Standardized threshold sets in RadResponder unlock rapid data visualization during radiological emergencies, empowering responders to make smarter, faster decisions that prioritize safety.

CRCPD E-43 Committee for Interagency Environmental Data Sharing and Communications Endorsed RadResponder Threshold Sets

Jill Slubowski,[1] Angela Leek,[2] William Irwin,[3] Amy Hass,[4] Hillary Haskins,[5] Sahar Azmat,[6] Theodore (TR) Wentworth,[7] Brennan Bruner,[8] Patrick Mulligan,[6] Jim Hardeman,[9] and Jeffrey Day[10]

Abstract: *Situational awareness is critical in radiological emergency response as it enables responders to understand and interpret real-time data to make informed decisions during high-stress situations. Effective situational awareness involves collecting accurate data on radiation levels, contamination zones, and potential exposure risks, and visualizing this data in a comprehensible format. Tools like RadResponder play a key role in this process by allowing users to assign severity levels to data records and view them on an event map, thus facilitating rapid and informed decision-making. The CRCPD E-43 committee has developed enhanced threshold sets for RadResponder to improve situational awareness during radiological incidents. These threshold sets, based on science and informed by nationally recognized reference documents or regulations, are designed to help responders quickly assess radiation levels and make informed decisions regarding public safety and emergency worker doses. By providing clear, easily identifiable values and a standardized approach to data visualization, these threshold sets enhance the effectiveness of radiological emergency response efforts. The committee also recommends upgrades to the RadResponder system for better visibility and management of threshold sets, ensuring responders can efficiently access vital information during emergencies. Health Phys. 128:248–256; 2025*

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[1]Ohio Department of Health, Columbus, Ohio; [2]Summit Exercises and Training LLC, St. Petersburg, FL; [3]Vermont Department of Health, Waterbury, VT; [4]Minnesota Department of Health, St. Paul, MN; [5]Oregon Health Authority, Salem, OR; [6]New Jersey Department of Environmental Protection, Trenton, NJ; [7]Michigan Department of Environment, Great Lakes, and Energy, Lansing, MI; [8]New Hampshire Department of Health and Human Services, Concord, NH; [9]Retired, Georgia Department of Health, Frankfort, KY; [10]Los Angeles County Department of Public Health, Baldwin Park, CA.

INTRODUCTION

THE Conference of Radiation Control Program Directors (CRCPD) E-43 committee was tasked with collaborated with the National Incident Response Team (NIRT) on a project aimed to enhance the threshold set functionality in RadResponder.[11] The scope of this project was focused on developing simple and intuitive threshold sets that RadResponder users could use as a starting point in establishing their own jurisdictional threshold sets. The goal of the thresholds is to facilitate situational awareness and allow users to make quick, effective decisions in high-stress situations. These threshold sets are based on typical emergency response decision points such as emergency worker dose limits, public dose Protective Action Guidelines (PAGs), and risk for biological health effects from radiation dose. By grounding these threshold sets in guidance documents or regulations from authorities like the US Environmental Protection Agency (US EPA), the US Department of Energy (US DOE), Federal Radiological Monitoring and Assessment Center (FRMAC), the

The Conference of Radiation Control Program (CRCPD) established the E-43 Committee within the Environmental/Nuclear Council to work on initiatives that enhance interagency environmental data sharing and communication, particularly in the context of radiological events. The committee's charges focus on developing policy, recommendations, and guidelines to support states in common data sharing initiatives, specifically the adoption and maintenance of RadResponder as a key data management tool for radiological incident response. E-43 encourages various organizations, including NRC licensees, laboratories, and civil support teams, to integrate RadResponder into their data management processes and pursue RadResponderPrepared status. Additionally, the committee supports the development and ongoing maintenance of RadResponder and other radiological data-sharing mechanisms, ensuring effective communication strategies and processes.

[11]RadResponder.net is a free, web-based platform housed within CBRNResponder.net that helps emergency response organizations manage radiological data during a nuclear or radiological emergency. It was developed by the Federal Emergency Management Agency (FEMA), US Department of Energy (US DOE)/National Nuclear Security Administration (NNSA), and US Environmental Protection Agency (US EPA).

Federal Emergency Management Agency (FEMA), and the National Council on Radiation Protection and Measurements (NCRP), these thresholds can be considered scientifically robust and aligned with health physics principles, while remaining actionable by incident commanders and decision-makers throughout a response.

