

**Plutonium In Soil As A Basis
For Studying Contaminant Releases**

**Health Advisory Panel
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Handouts & Support Materials

**Health Physics--In Review
August 1996 Version**

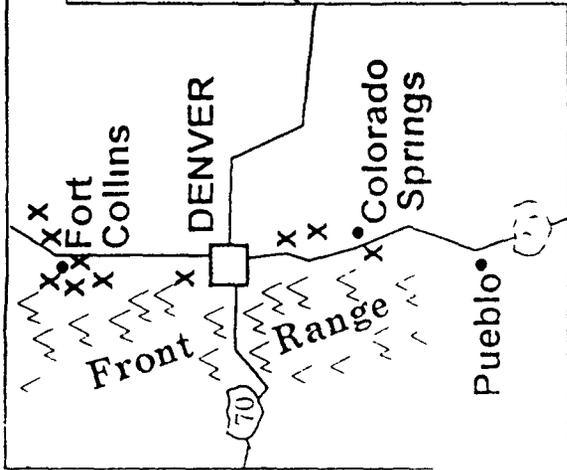
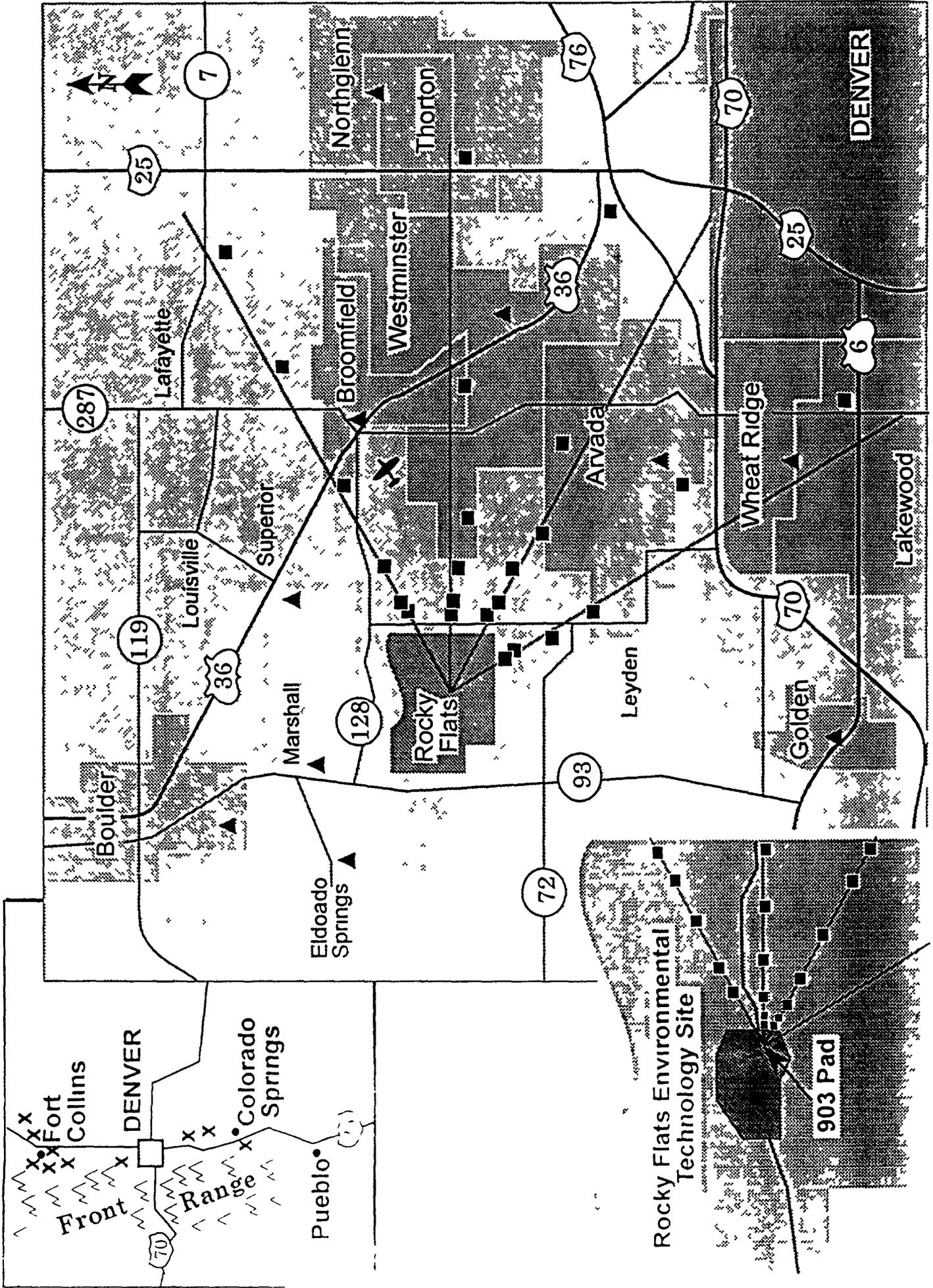
A Three-Dimensional Spatial Model of Plutonium in Soil Near Rocky Flats, Colorado

