INTEGRATION PROJECT EXPERT PANEL

Closeout Report for Panel Meeting Held

January 26 - 28, 2000

Prepared by the Integration Project Expert Panel

Panel Members:

Prof. R. L. Bassett
Dr. Edgar Berkey, Chairman
Dr. John G. Conaway
Prof. James R. Karr
Dr. Michael C. Kavanaugh, Vice-Chairman
Dr. John Matuszek
Mr. Ralph O. Patt
Dr. Peter J. Wierenga

Prepared for

U.S. Department of Energy
Bechtel Hanford, Inc.

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Executive Summary

This closeout report presents information from the full Integration Project Expert Panel (IPEP) meeting held at Hanford from January 26-28, 2000, as well as information reviewed before and after the meeting, including discussions among individual IPEP members. A full consensus was attained by the members of the IPEP on the scope and contents in all but a few instances. Thus, the report is careful to indicate areas having only the support of "some" or "most" of the Panel members.

Positive indications

It is the general view of most IPEP members that the Integration Project (IP) is now headed in a reasonable direction and is making progress toward the goal of being able to conduct a comprehensive impact assessment. At the January meeting, progress was evident in several areas, especially the System Assessment Capability (SAC), which finally has a draft plan that is effective in communicating the team's current plan and allowing reasoned discussion of the options. The SAC team is now embarked on what seems to be a generally defensible, if not optimal course. Optimization of that course will only be approached when the IP as a whole uses decision engineering tools (e.g., critical path analyses, cost-benefit analyses) to improve project planning. The large uncertainty that is likely to be present in the SAC outputs for some time is no reason not to proceed, in our view. A comprehensive impact assessment is needed at Hanford and the current plans for the SAC are heading in a reasonable direction to accomplish that.

The work performed by the S&T team to date has generally been well done. In the recent EMSP awards, the list of projects related to Hanford's needs is impressive, although it will be some time before it will be possible to assess whether these projects live up to their initial promise. IPEP members liked the efforts being made to connect potential users of S&T products from the EMSP with the scientists performing the development work through Scientist-User Coordination Teams. Establishing the Coordination Teams before the EMSP milestones are finalized might greatly improve the immediate utility of the research without adversely affecting the quality of the science, resulting in a more rapid return on investment.

The Vadose Zone Field Study currently being planned is an important activity and we support it. We applaud the fact that the draft study is the product of a number of scientists representing organizations both at Hanford and elsewhere, under the leadership of scientists from three different DOE national labs. The draft study plan supplies little detail on how the test volume will be evaluated during the study; a more robust and detailed discussion of the scientific and technical issues is needed before the plan is executed.

The Groundwater Modeling Expert Panel (GMEP) provides a case study in effective peer review processes that should be emulated in other important technical areas. The GMEP is composed of experts from outside Hanford, their recommendations have been penetrating, comprehensive, and frank. The relevant Core Project (Groundwater Monitoring) and the IP are responding constructively to those recommendations.

Based on the work reported to the IPEP regarding the 200 Area ER remedial action, this effort appears to be progressing in a competent, professional manner. FY99 products show effective approaches toward obtaining useful, quantitative characterization data in support of ER remedial decisions. Although not all data have been processed, the data quality appears sufficient for the purposes intended.

IPEP concerns

It is the view of most IPEP members that the rate of progress towards a comprehensive impact assessment is now dominated by factors over which the IP has little control. These factors include such potential barriers to progress as:

- *Generally accepted end states for cleanup at Hanford are lacking, including site use assumptions and compliance boundaries*.
- *The important decisions that must be supported by the IP have not been defined clearly.*
- *Budgets are inadequate and uncertain.*
- *The IP is (as of this writing) operating without a permanent DOE project manager.*
- *The chain of command for the Hanford River Protection Project lies entirely outside of Hanford control.*

The IP must do a better job of identifying such barriers to progress and proposing appropriate solutions. Similarly, higher level DOE management must address such barriers if the IP is to move forward efficiently.

In addition to the barriers that are not under IP control, the IP has had several persistent problems that are at least partly under their control, including:

- *There continues to be a lack of rigor in much IP planning including, for example, a lack of cost-benefit studies and critical path analyses.*
- *Progress towards development of a plan for the SAC has been (at least until recently) slow and seemingly undirected.* The IP cannot afford multiple false starts on major project activities as was the case with the SAC.
- *It appears that no one involved in SAC planning has begun the process of assessing the chain of uncertainties from source term to the various impacts on human health, ecological health, and culture*.
- *The IP still lacks a robust, coordinated, multi-layered peer review system.*

Most IPEP members believe some of the continuing problems in the IP indicate a need for improvement in IP management.

The IPEP is concerned about the apparent shift (including both DOE/RL and the RPP) away from adequately characterizing important source terms and the properties of the vadose zone; characterization efforts have been reduced substantially from those planned as recently as 1998. In our view, the current rate of progress of characterizing the vadose zone, one or two boreholes per year, will not produce a reasonable level of understanding in the time frame currently specified under the TPA. Thus, the critical path to a comprehensive impact assessment may lie, not in the SAC, but in characterization.

This trend away from adequate characterization comes at the same time that stunning discoveries are being made, including high concentrations of ^{99}Tc found in a groundwater well, high concentrations of tritium and gross-beta activity found in another, and ^{137}Cs, formerly thought to be essentially immobile in soil, found much deeper in the vadose zone than predicted. If the decision is made to continue the trend away from a minimum credible level of characterization, it should be made with the full realization that it is not supported by a scientific understanding of the issues.

The IPEP is concerned about the "mass balance" approach to estimating inventory, which has an unimpressive record dating back at least to the1985 review by the National Academy of Sciences/National Research Council of a mass balance model, TRAC, for estimating in-tank inventories. Analyses of tank cores failed to match the predictions from TRAC for the principal radionuclides. The IP is proposing to estimate the inventory of leaked waste using a mass balance model that appears to be much like TRAC, at least conceptually, in spite of the fact that estimates of inventories in the vadose zone are even less tractable than estimates of in-tank waste. This approach may be based more on expediency than merit.

Although the regional groundwater modeling performed to date has considered transport of chemicals, radioactive solutes, and tritium, this effort has not addressed reactive transport adequately. Capabilities for simulating complexation or colloid formation and more robust adsorption models than K_d will be required in the groundwater modeling effort, as well as in vadose zone simulations.

A list of IPEP concerns is given in Section 4 of this report. The following brief summary of formal IPEP recommendations is for the reader's convenience. The full text of the recommendations in Section 5 of this report should be consulted for clarity.

Summary of IPEP recommendations given in this report.

1. Higher level DOE managers must address the problem of barriers to IP progress that are not under IP control. Similarly, the IP must do a better job of identifying and proposing solutions to such barriers.
2. The RPP should commit to at least a minimum credible characterization plan along the lines of the one put forward by TWRS in 1998.
3. The IP must bring more rigor to the planning process.
4. A substantial, long-term commitment to development in support of remediation is needed using a private-sector approach of cost-benefit and return on investment assessments of the options.
5. The vacant post of DOE IP Manager needs to be filled quickly, on a permanent basis. The new project leader must be given the mandate to help develop solutions to high-level barriers to progress over which the IP currently has no control.

6. The SAC team should develop a draft compilation of all known sources of uncertainty and begin the process of determining how these uncertainties interact.
7. A vadose zone monitoring program should be undertaken, included calibrated gamma-ray logging and calibrated neutron moisture logging, along with other techniques, such as temperature logging, as appropriate.
8. The cooperative work among the IP and Core Projects, particularly the RPP, should be strengthened.
9. The IP should take steps to moderate expectations for the SAC and place this activity in realistic perspective with similar modeling at other sites where long-term containment is a contentious issue.

1 Introduction

The sixth meeting of the Hanford Integration Project Expert Panel (IPEP) was held from January 26 through 28, 2000. While the mandate of the IPEP relates mainly to the Integration Project (IP), the IP is intricately interwoven with various Core Projects and works entirely within constraints and budgets imposed by Hanford site management and, more indirectly, by DOE/HQ and Congress. As noted in the February 2000 Semi-Annual Report of the GW/VZ , the IPEP "provides broad oversight and feedback on all facets of the IP." While this report discusses issues mostly as they affect the IP, it is important that the reader keep this broader context in mind.

In addition to overview presentations and discussions regarding the overall status of the IP during the January meeting, we concentrated on selected topics in four areas:

- Science & Technology program
- System Assessment Capability
- Modeling and Transport
- Subsurface Investigations

IPEP members interacted with IP presenters before the meeting to explain what we wanted to learn in each of these specialized areas (the list of discussion points supplied before the meeting is given in Appendix A). Generally, IPEP members felt this approach to developing the agenda was an improvement from earlier meetings, and we will build on this improved protocol in the future. Each of these specialized areas is discussed in separate sections of this report.

