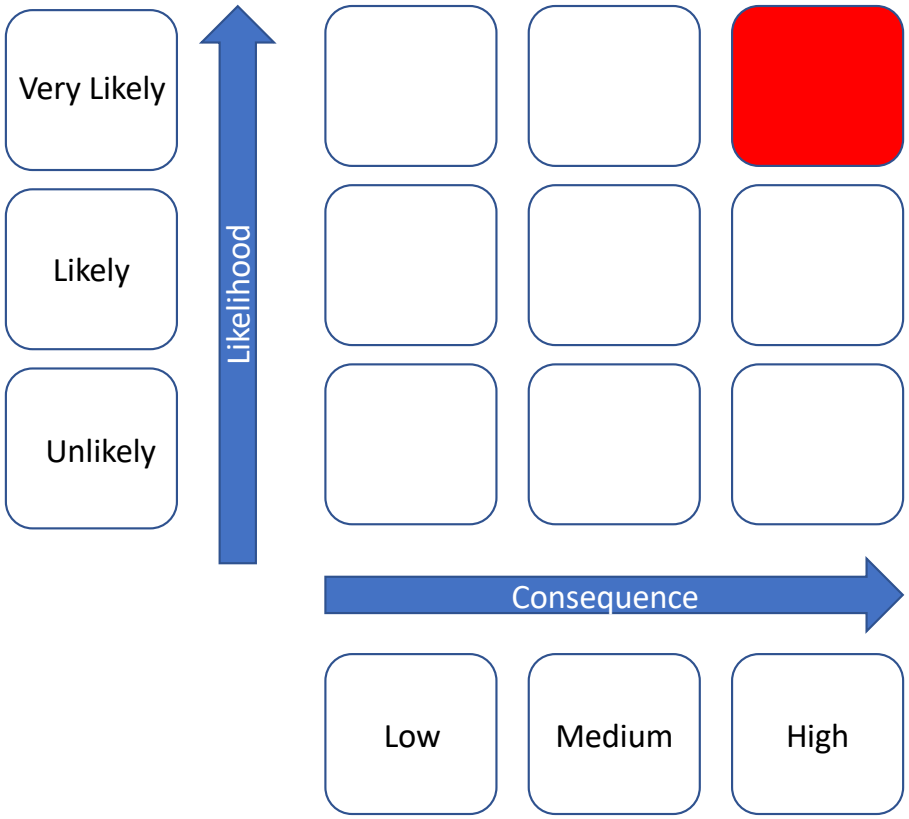
Matrix Development



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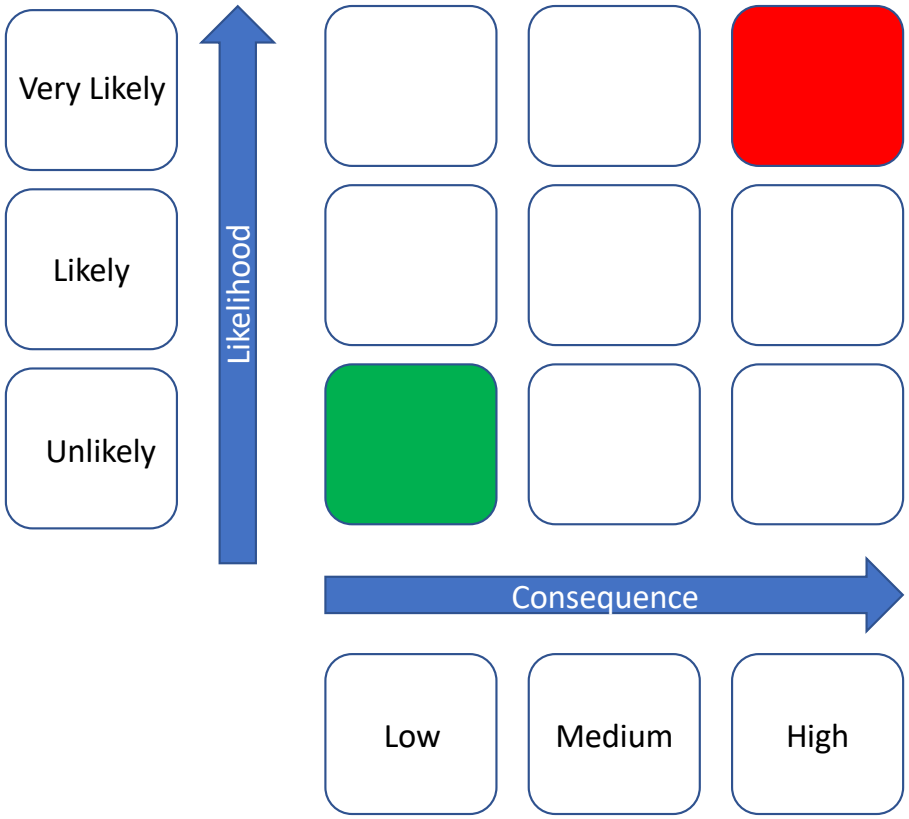
Matrix Development