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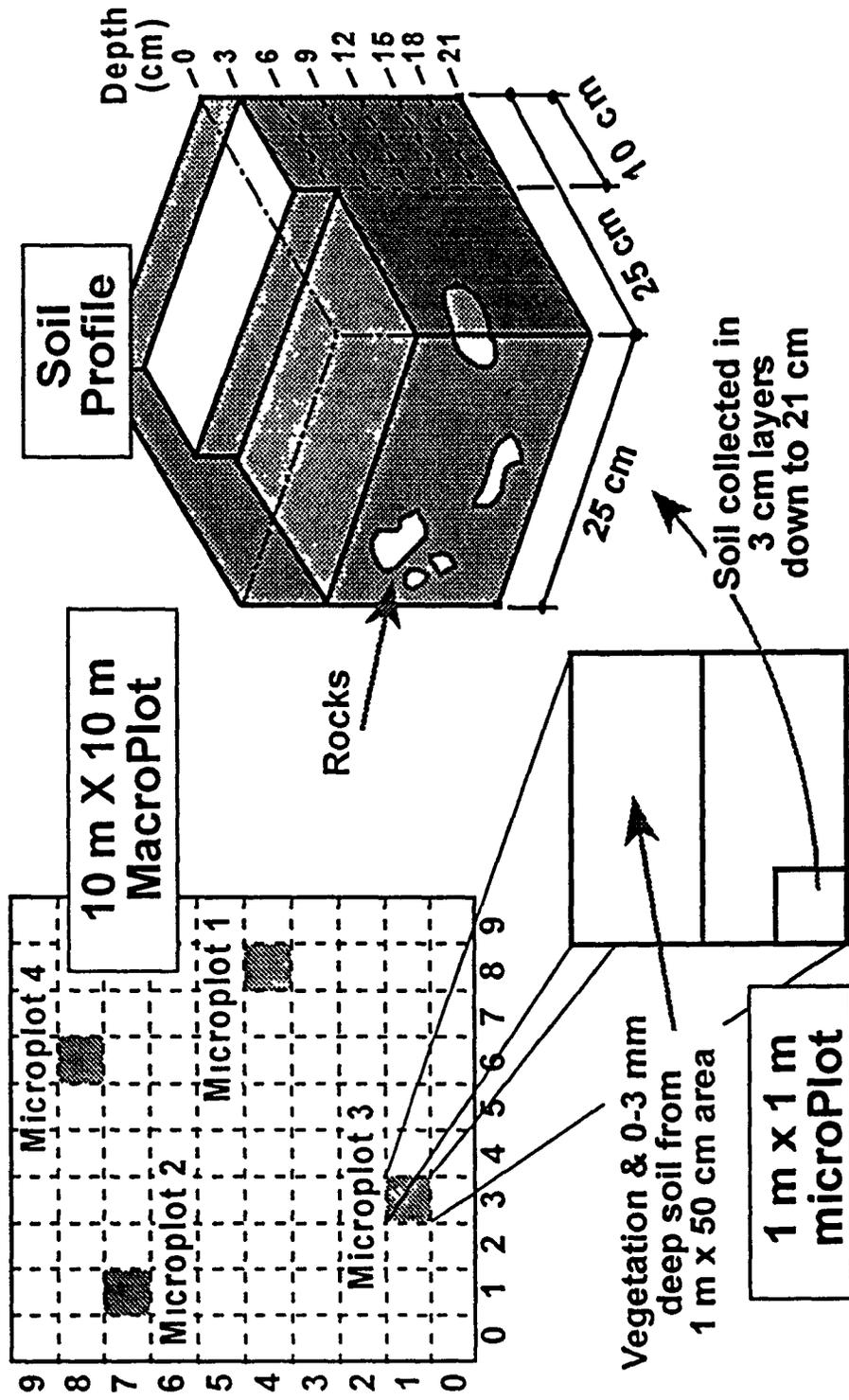
ABSTRACT

