

SPECIALIZED RADIOLOGICAL MONITORING AND HAZARD ASSESSMENT CAPABILITIES

1. GENERAL

a. This appendix provides information on service radiation monitoring teams (health physics, bioassay specialists, and a radiation equipment repair team) and on the DOE/NNSA and related monitoring and assessment capabilities.

b. The methods of detecting and/or measuring of different types of radiation and their inherent difficulties have been listed; however, in the event of an accident, radiation must be detected and/or measured. The need of preliminary data on the absence and/or presence of radiation for the DoD IC is imperative. Many military units and some civilian firms and/or agencies have alpha and gamma detection capabilities. These units and/or firms have equipment and individual monitoring capabilities that may provide radiation measurements and preliminary survey data; however, a finite definition of the accident area is needed to plan, initiate, and complete SR.

c. The radiological characterization of the accident site is an iterative process involving the systematic integration of data produced by several assessment techniques. Section 2 describes those resources available to enable theoretical, preliminary, and definitive site characterization for the DoD IC.

d. The radiological assessment of accident victims, bystanders, patients and response personnel operating in contaminated areas requires definitive results. Interpretation of radiological patient data and recommending treatments, as well as, interpretation of site data and recommending protective actions requires subject matter expertise. Next to rendering the weapon safe, taking care of the people is likely the DoD IC's prime concern. Sections 2.c and 2.d describe the capabilities of the military medical Special Teams.

2. THE DEPARTMENT OF DEFENSE

a. DTRA HPAC. HPAC is a forward deployable and/or reachback modeling capability available for Government, Government-related, or academic use. This software tool assists in emergency response to hazardous agent releases. Its fast running, physics-based algorithms enable users to model and predict hazard areas and human collateral effects in minutes. HPAC provides the capability to accurately predict the effects of HAZMAT releases into the atmosphere and their impact on civilian and military populations. Subparagraphs 2.a.(1) through 2.a.(5) provide information on HPAC modeling prediction shown in Figures 1 and 2.

(1) HPAC software uses integrated source terms, high-resolution weather forecasts, and particulate transport to model hazard areas produced by accidents. One of HPAC's strengths is fast access to real-time weather data through Meteorological Data Servers (MDS). HPAC also has embedded climatology or historical weather data for use when real weather data is not available.

Figure 1. HPAC Modeling Prediction: Surface Dose

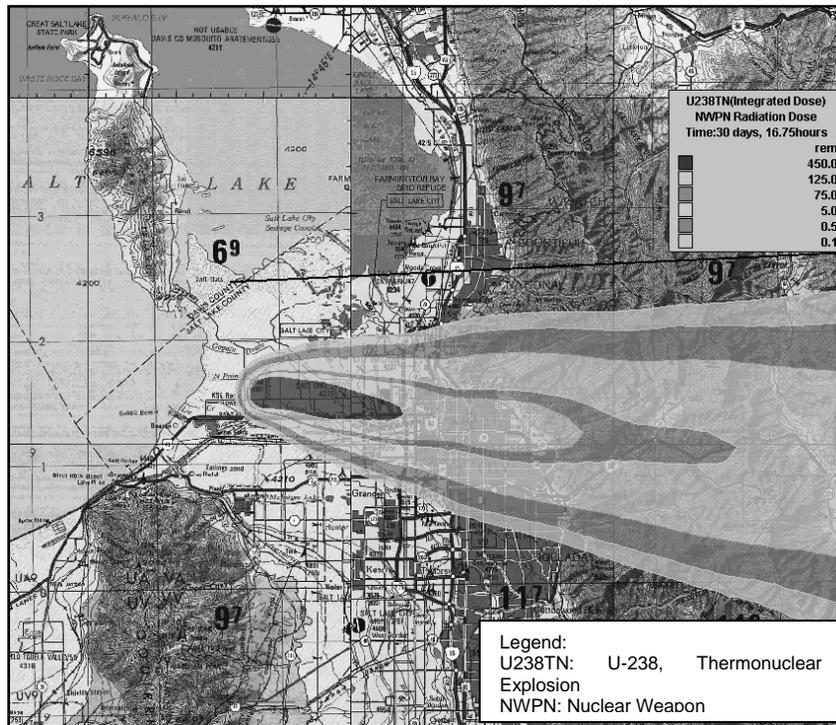
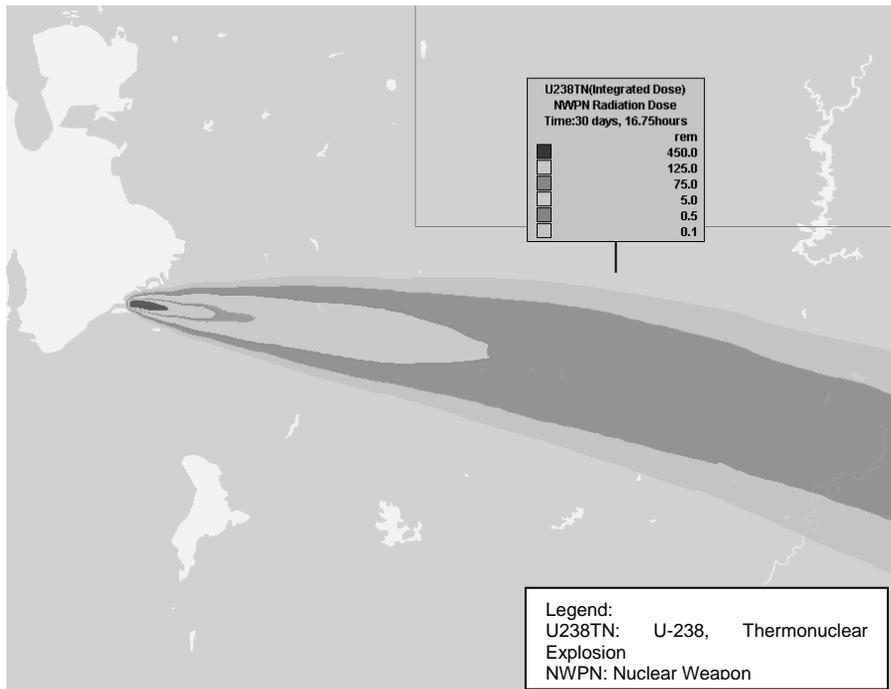


Figure 2. HPAC Modeling Prediction: Hazards Area Effects

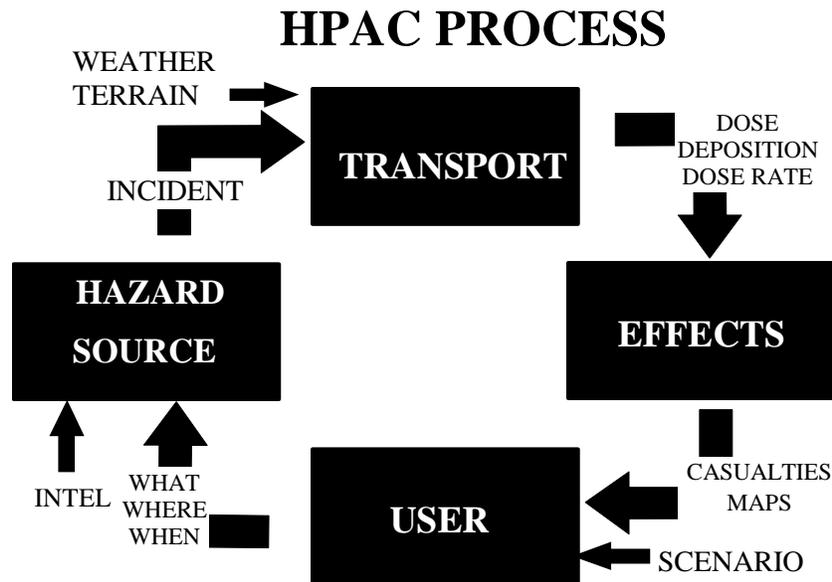


(2) HPAC models nuclear collateral effects of concern that may result from military or industrial accidents. HPAC provides source information on potential radioactive releases from nuclear weapons or reactor accidents.

