IMPACTS OF USING A DOSE-BASED REGULATORY APPROACH FOR DISPOSITION OF THE STRUCTURAL CONCRETE FROM BUILDINGS AT THE RFETS

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ABSTRACT

This paper reports the findings of an analysis of the potential technical and economic impacts that can be expected from the successful implementation of a dose-based approach in the Decontamination and Decommissioning (D&D) program in the plutonium and americium buildings at the Rocky Flats Environmental Technology Site (RFETS). The paper evaluates demolition of the six buildings containing plutonium and americium and placement of the structural concrete rubble from these buildings into an excavation that will remain after demolition of one of the buildings.

Property-specific Derived Contamination Guideline Levels (DCGLs) developed in accordance with guidance from DOE Order 5400.5 *Radiation Protection of the Public and the Environment* using the *RESRAD* and *DUST-MS* codes were based on a compliance analysis that identified pertinent regulatory requirements, including Federal and State of Colorado regulations. The property specific DCGLs are higher, by many orders of magnitude, than the conservative generic guideline of 100 dpm/100cm^2 currently used to guide D&D activities.

The impact that use of property-specific DCGLs would have on D&D activities was gauged using radiological survey data from RFETS Buildings. While there are some areas in the buildings where relatively high levels of contamination can be found, these are isolated and generally small in actual surface area. At this time, the greatest portion of project resources, for surveys and decontamination efforts, are spent on the remaining less-contaminated areas because of the use of the conservative generic guideline of 100 dpm/100cm^2 for gauging their significance.

The paper demonstrates that, by using a dose-based approach, acceptable concentrations of radioactivity on the building surfaces and in the concrete rubble can be derived that will permit recycling of the structural concrete rubble and maintain compliance with governing DOE and regulatory requirements. It further indicates that use of such an approach, if possible, would result in considerable project savings while still ensuring the safety of the public and the environment and compliance with all applicable regulations.

INTRODUCTION

The decontamination and decommissioning (D&D) of the plutonium handling facilities at the Rocky Flats Environmental Technology Site (RFETS) will generate a large amount of building rubble, some of which will be radioactively contaminated. Plans for dispositioning this material will depend primarily on its radiological characteristics. The Site currently plans unrestricted release for materials that meet the generic release criteria described in DOE Order 5400.5, i.e. material with surface radioactivity of less than 100 disintegrations per minuet (dpm)/100 cm^2 for transuranics. In addition to these requirements, Kaiser-Hill L.L.C., the Department of Energy (DOE) and the Colorado Department of Public Health and Environment (CDPHE) have agreed to implement the requirements from the Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM). MARSSIM describes a consistent approach for planning and performing building surface final status surveys in order to meet established dose/risk-based release criteria, and is implemented at the RFETS through the Pre-Demolition Survey (PDS) Plan.

The PDS Plan implements MARSSIM and uses the generic release criteria from DOE Order 5400.5 as the basis for its Derived Contamination Guideline Level (DCGL) for release of facilities. The Site will recycle the concrete portion of the rubble that can be released as backfill in decommissioning projects; and either recycle the non-concrete (e.g. metal) portion of the released rubble or dispose of it in a licensed landfill. The Site will dispose of materials with surface radioactivity greater than the limit for unrestricted release as low level waste (LLW). When practical, the material will be decontaminated, which will then allow the bulk of the material to be released; only the radioactive residue must be disposed of as LLW.

This analysis evaluates the use of a property-specific dose-based standard, also described in DOE 5400.5, as a potentially more cost-effective disposition pathway for building rubble that will still comply with negotiated regulatory commitments. Since the rubble would not leave the Site, rubble used to backfill depressions could meet a different set of release criteria. The development of a dose-based standard allows the current DOE 5400.5 DCGL to be replaced with a MARSSIM compliant, dose-based DCGL.

To supplant the current baseline approach to rubble disposition (i.e. decontaminate to unrestricted release, demolish the building, and recycle the concrete), a dose-based approach must be judged equal to or better than the baseline approach in three critical areas:

- ***Regulatory Requirements and Negotiated Commitments***. Under the provisions of national environmental laws, DOE, CDPHE, and the Environmental Protection Agency negotiated the Rocky Flats Cleanup Agreement (RFCA) to oversee and assure the safe cleanup of Rocky Flats. Both alternatives must meet the established requirements and operate within the established processes.
- ***Risk to the Public and the Environment***. The overwhelming risks posed by plutonium handling facilities are primarily associated with the interior plutonium-contaminated equipment, not the facilities. However, even after this equipment is removed, the residual radioactivity, if not mitigated, could pose an increased risk to the public and the environment that is small but may be estimated. While the regulatory requirements and negotiated commitments establish levels of public risk that cannot be exceeded either during demolition or after closure, the public has an interest in achieving the minimum risk commensurate with a reasonable expenditure of resources.
- ***Final Survey, Decontamination and Waste Management Cost and Schedule***. Site plans currently require that radioactive contamination on all interior surfaces of a building be less than the release limit of 100dpm/100 cm^2 prior to demolition. With the large area of facilities to be characterized and the sensitivity and number of the measurements required, the cost and duration of activities to assure that no areas inadvertently exceed this release limit is high. For each area to be decommissioned, the costs of surveying, decontaminating, re-surveying, and releasing for unrestricted use will be compared with the costs of characterizing, packaging, shipping, and disposing of the material as LLW. In some cases, the cost and schedule impact of the survey alone may be greater than the cost and schedule impact of disposing of the material as LLW, even if little or none of the area would required decontamination.

This paper summarizes the approach to use building rubble that exceeds the current unrestricted release limit as backfill. It presents the results of the regulatory analysis that forms the basis for establishing dose-based guidelines, the results of modeling both the long-term population dose after Site Closure and the acute population dose during demolition. The detailed cost and schedule analysis is then summarized. Additional qualitative considerations are then discussed and the conclusion presented.

DOSE-BASED APPROACH

Backfilling basements following D&D of the plutonium handling facilities will require a large volume of material – backfilling the basement of Building 371 alone requires more concrete than is present in all of Site plutonium facilities (designated Type 3 facilities under RFCA). The current Site approach is to recycle as much of the concrete debris as possible for this purpose, from buildings that will be released as less than 100dpm/100 cm^2, in preference to disposing of this rubble as waste offsite and then purchasing and importing equivalent backfill materials.

