

Wide Area Recovery & Resiliency Program
(WARRP)

**Interim Clearance Strategy for Environments
Contaminated with *Cesium-137***

July 2012



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14. ABSTRACT

This paper reflects an approach for state and local recovery managers to define the radiological clearance levels to be implemented following a terrorist detonation of a Cs-137 Radiation Dispersal Device (RDD). These clearance levels address public health and safety, debris management, business, agriculture, and environmental concerns. These values help the affected community define clearance goals, so the physical, social, political, cultural, and economic infrastructure of that community can be expeditiously recovered. The range of values is consistent with accepted risk assessment processes that bridge dose-and-risk criteria. The process described in this paper is designed to support a recovery timeframe goal of twelve to eighteen months. Critical infrastructure and other essential portions of the city, as designated by the decision makers and community, may be restored in a shorter time frame. For less inhabited or non-critical areas, the time frame may be longer. Because recovery is both time and budget sensitive, it is imperative that the community address these values, and have agreement, before a disaster strikes. A key principle is the inclusion of multiple stakeholders and the general public. Pre-event clearance level concurrence is key to a community's resiliency and speedy recovery.

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1. Purpose and Scope Statement

This paper reflects a sample approach for state and local recovery managers considering the radiological clearance levels to be implemented following the terrorist detonation of a Cs-137 Radiation Dispersal Device (RDD) in downtown Denver. The clearance strategy discussed in this paper address the range of values pertaining to public health and safety, debris management, business, agriculture and environmental concerns. These values help the affected community define the goals for site and incident specific clearance, so that the physical, social, political, cultural, and economic infrastructure of that community can be expeditiously recovered. The range of values discussed in this paper is consistent with accepted risk assessment processes that bridge dose-and-risk criteria.

The overall intent of this document is to assist planners and recovery workers with effectively recovering a community to viability (restore population, industry, commerce and the environment) to pre-event/near pre-event levels within a target period that is commensurate with the size, scope, and urgency of the recovery needs. The process described in this paper is designed to support a recovery timeframe from the Denver WARRP scenario with a goal of twelve to eighteen months. For critical infrastructure and other essential portions of the city, as designated by the decision makers and community, a shorter time frame may be possible. For less inhabited or non critical areas, the time frame may be longer. The time frame for recovery operations will be based on a phased approach that is technically and socio-economically driven and involves the inclusion of multiple stakeholders and the general public. Because recovery is both time and budget sensitive, it is imperative that the community address the range of values, and have agreement, before a disaster strikes. Pre-event clearance level concurrence is key to a community's resiliency and speedy recovery. As such, technical and socio-economic considerations (inclusive of stakeholders and public input) are factored into this approach

2. Documents

Radiological cleanups have been accomplished in multiple locations around the world over several decades. The sites have been large and small, urban and rural and have contained a plethora of radionuclides. The details on some of these cleanups are contained in the documents discussed in the Bibliography attached to this document. The document list also contains information pertaining to how the National Response Framework describes a radiological site cleanup approach with Federal agencies performing work consistent within their established roles, responsibilities, and capabilities all compatible with the Incident Command/Unified Command (IC/UC) structure embodied in the National Incident Management System (NIMS). The document list is not meant to be exhaustive. A brief synopsis is included with each document and is meant to assist the reader in selecting documents for further reading. The selected documents can be classified into 6 main categories. One group reports on the cleanup of specific sites: those containing only cesium-137 (Goiania) and those containing ¹³⁷Cs and other radionuclides (Chernobyl). Another group contains documents relevant to site survey

procedures, laboratory and field measurements, and risk assessment processes; yet another provides documentation on site cleanup and recovery criteria/guidelines. A “general reference” group of documents provides background information about ^{137}Cs , RDD planning guidance, and federal regulations. The sixth group of documents generally describes public health care of radioactively contaminated patients and models that estimate excess cancer risks. There is also a list of internet sites containing information on one or more of the preceding categories.

