Geologic Hazards

CVEN 3698

Engineering Geology

Fall 2016

Two types

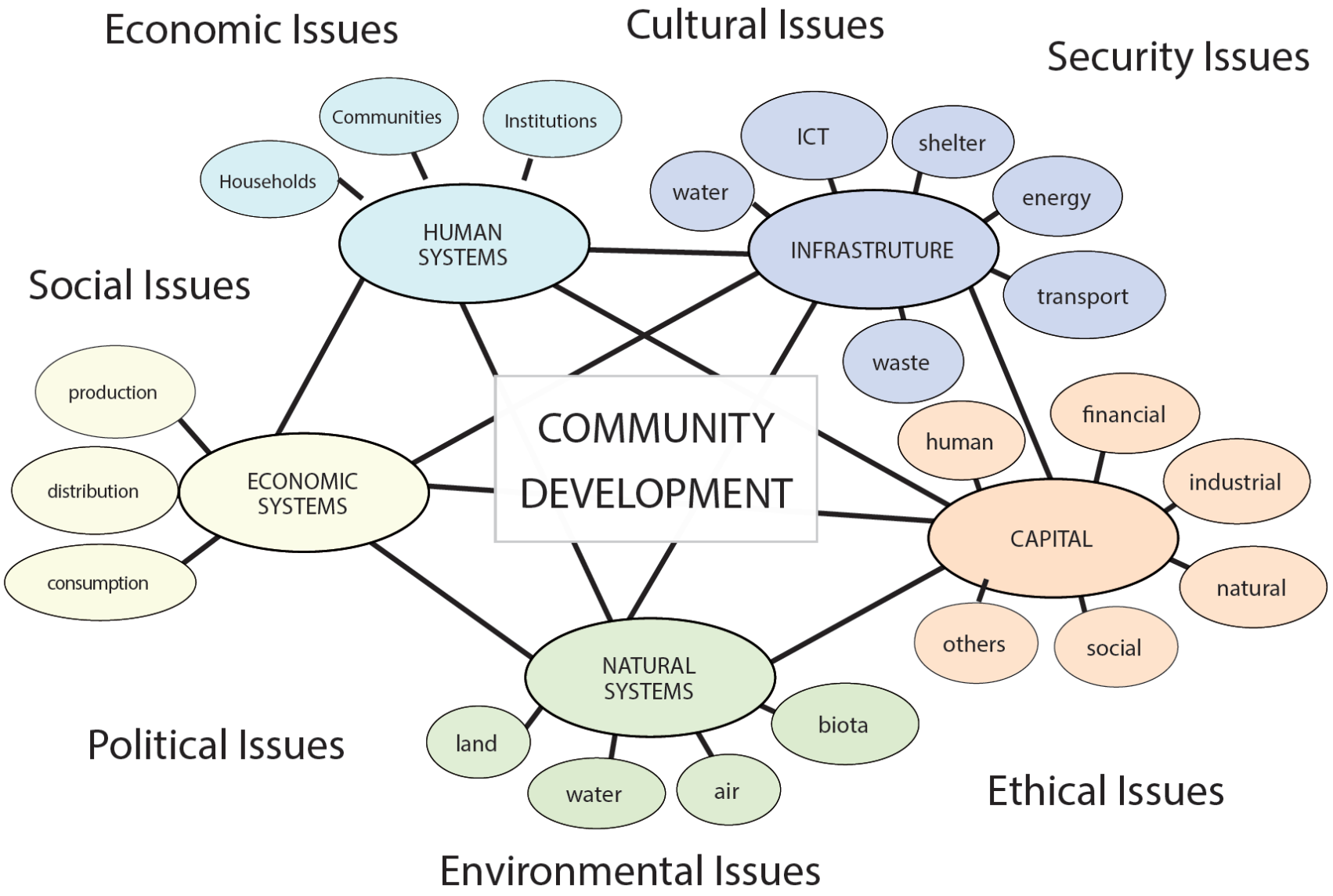
- Hazards associated with particular earth materials. Examples include swelling soils and rocks, toxic minerals (asbestos, acid drainage) and toxic gases (radon gas).
- Hazards associated with earth processes (earthquakes, volcanoes, landslides, avalanches, rock slides and rock falls, soil creep, subsidence, floods, frost heave, coastal hazards).