(3) HPAC includes the SCIPUFF model for turbulent transport, a new and advanced technology that provides a highly efficient and accurate prediction for a wide range of hazard scenarios. HPAC may also help answer the question, "How good is the prediction?" by providing probabilistic solutions to the atmospheric transport problem. HPAC builds source terms for hazardous releases for input to the atmospheric transport model, SCIPUFF. The current code hosts operator-friendly "incident" setup capability. Sample HPAC projects are provided that may be edited to suit a wide range of user requirements or accidents. Additional improvements in the software are planned, but user feedback shall ensure that these improvements include a user's perspective, not just a scientist's.

(4) The HPAC Process. The overall process starts first with the need to assess a hazard, then the statement of the problem in detail, followed by the definition of the hazardous event or source in HPAC. Meteorological data must be available. Then the SCIPUFF code transports the hazardous cloud (or "puffs") in the turbulent atmosphere. Effects of the HAZMAT at geographical locations are computed, and the results are provided to the user on a map or as a cross-section of the atmosphere. The overall process is summarized in Figure 3. The wide arrows indicate the major steps in the HPAC process. The narrow arrows indicate critical inputs to the process. The weather, terrain, and hazard particle size mainly determine where a HAZMAT goes. The accuracy of the effects of the hazard depends on such details, as well as the detailed knowledge of the hazard itself.

Figure 3. HPAC Process



(5) Weather and Terrain. Weather is a key ingredient to the HPAC process. Although the SCIPUFF is an accurate and efficient transport model, the results of a hazardous release are first and foremost affected by weather and how well the meteorology is defined. There are two types of inputs: observations and gridded numerical model data. Meteorological data are time

sensitive. To keep the level of understanding required to use HPAC and logistics to a minimum, the simpler meteorological inputs to the SCIPUFF (surface and upper air observations) are presented here. More advanced and accurate capabilities, such as very high resolution mesoscale weather models, are available on DTRA's MDS.

(a) In general, meteorological observations are very representative of the real world at the time and location where the data are taken. Assuming the weather does not change, reasonable results may be obtained for a period of two to four hours after the surface observations are taken. Upper air observations may be representative of a somewhat longer period of time. Observations at more locations, over a longer time period, are needed to accurately assess longer duration, longer range, and more lethal releases.

(b) Forecasts and/or updated observations are needed for longer duration releases, but gridded forecast data are sometimes difficult to get and often are not accurate for transport applications. A single set of meteorological observations becomes less representative with distance from the observation site, with time from which the data are taken, around complex terrain, near sunrise and sunset, near weather fronts, near urban areas, and near land and/or water interfaces.

(c) Fast access to weather data for HPAC users became highly advanced with the introduction of the DTRA MDS. Getting weather data is as easy as a click on a mouse with the HPAC's weather request generator, which provides access to forecast model and observation data in minutes.

(d) Terrain may have a large effect on where a HAZMAT is transported. In addition to working with a variety of weather data types, HPAC works with two types of terrain data. By default, HPAC assumes a flat earth for the terrain, and this may be a reasonable approximation for small spatial domains; however, users may choose to use complex, 3-D terrain data describing the topographic variations. When the complex terrain option is used, it automatically invokes a mass consistent wind and turbulence model that is embedded within HPAC. The digital terrain data files in HPAC were developed using Digital Terrain Elevation Data Level 0, a product of the National Imagery and Mapping Agency. HPAC terrain models include an urban setting to closely approximate the effects of high-rise buildings.

b. Air Force Institute for Operational Health (AFIOH). The AFIOH, Brooks-City Base, TX, provides the following radiation protection services:

(1) Conducts calibration, traceable to the National Institute of Standards and Technology, and minor repair services for portable instruments used and owned by the USAF Medical Service for detecting and measuring electromagnetic and ionizing radiation.

(2) Maintains the USAF stock of low-energy photon field survey instruments with trained operators to support disaster operations.

(3) Deploys a field-qualified team of health physicists, health physics technicians, and equipment called the AFRAT. This team is capable of responding worldwide to radiation accidents with air transportable equipment for detecting, identifying, and quantifying any type of radiation hazard; radioisotope analysis of selected environmental, biological, and manufactured materials; and on-site equipment maintenance and calibration.

(4) Conducts special projects dealing with long- and short-term evaluations of radiation exposures.

(5) Requests for additional information should be directed to AFIOH personnel. AFIOH services may be requested through the appropriate chain of command, i.e. the Combatant Command Operations Center.

c. U.S. Army. The Army maintains the primary DoD medical response nuclear team called the Radiological Advisory Medical Team (RAMT). The RAMT is based at Walter Reed Army Medical Center (WRAMC) in Washington, D.C. A mini-RAMT is also located in Landstuhl, Germany. The RAMT is a well-trained, well-equipped, robust team of physicians, health physicists and health physics technicians that provide both advice and assistance. The RAMT is a rapid response asset with a 2 hour assemble time and 4 hour departure time once notified. Radiological capabilities include patient monitoring and decontamination (20 litter patients per hour or 200 ambulatory patients per hour), bioassay program assistance and oversight, lung counting, gamma spectrometry, personnel portal monitor screening, dose assessment, alpha/beta/gamma/x-ray/neutron detection, exposure rate measurement, contamination and exposure limits guidance, protective action recommendations, and reoccupation guidance. The RAMT is CNWDI cleared, usually falls under the ASHG and can provide limited medical support during weapon recovery operations within the NDA.

d. Armed Forces Radiobiology Research Institute (AFRRI). The AFRRI maintains the Medical Radiobiology Advisory Team (MRAT) and a DoD-unique reach-back capability to perform gold-standard cytogenic (i.e., chromosome aberration) analysis of blood sample for dose assessment. The MRAT can deploy within 24 hours of notification. The MRAT consists of senior radiation medicine physicians and health physicists with subject matter expertise to provide timely advice to the DoD IC and interpret human data, modeling data and site data. The MRAT is typically configured with one physician and one physicist for deployment as augmentees to the DTRA CMAT. Radiological capabilities include interpreting models and measured data for assessment of radiological hazards, advice on patient treatments and protective actions for responders and the public. The MRAT is CNWDI cleared for split operations in the NDA and at the JOC.

3. THE DEPARTMENT OF ENERGY. Services of the DOE/NNSA capabilities shall be requested by the DOE SEO.

a. Hotspot Health Physics Codes.

(1) The LLNL developed the Hotspot Health Physics Codes for the DOE ARG to provide emergency response personnel and emergency planners with a fast, field-portable set of software tools for evaluating accidents involving radioactive material. The software is also used for safety-analysis of facilities handling nuclear material.

(2) Hotspot codes are a first-order approximation of the radiation effects associated with the atmospheric release of radioactive materials. The Hotspot atmospheric dispersion models are designed to determine close-in effects for short-term releases (up to a few hours) during steady wind conditions over flat terrain. Users requiring more detailed consequence assessments for

complex or large releases, or for releases over longer times, such as during conditions with spatial and temporal varying meteorology, or for flows affected by terrain effects, etc., are directed to more sophisticated modeling capabilities as DOE's NARAC. The Hotspot codes have been completely revised to take advantage of the WindowsTM 95/98/00/XP/NT operating system environment.

