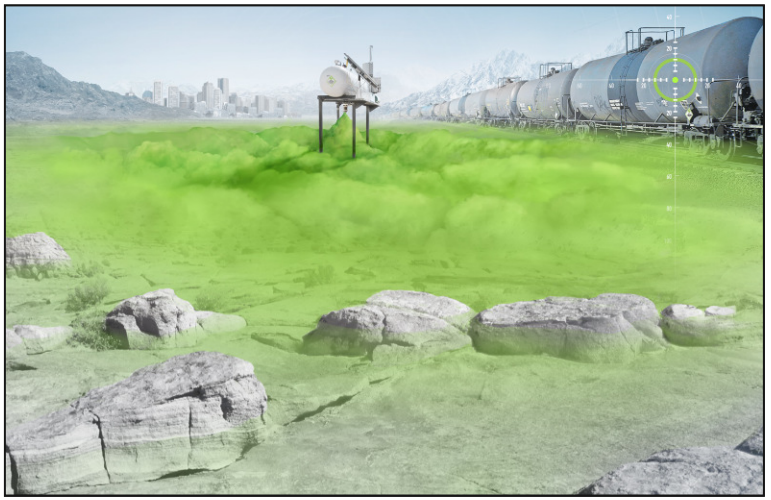
The DHS S&T CSAC and CI CRADA

New Chlorine Modeling, Pamphlet 74 Updates, and the Jack Rabbit II Program

November 12, 2014
Clorosur



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Chemical Security Analysis Center
DHS Science & Technology

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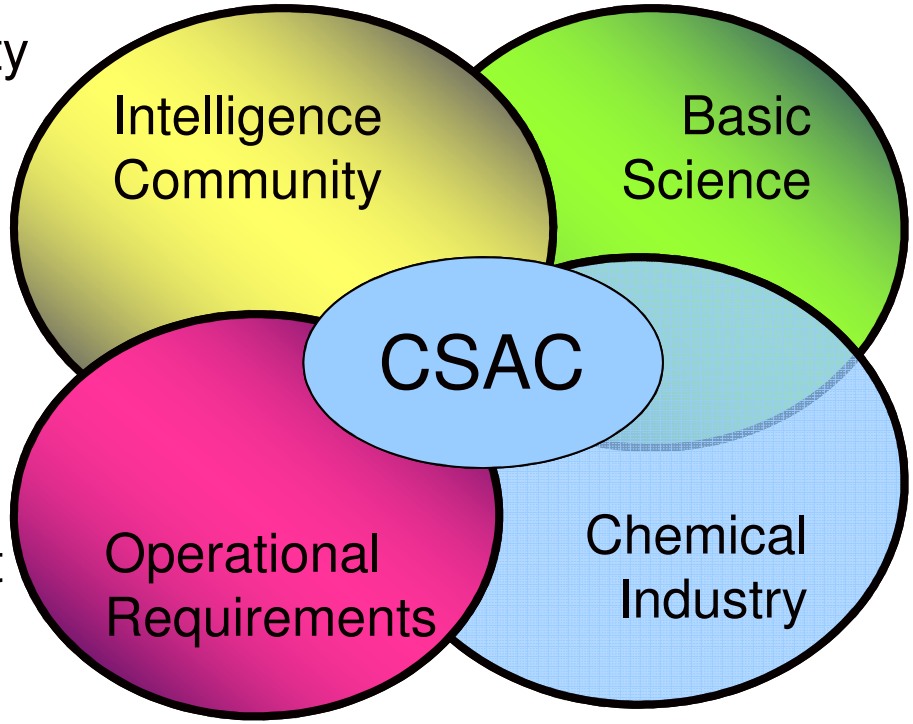
Chemical Security Analysis Center

Mission: To provide analysis and scientific assessment of the chemical threat against the American homeland and American public.

- Part of U.S. Dept. of Homeland Security
- Chemical hazard awareness, assessment and analysis
- Science-based assessment of risk
- Integration and analysis of chemical threat information and data
- Reachback capability to provide expert analysis support
- Fusion of information from different communities



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DHS CSAC and CI - CRADA

- CSAC and CI both share the goal of reducing the hazards and risks associated with chlorine
  - CI: Pamphlet 74 and other publications
  - CI: CHLOREP team training for hazard/risk reduction, resiliency
  - CSAC: Chlorine Hazard Assessment, CTRA
  - CSAC: Project Jack Rabbit
- CSAC and CI formalized collaboration to work together toward goals in 2013 with a CRADA
  - Cooperative Research and Development Agreement
  - CSAC: Use the findings from 2010 Jack Rabbit program to conduct updated modeling and guidance for Pamphlet 74
  - Work together at annual CHLOREP team training
  - Jointly plan and support the new 2014-2017 Jack Rabbit II chlorine release experiments

