

**Preliminary Evaluation of Available Data from P-4 From Geomorphic Perspective:  
What Do We Know and Where Do We Go From Here?**

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The following partial, preliminary summary is intended to gather my thoughts and to help generate discussion, particularly as concerns remaining significant uncertainties that should be targeted in next (final?) round of sampling in P-4. All thoughts welcome. Similar summary for LA-2 to follow.

Sample sites and geomorphic units in P-4 presented on FIMAD plot 105352 (contact Marcia Jones, 5-2807, for copy). I have Excel spreadsheets with particle size data for samples, Pu-239,240 values, preliminary calculations of Pu-239,240 inventories, and notes on each sample. Contact me for copies of the spreadsheets.

**Pieces of Working Conceptual Model**

Significant spatial variations in contaminant concentrations occur in sediments in all reaches. Important variables affecting concentrations of different contaminants in a reach include:

- 1) Grain size distribution of sediment deposit (in deposits from a single flood, the finest size fractions will typically have the highest concentrations of contaminants).
- 2) Age of deposit (the timing of peak contaminant concentrations in a reach are related to the time of maximum release at source areas and transport times: due to shorter transport times for finer-grained sediments carried in suspension in floods, the peak concentrations of contaminants in suspended sediments may precede peaks in channel sediments).
- 3) Source of sediment carried in specific floods (concentrations of contaminants can vary dependent on the percentage of sediment contributed from different sources; i.e., variable contributions from contaminated and uncontaminated tributaries may occur in different floods, and variable amounts of bank erosion in contaminated vs. uncontaminated deposits).

Complications in evaluating the relative importance of the above factors in explaining present variations in contaminant concentrations include the fact that geomorphic mapping units typically include deposits from many separate floods, spanning many years, with variable percentages of different sediment size fractions deposited in a single flood and between floods in a single unit. Variable amounts of fine-grained sediment with variable concentrations of contaminants can be added to deposits in one or more subsequent flood events.

Below, available data on the concentrations of select contaminants in P-4 are discussed as pertains to this working conceptual model, and what are perceived to be key uncertainties are highlighted.

**General Notes on Particle Size Variations (Texture) of Sampled Deposits**

Texturally, the sampled sediments in P-4 range from sand (<10% silt+clay) to loam (mixtures of sand, silt, and clay, with up to 51% silt and clay in the P-4 samples). Intermediate textures (loamy sand and sandy loam) are also present. Clean channel deposits in P-4 are classified as sand, representing the bedload of Pueblo Canyon in floods, and are dominated by medium to very coarse sand size particles (0.25-2 mm). Overbank deposits can be dominated either by fine sand or by silt, reflecting variations in the energy of the associated floodwaters at each point; textures of these



deposits are typically sandy loams, although they also include loams and loamy sands. Pure overbank deposits can occur within either floodplain or channel units. Intermediate particle size distributions can be produced by the addition of variable amounts of overbank sediments to channel deposits.

### Preliminary Interpretation of Pu-239+240 in Reach P-4

#### 1) Channel units can be grouped into 3 packages with different average Pu concentration:

A) c6, pre-late-1950s, post-1935 channel. Sand that constitutes bulk of deposit volume has relatively low Pu concentration (analyses of 0.23 and 2.5 pCi/g, average = 1.4). Fine-grained uppermost part of deposit has relatively high Pu (11.3 and 38 pCi/g), and can be distinguished as a separate stratigraphic unit for purposes of calculating an inventory.

B) c5 and c4b, ~mid-1950s to mid-1960s channel deposits. Includes highest measured concentrations of Pu in sand deposits (4.75-16 pCi/g), possibly recording timing of maximum concentrations of Pu in channel deposits. Variations in Pu in sands may be related to % fines (e.g., highest Pu in four c5 and c4b sand samples is in sample with most clay and most silt + clay). Uppermost parts of each unit, containing overbank sediments contemporaneous with or younger than the main sand deposits, have no significant difference in Pu concentration from the sands, so there is no basis for distinguishing a separate stratigraphic unit for purposes of calculating an inventory. (Note: deposits dating to period between 1945 and mid-1950s are not well defined, and peak Pu could have preceded deposition of uppermost c5 unit, and could possibly be buried at depth.)

C) c4a, c3, c2, c1, mid-1960s to 1990s channel deposits. Contains relatively low concentrations of Pu (0.54-2.4 pCi/g, 8 samples; average = 1.5). No significant difference recognized between youngest and oldest units, and surveillance data from routine sample site immediately east of reach also show no significant variations since the mid 1970s. Where samples obtained from depth (c3, P-4 east, 2 samples), Pu similar to surface samples. There is thus no recognized basis for subdividing these units for purposes of calculating an inventory. (Note: locally higher concentrations of Pu are possible where fines deposited in this unit, which have not yet been sampled, including the organic-rich sediments associated with the modern sewage effluent; higher concentrations are also possible below maximum sampling depths in c4a and c3.)

2) Floodplain units have been subject to only limited sampling so far, and the thickness and average Pu concentrations are relatively poorly constrained. The highest value yet obtained (6 pCi/g) may be from deposit from early-to-mid 1970s, post-dating the presumed maximum concentrations in P-4. A higher value of 15 pCi/g was reported for a "bank" sample in P-4 in the 1976-1977 FUSRAP study. Low values of ~0.15-0.25 pCi/g obtained from 0-3" at two f1 sites may indicate that the historic overbank deposits at these sampling sites are <3" (<8 cm) thick.

Sedimentologically, the overbank deposits overlying the historic channel units (c1 to c6) are equivalent to historic floodplain deposits (loams, sandy loams, and loamy sands), and can thus be considered part of the same data set. Within this data set, no systematic variation in Pu concentration with particle size is apparent. This suggests that the time-dependent variability in Pu concentration in floodwaters has been more significant than particle size variability in producing the observed distribution of Pu.

The highest concentration of Pu in obtained P-4 (38 pCi/g) is in the uppermost c6 unit adjacent to the late 1950s (c5) channel, suggesting that relatively old, historic overbank sediments have higher Pu concentrations than younger (post mid-1960s) deposits. Because the highest value obtained was from a relatively coarse floodplain deposit (29% silt+clay, vs. up to 51% silt+clay for other deposits in similar settings), maximum concentrations in finer-grained P-4 deposits of similar age could locally be significantly higher.

