

## Migration of Plutonium in the Soil at Rocky Flats Narrative of a Controversy and the Case for Public Oversight

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*Abstract:* Good results from the Actinide Migration Studies at Rocky Flats are crucial for setting site cleanup levels. The current studies, bedeviled by conflict of interest and scandal, lack credibility. They should be brought under the purview of an appropriate citizen oversight body charged with reviewing the mission of the Actinide Migration Study and overseeing future work in this area.

### Introduction

The issue of actinide migration lies at the heart of cleanup of Rocky Flats. Why? Because plutonium-239, the material of greatest concern at Rocky Flats, remains radioactive for 240,000 years, and because inhaling or ingesting a minuscule particle of this alpha-emitting material may result in cancer, genetic aberration, or damage to the immune system. People aware of these potentially adverse health effects don't want plutonium in their environment. Yet this material is already present in substantial amounts in the soil at Rocky Flats. The quantity is likely to increase when contaminated buildings are taken down. If plutonium and other radionuclides in the Rocky Flats soil migrate substantially, sooner or later they are likely to end up in the environment of people downstream and downwind of the facility -- and all residents of the Denver metro area are downwind of Rocky Flats some of the time.

M. Iggy Litaor, at the time an adjunct professor at the University of Colorado working under contract at Rocky Flats, created quite a sensation when he claimed to discover significant unexpected migration of plutonium in the soil at Rocky Flats during the heavy rains of spring and summer, 1995. His finding, he said, "challenges the framework of the suggested accelerated cleanup for Rocky Flats."<sup>1</sup> Litaor's contract was soon terminated, and resolving the issue that he had raised so forcefully was turned over to a newly constituted Actinide Migration Panel -- their work now part of a large project called the Actinide Migration Studies. Meanwhile, in 1997 water samples taken where Walnut Creek exits the Rocky Flats site showed actinide activities higher than the legally permitted standard of 0.15 picocuries per liter.

To what extent might plutonium in the soil at Rocky Flats migrate? A definitive, publicly credible answer to this question is crucial for the task of setting cleanup levels for the site. By all rights, the Actinide Migration Studies currently underway should produce precisely the sort of convincing answer the public requires. Unfortunately, as the following account demonstrates, the approach of the Actinide Migration Studies is badly flawed, so much so that any answer from this source almost certainly will lack convincing credibility.

### Plutonium migration and the Rocky Flats Soil Action Levels

The question of plutonium migration relates directly to the Radionuclide Soil Action Levels (RSALs) for Rocky Flats, since the latter specify how much plutonium and other radioactive material may remain in the soil at the site after cleanup. In 1996 DOE, EPA, and CDPHE proposed RSALs for Rocky Flats that would allow significant amounts of plutonium and other radionuclides to remain in the Rocky Flats soil. This proposal was opposed almost universally by members of the public who commented on the issue. Besides, broadly representative citizen bodies had already made it clear that they wanted a site much cleaner than what the agencies were proposing. In June 1995 the Rocky Flats Future Site Use Working Group, an ad hoc body convened to advise DOE, made a consensus recommendation that the site be cleaned to average background radiation level when it becomes technologically and economically possible to do this in an environmentally sensitive manner. The Rocky Flats Citizens Advisory Board soon thereafter made the same recommendation.

In October 1996 DOE and its regulators nevertheless adopted as "interim" standards the Rocky Flats RSALs they had all along proposed. These RSALs, which currently govern cleanup of the site, allow in the Rocky Flats buffer zone the equivalent of up to 1429 picocuries of plutonium-239/240 per gram of soil, which is 37,605 times average background level for plutonium of 0.038 picocuries per gram of soil. The site's industrial zone can contain the equivalent of up to 1088 picocuries of plutonium-239/240, or 28,632 times average background level.<sup>2</sup>

<sup>1</sup>"The spring of 1995 was unseasonably wet. . . . On May 17, 1995, significant overland flow occurred that remobilized an unknown amount of Pu (estimated between 10 microcuries to 0.5 curie). Following the May 17 overland flow, the soil became completely saturated and remained so for at least 65 days. Significant water flux was modeled and measured in the soil. . . . Using extremely conservative assumptions we calculated a minimum of 100 to 300 million picocuries of Pu were transported across the study site [below the 903 Pad area] through near-surface processes. With less stringent assumptions, over 1 billion picocuries of Pu were remobilized." Such transport "was not envisioned under any environmental condition or hydrogeochemical modeling scenarios considered for Rocky Flats." M. Iggy Litaor, "The Hydrogeochemistry of Pu in Soils of Rocky Flats, Colorado: Summary," Public Presentation, Denver, May 15, 1996.

<sup>2</sup>The 1429 picocuries per gram of soil (pCi/g) number applies in the hypothetical situation that the soil is contaminated only with plutonium-239/240. Since in reality some plutonium in the soil will have broken down into its daughter products and other radionuclides may be present as well, the RSALs provide ratio sum calculations for combinations of radionuclides that together produce a dose equal to that from 1429 pCi/g of pure plutonium. This alternate calculation allows in the site's buffer zone an amount of plutonium-239/240 up to 17,132 times average background level, plus americium-241 (a daughter product of plutonium) up to 10,935 times average background level (651 pCi/g of plutonium-239/240 plus 117 pCi/g of americium-241 versus average background levels of 0.038 pCi/g for plutonium-239 and 0.0107 pCi/g

Within a few months after adoption of these RSALs public interest groups, local governments, and the Rocky Flats Citizens Advisory Board called for an independent review of both the dose and calculation aspects of the new RSALs. Rep. David Skaggs asked for a review of the calculation aspect. (The dose part specifies a level of radiation exposure deemed acceptable by DOE and its regulators; the calculations purport to show how much radioactive material may remain in the soil without exceeding this dose.) DOE eventually agreed to an independent review of the calculation side of the equation only.<sup>3</sup> Accordingly, in January 1998 the Rocky Flats Radionuclide Soil Action Level Oversight Panel was formed to oversee this review.

