Process Safety
Facility Planning and Siting

23 March 2011

AIChE®

Facility Planning

- External
  - Location of Site / Effects on Community
  - Exterior Effects on Site
- Internal
  - Location/Arrangement within Site
- Incidents
- Risk Assessment Methodology

Facility Planning

- Why is location of site important?
- Why is proper planning important?
- Look at the present, learn form the past, and anticipate the future
- Include proper people in planning process
  - Engineers / Designers
  - Operations
  - Management
  - Emergency Services

External Siting

Types of Incidents

- Fires and Explosions
- Toxic Air Release
- Spill into Waterways
- Disruption of Public Wastewater Treatment Plant
- Groundwater Contamination
- Normal Air Emissions

External Siting

- Location of a site with respect to surrounding area and community.
- Evaluate the effects of an incident on areas outside the plant.
- Evaluate the effects of normal operation on areas outside the plant.
- NIMBY – Not In My Back Yard

External Siting

- Evaluate the effects of surroundings on the facility.
  - Adjacent Highways/Railways
    - Transport of Hazardous Chemicals
  - Environment
  - Weather

Incidents

Possible Effects of an Incident

- Loss of Life
- Loss of Jobs
- Business Interruption
- Increased Consumer Costs from Reduced Supply
- Increased Costs in Insurance Costs / Premiums
- Environmental Impacts
- Negative Impact on Company Reputation

Incident No. 1

Flixborough, UK

- 16:53 Saturday, June 01, 1974
- 28 People Killed, 36 Injured
- Fire on an 8 inch Pipe
- Bypass Pipe Containing Cyclohexane (150ºC, 10 bar) ruptured.
- 40 Tonnes Cyclohexane leaked – 100 to 200 m Vapor Cloud.