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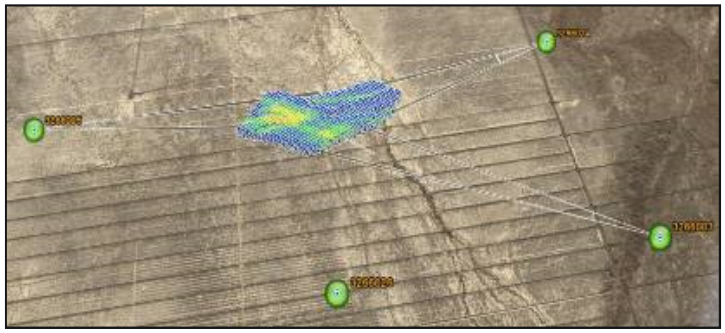
2010 Jack Rabbit I Trials

- Conducted during 4 weeks, Apr-May 2010 with Ammonia and Chlorine
- Total of 10 successful trials (2 pilot, 8 record)
- Extensive array of instrumentation deployed empirically recording various aspects of the chemical releases
- High definition video documentation captured from multiple angles
- DOD electronics and material exposure studies
- Industry and Government detector evaluation
- First recorded observation of previously unreported violent chemical eruptions (Rapid Phase Transitions)
- Weather variation provided a range of different conditions



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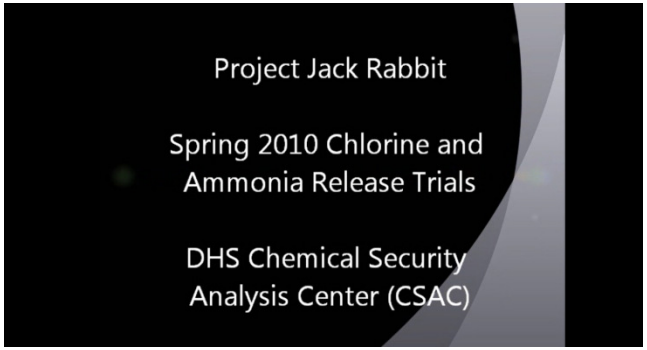
Jack Rabbit I - Release Videos

Trial	Date	Chemical	Amount
Pilot-NH_3	07-APR-10	Ammonia	1 Ton
Pilot-Cl_2	08-APR-10	Chlorine	1 Ton
01-RA	27-APR-10	Ammonia	2 Tons
02-RA	01-MAY-10	Ammonia	2 Tons
03-RC	03-MAY-10	Chlorine	2 Tons
04-RC	04-MAY-10	Chlorine	2 Tons
05-RC	05-MAY-10	Chlorine	2 Tons
06-RC	07-MAY-10	Chlorine	2 Tons
07-RA	20-MAY-10	Ammonia	2 Tons
08-RA	21-MAY-10	Ammonia	2 Tons



- Numerous videos were recorded
- Standard and high-definition
- Several different viewing angles for each trial

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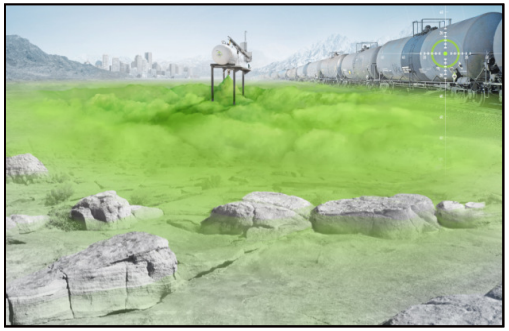
Jack Rabbit I - Findings

- Turbulent mixing is initially resisted by dense gas, resulting in cloud persistence near release
- Chlorine Rapid Phase Transition eruptions present an previously unknown hazard & more with impingement
- Behavior of source was observed to be **non-linear** with increasing release volumes
- For the determination of deposition with soil as a loss term for chlorine:
  - [Cl–] results from the top 1.3 cm vertical fractions were used
  - Analyses involved trials with low-wind (≤1.6 m/s) conditions.
  - **The analysis revealed up to 50% of a 1814-kg chlorine release could be removed within 20 m from the release point for soil with high organic matter (43%) and/or water content (29%).** *
    Journal of Hazardous Materials 252– 253 (2013) 107– 114.