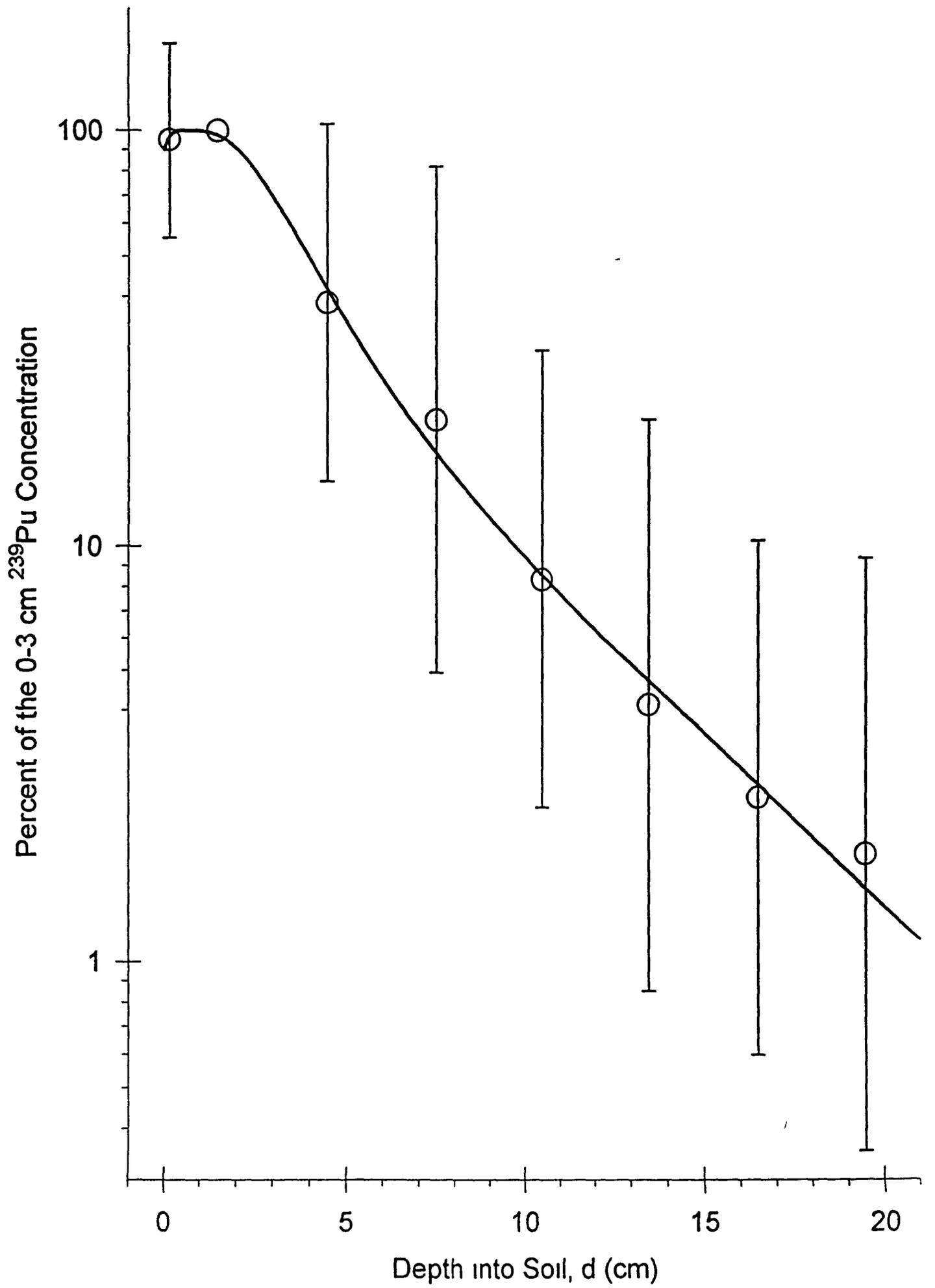
The horizontal and depth distribution of plutonium was measured in soil east of the Rocky Flats Environmental Technology Site (formerly the Rocky Flats Plant) near Denver, Colorado during 1992-1994. The study area was centered on the eastern plume of plutonium contamination and included transects extending from 0.2 km east of the primary origin of the contamination (the 903 Pad) to distances of up to 19 km northeast, east, southeast and south-southeast of the 903 Pad. Soil was collected in 3 cm layers down to 21 cm at exponentially increasing distances along the four transects. Plutonium concentrations decreased rapidly with depth, distance from the 903 Pad, and angle from due east. Depth distributions were independent of distance and angle from the 903 Pad, and our profile model can be used to adjust to a common basis, historical measurements made from sampling to different depths. Based on a total of ~1,400 independent measurements, mathematical functions were developed to describe the distance, directional, and depth relationships. These equations, combined with soil density and rock measurements, provided a new method to estimate the plutonium concentration or total deposition per unit area anywhere within the study area. Total deposition per unit area measurements at 50 sites provided an independent test of the model's predictive accuracy. Sampling coefficients of variation based on replicate samples at the main sampling locations averaged 33%, but ranged from 12 to 98%. The analytical measurement coefficient of variation averaged 8%. Mean 0-3 cm soil concentrations of $^{239,240}\text{Pu}$ among 10 Front Range "background" and 11 community locations near Rocky Flats were 2.1 and 2.3 Bq kg⁻¹, respectively.