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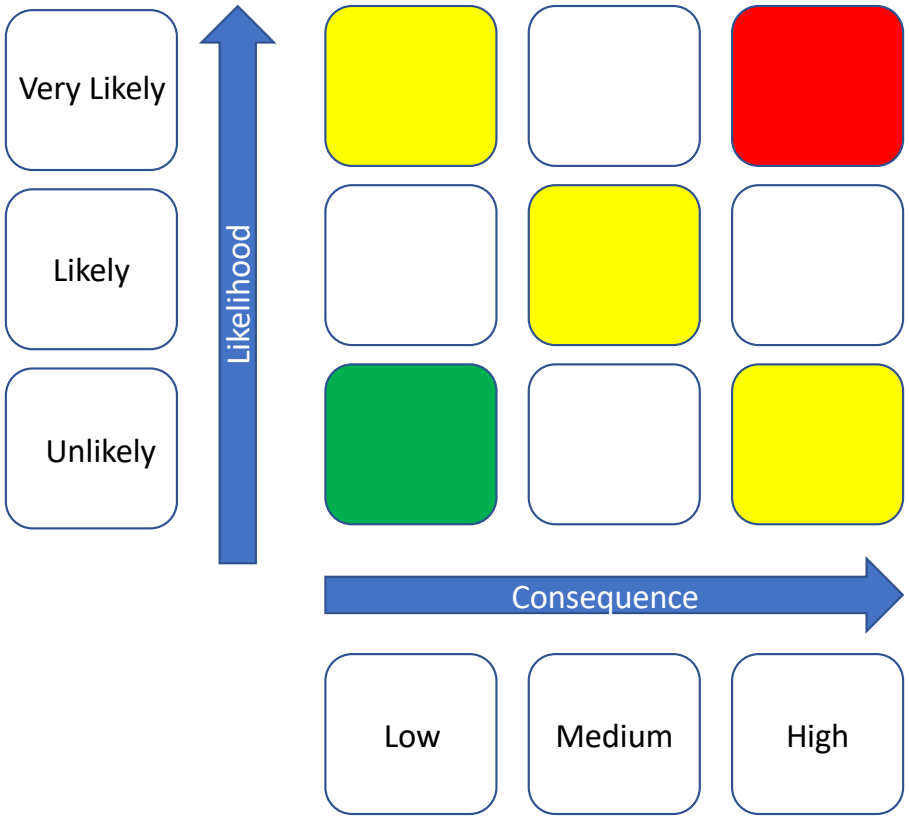
Matrix Development



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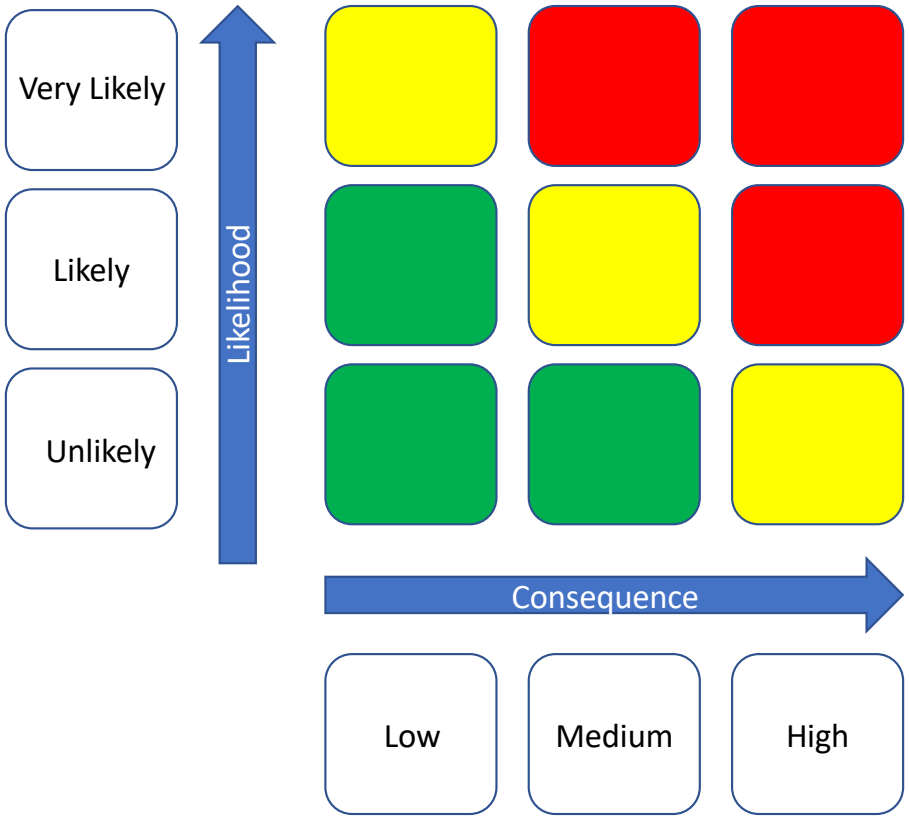
Matrix Development ~ Balance 3 x 3



