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UNITED STATES NUCLEAR REGULATORY COMMISSION'S

ADVISORY COMMITTEE ON NUCLEAR WASTE

August 2, 2005

The contents of this transcript of the proceeding of the United States Nuclear Regulatory Commission Advisory Committee on Nuclear Waste, taken on August 2, 2005, as reported herein, is a record of the discussions recorded at the meeting held on the above date.

This transcript has not been reviewed, corrected and edited and it may contain inaccuracies.

1 UNITED STATES OF AMERICA

2 NUCLEAR REGULATORY COMMISSION

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4 162ND MEETING

5 ADVISORY COMMITTEE ON NUCLEAR WASTE

6 (ACNW)

7 + + + + +

8 TUESDAY, AUGUST 2, 2005

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10 ROCKVILLE, MARYLAND

11 + + + + +

12

13 The Advisory Committee met at 8:30 a.m. in

14 T2B3 of Two White Flint North, Rockville, Maryland,

15 MICHAEL T. RYAN, Chairman, presiding.

16 PRESENT:

17 MICHAEL T. RYAN, Ph.D. Chairman

18 ALLEN G. CROFF, Ph.D. Vice Chairman

19 JAMES H. CLARKE, Ph.D. Member

20 WILLIAM J. HINZE, Ph.D. Member

21 RUTH F. WEINER, Ph.D. Member

22 ASHOK C. THANDANI Deputy Executive Director,

23 ACRS, ACNW

24 LATIF S. HAMDAN, Ph.D. ACNW STAFF

25 MICHAEL L. SCOTT ACNW STAFF

1 PRESENTERS:

2 KEN PICHA	DOE/EM
3 ANNA BRADFORD	NMSS/NRC
4 PAUL MURRAY, Ph.D.	AEA TECHNOLOGY ENGINEERING
5	SERVICES, INC.
6 BARRY BURKS, Ph.D.	TPG APPLIED TECHNOLOGY
7 DAVID KOCHER, Ph.D.	SENES/ACNW CONSULTANT
8 KEN GASPER, Ph.D.	DOE ORP, Ret.
9 JOHN PLONDINEC, Ph.D.	DIAGNOSTIC INSTRUMENTATION AND
10	ANALYSIS LABORATORY
11 LES DOLE, Ph.D.	OAK RIDGE NATIONAL LABORATORY

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P-R-O-C-E-E-D-I-N-G-S

(8:38 a.m.)

1) OPENING REMARKS BY THE ACNW CHAIRMAN

CHAIRMAN RYAN: This is the first day of the 162nd meeting of the Advisory Committee on Nuclear Waste. My name is Michael Ryan, Chairman of the ACNW. The other members of the Committee present are: Allen Croff, Vice Chair; Ruth Weiner; James Clarke; and William Hinze.

During today's meeting, the Committee will conduct a working group meeting on waste determinations. Latif Hamdan is the designated federal official for today's session.

The meeting is being conducted in accordance with the provisions of the Federal Advisory Committee Act. We have received no written comments, requests for time to make oral statements from members of the public regarding today's session. Should anyone wish to address the Committee, please make your wishes known to the Committee staff.

If we have overflow in this room from attendees, we have the capability to broadcast to other rooms that will be available in the building and I believe in the other building. And if that becomes necessary, Mr. Brown will help us make that hookup and

1 announce to everybody when our session here goes live
2 to other parts of the building.
3 We had one request to hook somebody up by
4 telephone, but evidently that individual is not
5 available at the moment. And if we do make that
6 connection, we will also advise when that telephone
7 participant hooks in if he is available by phone. He
8 doesn't seem to be available at the moment.
9 It is requested that speakers use one of
10 the microphones, identify themselves, and speak with
11 sufficient clarity and volume so they can be readily
12 heard. It is also requested that if you have cell
13 phones or pagers, kindly turn them off or place them
14 on mute.
15 I will now turn the meeting over to Mr.
16 Croff, Vice Chair, for the remainder of the day.
17 Allen?
18 VICE CHAIRMAN CROFF: Okay. Thank you,
19 Mike.
20 SESSION 1: INTRODUCTION AND BACKGROUND
21 2) INTRODUCTION TO WORKING GROUP
22 MEETING AND SESSION 1
23 VICE CHAIRMAN CROFF: On behalf of the NRC
24 Advisory Committee on Nuclear Waste, I would like to
25 welcome the Committee members, the ACNW staff, our

1 many speakers who have kindly shown up, as well as the
2 many observers here to this working group meeting on
3 DOE tank waste determinations.
4 Briefly stated, this working group meeting
5 was organized by the ACNW in consultation with NMSS
6 staff members to provide both organizations technical
7 insights relevant to preparation of a standard review
8 plan to determine the classification of waste in DOE
9 tanks by the NMSS staff and subsequent review of this
10 plan by the Committee.
11 To be clear on one point, this working
12 group meeting is not intended to focus on any specific
13 tank waste determination that has been or might be
14 developed by the Department of Energy.
15 The working group meeting is planned to
16 take two full days. And with the number of questions
17 I anticipate, I think we are going to need to be
18 somewhat ruthless about trying to keep people on
19 schedule here. We may get lucky, but I doubt it.
20 The working group meeting is divided into
21 an initial session that will provide background
22 information concerning the Department of Energy's tank
23 wastes and their plans for waste determinations and
24 then a discussion of criteria and historical NRC
25 activities concerning waste determinations.

1 This will be followed by a number of
2 speakers in three sessions, who will elaborate the
3 status and prospects of various scientific and
4 technical aspects of waste determinations.
5 Before we are introducing the first
6 speaker, I'd like to request we try to allow the
7 speakers in the first session to complete their
8 presentation with minimal interruptions for
9 clarification questions. After each of the first two
10 speakers, we will then entertain questions from the
11 Committee, NRC staff members. And then if any of the
12 other presenters have any questions, we will entertain
13 those.
14 To begin the meeting at the beginning, our
15 first speaker will provide an overview of DOE's
16 activities in planned waste leading to the need for a
17 waste determination.
18 I am pleased to introduce Ken Picha from
19 the Department of Energy, who is well-qualified to
20 provide such an overview. He has over 20 years of
21 experience in engineering, operations, and project
22 management for the government and the private sector.
23 He was previously the DOE's headquarters
24 program manager for radioactive start-up of high-level
25 waste immobilization facility at Savannah River and

1 has performed writing his reviews on a number of other
2 facilities.
3 More recently, he has coordinated the
4 complex-wide activities for the department's tank
5 waste program. In this capacity, he served as
6 sub-team leader for the development of the high-level
7 waste chapter in a revision of DOE's directive on
8 radioactive waste management.
9 Ken, the floor is yours.
10 3) OVERVIEW OF DOE'S APPROACH TO
11 MANAGING TANK WASTE
12 MR. PICHA: Good morning. Unfortunately,
13 I was delayed in the rush of people coming up, and I
14 didn't get a chance to do the logistics. How do we
15 forward the slides? Thank you.
16 Good morning. For some of you, you have
17 heard probably this presentation if you were there at
18 the first kickoff meeting of the National Academy of
19 Sciences study on certain radioactive waste back in
20 March. And for that, you may be bored. I'm sorry.
21 I've just got a few new slides to address
22 West Valley at the end, but other than that, it's
23 pretty much a repeat of that presentation because I
24 think it does set the stage for some of the specific
25 discussions that are going to come later today and

1 tomorrow.

2 We basically have four sites that the
3 department manages. That number up there of waste
4 represented about what was there prior to beginning
5 some of our mobilization efforts, tank waste retrieval
6 and mobilization efforts.

7 Basically we have three DOE-owned sites,
8 one at Hanford, one at Savannah River site, another at
9 the Idaho National Laboratory, and one site that's
10 owned by the State of New York: the West Valley
11 demonstration projection.

12 Our tank waste management strategy is
13 actually something that was developed pretty much in
14 the early '80s. So a lot of the activities that we
15 have been doing over the past few years was something
16 that started in the early to mid 1980s through
17 National Environmental Policy Act documents and
18 decisions resulting from those documents.

19 And so the fact that we had planned and
20 are implementing processes to basically take tank
21 waste, retrieve tank waste, treat some tank waste and
22 dispose of them as non-high-level waste have actually
23 been part of the department's plans for at least 20
24 years.

25 Of course, we certainly want to safely

1 store any waste that we have in our tanks to get it to
2 some form for disposal. We have to retrieve those
3 wastes. And then we have ended up pretreating waste
4 or planning to pretreat waste at Savannah River,
5 Hanford, and West Valley.
6 The low-activity waste stream, which is we
7 have separated the bulk of the radioactivity but kept
8 most of the volume, is intended to be disposed of on
9 site at the sites except West Valley. And then the
10 higher activity that contains the bulk of the
11 radionuclides but lesser the volume is intended to be
12 disposed of at a geologic repository.
13 At Savannah River, Hanford, and West
14 Valley, we intend to treat that high-activity waste
15 through the vitrification process. As I get to the
16 individual sites, I'll talk about the progress of each
17 of those sites.
18 The other thing I wanted to mention is I
19 think we have representatives from each of the
20 Savannah River, Hanford, and West Valley here, who may
21 be able to answer more specific questions if you have
22 any. I'm not sure there's anybody here from Idaho.
23 I don't see any familiar faces off the top of my head.
24 At Idaho, as I will talk about later, they
25 pretty much kept their waste in an acidic form. And

1 they basically denitrated that waste, the bulk of that
2 waste, and put it into a calcine form -- it's a dry
3 powder -- and have kept that in some storage bins
4 located on site while they made preparations to get
5 that ready to be packaged and disposed of at a
6 geologic repository.
7 And then, finally, as the speakers will
8 talk about today and tomorrow, there are going to be
9 some residues in the tanks that we will not be able to
10 retrieve. And we will have to disposition the tanks
11 and associated components.
12 At Savannah River and Idaho, we have
13 completed the environmental documentation to address
14 the alternatives associated with dispositioning of the
15 tanks and associated components.
16 We have not done a record of decision at
17 Idaho. And at Hanford and West Valley, the NEPA
18 documents associated with analyzing the alternatives
19 for handling the tanks and components are still in
20 progress.
21 At Savannah River site, we have about
22 130,000 cubic meters of waste. You can see the bulk
23 of that is -- somehow my math is wrong there. It's
24 about 38 million gallons. And so I have to get the
25 conversion. But obviously 11 in 127 and 130. So

1 something is off a little bit, but the proportions are
2 correct.
3 Most of the waste is in a salt or liquid
4 form and a lesser amount in sludge. It's about 430
5 million curies divided approximately equally between
6 the sludge and the salt and. supernate
7 It's alkaline waste. And it's generally
8 more homogenous than Hanford because they had less
9 reprocessing technologies that they use and less
10 variance in the fuels.
11 They have 51 tanks, 3 active evaporators,
12 which they use for controlling the volume and
13 minimizing the volume that they need to safely store.
14 They have active sludge pretreatment facilities that
15 they have been using since I guess about the mid 1990s
16 to prepare the sludge for vitrification in the
17 vitrification facility, the defense waste process
18 facility there.
19 And then at the DWPF, they have processed
20 and created over 1,500 cans of vitrified waste. Those
21 are stored in a separate facility adjacent to the DWPF
22 in an underground below-ground storage configuration.
23 The site is currently in the process of
24 designing and constructing facilities to handle the
25 salt waste portion of their tank waste. The

1 cornerstone of that will be a salt waste processing
2 facility that will basically separate out most of the
3 cesium, strontium, and the actinides at the site.
4 They're working on some other interim
5 processing facilities at this time. And their major
6 -- I'm not sure you can see that down here, but their
7 milestones for completing their process are 2019 for
8 immobilizing all of their high-level waste and the
9 early 2020s for closing all of the associated
10 facilities, high-level waste facilities, on the site.
11 We put these slides together. There's one
12 of these for each of the four sties. And it's
13 basically trying to simplify the waste management
14 strategy at each of the four sites. And I don't want
15 to belabor this a whole lot, but I'll just point out
16 some of the major aspects.
17 This represents all of the tanks down
18 here. The orange nominally represents a facility
19 associated with I'll say high-level waste. The green
20 facility, green shading, is for the low-activity waste
21 that we would then manage as low-level waste, dispose
22 of on site as low-level waste.
23 And the violet is -- basically that's a
24 facility for treating things like evaporator overheads
25 and some other related very low activity stuff that

1 eventually allows that waste stream to be discharged
2 through an NPDES permitted outfall on the site.
3 Some of the other aspects on this are the
4 dotted lines represent facilities that are in
5 construction or being designed. They don't exist at
6 this time. And if it's the solid, it does exist.
7 I probably should have dotted lined the
8 repository there, but, at any rate, one of the other
9 things you can see here is the division of radioactive
10 waste relative to what's going to be the high-level
11 waste going to a geologic repository and the
12 low-activity waste that would be disposed of on site.
13 It gives you a rough breakdown of both the
14 curies and the volume. I don't want to stress the
15 exact numbers, but that's a pretty representative cut
16 on the numbers. And then down here is an estimate of
17 the residual waste that would be left in all of the
18 facilities on the site.
19 Current status. As I mentioned earlier,
20 we have been operating the DWPF since 1996. The
21 planning for basically the retrieval and the
22 processing of salt waste through some interim
23 salt-processing facilities that we hope to begin,
24 either later this year or early next year, those will
25 be dependent upon a waste determination through a

1 process that was in the National Defense Authorization
2 Act of 2005, section 3116; and then a full capability
3 salt waste-processing facility that will hopefully
4 come on line in 2009.
5 Basically I mentioned that there. And
6 then the stabilization of residual waste in tanks via
7 grout was analyzed as one of the alternatives in a
8 NEPA document. And the actual disposition in that
9 regard would be dependent upon a waste determination
10 that would be prepared in accordance with section 3116
11 of the NDAA.
12 We had two tanks at Savannah River that
13 were closed in 1997, prior to DOE's order on
14 radioactive waste management and through consultation
15 process with the Nuclear Regulatory Commission. And
16 I think Anna or somebody will talk a little bit about,
17 touch on that later.
18 At our Hanford facility, we have a
19 separate office that was created in I think 1998, the
20 Office of River Protection, to manage the tank farms
21 and associated activities there to treat and
22 disposition the tank waste. There are about 200,000
23 cubic meters of waste, about 200 million curies in the
24 tanks.
25 Back in -- I can't even remember the time

1 frame, Bill -- '60s, '70s.

2 MR. HEWITT: Nineteen sixty-five to --

3 MR. PICHA: Okay. They processed out some

4 of the cesium and strontium and placed those into

5 capsules that are stored at their -- what was it, the

6 waste encapsulation storage facility on site.

7 This is certainly the bulk of the tanks in

8 the system, 177 tanks that are divided up into 149

9 what we call single shell tank, where there is not a

10 double containment kind of a system or confinement

11 system. Twenty-eight are double shell tanks.

12 They have constructed a high-level waste

13 canister storage building, which is going to be used

14 for storing both high-level waste and spent fuel. And

15 I believe some spent fuel is in there already.

16 One of the major drivers of the activities

17 at Hanford is a tri-party agreement, an agreement

18 between the state, the EPA, and the DOE, which

19 contains a number of milestones. In fact, I'm always

20 astounded at the number of milestones. But some of

21 the more significant ones are at 2024 to close all the

22 single shell tanks and 2028 to complete immobilization

23 of all the high-level waste, not the low-activity

24 waste. I'll talk a little bit about how this differs

25 a little bit from what is being done at Savannah

1 River.

2 This again shows the tanks. There's a
3 little bit of a different waste stream in here than
4 there was for Savannah River. At Hanford, a number of
5 tanks -- I think it's on the order of about 10 to 20
6 tanks -- contained some waste that resulted from, as
7 I understand it, plutonium purification activities.
8 And we would certainly propose that an argument could
9 be made that those were not associated directly with
10 reprocessing. And so, therefore, they were not waste
11 resulting directly from reprocessing. And so we are
12 looking at whether or not we could disposition those
13 as transuranic waste and send that to WIPP.

14 The other aspects are similar to Savannah
15 River. As I'm sure many of you know, the cornerstone
16 at Hanford is the waste treatment plant. It's a
17 facility or set of facilities that include both
18 pretreatment facilities, a laboratory, a low-activity
19 waste melter, vitrification melter building, and a
20 high-activity waste vitrification facility.

21 That's in construction now. And it will
22 receive waste directly from the tanks and then process
23 it as accordingly and do a separations process and
24 then either go to the high-level waste melter or to
25 the low-activity waste melter and then be disposed of

1 in an integrated disposal facility on site.

2 The other piece that is part of the

3 Hanford strategy is that the low-activity waste melter

4 vitrification capability is not sufficient to get them

5 to be able to complete their activities in a very

6 timely manner. I don't remember the date, but if you

7 relied only on that, it would send it out to I'm going

8 to say 2040 beyond.

9 So what they're looking at is some

10 alternative technologies to augment the low-activity

11 waste melters in the waste treatment plan. And,

12 actually, that will end up processing as much or more

13 of the low-activity waste than the low-activity waste

14 melters will be.

15 They are currently conducting a

16 demonstration project using an approach called bulk

17 vitrification. And I'm not sure exactly where they

18 are in that process, but some of the folks here from

19 the Hanford site can probably give you more details if

20 you are interested in that.

21 And, again, that waste will also go to the

22 integrated disposal facility on site; again, the

23 breakout of approximately what we're looking at in

24 terms of curies and volume in each of these

25 disposition paths.

1 And one thing I didn't mention, -- I did
2 globally but not specifically for Savannah River; I
3 probably should have -- the plan for the disposition
4 of Savannah River I mentioned was through a NEPA
5 process. And I think that was done in the early '80s,
6 '81-'82 process. I believe this was '85, something
7 like that.
8 Well, this strategy, this general strategy
9 -- I don't want to say all the specifics -- were
10 generally mapped out prior to any recognition in the
11 DOE sphere of an incidental waste process, but it was
12 clear that that was our intent at that time frame. In
13 fact, there are some words that I have in an
14 environmental impact statement from that time frame
15 that talks about that. I guess that's about it for
16 Hanford.
17 Current status is they have basically
18 completed the bulk of -- the transfer of the bulk of
19 the liquids and the single shell tanks to minimize
20 risk of leaks that are completing construction of the
21 waste treatment plant.
22 I already talked about this a little bit,
23 that approximately 50 percent or so will go through
24 the low-activity waste melters. The remainder will be
25 through the supplemental technologies, one of which

1 they're looking at is the bulk vitrification process.
2 They have completed retrieval and cleaning
3 of tank C-106. The site is currently in discussions
4 with the NRC here on a process that was included in
5 their tri-party agreement if they couldn't reach
6 certain retrieval milestones. And they're in the
7 process of working out some details of having the NRC
8 take a look at what they have come up with in terms of
9 the capabilities demonstrating that they have
10 retrieved what they can technically and economically
11 achieve. NRC needs some additional documents from
12 them to be able to complete that review.
13 As I mentioned in one of the earlier
14 slides, the environmental impact statement on closure
15 of single shell tanks is in process right now. And
16 then this last bullet refers to the pathway for
17 certain of the tank wastes to be dispositioned as
18 transuranic waste at WIPP.
19 At Idaho, I guess they had a good idea
20 back when they initiated processing by not
21 neutralizing their waste and storing waste in
22 stainless steel tanks. They have certainly less
23 volume of waste, both the stuff that has been calcined
24 and the liquid waste that still remains in the tanks,
25 about 25 million curies on site.

1 The facilities that they have there
2 primarily are 11 primary storage tanks, stainless
3 steel tanks, since they didn't neutralize their waste,
4 4 smaller auxiliary tanks. And then they have a
5 high-level waste calcine facility. And then they have
6 seven calcine bin sets, where they have stored the
7 calcine, one set of which has not been used yet.
8 They have several agreements with the
9 state in terms of when they need to complete their
10 activities. Probably the more important one is to
11 complete treatment of the remaining liquid wastes in
12 the tanks, of which is about 900,000 gallons, by 2012.
13 And then sort of associated with that is
14 ceasing use of the tanks by 2012 and then to treat the
15 calcine waste, which is normally the high-level waste,
16 to be road-ready for disposal by 2035.
17 Again, a similar diagram that's for
18 Hanford and Savannah River. Probably the one
19 exception here is that there they had some NEPA work
20 done in 1995 associated with spent fuel, actually,
21 where they had also looked at some of their -- an
22 early look at their high-level waste disposition. But
23 they didn't really complete their NEPA work until I
24 guess it was 2002 when they completed their final EIS.
25 And because they already pretreated,

1 treated their waste in some manner to a calcine, they
2 don't have the separations process in a low-activity
3 waste stream, like we do at Hanford and at Savannah
4 River. We have the calcine that would be nominally
5 packaged or treated as necessary to meet whatever
6 requirements that we ultimately have for a repository.
7 And then it would be sent to a repository. Again,
8 that's the bulk of the radioactivity. An estimate
9 right now is it would be about 5,000 cubic meters in
10 volume.
11 We have this what we call sodium-bearing
12 waste stream as primarily decontamination solutions
13 that were used throughout the facility there at Idaho,
14 the Idaho Nuclear Technology Engineering Center. It
15 included both the tanks. It included the reprocessing
16 facilities, the calcine facilities, that type of
17 thing. And that contains primarily, as I said,
18 decontamination solutions.
19 And then they have actually two
20 evaporators, but they all have this kind of effluent
21 treatment facility that will allow some on-site flow
22 of discharge of fluids that are very low in activity.
23 I think I probably covered most of this.
24 The second item here is that in, I want to say, May,
25 the department basically awarded a contract at Idaho

1 for management of these wastes and some other
2 associated activities and that one of the ways that
3 the contract was set up was to allow the contractor to
4 choose a technology for treating the sodium-bearing
5 waste.
6 And they have identified initially a
7 technology that we were in the process of trying to
8 make public through a Federal Register notice. And I
9 know that is in concurrence in our department right
10 now.
11 If we end up sending that waste to WIPP as
12 transuranic waste, it will require some kind of a
13 determination to be determined. As I'm sure many of
14 you know, waste that would be disposed of off site at
15 Idaho and Savannah River, for that matter, is not
16 covered under section 3116 of the National Defense
17 Authorization Act. So we would not do any kind of a
18 determination under that, but we're looking at other
19 approaches.
20 I think this number is a little low. I
21 think that number is now seven. I didn't go back and
22 update this slide. I think they've completed cleaning
23 and characterization of 7 of the 11 tanks that they
24 have done.
25 Again, because they have acidic waste,

1 they don't have the harder sludges that we have at
2 Savannah River and Hanford and West Valley. And, as
3 you can see, they were able to get down to a level of
4 less than 500 gallons in a tank that's nominally --
5 I'm not sure of the size. These are smaller tanks and
6 typical at Savannah River and Hanford, but that's I'll
7 say nominally a half an inch, an inch or so at the
8 bottom or even less.
9 The State of Idaho has approved -- I think
10 they used the term "partial RCRA closure plans" for
11 addressing those seven tanks. And then the
12 stabilization of the residual waste via grout was
13 analyzed in the alternative in their NEPA document.
14 And they have not issued a record of decision on that.
15 And certainly we would have to do a determination
16 under section 3116 of the NDAA to allow that to
17 proceed.
18 I was not intending to talk specifically
19 about any waste determination. Allen mentioned
20 something about that. I can answer some questions
21 later if you have some questions about where we are in
22 terms of planning for doing those, but I was not
23 intending to talk about that specifically. And I'm
24 just giving an overview of the department strategy in
25 managing the tanks and how we were just going to

1 disposition the waste.

2 Unfortunately, I put these slides together
3 and sent them to Latif before I had a chance to get
4 some review by the West Valley folks yesterday. So
5 there are some errors in here that I'll point out as
6 we go.

7 Originally they had about 2,300 cubic
8 meters of waste primarily in one tank at West Valley,
9 about 25 million curies. Again, primarily it was
10 alkaline waste. They did have some thorex acidic
11 waste that they had stored in a separate stainless
12 steel tank there. And they ended up blending it
13 through a very rigorous engineering analysis and
14 safety analysis that has now been primarily retrieved
15 with the other waste and treated, which I'll get into
16 here in a minute.

17 They had two primary tanks, storage tanks,
18 and two smaller stainless steel tanks. They had a
19 vitrification facility that operated from 1996 through
20 about 2002. That's in the process of being
21 dismantled. I'll talk to that a little bit more
22 later.

23 They have a high-level waste canister
24 storage facility. It's basically a set of racks that
25 were installed in the old chemical process cell that

1 was operated by the folks who operated the
2 reprocessing facility. They did a lot of D&D, took a
3 lot of the components out of that and put these racks
4 and storing the canisters there.
5 They have a separate drum cell, a shielded
6 drum facility for storing their low-activity waste
7 that they created as part of the tank waste
8 disposition process. I'll talk about that a little
9 bit later. And then they also had a pretreatment
10 facility that they used for pretreating the liquid
11 waste.
12 And there are several, I'll say,
13 unresolved issues with the State of New York on
14 various things: ownership issues, the waste, who is
15 going to pay for disposal, how much has to get cleaned
16 up by the department under the act, those kinds of
17 things.
18 Let's see. Similar slide as before. One
19 of the things that's wrong here is this has now been
20 done. And I'll talk about that waste stream in a
21 minute. This is not 20 cubic meters. It would be
22 nice if we could get it down to that level. It's
23 about 250 cubic meters. I'll say roughly .7, .8 cubic
24 meters per canister. There are 275 canisters.
25 The bulk of the radioactivity, though, is

1 in the canisters. This number is I am thinking about
2 a third of that. It had about a little less than
3 10,000 curies in their low-activity waste stream.
4 And what they did at West Valley is they
5 operated their pretreatment facility. They used a
6 zeolite ion exchange process. And then they ended up
7 dumping the ion exchange through the bottom of one of
8 the tanks using a grinder to mix it with the sludge
9 and sending it over to the vitrification facility.
10 The low-activity waste, they got very good
11 DFs through that process. And they ended up with I'll
12 say almost 20,000, a little bit short of 20,000. What
13 they did, rather than use faults, they ended up using
14 drums. And they are roughly 71-gallon. They are
15 actually steel square drums so they could put them on
16 an edge. And they're in this drum cell I showed on
17 the previous page awaiting an off-site disposal. And
18 there are my understanding is about 10,000 curies
19 associated with that.
20 The sodium-bearing waste water when they
21 were doing retrieval and transferring waste from one
22 tank to another, they only retrieve waste to go to the
23 vitrification building out of one tank. They ended up
24 with some pump seal water that was leaking into the
25 tanks. That's primarily what this is. And it's been

1 treated, and it's stored on site.

2 And I'm trying to recall the volume. I

3 want to say it was 5,000 gallons is the volume, but

4 the West Valley folks maybe can give you a better

5 number on that. I forget the curies. I think they

6 were on the order of perhaps what was in the

7 low-activity waste drums.

8 Because they are complete with their

9 high-level waste treatment, they're in the process now

10 of trying to do some things that they can do ahead of

11 completing their environmental impact statement for

12 long-term stewardship and decommissioning of the

13 entire site.

14 So they're dismantling a number of the

15 components there on site, the vitrification cell that

16 is there. They have pulled out some of the major

17 components and have those stored on site. And it may

18 be that some of those end up in concentrations that

19 would be above our transuranic waste classification

20 and may need to go to WIPP. There are some issues

21 associated with that in terms of defense waste that

22 would need to get resolved. So we have shown that as

23 a possibility. Most of it is going to go here and off

24 site.

25 As I mentioned, most of the pretreatment

1 activities were completed in the mid 1990s. They
2 completed vitrification in 2002. And they have
3 started initial project facilities cleaning and
4 dismantlement. And I mentioned the environmental
5 impact statement that is ongoing now to determine
6 final disposition of the tanks and some other
7 components on site. And I believe that's it.
8 VICE CHAIRMAN CROFF: Great. Thanks.
9 Let's try some questions here. Bill?
10 MEMBER HINZE: I'm interested in the
11 status of your vitrification process. Where do you
12 stand? Have you got all the problems taken care of
13 with -- thank you. I'm sorry. I tried to keep the
14 straight face. I just like to know where you are.
15 MR. PICHA: At DWPF, I showed that we had
16 over 1,500 canisters completed there. We have already
17 done a melter change out there. So we have
18 demonstrated that technology and that capability. I'm
19 not sure how many canisters we're on on the second
20 melter, but there have been some operational hiccups
21 with that, particularly with poor streams in terms of
22 wicking to the size of the walls and that kind of
23 thing. I think most of those have been ironed out.
24 I probably can't tell you too much more of
25 the specifics. I know we have been able to increase

1 waste loading. Some folks here could probably give
2 you more specifics on that. Ramp that up from I think
3 the high 20 percent or so to low 40s. So we have had
4 some success in that.
5 Again, we're not processing salt waste
6 component, which has the bulk of the radioactivity,
7 the nonactive ion radioactivity. At West Valley, we
8 had quite a bit of a success there. We were able to
9 complete that on the single melter over a six-year
10 time frame. And I think they're in the process of
11 doing some of the analysis to verify the little small
12 samples that they took are in agreement with the
13 projected performance that they suspected based upon
14 doing some of the projections.
15 At Hanford, we're in the middle of
16 constructing the vitrification facilities there for
17 both the high-activity and low-activity waste melters
18 at Hanford.
19 Did you want --
20 MEMBER HINZE: Well --
21 MR. PICHA: If you need something more
22 specific, I think we'll have to defer to some --
23 MEMBER HINZE: I'm sure we're going to
24 learn more as the program goes on. Let me ask you, is
25 there a difference between the vitrification process

1 for low-level waste and high-level waste? I was
2 surprised to see you going to the vitrification for
3 the low-level waste.
4 MR. PICHA: That was a process that was
5 ironed out with the states. And in I think the
6 environmental impact statement in the mid '90s, when
7 they went with that technology, in terms of the actual
8 differences, whether or not the feed process, whether
9 you use chemicals or whether you use FRIT, I can't
10 speak to that.
11 And I guess I would defer. I don't know
12 who the right person. Bill?
13 MR. HEWITT: Yes. The low-activity
14 process.
15 VICE CHAIRMAN CROFF: Come to a
16 microphone. Identify yourself.
17 MR. HEWITT: I'm Bill Hewitt with YASIC.
18 We support the Office of River Protection.
19 We're looking at two low-level processes.
20 Really, at the low-level waste, it's kind of the junk
21 end. It takes the stuff that we can't get in to
22 high-level waste, but it turns out of borosilicate
23 glass. And it ranges from 12 percent sodium to 20
24 percent. But it's similar glass.
25 MEMBER HINZE: And a similar process. Let

1 me ask you one more question, if I might. What are
2 the plans for the canisters on the glass blocks, glass
3 logs going into the high-level waste repository?
4 MR. PICHA: Well, as I showed, for
5 instance -- well, maybe it's not here. This happens
6 to be West Valley. I talked about the racks. Those
7 are being stored right --
8 MEMBER HINZE: Right. But I'm speaking
9 about them to the geological repository.
10 MR. PICHA: Well, the plans are there, at
11 least as far as I knew -- they were actually being
12 proposed to be co-disposed with spent fuel. And there
13 were different configurations being looked at.
14 I think at Hanford, where the canisters
15 were going to be 15 feet, the fuel assemblies from the
16 end reactor I think were comparable length. They were
17 proposing I think two fuel assemblies from end reactor
18 and two canisters from -- there's better, more
19 information --
20 MEMBER HINZE: Basically, alloy 22 can --
21 MR. PICHA: Oh, yes. Oh, yes.
22 MEMBER HINZE: Okay.
23 MR. PICHA: Absolutely.
24 MEMBER HINZE: Thank you.
25 VICE CHAIRMAN CROFF: Thanks. Mike?

1 CHAIRMAN RYAN: I guess this might be just
2 a comment. There may be a question in here somewhere.
3 When I think about these kinds of processes that you
4 have outlined for all of the facilities, the question
5 comes to my mind, "How much of the processing is done
6 because it's the way to do the chemical engineering
7 and the process to get it in the right waste form?
8 And then how much of it is aimed at meeting a waste
9 acceptance criteria?" And there's always that balance
10 in there.
11 And maybe that's such a global question
12 it's hard for you to answer now, but I guess as we
13 think about these couple of days, that's the sort of
14 thinking I'm focused on. And if you want to make an
15 opening comment on it, then we'll hear more about it
16 as we go along. That would be great. But what do you
17 think?
18 MR. PICHA: Well, it's sort of a chicken
19 and egg thing, I think. But, frankly, those decisions
20 were substantively made prior to me even getting
21 involved. And I'm not sure exactly how it evolved.
22 I'm pretty sure that it was probably -- let me strike
23 that.
24 I am going to guess that certainly some of
25 the chemical aspects drove to the selection of the

1 waste form, but I can't speak to that, whether --

2 CHAIRMAN RYAN: Fair enough. But, again,

3 as we kind of go through, I think that's -- you know,

4 when you think about the NRC's view of how they are

5 going to create a guidance document in this area, both

6 of those questions I think are at least intimate with

7 these whole processes.

8 And I think that's maybe one of the focus

9 points that the Committee will be thinking about as we

10 go through the two days. So I'd ask maybe the other

11 speakers and you as we participate to think about that

12 and maybe help us understand your insights there as

13 best we can.

14 Thanks.

15 VICE CHAIRMAN CROFF: Okay. Ruth?

16 MEMBER WEINER: I just have a couple of

17 questions. What is your curie loading going to be

18 like in 2024, 2028, in that kind of time frame? Some

19 of this stuff has been sitting in these tanks for a

20 while.

21 MR. PICHA: That's right. Well, if you

22 think, for instance, for cesium and strontium, which

23 have half-lives of about 30 years, if you're talking

24 almost a complete half-life, the bulk of this

25 radioactivity, well, I'm not sure how much -- it's

1 still I think primarily driven by cesium and strontium
2 in terms of bulk radioactivity. So it still, you
3 know, could be half that.
4 MEMBER WEINER: Have you looked at this in
5 terms of ultimate disposal, temporary disposal. I
6 mean, some of this stuff if you just let it sit long
7 enough at this point, the activity will decay away.
8 MR. PICHA: Actually, one of the things
9 that we're looking at in some early analyses here for
10 this liquid waste at Idaho is that to try to do, if
11 you will, a curie balance.
12 And one of the things is to try to start
13 with what was actually created as a result of
14 reprocessing and just looking globally at different
15 disposition paths. And certainly some of it is decay
16 since I'm not sure when they started, maybe late '50s
17 or early '50s, mid '50s in Idaho. That's almost two
18 half-lives. So, I mean, there's been a fair amount of
19 decay.
20 Now, whether or not you are asking a
21 technical question as to whether or not we would make
22 an -- or maybe a legal question or regulatory question
23 whether we would make an argument that towards the end
24 of our processing campaigns, that activity would be
25 low enough to say, "Maybe this doesn't warrant

1 geologic disposal." We're not in that mode right now.

2 MEMBER WEINER: Thank you.

3 You've mentioned several times disposal at

4 the WIPP. The rH TRU component at the WIPP by the

5 Land Withdrawal Act is five percent of the

6 million-barrel equivalents can be rH TRU.

7 What determinations are still required

8 before you can go through with that? Because

9 basically isn't the rH TRU the same stuff as

10 high-level waste? I mean, physically it's about the

11 same thing.

12 MR. PICHA: Well, I don't know necessarily

13 all the waste streams that were envisioned that would

14 make up the rH TRU process. But certainly some of the

15 waste streams are going to be isotopically probably

16 similar to high-level waste.

17 I do know that for this waste stream, for

18 the one on ORP, this waste stream here, that those are

19 part of the -- I forget the specific title of the

20 document, the EPA recertification document. Those

21 have been included in there for analysis. And I'm

22 going to say that some attempt has been done to look

23 at how that might stack up against the five percent.

24 We have actually backed off on doing

25 anything here vigorously until we get the remote

1 handle waste permit at WIPP because we don't want to
2 jeopardize that by pushing these things
3 simultaneously.
4 MEMBER WEINER: I see. Thank you.
5 What are you doing with the empty tanks?
6 What is going to be the final disposition? I remember
7 this has been a matter of discussion at Hanford for I
8 will say decades.
9 MR. PICHA: Sure. Well, at Hanford,
10 you're probably aware they are in the middle of doing
11 an environmental impact statement on looking at
12 alternatives for dispositioning the single shell tank
13 components and associated components. And we're not
14 at a draft -- we haven't issued the draft yet, right,
15 Bill? Yes.
16 So, as you might imagine, there are a lot
17 of regulatory issues as well as technical issues in
18 looking at alternatives there. And so I don't
19 remember exactly how many alternatives are being
20 evaluated -- I want to say three or four -- to look at
21 how we might disposition those tanks and associated
22 facilities.
23 But it's certainly to be determined in
24 terms of officially based upon any kind of NEPA
25 documents. However, clearly we're looking at trying

1 to get the bulk of the waste out that we can using
2 whatever measures are technically and economically
3 practical.
4 At Savannah River, for instance, the
5 preferred alternatives in the record of decision was
6 to close the tanks using grout as a stabilization
7 matrix after you have done the retrieval to the extent
8 practical.
9 At Idaho, we haven't issued a record of
10 decision, but that was the alternative there,
11 preferred alternative there. And at West Valley,
12 we're doing the NEPA to decide how we proceed at West
13 Valley.
14 In general, I was saying from an overall
15 Complex Y perspective, we're looking at closing tanks
16 with some residuals left. But at individual sites, it
17 may vary depending on how the NEPA turns out.
18 MEMBER WEINER: Is that also your
19 preferred alternative for Hanford, closing them and
20 grouting them?
21 MR. PICHA: Well, certainly we have done
22 a fair amount of effort there. I wouldn't say we --
23 until we do the NEPA, I don't think we can say we have
24 a preferred alternative. Is that --
25 MEMBER WEINER: Don't you have one in the

1 NEPA?

2 MR. HEWITT: There isn't a preferred

3 alternative.

4 MR. PICHA: Right.

5 MEMBER WEINER: Okay. Thank you.

6 Finally, how do you stabilize the calcine,

7 the INL calcine, physically? I mean, it's a very fine

8 powder.

9 MR. PICHA: It is. And I know that I've

10 not been involved in much of that. There are some

11 issues associated with that. I think they're looking

12 at different approaches, including, for instance,

13 whether or not you could use some kind of a fixative

14 to basically allow it to maintain some kind of I would

15 say assorted solid properties, if you will, for

16 purposes of shipping and disposal, but then we have to

17 demonstrate that that could satisfy the waste

18 acceptance requirements of Yucca Mountain.

19 Plus, there are some issues with the

20 hazardous aspect of that waste form that would have to

21 be resolved as well. And that's being looked at as

22 well.

23 So we haven't determined exactly what

24 needs to be done with that waste form to get it to

25 Yucca Mountain.

1 MEMBER WEINER: Thank you.

2 VICE CHAIRMAN CROFF: Jim?

3 MEMBER CLARKE: I was interested in the
4 ultimate disposition of the tanks as well. And I
5 guess we're going to hear more about that later. For
6 example, the cover systems that might --

7 MR. PICHA: Yes. I think throughout the
8 day today and tomorrow, you're going to hear different
9 aspects of the tank waste disposition program. And I
10 think there's one or two discussions by Barry and John
11 that are going to talk about characterization and
12 retrieval approaches that we have investigated and
13 used at the different sites.

14 Oak Ridge, I didn't talk about Oak Ridge
15 here, but they had some tank waste that they used some
16 innovative approaches to retrieving tank waste and
17 getting it prepared for disposal.

18 MEMBER CLARKE: Are there any design
19 requirements for ultimate covers if tanks are
20 stabilized and left in place?

21 MR. PICHA: For covers like a --

22 MEMBER CLARKE: Cap.

23 MR. PICHA: -- cap? Yes. While I won't
24 say there are final design requirements, there are
25 certainly some considerations. We actually had to

1 look at that for one of the waste streams at Savannah
2 River with regard to something similar to this
3 disposal facility at the vaults that would be
4 nominally used for disposing of salt stone.
5 If you want a specific answer at specific
6 sites, I think I would ask somebody to talk about, for
7 instance, at Savannah River. Sherry, can you answer
8 that?
9 MEMBER CLARKE: That's okay. We probably
10 need to keep moving, Allen. That's fine. Thank you.
11 VICE CHAIRMAN CROFF: Okay. I guess I've
12 got a couple of questions. First, it's going to be
13 maybe a bit of a lengthy one, but I'm trying to get
14 some idea of the range of wastes for which DOE may be
15 submitting waste determinations.
16 Now, we have talked about the closed
17 tanks. And we have talked about immobilized
18 low-activity waste that's disposed on site. And those
19 seem to be fairly generic. But I'm wanting sort of to
20 know, you know, what else may need to be considered in
21 the standard review plan. And let me give you some
22 examples.
23 MR. PICHA: Okay.
24 VICE CHAIRMAN CROFF: You can -- well, I
25 hope not run away screaming, but failed equipment,

1 such as a used high-level waste melter, piping that
2 connects tanks together and connects tank farms
3 together, evaporator systems, the cesium and strontium
4 capsules up at Hanford.
5 And, lastly, just to maybe really vex you,
6 at least at Hanford, there have been significant leaks
7 of tank wastes into the soil. How are you going to
8 deal with that soil?
9 MR. PICHA: Let me take the last one
10 first. I was not part of that, but a couple of weeks
11 ago, there was a meeting here at the NRC, announced
12 meeting, with regard to some technical topics. And
13 one of those was, how do we address contamination
14 spills and the like in our waste determination
15 process?
16 And I can tell you that the slides that we
17 use because I was on vacation when that was done. So
18 I don't actually have the specific outcome of the
19 discussions, but basically what we had proposed was
20 that those are nominally covered under other
21 environmental activities, like CRCLA, like primarily
22 CRCLA, I think, because those are not wastes that we
23 typically manage or actively manage and can have
24 control over. Those have been, unfortunately,
25 released to the environment. And they're part of a

1 cleanup action.

2 VICE CHAIRMAN CROFF: Okay.

3 MR. PICHA: So with regard to that. With
4 regard to you're right about the low-activity waste is
5 a major one that we look at doing waste
6 determinations. Residuals in high-level waste
7 management facilities would be another set of waste
8 determinations.

9 Contaminated equipment. I haven't shown
10 it on all of there. I did show it, though, in West
11 Valley because we are at that point where it is
12 starting to become an issue.

13 Certain of the components will clearly
14 require some kind of a waste determination, things
15 like melters, where we actually have obviously some
16 certain amount of waste left in the melters or, you
17 know, at least would be candidates for a waste
18 determination process, maybe some of the major vessels
19 associated with the vitrification process.

20 With regard to interconnecting piping and
21 evaporators, we're sorting that out right now at the
22 various sites. At Idaho, what we are considering
23 right now is a waste determination that covers these
24 components as well as the piping, the diversion boxes.

25 VICE CHAIRMAN CROFF: So you're going to

1 sort of bundle the piping and some of this closely
2 connected --
3 MR. PICHA: That is what we are looking at
4 right now.
5 VICE CHAIRMAN CROFF: Okay.
6 MR. PICHA: Savannah River I think is
7 looking at something comparable to that. And I think
8 Hanford is in the early stages of scoping their
9 determination process.
10 With regard to the cesium and strontium
11 capsules, I'm going to take a pass on that and let
12 maybe the Hanford folks address. As far as I know,
13 that's not something that's on our scope right now for
14 being looked at in terms of a waste determination.
15 VICE CHAIRMAN CROFF: Okay. On the -- go
16 ahead.
17 MR. PICHA: Did I miss anything?
18 VICE CHAIRMAN CROFF: No.
19 MR. PICHA: Okay.
20 VICE CHAIRMAN CROFF: On the soils, you
21 mentioned that DOE had I'll call it floated this idea
22 a couple of weeks ago. Who gets to say whether the
23 idea is a thumbs up or a thumbs down; in other words,
24 treating contaminated soils under CRCLA, for example?
25 MR. PICHA: Well, good question. Do you

1 mean --

2 VICE CHAIRMAN CROFF: Do you just sort of

3 say, "We're going to do this," and if nobody objects,

4 you go ahead?

5 MR. PICHA: I'd say that would be the

6 nominal plan. You know, we're not necessarily going

7 to go out proactively and say, "Okay. Is this okay."

8 VICE CHAIRMAN CROFF: Okay.

9 MR. PICHA: As part of the CRCLA process,

10 I think that that would be a way of getting to some of

11 that.

12 VICE CHAIRMAN CROFF: Okay. A second

13 question. In the West Valley tanks that have been I

14 guess retrieved as far as you intend to, about how

15 much waste is left in that in the bottom?

16 MR. PICHA: In terms of volume and --

17 VICE CHAIRMAN CROFF: I was thinking more

18 in terms of a thickness kind of a thing, you know, I

19 mean, half an inch, five inches.

20 MR. PICHA: The tank structure at West

21 Valley, particularly at the bottom, is very

22 complicated with a bunch of stiffeners throughout the

23 bottom of the tanks. I'm going to say it's probably

24 varied but less than an inch. Can you all carburet

25 that?

1 VICE CHAIRMAN CROFF: Roughly an inch.
2 Okay. All right. Thank you.
3 I guess do any NRC staff members -- Latif?
4 DR. HAMDAN: My question is, is there any
5 effective communication of knowledge, technology
6 information among the four sites or the issues are so
7 site-specific that everyone is a project by itself?
8 MR. PICHA: Well, the answer is yes, sort
9 of. From about I'd say mid 1990s through I'll say
10 2002, 2003, we had something called a tanks focus
11 area. It was a technology development and assessment
12 group that basically represented the four high-level
13 waste sites and Oak Ridge, where they really were a
14 technology integration group.
15 And we actually had champions. I think we
16 called them technical integration managers. And we
17 had one for each of the various functions associated
18 with managing tank waste.
19 We had one for retrieval. We had one for
20 characterization. We had one for mobilization. John
21 was the mobilization guy. Barry was part of that.
22 Were you one of the technology integration managers,
23 Barry?
24 DR. BURKS: Yes, robotics.
25 MR. PICHA: Robotics. Unfortunately,

1 through whatever means and thought processes, that
2 group was abandoned. And we don't have those focus
3 areas anymore.
4 So we're trying to figure out how we can
5 replace that function through other means. One of the
6 ways that has been doing is I know particularly at
7 Savannah River and Hanford, they have been very
8 proactive in establishing their own technology.
9 How would you characterize that, Sherry?
10 Technology, not transfer but technology sharing. What
11 do you call those meetings?
12 MS. MEADOR: Actually, I'm not involved.
13 MR. PICHA: You're not involved? Okay.
14 MR. GASPER: I was involved.
15 MR. PICHA: Okay, Ken.
16 MR. GASPER: I'm Ken Gasper from Hanford.
17 Just to supplement your comments, Ken,
18 prior to the tank focus area, we had an integration
19 organization with high-level activity, low activity,
20 low-level activity D&D.
21 And Bill Lawrence from West Valley chaired
22 the high-level. Don Woodrich and I represented
23 Hanford and our counterparts from Savannah River, for
24 example, and Oak Ridge were involved.
25 In the period since the tank focus area,

1 we have maintained the technical integration activity.
2 I was technical integration manager for the tank farms
3 at Hanford. And my counterparts at Savannah River
4 were Savannah River National Lab and the Savannah
5 River operations activity, were involved.
6 And we have had annual meetings, technical
7 exchange meetings. We had biweekly telephone calls.
8 And we focus on the processing activities, the safety
9 activities, the technology activities.
10 We published reports that were available
11 and still are available of those meetings, those
12 annual meetings. And this year we also began
13 involving Idaho Falls. In previous years, we had
14 involved Oak Ridge and Los Alamos because of their
15 technology support for the operations activities.
16 So we have tried to continue the same
17 communication that was facilitated by headquarters
18 with the tank focus area subsequent to the closing of
19 the tank focus area activity. So the same people at
20 the sites are participating.
21 And the field offices and headquarters
22 staff, such as Kurt Girdus or his representatives,
23 have participated in the meetings. And they are
24 always available to participate in the telephone
25 calls, the biweekly telephone calls, as are Pat Suggs

1 and Billy Moss, for example, at Savannah River and
2 Hanford.
3 So we're trying to continue that on an
4 organized, regular basis. And it seems to be working
5 quite well.
6 MR. PICHA: Thanks, Ken.
7 VICE CHAIRMAN CROFF: Thank you.
8 As a general comment before we go on with
9 any more questions, this entire session is being
10 recorded. And there will be a transcript produced.
11 So if you're back in the audience, you know, if you're
12 over here and wanting to respond to a question, please
13 identify yourself so we know who is speaking and then
14 go ahead and give a response.
15 With that, were there any other --
16 MR. THADANI: Yes. Ken, I look at this as
17 a somewhat complex set of plants, if you will, various
18 facilities. That means you have to build in design
19 considerations for these facilities, you have to
20 presumably postulate some potential things that might
21 go wrong and deal with those.
22 How do you go about establishing design
23 considerations? Is it done on the basis of some
24 predetermined state of conditions or is it some
25 probablistic thinking is brought into play here in

1 establishing design considerations?

2 MR. PICHA: Well, I'll tell you a little

3 bit. And if you need more information, I think you're

4 going to have to talk to some of our experts.

5 There are sort of I guess two primary

6 aspects that feed into the design considerations.

7 Certainly one of them is the technical aspects. You

8 had the waste. And you needed treated or pretreated

9 or whatever. So it has to meet certain requirements

10 in that regard.

11 And you've got to set limits. You're not

12 going to accept waste that has a molarity beyond *X* or

13 whatever. And certain constituents you don't want to

14 include at all perhaps. And so you may need to

15 separate those out.

16 And then you have the more driven ones

17 from an authorization basis, where okay. If you have

18 that, then you do a hazards analysis. And then you

19 start doing your safety analyses, your preliminary to

20 support construction and then your final safety

21 analyses.

22 I'm not sure where exactly. I sort of

23 lost track of that where we are in the department,

24 whether we're using probablistic or deterministic. I

25 think we use a little bit of both depending upon what

1 the various contractors decide. And if somebody in
2 the department has a better, more current thinking,
3 they can.
4 But I think it's not that dissimilar to
5 what the private sector would do in terms of as they
6 prepare licensing documents to submit to the NRC.
7 MR. THADANI: Thank you.
8 VICE CHAIRMAN CROFF: Thank you.
9 Seeing no more questions, thank you very
10 much, Ken.
11 MR. PICHA: Okay.
12 VICE CHAIRMAN CROFF: I think at this
13 point, what I'd like to do -- we're running a little
14 bit ahead. We show a break, but I'd like to postpone
15 that until after this talk. I think they fit a little
16 bit better together, but since we're doing so well,
17 Anna willing, our next talk is to get an overview of
18 what the NRC has done regarding previous waste
19 determinations and a summary of the current waste
20 determination criteria and some understanding of how
21 the NRC is proceeding.
22 I'd like to introduce Anna Bradford, who
23 is well-qualified to do this. She's a senior project
24 manager in the NRC's Division of Waste Management and
25 Environmental Protection.

1 She was in private industry for seven
2 years before coming to the NRC, where she has been for
3 five years. And within that, for the last three
4 years, she's been the project manager for waste
5 determination issues.
6 She is presently leading the ongoing waste
7 determination evaluation for the Savannah River site
8 and the development of the standard review plan for
9 waste determinations that we're focusing on here.
10 Anna, proceed when you are ready.
11 4) HISTORY AND BACKGROUND ON NRC INVOLVEMENT
12 IN WASTE DETERMINATIONS
13 MS. BRADFORD: As Allen said, my name is
14 Anna Bradford. I'm the senior project manager for
15 waste determination reviews at the NRC.
16 The Committee asked me to talk about our
17 historical involvement with waste determinations as
18 well as any upcoming activities that we see on the
19 horizon. So I am going to talk about the background
20 of waste incidental to reprocessing, or WIR; previous
21 NRC reviews for DOE draft WIR determinations; the
22 legislation regarding waste determinations. And I'm
23 going to talk about what we have accomplished recently
24 as well as what we see coming up in the future, both
25 programmatically and technically.