Incident No. 1

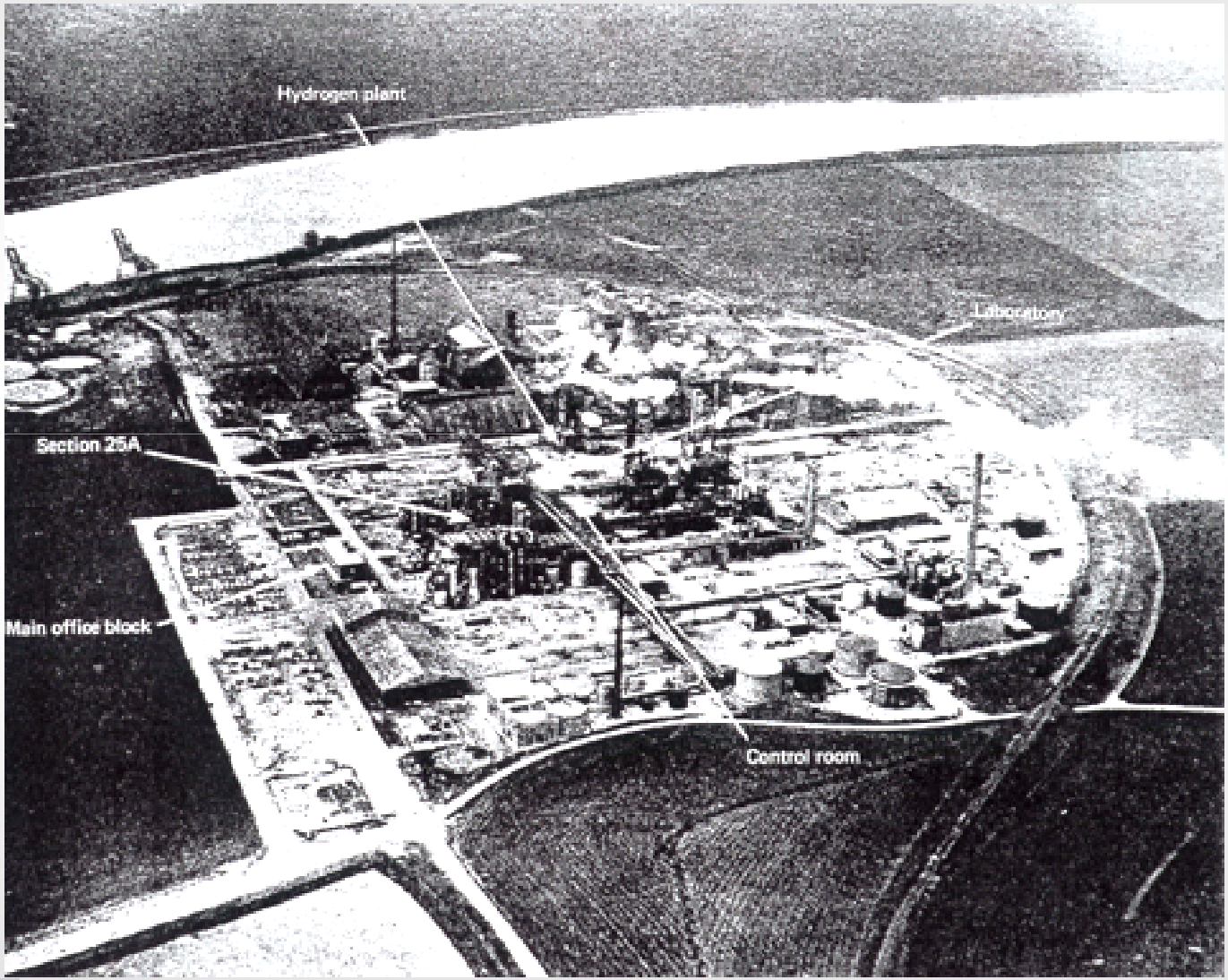
Flixborough, UK

- 1,800 buildings within 1 mile radius damaged
- Fires in area lasted for 10 days
- Explosion equivalent to 15 Tonnes TNT
- All 18 people in control room killed
- 500+ would have been killed during a weekday

Incident No. 1

Flixborough, UK

Incident No. 1



Incident No. 1

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Incident No. 2

Toulouse, France

- AZF – Fertilizer Manufacturing and Warehouse
- September 25, 2001 – Originally thought to be terrorism
- 300 Tonnes of Ammonium Nitrate Exploded
  - Mislabeled Chemical, Hot & Humid Conditions in Warehouse
- Crater – 100 ft deep, 650 ft diamter
- Steel structure found 3 km away
- Blast measured 3.4 on Richter scale, heard 80 km away

Incident No. 2

Toulouse, France

- Plant Built in 1924 – Rural Area
- 2005 Population – Over 400,000
- Residential area – 1 km away
- Schools, University and hospitals evacuated
- 29 deaths (28 plant, 1 nearby school)
- 2,500 serious injuries; 8,000 minor injuries
- City advised people to stay indoors and close windows
- Two-Thirds city's windows shattered
- 40,000 people homeless