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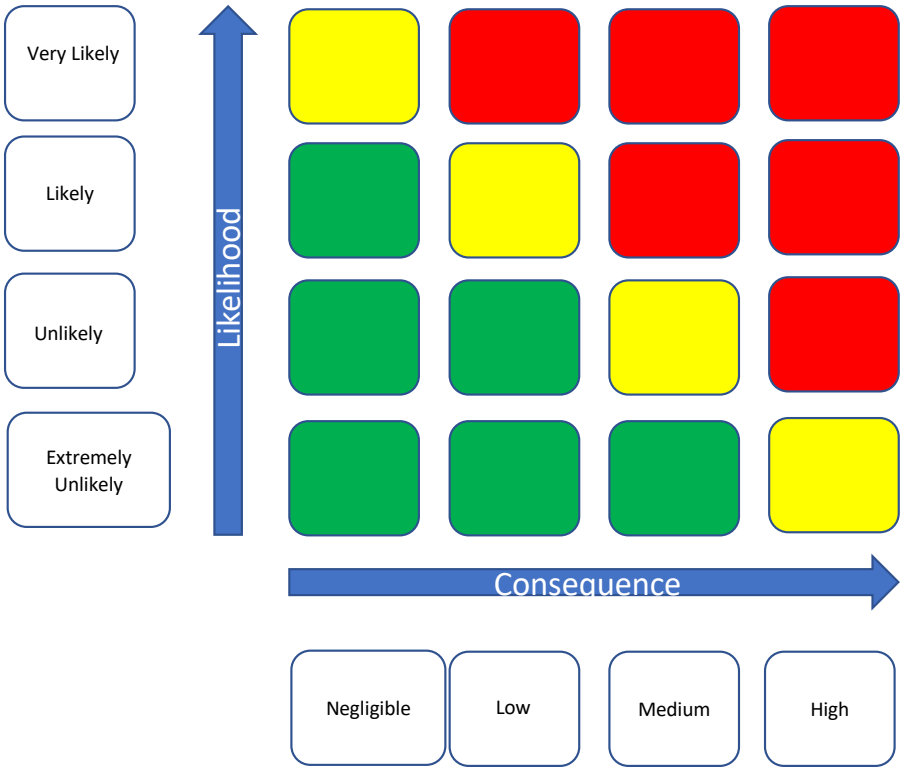
Matrix Development ~ Balanced 4 x 4



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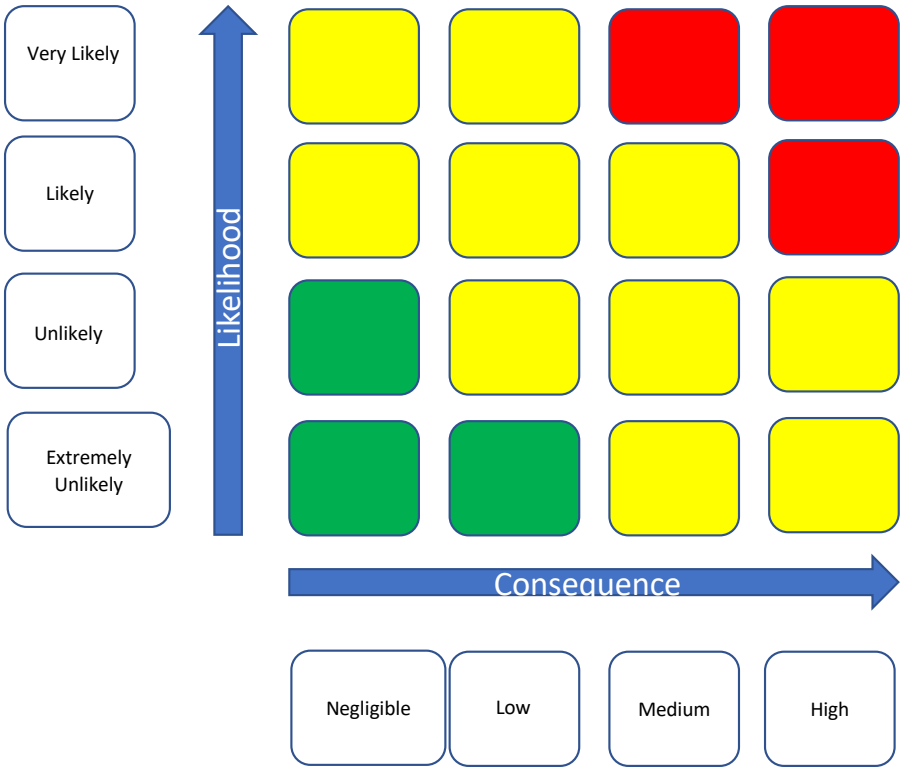
Matrix Development ~ Balanced 4 x 4