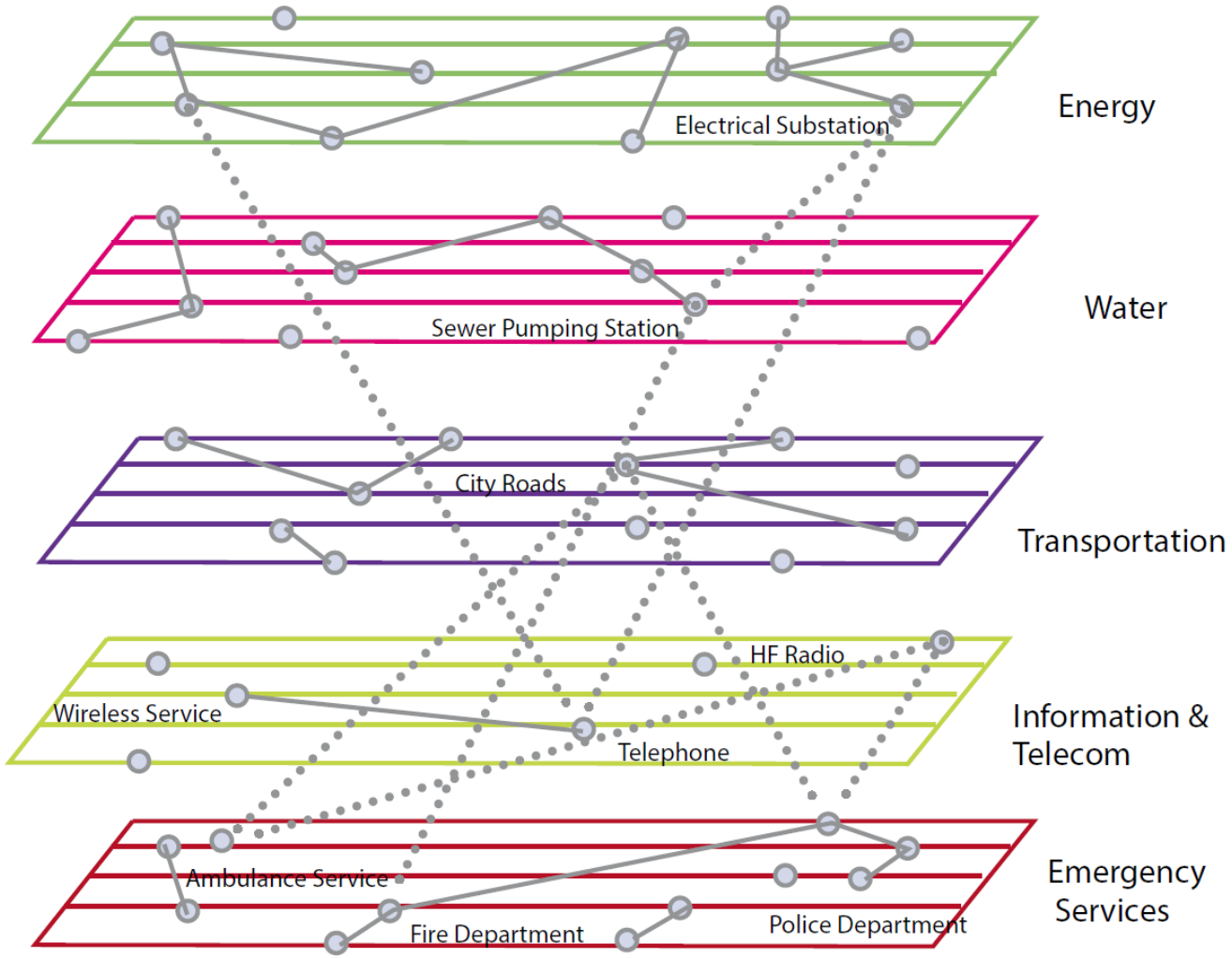
Geologic Hazards

- Earthquakes
- Landslides
- Rockfall
- Volcanic lahars
- Debris flows
- Sink holes
- Subsidence
- Expansive soils
- Melting permafrost

Man-made Hazards

- Natural hazards are complemented with man-made hazards such as water pollution, mine subsidence, rock bursts, pumping, waste disposal, carbon emission, global warming, and ozone depletion.
- Understanding these hazards requires a multidisciplinary approach. These issues are interdisciplinary with biology, engineering, chemistry, and environmental sciences.
- http://www.youtube.com/watch?v=_feWtkSucvE


Economic Issues
Cultural Issues
Security Issues
Social Issues
Political Issues
Ethical Issues
Environmental Issues
COMMUNITY DEVELOPMENT
HUMAN SYSTEMS
Communities
Institutions
Households
INFRASTRUTURE
ICT
shelter
water
energy
transport
waste
ECONOMIC SYSTEMS
production
distribution
consumption
CAPITAL
financial
human
industrial
natural
others
social
NATURAL SYSTEMS
land
water
air
biota


Energy
Electrical Substation
Water
Sewer Pumping Station
City Roads
Transportation
HF Radio
Wireless Service
Telephone
Information &
Telecom
Ambulance Service
Fire Department
Police Department
Emergency
Services

SOURCES of CASUALTIES	NUMBERS of CASUALTIES
Wars versus Earthquakes	
U.S. Battle Deaths in World War II	292,131
Atomic Bomb, Hiroshima, Japan 1945	80,000 to 200,000
EARTHQUAKE, Tangshan, China, 1976	242,000
U.S. Murders versus Single Volcanic Eruption	
Total murders U. S. , 1990	20,045
VOLCANIC ERUPTION, Colombia, 1985	22,000
AIDS Deaths in United States versus Single Landslide Event	
Total AIDS deaths U. S., through April, 1992	141,200
LANDSLIDES, Kansu, China, 1920	200,000
Greatest Atrocity versus Greatest Flood Events	
The Holocaust, Europe, 1939-1945	6,000,000
FLOOD Yellow River, China, 1887	900,000 to 6,000,000
FLOOD Yangtze River, China, 1931	3,700,000

(data on familiar societal catastrophes from *The World Almanac*, 1993, New York, Pharos Books; and *The Universal Almanac*, 1993, Kansas City, Andrews and McMeel; geological catastrophes compiled from Tufty, 1969, and Office of Foreign Disaster Assistance, 1992, *Disaster History*.)

