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Evaluating Uncertainties in Cellulose, Plastics, and Rubber Inventories in the Waste Isolation Pilot Plant

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Overview

- Introduction of work
- Description of processes evaluated
- Methodology
- Results and Conclusion
- Questions

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Introduction

- The inventory at the WIPP contains cellulose, plastics, and rubber (CPR) materials as constant values.
- EPA has questioned the estimation techniques associated with the CPR values and their uncertainties.

Objective

- Assess if CPR estimation techniques are biased.
- Quantify the uncertainty in CPR masses.

Approach

- **Bias estimated by comparing two methods of CPR measurement.**
- **Uncertainty in total CPR per room derived from uncertainty in CPR per waste container.**

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CPR Estimation Processes

- Real Time Radiography (RTR).
- Visual Examination (VE).
  - Generally performed on a subset of the waste containers to confirm RTR.
  - More thorough and considered more accurate.
- Want to asses if RTR estimates are biased relative to VE estimates.

Comparison

- Randomly selected 200 containers that had RTR and VE estimates.
- Assumed VE represents the true value.
- Paired differences between VE and RTR used to identify bias and errors.

Effects of Bias

- Random measurement errors tend to cancel in sums
- Bias is a systematic error in measurement
- Systematic errors are additive in a sum

Calculating Bias

- Bias is calculated by comparing the differences between each container to the "true" mean.
  - If the average ratio of container estimates divided by the mean is 1, there is no bias.
- The RTR values for each container were divided by the VE mean over the sampled containers.
- The average ratio was 1.011.
- The difference of the average ratio from 1.011 to 1 has a likelihood of 96.8% of being due to random error, based on a Student's-t test.

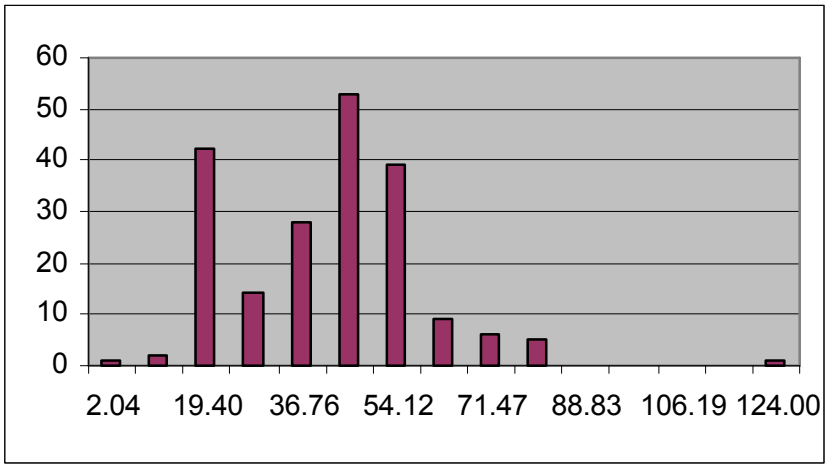
Individual Container Results

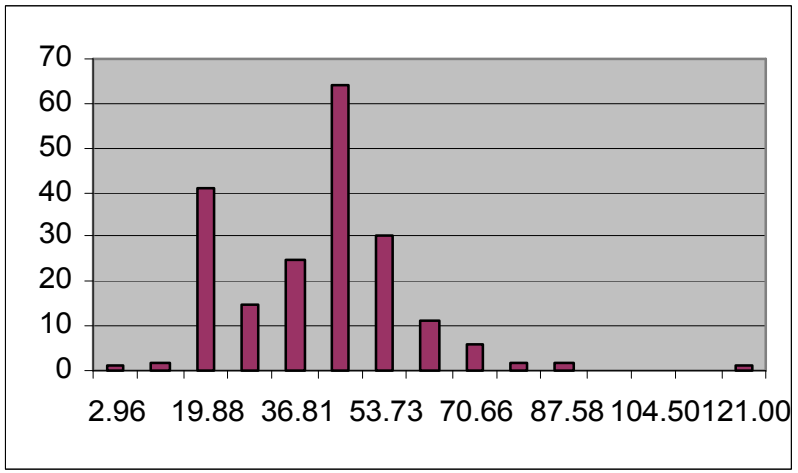
- **Bias is not significant.**
- **RTR methodology to estimate CPR masses is within 1%, on the average, to the VE methodology.**

	Average Weighted Mass	Standard Deviation	Standard Error
RTR Mass Estimate	36.8	17.4	1.23
VE Mass Estimate	36.5	16.5	1.17
Paired Difference (delta)	0.334	7.83	0.553
Error Ratio (bias)	1.011	0.271	0.019

Distribution of Estimates

- Distribution of RTR measurements (LEFT). Distribution of VE measurements (RIGHT). All measurements are in CEMs.