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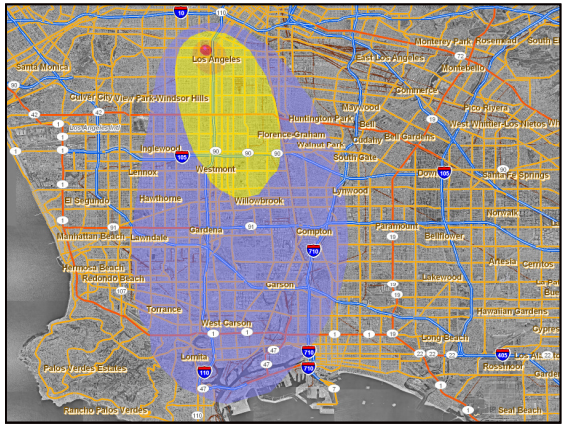
CSAC Modeling Capability

- CSAC Modeling team performs modeling and analysis to conduct chemical threat assessments and tailored assessments.



- CSAC Modeling Capability includes:
  - HPAC (Hazard Prediction and Assessment Capability) – Atmospheric dispersion and transport model created by DTRA (Defense Threat Reduction Agency). Has the capability of using high fidelity weather data to calculating the transport of chemical, biological, and radioactive agent in the atmosphere.
  - ALOHA (Areal Locations Of Hazardous Atmospheres) – Atmospheric dispersion model created by EPA.
  - QUIC (Quick Urban and Industrial Complex) – Urban Atmospheric dispersion model created by LANL. Has the capability of calculating the transport of contaminants through urban environments using calculated wind flow patterns and building layout data.
  - CONTAM – Indoor airflow model developed by NIST. Has the capability of calculating the transport of contaminants within an indoor setting.

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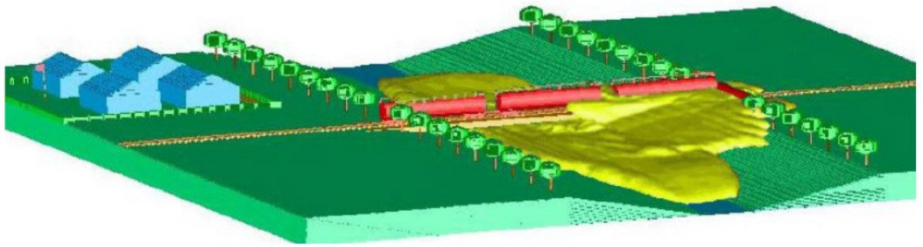
Reasons for Update

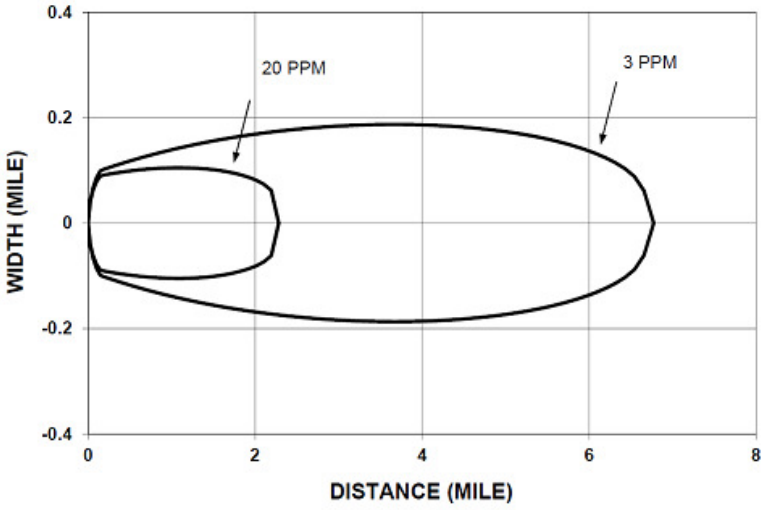
- Purpose: The current Pamphlet 74 is dated and does not incorporate new data and modeling techniques.
- Need:
  - Incorporate newer modeling techniques.