Using the building rubble for backfill at a level of surface contamination greater than 100dpm/100 cm^2, but significantly less than the maximum level indicated by the dose assessment, would substantially reduce the number and difficulty of the costly measurements that establish the lower release limit is met. It would reduce the decontamination to only those areas with elevated levels of contamination, and thus greatly reduce the decontamination cost and cost for LLW disposal of rubble that is below (and too expensive to release) or only slightly above the current unrestricted release limit.

The analysis supporting the approach examined the characteristics of the plutonium handling facilities (Buildings 371/374, 707, 771/774, 776/777, and 559), i.e. the nature, levels, and spatial distribution of the contamination. It assessed the impacts of decontaminating facility surfaces (after the gloveboxes and other equipment, that contain the vast majority of the hazard, have been removed) at varying levels of surface contamination. It identified and evaluated three major impacts from the approach that are related to the levels of facility surface contamination during demolition:

- Long-term public risk from the incremental increase in population dose due to ionizing radiation through the different exposure pathways
- Acute public risk from the increase in population dose from air dispersion of radioactivity during demolition
- Cost and schedule savings resulting from reduced surveys and decontamination

This analysis showed that under no scenarios would impacts to the public dose become significant at surface contamination levels less than 195,000dpm/100 cm^2, and then only in scenarios that assumed complete breakdown of administrative control and unrestricted public use of the rubble. Under more realistic scenarios, the contamination levels that would result in public risk approaching regulatory limits were greater than 1,000,000dpm/100 cm^2. Meanwhile, the Site could obtain substantial cost and schedule savings by increasing the maximum or average contamination level used as the release limit, i.e. the DCGL, from 100dpm/100 cm^2 to the range of 600-10,000dpm/100 cm^2. While the implementation of such an approach would require substantial discussions with federal and local government entities and the public, it is consistent with the intent of using a dose/risk-based approach to Site closure and Kaiser-Hill contractual provisions.

REGULATIONS APPLICABLE TO RUBBLE RECYCLING

Despite the potential for a considerable cost savings associated with the use of the proposed dose-based DCGLs for building rubble, to be feasible any alternative approach must comply with the regulatory requirements established by federal, state, and local governments, as well as the negotiated regulatory commitments. The overall regulatory requirements applicable to DOE and identified in RFCA and the decision documents resulting from it are summarized below as they apply to the proposed "release limit" for building rubble.

DOE Order 5400.5

The controlling regulation at DOE sites covering contaminated material that is to be released for unrestricted use is DOE Order 5400.5, *Radiation Protection of the Public and the Environment,* dated 1-7-93. The "radiological protection requirements and guidelines for cleanup of residual radioactive material and management of the resulting wastes and residues and release of property" are found in Chapter IV, "Residual Radioactive Material." The generic surface contamination guidelines are provided in Figure IV-1 of Chapter IV. The surface contamination guidelines for transuranic elements, including plutonium, are "Reserved" in this table. RFETS is currently using the conservative generic guideline of 100dpm/100 cm^2 derived from guidance in the Nuclear Regulatory Commission document *Regulatory Guide 1.86.*

In addition to providing the generic guideline, DOE Order 5400.5 also provides a basis for establishing dose-based guidelines using specific property data. The derived guidelines must be established such that exposure to a member of the public does not exceed 100 millirem (mrem) under the worst case or plausible-use scenario. The Order also requires that the derived guideline be consistent with limits and guidelines established in other applicable Federal and State laws.

The Colorado Department of Public Health and Environment

CDPHE's *Radiological Criteria for Unrestricted Use* establishes the requirements for licensees in Colorado to release materials containing residual radioactivity based on a dose limit of 25 mrem per year to an individual of the most highly exposed population. While this regulation is not directly applicable to RFETS, it indicates state regulators have accepted the dose-based standard.

Rocky Flats Cleanup Agreement

RFCA is the enforceable agreement signed by the DOE, the EPA, and the State of Colorado which implements the provisions of the federal Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and the State Colorado Hazardous Waste Act as they apply to the cleanup of the Rocky Flats Site. RFCA established the

"Rocky Flats Vision," future land uses, dose limits, and environmental quality restrictions. The "Tier II" limits for surface soils after cleanup are based on a dose limit of 15 mrem/year. Environmental quality limits that most impact this assessment are groundwater and surface water compliance limits. The Rocky Flats Vision established the future land use of the non-industrial areas of the Site as open space, and the industrial areas commercial land use with the continuation of administrative controls. In the event of a failure of institutional controls, the limiting dose would rise to 85 mrem/year.

This regulatory framework, which is the basis under which the DCGLs were derived, is shown in Figure - 1.