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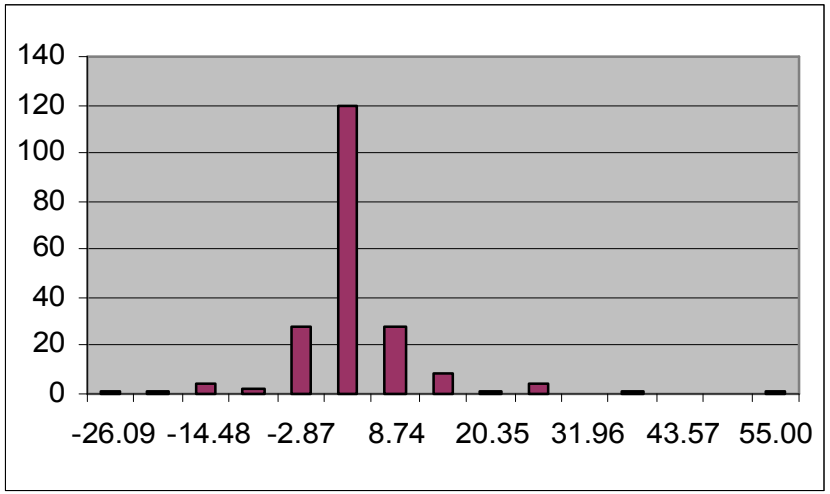
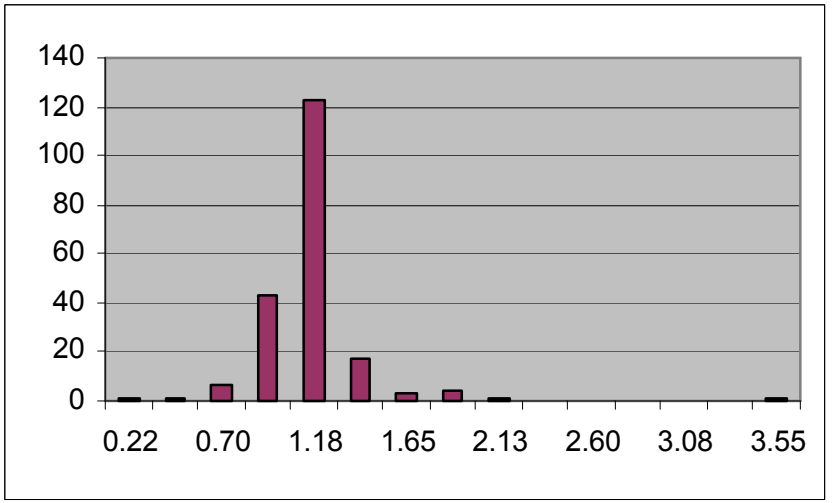
Distribution of Errors

- Distribution of errors (Delta) in RTR measurements (LEFT). Distribution of Error Ratios in RTR measurements (RIGHT). All measurements are in CEMs.