Based on the geomorphic history of reach P-4 and the available data on Pu concentrations, it is possible that average Pu concentrations in f1 units in P-4 east are significantly lower than in P-4 west. There may thus be rationale for assigning higher average Pu values to the f1 units in P-4 west.

### Geomorphic Issues in P-4

#### 1) Trends Over Time

Available data are consistent with the maximum concentrations of Pu in channel deposits in P-4 (and thus in sediments discharging into lower Los Alamos Canyon) occurring no later than the mid-1950s to mid-1960s. Deposits have not yet been identified to reliably test if the peak occurred prior to the mid-1950s, but channel sediments with higher Pu concentrations could potentially be buried at depth in units c5 or c4b.

No significant decreases in Pu concentration in channel deposits is recognizable in the past ~30 years, indicating that similar concentrations could be maintained for an indefinite period of time into the future. The apparent similarity in concentrations during this period may be due to remobilization of previously stored contaminants through gradual bank erosion, implying that these concentrations may be maintained until the Pu reservoir upstream has been significantly depleted.

The timing and concentrations of maximum Pu in suspended sediments are not determined, but are likely to have been contemporaneous with or prior to the peak in channel deposits, and are likely to have exceeded 38 pCi/g. The timing of the peak concentrations can probably not be determined with better resolution in P-4. The highest concentrations could perhaps be better constrained with more extensive sampling of floodplain deposits near c5 and c4b deposits.

#### 2) Inventory

The total Pu inventory in P-4 is not precisely known due to uncertainties in average Pu concentrations and in the thickness of units, but a revised inventory calculated using average values from the combined full-suite and limited-suite analyses are within 10% of inventories previously calculated using only full-suite data (using the same "best guesses" for unit thicknesses). Uncertainties in the average thickness of the geomorphic units may thus have greater effect on the inventory than uncertainties in the average Pu concentration.

**P-4 West.** The largest portion of the estimated inventory in P-4 west and the largest uncertainty is in c5, c4b, and f1. The uncertainty could be reduced by depth samples from c5 and c4b, and surface samples from f1. (Expected worst cases: Pu in c5 and c4b at depth could be higher than where sampled at the surface; average thickness could be underestimated; the thickness and average Pu concentration in f1 could be underestimated).

**P-4 East.** The largest portion of the estimated inventory in P-4 east and the largest uncertainty is in c3 and f1. The uncertainty could be reduced by depth samples from c3 and additional f1 samples. (Expected worst cases: Pu in c3 at depth could be higher than where sampled at the surface; average thickness could be underestimated; the thickness and average Pu concentration in f1 could be underestimated).

### Candidates For Next (Final) Round of Limited-Suite Sampling in P-4

Consider the following a first cut at identifying issues in need of resolution before we leave reach P-4, presented in no particular order. Once we reach consensus on significant data needs and number of samples needed, we can select specific sample sites and be ready to collect samples when the weather permits.

- 1) Depth samples in c5, c4b, and c3 sand deposits, to be analyzed for Pu-239,240. Perhaps 2-4 depth samples from 1 section in each of these 3 units. Goals would be to test assumed thickness of historic sediments, and to determine if Pu concentrations significantly higher at depth than at surface.
- 2) Surface and depth samples in f1, to be analyzed for Pu-239,240. Sample sites could be dispersed in both P-4 west and P-4 east to provide better geographic distribution and to further test assumptions about distribution and extent of historic Pu-bearing overbank deposits. Perhaps 5-10 samples total, with the higher portion in P-4 west because of the potential for higher Pu concentrations there.
- 3) Samples of relatively organic-rich sediments in c1 adjacent to the active effluent channel. Perhaps 2 samples, including analysis for TOC. Goal is to evaluate if significant modern Pu enhancement is occurring along the nutrient-rich channel in this geochemically unique setting. *Pu BINDS w/ ORGS*
- 4) Resampling of subset of prior sample sites where range of Pu obtained, to further test collocation of contaminants. Analyze for everything that was recognized above background (Pu-239,240, Pu-238, Am-241, Ag, Cd, Hg, . . .)? How many samples needed?
- 5) Analyze particle size separates of select samples for Pu-239/240, to evaluate concentrations in respirable fractions (clay-size particles, <2 microns). How many samples needed? Perhaps also analyze concentrations in silt+clay fraction and one or more sand size fractions in one or more samples.
- 6) Other outstanding issues???

