SRNL Atmospheric Technologies Group Support for the Graniteville Accident

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Atmospheric Technologies Group
Savannah River National Laboratory

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Incident Details

- Time of accident: 2:39 am Thursday January 6, 2005
- Situation: Norfolk Southern Railroad freight train collides with stationary train parked on a rail spur
- Accident involved rail cars of chlorine, cresol, and sodium hydroxide
- Chlorine greatest airborne concern due to high volatility

Photos Courtesy of Augusta Chronicle

Impacts to Community

- 9 Fatalities
  552 Injuries treated
  69 Patients admitted to local hospitals
- 5400 evacuated - sheltered for 5 days
- 200 evacuated - sheltered for 9 days
- Industry and retail businesses shutdown for 9 days

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SRS Assistance

- SRSFD
  - 16 On duty Haz Mat specialists
- Fire/Haz-Mat/ Law Enforcement Agencies
  - Approximate 30 volunteer members from SRS
- WSRC Emergency Management
  - 7 Critical Incident Stress Counselors

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SRS Assistance (cont.)

- SRS Operations Center (SRSOC)
  - 6 Personnel
  - Logistics requests
  - DOE Headquarters Briefings
  - Department of Homeland Security Briefings
- Wackenhut Services Incorporated
  - 7 Personnel
- SRNL Atmospheric Technologies Group
  - 6 Personnel
  - Consequence modeling & meteorological data
  - Weather forecasting & consulting

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SRNL – Atmospheric Technologies Involvement
Mutual Aid Agreements with Local Gov't

1996 Mutual Aid Agreements with local county EMA offices provides framework for meteorological assistance

- Participants: Aiken, Barnwell, Allendale, Richmond, and Columbia counties
- Agreements Identified three primary areas of collaboration:
  - Meteorological monitoring in critical hazard zones
  - Custom hazard consequence assessment software
  - Consultation and support, as requested

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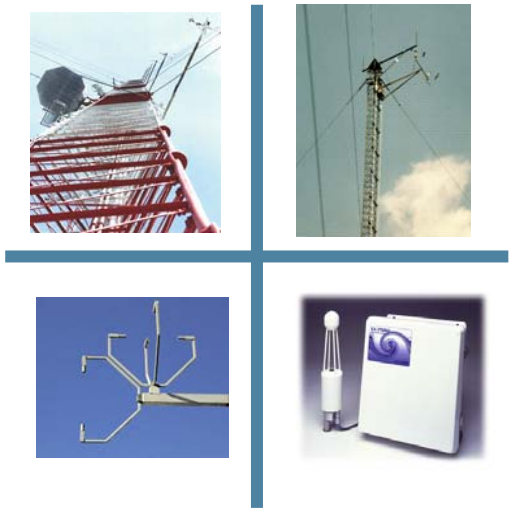
ATG Resources for Emergency Response

- Weather observations data available to SRNL in real-time
  - Towers at SRS and surroundings counties
  - Regional US observations



- Regional and Local Forecast modeling
- Suite of Consequence Assessment Models

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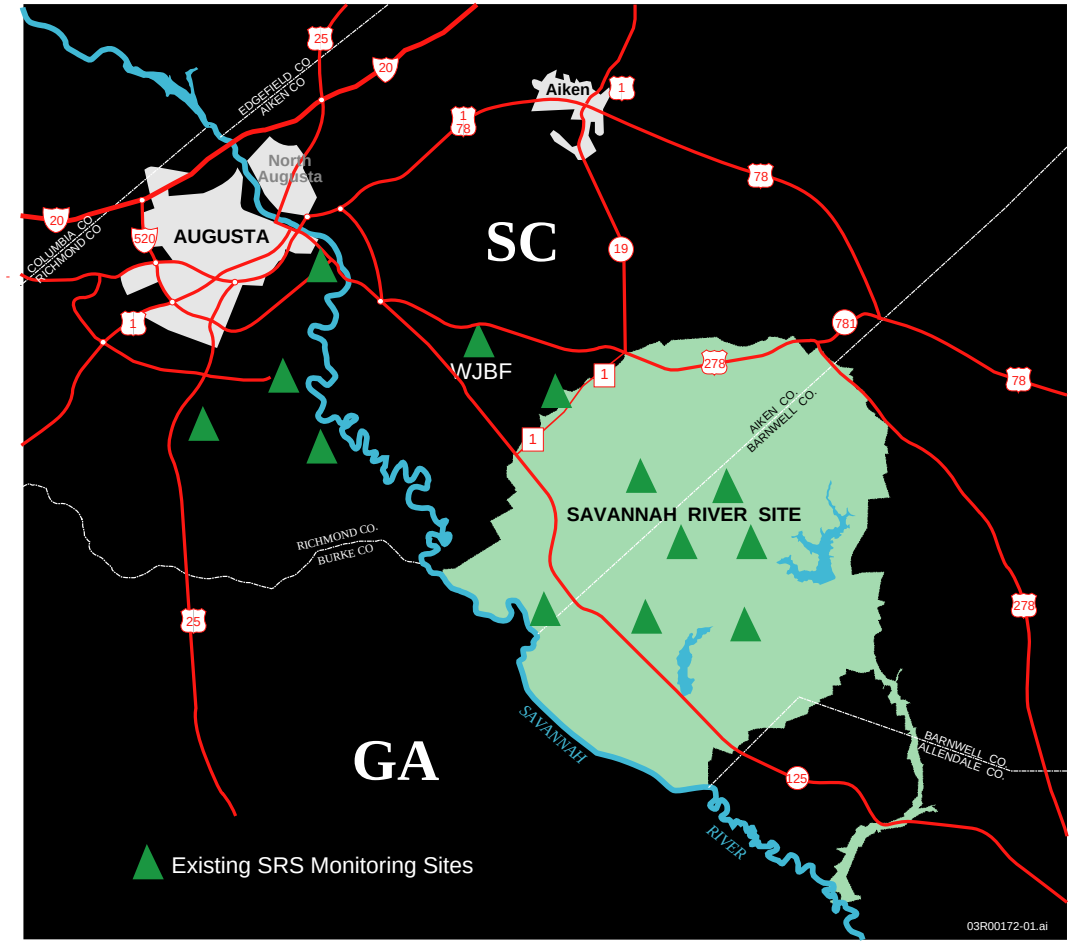
SRS Tower Network

- 9 towers on SRS (200 ft)
- 4 towers Richmond county (120 ft)
- 1500 ft TV tower
- data available every 15 min



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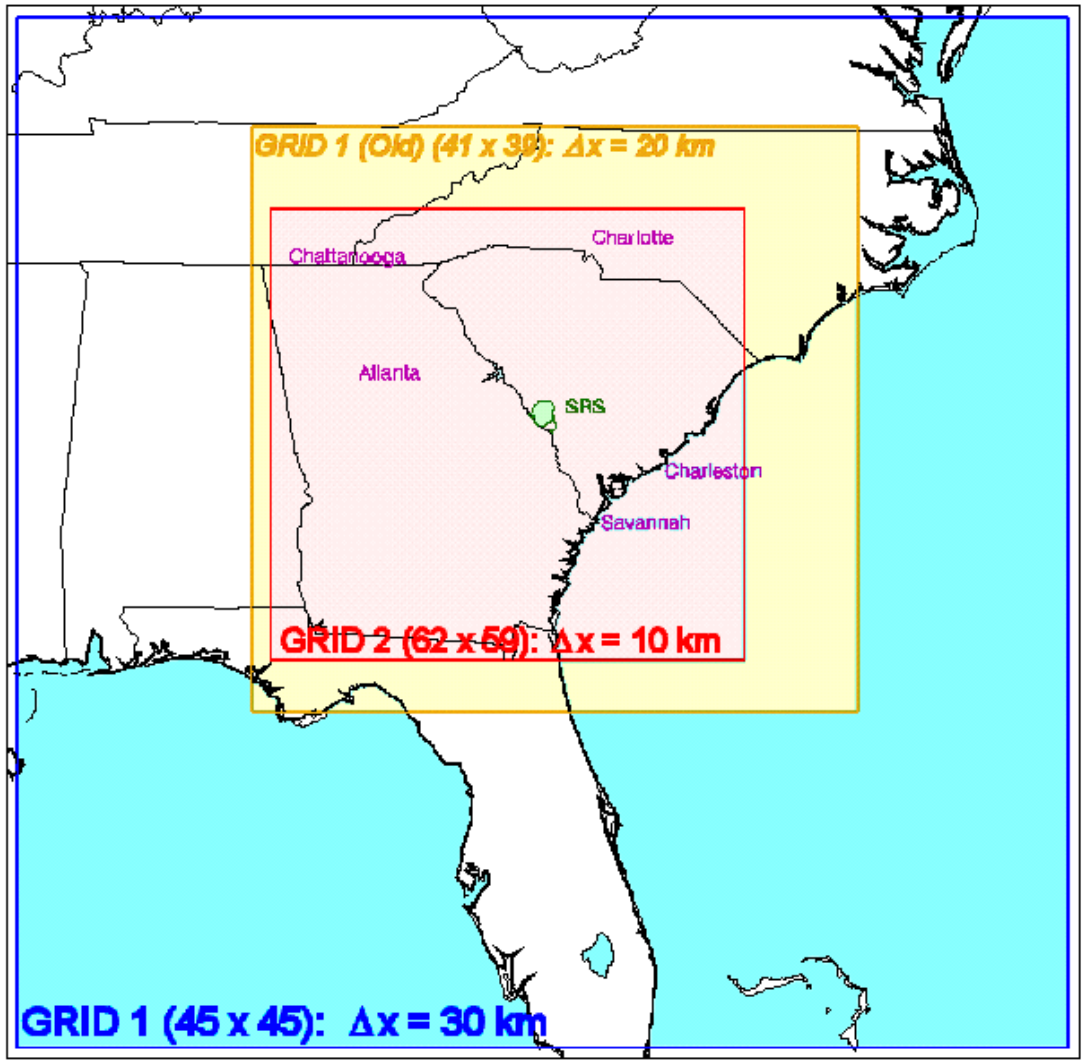
Regional Atmospheric Modeling at SRS