3. Discussion

The overall intent of this document is to assist planners and recovery workers with effectively recovering a community to viability (restore population, industry, commerce and the environment) to pre-event/near pre-event levels within target periods that are commensurate with the size, scope, and urgency of recovery needs. For purposes of this scenario, the goal is to recover Denver from the WARRP scenario (found in Appendix A) within twelve to eighteen months with possible shorter recovery times for some areas. The recovery will take a phased approach, in which critical infrastructures and regions can be prioritized over less critical ones, to allow for the greatest impact towards recovering the community to viability. There may also be less essential areas that cannot be fully recovered to pre-event conditions within the 18 month time frame, but will be addressed in later phases of the recovery. This paper recognizes that recovery to normal living conditions is in fact conditional and that what is considered “normal” will change over time. Given the realities of the situation, decision makers will likely work with inhabitants to determine the new “normalcy.”

Inhabitants of contaminated areas often face difficult personal choices concerning their future, and are particularly confronted by the dilemma of whether to leave or to stay. Experience shows that it is difficult to answer this question solely on the basis of radiation protection considerations. Many personal aspects enter into the balance; people living in contaminated areas are generally very reluctant to leave their homes, and hope to improve their living conditions. This situation calls for decision makers to develop protective actions, cleanup targets and consider initiatives to enhance the quality of life of the residents of the contaminated areas. Recovery experience from the Chernobyl incident have demonstrated that direct involvement of inhabitants and local professionals in management of the situation is an effective way to improve the recovery and rehabilitation process (Lochard, 2007). This requires regular information on the radiological situation, and the successes and difficulties with implementation of protection strategies. It is the responsibility of the decision makers (both national and local) to create the conditions and provide the means favoring the involvement and empowerment of the population. This is done by taking local social and economic living conditions into account to provide individuals with information, thus allowing them to understand and assess their personal situation and to maintain vigilance with the objective to improve their daily life and to protect themselves and their offspring for the future. The aim of the decision makers should be to help individuals regain control of their lives, in which radiation protection against the existing

contamination is a factor to add to several other factors affecting the rehabilitation of living conditions.

For the purposes of this document, state and local planners have defined “normalcy” to be 80% of pre-event conditions as follows:

- 80% displaced population returned
- 80% industry operational
- 80% agricultural lands released from quarantine
- 80% infrastructure intact
- 80% other aspects of recovery completed (Example: recognizing that the WARRP notional scenario involves significant damage to the United States Mint, as well as the complete destruction/demolition of the Anschutz Medical Center, 80% infers complete removal of debris, and either actual, or imminent, rebuilding of these facilities).

When considering what values to select from the range of clearance levels, it is important that local jurisdictions, with public and other stakeholder involvement, arrive at a consensus before an incident occurs, to the extent possible. Clearance levels for various sectors (see Section 5) should be adopted so they can be implemented in the late stages of response. Pre-selection of clearance levels is preferred and helps to promote resiliency in the community. Public and business acceptance of clearance levels before an incident offers assurance that there is a recovery goal, the goal is attainable and the goal is consistent with the health and safety of individuals at home, at school and at work. The goal to be selected (clearance levels) should take into consideration the following factors: (1) time to recover, (2) cost of recovery, (3) public health, (4) business competitiveness, (5) environmental impact, (6) acceptability to non-impacted communities, and (7) political-social drivers. The clearance levels goal(s) should be mutually agreed to and directed toward the recovery of the damaged community to a state that existed prior to the offending incident. For this scenario, and in reference to the seven factors identified above, state and local planners have prioritized the factors with a short justification, and ranking (primary, major, significant):

