Recent Improvements to Industrial Chemical Safety, Preparedness, and Response Modeling

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Outline

- Population “at-risk” versus “affected”
  (includes building protection for toxic chemicals)
- Goldfish field study
- Response Risk Assessment

Population “at-risk” versus “affected”

Models can be useful in emergencies

- Determining where to control access and how to approach the incident
- Support protective action decisions
- Assist in communicating with the public

But it takes time to develop an accurate model

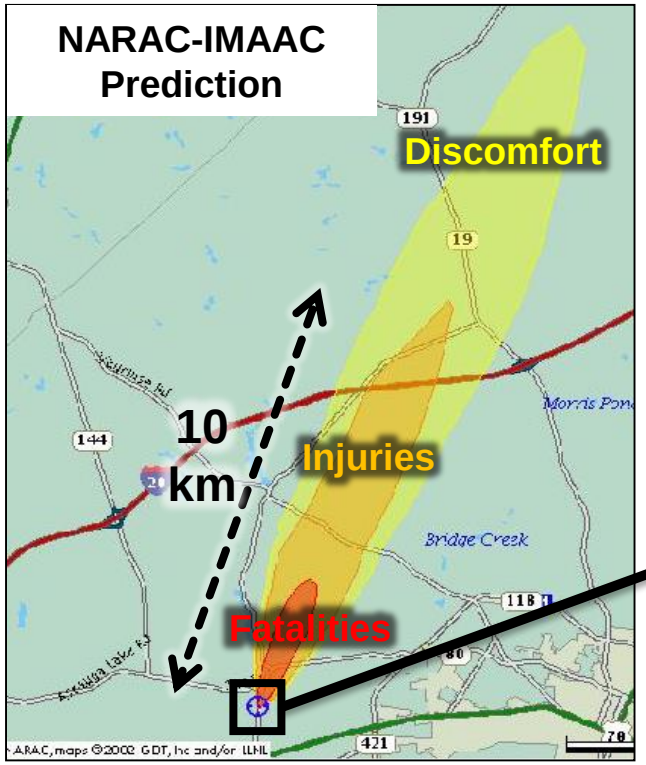
- Initially information is often limited
- High fidelity models often take awhile to run

Early response (and often planning) modeling generally errors on the side of caution
These models identify regions in which people might be at risk

Difference between “at-risk” and “likely affected”