The contents of this closeout report are somewhat longer and different from those of previous reports. Its contents are based not only on information developed from the January meeting, but also on information reviewed prior to and after the meeting. In addition, following the meeting, the IPEP engaged in a series of e-mail discussions and one conference call about the closeout report. A full consensus was attained by the members of the IPEP on the scope and contents in all but a few instances. Thus, the report is careful to indicate areas having only the support of "some" or "most" of the Panel members.

In addition, this report contains more extensive technical discussions in topic areas related to the specialized sessions held at the meeting which go well beyond what has been fully discussed by the IPEP as a whole. The write-ups for the closeout report were prepared by individual members of the IPEP having expertise in the area and are included for use by the Project. They do not necessarily represent a consensus view.

At the January meeting, progress was evident to the IPEP in several areas, especially the System Assessment Capability (SAC), which finally has a plan that is sufficiently coherent to discuss. With the arrival of the SAC plan, several major technical elements of the IP, as currently envisioned, have been documented in some detail. Thus, we are now in a position to make assessments, not only of individual major technical elements, but also of the overall IP taken in the context of the Hanford site remediation effort as a whole.

In this report, we consider the overarching issues first and then discuss the results of our sessions dealing with individual technical elements. This is followed by sections on IPEP Concerns and Recommendations and several Appendices.

Appendix B of this report presents IPEP responses to the concerns about the IP and the IPEP raised by the Washington Department of Ecology at the January meeting. Appendix C presents a proposed approach supported by most IPEP members on improving IPEP functionality, while Appendix D presents a preliminary list of topics for future IPEP meetings.

2 Is the IP "headed in the right direction and picking up momentum?"

At the January meeting, Hanford Site Manager Keith Klein said the IP "still has an academic feel to it" and asked the IPEP for a "straight assessment" as to whether the IP is "headed in the right direction and picking up momentum." It is the consensus view of the IPEP that the IP is now headed in a reasonable direction for the most part and is making progress. *Our best collective judgement is that the rate of progress of the IP toward the capability of providing a comprehensive impact assessment is now dominated by factors over which the IP has little control.*

At the January meeting, one regulator commented that "the Integration Project moves at the speed of a geologic process." This is one of several indications IPEP members have observed that at least some members of the stakeholder and Tribal Nation communities are becoming increasingly frustrated with the IP and the IPEP. IPEP members share this concern with the sometimes slow and uncertain progress in some areas of the IP (as elaborated in this and earlier IPEP reports).

Still, it seems to be generally agreed that most, if not all, of the various technical elements that comprise the IP are needed at Hanford in some form or other. Further, a great deal has already been invested in the IP, in terms of money, effort, time, and the expectations of the stakeholders. We believe the IP *can* achieve its goals given a) adequate financial and institutional support at all levels, b) effective leadership, and c) comprehensive and thorough oversight. However, we are not yet *confident* this will happen, because of significant barriers to success of the IP, as discussed in the next section.

In the section below, we present discussions of high-level barriers to success of the IP, persistent problems inside the IP, and the limited characterization effort. This is followed in the next section by a discussion of the status and rate of progress in specific IP technical elements.

2.1 Barriers to success of the Integration Project

It is important to note that, of the various barriers to progress faced by the IP, several important ones lie outside the control of project management, including:

- *Generally accepted end states for cleanup at Hanford are lacking, including site use assumptions and compliance boundaries.*

Site Manager Keith Klein made it clear in his remarks during the opening session of the January meeting that he is well aware of this problem and is trying to find ways to resolve it. However, it will presumably not be resolved quickly and it includes factors outside of DOE control such as potential disagreement among stakeholders, regulators, and Tribal Nations on some key issues. This will likely remain an impediment to IP progress for some time so creative ways must be sought to work within these restrictions and minimize their deleterious effects.

- *Important decisions that must be supported by the IP have not been defined clearly.*

  While the IP has been criticized for failing to identify these decisions, it is not clear they have been given the unambiguous mandate and necessary resources to do so. At the January IPEP meeting, Hanford Site Manager Keith Klein indicated that, in his view, the biggest challenge for the IP, something it needs to better focus its work, is strategic planning that clearly identifies key decisions and how the IP fits into that framework. His recognition of that need is a start toward resolving this issue. While the process of identifying the important decisions for the site extends well beyond the scope of the IP, it might be appropriate to assign the IP the lead role in laying out the framework and parameters necessary for decision making at Hanford, in coordination with DOE/RL and RPP managers. Whatever role is assigned the IP, the DOE/RL Site and RPP managers bear ultimate responsibility for formulating and defining the key decisions they envision will lead to successful remediation of the Hanford site.

- *The chain of command for the Hanford River Protection Project lies entirely outside of the Hanford Site Manager's control.*

  While we believe we understand at least part of the reason for this, it appears that the removal of responsibility for the tank farms from the DOE/RL site manager's control (however well intentioned) essentially eliminates the best chance for integrating activities. The resulting diffusion of responsibility and redundancy of operations is likely to reduce efficiency and increase costs, while gaps in responsibility between the entirely separate chains of command involved present a real danger of causing major problems over time. For the IP this issue does not seem to have been a major problem to date because of voluntary cooperation of the parties involved, but clearly it has the potential to become a major problem until individual and organizational responsibilities and authorities are defined appropriately in the RPP, Hanford Site management, and the IP.

- *The IP is (as of this writing) operating without a permanent DOE project manager.*

  This vacancy must be filled quickly with someone who is well qualified to provide the needed leadership and enjoys credibility with the stakeholders.

In addition to these barriers to progress, two other possible barriers should be noted. First, regulatory requirements could potentially be inconsistent with optimal progress in certain cases. Even requirements that make perfect sense when they are imposed or agreed upon can become persistent obstacles to efficient progress as conditions change. Sometimes regulatory deadlines, though selected with the best available knowledge at the time, may turn out not to be the best way to accomplish the overarching TPA goals as opposed to the detailed milestones. Secondly, some IPEP members are concerned that budgets may be inadequate and uncertain, including inadequate sustained development funding for developing or refining technologies that could potentially save a great deal of money over the coming years. Recent Hanford budgets have not even been adequate to satisfy all of the numerous existing legal obligations for meeting specific cleanup deadlines, the highest priority activities. Until recently, IP plans have not been concrete enough for us to assess the adequacy of budgets in the IP and related core projects, but we intend to consider this subject in the near future.

Higher level DOE managers must address the problem of barriers to IP progress that are not under IP control. Similarly, the IP must do a better job of identifying and proposing solutions to such barriers.

2.2 Persistent problems in the Integration Project

In addition to the barriers that are not under IP control, the IP has had persistent problems that are at least partly under their control, including the following:

- *There continues to be a lack of rigor in much IP planning.*

  We have commented on this lack of rigor previously, and it still seems to permeate the major technical elements of the IP. Where are the cost-benefit studies, the critical path analyses, that lend credibility and reliability to this type of planning?

- *Progress towards development of a plan for the SAC has been (at least until recently) slow and seemingly undirected.*

  The IP cannot afford multiple false starts on major project activities as was the case with the SAC.

- *It appears that no one involved in SAC planning has begun the process of assessing the chain of uncertainties from source term to the various impacts on human health, ecological health, and culture*.

  We do not see how meaningful progress can be made in selecting simulation models and defining data needs until this is done.

- *The IP still lacks a robust, coordinated, multi-layered peer review system.*

  We have seen no sign of progress in this area, which was identified by Under Secretary Moniz as highly important, since the Peer Review Processes Subpanel meeting roughly one year ago.

In addition to these persistent problems, some administrative roadblocks to IPEP effectiveness remain after some 18 months of IPEP operation, including inadequate lead time for preparation before meetings, although IP managers have readily agreed to fix these problems.

Because of the problems listed above and in earlier IPEP reports, most IPEP members believe there is a need for improvement in IP management. The argument can be made that some of these deficiencies are less a problem with IP management than a manifestation of the environment in which the IP operates, including possibly inadequate budgets and barriers to progress that are not under IP control. To be successful in this environment, IP managers will need to communicate clearly the adverse effects of such external constraints.

Furthermore, in any given project, there tends to be a tradeoff among (1) quality of outcome, (2) time, and (3) cost. Considering the broad scope and responsibility of the IP, it is proceeding on a modest budget (i.e. low cost), so quality or time (or both) must necessarily be adversely affected. We have not seen any discussion of the tradeoffs that are being made among quality, time and cost. Although some IPEP members feel there has been progress in leadership by IP management since inception of the project, continued improvements are needed to meet the demands of this complex project.

2.3 A retreat from characterization

The IPEP is concerned about the apparent shift (including both DOE/RL and the RPP) away from adequately characterizing important source terms and the properties of the vadose zone; characterization efforts have been reduced substantially from those planned as recently as 1998 (DOE, 1998b). This trend comes at the same time that stunning discoveries are being made such as the following examples.