- ***Time to recover:*** Acknowledging public health will be maintained, this is the *primary* emphasis of recovery, to ensure an impacted community can recover in a timely fashion
- ***Public health:*** This is a *primary* emphasis of recovery, to promulgate a recovery that ensures the public is safe. This factor includes the assurances an evacuated population needs before a return to residences and workplaces can occur
- ***Cost of recovery:*** While ensuring public health, this is a *major* emphasis of recovery, to keep recovery costs as low as possible
- ***Business competitiveness:*** This is a *major* emphasis of recovery, to help business be re-established and competitive (ensuring products are not boycotted or rejected)

- ***Environmental restoration***: This is a *significant* emphasis of recovery, acknowledging the importance of a clean environment, but only so far as the public is safe (this does not mandate “every radioactive atom be removed”, or “no radiation above background”)
- ***Acceptability to non-impacted communities***: This is a *significant* emphasis of recovery, it diminishes any negative concerns about the impacted community and reduces potential shunning of the population or its products
- ***Political/social drivers***: This is a *significant* emphasis of recovery, to maintain calm and credibility among the population and ensuring supportive political leadership

These specific factors are relevant not only for the determination of acceptable clearance levels for the sectors affected by the event, but also for the development of the comprehensive recovery plan for the entire impacted area.

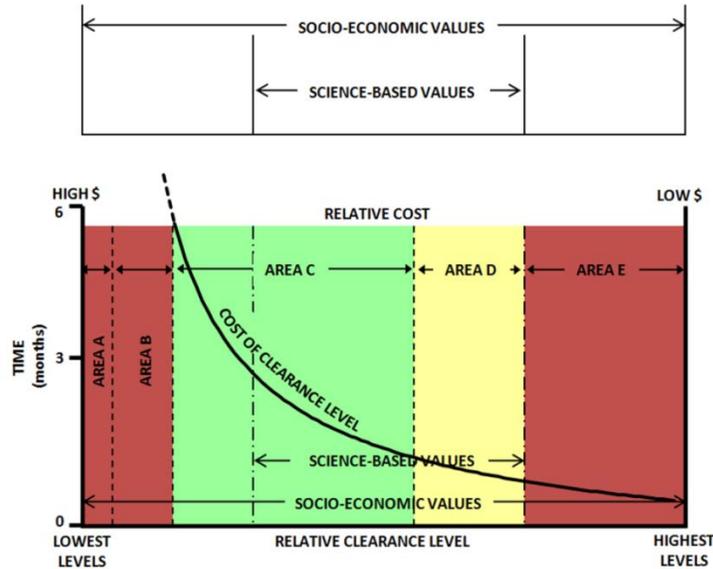
4. Dose- and Risk-based Clearance Levels

The clearance levels discussed in this paper are found in further detail in the original documents as shown in the bibliography. The range of the clearance levels is sector-based specific. In other words, agricultural considerations are different than residential, which are different than transportation. There is no single clearance level that will satisfy multi-sector considerations. An acceptable, negotiated range of values will be necessary - and delineated - in the late response phase in order to promulgate an immediate and effective recovery (as was done in Goiania, Brazil).

It is possible to graphically display the spectrum of clearance levels from various perspectives. The technically-based levels should be bounding, but also include other considerations, principally the political/social and business desires (which include the factors described above), presumably at opposite ends of the spectrum. For example, debate exists over technically sound levels, with the most conservative values espousing the lowest levels, where the political and social drivers may be associated. By comparison, the highest values will likely be associated with business-friendly perspective that encourages a quicker return to productivity.

The resultant illustration may look more like the one on the following page:

Figure 1. Recovery Cost Continuum



Area	Cost	Time for Initial Phase	Socio-Economic	Scientific & Medical
Area A	Too costly	Too long to achieve	Unjustified	Unjustified
Area B	Costly	Achievable in 6 months	Extreme	Unjustified
Area C	Within acceptable costs	Achievable in 6 months	Acceptable	Extreme – Acceptable
Area D	Within acceptable costs	Achievable in 6 months	Acceptable – Extreme	Justified
Area E	Least costly	Achievable in 6 months	Extreme	Unjustified

Site characterization and delineation of measurable residual quantities, above background concentrations associated with the cleanup goals must be derived taking into account radiological exposures and corresponding doses resulting from external and internal irradiation and intake of Cs-137 from all potential pathways and through all environmental media (e.g., building surfaces, soil, ground water, surface water, sediment, air, animals or plants). These values typically are derived considering reasonably anticipated future land use and publically inhabited areas, agricultural food production and supply, drinking water, and commerce patterns (See Section #5, below, “Sectors”).