| Notes on Sediment Samples For Reach P-4 |              |                 |                   |                  |                             |   |
|---|--------------|-----------------|-------------------|------------------|-----------------------------|---|
| Field Site #                            | Sample ID No | Geomorphic Unit | Sample Depth (in) | Type of Analysis | Laboratory Sediment Texture | Notes   |
| P4E-10                                  | 04PU-96-0025 | c3              | 28-35             | full suite       | loamy sand                  | relatively fine-textured buried floodplain layer; relatively high field alpha       |
| P4E-17                                  | 04PU-96-0026 | c3              | 10-14             | full suite       | sand                        | black sand (magnetite) rich layer; relatively high field alpha                      |
| P4E-18                                  | 04PU-96-0027 | c1b             | 0-2.5             | full suite       | sand                        | sand bar from 1991 flood  |
| P4E-19                                  | 04PU-96-0028 | c3              | 0-2               | full suite       | sand                        | pre-1986 channel sand deposit   |
| P4E-32                                  | 04PU-96-0029 | f1              | 0-2               | full suite       | sandy loam                  | relatively fine-grained overbank deposit, with historic driftwood                   |
| P4W-49                                  | 04PU-96-0030 | c5              | 0-1.5             | full suite       | sandy loam                  | fine-grained overbank layer, above late 1950s channel deposit; high field alpha     |
| P4W-50                                  | 04PU-96-0031 | f1              | 0-2.5             | full suite       | loamy sand                  | floodplain surface near late 1950s stream channel; sagebrush covered                |
| P4W-42                                  | 04PU-96-0032 | c5              | 0-3               | full suite       | sand                        | coarse sand lobe from late 1950s  |
| P4W-70                                  | 04PU-96-0033 | c6              | 0-3               | full suite       | loam                        | fine-grained overbank deposit, above post-1935 channel deposit; high field alpha    |
| P4E-21                                  | 04PU-96-0223 | f1              | 0-2.5             | Pu-239,240       | sandy loam                  | floodplain surface near pre-1986 channel  |
| P4E-21                                  | 04PU-96-0224 | f1              | 13-17             | Pu-239,240       | loamy sand                  | buried pre-1945 channel deposit below floodplain surface                            |
| P4E-23                                  | 04PU-96-0225 | f1              | 0-3               | Pu-239,240       | sandy loam                  | floodplain surface near pre-1986 channel  |
| P4E-23                                  | 04PU-96-0226 | f1              | 11-16             | Pu-239,240       | sand                        | buried pre-1945 channel deposit below floodplain surface                            |
| P4E-1                                   | 04PU-96-0227 | c1b             | 0-1.5             | Pu-239,240       | sand                        | sand bar from 1991 flood  |
| P4E-4                                   | 04PU-96-0228 | c3              | 0-2               | Pu-239,240       | sand                        | pre-1986 channel sand deposit   |
| P4E-24                                  | 04PU-96-0229 | f2              | 0-3               | Pu-239,240       | sandy loam                  | inferred prehistoric surface, above post-1945 floods                                |
| P4E-25                                  | 04PU-96-0230 | f2              | 0-2               | Pu-239,240       | loamy sand                  | inferred prehistoric surface, above post-1945 floods                                |
| W of P4W-42                             | 04PU-96-0231 | c6              | 0-8               | Pu-239,240       | sandy loam                  | relatively fine-grained surface layer above pre-late-1950s, post-1935 channel sands |
| W of P4W-42                             | 04PU-96-0232 | c6              | 10-18             | Pu-239,240       | sand                        | pre-late-1950s, post-1935 channel sand deposit                                      |
| PW4-42                                  | 04PU-96-0233 | c5              | 0-3               | Pu-239,240       | sand                        | coarse sand lobe from late 1950s  |
| PW4-52                                  | 04PU-96-0234 | c4b             | 0-4.5             | Pu-239,240       | sandy loam                  | relatively fine-grained surface layer above early-to-mid 1960s channel sands        |
| PW4-52                                  | 04PU-96-0235 | c4b             | 5-14              | Pu-239,240       | sand                        | early-to-mid 1960s channel sand deposit   |
| PW4-53                                  | 04PU-96-0236 | c4a             | 0-4               | Pu-239,240       | sand                        | mid-to-late 1960s channel sand deposit  |
| P4W-58                                  | 04PU-96-0237 | c4a             | 0-3               | Pu-239,240       | sand                        | mid-to-late 1960s channel sand deposit  |
| PW4-59                                  | 04PU-96-0238 | c4b             | 0-7               | Pu-239,240       | loamy sand                  | relatively fine-grained surface layer above early-to-mid 1960s channel sands        |
| PW4-59                                  | 04PU-96-0239 | c4b             | 7-15              | Pu-239,240       | sand                        | early-to-mid 1960s channel sand deposit   |
| P4W-70                                  | 04PU-96-0240 | c6              | 16-30             | Pu-239,240       | sand                        | pre-late-1950s, post-1935 channel sand deposit                                      |