At-Risk

Population in regions where adverse health effects *might occur*



Affected

Population *likely* to experience adverse health effects

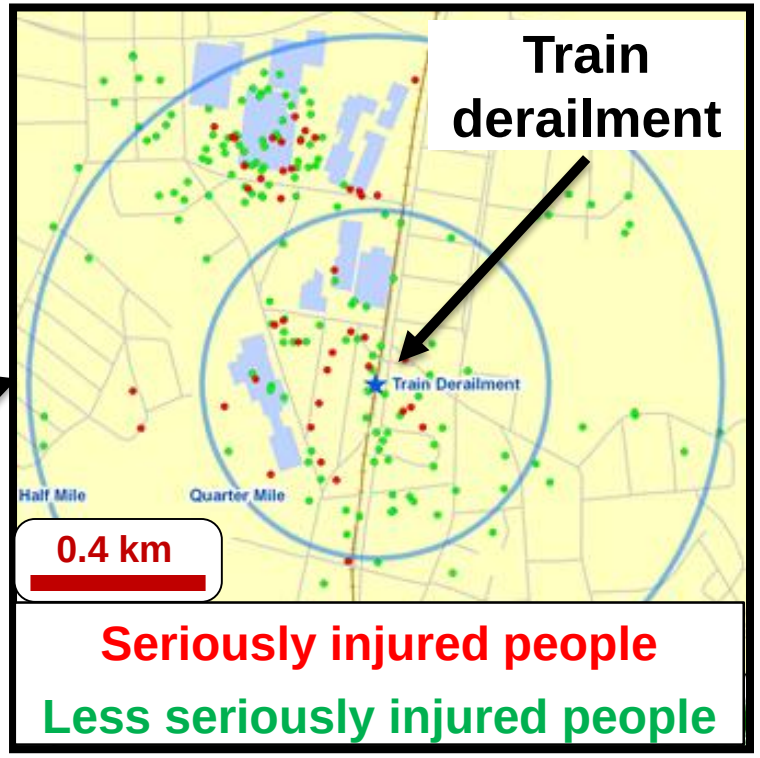


Image courtesy of South Carolina Department of Health and Environmental Control

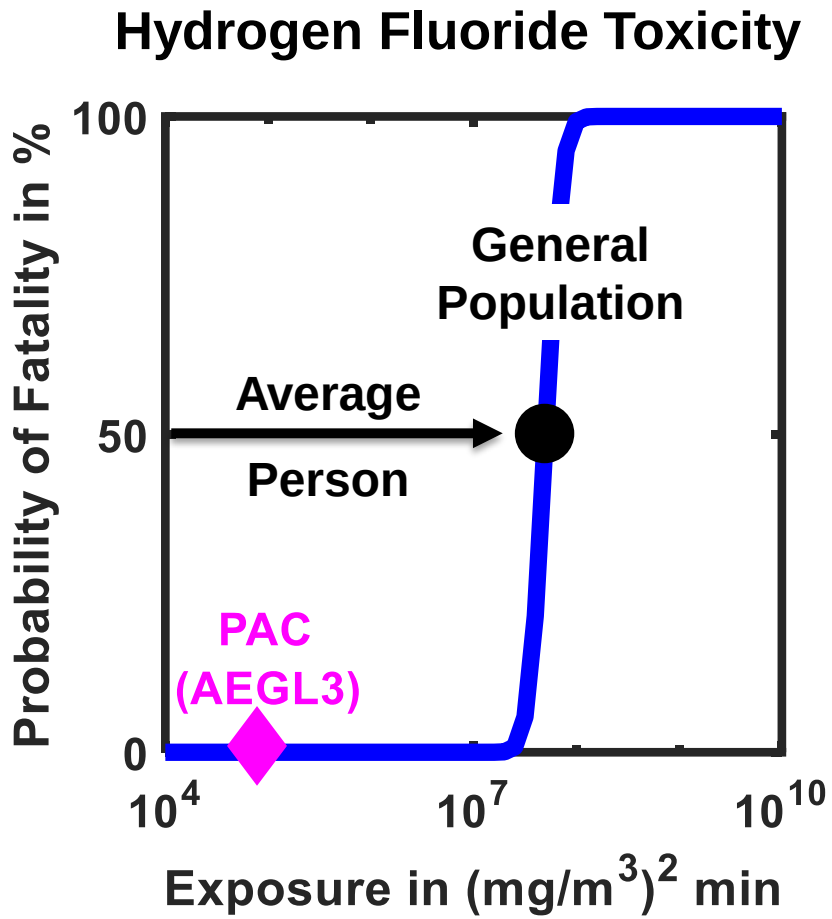
“At-risk” vs. “affected” considerations Health effects

People range in sensitivity

Response models often use **Protective Action Criteria (PAC)** - thresholds above which health effects may be seen in ***sensitive people***

For HF lethality,

The **PAC is 1,000 times lower than the exposure that affects the average person (LD50)**



“At-risk” vs. “affected” considerations
Building protection (shelter)

Normally operating buildings reduce indoor exposures to outdoor origin material (passive shelter)

Reduction depends on the chemical, health effect of interest, building, and plume properties

Reduction can be many orders of magnitude for acute exposure to toxic chemicals

Key considerations affecting indoor inhalation exposures to outdoor airborne hazards

https://figshare.com/articles/RSA_-_Illustration_of_Inhalation_Building_Protection/9505424

Illustrative HF Protection (Outdoor / Indoor)

Modern Weatherized House

Typical House (windows closed)