Dual Federal and State regulations and legislation governing radiological materials has been previously addressed in Denver and the State of Colorado at sites such as Denver Radium, Shattuck Radium, and Rocky Flats Environmental Technology Sites. These sites utilized a variety of public land-use criteria (ranging from residential to wildlife refuge) and regulations such as CERCLA (Comprehensive Environmental Response, Compensation, and Liability Act), SDWA (Safe Drinking Water Act), UMTRCA (Uranium Mill Tailings Radiation Control Act), Nuclear Regulatory Commission (NRC) and the State of Colorado NRC Agreement State status which utilizes “as low as reasonably achievable” (ALARA) practice. The key to setting appropriate remediation goals involved building a long-term protective public health and environmental criteria comparing lifetime cancer risk criterion with annual dose criterion

through the use of an effective risk communication process. Risk communication and the involvement of the public in the recovery process is a key issue in building community trust necessary for implementing satisfactory remediation levels. Federal, state, and local regulatory agencies should bring together a broad group of stakeholders, e.g., residents, local business owners, local government officials and others interested in the processes that will be required to restore their communities to the agreed upon criteria. The credibility of a community group is a function of its inclusiveness. It must represent all stakeholder interests to ensure it is a voice for the entire community rather than a few interested parties. Empowering individuals to assist in the process is important and effective. The affected local community will need to be involved until the site remediation activities are complete, and possibly beyond that if institutional and engineering controls are placed on some subareas of the site.

Dose and risk criteria currently established in regulations are important starting points for choosing remediation levels, for either intermediate or life-time levels, such as those found in NCRP# 146, Appendix C (October, 2004) and those shown in the table below:

Table 1. Comparison of Published Clearance Values

Agency/ Organization	Standard (above background level)	Reference	Risk per 30 years [†]
OSHA, NRC, DOE	5,000 mrem/yr (worker)	29 CFR 1910; 10 CFR 20; 10 CFR 835	7.5×10^{-2}
NRC	100 mrem/yr (public)	10 CFR 20.1301	1.5×10^{-3}
DOE	100 mrem/yr (public)	10 CFR 835.208	1.5×10^{-3}
ATSDR	100 mrem/yr (public)	Toxicological Profile for Ionizing Radiation (Chronic MRL)	1.5×10^{-3}
EPA	10 mrem/yr (air pollution) (public)	NESHAPS 40 CFR 61	1.5×10^{-4}
ICRP	100 mrem/yr; or if >100, not to exceed an average of 100 mrem/5 yrs (public)	ICRP Publication 60	1.5×10^{-3}
NCRP	100 mrem/yr continuous exposure (public)	NCRP Report 116	1.5×10^{-3}
NCRP	360 mrem/yr from background (public)	NCRP Report 116	5.4×10^{-3}

[†]Based on a fatal cancer risk of 0.0005 per rem risk. The EPA default exposure duration is 30 years (Risk Assessment Guidance, Part B).