If substantive movement of radionuclides in the soil can occur, the quantities allowed under the RSALs adopted in October 1996 will need to be greatly reduced. Otherwise, people downstream and downwind of Rocky Flats face a long history of potential exposure to plutonium particles with all the attendant negative health effects. It thus is essential to learn the truth about actinide migration.

#### Changing weather patterns?

A possible consequence of global warming is increased rain intensity over shorter periods of time in semi-arid areas like Colorado (a topic much discussed at the recent Kyoto conference on global warming). Locally, the heavy rains of spring and summer 1995 were followed by an unusually wet August 1996. Have global weather patterns already been altered to such a degree that the exceedingly wet conditions in which Litaor made his discovery will become the recurrent norm rather than the exception locally? This possibility underscores the necessity for coming to a clear understanding regarding actinide migration in the environment.

#### The scandal of Iggy Litaor's dismissal

One of the most disturbing events in the recent history of Rocky Flats was the dismissal of Iggy Litaor after he claimed to discover substantial migration of plutonium in the soil at Rocky Flats during the wet spring and summer of 1995. His finding, which was based on real-time measurements taken on the site in the midst of a rain storm, countered the received wisdom that plutonium, once deposited in the soil, remains more or less immobile -- a conclusion supported by his own previous work.<sup>4</sup> As noted earlier, his discovery flew in the face of DOE and Kaiser-Hill's plans for a quick "cleanup" and early closure of the Rocky Flats site. The significance of his finding, however, extends far beyond Rocky Flats. If true, it is of signal importance to all who live or work around plutonium-contaminated sites anywhere.

#### Lying about Litaor

How can we get the truth of what happened with the plutonium in the Rocky Flats soil in the 1995 rains and therefore of what might happen again here or elsewhere? We can't now get it from Litaor, since soon after his discovery of plutonium migration Kaiser-Hill terminated his contract. On learning of Litaor's dismissal, Prof. Niels Schonbeck of the Rocky Flats Health Advisory Panel (and now also of the RSAL Oversight Panel) wrote DOE urging that Litaor be retained in view of the far-reaching significance of his research. At the October 1995 meeting of the Rocky Flats Citizens Advisory Board one of Schonbeck's students inquired about Litaor's status. Litaor's supervisor from Kaiser-Hill said full funding had been restored and his work was continuing. CAB members learned a month later that this was not true. Subsequently some funding was restored, and Litaor did additional work. But by this time his original project, with the team of graduate students doing primary research in the field, had been effectively destroyed and the researchers were dispersed. Litaor soon left the area without completing his research on plutonium migration.

#### Litaor's association with Rocky Flats

Iggy Litaor's association with Rocky Flats began when EG&G, former operator of the Rocky Flats facility, contracted Litaor to map plutonium deposits around the Rocky Flats site. Knowledgeable members of the public typically understood plutonium offsite in terms of a southeast plume first sketched in 1970 by P. W. Krey of the Atomic Energy Commission (DOE's

for americium-241). The site's industrial zone can contain plutonium-239/240 up to 14,789 times average background level and americium-241 up to 9,439 times average background level (562 pCi/g of plutonium-239/240 plus 101 pCi/g of americium-241 versus average background levels at the aforementioned amounts).

<sup>3</sup>The dose aspect of the Rocky Flats RSALs (the 15/85 mrem/year exposure to targeted individuals in specific situations) is worth a separate essay. Let it suffice to say that no national standard for dose from cleanup of a site like Rocky Flats exists. The numbers adopted for Rocky Flats came from an EPA proposal for a national standard that was eventually withdrawn. Where and when standards for permissible exposure have been adopted the affected populations have had little to no say in setting the standards. The BEIR (Biological Effects of Ionizing Radiation) VII study just now being initiated by the National Academy of Sciences will review the adequacy of existing standards and possibly propose new guidelines. Responding to concerns about the dose side of the RSALS, Jacqueline H. Berardini, Deputy Director of CDPHE's Office of Policy and Public-Private Initiatives, proposed a nationwide public participation process for the BEIR VII review. Such a process is much to be desired. For a critique of the way standards for permissible exposure are set, see the reference to Rosalie Bertell in note 12.

<sup>4</sup>M. Iggy Litaor et al, "Fate and Transport of Plutonium-239 + 240 and Americium-241 in the Soil of Rocky Flats, Colorado," *Journal of Environmental Quality* 25 (1996): 671-683.

predecessor agency) and later adapted and modified by Carl Johnson, then head of the Jefferson County Health Department.<sup>5</sup> It surprised some of these people to hear from Litaor that he could find no well-defined plume, only scattered deposits and hot spots. If true, this was good news to Rocky Flats management as well as to all who live or work around the site, for it indicated possibly less contamination than some had feared. Litaor made a convincing case for the veracity of his data. It helped that he published his findings in peer-reviewed journals.<sup>6</sup> He rather quickly established a credibility with the public that is exceedingly rare for a scientist in the hire of Rocky Flats. His dismissal on the occasion of making a discovery that was bad news to Rocky Flats management therefore severely hurt relations with the affected public.

#### A questionable review of Litaor's work

In an apparent move to justify their dismissal of Litaor, Kaiser-Hill management commissioned a review of Litaor's work. The texts of this review and of Litaor's response were never circulated to the public, and I was unaware of their existence until very recently when a local acquaintance shared copies of both the review and Litaor's reply.