(3) Four general programs, Plume, Explosion, Fire, and Resuspension, estimate the downwind radiological impact after the release of radioactive material resulting from a continuous or puff release, explosive release, fuel fire, or an area contamination event. Additional programs deal specifically with the release of plutonium, uranium, and tritium to hasten an initial assessment of accidents involving nuclear weapons.

(4) The FIDLER program is a tool for calibrating radiation survey instruments for ground-survey measurements and initial screening of personnel for possible plutonium uptake in the lung.

(5) The Nuclear Explosion program estimates the effects of a surface-burst nuclear weapon. These include prompt effects (neutron and gamma, blast, and thermal), and fallout information. Fallout includes arrival time, dose rate at arrival time, and integrated dose contours for several time periods e.g., first six hours, first day, first week, etc.

(6) Hotspot is a hybrid of the well-established Gaussian plume model, widely used for initial emergency assessment or safety-analysis planning. Virtual source terms are used to model the initial atmospheric distribution of source material after an explosion, fire, resuspension, or user-input geometry.

(7) Hotspot incorporates both reference (ct) and the Federal Guidance Report No.13 (reference (cu)) DCFs for inhalation, submersion, and ground shine. In addition to the inhalation 50-year CEDE DCFs, acute (24-hour) DCFs are available for estimating non-stochastic effects. This acute mode may be used to estimate the immediate radiological impact associated with high acute radiation doses (applicable target organs are the lung, small intestine wall, and red bone marrow). Individual target organ doses are optionally output by Hotspot. Hotspot supports both classic units (rem, rad, Ci) and International System units (Sv, Gy, Bq). Users may add radionuclides and custom mixtures (up to 50 radionuclides per mixture).

(8) Tables and graphical output may be directed to the computer screen, printer, or a disk file. The graphical output consists of dose and ground contamination as a function of plume centerline downwind distance (see Figure 4), and radiation dose and ground contamination contours (see Figure 5). Users have the option of displaying scenario text on the plots.

Figure 4. Hotspot Downwind Plume Centerline (Stability A-F)

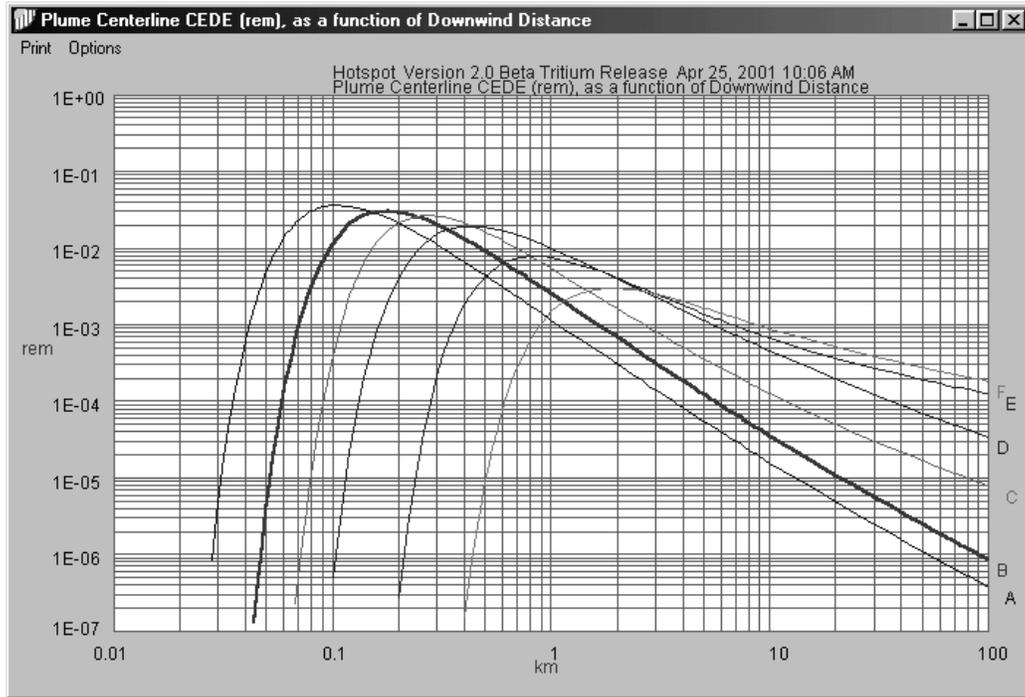
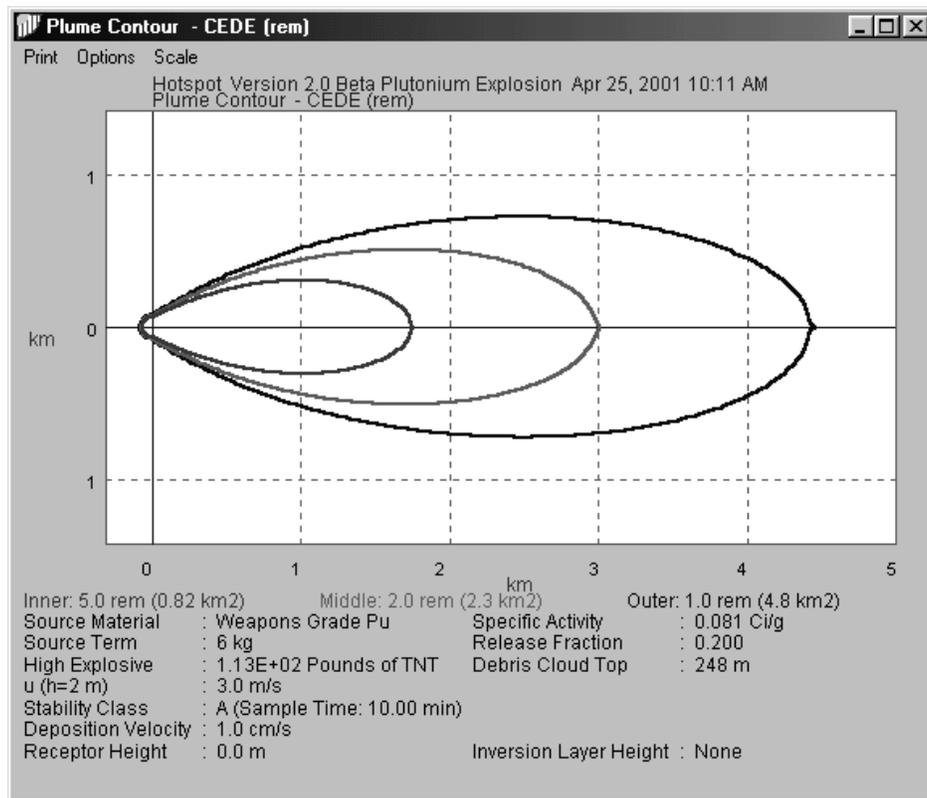
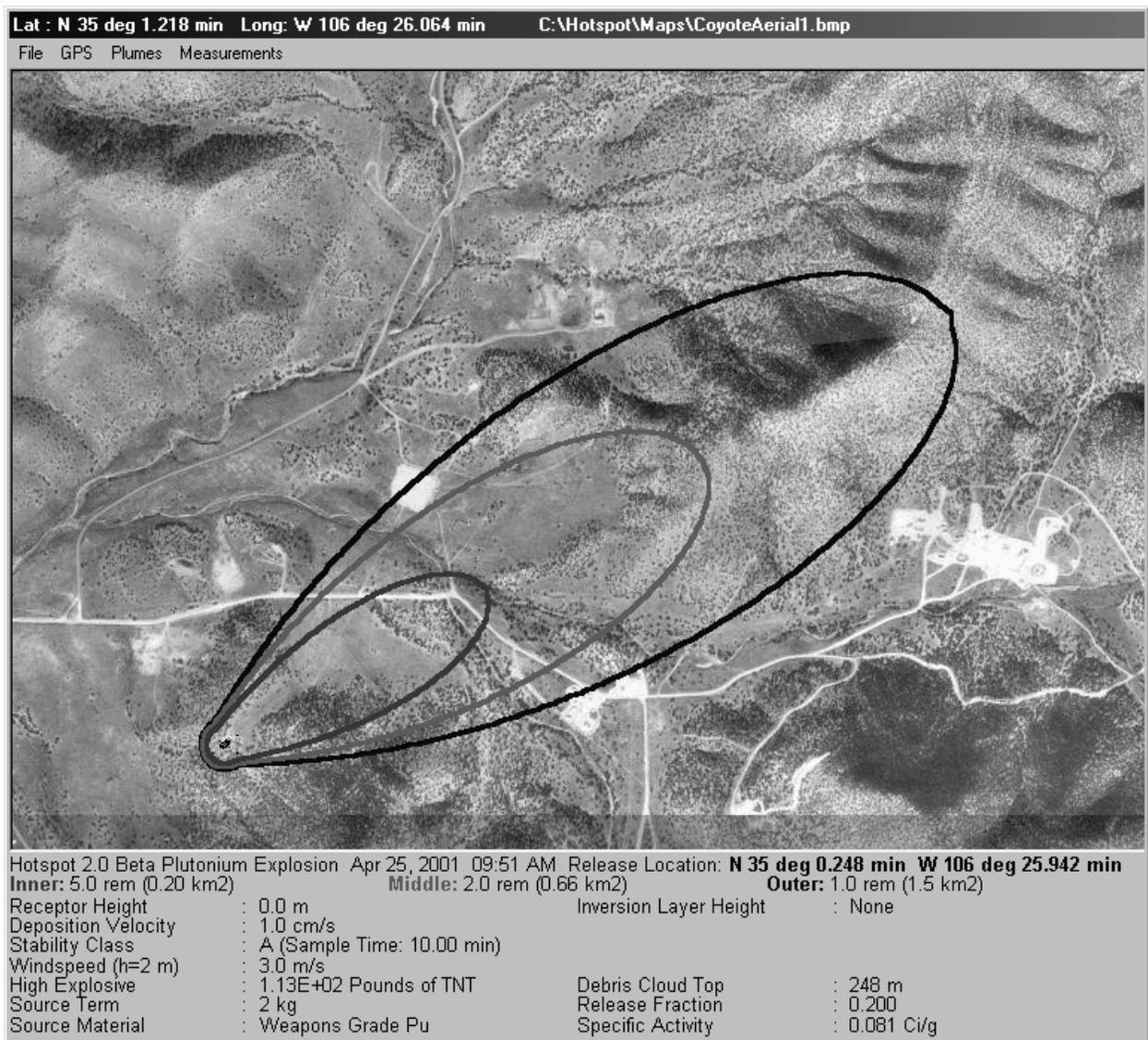