1 The first few slides go over some
2 background. At the most basic level, the idea behind
3 WIR is that certain wastes can be managed based on the
4 risks that they pose to human health and the
5 environment, rather than based on the source of the
6 waste. And the idea is that for some wastes that
7 result from the reprocessing of spent nuclear fuel,
8 some of it requires disposal in a geologic repository
9 while some of it does not. And the WIR process is
10 used to determine which of that waste does not require
11 disposal in a geologic repository.
12 Some general information about WIR.
13 Examples of potential WIR are the pumps and the
14 high-level waste tanks; waste removed from the tanks
15 that might be disposed of elsewhere, either on site or
16 off site; and residual waste remaining in the tanks
17 that may be disposed of in place.
18 WIR is not high-level waste, but it is
19 low-level waste or transuranic, or TRU, waste. And,
20 as Ken mentioned, there's potential WIR at four sites:
21 Hanford, Idaho National Laboratory, Savannah River
22 site, and West Valley.
23 The history of WIR goes all the way back
24 to 1969, when the NRC first published a draft policy
25 statement in a proposed appendix D to Part 50, which

1 involved the siting of reprocessing facilities. But
2 the first sort of modern WIR criteria that people
3 refer to were issued in 1993 in a denial of a petition
4 for rulemaking regarding Hanford.
5 Those criteria are listed here on this
6 slide. And they are that waste process removed key
7 radionuclides to the maximum extent technically and
8 economically practicable, the waste should be
9 incorporated into a solid physical form at
10 concentrations not exceeding class C concentrations,
11 and the waste should be managed so that safety
12 requirements comparable to the performance objectives
13 at 10 CFR Part 61, Subpart C, which are low-level
14 waste regulations, are satisfied.
15 And then in 1991, DOE included essentially
16 the same three criteria in their radioactive waste
17 management program, which is in their DOE order 435.1.
18 Then in 2000, during a WIR review that we
19 were conducting for the Savannah River site tanks, the
20 NRC dropped that second criterion regarding
21 concentration limits. And the commissioners decided
22 that concentration is not really a direct measure of
23 risk and that it would be adequate to use the
24 criterion one, which was removal of key radionuclides
25 to the extent practicable; and criterion three, which

1 was meeting the performance objectives of 10 CFR Part
2 61. And using those would be adequate to protect
3 public health and safety.
4 So then in 2002, along those same lines,
5 those two criteria were the ones included in NRC's
6 West Valley final policy statement, which set the
7 decommissioning criteria for that site.
8 And then most recently, at the end of
9 2004, new legislation was passed that set the waste
10 criteria for Savannah River and for Idaho. And that
11 gave NRC staff new responsibilities regarding waste
12 determinations. I'll talk more in detail about that
13 a little bit later.
14 One thing to note here is just because of
15 the wording in the legislation, DOE often refers to
16 these as non-high-level waste determinations or
17 section 3116 determinations. So you'll hear WIR,
18 non-high-level waste section 3116 depending on which
19 process you are talking about.
20 In the past, DOE has asked NRC to provide
21 technical advice and consultation on its methodology
22 in the conclusions of their WIR determinations.
23 It's important to note that we did not
24 have any regulatory or oversight role in these. We
25 conducted them at the request of DOE. They were

1 conducted on a reimbursable basis. DOE was the one
2 responsible for making the waste determinations. And
3 we were just providing technical advice.
4 The WIR determinations usually involve
5 demonstrating compliance with the applicable WIR
6 criteria. And it often included a performance
7 assessment.
8 We would assess the WIR determinations for
9 the soundness of the technical assumptions, the
10 analysis, and the conclusions. And we have conducted
11 four of those so far: one for Hanford for waste that
12 was removed from the tanks and meant to be disposed of
13 on site. That was completed in '97. Savannah River
14 tanks that were to be closed in place, that was
15 completed in 2000.
16 And we have done two for INL, one for
17 sodium-bearing waste removed from the tanks. That was
18 meant to be sent to WIPP. We completed that in 2002
19 and then a review for tank closure that was completed
20 in 2003.
21 And, in general, we concluded that the
22 performance objectives of 10 CFR 61, Subpart C could
23 be met. And, therefore, this was going to be
24 protective of public health and safety.
25 We offered recommendations for improvement

1 as DOE moved forward. For example, we might recommend
2 that they sample the waste as they remove it to make
3 sure that it confirmed the inventory estimates they
4 had made in their WIR determinations.
5 In case Ken didn't give you enough flow
6 charts, I included a couple in here also. This one
7 shows the major steps of our past NRC reviews. And,
8 like I mentioned, it would start with DOE requesting
9 the review. After that, we would develop an
10 interagency agreement to provide a funding mechanism
11 because these were done on a reimbursable basis as
12 well as a memorandum of understanding that would
13 describe the work we would be doing.
14 MOU and IA were then prior to signature
15 sent up to the Commission for approval so that they
16 saw we were doing this work and they approved it.
17 Once they issued an SRM saying essentially, "Yes,
18 staff, go ahead and do that," DOE would submit their
19 draft WIR determination. We would review that
20 submittal during a technical review of all of the
21 information they provided us and issue a request for
22 additional information in most cases, which is
23 essentially a list of questions for which we need
24 responses before we can complete our review.
25 DOE would respond to that RAI. In many

1 cases, they would revise their actual WIR
2 determination according to the comments that we gave
3 them. We would review that response, any revision to
4 the determination, any additional information, and
5 develop a draft technical evaluation report which
6 contained our findings.
7 That draft TER was sent up to the
8 Commission for their review and approval. And they
9 would issue an SRM, which either approved the TER as
10 it stood or gave us some comments from the TER and we
11 would revise the TER accordingly. And only after all
12 of that was the final TER sent to DOE.
13 One important thing to note here is under
14 this old process, we did not conduct any follow-up
15 activities. Once the TER was provided to DOE, because
16 we are only in an advisory role, we did not follow up
17 to see if they carried out any of our recommendations.
18 We provided our report, and that was the end of our
19 involvement.
20 The next two slides give a quick look at
21 the last four reviews that we have completed. I will
22 hit the highlights, but if you want the details, I
23 would suggest you look at the technical evaluation
24 reports, which maybe you already have. They are about
25 40 to 50 pages long, so not too bad, but the

1 highlights are captured here.

2 The first one was for Hanford: waste
3 removed from the tanks and disposed of on site. Like
4 I said, we completed that in '97. For that review, we
5 reviewed to all those of those original waste criteria
6 that were established in '93 with regard to Hanford.

7 But at the time, DOE was at a very
8 preliminary stage of their planning. Their
9 performance assessment was not complete. They called
10 it an interim PA at the time. They knew they planned
11 to revise it. I don't think they had picked their
12 waste disposal location on site yet. I don't think
13 the waste form was completely decided.

14 And so we looked at the information we had
15 and said, "Well, based on this, it looks okay," but we
16 couldn't -- you know, there was no numbers for the
17 final performance assessment. That's why it says,
18 "Not provided in the NRC report" for the doses here.
19 So it was a very sort of provisional agreement and
20 review on our part that it looked like they could meet
21 those criteria.

22 The next review was for Savannah River,
23 tanks closed in place, which we completed in 2000.
24 Originally the staff reviewed all three of those
25 incidental waste criteria again. And this is the case

1 that I mentioned previously where the Commission then
2 came back and told us, "Actually, staff, we want you
3 to focus only on criteria one and three."
4 So the draft TER that went up to the
5 Commission included some evaluation of that criterion
6 two, but the final TER that went to DOE emphasized one
7 and three in that final report.
8 The doses are given there in the third
9 column. And, as you can see, for the public and for
10 the intruder, they're well below the Subpart C
11 performance objectives.
12 This last half of the table talks about
13 the two INL reviews. The first was for the
14 sodium-bearing waste that was to be removed from the
15 tank and disposed of at WIPP. Since this was expected
16 to be TRU waste, for which we did not have a WIR
17 criterion -- remember, ours was for class C
18 concentrations -- and because it would be disposed of
19 at WIPP, we only looked at criterion one in that
20 review.
21 So, again, in the doses section, the
22 public and the intruder are not applicable because we
23 didn't look at a performance assessment for WIPP. And
24 the worker dose was not provided in the determination.
25 And that was actually one of our recommendations back

1 to them that they should include those worker doses in
2 their future evaluations.
3 Last, with the INL tanks to be closed in
4 place completed in 2003, in accordance with the West
5 Valley policy statement, which was issued in 2003, we
6 looked at criteria one and three. And, again, the
7 public and intruder doses are listed there as well as
8 the worker dose. And they're all well below the
9 standards of 10 CFR 61.
10 So, as I mentioned earlier, legislation
11 was passed that affected waste determinations. South
12 Carolina Senator Graham introduced legislative
13 language that would allow a process similar to the WIR
14 process at the Savannah River site only.
15 And the wording subsequently underwent
16 several revisions. We provided our input by
17 responding to two letters that we received from
18 senators requesting our reviews on incidental wastes.
19 And then in October, the President signed
20 the Ronald Reagan National Defense Authorization Act
21 for F.Y. 2005, which I'll go into more detail on the
22 next two slides.
23 NDAA requires DOE to consult with us for
24 all of its non-high-level waste determinations for
25 Savannah River and for Idaho. And the act itself sets

1 the criteria that should be used in these reviews.
2 And they are somewhat similar to the criteria we had
3 used previously. And they are that the waste does not
4 require disposal in a deep geologic repository.
5 The waste has highly radioactive
6 radionuclides moved to the maximum extent practicable.
7 And if the waste is class C, its disposal must meet
8 Subpart C. And if the waste exceeds class C, its
9 disposal must meet Subpart C and DOE must consult with
10 NRC on the development of its disposal plans.
11 It also requires that NRC in coordination
12 with the state monitor DOE's disposal actions to
13 assess their compliance with Subpart C. And we have
14 to report any noncompliance to Congress, the state,
15 and DOE.
16 And this is a new activity with regard to
17 the staff. So we're right now planning how we intend
18 to go about that. And although we do monitor them, we
19 still do not have any enforcement authority over DOE.
20 So there is some distinction there.
21 A few more points about the NDAA. It does
22 apply only to Idaho and Savannah River, does not apply
23 to West Valley or Hanford. You were asking about the
24 melter at West Valley. Although, like Ken said, they
25 may do a waste determination for that, they're not

1 required to send it to us for review since the NDAA
2 applies to Savannah River and Idaho. They may elect
3 to, and we may elect to go ahead and review that, but
4 it's not required under this act.
5 And it does not apply to waste shipped out
6 of those states but only applies to waste that will
7 remain in the states. The act also requires DOE to
8 reimburse us for our activities in F.Y. '05. And for
9 following years, we have to seek appropriations
10 through our normal budget processes.
11 And then section 3146 of the NDAA requires
12 a one-year study by the National Academy of Sciences
13 of DOE disposal plants for waste that will exceed
14 class C and that they do not intend to dispose of in
15 a geologic repository. And that Committee has met
16 several times already and plans to issue the interim
17 report very soon, possibly by the end of this week,
18 beginning of next week.
19 The next several slides cover what we have
20 accomplished recently as well as what we see coming
21 up. We developed a SECY paper, the numbers given
22 here, that describes in detail the staff's plans for
23 implementing our new responsibilities under the act.
24 Essentially we think the technical review will be
25 similar for those we perform for WIR determinations

1 except, of course, obviously we will be reviewing
2 whether they meet the NDAA criteria.
3 But the SECY paper went to the Commission
4 on April 28th of this year. And June 30th, we got the
5 staff requirements memorandum back in which the
6 Commission approved the staff plans. They had a few
7 comments, things like the staff process should be open
8 and transparent to the public and that the staff
9 should take the time necessary to complete its review
10 to help protect public health and safety.
11 So given the new volume of work, the
12 Division of Waste Management and Environmental
13 Protection established a new section within its
14 organization, which will handle the waste
15 determination reviews as well as low-activity waste
16 activities and some other things that sort of
17 naturally go together.
18 We have begun development of the standard
19 review plan. This will help guide our reviews. It
20 will help provide consistency across reviews. It will
21 also help DOE see the kind of information that we need
22 to have to be able to evaluate their submittals.
23 We plan to have a public scoping meeting
24 on the SRP this fall. And then we'll issue it for
25 public comment it looks like in the Spring of '06.

1 And then to help us conduct all of this
2 work and provide some technical expertise, we
3 established a contract with the Center for Nuclear
4 Waste Regulatory Analysis for technical assistance.
5 They assisted us on some of our previous WIR
6 determination reviews also.
7 Since January, we have met with
8 representatives of both South Carolina and Idaho to
9 talk about roles and responsibilities under the act as
10 well as schedules and how we can interact efficiently.
11 We have notified the states of meetings we have had
12 with DOE, and they have participated in many of those
13 meetings.
14 We also established an IA with DOE to
15 provide funding for F.Y. '05 as required by the
16 legislation. And we're currently drafting a
17 memorandum of understanding that will lay out the
18 rules and responsibilities of each agency. And that
19 MOU will need to go up to the Commission for approval
20 prior to signature.
21 And then we had some interactions going on
22 with the NAS committee. We have provided three
23 presentations to them so far: one at the kickoff
24 meeting talking about our role in waste
25 determinations; and then, two, presentations at

1 subsequent meetings talking about the previous WIR
2 reviews that we have done.
3 Okay. This slide shows how we envision
4 the process under the NDAA, the review process. It is
5 somewhat simplified from the previous one, as you can
6 see. And the biggest two subtractions from this slide
7 are that we no longer have to develop an MOU and an IA
8 for each review and don't have to send those to the
9 Commission for approval. The other difference is
10 removal of the need to go up to the Commission for
11 approval for each TER prior to issuance.
12 What we proposed in that SECY paper was to
13 have the Commission aware of our SRP and once they
14 signed off on that approach in the SRP, we could go
15 ahead and do these TERs without needing to go back to
16 the Commission for each one.
17 The other addition here is up toward the
18 right-hand corner, this do-loop of RAIs, where just if
19 the RAI responses are not adequate or complete, we may
20 need to go back and ask some more questions, but our
21 goal is always to be as efficient and complete as
22 possible and just do one round of RAIs there.
23 So Savannah River submitted the first
24 draft determination under the NDAA for salt waste
25 disposal. This is essentially low-activity waste in

1 some tanks that they would like to remove mixed with
2 some grout and pump and bulk volumes over to some
3 vaults on site where it would solidify. And that
4 would be the disposal area.
5 They submitted that to us at the end of
6 February, this past February. We reviewed that. We
7 transmitted our RAI on May 26th. The RAI consisted of
8 80 questions total. Twelve were clarification,
9 editorial-type questions. Sixty-eight were technical
10 questions.
11 DOE responded on July 1st to 61 of those
12 68 technical questions and on July 15th to the
13 remaining 7. They also gave us a significant amount
14 of supporting information along with those responses.
15 So we are in the process right now of conducting our
16 technical review of all of that information.
17 The other thing on schedule for them is it
18 is my understanding they expect to submit
19 determinations for the tanks in September. Again,
20 this is the latest information I have. And it's up to
21 DOE, really, when they submit these to us.
22 In Idaho, we met with DOE and the state to
23 talk about activities under the act. And DOE expects
24 to submit a draft determination for the tanks sometime
25 this month.

1 Prior to the new legislation, Hanford
2 asked us to review the adequacy of their waste removal
3 from one of their tanks, tank C-106. As Ken
4 mentioned, they have a tri-party agreement there with
5 the State of Washington and the EPA that requires them
6 to consult with us if they cannot remove 99 percent by
7 volume of the waste from their tanks.
8 So we entered into an interagency
9 agreement. DOE sent us the documents that supported
10 their belief that they removed as much waste as
11 possible from that one tank.
12 We reviewed that. We transmitted our RAIs
13 in January. We met June 1st to discuss proposed draft
14 responses to those RAIs and are currently waiting for
15 the formal RAI responses and part of that performance
16 assessment.
17 West Valley is a special case. We already
18 have responsibilities there under the West Valley
19 Demonstration Project Act. That site will use the
20 decommissioning criteria in NRC's West Valley policy
21 statement, which, as I mentioned, had that criteria 1
22 and 3 in it.
23 And we are expecting that WIR information
24 will be in DOE's draft EIS, which will be sent out for
25 cooperating agency review in August or September, and

1 also in the decommissioning plan, which we think will
2 be issued probably Summer of '06.
3 This last slide is really just some
4 references. You may already have many of these: the
5 SECY paper; the SRM; the Commission vote sheets on the
6 SECY, where each commissioner sort of gives their
7 opinion; the Saltstone RAIs; DOE's responses; the
8 letters to Congress that I mentioned.
9 And the one thing that I wanted to point
10 out on this slide is that we did recently establish
11 docket numbers for the sites because there is a large
12 amount of information in documents. And these are
13 solely for ease of tracking and finding documents for
14 members of the public or stakeholders or the staff to
15 be able to go into ADAMS and search on these docket
16 numbers and find any relevant documents.
17 That's all I had today. I'm happy to
18 answer any questions.
19 VICE CHAIRMAN CROFF: Okay. Thank you.
20 Jim?
21 MEMBER CLARKE: If I understood you, Anna,
22 you have done four determinations in the past. And
23 you have used either one, two, or three criteria.
24 MS. BRADFORD: Right.
25 MEMBER CLARKE: The Commission asked you

1 to drop one criteria. So you were left with two. The
2 act gave you four. What's the major difference from
3 where you sit from how you used to do these and how
4 you will be doing them in the future?
5 MS. BRADFORD: Right. Let me go back to
6 where those criteria are listed. The act, this first
7 one, the waste does not require disposal in the
8 geological repository, is really brand new, at least
9 being explicitly spelled out like that. You could
10 argue that all of these criteria are used to show that
11 it doesn't need to go to a geologic repository.
12 So that will be new, a new criteria that
13 we assess, a new section of our TERs, how I sort of
14 think about it when we're getting ready to issue our
15 TER.
16 The waste has had highly radioactive
17 radionuclides removed to the maximum extent
18 practicable. It's somewhat similar to previous
19 criteria of key radionuclides removed to the maximum
20 extent technically.
21 MEMBER CLARKE: You had an economic
22 consideration --
23 MS. BRADFORD: Right.
24 MEMBER CLARKE: -- which doesn't appear
25 here.

1 MS. BRADFORD: Right. But we would
2 consider it part of that maximum extent practicable,
3 consider the economics of their various alternatives.
4 And then the second one, I sort of think
5 of it as a 3A or 3B. You're either less than class C
6 or you're more than class C and you're forced into one
7 of those bins, which means we'll have to assess the
8 concentrations, which we had previously dropped.
9 But in terms of meeting the performance
10 objectives, that will be similar to our previous
11 reviews.
12 MEMBER CLARKE: Okay. Thank you.
13 CHAIRMAN RYAN: Just a quick follow-up
14 while you're on that slide. To me this is kind of
15 the real interesting center point of how you're going
16 to proceed in that it's a real opportunity to drift
17 away from what is an operationally based definition of
18 what WIR is, a real sort of risk-informed environment.
19 Of course, you're working on that as you
20 develop the standard review plan now. And thinking
21 through that in these couple of days will help you,
22 you know, gather information to do that.
23 Can you give us any insights at this point
24 or is it really too preliminary to think about it?
25 And is that point that we're really kind of moving

1 toward a risk-informed approach correct?

2 MS. BRADFORD: Yes, but I think I would

3 say that our previous reviews also tried to be

4 risk-informed and performance-based.

5 CHAIRMAN RYAN: Oh, sure.

6 MS. BRADFORD: There's a large amount of

7 information supporting all of these. And, you know,

8 our staff wanted to focus on the things that were most

9 important and really drove the results and could

10 change the conclusions. In terms of --

11 CHAIRMAN RYAN: Yes. Those are probably

12 very good foundational evaluations for moving forward.

13 I didn't mean to say they weren't. But I just think

14 it's exciting to recognize for probably the first time

15 explicitly that concentration isn't risk. It's kind

16 of related, but it's really not the only part of the

17 story here.

18 You're broadening your view to account for

19 other things that, you know, can also be probably

20 better or, you know, augment your percent or

21 evaluation and risk. And that's to be applauded, in

22 my view.

23 Thanks.

24 VICE CHAIRMAN CROFF: And I'm going to, as

25 Mike, follow up on this slide since we're here. In

1 what you called 3B, this phrase, "DOE must consult
2 with NRC in development of its disposal plants," what
3 does that mean? This whole thing looks like DOE is
4 consulting with NRC on its disposal plants.
5 MS. BRADFORD: Right.
6 VICE CHAIRMAN CROFF: What specific is
7 there?
8 MS. BRADFORD: Well, as of yet, we haven't
9 been forced into this criterion 3B sort of space. But
10 I think we have been thinking about that. I know DOE
11 has been thinking about that. I know both of our
12 general counsels have been thinking about that in
13 terms of interpretation of statute and how do you go
14 about interpreting it at this point. I'm not sure of
15 the answer to that.
16 VICE CHAIRMAN CROFF: Okay. Thank you.
17 Ruth?
18 MR. HODO: My name is Wayne Hodo. I'm
19 from the Engineering Research and Development Center.
20 I have a question about your program removal of salts.
21 CHAIRMAN RYAN: We will call on you first.
22 MR. HODO: Oh, I'm sorry.
23 CHAIRMAN RYAN: Thanks.
24 MEMBER WEINER: How and by whom is maximum
25 extent practicable determined?

1 MS. BRADFORD: In our -- well, I should
2 back up. DOE in their Saltstone submittal talked
3 about what they believe the maximum extent practicable
4 was. And they think it's broad. It can include
5 economic considerations, technical considerations,
6 programmatic considerations that DOE may have, risk
7 analyses, things like that, workers, a wide range of
8 things that DOE should and does consider when it makes
9 decisions for things like that.
10 And I think we would agree with that. I
11 don't think that this wording drops out the economic
12 and technical evaluation but probably just broadens it
13 further.
14 MEMBER WEINER: So it is really done on a
15 case-by-case basis?
16 MS. BRADFORD: Yes.
17 MEMBER WEINER: Mike alluded to another
18 question I had. Where do you consider worker doses in
19 disposition of any of the tank material? I notice you
20 didn't mention compliance with 10 CFR Part 20.
21 MS. BRADFORD: Right.
22 MEMBER WEINER: You do comply with ALARA.
23 MS. BRADFORD: Yes.
24 MEMBER WEINER: What's the NRC's take on
25 worker doses in this whole process?

1 MS. BRADFORD: Protection during
2 operations is one of the performance objectives in
3 Subpart C. And it refers I think back to Part 20.
4 DOE usually refers to their own worker radiation
5 standards to show that they are protecting the worker.
6 MEMBER WEINER: Finally, what is the NRC's
7 view of disposition of the empty tanks?
8 MS. BRADFORD: What is our view?
9 MEMBER WEINER: Well, what do you think
10 should be done? Have you considered this? What do
11 you think should be done with the empty tanks?
12 MS. BRADFORD: Well, I guess I would go
13 back to those letters that we sent to Congress, where
14 they asked us what do we think about the WIR process
15 in general. And I think we said it might not make
16 sense to expend large amounts of federal funds and
17 incur large worker doses and transportation risks to
18 dig up those tanks and transport them elsewhere if, in
19 fact, you can safely dispose of them in place. Again,
20 it is very case-specific.
21 MEMBER WEINER: Yes. Thank you.
22 VICE CHAIRMAN CROFF: Mike, any more?
23 CHAIRMAN RYAN: No. Thank you. I'm done.
24 VICE CHAIRMAN CROFF: Okay Bill?
25 MEMBER HINZE: Referring to the last

1 bullet on that slide 12, what is the NRC's view of the
2 word "monitor" here? What can we envision will be the
3 monitoring stance of NRC towards DOE's compliance with
4 61?
5 MS. BRADFORD: First of all, I need to
6 change this slide so you guys will ask me questions on
7 something else.
8 MEMBER HINZE: No. That was the word that
9 stuck out to me in your presentation.
10 MS. BRADFORD: Monitoring?
11 MEMBER HINZE: Monitoring.
12 MS. BRADFORD: Again, that would also be
13 conducted in a risk-informed performance-based manner.
14 And we're still thinking about how we'll implement
15 that because it is a new activity for us. But I think
16 the general process will be in that technical
17 evaluation report, we will identify the factors that
18 are important to showing compliance with Subpart C.
19 And those would be the types of things we would
20 monitor.
21 For example, if the reducing grout was
22 very important in meeting the performance objectives,
23 we might follow up on that to see if, in fact, the
24 reducing grout performed the way that DOE thought it
25 did in its draft determination.

1 And then there might also be an
2 environmental monitoring component to that, reviewing
3 site environmental reports, things like that.
4 MEMBER HINZE: So would this include doing
5 your own PAs on this, reviewing more than their
6 regulations, doing physical reviews, any or all of the
7 above?
8 MS. BRADFORD: We do often develop our own
9 models during the TER portion to inform our review and
10 make sure we don't get wildly different results. But
11 in terms of the monitoring stage, I don't know. I
12 don't think we have thought about that yet.
13 MEMBER HINZE: How will this monitoring be
14 coordinated with the states?
15 MS. BRADFORD: I think if we were visiting
16 the site, for example, to do a monitoring visit, we
17 would invite the state along. I would expect they
18 might invite us along if they were doing a monitoring
19 visit that they thought we might be interested in.
20 If we had -- the states are very familiar
21 with those states. And they know the important areas.
22 They know what has been going on in the past, what is
23 going on in the future. So we really want to work
24 closely with them on the monitoring.
25 I think if we maybe found a possible

1 non-compliance, we might talk to the state and say,
2 "Hey, we're finding this. What do you think about
3 this or is there anything we haven't considered here?"
4 So I think we'll be working with them all
5 along, not just up at the end when we're ready to
6 issue a report.
7 MEMBER HINZE: Thank you.
8 VICE CHAIRMAN CROFF: I had one additional
9 question, a confirmation question. As I understand
10 it, waste determinations leading to classification of
11 a waste as transuranic don't play in the 3116 arena.
12 This has nothing to do with it because it would
13 presumably be disposed of off site in WIPP, for
14 example.
15 MS. BRADFORD: Yes. If it was going to be
16 disposed of off site, this doesn't apply. It's just
17 for waste remaining in the --
18 VICE CHAIRMAN CROFF: Okay. Thank you.
19 NRC staff? No? Any of our other speakers
20 her? Dave?
21 DR. KOCHER: David Kocher. I want to beat
22 on the class C business again because I just get this
23 feeling in my bones that there is a tendency to forget
24 what was behind these class C limits when they were
25 developed.

1 And I guess I would caution people to not
2 forget history. For example, when this rule was
3 developed, there would be very small
4 VICE CHAIRMAN CROFF: Thanks. I think we
5 might be able to entertain a limited number of
6 questions from the audience. And I think somebody had
7 stepped up here. Your name and then --
8 MR. HODO: Excuse me for interrupting
9 earlier.
10 VICE CHAIRMAN CROFF: That's all right.
11 MR. HODO: My name is Wayne Hodo from the
12 Army Engineering Research and Development Center. I
13 am currently working on a project under Jacob
14 Phillips. But when you said the removal of odium and
15 placing it in grout, are you referring to cement
16 grout?
17 MS. BRADFORD: Yes.
18 MR. HODO: Okay. I'm not sure if you are
19 aware. Even with placing sodium in cement, it will
20 begin to leach out over time. And it will affect your
21 soil mineralogy.
22 Are there going to be any studies done?
23 MS. BRADFORD: Ken, did you want to answer
24 that about the formulation of the cement?
25 MR. PICHA: I'm not sure I do, but I think

1 we have somebody who might be able to. Can we call on
2 members of the public to answer a question?
3 VICE CHAIRMAN CROFF: That's good if we've
4 got somebody who can answer it.
5 MR. PICHA: Jim, can you answer that
6 question, Jim Cook? Is he there?
7 MR. COOK: Hi. I'm Jim Cook from Aiken,
8 South Carolina. And all I can say is that we have
9 done formulation and leach tests on our cement-based
10 waste forms.
11 In particular, sodium and nitrate are
12 things that we look at. We recognize it does come
13 out, but we try to formulate it so that it comes out
14 at small quantities at a time.
15 MR. HODO: That's based on soil type.
16 Have you done any studies on various types of soils?
17 MR. COOK: What I just said had to do with
18 the waste form, not with the soils. Our soils don't
19 particularly absorb sodium. And we haven't looked at
20 other soils. That is sort of a non-answer, but that
21 is the truth.
22 MR. HODO: I would like to go on and say
23 that is dependent on soil type. In particular, it is
24 known to the geotechnical community that if you bury
25 even a grout mixture within a cohesive or a clay soil,

1 you will have ion exchange. And you will have
2 dramatically changed the soil mineralogy. And it
3 would be detrimental to your whole burial process.
4 MS. BRADFORD: Thank you.
5 VICE CHAIRMAN CROFF: Okay. Thank you
6 very much. I think at this point I don't see anything
7 else. So we're going to declare a break here until
8 10:35. That's about 15 minutes. During the break,
9 what I'd like to do and do throughout the workshop is
10 rotate the next panel of speakers up onto the main
11 table here so they can be here.
12 And the current groups of speakers, I
13 would like waste determinations to get them back at
14 the second tier of tables if at all possible with a
15 microphone to allow them to participate if they can.
16 So with that, about 15 minutes.
17 (Whereupon, the foregoing matter went off
18 the record at 10:22 a.m. and went back on
19 the record at 10:39 a.m.)
20 VICE CHAIRMAN CROFF: Thank you. I'd like
21 to move on into our first -- what I'll call technical
22 session. And this concerns waste retrieval and
23 processing.
24 Before introducing our next speaker, I'd
25 like to note a slight change in protocol on how I'd

1 like to try to run this. And that is we've got our
2 next panel of speakers up here. There are five of
3 them.
4 I would like to try to get through all
5 five speakers with no more than clarification
6 questions. And then have you sit as a panel for about
7 an hour of questions and answers just sort of across
8 the board if my committee members will tolerate. So
9 that means we'll get into the Q&A sometime later in
10 the afternoon.
11 If that's not any problem, I'd like to --
12 MEMBER HINZE: Before lunch?
13 VICE CHAIRMAN CROFF: No, not before
14 lunch, Bill. Only for you. You're on a diet.
15 I'd like now to introduce Dr. Paul Murray
16 who will be the first speaker in this second session
17 on waste retrieval and processing technology.
18 Paul has over 25 years of experience in
19 the field of nuclear waste retrieval and handling.
20 For the last 18 years, he's been employed by AEA
21 Technology, initially working at reprocessing
22 facilities at Dounreay and Sellafield.
23 He transferred to the U.S. nine years ago
24 and has been working on waste retrieval projects
25 around the entire complex.

1 His presentation will focus on fluidic
2 approaches to retrieving waste from tanks.
3 Paul?
4 DR. MURRAY: Thank you very much. I have
5 a funny accent so I apologize now.
6 Okay. My presentation today will talk
7 about power of fluidics. During the presentation, I
8 will just talk about pulse jet mixers, RFD pumps for
9 pump immobilization, a little bit about tank grouting,
10 and then a consolidated system for mobilizing waste,
11 recovering the HLW, and then grouting the residual HLW
12 in place.
13 Power fluidics was invented over 25 years
14 ago. It is a prudent technology with multiple
15 deployments in the British nuclear arena. It has no
16 moving parts in contact with the fluid. It is
17 designed to be completely maintenance free. And it is
18 installed into all modern reprocessing plants.
19 Plant lifetime costs, it's ALARA because
20 it is no maintenance and it generates no secondary
21 waste. Okay?
22 The key components of the pulse jet mixer
23 are a jet pump pair, a charge vessel, and a nozzle.
24 I'll explain each of the components. The jet pump
25 pair consists of two air-driven jet pumps, one

1 connected up to the charge vessel and the other side
2 connected up to the vent side of the system.
3 For the purposes of everything that I'm
4 going to talk about today, everything from that point
5 downwards is considered active. Everything upstream of
6 the jet pumps is considered inactive. This is what a
7 jet pump pair looks like. It just looks like chunks
8 of steel.
9 So in the suction phase of a jet pump, you
10 put compressed air through the top ejector here. We
11 create a region of low pressure from Bernoulli's
12 equation, just like you see in your shower every time
13 you turn your shower on and the shower curtain moves
14 towards you. This region of low pressure allows us to
15 suck air from the charge vessel up to that region of
16 low pressure.
17 During the dry phase when we want
18 pressurize the charge vessel, we put compressed air
19 down the other jet pump. This jet pump is designed so
20 it doesn't create a region of low pressure here. But
21 actually causes a small leak back of air into the vent
22 system.
23 So pulse jet mixer, this is a really,
24 really simple piece of equipment. It's jet pumps,
25 charge vessel, and a nozzle in the waste. When we put

1 the vacuum on this side of the jet pumps, the region
2 of low pressure, pull the air out of the charge
3 vessel, the sludge and liquid moves into the charge
4 vessel.
5 When the charge vessel is full, we put
6 compressed air down this jet pump, pressurizing the
7 charge vessel, forcing the sludge and liquid back out
8 into the tank. Now air comes out of the charge
9 vessel. The system is designed so that no air comes
10 out of the charge vessel.
11 This is the C-tank system at Oak Ridge.
12 We vent the numerous tanks around the complex using
13 this system. The C-tanks are 62 feet long. They had
14 two manways in the hypervent and had cooling coils
15 along the base of the tank.
16 We installed charge vessels and manways at
17 the base of the tank. These are the charge vessels,
18 one went at either end of the tank. These are the
19 charge vessels during installation. And they're just
20 -- as I say, just charge vessels. No moving parts
21 down in the tank. That's the size of the nozzle we
22 put on the end of a charge vessel.
23 I hope this plays -- oh, it's playing.
24 It's not playing on the screen. This is the inactive
25 demo. What we're doing is we're looking down and

1 along the tank. This is the charge vessel discharging
2 with 60 psi in the charge vessel.
3 You can see the cooling coils here. So
4 there is not much that is going to stand in front of
5 that jet in the way of waste.
6 This is typically what the sludge looks
7 like in a tank before we start. And this is what the
8 tank looks like when we finish. The endpoint of a
9 tank is determined by DOE or the site operator before
10 we start.
11 The RFD pump, which I'd like to talk about
12 now, takes the concept of the pulse jet mixer one
13 stage further. You've got the jet pumps, the charge
14 vessel, now we've got a device called an RFD. It's
15 called a reverse flow diverter. And this acts like a
16 three-way valve. So one side of it is connected up to
17 the charge vessel. The other side is connected up to
18 a delivery line.
19 And all it is is basically two nozzles
20 housed in the teepee. This is just a cutaway view of
21 it. But it really is all it is.
22 This is a production unit. That side is
23 connected to the charge vessel. That side is the
24 delivery line. That side is open to the tank.
25 There are over 400 of them installed in

1 British nuclear plants. The longest has been running
2 for 25 years now. There are 480 components went into
3 the waste treatment plant at Hanford. These are the
4 high-level waste tanks at Sellafield. These are
5 cooling coils. These are the two RFD pumps down here.
6 So the RFD pump works, we put the suction
7 on the charge vessel again. We suck liquid in between
8 the two nozzles which fills the charge vessel. When
9 the charge vessel is full, we pressurize the charge
10 vessel, forcing liquid across the nozzles, up the
11 delivery line, and out. And the pumps will literally
12 pump anything.
13 They have minimum water requirements.
14 They can pump right down to hardly any water left in
15 the tank. There are no moving parts so you can't
16 break them.
17 We built a system, a demonstration system
18 for Hanford where we took the RFD system and we
19 connected it up to two stable nozzles. So now we
20 could take the waste from the tank and pump it back
21 in. I've got slides to show this, in fact.
22 So we can force the liquid out of the
23 charge vessel up, down through the stable nozzles, to
24 knock the waste back to the pump to pump it out. So
25 we literally keep recirculating the waste in the tank

1 without adding extra water into the tank to mobilize
2 the waste. Or we can send it through the outboard
3 nozzles to knock more waste down and send it back.
4 And I'll skip that one.
5 For the million-gallon tank retrieval, we
6 decided we need three independent systems working with
7 two nozzles each to cover the base of the tank and
8 return the waste. This is the size of the system
9 here.
10 We demonstrated that this system could
11 work on debris, which you typically find in a tank,
12 pieces of string, wood, gloves, plastic bags, sample
13 bottles. We demonstrated the system would not block
14 when it encountered these wastes. At Los Alamos when
15 we emptied the tank, we encountered a dead cat. So we
16 managed to retrieve that I'm afraid.
17 I hope this is going to play. So one of
18 the things -- I turned the volume down -- one of the
19 things we did last year was we showed that the system
20 could be used, once we got the bulk of the waste out
21 of the tank, we could put grout in and we could use
22 the system to mix the grout in the residual HLW. We
23 put a uniform mix in the tank.
24 So instead of just pouring the grout into
25 the tank, now we can mix the grout into the tank. And

1 this tank is about 25 foot long to give you some idea.
2 And the test proved very, very successful. The only
3 comment we got back was our tanks are cylindrical and
4 not horizontal.
5 This year, in September, we have built a
6 28-foot diameter tank with cooling coils across the
7 bottom. We have two pulse jet mixers operating
8 underneath the cooling coils. We have an RFD pump
9 feeding two external nozzles. We will demonstrate we
10 can recover the HLW from the tank and then jet grout
11 the residual HLW in the tank.
12 And if anybody wants to come to that
13 demonstration, my e-mail details are in the pamphlet.
14 You are more than welcome.
15 So in summary, we've had multiple
16 deployments around the complex. It's a very stout
17 system capable of adaptation. One of the things we
18 found is when you start recovering a tank, you come
19 across problems you don't expect. We've proven that
20 our system is capable of adapting to overcome those
21 problems.
22 It is a reusable, skid-mounted system so
23 once it has emptied one tank, you can move it on to
24 empty other tanks. You have a minimum water
25 requirement in the tank so if there is a problem with

1 the tank leaking, we just have to have a really small
2 amount of water there.
3 It is capable of bulk waste retrieval, HLW
4 recovery, and jet grout in the tank. And as I said,
5 there is this big demonstration in September in
6 Charlotte. And that's it.
7 VICE CHAIRMAN CROFF: Okay. Thank you
8 very much. People are being uncommonly brief this
9 morning.
10 Right now we show a lunch, having
11 anticipated we'd run quite a bit longer. And I don't
12 plan on going to lunch right now. So I think what I'd
13 like to do is just continue with the agenda and ask
14 Barry to come up and get him set up while I introduce
15 him.
16 And then I may make a liar out of myself
17 and entertain at least some retrieval questions before
18 we do lunch. And group those together before we move
19 on to a slightly different topic.
20 With that, thank you very much, Paul.
21 DR. MURRAY: Okay.
22 VICE CHAIRMAN CROFF: And the second
23 speaker in this section will address a different
24 aspect of waste retrieval technology. I'd like to
25 introduce Dr. Barry Burks, who is currently President

1 of TPG Applied Technology.

2 TPG was responsible for waste removal
3 operations from 25 underground storage tanks at Oak
4 Ridge National Lab. Barry was formerly the Robotics
5 Technology Integration Manager for the DOE tank focus
6 area, the Tank Waste Retrieval Product Line Manager
7 for the DOE Robotics Crosscut Program, and the Tank
8 Waste Removal Operations Manager for the gunite and
9 associated tanks remediation project.

10 As you might expect, Barry is going to
11 focus on the use of robotic devices for waste
12 retrieval.

13 DR. BURKS: Okay. Thanks, Allen.

14 Okay. There are three basic ways to
15 retrieve waste from tanks. And Paul talked about an
16 approach where you mix and pump. But you can also mix
17 and pump using remote systems. And I'll talk a little
18 bit about that.

19 The other two ways that you can remove
20 waste, depending on the form of the waste, is what I
21 call mechanical removal where you might scoop or
22 excavate, or drill, auger, you know remove the waste
23 in a more solid form rather than a slurry.

24 Then the other thing, you may have waste,
25 for instance, with ion exchange resins or something

1 like that that you would like to remove -- maybe burn
2 up those ion exchange resins before removing the rest
3 of the waste and treating it.
4 So three approaches. And I'm going to
5 talk primarily about mixing and pumping mechanical
6 removal but the way I look at retrieval is that you
7 have positioning tools and then you have the retrieval
8 tools themselves. The remote systems are what you use
9 to position your tools.
10 Typically what we're talking about are
11 vehicles and arms. And you deploy a variety of tools.
12 Those tools might be water jets used to create a
13 slurry, mechanical agitators, there might be pumps, it
14 could be the scoops, drills, augers, those sorts of
15 things that you use for mechanical retrieval. Or you
16 could be deploying a chemical reagent of some sort.
17 Okay. There have been a number of large
18 arms designed, some of them built, a few actually
19 deployed for tank waste retrieval. And this is not a
20 complete list by any means. I left off the ones that
21 only got as far as the drawing pad. If there wasn't
22 somebody that at least funded a conceptual development
23 activity, then I didn't include those.
24 But the arms, large arms include the
25 light-duty utility arm. Three of those were built --

1 and I'll talk about this on a later slide and
2 elaborate -- for Hanford and INEEL, a modified version
3 of that arm which was used at Oak Ridge National Lab
4 and then a companion arm for the MLDUA that was used
5 at ORNL.
6 And I will apologize to the folks who are
7 here from West Valley, the Tarzan manipulator, we
8 called it that, that's the nickname for this
9 manipulator. But it was politically unacceptable at
10 West Valley to call it a Tarzan manipulator so they
11 came up with an acronym that is totally unrememberable
12 -- or unmemorable, whatever you want to call it. And
13 so I just ignore that six letter, six word acronym and
14 call it what it really is. It's the Tarzan
15 manipulator.
16 West Valley also had a simpler
17 manipulator, just a telescoping mast with an arm that
18 folded out. And then the Fernald site had two of the
19 more novel approaches. Neither one got built but both
20 the development was pretty far along, something called
21 ReTRIEVR and EMMA that I'll talk about more.
22 And at Hanford, there is a fairly simple
23 arm that is an articulated mast that has been used
24 here recently. And they've completed cleaning up one
25 tank so far and have other deployments planned.

1 In addition to these large boom systems,
2 there are a number of companies that offer smaller
3 manipulators that can be attached to the end of a
4 large boom. And provide a more dexterous working
5 system for handling those retrieval tools.
6 Okay. The light-duty utility arms, these
7 were built by Spar Aerospace, Ltd. And if you are at
8 all familiar with the shuttle arm, this is very
9 similar technology, built by the same company that
10 built the shuttle arm. And it looks a lot like it, a
11 long skinny arm with several joints in it.
12 In this case, the LDUAs were customized
13 for tank environments at Hanford and at Idaho. These
14 arms were built primarily for characterization and
15 inspection. And the emphasis was on tools that could
16 be attached to the end of the arm, go through a 12-
17 inch diameter riser, and do sampling, inspection,
18 physical and chemical property measurements.
19 So the emphasis was on being able to reach
20 to the bottom of those 50-foot deep Hanford tanks.
21 Because of the limitation of going through a 12-inch
22 riser, they were only able to get about an 11-foot
23 horizontal reach with those systems, limited payload
24 of about 100 pounds.
25 And the LDUA system was originally

1 deployed at Hanford for characterization inspection
2 activity and then used at Idaho to support the
3 retrieval activities that they are doing. The
4 retrieval work is being done by water spray technology
5 but some of the sampling and surveillance oversight
6 activity that they're doing is being performed with a
7 light-duty utility arm.
8 At Oak Ridge, we didn't have the 12-inch
9 constraints that they had at Hanford. So what we did
10 was to modify the basic LDUA design so that we could
11 have a longer reach and a higher lift capacity. And
12 that higher lift capacity allowed us to handle big
13 enough tools to actually do retrieval, not just
14 characterization, sampling, inspection.
15 The original LDUA design was mounted on
16 the back of a truck so that at Hanford you could back
17 up over top of the riser and deploy the system. I'll
18 show a picture of that in a minute.
19 At Idaho and Oak Ridge, what we wanted was
20 an arm that was mounted on a skid that we could life
21 with a crane and place in position and move from place
22 to place on the tank farms.
23 The modified light-duty utility arm was
24 used at Oak Ridge to clean seven large underground
25 storage tanks between 1997 and 2000. This is a

1 cartoon that was drawn by folks at Hanford about 1996
2 now I guess it was.
3 But what it shows there's that truck-
4 mounted light-duty utility arm. This is the
5 containment structure. The arm would be driven to the
6 site, housed in that structure, which would be laid in
7 that yoke. And then once you got to the site, you
8 upright the arm, deploy through a containment
9 structure that had glove ports. And that's where you
10 would attach tools on the end of the arm.
11 And then the arm would then proceed down
12 into the tank. And you see the long, skinny arm like
13 the shuttle with a variety of tools on the end. And
14 there are other support systems, decontamination, the
15 analysis facilities for those, and characterization
16 tools for instance.
17 And there is a picture of the LDUA at
18 Hanford. You had a little bit better view of that
19 containment structure and the outriggers. There's the
20 truck.
21 And then this is the arm itself. Rather
22 than in a tank, this was in a test setup. Again, you
23 can see it is a multilink arm, seven degrees of
24 freedom. So it's highly dexterous with high-
25 positioning accuracy, .05 inches.

1 And that was needed, in part, because of
2 going through the risers at Hanford, which are not
3 true vertical, there are some off-vertical, and so
4 you're trying to put something that is 11 and a half
5 inches in diameter through something that is only 11.6
6 inches diameter. And not straight. So positioning
7 accuracy was required not only for the work being done
8 in the tank but also just to get into the tank.
9 The modified light-duty utility arm at Oak
10 Ridge had a similar enclosure for transport. And you
11 see we had some working platforms up here for certain
12 maintenance activities, connection to a glove box for
13 attaching tools, and then the arm could be deployed
14 into a tank.
15 In testing, we initially used the yellow
16 plastic enclosure for contamination control and
17 decided after a while that it was better to go clear
18 so that we could see if there were oil leaks from the
19 system. So in the actual tank deployments, we used a
20 clear cover.
21 What you also see in this picture is the
22 Houdini remotely-operated vehicle and our confined
23 sluicing end effector. And that that is attached to
24 something not very easily seen. But that's the waste
25 dislodging and conveyance system that we used at Oak

1 Ridge.

2 The tanks at Oak Ridge had gone through an
3 initial retrieval campaign where sluicing was used
4 back in the '80s. And what we were faced with in the
5 late '90s was a HLW that varied from six inches to
6 five feet deep. The bulk of the waste had been
7 removed.

8 And we used the arm, handling this
9 confined sluicing end effector to bring the level down
10 so that we could then get the Houdini vehicle in the
11 tanks and use the plow blade on the Houdini vehicle to
12 help move sludge to where we could reach it.

13 That confined sluicing end effector is
14 like a high performance carpet cleaner. Three
15 rotating heads that can put out water jets set up to
16 10,000 psi, which could break up hard waste, create a
17 slurry, and then we had a jet pump in the arm back
18 here that was attached through a pipeline and a
19 conveyance hose to an intake here at this confined
20 sluicing end effector. So as we broke up waste, we
21 were also evacuating it from the tank.

22 West Valley -- Ken Picha mentioned earlier
23 -- they've got a more complicated interior space in
24 their tanks. They have vertical supports that are
25 spaced ten feet apart. And then on the floor of the

1 tank there are girders that are several feet high.
2 And it is just a more complicated geometric
3 obstruction to work around.
4 What they have been able to do is to use
5 a telescoping mast system which then has an
6 articulating arm for spraying water to help move waste
7 HLW toward their retrieval pumps.
8 The more interesting work for folks
9 interested in robotics anyway, is this Tarzan
10 manipulator. And the concept there was that they
11 wanted to deploy a manipulator which could grasp one
12 of those pipes and be suspended from the pipe, hold a
13 spray nozzle or other tool from its other arm, and
14 assist in the HLW removal.
15 And in another version of that, which I'll
16 show you a cartoon of, had two arms that could grasp
17 two of the vertical supports and have a smaller, say
18 a Schilling TITAN manipulator in the middle of that
19 structure to help with retrieval.
20 Unfortunately, they weren't able to finish
21 that project. Found alternate means to get the work
22 done. And there were some prototype components that
23 were built but the full system was not built. And
24 this is just a cartoon showing how you could grip one
25 of those vertical support beams and then have an arm

1 out at the end handling a spray hose, for instance, or
2 for getting around in that more complicated support
3 structure, you might attach to two vertical supports
4 and then lean over with a dexterous manipulator.
5 Okay. I mentioned that Fernald with their
6 aboveground silos had two different projects that
7 featured design of large manipulators. The ReTRIEVR,
8 which was designed by Framatome, was a very large
9 multilink arm designed for Silo 3. And the way that
10 was going to be built, sections, eight- or ten-foot
11 sections of arm were to be assembled inside the
12 containment structure above the silos.
13 So you would insert the lower wrist and
14 gripper. And then stick in a section. Lower that,
15 stick in another section. So multi sections to build
16 up an arm that would be able to reach over 40 feet
17 down and across in those silos.
18 It got to the point where they had come
19 components fabricated. But then the project was
20 cancelled.
21 A similar application, the EMMA system,
22 developed by Grey Pilgrim, in this case it was a
23 cable-driven arm. And I'll show a picture of that
24 shortly. The tanks focus area or actually the
25 predecessor, Underground Storage Tank Integrated Demo,

1 actually funded a prototype system development. And
2 that was demonstrated and evaluated for tank waste
3 retrieval. But the full-scale version was not
4 constructed.
5 Okay. Another example of an acronym, the
6 Revolving Turret Reeled Cable Incremental Link
7 Extending Vacuuming Robot. ReTRIEVR is a whole lost
8 easier to say. See the large concrete silo and these
9 links that I was talking about, the multilink arm.
10 Again, it was a large cable reel down the inside.
11 This was designed to position a smaller manipulator at
12 the tank walls or silo walls and along the floor to
13 support waste retrieval.
14 And then EMMA, these are cylinders that
15 have about a half a dozen cables running through them
16 and back up to a cable management system up here. But
17 you could turn that arm up, down, sideways by pulling
18 on the cables one way or the other.
19 Okay. Neither of those fancy arms were
20 deployed at Fernald but there was a system that I have
21 some pictures of that was designed by our company and
22 operated by Fluor Fernald, a hydraulic mining system
23 where we had telescoping articulated masts with water
24 jets.
25 And then the WD&C System, the point there

1 was we have this three million dollar very precise
2 arm, a modified light-duty utility arm, and it was
3 going to be handling waste retrieval tools. But we
4 didn't want to bring the pipeline of waste up either
5 through that arm or attached to that arm.
6 So we built a half-million dollar arm
7 simpler, four degrees of freedom, which was basically
8 a pipeline. And the pipeline had motors in it to
9 articulate and place the end effector across the tank.
10 So we would lower the waste dislodging and
11 conveyance system into the tank. The MLDUA would
12 grasp the end effector and then lower the rest of the
13 arm into the tank and operate what is called a scara
14 position for that simple arm.
15 So all of the hammer effect of pumping
16 with that confined sluicing end effector was actually
17 taken up by the simpler arm. And the expensive arm
18 just had to deal with some simpler dynamic forces of
19 the jets rotating. So it kept the maintenance on the
20 more complicated arm much simpler. We weren't having
21 folks doing maintenance or attaching tools to that arm
22 right beside a pipeline that had waste going through
23 it.
24 Okay. And then this articulated mast from
25 Hanford, I've got a cartoon of that coming up. Oh, I

1 guess while I've got it there, in addition to the
2 confined sluicing end effector, we also had what we
3 called the gunite scarifying end effector in use at
4 Oak Ridge.
5 And every site is going to have different
6 criteria for what is clean enough to close a tank. At
7 Oak Ridge, the regulators wanted not only all the
8 visible sludge removed but they also wanted the walls
9 to be high-pressure washed to remove any loose
10 contamination that there would be on the walls.
11 So a similar tools was developed to the
12 confined sluicing end effector that simply had
13 rotating jets that we could operate at up to 50,000
14 psi. And that the MLDUA could then use to clean the
15 walls.
16 Okay. And this is the pump module for the
17 Fernald Advanced Waste Retrieval System. And there's
18 the pump itself, 600 gallon per minute sludge pump.
19 And it is being shown in a mock up that we built --
20 TPG built an 80-foot long, 20-foot wide, 15-foot high
21 swimming pool at our test facility. And did testing
22 and operator training for the Advanced Waste Retrieval
23 System.
24 And then Fernald had us take that down and
25 set it up there. And they set it up on site and

1 continue to use it there.