| Reach P-4 Pu Data, With Summary of Particle Size Data  |              |            |                 |                   |             |        |                 |           |       |      |                |                |
|--|--------------|------------|-----------------|-------------------|-------------|--------|-----------------|-----------|-------|------|----------------|----------------|
| Samples Separated By Sample Site and Geomorphic Unit   |              |            |                 |                   |             |        |                 |           |       |      |                |                |
| Field Site #   | Sample ID No | Request No | Geomorphic Unit | Sample Depth (in) | Lab Texture | Gravel | Coarse-Med Sand | Fine Sand | Silt  | Clay | Pu-238 (pCi/g) | Pu-239 (pCi/g) |
| P4E-1  | 04PU-96-0227 | 2829       | C1b             | 0-1.5             | s           | 2.2    | 83.5            | 12.2      | 1.7   | 2.8  | BDL            | 2.1            |
| P4E-18   | 04PU-96-0027 | 1938       | C1b             | 0-2.5             | s           | 4      | 92.42           | 6.6       | 0.78  | 0.2  | 0.003          | 0.539          |
| P4E-4  | 04PU-96-0228 | 2829       | C3              | 0-2               | s           | 12.1   | 81.5            | 12.5      | 3.6   | 2.4  | BDL            | 2.3            |
| P4E-10   | 04PU-96-0025 | 1938       | C3              | 28-35             | ls          | 6.5    | 38.75           | 39.46     | 18.59 | 3.2  | 0.003          | 1.49           |
| P4E-17   | 04PU-96-0026 | 1938       | C3              | 10-14             | s           | 3.5    | 88.81           | 11.12     | 0.07  | 0    | 0.005          | 1.06           |
| P4E-19   | 04PU-96-0028 | 1938       | C3              | 0-2               | s           | 8.4    | 84.96           | 12.7      | 1.94  | 0.4  | 0.002          | 0.759          |
| PW4-53   | 04PU-96-0236 | 2829       | C4a             | 0-4               | s           | 5.6    | 78.8            | 14.2      | 4.5   | 2.5  | BDL            | 2.4            |
| P4W-58   | 04PU-96-0237 | 2829       | C4a             | 0-3               | s           | 8.7    | 76.8            | 13        | 7.8   | 2.5  | 0.027          | 1.6            |
| PW4-52   | 04PU-96-0234 | 2829       | C4b             | 0-4.5             | sl          | 4.9    | 30.2            | 40        | 23.7  | 6.1  | 0.048          | 5.9            |
| PW4-52   | 04PU-96-0235 | 2829       | C4b             | 5-14              | s           | 3.4    | 90.8            | 5.1       | 1.5   | 2.4  | 0.083          | 8.5            |
| PW4-59   | 04PU-96-0238 | 2829       | C4b             | 0-7               | ls          | 8.8    | 49.1            | 26.2      | 20.2  | 4.5  | 0.045          | 7.4            |
| PW4-59   | 04PU-96-0239 | 2829       | C4b             | 7-15              | s           | 17.6   | 88.4            | 8.2       | 1.5   | 2.5  | 0.079          | 5.5            |
| P4W-49   | 04PU-96-0030 | 1938       | C5              | 0-1.5             | sl          | 0.2    | 34.52           | 17.64     | 40.84 | 7    | 0.038          | 4.23           |
| P4W-42   | 04PU-96-0032 | 1938       | C5              | 0-3               | s           | 4.5    | 87.17           | 10.41     | 2.01  | 0.4  | 0.021          | 4.75           |
| PW4-44   | 04PU-96-0233 | 2829       | C5              | 0-3               | s           | 5.2    | 79.8            | 12.2      | 4.9   | 3.2  | 0.064          | 16             |
| W of P4W-42  | 04PU-96-0231 | 2829       | C6              | 0-8               | sl          | 5.8    | 41.9            | 29.1      | 23.4  | 5.5  | 0.13           | 38             |
| W of P4W-42  | 04PU-96-0232 | 2829       | C6              | 10-18             | s           | 3.6    | 84.8            | 9.6       | 2.4   | 3.2  | BDL            | 2.5            |
| P4W-70   | 04PU-96-0033 | 1938       | C6              | 0-3               | l           | 3.5    | 20.88           | 27.37     | 44.44 | 7.3  | 0.075          | 11.3           |
| P4W-70   | 04PU-96-0240 | 2829       | C6              | 16-30             | s           | 12.6   | 91.1            | 4.8       | 1.6   | 2.4  | BDL            | 0.23           |
| P4E-32   | 04PU-96-0029 | 1938       | F1              | 0-2               | sl          | 3.2    | 11.62           | 33.44     | 49.84 | 5.1  | 0.038          | 6.21           |
| P4W-50   | 04PU-96-0031 | 1938       | F1              | 0-2.5             | ls          | 3.8    | 47.41           | 32.77     | 17.62 | 2.2  | 0.01           | 3.42           |
| P4E-21   | 04PU-96-0223 | 2829       | F1              | 0-2.5             | sl          | 14.7   | 31.3            | 33.7      | 30.1  | 4.9  | BDL            | 0.25           |
| P4E-21   | 04PU-96-0224 | 2829       | F1              | 13-17             | ls          | 9.2    | 59.9            | 22        | 14.5  | 3.6  | 0.014          | 0.038          |
| P4E-23   | 04PU-96-0225 | 2829       | F1              | 0-3               | sl          | 3.4    | 40.7            | 29.1      | 25.8  | 4.3  | 0.022          | 0.15           |
| P4E-23   | 04PU-96-0226 | 2829       | F1              | 11-16             | s           | 8.7    | 85.4            | 9.2       | 2.9   | 2.5  | BDL            | 0.024          |
| P4E-24   | 04PU-96-0229 | 2829       | F2              | 0-3               | sl          | 3.3    | 35              | 34.9      | 25.3  | 4.8  | BDL            | 0.16           |
| P4E-25   | 04PU-96-0230 | 2829       | F2              | 0-2               | ls          | 4.6    | 62.7            | 18.5      | 15.5  | 3.4  | 0.035          | 0.069          |
| Note on Particle Size Data: percentages of sand, silt, and clay fractions based on <2 mm fraction. |              |            |                 |                   |             |        |                 |           |       |      |                |                |
| Notes on Lab Texture: l = loam; ls = loamy sand; s = sand; sl = sandy loam                         |              |            |                 |                   |             |        |                 |           |       |      |                |                |
| BDL = Below Detection Limit  |              |            |                 |                   |             |        |                 |           |       |      |                |                |