Figure 5. Hotspot Plume Contour Plot



(9) Radiation dose and ground contamination contours may also be saved as mapping files for display on geographical maps. Latitude and Longitude, Universal Transverse Mercator, and Military Grid Reference System geographical coordinate systems are supported for interfacing Hotspot dispersion contours with commercial mapping systems. Dose and Deposition plume contours may also be overlaid on geographical maps (see Figure 6).

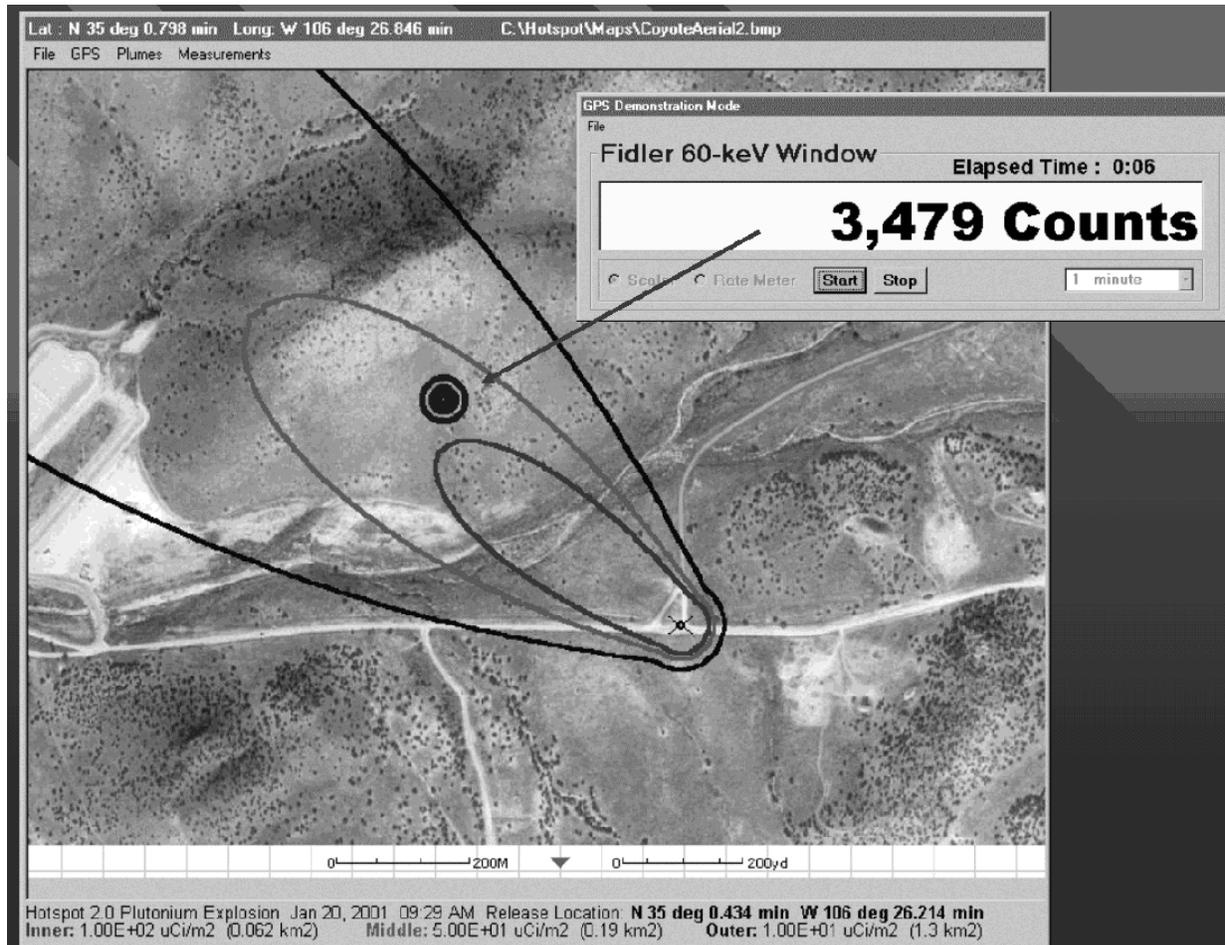
Figure 6. Hotspot Plume Contours Displayed on Aerial Photograph



(10) Image files (bitmap format) may easily be georegistered and added to a user's map library. GPS units may be used to generate real-time instrument response for exercise support. Users may add additional instruments as desired. Hotspot has an on-board selection of plutonium-detecting instruments (FIDLER, Violinist, alpha probes, etc.) that may interact with the GPS unit and/or map. Users may select an instrument and emulate the instrument's response to the current atmospheric concentration and ground contamination. The current GPS location

(Latitude, Longitude, Altitude) or mouse location is used for determining the applicable output values (see Figure 7).