Incident No. 2

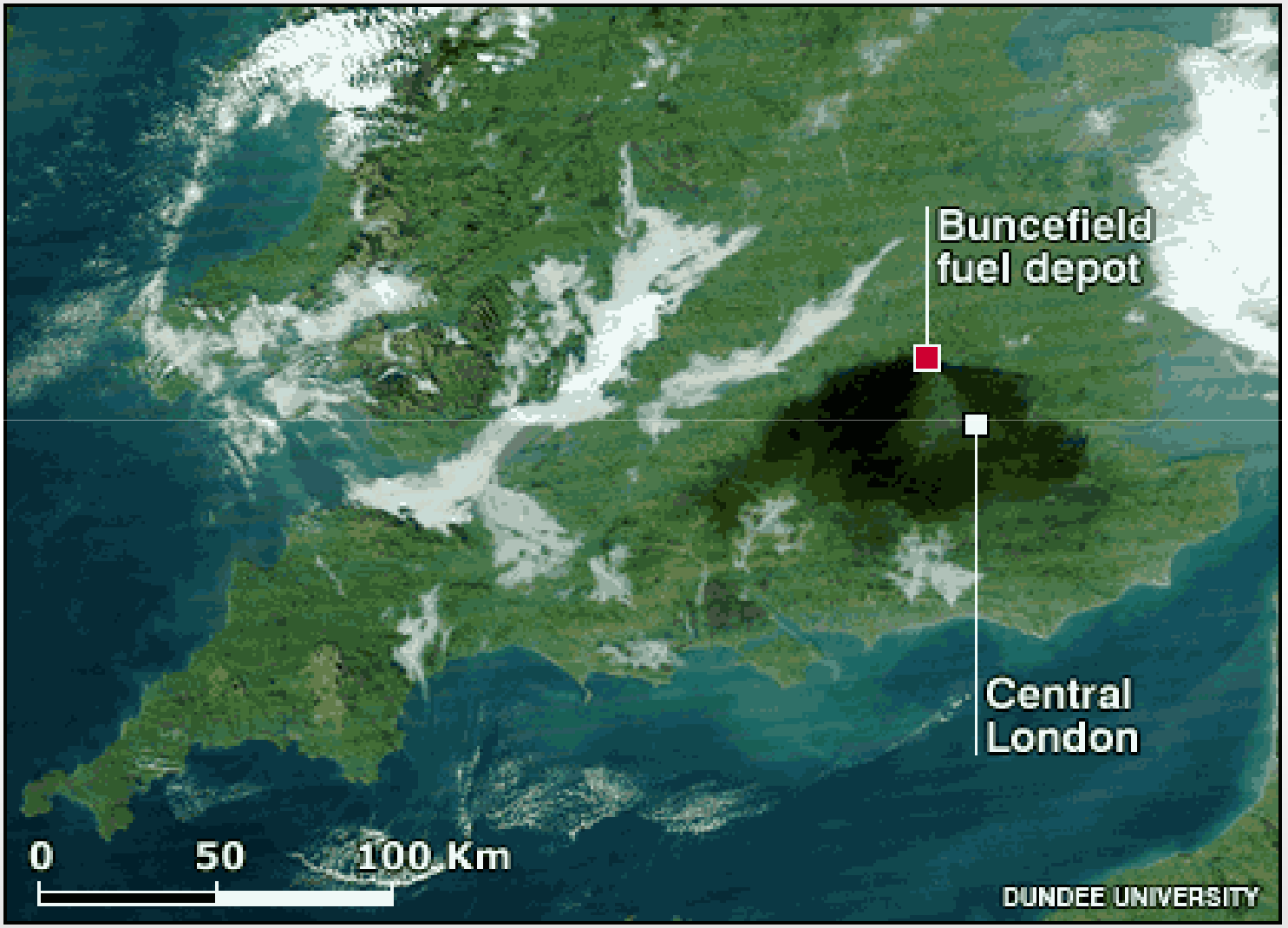
Incident No. 3

Buncefield Tank Farm

- Tank Farm in Hertfordshire, England
- Incident Occurred on December 11, 2005
- Overflow of Filling Gasoline Storage Tank and Resulting Explosion
- Flammable Cloud – 400m Across
- Explosion 2.4 on the Richter Scale
- 23 Storage Tanks on Fire
- 43 Injured, 0 Fatalities
- Fire Burned for Several Days

Incident No. 3

Incident No. 3



Incident No. 3

View From London

Incident No. 3

Incident No. 3

Incident No. 3

Incident No. 3

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Incident No. 3

Incident No. 4

Chemie-Pack, Moerdijk, The Netherlands

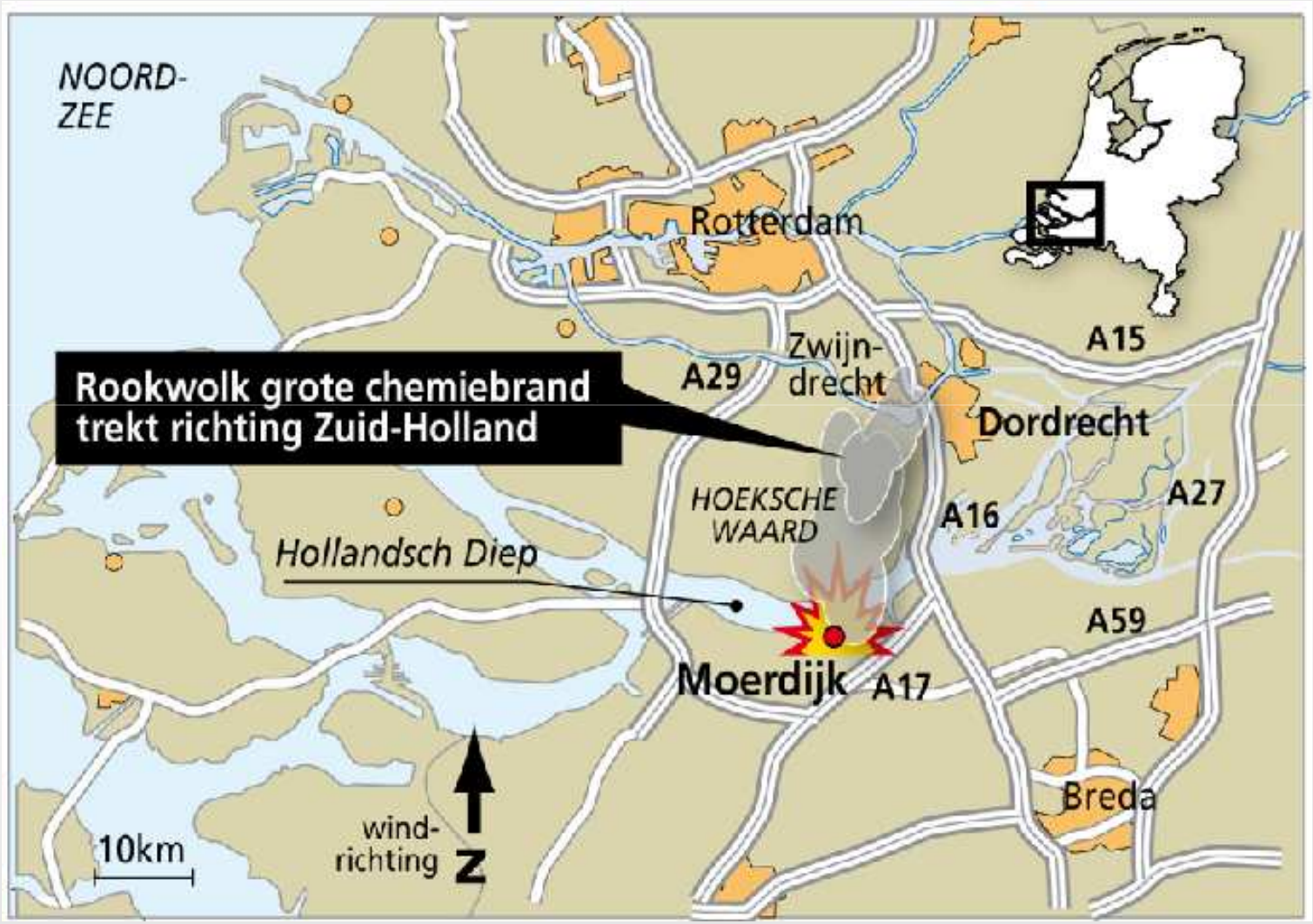
- Chemical Packing Plant – 50 Employees
- Incident Occurred on January 5, 2011
- No Immediate Injuries
- 400,000 L Carcinogenic Chemicals in Storage
- Flames 40m (130 ft) high
- Fumes and Smoke reached 3.2km away
- Company fined in 2006 for fire and safety violations

