Low Incidence, High Consequence Pipeline Risk to Schools

California Department of Education

Wilson Geosciences, Inc.

Fall Pipeline Safety Conference

Bakersfield, October 22, 2003

All Hazards are Not Equal

Risk to Life	High Incidence	Low Incidence
High Consequence	Forest Fires, Earthquakes	Dams, Pipelines, Tsunamis, Railroads
Low Consequence	Residual Soil Toxics, EMF, Traffic	Radon, Canals, Falling Flower-pots

Low Incidence, High Consequence

- Nuclear Power Plants
- Dams and Reservoirs
- Pipelines and Tanks
- Toxic Industry
- Cargo Ships
- Railroads
- Highways
- Aircraft
- Major Earthquakes
- Tsunamis
- Fires
- Landslides
- Floods
- Epidemics
- Howard Stern
- Large Meteorites

One Question, Differently Posed

- Public Tolerance of Involuntary Risk
- Parents:
  - “What are the chances my son or daughter will be killed or injured?”
- School Boards:
  - “How many will likely die or be injured?”
- Individual and Societal Risk

Pipelines in California

- 11,000 miles of natural gas transmission lines
  - Monitored by Public Utilities Commission
- 6,500 miles of liquid transmission lines
  - Regulated by State Fire Marshall
- National and International Pipeline Events

Title 5, Section 14010 (h)

- The site shall not be located near an above-ground water or fuel storage tank or within 1500 feet of the easement of an above-ground or underground pipeline that can pose a safety hazard as determined by a risk analysis study, conducted by a competent professional, which may include certification from a local public utility commission.

Pipeline Risk Analysis Protocol

- Three stages of analysis: Screening, Probabilistic-Consequential, Site Specific
  - Jet Fire, Toxic Vapor, Flash Fire, Blast Overpressure Wave
- Distance to 1×10^{-6} mortality
- Distance from fatal heat flux
- Estimates of individual and societal risk