SRNL uses the *Regional Atmospheric Modeling System* (RAMS) for operational forecasts of winds, etc. at SRS for:

- emergency response
- prescribed forest burns
- operational forecasting

- 24-36 hr regional forecasts updated every 12 hrs



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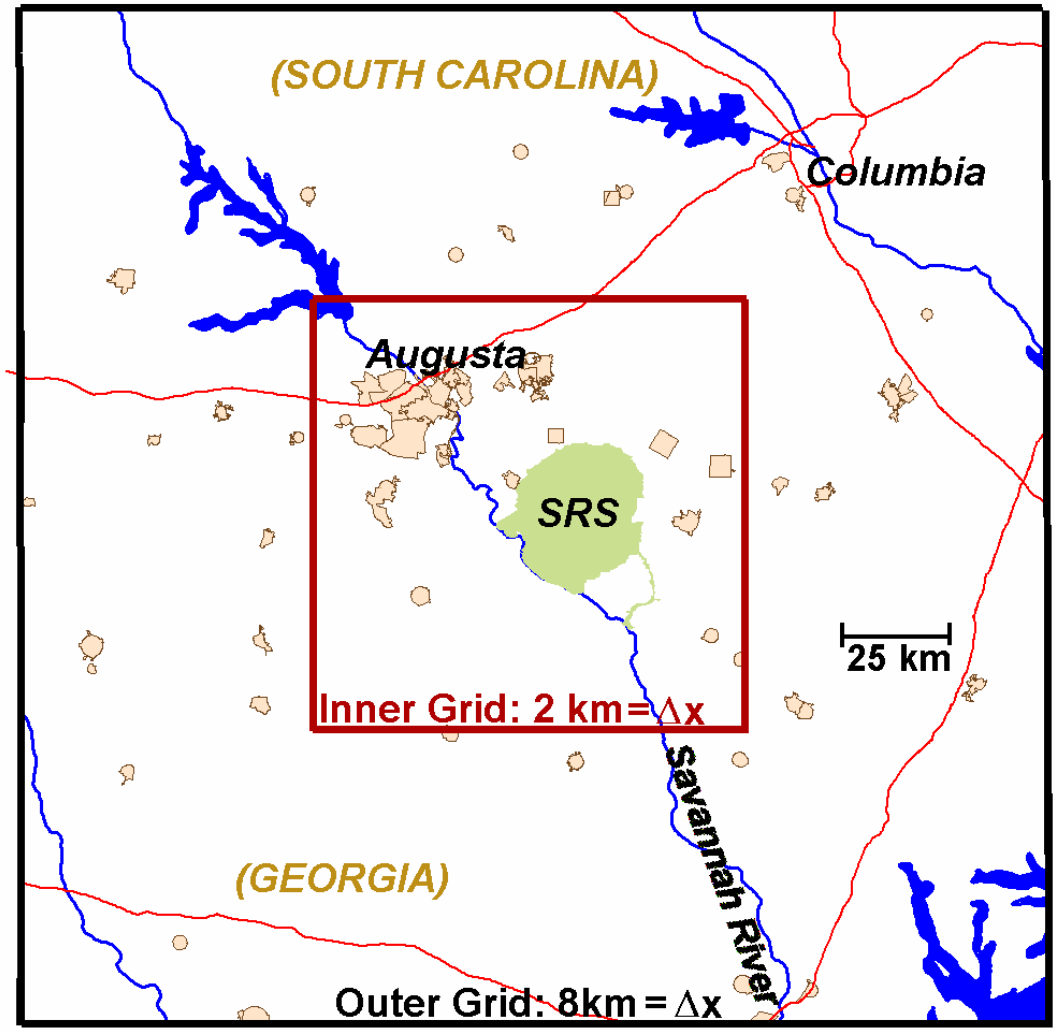
Local Atmospheric Modeling at SRS

SRNL uses RAMS to nest a fine scale forecast for winds etc. at SRS for emergency response

- 6-hour local area forecast updated every 3 hrs



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Consequence Assessment Modeling

- Hierarchical Menu of Consequence Assessment Codes
  - Area Evacuation (immediate phase, < 5 km)
  - Puff / Plume (early phase, 0.5 - 50 km)
  - 2DPUF (early- intermediate phase, 1 - 100 km)
  - LPDM (intermediate phase, 5 - 300 km)
  - Stream II (aqueous)
- Supporting codes:
  - NARAC, CAMEO/ALOHA, HOTSPOT, VSMOKE, HPAC, HYSPLIT

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Synopsis of Meteorological Conditions - Jan 6 (AM)

- High pressure off the Southeast U.S coast producing south to southwesterly flow over Georgia and South Carolina
- Partly cloudy sky with areas of fog
- Observations from the SRS Regional Tower Network

Wind:	SSW 2-4 mph (sfc); 6-8 mph (200 ft)
Temp:	Low 50s F
RH:	90-95%
Atm. Stability:	Slightly stable to neutral

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Initial SRNL Response (Day 1)

- Assistance requested shortly after 7:00 am
- First model result web-posted for external access by 8:00 am
- Updated model results posted throughout the day (every 2-3 hours)
- Ongoing discussions with Aiken County EOC and SC DHEC - briefings on current and forecast weather, model results, etc.
- Weather support for the SRS on-scene responder teams

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Ongoing SRNL Response (Day 2)

- Updated model results posted throughout the day (every 2-3 hours)
- Ongoing discussions with Aiken County EOC - briefings on current and forecast weather and model results.
- Modeling to support recovery actions

  Case 1: Spill of 40% inventory

  Case 2: Spill of 100% inventory

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AUTOMATIC MODE

INTERACTIVE MODE

PRINT SCREEN

METEOROLOGICAL CONDITIONS

08:00 EST 06-JAN-05

Date:	01/06/05	Wind Speed:	7.1 MPH	Mixed-Layer Depth:	1640 FT	Source:	SAM
Time:	09:00 EST	Wind Direction:	206	Plume Direction:	26	Stability Class:	D

MODEL RELEASE SYNOPSIS

Release Site:	UNKNOWN
Release Time:	08:00 EST 06-Jan-05
Release Height:	5 FEET
Model Time:	09:00 EST 06-Jan-05
Model End Time:	09:00 EST 06-Jan-05
Total Release:	1.80E+04 LBS