2 And there is a picture of the spray nozzle

3 which was a 3,000-gallon-per-minute nozzle. So pretty

4 healthy spray.

5 Okay. And I talked about that waste

6 dislodging and conveyance system arm. Just some

7 pictures showing the containment structure that you

8 would attach tools through or do maintenance. And

9 then the arm in its stowed configuration. And this

10 would be lowered down into the tank and then unfold at

11 that joint, operate then in a horizontal plane.

12 Okay. At Hanford, they are using an end

13 tank remotely operated vehicle along with an

14 articulated mast where a pump is located at the end of

15 the mast system. And the vehicle is used to push

16 waste and spray waste and help it move towards that

17 pump.

18 Okay. Now as far as manipulators go,

19 there have been several large complex systems designed

20 but only a couple that have been actually built and

21 deployed for tank waste retrieval, the MLDUA, in

22 particular. And then there are some simpler arms that

23 I mentioned that have been built.

24 For vehicles, actually there was a bigger

25 selection of vehicles for tank waste retrieval than

1 there are arms. And more of them have been deployed.
2 The Houdini vehicle, the primary feature
3 of the Houdini vehicle is that it can fold up so that
4 you can get a thousand pound mini bulldozer through a
5 20-inch riser. So it folds up, goes down in, and then
6 it can open up on the tank floor. And you have a very
7 versatile work platform.
8 We also deployed at Oak Ridge a modified
9 version of a Scarab vehicle. The vehicle that is
10 being used at Hanford is from Non-Entry Systems, Ltd.
11 And then there is a system that was custom developed
12 at SRTC for Savannah River. It deploys a water
13 cannon.
14 And then there are some other systems also
15 evaluated by the Underground Storage Tank Integrated
16 Demo that were never deployed. And I've got some
17 pictures of those sorts of things.
18 Liquid Waste Technology built something
19 called a Pit Hog. And, unfortunately, this is a
20 picture from the days before digital cameras were
21 widely used. But you can see a track vehicle with an
22 auger and a suction to an off-board pumping system.
23 And that's used in dredging ponds, for instance.
24 An ARD scavenger, wheels covered with mud,
25 you know, this was a picture taken from a test

1 environment where the vehicle got pretty well covered
2 with mud.
3 And then there is the track pump which of
4 all the vehicles that were explored by the Underground
5 Storage Tank Integrated Demo, this is probably the one
6 that had the most promise that didn't go on to get
7 deployed. And this is a vehicle that is commonly used
8 for cleaning out petroleum sludge tanks. So it can
9 handle a pretty thick sludge material.
10 It has got an auger in the front and then
11 there is a sludge pump here in the center. So between
12 the tracks and the auger, you could chew up the
13 sludge. And then suck it. And it could operate
14 completely submerged. So you didn't have to do bulk
15 retrieval by some other means.
16 Okay, Scarab III, ROV Technologies uses
17 those Scarab vehicles. It is a family of models for
18 power plant applications. And we worked with them to
19 build a stainless steel version that could be deployed
20 in the harsh environments that we find in storage
21 tanks. And did a deployment at Oak Ridge.
22 It was designed so that it could handle
23 retrieval tools but only deployed for sampling and
24 characterization activities.
25 The Houdini vehicles, we had a Houdini I

1 at Oak Ridge. And deployed it in three tanks. And
2 learned a lot about how to make it better. And had
3 that rare opportunity to actually build an improved
4 version and deployed it in four tanks, four large
5 tanks at Oak Ridge.
6 Again, versatile work platform, basically
7 a 1,000-pound mini bulldozer with a dexterous arm on
8 the end of it that could handle up to 250 pounds. Did
9 all sorts of useful things with that besides handling
10 the waste retrieval end effector and sampling.
11 We could also do things like if our
12 confined sluicing end effector got plugged with tape
13 and wire and plastic and those sorts of things, we
14 could basically pick the nose on the end effector and
15 clear it out if back flushing didn't work.
16 This is a picture of the Scarab, actually
17 Scarab III. And this is the glove box that was used
18 to deploy it in one of the tanks at Oak Ridge.
19 All right. Some pictures of Houdini. We
20 had an aboveground contamination control enclosure.
21 And the vehicle could be stowed in this compartment
22 and then deployed through a riser, work with the LDUA
23 or MLDUA, or it could handle that end effector and do
24 retrieval on its own.
25 Okay. At Hanford, the vehicle was

1 developed by CH2M HILL Hanford Group along with Non-
2 Entry Systems. And this is a very recent activity,
3 deployed in 2004, completed in 2005. In its first
4 deployment used to remove a HLW of over 3,000 gallons.
5 And additional deployments planned, as they say.
6 I'll show you some pictures of that. It
7 is a track vehicle with a tether to operate the
8 hydraulics on board. And you actually can see a
9 little more -- this is not a Hanford picture but this
10 is the commercial version before it was customized for
11 Hanford. But it is a more clear picture of the track
12 vehicle.
13 And you can see at that time, instead of
14 plow blade on front, they had an auger. This was used
15 for dredging operations.
16 Okay. For Savannah River, the folks at
17 SRTC developed a small track platform that could be
18 lowered into a tank. And then they could lower a
19 water cannon on top of it and remotely join the water
20 cannon to the vehicle. And it has been sufficiently
21 tested but it turned out not to be necessary yet.
22 Okay. So for vehicles, the Houdini
23 systems and the Non-Entry Systems, Ltd. vehicles are
24 examples of successes. Vehicles deployed for
25 successful tank waste retrieval applications.

1 A number of others that I showed you,
2 depending on the requirements, are technologies that
3 are available. And the vehicle, and it is true for
4 the arms, too, having deployable systems is really an
5 engineering challenge, not a science challenge. The
6 technology is mature. You just need to put the pieces
7 together for a specific set of requirements.
8 Conclusions, we've had some successes.
9 Usually the successes involve use -- well, usually you
10 either use the mixing system like a fluidic system or
11 a sluicing system to remove the bulk waste. And then
12 you could remove the HLW with remote systems.
13 You could use vehicles for HLW removal by
14 themselves. I showed you some examples. But
15 generally you have a more efficient operation if you
16 are playing pitch and catch where your pump is
17 relatively stationary and the vehicle is able to be
18 mobile around the entire tank and help bring the waste
19 to that pump.
20 And then the last line here says that
21 although many companies have contributed to remote
22 technology development for tank applications, there
23 has really been very little funding or activity in
24 that direction here lately. So there are not that
25 many folks active right now.

1 But if DOE, and I say, you know, I say get
2 serious -- they're very serious about tank waste
3 retrieval. The problem is you don't have anything yet
4 to -- where to dispose and store the waste. You don't
5 have the treatment facilities in place. And so it
6 doesn't make sense to pull waste out of the tanks
7 until you are ready to process and store.
8 But when DOE is ready to process and store
9 tank waste, the techno community has material
10 solutions that we can put forward. Thank you.
11 VICE CHAIRMAN CROFF: Thank you, Barry.
12 I think at this point what I'd like to do
13 is go ahead and entertain questions on the retrieval
14 issue, if you will, to both Paul and Barry. So, I
15 guess, Barry, you know, you can stay there with that
16 microphone or sit down over here with Paul as you
17 wish.
18 Bill?
19 MEMBER HINZE: Well, all this is very
20 fascinating. And it shows a lot of ingenuity.
21 A couple of questions. Barry, you talk
22 about using the vehicle system for removing of the HLW
23 and this is with a pressurized system associated with
24 it I assume.
25 DR. BURKS: That's correct.

1 MEMBER HINZE: And yet we hear from Paul,
2 can your system also get the HLW out without a vehicle
3 system associated with it?
4 DR. MURRAY: It depends on the HLW.
5 MEMBER HINZE: Well, that was also another
6 concern of mine. You are obviously losing pressure as
7 you move away from your arm that goes down. So you
8 must have a fairly high pressure to remove a HLW or
9 even to move the sludge. What kind of dissipation of
10 pressure do you get? And how do take that into
11 account?
12 DR. MURRAY: The pressure we use is really
13 low. It's about 60 psi. And what we rely on is the
14 mass of water coming out the nozzle. So the nozzles
15 themselves are inch and a half diameter.
16 MEMBER HINZE: Okay. So it is the
17 momentum of the water itself that -- okay.
18 I guess that really gets at another
19 question that I had that relates to the problem
20 associated with causing leaks in tanks with all this
21 equipment. And how do you know that you are not
22 causing leaks or how do you know you are not
23 pressurizing the fluids through minute cracks in the
24 tanks? How do you monitor all of this?
25 DR. BURKS: Let me respond to your first

1 question also. The tank geometry is partly what
2 drives the solution for retrieval. If you've got a
3 tank, a Hanford tank, with a limited number of
4 penetrations. And you've got 15 feet of dirt over top
5 of your tank. It's very expensive to add
6 penetrations.
7 So if you can remove the waste using the
8 existing penetrations, then that is going to save a
9 lot of money and perhaps exposure. And the best way
10 to do that may be an arm or a vehicle.
11 Whereas those horizontal tanks that Paul
12 was showing, if you've got horizontal tanks with a row
13 of penetrations or spargers down the center, you know
14 it may make a whole lot of sense to just use a
15 fluidics mixing approach because the geometry, the
16 rounded bottom on that tank favors that approach.
17 Whereas a large, flat-bottom tank may be
18 difficult to clean using -- it takes a lot more jets
19 or a lot more directional control, for instance, on
20 that.
21 Now could you be creating leaks?
22 Potentially, you could be unplugging some piece of
23 waste that has been plugging a leak for a period of
24 time.
25 MEMBER HINZE: Right.

1 DR. BURKS: You know that is certainly a
2 possibility. And in the tanks like at Savannah River
3 where you have an annulus, you have some opportunity
4 to monitor that. At Hanford, the single-shell tanks,
5 it's not going to be as easy.
6 And what you are counting on there is that
7 you are bringing the waste, the contamination, down to
8 the bottom of the tank and pumping it out. You are
9 not maintaining a large amount of free liquid in the
10 tank.
11 As soon as you create that free liquid,
12 you want to evacuate it, which helps minimize the
13 potential for migration through a leak, which is an
14 advantage for these minimum added water approaches
15 compared to the traditional sluicing where you are
16 putting a lot of water in and you are counting on
17 keeping a large volume of water with waste suspended
18 in it.
19 So you minimize the potential by
20 minimizing the free liquid.
21 MEMBER HINZE: And not necessarily any
22 monitoring system associated with it?
23 DR. GASPER: I'll try to address -- Kenny
24 Gasper from Hanford. I'll try and address your
25 question, Bill.

1 And that is in the case of retrieval on
2 single-shell tanks where we're dealing with 75-foot
3 diameter flat bottom tanks basically, Washington
4 Department of Ecology, working with the Department of
5 Energy, reached agreement that we would put some
6 demonstration monitoring capability around our tanks
7 to try to determine whether there was any leakage
8 occurring.
9 And the way we did it was in separate
10 technology development activities, evaluated
11 competitive techniques. But we ultimately used
12 electrical conductivity probes surrounding the tanks
13 using the monitoring wells that already were in place.
14 And we basically monitored the conductivity of the
15 soil grid surrounding the tank.
16 And that proved for the demonstration that
17 was done this past year to be able to pick up moisture
18 that was coming from rain. And we don't get heavy
19 rainfalls in the desert of Hanford. And so the
20 monitoring system was able to pick up that kind of
21 moisture difference. And we were not seeing from our
22 retrieval operations any leakage associated with the
23 retrieval operation.
24 But your point is well taken that you may
25 have to put in sophisticated leak detection capability

1 if you are dealing with the large diameter, single-
2 shell tanks at Hanford that don't have the annulus to
3 sense and don't have the rounded bottoms of some of
4 the horizontal tanks.
5 So that becomes a separate technology
6 evaluation activity that we've had to go through.
7 MEMBER HINZE: Thank you.
8 One of the things that is very appealing
9 about Paul's system that he described as simplicity,
10 when you get into something like the vehicles, these
11 are highly complex systems. I'm wondering are you
12 concerned about any explosive in the tank? Do you
13 pump inert gas into the tank so that there are no
14 explosions that could come from static electricity or
15 from metal to metal scraping?
16 And I'm also wondering with those robotic
17 tanks, how you do the decontamination after retrieving
18 that vehicle. That must be a lot more difficult than
19 with a simple device like Paul was describing.
20 DR. BURKS: I'll address the last one
21 first because it is easier.
22 MEMBER HINZE: Okay.
23 DR. BURKS: They are all designed -- if
24 they are designed for tank waste retrieval, then they
25 are designed for decon. And like that LDUA with the

1 plastic sleeve on it, it was designed so that you are
2 cleaning a plastic sleeve rather than cleaning the
3 metal arm that has maybe exposed screw holes or that
4 kind of thing. So there are techniques to avoid
5 getting or to simplify the decon process.
6 But then you see on these track vehicles,
7 there are nooks and crannies. And there's places for
8 waste to become embedded. So what we did at Oak Ridge
9 and also it was done at Hanford and Idaho is to design
10 a spray ring so that when we pull the vehicle or the
11 arm up, we pass it through a high-pressure wash. In
12 our case it was 2,000 psi.
13 And it did a pretty good job of cleaning
14 off the vehicle or the arm when it was pulled up into
15 its containment structure. But, again, our emphasis
16 was on clean enough to move to the next tank and
17 continue operations in a production line kind of a
18 mode as opposed to trying to release it for, you know,
19 free release afterward.
20 They are more complex than piping, than
21 the fluidics. You have to look at the requirements.
22 At gunite tanks, we had to take three-inch cores in
23 the gunite walls before and after cleaning. And then
24 cut those into slices to demonstrate that we had
25 cleaned sufficiently and that there wasn't

1 contamination that had migrated deep into that
2 concrete structure.
3 You know you can't do that with something
4 designed just to remove waste. You need a
5 multipurpose system. So in addition to the retrieval,
6 if you have other requirements, you may still end up
7 after cleaning a tank with fluidics having to go in
8 and do some kind of sampling or characterization
9 activity with a different system.
10 You are driven by the requirements. And
11 every site is different.
12 As far as the explosive potential, we
13 always operated with a negative pressure in the tanks
14 when we were doing operations at Oak Ridge. And so if
15 we -- and we started out with an atmosphere in the
16 tanks that was not potentially explosive. But we
17 operated with a negative pressure.
18 At Hanford, I know that they have some
19 tanks that are on the watch list for potential
20 hydrogen concentration. And if you are doing
21 retrieval from those tanks, then you are going to
22 aggressively ventilate to try to avoid a threshold
23 concentration of potentially explosive material.
24 But the other thing you can do is design
25 the systems with intrinsically safe electronics --

1 move as much electronics as possible off board, which
2 is what we've done, use some intrinsically safe
3 materials. So you can minimize that risk.
4 MEMBER HINZE: It's just a potential
5 concern. And that's why I wanted to raise it.
6 DR. BURKS: It is.
7 MEMBER HINZE: Thank you.
8 VICE CHAIRMAN CROFF: Okay, Mike?
9 CHAIRMAN RYAN: I second Allen's comments,
10 creative and innovative engineering. You both ought
11 to be applauded for looking at tough problems and
12 coming up with innovative solutions. It is really
13 interesting to hear your presentations.
14 I think a little bit down the road a bit,
15 I took one note of 50,000 psi out of a hydrolaser.
16 That's pretty aggressive cleaning. And it kind of
17 leads me to the question that I think about. At the
18 end of the day when the tank is "done", whatever done
19 is and I know that is going to vary a bit, have you
20 left it in a state that you can really predict how it
21 is going to behave in performance assessment?
22 And I raise the question. For example,
23 you attack something with 50,000 psi. You can back
24 up. I mean you could create holes in the thing you
25 think is intact. And things like that. Have you

1 gotten into those kind of assessments? I know I'm
2 asking a tough question because maybe you are not
3 there yet. But tell me what your thinking is on how
4 do you decide when to stop.
5 DR. BURKS: Well, for the gunite tanks, we
6 went through a cold test program that included our EPA
7 and DOE and the people who were going to be involved
8 in the readiness reviews and they just wore me out
9 doing demonstrations basically. And wore out the
10 Houdini I practically. That's why we had to have a
11 second one.
12 What we did there was to demonstrate the
13 limits of the technology in a cold environment. And
14 the regulators used that cold environment result to
15 help define what the end state would be.
16 In that case, we were able to remove all
17 visible sludge and, again, the loose contamination on
18 the wall through that scarifying. So that was our
19 criteria. Remove all visible sludge. Remove the
20 scale. And there were other sampling guidelines along
21 the way.
22 But what we left behind in the gunite
23 tanks -- and these are large, flat-bottom tanks, what
24 we left behind was typically a half inch to three-
25 quarters of an inch of our decon water. You know that

1 last pass cleaning the systems as you pull them out of
2 the tank generated some dirty water.
3 But the disposition of those tanks was to
4 grout. So having a half inch of dirty water in the
5 bottom of a tank that is going to be grouted was
6 perfectly acceptable.
7 CHAIRMAN RYAN: Yes. I guess the point
8 I'm trying to make, and I know you've given us
9 specific examples, it would be an interesting goal to
10 not only think about criteria that are operational,
11 like no visible sludge and some decon standard or some
12 number of disintegrations per minute per 100 square
13 centimeters or micro arc per hour per square meter or
14 whatever you want to do.
15 But it would be interesting to think about
16 leaving it in such a way so that it has a high
17 predictability as you go to the next step of
18 predicting performance in the longer haul for
19 determining that it is okay to leave it behind. Have
20 you ever thought in that way about it? Or not?
21 DR. BURKS: Well, I know that both Hanford
22 and Savannah River have clean-up criteria based on the
23 number of curies that they are able to leave behind in
24 a tank. And that is based on a, I guess, a risk
25 model.

1 CHAIRMAN RYAN: Okay.

2 DR. BURKS: And our acceptance criteria at
3 Oak Ridge is also based on a risk model. The bottom
4 of our tanks were below the water table because of the
5 hydrology in Oak Ridge. We have creeks that are
6 nearby. So the risk numbers had been run. The model
7 had been run to see what would be acceptable.

8 And, you know, one of the alternatives was
9 remove the tank shells altogether. But it was
10 determined that if we could remove a sufficient amount
11 of the radioactive material and then stabilize the
12 shells and material that might be left remaining in
13 the shells and on the floor, that that would be
14 acceptable from the risk model perspective.

15 Other folks are going to have different
16 drivers. And probably be allowed to leave a whole lot
17 more in the tanks.

18 West Valley has a different situation.
19 They were getting down to the millimeters of material
20 left in places on the bottom -- in terms of solids,
21 millimeters of solids on the bottom of their tanks
22 because they started with a material that was so much
23 hotter than our sludge that it took a whole lot
24 smaller volume to get to an acceptable residual.

25 Hanford and Savannah River are more like

1 West Valley in that regard. Not as extreme.

2 And a part of what you are asking about is

3 the condition of the shells. At Fernald, those silos,

4 you know the analyses tell you they should have

5 collapsed 20 years ago.

6 At Oak Ridge, the gunite tanks are really

7 in very good shape except for one where we see rebar.

8 There's obvious spalling that has occurred inside a

9 tank. So stabilizing with grout worked just fine

10 there.

11 At Hanford, it's going to be so expensive

12 to pull those tanks out of the ground, they need to

13 find a way to stabilize them in place and make them

14 acceptable.

15 CHAIRMAN RYAN: So I guess in that sense

16 it really is a one off situation. Each one has its

17 own unique features. Is that really where you are

18 now?

19 DR. BURKS: Yes, different geological or

20 hydrogeological constraints. And what is acceptable

21 to their regulators.

22 CHAIRMAN RYAN: Thanks. That's a helpful

23 insight. I appreciate it.

24 MEMBER WEINER: Again, I think this is

25 fascinating. And I'm so happy to see this technology

1 developed because I remember 20, 25 years ago, we were
2 told oh, you'll never do this. You'll never clean
3 those tanks out.
4 My question is you mentioned that you only
5 decontaminate them enough to use the instrument on the
6 next tank. So at some point, it must become so
7 contaminated that you can't use it any more. Is that
8 the case? And if it is, what do you do with it then?
9 DR. BURKS: Actually, we ran out of tanks
10 before we got to that point.
11 MEMBER WEINER: Well, good for you.
12 That's great.
13 DR. BURKS: And actually at the conclusion
14 of the gunite tanks project, I tried to interest other
15 sites into using the equipment. And there were
16 several reasons why we weren't successful in doing
17 that.
18 One of the prominent reasons was because
19 of the level of contamination. Most folks would
20 rather start with a cold system that they can go
21 through a cold testing program and operator training
22 on than deal with the hassles of starting with a
23 contaminated system.
24 MEMBER WEINER: What do you do with your
25 contaminated instruments? Your contaminated robots

1 and arms and things?

2 DR. BURKS: The two Houdini systems and

3 the modified LDUA are in a scrap yard, contaminated

4 scrap yard at Oak Ridge.

5 MEMBER WEINER: So they become low-level

6 waste.

7 Paul, what do you do?

8 DR. MURRAY: Our systems, the small mobile

9 system we built at Oak Ridge, after it finished

10 emptying tanks at Oak Ridge was moved to Mounds and it

11 continued to empty tanks at Mounds. Because it was

12 used on plutonium contaminated wastes, it could not go

13 to any other place.

14 And so it is disposed of completely apart

15 from the control head and the off gas system were

16 given back to us and we're about to reuse that

17 equipment for some tanks at Idaho.

18 We generally abandon the nozzles in place

19 in the tank. The big charge vessels I showed you,

20 after they finished emptying the C-tanks at Oak Ridge,

21 were picked out and permanently deployed on the CIP

22 tanks, capacity increase tanks at Oak Ridge. And

23 they'll be used for the next 20 years at that site.

24 In other systems, once we've emptied a

25 tank, people tend to fill them up again after us. So

1 they are in continuous operation.

2 MEMBER WEINER: Oh, I see. Thank you.

3 VICE CHAIRMAN CROFF: Jim?

4 MEMBER CLARKE: Yes, just picking up and

5 let me fifth what everyone has said. Very creative,

6 innovative technologies. Fascinating presentations.

7 A couple questions on some of the details.

8 And this may not be a fair question. But is there an

9 average time it takes to do something like this? For

10 example, Paul, your cycle time on your charge and

11 drive, you know, can you give us a feel for that?

12 DR. MURRAY: About two to two-and-a-half

13 minutes on the big charge vessels to fill and cycle.

14 Obviously, it depends on altitude. And when we get up

15 to Los Alamos, it takes a bit longer. But it is

16 generally about two, two-and-a-half minutes to fill

17 the charge vessel before it discharges.

18 MEMBER CLARKE: And I think, Barry, you

19 said that you really target the tool to the tank. So

20 depending on the configuration of the tank, you'd use

21 one approach or another.

22 I guess Hanford might be an example. But

23 are there sites where you have encountered different

24 designs for different ages of tanks? And you really

25 need to use different approaches?

1 DR. BURKS: Again, the geometry and the
2 waste form itself are the two big drivers for what the
3 tool is going to be. And there have been a number of
4 different systems evaluated for use at Hanford that
5 have different strengths applicable to the various
6 problems.
7 You know I showed you the Tarzan
8 manipulator.
9 MEMBER CLARKE: Yes.
10 DR. BURKS: There is only one site that
11 has that kind of constraint to drive you to that
12 complicated a system.
13 MEMBER CLARKE: You know this is more of
14 a question, I guess, about the tanks themselves. But
15 do you encounter different designs on the same site?
16 CHAIRMAN RYAN: Yes.
17 DR. BURKS: Different numbers of
18 penetrations, different sizes of penetrations,
19 different depths, diameters.
20 DR. GASPER: Even at Hanford -- this is
21 Kenny Gasper -- even at Hanford on our single-shell
22 tanks, some are flat bottom, some are slightly dished.
23 That is between the center of the 75-foot diameter
24 tank and the rim at the bottom, there may be a one-
25 foot slope to it. And that's what I mean by the dish.

1 The other problems that we have with
2 regard to evaluating the technologies as Barry says is
3 the kinds of waste. We have such a variety. I'm not
4 talking about chemically. I'm really talking about
5 physically. That is the waste in some cases is very
6 soluble.
7 And to the extent that it is either
8 soluble or it is somewhat mobile in terms of pumping
9 and sluicing, even with the limited volume sluicer,
10 kind of like a shop vac, versus if the material has
11 aggregated more into course gravel or cobble, when we
12 encounter that kind of material and we hit it with a
13 sluice nozzle, it just moves.
14 And our C-106 problem was not that we
15 ended up with solid concrete-like material but rather
16 that we had cobble that we chased around the bottom of
17 the tank. It's kind of like trying to wash coarse
18 gravel off of your driveway with a garden hose. Well,
19 we were using a fire hose in a sense on a couple
20 different penetrations through the top of the tank and
21 trying to wash it over to where the collection pump
22 was.
23 The pump was fully capable of pumping it
24 if we could get it there. It's just that how do you -
25 - when you've got a 75-foot diameter and you've got

1 this hose coming down through this end, your
2 probability of with two hoses getting it to your
3 collection point, we exhausted our resources and
4 basically found that we were not quite achieving the
5 99 percent number to the plus or minus accuracy that
6 was required by our agreement.
7 We were at -- let's say we were supposed
8 to be at 360 plus zero minus whatever we wanted on
9 cubic feet and we calculated that we were at something
10 like 345 plus or minus something. And what do you do?
11 Well, we didn't meet the criteria. And we
12 weren't sure -- it was definitely the law of
13 diminishing return of how much resources you spend to
14 chase this material where the material was so
15 insoluble that it wasn't releasing anything.
16 And so that's where we're at with C-106
17 with talking with the NRC and talking with ecology
18 about what do we do on a tank like that?
19 In the case of S-102, well S-112 dissolved
20 well down to a certain point where the salt cake was
21 so reconstituted that it basically quit dissolving and
22 we could hit it with hot water or cold water and we
23 were running out of ability to add water, let it sit,
24 pump it out and get any degree of removal.
25 In the case of S-102, we had just enough

1 sludge around the material at the bottom of the tank
2 that it was clogging the inlet to the pump that we
3 were retrieving with. And we're working that problem
4 right now.
5 So when Barry says it really depends on a
6 combination of the configuration of the tank and the
7 constituency of the material, that's --
8 DR. BURKS: And the requirements of your
9 regulators.
10 DR. GASPER: Yes. But even with a common
11 set of regulators, we are just having a difficult time
12 projecting how a particular tank is going to retrieve
13 when you begin using a particular technology to do it.
14 MEMBER CLARKE: And if I could just
15 interject one more, this is the last one.
16 I assume you are visually monitoring this
17 during the course of the clean out so you've got a
18 record of every stage of it?
19 DR. GASPER: Yes, we have TV cameras down
20 in.
21 VICE CHAIRMAN CROFF: Okay. I've got a
22 question or two or four.
23 I guess first on the fluidics technology,
24 are you proposing that for bulk waste retrieval, you
25 know the first 20 or 25 feet kind of stuff?

1 DR. MURRAY: It depends on the tank. If
2 it is salt cake like Ken was talking about, then just
3 past practice sluicing will dissolve the waste up.
4 And it is a very, you know, viable and efficient way
5 of doing it.
6 And fluidics then comes into its own at
7 the end to recover the HLW and potentially grout the
8 HLW in place.
9 VICE CHAIRMAN CROFF: For the -- well, let
10 me call it massive amounts of mobile stuff, not just
11 the salt cake but the, you know, sludge that can be
12 moved around by a mixer pump, is it more efficient to
13 use the mixer pump, you know I mean down to a certain
14 point?
15 DR. MURRAY: There are two ways of looking
16 at it. You can try and completely homogenize the tank
17 with your mixer pump and then feed forward from that.
18 Or you can use a set volume for the charge vessel and
19 suck so much sludge into the charge vessel, dilute it
20 with supernated water, pump that forward, monitor what
21 you pump forward, and then adjust your amount of
22 dilution the next time.
23 So instead of trying to mix the entire
24 tank, you're trying to control a 300- or 400-gallon
25 volume. You see what I'm saying? It gives you a

1 different option.

2 VICE CHAIRMAN CROFF: Yes.

3 DR. MURRAY: Because you've got to turn

4 the mixer pumps off at some point because of minimum

5 submergence of the mixer pumps.

6 VICE CHAIRMAN CROFF: Right. As I

7 understood what you said, with the fluidics

8 technology, you can get down to on the order of an

9 inch or a half an inch kind of stuff --

10 DR. MURRAY: Yes.

11 VICE CHAIRMAN CROFF: -- if I'm going to

12 assume there is not a bunch of stuff on the bottom of

13 obstructions, which is about the same, I think, as

14 some other technologies.

15 Is it your belief that this fluidics thing

16 is just a more efficient way to get down to that level

17 if you will?

18 DR. MURRAY: It will use much less water

19 to get down to that level. We can continuously

20 recirculate the water in the tank to concentrate up

21 the sludge before we pump it out. Past practice

22 sluicing, you have to have recirculation loop and

23 stuff like that.

24 VICE CHAIRMAN CROFF: Okay. You mentioned

25 this demonstration in September. Has a date been

1 picked?

2 DR. MURRAY: It's going to be the week

3 after Labor Day.

4 VICE CHAIRMAN CROFF: Okay. But not a

5 specific day in the week yet?

6 DR. MURRAY: No. If anybody is

7 interested, as I said, if they'd e-mail me, we'll make

8 sure you get invitations.

9 VICE CHAIRMAN CROFF: Okay. Barry, on

10 some of your stuff, I gather autonomous vehicles for

11 in tank, nobody has -- it's not worthwhile going that

12 far?

13 DR. BURKS: No, the environment is

14 unstructured enough that you are better off just to go

15 with a tele-operated system.

16 VICE CHAIRMAN CROFF: Okay. At West

17 Valley, you mentioned getting down to very low levels.

18 What technology did they use to get down to

19 millimeters?

20 DR. BURKS: They used water jets and

21 mixing pumps.

22 PARTICIPANT: On the walls, they

23 burnished.

24 DR. BURKS: Yes. But for their HLW

25 removal, they were using water jets to move the sand

1 basically to where their mixer pumps could pick them
2 up.
3 VICE CHAIRMAN CROFF: Okay.
4 DR. BURKS: But it was -- Ken talked about
5 reaching diminishing returns. They were really way
6 out on the end of the curve as far as what you are
7 picking up per amount of time you are spending.
8 VICE CHAIRMAN CROFF: I guess I should say
9 by way of background, you know, that what I'm focused
10 on is this maximum extent practicable thing and what
11 is practicable. And it seems that in a nice open tank
12 you can get down to just about nothing. And maybe
13 with some debate on whether all of the remote systems
14 are really worth it or not depending on dilution.
15 But in some other tanks, it can be a good
16 deal tougher. And the economics, like the curve
17 starts to go up fairly quickly from what I think I'm
18 understanding.
19 Again on the remote system, there were a
20 lot of midstream cancellations. You know for defined
21 applications like Fernald and West Valley, why did
22 they get, you know, part of the way in and then just
23 say we're not going to do that?
24 DR. BURKS: Variety of reasons.
25 VICE CHAIRMAN CROFF: Okay.

1 DR. BURKS: The contractor, for instance,
2 on Silo 3 bailed out. You know they defaulted on
3 their contract.
4 VICE CHAIRMAN CROFF: Yes.
5 DR. BURKS: That was Rocky Mountain
6 Remediation Services.
7 There was -- Foster-Wheeler had the
8 contract to do Silos 1 and 2. And after getting about
9 80 percent of the way through design and fab, they
10 entered negotiations on a large change order with
11 Fluor Fernald and DOE. The decision was made to
12 terminate for convenience. And Fluor finished the
13 contract.
14 They picked up all of our stuff that we
15 were building for Foster-Wheeler. But they eliminated
16 the EMMA arm, for instance. And decided they would
17 just rely on hydraulic mining.
18 VICE CHAIRMAN CROFF: Yes.
19 DR. BURKS: So there's contract management
20 issues that have entered.
21 For the Tarzan system, design progressed
22 pretty well until a certain point. And then they got
23 to a point where there was some question about whether
24 those vertical supports could handle the stress. And
25 when those questions came up, the cost to resolve

1 those questions versus continuing with the approach
2 that was working but working minimally at that point,
3 the decision was made to keep going without the
4 Tarzan.
5 VICE CHAIRMAN CROFF: Okay. Final
6 question. Savannah River has -- I don't know -- on
7 the order of 50 tanks, the inside of which is
8 basically a forest of cooling coils, vertical cooling
9 coils in this case. What are your thought on -- what
10 can you do to retrieve that kind of tank to get the
11 waste out from amongst all those coils? What is
12 practical or reasonable in there?
13 DR. BURKS: Well, mixer pumps, mixer
14 systems are going to get you a long ways. And then it
15 is just a question of how much of the HLW do you want
16 to retrieve. And you're going to have to deliver more
17 energy into that HLW to get it mobilized. Whether
18 that is with a vehicle, an arm, or a pulse jet, that's
19 determined -- the deployment system is really
20 determined by the number of access penetrations.
21 VICE CHAIRMAN CROFF: Yes.
22 DR. BURKS: And my feeling anyway, you can
23 come up with an arm, you can come up with a vehicle.
24 The real question is how much can you leave behind.
25 VICE CHAIRMAN CROFF: I take it from what

1 you are saying, you know, it would be very costly to
2 maneuver in around all those coils.
3 Paul, do you have any thoughts on that?
4 DR. MURRAY: Yes, we looked at Tank 48 at
5 Savannah River. And we concluded we could retrieve
6 most of the waste from the tank using free
7 penetrations into the tank. And then we were
8 proposing a chemical solution to basically finish off
9 the tank.
10 VICE CHAIRMAN CROFF: Okay. In this case,
11 how much was most? I mean in inches or something like
12 --
13 DR. MURRAY: It is hard to say. It's hard
14 to quantify what is in the tank --
15 VICE CHAIRMAN CROFF: Okay.
16 DR. MURRAY -- to begin with. That's
17 always a problem. In our experience, whatever data
18 we're given to begin with about the tank, you know,
19 nod and smile and put it on one side and design for
20 the worst case because you never know what is in that
21 tank.
22 VICE CHAIRMAN CROFF: Okay. So that's
23 just basically sort of an unknown at this point.
24 DR. MURRAY: Yes.
25 VICE CHAIRMAN CROFF: Until you get there.

1 DR. MURRAY: Yes.

2 VICE CHAIRMAN CROFF: Okay.

3 DR. BURKS: Well, let me comment.
4 Although I really enjoy the more complicated systems,
5 in practice what I push is the simplist approach that
6 meets your requirements. And so in some cases, it is
7 an articulated mast that only has two joints.

8 VICE CHAIRMAN CROFF: Okay. Anybody?
9 Latif?

10 DR. HAMDAN: Yes, Barry, you did not
11 discuss this. What kind of information do you
12 collect? Major items in your checklist, if you like,
13 that you have before you receive the waste, during the
14 waste retrieval, and afterwards? The things that you
15 worry about the most.

16 DR. BURKS: Well, system requirements is
17 the waste composition, pH, the RAD levels, I've
18 mentioned the access penetrations that really drives
19 the size of things you are putting in there,
20 constraints such as explosive environments, walls that
21 maybe can't take 50,000 psi.

22 Floors could also be an issue because at
23 Hanford, the leaks may be from the bottom of the tank,
24 not the sides. Who knows? So there are lots of
25 constraints that have to do with the tank itself and

1 the waste.

2 Beyond that, where is it going to go and

3 how do I get it there. At Oak Ridge, we were using

4 one of our tanks -- the last one we cleaned out was

5 the one we used as our mixing tank. And then from

6 there, we transported over a mile away to the Mountain

7 Valley storage tanks where a treatment facility is

8 being built or has been built at this point.

9 I was going to have to dilute the sludge

10 to pump it a mile across site. So it didn't make

11 sense for me to spend a lot of money to recirculate

12 contaminated water when I had to add water sooner or

13 later anyway.

14 We had evaluated using contaminated water

15 supernate, in our confined sluicing end effector for

16 the nozzles. It didn't make sense because we were

17 going to have to add water to dilute it anyway.

18 Other sites, a minimum added water

19 approach may be more important to you than a lot of

20 other aspects. Savannah River and Hanford, they have

21 a water management problem right now.

22 And when I said at the end of my slide,

23 you know, when DOE is ready to get serious about waste

24 retrieval, the tools are there. By get serious, I

25 mean have the treatment, processing, storage

1 facilities in place so that you can go forward.

2 The retrieval approach is just the front

3 end of the process. You want to retrieve the waste in

4 the form that is going to be most easily treated.

5 We've got work that we're going, and Paul

6 is part of this project as well, at Mountain Valley.

7 And they want a particular feed stock into their

8 treatment process. So the retrieval process is

9 matched up with that treatment process.

10 The other thing, you know, operational

11 issues. I want to know what kind of debris are in the

12 tank. Am I dealing with dead cats? Or aircraft

13 cable? We had a lunch box in one of the tanks at Oak

14 Ridge. If you know you are going to have plastic

15 tape, you know, wrenches, gaskets, all kinds of stuff

16 like that, then you have to design for that.

17 Rotating pieces of equipment, for

18 instance, don't do well with ropes and wires. So

19 there are operational issues.

20 Decon issues, you know at Oak Ridge, I

21 could leave a half an inch of dirty water in the tank.

22 Can I do that at Savannah River? Hanford?

23 I can go on and on as far as the design

24 issues. But those are some that come to mind quickly.

25 VICE CHAIRMAN CROFF: Okay. Thank you

1 very much Barry and Paul. If there are any more
2 questions, we'll go ahead and take them a little bit
3 later in the day.
4 Mike, did you have something?
5 CHAIRMAN RYAN: Yes, actually Mike Scott
6 is over here. And he and other members of the NRC
7 staff will help all of our visitors get downstairs.
8 You must be escorted if you wearing a visitor's badge.
9 So if you can help on that.
10 MR. SCOTT: Yes, the other thing is I'm a
11 bit of a bearer of bad news. With the current
12 heightened security requirements, you need to -- if
13 you are a visitor, you need to be escorted anywhere in
14 the building, Security informs me. Which means that
15 even if you want to have lunch in the NRC cafeteria,
16 you need to have a staff escort.
17 Not to be inhospitable but my
18 recommendation would be to you, if you are a visitor,
19 you might want to consider going next door to Eatsies
20 where you don't have to deal with these escort issues.
21 Hopefully we'll work our way through this.
22 There have been some discussions internally about it
23 as to whether this is the right way to go. But that's
24 what Security is saying now.
25 Thank you.

1 CHAIRMAN RYAN: Okay. And we'll restart
2 at one o'clock. Thank you.
3 (Whereupon, the foregoing matter went off
4 the record at 12:05 p.m. to be reconvened in the
5 afternoon at 1:02 p.m.)
6 VICE CHAIRMAN CROFF: Mike Ryan will be
7 out for a couple of minutes, so he said we should get
8 going, and let's try for an on-time departure here, so
9 we have some time to talk later in the day.
10 The third speaker in this session
11 continued over from the morning is Dr. Dave Kocher.
12 Dave spent 30 years at Oak Ridge National Lab, and is
13 presently a Senior Research Scientist at SENES Oak
14 Ridge. He's been actively involved in issues of waste
15 classification for the past 20 years, was a member of
16 the committee that produced the NCRP report on risk-
17 based classification of radioactive and hazardous
18 chemical waste.
19 In this presentation, Dave is going to
20 talk about highly radioactive and what it means.
21 Dave?
22 DR. KOCHER: A couple of really important
23 disclaimers at the beginning. I'm expressing my
24 opinion, nothing more, nothing less. The second thing
25 is that I'm not going to spend 15 minutes talking

1 about what this term in the law means or how it should
2 be interpreted for specific sites and specific waste.
3 This is basically a history lesson from a
4 personal point of view about what this term has meant
5 in the past and what it may or may not have to do with
6 how it's interpreted at present.
7 Basically, three discussion topics.
8 What's the meaning and quantification of this term
9 "highly radioactive" in the historical context of
10 defining high-level waste? And once we understand
11 what highly radioactive has meant historically, what
12 is the importance of that to long-term performance of
13 waste disposal systems? And, third, and very little
14 -- I'll say a little bit about this strange term,
15 "highly radioactive radionuclides," that appears in
16 this law. It troubles me.
17 As far as I could tell in my looking into
18 the matter, the term "highly radioactive" first
19 appeared in the definition of high-level waste in the
20 Nuclear Waste Policy Act. And to me, one of the keys
21 is it refers to highly radioactive material, not
22 highly radioactive radionuclides. That's important.
23 You all are familiar with this. There's
24 two problems here. One, there's no quantification of
25 what highly radioactive means, but more important to

1 me I think is that there is ambiguity about, well,
2 obviously, the radionuclides that are included. I
3 would describe the ambiguity this way: is "highly
4 radioactive" a defining characteristic of high-level
5 waste or is it the defining characteristic of high-
6 level waste?
7 These words are ambiguous, and there's a
8 big difference between one of several characteristics
9 or it's the only characteristic.
10 So we go back in time and see how all of
11 this got started. Really, the first extensive
12 writings on high-level waste appeared in the timeframe
13 of around the mid-1950s, and high-level waste was
14 always described as having high levels of decay heat
15 and external radiation. This is what made this stuff
16 high level.
17 And, of course, these attributes were due
18 mainly to high concentrations of shorter-lived fission
19 products. And as you all know, if you age the waste
20 for a few years -- basically this is strontium and
21 cesium -- are contributing to waste having high levels
22 of decay heat and external radiation.
23 This waste was liquid and it either -- it
24 required some kind of active or passive cooling and
25 extensive shielding to protect workers during waste

1 operations and storage. It's really, really important
2 to remember that all this got started because of waste
3 definitions that had nothing to do with disposal. It
4 was only about protecting workers on the job.
5 So what they really were worried about was
6 boiling waste that would release aerosols and high
7 levels of external radiation that would zap the
8 workers. Nothing to do with disposal.
9 Well, there were early quantifications of
10 this term, and, again, these are operational
11 definitions to let people at AEC sites in those days
12 do their job in a way that stored the waste safely and
13 protected their workers. You see descriptions in
14 terms of external exposure rate. Let me skip this one
15 for a second. Total activity concentration was a
16 favorite. MPC stands for maximum permissible
17 concentration back in the old Part 20 days.
18 The IAEA -- this 10 -- greater than 10^4
19 curies per cubic meter, the early IAEA recommendations
20 never really talked about high-level waste. They had
21 Category 1, 2, 3, 4, and 5 -- a whole new terminology,
22 which mercifully did not catch on. This highest
23 category of cooling of the stored waste was necessary
24 in their Category 4 waste, which went down to .1, five
25 orders of magnitude lower, required shielding.

1 Now, all of these, including MPC, this --
2 these quantifications were driven by the
3 concentrations of shorter-lived fission products. The
4 concentrations of longer-lived alpha-emitting
5 transuranics in these wastes were only marginally
6 important, if at all important, in determining whether
7 these criteria were met. This was driven by short-
8 lived stuff.
9 So, to me, this in essence quantifies
10 highly radioactive as it was thought of in the early
11 days. A useful thumb rule -- 100 curies of fission
12 products is on the order of one watt of thermal power.
13 So this is all about short-lived stuff was --
14 determined these quantifications and classifications.
15 Well, there was further subclassification.
16 This liquid high-level waste, some of it was toastier
17 than others, so at the Hanford site -- and, actually,
18 some of the other AEC sites as well -- they had two
19 subcategories of liquid high-level waste.
20 The first category was called self-heating
21 waste. And if the thermal power density was greater
22 than numbers in this ball park, the waste was capable
23 of boiling, if you did not take active cooling to
24 mitigate that. So you see all these cooling coils in
25 some of these tanks, that was the whole idea. Non-

1 heating waste had lower thermal power density, and all
2 you needed was passive cooling.
3 Again, this is determined by the shorter-
4 lived stuff in the waste, similar subclassifications
5 elsewhere.
6 This is actually a bit of a diversion, but
7 I'm just kind of gathering information to show how
8 this term was used in various arenas. Early
9 quantifications of solid high-level waste. Now, let
10 me make it perfectly clear, this is not solidified
11 high-level waste from AEC tanks. This is solid waste
12 that came from other things.
13 Remember back in the '50s and '60s there
14 were no -- back in the '60s there were no commercial
15 burial grounds for low-level waste. And so as the
16 commercial power industry got going, they needed low-
17 level waste sites. Oak Ridge was the eastern regional
18 burial ground for commercial low-level waste during
19 that period of time, and they had their own little
20 language about what was high-level waste for their
21 purposes.
22 And you see exposure rate criteria
23 concentrations. This one was admitted by Bill to be
24 arbitrary for various purposes. 2R per hour, we saw
25 that before. This is the IAEA Category 3 of solid

1 waste, requiring special precautions for handling and
2 transport.
3 But, again, the idea of high-level stuff
4 was external exposure, lots of activity -- again,
5 driven by short-lived stuff.
6 The first regulatory definition of high-
7 level waste was Part 50, Appendix F, in 1970. This
8 was strictly a source-based definition. What was in
9 it was not mentioned. The radiological properties of
10 this material was not mentioned. It contained the
11 term "concentrated waste," but that term was not
12 defined. So this is really vague, but it's clear that
13 it was, you know, waste from a certain source, fuel
14 reprocessing.
15 But there were companion reports that the
16 AEC put out -- and I have a reference list at the end
17 if you want to go look these up -- that this
18 definition implied that high-level waste had two
19 attributes. One was that it produced high levels of
20 decay heat and external radiation, again due mainly to
21 the fission products, shorter-lived stuff.
22 And the second attribute was that it
23 required long-term isolation from the biosphere to
24 protect public health, due primarily to the long-lived
25 transuranics. It was well known by this time, it had

1 been known by the late '50s, that a geologic
2 repository was probably going to be required for this
3 stuff.
4 But my reading of this early work is that
5 these two properties were considered separate and
6 distinct. That's my interpretation. I could be
7 wrong, but I just don't believe in the early days that
8 they thought that high concentrations of fission
9 products such as existed in tank waste would, by
10 themselves, require a geologic repository. I think
11 they -- they clearly viewed this, in my estimation, as
12 two separate and distinct properties.
13 Gosh, I could spend two hours talking
14 about this one. The NRC in the mid '80s undertook an
15 effort to quantify the clause B definition in the
16 Nuclear Waste Policy Act, and they published the staff
17 report. This is Dan Fehringer's work. They evaluated
18 the clause B definition in the Nuclear Waste Policy
19 Act. They focused only on the "requires permanent
20 isolation" part. They did not consider the meaning of
21 "highly radioactive."
22 But they came up with basically two
23 conclusions. One was that the Class C limits that had
24 been promulgated in Part 61 three years previously,
25 they were not appropriate for defining waste that

1 requires permanent isolation. In other words, there
2 was a lot of room between acceptable near surface
3 disposal and require a repository up here, and they
4 definitely had in mind, you know, greater confinement
5 disposal, something like that.
6 They needed to -- needed room, and this
7 report suggested that something like 30 times Class C
8 might define "requires permanent isolation." But I
9 would emphasize that this was not based on any kind of
10 risk analysis. It was just based on looking at
11 compositions of selected waste. They looked at five
12 different waste streams, and they said, "Ah, you know,
13 30 times Class C appears to describe this stuff." It
14 would be candidate reprocessing waste, commercial
15 spent fuel, things like that.
16 Thirty times Class C for strontium and
17 cesium is about a kilowatt per cubic meter. Again,
18 they did not consider what "highly radioactive" meant,
19 only looking at "requires permanent isolation."
20 I think transuranic waste acceptance
21 criteria are a useful piece of history for sort of
22 getting at what "highly radioactive" has meant in the
23 past. Remote-handled waste at WIPP, there's
24 acceptance criterion of three watts per package. A
25 package is about one cubic meter in round numbers.

1 And this is based on a certain thermal loading per
2 area and a prescribed aerial density of the waste.
3 And there's a five times safety factor built into
4 there.
5 External dose rate, 100 rem per hour at
6 the surface based on provisions for what kind of
7 shielding can they actually do at that site, and what
8 can their waste hoist lift? That's a pretty high dose
9 rate.
10 Contact-handled waste even has some useful
11 ideas. Less than 15 watts per cubic meter in stacked
12 containers at WIPP. No credit taken for space. Based
13 on considerations of what would the -- what would that
14 thermal loading do to salt? 40 watts per cubic meter
15 in transport containers. What kind of levels of heat
16 generation were important to container designer? was
17 the basis for this. A very -- a rather low external
18 exposure rate for handling and transport.
19 Again, the very idea of contact-handled
20 waste means you shouldn't need a lot of shielding to
21 handle it. You kind of defeat the purpose.
22 Allen and I got involved in an effort for
23 DOE back in the mid to late 1980s, again to quantify
24 this clause B definition, the part that NRC could
25 define as other than reprocessing waste could be

1 included in high-level waste. We quantified both
2 terms. We quantified "highly radioactive" and
3 "required permanent isolation" separately. We treated
4 these as two separate and distinct attributes of high-
5 level waste.
6 Our definition of highly radioactive was
7 greater than about 50 watts per cubic meter, external
8 dose rate greater than 100 rem per hour at one meter.
9 It turned out sort of by accident, but also it's quite
10 convenient, that this 50 watts per cubic meter is the
11 strontium 90 Class C limit. I mean, the
12 correspondence is there. We did not base it on that,
13 but that's a very convenient metric to use.
14 The 100 rem per hour is approximately
15 equal to the Class C limit for cesium, depending on
16 what you assume about the waste form in the package,
17 of course.
18 There was a lot of history behind this
19 50 watts per cubic meter. It's clear that above a
20 certain level you have to remove heat from waste for
21 purposes of safe storage or disposal. So to us that
22 was a reasonable criterion. The dose rate is clearly
23 more arbitrary.
24 It was supported by the remote-handled
25 waste limit at WIPP, but it turned out that for almost

1 every radionuclide of concern, except for cesium 137,
2 the thermal power density would dive the definition of
3 "highly radioactive." Only for cesium was this number
4 more restrictive. And, again, we also quantified
5 "requires permanent isolation" separately.
6 CHAIRMAN RYAN: Just a quick point.
7 DR. KOCHER: Sure.
8 CHAIRMAN RYAN: The dose rate in part 2 is
9 much easier to correct.
10 DR. KOCHER: Oh, sure. Yes. I think in
11 hindsight, and I'll speak for Allen out of turn, that
12 criterion basically has no use and is not really
13 meaningful. I mean, you're going to protect your
14 workers. Period.
15 The IAEA, again, has weighed in. The 1970
16 Category 1, 2, 3, 4, 5, made way to terms that we
17 recognize today. Their current system in 1994, their
18 definition now includes a thermal power density
19 greater than two kilowatts per cubic meter. Again,
20 this would be driven by shorter-lived stuff.
21 But this number was not based on any kind
22 of consideration of impacts of heat generation. They
23 just looked at typical levels in various kinds of
24 waste 10 years after discharge and said, "You know,
25 two is at the lower bound of that, so we'll define

1 high-level waste as greater than two."

2 But hopefully coming down the pike for you

3 all fairly soon will be some very interesting draft

4 recommendations where they have dropped this

5 criterion. Now they just refer to high-level waste as

6 something that has significant quantities of decay

7 heat, and they let significant kind of just sit there

8 by itself.

9 What to make of all of this? Well, the

10 original description of high-level waste as highly

11 radioactive, it clearly meant high decay heat and

12 external radiation. And it was based originally on

13 the need to protect workers during waste operations

14 and storage. It was not based on requirements for

15 safe disposal.

16 However, if you interpret highly

17 radioactive as being these attributes -- big "if" --

18 then it's clear that thermal power density is a

19 reasonable criterion to take into account. When you

20 put waste into the ground, the amount of heat that it

21 gives off is an important consideration in terms of

22 ensuring the long-term safety of that disposal

23 facility after you zip it up and go away. You don't

24 want to boil water in the rock -- that kind of thing.