Critique of Litaor: A 33 page "Technical and Peer Review," dated September 22, 1995, was produced by "Technical Lead" Bruce D. Honeyman of the Colorado School of Mines with David L. Clark, Edward H. Essington, Wayne R. Hansen, and Brian P. Wilcox -- all from DOE's Los Alamos Lab. The reviewers faulted Litaor as follows:<sup>7</sup>

- "Most egregious was the failure to address the question of the chemical form, i.e., speciation, of plutonium in the environment." This criticism gets stated repeatedly. Litaor had focused mainly on the means of possible physical transport of actinides rather than on the chemical form of the material, a point discussed more fully below.
- Based on their literature search, the Los Alamos group insisted that the chemical form of plutonium in the Rocky Flats soil is unknown, while Litaor operates on the assumption that most of it is in oxide -- that is, solid or particle rather than soluble -- form.
- Litaor and his team worked in isolation from other knowledgeable researchers.
- The peer review provided by the *Journal of Environmental Quality* where some of Litaor's findings had been published is "insufficient," since "it is an applied research journal with typically a less stringent review process" than required elsewhere.
- Litaor was too preoccupied with sampling soils so as to determine actinide distribution.

Litaor's rebuttal: Litaor responded with a November 1, 1995, 6 page letter addressed to Bruce D. Honeyman. Main points of his response are as follows:<sup>8</sup>

- Litaor's work was terminated on June 16, 1995 (he found plutonium migration in May 1995). The review of his work "was initiated due to a public outcry" over his dismissal.
- Litaor was not asked to provide data for the review. Kaiser-Hill supplied the reviewers "with a terribly incomplete list of publications and reports." Omitted were "the [four] governing documents" that dictated the scope of his work, as well as thirteen other items.
- Litaor and his group "closely collaborated with several scientists across the country" (he gives names and describes the nature of the collaboration).
- Demeaning the *Journal of Environmental Quality's* peer review process "diminishes the credibility" of this critique and insults "over 6000 members of the Soil Science Society of America who see *JEQ* as their premier journal for environmental issues."
- Litaor agrees that the exact chemical form of plutonium in the Rocky Flats soil is unknown; he cites other studies that support his conclusion that most is in oxide form.
- Regarding speciation, Litaor insists that knowing the chemical form of plutonium in transport is not necessary. "My main objectives . . . have been characterization and quantification of the physical processes that control Pu mobilization." Toward this end he designed and installed a "real-time in-situ remotely controlled monitoring system," and it was this system that observed the "unexpected phenomenon" of plutonium migration during the heavy rains of spring and summer 1995. Speciation studies done earlier provided nothing that accounts for what was actually observed in the storm. Studying plutonium in a beaker in a lab, as speciation specialists do, means "you merely study the beaker environment."
- Environmental technology he developed for Rocky Flats was excluded from the review.
- Litaor called for a new review on the full scope and merit of his team's work.

#### Concluding observations

<sup>5</sup>See LeRoy Moore et al, *Citizen's Guide to Rocky Flats* (Boulder: Rocky Mountain Peace Center, 1992), pp. 18-19.

<sup>6</sup>Litaor et al, "Plutonium-239 + 240 and Americium-241 in Soils East of Rocky Flats, Colorado," *J. Environ. Qual.* 23 (1994): 1231-1239; Litaor, "Uranium Isotopes Distribution in Soil at Rocky Flats, Colorado," *ibid.* 24 (1995): 314-323; Litaor, "Spatial Analysis of Plutonium-239 + 240 in Soils around Rocky Flats, Colorado," *ibid.* 24 (1995): 506-516; exchange, *ibid.*, 24 (1995): 1229-1231; Litaor et al, "Comprehensive Appraisal of <sup>239</sup> + <sup>240</sup> Pu in Soils around Rocky Flats, Colorado," *Health Physics* 69 (1995): 923-935; Litaor and L. Allen, "A Comprehensive Appraisal of <sup>241</sup>Am in Soils around Rocky Flats, Colorado," *ibid.* 71 (1996): 347-357; Litaor et al, "Fate and Transport. . ." (1996) [see note 4]; Litaor and S. A. Ibrahim, "Plutonium Association with Selected Solid Phases in Soils of Rocky Flats, Colorado, Using Sequential Extraction Technique," *J. Environ. Qual.* 25 (1996): 1144-1152; Litaor et al, "The Behavior of Radionuclides in the Soils of Rocky Flats, Colorado," *Journal of Environmental Radioactivity* 38 (1998): 17-46.

<sup>7</sup>"Technical and Peer Review" of M. Iggy Litaor's work by Bruce D. Honeyman et al (Subcontract No. KH 353044ED3), September 22, 1995. All quotations in this section are from this document.

<sup>8</sup>M. Iggy Litaor to Bruce D. Honeyman, November 1, 1995. All quotations in this section are from this letter.

- Litaor received no reply.
- The texts of the review and of Litaor's rebuttal were never shared with the public.
- Those who performed the review faulted Litaor for not doing what they would have done -- that is, study chemical speciation of plutonium.

#### Creation of the Actinide Migration Panel/Studies

Though Litaor was unable to complete his own research on migration of plutonium in the soil at Rocky Flats, he succeeded in getting this issue on the agenda of people concerned with cleanup of the Rocky Flats site. In June 1996 Rocky Flats management appointed an Actinide Migration Panel composed of Bruce D. Honeyman of the Colorado School of Mines, Peter Hans Santschi of Texas A&M University, plus David R. Janecky and David L. Clark, both of DOE's Los Alamos Lab. In October 1997 two new members, Jim Ball and D. Kirk Nordstrom, both of USGS, were added to the Panel's original four, and what once was called a Panel is now referred to variously as the Actinide Migration Studies or the Actinide Migration Investigation.

Subsequent sections of this paper will point to numerous problems with the Panel/Studies. For starters, the reader is invited to consider:

- No public participation went into the selection process or into designing what should be examined by the Actinide Migration Panel/Studies.
- The Kaiser-Hill manager who misled the Citizens Advisory Board about Litaor continues to supervise the Actinide Migration Panel/Studies.
- Conflicts of interest appear in that two DOE employees are on the Actinide Migration Panel and companies responsible for Rocky Flats cleanup are involved in the Studies.
- Two of the original Panel members, speciation specialists Honeyman and Clark, were involved in the review of Litaor's work mentioned above.
- The first act of the newly created Actinide Migration Panel was to review all available data regarding actinide migration. Part of this review was a two day meeting with Litaor.<sup>9</sup> Records of this meeting have been requested but to date have not been made available.