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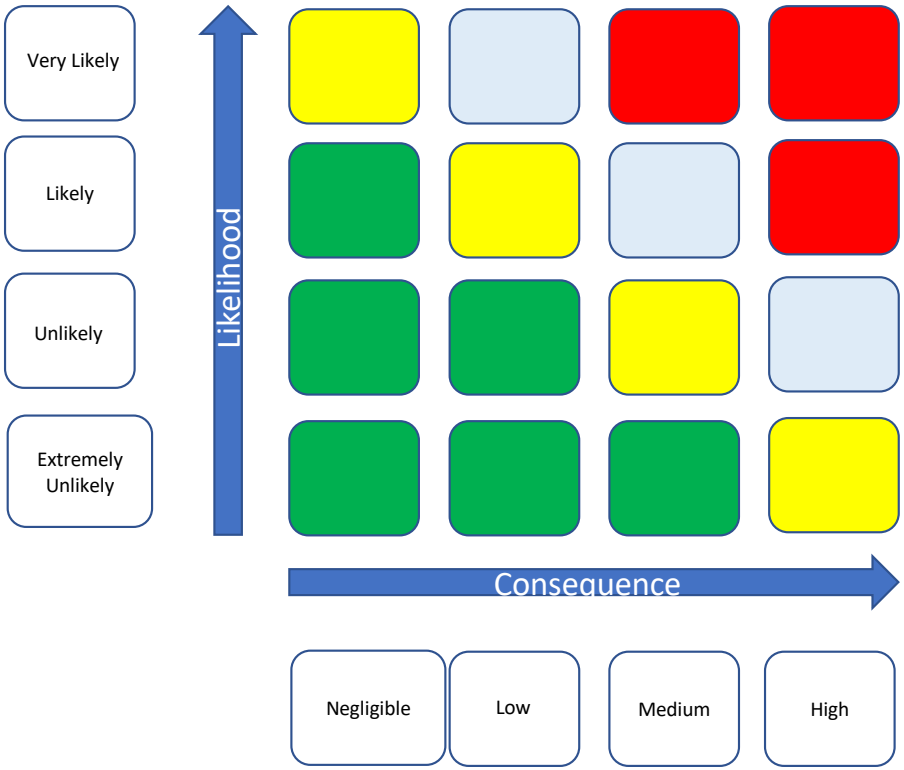
Matrix Development – Balance 4 x 4



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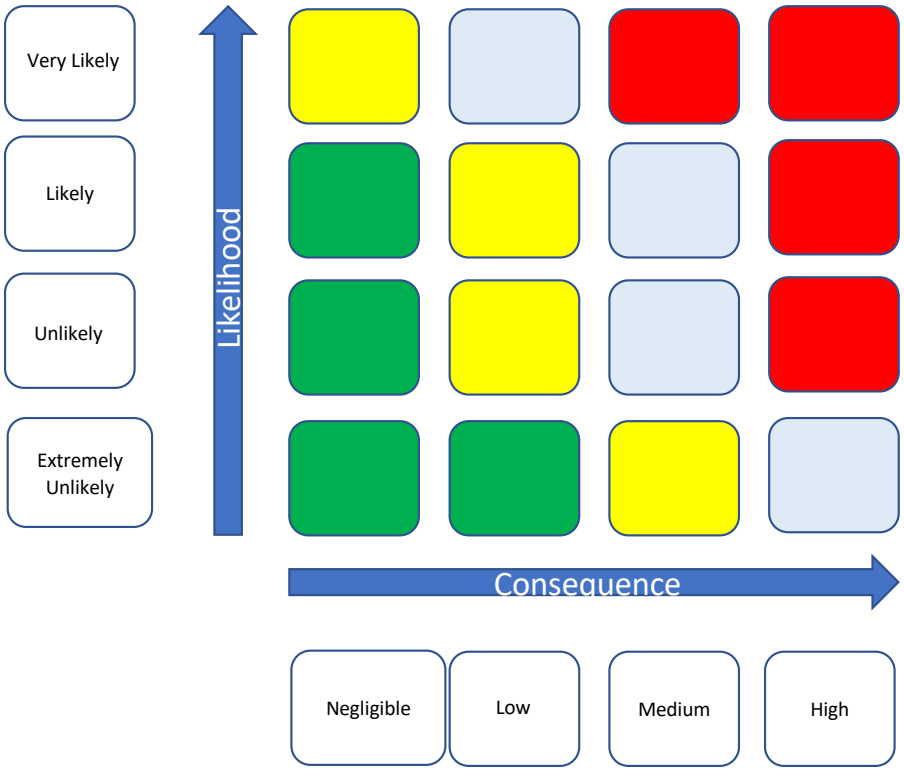
Matrix Development ~ Risk Limiting