- ^{99}Tc has been found in a groundwater well at 38 times the federal maximum contaminant level, or MCL, for drinking water.
- ^{3}H (tritium) has been found in water in another well at 400 times the MCL (8 million pCi/L) and only 3.6 miles from the Columbia River. Perhaps of even greater concern, depending on which radionuclides are found to be present in ongoing analyses, is the gross-beta screening value of 4-million pCi/L found in a follow-up sample from the same well (nearly 270,000 times the level requiring that a determination of man-made radionuclides be made).
- ^{137}Cs, a radionuclide formerly thought to be essentially immobile in soil, has been shown to have been transported much deeper into the vadose zone under and near some tanks than predicted.

If the decision is made to continue the trend away from a minimum credible level of characterization, it should be made with the full realization that it is not supported by a scientific understanding of the issues.

While it is clear that the Hanford vadose zone will not and cannot be fully characterized in the foreseeable future, an optimal balance must be struck between obtaining important information and economy. In the absence of characterization information, there has sometimes been a tendency at Hanford to assume “average” or “typical” conditions. However, the subsurface (as one example) is not composed entirely of average or typical conditions. It is the conditions that are two or more standard deviations off the mean that will invalidate this generalized approach, with potentially serious consequences. In considering flow and contaminant transport through the vadose zone, heterogeneity and other atypical conditions can sometimes dominate the transport regime, a fact that must always be carefully considered in modeling work at Hanford (e.g., VZEP, 1997).

The TPA milestone for completion of characterization currently lies in 2008. In our view, the current rate of progress of characterizing the vadose zone, one or two boreholes per year, will not produce a reasonable level of understanding in that time frame. At the Vadose Zone Expert Panel (VZEP) meeting of June 23 – 25 1998 (VZEP, 1999), scientists from Lockheed-Martin put forward a tank farm characterization plan, released later that year (DOE, 1998b), that was science-based and appeared to be a reasonable minimum-credible plan (some may argue that minimum-credible is still insufficient). The Tank Waste Remediation Systems (TWRS, now RPP) characterization plan was based on the reasonable premise that “TWRS cleanup decisions are dependent on understanding contaminant migration in the vadose zone,” and included drilling some 25 boreholes, 17 of those over the five year period beginning FY99, with budgets for those five years of $11.6M, $12.9M, $8.0M, $10.7M, and $10.2M, respectively (DOE, 1998b). The remaining eight boreholes were to be emplaced during the two to three years following (through FY06). A set of selection criteria was assembled in tabular form that allowed the borehole locations and the sampling goals to be developed in a technically defensible manner, resulting in a plan for an “initial campaign” to study eight past leak locations in seven tank farms.

The TWRS vadose zone plan presented to the VZEP in 1998 was “focused on the next two years.” We are now nearing the end of that two year time frame and have seen only one new borehole, some sampling during decommissioning of an earlier (1997) drywell, and plans for a second new borehole during FY2000. The data and insights from the borehole and driven casing are of major value, leading to a number of surprising observations, underscoring the importance of committing to a minimum-credible characterization program.

The IPEP is concerned about statements made by the IP Manager at the January meeting that there is no intention to drill in every tank farm, that it is probably not necessary, and that at one million dollars per borehole, it is too expensive. We have seen no objective data or rigorous planning to support such a decision, and we plan to review this issue. We understand that characterization is costly, but the costs of mistakes in remediation decisions are potentially far greater.

2.4 Integration under the auspices of the IP

The IP has been successful thus far in developing an unusually high degree (for Hanford) of interaction and cooperation with other projects. So far, this seems to have been largely dependent on the good will of the individuals involved. Integration would be more robust if all parties involved were assigned unambiguous responsibility, and delegated adequate authority, to formalize this cooperative interaction. The assignment of unambiguous responsibility for contributing to the success of this effort must extend to all relevant DOE and contractor managers.

The formal name of the IP is the *Groundwater/Vadose Zone Integration Project*, but integration needs to go well beyond activities related to those two geologic regions. We note that Site Manager Keith Klein initiated a reorganization intended to increase efficiency of operations and reduce stovepiping. His appointment of an expert in tank farms operations, Harry Boston, as Deputy Site Manager, should aid coordination with the River Protection Project, which has responsibility for tank farms remediation. Similarly, his appointment of Wade Ballard to encourage integration on a site-wide basis should be a positive step. We hope that these recent initiatives at the site management level set the stage for major advances in integration and operational efficiency at Hanford.

3 Status and progress in the IP technical elements

3.1 System Assessment Capability

3.1.1 Status

After a slow start that consumed a great deal of time, there now exists a reasonably robust draft plan for the development of the SAC (DOE, 1999a). The draft SAC document is effective in communicating the thinking of the SAC team at this stage and allowing reasoned discussion of the options. They are now embarked on what seems to be a generally defensible, if not optimal course. Optimization of that course will only be approached when the IP as a whole uses decision engineering tools (e.g., critical path analyses, cost-benefit analyses) to improve their planning.

The SAC plan has been criticized by some because, according to the plan, the SAC will not be in a position to support site-wide decisions until the release of Rev. 1 in the third quarter of FY02. Now that we have seen the draft plan for the SAC, we are concerned that expectations for Rev. 1 may be too high. If the SAC team ***today*** had perfect computer programs to simulate flow and transport through the vadose zone and groundwater, they could only run hypothetical, idealized simulations and in general could contribute little to important decisions because of the current lack of reliable empirical information and understanding of the contaminant inventories (source terms) and subsurface conditions affecting flow and transport of contaminants.

The IPEP has previously recommended (but has not yet seen) critical path analyses of IP plans and schedules and how those fit in with the broader picture at Hanford. In the absence of hard planning data, it is the judgement of most IPEP members that the critical path to being able to conduct a comprehensive impact assessment probably lies, not in the SAC, but in characterization. Many of the key characterization activities, particularly those related to contents of and leaks from high-level waste tanks, are under the control of the River Protection Project (RPP) and not the Hanford Site chain of command, and the RPP budgets for characterization are substantially reduced from those proposed as recently as two years ago.

At the current rate of characterization of the vadose zone, if the SAC (Rev. 1) is operational in FY02 as promised, inventory, flow, and transport data will still be extremely sparse, resulting in large uncertainties in the simulations that SAC performs. These large uncertainties will necessarily render SAC Rev. 1 more of a performance assessment tool (at best) than a useful tool for risk and impact assessment, and it is entirely possible that this limitation will persist well beyond Rev. 1 unless the rate of characterization is substantially increased.

The SAC team has come under pressure to make Rev. 0 useful for at least some decision making, but the team has insisted that will not be possible; we agree with that assessment. Some IPEP members believe Rev. 0 will be useful at least for guiding some of the work within the IP and related Core Projects, while other members are less optimistic, fearing that the model will barely be functional as a unit by the deadline, that the new model components will be uncalibrated, and that the output will be little more that a simplified example.

With the release of the SAC report, enough planning detail is available to give us more confidence that a useful tool can eventually be developed. The large uncertainty that is likely to be present in the SAC outputs for some time is no reason not to proceed. Uncertainty can be reduced as the SAC team tests their models and addresses the areas where uncertainty is greatest, either through field characterization programs or new S&T programs. A comprehensive impact assessment is needed at Hanford and the current plans for the SAC are heading in a reasonable direction to accomplish that.

3.1.2 Areas of concern

Expectations for the SAC need to be moderated and placed in the perspective of similar modeling at other sites where long-term containment is a contentious issue. For example, the WIPP (Waste Isolation Pilot Plant) site in Carlsbad, NM, and the Yucca Mountain site in Nevada have required decades of geologic characterization, even without the complications presented by the intense radiation fields encountered at Hanford. The great effort put into the performance assessments at those two sites must be studied carefully and the lessons learned used to reduce the development time and cost for the SAC. We understand the SAC team has made some initial efforts along those lines, and we urge them to increase that activity, including bringing in external experts to assist.

At the January IPEP meeting, we learned that little has been done toward assessing the various uncertainties with which the SAC will have to deal and how those uncertainties will interact and propagate. While we understand it is not possible to do everything at once, it is nonetheless essential that this process be started as soon as possible, in order to help prioritize various activities inside SAC as well as related data gathering (field and laboratory) and S&T. Naturally, the process of developing and evaluating the list of uncertainties should involve discussions with regulators, Tribal Nations, and other stakeholders, but the IP should take the initiative and develop an initial draft list, including both uncertainty in numerical parameters and the more insidious uncertainties in conceptual models. At the January meeting, Professor Steven Gorelick pointed out that care must be taken to avoid eliminating any possible source of risk because it is not understood.

As described in the Preliminary SAC document, it appears that a “Distributed Collaboration” is the preferred architecture for Rev. 0, to best allow for “requirement creep and change” (p. 5-15, DOE, 1999a). The urgent need to develop a functioning SAC computational tool understandably required that the computer models that comprise the SAC assessment code be defined early. The SAC team made their selections for the model components choosing between “legacy” codes and new codes. Even though modularity is espoused, IPEP members are concerned there may be a tendency to essentially “hardwire” the components together for the sake of meeting deadlines. This raises the possibility that models describing transport in the vadose zone (which remains an area of great uncertainty in terms of inventory and transport characteristics) will continue to be modeled with a simple code. It is our view that a one-dimensional model based on K_d will likely not be adequate for vadose zone transport calculations in future revisions of the SAC. Thus, modularity that allows for easy substitution of more complex simulation codes must be maintained.