CRCPD and the E-43 Committee

The Conference of Radiation Control Program Directors (CRCPD) is a nonprofit organization dedicated to the protection of radiation health and safety. It supports its members, who are primarily radiation control program professionals, by providing resources, education, and a platform for collaboration. The E-43 Committee, under the Environmental/Nuclear Council, focuses on interagency environmental data sharing and communication. This committee is comprised of members and advisors from various state, local, and federal agencies and industry partners. The primary objectives of the E-43 Committee include developing policies, recommendations, and guidelines to assist states in adopting RadResponder for data management, encouraging other organizations to achieve RadResponderPrepared status, and supporting the development and maintenance of radiological data sharing and communication strategies. The committee's work is crucial in ensuring effective and standardized responses to radiological emergencies through enhanced data management and interagency cooperation (CRCPD 2024)

Radiological incident response

Radiological incidents can occur across a wide range of scenarios, each requiring specific strategies and tools to manage data and decision-making effectively. Understanding the priorities for each incident type is essential for developing comprehensive response plans and implementing tools like RadResponder. RadResponder data management and mapping functionality can assist in visualizing radiation information and data, but users must first understand the scope and scale of the incident and how this information is being used for discussion or decision-making to effectively improve situational awareness. The following paragraphs outline the radiation incident types that were considered by the E-43 committee when establishing these threshold sets.

Nuclear power plant radiological emergency preparedness (REP). Incidents at nuclear power plants can occur due to equipment failure, human error, or natural disasters. Such events can lead to the release of radioactive materials into the environment, necessitating protective actions, such as shelter-in-place or evacuation, to protect public health and safety. REP involves coordinated efforts between plant operators, local, state, and federal agencies to monitor radiation levels, implement evacuation or shelter-in-place orders, determine appropriate food and water interdiction, and manage long-term decontamination and recovery efforts. The planning zones for nuclear power plant response currently include a 10-mile emergency planning zone which extends further to consider longer-term protective actions that might be necessary out to 50 miles or beyond (US NRC 2019). The release from a nuclear power plant contains a multitude of different radioactive materials called "fission products" and most areas where the deposition could occur will result in relatively low to moderate dose rates within the microrem (microSv) per hour or millirem (milliSv) per hour range in the areas where response actions would be necessary outside of the plant boundary.

Radiological dispersal device (RDD). Often referred to as "dirty bombs," RDDs combine conventional explosives or other dispersal mechanisms with radioactive material, aiming to cause widespread contamination and panic rather than large-scale destruction. The primary challenge in RDD incidents is the rapid situational awareness to establish a hot zone and guide protective action decisions within the impacted area. Rapid visualization of the projected and measured deposition of radioactive materials, facilitating decisions regarding shelter in place or evacuation, decontamination priorities, and other public safety measures. The impacted area requiring protective action for an explosive RDD is expected to be within a 500-m radius of the explosion site and 2,000 m downwind, if the radioactive materials are aerosolized and dispersible (US DHS 2017). Some dose rates within this zone could be relatively high, but the overall scale of the areas where immediate public protection would be necessary in a RDD incident is expected to be less than 2 miles, which is several times smaller than a nuclear power plant incident (US DHS 2017). Measurable contamination would likely extend a few miles beyond this initial protective action area; however, the concentrations would be low and would not require specific immediate protective actions (US DHS 2017).

Nuclear detonation. This scenario involves the explosion of a nuclear weapon or improvised nuclear device, resulting in massive destruction at the detonation site, prompt radiation, fallout radiation, and long-term environmental contamination. The response to a nuclear detonation requires coordinated efforts to address acute traumatic injuries, the potential for significant radiation doses, and contamination control. A nuclear detonation can result in very high dose rates within the severe and moderate damage areas and where fallout is deposited, which can result in very high dose rates tens of miles from the detonation area (FEMA 2022). The radiation levels from fallout decrease rapidly over the first few hours and days of the incident due to decay of the short-lived isotopes; however, it will be critical to manage emergency worker doses and time spent in these relatively high radiation areas to ensure their health and their continued availability to provide response capabilities (FEMA 2022; NCRP 2011). The sheer scale of a nuclear detonation incident necessitates robust coordination to manage the vast amounts of data generated, track radiation levels, and guide emergency actions and prioritization of resources across multiple jurisdictions.

Importance of situational awareness

Situational awareness is paramount for all radiation incidents as it enables responders to understand and interpret real-time data to make informed decisions during high-stress situations. Effective situational awareness involves collecting accurate data on radiation levels, contamination zones, and potential exposure risks and further visualizing this data in a comprehensible format. RadResponder and similar situational awareness tools play a key role in this process by providing jurisdictions with a centralized system where predictive model products, field data and samples, and other response information are gathered and shared through partnerships (FEMA 2023). The map feature within RadResponder is key to the visualization of the vast amounts of data, and the ability to assign severity levels and colors to data records facilitates rapid understanding of the data and informs decision-making. This enhancement of situational awareness ensures that responders can quickly identify critical or dangerous areas, prioritize actions, and allocate resources effectively, thereby minimizing the impact of radiological incidents on public health and safety.