Risk Thresholds

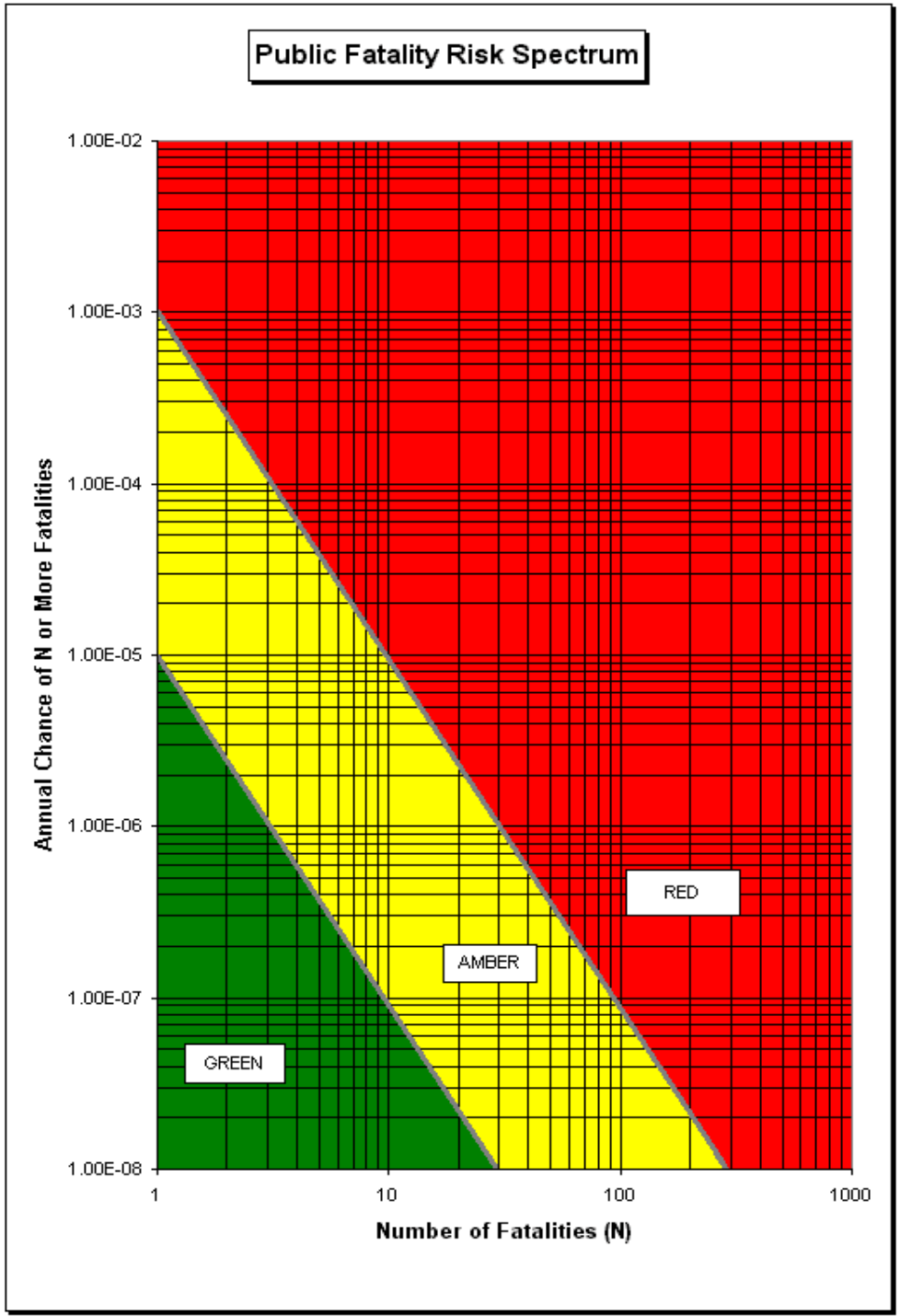
Individual Annual Risk

- Fatality Threshold = $1x10^{-5}$ (1 chance in 100,000 of perishing)
- Injury Threshold = $1x10^{-3}$ (1 chance in 1,000 of being injured)