Abbrev: OSHA=Occupational Safety and Health Administration; NRC=Nuclear Regulatory Commission; DOE=Department of Energy; mrem/yr=millirem per year; MRL=minimal risk level; NESHAPS=National Emissions

Decision makers must consider not only the socio-political-economic recovery implications (e.g. costs, resources required, level of societal disruption) but they must also select clearance values that reduce the dose to the individual (dose avoidance) and the potential long-term cancer risks to the communities' public health (adverse risk reduction). The residual risk from the criteria chosen is dependent upon post-cleanup contamination and exposure levels, future land use assumptions, future occupancy and activities, dose-and-risk assessment methodologies, as well as uncertainties associated with site characterization and dose and risk assessments. Denver and the State of Colorado has used public stakeholder involvement and pragmatic processes to select and implement clearance levels for Superfund sites that addressed societal needs, to include protection of the public health and the environment, using both a dose-and-risk criteria. While much can be learned from past processes, decision makers should be aware of the unique differences inherent in the terrorist attack scenario.

5. Sectors

A site or area may reasonably be anticipated to support a range of uses, so cleanup goals (time frame and clearance levels) may be different for different subareas of the impacted area.

Publicly Inhabited Areas: Decisions for prioritizing recovery assume that any site use by the public will be considered as an area of unrestricted access and use. This would typically cover areas such as: residential homes, critical infrastructure and key resources (CIKR) and business areas, and outdoor recreational areas.

Agricultural food production and supply: This sector's recovery is focused upon the reduction of dose-risk to the general public from the consumption of contaminated food items, restoration of agricultural productivity in the contaminated areas, and returning public confidence in the safety of food products and its food supplies.

Drinking water: This sector's recovery is focused on the radionuclide concentration in drinking water as supplied to the public, i.e. at the tap not in open air water reservoirs, surface waterways, or private cisterns. The sector is predominately managed for the reduction of contamination in drinking water and subsequent ingestion doses by those consuming water supplied to the public.

Areas of special significance: Buildings or other places of religious, historical, national, or regional significance may require separate consideration when determining appropriate cleanup levels. Proper realistic exposure scenarios and model parameters must be used to insure that the clearance levels for these buildings and areas allow for their continued use as much as possible.

6. Implementation of cleanup and clearance ¹

¹ This cleanup process does not rely on and does not affect authority under the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA), 42 U.S.C. 9601 et seq. and the National Contingency Plan (NCP), 40 CFR Part 300. This document expresses no view as to the availability of legal authority to implement this process in any particular situation.

Final recovery after RDD incidents would involve the collection, monitoring, and assessment of large amounts of radiological data from contaminated soils, building, infrastructural, and agricultural debris. This information, coordinated thru Federal, State, and local field personnel in the Federal Radiological Monitoring and Assessment Center would provide finished data analyses and interpretation products to decision makers (Appendix 3, Federal Register Notice, DHS, 1 August 2008). These final decisions would enable the reconstruction of buildings, re-establishment of infrastructure and return of the populace and community businesses.

To do this, agreed upon exposure values, based on radiation dose, risk or other suitable quantity should be established that are commensurate with the site-specific recovery needs. There will be inherent conflict between achieving maximum dose or risk reduction and minimizing cleanup cost and time. The lower the dose or risk goal, the more time, money and effort are required to achieve it. A phased approach will need to be utilized to initially target the most critical infrastructure and areas. Priority should then be given to actions that maximize exposure reduction and minimize cleanup time. Existing cleanup reference levels or goals may be useful as the starting point for the process. In determining cleanup goals for specific locations, a process which recognizes the many factors inherent in such decisions should be used. As part of an ongoing iterative process, cleanup goals are informed by the feasibility of cleanup strategies and specific cleanup strategies adjust as experience is gained. This process must include input from the relevant community. Some of the factors that might be considered include community risk tolerance, proposed future land use, and expected occupancy. There must be balance between the desired levels of exposure reduction with the extent of the measures necessary to achieve it.