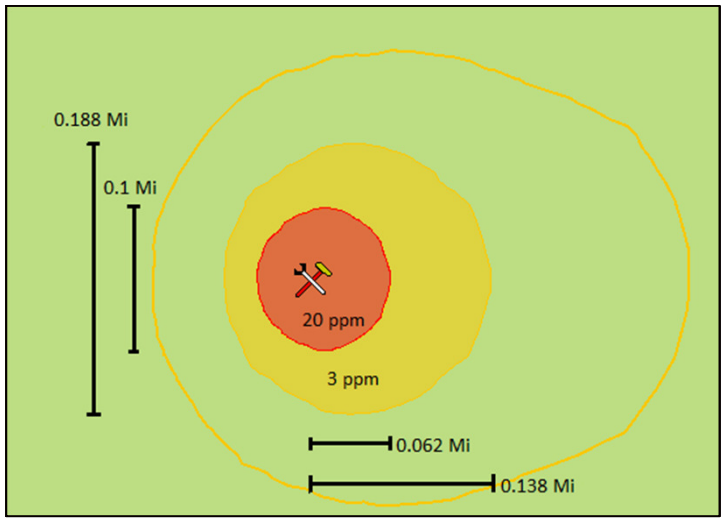
  - Incorporate information gathered from the Jack Rabbit Field Trials which provide improved understanding of dense-gas behavior and chemical reactivity.
  - **Improve accuracy of results to better reflect real life scenarios**
- Solution: Perform modeling using updated model (HPAC) and data retrieved from the Jack Rabbit field trials.
- Output: Updated modeling output that can be used to improved capabilities and efficiencies in planning, response and mitigation
  - Experimentally informed, improved modeling
  - Resiliency - better planning, emergency response
  - Vulnerability and impact reduction - Risk mitigation

Pamphlet 74 Updates

- Performed Q1 of 2014
- All scenarios in the previous Pamphlet 74 were reinvestigated
- CSAC used HPAC model updated with new data learned in Jack Rabbit
- New modeling uses chlorine reactivity to remove it
- New hazard footprints were retrieved along with updated maximum concentration plots and time history plots.



Original TRACE Example



Updated HPAC Example

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TRACE v HPAC (using updated data)

TRACE (original)	HPAC (using updated data)
TRACE is commercial model used widely by industry	HPAC is the accepted standard model used for threat assessments by multiple government agencies.
Did not consider chlorine being removed through reactivity	Includes chlorine's removal through reaction with soil
Only considers chlorine reactivity for scenarios involving fires & explosions	Considers chorine reacting away with the terrain
Limited meteorological options – for lower wind speed, stability	Updated accounting for stable, low winds, persistence near release site
Concentration footprints depict maximum concentrations	Concentration footprints depict time averaged concentrations

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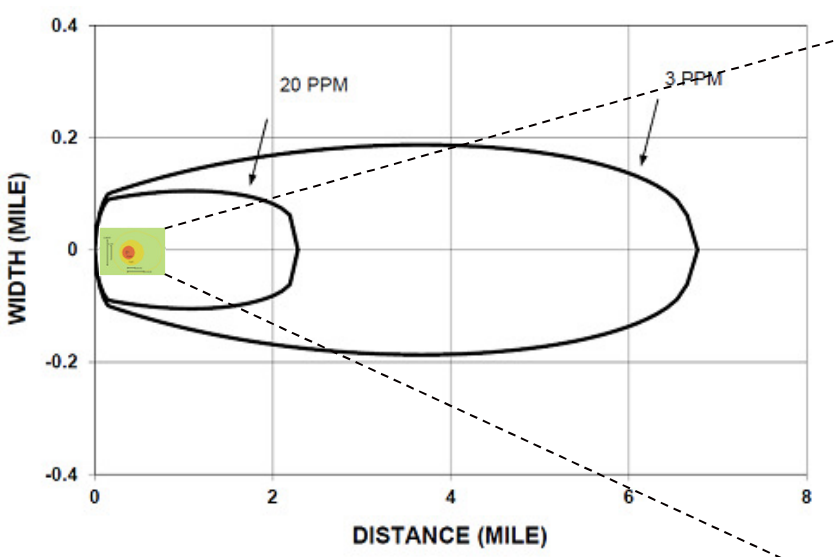
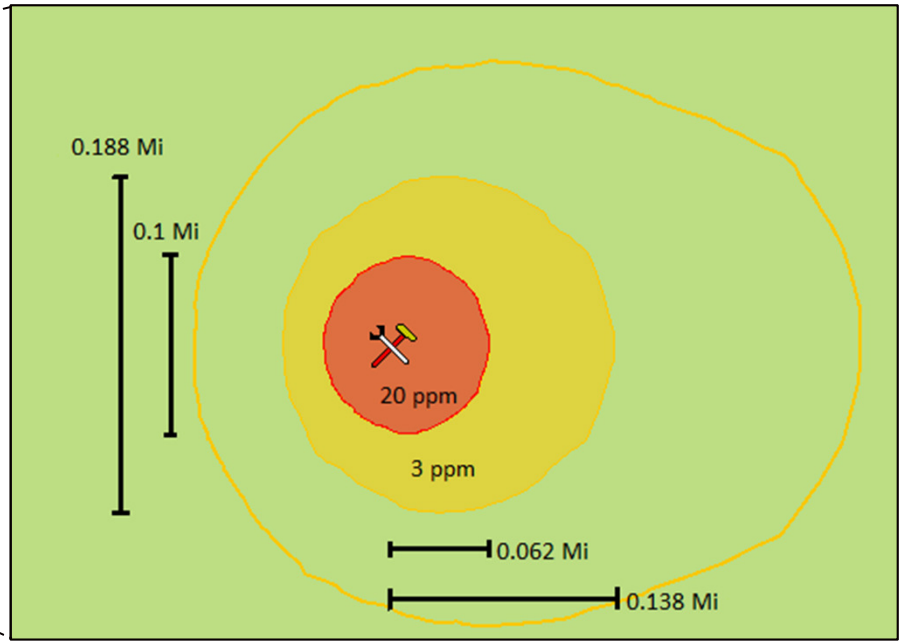
How Results Differ