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| Reach P-4 Particle Size Data  |              |            |                 |                   |        |                |             |             |           |              |                      |                     |      |        |                 |           |      |      |             |
|---|--------------|------------|-----------------|-------------------|--------|----------------|-------------|-------------|-----------|--------------|----------------------|---------------------|------|--------|-----------------|-----------|------|------|-------------|
| Field Site #  | Sample ID No | Request No | Geomorphic Unit | Sample Depth (in) | Gravel | V. Coarse Sand | Coarse Sand | Medium Sand | Fine Sand | V. Fine Sand | Coarse & Medium Silt | Fine & V. Fine Silt | Clay | Gravel | Coarse-Med Sand | Fine Sand | Silt | Clay | Lab Texture |
| <b>P-4 Full Suite Samples</b>   |              |            |                 |                   |        |                |             |             |           |              |                      |                     |      |        |                 |           |      |      |             |
| P4E-10  | 04PU-96-0025 | 1938       | C3              | 28-35             | 6.5    | 6.28           | 11.39       | 21.08       | 21.74     | 17.72        | 12.99                | 5.6                 | 3.2  | 6.5    | 38.75           | 39.5      | 18.6 | 3.2  | ls          |
| P4E-17  | 04PU-96-0026 | 1938       | C3              | 10-14             | 3.5    | 2.68           | 50.85       | 35.28       | 10.83     | 0.29         | 0.07                 |                     |      | 3.5    | 88.81           | 11.1      | 0.07 | 0    | s           |
| P4E-18  | 04PU-96-0027 | 1938       | C1              | 0-2.5             | 4      | 14.74          | 53.23       | 24.45       | 5.49      | 1.11         | 0.69                 | 0.1                 | 0.2  | 4      | 92.42           | 6.6       | 0.78 | 0.2  | s           |
| P4E-19  | 04PU-96-0028 | 1938       | C3              | 0-2               | 8.4    | 0.17           | 54.86       | 29.93       | 10.51     | 2.19         | 1.54                 | 0.4                 | 0.4  | 8.4    | 84.96           | 12.7      | 1.94 | 0.4  | s           |
| P4E-32  | 04PU-96-0029 | 1938       | F1              | 0-2               | 3.2    | 0              | 4.02        | 7.6         | 10.8      | 22.64        | 38.04                | 11.8                | 5.1  | 3.2    | 11.62           | 33.4      | 49.8 | 5.1  | sl          |
| P4W-49  | 04PU-96-0030 | 1938       | C6              | 0-1.5             | 0.2    | 0              | 8.32        | 26.2        | 11.72     | 5.92         | 20.54                | 20.3                | 7    | 0.2    | 34.52           | 17.6      | 40.8 | 7    | sl          |
| P4W-50  | 04PU-96-0031 | 1938       | F1              | 0-2.5             | 3.8    | 0              | 19.68       | 27.73       | 18.59     | 14.18        | 13.82                | 3.8                 | 2.2  | 3.8    | 47.41           | 32.8      | 17.6 | 2.2  | ls          |
| P4W-42  | 04PU-96-0032 | 1938       | C6              | 0-3               | 4.5    | 0.17           | 54.92       | 32.08       | 8.8       | 1.61         | 1.51                 | 0.5                 | 0.4  | 4.5    | 87.17           | 10.4      | 2.01 | 0.4  | s           |
| P4W-70  | 04PU-96-0033 | 1938       | C6              | 0-3               | 3.5    | 0.03           | 9.24        | 11.61       | 13.18     | 14.19        | 28.54                | 15.9                | 7.3  | 3.5    | 20.88           | 27.4      | 44.4 | 7.3  | l           |
| <b>P-4 Limited Suite Samples</b>  |              |            |                 |                   |        |                |             |             |           |              |                      |                     |      |        |                 |           |      |      |             |
| P4E-21  | 04PU-96-0223 | 2829       | F1              | 0-2.5             | 14.7   | 9.9            | 8.9         | 12.5        | 18.1      | 15.6         | 24.8                 | 5.3                 | 4.9  | 14.7   | 31.3            | 33.7      | 30.1 | 4.9  | sl          |
| P4E-21  | 04PU-96-0224 | 2829       | F1              | 13-17             | 9.2    | 14.8           | 23.5        | 21.8        | 13.1      | 8.9          | 10.8                 | 3.7                 | 3.6  | 9.2    | 59.9            | 22        | 14.5 | 3.8  | ls          |
| P4E-23  | 04PU-96-0225 | 2829       | F1              | 0-3               | 3.4    | 8.4            | 16.9        | 15.4        | 14.6      | 14.5         | 19.6                 | 6.2                 | 4.3  | 3.4    | 40.7            | 29.1      | 25.8 | 4.3  | sl          |