What is the Problem: The Need for a Resilient Nation

Photo: Joplin, MO after the May 22, 2011 tornado
Source: Charlie Ridel/AP Photo

- Beyond the unquantifiable costs of injury and loss of life from disasters, statistics for 2011 alone indicate economic damages from natural disasters in the United States exceeded $55 billion, with 14 events costing more than $1 billion in damages each.

- No person or place is immune from disasters or disaster-related losses.

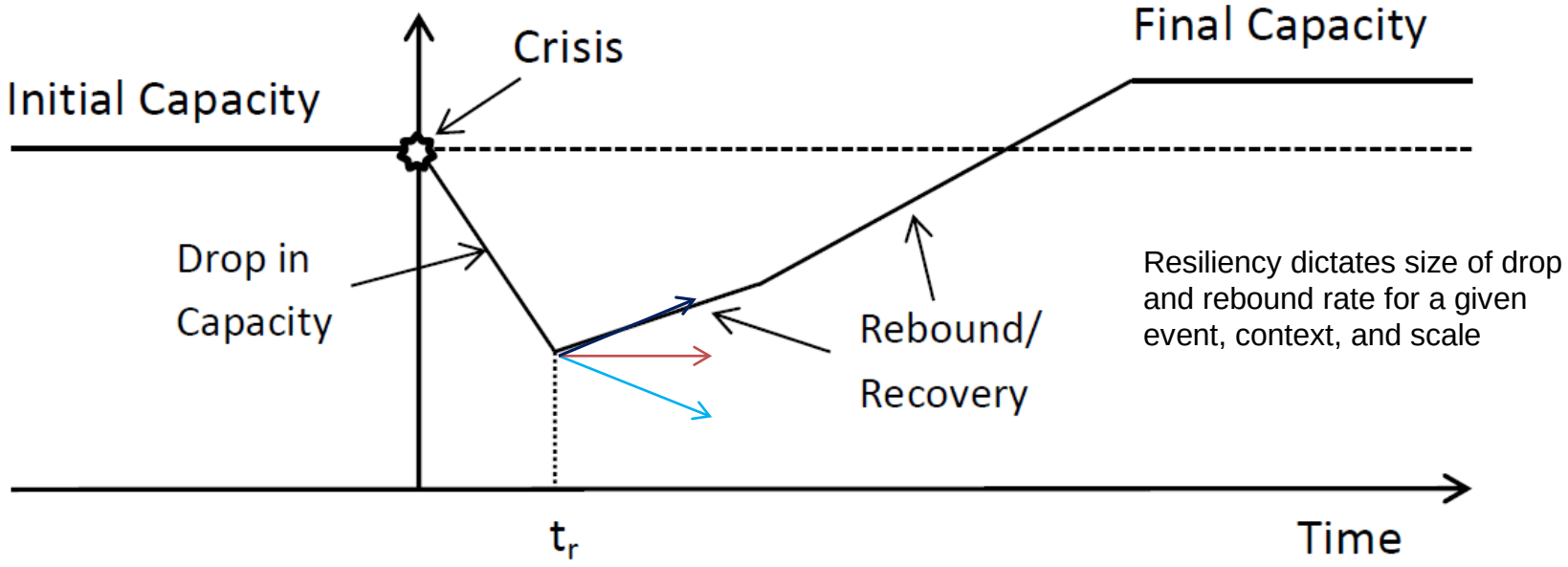
- Communities and the nation face difficult fiscal, social, cultural, and environmental choices about the best ways to ensure security and quality of life against natural and human-induced disasters.

Resilience to Risk

- Effective risk management and capacity building lead to community resilience

Risk = Event x Exposure x
(Vulnerability – Capacity)

Capacity and Resilience



- What level of disruption is acceptable?
- What level of protection are we willing to pay for?
- Critical vs. non-critical

The Choice:
Proceed with the Status Quo OR Become More Resilient?

- Disasters continue to occur, both natural and human-made, throughout the country; costs of responding continue to rise
- More people are moving to coasts and southern regions – higher exposure to drought and hurricanes
- Population continues to grow and age
- Public infrastructure is aging beyond acceptable design limits
- Economic and social systems are becoming increasingly interdependent
- Risk can not be completely eliminated; residual risk must be managed
- Impacts of climate change and environmental degradation of natural defenses such as coastal wetlands make the nation more vulnerable

What is Resilience?

The ability to prepare and plan for, absorb, recover from, or more successfully adapt to actual or potential adverse events

Photo: Cedar Rapids, IA during the 2008 flooding
Source: AP photo/Jeff Robertson

Characteristics of a Resilient Nation in 2030

- Individuals and communities are their own first line of defense against disasters.
- National leadership in resilience exists throughout federal agencies and Congress.
- Community-led resilience efforts receive federal, state, and regional investment and support.
- Site-specific risk information is readily available, transparent, and effectively communicated.
- Zoning ordinances are enacted and enforced. Building codes and retrofit standards are widely adopted and enforced.
- A significant proportion of post-disaster recovery is funded through private capital and insurance payouts.
- Insurance premiums are risk based.
- Community coalitions have contingency plans to provide service particularly to the most vulnerable populations during recovery.
- Post-disaster recovery is accelerated by infrastructure redundancy and upgrades.