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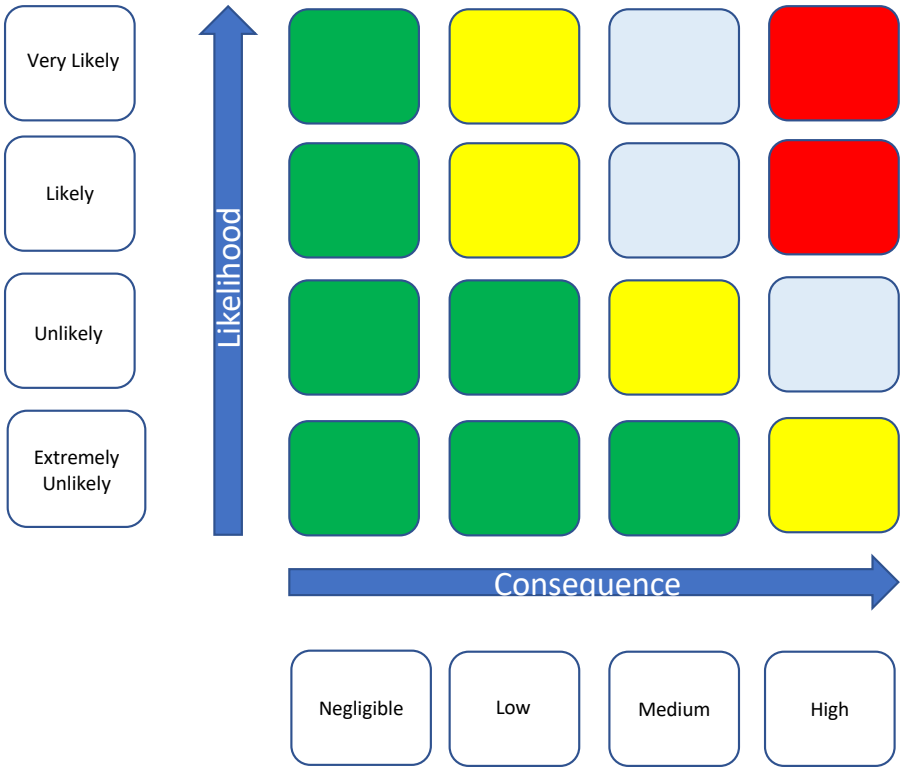
Matrix Development ~ Risk Taking



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Matrix Development ~ Simplified Rules

- ✓ Develop Consequence Definitions
  - ✓ Gradient of Consequence
    - ✓ Three = 3 x 3
    - ✓ Four = 4 x 4
    - ✓ Five = 5 x 5
  - ✓ Include Lowest
- ✓ Develop Likelihood Definitions
  - ✓ Match # Consequence
  - ✓ Include Lowest
- ✓ Colors
  - ✓ Three Colors Minimum
  - ✓ Maximum Colors Match Matrix
  - ✓ Don't Jump Colors with Adjacent Bins
- ✓ Determine Balance of Risk

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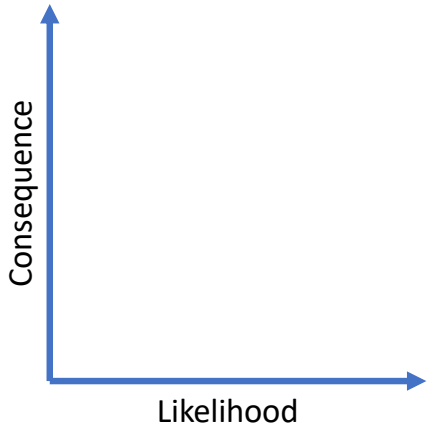
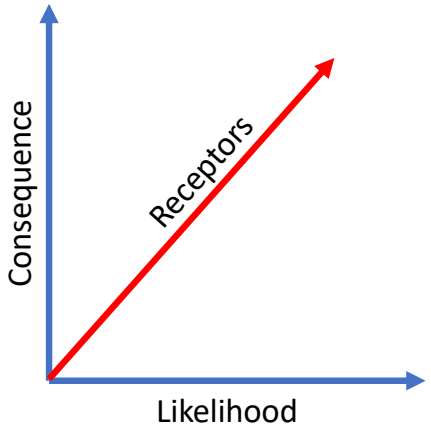
Matrix Development ~ Z Axis Receptors