METHODS—DEVELOPMENT OF THE THRESHOLD SETS

The E-43 Committee for Interagency Environmental Data Sharing and Communication is a key working group under the Conference of Radiation Control Program Directors (CRCPD). The E-43 Committee's primary mission is to facilitate effective communication and data sharing among various agencies during radiological emergencies, enhancing the overall preparedness and response capabilities of federal, state, local, tribal, and territorial jurisdictions (CRCPD 2024). This is accomplished through the development of policies, recommendations, and guidelines to support states in adopting and managing data in a radiological incident, focusing on RadResponder as a key system for data management.

The RadResponder system currently had functionality to allow threshold values to be used by jurisdictions, but the default values were generally set and required each jurisdiction to determine their own appropriate values. Due to the shared nature of the system, the radiological response community and the CRCPD felt that the establishment of scientifically based recommendations for the application and use of these thresholds would be beneficial. The National Incident Response Team (NIRT) initiated a project to enhance the RadResponder functionality and establish recommended threshold sets, with the following list of criteria for the establishment of threshold sets:

1. Simple and intuitive: The threshold sets must be simple and listed in a way that a response organization or RadResponder user can quickly choose a threshold set that meets their response needs. Intuitive and efficient threshold options are important to users because they will be working during an emergency, which is a high-stress situation, and most users do not use RadResponder regularly.
2. Response decision-based: The threshold sets should be designed to help users make decisions. During an emergency, decision makers base their decisions on emergency worker dose limits, public dose Protective Action Guidelines (PAGs), biological health effects, emergency worker dosimeter decision points, etc. Developing thresholds that contain ranges based on science and informed by nationally recognized guidance documents or regulations routinely accepted as the basis for decision points throughout a response could help decision makers visualize the data and justify their recommendations or decisions at various phases of the incident response (early, intermediate, and late). Basing the threshold sets on science and informing them with nationally recognized guidance documents also satisfied the requirement for this project set by the Nuclear Incident Response Team (NIRT) to ensure the thresholds recommended for use in RadResponder were based on health physics principles.
3. Easily identifiable values: The committee also determined that the ranges in each threshold set should include values that are easily identifiable by the radiation protection and radiological emergency response community. Threshold sets should also include ranges derived from values that are related to established response zones currently used in many plans and procedures, and the range of colors should have a consistent meaning where possible. For example, a data point with the color indicator of red should always indicate that the data point exceeds an established limit, and the color indicator of green should indicate the data point is at background or levels below an actionable level.

RESULTS—E-43 COMMITTEE ENDORSED THRESHOLD SETS

The tables presented offer recommended threshold sets for use in RadResponder based on radiological incidents and common response decision points associated with these

Table 1. Accumulated dose thresholds for nuclear power plant incidents.

Decision Level	Low (mrem or mR)	Medium-Low (mrem or mR)	Medium (mrem or mR)	Medium-high (mrem or mR)	HIGH (mrem or mR)	Basis Document
Emergency Worker Accumulated Dose 25 rem Decision point[a]	0–100	100–5,000	5,000–10,000	10,000–25,000	> 25,000	FEMA REP Program Manual (FEMA 2019)
Emergency Worker Accumulated Dose 5 rem Decision point	0–100	100–1,000	1,000–3,000	3,000–5,000	> 5,000	EPA PAG Manual (US EPA 2017)
Emergency Worker Direct Reading Dosimeter Decision Point[b] set at 1R	0–500	Not used	500–750	750–1,000	> 1,000	FEMA REP Program Manual (FEMA 2019)

[a] The emergency worker dose of 5 Rem is indicated by the Medium Range in the 25 Rem threshold set.
[b] FEMA REP requires a dosimeter decision point based on the ratio of 5 to 1, TEDE to external gamma radiation dose.

incidents. These thresholds are meant for use by the entire jurisdictional team, comprised of technical health physicists, incident commanders, responders in the field, and decision makers. The committee focused the development of these thresholds on three radiological incident types: nuclear power plant (NPP) accident, radiological dispersal device (RDD) incident, and nuclear detonation (ND). These tables also include references to the documents used to support the threshold values that were chosen for each range. The NPP thresholds were separated from the RDD and ND thresholds because the response considerations and actions recommended through FEMA Radiological Emergency Preparedness program (REPP) is different than the guidance for RDD/ND. For example, REPP does not regularly use hot zone or dangerous radiation terminology in the guidance documents, but rather uses pre-defined emergency classification levels (ECLs) and emergency planning zones (EPZ) to determine and communicate protective action recommendations (FEMA 2019). The RDD and ND incident types are grouped together because the guidance for both use the same hot zone and dangerous radiation zone terminology and values.

Nuclear power plant accidents

The following tables outline threshold sets that could be applied relative to the situational awareness and decision aspects necessary for responding to an incident involving a nuclear power plant. Table 1 outlines thresholds that could be applied for visualizing the accumulated external doses recorded by responders from their personal radiation detectors or direct reading dosimeters. Table 2 outlines thresholds that could be applied for visualizing field survey readings recorded by responders entering exposure rate data collected in the field.