Incident No. 4

Chemie-Pack, Moerdijk, The Netherlands

- Shipping on Hollands Diep River was halted for the area
- A16 and A17 Roads Closed
- Train Traffic Stopped
- Fire spread to the nearby Wärtsilä engine factory
- Government stopped sale of vegetables from nearby farms
- Children to stay indoors while environmental impact was assessed

Incident No. 4



Incident No. 4

Incident No. 4

Incident No. 4

Incident No. 4

Incident No. 4

Incident No. 5

Port Wentworth, Georgia

- February 7, 2008
- Imperial Sugar Plant Explosion
- 112 people at the plant -14 Killed, 42 Injured
- CSB Investigation
  - Poor Equipment Design, Maintenance and Housekeeping
  - Sugar Conveyor was inadequately designed with dust buildup
  - No evacuation drills, Emergency Lighting disabled

Incident No. 5

Incident No. 5

Incident No. 5

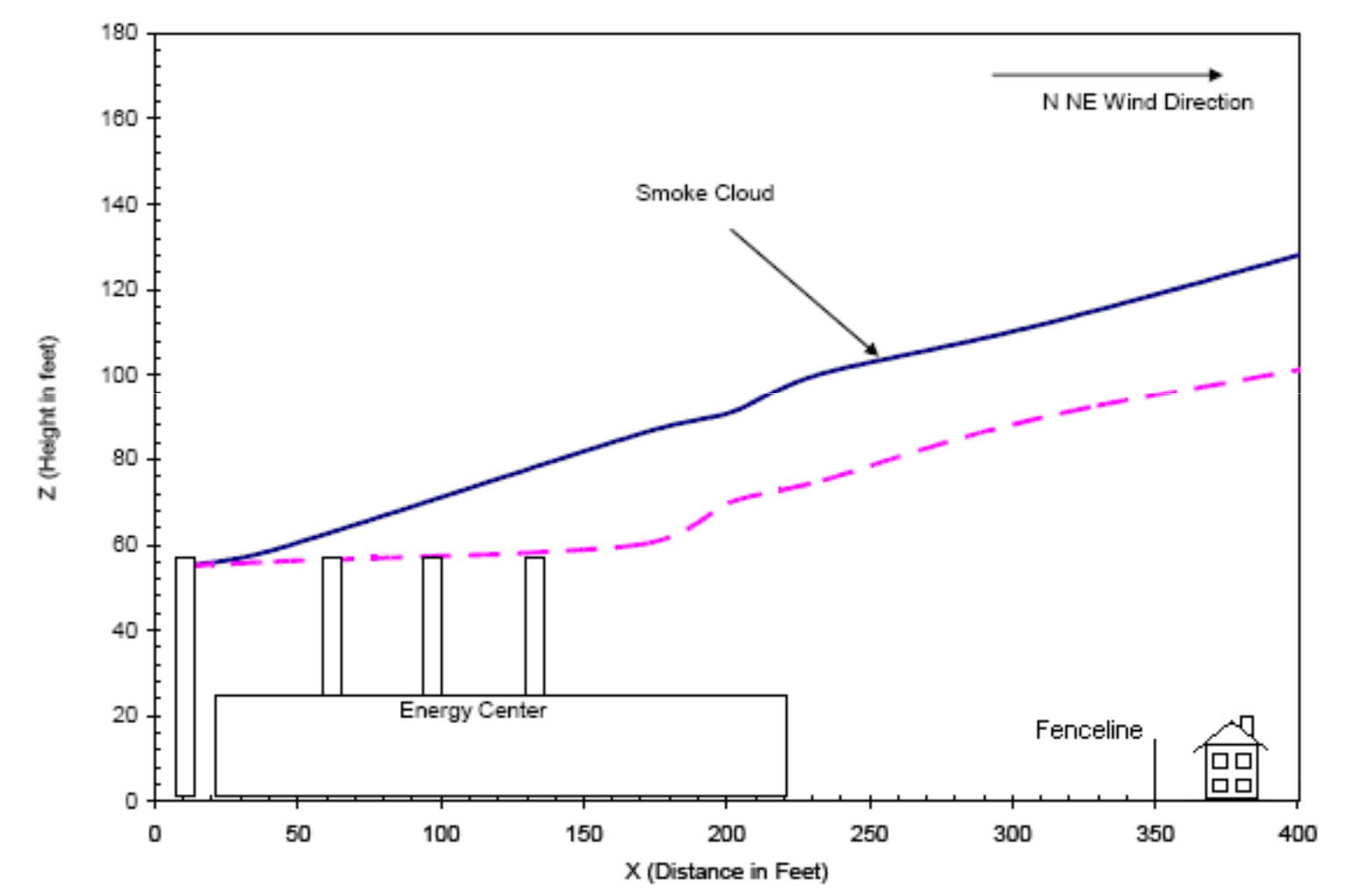
Normal Operations

Evaluate

1. Air Emissions
2. Adjacent Waterways
3. Flood Plains
4. Noise Pollution
5. Light Pollution
6. Effects on Traffic
7. Maintenance
8. Infrastructure – Utility Needs
9. Site Security