A resilient nation in 2030 also has a vibrant and diverse economy and a safer, healthier, and better educated citizenry than in previous generations.

Risk Analysis

- What could wrong? Impact? Costs? Probability?
- Risk management: identification, prioritization, resolution, and monitoring of risks and their management

Definitions

- Substitute “surprises” for “risks”
- Risk is the possibility that an undesired outcome – or the absence of a desired outcome – disrupts a project.
- Risks exist in all parts of ADIME-E framework
- An issue = certain (100%) risk
- Risk could be an opportunity
- Risk earmarks: uncertainty, loss, time component
- Risks prior to project and risks after projects

Risks originate from

- Factors that are under the control of those involved in the project such as poor planning, design, management, and/or execution;
- Decisions made by others such as policy makers and institutions not necessarily directly involved in the project; and
- Uncontrollable factors such as those associated with natural hazards or socio-economic or political issues.

DFID, 2002

Risk vs. Uncertainty

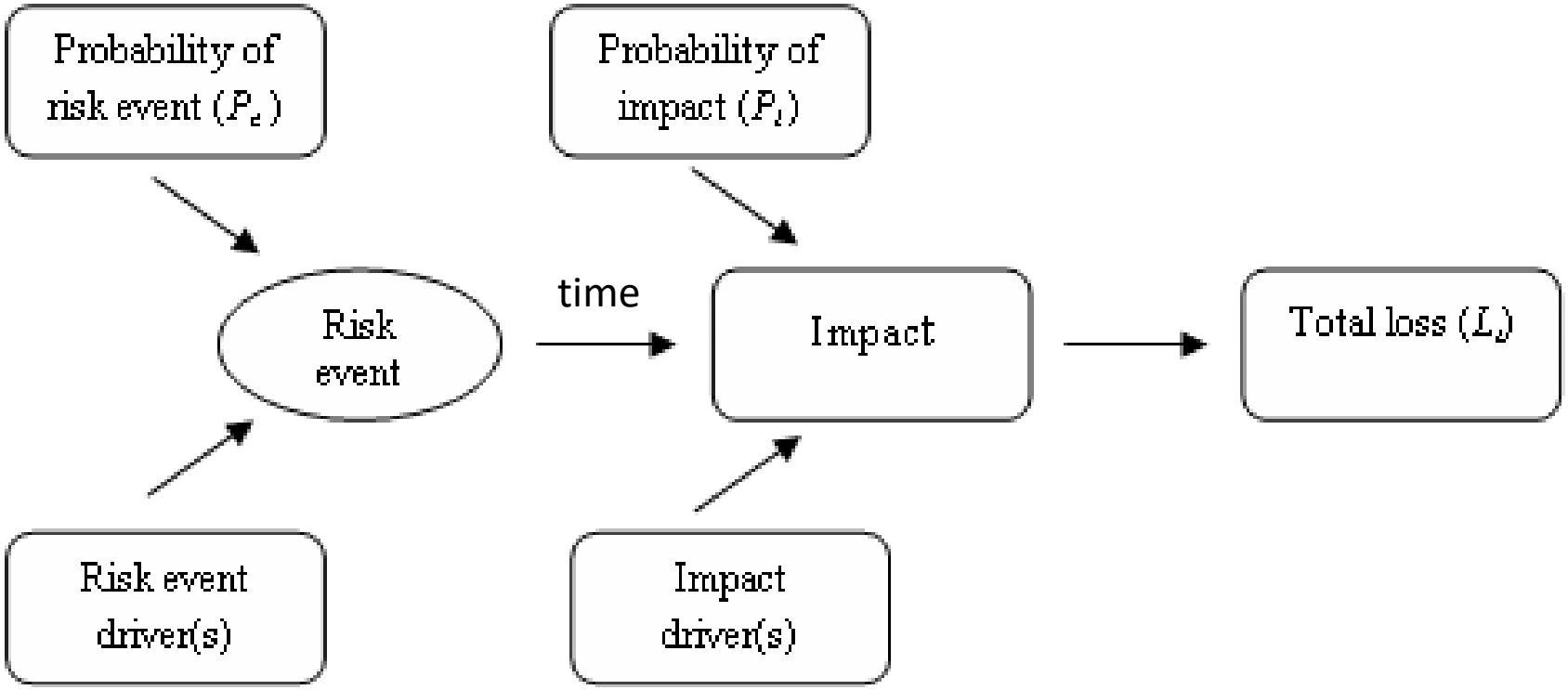
- Risks arise with the uncertainty of the situation the project is faced with.
- Risk differs from uncertainty in the sense that with risks, we have some ideas of the odds that something will happen and we can assign probabilities for that happening (Knight, 1921).

- Risks (what could go wrong?), risk drivers (what makes each risk real), and likelihood (probability estimated based on risk drivers);
- Impacts (cost, work days, calendar days, staff months, space, etc), impact drivers (what makes each impact real) and likelihood (probability estimated based on impact drivers)
- Total possible loss expressed in quantitative way (time, money, etc) or qualitative way (high, medium, low, critical, etc).