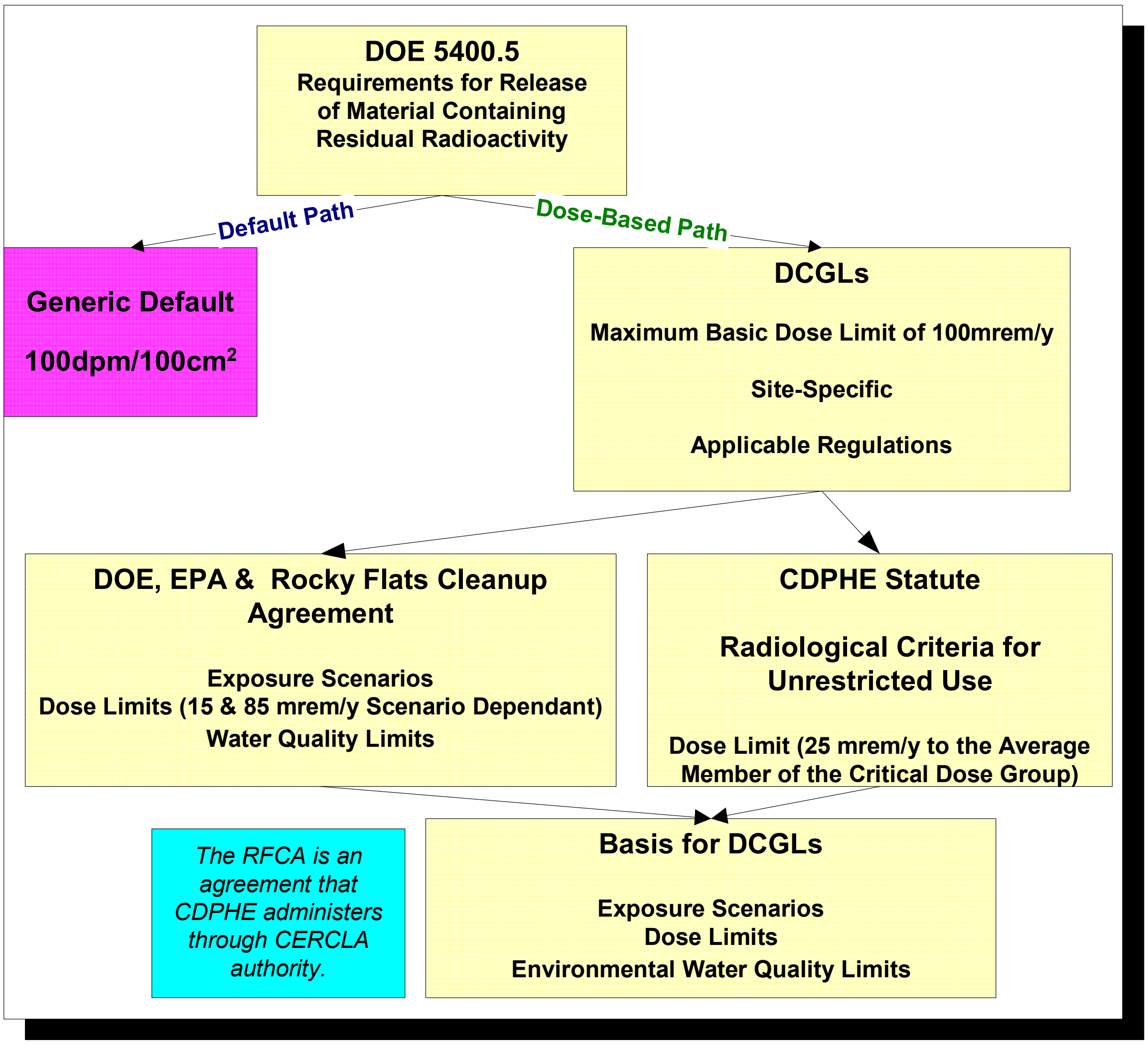

Fig. 1. Regulatory Framework for Developing DCGLs

RUBBLE RECYCLING POST-CLOSURE DOSE MODELING

Kaiser-Hill conducted a dose modeling study to evaluate the upper limits of surface contamination that could remain on facility surfaces and the dose that the public will receive over time for a variety of exposure scenarios. The study primarily used RESRAD, the prevalent dose modeling code used throughout DOE and the modeling code used in calculating the Soil Action Levels for the RFCA. Other codes addressing leaching, local hydrology, and geochemical issues were also used to augment RESRAD. The study assumed that the building rubble will be sized and mixed to meet construction backfill specifications and that it will be placed in an unlined depression and covered with a meter of uncontaminated local soil to minimize erosion. The code was run multiple times using the range of dose guidelines contained in the regulations listed in the previous section. Various occupant scenarios were assumed for each dose to allow for the presence or absence of institutional controls. Site-specific meteorological, hydrogeological, and geotechnical information, along with exposure factors developed from previous dose modeling to establish soil action levels, were used to assess doses and to model radionuclide migration to groundwater and surface water points of compliance.

The evaluation first considered the concentrations of radionuclides that can exist in the recycle concrete (i.e., the rubble) that will not produce exceedance of dose or environmental quality limits. The concentrations that can exist in the recycle concrete, reported in units of picocuries per gram (pCi/g), are functionally analogous to soil action levels or preliminary remediation goals. Secondly, these concentrations in the recycle concrete are related back to the concentrations of total surface radioactivity that can exist on the building surfaces. It is this latter concentration, the concentration of total surface radioactivity that can exist on the building surfaces, that is the DCGL. DCGLs are reported in units of disintegrations per minute/100cm^2 of surface area (dpm/100cm^2).

The role of the DCGL, according to MARSSIM*,* is that of a release criterion or cleanup level (EPA, 1997). Therefore, the DCGL must equate, through exposure pathway modeling, the concentration that can be measured on the Type 3 building concrete surfaces, to the regulatory benchmarks discussed above. The conceptual exposure pathway model is presented in Figure 2. Key points displayed in Panel A are:

- **Component 1** - An estimation model, based on uniform distribution of activity, between the Primary Source (Type 3 Building Concrete Surface Radioactivity) and the Secondary Source Material placed in the Building 371 excavation after demolition, and

- **Component 2**- A transport and fate model from the Secondary Source to the Human Receptor and/or Environmental Quality Point of Compliance. Transport and fate analysis will be accomplished with *RESRAD*, Version 5.95 (DOE, 1999). An analysis of the impacts to groundwater and surface water using DUST-MS coupled to *RESRAD*, as an alternative to *RESRAD* singularly, is also provided.

Panel B focuses on Component 1 and illustrates the relationship between the total residual radioactivity concentration distributed on all cementatious surfaces, and the activity inventory in the mass of cementatious building materials. The resulting total residual radioactivity concentration in the fill material, uniformly distributed, will vary with the surface activity inventory as indicated.

The results were then combined with Site facility surface contamination data to calculate surface contamination levels associated with each dose scenario. Reconnaissance-Level Characterization (RLC) efforts surveyed and sampled thousands of locations in each facility and have identified the maximum and average level of contamination within each facility on a room-by-room basis. With this data, it was possible to calculate the actual quantity of material that would remain after the facility was decontaminated to a particular DCGL, which is particularly important since a relatively few facility areas contain the bulk of the contamination. The scenarios, dose limits, and pertinent environmental quality limits are summarized in Table I. Each exposure scenario is discussed below.

Scenario 1 – concrete rubble is placed in the basement of Building 371, covered with one meter of soil and remains undisturbed. This scenario is consistent with the Rocky Flats Vision for the Protected Area (PA). Active institutional controls are maintained, land use in the PA is limited so that the rubble does not reach the surface, and Commercial/Industrial development occurs. The uncontaminated local soil cover is not breached so that there is effectively no exposure to the Office Worker. The DCGL, in this case, is controlled by the *Offsite Resident* at a dose limit of 15 mrem/y, received as a result of the leaching of radionuclides to groundwater and surface water and compliance with water quality standards specified in the RFCA.