Normal Operations

Normal Operations



Normal Operations

Traffic Effects from Facility

Internal Siting

Location of Facilities within Plant

- Isolate Critical Buildings and Utilities from Hazards
- Redundancy on Utilities and Controls
- Proper Design of Utilities, Buildings and Structures for Overpressures and Fires
- Proper Level of Emergency Services

Internal Siting

Location of Facilities within Plant

- Control Buildings
- Firefighting Equipment
- Power Generation
- Water Utilities
- Shelter In Place

Internal Siting

How will Incident in a Plant Affect:

- Short Term Operations
- Long Term Operations
- Occupied Areas
- Emergency Services
- Ability to Evacuate the Site
- Escalation of Incident

Internal Siting

Location of Facilities within Plant

- Heat Flux Consequences

Thermal flux (kW/m^2)	Consequences
1 – 1,5	Sunburn
5 – 6	Personnel injured (burns) if they are wearing normal clothing and do not escape quickly
8 – 12	Fire escalation if long exposure and no protection
32 – 37,5	Fire escalation if no protection (consider flame impingement)
Up to 350	In flame. Steel structures can fail within several minutes if unprotected or not cooled

Source: IP-19, Table 2.1

Internal Siting

Location of Facilities within Plant

- Overpressure Consequences

Static overpressure (barg)	Consequences
0,01	10% window breakage
0,03	Injuries from flying glass. 50% window breakage
0,15	Partial collapse of brickwork, roofs lifted. 100% window breakage
0,3	Destruction of steel-framed buildings, ear-drum rupture. Severe roof damage, people killed by falling masonry
0,5	People in the open picked-up and thrown. Severe masonry damage, rail tank wagons overturned, trees snapped in half
0,7	Severe structural damage to heavy steel and reinforced concrete buildings. Rail tank wagons ruptured and reactors overturned

Source: IP-19, Table 2.2

Planning Process

Site Location and Layout

- Perform Risk Assessments on:
  - Process
  - Operations
  - Equipment
  - Site Layout
  - Emergency Operations

Planning Process

Steps to Risk Assessment

1. Identify the Hazards
2. Identify Who Might be Harmed and How
3. Evaluate the Risks and Methods of Mitigation
4. Record the Findings and Implementation
5. Review the Assessment and Update as Required

Planning Process

Types of Risk

1. Fire and Explosion
2. Materials and Equipment
   - Hazardous Materials, Maintenance, Proper Selection
3. Personnel and Practices
4. Environment
5. Business Interruption
6. Company Reputation