Figure 7. Virtual FIDLER Detector for Exercise Support



(11) Hotspot strictly follows the well-established Gaussian model, and does not use any “black-box” techniques. All algorithms are presented and referenced in the onboard documentation.

b. Atmospheric Release Advisory Capability (ARAC). ARAC is a DOE/NNSA and DoD resource, directed by the LLNL, that supports emergency response teams during accidents involving radioactive materials.

(1) ARAC provides the user with computer model estimates of the contamination distribution resulting from a nuclear weapon accident. ARAC products include computer-generated estimates of the location and contamination levels of deposited radiological material and radiation dosage to the exposed population in the surrounding areas. Until time and equipment allow completion of extensive radiation surveys and bioassays, ARAC projections

shall help assess the potential impact of an accident and identify areas for initial investigation by response force radiological teams.

(2) In the event of a nuclear weapon accident, at or near an ARAC-serviced facility, the ARAC Center shall be alerted by the facility's personnel using the ARAC site system computer located at the installation, immediately after the initial report to the NMCC is completed. If the accident occurred in a CONUS area, remote from an ARAC-serviced DoD installation, the NMCC's JNAIRT shall notify ARAC; however, ARAC may be contacted directly by the installation initiating the OPREP-3 by calling the ARAC's emergency number: commercial (925) 422-9100.

(3) During normal working hours (currently 0730 to 1615 Pacific Time), initial estimates of the extent of contamination may be ready for transmission from ARAC about 30 minutes after ARAC has been notified of the:

- (a) Accident location.
- (b) Time of accident.
- (c) Type and quantity of weapons involved in the accident.

(4) Responses outside the hours listed above are subject to an additional 60- to 90-minute delay.

(5) Every effort should be made to provide updated or supplementary information to the ARAC Center as soon as it is available. Desired information includes:

(a) Observed wind speed and wind direction during the accident and later weather changes.

(b) Description of accident particulars, including line numbers for the specific weapon(s) releasing contamination, type and amount of fuel involved (ARAC has typical values for DoD aircraft and other transport vehicles), and measured contamination at specific locations with respect to the contamination source, if available.

(c) Specific details of accident fire or explosion, such as mechanism of the release (HE detonation or fire), duration of any fire, and height and size of the plume or cloud (if available from reliable observers).

(6) About 30 minutes after the ARAC facility has been notified of the necessary accident information, a computer-generated estimate of maximum credible ground-level contamination spread and projected whole-body effective dose to exposed persons in the downwind area shall be available. Conservative assumptions are made in computing the amount of radiological material released so that these initial projections place an upper bound on levels of resulting contamination and dose. Weapons at risk, when exposed to unusual stress during the accident, may undergo a non-nuclear HE detonation. It is assumed that all the nuclear material at risk shall be released in an aerosolized form. Similar conservative assumptions are made where specific accident information is missing or unknown. If the accident location is not close to an ARAC-serviced CONUS site, the initial projections are not likely to include geographic features (roads, city boundaries, etc.). ARAC-projected doses shall help initial response efforts evaluate the potential

hazard to the general public until comprehensive radiation measurements and bioassays may be performed. Projected deposition patterns shall assist estimates of SR efforts.

(7) About 60 to 90 minutes after notification of ARAC, a more refined projection shall be available if somewhat less conservative assumptions are made in estimating the actual amount of material at risk released during the accident. (Estimates are now based on only those weapons known to have undergone an HE detonation or to have been consumed in a fire.) For consequence analyses, ARAC may generate a computation based on a meteorological forecast to give projected contamination patterns in case of dispersal during a weapon safing operation. Although the initial projections are shown typically on a 30 by 30-kilometer grid, these refined projections may cover either a larger or smaller area depending on the downwind extent of the contamination. Note that ARAC may generate projection plots to match a given map scale (for example, 1:50,000) for ease of overlaying the projected deposition pattern.

(8) When available, ARAC projections may be sent to the ARAC site system computer located at most ARAC-serviced sites. If the site does not have a site system computer, the projections may be telefaxed. Subparagraphs 3.b.(8)(a) through 3.b.(9)(c) provide information on the ARAC example “initial” projections shown in Figures 8 and 9.

(a) Geographic Contour Display. Release location is centered in this area (refined projections may have release location offset from center) with a 2,000-foot fragmentation circle drawn around the release point. The display is always oriented with north toward the top. A maximum of three contoured areas shall be shown emanating from the release point that shall, in most cases, overlay a geographic representation, showing road networks and waterways, etc., of the area around the accident site. Printed across the top of each graphic display area shall be the title of the underlying computer estimation denoting either a “50-Year Whole Body Effective Dose” or “Cumulative Deposition” plot.