#### Confusion regarding the mission of the Actinide Migration Studies

- When first created, in the midst of the controversy surrounding Litaor's departure, members of the public had the impression that the mission of the Actinide Migration Panel was to critique Litaor's work. Though, as noted above, a critique of sorts had been done by a group that included two members of the new Panel, the results were not shared with the public.
- Later, it became clear that the Panel's mission was to review the current state of knowledge regarding radionuclides in the environment so as to advise Rocky Flats management on remediation of the site.
- By June 1997 the Panel was expected to develop an understanding of radionuclide mobility sufficient "to build a defensible conceptual model that may guide remedial activities for Site closure."<sup>10</sup>
- Now we are told the Studies will determine whether plutonium and other radionuclides can or cannot move off the Rocky Flats site in the future.
- At a March 4, 1998, meeting a greatly expanded plan for the study was outlined, even as it was made clear that other aspects of this complex task of analyzing actinide migration will be added later. It appears that the mission of the Actinide Migration Study is being continuously enlarged to respond to public concerns -- but without any direct public participation in the process, not to say public oversight.

#### Confusion regarding the timeline of the Studies

- When the Actinide Migration Panel was originally introduced to the public, it appeared that the Panel's work would be completed rather quickly.
- Now members of the RSAL Oversight Panel are told that the Actinide Migration Studies is a multi-year project and thus that definitive results from the investigation cannot be incorporated into an independent review of the RSALs. Meanwhile, everyone recognizes that definitive data on actinide migration is required for establishment of RSALs.

#### Dollar costs of the Actinide Migration Investigation

- One of the reasons cited for Litaor's dismissal was the necessity of cutting costs.
- In June 1997 Mr. John Rampe, then DOE manager for this work, told the author that Panel member Bruce Honeyman, was receiving \$100,000 per year for his work on this study.
- Costs for "General Actinide Migration Investigation" were recently revealed:
  - FY 1996: \$175,000 (all to subcontractors, that is, the Panel; the real cost exceeds the amount given, since amounts for on-site expenditures are not available)
  - FY 1997: \$200,000 (\$50,000 on-site; \$150,000 to subcontractors)

<sup>9</sup>Letter from Christine S. Dayton of Kaiser-Hill to LeRoy Moore, April 20, 1998 (98-RF-02025).

<sup>10</sup>"Proposed Path Forward for the Actinide Migration Studies" (June 1997), p. 2.

- FY 1998: \$750,000 (\$250,000 on-site; \$500,000 to subcontractors)
- FY 1999: \$750,000 (no breakdown has been provided)
- FY 2000: \$750,000 (no breakdown has been provided)

#### Physical transport versus chemical speciation

- Members of the original Actinide Migration Panel seemingly came to Rocky Flats with their own agenda, namely, researching chemical speciation of radionuclides -- that is, trying to determine the chemical processes that enable plutonium and other radionuclides to migrate. Believing that plutonium in soluble form migrates more readily than the same material in insoluble form, they wanted to discover the conditions under which plutonium might appear in soluble form.
- The Actinide Migration Panel set out to determine the  $K_d$  for actinides in the Rocky Flats soil.  $K_d$  is "simply the ratio of the activity [disintegrations per minute] concentration of an element in the [less mobile] particle phase to the corresponding activity concentration in the [more mobile] 'dissolved' phase."<sup>11</sup> An element with a low  $K_d$  will be more easily dissolved and transported in water; an element with a high  $K_d$  is more likely to be insoluble and thus not very mobile in water.
- The emphasis on chemical speciation points to what seems a crucial difference in approach between Litaor, who measured physical transport via erosion and near-surface throughflow, and the Actinide Migration Panel, which contends that a given radionuclide's movement depends on its chemical form in the environment. Based on his own speciation studies, Litaor estimated that 83 to 97% of the radionuclides that would migrate in water were in particle -- that is, solid -- form. He concluded that "the common use of  $K_d$  values in predicting the movement of radionuclides in the soil is questionable."<sup>12</sup>

#### Carelessness in presenting results

At a March 31, 1997, presentation Actinide Migration Panel spokesman Bruce Honeyman concluded: "All evidence suggests that 1 to 10 microcuries of Pu was transported from the 903 Pad hillside area to Pond C-2 in late spring 1995, not ca. 0.5 curie as has been suggested by Litaor." This statement is full of problems. First, Honeyman didn't really consider "all evidence," since, as he admitted, he based his own estimate not on samples but on running numbers through a standardized computer program. Second, using a standardized program is no way to test a hypothesis about plutonium migration that calls into question standardized approaches. Third, Litaor claimed only that plutonium moved in the spring 1995 rains, not that it moved all the way, per Honeyman, from the 903 Pad hillside to the C-2 holding pond. But the biggest problem with Honeyman's statement was the contrast he made between his and Litaor's estimates of the magnitude of plutonium migration. Consider:

- Honeyman was emphasizing to his audience the huge gap between his estimate of 1 to 10 microcuries having moved and Litaor's of 0.5 curie (a microcurie = 1/millionth of a curie).
- Litaor had previously stated: "On May 17, 1995, significant overland flow occurred that remobilized an unknown amount of Pu (estimated between 10 microcuries to 0.5 curie)."<sup>13</sup>
- There thus is a very large discrepancy between what Litaor is known to have said and what Mr. Honeyman alleges that he said. Either Litaor said different things at different times, which would discredit his work, or Honeyman misrepresented the conclusions of another scientist, which would reflect negatively on his work.
- To clear things up, on April 9, 1997, I wrote Mr. Honeyman asking him to document what he had said about Litaor. A conversation on May 1 led me to conclude that he had misrepresented Litaor. I nevertheless urged him to provide evidence to the contrary if he had it.
- What came was not the evidence I sought but a request from John Rampe of DOE that I send future queries meant for Bruce Honeyman or the Actinide Migration Panel not to them but to their supervisors, namely, himself or Chris Dayton of Kaiser-Hill. I told Mr. Rampe in a July 17, 1997, letter that I was happy to comply, but that it didn't please me "that Mr. Honeyman may be allowed to duck his responsibility to be forthcoming when he has been careless or untruthful in presenting information to the public. . . . How does he expect to gain the trust of people?"