25 So thermal power density is a reasonable

1 criterion to consider, and values somewhere on the
2 order of 10 to 100 watts per cubic meter generally
3 need to be taken into account in designing disposal
4 facilities. So that -- if you think of highly
5 radioactive this way, that's a useful criterion.
6 I think it's clear -- and I already said
7 this to Mike -- external dose rate is -- is not a
8 useful criterion to define "highly radioactive" for
9 purposes of waste disposal. It's very important for
10 purposes of getting it into the ground, getting your
11 workers up above ground again. But when you zip it
12 up, it has no meaning.
13 It takes humongous photon dose rates to
14 significantly affect leeching of radionuclides from
15 waste form. It takes humongous doses of alpha
16 radiation to cause significant damage to waste forms.
17 This is lala land. So that's not useful.
18 What radionuclides make waste highly
19 radioactive? Well, it depends on what you mean by the
20 term. If you look at highly radioactive in the
21 historical context, which I have done here, highly
22 radioactive clearly includes waste with high
23 concentrations of these shorter-lived fission
24 products, and something on the order of greater than
25 Class C limits for strontium and cesium.

1 Why? Because at this level, you're
2 talking about thermal power densities, which you have
3 to take into account to ensure safe waste disposal.
4 You've got to have a way to dissipate that heat
5 without harming the host environment or impacting the
6 ability of the facility to limit releases.
7 Two is a throwaway for your amusement
8 only. I got curious about commercial spent fuel, and
9 what about the transuranics in commercial spent fuel.
10 By themselves, it's about a kilowatt per cubic meter.
11 That would be highly radioactive according to these
12 definitions in any man's language. That's just for
13 amusement, because DOE reprocessing wastes are much
14 cooler.
15 Typical -- this is round numbers --
16 typical tank waste at Savannah River is about .1 watts
17 per cubic meter, you know, way -- four orders of
18 magnitude below this. But I thought this was fairly
19 amusing.
20 Well, what about this? The term "highly
21 radioactive radionuclide" does not make sense to me.
22 I would put it this way. A radionuclide is not
23 inherently highly radioactive, lowly radioactive, or
24 intermediately radioactive. It just is. It all
25 depends on how much. Okay?

1 This may be harmless language, but it's
2 new. It has never been anywhere before. Where did it
3 come from and why? So much funny has happened in the
4 waste business, I just am suspicious. The intent of
5 this is not clear. Are radionuclides that are not
6 highly radioactive excluded from the requirements of
7 this law? I suppose so.
8 To me, the language in the DOE order is
9 reasonable. It refers to removing key radionuclides,
10 and I think everybody has a common understanding of
11 what "key" means. My opinion -- and I think most
12 people in this room would share that opinion -- that
13 the goal for these -- all these tank wastes, the stuff
14 that you leave behind, and the stuff you take out of
15 the tanks and then process, the goal should be to
16 remove radionuclides that significantly impact risk
17 from disposal. Period. Don't give it a name. It's
18 just stuff.
19 I just foresee all kinds of problems, and
20 we can talk about that in the Q&A if you're
21 interested. But it's just me ranting.
22 Now, if you define "highly radioactive" as
23 I did in the previous slides, in terms of its
24 historical context, this term has no importance to any
25 of these residual tank wastes. The stuff is not

1 highly radioactive as defined historically. It's
2 clear that this term has an entirely different meaning
3 in this current law, and it remains to be seen how
4 this will work out. And I'm not going to tell you
5 what I think the answer is, because I've been on the
6 job here two weeks. This is all new to me.
7 But this is -- I guess the message I want
8 to leave you with is that the way we're being forced
9 to interpret this term has nothing to do with the
10 historical antecedents of what highly radioactive
11 meant in the past. So it's new ground. But it should
12 be focused on risk reduction, risk control.
13 I think NRC and DOE have been trying to do
14 the right thing historically, and I just hope we don't
15 get tripped up over language like this.
16 CHAIRMAN RYAN: So what you're saying,
17 Dave, is that your Rosetta stone just got a little
18 bigger -- of definitions and so forth?
19 DR. KOCHER: Well, yes. What clearly has
20 been lost -- and there may be good reason for it. I
21 haven't thought it through. The historical idea that
22 highly radioactive was a separate attribute from
23 "requires permanent isolation," that distinction has
24 now been smushed into a blob, as I see it. That may
25 be a good thing. That may be a poor thing. We'll

1 have to see. But we've kind of lost the history.

2 CHAIRMAN RYAN: Well, but as you said

3 earlier, I mean, the idea that there's a worker dose

4 protection requirement, and then there's, you know,

5 maybe somewhere in the '70s, the first view of long-

6 term performance once disposed. You know, we've sort

7 of taken it maybe a half-step backward and --

8 DR. KOCHER: Yes.

9 CHAIRMAN RYAN: -- something that seems to

10 foster that old separation.

11 DR. KOCHER: Yes. My bias throughout all

12 of this was -- my concern was permanent disposal, and

13 I'm assuming that workers will be protected, because

14 they will be. And my whole concern was: what's the

15 impact on safety of waste disposal?

16 CHAIRMAN RYAN: Thank you.

17 VICE CHAIRMAN CROFF: Okay. Thanks, Dave.

18 We'll corner all these fellows here in a panel

19 discussion later on for -- and we'll hear what Dave

20 really thinks then.

21 (Laughter.)

22 So --

23 MEMBER HINZE: You want to find out

24 whether he has any strong opinions, right?

25 VICE CHAIRMAN CROFF: Right. That's it.

1 You got it.

2 I'd like to move on to -- our next speaker

3 is Dr. Ken Gasper. During the '80s, Ken served as the

4 Program Manager at Hanford's B plant for separating

5 hundreds of millions of curies of cesium-137 and

6 strontium-90 from the Hanford tank waste. That begat

7 the capsules.

8 In the 1990s, Ken served as the Program

9 Manager for the initial pre-treatment module, the pre-

10 cursor for the large tank waste treatment and

11 immobilization plant currently under construction at

12 Hanford. And for the last several years until his

13 retirement, Ken has been responsible for supplemental

14 pretreatment activities being developed from removing

15 cesium-137 and other isotopes from selected tank

16 wastes and integration of these activities, with

17 similar efforts underway at Savannah River and Idaho.

18 And today he's going to discuss the

19 prospects of technologies to remove key radionuclides.

20 DR. GASPER: I'm going to be talking about

21 the removal of key radionuclides from tank waste, and

22 in that context I'm going to be talking about all of

23 the tank waste, the constituents being the liquid or

24 supernatant, the salt cake, and the sludge.

25 The key radionuclides that I'll be talking

1 about are the cesium-137, and throughout the
2 presentation I'll talk about cesium-137. I recognize
3 that there's associated barium. Technetium-99 and
4 iodine-129 and strontium-90 and the transuranics.
5 Let's start with the cesium-137. That
6 normally occurs in the liquid aqueous phase, and that
7 is the -- the phase that is either the supernatant
8 sitting in the free liquid above the waste or as the
9 interstitial liquid in the saturated salt cake or the
10 saturated interstitial liquid in the sludge.
11 For Hanford, just to refresh your memory
12 -- and I'll get into it -- all of our single-shell
13 tank waste has had the cesium removed once. That is,
14 in this campaign that we referred to earlier today
15 that started in the second half of the '60s and ran
16 through 1979, we did a cesium and strontium -- cesium-
17 137 and strontium-90 removal primarily to allow us to
18 concentrate the waste and eliminate the high heat
19 problem.
20 But at the same time an equal argument was
21 that those were potentially useful byproducts. So you
22 had those two camps aligning to result in us removing
23 a significant amount of the cesium. So you're going
24 to see me talking about salt cake at Hanford single-
25 shell tanks as being considerably lower than our

1 double-shell tank waste, and even our double-shell
2 tank waste is quite old compared to some of the
3 Savannah River waste, since we -- we did know fuel
4 irradiating after the early '80s.
5 For the Hanford double-shell tank waste,
6 the curie content of cesium is the third to a half a
7 curie per liter at seven molar sodium. For the
8 single-shell tank waste, the interstitial liquid has
9 a tenth to two-tenths of a curie per liter at seven
10 molar sodium. The molarity of the sodium may be a
11 little higher or a little bit lower, and so I've
12 normalized it to that.
13 By the way, we don't have any supernatant
14 in our single-shell tanks. What we did was we -- we
15 first ran all of the single-shell tank waste through
16 that cesium-strontium campaign, and then we took the
17 -- removal campaign, and then we took the waste and we
18 ran it through an evaporator and boiled off as much
19 water as we could. And we sent the waste out to the
20 tank, and it cooled off and the salt crystallized out
21 of it, and there was some supernatant sitting on top.
22 And then, we drilled a hole down through
23 the center of the salt cake and installed what we call
24 salt wells, and we inserted basically a sump pump down
25 to the bottom of the tank and we pumped out all of the

1 drainable liquid to the extent that was technically
2 practical, which was as long as the pump was working
3 and the flow rate was .05 gallons per minute or less.
4 So we -- we definitely still have
5 interstitial liquid, but it is not pumpable liquid.
6 It's not drainable liquid. And it -- it sits at one
7 to two-tenths of a curie per liter.
8 The technetium, what we have learned
9 through the extensive characterization programs
10 conducted in the '90s to support our tank safety
11 program is that most of the technetium sits in the
12 tank, in the single-shell tanks as pertechnetate.
13 That's the chemical species. It's the oxidized state,
14 and it's in the aqueous phase.
15 And so what we're going to be able to talk
16 about is that for the most part the technetium moves
17 right along with the cesium. So whatever we do with
18 the cesium it -- we also do with the cesium. And by
19 the way, the iodine -- total iodine, and, therefore,
20 iodine-129 also falls -- flows along with the cesium,
21 because it's in the aqueous phase.
22 The strontium-90 and the transuranics
23 normally occur in the solids and in the solid phase.
24 So it's in the sludge and it's in the solids of the
25 sludge rather than even in the interstitial liquid of

1 the sludge. It's only sparingly present in the liquid
2 aqueous phase at Hanford, perhaps a little bit more
3 with the higher hydroxide concentrations in the
4 Savannah River waste.
5 And so the treatment to make sure that you
6 are removing all of the TRU from the liquid becomes a
7 little bit more important at Savannah River, and
8 they've got a treatment step inserted into their plan.
9 It's present in the liquid aqueous phase
10 in the presence of organic complexants. We have a
11 couple tanks at Hanford -- we call them complexant
12 concentrates, or CC waste -- and those tanks come from
13 the strontium recovery operations that took -- that we
14 conducted in the '70s and early '80s at B plant, and
15 so those complexants do result in some strontium and
16 TRU being in -- in solution.
17 The cesium removal technology -- I'm going
18 to take you through cesium removal technology and then
19 strontium removal technology. And the question will
20 be both in terms of proven technology and developing
21 technology.
22 What's proven? Well, clearly, our B plant
23 operation is proven technology where we -- we removed
24 146 million curies of cesium-137 using ion exchange
25 for the most part. We also used phosphotungstic acid,

1 precipitation for acid heat. In other words, after we
2 had processed a lot of our tank waste, it was
3 neutralized waste, alkaline waste, using ion exchange.
4 We did install a stainless steel pipe from
5 Purex over to B plant, so that we could run current
6 acid waste we called it -- that is, waste coming
7 directly out of the Purex plant before neutralization,
8 and so that acidic waste we ran over to B plant and
9 used a slightly different process for taking out the
10 cesium. Namely, we precipitated it with
11 phosphotungstic acid.
12 Now, I'm only dealing with the recovery
13 operations these activities had following the
14 purification operations that resulted in high purity
15 cesium and high purity strontium for purposes of
16 putting it in the capsules. But the recoveries are as
17 quoted, and here you see that we were dealing with
18 cesium concentrations up to 220 curies per liter.
19 And we over -- over this more than a
20 decade campaign -- recovered grossly over 90 percent
21 of the cesium using the ion exchange process and over
22 95 percent using the phosphotungstic acid process.
23 The ion exchange process was subsequently
24 used at West Valley. Their mechanism for using it was
25 a little bit different, but they did use ion exchange

1 material and absorb the cesium on it, and then do a
2 different kind of separation. But, so that -- that
3 ion exchange process was well developed.
4 Strontium removal during this time -- we
5 recovered 68 million curies of strontium. There were
6 more strontium to be recovered than we recovered. You
7 see that we recovered only half as much strontium as
8 we did cesium, and the reason for it is because even
9 in the '60s and '70s, since the strontium is sitting
10 in the sludge, the sludge was becoming hard pan. It
11 was baking. It was becoming difficult to remove, to
12 retrieve, and so we only recovered half as much cesium
13 or strontium as we did the cesium, all of which was in
14 the liquid material.
15 The concentrations of the strontium-90
16 that we retrieved were up to two curies per liter
17 after dissolving the strontium-bearing solids. You
18 know, we had to work at it to get the solids into
19 solution, and then we were then dealing with two
20 curies per liter.
21 We recovered 80 to 90 percent of the
22 strontium in the solids into the -- the 80 to 90
23 percent of the strontium that we got dissolved and
24 into our solvent extraction columns. Eighty to 90
25 percent of that strontium we were able to recover.

1 The strontium recoveries in the solvent extraction
2 process were over 97 percent.
3 So I broke those out so that you
4 understood what were demonstrated efficiencies for
5 this timeframe.
6 Cesium removal technology continued to
7 evolve, and in the '90s Savannah River developed the
8 tetraphenyl borate precipitation process with the
9 intent of precipitating cesium that way for recovery
10 and sending over to DWPF with the resultant
11 decontaminated material being available for salt
12 stone.
13 I might back up and comment that we also
14 at Hanford had used a ferrocyanide precipitation out
15 in our tank farm with no recovery intended, but in
16 order to -- to cause precipitation of cesium-bearing
17 compound. And then, we decanted the solution off of
18 it, and those were pre-B plant days. And I -- we
19 don't have the quantitative information to share with
20 you.
21 And as far as commenting about the use of
22 that kind of technology, which, by the way, is the
23 technology that Russia used for doing its cesium
24 separation, we -- we encountered quite a bit of
25 problems with having ferrocyanide in our tanks in

1 terms of being concerned about the safety problems
2 associated with potential uncontrolled energy release
3 from the decomposition of the ferrocyanide in the '90s
4 as part of our safety program.
5 So we have ruled out using a ferrocyanide-
6 based process for cesium recovery, and I chose not to
7 give you details on -- on it quantitatively.
8 At Hanford, we continued to pursue the ion
9 exchange approach while Savannah River was pursuing
10 the tetraphenyl borate in the early '90s. We
11 continued to base our ongoing plans for further
12 pretreatment on our experience with ion exchange. And
13 in cooperation with Savannah River, we evaluated
14 resorcinol formaldehyde resin in those days, which was
15 an eludable resin, and crystalline silicotitinate,
16 which was a non-eludable resin.
17 The difference between those is you can
18 use an eludable resin over and over again by acid
19 stripping off the radionuclide in a separate operation
20 and then recycling. In the non-eludable, you have to
21 take the cesium-contaminated crystalline
22 silicotitinate and plan on a disposal of that
23 particular material.
24 And John, in fact, at Savannah River led
25 a team to evaluate how -- how you might incorporate

1 such loaded CFC into glass.

2 A little later in the '90s, as the waste
3 treatment plant activity moved forward, they looked at
4 alternatives to those ion exchange resins and settled
5 for cesium removal on a SuperLig 644 resin. And that
6 continues to be the current technology approach
7 planned for cesium removal in the waste treatment
8 plant.

9 At Hanford, during the '90s, in the
10 laboratory we also investigated and demonstrated the
11 ability to remove cesium from salt cake waste solution
12 using fractional crystallization. This is roughly the
13 same kind of process that's used for purifying table
14 salt, purifying sugar.

15 The particular problems that we
16 encountered were that we had to do it on the acid
17 side, we had to dissolve and work on the acid side.
18 And since we are now dealing with neutralized waste,
19 that meant reacidifying it. But with a multi-stage
20 fractional crystallization, we were able to get clean
21 salt.

22 What I mean by "clean salt" is that the
23 decontamination was such that the resulting salt
24 product was -- had no detectable radiation. That was
25 a multi-stage acidified process, and we -- we remember

1 doing it and we'll revisit that later.

2 CHAIRMAN RYAN: Ken, before you leave

3 that, I just want to ask about less than Class A.

4 There is no lower limit to Class A, so nothing is less

5 than Class A.

6 DR. GASPER: I understand, and that --

7 that was, incidentally, the --

8 CHAIRMAN RYAN: Much less than the limit

9 of Class A going to B, I understand.

10 DR. GASPER: I definitely mean less than

11 the limit of Class A. And if there were ever a

12 de minimis declared for releasing something that was

13 -- that came through this chain, our intent was that

14 we apply for -- for getting a release of this material

15 such that it could be used, for example, as fertilizer

16 on Hanford's grass that we grow.

17 I appreciate the clarification. Part of

18 the reason why this died as a process was because we

19 had no path for disposal of it in anything other than

20 low-level waste. And because it was sodium nitrate,

21 it was a very soluble material that was going to have

22 to be fixed in order to make it non-leechable.

23 CHAIRMAN RYAN: Just to --

24 DR. GASPER: It's a good clarification.

25 CHAIRMAN RYAN: I want to make sure that

1 everybody releases there is no --

2 DR. GASPER: There is no lower limit.

3 CHAIRMAN RYAN: There's nothing below

4 Class A. Class A goes to this --

5 DR. GASPER: Yes. And we -- we worked

6 with DOE to petition to get a de minimis ruling, and

7 we couldn't get there.

8 At Savannah River, as time progressed, the

9 tetraphenyl borate approach for in-tank precipitation

10 was abandoned because it could not be safely operated

11 at the necessary production rates. And so Savannah

12 River evaluated alternates, and in 2001 selected

13 caustic-side solvent extraction and -- as the mainline

14 approach to move forward.

15 And the conceptual design associated with

16 using that technology into equipment has been

17 completed and the design is moving forward, they plan

18 on using a -- a modular version of this in the

19 2006/2007 timeframe, and they plan on completing the

20 construction of the full-scale system such that it

21 will be deployed in 2009. And the Nuclear Regulatory

22 Commission has participated in the -- in the waste

23 determination discussions as was mentioned earlier

24 today.

25 The caustic-side solvent extraction

1 product will meet Class A such -- for example, a curie
2 per cubic meter, or I'm using now also .001 curies per
3 liter for cesium-137. I'm doing that so that when I
4 go back and compare to Hanford where I'm talking in
5 curies per liter -- just refresh your memory on that
6 conversion. And this reflects a decontamination
7 factor for the Savannah River waste of greater than
8 40,000.
9 They are also in the period before 2009
10 moving forward with a deliquification/dissolution and
11 adjustment process which will separate the
12 concentrated supernate liquid and the associated
13 interstitial liquid from the solid salt cake, separate
14 that, and then dissolving the remaining salt cake
15 matrix and sending that dissolved material to the salt
16 processing facility. And they estimate that they'll
17 be able to achieve 27 curies per cubic meter, or .027
18 curies per liter concentration.
19 Again, I want to set the stage for showing
20 you a comparable process at Hanford. Capability to
21 process is currently available. That is, they have
22 the capability to -- to move forward with this that
23 can produce this -- this kind of decontamination.
24 And it's important to them to be
25 proceeding because of, one, their need for tank space,

1 and this will free up some tank space so material fits
2 this category, and also it will enable them to provide
3 feed for their DWPF, defense waste processing
4 facility.
5 At Hanford, to continue at -- the waste
6 treatment plant flow sheet settled on the ion exchange
7 material being SuperLig 644, and the flow sheet that
8 is a part of this pre-treatment plant that's being
9 constructed currently will use two stages of ion
10 exchange, each with a decontamination factor of about
11 100. So they'll get a 10^4 decontamination.
12 Now, the contract limit that they are
13 obliged to meet with this capability is .0017 curies
14 per liter at seven molar sodium. And that corresponds
15 to a waste loading in the glass of 14 percent, or
16 something like that.
17 If the waste loading in the glass goes up,
18 the concentration allowable that they must deliver
19 would go below the .0017. But they have a technology
20 that in their laboratory work, both at Hanford and
21 support that they receive from Savannah River National
22 Lab, suggests that that's readily doable with the
23 SuperLig 644.
24 The waste treatment plant is now
25 anticipated to begin processing in 2011. As a backup

1 technology to the use of the SuperLig 644, the waste
2 treatment plant is continuing to fund evaluation of
3 the resorcinol formaldehyde resin that we began work
4 with them on in the early 1990s.
5 Meanwhile, as Ken Picha mentioned, one of
6 the things that we're looking at at Hanford is a way
7 to offload the low activity waste vitrification plant
8 to the tune of about half of its workload, in order to
9 be able to finish up the processing of the waste in
10 the 2024 timeframe.
11 So we have been pursuing a supplemental
12 treatment program where the vitrification work would
13 be done with both vitrification, in-container
14 vitrification, and the liquid that would be used as
15 feed would be the dissolved salt cake. Some of the
16 dissolved salt cake, by virtue of draining off --
17 first of all, remember, we removed the bulk of the
18 cesium in the 1967 to 1979 timeframe, and then we put
19 salt wells down in each of the solidified salt cake
20 and pumped out all of the drainable liquid.
21 Now, as we begin adding water on top of
22 the salt cake, as we begin the retrieval operation, if
23 we pump off that first liquid and send it off to the
24 waste treatment plant, and now that will wash out the
25 interstitial liquid that's left in the salt cake, and

1 what's left behind, then, as we begin the bulk
2 dissolution of that salt cake becomes analogous to the
3 Savannah River process of their DDA, where the first
4 deliquify. We've already deliquified, and then they
5 dissolve.
6 And so we are able to achieve
7 concentrations on the order of .007 curies per liter,
8 and we have already demonstrated that on S-112. We
9 have now retrieved 99 percent of the waste from that
10 tank, and we're actively doing it on S-102 right now.
11 And we're planning on doing it with S-109 beginning
12 this fall.
13 So that's -- that's available feed
14 potentially for meeting the criteria that would be
15 such that we could have contact-handled containers of
16 bulk vitrification.
17 On the other hand, there's still a lot
18 more waste that's a little bit higher in curie content
19 in the salt cake that really needs additional
20 decontamination of the cesium, if we want to achieve
21 the same kind of decontamination that the waste
22 treatment plant is planning for the waste that they're
23 processing through their pretreatment facility before
24 going to their low activity waste at their plant.
25 So we went out with a competitive contract

1 funded through the Office of Cleanup Technologies to
2 explore what was available technology. And we opened
3 it to all technology options, and we did this a year
4 ago. We also internally went ahead with fractional
5 crystallization on the alkaline side, much as we
6 envisioned we might use on the salt cake material.
7 And a competitive contract was let.
8 Georgia Tech, Swenson Technologies, Cogema, and
9 Framatome were the winning contractors, and so we have
10 in place a program going on to see if they can meet
11 the waste treatment plant's pretreatment spec for
12 cesium decontamination -- .0017 curies per liter --
13 and how well can they do on separating the sodium, and
14 how well can they do on separating the sulfate,
15 because sulfate impacts the ability of the
16 vitrification plants. It limits their waste loading
17 that they can have.
18 And so far, a year into it, and our
19 internal work, have all supported that we are able to
20 achieve the cesium-137 decontamination of -- the
21 desired decontamination corresponding to the waste
22 treatment plant spec of .0017 curies per liter.
23 And we can do it with both the single-
24 shell tank waste -- that is, recovered salt cake --
25 and we can also do it with the double-shell tank salt

1 solutions that currently exist which basically are of
2 the same type, and some of them have come from our
3 retrieving solution out of the single-shell tank such
4 as S-109, S-112, and S-102.
5 So that looks good. Is that demonstrated
6 technology? Well, it's only demonstrated at the
7 laboratory, our laboratories and the contractors'
8 laboratories. The deployment concepts -- right now,
9 the current plan is that they could be implemented in
10 the 2009 timeframe. We don't have it in our current
11 baseline plan. We're going ahead with further lab and
12 full-scale design concept work funded by the Office of
13 Cleanup Technologies in fiscal year 2006.
14 Strontium removal -- Savannah River, in
15 the '90s, established crossflow filtration as the
16 preferred approach for doing the solids/liquids
17 separation to remove the insoluble strontium and
18 actinides.
19 The B plant activity of the '60s and '70s
20 used centrifuges. So centrifuges were a demonstrated
21 technology. Savannah River did an extensive
22 evaluation and concluded crossflow filtration was the
23 way to go. They have put that capability into place
24 at Savannah River to support their feed to the DWPF.
25 The waste treatment plant -- well, first

1 of all, the initial pretreatment module at Hanford,
2 and then out of that, the waste treatment plant
3 currently at Hanford have gone ahead and done further
4 evaluation and accepted the crossflow filtration as
5 the preferred approach for solids/liquids separation
6 to support the pretreatment activity at Hanford going
7 to the waste treatment vitrification facilities.
8 I mentioned that particularly with the
9 higher hydroxide content material at Savannah River
10 that there is a small amount of solubility of
11 strontium and TRU in their waste. And the way that
12 they have identified to treat that, and every
13 indication is that it just works fine, is monosodium
14 titinate, MST, addition to remove the soluble
15 radioactive strontium and actinides by sorption.
16 And so they -- they have that capability
17 in place, and the kinds of concentrations that result
18 in the liquid are as noted there, and the waste
19 determination at Savannah River sent out in -- at the
20 end of February contains this information.
21 So Hanford accepted the crossflow
22 filtration, and instead of using monosodium titinate
23 for our particular waste streams to remove any soluble
24 radioactive strontium and actinides, on a case-by-case
25 basis as the feed moves through the waste treatment

1 plant, this is the plan. They will sample, and if
2 need be they will add strontium nitrate and
3 permanganate to get the desired decontamination.
4 For the supplemental pretreatment, our
5 demonstration that's going forward -- and Ken referred
6 to we're going forward with S-109 with a demonstration
7 of full-scale bulk vitrification. We have done
8 sampling such that we know that if -- that our liquid
9 solution is -- meets the strontium and permanganate --
10 the strontium and actinide requirements, but we are
11 adding a -- at the tank retrieval a hydrocyclone to
12 ensure that all particulate matter goes right back
13 into the tank and none goes over to the bulk
14 vitrification.
15 We haven't made a determination, and we're
16 letting the contractor in the conceptual design work
17 for the fractional crystallization make the
18 determination and make their recommendations to us as
19 to what -- what kind of solids/liquids separation they
20 might employ for that. At this point, there are
21 several options open to them that seem to work well.
22 Let's move on. I talked about cesium and
23 strontium. Now I'd like to touch on technetium-99,
24 which our performance assessment, as part of the total
25 process of identifying what were the important

1 radionuclides to consider, given that the waste --
2 large volume of the waste that's going to be buried at
3 Hanford and the high level sent off to the deteologic
4 repository.
5 Technetium-99 was a primary item, and so
6 the Department of Energy and the Washington Department
7 of Ecology have been particularly interested in what
8 we were doing about technetium, particularly as we
9 move forward with supplemental treatment.
10 All of our work to date continues to say
11 that the bulk of our technetium is in the
12 pertechnetate state, and, as such, the waste treatment
13 plant identified that SuperLig 639 resin was a
14 potential ion exchange media approach for removing the
15 technetium-99 after the material went through the
16 cesium ion exchange with SuperLig 644.
17 Subsequently, DOE and the contractor
18 determined -- that is, in the early 2000s -- that this
19 separation process was not viable for the current
20 project, and that the requirement to conduct the
21 technetium-99 separation was deleted from the waste
22 treatment plant current contract.
23 For supplemental treatment, all of our
24 work -- that is, where we might use fractional
25 crystallization -- all of our work supports that the

1 pertechnetate follows where the cesium goes. And it
2 tends to stay in the aqueous phase exclusively in the
3 salt cake dissolution and retrieval process, and can
4 be sent to the stream going to the waste treatment
5 plant.
6 In the fractional crystallization process,
7 it stays in the cesium-rich phase. And it can be
8 separated from material which is going to bulk vit.
9 So to the extent that we are decontaminating the feed
10 going to bulk vit, the same decontamination is
11 occurring for the technetium. In that sense,
12 fractional crystallization treats technetium the same
13 way as it treats cesium.
14 At Savannah River, the caustic-side
15 solvent extraction, being a different technology, it,
16 in fact, selectively decontaminates the cesium, so the
17 technetium does not get decontaminated.
18 Same thing -- next slide. The same thing
19 happens with iodine. The iodine goes the same way as
20 the technetium and the same way as the cesium in
21 fractional crystallization. On the other hand, just
22 as caustic-side solvent extraction is selective for
23 cesium and doesn't do anything about technetium, it
24 doesn't do anything about iodine either.
25 So the caustic-side solvent extraction

1 will selectively take out the cesium and leave behind
2 the iodine and the technetium.
3 So, in conclusion, Hanford and Savannah
4 River, supported by lab studies at Savannah River, at
5 Battelle, at Oak Ridge, at Los Alamos, have provided
6 experience and offer insight and potential
7 possibilities for removal of cesium-137, strontium-90,
8 transuranics, technetium, and iodine.
9 Dr. Croff?
10 VICE CHAIRMAN CROFF: Okay. Thank you
11 very much. I think we're going to go on and catch our
12 last presentation here, and then we will open it up
13 for probably a long session of Q&A to everybody
14 involved.
15 Our last speaker in this session is Dr.
16 John Plodinec. John is a recognized expert in nuclear
17 waste characterization and disposition. He works at
18 Savannah River site for about 22 years, and there was
19 involved in many aspects of tank waste processing and
20 mobilization.
21 His technical studies of glass and grout
22 waste forms provided the basis for decisions to
23 vitrify high-level waste in the tanks at Savannah
24 River. More recently, he has been Director of the
25 Diagnostic Instrumentation and Analytical Laboratory

1 at the Mississippi State University.

2 John?

3 DR. PLODINEC: Thanks, Allen. I didn't

4 even have to die to get that nice introduction.

5 VICE CHAIRMAN CROFF: Well, it's coming

6 up. Today John is going to discuss basically

7 characterization of what's left in the tanks after

8 Paul and Barry finish doing their thing in the tanks,

9 if you will. So that's where this enters in, we hope.

10 DR. PLODINEC: Okay. What I what to do is

11 start talking about the general requirements, talk a

12 little bit about what each of the sites has done in

13 terms of characterizing what's left behind in a tank

14 after they've got done cleaning it, and then talk

15 about some new technology and wrap up with some fairly

16 general conclusions.

17 First, requirements for the methods that

18 you use to characterize what's left in the tank. You

19 need two things, of course. You need, first, what's

20 the volume of material left behind, and that's an

21 important point -- part of determining the source

22 term, but then as well you have to know the

23 radionuclide content of what's left behind. So the

24 methods have to be able to provide quantitative

25 information about that.

1 We live in an open society. Therefore,
2 there has to be a certain amount of acceptance by the
3 stakeholders in terms of -- is the data complete
4 enough, are the errors small enough for the
5 consequences of the decisions. And, of course, all of
6 the typical data has got to be traceable, defensible,
7 reproducible.
8 We can't forget that the methods also have
9 to be safe and operator-friendly. We can come up with
10 some pretty high-tech solutions that won't work,
11 because we can't find anybody to actually perform the
12 operations. Of course, all of this, we're talking
13 about remote environments, and ideally whatever we do
14 we need it to be simple, reliable, and ideally
15 reusable.
16 Now, this is a very general picture of a
17 tank. And I use this to illustrate some of the
18 problems that make this a very non-trivial exercise.
19 First, you're going to have in general a liquid level,
20 and you'll have solids mostly -- well, depending on
21 the tank, mostly immersed in that liquid. But how
22 much is below there?
23 Secondly, though, you will have hills
24 sticking up out of the liquid level. You'll have
25 pillars, cooling coils, you'll have material -- in

1 some cases gridwork on the bottom of the tanks, and
2 the idea of the shadow here is to say if you're using
3 an optical technique, it's going to be awfully
4 difficult to see through this mass of stuff that's
5 down there.
6 In addition, of course, you have high
7 radiation fields. And as I think Barry quite
8 appropriately pointed out, that for most of the tanks
9 that we're concerned about it's not very practical to
10 consider an in-tank, i.e. something under the bottom
11 kind of a rover, particularly if you've got cooling
12 coils there.
13 So you're going to have to deal with the
14 fact that you -- you're, you know, looking at very
15 long distances from the top of the tank to where
16 you're trying to see down at the bottom.
17 I'm going to talk about the four major
18 tank sites. I will quickly say, of course, that the
19 Oak Ridge gunite tanks in a sense are not part of this
20 discussion in terms of incidental waste or waste
21 reclassification. However, they do provide I think
22 useful experience in terms of characterization of
23 what's left behind.
24 Okay. The process at Oak Ridge has been
25 described pretty well. Essentially, what we're

1 talking about is on the order of about an inch heel,
2 roughly 1,000 gallons. Now, in the case of Oak Ridge,
3 they used the robotic systems to give them pretty good
4 ideas of the residual depth, and the accuracy -- plus
5 or minus one inch, that's probably an overstatement.
6 But it was, you know, fairly significant
7 because you're basically working with an end effector
8 and a ruler. And, you know, how well do you stand it
9 up and that kind of thing.
10 The source term estimate that they were
11 using took into account the tank heel as well as, in
12 their case, the concrete wall. Barry alluded to the
13 fact that the gunite tanks -- cores were taken of
14 those walls. The reason was that, in fact, there was
15 concern about how far had radionuclides migrated into
16 the gunite.
17 What they found was that, in point of
18 fact, 90 percent of the activity was within the first
19 eighth of an inch. So it hadn't gone all that far
20 into the concrete. But for tanks, for example, that
21 have an annulus or a partial annulus at other sites
22 where, in fact, they have a concrete secondary as
23 opposed to a full metal, this is a similar
24 consideration.
25 Now, they make some assumptions in

1 determining the curie content. Assume the material
2 was 50 percent sludge. They used the sludge curie
3 content as the heel source, and then they actually had
4 the analytical results on the core samples. I will
5 mention -- or should mention, as I do here in the
6 slide, that the amount that was left behind in the
7 wall was insignificant for all but two of the tanks.
8 Okay. This is one of the examples at
9 Hanford, C-203. Remove the material with slurry pumps
10 up to about 100 gallons in the smaller tank, and an
11 estimate of about 38 gallons on the tank wall. In
12 this case, the residual waste volume was calculated as
13 the heel volume plus the material in the tank along
14 the structure. Plus, they tried to do some
15 determination of how much was left in equipment,
16 things like pumps that might have been left behind,
17 piping, and so forth.
18 As is going to be a continuing theme,
19 essentially it's an optical technique for determining
20 the volume of the heel, looking at how much have we
21 pumped out, where are we in the tank, looking at known
22 features to try to pick up levels. Using those --
23 that information, and in comparison, as I said, to
24 known locations in the tank and the as-built drawings,
25 they developed a 3-D model of the heel.

1 The estimate of the material left on the
2 wall was intentionally biased high in terms of aerial
3 coverage of the wall. The estimate of the average
4 thickness on the wall -- of the waste on the wall was
5 about a sixteenth of an inch, and that was estimated
6 based on the contrast of shadows in the video. So
7 source term then was, okay, what's in the heel, what's
8 in the wall.
9 Idaho -- a couple of the smaller sodium-
10 bearing waste tanks have been empty. Again, volume of
11 the residual waste estimated by comparison of the
12 video views of the solids, to features of known height
13 in the tank -- cooling coil brackets and things like
14 that. They estimated in these particular cases
15 heights between zero and half an inch.
16 Again, they developed a 3-D model by
17 computer ledger domain, and ended up with -- you know,
18 using that volume to calculate the source term. Now,
19 in their case, that source term was the activity of
20 the liquid plus the activity of the solid. They were
21 able to get samples of the liquid, basically what I
22 call soap on a rope. You drop a thing -- you know, a
23 cup in and pull the sample back out.
24 They couldn't get samples of the solid.
25 They were able to get samples of solids from a

1 companion tank, and they used that radionuclide
2 inventory to basically calculate what the -- was left
3 in the other tank. Again, they used Origin-2 to get
4 a more complete radionuclide inventory.
5 I'm leaving out all my editorial comments
6 about what they did.
7 CHAIRMAN RYAN: We'll get back to those.
8 DR. PLODINEC: Yes. Savannah River -- I
9 think you're going to be there next week. So any
10 mistakes I make are my fault, and what they tell you
11 next week is probably, without a doubt, more accurate.
12 But essentially on the two tanks that are,
13 you know, completely documents on the closure,
14 basically it's the same process, the big slurry pumps,
15 getting it down. Roughly five inches or so of the
16 supernatant liquid covering a thinner layer of sludge,
17 but, again, as I indicated the mounds protruding
18 through it. So it's a non-trivial problem to
19 calculate how much sludge do you have, for example.
20 What they -- the way they went about this
21 was to -- they're continuously looking via cameras,
22 three cameras in the tank, at the liquid as it's being
23 taken out. When they first see a mound protrude out
24 the top of the liquid, they basically go one time step
25 before that and say, "Okay. That's where we were at

1 that point." And they have -- they're taking real
2 tape measurements of the height.
3 And that gives them, then, the height of
4 the feature. The area of the feature is much tougher,
5 as you -- if you remember back to my cartoon, because
6 how far does it extend underneath the liquid? Well,
7 that's tough to tell. And certainly in their case
8 they'll be the first to tell you that that's a big
9 source of their errors.
10 Again, as with the other sites, they use
11 known features in the tank to go back and calculate
12 areas, particularly areas, but also to doublecheck
13 heights.
14 And then, what they are basically trying
15 to do is to, as they keep going down, they -- of
16 course they're exposing more and more of a particular
17 mound, and that gives them some idea as well as to how
18 the ultimate area may look.
19 So then, again, the source term -- they
20 sample the material to determine the curie content,
21 and then use the volume to determine the source term.
22 Explicitly, they don't consider wall
23 deposits, but a correction to what I've said here is
24 that in the performance assessment they take into
25 account -- I think they give about a 20 percent

1 correction factor, which is probably way, way high
2 given the cleanliness of the tanks.
3 What are some of the potential problems?
4 In a sense, the biggest one may be the optics, and I
5 don't mean that in the strict sense. There's no
6 independent verification of the calculation methods.
7 each one, you know, a little bit different. They're
8 all doing it the same way, which -- and I -- frankly,
9 I don't see any inherent difficulties with it, except
10 that we don't know just how good or not good they are.
11 CHAIRMAN RYAN: Isn't that an inherent
12 difficulty?
13 DR. PLODINEC: Yes.
14 CHAIRMAN RYAN: Okay.
15 DR. PLODINEC: No question. Further, it's
16 difficult to discern the depths below the supernatant
17 liquid. The contributions of wall deposits have not
18 been handled consistently. You know, in one case they
19 actually try to measure them. In another case, we
20 throw in a correction factor.
21 Nobody right now is looking at the
22 annualae in terms of how do we take that space into
23 consideration. For one thing it's -- you know, it's
24 a constrained space. You can look at it. It's pretty
25 difficult to get at it and make some kind of a

1 measurement.

2 As I mentioned, the bottom-dwelling robots
3 aren't going to be generally useful, particularly
4 because of the additional superstructure like cooling
5 coils most specifically. And the other part of it is
6 that the uncertainties themselves in general just
7 aren't real well defined. They're probably bounded,
8 and probably the values that we have are biased high.
9 But they're open to questioning, bottom line.

10 CHAIRMAN RYAN: For clarification on that
11 point, that seems contradictory to me. Put that back
12 up. I'm certain these are not well defined, yet
13 they're satisfactory. How can you determine a
14 conclusion if you don't have it well defined?

15 DR. PLODINEC: I think that's more than a
16 clarification. We might want to talk about that more
17 in Q&A.

18 CHAIRMAN RYAN: Okay. All right. Fair
19 enough.

20 DR. PLODINEC: I will give you the quick
21 answer that the "probably" is a subjective on my part.
22 But I stand ready to try to defend it.

23 Okay. Emerging technologies. Work has
24 been done to try to do a laser range-finding
25 technique. It works. It has some operational

1 difficulties, particularly if you've got a lot of
2 obstructions in the tank.
3 We've been -- we -- folks at Mississippi
4 State have been developing a technique called Fourier
5 transform profilometry that has a lot of promise, at
6 least in addressing some of the problems with the
7 current methods. And I'll come back to explain that
8 in a moment.
9 From the source term standpoint, when I --
10 when I say "source term," I mean here specifically the
11 radionuclide inventory problem. There is ongoing
12 work, both at PNNL and at Mississippi State, looking
13 at laser-based techniques to identify the radionuclide
14 inventory, as I'll -- as is said here, these are far
15 from deployment in terms of remote technology.
16 Spectral imaging is an interesting one
17 that I personally think has a lot of potential. But,
18 again, the equipment has just not been developed for
19 deployment.
20 FTP, real simple technique, long name.
21 Essentially you have a light source, you have a
22 camera, and in front of the light source you put a
23 line pattern. And it's -- anybody who has had to do
24 image analysis knows that it helps solve that one
25 problem we all have had who have had to do this, which

1 is, okay, I'm looking at a picture, I see a feature,
2 a -- you know, in the third dimension, is it an innie
3 or an outie?
4 Well, simply by whether the lines are
5 being contracted or expanding, you can -- and knowing
6 the direction of the light, you can quickly determine,
7 okay, this is a hill or a valley. But the neat thing
8 about this is that you can take a two-dimensional
9 image and, in fact, then calculate a three-dimensional
10 map of the surface.
11 It's not perhaps as apposite in this
12 application, but, in fact, what the folks at DIAL are
13 doing is, in fact, matching this up with video speed.
14 So this is really real-time video camera in the tank.
15 And as it sweeps the tank, you get the map back out in
16 virtually real time.
17 Nice technique. But does it work? Well,
18 this is not a tank, but this is work done by the Corps
19 of Engineers using the algorithms we developed to do
20 close to the shore mapping. This was done for black-
21 type applications. But you can imagine, you know, why
22 would you want to know whether -- what the sand is
23 around different shorelines.
24 But you can see that things sticking up
25 can be quantified quite nicely. And, in fact, you can

1 even do the profile underneath. So it begins to
2 provide an absolute measurement of areas that -- where
3 you could only kind of relatively pick out before.
4 This is what the hardware looks like.
5 Assume this is the tank top. There's a mast, and then
6 a long arm that gets inserted. This is the end of the
7 arm, and these holes are the light source and where
8 you have the camera. And this will tilt up and down,
9 and it allows you to look at the complete interior of
10 the tank, as long as the view is not obstructed too
11 much.
12 It's also able to be deployed in any riser
13 four inches or larger. So it's pretty robust in that
14 sense. And this is sticking it in the tank.
15 What's the error? Again, one of the nice
16 things about this technique is that it is -- you can
17 quantify how well you're doing. In this case, the
18 inherent errors are on the order of about one to two
19 percent.
20 Now, this is with ideal conditions. What
21 we found is that these numbers go up to four or five
22 percent when you put it into a -- you know, a long arm
23 configuration. And as opposed to some assumed bias,
24 these are -- these are, in essence, truly random
25 errors.

1 Now, one of the problems, you know, you
2 get into is if you're looking through water you have
3 to correct for the refraction effects. And folks have
4 done that, and you can see now we're talking errors on
5 the order of 10, 15 percent for submerged objects.
6 And it doesn't really matter if you're talking about
7 the peak height or the peak area, the errors are about
8 the same.
9 I don't have a slide on this, but do let
10 me say a word about radionuclide inventory. From a
11 worker dose standpoint, any time you've got to go into
12 a tank and pull a sample you're exposing a worker to
13 risk. So I think there's real value in developing
14 techniques that can easily, reliably determine the
15 inventory in situ.
16 Further, one of the things that clearly is
17 -- we're all open to question to -- question on is we
18 know that the materials in these tanks in many cases
19 have been layered. If I take a sample here, is that
20 going to be the same as the sample over there? In
21 other words, how consistent is the source term
22 throughout the tank? And that's kind of an unknown.
23 One of the nice things about techniques
24 such as spectral imaging is that they allow you to get
25 -- well, like the FTP as well -- a full view of the --

1 the full field of view for whatever the camera can
2 see, and it can pick out differences in that whole
3 field of view.
4 And I think there's a lot to be gained by
5 trying to deploy -- develop those techniques, so that
6 ultimately the operator doesn't have to be pulling
7 samples.
8 Okay. Quick summary. The methods
9 currently being used are providing quantitative
10 information. We'll deal with the "probably" later, in
11 terms of data being completed, not the size of the
12 errors, however with the current methods are open to
13 the criticism that they're not completely
14 characterized, nor have they been independently
15 verified by some other technique.
16 I think one of the things that the NRC,
17 looking at all this data, is going to do is to push
18 the whole system to a more common method of dealing
19 with things like wall deposits and annular spaces.
20 One thing that I'm particularly concerned
21 about is that the -- there hasn't been a lot of
22 thinking through I think of the QA requirements for
23 the data, the data quality issues. And as an old
24 operational type person, I worry about that, because
25 I -- I've been on a couple of panels that have had to

1 look at the WIPP mess, and I use that term advisedly,
2 where you're forcing way more work than is justified
3 by the risk.
4 There are some alternative techniques
5 being developed. There's a -- the FTP technique will
6 be going to large-scale testing this year, this coming
7 year -- fiscal year. But I don't think that the
8 techniques will be available for deployment for
9 radionuclide inventory for another three to four
10 years.
11 Okay? Any clarifying questions?
12 VICE CHAIRMAN CROFF: Okay. Thanks, John.
13 You might want to consider a seat. We may go on for
14 a bit here. The agenda showed a break before our
15 discussion, but I think we're far enough ahead, I
16 think it's prudent to at least begin the Q&A here, and
17 if it runs too long we need to clear a break in a
18 while, but with that -- well, I'm going to start in
19 the middle. Let's let Mike go. And any of the five
20 are fair game here. If we got redirected, Paul and
21 Barry, that's here too.
22 CHAIRMAN RYAN: John, let's start where we
23 just finished up a bit. A couple of things strike me
24 as you made your comments. One is, you can't conclude
25 that something is not a problem if you haven't done

1 the analysis to demonstrate that. That's a problem.
2 I understand that judgment comes in and experience
3 comes in, but the systematic approach would be to do
4 some kind of analysis of the error.
5 For example, and I'll give you a way that
6 I would approach it, is to try and figure out what the
7 end point of the data is I'm collecting. For example,
8 I want to now radionuclide inventory. Well, I want to
9 know that for a couple of reasons. One is, I'm going
10 to create a waste and I have to know it's compliant
11 with some probably concentration limit. Well, you can
12 test this system you used to make a calculation and
13 measurement statistically and say if the errors are in
14 these ranges and those ranges, do I have enough
15 statistical power to do decision-making that I'm
16 claiming I can do? And that rigor, I think, is what
17 you ought to use to decide whether the sampling that
18 you are doing makes sense or not, and that's kind of
19 the first step toward risk informing this approach,
20 what's important and what's not.
21 DR. PLODINEC: I would agree, basically,
22 and that was kind of the thrust of what I was saying,
23 was I think when that analysis is done, that it will
24 be -- ultimate conclusion will be that the sites have
25 erred on the side of conservatism enough that they

1 come to an answer that's --

2 CHAIRMAN RYAN: But you'll have to agree

3 right now on your part that's an educated guess.

4 That's not --

5 DR. PLODINEC: Absolutely. That's why I

6 made the point basically leading to the conclusion

7 that needs to be done.

8 CHAIRMAN RYAN: And I guess what I'm

9 trying to emphasize is making that educated guess is

10 a potential step into scuba diving in oatmeal. You

11 really don't know where you're going or why, so it's

12 a strong caution I'm offering that judgment of 20

13 years or 30 years of conventional wisdom might bite

14 you. You know the use of ORIGEN calculations, for

15 example - everybody knows ORIGEN was designed as what

16 kind of code, fuel burn-up. It was designed to

17 accurately predict the residual Uranium 235 or

18 Plutonium 239 content, not fission product

19 inventories. And while there's been lots of efforts

20 to upgrade the cross-section sets, et cetera, and so

21 on, we don't know how good it is. So again, that's

22 not to necessarily discount it, but I think in order

23 to use it, you have to at least evaluate, propagate,

24 or theorize what the uncertainties in those results

25 are. One element of the system.

1 DR. PLODINEC: I think the real key there
2 is, for example, if you look at Hanford, they've done
3 a pretty good job of looking at what I'll call the
4 random errors. And, Ken, you correct me if this is
5 incorrect, but I think it's bounded around 20 percent,
6 is the nominal uncertainty of the random errors.
7 However, they have --
8 CHAIRMAN RYAN: I'm not sure what nominal
9 uncertainty of the random errors exactly is, but --
10 DR. PLODINEC: I think basically, having
11 gone through propagation of error, of those things
12 that are truly random, you end up with a sigma of
13 about 20 percent, relative sigma. On the other hand,
14 they have also, two or three places, big systematic
15 biases where they have - and they quite honestly own
16 up to it - they have over-estimated, or at least they
17 think they've over-estimated, but the degree to which
18 they've over-estimated is unknown.
19 CHAIRMAN RYAN: It likely dwarfs the known
20 systematic 20 percent errors. That's like saying
21 well, my instrument error is 1 percent.
22 DR. PLODINEC: I agree.
23 CHAIRMAN RYAN: My sampling error could be
24 two orders of magnitude, so again, I think a real true
25 evaluation of this is somehow to go through it and

1 rank it, and understand it in a systems approach, not
2 necessarily side wind yourself with individual errors.
3 DR. PLODINEC: We're in violent agreement
4 here.
5 CHAIRMAN RYAN: It's not so violent. It's
6 something that I think we tend to worry about. Yes.
7 MR. THADANI: I just want to be sure that
8 you're talking about also epistemic uncertainties in
9 the model that you're using, trying to understand how
10 that might influence your --
11 CHAIRMAN RYAN: Epistemic?
12 MR. THADANI: Well, that's a term that's
13 used. Alliatory and epistemic, they are the popular
14 terms.
15 CHAIRMAN RYAN: At least in some places.
16 But to me, the kind of key point in all this risk
17 discussion is that two things are happening. One is,
18 you're trying to understand that inventory of
19 radioactive material for a couple of purposes. One is
20 to make sure that you leave residuals that are
21 acceptable by some measure, and make sure that you put
22 that waste in a format and form that's acceptable to
23 somebody that's taking it away. And it would be
24 interesting to think about, for example, your example
25 of 20 percent random error, whatever those are. And

1 so okay, well, I can test that. I'm going to go in
2 that tank and take 10 samples and see what the sample
3 standard deviation is. I'm going to bet you it's more
4 than 20 percent in some cases, perhaps.
5 DR. PLODINEC: Well, in fact, in the cases
6 like, for example, actual measurement of radionuclide
7 content, there they were using pool standard
8 deviations of several different sampling events into
9 the same tank. Now one could talk about well, how
10 representative are the samples, et cetera, et cetera.
11 CHAIRMAN RYAN: And should.
12 DR. PLODINEC: But from the standpoint of
13 the statistical development, in that case they tried
14 to do it. In other cases, for example, at Savannah
15 River, they have not used ORIGEN, but there they have
16 done -- Ned Bimler has done some very elegant work,
17 where he's looked at ORIGEN and ORIGEN-like
18 calculations versus what you actually find in the
19 waste, and has come up with some big discrepancies
20 that are explainable based on the nature of the
21 irradiated materials. And so Sumarium is one of them
22 that's either -- I think it's way low in terms of
23 what's actually there. And again, it's one of these
24 self-absorption type things.
25 CHAIRMAN RYAN: Again, I think when we

1 think about NRC's role of making determinations, I
2 think the issue that you've raised of data quality and
3 accuracy - I mean, quality can be a precision question
4 or an accuracy question, or a data management
5 question. Let me focus my point on the idea of
6 accuracy; that is, is it true or not. It ought to be
7 part of what's covered in the standard review plan,
8 and I think some of these things that we're kicking
9 around as more formal approaches to uncertainty
10 analysis is going to be something we'll consider in a
11 little bit more detail, but I think it's a critical
12 question to get at, other than oh, we think it's okay.
13 DR. PLODINEC: Well, the other thing,
14 though, to remember, and I'm certainly not
15 disagreeing, but as a cautionary note back, taking
16 those 10 samples so that you can get better
17 statistics, some wise guy once said that statistics
18 are people with the tears washed off. Real people
19 have got to take those samples, and take a risk
20 associated with that dose.
21 CHAIRMAN RYAN: And I sure appreciate that
22 being an operational guy myself. On the other hand,
23 I think that if you end up with a gazillion dollar
24 project where you've created a waste that can't be
25 disposed, you've got a much bigger problem. So

1 somewhere in the middle there's a balance, and I think
2 if you even do kind of theoretical thinking about
3 error and error analysis for the purpose of decision-
4 making with whatever guidance you can derive from your
5 data, it's worth pushing the pencil around and the
6 paper a while to do that. Thanks. I think I made
7 enough comment. Ruth.
8 MEMBER WEINER: I have a number of
9 different questions for a number of different people.
10 Dr. Kocher, I'm very intrigued by having wrestled as
11 a teacher with those definitions. I'm very intrigued
12 by your statement. What do you think we should do
13 regarding the definition of high-level waste? And the
14 reason I ask the question is, your talk was very
15 illuminating, but we are where we are right now, and
16 we're with a definition that is in tuned, if you will,
17 in regulation and law, and so on. What would you
18 suggest that we do? What would you suggest that we
19 advise?
20 DR. KOCHER: Oh, that's two different
21 questions.
22 MEMBER WEINER: Well, okay. It's two
23 different questions.
24 DR. KOCHER: What should we do is obvious.
25 But the whole system into the garbage bag and start

1 over with a risk-based waste classification system
2 that has nothing to do with where it comes from.
3 MEMBER WEINER: Okay.
4 DR. KOCHER: But the truth of the matter,
5 apparently, is that you can't do that. You can't get
6 there from here.
7 MEMBER WEINER: Okay. How do we get
8 there?
9 DR. KOCHER: So it's patch and fix, patch
10 and fix, get more string, get more bailing wire, get
11 more wax, patch and fix. This language in this law -
12 I think I said this before - in my opinion, is kind of
13 uncharted territory, so you're going to be feeling
14 your way as you go along about what it means. And I'm
15 not going to sit here and advise you about what that
16 should mean.
17 MEMBER WEINER: Can't even give us the
18 first patch?
19 DR. KOCHER: Well, I think the sensible
20 approach is what's important to risk, and I can't
21 think of anything else that's sensible.
22 MEMBER WEINER: Thank you. That is, in
23 fact, a very good starting point.
24 DR. KOCHER: From what little I have read,
25 that appears to be the way the agencies are thinking

1 about this problem, is they tap-dance around.