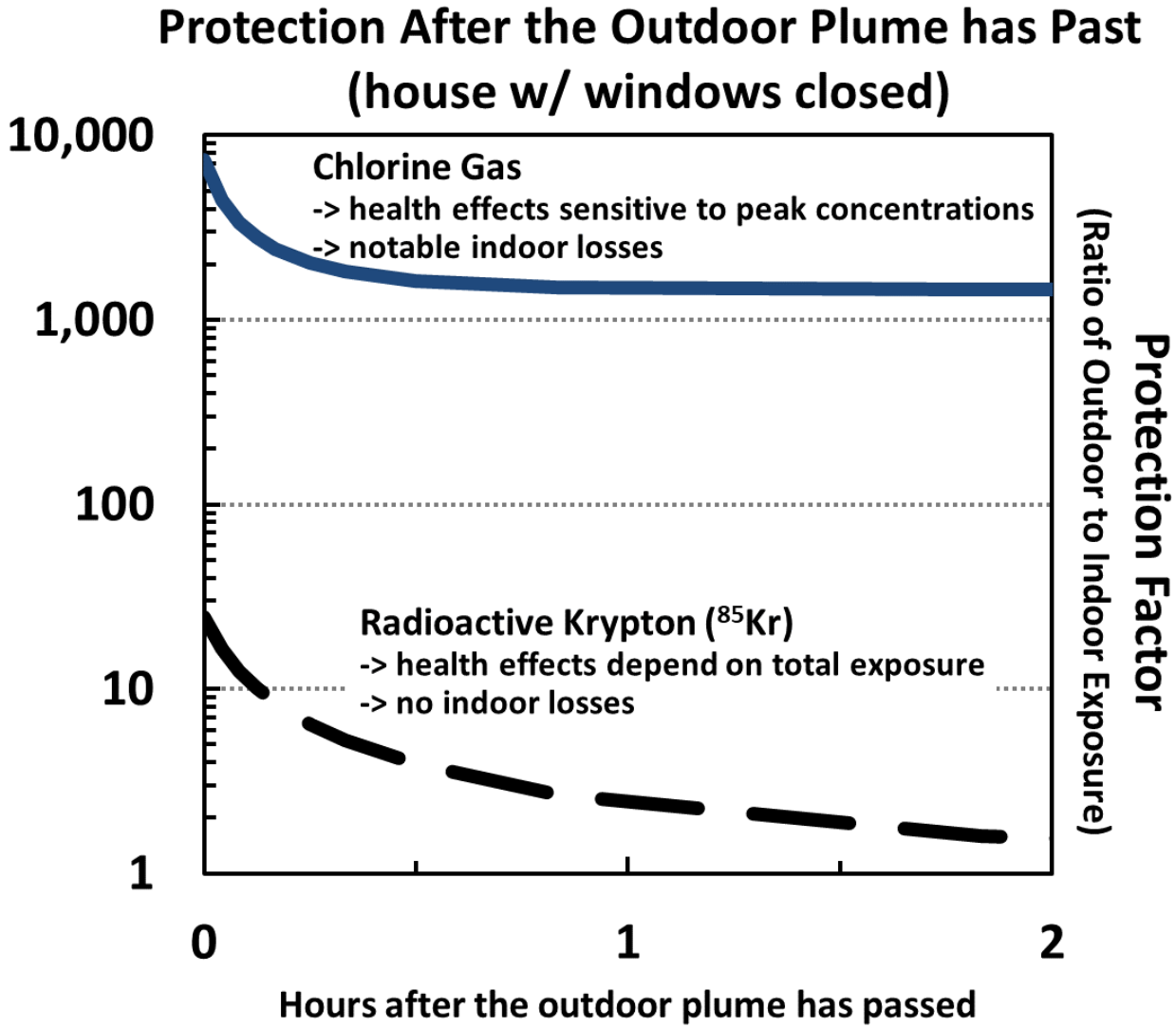
Modern Commercial (HVAC on)

Exiting shelter

For hazards with notable indoor losses or sensitivity to peak concentration…

Sheltering can be a particularly effective response strategy

For these hazards, exiting shelter in a timely manner is less important than for other hazards



Illustrative protection factors shown

Final thoughts on “at risk” vs “likely affected”

- Response models and products often identify regions where people may be **at risk**
  - Dispersion models can often accurately predict downwind air concentrations
  - Additional, scenario-dependent considerations can reduce (or sometimes extend) the hazard extent

- More realistic modeling can account for many of these considerations

- Response and medical countermeasure planning can benefit from more realistic estimates of population likely to be **affected**
  - Supports improved decision making
  - **Improves targeting of scarce resources to those most in need**