1 ton release previous version



1 ton release updated modeling

Updated modeling shows dangerous concentration levels (ERPG-2 and -3) extend much shorter distances, both downwind and laterally.

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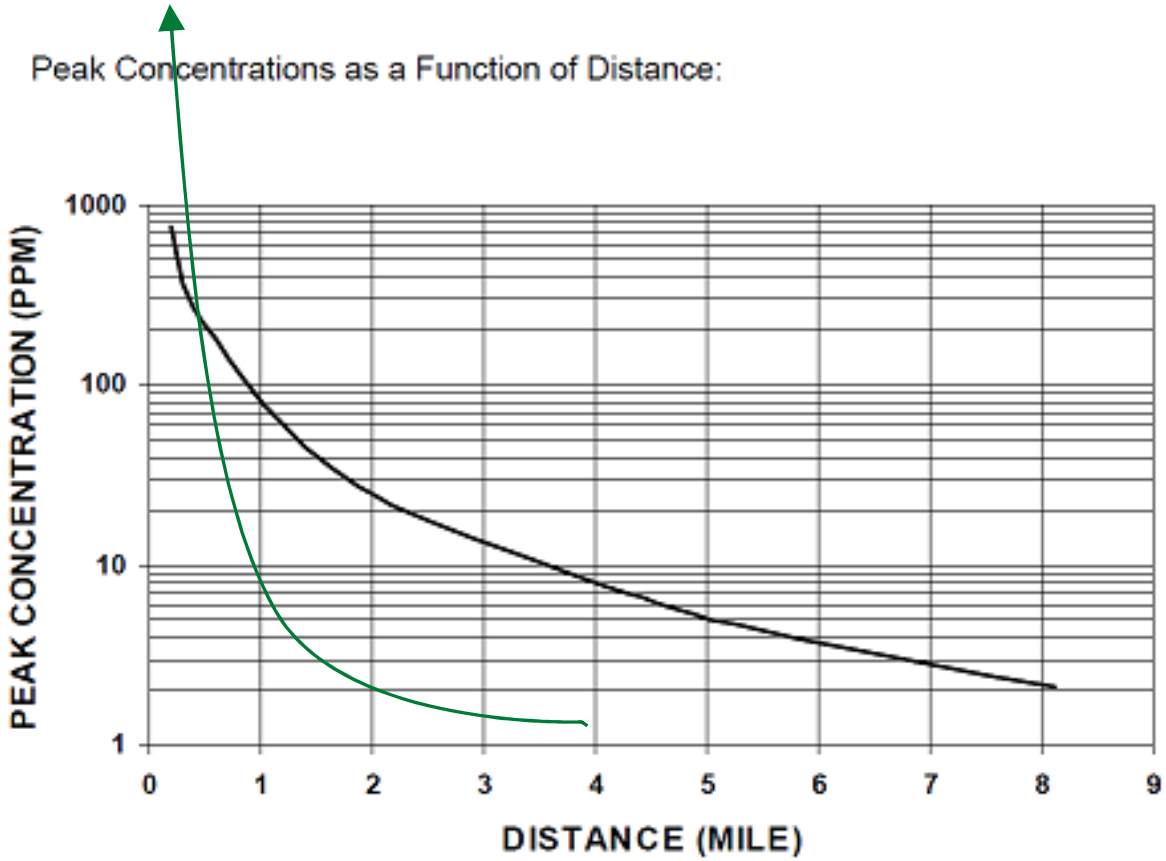
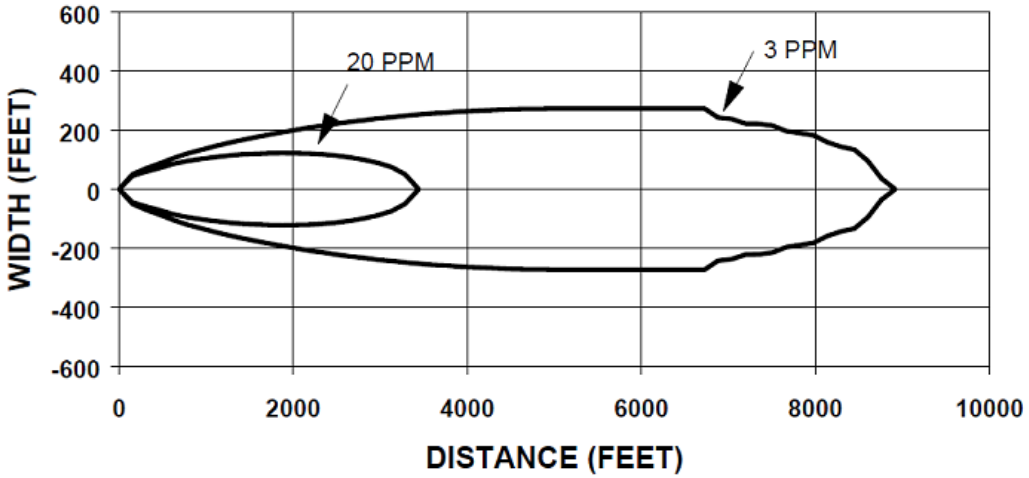
How Results Differ