Nuclear detonation/radiological dispersal device (RDD) incidents

The following tables outline threshold sets that could be applied relative to the situational awareness

Table 2. Field survey thresholds for nuclear power plant incidents.

Decision Point	Low[a] (mrem/h or mR/h)	Medium-Low (mrem/h or mR/h)	Medium (mrem/h or mR/h)	Medium-high (mrem/h or mR/h)	HIGH (mrem/ h or mR/h)	Basis Document
Emergency Worker dose rate Decision Point[b] at 1 R h^{-1}	0–0.090	0.090–125[c]	125–500[d]	500–1,000	> 1,000	FEMA REP Program Manual (FEMA 2019)
DRL WITH radioiodine's 4-day evacuation/shelter PAG	0–0.090	Not used	0.090–1	1–2[e]	> 2	2010 FRMAC Assessment Manual (Vol 2) (FRMAC 2010)
DRL WITHOUT radioiodine's 4-day evacuation/shelter PAG	0–0.090	Not used	0.090–5	5–10[f]	> 10	
1st Year Relocation DRL	0–0.090	Not used	0.090–2.5	2.5–5	> 5	

[a]Low range indicates background using 3 times average background levels of 30 μR h^{-1} to indicate low impacted areas. It is recommended that users adjust the background range according to their geographic area.
[b]FEMA REP requirement for states to have a dosimeter decision point for emergency workers during the plume phase. Many states dosimeter value decision point is 1 R. Mission stay times need to be limited so dosimeter value decision points are not exceeded. Adjust according to your state's dosimeter value decision point.
[c]125 μR h^{-1} is equivalent to 1 R received in an 8-h shift. Adjust according to your dosimeter decision point and emergency worker shift length.
[d]500 μR h^{-1} is equivalent to 1 R received in a 2-h shift. Adjust according to individual dosimeter decision point and emergency worker shift length.
[e]EPA PAG of 1 rem TED roughly equates to a 2 μR h^{-1} exposure rate with radioiodine's present. This threshold set is to assist with plume model validation.
[f]EPA PAG of 1 rem TED roughly equates to a 10 μR h^{-1} exposure rate without radioiodine's present. This threshold set is to assist with plume model validation.

Table 3. Accumulated dose thresholds for nuclear detonation and RDD incidents.

Decision Point	Low (mrem or mR)	Medium-Low (mrem or mR)	Medium (mrem or mR)	Medium-high (mrem or mR)	HIGH (mrem or mR)	Basis Document
Emergency Worker Accumulated Dose	0–5,000	5,000–10,000[a]	10,000–25,000	25,000–100,000[b]	>100,000	US EPA PAG Manual (US EPA 2017) NCRP Report 165 (NCRP 2011)

[a]Biological effects could begin at 10,000 mrem and increase in a linear relationship as the dose increases and is indicated by the medium range.
[b]NCRP report 165 allows 50 rem or higher for lifesaving missions and greater than 100 rem at incident commander's determination.

and decision aspects necessary for responding to an incident involving nuclear detonations or radiological dispersal devices. Table 3 outlines thresholds that could be applied for visualizing the accumulated external doses recorded by responders from their personal radiation detectors or direct reading dosimeters. The exposure rates where responders will need to operate in and the amount of lifesaving response activity necessary during RDD or nuclear detonation incidents are higher than those expected in a nuclear power plant incident. Therefore, the accumulated dose threshold levels in Table 3 are set higher than those outlined in Table 1 for nuclear power plant incident response.

Table 4 outlines thresholds that could be applied for visualizing field survey readings recorded as exposure rate data collected in the field. These thresholds are based on hot zone and dangerous radiation zone levels outlined in response guidance.

Table 5 outlines thresholds that could be applied for visualizing field survey readings recorded as contamination concentration data collected in the field. It is important to note that the values used in this threshold were established according to the values listed in the guidance used for assisting with establishing a hot zone and other protective action decision making. These contamination threshold values are not meant to be used for long term decontamination or cleanup visualization. The thresholds are provided in the concentration units as dpm/100 cm^2, which were converted from the guidance units of dpm/cm^2 where 60,000 dpm/cm^2 is equivalent to 6,000,000 dpm/100 cm^2 and 6,000 dpm/cm^2 is equivalent to 600,000 dpm/100 cm^2. In order to use the threshold sets in Table 5, users will need to convert concentration readings from cpm to dpm and to 100 cm^2 depending on the efficiency and size of the detector used in the field.