Goldfish Field Study

Goldfish field study
Large scale release of superheated Hydrogen Fluoride

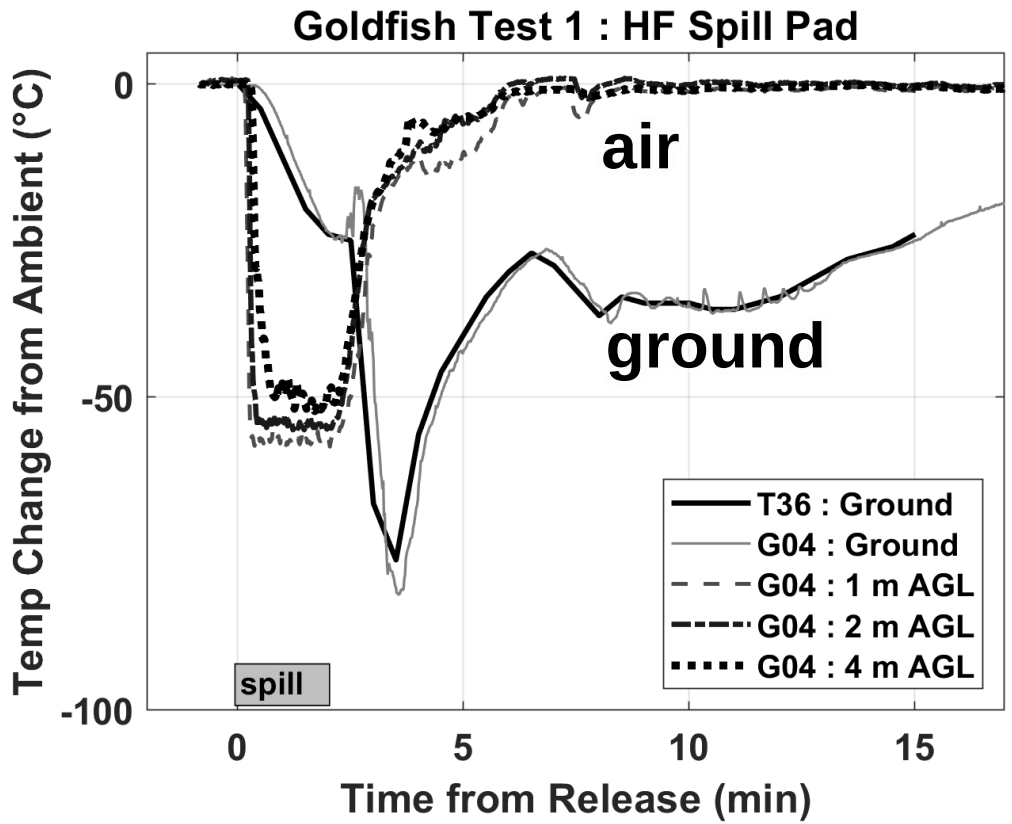
- Large **Hydrogen Fluoride (HF)** release
- Jointly led by LLNL and Amoco Oil Company
- Results used to
  - Validate and refine physics-based episodic accidental release models for consequence assessments
  - Guide water spray mitigation research
  - Develop guidance for management of accidental releases

Experiment performed in 1987 Final technical report now being completed (expected Jan 2020)

Goldfish field study
Final report teaser

Detailed data available

- HF concentrations
- Meteorology
  - Wind
  - Temperature,
  - Relative humidity
- Heat flux

