

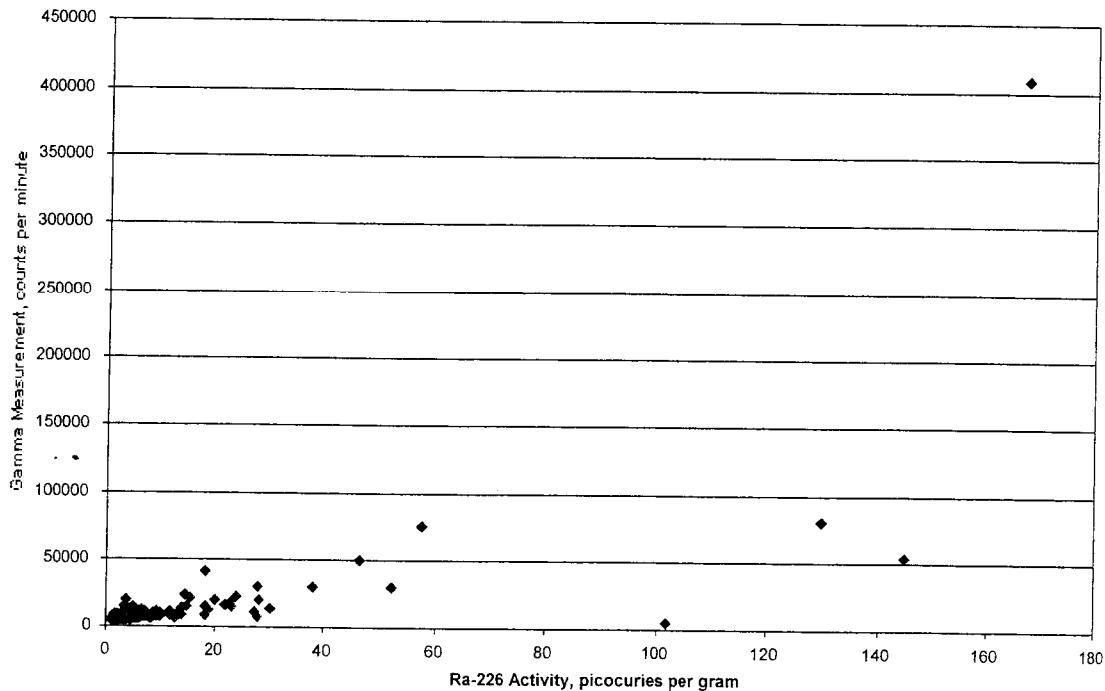
Standard Operating Procedure Gamma Meter Screening Level Determination for the CSMRI Site

The majority of the radioactive material at the CSMRI site is either residual uranium ore or the tailings from experimental milling processes. The relationship between Ra-226 activity and gamma survey instrument measurements is necessary in order to determine the gamma screening level for the excavation of the Class 1 material.

Per a determination from CDPHE, the ANSI standard will serve to define the lower bound limit for excavation of Class 1 soils. The ANSI standard stipulates that roughly 95% of the material must be measured at an average of 3 pCi/g plus background (i.e. 2.7 pCi/g for the CSMRI site). The ANSI standard also allows a small percentage (~5%) of the material to be up to ten times the average activity (assumes a somewhat normal distribution). Using the defined limits in the ANSI standard and a general assumption of secular equilibrium, the allowable Ra-226 activity is 0.88 pCi/g. Accordingly, the absolute upper limit for the Ra-226 concentration is calculated to be $0.88 \times 10 + 2.7$ or 11.5 pCi/g. Because the uncertainty associated with the exact field measurement of the various waste streams historically present at the site, the ISOCS computer software interpretation of the activity of the many different wastes and for simplicity, an upper limit of 10 pCi/g will be used for the designation of Class 1 material.

Data collected during the surface soil sampling effort is plotted using MS Excel and the Excel curve fitting routine (trendline - a least squares fit) is used to determine a linear relationship for Ra-226 activity (picocuries per gram) versus the gamma reading (counts per minute). The plotted data shows a number of outliers. The data point that represents the largest activity (and largest gamma reading) is eliminated from the data set because of the large amount of leverage it has on the data set (see Figure 1).