DISCUSSION

The E-43 Committee has developed and endorsed the threshold sets presented herein to enhance the situational awareness and decision-making process during radiological incidents. These thresholds provide clear, scientifically backed ranges for jurisdictions to consider when establishing their own decision points throughout a response, facilitating more structured and effective coordination across jurisdictions. Establishing recommended threshold sets provide for standardization across the nation when using the whole community data sharing platform, RadResponder, which is critical when multiple jurisdictions or shared resources like the Radiological Operations Support Specialist (ROSS) are responding in partnership with one another. In addition, some jurisdictions have yet not considered the use of thresholds in the context of situational awareness in RadResponder, and these endorsed threshold sets provide a starting point for these jurisdictions.

The threshold sets are presented in two categories to allow the specific decision points and considerations outlined by FEMA Radiological Emergency Preparedness (REP) program for nuclear power plant response to be designated. Many of the specifically defined factors for nuclear power plant response would not translate to other types of radiological incidents, so they were categorized separately from the RDD and Nuclear Detonation threshold tables. The RDD and Nuclear Detonation incidents were categorized together because they both commonly use the Hot Zone and Dangerous Radiation Zone definitions to guide their response actions. For the most part, the committee attempted to set the low-medium (yellow-orange) threshold values at general guidance values and reserve the high range (red) threshold values to those that may correspond to rapid accumulation of dose that may result in adverse health effects ranging from increased cancer risk to deterministic effects. These thresholds may be used in a

Table 4. Field survey (area survey) thresholds for nuclear detonation and RDD incidents.

Decision Point	Low (mrem/h or mR/h)	Medium-Low (mrem/h Or mR/h)	Medium (mrem/h or mR/h)	Medium-high (mrem/h or mR/h)	HIGH (mrem/h or mR/h)	Basis Document
Hot Zone and Dangerous Radiation Zone definitions	0–1	Not used	1–10	10–10,000[a]	>10,000	FEMA Planning Guidance for Response to a Nuclear Detonation (FEMA, 2022) NCRP Report 165 (NCRP, 2010)

[a]NCRP 165 definition of the hot zone is 10 mrem h^{-1} and definition of dangerous radiation zone is 10 rem h^{-1}.

Table 5. Field survey (contamination) thresholds for nuclear detonation and RDD incidents.

Decision Point	Low (dpm/ 100 cm^2)	Medium-Low (dpm/100 cm^2)	Medium (dpm/100 cm^2)	Medium-high (dpm/100 cm^2)	HIGH (dpm/100 cm^2)	Basis Document
Beta-gamma Contamination	0–60,000	60,000–600,000	600,000–6,000,000	>6,000,000	User defined	Radiological Dispersal Device (RDD) Response Guidance Planning for the First 100 Minutes (DHS 2017)
Alpha Contamination	0–6,000	60,00–60,000	60,000–600,000	>600,000	User defined	NCRP Report 165 (NCRP 2011)

variety of ways by the jurisdictions, but the expectation is that these color-coded values will only assist with rapid visualization of the available field data. This field data is only one component of the overall information that a jurisdiction will use for decision-making throughout an incident.

The presented threshold sets are not meant to be used without context of a jurisdiction's procedures or consideration of the question posed while the thresholds are being applied. The goal of the project was to adapt commonly used guidelines to the color scheme available in the RadResponder tool, which was limited to five levels. The committee decided to break the threshold sets into the presented tables to offer more gradients and options to the use of the colors, depending on the incident type and decision being considered.

Nuclear power plant accident thresholds

For nuclear power plant incidents, the threshold sets are categorized into two tables, each with five ranges: Low, Medium-Low, Medium, Medium-High, and High that correspond to units appropriate for the data. The first set of thresholds in Table 1 provides two choices for visualization of emergency worker accumulated dose data in the RadResponder system, depending on the set decision points for specific workers. When viewing dosimetry data for lifesaving activities, the threshold set titled "Emergency Worker Accumulated Dose—25 rem (0.25 Sv) decision point? can be used to set the high range to above 25,000 mrem (250 mSv), based on FEMA REP Program Manual and US EPA PAG Manual guidelines for lifesaving activities (US EPA 2017; FEMA 2019). Alternatively, when viewing data for emergency workers for emergency response activities, the threshold set titled "Emergency Worker Accumulated Dose—5 rem (0.05 Sv) decision point" can be used to set the High range to above 5,000 mrem (50 mSv). Because most dosimetry data is recorded in RadResponder as external dose, an additional threshold set was developed to trigger High when 1,000 mrem (10 mSv) is recorded to visualize workers who may need to be assessed for any additional internal exposure contribution in order to determine their total effective dose and guide additional dose allowance. The threshold sets provided in Table 1 focus on the operational objectives of managing emergency worker dose, and not on public protective action levels or doses because actual field data reflecting accumulated doses for the public would not be entered into RadResponder. Public doses during the early phase of a NPP accident are most commonly reflected as projected doses and the field data related to these values are more commonly reflected as derived response levels (DRLs) which are provided in Table 2.