Regarding simulations of transport in the vadose zone, a K_d approach was the only option chosen for Rev. 0. Data recently obtained from the the borehole 299-W23-19 clearly indicate multi-component transport, which is difficult to explain with a simple K_d approach. Sorption is pH and ionic strength dependent and reactive transport will require a more sophisticated adsorption simulator than provided by K_d. Similarly, the composition of the solution and the dissolution and precipitation of solid phases will require a speciation code. Such codes are available and are being reviewed by RPP personnel and should eventually be considered in SAC revisions.

3.2 Science and Technology Program

The National Academy of Science is establishing a panel of about 15 members to review the quality of S&T research plans and evaluate how they link with site needs. At the time of our January meeting, their initial meeting was scheduled tentatively for mid-March, with a planned time frame of approximately 18 months until the report is released. IPEP members believe this kind of focused study should prove valuable for the Hanford site and the DOE complex as a whole. In the meantime, we will continue our interactions with the IP regarding the S&T efforts.

3.2.1 Status

The work performed by the S&T team to date has generally been well done. In the recent EMSP awards, the list of projects related to Hanford's needs is impressive, although these projects are at a very early stage and it will be some time before it will be possible to assess whether their effectiveness in providing useful technology lives up to the initial promise. At the January IPEP meeting, we were told that the S&T roadmap is currently being revised and will be released in April 2000, in time for the IPEP's planned May meeting. At that time, we plan to explore the results of the 1999 EMSP awards and the status of the S&T effort.

IPEP members liked the efforts being made to connect potential users of S&T products from the EMSP with the scientists performing the development work through Scientist-User Coordination Teams. However, in most cases this coordination will likely have only a modest effect in terms of making the development work useful to Hanford because those receiving EMSP funding have already agreed to a set of milestones and deliverables; thus, even scientists who might be delighted to modify their work to give more assistance to Hanford (or other) users may not be able to do so. Although we recognize that EMSP awards are not generally intended to support the specific needs of one end-user, establishing the Coordination Teams before the EMSP milestones are finalized might greatly improve the immediate utility of the research without adversely affecting the quality of the science, resulting in a more rapid return on investment.

The Vadose Zone Field Study currently being planned is an important activity and we support it. We applaud the fact that the draft study plan (Anonymous, 2000) is the product of a number of scientists representing organizations at Hanford and elsewhere, under the leadership of scientists from three different DOE national labs.

3.2.2 Areas of Concern

At the January meeting, we were told that the 1999 round of EMSP awards was Hanford's "main shot" at funding for needed basic research, a disturbing revelation. A substantial, long-term commitment to research and development in support of remediation is needed using a private-sector approach of cost-benefit and return on investment assessments of the options. A long-term R&D program should be instituted with expenditures keyed to a per cent of life cycle cost savings based on those objective assessments, along with critical-path planning to help ensure that important technology is available when needed.

In a recent study (WAG, 1999), the Washington Advisory Group noted that:

> *"…the current level of funding for long-term scientific research and technology development is inadequate to meeting DOE's remediation and stewardship responsibilities. In particular, the budget for research, technology development, and deployment (RD&D) in subsurface science should be sized to reflect a meaningful investment in reducing the long-term costs and improving the effectiveness of remediation and stewardship through new knowledge and technology."…*
>
> *"A key element in bolstering the basic science component of an appropriate RD&D program is a significantly increased investment in the Environmental Management Science Program (EMSP). …to have the impact Congress intended, EMSP funding should be increased about fourfold from recent levels."*

We concur with those observations.

Beyond EMSP, it appears that technology development is not receiving the attention it needs in the IP's S&T planning, which has so far been weighted more toward basic science. This is perhaps a natural result of having the S&T plan developed largely by a National Laboratories team. The IPEP (and the earlier VZEP) have repeatedly emphasized the importance of funding developments aimed at reducing the cost and increasing the effectiveness of critical procedures such as drilling, sampling, and logging; investment in these areas will reduce operational costs in the long run, thereby yielding more information for a given level of expenditures. The search for cost savings should remain a constant, high-priority endeavor of the IP and related Core Projects, so more money becomes available for characterization and other high priority goals.

The schedule for the Vadose Zone Field Study (Anonymous, 2000) indicates a detailed test plan is due in April 2000 with the test beginning in May. This draft test plan supplies little detail on how the test volume will be evaluated during the study. Gathering and interpreting valid data are generally weak points in field studies of this nature and the study plan must go well beyond simply listing types of geophysical surveys and borehole sensors that (it is hoped) will provide useful data. In general, the document is too vague to serve as the foundation for a successful and cost-efficient set of experiments; a more robust and detailed discussion of the scientific and technical issues is needed before the field study begins.

When asked whether any of the S&T work is absolutely necessary for meeting milestones, acting IP manager Mike Thompson replied that the milestones will have to be met regardless, but that the quality will suffer. He stated that one of the IP's roles is to point out to the decision makers "situations where the necessary science is not available for making a good decision". Thus, one consequence of regulatory milestones could be that a bad decision might be adopted in lieu of a delayed decision, even though that bad decision could cause more harm than good. We are seeing little discussion of these important issues in IP documents; these issues need a full and public airing to foster dialog among the DOE, regulators, Tribal Nations, stakeholders, and others.

3.3 Modeling and Transport: groundwater

3.3.1 Status

In our view, the Groundwater Modeling Expert Panel (GMEP) selected by DOE/RL provides a case study in effective peer review processes that should be emulated in other important technical areas. The GMEP is composed of experts from outside Hanford, their recommendations have been penetrating, comprehensive, and frank, and the Core Project (Groundwater Monitoring) and the IP are responding constructively.

IPEP members have read the GMEP reports, considered their findings, and cited some of their recommendations in our reports, thereby adding another layer of review which adds credibility and confidence to the process. The IPEP has also interacted directly with the GMEP in two ways: (1) we appointed a liaison from the IPEP (Peter Wierenga), and (2) the participation of Professor Steven Gorelick (Chairman of the GMEP) in the January IPEP meeting was most beneficial to us.

3.3.2 Areas of concern

Recent recommendations from the GMEP focused on improving the conceptual model of flow and improving and narrowing the uncertainly of flow pathways; however, little attention has been given to the chemical requirements of the sitewide groundwater model. Although the regional groundwater modeling done to date has considered transport of chemicals, radioactive solutes, and tritium, this effort does not seem to have addressed reactive transport.

Solution speciation and surface reactions must be simulated as part of the site assessment. Some species such as U and Pu form complexes that significantly enhance mobility; a speciation code will be required to account for the complexes and colloids. Similarly, based on historical site evidence as well as recent borehole and other field data, some strongly sorbed species may actually be mobilized sufficiently to pass though the vadose zone into the ground water. Therefore, as part of the regional groundwater transport modeling effort, it may be necessary to consider mobilization of surface reactive species like Sr and Cs that typically sorb and participate in ion exchange, and it will certainly be necessary to consider sorption of Cr, as well as U, Pu, and many other radioactive species.

It is not clear at present whether the existing code CFEST will be enhanced to accommodate reactive transport or whether in the future another code will be adopted or developed for that purpose. Capabilities for simulating complexation and more robust adsorption models than K_d will be required in the groundwater modeling effort, as well as in the SAC simulations, and this is not available in the currently used code. This evaluation of chemical modeling needs and capabilities should be considered along with the evaluations of flow modeling.

3.4 Modeling and Transport: vadose zone

3.4.1 Status

A number of vadose zone transport codes are available and with most of these it is possible to predict the movement of contaminants through a uniform or layered, unsaturated soil column, given enough valid input data. Making predictions becomes more difficult when the subsurface geology is unknown, ill defined, or highly heterogeneous, and when complex chemical or physical processes or features affect transport and have to be modeled. Furthermore, most unsaturated zone transport models have not been adequately tested with field data.

For a variety of reasons, the IP decided to revisit the vadose zone computer code selection. A draft document was prepared by the IP (Mann et. al., 1999), listing the selection criteria for flow and transport code(s) to be used in vadose zone calculations in Hanford's Central Plateau. Input regarding the selection criteria was solicited and received from project personnel, stakeholders and regulators. A call for proposals was issued, and thirteen simulation programs were submitted in response; as of this writing, a decision on selected codes is expected soon.

In the code selection process process, there has been interaction with modeling groups at other national laboratories, a positive result of the integration project. During the past several months there has been interaction between Science and Technology and EMSP investigators familiar with vadose zone transport codes developed by PNNL, Los Alamos, the Yucca Mountain Project, and Lawrence Berkeley Labs. Several national labs have state-of-the-art transport codes that could well be of value for modeling at Hanford. Although no outcomes of these meetings were reported at the January IPEP meeting, this sort of collaboration is an important function of the IP, and we applaud it.