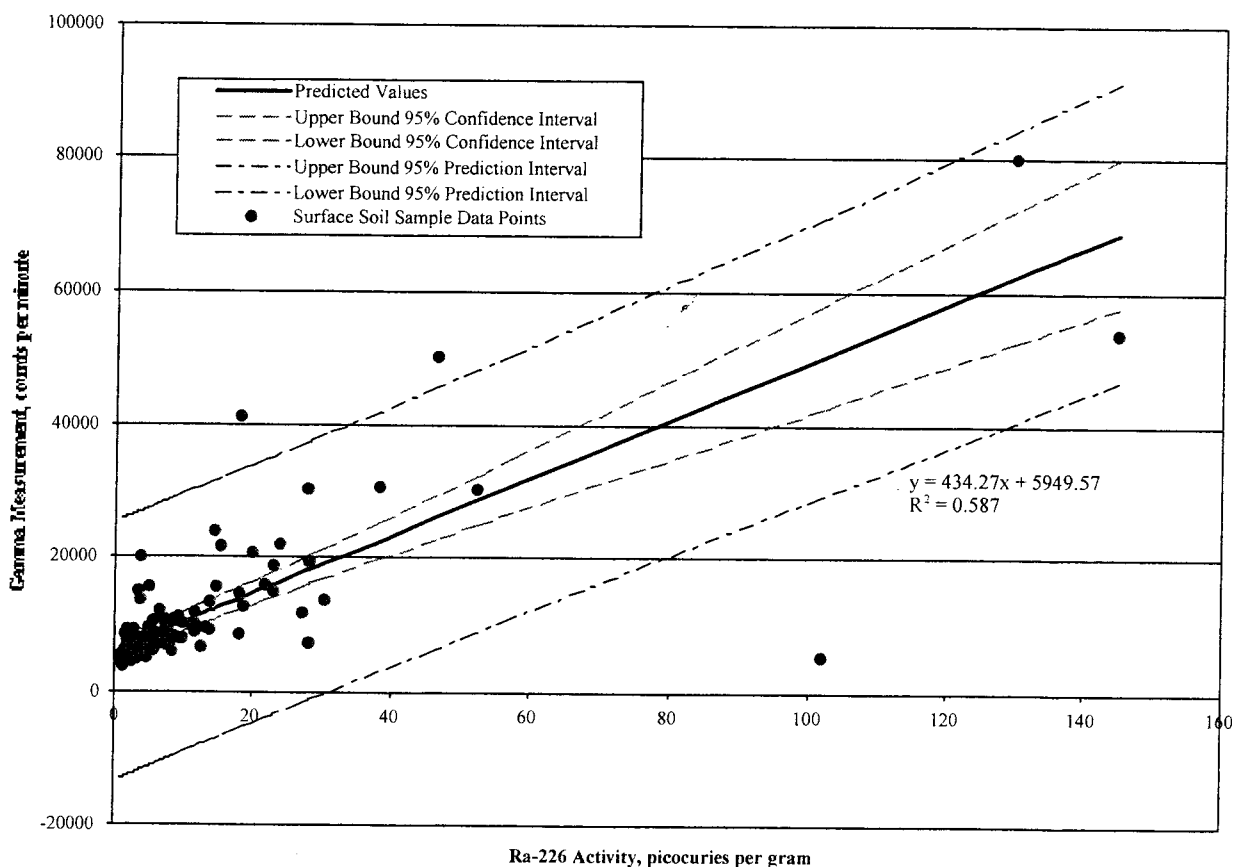
Figure 1 Ra-226 Activity vs In Field Gamma Measurements



The relationship between activity and gamma readings indicates that at 10 pCi/g the expected gamma reading is 10,292 cpm (including background). However, the coefficient of determination value (or R squared value²) for the trendline is only 0.587. The trendline is most reliable when the coefficient of determination value is at or near 1.0.

Examination of the plotted data (see Figure 2) shows there is significant scatter around the trendline. The scatter indicates that there is some uncertainty about the predicted gamma measurement to be used for the screening level. In order to quantify the uncertainty the confidence interval and the prediction interval is determined (assuming a 95% confidence level). The confidence and prediction intervals are displayed in Figure 2. At 10 pCi/g the upper confidence interval is 11,810 cpm and the upper prediction interval is 29,669 cpm.

Figure 2 Relationship of Ra-226 Activity to Gamma Measurements



Because of the high variability of the gamma signature for the various types of waste materials at the CSMRI site and the variability associated with the measurement, the initial screening level (maximum upper limit) for the Class I material cutoff will be 15,000 cpm (including background). If ISOCS and laboratory data suggest the value is too high, the screening level will be reduced to 10,000 cpm. The screening level will be evaluated real time to ensure the Class I target material is removed, and that the cutoff for the removal of the Class I material is not over estimating values (increasing volume).