Legend

20 ppm

3 ppm

1 ppm

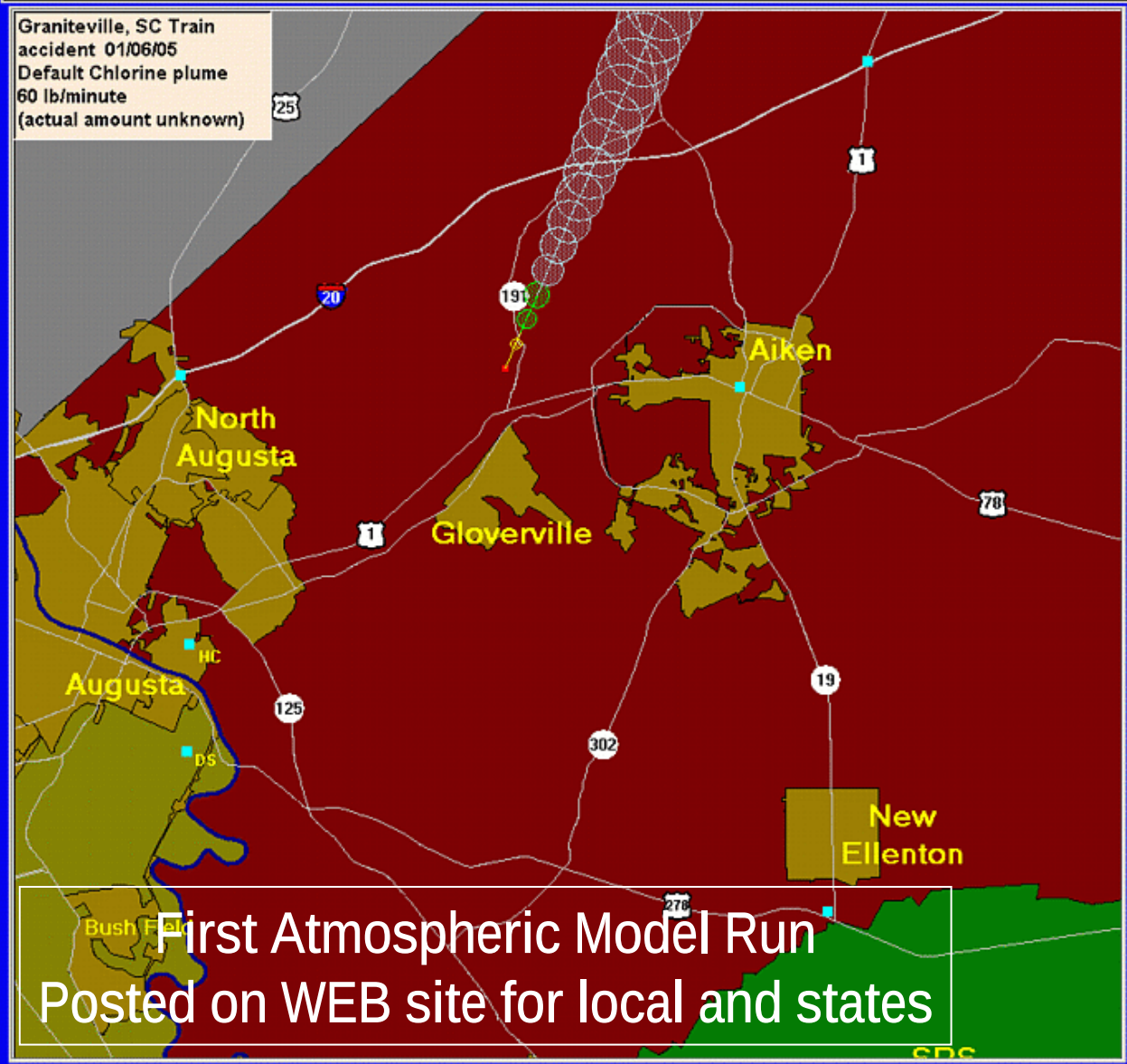
0 ppm

Known Positions

Forecast Positions

CHLORINE

Arrival Time (hh:mm)	Distance (miles)	Conc (ppm)
08:15 EST	2.4	8.2E-01
08:19 EST	3.0	6.2E-01
08:24 EST	3.5	5.0E-01
08:28 EST	4.1	4.2E-01
08:31 EST	4.7	3.6E-01
08:36 EST	5.3	3.2E-01
08:40 EST	5.9	2.8E-01
08:43 EST	6.5	2.6E-01
08:47 EST	7.1	2.4E-01
08:52 EST	7.7	2.2E-01
08:56 EST	8.3	2.1E-01
09:00 EST	8.9	2.0E-01



First Atmospheric Model Run
Posted on WEB site for local and states

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ATmospheric Technologies Group

XY – PLOTS

Maximum Concentration Vs. Downwind Distance

Plume Height Vs. Downwind Distance

Duration Exposure Vs. Downwind Distance

SELECT BACKGROUND MAP

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AUTOMATIC MODE

INTERACTIVE MODE

PRINT SCREEN

METEOROLOGICAL CONDITIONS

13:21 EST 07-JAN-05

Date:	01/07/05	Wind Speed:	7.2 MPH	Mixed-Layer Depth:	3281 FT	Source:	SAM
Time:	14:40 EST	Wind Direction:	188	Plume Direction:	8	Stability Class:	A

MODEL RELEASE SYNOPSIS

Release Site:	UNKNOWN
Release Time:	12:40 EST 07-Jan-05
Release Height:	2 FEET
Model Time:	14:39 EST 07-Jan-05
Model End Time:	14:39 EST 07-Jan-05
Total Release:	2.16E+05 LBS

Legend

20 ppm

3 ppm

1 ppm

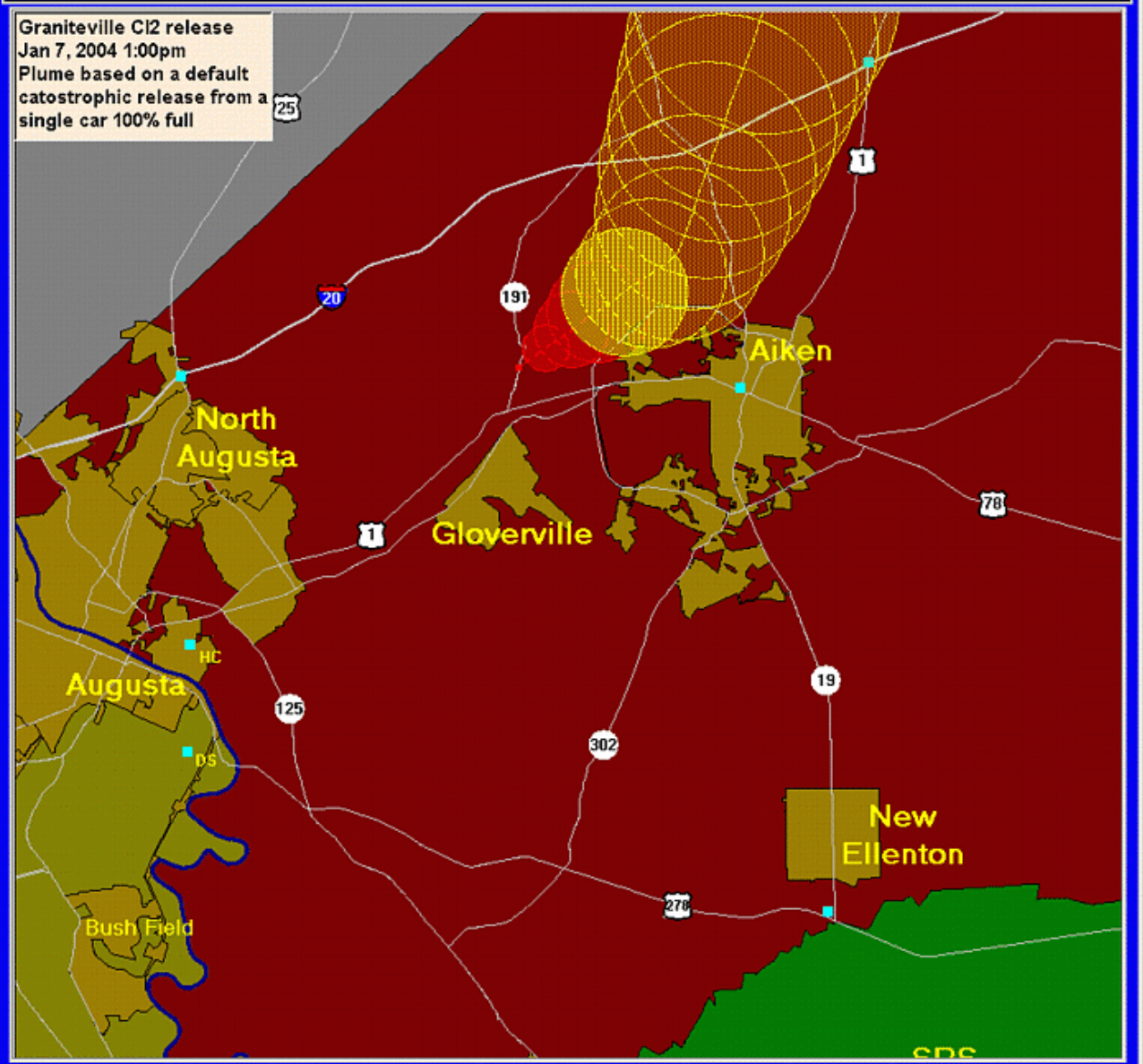
0 ppm

Known Positions

Forecast Positions

CHLORINE

Arrival Time [hh:mm]	Distance [miles]	Conc [ppm]
12:49 EST	0.7	1.6E+02
12:59 EST	1.4	4.9E+01
13:10 EST	2.2	2.4E+01
13:19 EST	2.9	1.7E+01
13:29 EST	3.6	1.4E+01
13:39 EST	4.3	1.2E+01
13:48 EST	5.3	1.0E+01
14:00 EST	6.3	9.0E+00
14:09 EST	7.3	8.3E+00
14:19 EST	8.3	7.7E+00
14:30 EST	9.2	7.3E+00
14:39 EST	10.2	6.9E+00