Figure 8. ARAC Plot: Lung Dose

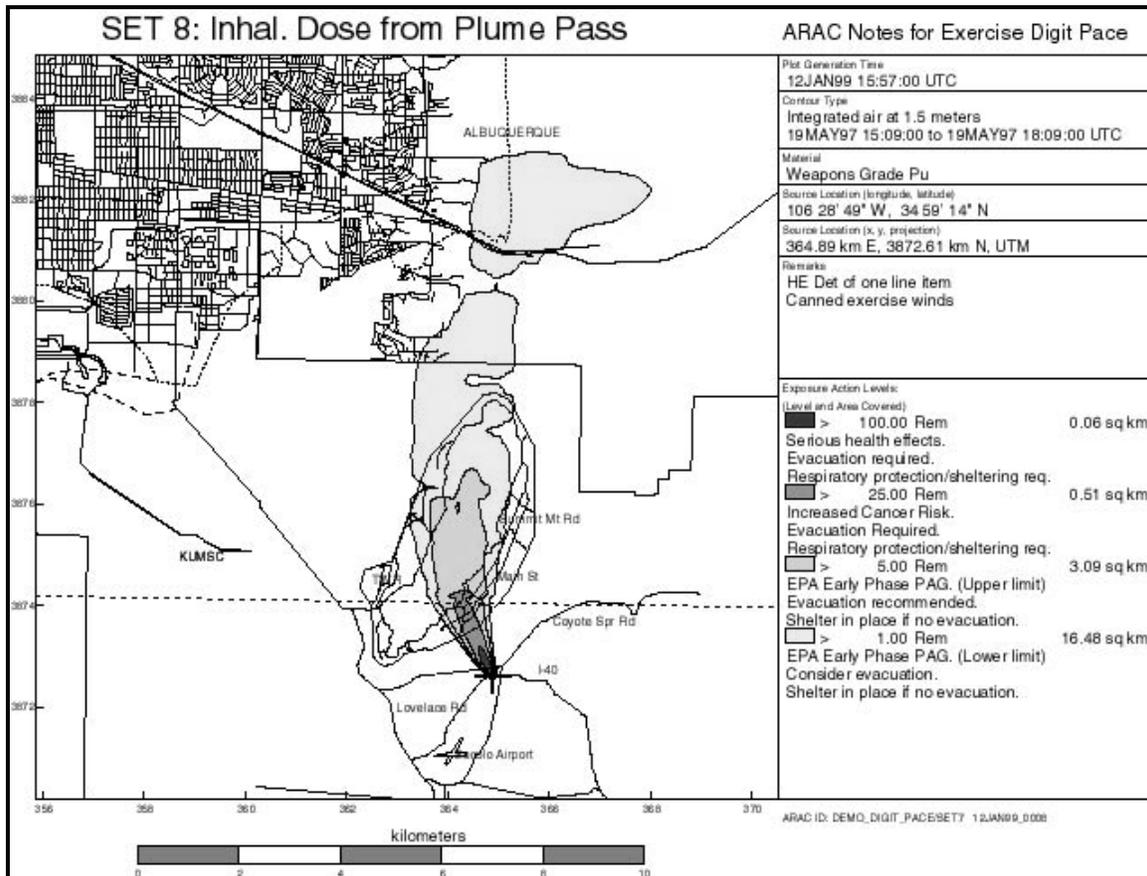
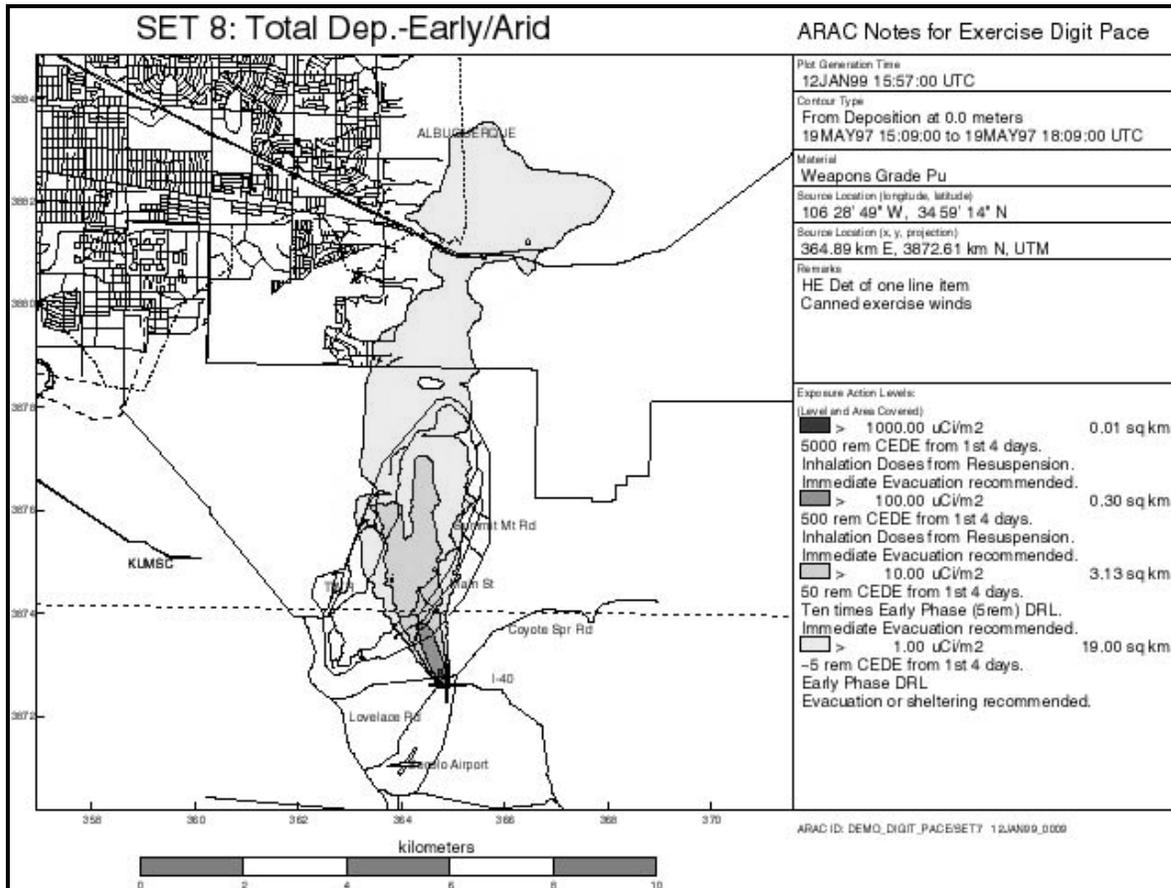


Figure 9. ARAC Plot: Deposition



(b) Descriptive Notes. To the right of the contour display shall be a legend. The first line is a title line for these notes. The second line shall denote the date and time that the specific computer model estimation was produced. Lines three through six shall be reserved for general amplifying remarks about the computer estimation. Line seven identifies either the dose integration period or total deposition period time, as appropriate. (All times shall be shown as "Z" or Zulu time. "Z" is equal to Universal Coordinated Time (UCT), which has replaced the more familiar Greenwich Mean Time.) Line nine shows the radiological material modeled, and the height above ground level at which the contour levels are computed and displayed. Lines 10 through 22 shall show the specific computer estimation action levels as computed for that particular plot. The next several lines (down to the scale of the display shown in both kilometers and feet) comprise three separate blocks of information. Within each block is an area showing a particular contour crosshatch pattern used to mark areas in the contour display where the dose or deposition is greater than the stated value, the area covered by this particular pattern in square kilometers, and abbreviated, generalized actions that may be considered within this area. Note that the area given shall include the area of all higher levels shown (for example, the area given for exceeding 25 rem is the sum of the area covered by the 25 and 150 rem contour patterns). At most, projections are made for three cumulative deposition and four dose exposure levels. Only the areas with the three highest projected levels shall be shown on any ARAC plot. Projected

cumulative depositions are for levels greater than 600, 60, and 6 $\mu\text{Ci}/\text{m}^2$. Dose exposures are projected for levels greater than 150, 25, 5, and 0.5 rem, which refer to a 50-year whole body effective dose through the inhalation pathway.

(9) Wording that Accompanies the Action Levels in the Legend.

(a) 50-Year Whole Body Effective Dose “Exposure Action Levels.” Projected doses apply only to people outdoors without respiratory protection from the time of the accident until the valid time of the plot, and recommended actions are to reduce the projected dose to those people exposed.

1. Greater than 50 rem. Immediate respiratory protection and evacuation recommended.

2. Greater than 25 rem. Prompt action required; respiratory protection required; consider sheltering or evacuation.

3. Greater than 5 rem. Respiratory protection required; recommend sheltering; consider evacuation.

4. Greater than 0.5 rem. Consider sheltering.

(b) Cumulative Deposition “Exposure Action Levels”.

1. Greater than 600 $\mu\text{Ci}/\text{m}^2$. Immediate action may be required until the contamination is stabilized or removed; issue sheltering instructions; recommend controlled evacuation.

2. Greater than 60 $\mu\text{Ci}/\text{m}^2$. Supervised area; issue sheltering instructions; recommend controlled evacuation for 2 to 14 days.

3. Greater than 6 $\mu\text{Ci}/\text{m}^2$. Restricted Area (RA); access on need-only basis; possible controlled evacuation required.

(c) The wording of the deposition action levels in subparagraph 3.b.(9)(b) was contracted because of space limitations on the ARAC plots. The full wording follows:

1. Greater than 600 $\mu\text{Ci}/\text{m}^2$. Immediate action required. Urgent remedial action may be needed from within a few hours up to two days. Full personal protective clothing and respiratory protection required by all emergency staff in this area. Residents should stay indoors with doors and windows closed. Consider turning off heating, ventilation, and air conditioning (including room air conditioners). Controlled evacuation of children and adults should be considered urgent. All work on, or the use of, agricultural products and/or meat and poultry must be controlled and further action on them assessed.

2. Greater than 60 $\mu\text{Ci}/\text{m}^2$. Supervised Area. Controlled evacuation should be considered and may have to occur, lasting between two days and two weeks or more. All activities should be carefully considered and supervised. Full anti-contamination clothing and respirators should be required for all personnel engaged in heavy work or dusty, windy

operations. Residents should stay indoors with windows closed unless evacuation is in progress or there is no significant airborne hazard and none forecasted to occur through resuspension.