2 MEMBER WEINER: For everybody else who

3 spoke up, we're going to get some liquid waste, or

4 waste anyway from reprocessing, and we're going to

5 continue to generate in one form or another

6 radioactive waste. Any or all of you, what do you

7 think should be done as far as using tanks, not using

8 tanks, other methods of storing the waste until some

9 disposal methods is found. I mean, we've had a lot of

10 experience now with tank waste, and we're faced with

11 these tank wastes that are difficult and dangerous,

12 and expensive to remove, and to dispose. So again,

13 where should we go from here with newly generated

14 liquid waste?

15 DR. PLODINEC: Fools rush in where wise

16 men fear to tread, so I'll be first in line. I think

17 clearly there's a theme that's run through a couple of

18 the talks, and I think those who were involved early

19 in the AEC processes realize that the preferred route

20 was stainless steel tanks. Hanford and Savannah River

21 couldn't get enough stainless steel at a reasonable

22 enough cost to have stainless steel tanks.

23 I think smaller stainless steel tanks,

24 better segregation of waste, clearly would be the

25 direction that you'd want to go. I'm going to put

1 words in Ken's mouth, not for the first time, but one
2 of the reasons why the problems at Savannah River have
3 been, I think, a lot easier to solve than some of the
4 ones at Hanford has been that the folks at Savannah
5 River historically (a) have fewer processes, but (b)
6 segregated the waste more. And as a result, it's made
7 life a lot easier, and easier to get the retrieval
8 going and the processing up and running. But I think
9 those are the two things.
10 You're almost forced to use tanks, because
11 where are you going to go with this stuff? You just
12 don't have the capacity in the system many times, but
13 the other thing that I think is an overriding issue
14 that's probably also extremely important for what you
15 all are doing, is that you have to look at this as an
16 overall system. If you just look at the question that
17 the NRC is faced with, the maximum extent practical,
18 or whatever words you want to use, that's not simply
19 a tank-by-tank issue.
20 If you look at Savannah River, they have
21 a severe constraint just simply because they could
22 probably, in theory, discontinue to pump the water
23 down and slew stuff back up. Unfortunately, they
24 don't have any place to put the water, and so it's a
25 system -- again, it's a system problem that you have

1 to deal with. And it becomes a very big issue in
2 terms of determining the practical aspects of how far
3 down to go.
4 MEMBER WEINER: And when you say
5 segregating the waste, you're implying that as part of
6 the process, since these are waste from separation
7 processes, you could carry on and separate out other
8 radionuclides, or separate out the waste, segregate
9 chemically, or whatever.
10 DR. PLODINEC: Yes. I think specifically,
11 for example, by fuel type.
12 MEMBER WEINER: Oh, okay.
13 DR. PLODINEC: That would be the first
14 line of segregation. Again, it's a question of how
15 money you've got, how much you've got, how many tanks
16 you can afford.
17 CHAIRMAN RYAN: Let me just ask John a
18 quick question, if I may. It follows on exactly with
19 what Ruth has asked. What do you think about Dave's
20 idea as to the maximum extent practical, and all your
21 examples should have -- the common currency to me is
22 risk, whether it's Hanford, or Savannah River, or
23 whatever. Important to risk is a phrase I don't want
24 to lose, we kind of raced through that, but it seems
25 that whether it's the technology of taking stuff out

1 of tank, or whether it's thinking about in terms of
2 ultimate waste form and what you leave behind, the
3 important to risk, that needs some further definition,
4 but that seems to be the common theme that I could
5 string through all the presentations. Sorry, I just
6 wanted to jump on --
7 MEMBER WEINER: No, that's a very good
8 comment.
9 CHAIRMAN RYAN: I would agree, certainly.
10 And so would David, since he said it.
11 MEMBER WEINER: David.
12 DR. KOCHER: To me the analogy here is
13 that to the extent practical is kind of ALARA for the
14 waste extraction business, and you can't quantify it,
15 but you sort of know when you get there, and it's an
16 overall general touchy-feely cost benefit kind of a
17 situation, but no differential equations, please.
18 CHAIRMAN RYAN: Or it could be Option A or
19 Option B, and just look at relative measures.
20 DR. KOCHER: Yes.
21 CHAIRMAN RYAN: Right?
22 DR. KOCHER: You don't want a universe of
23 a thousand choices.
24 CHAIRMAN RYAN: No, maybe three. But then
25 the point is that there is a framework that has some

1 structure that we could lean on.

2 MEMBER WEINER: I'd like to ask Ken to

3 comment with all of the experience with Hanford and

4 with separating our Cesium and Strontium, and dealing

5 with all those single shell tanks.

6 DR. GASPER: If I take John's comment, I

7 have to be a qualifier, but we're here. If I could

8 replay the record, we might not have got here, but

9 we're here. And we have the variety of waste that we

10 have in the tanks. We can't go back and separate and

11 segregate, and so it's the path forward that is the

12 critical one for us. I certainly agree with the two

13 of them that it makes sense to do it on a risk basis,

14 but at the same time that I say that, there are

15 regulations in place that for us to say that we're

16 going to go ahead on a risk basis can mean that some

17 of those really ought not to be constraints upon us.

18 I'll give you an example. An example is

19 that we are forbidden to use any of our single shell

20 tanks for addition of liquid, and yet we have no other

21 processing vessels other than our double shell tanks,

22 which are nearly full. And they will remain nearly

23 full until the waste treatment plant, or possibly

24 supplemental treatment, begin to provide an outlet for

25 them.

1 At the same time, we have reasonable
2 confidence that some of our single shell tanks that
3 are more or less empty would be vessels that would
4 enable us to do something, such as segregate some
5 waste, so that we can facilitate overall risk
6 reduction perhaps by retrievals or otherwise, that
7 we're not permitted to do. So it's a concept to say
8 that we want to do something that minimizes risk, at
9 the same time the question is what ground rules are we
10 able to tamper with?
11 MEMBER WEINER: I think you've raised a
12 very good point, and I would hope that one of the
13 things that we can do is to focus on those areas where
14 the wording of a regulation or an agreements gets the
15 soonest kind of fix, where you can't do something that
16 would, in fact, minimize risk.
17 DR. BURKS: Ruth, you asked a question
18 about what do we do with liquid waste as we generate
19 it going forward. One of the comments I'd make is
20 that if we're going to put it in tanks, let's put it
21 in tanks that were designed to be emptied. When
22 Fernald cleaned up Silos 1 and 2, and moved that
23 material into temporary holding tanks while waiting
24 for their treatment facility, they stored that
25 material in tanks that also when the tanks were being

1 built had retrieval systems built in, so now when
2 their treatment system is ready, they can flip the
3 switch and start moving material immediately. So if
4 we're going to use, or use more tanks, then let's at
5 least do a better job of designing them to be cleaned.
6 Put those mixing systems in at the beginning.
7 DR. MURRAY: I think it's fair to say that
8 I've been working recently with the Italians, the
9 Canadians, Beckford, BNFL, and Dounreay, and their
10 wastes are segregated, kept in acidic waste forms, and
11 they don't have sludges in their tanks. And you can
12 see this in Idaho in the sodium barren waste tanks,
13 basically a pure feed going into those tanks, and
14 hence it's much easier to retrieve the tanks.
15 MEMBER WEINER: That's it. Thank you.
16 CHAIRMAN RYAN: Jim.
17 DR. CLARKE: Just to follow-up on that,
18 and Barry spoke to something I was going to ask. And
19 I think if we were going to do this again, people are
20 reprocessing. As Ruth mentioned, what the lessons
21 learned? I mean, the tanks, if you have to use them,
22 are now part of a process, they're not the end of the
23 process, so how do you put them in the tanks? How do
24 you get it out of the tanks, and how long do you leave
25 it in the tanks? I mean, all of those questions - I

1 think there would be merit to thinking about that.
2 I'd sure like to see us capture these lessons learned,
3 if for no other reason, just their intrinsic value.
4 The phrase highly radioactive waste
5 reminds me of another troublesome phrase that I've
6 wrestled with for a long time, and that's called toxic
7 chemical. And these terms just have no meaning. They
8 obviously have meaning only within the context of an
9 exposure scenario. There's a public perception issue
10 that's really difficult to deal with. I guess, Dave,
11 when you say risk-based classification system, you've
12 inherently built into that the exposure scenario.
13 There's a friend of mine back in the early
14 days of hazardous chemicals said that every time
15 somebody asks me if a chemical is hazardous, I have to
16 ask them what they want to do with it. Do they want
17 to eat it, do they want to transport it? What do you
18 want to do with it? That's really I think where we
19 have to get to from where we are with these
20 definitions, and source-based definitions, and other
21 kinds of definitions. I guess that's more of a
22 comment than a question.
23 The last thing I wanted to ask, John, I
24 guess you, is taking a data quality objectives
25 approach where you're going out to get data, and you

1 really shouldn't do that until you know what you want
2 to do with the data. And one usage would be,
3 obviously, to know what's in the tanks as best you
4 could before you started doing anything. The other
5 would be to try to figure out what would be left when
6 you finish doing that.
7 How useful is information you could get
8 from what you take out of the tanks to answering the
9 question of what you've left behind?
10 DR. PLODINEC: That's a great question,
11 and one that I'm not going to give you a great answer
12 to. The data we have isn't really quite on point, but
13 here's what we think we know. When we process what we
14 call in DWPS space a macro batch of waste, which is
15 waste from a bunch of tanks, it is surprisingly
16 uniform. I mean, we're talking about something that
17 truly is like what you might get for a single mixture
18 of chemicals that was just a single batch. It's
19 amazing how over months, maybe even years of time,
20 that sludge will have the same composition. And, in
21 fact, will have the same composition as a grab sample
22 that was pulled before they actually began processing.
23 So that would indicate that maybe there's a lot of
24 probative value of those samples.
25 I indicated an example, I think it's

1 Idaho, where they had used a sister tank, where they
2 could, in fact, sample, and they used that so the
3 implicit assumption there was, in fact, that you could
4 transfer those kinds of information across.
5 The niggling worry, though, is that those
6 of who've been involved in waste characterization know
7 that those tanks have been stratified, or the waste I
8 should say has been stratified. And so what we have
9 is this indirect body of evidence, but we don't have
10 pluperfect evidence in all cases that says yes, it's
11 uniform.
12 Now I have to say, though, I think you
13 probably are going to be in a much better position to
14 get an answer to that question, because when you go to
15 Savannah River, in particular, I know with Tank 11
16 they've got a series of data that ought to be able to
17 address that question. And they would be the best
18 people to answer it.
19 CHAIRMAN RYAN: Thank you. Bill.
20 MEMBER HINZE: Well, I wanted to ask John,
21 in terms of this FTP procedure, we've gone a long way
22 in terms of subsurface acoustical imaging techniques,
23 as you're probably more than aware. I sense that from
24 your description that this was largely a surface
25 measuring technique, but you also when you talked

1 about refraction through the liquid. And is your wave
2 lengths of the light sufficient to give you
3 penetration? Is this transparent enough?
4 DR. PLODINEC: Yes. We've done - the
5 folks that are actually doing the work - have done
6 testing on the order of the same depths as Savannah
7 River, five inches or so of liquid, and various types
8 of objects. The Army, if you remember that slide that
9 I threw up there, in their case they had gone down to
10 about plus or minus a foot, foot and a half. So yes,
11 it's quite doable.
12 MEMBER HINZE: With using the right
13 frequencies you can get a little further than that,
14 and still get very good resolution.
15 DR. PLODINEC: Yes.
16 MEMBER HINZE: And I'm wondering if your
17 layering problem -- I'm very sympathetic to your
18 sampling, and layering, and representative samples and
19 all, and I wonder if you can't actually develop a
20 three-dimensional image, rather than two-dimensional
21 image.
22 DR. PLODINEC: Well, this is actually a
23 three-dimensional image. But you're right, you don't
24 get any further beyond the --
25 MEMBER HINZE: And the --

1 DR. PLODINEC: But the other problem you
2 run into is that application of acoustic techniques in
3 tank environments, particularly when you've got that
4 super structure is going to be a bear. And
5 unfortunately, there's not a great answer to how
6 you're going to deal with this even optically because
7 again, you've got a lot of obstruction.
8 MEMBER HINZE: You can do a lot with
9 multiple sensors, though.
10 DR. PLODINEC: Yes, and that's, in fact,
11 what they've done with --
12 MEMBER HINZE: It's a nice reaction
13 problem that should be able to be -- well, this is a
14 correct path to what apparently is a significant
15 problem, but I think the technologies are even further
16 that are available, that should be at least
17 considered.
18 Dave, I had a question that came up in my
19 mind when you were giving your discussion, and that
20 regarded the risk-informing in relationship to the
21 heat generation. Heat generation as I interpreted
22 your comments were used as, number one, a surrogate
23 for radiation, if you will. And number two, that this
24 is a problem in itself, the heat is a problem in
25 itself. And you spoke about boiling of the water in

1 the subsurface. Has there been any risk analysis done
2 on the problems of heat generation associated with
3 radioactive decay?
4 DR. CLARKE: Well, there certainly was
5 Project Salvault many years ago.
6 MEMBER HINZE: Okay. You've got me. What
7 --
8 DR. CLARKE: I was still in knickers, so
9 I --
10 MEMBER HINZE: This was the --
11 DR. CLARKE: The first proposal for a salt
12 repository --
13 MEMBER HINZE: Oh, the Texas work.
14 DR. CLARKE: Lyons, Kansas.
15 MEMBER HINZE: Right. It was Lloyd
16 Bennett --
17 DR. CLARKE: Yes.
18 MEMBER HINZE: But I just wonder how much
19 of a problem heat really is.
20 DR. CLARKE: I don't really know the
21 extent to which detailed risk analyses have done, but
22 it's generally considered not good form to have water
23 boiling in your rock.
24 MEMBER HINZE: I'd like to see what the
25 risk is from it.

1 DR. CLARKE: There's some feeling that
2 geochemical processes are enhanced at higher
3 temperatures. That may or may not be true. I think
4 it's -- my impression is that yes, it's been looked
5 at, but as much as anything else, it's kind of a
6 boundary condition. It's kind of something that since
7 it's an easy problem to avoid, just don't go there.
8 You're not severely impacting your ability to dispose
9 of waste if you kind of take thermal power loadings
10 into account in designing your facility and placing
11 the waste.
12 MEMBER HINZE: Well, if we're going to
13 have risk-informed, we ought to go all the way.
14 DR. CLARKE: Fair enough.
15 MEMBER HINZE: I think that boiling water
16 is not a good idea in a repository but I can't tell
17 you why.
18 VICE CHAIRMAN CROFF: Bill, let me take a
19 crack at your question by example, and that's the
20 Yucca Mountain Repository where for years there was a
21 raging debate of hot versus cold. And in my view,
22 there was never really anything -- a definitive
23 process to go through to attach it quantitatively to
24 risk. There was a lot of judgment used to decide the
25 way they were going, and I think that's sort of what

1 Dave's saying. It's so complicated, they haven't been
2 able to get there, so they made it a judgment call.
3 That's observation, not saying it should be.
4 I've got a couple of questions. I think
5 at least to start with, directed at Ken. You reminded
6 me of the ferrocyanide business in the Hanford tanks,
7 and sort of recounted some of the history there. And
8 I sort of remember the flap it caused at the time, but
9 ultimately, a bunch of people did some science and
10 studied the tanks, and my memory of the final outcome,
11 which was -- I thought the final outcome was that it
12 never was a problem.
13 DR. GASPER: The final outcome was that
14 the ferrocyanide had been radioactively degraded so
15 that the bulk of the organics in the tank now were
16 down to oxalates predominantly.
17 VICE CHAIRMAN CROFF: It's gone a long
18 way.
19 DR. GASPER: In other words, they've gone
20 a long way. And the energy content, therefore, of the
21 residual material in the waste was very low. But
22 that's quite different than saying that we want to use
23 a ferrocyanide process with fresh chemicals, and then
24 have to worry about handling the process of waste
25 multiplication, and what we do with the residuals from

1 it. So when the competitive bids went out, one of the
2 competitive bids that came in - three of them that
3 came in were for fractional crystallization, and one
4 acid site, two alkaline, one of them was we're using
5 the ferrocyanide process. And, of course, it wouldn't
6 be in large tanks, it would be in process vessels.
7 But it's kind of like the tetraphenylborate, we just
8 didn't want to have to deal with the complex organics
9 again as derivative waste products.
10 VICE CHAIRMAN CROFF: Okay, thanks. I
11 wanted to go on to a somewhat larger picture
12 concerning this maximum extent practicable, I guess
13 separation of radionuclides - let me put it in that
14 terms. I don't want to talk about retrieval at this
15 point. When I sort of look at what you described up
16 there, and think about it, I see three sites that have
17 relatively similar waste; West Valley, Savannah River,
18 and Hanford being neutralized alkaline waste for the
19 most part. And then when I look at the processes, let
20 me call them the mainline processes they want to use
21 for radionuclide separations into the future, they
22 seem to be going or have gone very different
23 directions, solvent extraction, ion exchange, and then
24 a, I guess, what would you call West Valley absorption
25 precipitation kind of thing.

1 DR. GASPER: It's an ion exchange.

2 VICE CHAIRMAN CROFF: Of a sort, I guess.
3 And then when you look at some of the nearer term
4 proposals or interim operations, if you will, at the
5 site, there's not so much separation there at all, or
6 a much lesser degree of separation because they're
7 using more physical kinds of separation. And I'm sort
8 of struggling with, first, how do they all end up
9 going in different directions when the waste aren't
10 that dissimilar, and can all of this represent to the
11 maximum extent practicable? I'm not asking you to
12 defend DOE's position, understand, but some technical
13 insights as to how do we get here.

14 DR. GASPER: Ion exchange is an approach
15 that Hanford had a lot of experience with because of
16 their separation, so they had built an infrastructure
17 and their familiarity, they used that infrastructure
18 to support getting West Valley going. It was Hanford
19 people working with West Valley people and importing
20 the ion exchange technology that they use there.

21 At the same time, Savannah River had
22 maintained a solvent extraction familiarity that
23 Hanford had not maintained, so in the 90s we were
24 comfortable continuing where we had left off with our
25 ion exchange work, B-plant, and that train of thought

1 has continued for Cesium removal.

2 The solids/liquid separation step is a

3 step that we're lock-stepping with Savannah River on.

4 We're doing it the same way. Then you move to whether

5 or not we -- to the extent that we need to treat any

6 of the waste to reduce the Strontium and the actinides

7 from the solids, there's a case where using monosodium

8 titanate at Savannah River has been underway for a

9 long time, and we certainly could use that. We found

10 that it was a bigger hammer than we needed, and we

11 could co-precipitate just by adding some inert

12 chemicals and drive the equilibrium sufficiently over,

13 and that's what we're doing when we add the Strontium

14 and Permanganate.

15 Caustic site solvent extraction is a major

16 new facility for Savannah River. If we were to adopt

17 that for supplemental treatment, for example, we'd

18 have to stand in line funding-wise behind Savannah

19 River. I don't know what the current estimate was,

20 but last November the estimate was $500 million in

21 2009 for finishing the design and completing the

22 facility. If we want to get in place for doing some

23 supplemental treatment, we need to do something that

24 doesn't require a major new capital facility. So

25 those are the kinds of factors that cause us to not

1 necessarily stay in lock-step, certainly
2 vitrification. We're staying with the DWPF flow sheet
3 for high level waste. Having diverted from a salt
4 stone base in 1990, and gone with low activity waste
5 vitrification instead of salt stone, and that was a
6 change, that change came as the Department accepted
7 the ground swell to deal with all of the single-shell
8 tank waste. Up until then, when they were planning on
9 grouting, they were planning on grouting just the
10 double-shell tank low activity waste portion, but when
11 they made the determination to retrieve all of the
12 single-shell tank waste, the volume grew too much.
13 VICE CHAIRMAN CROFF: Ken, I was wanting
14 to get to it a little bit more in a forward looking
15 sense.
16 DR. GASPER: Okay.
17 VICE CHAIRMAN CROFF: At some point,
18 there's going to be the need -- I mean, determinations
19 are going to be submitted that will require some kind
20 of an analysis to show that whatever is being done is
21 the maximum extent practical. And you've recounted
22 some of the historical thinking, but it sort of seems
23 to me to be leading to a very interesting decision-
24 making problem on a forward looking sense that there's
25 existing plans that sort of have to be reconciled with

1 a new regulatory framework, and how in a standard
2 review plan to articulate all of these considerations.
3 CHAIRMAN RYAN: Just a follow-on to that,
4 Allen, I think you've summarized it really well. To
5 me, again, the common currency is not chemical
6 engineering Case A, chemical engineering Case B, C, D,
7 and E, and F, and G across the complex. It's how
8 important is any of that to risk in any given case.
9 And the risk, to me the focused risk that the
10 determination addresses is not disposal at a waste
11 outlet. That's determined by the disposal outlet
12 typically translated into their waste acceptance
13 criteria in one form or fashion. The risk context is
14 what's left behind. So all this about processing and
15 clean-out, and all the rest, at the end of the day you
16 have to have an accurate inventory of what's left
17 behind, and how it's going to behave, and what your
18 prospective view of protecting public health and
19 safety from the first bullet that was in Anna
20 Bradford's slide - that is the currency. So I guess
21 what I'm trying to suggest, Allen, is that there's a
22 component of all the engineering, and all the
23 chemistry, and all of that gets you to a confidence
24 judgment about what do I know about what I'm leaving
25 behind?

1 DR. GASPER: Well, let me suggest that
2 what we're leaving behind is -- the amount that's
3 being left behind in the tanks is a trivial amount
4 compared to the amount that's being left behind at the
5 site, either in the material that we've converted to
6 low activity waste, whether it be salt stone or low
7 activity waste vitrified. That's a major component.
8 It dwarfs the amount left behind in the tank.
9 CHAIRMAN RYAN: Well, I hear you and I
10 appreciate the difference, but by the same token,
11 that's an independent question from the WIR
12 determination. What I'm trying to focus on --
13 DR. GASPER: I don't know that it is. Why
14 is the amount of radioactivity that we take out of the
15 tank and put in the ground four miles over not a WIR
16 determination?
17 CHAIRMAN RYAN: Well, I guess I see it as
18 an independent component of the same process, clearly.
19 DR. GASPER: Oh, yes.
20 CHAIRMAN RYAN: That much I agree, but
21 that's evaluated on its own merit.
22 DR. GASPER: Well, that's what your WIR
23 determination for your Savannah River was all about
24 this year.
25 CHAIRMAN RYAN: You've all done very well

1 to describe how they're all different. My point, I
2 guess, that I'm trying to focus on is that risk
3 evaluation of some assessment of dose to the public
4 health and safety is the common currency of all of it.
5 DR. GASPER: We agree to that.
6 CHAIRMAN RYAN: All right.
7 VICE CHAIRMAN CROFF: I think in this
8 there may be an issue that the committee will need to
9 talk about after we finish the working group meeting,
10 and the issue I see -- well, the Subpart C objectives
11 have dose limits, ALARA, and this kind of thing in
12 them, and then there's this maximum extent practicable
13 business. And should the maximum extent practicable
14 recoveries, if you will, be interpreted in a way that
15 essentially duplicates the Subpart C objectives, or is
16 there something else in there that either the law will
17 force you to consider; in other words, a more
18 technical or engineering consideration?
19 I'm not necessarily advocating that, but
20 there's these two provisions, and if you look at them
21 one way, they're basically driving toward the same
22 end, but if you look at them in another, they can drag
23 you in a different direction. And maybe there's
24 something you want to say about that.
25 DR. GASPER: Allen, as you asked the

1 question and the information that I gave you in the
2 presentation was intended to give you, as a committee,
3 input that suggests that what is to the maximum extent
4 practical, is a moving target. I can tell you what has
5 been demonstrated thoroughly such that you can
6 evaluate the economic aspect, among other aspects, and
7 that information has long ago been transmitted to you
8 for Hanford, but what is maximally extent practical
9 for right now, or for 2007, or for 2010, or for 2012,
10 I tried to give you some benchmarks of what has been
11 done and what is being done, but none of those newer
12 things have, in fact, been demonstrated to the extent
13 that we can provide you with the confidence that the
14 goals will, in fact, be achieved, or to what extent
15 those goals will be achieved with yet to be determined
16 economics.
17 VICE CHAIRMAN CROFF: Ken, I understand
18 that, and what we asked all of you to do is basically
19 give us technology status. And the job we're faced
20 with in NMSS staff in our various roles is trying to
21 abstract that into what goes into a standard review
22 plan.
23 DR. GASPER: Yes. A difficult job.
24 VICE CHAIRMAN CROFF: So to tell what
25 kinds of considerations go there, and that's what I'm

1 trying to ferret out here. We're running a bit long.
2 I'd like to ask one final question, I think mainly of
3 the retrieval people. Somebody, maybe it was John
4 brought this up, but he may have a role in it, and
5 that is, in particular at Savannah River, a number of
6 the tanks have annuli, and some of them have some
7 amount of leaked waste in them. Has there been any
8 thought given to technologies for retrieving that
9 material that's sort of in the sauce or around the
10 teacup, if you will?
11 DR. MURRAY: Yes, we're doing a
12 demonstration this year as part of a cow sign bin
13 retrieval. We're designing technology to retrieve the
14 cow sign bin by pneumatic conveying. That technology
15 is very applicable to recovering any waste that's been
16 spilled annuli of Savannah River tanks. Savannah
17 River is completely aware of that work and what we're
18 doing, and there will be a separate demonstration on
19 that work later this year, and Savannah River will
20 attend that.
21 VICE CHAIRMAN CROFF: Okay. And thoughts,
22 Barry?
23 DR. BURKS: Yes. When the tanks focus
24 area was active, there was a development project
25 focused on retrieval from the annulus at Savannah

1 River. The project was never completed, but there was
2 a concept that got off the ground, anyway.
3 VICE CHAIRMAN CROFF: Okay. I didn't know
4 that. John, any thoughts on characterizing stuff in
5 an annulus?
6 DR. PLODINEC: We've had some discussions
7 with Savannah River about using the complete -- the
8 situation that's more likely to obtain is that you're
9 not going to go into the annulus unless you absolutely
10 have to. But we know that on a -- I don't know about
11 Hanford, but I know at Savannah River, a lot of the
12 cracks are sealed over with high level waste solid.
13 VICE CHAIRMAN CROFF: We have no leakage
14 in the double-shell tanks, and our single-shell tanks
15 have no annuli.
16 DR. PLODINEC: So what you need is
17 something to characterize the amount that's there.
18 VICE CHAIRMAN CROFF: Okay. Are there any
19 questions from staff here? Latif.
20 DR. HAMDAN: Yes, I have a question for
21 John, and maybe one for Ken. John, these methods to
22 calculate the HL levels(3:24:19), whether it's
23 radioactive volume, do you use more than one method on
24 the same tank to compute the results from the first?
25 DR. PLODINEC: Well, realize that I'm

1 talking about other people's livelihoods here, which
2 makes it easy for me, I guess. No. I think that's
3 one of the weaknesses, is that there hasn't been an
4 independent verification of the calculational methods.
5 And that's what I was trying to lead you to conclude.
6 Thank you for being led.
7 DR. HAMDAN: And actually, you don't have
8 real data to compare the calculation, any one method
9 with real data --
10 DR. PLODINEC: Well, now having said that,
11 let me say the flip side, which is that they are
12 trying to compare their assumptions, if you will, not
13 assumptions but their calculations against known
14 locations in the tanks, so to that extent there is a
15 certain amount of de facto verification, even if it's
16 not de jure.
17 DR. HAMDAN: One question for Ken now.
18 VICE CHAIRMAN CROFF: Go ahead. Try and
19 keep it short.
20 DR. HAMDAN: Yes, one more question. The
21 change in efficiency in the technologies that you
22 mentioned is a different volume of efficiency or the
23 cause, or both, and the other question that I have
24 really is, does the cost go down with this new
25 technology as you improve efficiency?

1 DR. GASPER: The historical efficiencies
2 I report as what they were. The efficiencies for the
3 future, more technologies, I think we're at too early
4 a stage to tell you what we expect will be the
5 results. Fractional crystallization, for example,
6 versus Caustic Site Solvent Extraction, there are
7 ground rules that we wanted a process that didn't
8 require a new capital facility, major new capital
9 facility, so we expect it to be a much cheaper
10 process, and we recognize it will come with a somewhat
11 lower decontamination factor.
12 VICE CHAIRMAN CROFF: Okay. Thank you.
13 Let's go ahead and take a break now. We've been
14 sitting for a while. Come back at 3:45, if we can.
15 (Whereupon, the proceedings in the above-
16 entitled matter went off the record at 3:27:32 p.m.
17 and went back on the record at 3:49:45 p.m.)
18 VICE CHAIRMAN CROFF: I'd like to begin
19 the third session of the workshop. We're running a
20 little bit ahead, but in fairness of people who might
21 have planned to show up tomorrow morning to listen to
22 our first speakers, we're not going to bring any of
23 them up today, so we're going to have one more
24 presentation here. I think maybe take some Q&A on
25 that presentation given we're going into the

1 overnight, and then we'll call it quits for today. So
2 we're moving into this third session. The second
3 session revealed two major, let me call them waste
4 streams or end-points. One is a tank in the ground
5 mostly empty, filled with some kind of material like
6 a grout, and the other is an immobilized low activity
7 waste, again potentially in material such as a grout.
8 And this session is going to address a couple of
9 important aspects of disposing of these wastes. One
10 is how to stabilize them, and then performance
11 assessment, and decision-making concerning these
12 wastes.
13 The need to fill the tanks and immobilize
14 the waste has led to considerable activity concerning
15 cements and grouts, and they seem to be the materials
16 of choice in many instances. As a consequence, the
17 durability of these materials has come to the
18 forefront as an area of interest, and to begin to
19 address this, I'd like to introduce Dr. Les Dole. Les
20 has studied corrosion and radionuclide propagation in
21 Westinghouse nuclear power plants, directed research
22 on engineered barriers for some predecessors to the
23 Office of Civilian Radioactive Waste Management, and
24 led a group at Oak Ridge National Laboratory for about
25 10 years that developed and tested waste forms for

1 various hazardous and radioactive waste across the BUE
2 complex. Those are hazardous chemical wastes, of
3 course. And he served as Technical Director of
4 Qualtrek, a major super fund remediation contractor.
5 Les, it's your's.
6 DR. DOLE: Mike talked earlier about scuba
7 diving in oatmeal. We're going to scuba dive in
8 cement right now. Okay. Cement is one of those
9 issues, how many people here have cement sidewalks,
10 patios or driveways. Okay. How many of you have
11 cracks in them? Everybody. I do, too, so that's
12 going to be tough room.
13 Basically, as I explained to Ed, my
14 counterpart from this is that there's dirty water
15 cement chemists and clean water cement chemists, those
16 guys who civil engineering and structural work with
17 cements, and they use clean water. And then there's
18 the rest of us poor souls that mix cement with all
19 kinds of things that should never have been used.
20 So basically, I'm going to talk about
21 hydraulic cements. Basically, they're a powder and
22 you mix it with water and it ends up like a stone.
23 And the ones I'm going to concentrate on are the first
24 three on the list, which are the ones that are most
25 commonly used in waste management. There are others

1 and they have their niches, but most of the waste is
2 treated with Portland or a variation with a lime slag
3 silicate, and I'm not going to say anything about the
4 organic ones. Most things have their niche, some are
5 still looking for it.
6 Basically, I could spend the rest of the
7 day on this talk because it summarizes so many aspects
8 of what we're talking about when we deal with cement
9 chemistry, is that we start out as a slurry, in which
10 the contiguous phase is water, and it goes through a
11 phase where it forms these tendrils of CSH which is
12 calcium silica hydrate, and eventually that locks
13 together slowly. You notice the time scale is non-
14 linear, over 28, 90, and even hundreds of days to
15 thousands of years, the reactions continue to evolve
16 so it's a sequence of reactions. So you can imagine
17 that if you mix these with dirty water, things that
18 would affect the slurring properties, affect the
19 processability and the flow characteristics, things
20 that steel calcium or silica from the system interfere
21 with the cement reactions and get these all out of
22 sequence. So when you start to deal with waste, you
23 have to deal with the interferences from the
24 constituents of the waste.
25 Now cement material is basically taking

1 clay and lime, and roasting it, and then grinding it
2 into a fine powder, and that's really a product that's
3 made from the crust of the earth, so it has a lot of
4 elements in it. The principal ones are, of course,
5 calcium silica, aluminum and iron, but what's in the
6 crust of the earth, you find in cement.
7 Basically, the basic reaction is you take
8 like tricalcium silicate, reactor it with water, it
9 forms a calcium hydrate, usually at first it's a very
10 non-differentiated amorphous gel, and the reaction
11 releases calcium hydroxide. Now I'm going to
12 foreshadow because if you add glass silica to it,
13 fosilon, that silica then will react with the tree
14 hydroxide and make it disappear. We'll see later that
15 might be important. So basically, we have complex
16 alumina silicates that first form a very fine texture.
17 It's very difficult to analyze, the spots are usually
18 bigger than the fabric so it's hard to isolate
19 individual phases. And it starts out with a large
20 fraction of amorphous material that continues to
21 differentiate itself into possibly a large number of
22 different phases.
23 Okay. These components react at different
24 rates. And particularly when they interact with the
25 ground water, because different components of the

1 system lead to different rates, and they interact with
2 the ground water, and you get reprecipitation, and so
3 these interactions will be interesting.
4 Basically when you mix it with a waste,
5 the waste comes with a variety of compounds, elements,
6 anions, and they tend to accelerate or retard the
7 cement reactions. And realistically, when you look at
8 a real waste using this glueous complex, you can't a
9 priori predict what wins in a particular case. You
10 almost always have to start at least at some point
11 treatability studies to see how interaction between
12 the waste and spent chemistry behaves.
13 Second, you've got other things in the
14 waste, particularly when you talk about surfactants,
15 kelating agents, hydrolysis products like
16 tributylphosphate, they also influence the rheology in
17 the cement chemistry. Furthermore, since it starts
18 out to be a slurry, it's very sensitive to ionic
19 strength, and so the ionic strength has a large impact
20 on this processability, how fluid it is, how thick it
21 is, and how you replace it. And so you can manage it,
22 for instance, with low ionic strength you tend to use
23 a series of things like bentonite, ilite, and
24 kaolinite. If you have very high ionic strengths, you
25 use netolite, minerals such as attpulgite and fly

1 ashes and other materials.

2 So when we consider formulating a waste
3 form we've got a broad spectrum of cement types that
4 are usually characterized by its constituency and its
5 set, and then you can modify the behavior of that
6 catalogue of cements by adding silicates and other
7 additives. Silicates are -- everybody saw "The Greek
8 Wedding" where the father says whenever he gets a
9 little burn he puts Windex on it - okay. I'm going to
10 start to sound like about silicates, because all the
11 problems we have - well, not all of them, but many of
12 the problems are mitigated by adding reactive silica.
13 So reducing the calcium silica ratio, the aluminum
14 silica ratio, and you reduce the permeability and its
15 susceptibility to permeation and reactions that would
16 degrade the matrix.

17 Also, you add additives to increase the
18 internal the best. You may use clays in one aspect to
19 control viscosity and the processability of the mix,
20 but adding clays to it also highly modifies the
21 internal ion exchange capacity, and we'll see how that
22 reduces the diffusion coefficients. And then the
23 effect of reducing -- certainly, one of the tricks for
24 controlling Technetium is to add a reducing agent,
25 reduced to a very immobile Technetiumoxide. For

1 instance, blast furnace slags are a classic mechanism
2 to add sulfur and reducing iron into the mix, so it's
3 very effective in controlling Technetium.
4 One other issue is how to predict the long
5 term behavior of this. That's one of the major
6 issues, is that once you've found a mix that meets,
7 that's compatible with the waste stream and compatible
8 with the processing equipment, then you start to worry
9 about how durable is it in a sense of being a long-
10 term waste run. And the first impulse is to test
11 these at elevated temperatures to accelerate reagent
12 reactions. And as I pointed out, the cement systems
13 are fairly complex series of sequential and parallel
14 reactions, so the real essence of changing the
15 temperature is to change the reaction paths. So here
16 are some common minerals that cement matrices evolve
17 to over very long periods of time. And you can see
18 that their free energies change value significantly by
19 raising the temperature from 25 to 100 degrees C. So
20 you have to be very careful when you look at the idea
21 of trying to accelerate aging tests by elevating the
22 temperature because it just doesn't evolve in the same
23 way.
24 So where does that leave us? Well, the
25 other option is to look at anthropologic and natural

1 analogs. Now the problem is that the Romans didn't
2 put Plutonium in their grouts, but the other problems
3 is that they used materials that were different than
4 us. And we can't always determine what was used in
5 the first place, and we certainly can't always deduce
6 the conditions it's seen over the last 2,000 years
7 while were looking somewhere else.
8 There are also natural formations, Texas,
9 Israel, Ireland, where magma has intruded into
10 formations and made cement linger in situ. And we can
11 go back and look at these, and unravel ten thousands
12 to maybe a million years of it in environmental
13 exposure. Now there's great difficulty in using
14 natural analogs, but they are good at bounding things,
15 they are good at looking at systems that evolve at
16 more ambient temperatures for very long periods of
17 time, and gives us some idea of where to look when we
18 examine modern cements.
19 Now if we can't accelerate the reactions
20 reliability by temperature, that means we have to age
21 them in real laboratory time, and so the hope there is
22 that perhaps some of the modern microprobe tools will
23 be able to look at the phases forming on the surfaces
24 and get an early indication of where the system is
25 going to. And then try to link them to the agent

1 systems using some mass transfer coupled thermodynamic
2 model. Now again, much of the thermodynamic data is
3 missing for many of the key cement phases, and the
4 models have difficulty handling some of the metastable
5 intermediates because in the end the systems end up as
6 - after they form first as amorphous systems, there's
7 still a solid diffusion control reaction, so they're
8 very slow. And so you can get microsystems within the
9 matrix that have one composition versus another, and
10 so one part of the system is evolving in a different
11 direction. But given all these difficulties, it's
12 really the only place we have to go to really unravel
13 the very long term, if we're going to look at
14 certainly transuranics when we're looking at hundreds
15 of thousands of years of performance.
16 Now let's talk about the leach
17 performance, which is really the risk. The whole idea
18 of this is you have a waste stream, because of its
19 chemistry and its liquid, it represents a risk, and
20 you mix it with this stuff, and you reduce the risk,
21 so how do we assess that reduction in risk? We really
22 have two extremes to look at; one, a quasi-static
23 system where you have a waste form in very low flowing
24 water where it comes to equilibrium with the water
25 adjacent to it, or near equilibrium. I mean, in some

1 cases the waters in Yucca Mountain are a thousand
2 years old and it's still not in equilibrium, but here
3 you have a case where you have a very low, so you
4 would design for a very low solubility, very low flow.
5 That would be an optimum risk, that would be a good
6 risk case.
7 The other case is where you have a dynamic
8 system where you have an advection of ground water
9 that flows passed the waste stream fast enough that it
10 never reaches saturation in the fill, and you have a
11 diffusion control release from the waste run.
12 Now in practice, probably familiar with
13 those, but basically one aspect of the waste form in
14 a dynamic system is you make a case that if you have
15 a model that's embedded in a geochemistry, and if it
16 is 100 times less permeable than the surrounding
17 geology, that an affected particle of water goes
18 around rather than through. So a threshold is if you
19 build a waste form that's 100 times less permeable
20 than its site, then you've eliminated advection as a
21 mechanism by which it can release its activity to the
22 biosphere.
23 Now then we come to diffusion control. So
24 now we start looking into our bag of tricks on how we
25 design a matrix of a waste form for diffusion control.

1 And this is an idealized occasion when, in fact, you
2 can never really isolate all the variables, but it at
3 least gives you a sense of what you're trying to do.
4 You're trying to increase the virtuosity, in other
5 words the fineness of the structure. You're trying to
6 induce a material into it that has a high exchange
7 capacity for the individual, and you're trying to
8 reduce the porosity, so these are all the kinds of
9 things you can do to silicates and clays. And so we
10 know how to do that, except that that model really
11 only works for Cesium. When you start looking at
12 Strontium and other -- especially the transition
13 metals and the Uranium, Plutonium, there's a whole
14 complex silicate chemistry that's going on, so it's
15 not a simple exchange matter. So perhaps only for
16 Cesium, and maybe Iodine-129 you can make a case for
17 an exchange model, but at least these gives you some
18 sort of guidance what you want to do when you try to
19 design a waste form.
20 So I just luckily picked examples from the
21 W-9 gunite tank at Oak Ridge, in which we measured the
22 effective diffusion coefficient for Strontium of 10 to
23 the minus 13 square centimeters per second, and so
24 what's that going to mean? Basically, in the first 20
25 percent of dilution from a body, geometry is not

1 important. You just use an in finis slab model. This
2 is a simple in finis slab model where you have the
3 ratio of the surface to volume, the square root of the
4 diffusion coefficient times the time. And when you
5 get beyond 20 percent, then you have to introduce an
6 equation that accounts for the geometry of the system,
7 and this has been a very effective model for us. I
8 won't go into details, but basically these are the
9 results.
10 You have decay for Strontium, then you
11 have the diffusional release from the body of the
12 model, about the size of a W-910, and so when you
13 combine diffusion and decay, you see that the DF is
14 .05, and that's a maximum release, and that's without
15 any dilution for ground water. That's the amount of
16 curies in time that it released, so you can see for
17 the things like Cesium, Strontium, and Cobalt-60, the
18 combination of decay and diffusion is really a minor
19 risk. So certainly in the case of the case of the
20 gunite tanks and the case of many of these fields, if
21 you fix them in place and you have that kind of
22 diffusion coefficient in the waste form, you're
23 essentially never going to get it to diffuse fast
24 enough to be a hazard to the local surroundings.
25 Talk about some of the issues with doing

1 leach tests, and I've been in rooms arguing about
2 leach tests for 30 years. And the only thing we've
3 ever resolved in those 30 years is we've agreed on a
4 surface-to-volume ratio as a standard part of the
5 test. But the interpretation of these tests gets a
6 little wild.
7 The whole idea is that you have a static
8 system, you close your waste formula and you measure
9 the constituents concentration in the leaching, and it
10 takes off. Well, it reaches saturation, but then
11 there are other elements in the cement that are also
12 leaching, particularly the hydroxide. If it's OPC,
13 Ordinary Portland Cement, you have hydroxides,
14 carbonates in the water, and they start to
15 precipitate. So now the concentration is determined
16 by this partitioning with the precipitate. Then later
17 on as the calcium, and the silica, and the aluminum
18 leach, they start to reprecipitate and form secondary
19 minerals which then greatly reduce it more, so you end
20 up certainly in a cementitious systems, if you do a
21 closed leach you end up consistently with a Volkswagen
22 isothermacite, if I may refer to it. One variation
23 is, is that sometimes this film is very tight and
24 there's an osmotic rupture as you get little
25 Volkswagens reproducing themselves as time goes on.

1 But the other point of this is how do you interpret
2 this as a leach rate, because if you take this period
3 you get this one result, but as you can see, as you
4 choose different time periods - I thought that was a
5 French program. They'd always wait until they got to
6 here and then pick that as a leach rate, so it's very
7 subjective.
8 So then to some extent design of the waste
9 form is about controlling how it interacts with the
10 local geochemistry. Certainly one thing you can do to
11 help yourself right away, and again put silica on it,
12 if you adjust the calcium silicate ratio, you get in
13 this regime where you cannot have three hydroxides and
14 that helps you in several ways. One, it makes the
15 matrix more dense, less permeable, lower porosity, and
16 you don't have the leaching of the calcium hydroxide,
17 it opens the internal pore space so there's a lot of
18 advantages to going to that type of system.
19 But there's an other thing that happens,
20 is that also this has a decrease in calcium silicate
21 ratio, if you increase the silica going this way, you
22 increase the amount of soluble silica, and if that
23 interacts with the ground water, particularly like in
24 the case of Uranium, you start forming very, very
25 insoluble uranium silicates. We're moving pretty

1 quick, and there's a quiz afterwards. But this gives
2 you some idea of the power limits of uranium silicates
3 that can form, and so very rapidly you get the
4 shoepite, and it modifies, it evolves Sunnite, but it
5 eventually goes to the hematite, so you find these
6 very, very ersalite, very stable uranium silicates, so
7 we've tried to make a case that certainly in Yucca
8 Mountain they ban cements, but they did consider that
9 if you use high silica cements you can actually
10 greatly reduce the mobility of Uranium. And their
11 current model doesn't account for that. And so if you
12 look like waste like spent fuel adjacent to cement,
13 the cement then can promote these protective layers on
14 the Uranium, and it's very dense. And even in a case
15 where you have radiolysis and oxidizing conditions
16 adjacent to the Uranium, its solubility is greater
17 reduced by the -- we've done tests like this.
18 This is a centered urania and GI water for
19 six months, this is the same sample in a cement core
20 solution in six months, and you can see that the
21 surface is almost complete occluded by calcium
22 silicates that were spawned by the cement. Okay. So
23 it's really difficult to interpret these tests,
24 particularly, as Yogi Bera says, it's hard to predict
25 things, especially when they're in the future. But

1 short term leach tests are conservatives if you have
2 the quality there. You don't form a second -- if you
3 can assign a leach test where you don't allow the
4 secondary stages to form, you get pretty conservative
5 results. That's truly stripping away the surface.
6 And if you look at the early phase of the glass
7 leaching where you're diluting the surface of the
8 glass, that's exactly what you have, but if you wait
9 long enough, the secondary minerals form in the glass
10 and you can get the Volkswagen started.
11 They're also conservative if the monolith
12 matrix is relatively stable and the geochemistry of
13 the disposal horizon. It doesn't hurt to try to match
14 your waste form with its element disposal horizon.
15 Now you minimize physical degradation of it. And
16 ultimately, what you want to achieve is a waste form
17 in a geochemical environment where all the reactions
18 are pretty much controlled by diffusion, solid
19 diffusion, and now we're trying to interpret the
20 geological eras in terms of things like that, which is
21 what we need in the case of transuranics.
22 To summarize, there's a tremendous body of
23 knowledge. Cementitious waste form is probably the
24 most widely used treatment across the DOE complex, so
25 here's an enormous body of engineering knowledge on

1 how to make waste forms and process the cementitious
2 waste. All this disagreement about how to
3 characterize risk in a near field transport, and the
4 element of leaching the interaction, and there's
5 really no coordinated effort at this time across
6 anthropologists, and geologists, or repository
7 designers on how to reconcile and coordinate the
8 collation and taking of data, and trying to use
9 natural and anthropomorphic analogs to make the fix.
10 And that's it.
11 VICE CHAIRMAN CROFF: I'm going to --
12 first, I think we should do the questions and answers
13 for Les right now while we've got it fresh in our
14 mind, and then we'll adjourn.
15 DR. DOLE: I'll be back.
16 VICE CHAIRMAN CROFF: Well, I'm counting
17 on that, and tomorrow we'll hear from the rest of this
18 particular panel, and then we'll open it for -- Les
19 will be here for rebuttal and this kind of thing. I'm
20 going to assert the chairman's prerogative and ask a
21 couple of things to start, and that is, my sense is
22 what I'm hearing from you is that grout cements do
23 pretty darned good in most cases when they, let's say,
24 maintain their integrity, if you will. And I'd like
25 your views on the susceptibility to degradation by a

1 couple of mechanisms.

2 I think one is - let me just say cracking

3 - in other words, over time through physical or

4 whatever stresses, it cracks and it becomes a lot more

5 permeable to water, which can get to it. And

6 secondly, thinking about the example of something like

7 a salt stone, something that has an awful lot of

8 sodium in it, as the fellow from the Corps of

9 Engineers brought up this morning, what does that do -

10 I mean, if you get 15 or 20 percent sodium nitrate in

11 this thing, does it sort of turn into - I don't want

12 to call it swiss cheese, but something that a whole

13 heck of a lot of water can get through and get to the

14 radionuclides?

15 DR. DOLE: Let's take on the cracking. In

16 so much as the ultimate transport surface from inside

17 the monolith outside is the surface-to-volume ratio,

18 we have cracking from tectonic produce some fissures

19 through a monolith, but probably wouldn't change that

20 ratio very much. You may be talking about crepitation

21 like from heat shrinkage, we have fine micro cracks.

22 The trick that is that, for example, when you cast

23 these enormous monoliths for dams, you actually have

24 to pout cooling coils in them to take the heat out.

25 The heating reaction is intense for the cement

1 reactions. That's another reason, so you can slow
2 that down so that with a monolith the idea is to have
3 a reaction rate low enough that you never really make
4 the temperature rise enough where you get shrinkage
5 crack. That's one trick, is to control the reaction
6 rate so that it develops properties at a regular
7 steady rate and doesn't overheat. That is one way to
8 reduce the cracking.
9 The other way to reduce cracking is
10 basically we design them so they're slightly
11 expansive. We like it when the final formula swells
12 a little bit, we're talking about .005 percent
13 dimensional changes. If they are slightly swelling,
14 then they create these internal stresses that actually
15 close cracks. And finally, if you put excess
16 silicates in here, there's a possibility that the
17 unreacted components when they're exposed during
18 cracks, they heal themselves, so all those things get
19 popped. But the bottom line is that cracking is not
20 a problem unless you reduce the surface-to-volume
21 ratio to the point where the transport is
22 unacceptable, and that's pretty rare.
23 Now the other question was?
24 DR. HAMDAN: Sodium.
25 VICE CHAIRMAN CROFF: High chemical

1 content effects on degradation.