Risk and Drivers	Risk Likelihood	Impacts and Drivers	Impact Likelihood	Action Plan	Monitoring and Metrics

Standard Risk Model

Expected loss: $L_e = L_t * P_e * P_i$



Smith and Merritt, 2002

Risk Management Process

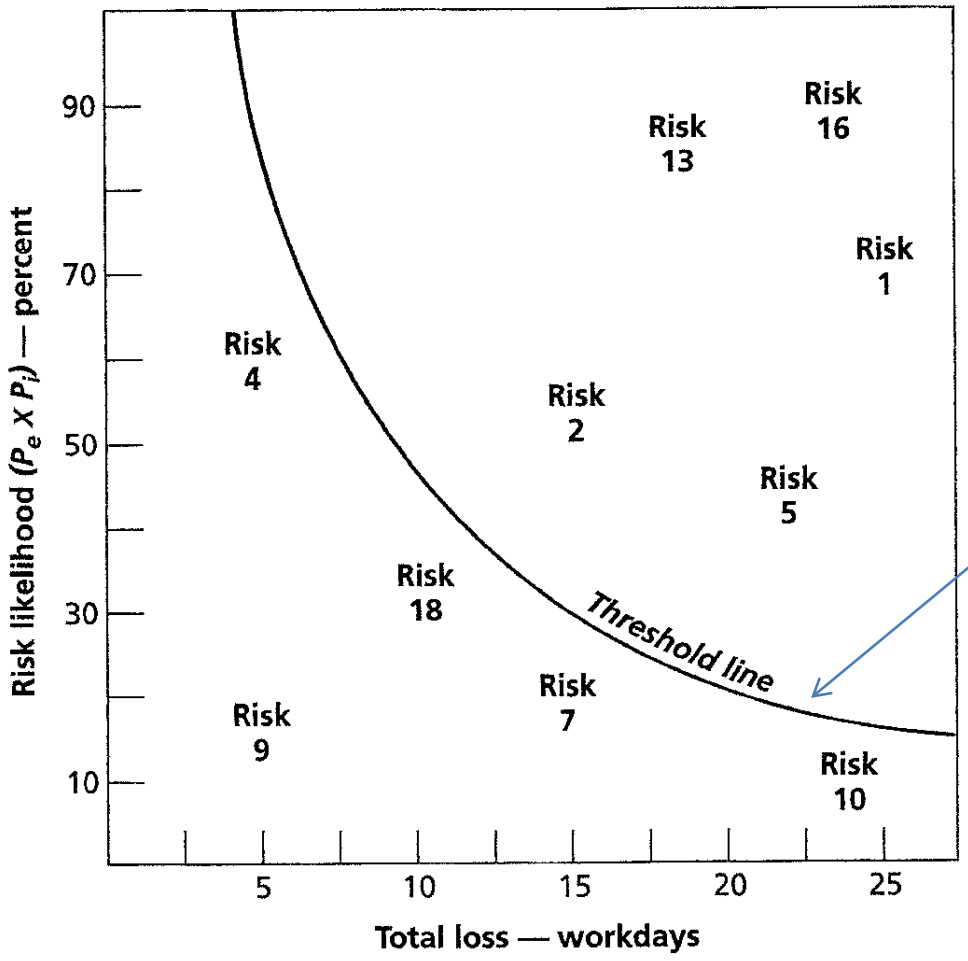
Steps

- Identify risks >>>>>>>>>>
- Analyze risks >>>>>>>>>>
- Prioritize and map risks >>>
- Resolve risks >>>>>>>>>>
- Monitor risks >>>>>>>>>>

Critical Information

- Risks events and impacts
- Drivers, probabilities, and total loss
- Subset of risks to be managed
- Action plan: avoidance, transfer, redundancy, mitigation (prevention, contingency, reserves)
- Status and closure of risks; identify new risks

Risk Map



For given expected loss

$P_e * P_i = L_e / L_t$

Risk Management Strategies

- *Avoid* the risk by reversing decisions that were made that would cause the risk. Abandoning the project might be an option.
- *Transfer* the risk (or impact) to another party that may have a better potential (knowledge, resources) to tackle the problem
- *Redundancy* thus reducing the effect of the risk event by providing parallel solutions paths, and back-up options
- *Tolerate* risk but at the same time *mitigate* the risk/impact and risk/impact drivers (to make it less severe) either by developing: a *prevention* plan (works on reducing risk and risk drivers); a *contingency* plan (works on impact and impact drivers); or a *reserve plan* (risk occurs and we need to cover the losses)

Coping with geologic hazards

- Avoid the areas where known hazards exist. Such areas can be converted into parks, for instance.
- Evaluate the potential risk of a hazard, if activated.
- Minimize the effect of the hazards by engineering design and appropriate zoning.
- Develop a network of insurance and contingency plans to cover potential loss or damage from hazards.