- Consequence of events change with receptors
- Likelihood of events does not change with receptors

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DOE STD 3009 Compare ‘14 vs ‘94

DOE-STD-3009-1994 (Table A-1 Qualitative Risk Ranking Bins) ~ Example

Cons/Freq	BEU	EU	U	A
High	III	II	I	I
Moderate	IV	III	II	I
Low	IV	III	III	II
No	IV	IV	IV	III

DOE-STD-3009-2014 (Table A-1 Qualitative Risk Ranking Bins) ~ Example

Cons/Freq	BEU	EU	U	A
High	III	II	I	I
Moderate	IV	III	II	II
Low	IV	IV	III	III
Negligible	IV	IV	IV	IV

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QRA - Adequacy of Safeguards

- ✓ Estimate Scenario Risk Then Determine Acceptance
- ✓ Identification of Scenarios Using Scenario Based HE Method
  - ✓ Develop Cause-Consequence Pairs
  - ✓ Cause = Frequency
- ✓ Severity of Consequences
  - ✓ Remember Difference Between Loss Event & Impact
  - ✓ Loss Event ~ Irreversible Point in Event
  - ✓ Supports Prevention versus Mitigation of Event
  - ✓ Qualitative Versus Quantitative Assignment of Consequence Severity

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Adequacy of Safeguards

- ✓Preventative Controls
  - ✓Reduce Frequency
  - ✓Prevent Loss Event
- ✓Mitigative Controls
  - ✓Reduce Consequence
  - ✓Mitigate Loss Event