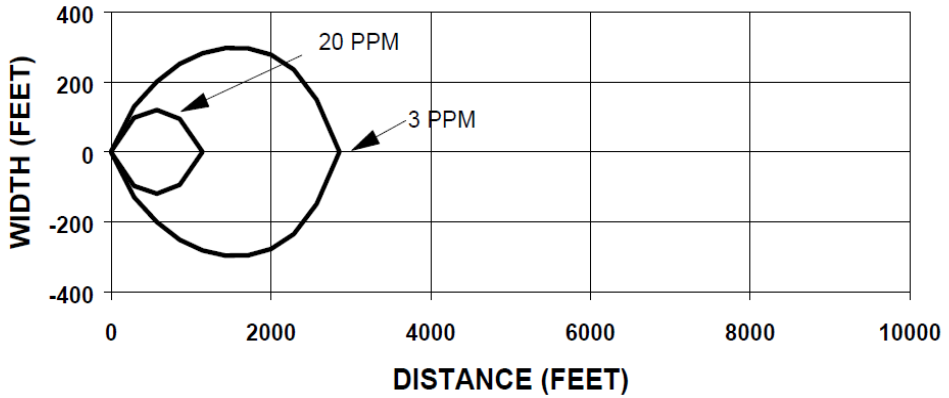
- 1-Ton Release: Updated modeling shows that higher chlorine concentrations remain closer to the source.
  - **Black: Original**
  - Green: Updated

How Results Differ

Original



Updated



Updated modeling show that under F stability (highly calm, stable atmosphere) the plume does not travel as far downwind.