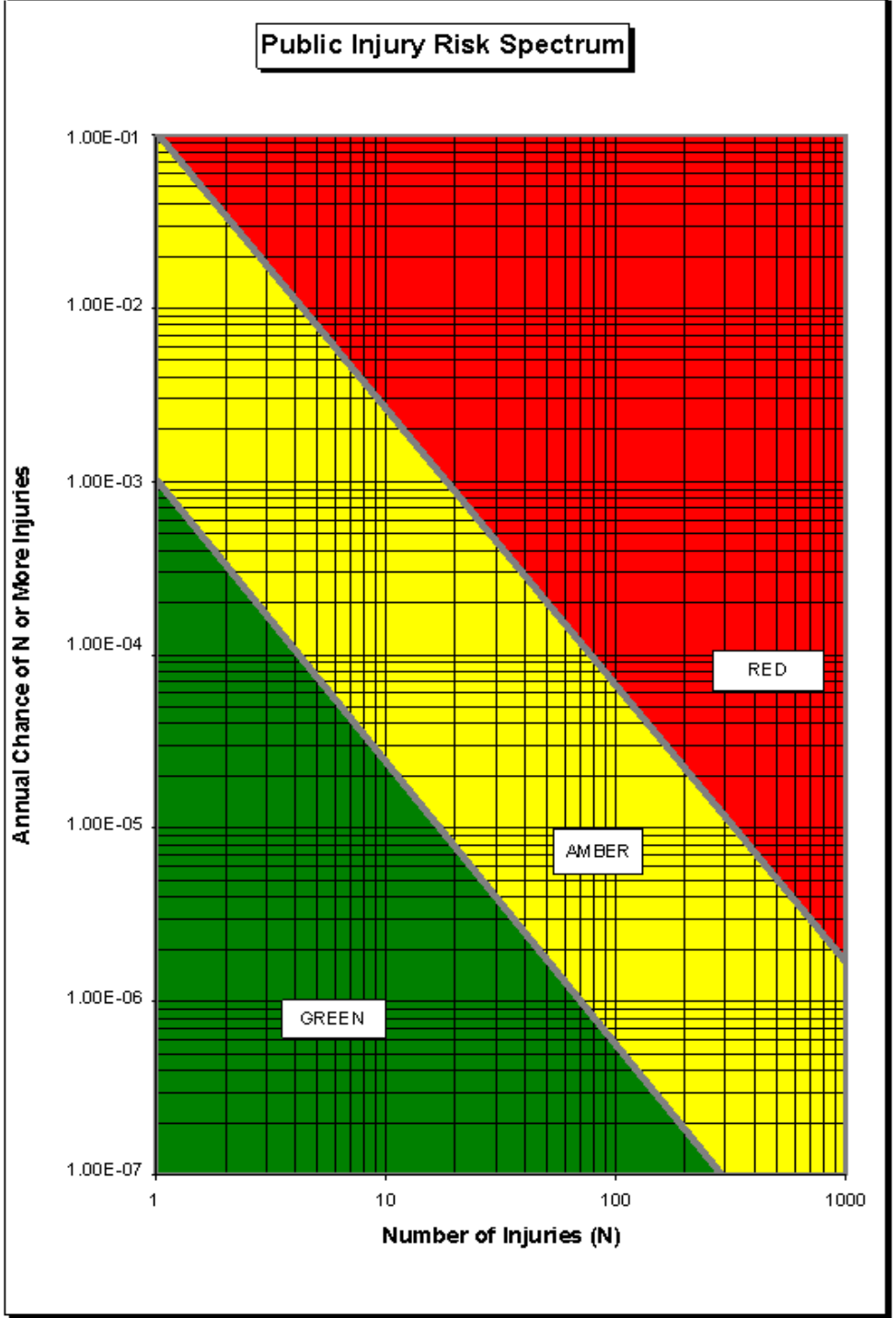
Societal Risk

- Fatality Threshold = $3x10^{-6}$ (3 people in 1 million would perish)
- Injury Threshold = $70x10^{-6}$ (70 people in 1 million would be injured)

Fatality Risk Thresholds



Injury Risk Thresholds



Pipeline Failure: Possible Outcomes

- Pool fire: Burning Liquid
  - Circular Pool
  - Rectangular Channel
- Flash Fire: Flammable Vapor Cloud
- Vapor Cloud Explosion
  - Confined
  - Unconfined

Pipeline Failure: Possible Consequences

- Thermal Radiation
  - Pool Fire
  - Flash Fire
- Blast Overpressure
  - Vapor Cloud Explosion
    - Confined
    - Unconfined

Factors Affecting Severity of Consequences

- Site to Pipeline, Pool, or Channel Distance
- Type of Liquid Product (Crude Oil, Diesel, Jet Fuel, Gasoline)
- Pipeline Diameter and Pressure
- Location of Shut-off Valves, Activation Method, and Time to Shut Down
- Local Terrain and Pipeline Drainage
- Wind Patterns and Land Use

Annual Pipeline Failure Frequency

- CDE Protocol, State & Federal Databases
  - Company Specific
  - Product Specific
  - Industry Average
- Site- and Pipeline-Specific Calculation
  - Pipeline Age, Diameter, Construction Method
  - Geology and Earthquake Hazards

Data Needs: Stage 1 and 2 Analysis

- Type of Product
- Pipeline Location and Diameter
- Product Flow Rate and MAOP
- Shut-off Valve Locations
- Estimate Time to Shut Down Flow

Data Needs: Stage 3 Detailed Analysis

- Same as Stage 1 and 2
- Pipeline Segment Age
- Pipeline Design Parameters
  - Depth of burial and wall thickness
  - Material grade and hoop stress (% SMYS)
- Historical Release Record