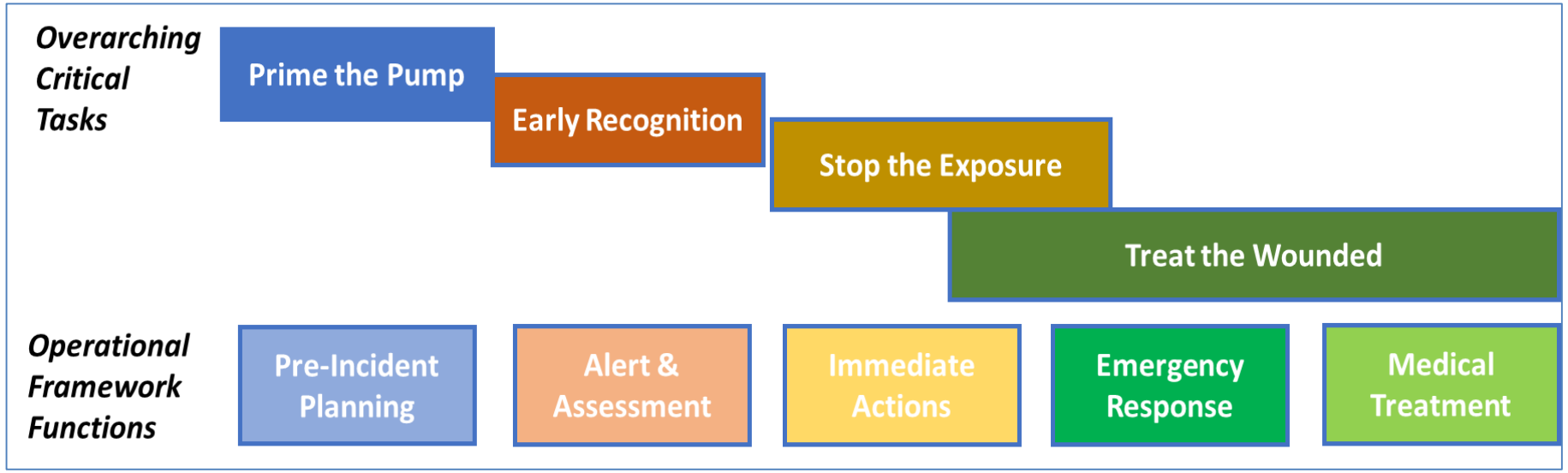


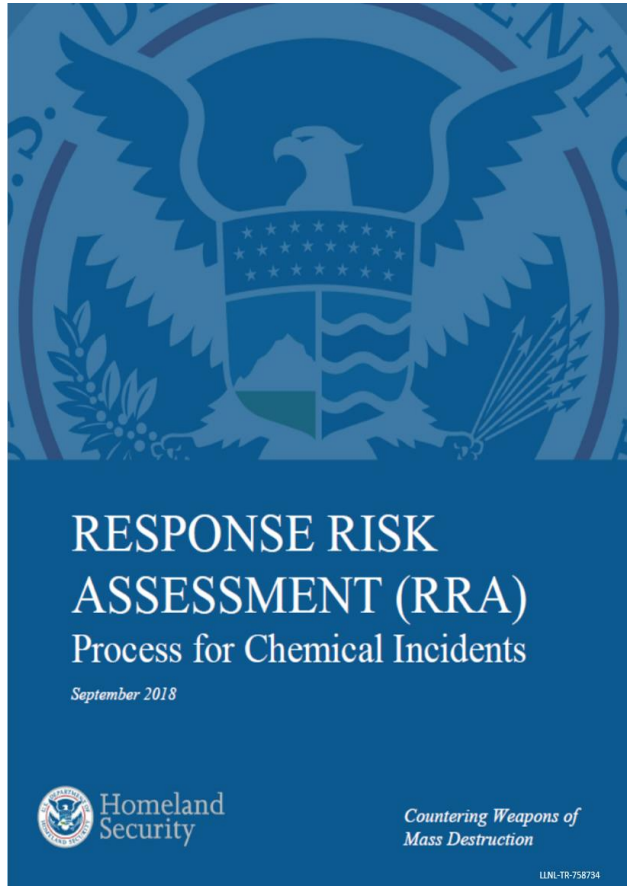
Near spill point ground was cooled more than nearby air

Response Risk Assessment

Response Risk Assessment (RRA) Introduction

- For mass casualty chemical incidents, a Response Risk Assessment
  - **Evaluates community** response **capacity** and **capability**
  - Supports **planning by testing and validating** capabilities.
  - **Illustrates potential outcomes**.
- Developed under **DHS CWMD** sponsorship