Scenario 2 – concrete rubble is place in the basement of Building 371, with subsequent industrial development. This scenario is inconsistent with the Rocky Flats Vision for the PA. Active institutional controls fail, the rubble reaches the surface, and Commercial/Industrial development occurs. The DCGL, in this case, is controlled by the exposure to the *Office Worker* at a dose limit of 15 mrem/y. another location on RFTES and open-space land use occurs). The DCGL, in this case, is controlled by the exposure to the *Open Space Receptor* at a dose limit of 15 mrem/y.

Scenario 3 – concrete rubble is placed in the basement of Building 371, with subsequent use as open space. This scenario is inconsistent with the Rocky Flats Vision for the PA. Active institutional controls fail, the rubble reaches the surface, and open-space land use occurs in the PA (alternatively, the rubble is transported to another location on

RFTES and open-space land use occurs). The DCGL, in this case, is controlled by the exposure to the *Open Space Receptor* at a dose limit of 15 mrem/y.

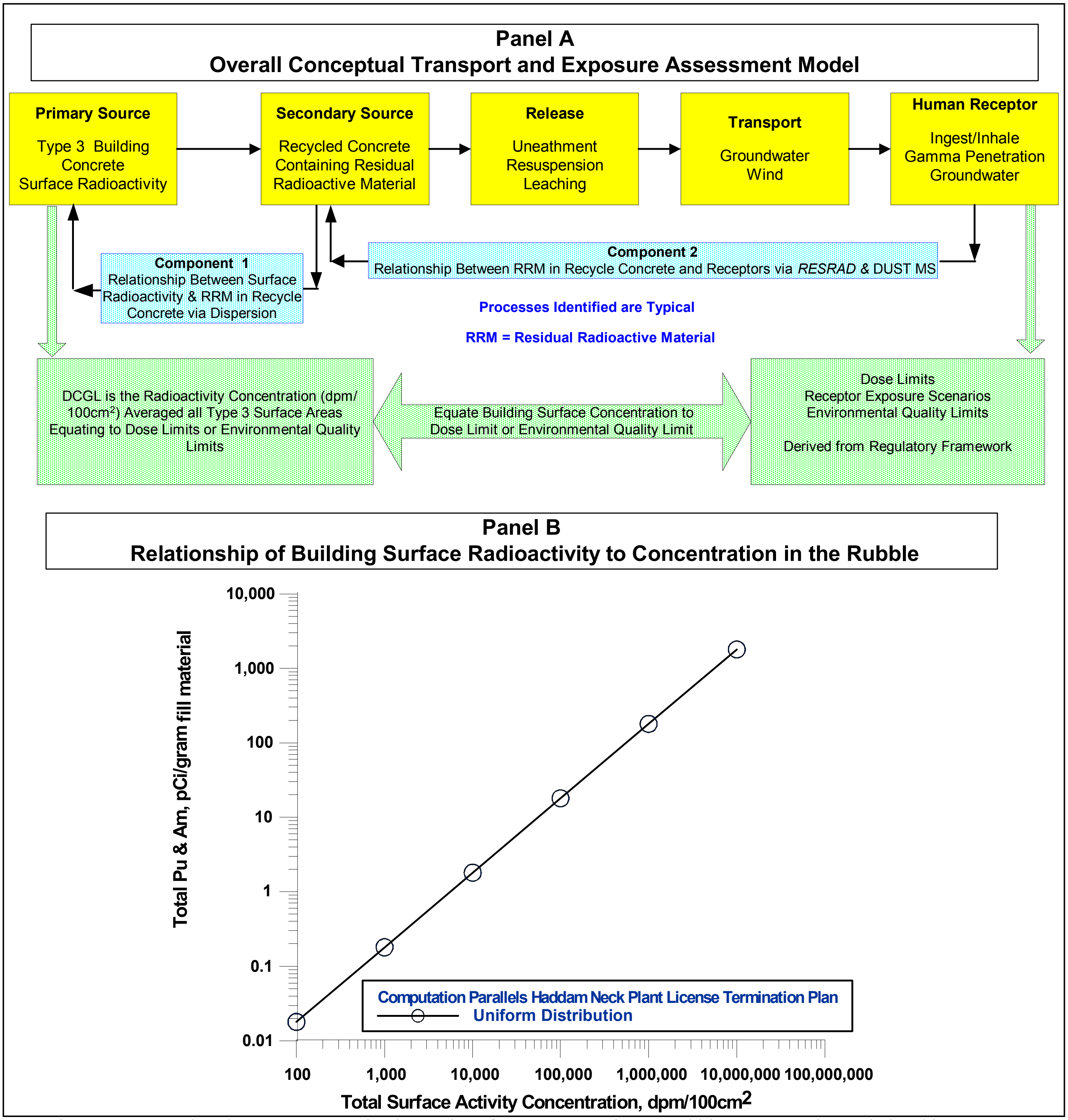

Fig. 2. Conceptual Pathway DCDL Evaluation and Surface Concentration to Rubble Concentration Relationship

Scenario 4 - concrete rubble is placed in the basement of Building 371, with subsequent residential use. This scenario is inconsistent with the Rocky Flats Vision for the PA. Active institutional controls fail, the rubble reaches the surface, and residential land use occurs in the PA. The DCGL, in this case, is controlled by the exposure to the *Onsite Resident* at a dose limit of 85 mrem/y.

Scenario 5A – no restrictions are placed on the use of concrete rubble after demolition, residential receptor. This scenario is inconsistent with the Rocky Flats Vision for the PA. Active institutional controls fail, the rubble is excavated and taken off the Site, and it is used in a residential setting. This scenario reflects the fact that the rubble pH of approximately 11 will prevent growing foodstuffs and for this reason, there is no consumption of locally produced fruits or vegetables. The DCGL, in this case, is controlled by the exposure to the *Offsite Resident* dose limit of 25 mrem/y. This scenario is consistent with the CDPHE's *Radiological Criteria for Unrestricted Release* (CCR, 1999).