Planning Process

Risk Control

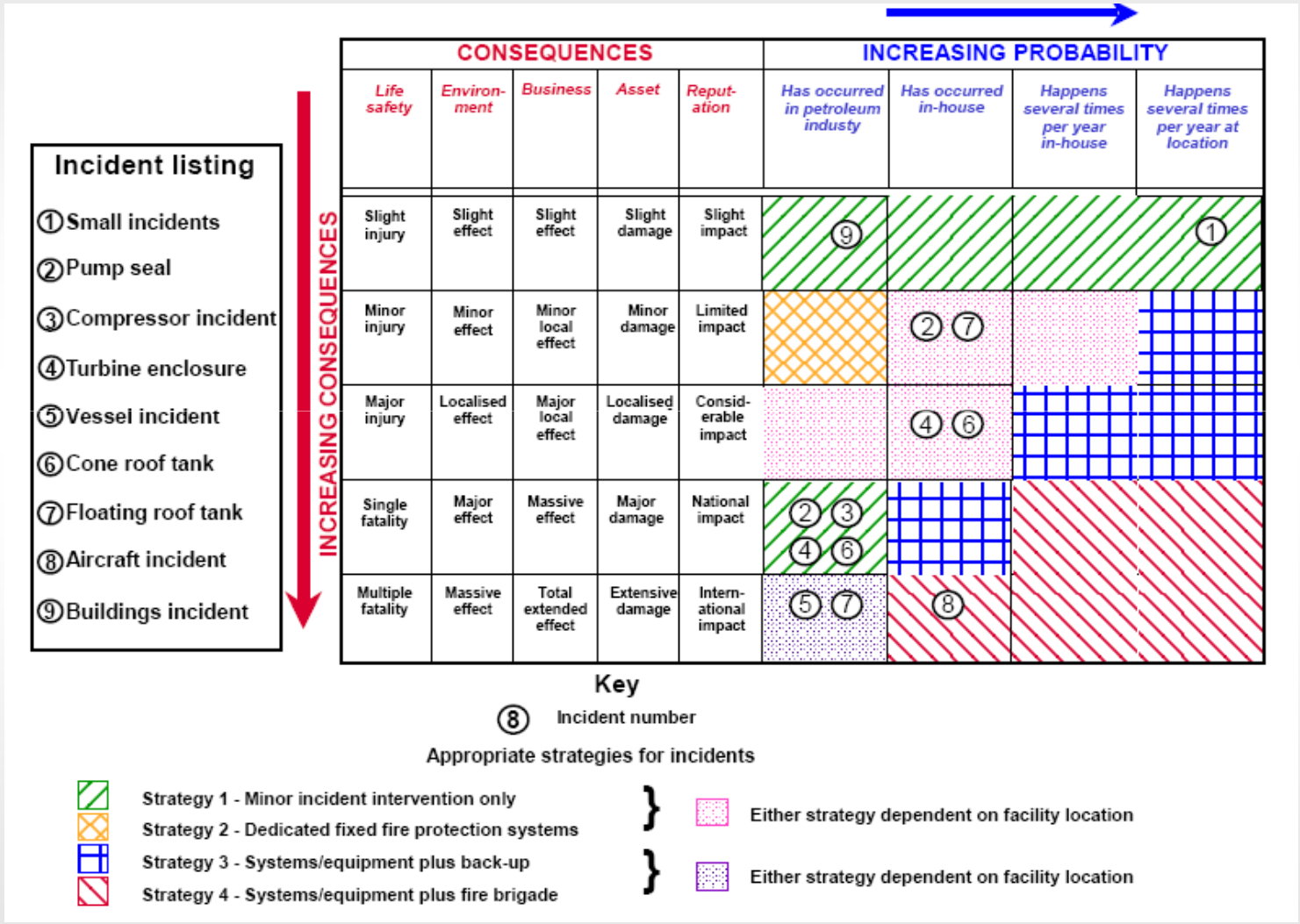
1. Eliminate the Hazard
   - Use Less Hazardous Chemicals or Process
2. Loss Prevention
   - Prevent Accidents From Occurring
3. Loss Reduction
   - Building Construction, Firefighting Systems
4. Segregation of Exposures
   - Location of Critical Buildings and Processes
5. Transfer of Risk
   - Contract Manufacturing for Materials

Planning Process

Determine Level of Acceptable Risk

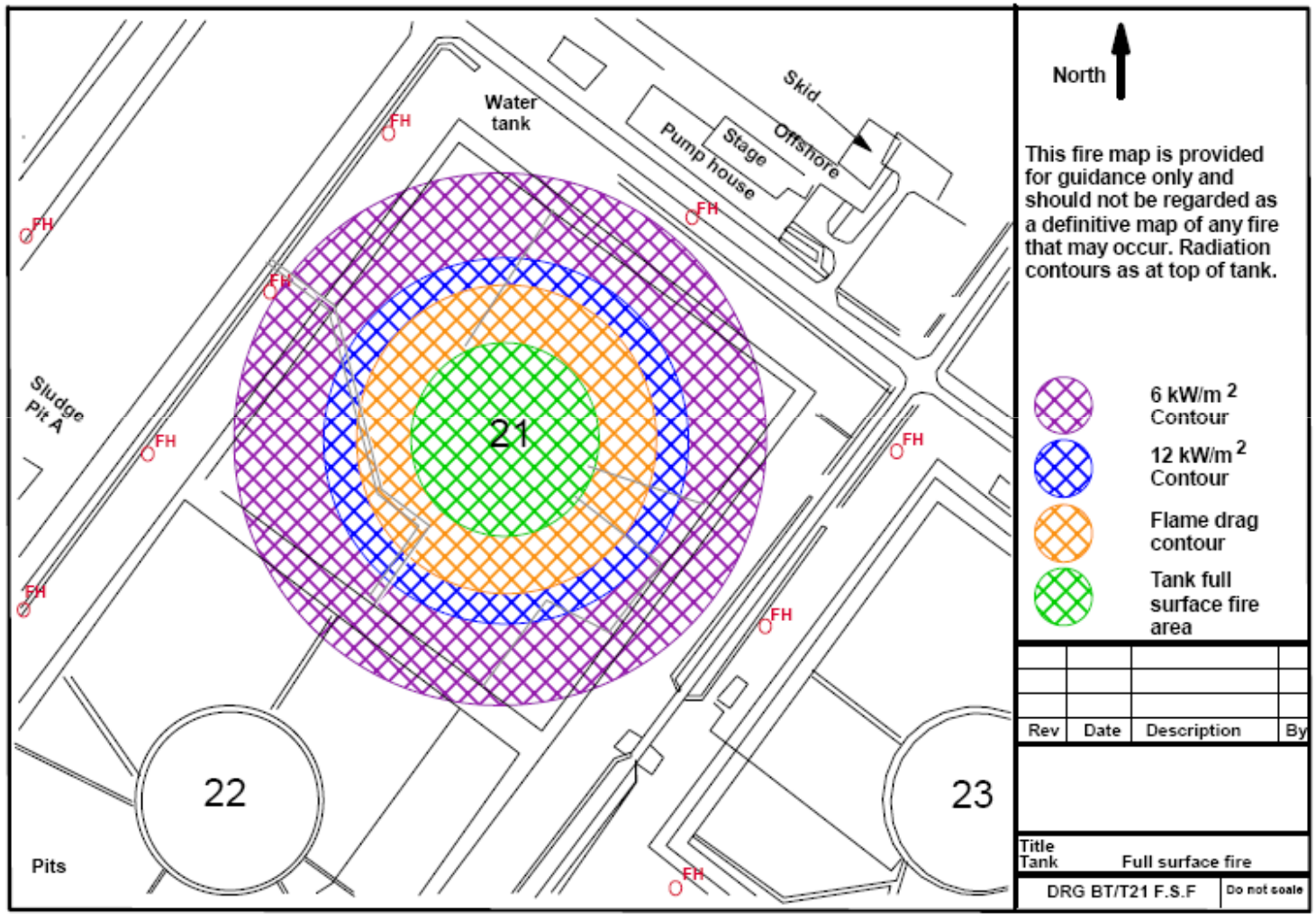
- Based on Probability and Consequences of an Incident
- Industry Standards
- Corporate Standard
- Insurance Requirements