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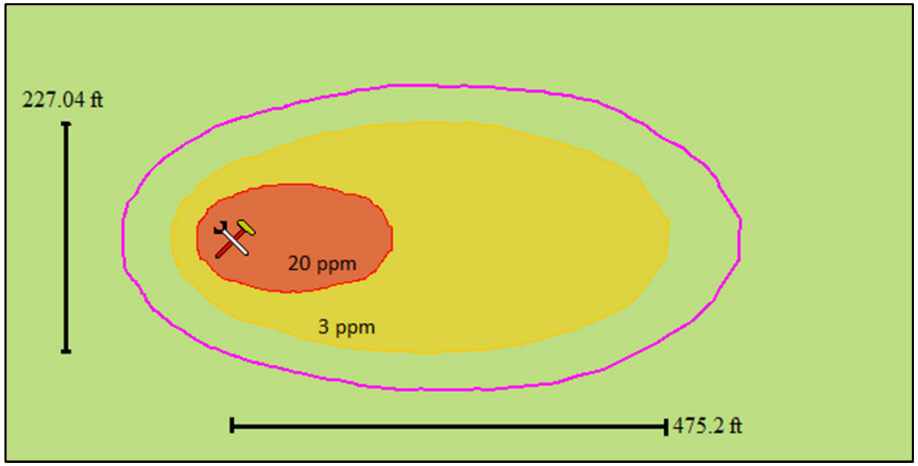
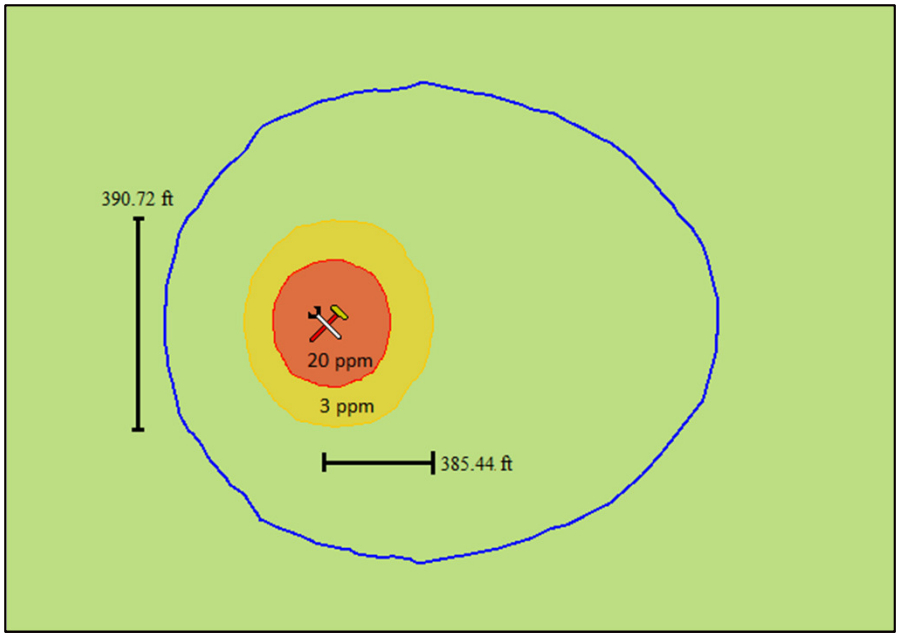
How Results Differ

D Stability



F Stability



Updated modeling shows that lower wind speeds and stable atmosphere (D and F stability) do not carry the plume as far down wind as previously expected.

CI / DHS CSAC Project - Summary

- The Need:
  - Incorporate newer modeling input data and advances.
  - Incorporate information gathered from the Jack Rabbit Field Trials which provide improved understanding of dense-gas behavior and chemical reactivity.
  - Improve accuracy of results to better reflect real life scenarios

- Use of New Modeling:
  - HPAC was used to calculate the transport of chlorine
  - New deposition data from the Jack Rabbit field trials and literature were used in the modeling.
  - Time averaged concentrations were used instead of maximum concentrations were used in the analysis

- Results:
  - With the use of new data and modeling techniques, chlorine plume did not travel as far as previous modeling has shown
  - New modeling shows a faster drop in concentration as downwind distance increase
  - New modeling shows the plume in low wind and stable atmosphere (night release - F stable) does not travel as far downwind as previously modeled

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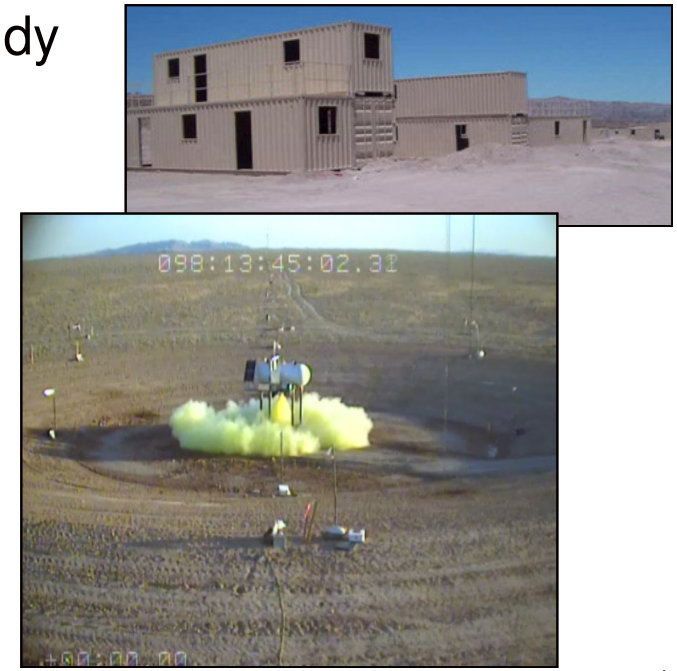
Jack Rabbit II

Conduct a new series of open-air chlorine release trials in a multi-agency effort, building upon the work achieved in Jack Rabbit I