<u>Scenario 5B – no restrictions are placed on the use of concrete rubble after demolition, subsistence farmer receptor.</u> This scenario is inconsistent with the Rocky Flats Vision for the PA. It is identical to Scenario 5A except growing foodstuffs and consumption of locally produced fruits or vegetables is assumed. The DCGL, in this case, is controlled by the exposure to the *Offsite Resident* dose limit of 25 mrem/y. This scenario is inconsistent with the CDPHE's *Radiological Criteria for Unrestricted Release* (CCR, 1999). It assumes consumption of locally produced fruits or vegetables (CCR 1996 specifies a dose limit of 25 mrem/y to the average individual of the critical dose group. The average individual could not consume locally produced fruits or vegetables).

<u>Citizen's Advisory Board (CAB) Scenario – no restrictions are placed on the use of concrete rubble after demolition, subsistence rancher receptor.</u> The CAB scenario is inconsistent with the Rocky Flats Vision for the PA. Active institutional controls fail, the rubble reaches the surface, residential land use in the form of a subsistence rancher "living off the land" occurs in the PA, the rancher consumes affected groundwater (unlikely given the low yields in the Rocky Flats Alluvium). The CAB exposure scenario at a dose limit of 15 mrem/y, in this case, controls the DCGL.

Table I. DCGLs Based on Pertinent Exposure Scenarios and Dose Limits As Calculated by RESRAD

DCGLs Based on a Range of Exposure Scenarios and Pertinent Dose Limits						
Scenario 1	**Scenario 2**	**Scenario 3**	**Scenario 4**	**Scenario 5A**	**Scenario 5B**	**CAB Scenario**
Soil cover **Is Not** Breached 15 mrem/y Offsite Resident RFCA Water Quality Standards	Soil cover **Is** Breached 15 mrem/y Office Worker RFCA Water Quality Standards	Soil cover **Is** Breached 15 mrem/y Open Space Receptor RFCA Water Quality Standards	Soil cover **Is** Breached 85 mrem/y Onsite Resident RFCA Water Quality Standards	Rubble **Taken Offsite** 25 mrem/y Offsite Resident RFCA Water Quality Standards "CDPHE Unrestricted Release Scenario"	Rubble **Taken Offsite** 25 mrem/y Offsite Resident RFCA Water Quality Standards "CDPHE Unrestricted Release Scenario"	Subsistence Rancher & Fire 15 mrem/y Onsite Resident Groundwater Consumption
Total Average Activity in "Soils" as Pu^{239} and Am^{241} in pCi/g $_{\text{fill material}}$ at ~ Equilibrium Equaling the Dose and/or Concentration Limits						
4, 700,000	**340**	**1,020**	**602**	**177**	**118**	**35**
DCGL in dpm/100cm^2 Averaged Over Entire Interior Surface Area Equaling the Dose and/or Concentration Limits						
26,000,000,000	**1,900,000**	**5,700,000**	**3,400,000**	**987,000**	**658,000**	**195,000**
Extrapolated Dose to the Public in mrem/y, based on a DCGL of 10,000 dpm/100cm^2						
.0000058	**0.08**	**0.026**	**0.25**	**0.25**	**0.38**	**0.77**

The results in Table I demonstrate that the average DCGLs that would result in unacceptable exposure to an individual residing in the midst of the rubble, and eating vegetables growing from it are in excess of 195,000 dpm/100 cm^2 (the Soil Action Level proposed by CAB). These calculations suggest that at the DCGLs of interest, the impact would be greater than an order of magnitude below the most restrictive of these scenarios. It should be noted that in the scenario where administrative controls are maintained, the annual dose to the public does not become appreciable for over 1,000 years. In the bottom row an extrapolation of the dose that the public would receive under the different scenarios from a DCGL of 10,000dpm/100 cm^2 is shown for reference.

RUBBLE RECYCLING DOSE MODELING DURING DEMOLITION

In a number of public meetings the public has expressed an interest in the dose that they, the decommissioning workers, and the co-located Site workers would receive from any radioactivity in the dust released during demolition. Since the use of DCGLs greater than 100dpm/100 cm^2 would presumably release more radioactivity during demolition, the behavior of radioactivity released at a range of DCGLs was also analyzed.[1]

The analysis used the AIRDOS-PC program for modeling the extended release inhalation exposures, and used the HOTSPOT 98 program for short-range and short-duration release inhalation modeling, which provide the relationship between receptor population dose and radioactivity released. The limiting doses of the three receptor populations were used to back-calculate radioactivity release quantities, with the overall limiting quantity of released radioactivity being the minimum of the three quantities. The receptor population that most often limited the overall released quantity was found to be the dose to the D&D worker, at 500 mrem/y, located nominally 30 meters from the facility being demolished.

The analysis then used RLC data from the different facilities to estimate the quantity of radioactivity that could be released based on given DCGLs. It modeled the fraction of the total radioactivity that would be released based on three different demolition methods: large shears, a wrecking ball, and explosives. The effects of water sprays, fixatives, respirator use (D&D workers only), and complete containment (no credit for additional engineering controls, e.g. HEPA filtering or pressure differential with outside air) were then applied. Costs to implement the engineered controls were also estimated. Costs per facility range from no additional cost for the water mist, since this will be done to control fugitive dust in any case, to about $270,000 for either fixative application or respirator use. An enclosure would cost between $6M and $8M per facility.

The most dust-producing method examined was the wrecking ball, which has similar contamination dispersion characteristics to the vibratory hammer. The data for the wrecking ball method is shown in Table II. Other demolition methods (mechanical shears and explosives) dispersed less contamination. Thus, depending on the engineered controls implemented, a DCGL of between 4 and 65 times greater than those shown in Table II could be used with no increased release of radioactive material or public dose.

The results in Table II shown in **bold** characters are the average DCGLs that could be allowed without exceeding the worker exposure limit of 500mrem. All of these DCGLs are in excess of 500,000dpm/100 cm^2. It is likely that the normal combination of equipment, expected use of water sprays, and relocation of non-radiological workers that will occur anyway over time could increase this limit to greater than 1,000,000 dpm/100 cm^2. Given that the DCGLs are limited by Site worker dose, the maximum dose to the public, an individual located at the Site boundary for the whole demolition period, would be 0.26mrem, well below the 10mrem per year allowed by regulation. Note that the DCGLs shown above are similar in magnitude to those in Table I, derived from the post-closure population dose modeling.