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LPDM: Concentration Loop

- Assume continuous unit release from crash site from 0240 LST to 1900 LST, 06 January.
- Dense gas *not* modeled here. Indication of general transport only.
- Transport directed between N and NNE.

Post-Accident Analyses

- Surveys of the area - mapping vegetation damage
- Detailed simulations of local winds (RAMS)
- Transport Modeling (LPDM, HPAC)

Courtesy: Robert Buckley

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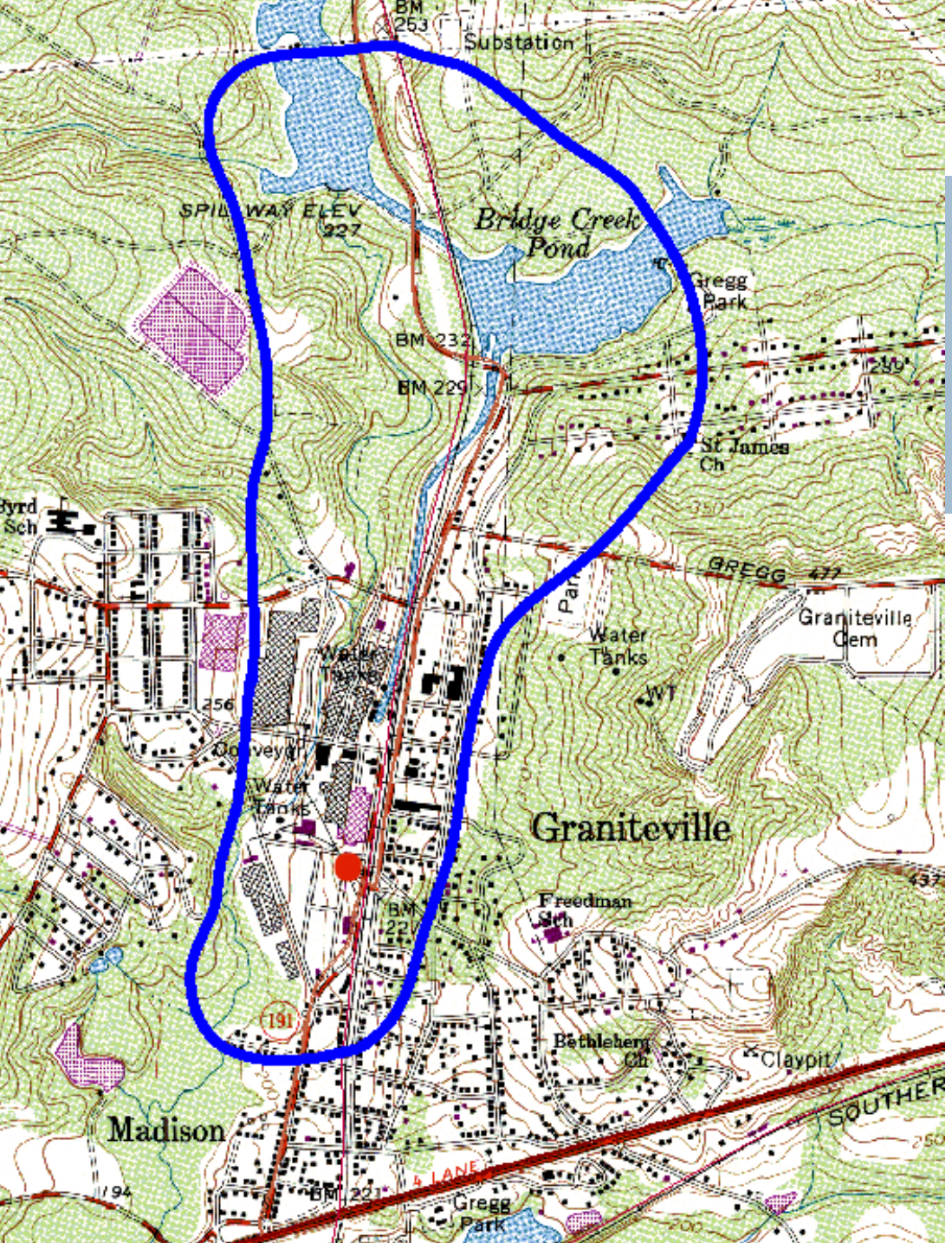
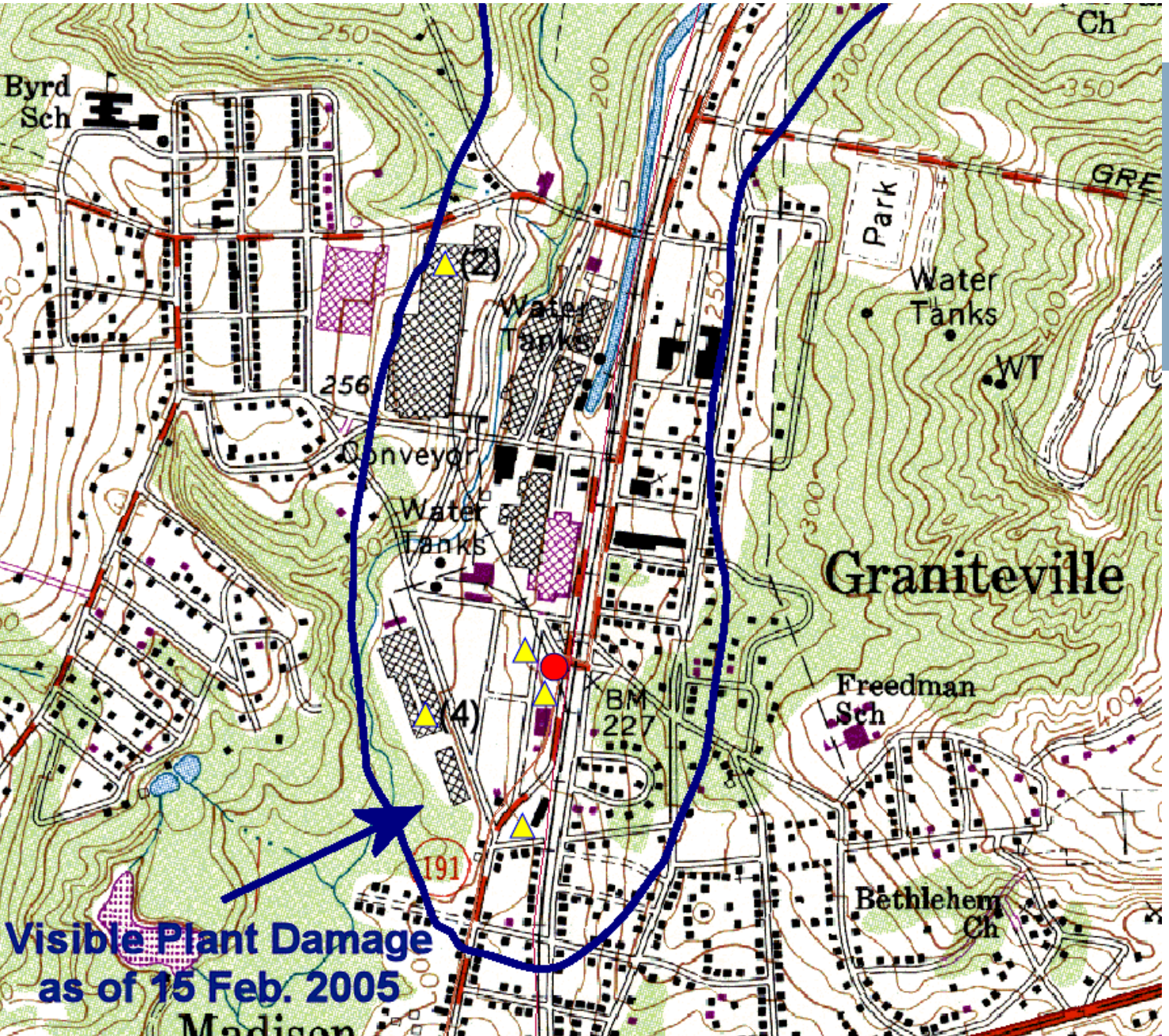