| P4E-1   | 04PU-96-0226 | 2829       | F1              | 11-16             | 8.7    | 27.5           | 40          | 17.9        | 6.4       | 2.8          | 1.5                  | 1.4                 | 2.5  | 8.7    | 85.4            | 9.2       | 2.9  | 2.5  | s           |
| P4E-23  | 04PU-96-0227 | 2829       | C1b             | 0-1.5             | 2.2    | 10.2           | 38.6        | 34.7        | 9.9       | 2.3          | 0.1                  | 1.6                 | 2.8  | 2.2    | 83.5            | 12.2      | 1.7  | 2.8  | s           |
| P4E-4   | 04PU-96-0228 | 2829       | C3              | 0-2               | 12.1   | 20.3           | 36.9        | 24.3        | 9.8       | 2.7          | 1.4                  | 2.2                 | 2.4  | 12.1   | 81.5            | 12.5      | 3.6  | 2.4  | s           |
| P4E-24  | 04PU-96-0229 | 2829       | F2              | 0-3               | 3.3    | 9.6            | 13.5        | 11.9        | 15.8      | 19.1         | 19.7                 | 5.6                 | 4.8  | 3.3    | 35              | 34.9      | 26.3 | 4.8  | sl          |
| P4E-25  | 04PU-96-0230 | 2829       | F2              | 0-2               | 4.6    | 18.5           | 28.8        | 17.4        | 9.9       | 8.8          | 12.1                 | 3.4                 | 3.4  | 4.6    | 62.7            | 18.5      | 15.5 | 3.4  | ls          |
| W of P4W-42   | 04PU-96-0231 | 2829       | C6              | 0-8               | 5.8    | 7.8            | 15.3        | 18.8        | 15.3      | 13.8         | 19.2                 | 4.2                 | 5.5  | 5.8    | 41.9            | 29.1      | 23.4 | 5.5  | sl          |
| W of P4W-42   | 04PU-96-0232 | 2829       | C6              | 10-18             | 3.6    | 13.1           | 42.3        | 29.4        | 7         | 2.6          | 1                    | 1.4                 | 3.2  | 3.6    | 84.8            | 9.6       | 2.4  | 3.2  | s           |
| PW4-42  | 04PU-96-0233 | 2829       | C6              | 0-3               | 5.2    | 20             | 37.3        | 22.5        | 8.4       | 3.8          | 2.5                  | 2.4                 | 3.2  | 5.2    | 79.8            | 12.2      | 4.9  | 3.2  | s           |
| PW4-52  | 04PU-96-0234 | 2829       | C4b             | 0-4.5             | 4.9    | 3.2            | 8.4         | 18.6        | 24.4      | 15.6         | 15.9                 | 7.8                 | 6.1  | 4.9    | 30.2            | 40        | 23.7 | 6.1  | sl          |
| PW4-52  | 04PU-96-0235 | 2829       | C4b             | 5-14              | 3.4    | 31.8           | 43.2        | 15.8        | 3.8       | 1.3          | 0.1                  | 1.4                 | 2.4  | 3.4    | 90.8            | 5.1       | 1.5  | 2.4  | s           |
| PW4-53  | 04PU-96-0236 | 2829       | C4a             | 0-4               | 5.6    | 15.6           | 36.2        | 27          | 10.4      | 3.8          | 2.7                  | 1.8                 | 2.5  | 5.6    | 78.8            | 14.2      | 4.5  | 2.5  | s           |
| P4W-58  | 04PU-96-0237 | 2829       | C4a             | 0-3               | 8.7    | 20.2           | 34.3        | 22.3        | 9         | 4            | 6.1                  | 1.7                 | 2.5  | 8.7    | 76.8            | 13        | 7.8  | 2.5  | s           |
| PW4-59  | 04PU-96-0238 | 2829       | C4b             | 0-7               | 8.8    | 13.6           | 19.5        | 16          | 17.1      | 9.1          | 14.7                 | 5.5                 | 4.5  | 8.8    | 49.1            | 26.2      | 20.2 | 4.5  | ls          |
| PW4-59  | 04PU-96-0239 | 2829       | C4b             | 7-15              | 17.6   | 27.4           | 39.3        | 21.7        | 6.4       | 1.8          | 0.1                  | 1.4                 | 2.5  | 17.6   | 88.4            | 8.2       | 1.5  | 2.5  | s           |
| P4W-70  | 04PU-96-0240 | 2829       | C6              | 16-30             | 12.6   | 37             | 40.3        | 13.8        | 3.4       | 1.4          | 0.6                  | 1                   | 2.4  | 12.6   | 91.1            | 4.8       | 1.6  | 2.4  | s           |
| Note on Particle Size Data: percentages of sand, silt, and clay fractions based on <2 mm fraction |              |            |                 |                   |        |                |             |             |           |              |                      |                     |      |        |                 |           |      |      |             |
| Notes on Lab Texture: l = loam; ls = loamy sand; s = sand; sl = sandy loam.                       |              |            |                 |                   |        |                |             |             |           |              |                      |                     |      |        |                 |           |      |      |             |