EXTENT OF SURFACE RADIOACTIVITY CONTAMINATION

A key element in the evaluation of the recycling of structural concrete as fill was gaining an understanding of the extent of surface radioactivity that exists in the Type 3 buildings. This knowledge lead to an understanding of how much surface area in the Type 3 buildings is contaminated at different concentrations and produced insight into the magnitude of the potential influence of the dose-based DCGL approach. The extent of affected area has a

Table II - Maximum Allowable Surface Contamination and Dose from Airborne Contamination Released using the Wrecking Ball Method of Building Demolition, as a Function of Engineered Controls

	Engineered Control				
	DCGLs, Release Limit in dpm/100 cm^2				
Exposure Scenario Resulting in DCGL	None	Water Mist	Fixative	Worker Respirator	Enclosure
D&D Worker (500 mrem@30 m)	**550,000**	**1,100,000**	**1,950,000**	55,000,000	**5,500,000**
Co-located Worker (100 mrem@100m)	680,000	1,400,000	2,400,000	**680,000**	6,800,000
General Population (10 mrem @Site Boundary)	26,000,000	52,000,000	92,000,000	26,000,000	260,000,000
	Population Dose Extrapolated from DCGLs, Dose in mrem				
Extrapolated Population Dose from Worker-Limited DCGL (mrem @ Boundary)	0.21	0.21	0.21	0.26	0.21
Extrapolated Population Dose for a DCGL of 10,000 dpm/ 100 cm^2 (mrem @ Boundary)	0.0038	0.0019	0.0011	0.0038	0.0004

bearing on the scale of decontamination, survey, waste management, and ultimately the inventory of residual radioactivity material in the recycle concrete. In order to gauge the effect that the use of any of the DCGLs could have on the recycle concrete approach, recent survey data from Buildings 707 and 779 was obtained and evaluated, and then used to extrapolate to remaining buildings. This data is shown graphically in Figure 3.

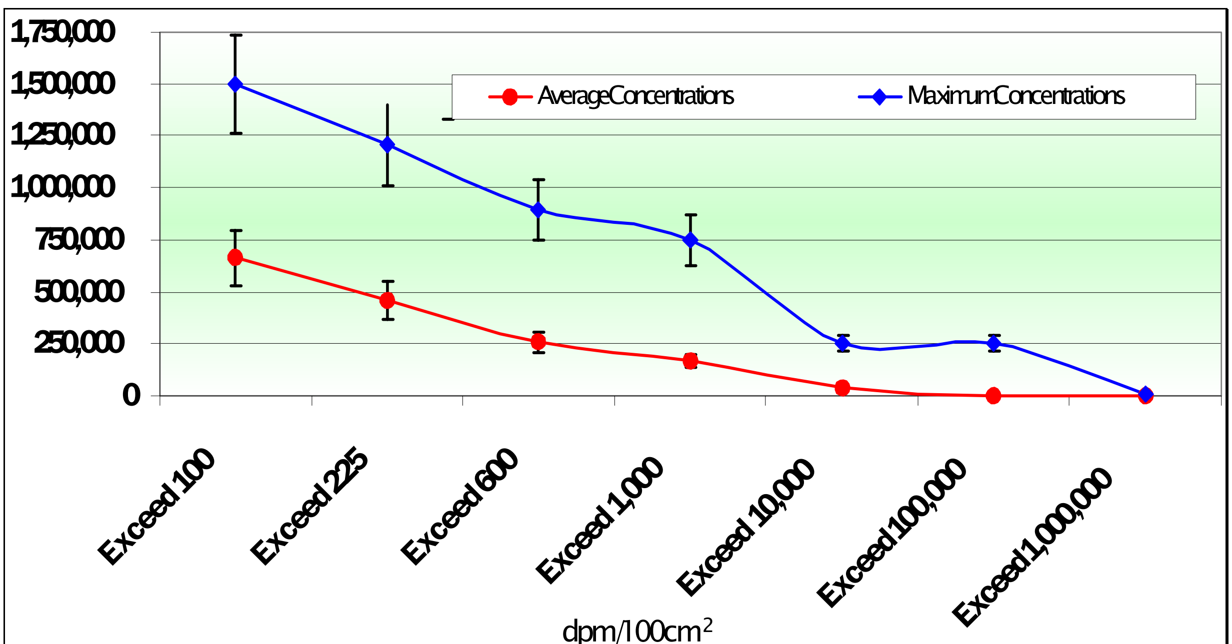

Fig. 3. Estimated Cementitious Surface Area (ft^2) Exceeding Benchmark Concentrations For All Six Type 3 Buildings

Figure 3 summarizes the evaluation and extrapolation, and provides an estimate of the extent of surveyable cementitious surface contamination in the Type 3 buildings for a range of benchmark total surface activity concentrations. The Figure includes all cementitious surfaces composed of concrete and cider block (i.e., those structural concrete materials that would be rubblized). Two curves are provided in the Figure, the top curve depicts the distribution of maximum concentrations over all surfaces, and the bottom curve represents the estimated distribution of survey unit average concentrations.

Key points in inspection of Figure 3 include:

- Nearly 700,000 square feet of surface area have average area concentration exceeding 100 dpm/100cm^2 and nearly 1,5000,000 square feet of surface area have maximum concentrations exceeding 100 dpm/100cm^2.
- Nearly 200,000 square feet of surface area have average area concentration exceeding 1,000 dpm/100cm^2 and approximately 750,000 square feet of surface area have maximum concentration exceeding 1,000 dpm/100cm^2.
- Both curves taper considerably at concentrations exceeding 1,000 dpm/100cm^2, which indicates that there is relatively little surface area in the buildings with dramatically, elevated concentrations of surface residual radioactivity. This observation underscores the concept that most of the significant contamination is localized into "hot spots" in the processing areas.
- There is relatively little area in the Type 3 buildings with surface radioactivity concentrations in excess of 100,000 dpm/100cm^2.