3.4.2 Areas of concern

The lack of a plan for a vadose zone monitoring program, including gamma ray and neutron moisture logging (other monitoring techniques should also be considered), concerns the IPEP. The great value of repeated gamma-ray logging has already been clearly demonstrated (e.g., Randall and Price, 1998; Randall et al., 1999; Stromswold, 1999; Wilson, 1999). A baseline of ***calibrated*** neutron moisture measurements is needed for model testing, for studying infiltration including a short-term infiltration event (e.g., a major snow melt), and to allow monitoring for leaks during sluicing of the tanks. At a minimum, periodic monitoring is needed in areas where tank leaks are known or possible and in zones where the umbrella infiltration effect can be studied.

The code selection document (Mann et. al., 1999) presents a generic set of criteria modified and expanded from earlier documents (Voogd al., 1998; Mann and Myers, 1998; Mann, 1995) and purports to represent the needs of SAC, ILAW, RPP, and the 200 Area Remediation Program. Missing from this effort is the specific, as opposed to general, needs and criteria of each of these organizations. Rather than define what each group will require, the document defines a minimum set of criteria that all need and presents a list of desirable criteria that some may need.

The process and criteria to be used for model selection are not well defined in the code selection document. The IPEP is concerned that selections be defensible, objective, and appropriate.

- Defensibility requires that the codes be sophisticated enough to deal successfully with the anticipated chemical and hydrologic complexity. However, if this level of complexity is not a required criterion, then vendors, universities, or National Labs with advanced codes may not respond.
- Objectivity requires that a clear mechanism for evaluating the codes be defined well in advance of any decision, preferably when the solicitation is published, and as of the January IPEP meeting this had not been done.
- Appropriateness may seem obvious, but without specifically defining the project needs (not general criteria), reviewing them in an open forum, and selecting for optimum capabilities, rather than minimum, there is the risk of obtaining models that could quickly become obsolete for this application. Comments at the January meeting on this topic by the SAC team seemed to favor relying on code modification to meet changing needs.

  In our opinion, it would be better to select models that actually can meet the known requirements, erring on the side of excess capabilities. As an example, the "mandatory criteria" for aqueous chemistry and sorption are minimal and could be met by many codes that are inappropriate for reactive transport calculations under Hanford conditions. To select such a basic code, assuming one could always modify it, is a potentially hazardous course given current constraints on budget and time. The chemical speciation, sorption and mass transfer "desirable criteria" are in fact the ones needed to define reaction under variable conditions of pH, ionic strength and mineral surface variability. Many codes can already do this, and can always be run in a simpler mode, reducing the likelihood of costly regrouping when the selected code turns out to be too simplistic.

To IPEP members who are familiar with many of the codes on the short list, it seems that a mechanism other than the list of computer code selection criteria given in Mann, et al. (1999) will be required for an objective decision to be reached. Two issues must be addressed regarding this current state of evaluation.

- Some of the models on the short list are complex reactive transport codes with completely different approaches to sorption, ion exchange, and speciation, along with multi-dimensional flow and multi-component options. In order to maintain credibility and provide defensible simulations, it will be important for the RPP, the SAC team, and other users to document clearly the reasons for selecting a given code.

  Comments made at the January IPEP meeting implied that the selection might be made based on vendor descriptions of the codes; it would be unwise to proceed very far based on vendor descriptions alone. Further, arguments have been made for the use of legacy codes, but we strongly recommend that legacy be a secondary consideration with primary emphasis being placed on objective performance and capability criteria.

- The process of code selection could be made more rigorous by providing each vendor with test data sets and requesting results for comparison. If a given vendor[1] cannot respond efficiently to this, then this may speak to the ease of use and the availability of future technical assistance. Evaluation can be based on accuracy, input file size, structure and complexity, computational time, and utility of output, among other criteria.

The code selection criteria document seems to indicate that Hanford does not consider access to the source code as being necessary. We believe this is a mistake; it seems that access to the source code could become critical if questions arise as to the validity of the coding (as opposed to the validity of the concepts and physics underlying the code). In passing, we note that in the selection criteria document there are errors in the tables that summarize the selection criteria and indicate which organizations consider which criteria to be mandatory, desirable, or otherwise; these errors could cause some confusion.

A higher priority should be given to model testing using well documented data sets from laboratory and field studies, including field tracer tests, data from the recently completed boreholes in the tank farms, and some of the salient phenomena observed in the recently performed field studies.

3.5 Subsurface Investigations: 200 Area ER Remedial Action

Based on the presentations to the IPEP regarding the 200 Area ER remedial action, this effort appears to be progressing in a competent, professional manner. FY99 products show creativity in developing effective approaches toward obtaining useful, quantitative characterization data in support of ER remedial decisions.

The preliminary effort at four representative sites[2] reported at the meeting, when extended to the 23 sites making up this project, should significantly reduce the uncertainty in inventory estimates for those sites, and evaluation of contaminant migration will aid in the development of representative simulation models.

Another goal of the ongoing fieldwork, in addition to gathering data, is to develop streamlined characterization techniques to support remedial decisions. Cleanup standards and effects on final land use decisions for the 200 Area have not been determined by regulators. This effort is important for estimating the costs and feasibility of cleanup actions in the 200 Area soil sites (excluding the Tank Farms). It is an

[1] Because DOE labs may be prohibited from performing work that is unfunded, some funding may be required for such a comparison.

[2] The four representative sites, which have since been decommissioned and back-filled, were 216-B-3 Main Pond (46 acres), Gable Mountain Pond (71 acres), 216-B-3-3 ditch (3,700 ft), and 216-B-2-2 ditch (3,500 ft). The open, unlined ditches (trenches) were used to transfer cooling water from 200 Area facilities to the holding ponds. There were additional unplanned chemical and fission product releases to the trenches and ponds that have raised concerns in addition to the cooling water.

important part of the IP because contaminants moving from these sites could affect cumulative impacts along the Columbia River.

Soil samples were obtained by excavating test-pits to a nominal depth of 25 ft. using an excavator ("steam shovel") and collecting the samples from material in the shovel. Also, boreholes were drilled to depths as deep as 37 ft to obtain supplementing data and to correlate with the results obtained by excavation. This approach, using excavated trenches and shallow boreholes, seems to be an effective and relatively inexpensive method of investigating these and other representative ponds and ditches. Although not all data have been processed, the data quality appears adequate for the purpose intended.

Conceptual models of the four sites were presented to the IPEP at the January meeting, representing contaminant distribution in the vadose zone based on the known and estimated discharges to the ponds and ditches. From known and extrapolated geology and data from groundwater monitoring, the conceptual models "fill in" the sparse information in the vadose zone beneath the ponds and ditches and in the saturated zone (groundwater). IPEP members believe the conceptual models are reasonable first interpretations based on empirical data.

Based on what we have seen to date, the IPEP feels this Remedial Action Investigation is proceeding in a reasonable, cost effective way. We were particularly pleased that this project addressed the three "expectations" (five-year plan, relevance to SAC needs, and a summary of FY99 accomplishments) that we provided prior to the January meeting.

3.6 Subsurface Investigations: River Protection Project

3.6.1 Status

It was noted in the closeout report following the March 1999 meeting of the Subsurface Investigations Subpanel that the level of cooperation between the RPP and the IP was excellent, and that continues to be the case. The FY99 field and laboratory efforts were generally successful and much of the data presented at the January IPEP meeting should be useful in the process of developing a vadose zone conceptual model, at least for the conditions at the SX tank farm. Several innovative sampling and analytical techniques were attempted during this past fiscal year. Some were successful, some less so, but regardless of the level of success of any particular technique, the underlying effort to achieve more and better data, as well as to point the way to future improvements in technology and potential for cost reduction per borehole, is clearly in concert with recommendations by the IPEP and the desires of RPP and DOE/RL managements.

3.6.2 River Protection Project (RPP) Plans

The FY00 RFI/CMS Work Plan Addendum For WMA S-SX, released October 1999 (DOE, 1999b), identifies RPP characterization efforts agreed upon with regulators through the data quality objectives (DQO) process for the next characterization effort to fulfill proposed Tri-Party Agreement Milestone M-45-52. Because the IPEP was not afforded adequate opportunity to review the document before the meeting, we were unable to explore the details of the FY00 Work Plan during the discussion session that followed the RPP presentation. Field characterization efforts include the collection of vadose zone data from the following:

- *Cone Penetrometers in Tank Farm.*

  This investigation will collect sediment samples via direct push technology in the northern portion of the S tank farm and/or between the S and SX tank farms. This technology has not been previously deployed in the tank farms. Direct push technology has significant depth constraints and consequently may add little data relevant to leaks that occurred at the bottom of the tanks, but it may help characterize surface spills, transfer line leaks, and leaks that may have occurred higher up in the tanks and subsequently spread laterally. The IPEP recognizes the limitations of direct push technology but agrees it is worthwhile to pursue.

- *SX-108 Slant Borehole.*

  Slant boreholes have the potential to sample near-vertical features, obtain samples for directly beneath structures such as tanks, and obtain samples at depth while avoiding shallower, highly contaminated zones. They can potentially help improve estimates of in-ground contaminant inventories and understanding of processes that control migration of contaminants, including potential drivers and the effects of tank leaks on soil properties to support predictive modeling efforts necessary to evaluate potential future groundwater impacts.