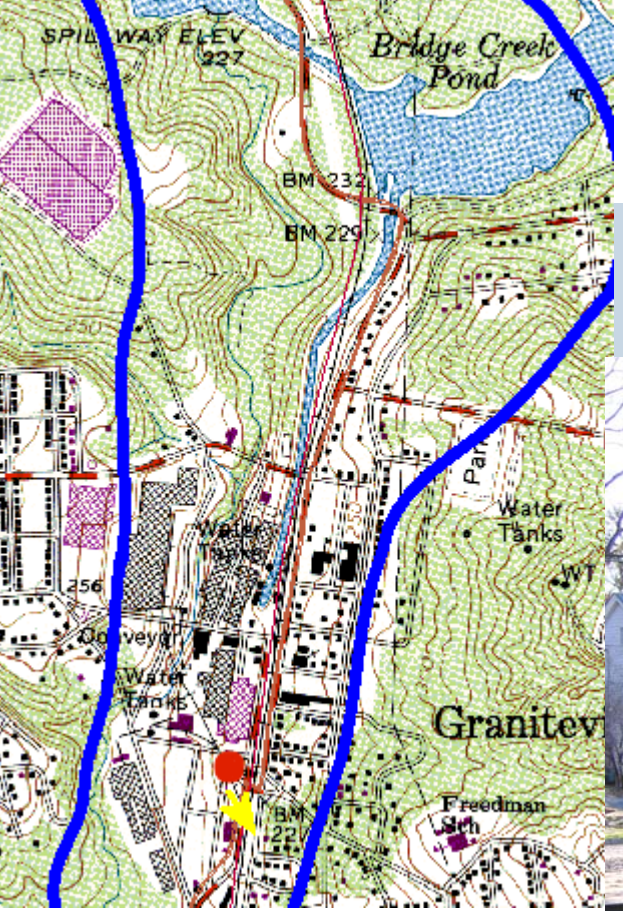
Map of Graniteville

- Collision site (RED DOT)
- Estimated spatial extent of damage to plant life in the area (blue line)
- Suggests threshold concentration of approx 5 ppm

Closer Look at Graniteville



- Collision site (RED DOT)
- Estimated spatial extent of damage to plant life in the area (blue line)
- Fatalities (yellow triangle)



Closeup of railroad track “spur”

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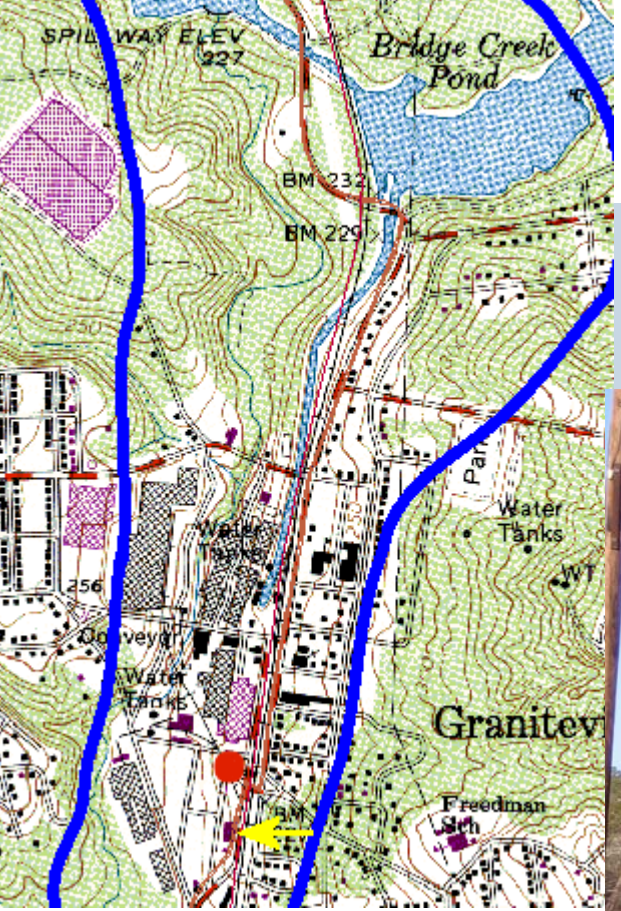
Dying pine tree due south of crash site



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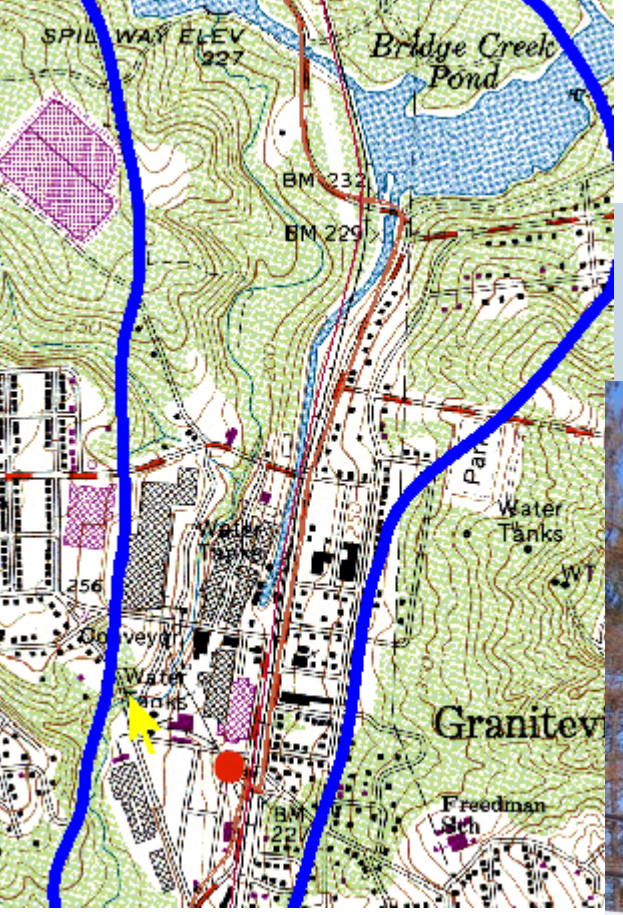

Note the green tree tops. Possible indication of plume depth.

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AUTOMATIC MODE

INTERACTIVE MODE

PRINT SCREEN

METEOROLOGICAL CONDITIONS

10:23 EST 09-FEB

Date:	01/06/05	Wind Speed:	7.0 MPH	Mixed-Layer Depth:	1640 FT	Source:	MA
Time:	03:50 EST	Wind Direction:	205	Plume Direction:	25	Stability Class:	E

MODEL RELEASE SYNOPSIS

Release Site:	UNKNOWN
Release Time:	02:50 EST 06-Jan-05
Release Height:	20 FEET
Model Time:	04:47 EST 06-Jan-05
Model End Time:	04:47 EST 06-Jan-05
Total Release:	1.60E+05 LBS