Although it may take years to achieve the final cleanup goals for all land uses, re-occupancy of the affected area will be possible when interim cleanup can reduce short-term exposures to acceptable levels during the time it takes to achieve the long-term goals. There may be institutional or engineering controls placed on some portions of the site to prevent potential exposures until further active remediation, radioactive decay, or natural weathering allow the site to meet cleanup goals. An example of an institutional control might be a restriction on planting vegetable gardens to avoid ingesting radio-nuclides that may be taken up by the plant roots from the soil. An example of an engineering control to limit exposures might be adding a layer of pavement or cement over ^{137}Cs gamma emanation that may have become fixed in place by sorbing onto the street and sidewalks. This may be an iterative process. As experience is gained, adjustments may be required to achieve long-term goals.

Regardless of the prioritization of the recovery sectors, the desirable outcome is to fully restore the city by means of a systematic decontamination and reconstruction program. Criteria used to prioritize are factors with which tradeoffs between alternatives are assessed so that the best option will be chosen, given site-specific data and conditions. Local acceptance will be a key component of a fully transparent approach to long-term remediation and cleanup. Factors to consider in determining cleanup actions are (Federal Register Notice, DHS, 1 August 2008):

- Areas impacted (e.g., size, location relative to population).
- Types of contamination (e.g. radiological).
- Other hazards present (e.g. hazardous materials)

- Human health risk.
- Public welfare.
- Ecological risks.
- Clearance actions already taken in earlier restoration activities.
- Projected land uses.
- Preservation or destruction of places of historical, national, or regional significance.
- Technical feasibility.
- Wastes generated and disposal options and costs.
- Costs and available resources to implement and maintain remedial options.
- Short-term effectiveness.
- Long-term effectiveness.
- Timeliness.
- Public acceptability, including local cultural sensitivities.
- Economic effects (e.g., on employment, tourism, and business).
- Intergenerational equity.
- The ability of a remedy to maintain reliable protection of overall human health and the environment over time.
- Assessing the relative performance of treatment technologies on the toxicity, mobility or volume of contaminants.
- The success or effectiveness of the cleanup or remediation as the cleanup progresses (contaminant removal).
- Addressing the adverse impacts on human health and the environment that may be posed in the time it takes to implement the remedy and achieve the community-based remediation goals.
- Evaluating the technical and administrative feasibility of the remedy, including the availability of materials and services needed to implement each component of the option(s) chosen.
- The cost of each alternative, including the estimated capital and operation and maintenance costs, and net present value of capital and operation and maintenance costs.
- Local community and State concurrence with the remedy.

7. Recommendation

In the particular situation being used for this case study, ^{137}Cs is one of the more heavily studied and one of the more easily detected and measured radionuclides. The community, in conjunction with technical experts, and state, local and federal officials needs to reach agreement on the acceptable clearance value. The range of clearance values for remediation and recovery should account for all possible receptor(s) exposure pathways combined, and expressed in terms of radiological dose-and/or-risk criteria. These criteria must clearly transverse through current risk management processes that bridges dose-and-risk thereby using measurable radiological exposure/dose criteria “*in situ*” for delineation and protection of public health and the environment. These criteria must recognize current Federal, State, and local applicable regulations and standards. In the United States, a range of 1 in a population of ten thousand (10^{-4}) to 1 in a population of one million (10^{-6}) excess cancer incident outcomes is generally

considered protective for both chemical and radioactive carcinogenic contaminant exposures. This range is the regulatory standard generally used in the context of EPA Superfund response actions. The Nuclear Regulatory Commission's decommissioning and decontamination process outcomes are usually in or near this range as well. A similar risk range may be appropriate for NPP, RDD, or IND events that affect areas of comparable size. However, such risk ranges may not be practically achievable for major incidents that result in the contamination of very large areas. An example is the ongoing response at the Fukushima Daiichi Nuclear Power Plant, which covers an area the size of Connecticut. In making decisions about cleanup goals and reference levels for a particular event, decision makers must balance the desired level of exposure reduction with the extent of the measures that would be necessary to achieve it, in order to maximize overall human welfare. The final outcome is a pragmatic risk management process that incorporates public stakeholders to arrive at a remedy that protects public health and the environment.