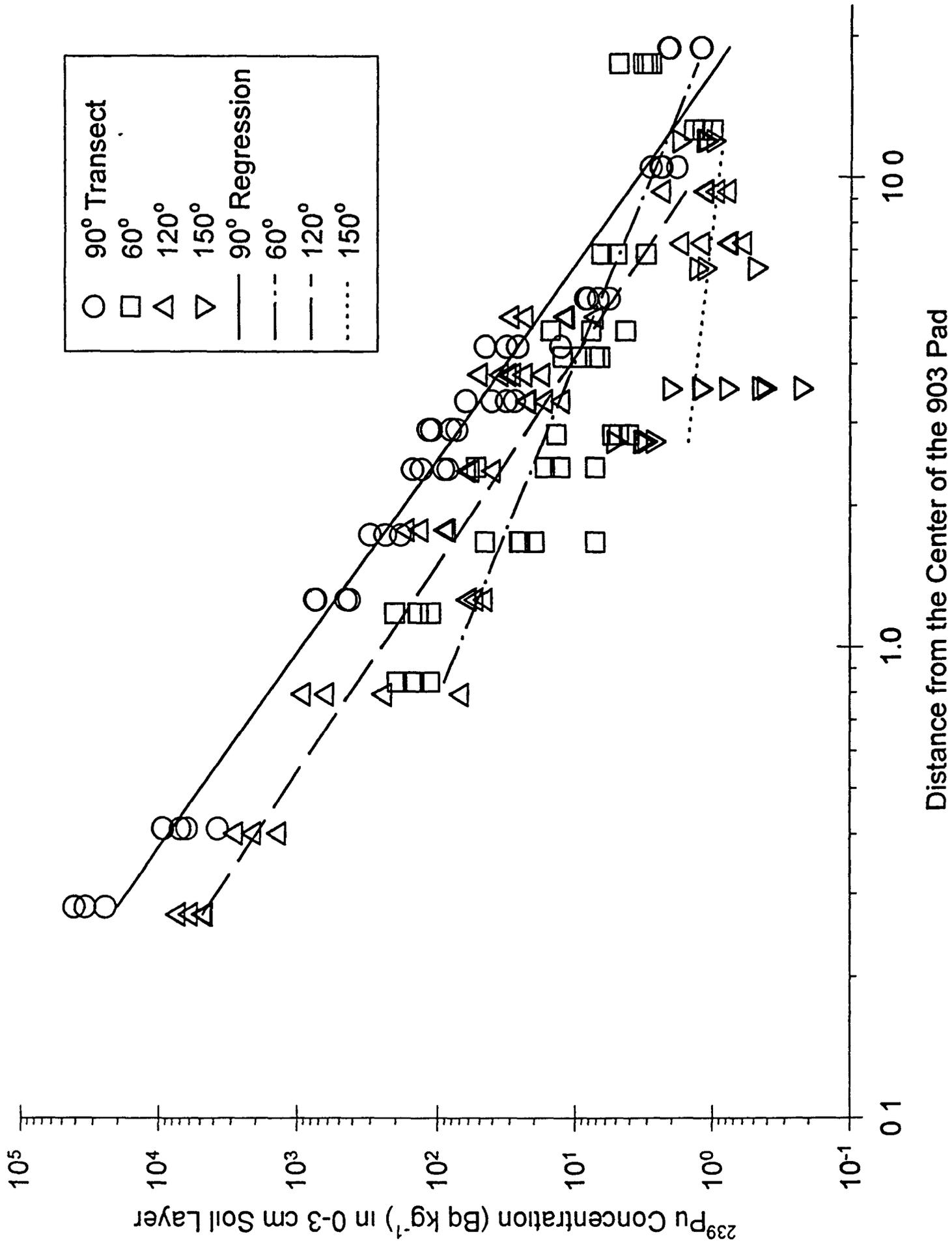


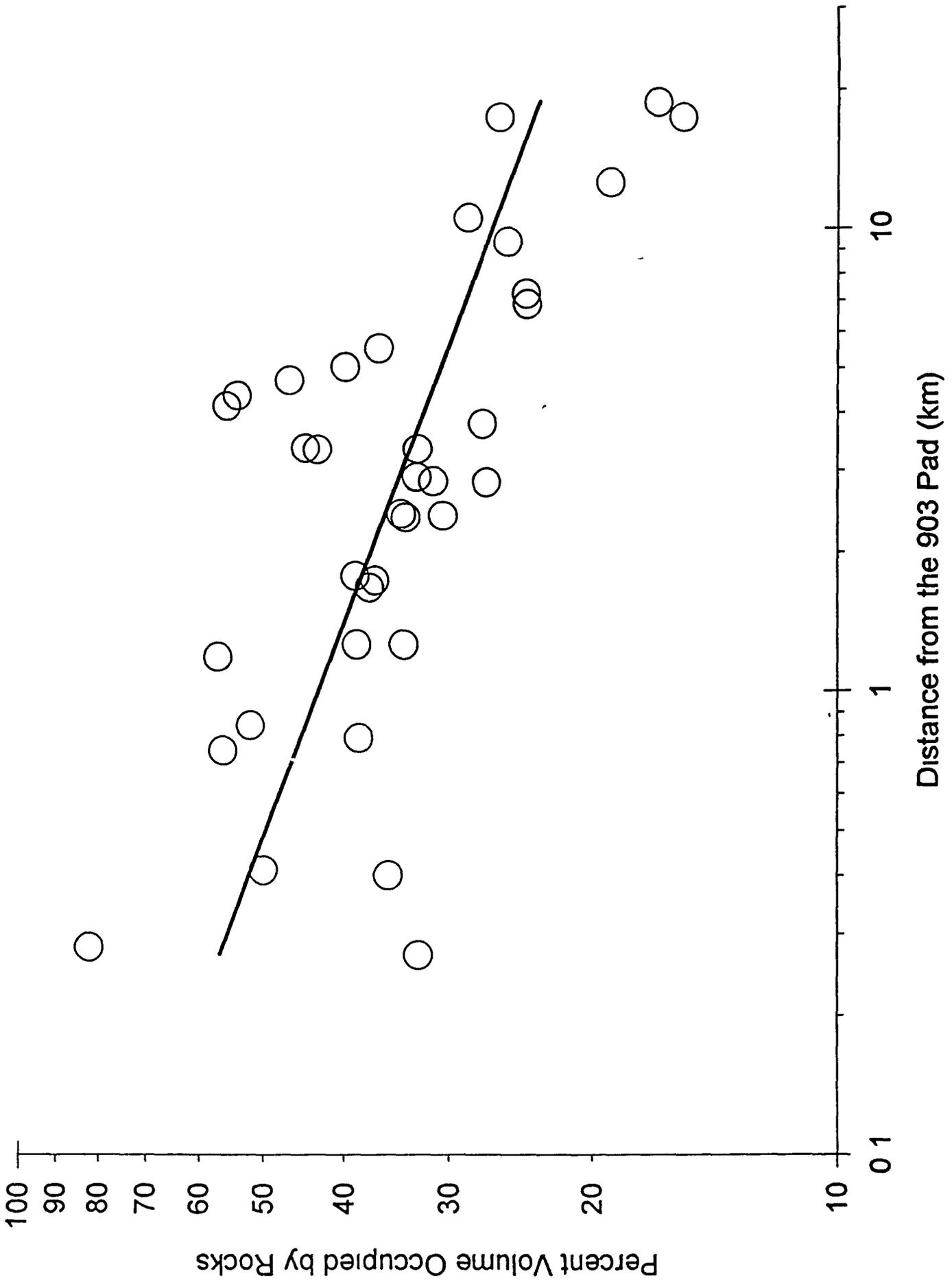
Rocky Flats Environmental Technology Site