3. Greater than 6 $\mu\text{Ci}/\text{m}^2$. Restricted Area. Entry restricted to those who live, work, and/or have a need to be there. Decontamination personnel and public health and safety staff should wear limited personal protective clothing. Controlled evacuation of residents, especially children, is possible during decontamination if there is a possibility of airborne contamination through resuspension.

c. Aerial Measuring System (AMS).

(1) General. The DOE/NNSA AMS has four capabilities available to support a weapon accident: aerial radiological mapping; aerial search for weapons and/or weapon components; multispectral, hyperspectral, and/or thermal imagery; and aerial photography.

(2) Aerial Radiological Mapping. Aerial radiological surveys provide rapid assessment and thorough coverage of large areas and yield average ground concentration of the contaminant. The system may also be used to quickly prepare lower sensitivity, but appropriately scaled, incident site maps. Instrumentation includes large volume, NaI gamma-ray detectors, data formatting and recording equipment, positioning equipment, meteorological instruments, direct readout hardware, and data analysis equipment. A variety of DOE/NNSA-owned aerial platforms (fixed-wing and helicopter) are dedicated to supporting this mission; in the near future, unmanned aerial vehicles (UAVs) may also be available. Also, equipment capable of being mounted on a variety of DoD helicopters is available to perform survey missions, as needed. The availability of North Atlantic Treaty Organization (NATO)-standard pods reduces the time required for airframe preparation.

(a) In a nuclear weapon accident, a preliminary radiological survey would establish whether radioactive materials had been dispersed from the weapon. Dispersion patterns and relative radiation intensities, immediately available from the initial survey, may be used to guide radiation survey teams to the areas of heaviest contamination. AMS personnel shall help interpret and coordinate their information with other radiological survey data through the FRMAC. Additional data processing shall establish the identity and concentration of the isotopes involved. Later surveys might provide data on the progress of cleanup operations.

(b) The first radiological survey conducted after a nuclear weapon accident is likely to follow this protocol and timeframe:

1. The fixed-wing aircraft should arrive six to 12 hours after notification.
2. The fixed-wing aircraft should be refueled and the crew should get instructions within two hours.
3. A survey should be conducted in a serpentine pattern of survey lines 0.5 to 5 miles apart to find:
 - a. Radiological deposition outline.
 - b. Direction of the plume centerline.

c. Approximate radiation levels along the plume centerline.

d. Dominant isotopes.

4. The survey information should be sent by radio or satellite telephone to the FRMAC during the survey.

5. The analysis laboratory should arrive four hours (plus driving time) after notification.

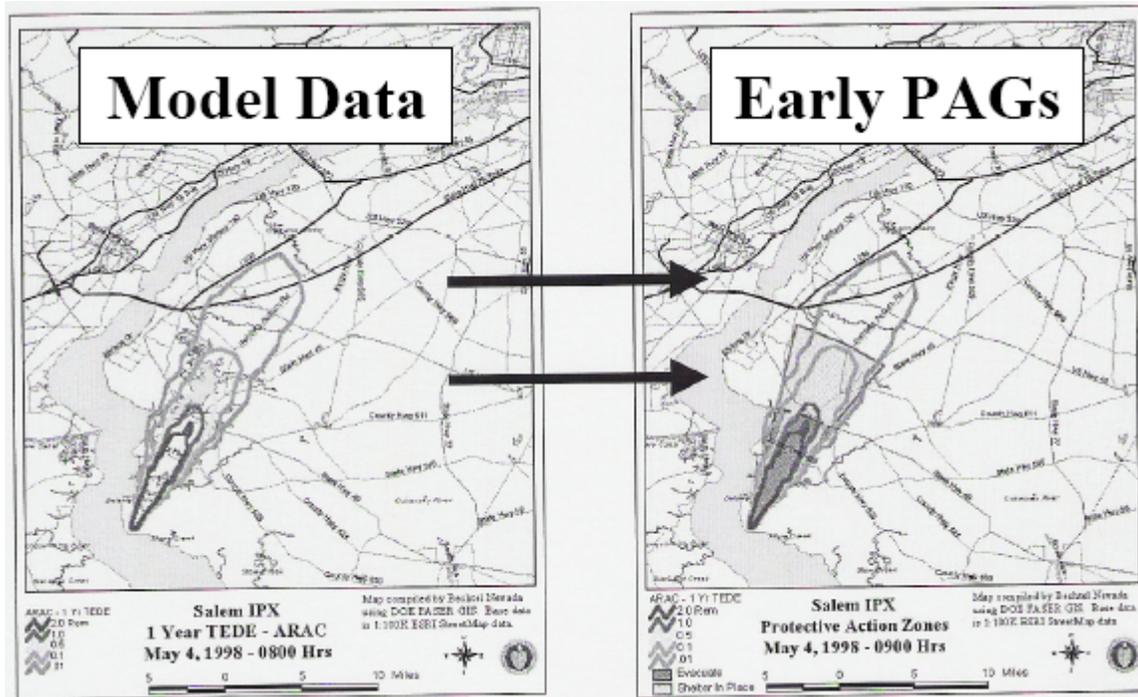
6. Full analysis of flight results should be available six to 12 hours after the flight is completed or after the analysis laboratory arrives.

(c) After the first broad survey is completed, a series of smaller area surveys should be initiated with the AMS helicopter. The flight altitude is likely to be 100 to 150 feet with 200-foot line spacings. The AMS helicopter has a detector field of view around 300 feet in diameter. The purpose of these surveys should be to map the contaminated area in detail. The length of time required to complete this series of surveys may be from one to five days, depending on the area to be surveyed and the weather.

(d) Another survey that might be initiated is called the KIWI. The KIWI uses the same system used on a helicopter, but is mounted on a four-wheel drive vehicle instead. Unlike the AMS helicopter, the KIWI is about three feet above the ground and has a detector field of view around 10 feet in diameter. The KIWI gives a high-spatial resolution mapping of contamination.

(e) The results of an aerial survey to produce early phase radiological data and radiological data measurements are shown in Figures 10 through 12.

Figure 10. Aerial Survey Results: Early Phase Radiological Data



Legend:

ESRI: Environmental Systems Research Institute

IPX: Ingestion Pathway Exercise

TEDE: Total Effective Dose Equivalent

DOE FASER GIS: DOE Field Analysis System for Emergency Response, Geographic Information System

Figure 11. Aerial Survey Results: Radiological Data Measurements, AMS Serpentine, and Field Measurements