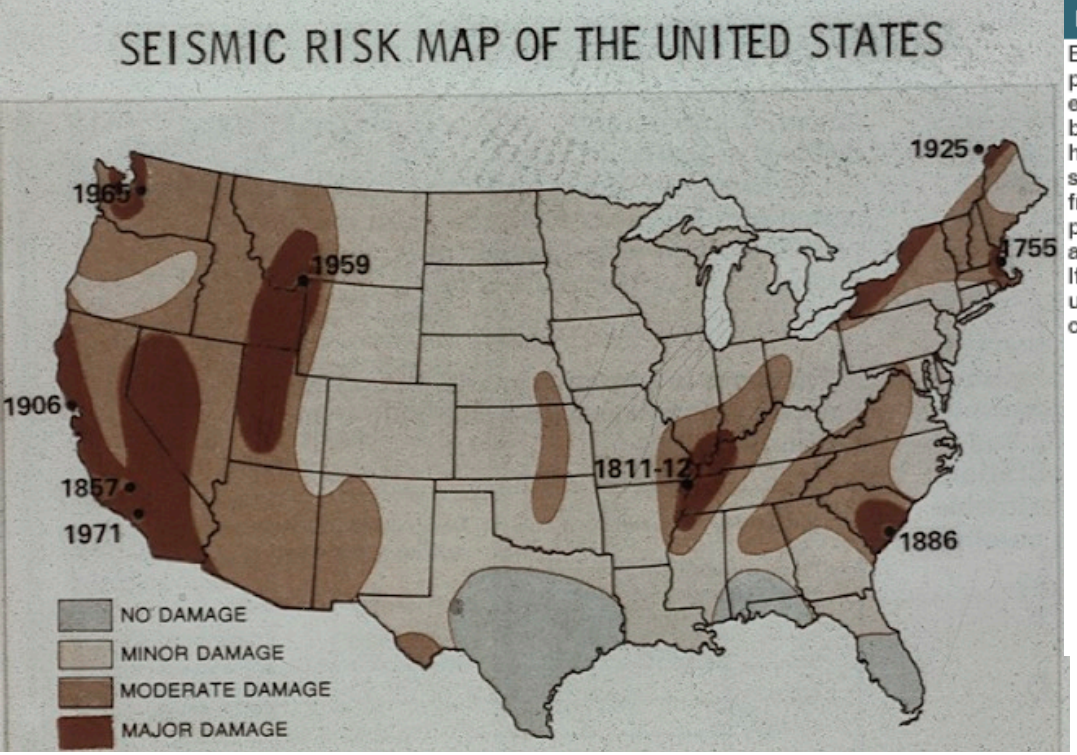
Due Wednesday October 14, 2015

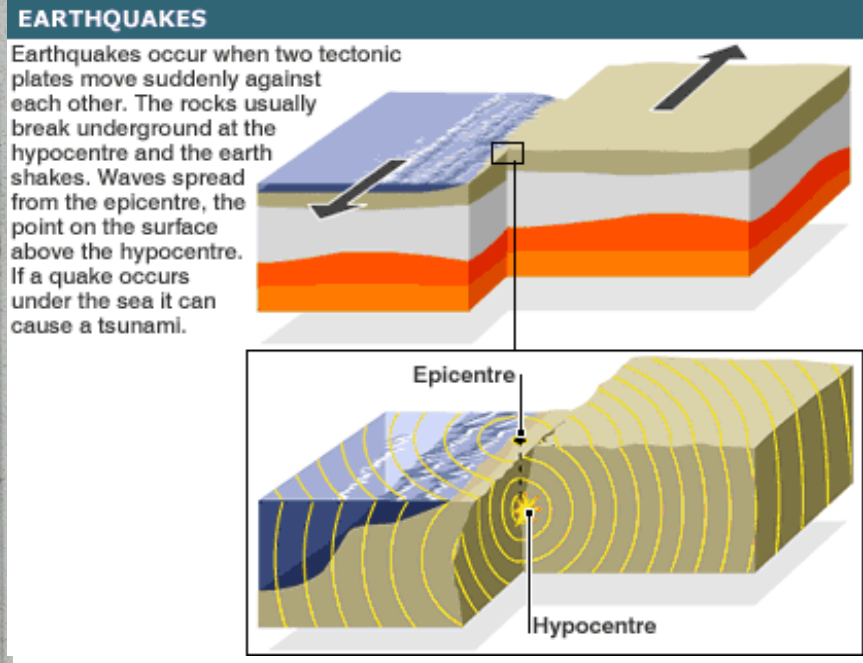
1) Visit the Colorado Geological Survey web: http://www.coloradogeologicalsurvey.org
Browse through the list of documents addressing geologic hazards in the State of Colorado. Counties and municipalities in Colorado primarily regulate geologic hazards in four different ways. What are they?

2) Go to the following web sites:
- Colorado Geological Survey: : http://www.coloradogeologicalsurvey.org
- Boulder County Comprehensive Plan:
http://www.bouldercounty.org/property/build/pages/bccp.aspx
- Geology of the Boulder area: http://bcn.boulder.co.us/basin/watershed/geology
- Geologic History of Boulder area: http://bcn.boulder.co.us/basin/natural/geology/historic.html
- Map of Geologic Hazards for Boulder County:
http://www.bouldercounty.org/doc/landuse/bccpmapghca.pdf

3) Answer the following questions:
1. What is the difference between a geologic hazard and a geologic constraint?
2.What are the major geologic hazards and constraints in Boulder City and Boulder County?
3. Where should one go to get more information about the extent and importance of those hazards and constraints (city offices, county offices, etc.)?