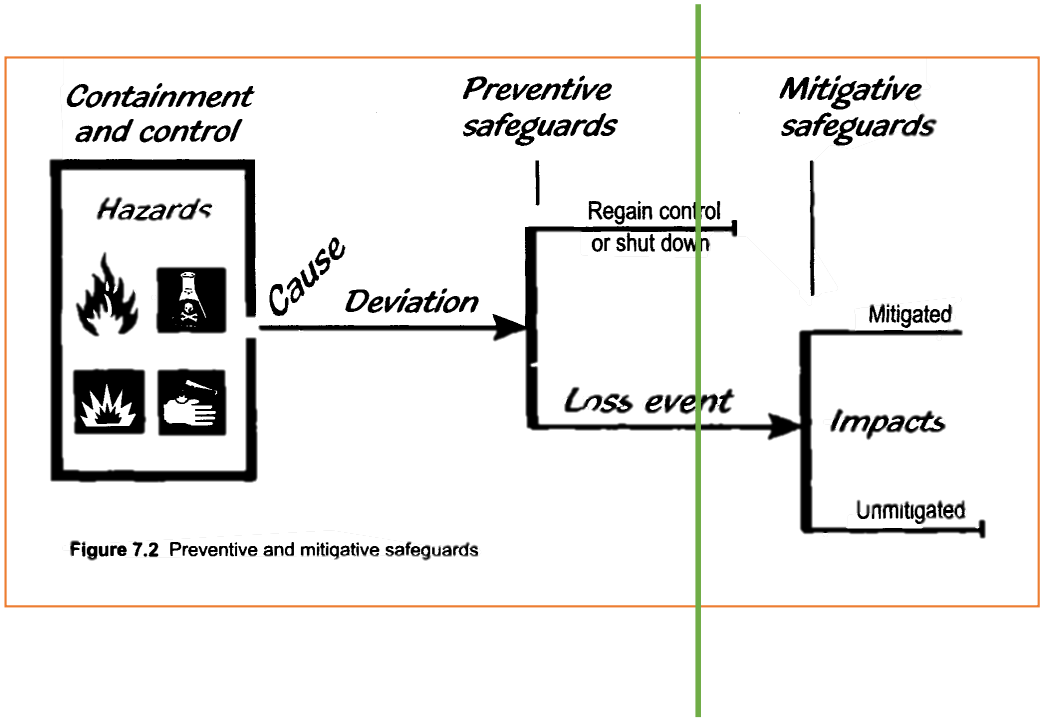

Figure 7.2 Preventive and mitigative safeguards

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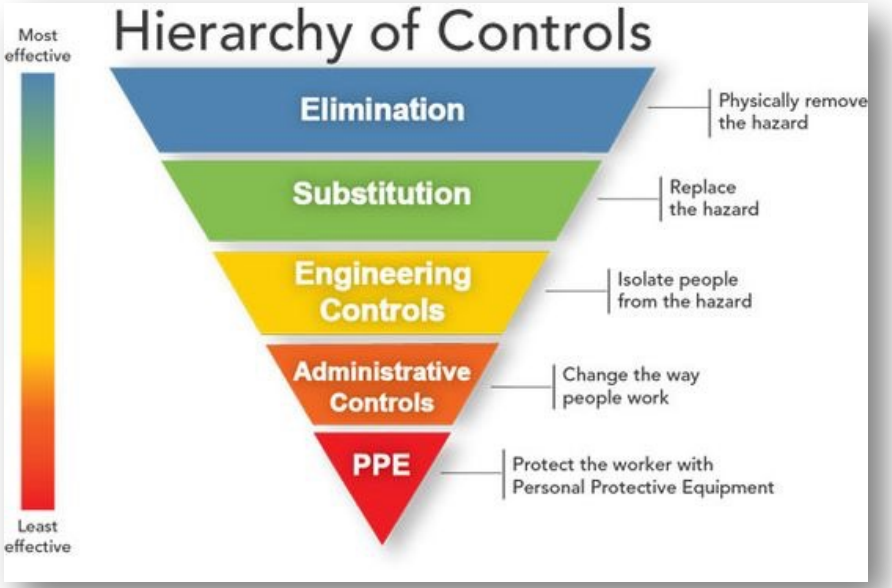
QRA - Adequacy of Safeguards

- ✓Follow Hierarchy of Controls
  - ✓Prevent vs Mitigate
  - ✓Start with Preventative
  - ✓Overlay Controls Until Acceptable Risk



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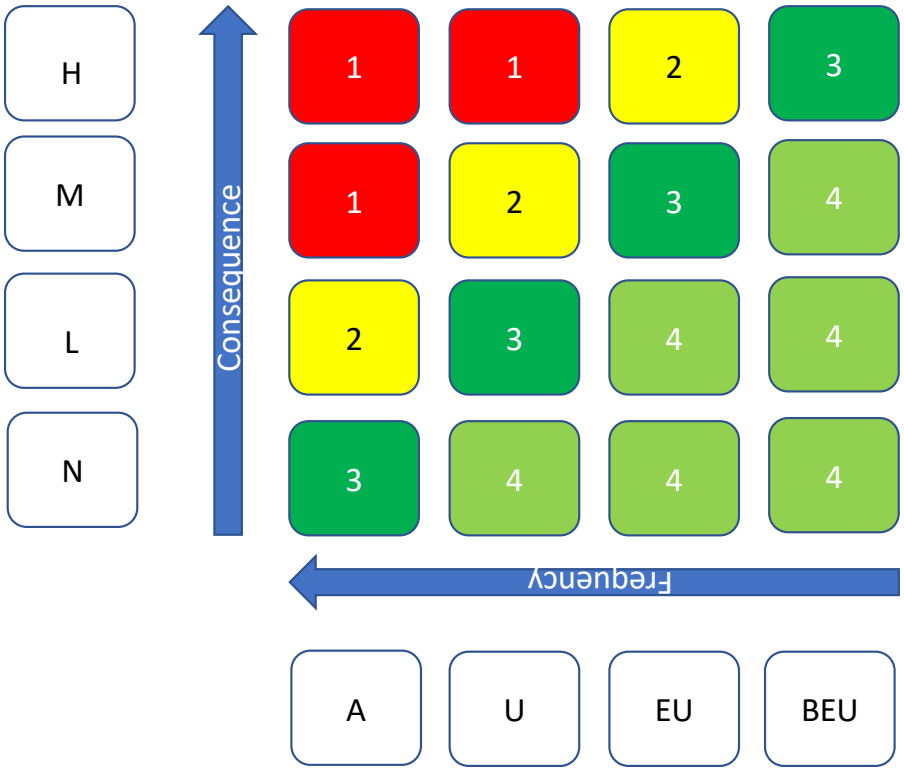
Adequacy of Safeguards



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Adequacy of Safeguards

Scenario	Consequence	Frequency	Risk	Controls	Consequence	Frequency	Risk
1	H	A	1	P-1 M-1	M	U	2
2	H	EU	2	P-1 M-1	M	BEU	4
3	M	U	2	P-1 M-1	L	EU	4
4	M	EU	3	P-1 M-1	L	BEU	4
5	L	EU	4	P-1 M-1	N	BEU	4

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Adequacy of Safeguards

Scenario	Consequence	Frequency	Risk	Controls	Consequence	Frequency	Risk
1	H	A	1	P-1 M-2	L	U	3
2	H	EU	2	P-1	H	BEU	3
3	M	U	2	P-1	L	U	3
4	M	EU	3	P-1 M-1	L	BEU	4
5	L	EU	4	-	-	-	-

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Residual Risk ~ Unacceptable Risk

- Brainstorm Additional Controls

- Focused Efforts on Preventive
  - Interlocks?
  - Valve Redundancy?
  - Train Redundancy?