Legend

Known Positions

Forecast Positions

20 ppm

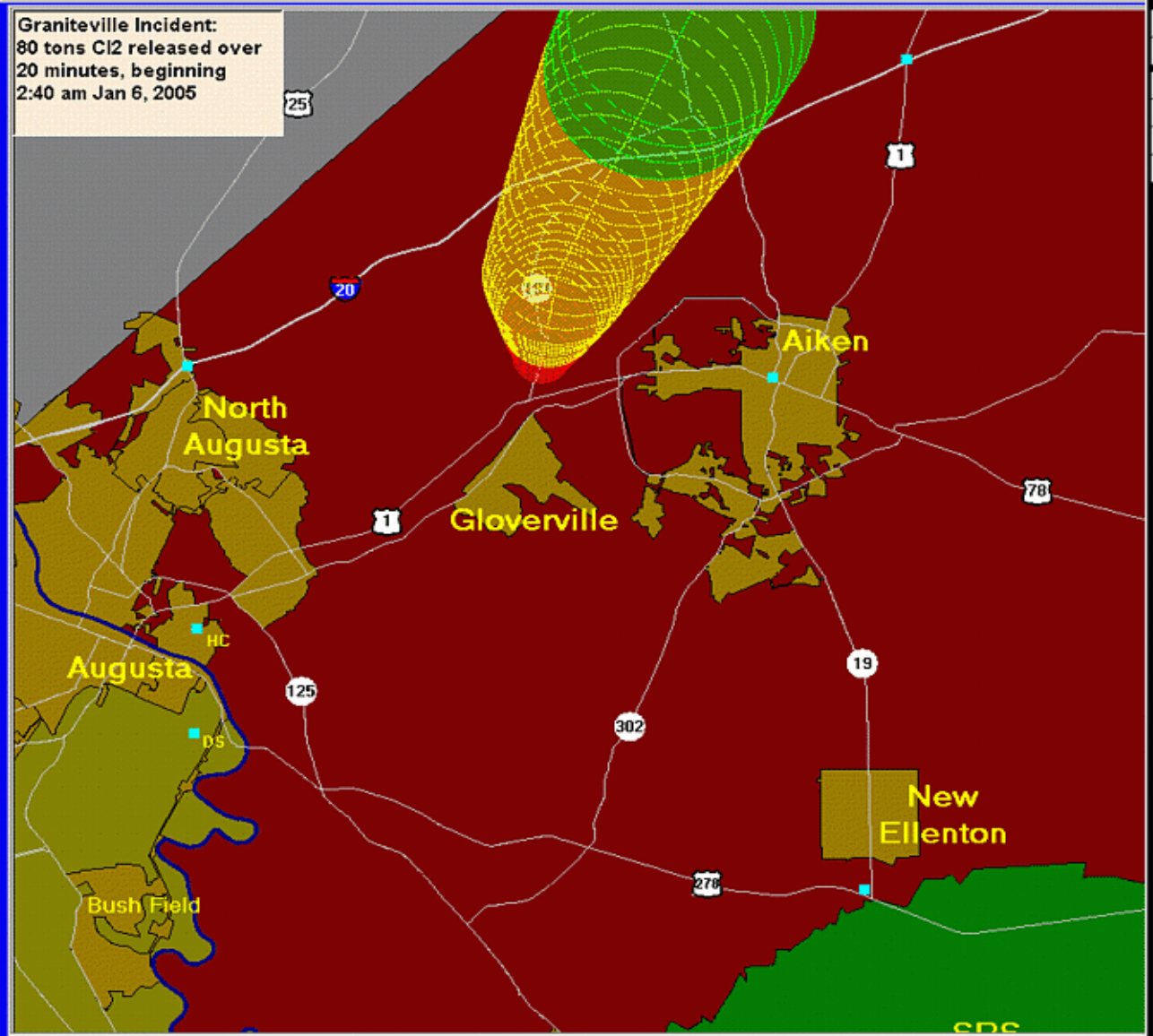
3 ppm

1 ppm

0 ppm

CHLORINE

Arrival Time [hh:mm]	Distance [miles]	Conc [ppm]
04:01 EST	3.4	5.6E+00
04:05 EST	3.9	4.9E+00
04:10 EST	4.3	4.4E+00
04:12 EST	4.8	4.0E+00
04:17 EST	5.3	3.7E+00
04:21 EST	5.7	3.4E+00
04:26 EST	6.2	3.2E+00
04:28 EST	6.7	3.0E+00
04:33 EST	7.1	2.9E+00
04:37 EST	7.6	2.8E+00
04:42 EST	8.1	2.6E+00
04:44 EST	8.5	2.5E+00



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XY – PLOTS

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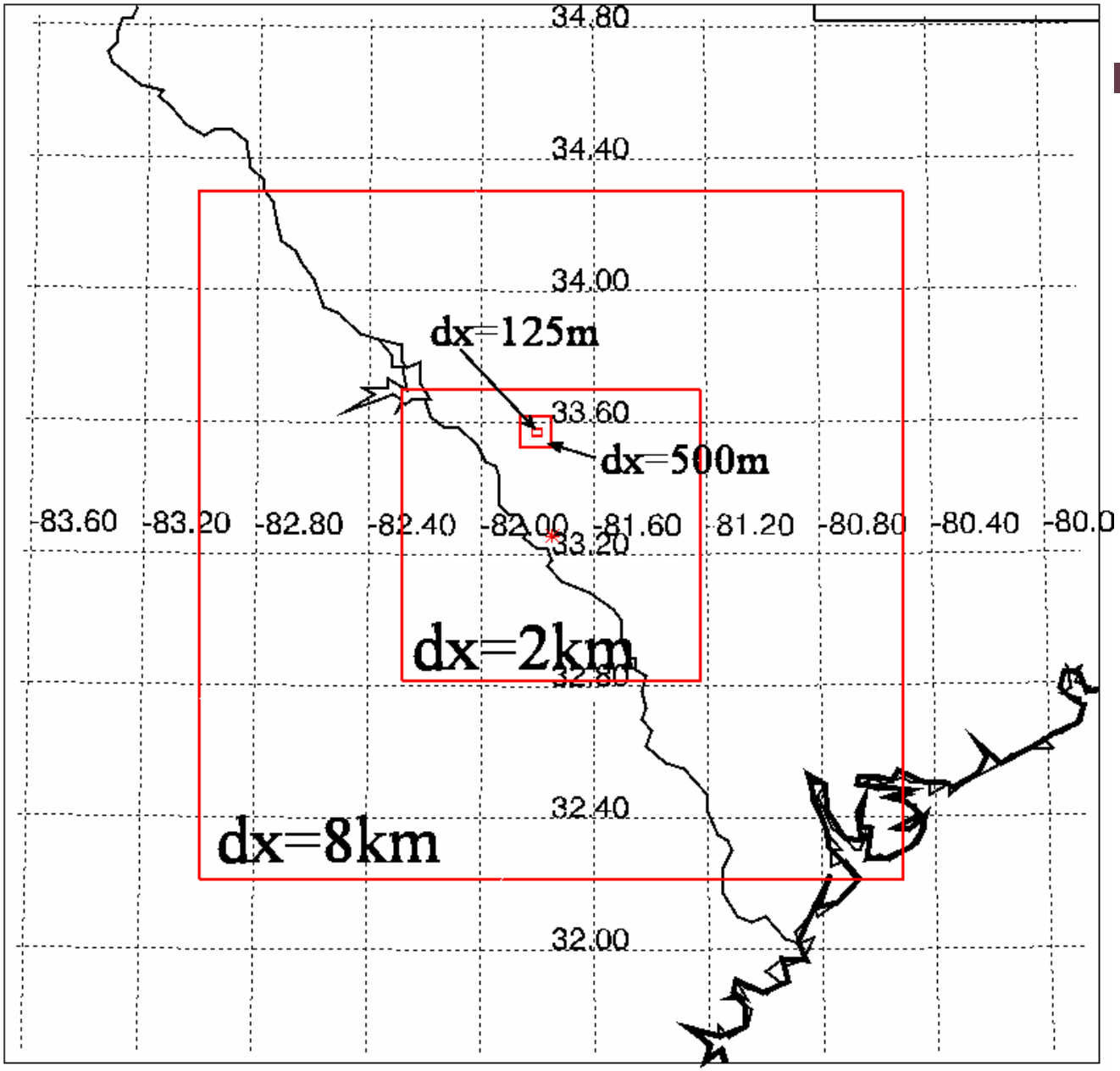
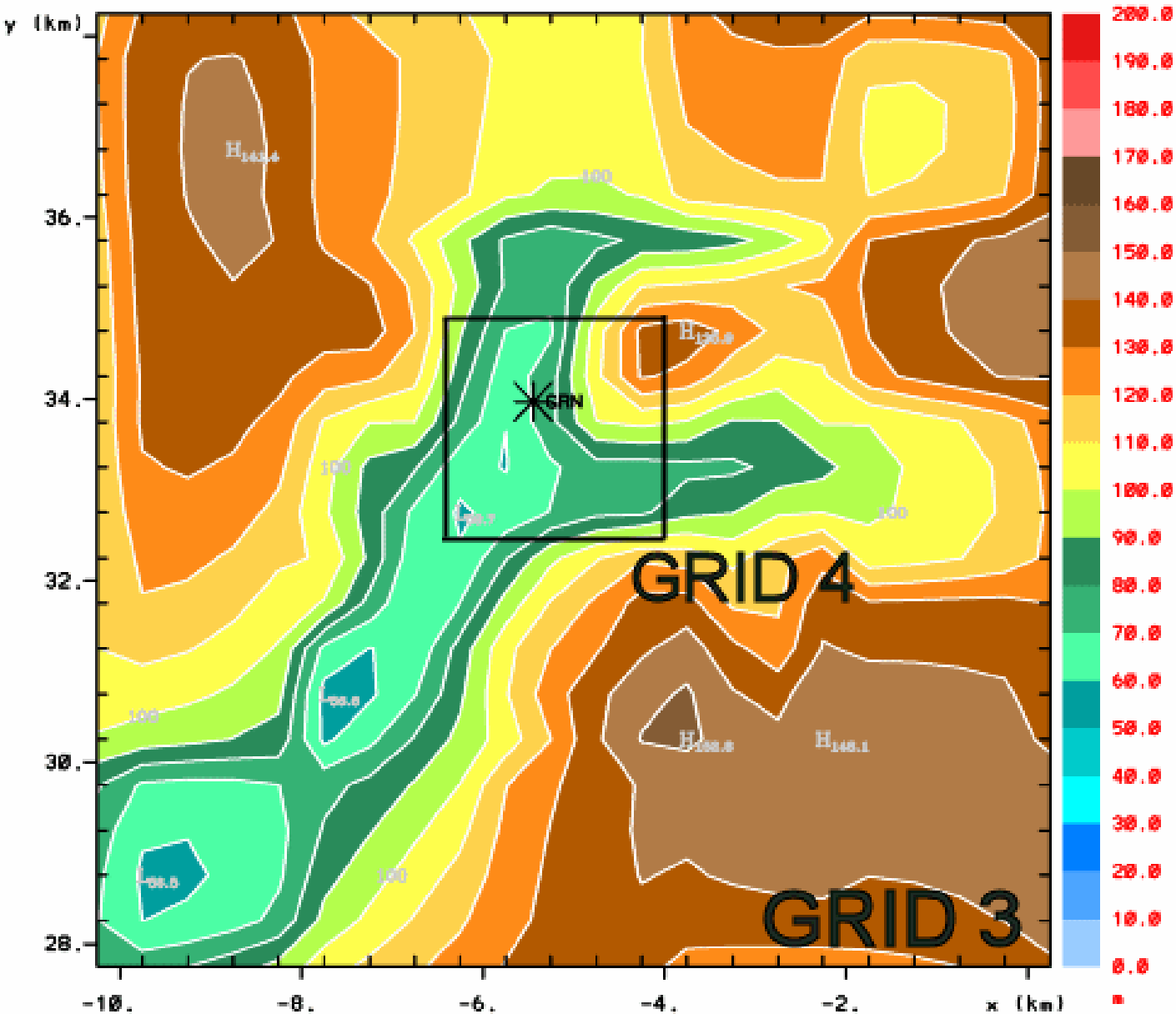
Detailed RAMS Simulations – Grids Nesting