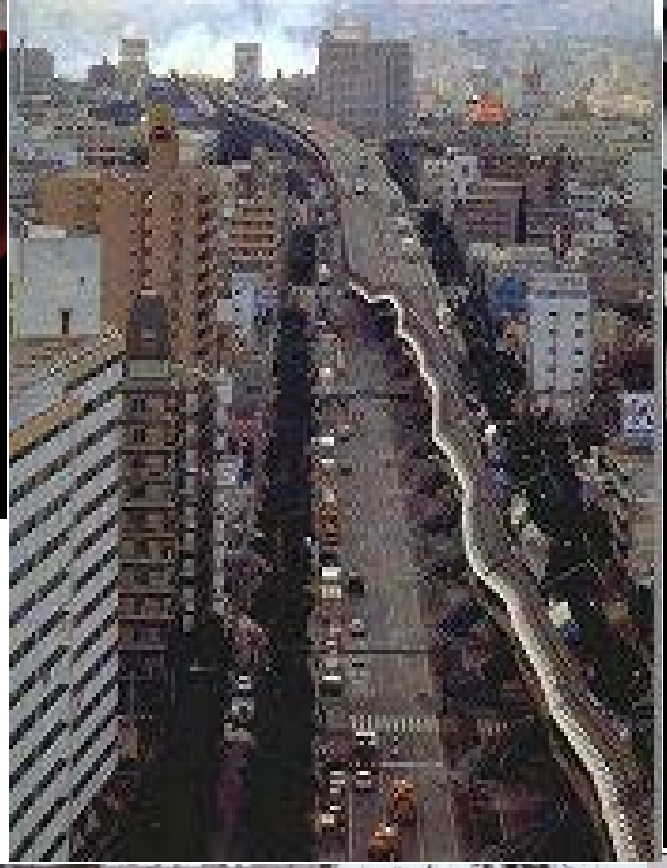
This is a group project.


SEISMIC RISK MAP OF THE UNITED STATES
1925
1965
1959
1755
1906
1811-12
1857
1971
1886
NO DAMAGE
MINOR DAMAGE
MODERATE DAMAGE
MAJOR DAMAGE


EARTHQUAKES
Earthquakes occur when two tectonic plates move suddenly against each other. The rocks usually break underground at the hypocentre and the earth shakes. Waves spread from the epicentre, the point on the surface above the hypocentre. If a quake occurs under the sea it can cause a tsunami.
Epicentre
Hypocentre

Link


NIIGATA, APARTMENT BUILDINGS




ERISCO
PAWN SHO

http://video.nationalgeographic.com/video/environment/environment-natural-disasters/earthquakes/earthquake-101/

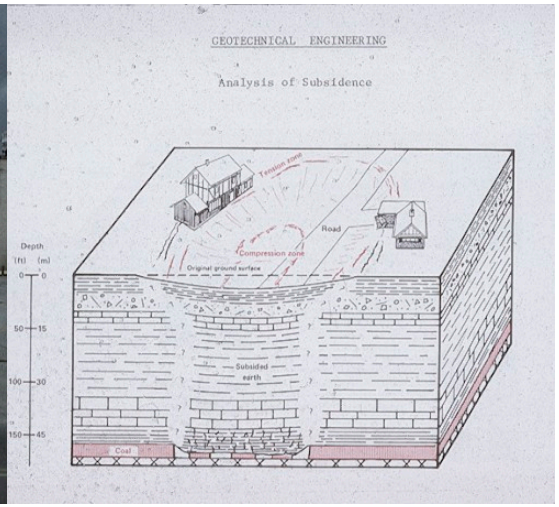





http://www.wimp.com/extremelandslide/
http://mefeedia.com/entry/3158814/
http://www.bing.com/videos/search?q=landslides+videos&mid=4D4E8E0A86218092ABB34D4E8E0A86218092ABB3&view=detail&FORM=VIRE1

http://www.youtube.com/watch?v=vBJ9xZws7ro&feature=related

http://www.youtube.com/watch?v=j-zczJXSxnw


GEOTECHNICAL ENGINEERING
Analysis of Subsidence
Tension zone
Road
Compression zone
Original ground surface
Depth
(ft) (m)
0 0
50 15
100 30
150 45
Subsided earth
Coal