  The proposed SX-108 slant borehole is intended to provide information on what is thought to be the second largest source, the leak from tank SX-108. The proposed angle of 30 degrees should provide data from beneath the tanks that has not been retrieved before in any Hanford tank farm. The IPEP (like its predecessor, the VZEP) has strongly recommended this type of drilling and data collection at Hanford and will follow this effort closely. The plan for the SX-108 slant borehole is to stop drilling and sampling at the top of the Plio-Pleistocene unit, which will limit the characterization to approximately the upper half of the vadose zone beneath the SX tank farm. Extension of the slant well approach to the full depth of the vadose zone will be necessary to adequately characterize the vadose zone beneath the tanks.

3.6.3 RCRA wells

In general, the IPEP was satisfied with the coordination between the Office of River Protection and the IP in terms of folding IP data needs into the development of new RCRA wells, and that recommendations from the IPEP were being incorporated.

However, the IPEP is concerned about a possible lack of funding for RCRA well construction, expressed by Ecology in a letter to DOE, dated September 27, 1999 (Ecology, 1999). That letter states,

> *"It is Ecology's understanding that well construction and decommissioning activities are not funded for Fiscal Year (FY) 2000 and beyond… Ecology does not understand how USDOE has determined that these issues do not deserve funding. Ecology hereby advises USDOE that the current Multi-Year Work Plan (MYWP) funding profile is unacceptable."*

This type of funding issue seems to occur each year at Hanford and is counterproductive to effective planning for essential data collection for the characterization program. DOE's failure to develop **and effectively implement** long range plans appears to be a major impediment to achieving approval for annual work plans in this and other areas, such as for vadose zone characterization. The IPEP supports Ecology's request that, "USDOE procure adequate funding for the installation of groundwater monitoring wells at TSDs and tank farms in fiscal year 2000 and beyond."

3.6.4 Temperature logs and subsurface inventory estimates

One recommendation of the former Vadose Zone Expert Panel (VZEP) was to evaluate borehole temperature measurements as an additional tool for studying subsurface radioactive contamination in the tank farms (VZEP, 1999). Preliminary results of such a study have now been reported (Piepho, 1999) showing the results of 3-D simulations of the thermal effects of a given amount of radioactivity within an enclosing volume (i.e., in Ci/m^3). The work leading up to this report was completed before the field and lab work for FY99 had been completed so approximations were used in lieu of measured ^{137}Cs concentrations along Borehole 41-09-39.

A copy of the report was furnished on request to interested IPEP members. Unfortunately, time was not available before or during the meeting to explore the merit of this method for estimating radionuclide inventory. However, it is clear from the report that the contribution of heat-producing contaminants to borehole temperature is significant if the total magnitude and distribution of contaminating radionuclides are large. This last is a key issue, for while all other contaminant sources may add increments to the cumulative hazard presented by the site, the very highly contaminated regions among and beneath the tanks are likely to dominate both the magnitude and the uncertainty of cumulative hazard. This fact provides a compelling reason to reduce the uncertainty in the tank-farm inventories by any means available, including thermal investigations.

A brief discussion during the meeting indicated that the infrared (IR) temperature logging probe may not be sufficiently precise or adequately calibrated for the environment being investigated. When the 41-09-39 casing was withdrawn, a significant difference between casing temperature and that of the formation soil was observed but has not been explained. It may be an instrumentation problem, a calibration problem, or the result of some *in situ* factor. For example, an evaporative decrease in formation temperature as soil is exposed to air when the casing is withdrawn may contribute a bias by lowering the formation temperature relative to that of the casing at the same depth. On the other hand a preliminary graph of the set of formation-temperature measurements seems to exhibit "structure" similar to that of the gamma spectral logs of borehole 41-09-04 (VZEP, 1997), a companion borehole to 41-09-39, that is only 5-ft distant. This deserves further attention.

3.6.5 Areas of concern

Our greatest single concern related to the RPP is their retreat from the characterization schedule presented in their work plan (DOE, 1998b, to which annual addenda are issued detailing the specific characterization program for each fiscal year). This was described at some length earlier in this report.

Before the January IPEP meeting, IPEP members received a document (Johnson et al., 1999) entitled "Subsurface physical conditions description of the S-SX Waste Management Area." This document was discussed briefly at the January meeting, and the IPEP received decidedly mixed messages. We were told this was the first of a series of subsurface conditions documents that will be prepared for various waste management areas to "establish a common level of knowledge," provide "the basis of work plans," and "set up the DQO process." At the same time, the impression from the ensuing discussion was that preparation of these documents is largely a formality, boxes to be checked off as part of a mandated approval process. We have occasionally noticed such an attitude before toward certain mandated processes, including toward parts of the DQO process conducted last spring for the characterization work done in SX tank farm in FY99.

The subsurface conditions document itself contains a great deal of potentially useful information and is a good initial effort, but it is not rigorous enough to be truly useful for people trying to gain an accurate understanding of the S-SX subsurface. However, there are many unsubstantiated statements, supposedly of fact, many opinions given without mentioning alternatives, and too few references. Since the document is essentially a somewhat general review, it needs more references to specific studies to allow readers to explore selected issues in more depth and, indeed, draw their own conclusions regarding the issues at hand. The important message here is that Hanford sometimes produces documents that do not meet reasonable standards of quality, apparently simply to meet some requirement. Documents that do not meet reasonable standards of accuracy and rigor may propagate misinformation and do more harm than good. Of course, a good peer review system should weed these out before they are distributed.

3.7 Inventory

The success of any comprehensive impact assessment for the Hanford Site, and associated environmental mitigation measures, will depend on DOE's ability to project levels of risk to populations living both near to and far from the site over time periods ranging up to thousands of years. Essential to estimating these long-term risks is knowing the source term, or inventory of environmental contaminants, due to:

- Environmental contamination already in place from earlier tank leaks and other inadvertent losses, and from planned releases (solid and liquid waste disposal sites, cribs, ponds, etc);
- Losses to the environment while retrieving high-level radioactive waste (HLW) from the tanks;
- Residuals (heels) to be left in the tanks after removing most of HLW from the tanks; and
- Emplacement of radioactive and toxic waste on-site during emptying of the tanks, processing of the waste, and cleanup and decommissioning of facilities, along with additional waste brought in from facilities outside of Hanford.

Reduction of the currently huge uncertainty (DOE, 1996; DOE, 1998a) associated with the inventory of contaminants is critical to making a variety of important decisions[3] ranging from what residuals can be left in the tanks and other mitigated disposal sites and facilities to what losses will be considered allowable during mitigation (e.g., tank leaks during retrieval of tank waste or removal of fuel from the canyons).

The inventory of hazardous radioactive and chemical wastes at Hanford is complex and widely variable in magnitude from facility to facility. The greatest radiological hazard may result from HLW that has already leaked from the tanks and from the residuals following removal of HLW from the tanks, although this remains to be proven. In part because we have not seen information on which to base an assessment of the greatest chemical waste hazard, the IPEP has focused in the past primarily on the potential radiological hazard, especially in relation to the waste in, and leaked from, the single shell tanks.

The IPEP is concerned that the effort being made to establish the inventory of leaked waste is inadequate. Instead, current indications are that SAC risk assessments will rely on "mass balance inventories", estimates made by extrapolating back in time using current in-tank characterization data and process records from the past. We fail to see the wisdom of this retrenchment, considering that the IP's colleagues in the RPP described in the November/December 1999 issue of Radwaste Magazine (Heaston et al., 1999) the paucity of information to support such an effort. We quote from Heaston et al:

> *"From the early years at Hanford through the height of the Cold War, plutonium production was paramount. Waste management was something that had to be done, but waste treatment and storage practices were not up to today's standards. Generally, waste sent to the tanks was not analyzed. Waste was transferred from tank to tank and from tank to waste processing units and back again with limited documentation. Record keeping was minimal, especially prior to 1980[4].* ***It was almost impossible to determine the fate of individual batches of waste. [****Emphasis added].*

> *"Two practices, cascading and evaporation, were major contributors to the confusion. Underground 3-in pipes offset by 1 ft of elevation connected anywhere from two to six tanks in cascade. Waste was allowed to fill the first tank in cascade and overflow into succeeding tanks. Solids settled in the first tanks in a cascade, leaving liquid in the final tanks. No record was kept of the amount or composition of the solids that dropped out in each tank. Evaporation was used to reduce waste volumes. Wastes from a number of tanks were mixed in waste receiver tanks, transferred to the evaporator, concentrated, transferred to the bottoms receiver tanks, and redistributed back to the tank farms. In addition to redistributing wastes among the tanks, evaporator campaigns promoted chemical reactions, evaporated some organic species, and concentrated waste, causing additional precipitation.*

[3] The IP states that project results will influence key Hanford Site cleanup decisions, including 1) groundwater remediation, 2) interim actions to protect groundwater and the river, 3) 200 Area waste remediation, 4) composite analysis and impacts, 5) single shell and double shell tank waste retrieval, 6) single shell and double shell tank closure, 7) disposition of canyon facilities, and 8) final remediation of the 100, 200, and 300 areas (DOE, 2000).