#### Confusion regarding findings of the Investigation

- On August 20, 1997, Bruce Honeyman made a solo appearance to update the public on the Panel's findings. Emphasizing that his conclusions were preliminary, he said he was convinced that up to 90% of the plutonium in the Rocky Flats soil was chemically in organic form, the form in which it could most readily become soluble and thus be susceptible to transport.<sup>14</sup> He

<sup>11</sup>Bruce D. Honeyman and Peter H. Santschi, "A Conceptual Model of Pu Movement through RFETS Soils" (May 26, 1997; Document # CSM-3-97), p. 2.

<sup>12</sup>Litaor et al (1998): 44 [see note 6 for reference].

<sup>13</sup>M. Iggy Litaor, "The Hydrogeochemistry of Pu in Soils of Rocky Flats, Colorado: Summary," Public Presentation, Denver, May 15, 1996.

<sup>14</sup>The "Record of Meeting Notes, Actinide Migration Status Report, August 20, 1997," contains the following exchange, beginning with remarks addressed to Honeyman:

"• Earlier findings indicated that plutonium in the environment was in an insoluble state . . . , but now your data contradicts the earlier results and says that 90% of the plutonium is soluble.

• Honeyman: Yes, when you include plutonium with organic complexes, it can become very soluble, and under certain conditions the plutonium can become very mobile in that form.

• Does this preliminary finding mean that the plutonium is going to move offsite in the long-term?

was clearly excited, as if he thought he had found the mechanism by which substantive migration of plutonium in the soil at Rocky Flats could occur.<sup>15</sup> The great unknown, he said, is what initiates the mobility.

- Two months later, on October 28, Mr. Honeyman spoke again. This time he offered a totally different, more orthodox picture, one of plutonium's relative stability in the soil. This latter presentation coincided with the addition of new members to the Actinide Migration research team. That all six members of the team were in attendance led some from the public to speculate that Honeyman had been reined in. An alternate view is that on August 20 he had simply misinterpreted his results.

#### What about peer review?

- Aware of credibility problems, Kaiser-Hill appointed Prof. Greg Choppin of Florida State University to serve as outside peer reviewer for the Actinide Migration Panel -- a step taken again without any consultation with the affected public.
- A public meeting with Prof. Choppin occurred on November 19, 1997. In this meeting Prof. Choppin was asked whether in his view the Actinide Migration Panel would be able to assure the affected public that harm from offsite plutonium exposure could be minimized because plutonium migration could be prevented. Saying he couldn't really answer this question, he launched into a sermonette to the effect that the public need not be concerned since there is a threshold for radiation exposure below which harm does not occur. He thus simultaneously exposed his bias and revealed his ignorance of the large body of scientific literature which shows that very low-dose exposure may be more harmful per unit dose than higher-dose exposure.<sup>16</sup> He seemed completely unaware that he was discrediting himself with the very public whose trust he needs to win.
- To date, the work of the Actinide Migration research team has not been subjected to critical peer review by specialists outside their own self-selected inner circle. None of their findings have been published in professional peer reviewed journals.
- For Litaor's critique of the Panel's recent annual report see below.

#### What about soil sampling?

- Members of the Actinide Migration Panel are not taking their own soil samples, but use samples collected by Rocky Mountain Remediation Services, L.L.C. (RMRS), one of Kaiser-Hill's on-site corporate subcontractors.<sup>17</sup> The researchers, thus, do not control the material they analyze.
- A limited number of samples are taken and analyzed. The decision on the number of samples appears to be driven primarily by cost.<sup>18</sup>

• Honeyman: Yes, but additional work is needed to determine the rate of movement."

<sup>15</sup>Litaor and Ibrahim (1996) [see note 6 for reference] earlier estimated that up to 65% of plutonium in Rocky Flats soil is associated with organic matter. They did not think this guaranteed its mobility.

<sup>16</sup>For a concise statement, see the interview with Karl Z. Morgan, Director of Health Physics at DOE's Oak Ridge Lab for 29 years, in Robert Del Tredici, *At Work in the Fields of the Bomb* (N.Y.: Harper & Row, 1987), pp. 132-134. Dr. Rosalie Bertell of the International Institute of Concern for Public Health, Toronto, simultaneously criticizes the way standards for permissible exposure are set and provides a wealth of information on effects from low-dose exposure in "Limitations of the ICRP Recommendations for Worker and Public Protection from Ionizing Radiation," prepared for the European Parliament, Brussels, February 5, 1998 (a copy will be provided on request). See also Bertell, *No Immediate Danger* (Summertown, TN: Book Publishing Co., 1985); John W. Gofman, *Radiation & Human Health* (N.Y.: Pantheon, 1983); Gofman, *Radiation-Induced Cancer from Low-Dose Exposure* ( San Francisco: Committee for Nuclear Responsibility, 1990). One explanation for why harm from low-dose exposure may exceed that from higher doses was advanced by Canadian scientist Abram Petkau in 1972; see Petkau, "Effect of Na<sup>22</sup> on a Phospholipid Membrane," *Health Physics* 22 (1972): 239-244, and Ralph Graeb, *The Petkau Effect* (N.Y.: Four Walls Eight Windows, 1994), pp. 86-101. Other researchers important on this topic include Alice Stewart, Ernest J. Sternglass, Thomas F. Mancuso, and Edward A. Martell (whose soil samples east of Rocky Flats after the May 1969 fire first brought off-site radioactive contamination from Rocky Flats to the public's attention).