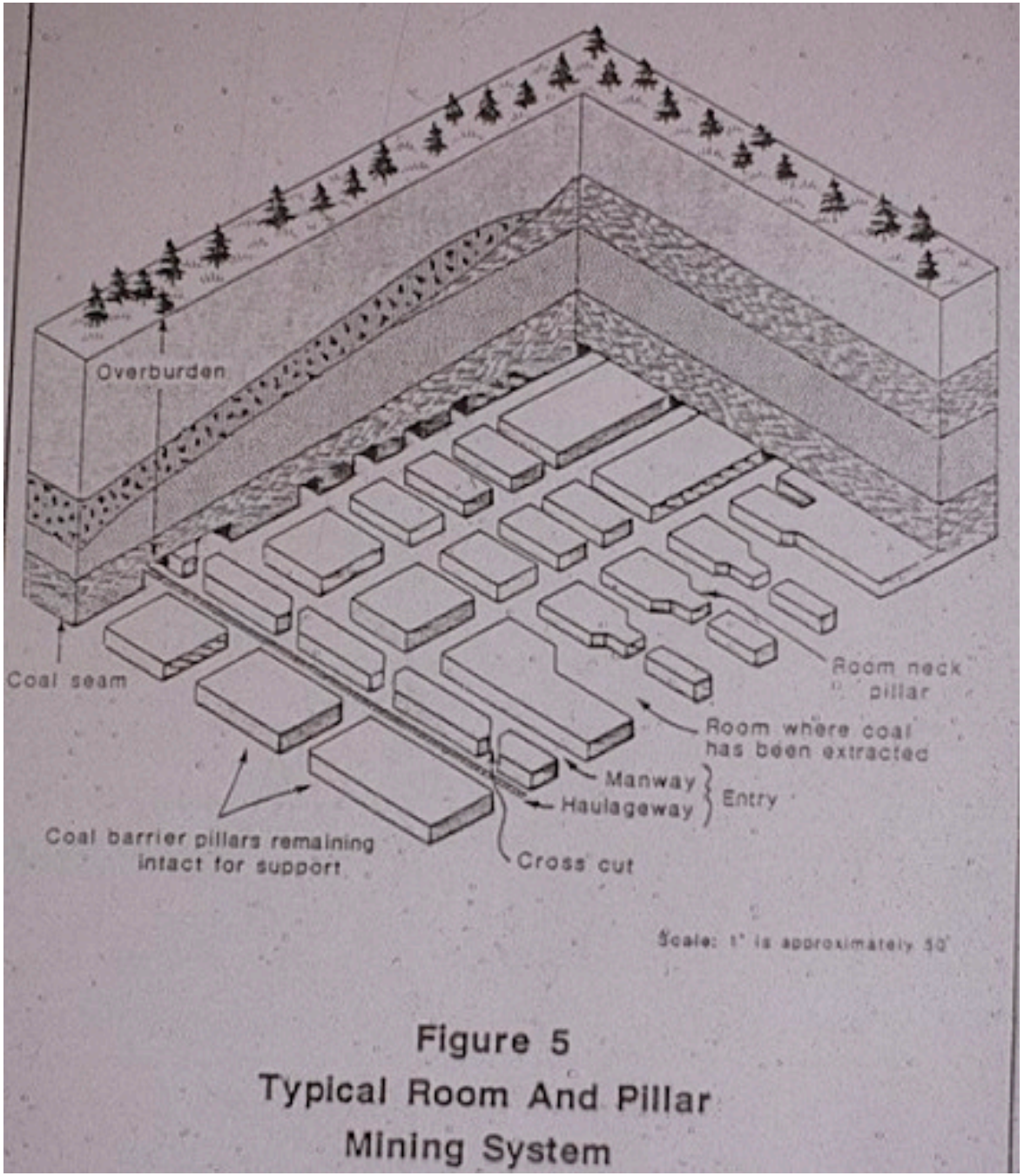
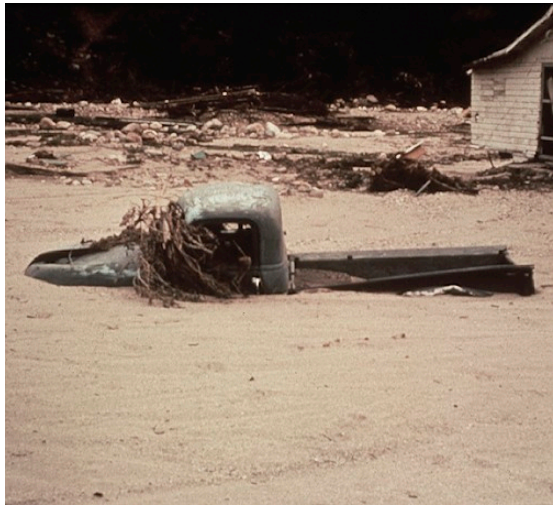
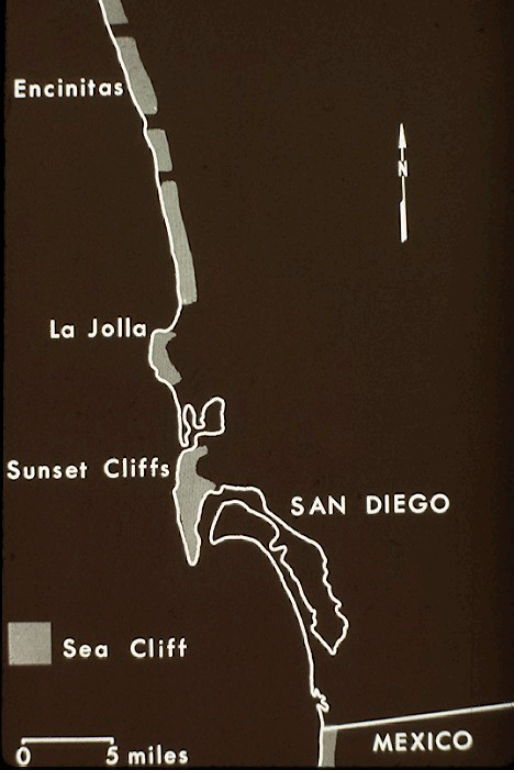


Figure 5
Typical Room And Pillar
Mining System



http://www.flixxy.com/japanese-tsunami-viewed-from-a-car.htm

http://www.youtube.com/watch?v=rF0dy5DjEmQ


Encinitas
N
La Jolla
Sunset Cliffs
SAN DIEGO
Sea Cliff
0
5 miles
MEXICO

Earthquake Movie

http://www.bing.com/videos/search?q=when+the+bay+area+quakes+video&FORM=VIRE1#view=detail&mid=222EF4F4896797349C06222EF4F4896797349C06