Stage 2 Probabilistic Analysis Results

- Individual Fatality Risk Estimate
  - Annual Probability of one death
  - Compare to 1×10^{-6} maximum
- Societal Risk Estimate
  - Pool fire, flash fire, explosion
  - Number of fatalities from site population
  - Compare to Santa Barbara Fatality Risk Spectrum

Stage 3 Detailed Analysis Results

- Individual Fatality Risk Estimate
  - Annual Probability of one death
  - Compare to 1×10^{-6} maximum
- Societal Risk Estimate
  - Pool fire, flash fire, explosion
  - Fatalities: site population/campus layout
  - Compare to S.B. Fatality Risk Spectrum
  - Define Mitigation Measures

Sample Outcome: Pool Fire

Figure 4-1. Elevation of Pool Fire Flame -- Hole in Petroleum Products Pipeline

Sample Consequences: Pool Fire

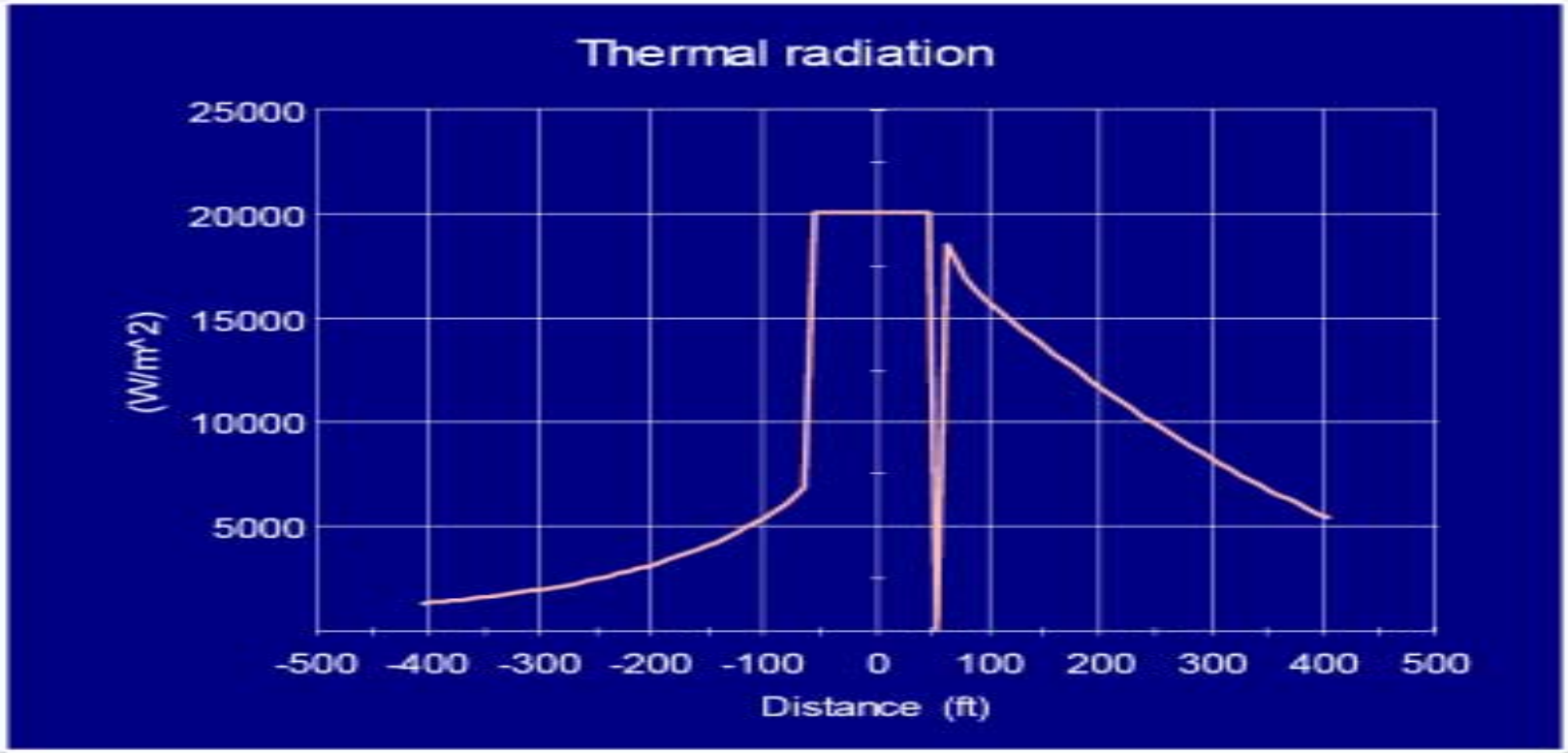


Figure 4-2. Thermal Radiation of Pool Fire -- Hole in Petroleum Products Pipeline

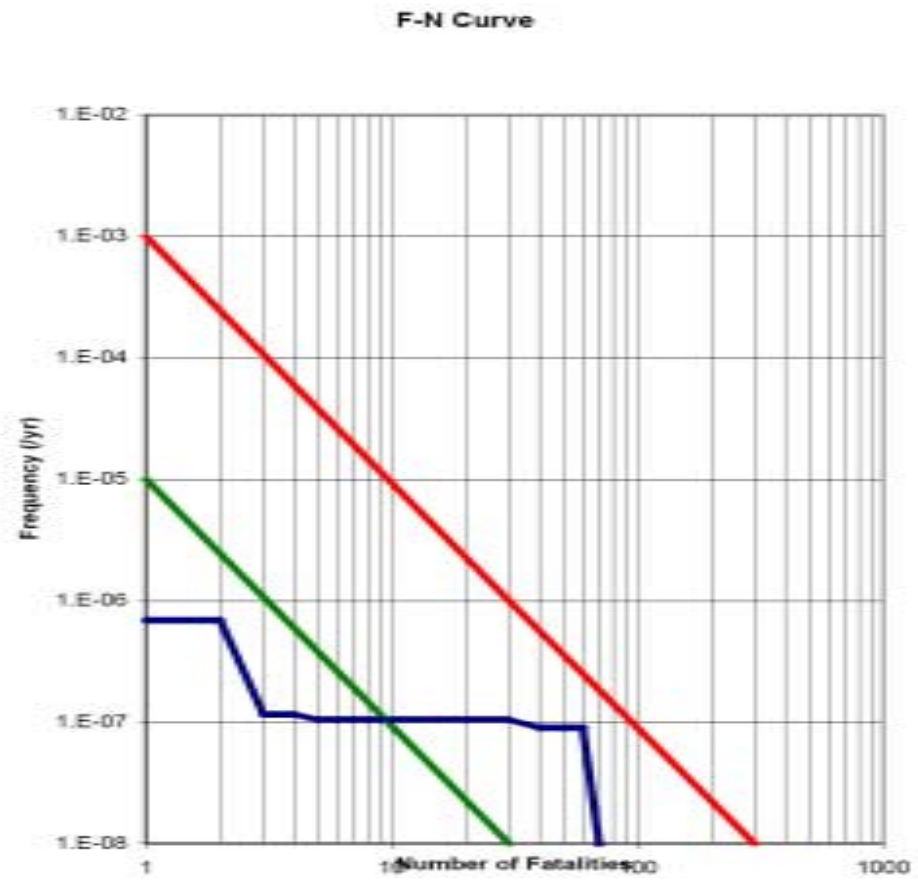
Sample Stage 3 Result

Option 3

Probability of Outdoor Fatality = 0.01 (1%)
Probability of Indoor Fatality = 0.1 (10%)

Annual Individual Risk = 2.77 E–07

Societal Risk:



An Ounce of Prevention

- Tolerable Risk and Avoidance of Catastrophic Risk
- Risk analysis when school is within 1500’
- Risk Assessment Protocol: Three levels of analysis
- A Safe Distance, and Other Prevention Measures