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Control Adequacy

- Independent Protection Layers (IPL)
- Layers of Protection Analysis (LOPA)
- Safety Integrity Levels (SILs)

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Over Complication ~ Weighting of Controls

- Giving Weight to Different Types of Controls
- Giving Weight to Different Controls within a Type

Control	Definition	Reduction and Risk Factor		Example
Elimination Likelihood	• Design a task, step, equipment, material or tool to be eliminated before it is put into production or use. • Eliminate human interaction • Replace/ eliminate a reaction step, etc. • Eliminate pinch points (increase clearance)	0%		Elimination (e.g., human interaction) may also eliminate Exposure. In this case, re-do the Risk Assessment based on the new task.
		100%		
Substitution / Reduction Likelihood & Consequence	• Reduce interaction with hazard (isolation, automated/remote handling, limit interaction time, etc.) • Replace with less hazardous material • Reduce hazard (speed, noise, weight, energy, etc.)	0%		• Ex: replace oil with water, replace lifting 75 lbs with 5 lbs, etc. • Ex: replacing flammable with no-combustible, replace lifting 75 lbs with 20 lbs., etc. • Ex: automate material handling where humans have been removed except for upset conditions, etc.
		80%	Reduction of current hazards.	
		90%	Substitution of current hazards with lesser hazards.	
Engineering Likelihood & Consequence	• Barriers • Interlocks • Presence Sensing Devices (light curtains, safety mats, etc.) • Fixed machine guards, Emergency stops, etc. • Pressure relief valves, Energy isolation valves, etc. • Non-skid floor coatings, • Local exhaust ventilation, containerization, etc. • Two Hand Controls, etc.	0%		
		40%	Engineering controls that require admin intervention to initiate.	Ex: LOTO where a physical device like a lock requires human intervention to initiate.
		50%	Single engineering control.	Ex: two hand control, light curtain, physical barrier, etc.
		60%	Multiple separate engineering controls.	
		70%	Redundant engineering controls.	Ex: Engineering controls like guards that also have interlocks
Administrative Likelihood & Consequence	• Safe work procedures • Safety inspections • Training • Lights, beacons, and strobes • Computer warnings • Worker rotation • Alarms (gas meter, fire, etc.) • Barrier tape, tags, floor markings, etc. • Signs and Labels • Beepers, horns and sirens, etc. • Buddy Systems, attendants, observers, supervision, schedule limits, etc.	0%		
		20%	Training, warnings signs, etc. without verification or inspections	Ex: Training that does not require verification or inspection that is was completed.
		30%	Training, warnings signs, etc. with verification or inspections	Ex: Training plus inspection or verification to verify that procedures are being completed or followed.
Personal Protective Equipment (PPE) Consequence	• Ear plugs, gloves, respirators, etc. • Safety Glasses, face shields, etc.	0%		
		5%	Single PPE	PPE must be specific to the hazard
		10%	Multiple PPE	Multiple PPE has to be for the same hazard.

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QRA Lessons Learned – Risk Matrix Benefits

- ✓Practical & Easy Tool to Support a Risk Management Program
  - ✓ Promote Robust Discussion
  - ✓ Provide Consistency Prioritizing Risks
  - ✓ Focus on Higher Priority Risks
  - ✓ Present Data in Easily Understood Format
  - ✓ Potential Systematic Screening Levels

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QRA Lessons Learned – Risk Matrix Limitations

- ✓Subjective Interpretation
  - ✓Consequence
  - ✓Frequency/Likelihood
- ✓Misleading Rankings of Risk
  - ✓Inexperienced
  - ✓Biased
  - ✓Agenda

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QRA Lessons Learned – Risk Matrix Limitations

- ✓Assign Identical Risks to Different Cause-Consequence Pairs
  - ✓Frequency can Mask Consequence
- ✓Static View
  - ✓Risk of Event May Change Over Time
    - ✓Material at Risk Increases
    - ✓Receptor Encroachment
    - ✓Exposure Standards Changes

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QRA Lessons Learned – Risk Matrix Limitations

- ✓Actual Events Not Incorporated into Risk
- ✓Focusing on Probability Numbers Versus Comparative Value
- ✓Subjective Assignment of Consequence & Frequency
- ✓Two Different People Yield Comparable But Different Risks for Same Scenarios
- ✓Not Assigning Frequency Controls Before Consequence Controls

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Parvati Preferred QRA Methodology

- Perform Additional Hazard Evaluation and/or Accident Analysis If Necessary
  - Higher/Unacceptable Residual Risk
  - Unclear Control Strategies
  - Better Definition of Frequency or Consequence
- Use of Risk to Determine Control Adequacy
  - Standard Frequency, Consequence, & Risk Tables
  - Qualitative Analysis
  - Analyze Unmitigated Consequence & Frequency ~ Inherent Risk
  - Apply Identified Preventative/Mitigative Controls
  - Determine Mitigated Consequence & Frequency ~ Residual Risk

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