<sup>17</sup>RMRS is the name taken at Rocky Flats by a partnership between two companies, one of which is British Nuclear Fuels, Inc., a wholly-owned subsidiary of British Nuclear Fuels Limited (BNFL), a government-owned corporation created by the British government to operate Britain's military and civilian nuclear industry. BNFL, whose record of duplicity and damage is well documented, has never been subject to the public scrutiny and regulatory oversight to which DOE has had to adjust in the U.S.A. More an agency of a foreign government than a private corporation, BNFL is a major mover globally on behalf of a plutonium economy, with all the nuclear-proliferation dangers this entails. Its claim to experience in the realm of nuclear remediation stems from its "cleanup" of a large uranium enrichment plant at Capenhurst in England. My inquiries to BNFL as to whether there was any external regulation or independent review of the quality of the cleanup at Capenhurst went unanswered. Professor Anne Seller of the University of Kent in Canterbury made inquiries within Britain, only to learn that there's "no public record" of cleanup activities at Capenhurst. BNFL's presence at Rocky Flats in the form of a subsidiary was never subject to public review, though such a review was requested. The information in this note is from a fact sheet I prepared in December 1994 (a copy will be provided on request).

<sup>18</sup>Response to CDPHE Comments on Actinide Migration Documents, DCS-015-97 (August 5, 1997), p. 10.

Nevertheless, the Panel concludes, plutonium does move

- At a November 6, 1997, meeting and in their "Final Report" for FY 1997 (dated December 15, 1997), the Actinide Migration study team concluded that plutonium transport is primarily by physical processes, such as particle transport down-gradient, which is precisely what Litaor claimed to discover.
- The Actinide Migration researchers also conclude that dominance of plutonium in the organic form (16 to 80%) "suggests that it has the potential for mobility over a greater range of environmental conditions than perhaps anticipated."

Litaor's critique of the latest report from the Actinide Migration Panel

On December 15, 1997, the Actinide Migration Investigation researchers released a "Final Report" on their work for FY 1997. Iggy Litaor provided a critique,<sup>19</sup> to which the researchers responded.<sup>20</sup> Here are a few points from Litaor's critique and their response:

- The soil samples were not taken by the primary researchers but by a subcontractor, and the area from which the samples were taken was already "highly disturbed due to past RFP [Rocky Flats Plant] activities." In reply, those involved in the Actinide Migration Studies identify the RMRS person responsible for taking the samples and say the samples were not taken from a disturbed area. Litaor continues to strongly disagree.
- The sampling protocol described in the report is "haphazard," a point denied by the Actinide Migration Studies personnel. They do say that sample selection is limited by the budget.
- A fundamental flaw in their experimental design is "the implicit assumption that the entire soil matrix is wet," a situation rare in reality. "Hence, the  $K_d$  experimental protocol as described by this report has little merit in the real soil environment." Those criticized say their work plan for FY 1998 will address Litaor's concerns.
- "The authors assume that all flow [off the 903 Pad area] reached the [C-2] settling pond. This is far from the truth." An unknown amount of plutonium never reaches the pond but gets trapped in the South Interception Ditch (SID). Failure to account for this means the authors greatly underestimated the amount of plutonium transported over the years. Their study thus provides a poor foundation for calculating "the potential of plutonium remobilization during normal and/or extreme events." The Actinide Migration Panel accepts this criticism and says future work will deal with material trapped in the SID.
- The authors' admission that mechanical erosion plays a bigger part in plutonium transport than geochemical processes "points to an internal flaw in their argument for further geochemical work." In response, the authors insist on the necessity for more geochemical modeling.
- Their report "is riddled with citing inaccuracies," which they acknowledge.
- In general, Litaor's critique and the response made to it by the Actinide Migration Studies researchers (the foregoing barely touches the issues raised and responded to) show the value of mutual criticism and independent peer review.

Conflict of interest

- Two members of the original Actinide Migration Panel are from DOE's Los Alamos Lab. On March 4, 1998, it was revealed that more of the actinide migration research is being conducted at Los Alamos. This constitutes a basic conflict of interest in that a public whose trust has already been severely violated is being asked to trust DOE personnel to study a DOE site and to produce results that will gain public confidence.
- A second conflict of interest lies in the fact that Kaiser-Hill, the contractor principally responsible for cleanup of the Rocky Flats site, administers the Actinide Migration Studies, the results of which are crucial for determining cleanup. Consider:
  - Kaiser-Hill has shown itself inept at cleanup activity at Rocky Flats (e.g., it botched the relatively simple T-3/T-4 Trench and Mound projects).
  - Kaiser-Hill nevertheless says it intends to achieve a rapid cleanup and closure of Rocky Flats.
  - Kaiser Hill dismissed Iggy Litaor just as he made a discovery that flew in the face of its plans for rapid cleanup of Rocky Flats.
  - Kaiser-Hill selected those who would review Litaor's work, provided them with incomplete data, did not respond to Litaor's request for a new review, and never made the text of the review and of Litaor's rebuttal public.
  - Kaiser-Hill selected those doing the Actinide Migration Study as well as those expected to provide external review.
- A third basic conflict of interest occurs in that RMRS, one of Kaiser-Hill's corporate subcontractors for the cleanup at Rocky Flats, is integrally involved in the actinide migration research. As indicated above, their provision of soil samples means that the Actinide Migration Panel members do not control their own samples. This violates a fundamental principle of independent research.
- A fourth conflict of interest is that two of the original members of the Actinide Migration Panel, Messrs. Honeyman and Clark, participated in the questionable review of Litaor's work. That they neither dissociated themselves from a review based on incomplete data nor called for a second review based on full data seems professionally questionable at best. To have them

<sup>19</sup>M. Iggy Litaor to LeRoy Moore, letter and attachments, dated January 11, 1998 (a copy will be provided on request). All quotations in this section of the text are from this letter.