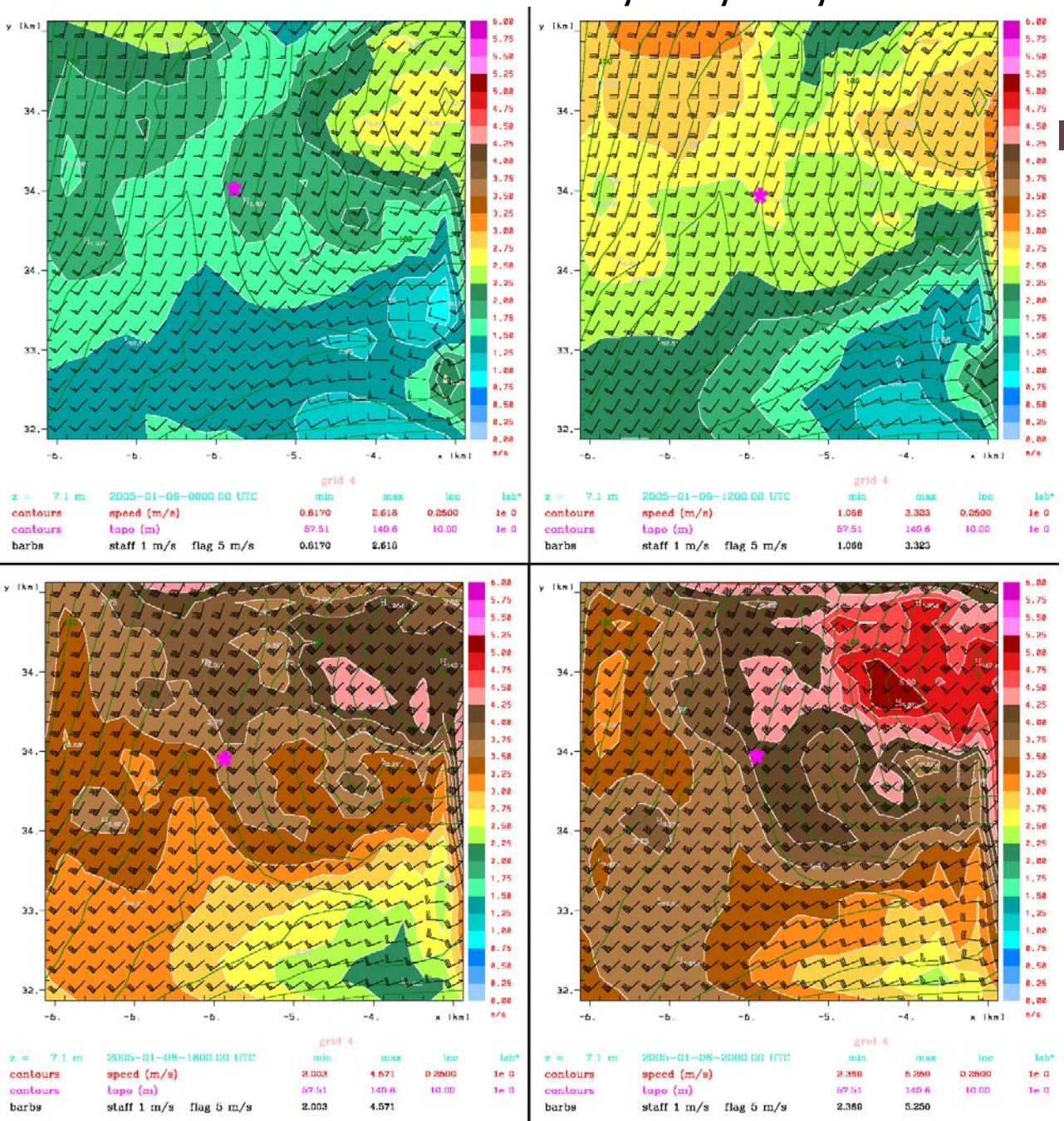
- Lowest level above ground (outer 2 grids, 15 m AGL; inner 2 grids, 7 m AGL).
- Initialize model with RUC and nudge to lateral BC's every 3 hours
- Simulate from 18UTC, 05 Jan to 00UTC, 07 Jan

Land-Use Features for Inner Grids



- Topography shows north-south oriented valley in which Graniteville is located.

Surface Winds at 03, 07, 11, and 15 LST (inner grid)



- Colored contours indicate speed; location of accident indicated by asterisk.
- Winds generally from SSW to SW throughout period.

Transport Models

- Lagrangian Particle Dispersion Model (LPDM):
  - Advect, disperse particles in 3-D and time using RAMS winds and turbulence fields.
  - More realistic meteorology and topography used.
- Hazard Prediction and Assessment Capability (HPAC):
  - Use of SCIPUFF with RAMS-generated winds, temperature, and moisture fields.
  - More realistic source term.