| Preliminary Pu-239,240 Inventory, Reach P-4  |          |         |                        |               |           |                          |            |                               |            |                    |                  |                              |   |                  |      |        |  |
|--|----------|---------|------------------------|---------------|-----------|--------------------------|------------|-------------------------------|------------|--------------------|------------------|------------------------------|---|------------------|------|--------|--|
| (note: 1/97 estimate, using full-suite data on Pu-239,240)   |          |         |                        |               |           |                          |            |                               |            |                    |                  |                              |   |                  |      |        |  |
|  |          |         |                        |               |           |                          |            |                               |            |                    | Estimated        |                              | Measured  |                  |      |        |  |
|  |          |         |                        |               |           |                          |            |                               |            |                    | Range in         |                              | Estimated   |                  |      |        |  |
|  |          |         |                        |               |           |                          |            |                               |            |                    | Pu-239,240       |                              | Pu-239,240  |                  |      |        |  |
|  |          |         |                        |               |           |                          |            |                               |            |                    | Average          |                              | Average   |                  |      |        |  |
|  |          |         |                        |               |           |                          |            |                               |            |                    | (pCi/g)          |                              | (nCi)   |                  |      |        |  |
|  |          |         |                        |               |           |                          |            |                               |            |                    | (n=4)            |                              | (nCi)   |                  |      |        |  |
| Unit   | Location | Section | Area (m <sup>2</sup> ) | Thickness (m) | Range (m) | Volume (m <sup>3</sup> ) | Length (m) | Unit Vol. (m <sup>3</sup> /m) | Gravel (%) | Portion Non-gravel | Range Non-gravel | Density (g/cm <sup>3</sup> ) | notes on concentrations                             |                  |      |        |  |
| c1   | P-4 west | 0-max   | 1903                   | 0.5           | 0.1-1.0   | 953                      | 470        | 2.03                          | 15         | 0.85               | 0.7-1.0          | 1.25                         | "c1"  | n.m.             | 0.55 | 557    |  |
| c1b  | P-4 west | 0-max   | 1652                   | 0.5           | 0.1-1.0   | 826                      | 470        | 1.76                          | 5          | 0.95               | 0.85-0.98        | 1.25                         | P4-18 ("c1")  | 0.539 (1)        | 0.55 | 540    |  |
| c2a  | P-4 west | 0-max   | 574                    | 0.5           | 0.1-1.0   | 287                      | 470        | 0.61                          | 15         | 0.85               | 0.7-1.0          | 1.25                         | av of "c1" + P4-19 (upper c3 sand)                  | n.m.             | 0.65 | 198    |  |
| c2b  | P-4 west | 0-max   | 2643                   | 0.5           | 0.1-1.0   | 1322                     | 470        | 2.81                          | 15         | 0.85               | 0.7-1.0          | 1.25                         | av of "c1" + P4-19 (upper c3 sand)                  | n.m.             | 0.65 | 913    |  |
| c2c  | P-4 west | 0-max   | 3295                   | 0.5           | 0.1-1.0   | 1647                     | 470        | 3.51                          | 15         | 0.85               | 0.7-1.0          | 1.25                         | av of "c1" + P4-19 (upper c3 sand)                  | n.m.             | 0.65 | 1138   |  |
| c3   | P-4 west | 0-max   | 275                    | 0.5           | 0.1-1.0   | 137                      | 470        | 0.29                          | 15         | 0.85               | 0.7-1.0          | 1.25                         | av. of P4-10, 17, 19 ("c3"), assumes 1/3 fines      | 0.759-1.494 (3)  | 1.1  | 160    |  |
| c4a  | P-4 west | 0-max   | 8696                   | 1.5           | 1.0-2.0   | 13044                    | 470        | 27.75                         | 5          | 0.95               | 0.85-0.98        | 1.25                         | av. of "c3" and "c5"                                | n.m.             | 2.9  | 44919  |  |
| c4b  | P-4 west | 0-max   | 3202                   | 1.5           | 1.0-2.0   | 4804                     | 470        | 10.22                         | 5          | 0.95               | 0.85-0.98        | 1.25                         | av. of "c3" and "c5"                                | n.m.             | 2.9  | 16543  |  |
| c5   | P-4 west | 0-max   | 3996                   | 1.5           | 1.0-2.0   | 5993                     | 470        | 12.75                         | 5          | 0.95               | 0.85-0.98        | 1.25                         | P4-42 ("c5")  | 4.233-4.746 (2)  | 4.7  | 33451  |  |
| c6   | P-4 west | 0-max   | 4060                   | 1.5           | 1.0-2.0   | 6091                     | 470        | 12.96                         | 5          | 0.95               | 0.85-0.98        | 1.25                         | "c5" + 20% overlying overbank sedts (P4-70)         | 11.265 (2)       | 6    | 43396  |  |
| f1   | P-4 west | 0-max   | 16585                  | 0.2           | 0-0.4     | 3317                     | 470        | 7.06                          | 3          | 0.97               | 0.95-1.0         | 1.25                         | av. of P4-32, 50, 70                                | 3.416-11.265 (3) | 7    | 28153  |  |
| fla  | P-4 west | 0-max   | 1388                   | 0.2           | 0-0.4     | 278                      | 470        | 0.59                          | 3          | 0.97               | 0.95-1.0         | 1.25                         | av. of P4-32, 50, 70                                | 3.416-11.265 (3) | 7    | 2357   |  |
| Total  |          |         |                        |               |           | 38698                    |            |                               |            |                    |                  |                              | Total   | 0.539-11.265 (9) |      | 172325 |  |
| c1   | P-4 east | 0-max   | 9729                   | 0.5           | 0.1-1.0   | 4865                     | 530        | 9.18                          | 15         | 0.85               | 0.7-1.0          | 1.25                         | "c1"  | n.m.             | 0.55 | 2843   |  |
| c1b  | P-4 east | 0-max   | 3579                   | 0.5           | 0.1-1.0   | 1790                     | 530        | 3.38                          | 5          | 0.95               | 0.85-0.98        | 1.25                         | P4-18 ("c1")  | 0.539 (1)        | 0.55 | 1169   |  |
| c2a  | P-4 east | 0-max   | 510                    | 0.5           | 0.1-1.0   | 255                      | 530        | 0.48                          | 15         | 0.85               | 0.7-1.0          | 1.25                         | av of "c1" + P4-19 (upper c3 sand)                  | n.m.             | 0.65 | 176    |  |
| c2b  | P-4 east | 0-max   | 315                    | 0.5           | 0.1-1.0   | 158                      | 530        | 0.30                          | 15         | 0.85               | 0.7-1.0          | 1.25                         | av of "c1" + P4-19 (upper c3 sand)                  | n.m.             | 0.65 | 109    |  |
| c2c  | P-4 east | 0-max   | 343                    | 0.5           | 0.1-1.0   | 171                      | 530        | 0.32                          | 15         | 0.85               | 0.7-1.0          | 1.25                         | av of "c1" + P4-19 (upper c3 sand)                  | n.m.             | 0.65 | 118    |  |
| c3   | P-4 east | 0-max   | 12516                  | 1.25          | 0.5-2.0   | 15645                    | 530        | 29.52                         | 5          | 0.95               | 0.85-0.98        | 1.25                         | av. of "c3" and "c5" (assumes "c4" and "c5" buried) | 0.759-4.746 (5)  | 2.9  | 53876  |  |
| f1   | P-4 east | 0-max   | 28521                  | 0.2           | 0-0.4     | 5704                     | 530        | 10.76                         | 3          | 0.97               | 0.95-1.0         | 1.25                         | av. of P4-32, 50, 70                                | 3.416-11.265 (3) | 7    | 48415  |  |
| Total  |          |         |                        |               |           | 28587                    |            |                               |            |                    |                  |                              | Total   | 0.539-11.265 (9) |      | 106706 |  |
| equations:   |          |         |                        |               |           |                          |            |                               |            |                    |                  |                              |   |                  |      |        |  |
| Inventory (nCi) = concentration (pCi/g) * density (g/cm <sup>3</sup> ) * portion non-gravel * volume (m <sup>3</sup> ) |          |         |                        |               |           |                          |            |                               |            |                    |                  |                              |   |                  |      |        |  |
| Inventory per unit length (nCi/m) = Inventory (nCi) / Length of unit (m)   |          |         |                        |               |           |                          |            |                               |            |                    |                  |                              |   |                  |      |        |  |