<sup>20</sup>"Actinide Migration Studies Response to Comment Letter from Dr. M. Iggy Litaor of Tel-Hai College, Upper Galilee, Israel," dated January 11, 1998 (no date on the response document). All references in this section to responses to Litaor's critique are from this document.

replace the person they criticized compounds conflicts of interest and undermines the possibility for public trust. In addition, Mr. Honeyman has never explained why he misrepresented the work of Litaor in a public presentation.

#### Public participation

Public participation to date has been limited to spectator activities of attending public meetings and commenting on what is presented by "experts" chosen with no input from those affected by actinide migration.

#### Conclusion

The essential question remains: To what extent might plutonium in the soil at Rocky Flats migrate? What happened with this material in the spring and summer of 1995? How much moved and how rapidly? Under what conditions can this happen again? The affected public, including the Rocky Flats RSAL Oversight Panel, requires a clear, convincing response from researchers who inspire public trust.

Given the controversy surrounding this matter, and given the significance of the issue for all plutonium-contaminated sites as well as its special relevance to review of the Rocky Flats RSALs, DOE should place the Rocky Flats Actinide Migration Study under the purview of an appropriate citizen oversight body charged with reviewing the mission of the Actinide Migration Study and overseeing future work in this area through to completion. The goal of this review and oversight is to ensure that the Actinide Migration Study gains public confidence by producing credible results. This may entail combining chemical speciation study with the unfinished physical-movement study begun by Iggy Litaor. This study should include personnel able to work closely with Litaor to assess his findings and to see that the work he began is carried to conclusion by someone able to gain public trust. As for what entity should perform this oversight function, perhaps the most appropriate body is the Radionuclide Soil Action Level Oversight Panel -- provided this Panel is willing to assume this role.

Short of a move like the one here recommended, not only will we all remain ignorant about plutonium migration, but distrust will prevail, and the agencies responsible for cleanup of Rocky Flats will lack the support they need to develop the RSALs required for site cleanup.

APPENDIX: The Sham Review of Litaor's Work  
by LeRoy Moore (March 27, 1998)

Re: "Technical and Peer Review" of M. Iggy Litaor's work by Bruce D. Honeyman et al  
(Subcontract No. KH353044ED3), September 22, 1995, 33 pages.  
Litaor's reply in a letter addressed to Bruce D. Honeyman, November 1, 1995, 6 pages.

This appendix is based on information that came into my hands after the foregoing paper had been written and circulated. The paper says (page 4) that if a critique of Litaor's work was produced by members of the Actinide Migration Panel it had not been shared with the public. In fact, the above-referenced critique was produced and Litaor wrote a reply. The following summarizes these documents, then concludes with comments and questions.

Critique of Litaor's work: The above-noted review was prepared by Bruce Honeyman of Colorado School of Mines [technical lead] and David L. Clark, Edward H. Essington, Wayne R. Hansen, and Brian P. Wilcox of the Los Alamos Lab. They fault Litaor chiefly as follows:

- "Most egregious was the failure to address the question of the chemical form, i.e., speciation, of plutonium in the environment." This criticism gets stated repeatedly.
- Litaor and his team worked in isolation from other knowledgeable researchers.
- The peer review provided by the *Journal of Environmental Quality* where some of Litaor's findings had been published is "insufficient," since "it is an applied research journal with typically a less stringent review process" than required elsewhere.
- Litaor was too preoccupied with sampling soils so as to determine actinide distribution.
- The Los Alamos group says the chemical form of plutonium in the Rocky Flats soil is unknown, while Litaor operates on the assumption that most of it is in oxide form.

Litaor's response: The following summarizes some of Litaor's rebuttal of the review:

- Litaor's work was terminated on June 16, 1995 (he found plutonium migration in May 1995). The review of his work "was initiated due to a public outcry" over his dismissal.
- Litaor was not asked to provide data for the review. Kaiser-Hill supplied the reviewers "with a terribly incomplete list of publications and reports." Omitted were "the [four] governing documents" that dictated the scope of his work, as well as thirteen other items.
- Litaor "closely collaborated with several scientists across the country" (he shows how).
- For the reviewers to demean the review process of the *Journal of Environmental Quality* "diminishes the credibility of your review" and insults "6000 members of the Soil Science Society of America who see *JEQ* as their premier journal for environmental issues."
- Litaor agrees that the exact chemical form of plutonium in the Rocky Flats soil is unknown, but he cites other studies that support his conclusion that most is in oxide form.
- Regarding speciation, Litaor says knowing the chemical form of plutonium in transport is not necessary. "My main objectives . . . have been characterization and quantification of the physical processes that control Pu mobilization." Toward this end he designed and installed a "real-time in-situ remotely controlled monitoring system," and it was this system that observed the "unexpected phenomenon" of plutonium migration during the heavy rains of spring and summer 1995. Speciation studies done prior to this storm event provided nothing that accounts for what actually happened. Studying plutonium and other chemicals in a beaker in a lab means "you merely study the beaker environment."
- Environmental technology developed by Litaor was excluded from the review.
- Litaor concludes that "a new review is required." He offers to help Kaiser-Hill provide "a detailed dossier," so the full scope and merit of his team's work can be ascertained.

Conclusion

- Litaor received no reply to his rebuttal of the review; no new review was initiated.
- Who at Kaiser-Hill commissioned the review and gave incomplete data to the reviewers?
- What is the responsibility of reviewers when they learn that they have produced an evaluation based on incomplete information? Do they have an obligation to call for a new review, so they will not have participated in a professionally questionable process?
- What is DOE's responsibility in a situation like this?