2 DR. DOLE: Well, it varies. Certainly,

3 the sodium and the nitrate will leach. I mean,

4 obviously, if you have -- the hydro fracture grouts

5 were also made with sodium nitrate solutions about 12

6 mol or 15 mol, and yes, sodium and nitrate leach out

7 at a rate. The good news is that at the same time the

8 sodium and nitrates are being diluted, the Strontium,

9 Cesium, Cobalt-60 are not. That's one important

10 thing. Yes, there is definitely a dynamic in which

11 the diffusion coefficients for sodium and nitrate will

12 probably be on the range of 10 to the minus 8, to 10

13 to the minus 9 centimeters squared per second at a

14 time when the Cesium and Strontium, and Cobalt-60

15 would be 10 to the minus 10, 10 to the minus 13. So

16 yes, it doesn't move in saturated water. And the

17 goods news is, is that the nuclides don't follow it.

18 And second, given the leach rate and the flux of

19 water, like the shell and barrier, especially at Oak

20 Ridge with 45 to 55 inches of veneer, and most of the

21 hydrolysis in the first meter, how much exchange do

22 you get with the biosphere? Is that an unacceptable

23 loading, does that cause problems? Is the grass

24 greener down range from your burial pit? Did I answer

25 the question? It will leach. It'll leach at a

1 different rate.

2 VICE CHAIRMAN CROFF: The message I'm

3 getting is that chemicals will leach out, but they

4 don't -- well, most of them don't tend to affect the

5 grout properties and its retention of radionuclides

6 very much.

7 DR. DOLE: At least in the first 20-30

8 years that we noticed. Now you can make some case

9 that the illusion of the -- if you have solid bodies

10 of sodium nitrate in there and then opened up the

11 structure, would it change? We haven't seen it yet.

12 VICE CHAIRMAN CROFF: Okay. But the

13 experience base is decades on this kind of thing.

14 DR. DOLE: Yes. And that's all you --

15 well, you would like to have 300 years.

16 VICE CHAIRMAN CROFF: Technetium maybe a

17 couple of more years. Okay. I'm going to pass.

18 Ruth.

19 MEMBER WEINER: I just have one questions.

20 I notice that your chart of principal compounds,

21 Uranium-containing compounds, you cite Uranium-6, and

22 we found on the WTP Project that Uranium-6 solubility

23 is very strongly dependent on pH.

24 DR. DOLE: Yes.

25 MEMBER WEINER: Do you find a problem when

1 you get off of a pH, if your pH changes?

2 DR. DOLE: On pH if you don't silicates.

3 MEMBER WEINER: But the silicates will

4 mitigate that.

5 DR. DOLE: And that's exactly what

6 happened in the Yucca Mountain model. They put in the

7 -- Rob Ewing put in the carbonate and the combination

8 of carbonate and high pH gives you a very mobile

9 uranialcarbonate complex. But even disregarding the

10 presence of cement, if you have the silicates coming

11 in from the top, it's not very mobile.

12 MEMBER WEINER: Thanks.

13 VICE CHAIRMAN CROFF: Jim.

14 DR. CLARKE: I just wanted to follow-up a

15 little with you, Les, on your second point on your

16 last slide. There's disagreement on how to measure,

17 and there are different ways to measure leaching to

18 put site specific factors into the test and all of

19 that. And there's disagreement on which model they

20 use, and I just wondered how far off are we on that?

21 What is our ability to compare measured leaching rates

22 to model predictions?

23 DR. DOLE: Basically, we do the ANS-16.1

24 for the dynamic leaching test, and if you take the

25 early data from static leach tests, those are very

1 conservative. And if you take those data and put them
2 in your near field transport model, and things are
3 okay, you're probably all right.
4 DR. CLARKE: What does "probably all
5 right" mean? I just wonder about the uncertainty.
6 DR. DOLE: It depends on the setting.
7 Once it's released to the waste form it goes into the
8 near and far field transport models, depending on
9 where your nearest receptor is, what the geology is.
10 DR. CLARKE: A more basic question, the
11 agreement between the measured leaching rates and the
12 predicted, how well can we do that?
13 DR. DOLE: Okay. That's where we really
14 disagree. Some people think that you really predict
15 something with a leach test, and I question that.
16 You've predicted what you've done in the lab. You've
17 done a post mortem on your laboratory test, how that
18 relates to the real case. You can do the best you can
19 to model it, and you try to do it in such a way that's
20 conservative. That's the only thing you can try to
21 do, is to design the laboratory test so it's
22 conservative. And how do you do that? Well, you use
23 real ground water, that helps because a lot of times
24 ground water comes with alumina silicates, but to use
25 deionized water, then that may be too much. That's

1 very aggressive leaching, and so the tendency is not -
2 - because you can reproduce deionized water, it's
3 really hard to reproduce ground reliably and
4 consistently, so the tendency is to use deionized
5 water. Those are very conservative results, and if
6 you can live with that answer, that's fine.
7 MEMBER HINZE: Les, speaking about grout
8 and steel containers, what is the impact of iron on
9 the grout, and grout on the iron containers?
10 DR. DOLE: I hate to sound like I say high
11 silica all the time, but it's been my experience that
12 certainly with high silica, the silicates.. I would
13 see cases where I used to fish off -- in World War II
14 they made barges out of cement because they were low
15 on steel, and they used reinforced concrete barges,
16 and I used to fish off a barge at the north entrance
17 to Largo Sound, and one day they weren't biting, so I
18 went over and I found a piece of iron and I hit a
19 piece of concrete that was on a rebar. When it broke
20 away, you could still see the machine marks on the
21 rebar because the lightweight formula was use silica,
22 and so you could see that it was right in the splash
23 zone for 25 years and still was able to protect that
24 surface.
25 MEMBER HINZE: And the grouting of the

1 waste in the stainless steel containers, do they use
2 high silica?
3 DR. DOLE: Don't know. Who, which?
4 MEMBER HINZE: Yes. Okay. Thank you.
5 CHAIRMAN RYAN: Thanks for a great
6 presentation. I really enjoyed it. You covered 30
7 years of cement chemistry and history in a short
8 period, and gave us a good run through it. You
9 mentioned a number of kind of what-if cases, if you do
10 this, or if you add silica you'll get this kind of
11 result. Has anybody taken a numerical view of trying
12 to look at that as a system, like we've talked about
13 in terms of estimating propagated uncertainties, and
14 things of that sort?
15 DR. DOLE: Not in particular. I guess the
16 closest they come is -- what were they called?
17 Neurex was developing an expert system by using rules
18 of thumb to design grouts for some of the --
19 CHAIRMAN RYAN: Yes, have an expert
20 elicitation sort of approach.
21 DR. DOLE: Yes, but it doesn't address the
22 kind of issues you were talking about.
23 CHAIRMAN RYAN: Well, it's an interesting
24 thing to think about, I would suggest, and tell me if
25 I'm wrong, that if we took a system, tried to define

1 some system and said well, if we added silicate we'd
2 get this kind of benefit. If we didn't add silicate,
3 we'd get this kind of detriment, and then look at the
4 ins and the outs, and try and get some assessment of
5 what works and what doesn't. Not only that, but how
6 much, what might it be. I mean, do you get an order
7 of magnitude change, or a factor of 1.3, or six orders
8 of magnitude change? It would be interesting to try
9 and systematically find out where the bang for the
10 buck is here, where do you get a big return?
11 DR. DOLE: Where we are right now, I don't
12 want to get too Aristotelian, but we're looking at the
13 shadows on the page, you're looking at the porosity
14 changes, you're looking at the strength changes,
15 things like that, permeability, physical things you
16 can measure, but not down to the fabric and the
17 chemistry of the fabric. That's why we bring up the
18 idea of doing some of these -- trying to develop a
19 thermodynamic diffusion control model, because in the
20 end these things go rapidly and they're very
21 amorphous, and then things start to evolve very
22 slowly. How you do that, and you can imagine being
23 trapped in intermediates, metastable intermediates
24 because of the diffusion and so forth and so on.
25 There's a big gap between what we see at

1 the bench and what these guys see in autoclaves with
2 gold capillaries. There's a big gap in there.
3 VICE CHAIRMAN CROFF: Okay.
4 DR. HAMDAN: Yes.
5 VICE CHAIRMAN CROFF: How did I know this?
6 DR. HAMDAN: Yes, excellent presentation.
7 Are there alternatives to grout for radionuclide?
8 DR. DOLE: Silicate? Calcium silicate,
9 alumina systems? Well, certainly people have used
10 Gypsum and phosphate cements, and they have some
11 advantage. For instance, Argonne has used phosphate
12 cements, and it doesn't require that you -- when you
13 use a regular Portland cement you have to neutralize
14 the waste. You use a phosphate cement it can fix
15 acids directly with out neutralization.
16 I guess where I came from, again you talk
17 about institutional -- Oak Ridge drifted into high
18 silica cements in the late 50s, and so we've been
19 stuck in the 50s for a long time. And we've been able
20 to use it very successfully. And one of the things we
21 do is we look out our window and we see mountains that
22 were 240 million years old once, and they were alumina
23 silicates, and so phosphate, there are phosphate
24 formations, there are Gypsum formations, but they're
25 pretty rare, so the majority of the systems in the

1 crust of the earth that have lasted for a very long
2 time have been alumina silica systems, so we stayed
3 pretty with that. But there are other approaches.
4 VICE CHAIRMAN CROFF: Any other questions
5 from anybody? I think we've worn them down today.
6 Okay. I think that's it for the working group per se
7 today. We'll reconvene at 8:30 tomorrow on that.
8 Mike, do you have any non-working group administrative
9 --
10 CHAIRMAN RYAN: Again, I think everybody
11 that's got a V in the red badge, if you'll hook up
12 with a staff person to take you back downstairs, we'll
13 be happy to help you. And then also, we're scheduled
14 to start at 8:30 in the morning so if you would get
15 here maybe a little bit ahead of that, we'll be down
16 to help get you back upstairs and there won't be such
17 a crunch to get everybody in the door. That would be
18 helpful, as well, so we're happy to help do that. Any
19 other questions or needs from the audience? Okay.
20 Then I guess we'll adjourn for the day and reconvene
21 at 8:30 tomorrow morning. Thank you very much.
22 (Whereupon, the proceedings in the above-
23 entitled matter went off the record at 4:30 p.m.)
24
25

CERTIFICATE

This is to certify that the attached proceedings before the United States Nuclear Regulatory Commission in the matter of:

Name of Proceeding: Advisory Committee on Nuclear Waste 162nd Meeting

Docket Number: n/a

Location: Rockville, MD

were held as herein appears, and that this is the original transcript thereof for the file of the United States Nuclear Regulatory Commission taken by me and, thereafter reduced to typewriting by me or under the direction of the court reporting company, and that the transcript is a true and accurate record of the foregoing proceedings.

Eric Hendrixson
Official Reporter
Neal R. Gross & Co., Inc.

Status of Technology for Using Cementitious Materials to Stabilize Wastes

Les Dole

162st NRC Advisory Committee on Nuclear Waste: Working Group

Meeting on Waste Incidental to Reprocessing

August 2-4, 2005

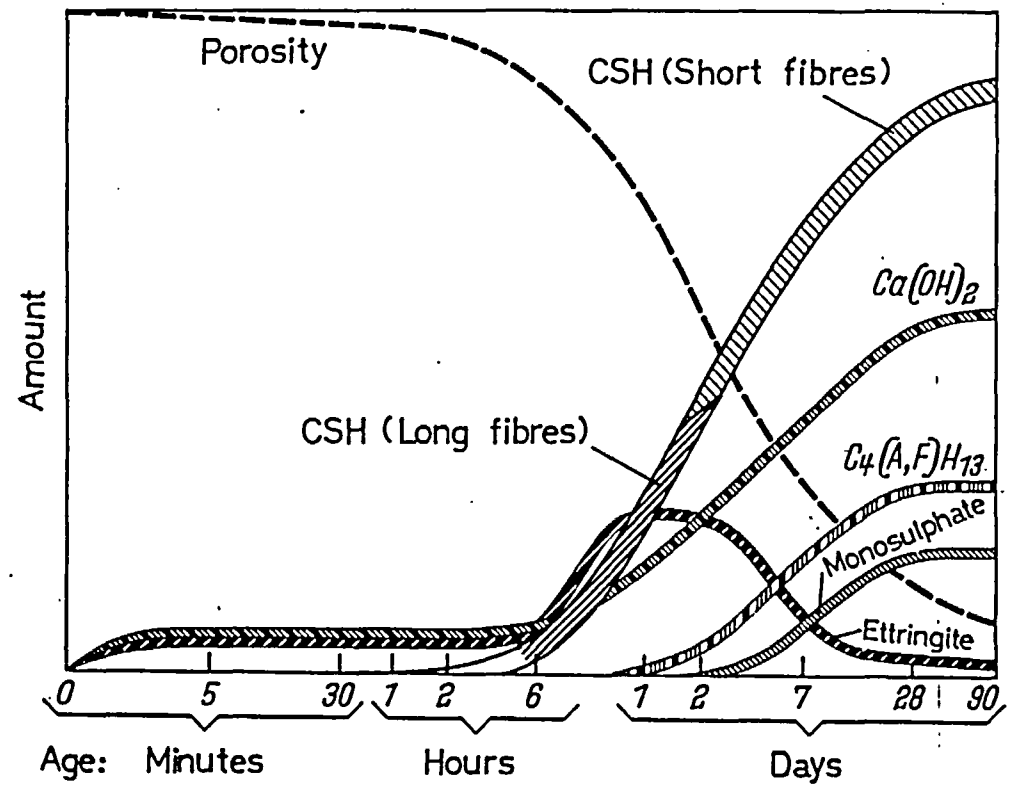
Washington, DC

contact: dolelr@ornl.gov 865-576-4319

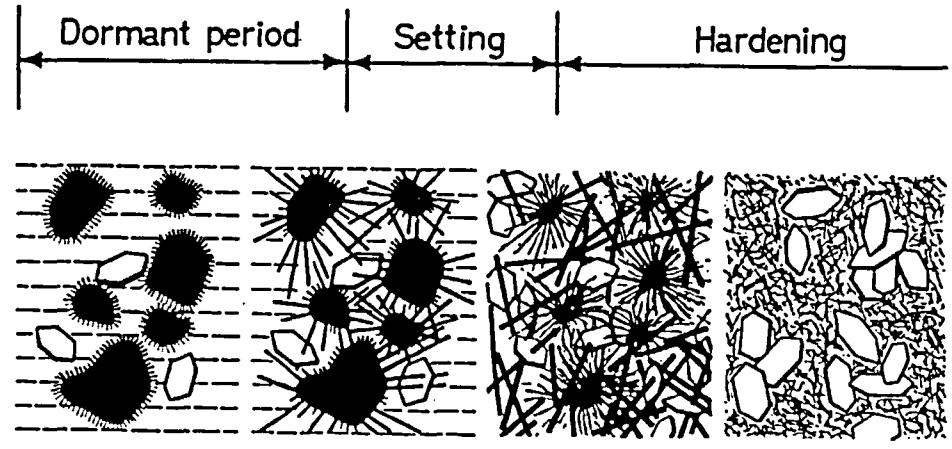
What Is a Hydraulic Cement

- Powder that reacts with water to form a "stone-like" solid
- Examples are
  - Portland cement
  - Lime silicates
  - Blast furnace slags
  - Phosphates
  - Gypsum (plaster of Paris)
  - Aluminates
- Not organic like urea-formaldehyde, polyesters, polyurethanes, thermoplastics (bitumen, polyethylene, etc.)

Reaction Sequence in Portland Cements



I. Soroka, Portland Cement Paste and Concrete, Chemical Publishing Co., 1979



What's in it and How it Reacts

- Various ranges of CaO, SiO_2, Al_2O_3, Fe_2O_3, MgO, $Na_2O + K_2O$, TiO_2, P_2O_5, and SO_2
- Clay and limestone heated to form clinker above 1250 – 2200°C, then ground to fine powder
  - C2S, C3S, C3A, and C4AF
  - Where C= CaO, S= SiO_2, A= Al_2O_3, and F= Fe_2O_3 are 90% of the solids
- These react with water exothermally
  - 2 (CaO)3SiO2 + 7H2O(l) = 5Ca(OH)2 + CaO*2SiO2*2H2O
    ΔG35°C = -32 kcal/mol
  - Ca(OH)2 + 2SiO2(G) + H2O = CaO*2SiO2*2H2O
    ΔG35°C = -9 kcal/mole

Evolution of the Cement with Time

- Complex alumina-silicates with fine-textured mineral phases and large fraction of amorphous hydrosilicate phase, both of which slowly undergo diagenesis
- Matrix components leach at different rates and results in a complex series of solution reactions with groundwater adjacent to the surface with reprecipitation

Waste Constituents Influence Curing and Rheology

- Cations
  - Accelerate set:
    $Ca^{++} > Ni^{++} > Ba^{++}, Mg^{++} > Fe^{+++} > Cr^{++} > Co^{++} > La^{+++} >> NH4^{+}, K^{+} > Li^{+} > Cs^{+} > Na^{+}$
  - Retard set:
    $Cu^{++} > Zn^{++} > Pb^{++}$
- Anions
  - Accelerate set:

    $OH^{-} > Cl^{-} > Br^{-} > NO_3^{-} > SO_3^{=} >> CH_3O_2^{-}$
- Surfactants, sugars, borates, tributylphosphate, others greatly retard set
- Rheology controls processing and pumpability
  - Low ionic strength wastes use smectitc clays like bentonite, illite, and kaolinite
  - High ionic strength wastes use attpulgite and other needle crystalline materials and Class F fly ashes

Material Choices to Mitigate Waste Constituents' Impacts on Waste Form Performance

- Choices of cement types
- Choices of admixtures to control waste form physical and chemical properties
  - Pozzolanic silicates
    - Reduce Ca/Si ratios
    - Reduce Al/Si ratios
    - Reduce permeability (H_2O, O_2, $SO_4^{=}$, Cl^-, etc.)
  - Increase internal ion exchange capacity
  - Effect reducing conditions (Eh/pH regime)

Issues with Accelerated Aging at Elevated Temperatures to Test Long-Term Durability

Conditions	Result
100°C for 10 minutes	Boiled egg
25°C for 28 days	Chicken
15°C for 60 days	Rotten egg

Formation Energies of Phases That Can Form in Aging Cement Pastes

Product	At 25°C	At 100°C
Hillebrandite $Ca_6Si_3O_9(OH)_6$	-2.42	-1.60
Afwillite $Ca_3Si_2O_4(OH)_6$	+3.94	+6.82
Xonotlite $Ca_6Si_6O^{17}(O_2H)$	-0.42	+0.49
Tobermorite $Ca_5Si_6O_{16}(OH)_2 \cdot 4(H2O$	-1.38	+0.18

Anthropomorphic and Natural Analogs

- **Anthropomorphic for 2000 to 3000 years**
  - Gallo – Roman
  - Nabateans
- **Natural for over 10,000 to 1,000,000 years**
  - Million-year-old natural samples from sanidinite-facies metamorphic rocks in Marble Canyon, Texas.
  - Hatrurim formation in Israel. These formations contain many of the same phases that form in high-silica cements. For example, the minerals are natural analogs for the common cement-clinker phases "alite" (Ca_3SiO_5, C3S) and "belite" (Ca_2SiO_4, C2S).
  - Scawt Hill, Northern Ireland, occurs in a region with high precipitation.

These cementitious analogs and their alteration products provide the opportunity to study transport processes and mineral metamorphisms on geologic time scales.

Missing Links Between Studies of Ancient Cements and Laboratory Tests

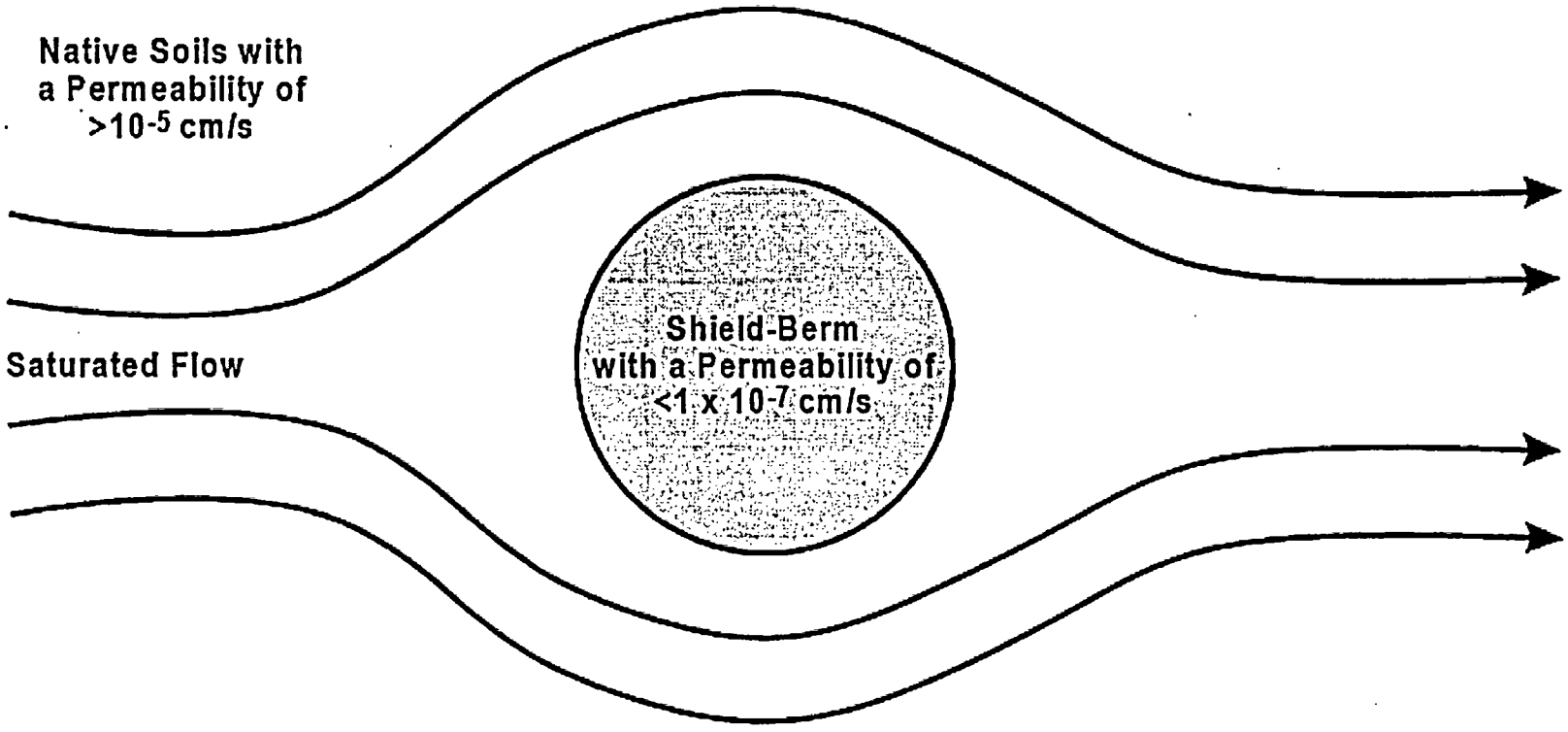
- Mass transfer coupled thermodynamic model
  - Thermodynamic data missing
  - Need for models for metastable intermediates trapped by diffusion-controlled metamorphisms
- Microprobe analytical tools to see start of phase transitions

Assessing Leach Performance at Hydraulic Extremes

- Quasi-static flow (episodic saturation)
  - Solubility control
  - Ion exchange equilibrium
  - Source-term = C_{sat} x Flow
- Dynamic (monolith permeability <1/100 soil)
  - Advection of saturated groundwater
  - Release to groundwater limited by diffusion within the monolith
  - Source-term $A_0 \{S/V\} (D_{diffusion}/time)^{1/2}$

A Relatively Impermeable Monolith Has no Advection

A Differential Permeability of 100 Times Ensures that Saturated Flow By-Passes the Matrix



A Not-so Practical Model for the "Effective" Diffusion Coefficient

$$K_{MB} = \left[\frac{\left(\frac{mole\ of\ species}{mass\ of\ porous\ solid} \right)}{\left(\frac{mole\ of\ species}{volume\ of\ liquid} \right)} \right].$$

$$D_e = \left[\frac{D_f}{\tau^2 \cdot \left[1 + \rho_b \cdot \left[\frac{(1-\epsilon)}{\epsilon} \right] \cdot K_{MB} \right]} \right],$$

where

τ = tortuosity, *dimensionless* (This study assumed that τ was equal to 1.47 for the compacted berm soils.)

ρ_b = bulk density of porous soil, g/cm^3

ϵ = average *effective* open porosity, *dimensionless*.

500-Year Fractional Release (FI) Model for Sr-90 Activity from Grouted GAAT Sludge from Gunite Tank W9

Effective diffusion coefficient:

$$D_e := \left(2.6 \cdot 10^{-13}\right) \cdot \frac{cm^2}{sec}$$

** Data from similar hydrofracture grouts*
** assumes most activity is Sr-90*

Time iteration

$$i := 0, 10 .. 500$$

$$t_i := i \cdot yr$$

Surface to volume:

$$\frac{S}{V} = 5.125\,cm^{-1}$$

** Assumes entire surface on the monolith is exposed to flowing groundwater. No credit is given for the existing tank walls.*

Infinite slab diffusion model:

$$FI(t) := 2 \cdot \frac{S}{V} \cdot \sqrt{\frac{D_e \cdot t}{\pi}}$$

** calculates a conservative overestimate of release*

$$t2 := \left(0.2 \cdot \frac{V}{S \cdot 2}\right)^2 \cdot \left(\frac{\pi}{D_e}\right) \qquad t2 = 145.805yr \qquad FI(t2) = 0.2$$

**On-set of geometry specific effects*

$$t5 := \left(0.5 \cdot \frac{V}{S \cdot 2}\right)^2 \cdot \left(\frac{\pi}{D_e}\right) \qquad t5 = 911.278yr \qquad FI(t5) = 0.5$$

**Chemical half-life in monolith*

Onset of Geometric Model at FC□0.2

Nestor, C. W., Jr., *Diffusion from Solid Cylinders*, **ORNL/SDTM-84**, Lockheed Martin Energy Research Corp., Oak Ridge National Laboratory, Oak Ridge, Tennessee, January 1980.

$$\alpha_j := \frac{\mathrm{root}(J0(j), j)}{a}$$

De = effective diffusion coefficient, cm2 s-1
a = cylinder radius, cm
j = *j*th positive root of a zero-order Bessel function [*J*0(*m*)]
L = cylinder half-height, cm.

Diffusion from a Cylinder:

$$FC(t) := 1 - \frac{32}{\pi^2 \cdot a^2} \cdot \sum_n \sum_j \frac{e^{-\left[D_e \cdot \left[(\alpha_j)^2 + (2 \cdot n - 1)^2 \cdot \frac{\pi^2}{4 \cdot L^2}\right] \cdot t\right]}}{(2 \cdot n - 1)^2 \cdot (\alpha_j)^2}$$

$FC(t2) = 0.223$ $\quad FS(t) := \mathrm{if}(t > t2, FC(t), FI(t))$ $\quad F_i := FS(t_i)$ $\quad FI_i := FI(t_i)$

Example: Diffusion-Controlled Release of ^{90}Sr from a Monolith

Fraction Released

$F_{30} = 0.091$

$F_{300} = 0.303$

$F_{500} = 0.379$

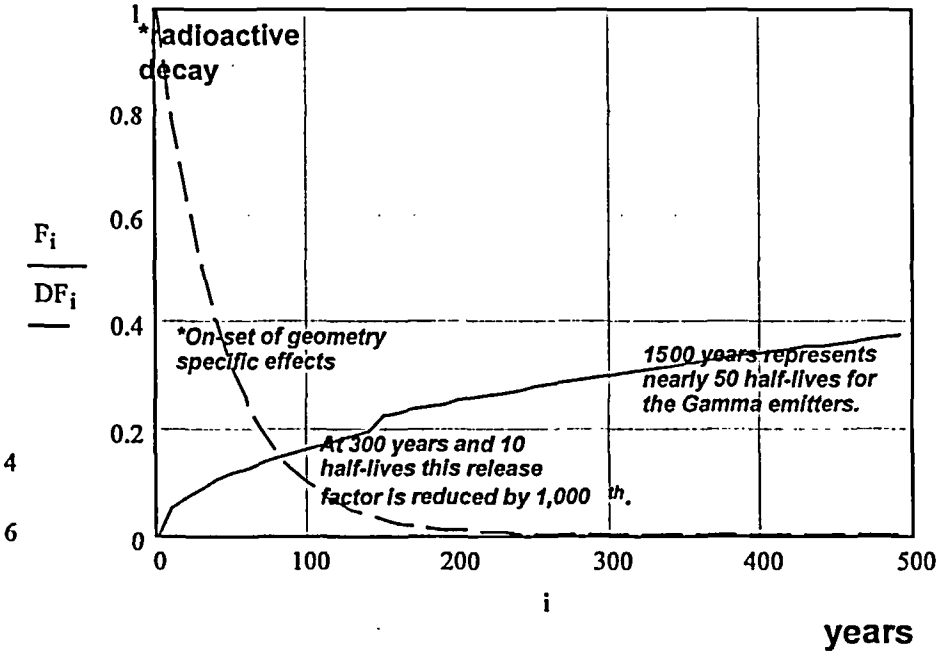
Radioactive Decay Factor

$DF_{30} = 0.5$

$DF_{300} = 9.766 \times 10^{-4}$

$DF_{500} = 9.612 \times 10^{-6}$

CURIE RELEASE FROM W9 MONOLITH as Sr-90



Decay Fraction X Release Fraction

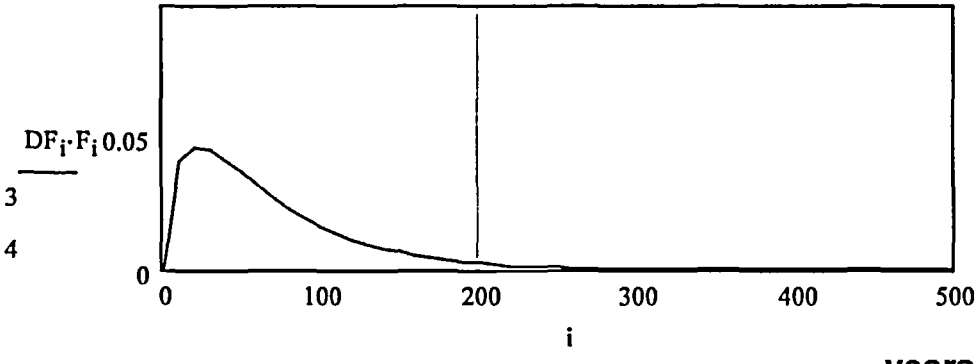
$DF_{30} \cdot F_{30} = 0.045$

$DF_{90} \cdot F_{90} = 0.02$

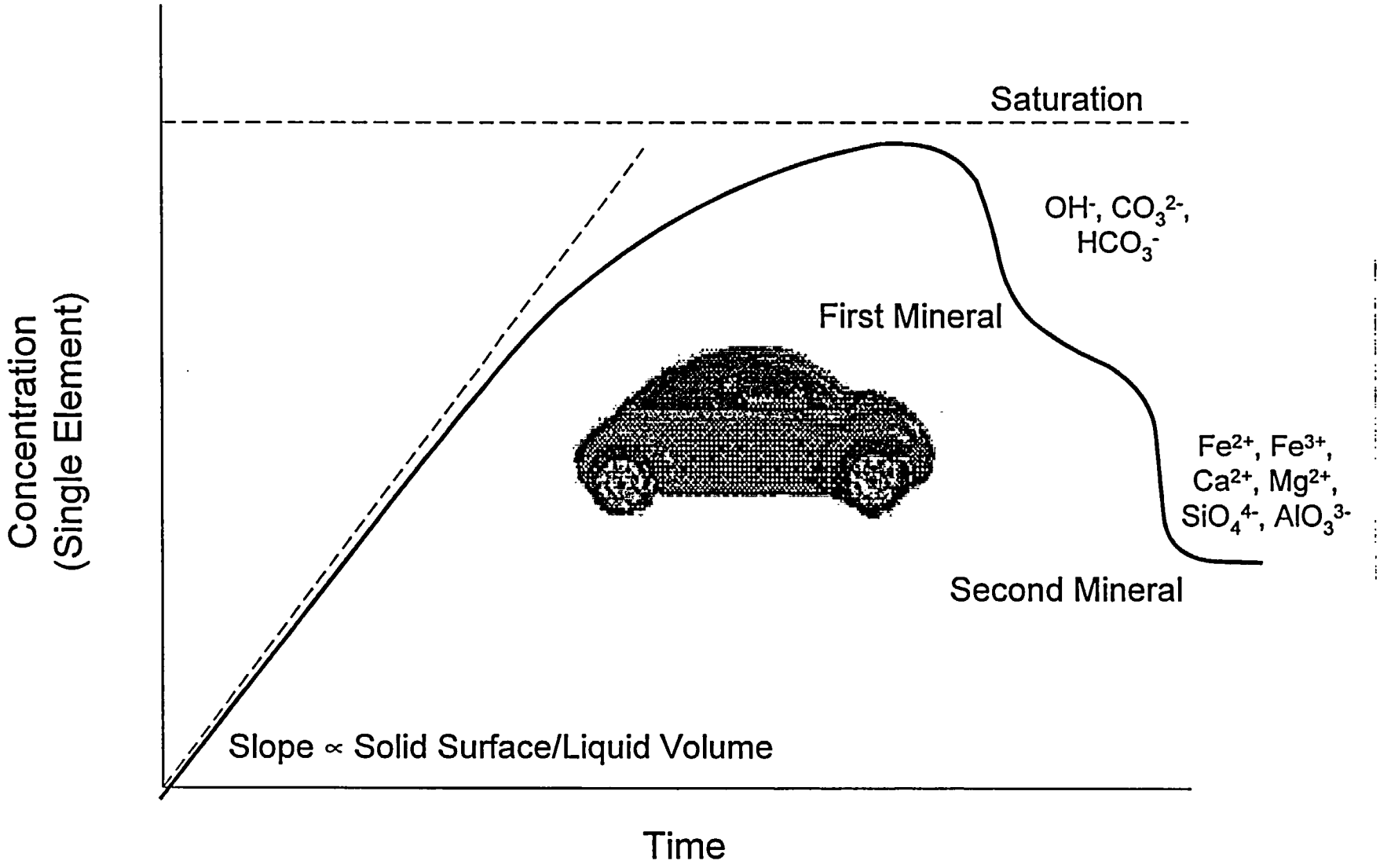
$DF_{150} \cdot F_{150} = 7.047 \times 10^{-3}$

$DF_{300} \cdot F_{300} = 2.955 \times 10^{-4}$

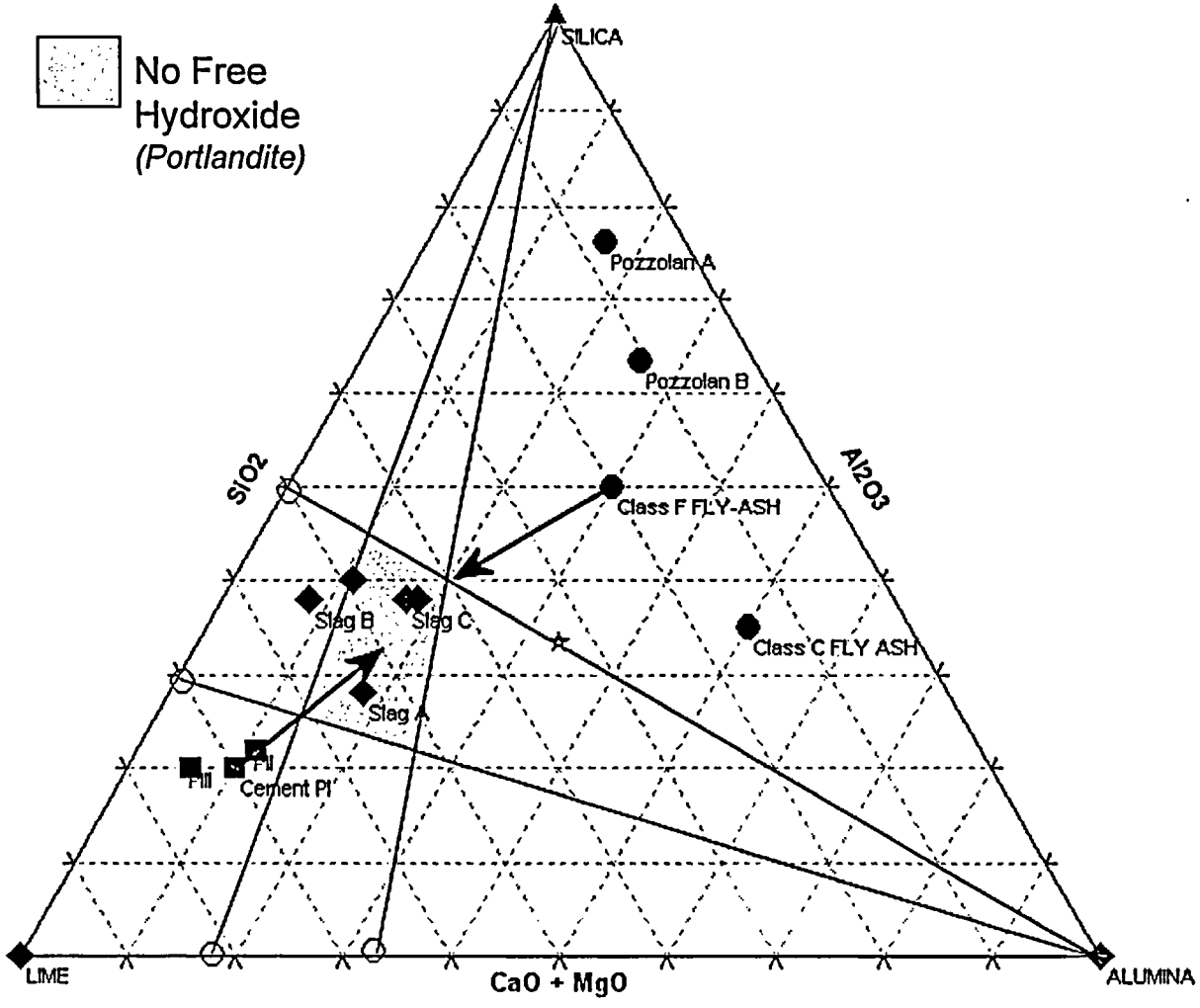
Combination of Decay and Diffusion Controlled Release



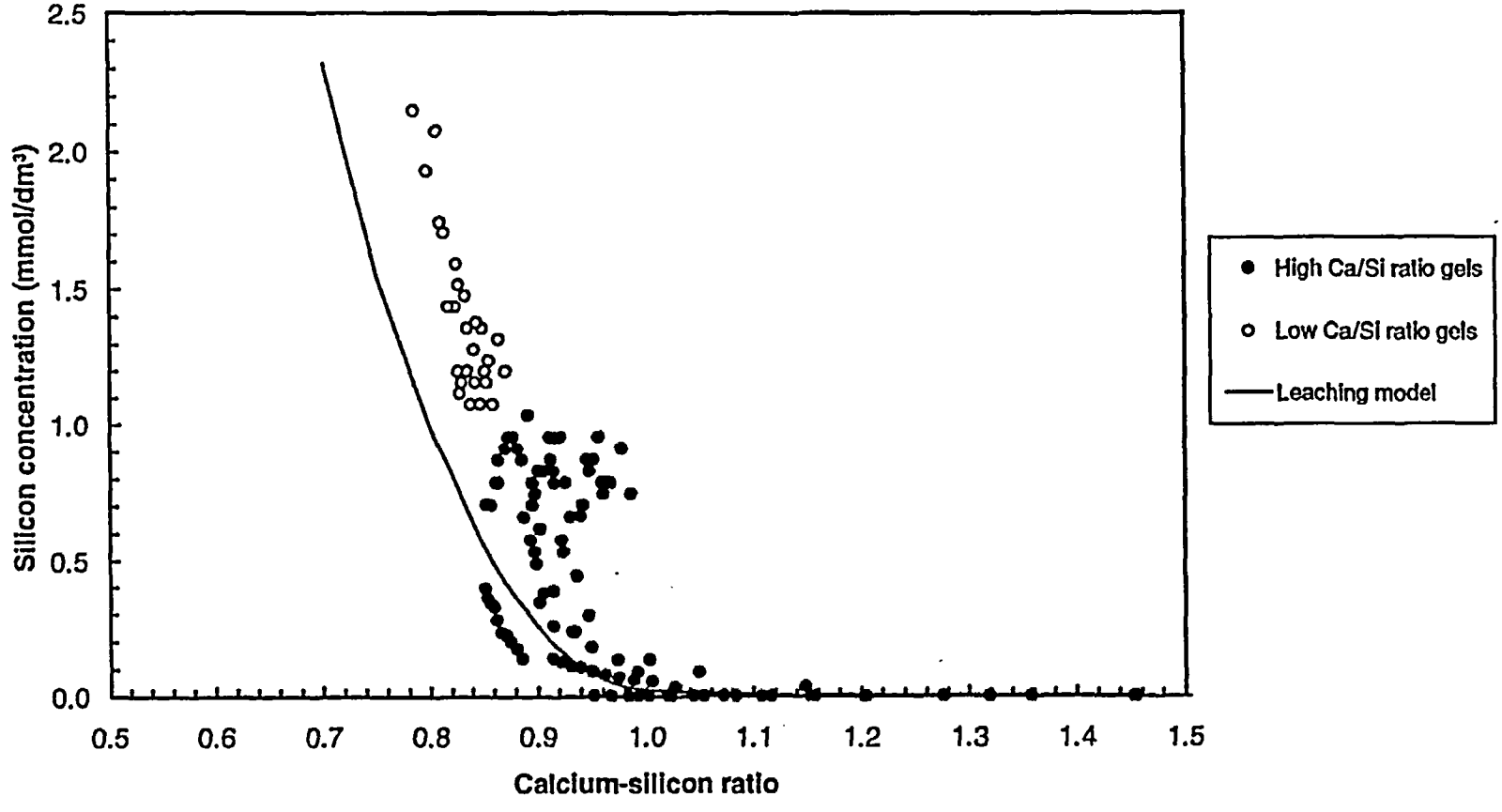
Static Leaching with Secondary Mineral Formation



Formulation of Grouts to Prevent $Ca(OH)_2$

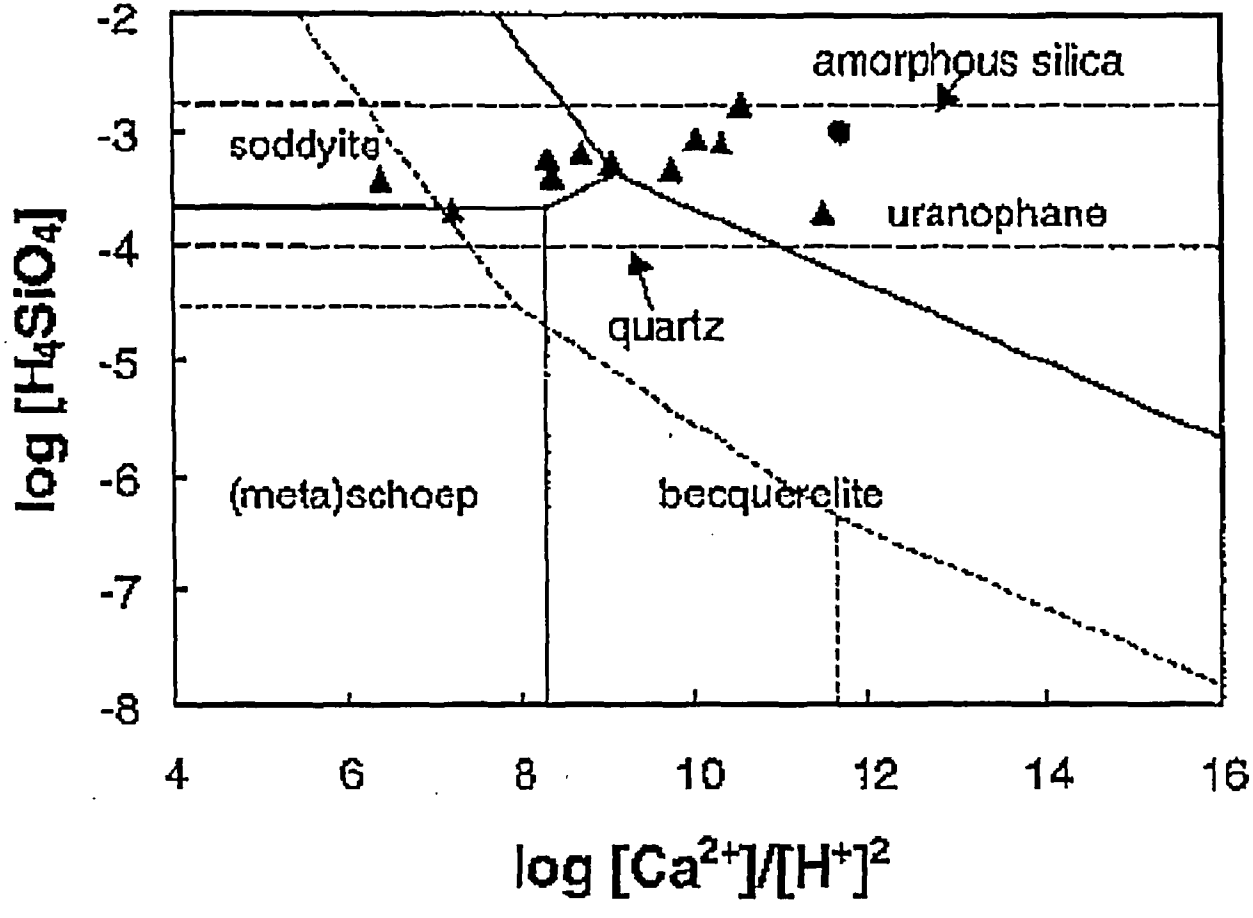


Increasing Silica in Cement Increases Silica in Leachates



Harris, A.W., M.C. Manning, W.M. Tearle, and C.J. Tweed, Testing of models of the Dissolution of cements—leaching of synthetic CSH gels, Cement and Concrete Research, 32, pp 731–746, 2002.