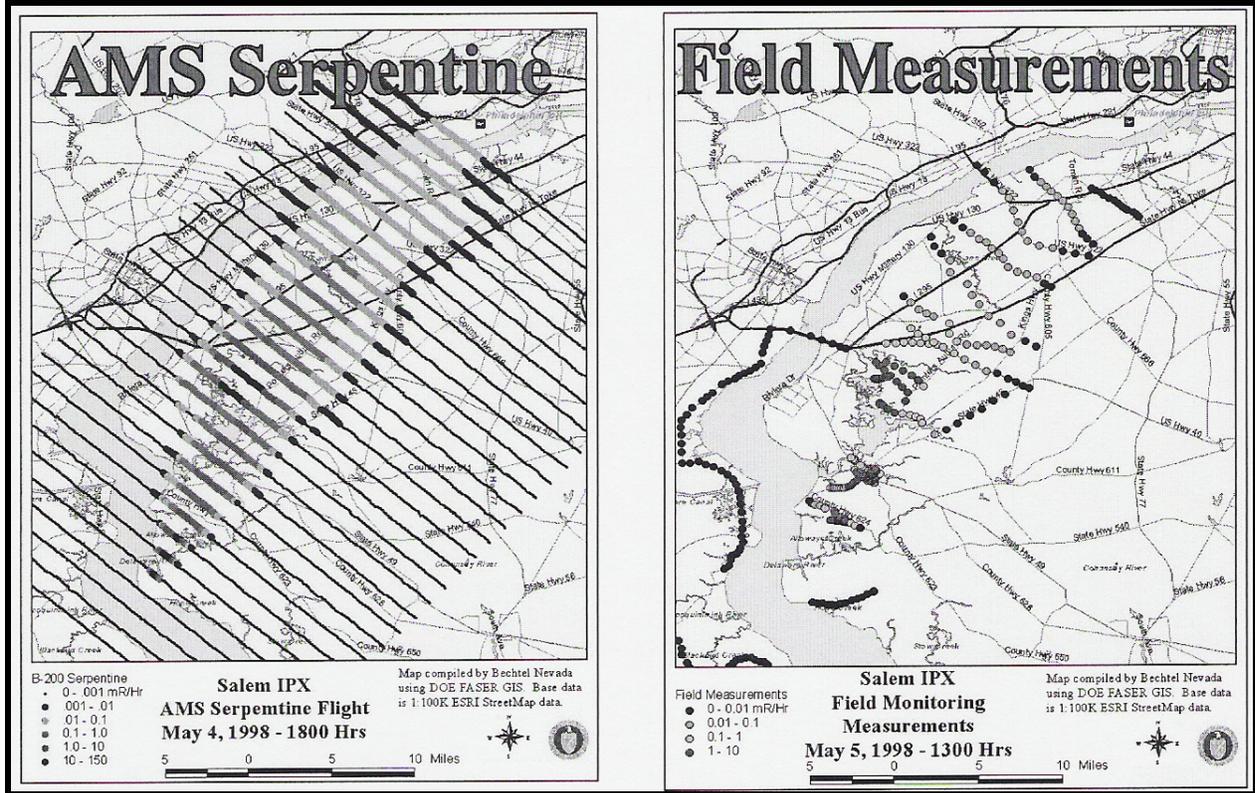
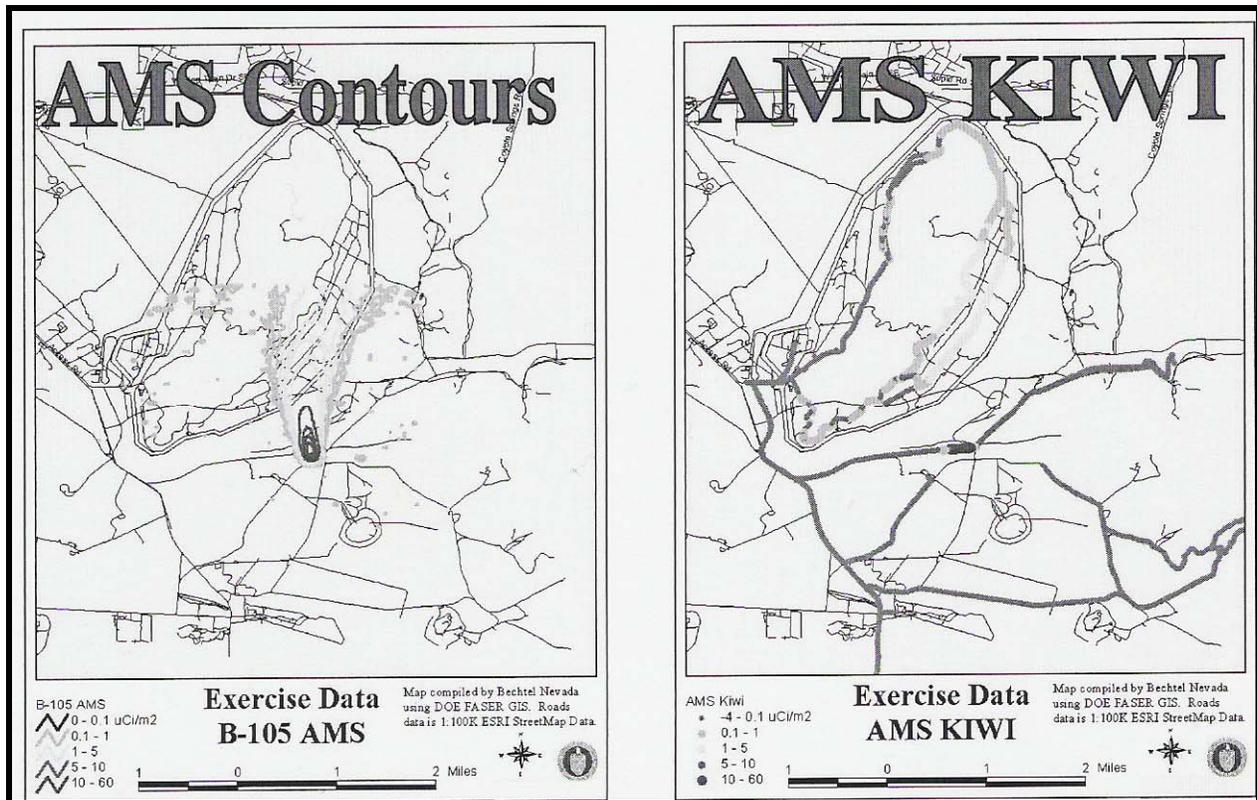


Figure 12. Aerial Survey Results: Radiological Data Measurements, AMS Contours, and AMS KIWI



(f) The sensitivity of the system depends on the flight altitude, area of contamination, and the interference of other isotopes (both natural and manmade). Experience has shown that the lower level of detectability of Am-241 may be expected to be 0.03 to 1.0 $\mu\text{Ci}/\text{m}^2$, and 0.03 to 0.3 $\mu\text{Ci}/\text{m}^2$ for both Cesium-137 and Iodine-131. The americium concentrations shown are on the order of one to 10 $\mu\text{Ci}/\text{m}^2$ of plutonium.

(g) Comparison with ground-based survey and sample results should be done with caution. The area sampled in a single aerial measurement is on the order of 1,000 times the area sampled by a FIDLER-type instrument at one foot above the ground and 1,000,000 times larger than the area sampled by an alpha probe or a soil sample. The aerial survey results weight the average of each scale and take into account the overall effect of roads, ditches, water bodies, vegetation cover, and terrain effects.

(3) Aerial Search. In certain scenarios, the aerial search capabilities available from AMS capabilities may need to be used. These consist of gamma and neutron detector modules designed for the DOE/NNSA-owned B0-105 or Bell 412 helicopters or portable modules that may be used in helicopters, such as the UH-60 and UH-1 with appropriate modifications. This capability may be useful only for certain sources of known detectability and usually requires low altitudes (100 feet or less) and slow speeds (about 60 knots). Aerial search personnel shall be able to determine the appropriate flight limits when notified of the particular scenario.

(4) Aerial Multispectral, Hyperspectral, and/or Thermal Imagery. Aerial imagery using a variety of sophisticated sensor suites may be used to find debris that has scattered around the accident site. Rigorous analyses allow for specific georeferences to be applied to each pixel of an image.

(5) Aerial Photography. Two major photographic systems are used to acquire detailed aerial photos over a site. One system consists of a large format aerial mapping camera operated in fixed-wing aircraft, which produces detailed aerial photographs. A second system operates out of helicopters, using the Hasselblad 70mm cameras to produce color photographs. Film from the Hasselblad system may be produced and printed under field conditions. Large prints up to 20 x 24 inches produced to map scales may be printed on-site, usually within hours of the completion of the flight. Digital photography is also available.