COST AND SCHEDULE IMPACTS OF RUBBLE RECYCLING

After reviewing the Closure Baseline, this analysis identified the three cost elements (final surveys, decontamination, and waste handling) that were the primary direct project cost elements that decrease as the DCGL increases. The analysis first identified the "direct" costs, i.e. the craft labor and material cost of the elements. After that, the analysis evaluated two additional components regarding schedule. First, it identified the number of days of early facility closure that will be achieved in each of the facilities by reducing the activity duration and resources for each of the activities associated with the above cost elements. Second, it identified days of early Site closure will be realized due to these early facility closures. These days of early closure create another cost impact based on savings realized from the reduction in facility and Site "overhead" budgets, i.e. the Project Management, Environmental Health and Safety, and other time-dependent or fixed costs not directly associated with work execution. Thus, the overall cost impact is the sum of the facility's cost savings resulting from reduced final survey, decontamination and waste handling "direct" costs; the reduction in facility "overhead" costs from the days of early facility closure; and finally, the reduction in Site "overhead" costs from the days of early Site Closure.

The analysis for the cost reductions due to reduced craft labor and material costs for the three cost elements was based on taking the RLC data, (maximum and average contamination levels) and applying it on a room-by-room and square footage basis for each of the four plutonium handling facilities. Estimates were made that extended the RCL paint and under-paint contamination data to cover all painted facility surfaces, based on the correlation between the RLC paint and the RLC direct surface contamination data. The rooms were then grouped by decommissioning "Area" (i.e. the work element that is the basis of the budget and baseline contained in the BEST 2000 system) for final survey, decontamination, and waste handling.

Two spreadsheets were developed – one for the "maximum" and one for the "average " contamination levels for the facilities. The surface areas within each "Area" were arranged into nine groupings, based on the contamination in each room, with each grouping representing a range of potential DCGLs (the groupings are displayed in the first row of Table III). The surface areas in each grouping were then summed and used as the basis to distribute the Site 2006 Baseline budget elements for the final survey, decontamination and waste handling. Finally, "cost savings" were identified as the sum of the budgets for each proposed DCGL grouping. These "cost savings" represent the budget elements for final survey, decontamination, and waste handling that would now not be required based on a higher DCGL criterion.

The analysis used to identify cost savings resulting from reduced "overhead" costs first used the Site critical-path schedule to identify the closure activities and related durations and resources for each facility. It then created alternative schedules, both for each for each facility and for the Site as a whole, to be used for the analysis. In each alternative schedule, the relevant facility activities (i.e. final survey, decontamination, and waste handling) were rescheduled, with their durations and resources were reduced in proportion to the reduction in scope resulting from the increase in DCGL. After comparing the baseline schedule with the alternative schedule, earlier dates for facility closure were identified. This determined the days saved by the early closure of each facility. Finally, the "overhead" cost savings from early facility and Site closure was determined based on the days saved for each facility and the Site, multiplied by the daily project "overhead" costs (from the appropriate time period) for each facility and the Site, respectively.

The results of the analysis are shown in Tables III and 4, and in Figure 4. Table III shows the savings for each of the plutonium handling facilities, and the total savings, based on decontaminating room maximums to less than the listed DCGL. The facility cost savings combine both the "direct" cost reductions and the schedule-based "overhead" cost reductions. The row labeled "Site" consists of just the savings that result from the reduction in overall Site "overhead." Table IV shows the equivalent figures when only the room averages are required to meet the DCGLs. Figure 1 shows the maximum and average totals graphically.

Table III. Cost Savings for Decontamination, Waste and Final Status Surveyat Selected DCGLs using Room Maximum Contamination Values

Facility	100 dpm/ 100 cm2	225 dpm/ 100cm2	300 dpm/ 100cm2	600 dpm/ 100cm2	1000 dpm/ 100cm2	10,000 dpm/ 100cm2	100K dpm/ 100cm2	1M dpm/ 100cm2	Demolish Buildings as-is
371/374	0	5,054,373	6,849,248	9,409,953	10,509,890	15,037,994	15,049,911	17,925,999	18,169,577
559	0	0	0	0	0	1,732,646	2,100,303	2,498,599	2,908,006
707	0	1,433,939	1,433,939	2,565,807	3,510,531	7,029,192	13,848,241	15,300,857	15,572,595
771/774	0	2,386,452	2,386,452	2,386,452	2,407,089	4,020,009	4,352,798	8,361,408	8,361,408
776/777	0	0	0	0	683,632	2,426,383	4,931,427	18,727,277	22,299,715
Site	0	5,108,510	6,508,852	8,620,533	9,487,992	15,798,880	18,395,587	27,408,032	28,850,586
Total	0	13,983,275	17,178,492	22,982,744	26,599,134	46,045,103	58,678,267	90,222,172	96,161,887

Table IV - Cost Savings for Decontamination, Waste and Final Status Survey at Selected DCGLs using Room Average Contamination Values

Facility	100 dpm/ 100 cm2	225 dpm/ 100cm2	300 dpm/ 100cm2	600 dpm/ 100cm2	1000 dpm/ 100cm2	10,000 dpm/ 100cm2	100K dpm/ 100cm2	1M dpm/ 100cm2	Demolish Buildings as-is
371/374	10,779,474	14,683,005	14,683,005	15,037,994	15,037,994	15,818,542	17,925,999	18,169,577	18,169,577
559	780,986	1,732,646	1,732,646	2,100,303	2,100,303	2,498,599	2,896,894	2,896,894	2,908,006
707	3,676,370	6,180,618	7,029,192	11,426,667	12,883,054	15,239,490	15,300,857	15,572,595	15,572,595
771/774	1,826,519	2,514,374	2,514,374	2,847,163	4,412,246	4,412,246	8,361,408	8,361,408	8,361,408
776/777	0	0	0	0	344,716	1,472,899	8,504,922	22,299,715	22,299,715
Site	14,838,117	16,711,687	16,899,965	17,783,766	19,966,521	20,933,730	25,581,694	28,850,586	28,850,586
Total	31,901,466	41,822,330	42,859,182	49,195,893	54,744,835	60,375,507	78,571,774	96,150,775	96,161,887

The results show that where the DCGL value is applied based on the maximum level of contamination in a room, savings of \$23M, \$27M, and \$46M are achieved at DCGLs of 600, 1,000, and 10,000 dpm/100 cm^2, respectively. Where the DCGL level is applied to the average on a room-by-room basis, a savings of \$49M, \$55M, and \$60M are achieved at the same DCGLs.