[4] Note added by IPEP: Most of the leaks, at least in the high heat tanks, developed in the 1950s and 1960s.

"Complex Chemistry

> *"To make matters still more complicated, the composition of the waste changed over time. High concentrations of radioactive species released significant amounts of heat, causing evaporation of water and precipitation of a variety of compounds as solubility limits were reached. Additional precipitation occurred as radioactivity decayed, and tank temperatures decreased. Precipitation added complexity to the waste since large numbers of compounds could be formed from components of the waste. Other complicating processes include the evaporation of organic solvents and the formation of gases by the radiolytic and chemical decomposition of organic and inorganic compounds in the waste. Last but not least, more than 60 single-shell tanks leaked. Total leakage is unknown but is estimated to be in excess of 1 million gal containing more than a million curies and unknown quantities of various chemicals."*

In light of this information, the IPEP is concerned that the mass-balance approach to estimating inventory is based more on expediency than valid technical considerations.

We note that this is not the first time a mass balance approach has been proposed for establishing inventory. In 1985, the then Hanford manager requested a review by the National Academy of Sciences/National Research Council (NRC) of a mass balance model, TRAC, for estimating in-tank inventories, especially of the radionuclide of concern at the time, ^{239}Pu. Following initial presentations of the model and expected outcomes, the reviewing panel recommended test drillings into the waste in the thirty tanks predicted by the model to have the greatest concentrations of ^{239}Pu. Analyses of the cores from nine of the tanks thought to be the most highly loaded failed to match the predictions from TRAC, not only for ^{239}Pu but for the other principal radionuclides as well, so the effort was discontinued short of completion.

The above discussion deals with the less complicated of the inventory problems - estimating the current contents of the tanks, where some empirical data gathering is feasible. The IP (SAC and S&T) is proposing to estimate the inventory of the leaked waste using a mass balance model that appears to be much like TRAC, at least conceptually. However, estimates of inventories in the vadose zone are even less tractable than estimates of in-tank waste. The vadose zone inventory estimates will necessarily require reconstructing and verifying what leaked from the tanks decades ago, when all of the complex interactions and reactions described by Heaston et al (1999) were ongoing, with the volumes leaked described as "unknown".

The question of volume estimates appears to present large uncertainties as well. A contract was let to Steve Agnew of Los Alamos National Laboratory to estimate the volume of leaks from the four tanks surrounding the highly contaminated zone being evaluated by the research drywell 41-09-39, in the SX tank farm. Agnew's estimate of the total amount of waste leaked from the four tanks exceeded 1-million gal, the amount currently ascribed as the total volume leaked from all 69 leaking (or suspected) tanks (Agnew and Corbin, 1998). For individual tanks, Agnew's estimates differ from presently accepted values by more than an order of magnitude. The IPEP has been told on several occasions that Agnew's methodology was "flawed"; Agnew's extensive work is now largely ignored and the leak estimates being used currently are those first produced in the early 1960s (these latter estimates carry 1999 publication dates, but actually are historic values being republished monthly in tank farm update reports). We will consider this issue in some detail in the near future.

In both the Agnew and historic models, the same waste transfer and volume measurement data bases are used; also, the radionuclide inventory codes such as the Oregin2 and the Hanford Defined Waste models. Agnew, however moved beyond convention using his historical leak model (HLM) to provide estimates of heat loads in tanks, heat losses to surroundings, and calculated evaporative losses. Whether Agnew's more complex model provides more realistic estimates of leak volume remains to be tested.

The great difficulty involved in using the mass balance approach to inventory estimation is clear. The uncertainty in estimates of volumes leaked from any single tank appears to range over an order of magnitude or two, while the uncertainty in estimates of waste concentrations and species ranges over several orders of magnitude. The IPEP has little confidence that this approach can succeed, unless the mass balance model is calibrated and verified using a fairly extensive empirical data base developed from a comprehensive field characterization program.

4 IPEP concerns

The positive conclusions reached by the IPEP regarding the status of the IP are presented in the Executive Summary of this report and are not repeated in the body of the report. Rather, this section focuses on a series of concerns about the IP that continue to exist in the minds of IPEP members. They are presented for the Project's consideration and action.

1. The rate of progress of the IP toward the capability of providing a comprehensive impact assessment now seems to be dominated by factors over which the IP has little control.
2. The IP planning process still lacks rigor. Plans are being developed without first identifying decisions, needs, and end points. Plans and decisions are not generally based on objective tools such as cost benefit assessments and critical path analyses.
3. It appears to the IPEP that the critical path for performing a comprehensive impact assessment may lie in characterization rather than in development of the SAC.
4. The RPP characterization program, if it continues at its current pace, is unlikely to provide a satisfactory level of understanding of the subsurface, especially the vadose zone, in the time frame specified by the TPA.
5. The SAC team has not yet developed a draft compilation of all known sources of uncertainty, including uncertainty in numerical parameters and other empirical information as well as uncertainty in subjective processes such as conceptual models. This is a critical step in the planning process.

6. IP personnel still have not adequately linked project outputs to site decisions, nor made it clear to customers what the benefits of those outputs will be.

7. The lack of a plan for a vadose zone monitoring program, including gamma ray and neutron moisture logging (other monitoring techniques should also be considered), concerns the IPEP.

8. The IP is proceeding on a very modest budget considering its broad scope and responsibility, and the environment within which it operates, a fact that necessitates tradeoffs between quality of product and delivery timeline. The IP has not adequately communicated the tradeoffs that are being made among budget, quality, and time.

9. There is still a tendency to treat required processes and documents (e.g., DQO process, subsurface conditions documents) as mere formalities involving form but little substance. These tools were developed to lend rigor to planning and implementation of field activities and should be used constructively, as they were originally intended, or eliminated in cases where a good argument can be made to do so.

10. Now that we have seen the plan for the SAC we are concerned that expectations may be too high. It appears likely that large uncertainties in concepts and input parameters will necessarily render SAC Rev. 1 more of a planning and performance assessment tool than a useful tool for risk and impact assessment, and it is entirely possible that limitation will persist well beyond Rev. 1.

11. It appears that technology development is not receiving the attention it needs in the IP's S&T planning, which has so far been heavily weighted toward more basic science. The IPEP (and the earlier VZEP) have repeatedly emphasized the importance of funding developments aimed at reducing the cost and increasing the effectiveness of critical and costly procedures such as drilling, sampling, and logging; investment in these areas will reduce operational costs in the long run, thereby yielding more information for a given level of expenditures.

12. The IP still lacks a "robust, multi-layered peer review system" as described by Undersecretary Moniz and recommended by the IPEP. While some elements of such a system are in place they are not adequately coordinated, nor consistently applied, and multi-layer robustness has not been achieved.

13. Work done to date still seems to support the possibility of using temperature logging along with heat transfer computer models as a means of identifying large inventories of heat-producing radioactive waste in the vadose zone. This is important because the large "source terms" (inventories) will likely dominate the risk estimates that will result from simulations using the SAC models.

14. We were told at the January IPEP meeting that there is no intention to drill in every tank farm, that it is probably not necessary, and that at one million dollars per borehole, it is too expensive. This suggests that a major decision of fundamental importance has been made, yet we have not seen objective data or rigorous planning to support such a decision .

15. Some IPEP members feel they are not being kept sufficiently informed in their areas of expertise and interest. A proposed remedy is presented in Appendix C.

5 IPEP recommendations

In the following list of recommendations prepared by the IPEP, the items having the greatest potential effect on success (or failure) of the IP are listed first.

1. In order for the IP to move forward efficiently, higher level DOE managers must address the problem of barriers to IP progress that are not under IP control, such as those discussed in this report. Similarly, the IP must do a better job of identifying and proposing solutions to such barriers. (See also Recommendation #5).

2. We recommend that the RPP commit to at least a minimum credible characterization plan along the lines of the one put forward by TWRS in 1998, as discussed earlier in this report in the section entitled *"3.1 A retreat from characterization."* Both the IP and the RPP must develop **and subsequently be provided sufficient funds to follow** long term plans, at least of 5-year duration. These plans should be developed in concert with regulators (modifications of the TPA) and with input from stakeholders and Indian Nations.

3. The IP must bring more rigor to the planning process, emphasizing the importance of identifying decisions, needs, and end points, and basing plans and decisions on objective tools such as cost benefit assessments and critical path analyses. A critical path analysis of the Hanford Site environmental work as a whole is urgently needed to support the goal of a comprehensive impact assessment.

4. A long-term R&D program should be instituted with expenditures keyed to a per cent of life cycle cost savings based on those objective assessments, along with critical-path planning to minimize the possibility of valuable technology being delivered too late to be useful.

5. The vacant post of DOE IP Manager needs to be filled quickly, on a permanent basis. The new project leader must be given the clear mandate and authority to identify, and help develop solutions to, high-level barriers to progress over which the IP currently has no control.