The issue of actinide migration lies at the heart of cleanup of Rocky Flats. Why? Because plutonium-239, the material of greatest concern at Rocky Flats, remains radioactive for 240,000 years, and because inhaling or ingesting a minuscule particle of this alpha-emitting material may result in cancer, genetic aberration, or damage to the immune system. People aware of these potentially adverse health effects don't want plutonium in their environment. Yet this material is already present in substantial amounts in the soil at Rocky Flats. The quantity is likely to increase when contaminated buildings are taken down. If plutonium and other radionuclides in the Rocky Flats soil migrate substantially, then sooner or later they are likely to end up in the environment of people downstream and downwind of the facility -- and all residents of the Denver metro area are downwind of Rocky Flats some of the time.

Iggy Litaor, at the time an adjunct professor at the University of Colorado working under contract at Rocky Flats, created quite a sensation when he claimed to discover significant unexpected migration of plutonium in the soil at Rocky Flats during the heavy rains of spring and summer, 1995. His finding, he said, "challenges the framework of the suggested accelerated cleanup for Rocky Flats." Litaor's contract was soon terminated, and resolving the issue that he had raised so forcefully was turned over to a newly constituted Actinide Migration Panel -- their work now part of a large project called the Actinide Migration Studies. Meanwhile, in 1997 water samples taken where Walnut Creek exits the Rocky Flats site showed actinide activities higher than the legally permitted standard of 0.15 picocuries per liter.

To what extent might plutonium in the soil at Rocky Flats migrate? A definitive, publicly credible answer to this question is crucial for the task of setting cleanup levels for the site. By all rights, the Actinide Migration Studies currently underway should produce precisely the sort of convincing answer the public requires. Unfortunately, as the following account demonstrates, the approach of the Actinide Migration Studies is badly flawed, so much so that any answer from this source almost certainly will lack convincing credibility.

The question of plutonium migration relates directly to the Radionuclide Soil Action Levels (RSALs) for Rocky Flats, since the latter specify how much plutonium and other radioactive material may remain in the soil at the site after cleanup. In 1996 DOE, EPA, and CDPHE proposed RSALs for Rocky Flats that would allow significant amounts of plutonium and other radionuclides to remain in the Rocky Flats soil. This proposal was opposed almost universally by members of the public who commented on the issue. Besides, broadly representative citizen bodies had already made it clear that they wanted a site much cleaner than what the agencies were proposing. In June 1995 the Rocky Flats Future Site Use Working Group, an ad hoc body convened to advise DOE, made a consensus recommendation that the site be cleaned to average background radiation level when it becomes technologically and economically possible to do this in an environmentally sensitive manner. The Rocky Flats Citizens Advisory Board soon thereafter made the same recommendation.

In October 1996 DOE and its regulators nevertheless adopted as "interim" standards the Rocky Flats RSALs they had all along proposed. These RSALs, which currently govern cleanup of the site, allow in the Rocky Flats buffer zone the equivalent of up to 1429 picocuries of plutonium-239/240 per gram of soil, which is 37,605 times average background level for plutonium of 0.038 picocuries per gram of soil. The site's industrial zone can contain the equivalent of up to 1088 picocuries of plutonium-239/240, or 28,632 times average background level.

Within a few months after adoption of these RSALs public interest groups, local governments, and the Rocky Flats Citizens Advisory Board called for an independent review of both the dose and calculation aspects of the new RSALs. Rep. David Skaggs asked for a review of the calculation aspect. (The dose part specifies a level of radiation exposure deemed acceptable by DOE and its regulators; the calculations purport to show how much radioactive material may remain in the soil without exceeding this dose.) DOE eventually agreed to an independent review of the calculation side of the equation only. Accordingly, in January 1998 the Rocky Flats Radionuclide Soil Action Level Oversight Panel was formed to oversee this review.

If substantive movement of radionuclides in the soil can occur, the quantities allowed under the RSALs adopted in October 1996 will need to be greatly reduced. Otherwise, people downstream and downwind of Rocky Flats face a long history of potential exposure to plutonium particles with all the attendant negative health effects. It thus is essential to learn the truth about actinide migration.

One of the most disturbing events in the recent history of Rocky Flats was the dismissal of Iggy Litaor after he claimed to discover substantial migration of plutonium in the soil at Rocky Flats during the wet spring and summer of 1995. His finding, which was based on real-time measurements taken on the site in the midst of a rain storm, countered the received wisdom that plutonium, once deposited in the soil, remains more or less immobile -- a conclusion supported by his own previous work. As noted earlier, his discovery flew in the face of DOE and Kaiser-Hill's plans for a quick "cleanup" and early closure of the Rocky Flats site. The significance of his finding, however, extends far beyond Rocky Flats. If true, it is of signal importance to all who live or work around plutonium-contaminated sites anywhere.

How can we get the truth of what happened with the plutonium in the Rocky Flats soil in the 1995 rains and therefore of what might happen again here or elsewhere? We can't now get it from Litaor, since soon after his discovery of plutonium migration Kaiser-Hill terminated his contract.

Iggy Litaor's association with Rocky Flats began when EG&G, former operator of the Rocky Flats facility, contracted Litaor to map plutonium deposits around the Rocky Flats site. It surprised some of these people to hear from Litaor that he could find no well-defined plume, only scattered deposits and hot spots. If true, this was good news to Rocky Flats management as well as to all who live or work around the site, for it indicated possibly less contamination than some had feared. Litaor made

a convincing case for the veracity of his data. It helped that he published his findings in peer-reviewed journals. He rather quickly established a credibility with the public that is exceedingly rare for a scientist in the hire of Rocky Flats. His dismissal on the occasion of making a discovery that was bad news to Rocky Flats management therefore severely hurt relations with the affected public.