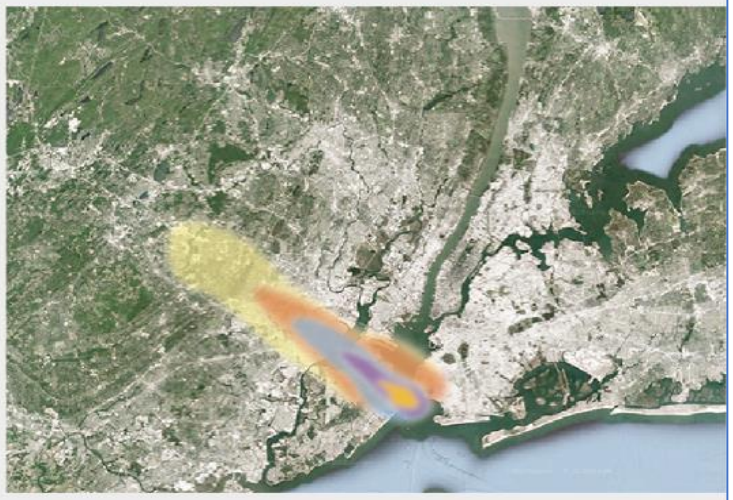




Example Case Study

SCENARIO #1

A local chemical plant located near schools, restaurants, parks, and other infrastructure has the potential for release from a fire, earthquake, terrorist attack, etc.



RRA TEAM TASK

A plume model is developed and indicates the potential for exposure to the surrounding infrastructure and local populations.

ACTION

Partners/stakeholders discuss their emergency response to the procedure.

LESSON LEARNED

- Early warning systems that convey key instructions and information to areas at risk (e.g. shelter-in-place) are critical to preventing exposure
- Transportation capacity to hospitals (if needed) is critical for treatment and saving lives
- Hospital staff capabilities are critical for treatment and saving lives

RRA Outcome
Improved Community Resiliency

Bring partners together to work through real-world examples of potential outcomes

Understand strengths and weakness of **current response capabilities**

Develop emergency response **improvement plans** which

- Identify specific improvement actions
- Have stakeholder support to implement and track

Partner interactions during the RRA create opportunities for new capabilities.

Thank you for your attention

For additional information,

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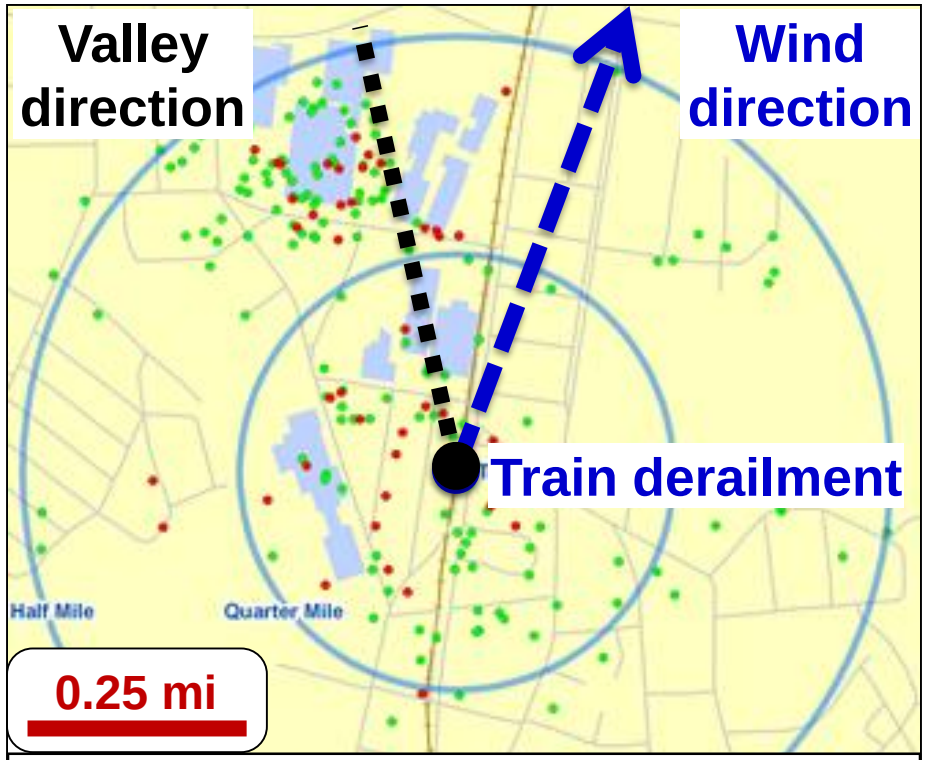
“At-risk” vs. “affected” considerations
Terrain effects