Table 2 provides visualization of the field survey data provided in an exposure or dose rate, and the presented field survey thresholds offer ranges to represent worker or public decision-making dose levels. The emergency worker dose rate relative to the decision point at 1 R h^{-1} is provided in this table as an exposure rate, with 125 mR h − 1 as the point where the color changes from Medium-Low to Medium. This value was selected because it is the rate at which a 1R dose would be received in an 8-hour mission or work shift and would allow time to make adjustments to the assigned work before the 1R dose was received.

The tables referencing the derived response levels (DRLs) are intended to assist with plume model validation, aligning with US EPA's guidelines for protective action recommendations for the public (US EPA 2017). DRLs are commonly applied in radiological emergency response to translate actionable doses or concentrations into measurable exposure rate values that can be measures in the field. The DRL values used to establish this threshold set were provided in the 2010 FRMAC Assessment Manual (Vol. 2) (FRMAC 2010) and the assumption is that the associated field measurements assigned to this threshold set would be obtained in the manner prescribed in jurisdictional procedures for the application of these DRL values. While these DRL values are not included in subsequent versions of the FRMAC Assessment Manual, the E-43 Committee assessed that the values could serve as a good starting point since the derivation of more specific DRLs could take time. It is recommended that these DRL values be changed as soon as more specific DRLs based on the specifics of the radiological release and deposition characteristics are available.

Nuclear detonation and radiological dispersal device (RDD) incident thresholds

In the context of nuclear detonation or RDD incidents, the accumulated dose thresholds are categorized similarly to those in the nuclear power plant incident thresholds, but with higher upper limits to account for the need to operate in high radiation areas or hot zones to manage the severity and extent of the impact from of these scenarios. These threshold values are intended to be used with guidance documents and jurisdictional procedures and provide rapid visualization of the field data to aid in situational awareness. Each jurisdiction should determine the appropriate upper limits, especially in the case of a nuclear detonation incident where considerations for actions will be made in the range above that represented by the highest (red) threshold color.

The "Emergency Worker Accumulated Dose" set sets a high range of over 100,000 mrem (1,000 mSv), reflecting the threshold where acute radiation syndrome could begin to manifest. This leaves the lower threshold levels to reflect the 5 rem (0.05 Sv), 10 rem (0.1 Sv), 25 rem (0.25 Sv), and 50 rem (0.5 Sv) operational dose decision points as recommended by the US EPA PAG Manual and NCRP Report 165 (US EPA 2017; NCRP 2011).

The field surveys threshold sets recommended for use in an RDD or nuclear detonation incident define critical response zones such as the "Hot Zone" (1-10 mrem h^{-1} or 0.01-0.1 mSv h^{-1}) and the "Dangerous Radiation Zone" (above 10,000 mrem h^{-1} or 100 mSv h^{-1}), based on FEMA planning guidance for response to a nuclear detonation, the US DHS guidance for response to a RDD, and NCRP recommendations (FEMA 2022; US DHS 2017; NCRP 2011). These definitions assist in identifying areas requiring immediate action and prioritizing resources for containment and evacuation. Because RDD incidents can have specific radionuclides with protective actions guided by contamination levels, the field survey thresholds also include consideration of beta-gamma and alpha deposition contamination as stated in the Radiological dispersal device (RDD) response guidance: Planning for the first 100 minutes (US DHS 2017). The use of these contamination threshold sets is expected to be applied only for RDD incidents as outlined by this guidance.

The beta-gamma contamination thresholds range from 0 to over 6,000,000 dpm/100 cm^2 and the alpha contamination ranges to 600,000 dpm/100 cm^2 which correspond to the "Hot Zone" as defined by NCRP recommendations and the DHS guidance for response to a RDD (US DHS 2017; NCRP 2011). It should be noted that the definition of the hot zone in the guidance documents are listed in cm^2, which is 60,000 dpm/cm^2 for beta-gamma contamination or 6,000 dpm/cm^2 for alpha contamination (US DHS 2017; NCRP 2011). The recommended values for the threshold sets have been converted to dpm/100cm^2 to align with the surface area of many radiation detection equipment commonly used for alpha and beta-gamma measurements; however, users should note the surface area for the radiation detection equipment in use and convert the data entries as appropriate to use these threshold sets. Additionally, users should understand that these thresholds cannot be used directly with detection equipment readings when they are entered into RadResponder as counts per minute (cpm) and must be converted to disintegrations per minute (dpm) using the detection efficiency of the specific equipment in use.