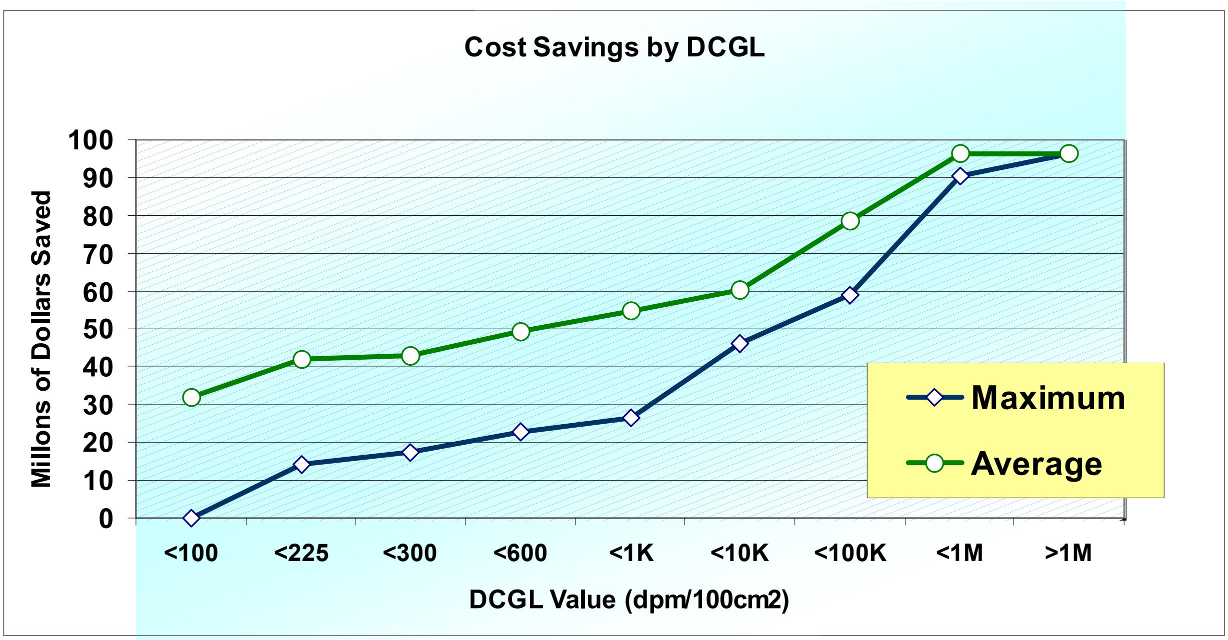

Fig. 4 - Cost Savings for Decontamination, Waste and Final Status Survey by DCGL Grouping

CONCLUSION

Modifying the current Site DCGL in accordance with the guidance in DOE Order 5400.5 to incorporate dose-based limits (or obtaining an exemption to DOE 5400.5) will save approximately $60,000,000. This value probably significantly understates the actual savings due to the conservatism of the assumptions. The data summarizing the dose at the different DCGLs is shown in Table V. The table shows the DCGL based on the RFCA commitments, and on both the most conservative assumptions from soil exposure and building demolition air release pathways. The Allowable Public Dose is the dose allowed to the public by regulation. For the cases that are not driven by a dose to the public (i.e. the contamination limit is set independently) an approximate "derived public dose" is also shown that indicates the magnitude of the public dose at the given DCGL.

The DCGL approach is consistent with DOE Orders, Federal and State regulations and the Kaiser-Hill contractual provisions. In fact, it is the recommended approach, as the regulations typically recognize that the generic or default approaches are unnecessarily conservative.

The cost analysis is conservative. It accounted only for the direct cost reduction associated with the final survey, decontamination, and waste handling and a pro-rated portion of project management cost. There are considerable additional costs associated with project "overhead" that can be reduced – engineering, technical support – that could not be quantified and were not included. Also, the cost to perform a final status survey, as estimated from the number of survey locations required, decreases faster than the area to be decontaminated, yielding greater savings at lower DCGLs.

Finally, using building rubble as backfill will reduce both health and construction safety risk, while implementing the principles of ALARA by reducing worker exposure per the following:

- The proposed approach is consistent with worker safety and ALARA principles, in that it will reduce the higher OSHA risk decontamination activities, and reduce dose due to inhalation of contaminated dust generated by scabbling or hydrolazing. Only the most contaminated surfaces will require decontamination to meet a higher DCGL. . This will reduce the time workers spend in the radioactive work environment and in performing hazardous decontamination activities.
- A higher DCGL will be much easier and quicker to detect and more defensible than the 100dpm/100 cm^2 level currently required for unrestricted release. Surveying and characterization will involve significantly less time, and therefore less exposure, for workers.

- The amount of low-level waste to be packaged and transported for disposal will be greatly reduced, resulting in a lower worker exposure to LLW, significantly fewer truckloads and volume of LLW traveling on public highways. This also reduces public risk due to accidents and the environmental impact due to vehicle exhaust.

Table V - Comparison of Allowable Dose with Dose from Generic and Proposed Release Limits

Dose Requirement Or Release Limit	**Allowable Public Dose (mrem/y)**	**Equivalent DCGL (dpm/100cm^2)**	**Derived Public Dose (mrem/y)**
Rocky Flats Cleanup Agreement			
1. Rocky Flats Vision Scenario	**15mrem/y**	**26,000,000,000**	**15mrem/y***
2. Citizens Advisory Board Scenario	**15mrem/y**	**195,000**	**15mrem/y***
Demolition Airborne Release			
1. Allowable Surface Contamination (Allowable Public Dose)	**10mrem/y**	**26,000,000**	
2. Allowable Surface Contamination (Worker limited dose)	**N/A**	**550,000**	**0.26 mrem/y**
Current Generic Release Limit		**100**	**0.007mrem/y**
Proposed Dose-Based Release Limit		**10,000**	**0.7mrem/y**

* Same as Allowable Public Dose

The overall decision process to determine the appropriate DCGL to use for decommissioning the plutonium buildings at the Rocky Flats Site is still being negotiated, and the ultimate decision will be based on a broad range of inputs. Inputs in addition to the regulatory feasibility and cost impacts discussed in this paper include public perceptions and concerns and an interplay of environmental restoration issues regarding the quantities of radioactivity that will remain after Site closure. The DCGLs that will be implemented are expected to result from the negotiations addressing these comprehensive issues.

FOOTNOTES

[1] The basis of this analysis was work provided under contract to Kaiser-Hill in the report, "Decommissioning Criteria Document for United States Department of Energy Facilities", prepared by TRU Tech L.L.C., April, 2001.