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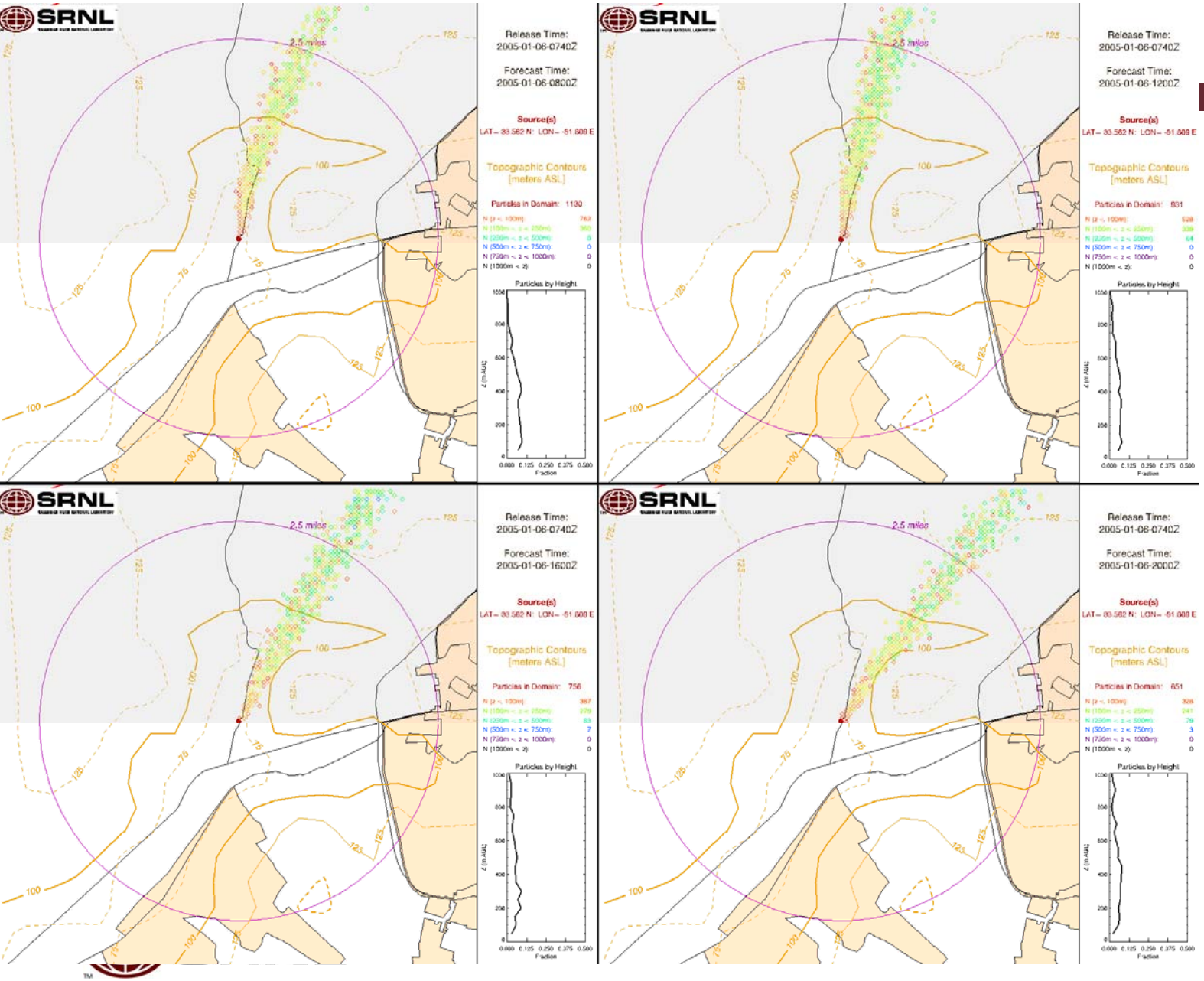
LPDM: Unit Release, Particle Location



- Times: 03, 07, 11, 15 LST
- Particles colored by height
- Topography indicated by tan contours.

LPDM: Concentration Loop

- Assume continuous unit release from crash site from 0240 LST to 1900 LST, 06 January.
- Dense gas *not* modeled here. Indication of general transport only.
- Transport directed between N and NNE. In general agreement with vegetative damage.

Transport/Dispersion using HPAC

- Use HPAC, Version 4.0.4 (2004)
- Simulate industrial accident (railcar)
- Assume major leakage of ~62000 kg of Cl^2 in gaseous and aerosol phase (instantaneous). Dense gas physics incorporated into model calculation.
- Use detailed winds/temperature/humidity fields from RAMS (grid 3) as meteorological input.
- Compute surface dose one hour after incident
- Plot indicates varying levels of median lethal (LCt) and incapacitating (ICt) concentration thresholds, as well as temporary emergency exposure limits (TEEL)

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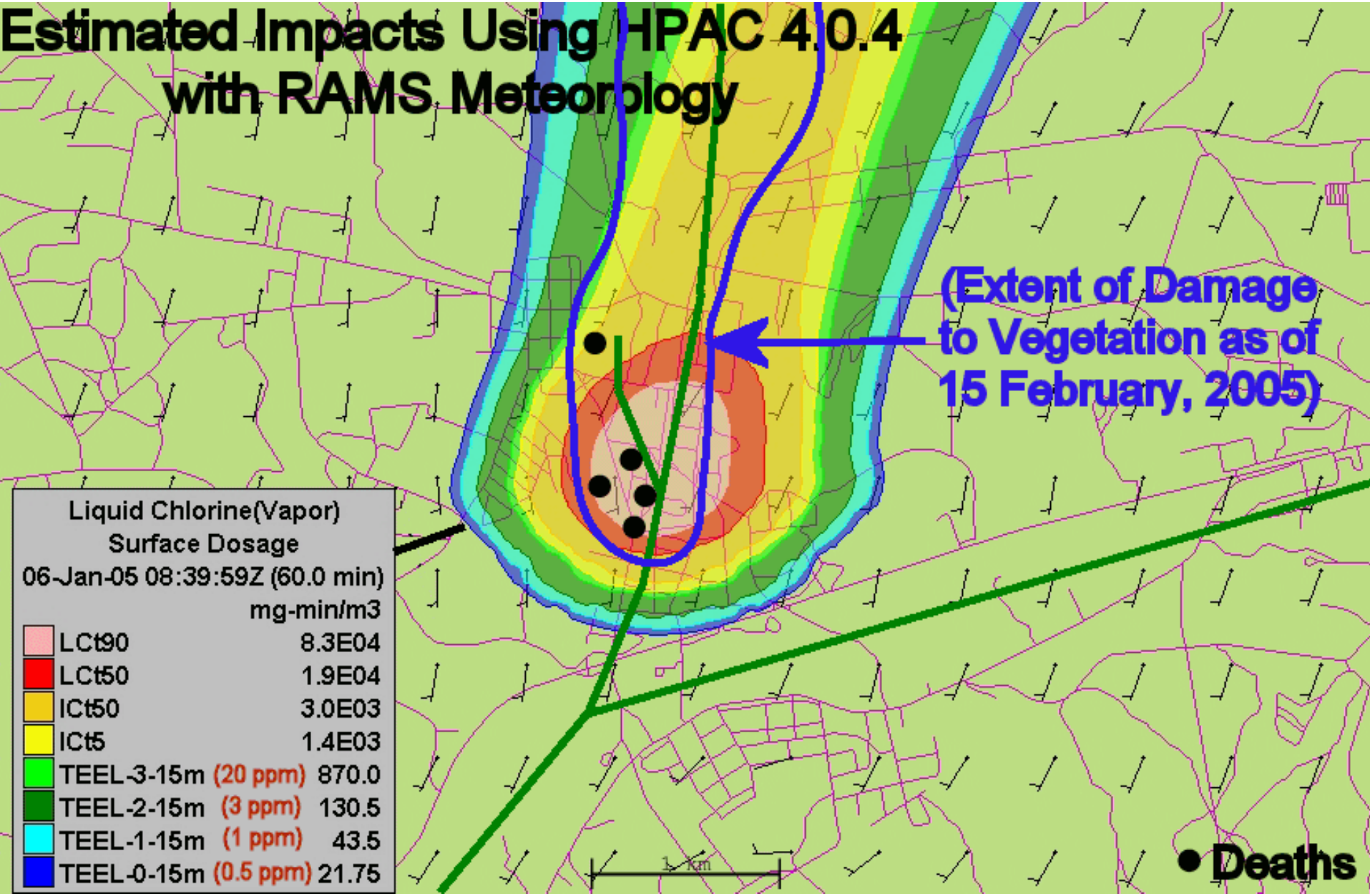
Estimated Impacts Using HPAC 4.0.4 with RAMS Meteorology



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Conclusions

- Consequence assessment resources worked as design, providing timely information to local decision-makers
- Model simulations (response and post-accident phase) compare well with nearby observations
- Gravity driven initially toward SW (lower elevation); later dispersed toward N and NE
- Use of dense gas model shows agreement with fatalities in the immediate vicinity and damage to vegetation

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