- Large volume chlorine field releases from 5 to 20 tons
  - Continuing evolution of higher quantity releases – scaling is non-linear
  - 20 tons represents 100% of tanker truck transport volume, and a large fraction of a railcar release
- Construct a mock-urban test environment at Dugway Proving Ground to be impacted by release cloud
- Largest & most comprehensive source term study
- Longest down-wind dispersion study of its kind
- Quantitative determination of chlorine removal via reactivity with soil, atmosphere, vegetation, metals, urban surfaces, and photolysis



Anticipated Jack Rabbit II Results
- **Tanker size Source Terms**
- **Downwind Concentrations**
- **Soil and Vegetation Effects**
- **Data on Mitigation Strategies**
- **Equipment & Detector Validation**

Jack Rabbit II Objectives

Success for the Jack Rabbit II Program will be achieved through the accomplishment of these primary objectives:

1. Conduct a series of large-scale chlorine field release trials at operationally-relevant volumes (5 to 20 tons) to experimentally fill critical knowledge and data gaps needed to ***improve modeling*.**

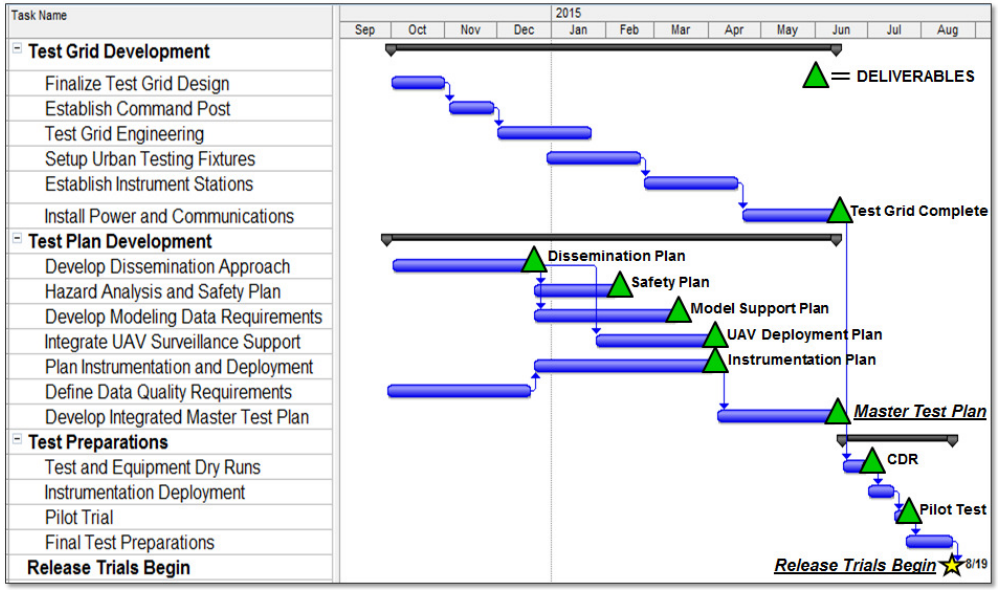
2. Experimentally investigate and quantify ***chlorine reactivity and exposure impacts*** on materials, equipment, urban infrastructure, and the surrounding environment.

3. Conduct targeted experiments to develop data, materials, training opportunities, and guidance to ***enhance emergency response*** capabilities, efficiencies, safety, and procedures.

4. Experimentally investigate, analyze and scientifically evaluate potential chlorine cloud and ***hazard mitigation strategies.***

Jack Rabbit II - Timeline

- FY14: Coordination with stakeholders and partners; approvals and compliance; test plan development
- FY15: First series of release trials
- FY16: Analysis of initial release trials; planning and execution of second series of release trials
- FY17: Analysis Phase
  - Data quality
  - Data reduction
  - Data distribution
  - Transition efforts
- FY17+: Transition Phase
  - Emergency responders
  - Emergency planners
  - Trainers
  - Industry
  - Modeling community – enhanced methodologies



18

Partnership Opportunities

- Seeking additional partnerships with key stakeholders
- Several organizations have already committed financial support or plans to participate in Jack Rabbit II
- Potential partnership and support opportunities:
  - Direct investment of funding support
  - Contribution of key SME or technical personnel
  - Sponsoring of targeted experiments
  - Fielding and operating instrumentation with mutual data-sharing
  - Conducting or funding critical studies from the resulting data
- Partnership with private-sector chemical industry coordinated through our CRADA with the Chlorine Institute
- To discuss support or participation opportunities contact:

Dr. Shannon Fox, DHS CSAC
Shannon.Fox@st.dhs.gov
410-417-0906

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