Plume moves along valleys and streets

Impacted areas may

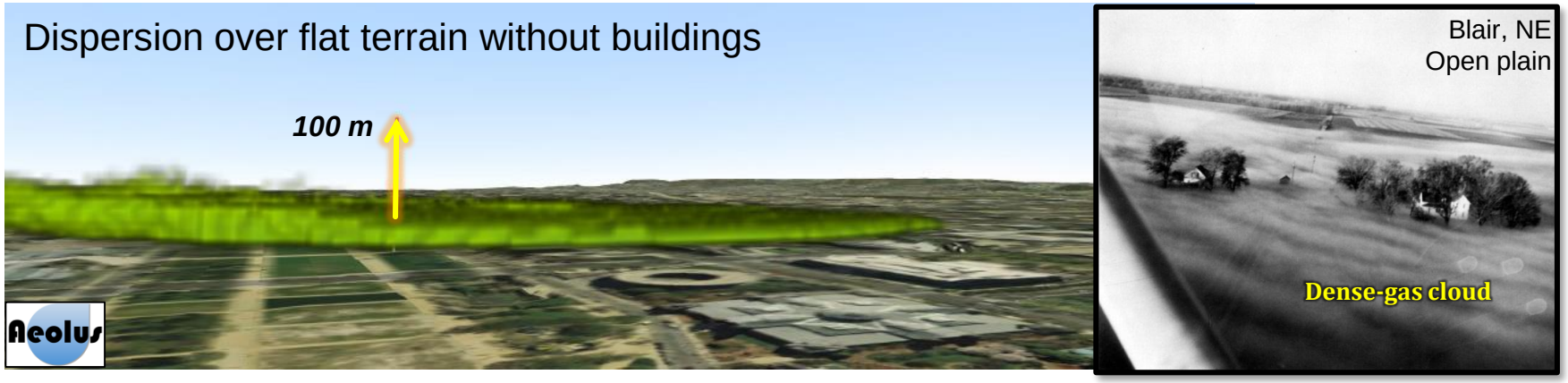
- **Not align with winds**
- **Widen** relative to the “flat-earth” case

Graniteville, SC chlorine accident



Original image courtesy of South Carolina Department of Health and Environmental Control

“At-risk” vs. “affected” considerations
Urban and forest effects



Going up to escape the plume may be less effective in urban environments

Top photo credit: Enterprise Publishing Company, Blair, N.E.
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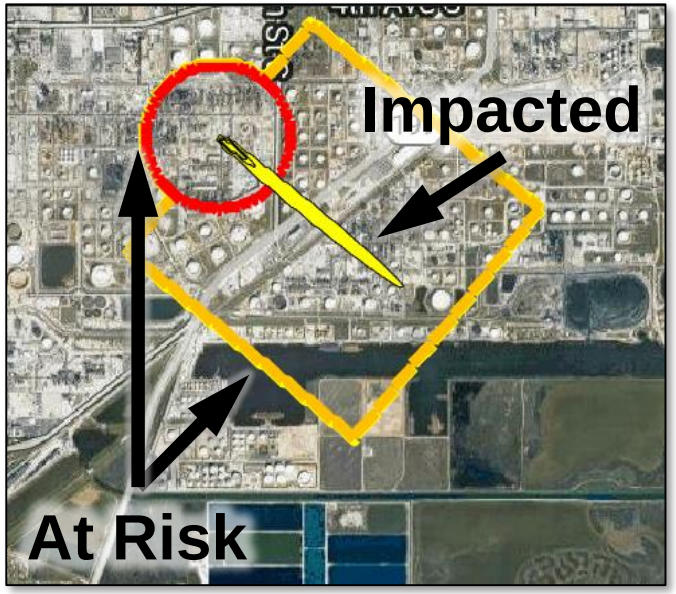
“At-risk” vs. “affected” considerations

Weather



The **plume** may **impact** only a **portion of the region** at-risk

(which portion can be hard to determine)

Material Released

Photographer unknown

In the Graniteville, SC accident, only **half** of the chlorine **escaped to the atmosphere**

“At-risk” vs. “affected” considerations

Mitigation Measures

Water spray on HF cloud

Properly configured, **water sprays** can **reduce** HF **concentrations by 95 %.**

Environmental Losses

Vegetation damage after Graniteville, SC chlorine accident

Deposition may reduce the hazard extent