Impact of using thresholds

The initial default thresholds in RadResponder were developed using general values but were not tied specifically to guidance or operational objectives. By applying the appropriate threshold for the operational consideration under review, the field data can be more rapidly reflected in proper context to the guidance parameter of interest. As an example, Fig. 1 reflects the field data using the original default threshold set available for field survey data in RadResponder. Fig. 2 is updated in RadResponder using the field survey threshold for the emergency worker decision dose at 1 R h^{-1} from Table 2 for Nuclear Power Plant accidents. It should be noted that the values of these data points did not change, only the color assigned to them. The main difference is the change of color for two data points from red to a light green. Used in this context, Fig. 2 shows how RadResponder more clearly provides rapid situational awareness for discussions regarding emergency worker doses. The green color across the entire area of interest indicates that it is unlikely that any workers in the area

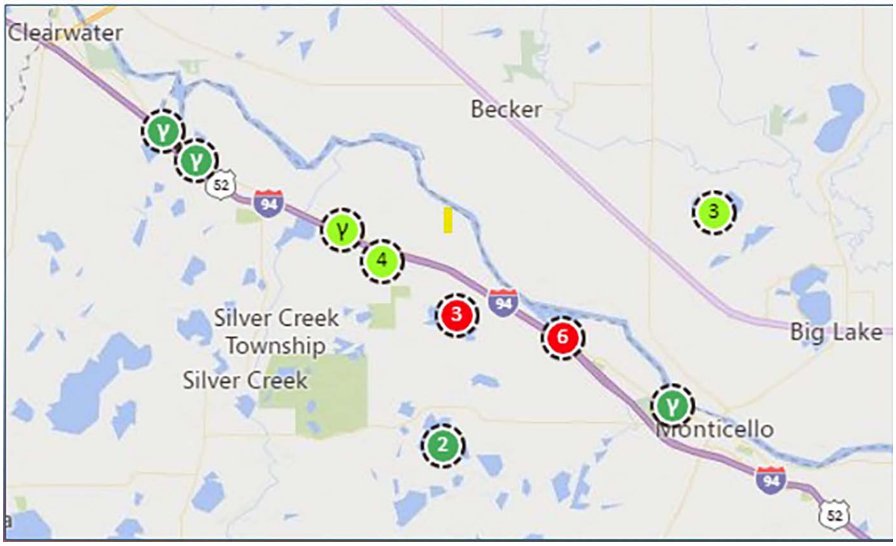

FIG. 1. Visualization of survey field data in RadResponder map using original threshold

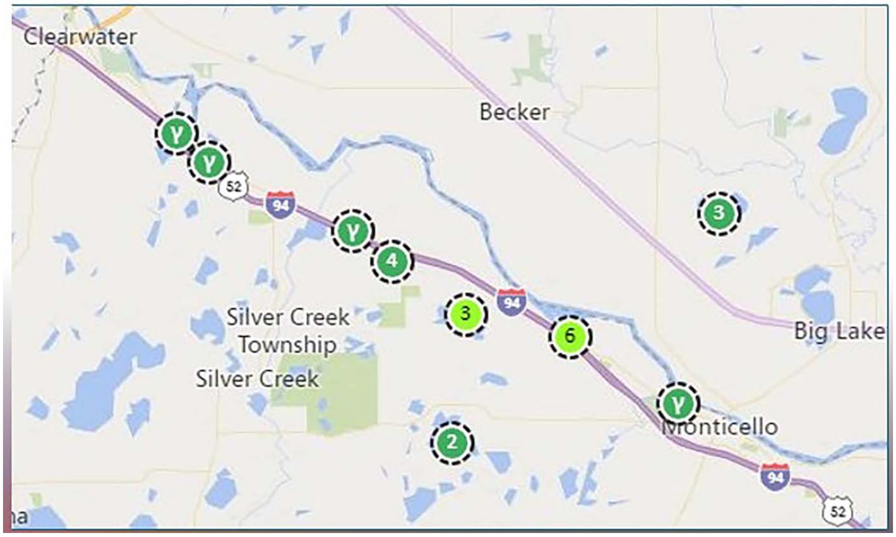

FIG. 2. Visualization of survey field data in RadResponder map using updated threshold set for NPP emergency worker decision point at 1 R h^{-1} from Table 2.

would reach the 1 R h^{-1} decision point in an 8-hour shift.

Importance of customization and flexibility

The committee emphasizes that these threshold sets should not be viewed as default, but as adaptable tools tailored to specific incident needs. Each jurisdiction is encouraged to review and incorporate these thresholds into their emergency plans, adjusting them as necessary to reflect local conditions and operational practices. Training and exercises should be conducted to ensure responders are proficient in using these thresholds and the RadResponder system under real-world stress conditions.

Precautions and limitations

The E-43 committee recommends that users do not consider these threshold sets to be "default" threshold sets but instead view them as options that provide a strong basis and justification for the visualization of field survey and dose accumulation data. All thresholds used by a jurisdiction should be reviewed and implemented in a way that best serves the needs of each jurisdiction and their decision makers. In addition, in an effort to stay within the scope and timeline of the NIRT project, the committed limited their consideration of thresholds to the application of thresholds in the RadResponder system for the early phases of a response when there is not much information or time available to consider the establishment of thresholds. The committee cites that there are many other potential applications of these threshold set color schemes outside of RadResponder and expects that jurisdictions will develop and use their own threshold sets as appropriate to facilitate situational awareness and to inform their decisions.