6. The SAC team should develop a draft compilation of all known sources of uncertainty, including uncertainty in numerical parameters as well as uncertainty in subjective processes such as conceptual models, and begin the process of determining how these uncertainties interact. No sources of uncertainty should be eliminated because they are not understood.

7. We recommend that a vadose zone monitoring program be undertaken that can be regarded at least as a minimum credible effort, including calibrated gamma-ray logging and calibrated neutron moisture logging, along with other techniques, such as temperature logging, as appropriate. A baseline of ***calibrated*** neutron moisture measurements is needed for model testing, for studying infiltration including a short-term infiltration event (e.g., a major snow melt), and to allow monitoring for leaks during sluicing of the tanks. At a minimum, periodic monitoring is needed in areas where tank leaks are known or possible and in zones where the umbrella infiltration effect can be studied.

8. The cooperative work among the IP and Core Projects, particularly the RPP, should be strengthened by assigning unambiguous responsibility, and delegating adequate authority, to all parties involved.

9. The IP must take steps to moderate expectations for the SAC and place this activity in realistic perspective with similar modeling at other sites where long-term containment is a contentious issue, such as the WIPP (Waste Isolation Pilot Plant) site in Carlsbad, NM, and the Yucca Mountain site in Nevada This should include comparisons of the scale of the problem, the nature of the technical challenges, and the budgets involved, among other things.

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Appendix A: IPEP expectations for specialized sessions at the January meeting

The IPEP expectations for the January meeting, as provided to the IP before the meeting, are reprinted below.

Project Accomplishments and Status (Contact: E. Berkey)

Address, as appropriate, IPEP conclusions and recommendations in 9/99 Closeout Report that relate to the Project as a whole. Note: Some conclusions and recommendations may be more properly addressed in the Focus Area discussions.

Science and Technology (Contact: M. Kavanaugh)

1. Provide a brief update on status of following activities:

    a. Soil inventory task- with emphasis on inventory estimation methodology, given limited data.

    b. Vadose Zone Transport work, with emphasis on status of leak estimation methodologies. How will these techniques be verified as to accuracy?

    c. Review of EMSP projects and how they relate to prioritization of needs.

    d. Scope and direction of NAS panel

2. Provide a "case study" of the relation between EMSP funded projects and ONE key problem facing the Project. (A suggested example is the relation between several projects and the carbon tet cleanup. The following PIs and projects have objectives directed at accelerating the CCl_4 cleanup - McCarty, Valocchi, Powers, Angel, Brown, Brockman.)

3. Provide an overview, and specific examples of how the S&T plan, and EMSP projects will interface with the SAC. How will this interface be managed and how will the activities be tracked and reported?

4. (Optional) Provide a short discussion on the issue of uncertainty. How are the S&T activities addressing the issue of making decisions with limited data? What are the scientific opinions regarding the level of accuracy needed for decision making during the Hanford cleanup?

Project Management Focus Area -- System Assessment Capability (Contact: E. Berkey)

1. Give a hypothetical but realistic example of how the SAC will take input and provide output.

2. Indicate how the output will relate to a decision that has to be made.

3. Discuss how SAC Rev. 0 could be simplified and made more useful to the Project.

Modeling and Transport Focus Area (Contact: P. Wierenga)

1. Discuss the status of the groundwater modeling effort. (DOE/PNNL and Gorelick)

2. Discuss the status of vadose zone modeling, including model selection. (DOE/PNNL/BHI)

3. Discuss modeling relative to the S&T program. (DOE/PNNL)

Subsurface Investigations Focus Area (Contact: J. Matuszek)

1. Lay out a 5-yr subsurface characterization plan. What are the VZ characterization needs so SAC can make the inventory estimates proposed on page 13 of the SAC Software Requirements Specification?

2. How does the subsurface investigations work proposed in the FY2000 Addendum address SAC needs? ORP has prepared a draft (maybe final by now) Workplan Addendum for this summer's drilling program.

3. Provide status report on field work completed last year.

Appendix B: Stakeholder, Tribal Nation, and Regulatory Input

Concerns of the Washington Department of Ecology

The Washington State Department of Ecology requested a session with the IPEP at the January meeting to discuss concerns they have regarding IP progress and direction as well as their desire to see the IPEP become more effective. To ensure that sufficient time would be available for this important discussion, we arranged for the Stakeholder, Tribal Nation, and Regulator Input session, which is a regular part of our meetings, to be the final session on the afternoon of the first day, with the idea being that we could go as late as necessary to ensure a complete discussion of the issues.

In Ecology's presentation viewgraphs, three items in the Conclusions section dealt specifically with the IPEP. These are discussed here.

1. Ecology believes that an IPEP that is focused and has the time to make detailed assessments of programmatic and technical issues is absolutely necessary. We want the IPEP to function like the old SX Panel.

Response: The Panel appreciates the support of Ecology and wants to periodically function "like the old SX Panel." There are time and budget constraints. The SX Panel was brought in to focus on one specific issue, movement of Cesium-137 in the vadose zone beneath certain single shell tanks. The present Panel has a much more general task, looking at integration. We intend, by using task groups from within the Panel, to focus on important specific issues.

2. IPEP must increase its dialogue with regulators, Indian Nations and Public Interest Groups to understand their positions on GW/VZ issues. Dialogue should be constant and not restricted to 1 or 2 hours during IPEP site meetings.

Response: The Panel agrees with this proposition and has taken steps to provide a liaison at more meetings other than IPEP site meetings. Unfortunately, substantially increasing IPEP effort in a given area will require either an increase in budget or a decrease in effort in other areas.

3. Ecology will not accept statements made in IPEP reports that involve Ecology participation if Ecology has not had an opportunity to answer IPEP questions or engage in substantive dialogue with IPEP or its individual members on IP issues.

Response: The Panel understands Ecology's position and intends to have a better interaction and dialogue with Ecology staff.

Appendix C: Improving IPEP functionality

In the closeout report for our September 1999 meeting, we noted that:

> *"…it is not unusual for us to learn after the fact that external reviews have been performed, but without learning anything of the results... This lack of consistent communication on important issues about which the IPEP should be informed, in our view, must be addressed. While we do receive some meeting minutes by email, this is not the same as direct notification regarding these important events."*

This lead us to make the following recommendation in that report:

> *"While the current IPEP point-of-contact at Hanford responds ably to our requests, we recommend that she or another person be assigned the active responsibility of keeping IPEP members apprised, in a timely manner, of peer review activities, workshops, release or impending release of major documents, major decisions or impending decisions, and similar events that have a significant bearing on the Integration Project and related activities."*

So far, this recommendation has not resulted in any evident action with the result that some IPEP members are still concerned that we are not being kept informed of ongoing developments at Hanford in our areas of expertise and interest. As part of our continuing effort to improve IPEP functionality, we propose that technical experts at Hanford immediately be assigned the responsibility to brief on an ongoing basis, and otherwise interact with, IPEP members in the following areas:

- Edgar Berkey: Project and program management, impact assessment, environmental technology development, application, and analysis.
- R. L. Bassett: Reactive transport modeling, isotopic geochemistry, characterization
- John Conaway: Borehole logging, geophysics, vadose zone monitoring.
- James Karr: River, ecological health effects (measuring and understanding); both river and terrestrial effect
- Michael Kavanaugh: Subsurface remediation, pump and treat systems, CCl_4 plume remediation, Science & Technology plans
- John Matuszek: Radiochemistry, risk assessment (human health effects), subsurface and environmental chemistry of radionuclides and inorganic chemicals
- Ralph Patt: Drilling, sampling, IPEP outreach issues
- Peter Wierenga: Vadose zone flow and transport, vadose zone and groundwater monitoring, model testing

Appendix D: Preliminary list of topics for future meetings

Below is a preliminary list of topics for future IPEP meetings based largely on the findings presented in this report, loosely grouped by topic area.

Management issues

- Bringing rigor to IP planning processes
- Potential IP in identifying and developing solutions to high-level barriers to progress
- Determining the critical path for performing a comprehensive impact assessment
- Adequacy of budgets for IP and related core projects. Efficiency of spending
- What tradeoffs are being made among budget, quality of product, and delivery timeline?
- Update on the development of a robust, coordinated, multi-layered peer review system
- Implementing a minimum credible characterization plan
- What is the basis for the statement that there is no intention to drill in every tank farm?

System Assessment Capability

- Uncertainty and the SAC
- Expectations for the SAC

Borehole logging

- Developments and plans in borehole logging
- Temperature logging and modeling
- Vadose zone monitoring program

Science and Technology

- How does the S&T work fit in with the overall site needs?
- How EMSP results will be translated into more effective Hanford remediation decisions
- Technological developments that could reduce lifecycle costs
- The revised S&T Roadmap

Inventory

- Problems with Steve Agnew's approach to inventory estimates
- Addressing limitations of mass balance approach to inventory estimates
- Reconciliation of inventory discrepancies at the carbon tetrachloride spill area