903 Pad









Equations for *A Three Dimensional Model of Plutonium in soil near Rocky Flats* by Webb, Ibrahim, and Whicker were written in Microsoft Word (ver 7 0) and Microsoft Equation (ver 2 0) This sheet is in a file named **eq.doc**.

$$[^{239}\text{Pu}]_d = [^{239}\text{Pu}]_{0-3\text{ cm}} \cdot 1 - (1 - 1.41e^{-0.71d} - 0.16e^{-0.19d})^4 \quad (\text{Eq 1})$$

$$\begin{aligned} [^{239}\text{Pu}]_{0-3\text{ cm}}^{60} &= 72D^{-1.40} \\ [^{239}\text{Pu}]_{0-3\text{ cm}}^{90} &= 925D^{-2.42} \\ [^{239}\text{Pu}]_{0-3\text{ cm}}^{120} &= 250D^{-2.26} \end{aligned} \quad (\text{Eqs 2})$$

$$[^{239}\text{Pu}]_{0-3\text{ cm}}^{\theta,D} = [1e^{15.3\sin(\theta-4)-8.6}] D^{-0.4e^{2.4\sin(\theta-10)-0.6}} \quad (\text{Eq 3})$$

$$\rho = 0.79 d^{0.24} \quad (\text{Eq 4})$$

$$I^{\theta,D} = [^{239}\text{Pu}]_{0-3\text{ cm}}^{\theta,D} \int_0^{21\text{cm}} [^{239}\text{Pu}]_d \rho \cdot dd \quad (\text{Eq 5})$$

$$I^{\theta,D} = 53 [^{239}\text{Pu}]_{0-3\text{ cm}}^{\theta,D} (\text{Bq m}^2) \quad (\text{Eq 6})$$

$$I^{\theta,D} = 53 (1 - 0.45D^{-0.21}) [^{239}\text{Pu}]_{0-3\text{ cm}}^{\theta,D} (\text{Bq m}^2) \quad (\text{Eq 7})$$

Inventory Estimates of ^{239}Pu in Soil East of Rocky Flats, Colorado

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ABSTRACT

Through extensive geographic and depth-profile sampling of soils and radiochemical analysis and statistical models of the resulting data, we estimated the total inventory of $^{239,240}\text{Pu}$ released by the Rocky Flats Environmental Technology Site to the soil east of a remediated drum storage area known as the 903 Pad. Our best geometric mean estimate, which applies only to a sector located between 0.2-19 km from the 903 Pad and within an arc from 60° - 120° true bearing is 53 GBq (1.4 Ci) with a geometric standard deviation of 1.6. This value is roughly a fraction of two lower than several historical estimates of environmental plutonium contamination of soil in the same area. Our estimate apparently differs from previous work because it includes the effect of soil displacement by rock, which is very abundant in the study area and which contains very little, if any plutonium. We considered all sources of error in calculating the geometric mean and standard deviation, using a Monte Carlo approach. The primary source of uncertainty in the total inventory estimation was the statistical variance in the parameter estimates for the equations used to calculate the inventory. Although, the relative uncertainty for our estimate was greater than those reported for earlier studies, it may better-reflect the actual variance of the plutonium inventory east of the RFETS.