High-Silica Forces Formation of Insoluble Uranium Silicates



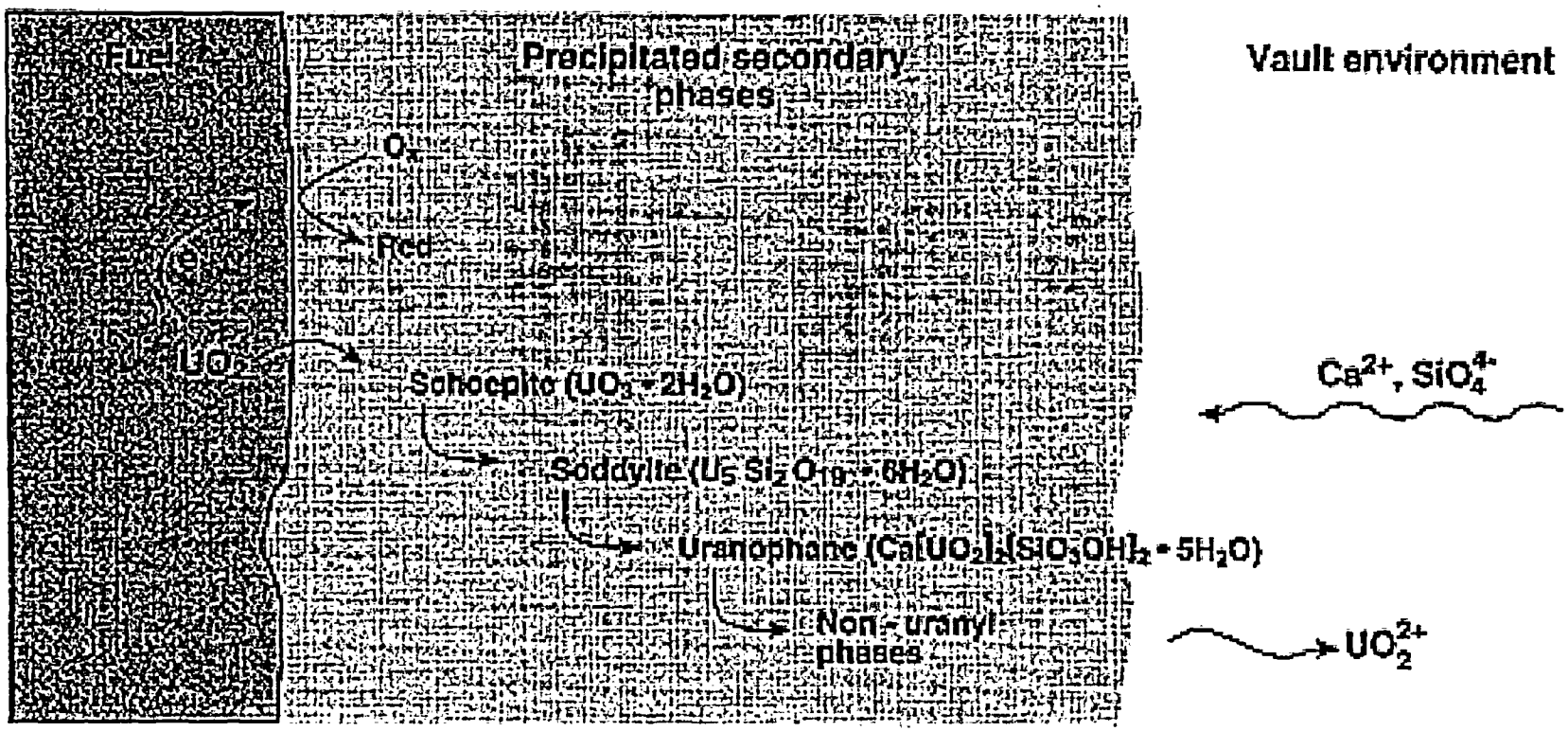
Principal U(VI) Compounds

Values of ? $G^{\circ}_{f,298}$ for the U(VI) minerals used in the construction of Fig. 7 (Chen 1999)

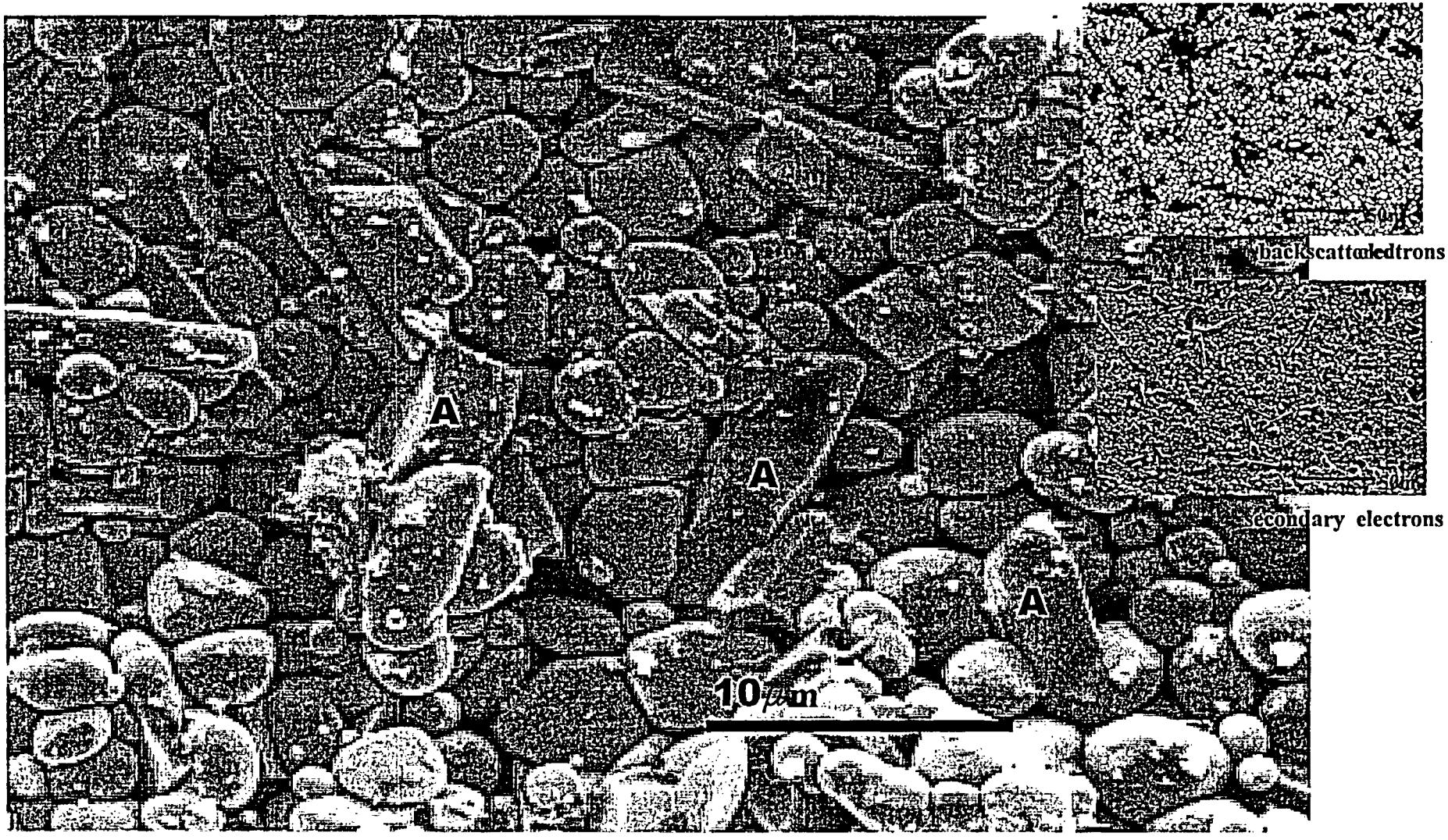
Uranyl phases	Formula	kJoule/mol[a]	kJoule/mol[b]
Metaschoepite	$[(UO_2)_8O_2(OH)_{12}]*(H_2O)_{10}$	–13,092.0	–13,092.0
Becquerelite	$Ca[(UO_2)_6O_4(OH)_6]*(H_2O)_8$	–10,324.7	–10,305.8
Rutherfordine	UO_2CO_3	–1,563.0	–1,563.0
Urancalcarite	$Ca_2[(UO_2)_3(CO_3)(OH)_6]*(H_2O)_3$	–6,036.7	–6,037.0
Sharpite	$Ca[(UO_2)_6(CO_3)_5(OH)_4]*(H_2O)_6$	–11,607.6	–11,601.1
Fontanite	$Ca[(UO_2)_3(CO_3)_4]*(H_2O)_3$	–6,524.7	–6,523.1
Liebigite	$Ca_2[(UO_2)(CO_3)_3]*(H_2O)_{11}$	–6,446.4	–6,468.6
Haiweeite	$Ca[(UO_2)_2(Si_2O_5)_3]*(H_2O)_5$	–9,367.2	–9,431.4
Ursilite	$Ca_4[(UO_2)_4(Si_2O_5)_5(OH)_6]*(H_2O)_{15}$	–20,377.4	–20,504.6
Soddyite	$[(UO_2)_2 SiO_4]*(H_2O)_2$	–3,653.0	–3,658.0
Uranophane	$Ca[(UO_2)(SiO_3OH)]_2*(H_2O)_5$	–6,192.3	–6,210.6

[a] Chen 1999 [b] Finch 1997

Silicates Form a Dense Diffusion Layer on the Surface of UO2 even under Oxidizing Conditions



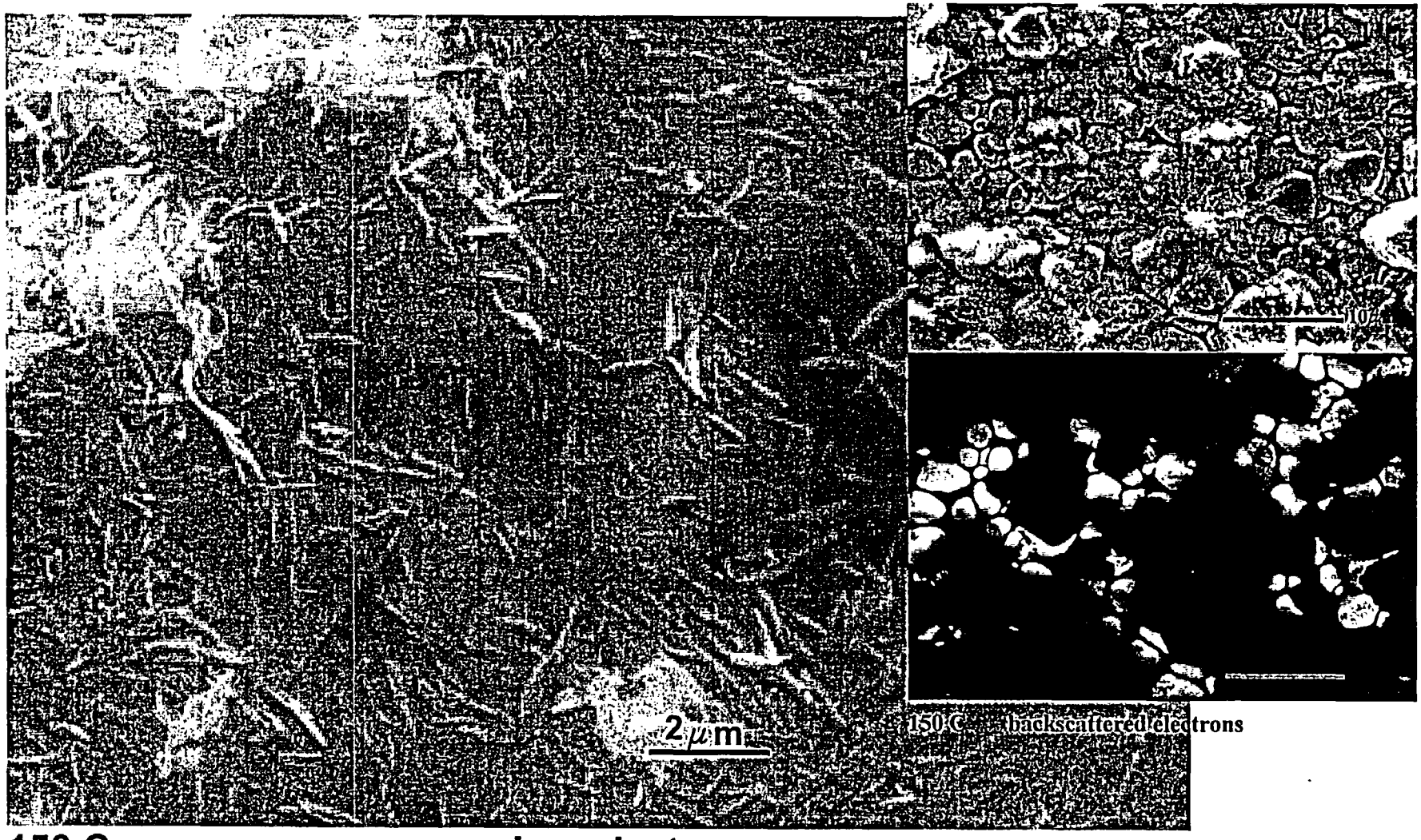
DUAGG after 6 Months in DI Water



150 C secondary electrons

A contain Ti and some Mg

DUAGG after 6 Months in Cement Pore Solution



150 C secondary electrons

Cement hydration products cover surface with phases with Ca, Si, and Al.

Conclusions About Leach Testing

Short-term leach testing is conservative IF:

- Test does not allow for the effects of secondary minerals, which
  - Are highly selective for contaminant species
  - Forms protective diffusion surface barriers
- The monolith matrix is relatively stable in the geochemistry of the disposal horizon
  - Shares same regions of the geochemical stability fields
  - Has similar SiO_2-Al_2O_3 composition ranges
- Ultimate mechanisms of leaching, alterations, and weathering are controlled by solid-diffusion rates

General Conclusions

- There is a great body of knowledge on how to formulate cementitious waste forms to process and solidify radwastes from across the DOE complex.
- There is disagreement on how to measure and model source-terms for the leaching for nuclides in to the near-field transport models.
- There is no coordinated effort to reconcile measured waste form performances with accelerated testing and natural/anthropomorphic analogs.

Tank Waste Retrieval Using Remotely Operated Systems

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Dr. Barry L. Burks
TPG Applied Technology

ACNW Working Group Meeting on Waste Determinations – August 2-3, 2005

Three Basic Approaches to Tank Waste Retrieval

- **Mix and Pump** – utilize a mixing system (water spray or mechanical agitation) to suspend solids in a slurry and then remove the slurry by pumping.

- **Mechanical Removal** – utilize mechanical tools to scoop, auger, excavate, fracture or drill to remove waste without creating a slurry or significantly changing the chemical / physical properties.

- **Chemical Reduction** – utilize additives or heat to change the chemical / physical properties of tank waste to either vaporize or make pumpable.

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Remote Systems + Retrieval Tools = Waste Removal System

- **Remote Systems** – remotely operated vehicles and manipulator systems that can be used to deploy retrieval tools.

- **Retrieval Tools**
  - o Water jets or mechanical agitators used to create slurries.
  - o Slurry pumps
  - o Scoops, drills, augers, etc. used for mechanical removal
  - o Chemical reagents

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Manipulator Arms for Waste Tanks

- **Many manipulator arms have been designed or conceptualized for tank applications, but few have actually been built and deployed.**
  - Light Duty Utility Arm (LDUA) – Hanford and INEEL
  - Modified LDUA (MLDUA) - ORNL
  - Waste Dislodging and Conveyance System – ORNL
  - Tarzan Manipulator – West Valley Demonstration Project (WVDP)
  - Mast Manipulator – WVDP
  - ReTRIEVR – Fernald
  - EMMA – Fernald
  - Hanford Articulated Mast – Hanford
- **Smaller manipulators exist that can be attached to large boom systems.**
  - Schilling, Kraft, Western Space & Marine
  - AEA Artisan

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Light Duty Utility Arms

- Three **LDUA** systems were built in the mid 1990's by Spar Aerospace Limited. One was used at Hanford and two were used at INEEL for *characterization and inspection* tasks.
  - 2 truck –mounted, 1 skid mounted for portability
  - Long vertical reach (50 ft), limited horizontal reach (11 ft)
  - Limited payload (100 lbs) but very precise positioning
  - Custom built for tank environment
- One **Modified LDUA** built for *tank waste retrieval* at ORNL.
  - Longer horizontal reach (16 ft), higher lift capacity (250 lbs.)
  - Skid mounted for positioning on tanks by crane
  - Used to clean 7 large underground tanks – Gunite and Associated Tanks Remediation Project 1997 – 2000.

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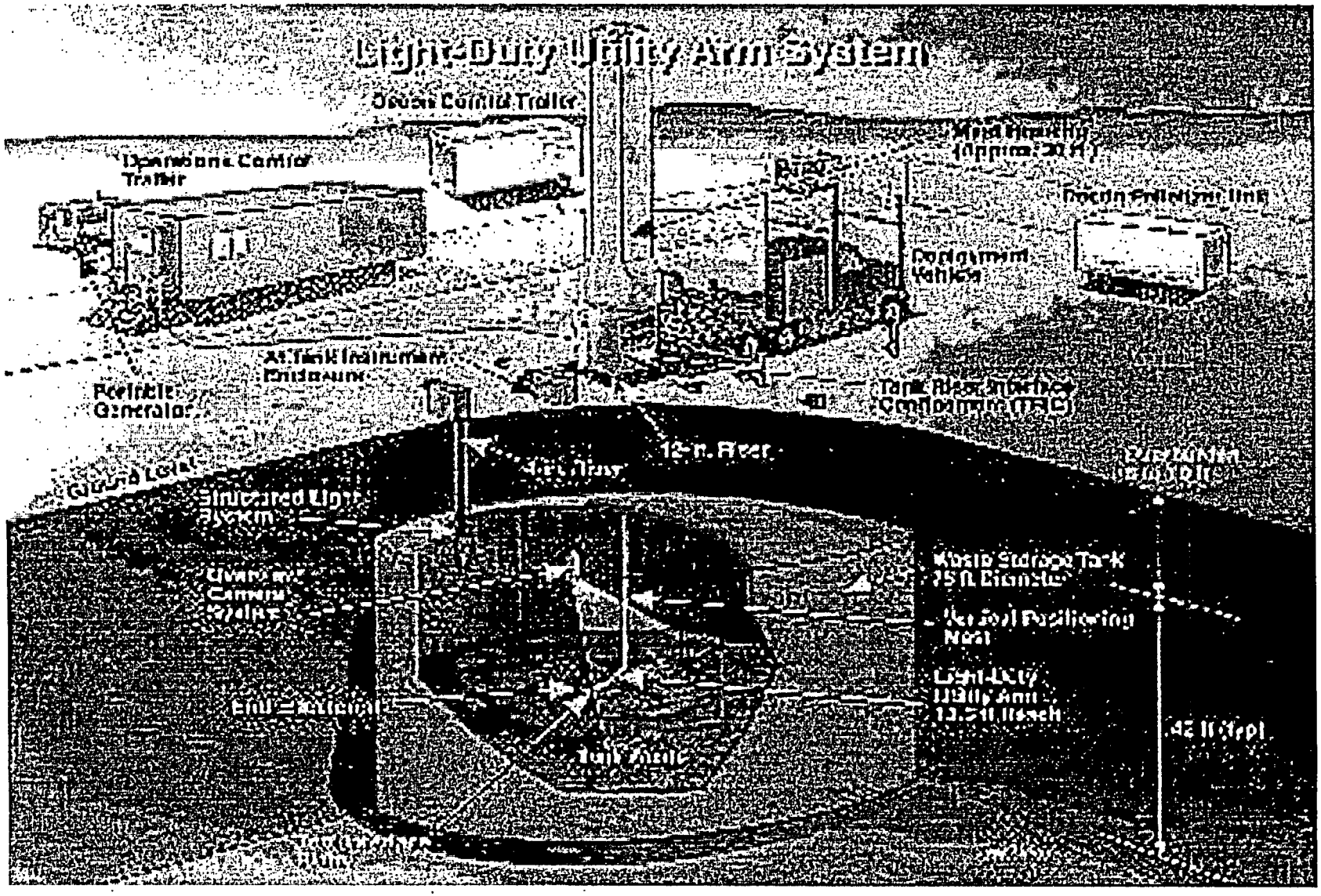
LDUA – Light Duty Utility Arms
Spar Aerospace



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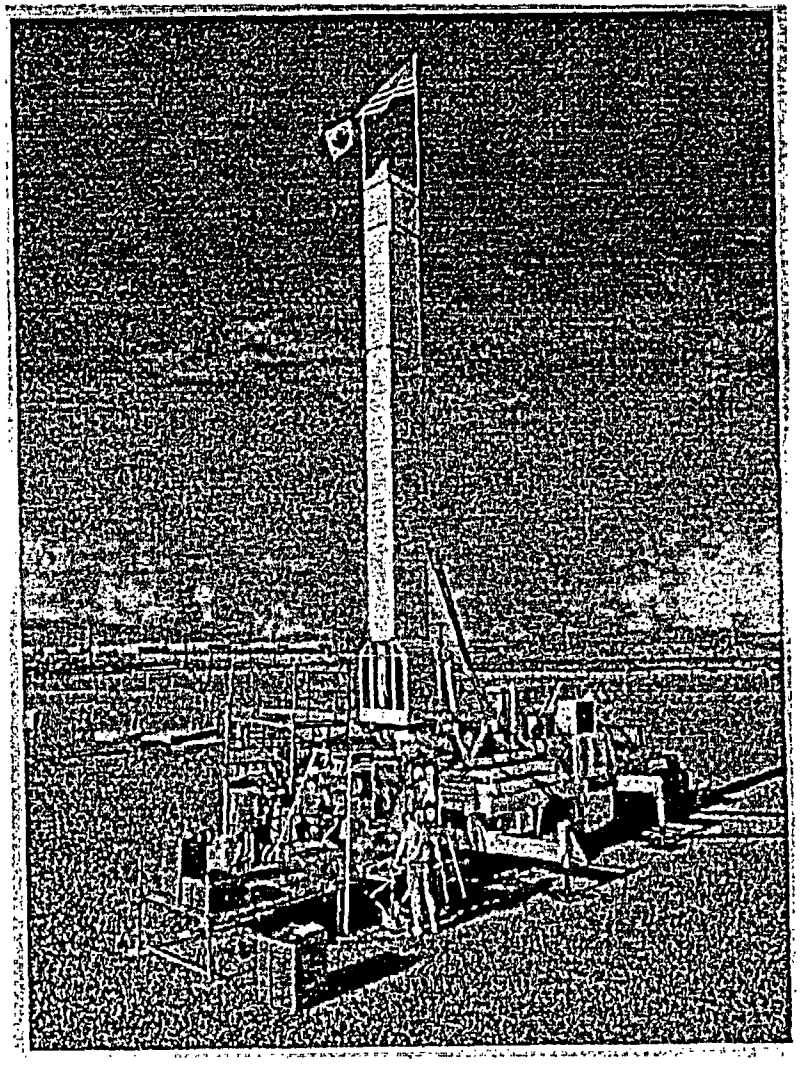
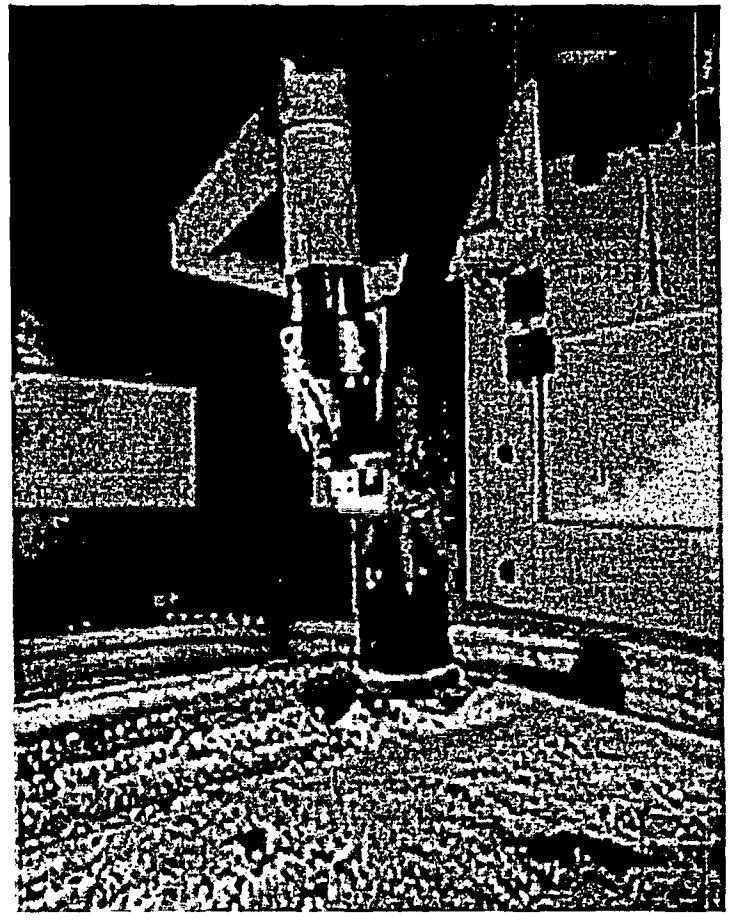
LDUA – Light Duty Utility Arms
Spar Aerospace





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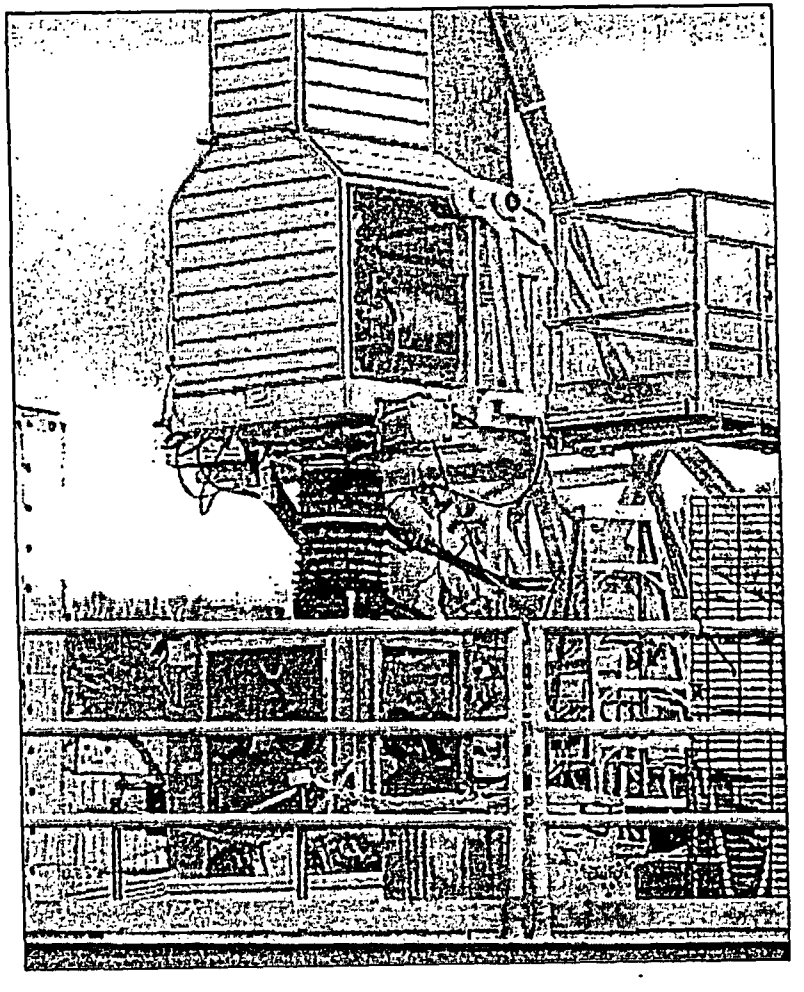
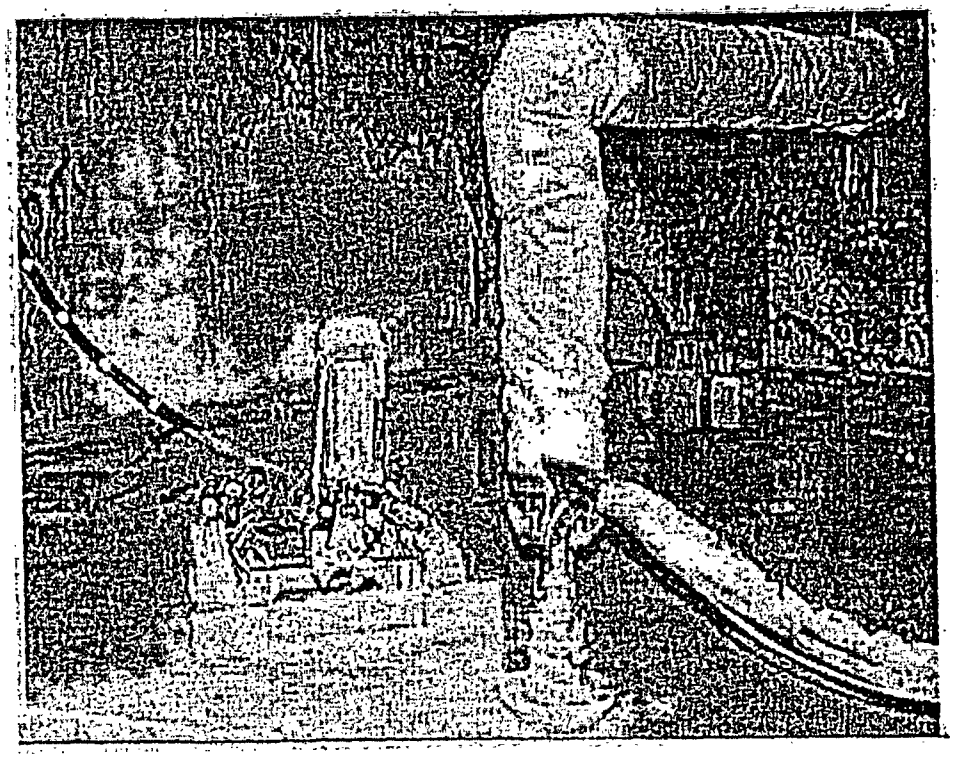
MLDUA – Modified Light Duty Utility Arm

Base of MLDUA Vertical Positioning Mast Housing





MLDUA – Houdini – WD&C

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West Valley Manipulator Arms

- West Valley Tanks are large, with limited access, highly obstructed by vertical support pipes spaced at 10 ft. centers.
- Telescoping mast system developed and utilized for water jet spray to slurry heel and move heel waste toward retrieval pumps.
- Tarzan manipulator designed by Redzone Robotics Inc. to grasp vertical pipe supports and "swing" from pipe to pipe to navigate throughout tank volume.
  - o Grippers on each end to grasp pipes
  - o Work platform to mount a Schilling Titan manipulator
  - o Pipe loading issues lead to cancellation of project

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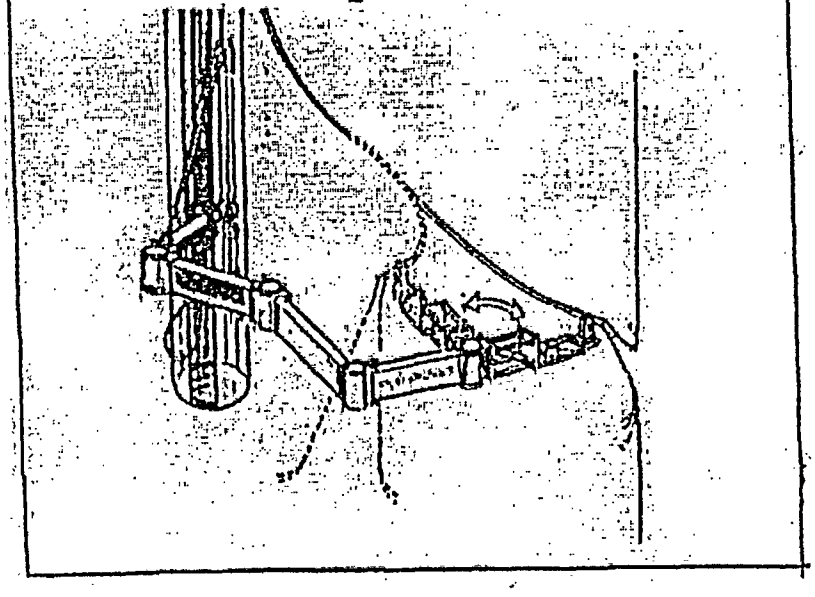
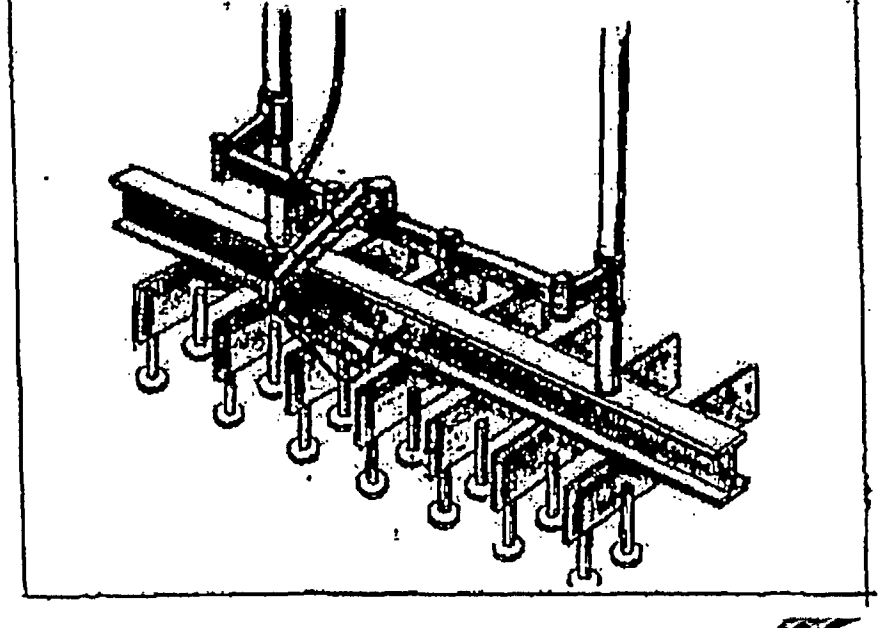
Redzone -- Tarzan Manipulator

Phase 2 Work Capabilities



Phase 3 Work Capabilities



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Manipulator Arms for Use at Fernald

- ReTRIEVR – large, multi-link, modular arm, designed by Framatome for Silo 3 waste retrieval.
  - o System design completed
  - o Prototype components fabricated
  - o Project cancelled before fabrication completed

- EMMA – large, cable-driven arm, with multiple rigid sections designed by Grey Pilgrim, Inc., for Silo 1 & 2 waste retrieval
  - o Design completed
  - o Quarter scale prototype built and tested
  - o Project cancelled before full scale fabrication completed

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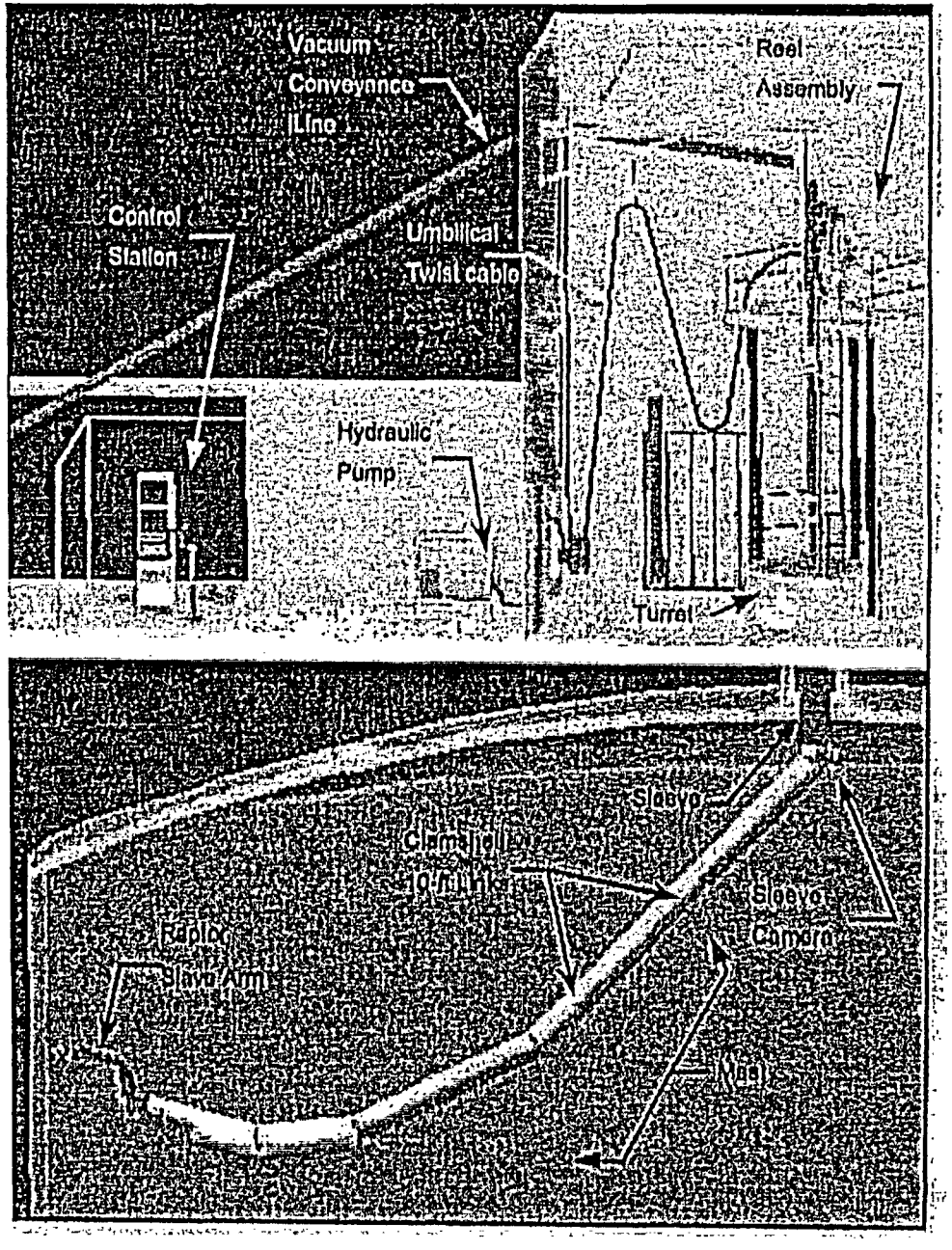
ReTRIEVR

REvolving
Turrent **R**eeled
cable
Incremental link
Extending
Vacuuming
Robot



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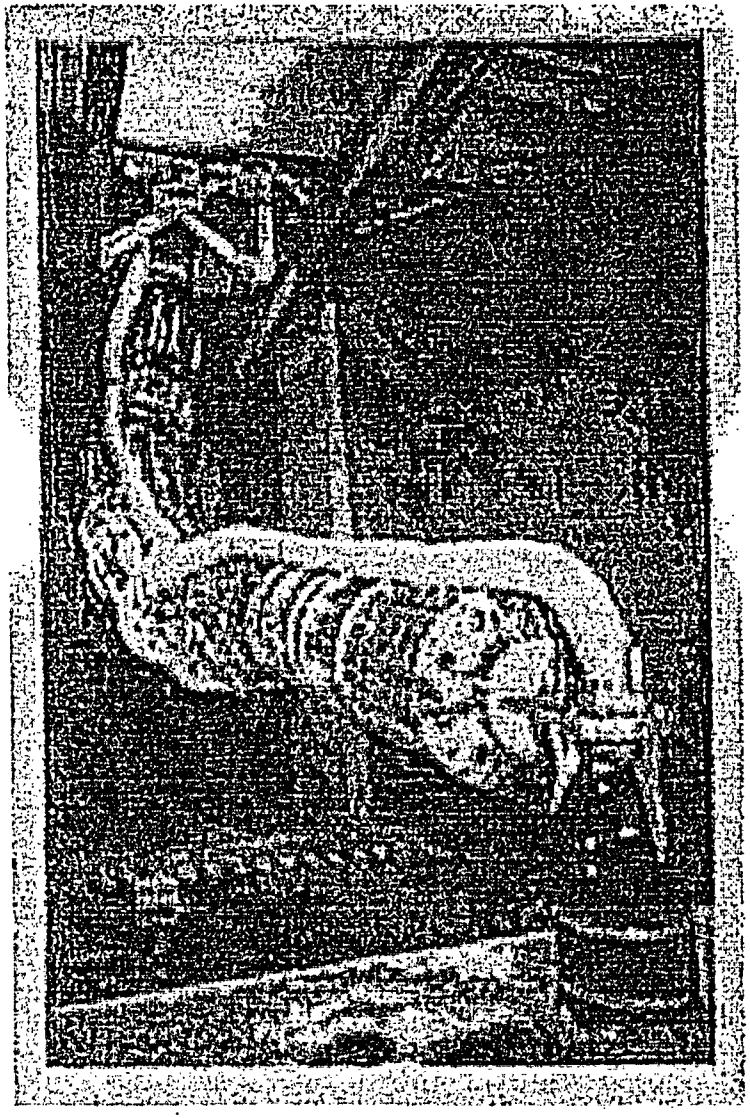
EMMA



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Simpler Arms that Actually Were Deployed

- Fernald advanced Waste Retrieval System – Hydraulic mining system designed by TPG Applied Technology
  - Telescoping, articulated masts for water jet nozzles
- ORNL Waste Dislodging & Conveyance System – Designed and built by TPG staff for use with the MLDUA and/or Houdini vehicles.
  - Four degree-of-freedom arm that served as the waste removal pipeline
  - Confined sluicing end-effector for creating slurry from sludge and hardpan
  - Gunite Scarifying end-effector for pressure washing tank walls
- Hanford articulated mast
  - Deployed in concert with remote vehicle for cleaning Tank C-203

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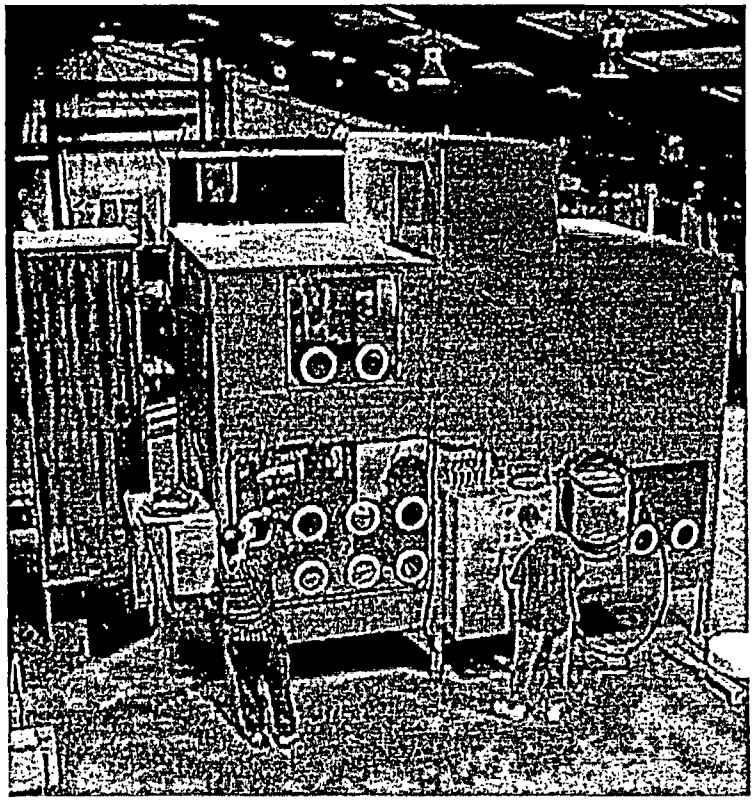
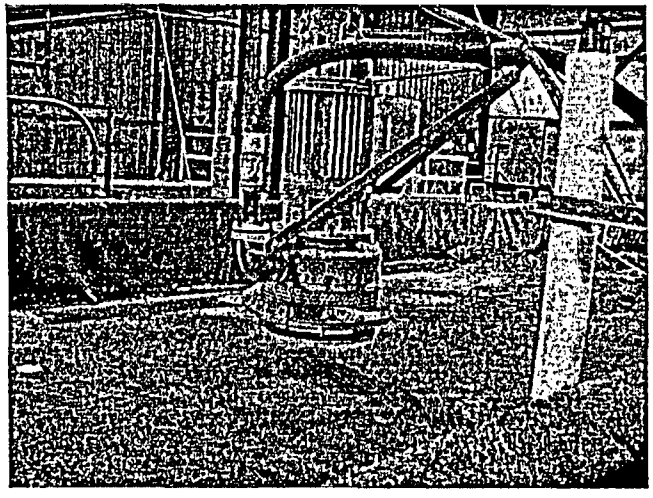
Silos Retrieval System





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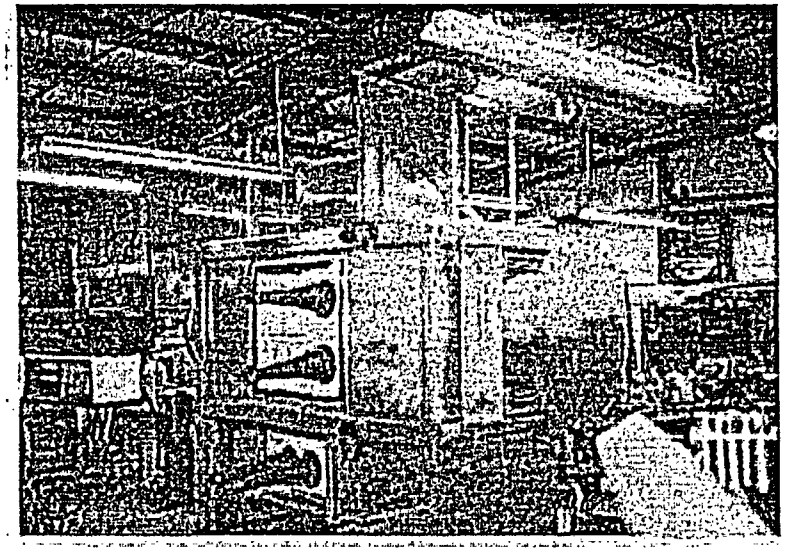
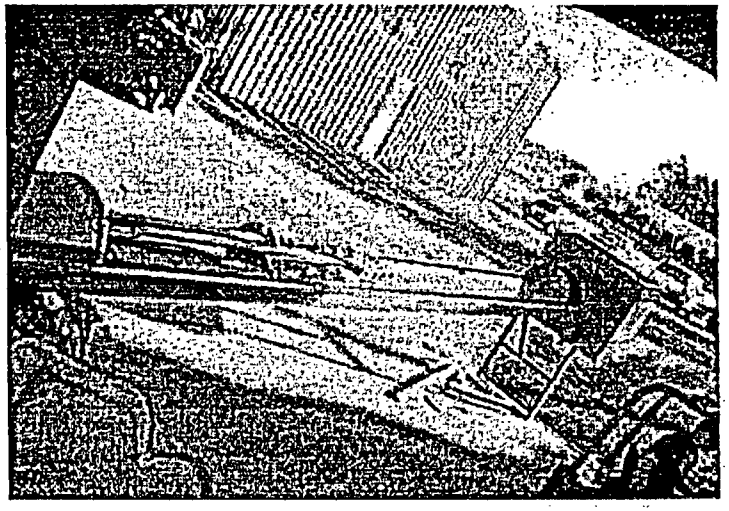
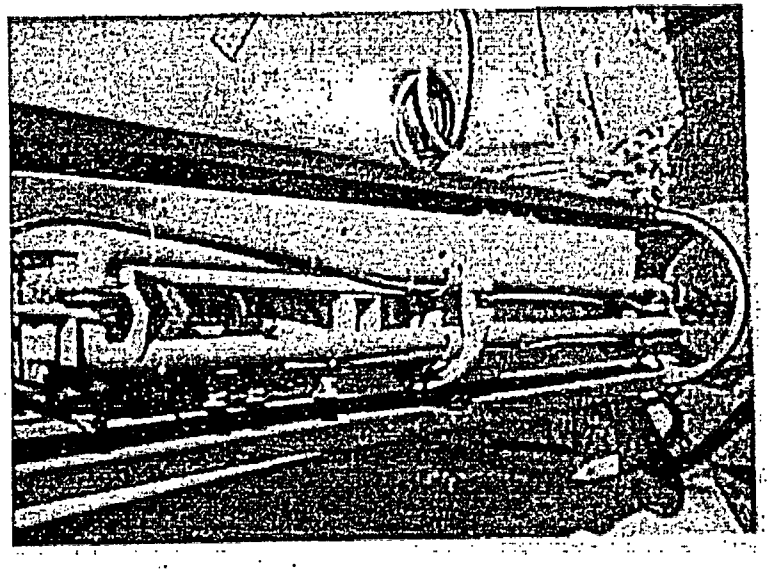
WD& C System







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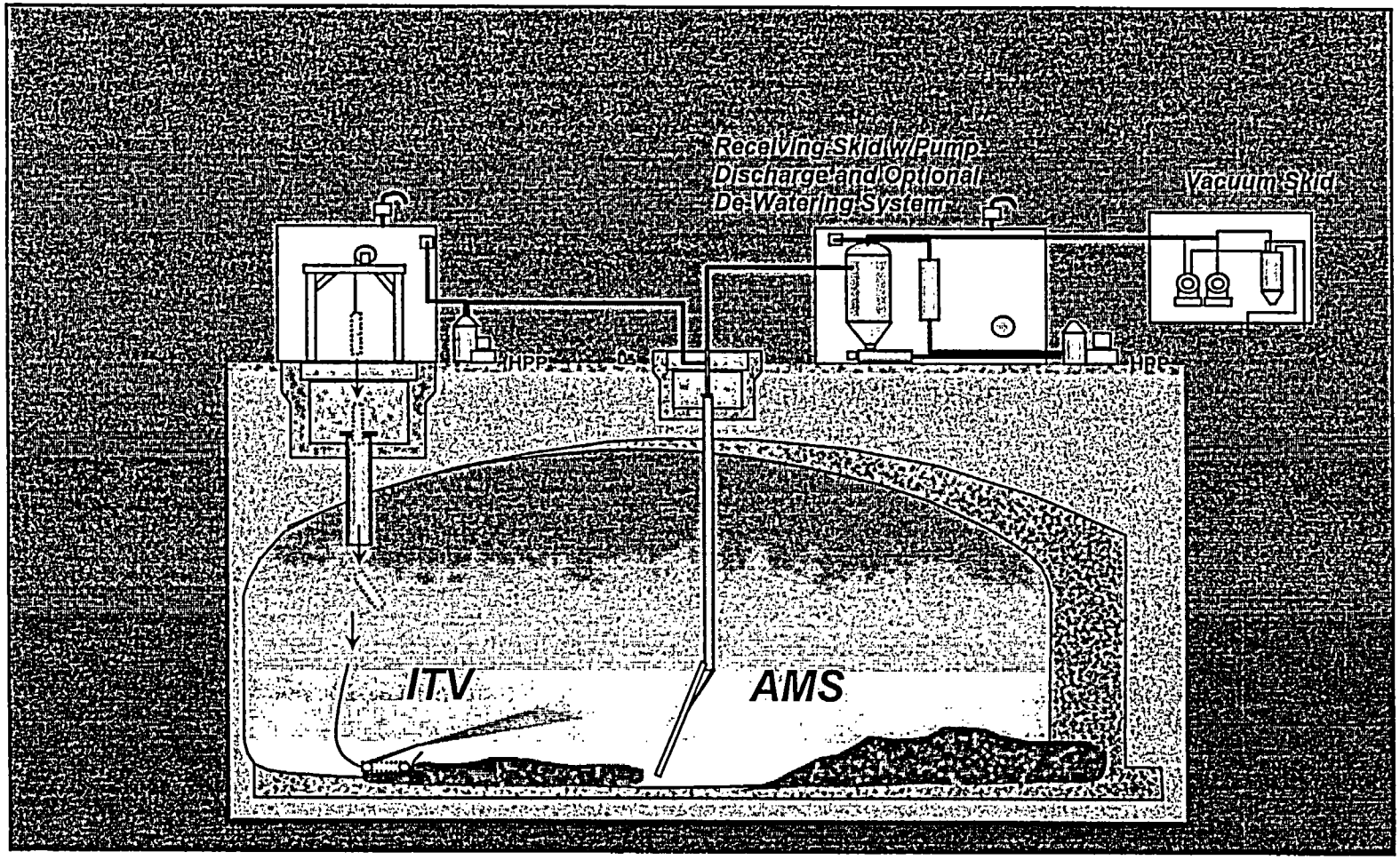
Hanford In-Tank Vehicle + Articulating Mast



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Summary of Manipulator Arm Technologies

- Several large, complex systems designed but only the MLDUA system was actually built and deployed for tank waste retrieval.
  - **ReTRIEVR** and **EMMA** may be viable alternatives but fabrication cancelled
- Several simpler arms used in successful tank waste retrieval projects:
  - **Hanford**
  - **ORNL WD&C system**
  - **Fernald AWRS**
  - **West Valley Demonstration Project**

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Remote Vehicles for Waste Tanks

- **Many remotely operated vehicles developed for in-tank use:**
  - o Houdini by Redzone Robotics Inc.
  - o Scarab by ROV Technologies and TPG Applied Technology
  - o Non-Entry Systems Limited dredging systems
  - o SRTC Water Cannon System
- **Some were tested by DOE but never deployed:**
  - o Pit Hog by Liquid Waste Technology
  - o ARD Scavenger systems
  - o ESG/LATA Trac-Pump

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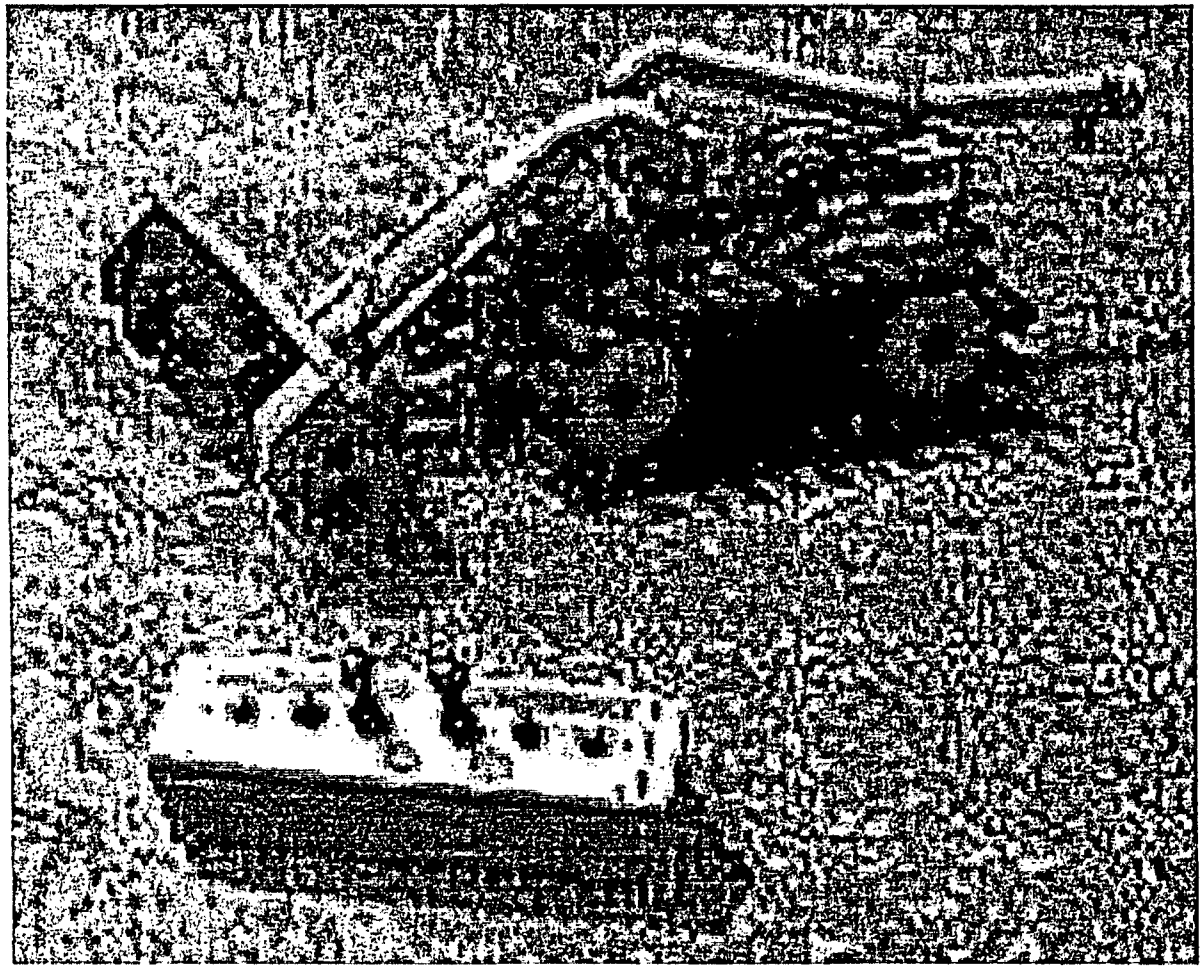
LWT Pit Hog Robotic Crawler