The threshold set functionality in RadResponder currently allows only one threshold to be chosen for each data type across the event. This means that if a user changes the active threshold set for a data type within an event, it will change for all users viewing that data on that event. Event managers and other users with permission to change this setting must be aware of this and coordinate with other users across the entire event before changing to a new threshold set.

Since the RadResponder Event Map can present an immense amount of data, the "Saved Map Views" feature can further help organizations and users as this capability will save a map view containing user specified filters and applied thresholds for later use. The thresholds sets presented in this document can help with data visualization; however, it is recommended to use map filters to display only data relevant to the discussion or decision being made at the time the map is used

Most of the dosimetry data collected by field teams and entered into the RadResponder system represent external doses from direct reading dosimeters or personal radiation detectors, which represents external dose only. Some of the threshold values and guidance related to DRLs account for this, but jurisdictions should consider how the external dose data provided from the field is incorporated into the larger assessment of dose overall.

The various references and guidance documents that support the threshold set tables refer to a variety of units of exposure or dose; roentgen (R), absorbed dose (rad), or dose equivalent (rem) with the associated SI units (Gy or Sv) provided for cross reference. For simplicity, the units of R and rem are listed first in the threshold set tables because the majority of the radiation detection equipment in the United States currently reads in traditional units. However, RadResponder users or organizations should use units, including SI units, which are appropriate to their procedures and align with the output of their specific field equipment.

RadResponder update recommendations for enhancing visualization and use of thresholds

To improve usability, the committee recommends that the RadResponder functionality be updated to offer an option to display a legend on the event map indicating the active threshold set in use, helping users quickly interpret data points and minimize any misinterpretation of the colors presented. Additionally, a proposed system upgrade to allow threshold sets to be selected and viewed at the individual user account level without changing them for all event users would enhance the flexibility and use of the thresholds for tailored and effective data visualization without inadvertently affecting other users across the event.

CONCLUSION

The comprehensive efforts of the CRCPD E-43 committee to develop and endorse scientifically based threshold sets for RadResponder can significantly enhance situational awareness and decision-making capabilities during radiological incidents. By providing clear, easily identifiable visualization of common values for emergency worker dose limits, public dose Protective Action Guidelines (PAGs), and other critical decision points, these threshold sets enable responders to interpret data more effectively. The scientific foundation for the application of these threshold values is crucial for ensuring that the use of these thresholds during response actions are justified and appropriate across various phases of an incident.

The project emphasizes the importance of developing threshold sets that are simple, intuitive, and based on science and informed by nationally recognized guidance documents or regulations. These threshold sets cater to the unique requirements of different radiological incident types, including nuclear power plant incidents, nuclear detonations, and radiological dispersal devices (RDDs). The flexibility built into these threshold sets allows for their adaptation to specific incident needs or jurisdictional procedures, ensuring that they can be tailored to meet the demands of real-world emergency scenarios.

RadResponder.net, as part of the broader CBRNResponder.net platform, plays a vital role in enhancing situational awareness and providing a common operating picture across federal, state, local, tribal, and territorial jurisdictions. The system's ability to collect, visualize, and share radiological data across the entire response community in real-time is indispensable for coordinated decision-making and response efforts. By integrating these endorsed threshold sets into the RadResponder system, responders can make informed decisions to effectively prioritize actions and allocate resources. The committee's recommendations for displaying legends on event maps and enabling threshold set management at the user account level further enhance the usability and effectiveness of the system. These enhancements, along with continuous feedback and regular updates, ensure that the RadResponder system remains responsive to the evolving needs of the radiological emergency response community. These endorsed threshold sets will be provided through the CBRNResponder system along with supporting documentation reflecting the justification as outlined in this publication. With the conclusion of the NIRT project, the E-43 Committee role in establishing recommended threshold sets in finished. However, as jurisdictions establish additional threshold sets to be used in RadReponder, it is recommended that jurisdictions and CRCPD continue to share best practices, and new threshold sets across the entire RadResponder user community.

Jurisdictions are encouraged to review and incorporate these threshold sets into their existing emergency response plans and procedures. This integration, coupled with appropriate training and exercises, will ensure that responders are well-prepared to use the RadResponder system under stress conditions, ultimately improving the overall effectiveness of radiological incident response efforts. The endorsed threshold sets developed by the E-43 Committee provide a framework for enhancing situational awareness and decision-making during radiological incidents. By incorporating these thresholds into their emergency plans and procedures, jurisdictions can ensure a more effective and coordinated response, ultimately improving public safety and resilience in the face of radiological threats.

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