| Preliminary Pu-239,240 Inventory, Reach P-4  |          |         |                   |           |         |                   |        |                     |        |            |            |                      |                                    |               |         |           |
|--|----------|---------|-------------------|-----------|---------|-------------------|--------|---------------------|--------|------------|------------|----------------------|------------------------------------|---------------|---------|-----------|
| (note: 2/21/97 estimate, using new data on Pu-239,240 and keeping unit dimensions from before)                         |          |         |                   |           |         |                   |        |                     |        |            |            |                      |                                    |               |         |           |
|  |          |         |                   |           |         |                   |        |                     |        |            |            | Measured             |                                    |               |         |           |
|  |          |         |                   |           |         |                   |        |                     |        |            |            | Range in             |                                    | Estimated     |         |           |
|  |          |         |                   |           |         |                   |        |                     |        |            |            | Pu-239,240           |                                    | Pu-239,240    |         |           |
| Unit   | Location | Section | Area              | Thickness | Range   | Volume            | Length | Unit Vol.           | Gravel | Portion    | Range      | Density              | notes on                           | (pCi/g)       | Average | Inventory |
|  |          |         | (m <sup>2</sup> ) | (m)       | (m)     | (m <sup>3</sup> ) | (m)    | (m <sup>3</sup> /m) | (%)    | Non-gravel | Non-gravel | (g/cm <sup>3</sup> ) | concentrations                     | (n=*)         | (pCi/g) | (uCi)     |
| c1   | P-4 west | 0-max   | 1905              | 0.5       | 0.1-1.0 | 953               | 470    | 2.03                | 15     | 0.85       | 0.7-1.0    | 1.25                 | av. of c1, c3, c4a                 | 0.539-2.4 (8) | 1.5     | 1518      |
| c1b  | P-4 west | 0-max   | 1652              | 0.5       | 0.1-1.0 | 826               | 470    | 1.76                | 5      | 0.95       | 0.85-0.98  | 1.25                 | av. of c1, c3, c4a                 | 0.539-2.4 (8) | 1.5     | 1471      |
| c2a  | P-4 west | 0-max   | 574               | 0.5       | 0.1-1.0 | 287               | 470    | 0.61                | 15     | 0.85       | 0.7-1.0    | 1.25                 | av. of c1, c3, c4a                 | 0.539-2.4 (8) | 1.5     | 458       |
| c2b  | P-4 west | 0-max   | 2643              | 0.5       | 0.1-1.0 | 1322              | 470    | 2.81                | 15     | 0.85       | 0.7-1.0    | 1.25                 | av. of c1, c3, c4a                 | 0.539-2.4 (8) | 1.5     | 2106      |
| c2c  | P-4 west | 0-max   | 3295              | 0.5       | 0.1-1.0 | 1647              | 470    | 3.51                | 15     | 0.85       | 0.7-1.0    | 1.25                 | av. of c1, c3, c4a                 | 0.539-2.4 (8) | 1.5     | 2626      |
| c3   | P-4 west | 0-max   | 275               | 0.5       | 0.1-1.0 | 137               | 470    | 0.29                | 15     | 0.85       | 0.7-1.0    | 1.25                 | av. of c1, c3, c4a                 | 0.539-2.4 (8) | 1.5     | 219       |
| c4a  | P-4 west | 0-max   | 8696              | 1.5       | 1.0-2.0 | 13044             | 470    | 27.75               | 5      | 0.95       | 0.85-0.98  | 1.25                 | av. of c1, c3, c4a                 | 0.539-2.4 (8) | 1.5     | 23234     |
| c4b  | P-4 west | 0-max   | 3202              | 1.5       | 1.0-2.0 | 4804              | 470    | 10.22               | 5      | 0.95       | 0.85-0.98  | 1.25                 | av. of c4b and c5                  | 4.23-16 (7)   | 7.5     | 42782     |
| c5   | P-4 west | 0-max   | 3996              | 1.5       | 1.0-2.0 | 5993              | 470    | 12.75               | 5      | 0.95       | 0.85-0.98  | 1.25                 | av. of c4b and c5                  | 4.23-16 (7)   | 7.5     | 53379     |
| c6   | P-4 west | 0-0.2   | 4060              | 0.2       | 0-0.4   | 812               | 470    | 1.73                | 5      | 0.95       | 0.85-0.98  | 1.25                 | av. of c4b, c5, c6, fl sfc. layers | 0.15-38 (9)   | 8.5     | 8197      |
| c6   | P-4 west | 0.2-max | 4060              | 1.3       | 0.8-1.8 | 5279              | 470    | 11.23               | 5      | 0.95       | 0.85-0.98  | 1.25                 | av. of c6 sands                    | 0.23-2.5 (2)  | 1.4     | 8776      |
| fl   | P-4 west | 0-max   | 16585             | 0.2       | 0-0.4   | 3317              | 470    | 7.06                | 3      | 0.97       | 0.95-1.0   | 1.25                 | av. of c4b, c5, c6, fl sfc. layers | 0.15-38 (9)   | 8.5     | 34186     |
| fla  | P-4 west | 0-max   | 1388              | 0.2       | 0-0.4   | 278               | 470    | 0.59                | 3      | 0.97       | 0.95-1.0   | 1.25                 | av. of c4b, c5, c6, fl sfc. layers | 0.15-38 (9)   | 8.5     | 2862      |
| Total  |          |         |                   |           |         | 38698             |        |                     |        |            |            |                      | Total                              | 0.15-38 (23)  |         | 181815    |
|  |          |         |                   |           |         |                   |        |                     |        |            |            |                      |                                    |               |         |           |
| c1   | P-4 east | 0-max   | 9729              | 0.5       | 0.1-1.0 | 4865              | 530    | 9.18                | 15     | 0.85       | 0.7-1.0    | 1.25                 | av. of c1, c3, c4a                 | 0.539-2.4 (8) | 1.5     | 7753      |
| c1b  | P-4 east | 0-max   | 3579              | 0.5       | 0.1-1.0 | 1790              | 530    | 3.38                | 5      | 0.95       | 0.85-0.98  | 1.25                 | av. of c1, c3, c4a                 | 0.539-2.4 (8) | 1.5     | 3188      |
| c2a  | P-4 east | 0-max   | 510               | 0.5       | 0.1-1.0 | 255               | 530    | 0.48                | 15     | 0.85       | 0.7-1.0    | 1.25                 | av. of c1, c3, c4a                 | 0.539-2.4 (8) | 1.5     | 406       |
| c2b  | P-4 east | 0-max   | 315               | 0.5       | 0.1-1.0 | 158               | 530    | 0.30                | 15     | 0.85       | 0.7-1.0    | 1.25                 | av. of c1, c3, c4a                 | 0.539-2.4 (8) | 1.5     | 251       |
| c2c  | P-4 east | 0-max   | 343               | 0.5       | 0.1-1.0 | 171               | 530    | 0.32                | 15     | 0.85       | 0.7-1.0    | 1.25                 | av. of c1, c3, c4a                 | 0.539-2.4 (8) | 1.5     | 273       |
| c3   | P-4 east | 0-max   | 12516             | 1.25      | 0.5-2.0 | 15645             | 530    | 29.52               | 5      | 0.95       | 0.85-0.98  | 1.25                 | av. of c1, c3, c4a                 | 0.539-2.4 (8) | 1.5     | 27867     |
| fl   | P-4 east | 0-max   | 28521             | 0.2       | 0-0.4   | 5704              | 530    | 10.76               | 3      | 0.97       | 0.95-1.0   | 1.25                 | av. of c4b, c5, c6, fl sfc. layers | 0.15-38 (9)   | 8.5     | 58789     |
| Total  |          |         |                   |           |         | 28587             |        |                     |        |            |            |                      | Total                              | 0.15-38 (23)  |         | 96528     |
|  |          |         |                   |           |         |                   |        |                     |        |            |            |                      |                                    |               |         |           |
| equations:   |          |         |                   |           |         |                   |        |                     |        |            |            |                      |                                    |               |         |           |
| Inventory (uCi) = concentration (pCi/g) * density (g/cm <sup>3</sup> ) * portion non-gravel * volume (m <sup>3</sup> ) |          |         |                   |           |         |                   |        |                     |        |            |            |                      |                                    |               |         |           |
| Inventory per unit length (uCi/m) = Inventory (uCi) / Length of unit (m)   |          |         |                   |           |         |                   |        |                     |        |            |            |                      |                                    |               |         |           |

CORRECTION FOR  
INCLUSION OF GRAVEL  
(SIEVED OUT FOR ANALYSIS)  
BUT ADDED BACK IN  
FOR INVENTORY