Risk Matrix



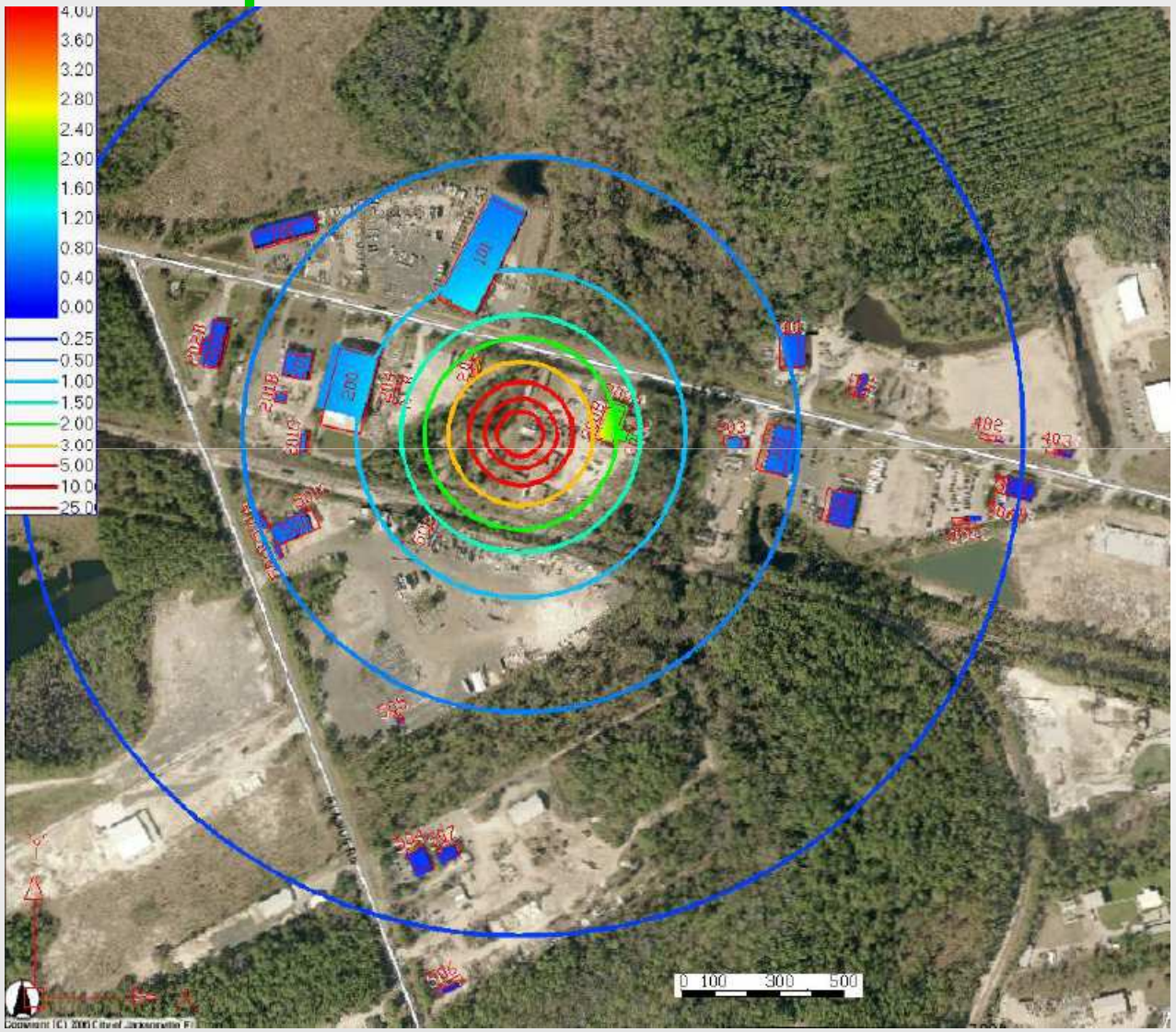
Source: IP-19, Figure 3.2

Heat Radiation Contours

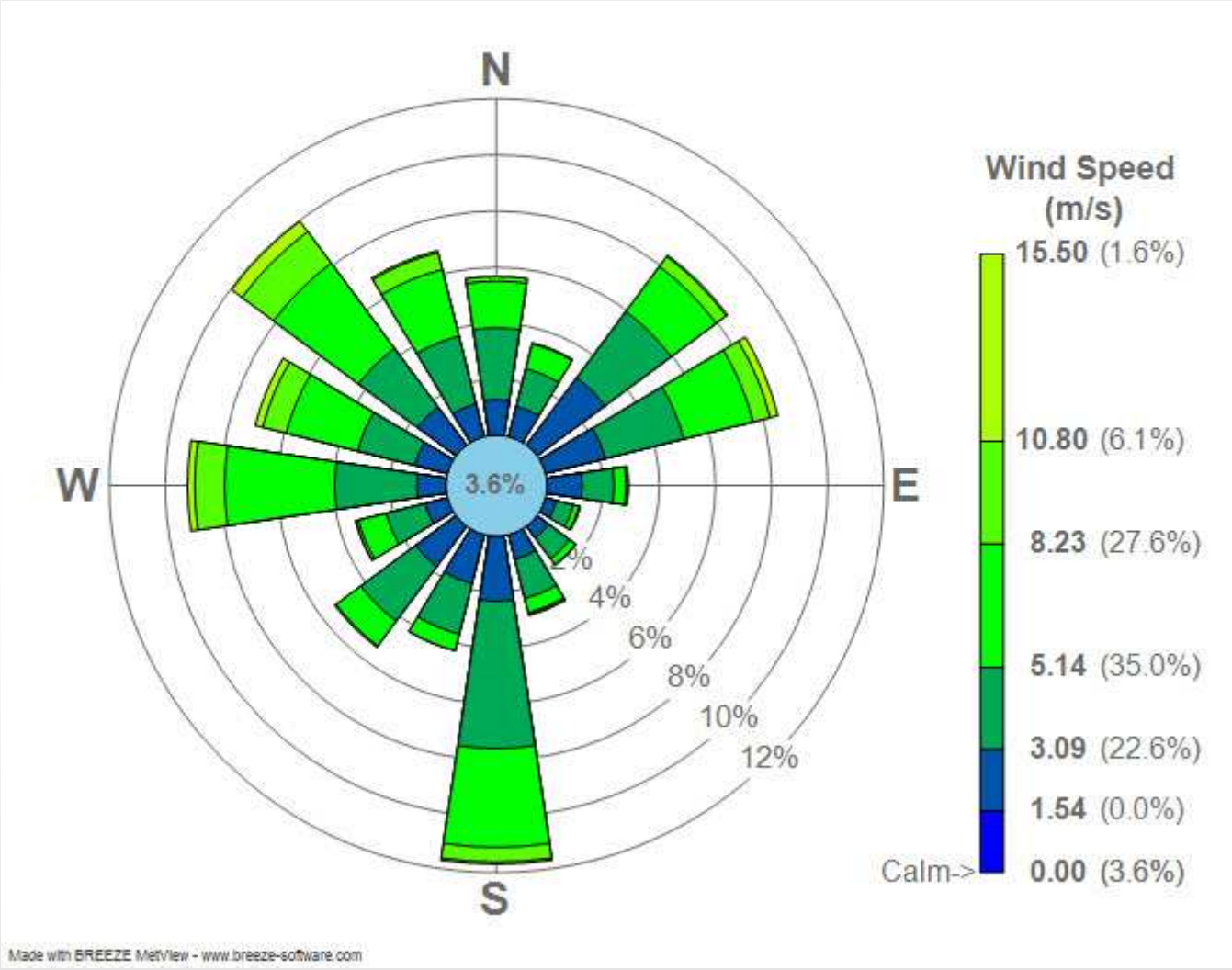


Source: IP-19, Figure G.1

Overpressure Contours



Wind Rose Plot



Planning Process

Determine Methods to Reduce Risk

- Change Process
- Safety Interlocks and Controls
- Automate Process
- Pressure Relief and Explosion Prevention Systems
- Fire Protection Systems
- Preventative Maintenance
- Training and Drills
- Management of Change

Reference Standards

- **API 752**: Management of Hazards Associated with Location of Process Plant Permanent Buildings
- **API 753**: Management of Hazards Associated with Location of Process Plant Portable Buildings
- **IP-19**: Fire Precautions at Petroleum Refineries and Bulk Storage Installations (UK)
- **FM LPDS 7-42**: Guidelines for Evaluating the Effect of Vapor Cloud Explosions Using a TNT Equivalency Method
- **FM LPDS 7-44**: Spacing of Facilities in Outdoor Chemical Processing Plants
- **Seveso II Directive**
- **COMAH** – Control of Major Accident Hazard Regulations (UK)

Open Discussion

Questions??

- Call Bob Moser (day or night) at 1.610.888.6920