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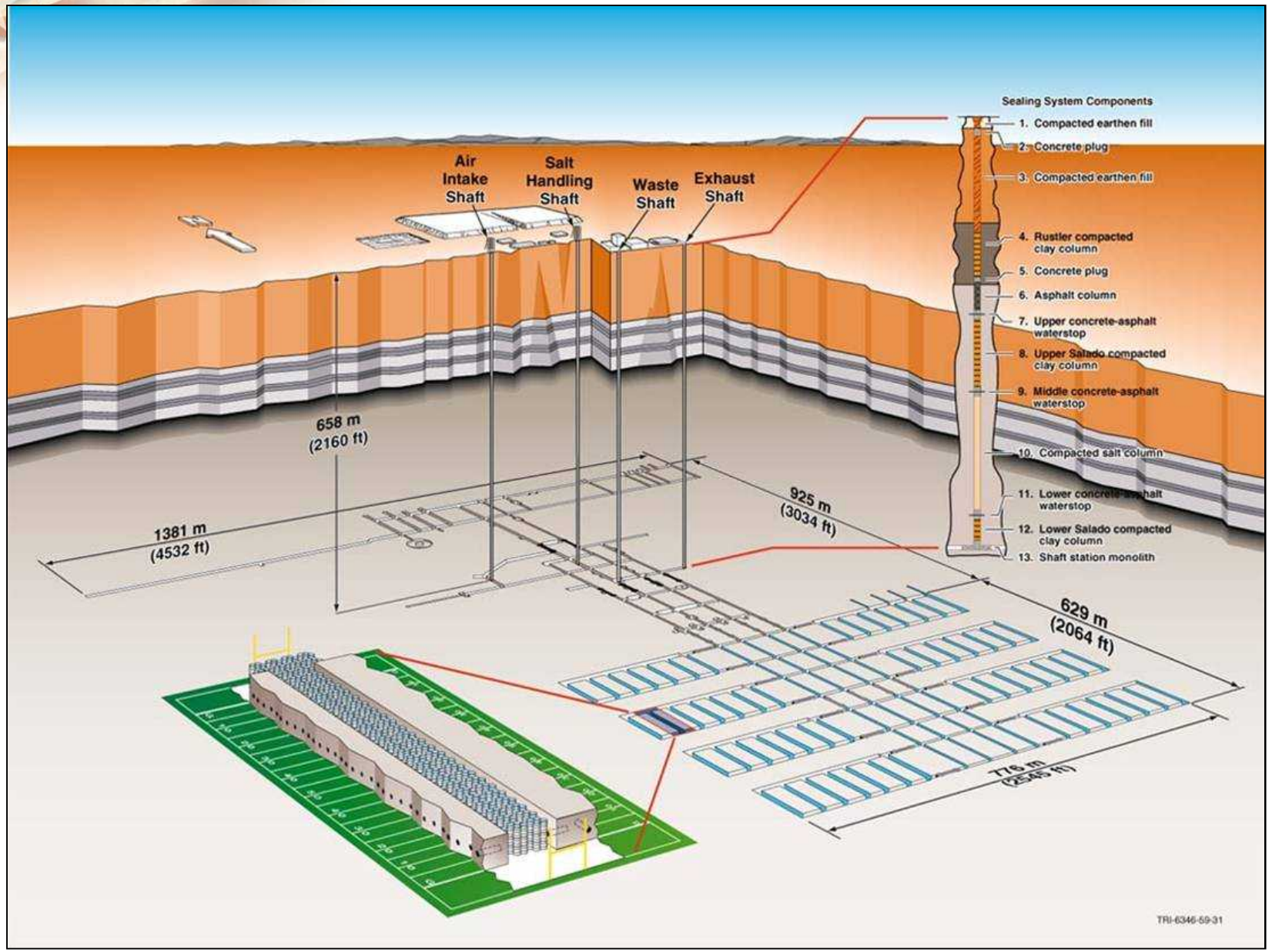

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Estimating the Uncertainty in Total CPR

- **Assuming that the waste containers sampled represent all the waste containers and no bias is present:**

$$\text{Total CPR Mass} = \text{Number of Containers} \times \text{Average CPR Per Container}$$

- **and**

$$\sigma_{\text{Total}} = \sigma_{\text{Differences}} \times \sqrt{\text{Number of Containers}}$$

- **Thus the relative variability, or coefficient of variation (CV) for the total is**

$$CV = \frac{\sigma_{\text{Total}}}{\text{Total CPR Mass}}$$

Total CPR Uncertainty Results

- The relative uncertainty (σ_{total}/Total CPR Mass) of the mass of CPR waste in the room would be 0.00204, or about 0.2%.
- A Monte Carlo simulation shows that the estimates of the uncertainty are consistent with the theoretical results.

Conclusions

- The Student's-t test shows that bias is not significant in RTR measurements.
- Therefore, it is appropriate to assume that the total of the CPR measurements is the best estimate of the true value of the total.
- Because of the large number of containers, large uncertainties in CPR masses per container have minimal impact.
- Relative uncertainty of CPR mass in a room is very small, 0.2%
- The Monte Carlo analysis shows that the uncertainty in the total mass of CPR in a room is less than 0.3% when RTR is used.

Questions

Backup Slide, Monte Carlo Results

Parameter	*Predicted*	*Observed*
Mean (True value)	401500	401606
Mean (Additive error)	405174	407701
Standard deviation (Additive error)	821	746
Coefficient of variation (Additive error)	0.00204	0.00187
Mean (Proportional error)	405916	407534
Standard deviation (Proportional error)	1037	892
Coefficient of variation (Proportional error)	0.00255	0.00222