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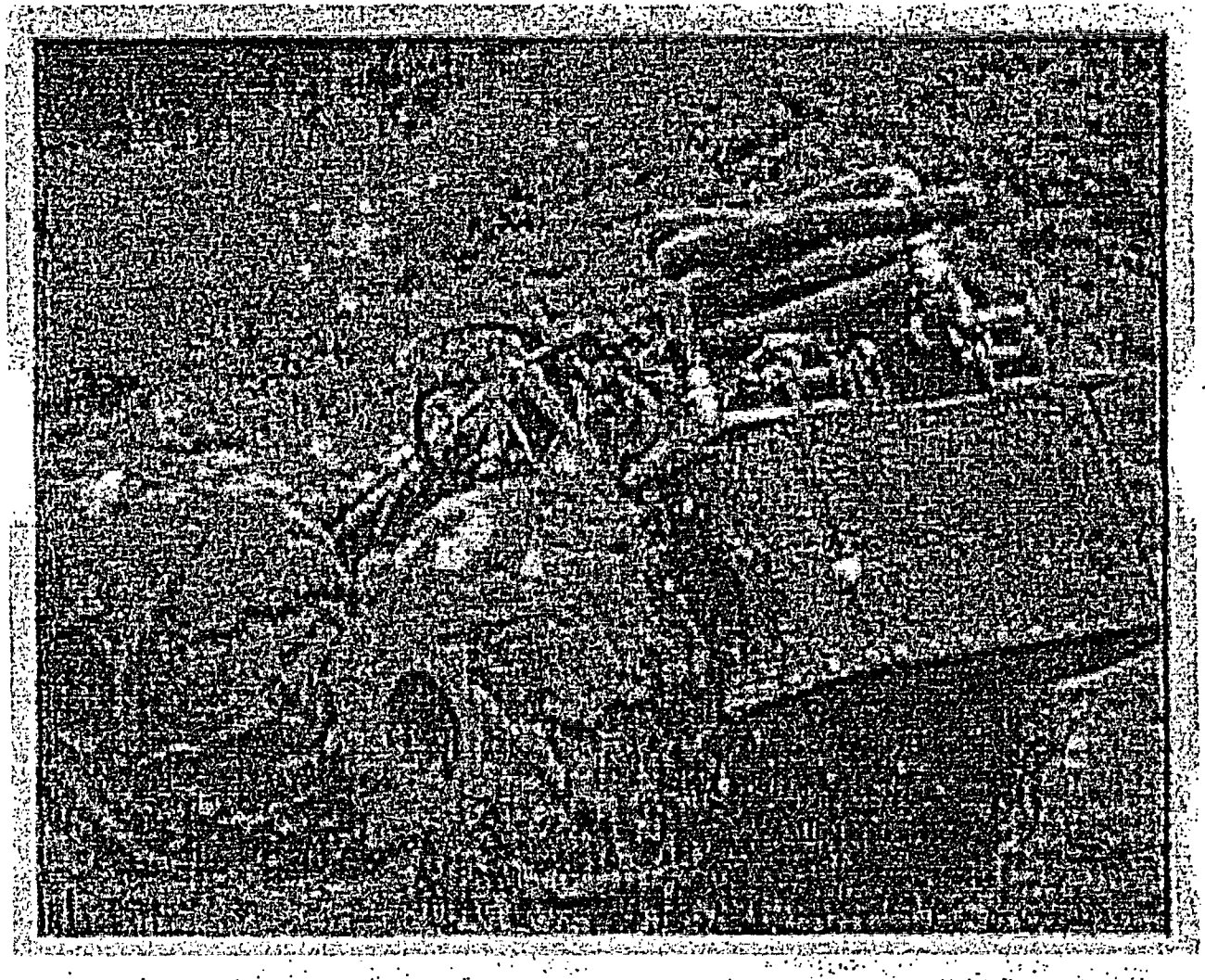
ARD Scavenger Systems



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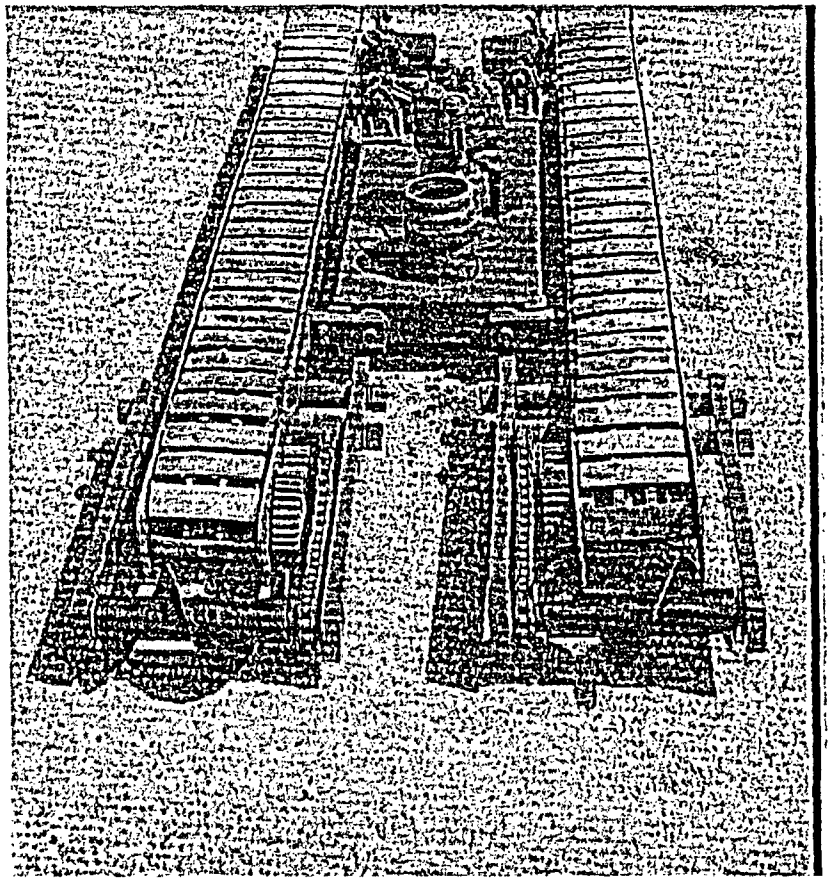
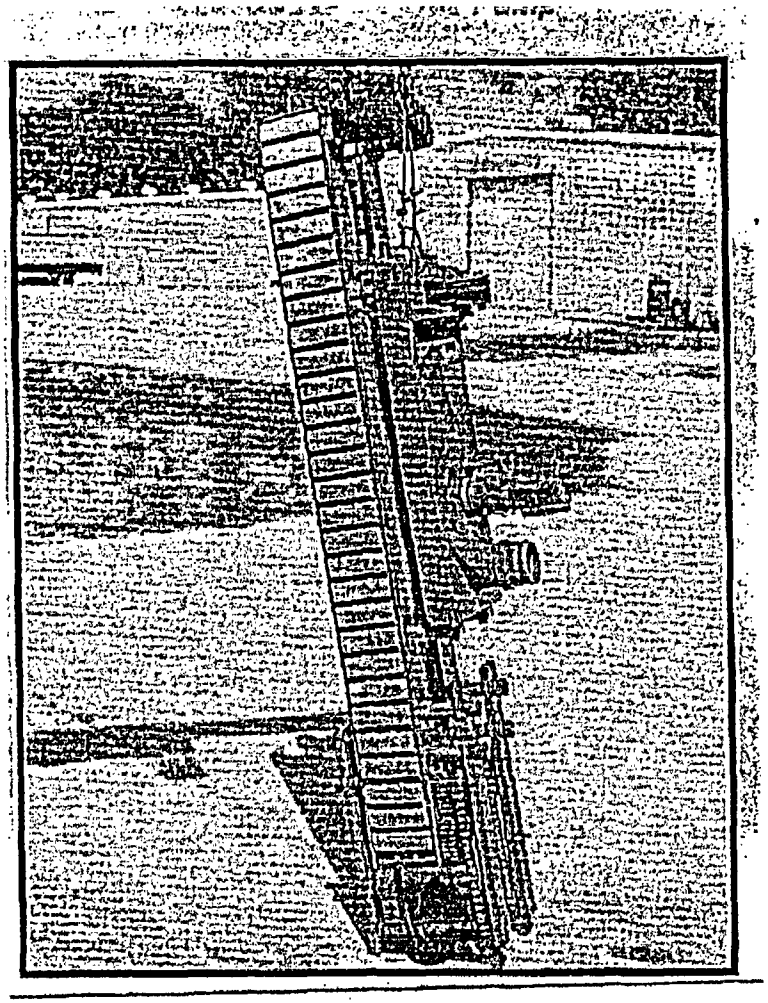
ESG/LATA Trac-Pump Systems





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Remotely Operated Vehicles Deployed at ORNL Tanks

- **Scarab-3 system used for sampling and inspection of one ORNL Federal Facility Agreement tank.**
  - o Customized version of Scarab system used for power plant applications
  - o Designed for tank environments
  - o Designed to also deploy retrieval tools
- **Houdini and Houdini-II vehicles used for tank waste retrieval in 7 tanks, Gunite and Associated Tanks Remediation project 1997 – 2000.**
  - o Versatile work platform, 1000 lb. mini bulldozer
  - o Schilling manipulator provided dexterous, powerful arm
  - o Reconfigurable to be inserted through 20 inch risers

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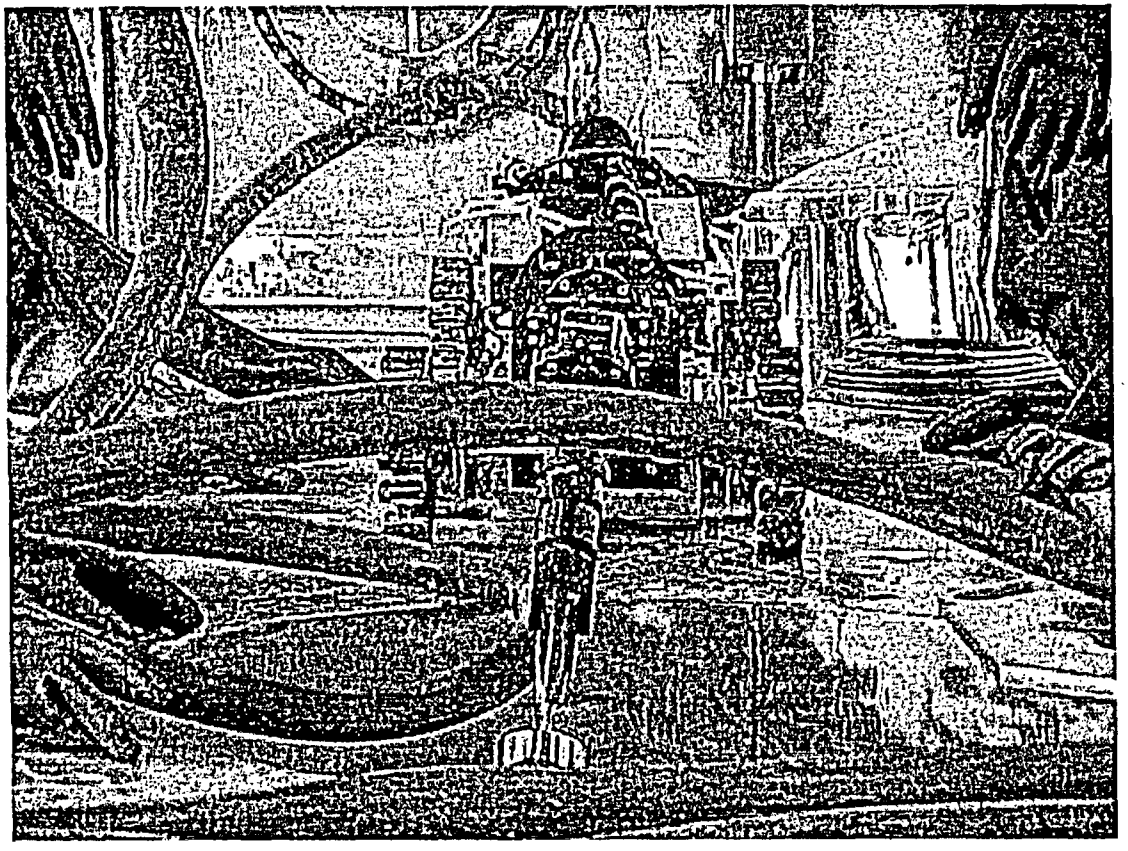
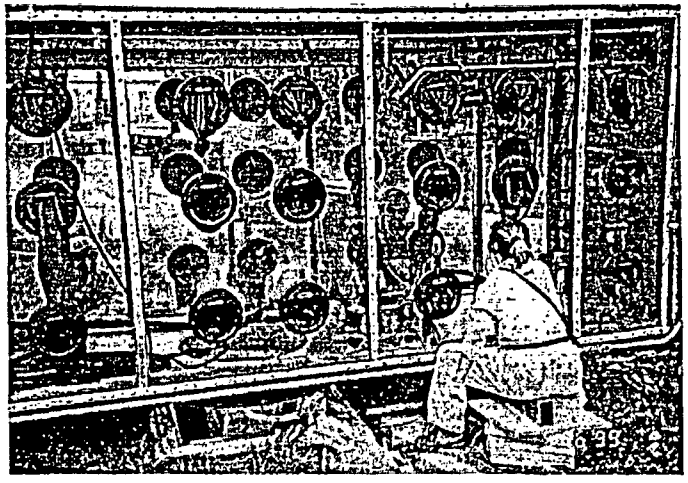
Scarab





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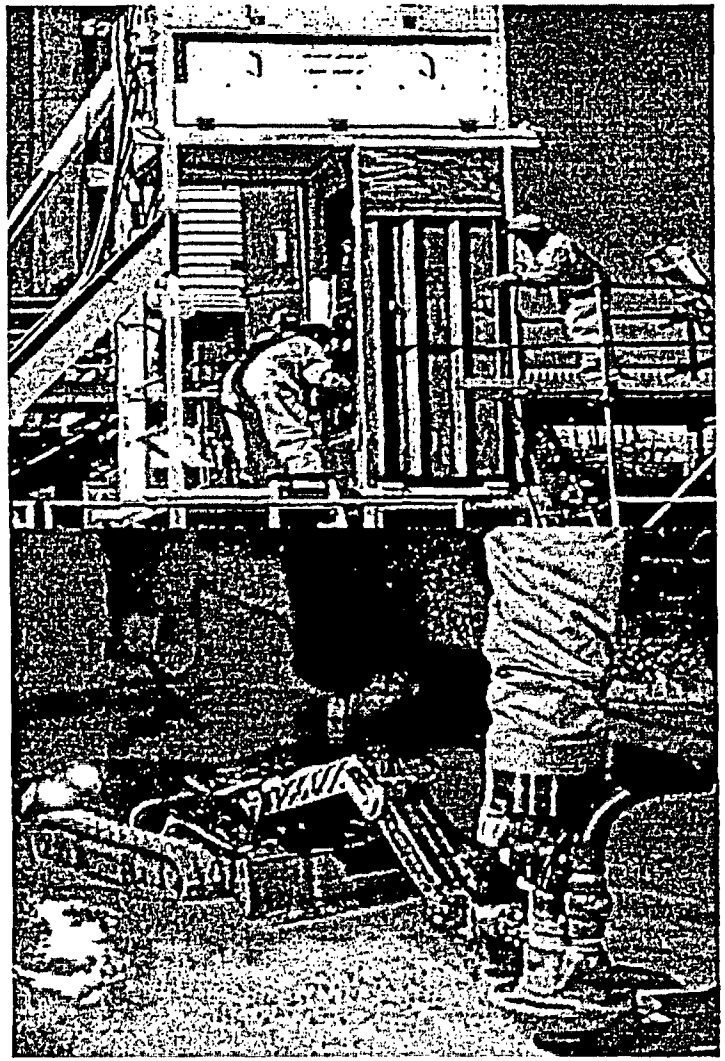
Houdini



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Remotely Operated Vehicles Deployed at Hanford Tanks

- Non-Entry Systems Limited and CH2M Hill developed a tracked vehicle that was deployed in Tank C-203 in 2004-2005.
  - o Operated in conjunction with articulated mast
  - o Removed over 3000 gallons of sludge waste
  - o Additional deployments planned

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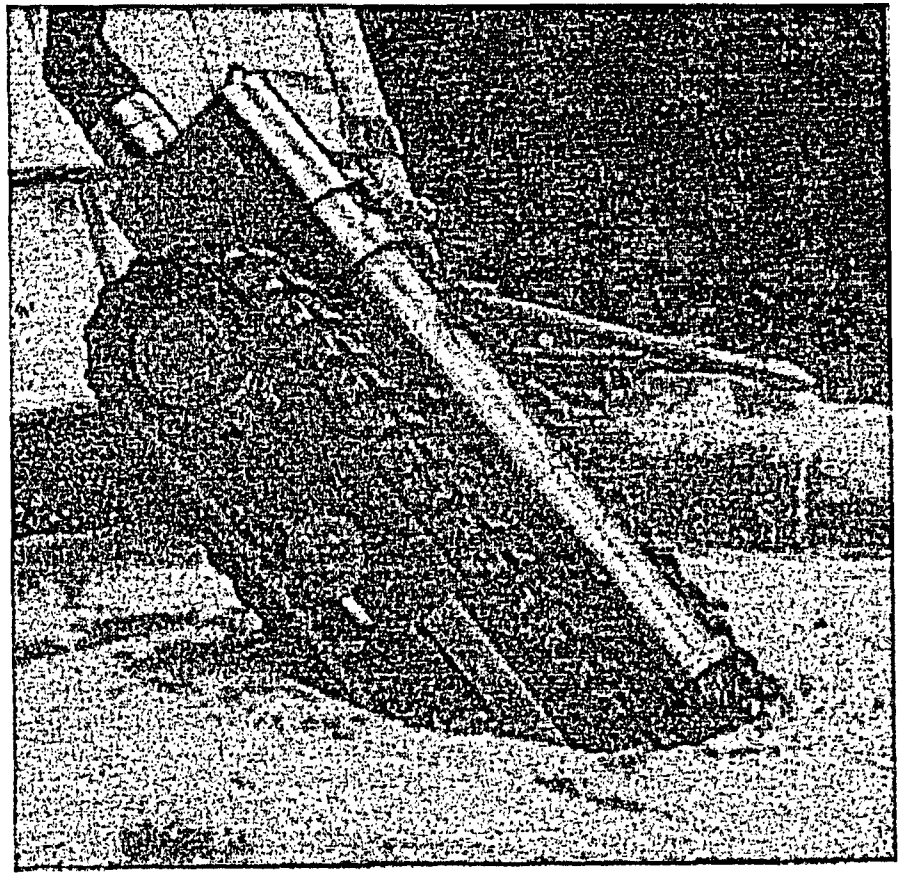
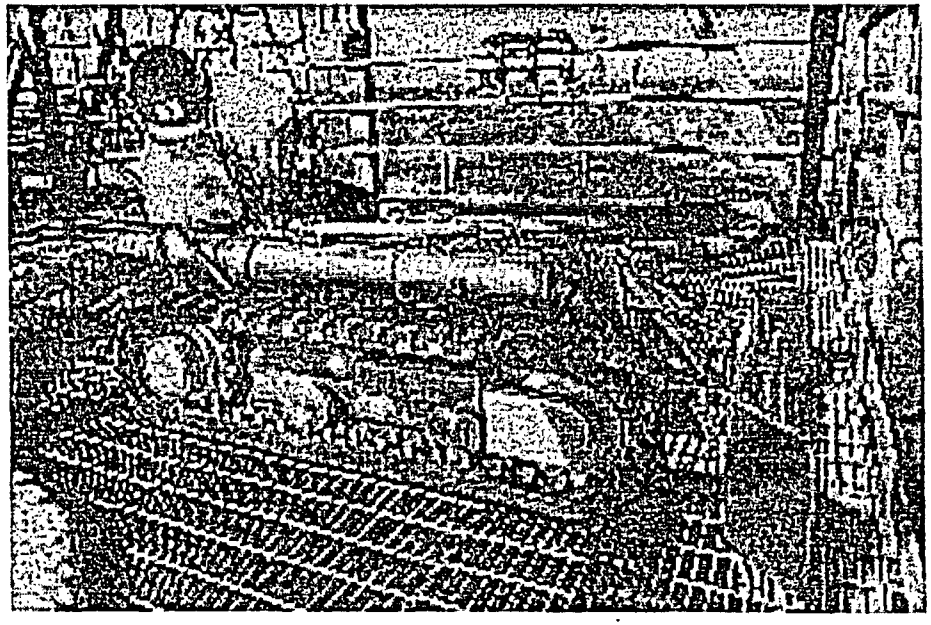
NESL
Non-Entry Systems Limited





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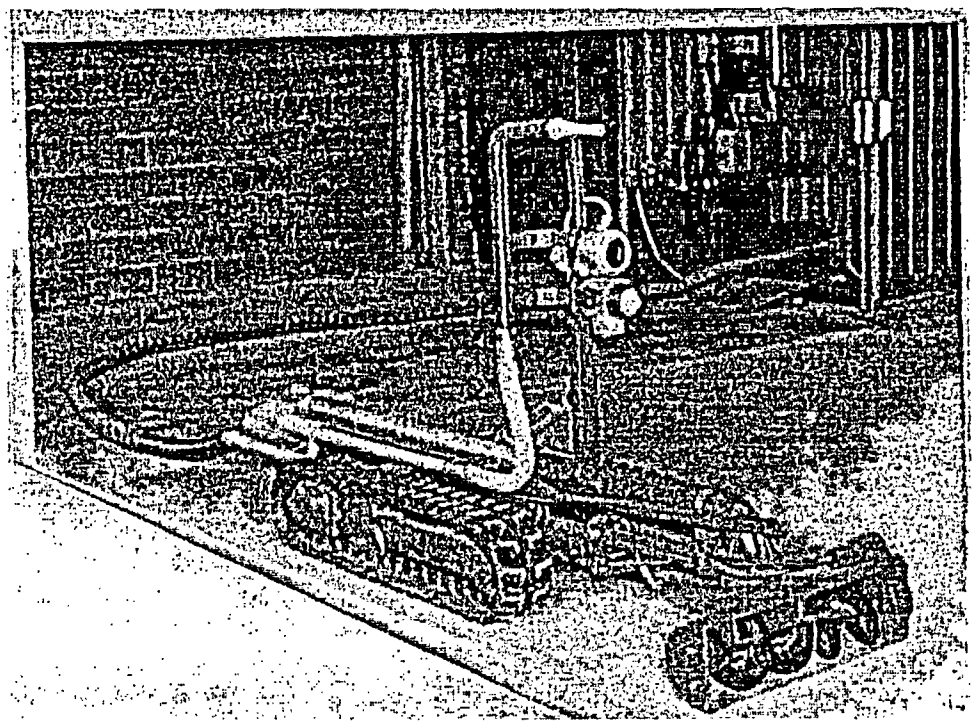
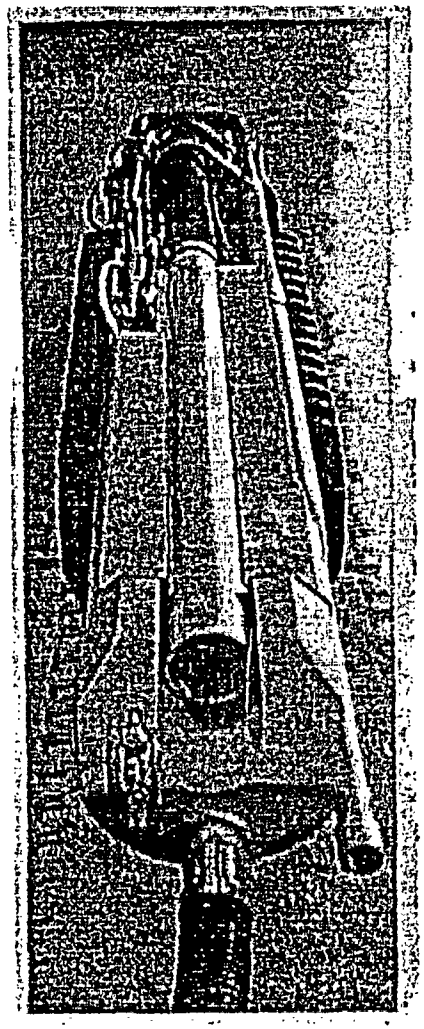
NESL
Non-Entry Systems Limited





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ROVs Deployed at Savannah River Tanks

- Customized vehicle developed at SRTC to deploy a water cannon
  - **System built, tested, but not deployed**

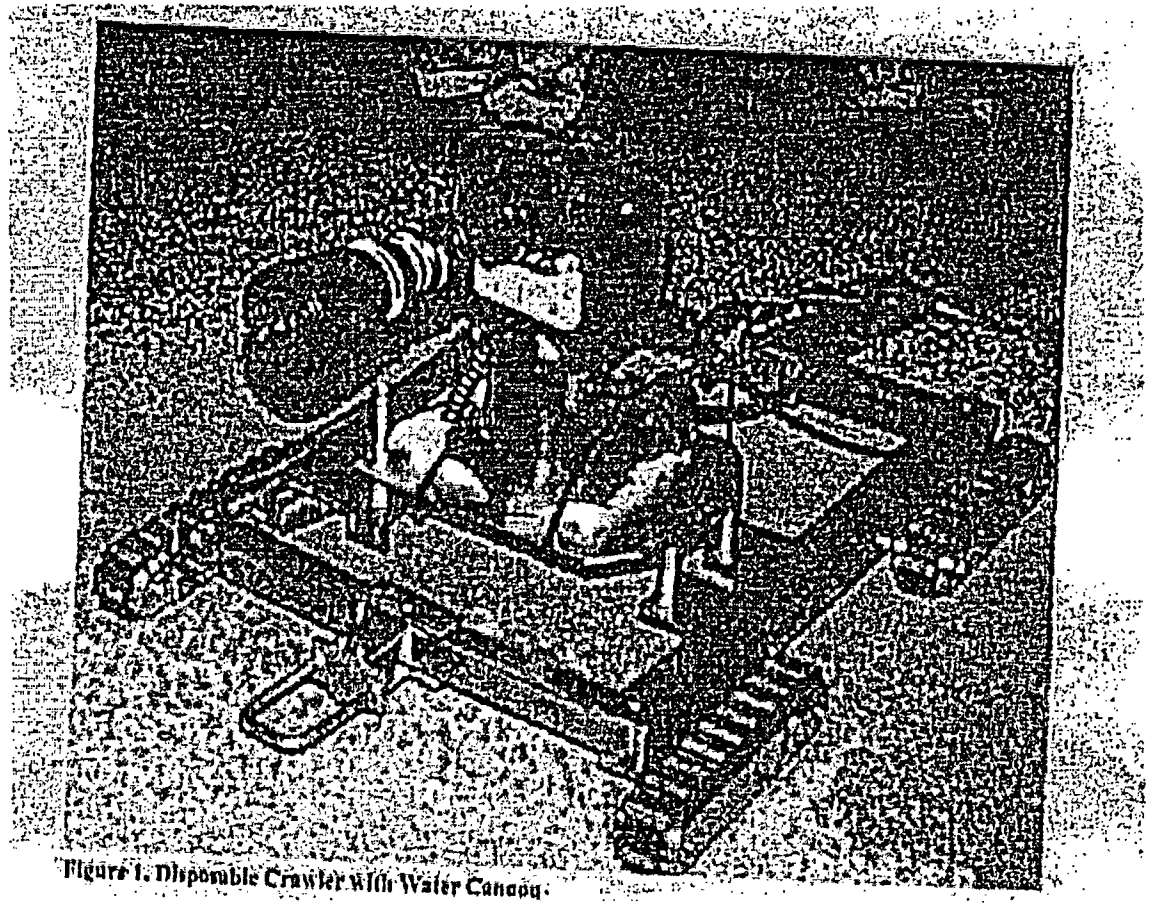

Figure 1. Disposable Crawler With Water Canopy.

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Summary of Remote Vehicle Status for Tanks

- Several remotely operated vehicles have been developed and successfully deployed for tank waste retrieval.
  - o Houdini and Houdini-II at ORNL
  - o NESL at Hanford
- **The Technology exists and many lessons have been learned in deployments.**
  - o Development of deployable systems is an engineering challenge not a scientific challenge.

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Conclusions

- Remote systems have been successfully used for tank waste retrieval.
  - o Typically utilize mixing systems or arm-based systems (or a combination of both) to reduce tank volumes
  - o Vehicle systems have been primarily used for heel removal
  - o Vehicles designed for dredging can also be used for bulk waste removal
  - o Combined use of arms and vehicles has been most successful
- Although many companies have contributed to remote technology development for tank applications, the recent lack of funding/procurement opportunities resulted in few companies remaining active in this area.
  - o If DOE sites get serious about tank waste removal, then the technical community will respond with mature technological solutions.

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Determination of Volume and Composition of Residual Tank Wastes

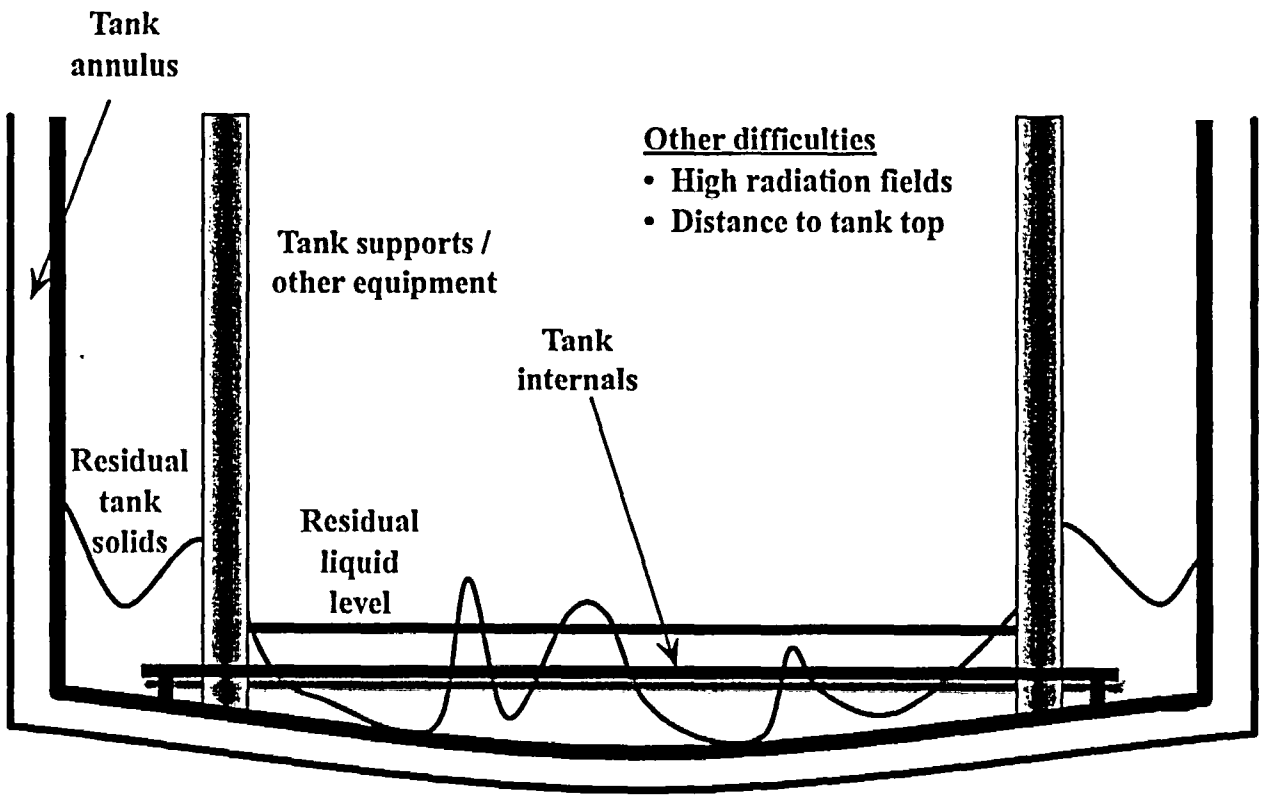
M. John Plodinec

Diagnostic Instrumentation and Analysis Laboratory at Mississippi State University

Requirements for methods

- Able to provide quantitative information on volume, radionuclide content
- Acceptable to stakeholders - data complete enough and errors small enough for risk-based decisions
- Data traceable, defensible, reproducible, reasonably transparent
- Safe and operator friendly
- Capable of operation in a remote environment
- Equipment simple and reliable, and, ideally, re-usable

Characterization of tank residual waste is not trivial



Other difficulties

- High radiation fields
- Distance to tank top

DOE experience in residual waste characterization

- Oak Ridge
  - Several gunite tanks
- Hanford
  - Smaller single shell tanks containing HLW
- Idaho
  - Tanks containing sodium-bearing waste
- Savannah River
  - Older HLW tanks

Oak Ridge

- Cleaning process - remove interior obstructions (pipes) - remove bulk of sludge - clean walls - high pressure water wash; remove sludge heel (1" heel ~1000 gal)

- Residual waste volume - robotic measurements of depth; accuracy +/- one inch

- Source term estimate = tank heel + tank wall
  - Assumed material was 50% sludge, used sludge Ci content as heel source term
  - Drilled four cores in each tank (>90% of activity in first 1/8 inch), averaged over entire wall volume; insignificant for all but two tanks

Hanford

- Cleaning process - remove material with slurry pumps - up to about 100 gal left in smaller SST + 38 gal on tank wall (241-C-203)

- Residual waste volume = heel volume + material on tank wall and structure + material in equipment in tank
  - Volume estimated by volume displacement / submergence, and comparison to known locations in tank, using as-built drawings
  - 3D model of heel
  - Biased-high estimate of 65% of wall covered with waste
  - Estimate of average thickness of waste on wall of 1/16", based on contrast of shadows in video recording

- Source term = heel + wall

Idaho

- Have emptied smaller tanks containing SBW

- Volume of residual solids estimated by
  - Comparison of video views of solids to features of known height in the tank, e.g., cooling coil brackets and associated welds (Height 0 - 0.5")
  - Development of 3D model of residual solids from these measurements by krigging
  - Volume of residual liquid estimated by comparison to tank sump lines (~1 inch)

- Source term: total activity = activity of liquid + activity of solid
  - Analyzed samples taken from liquid
  - Solids left behind not sampled due to insufficient material; used results from samples from "sister" tank (same waste received)
  - Used ORIGEN-2 calculations to provide radionuclide inventory

Savannah River

- Cleaning process - remove material with large slurry pumps and water - 5 inches of supernatant liquid covering thinner layer of sludge, with mounds protruding, esp. in difficult-to-clean areas

- Residual waste volume
  - Monitor removal of material with video and reel tape (height of mounds)
    - Cooling coils, tank columns, slurry pump columns and transfer pump sleeve used as reference points in videos, esp. for area
    - Record when and where sludge mounds appear - monitor every 2 h
    - Calculate development of mounds (height and area) as tank emptied

- Source term
  - Sample to determine curie content
  - Use volume to determine source term; does not consider wall deposits

Potential problems with current methods

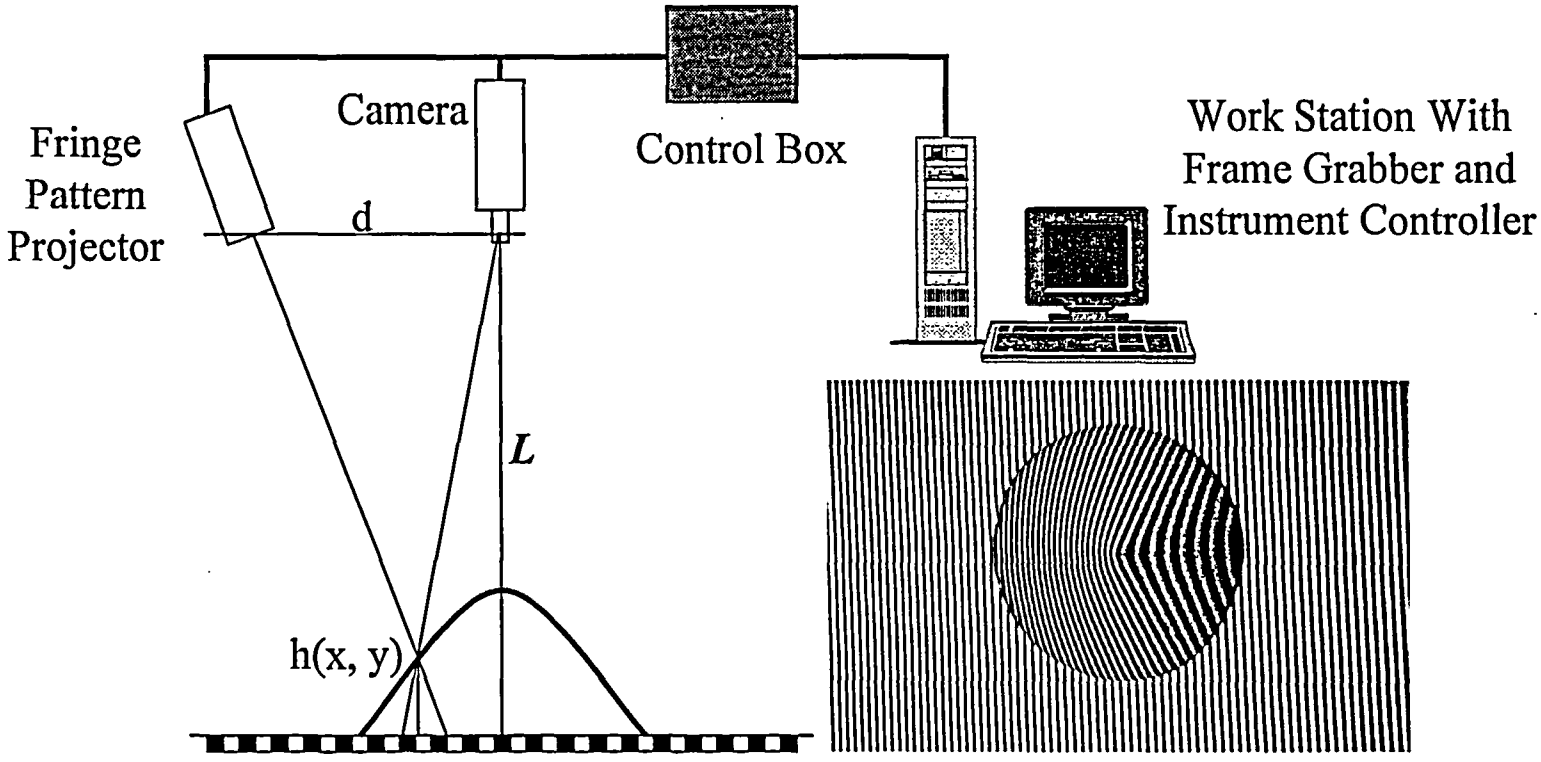
- No independent verification of calculation methods
- Difficult to discern depth below supernatant liquid
- Contribution of wall deposits to source term not handled consistently
- No method available for annuli
- Additional superstructure in newer tanks (e.g., cooling coils) will make use of visual methods more difficult
- "Bottom-dwelling" robots not generally useful
- Uncertainties not well defined; probably satisfactory for quantifying risk

Emerging technologies

- Residual waste volume
  - Laser range finding
    - Developed by ORNL
    - Used at Fernald
    - Not very successful in Hanford tanks
  - Profilometry
    - Being developed by DIAL at MSU
    - Not yet in use - full-scale testing this fall

- Source term
  - Laser-based techniques: PNNL and DIAL
  - Spectral imaging: DIAL
  - Far from deployment

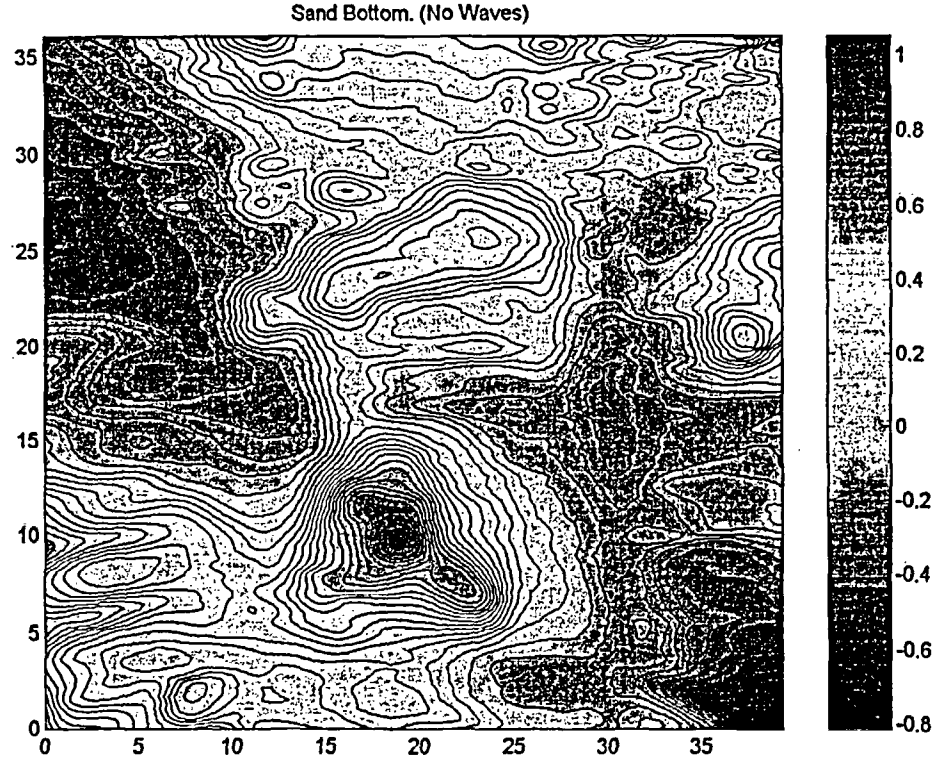
Fourier transform profilometry basics



$$h(x, y) = \frac{L\Delta\Phi(x,y)}{\Delta\Phi(x,y) - 2\pi f_0 d}$$

Where:
h = height
$\Delta\Phi$ = phase variation
f_0 = fundamental frequency

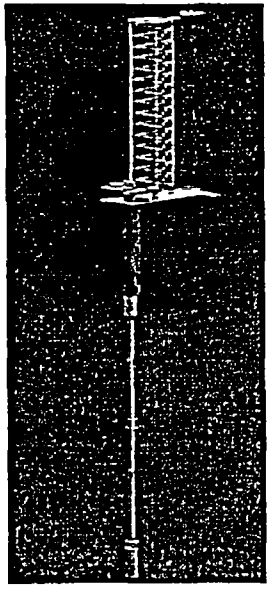
Profile of sediments and beach



Sand profile determined by Corps of Engineers through still water

FTP probe

Probe fully extended into tank

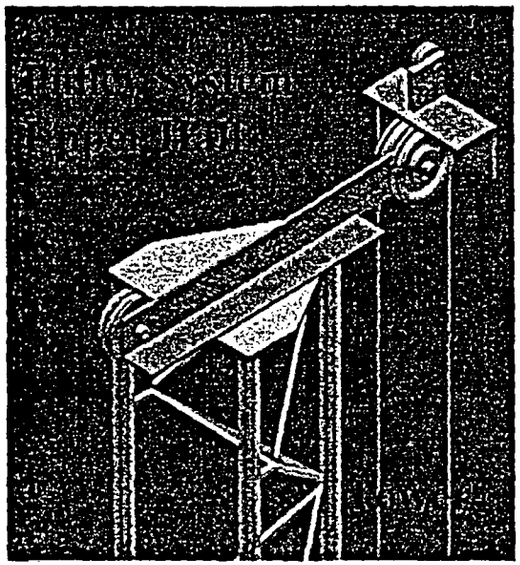


Elbow Straight

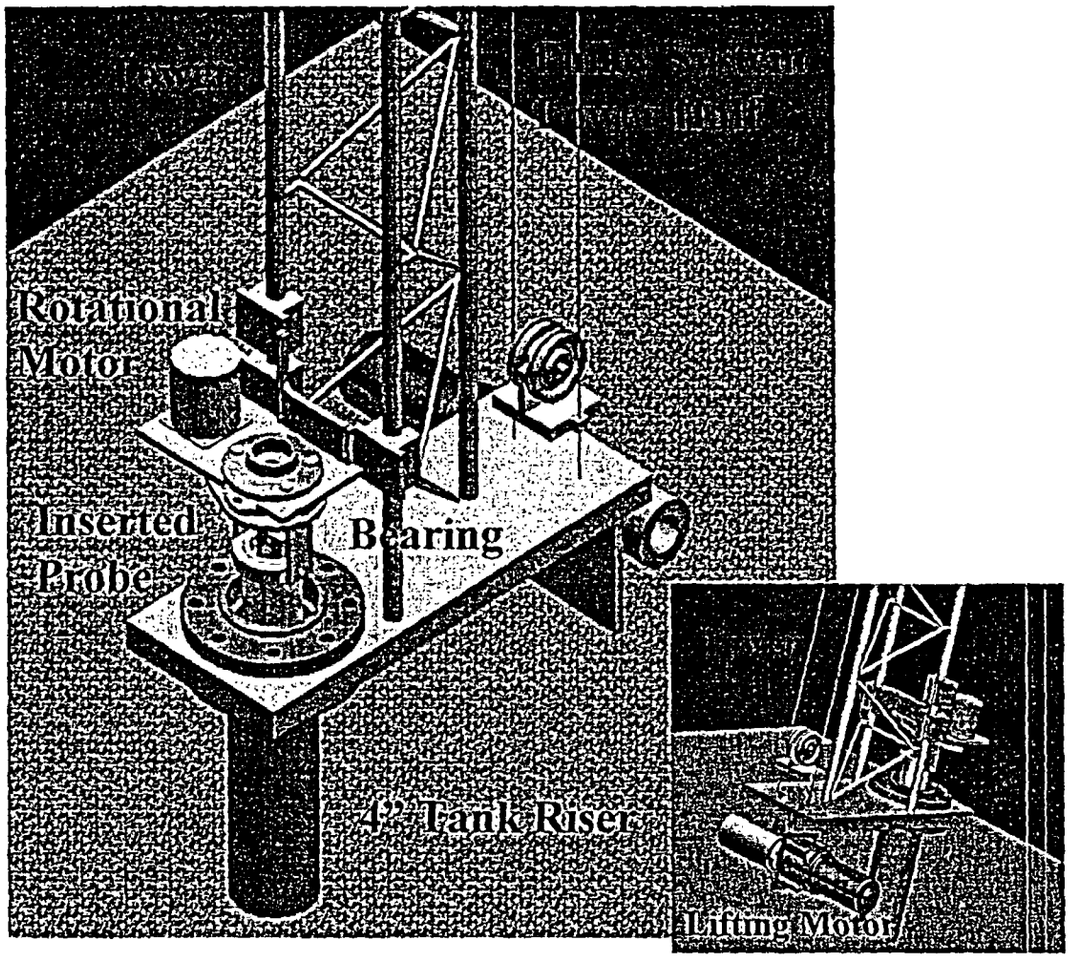
Mirrors redirect light through holes in the probe arm.

Elbow Bent

Insertion mechanism



Lifting cable runs from lifting motor, through pulley system, and connects to innermost tube.



Intrinsic system performance

- Intrinsic accuracy of FTP height determinations is typically to within 1% (or less) of true value.
- Intrinsic accuracy of FTP volume determinations is typically to within 1-2% of true value.
- Deployment as probe will slightly decrease accuracy.

Camera-to-Target (cm)	Peak Height (cm)	Error (%)	Volume (cm^3)	Error (%)
462.3 (15.17 ft)	10.30	1.0	1904.48	1.9
617.2 (20.25 ft)	10.39	0.1	1978.90	2.0
828.3 (27.17 ft)	10.44	0.4	1960.11	1.0

Performance on submerged objects

- Intrinsic performance applicable to mounds above supernatant liquid
- Submerged objects distorted by light refraction

Target	Peak Height (cm)	Error (water depth: 3.7cm)		Error (water depth: 2.6cm)		Error (water depth: 2.0cm)		Measured without Water (cm)	
		Before	After	Before	After	Before	After		
Large Cone	3.645	+2.3%	+7.5%	+2.1%	+7.8%	+2.1%	+8.1%	3.75	+2.9%
Medium Cone	2.531	+6.7%	+5.1%	-36.4%	+1.9%	-30.1%	-11.5%	2.53	-0.04%
Small Cone	1.940	+16.0%	+4.6%	-28.4%	-6.7%	-32.5%	-9.3%	1.86	-4.1%

Summary

- Methods currently being used are able to provide quantitative information on volume, radionuclide content

- Data probably complete enough; errors probably small enough; for risk-based decisions
  - However, errors not completely characterized, nor methods independently verified
  - Wall deposits and annular space need to be considered
  - Quality assurance requirements for data not well-defined (need to avoid WIPP approach)

- Alternative techniques being developed
  - Volume determination ready for deployment in 2006
  - Radionuclide inventory determination probably not ready for 3-4 years

Status of Technology for Removing Common Target Radionuclides from Waste

Presented to the ACNW Working Group Meeting on Waste Determinations

Kenneth A. (Ken) Gasper

August 2, 2005

Target Radionuclides

- Cesium-137 (including Ba-137m)
  - Technetium-99 and Iodine-129
- Strontium-90 and Transuranics

Cesium-137 (and Technetium-99)

Cesium normally occurring in the liquid, aqueous phase, particularly in saturated salt solution/ salt cake waste

For Hanford Double Shell Tank Waste 0.3-0.5 Curies/liter @ 7M sodium

For Hanford Single Shell Tank Waste Interstitial liquid 0.1-0.2 Curies/liter @ 7M sodium

Technetium normally occurring as the pertechnetate ion along with the cesium

Strontium-90 and Transuranics

- Normally occurring in the solid, sludge phase in the absence of organic complexants
- *Sparingly present in the liquid, aqueous phase in the absence of organic complexants or high hydroxide concentration (e.g. SRS waste)*
- Present in the liquid, aqueous phase in the presence of organic complexants

Cesium Removal Technology-1960's-1970's

- At Hanford's B-Plant 146 million curies of cesium-137 were removed using ion exchange (IX) for most of the feed (alkaline) and phosphotungstic acid (PTA) precipitation for the acid feed
  - Concentrations of cesium -137 ranged up to 220 Ci/l
  - Cesium recoveries were over 90% for the IX process and over 95% for the PTA process

Strontium Removal Technology-1960's-1970's

- At Hanford's B-Plant 68 million curies of strontium-90 were removed using solvent extraction (SX) of an acidified feed Concentrations of strontium-90 ranged up to 2 Ci/l after dissolving the strontium-bearing solids
  - 80-90% of the strontium in the solids were recovered into the SX feed. Strontium recoveries were over 97% for the SX process

Cesium Removal Technology-1990's

- At Savannah River the tetraphenyl borate precipitation of cesium was pursued for feed for Salt Stone and DWPF.
- At Hanford IX was pursued for the Initial Pretreatment Module (IPM) and later the Pretreatment Plant of the Waste Treatment and Immobilization Plant (WTP)
  - Resorcinal-Formaldehyde (RF) Resin was pursued (elutable)
  - Crystallized Silico-titanate (CST) Resin was pursued (Non-elutable)
  - SuperLig 644 resin was later pursued by WTP

Cesium Removal Technology-1990's (cont.)

- At Hanford Fractional Crystallization (acid side) was demonstrated at lab scale: clean salt
  - Product met rad con release limits (<< Class A)

Cesium Removal Technology-1990's-2000's at Savannah River

- At Savannah River the In-Tank Precipitation (ITP) process involving cesium tetraphenylborate salts was abandoned because it could not be safely operated at the necessary production rates
- Caustic Side Solvent Extraction (CSSX) was selected by the Salt Waste Disposal project (2001)
  - Conceptual Design is complete; design is underway
  - Modular CSSX (MCU) will be deployed in 2006-2007
  - Full scale CSSX will be deployed in 2009

Cesium Removal Technology 2000's at Savannah River (cont.)

- CSSX Product
  - Will meet Class A (e.g. 1 $Ci/m^3 = 0.001$ Ci/l for Cs^{137}); Decontamination Factor of *greater than* 40,000
- Deliquification, Dissolution, and Adjustment (DDA) will separate the concentrated supernate and interstitial liquid from the solid saltcake; then dissolve the remaining saltcake matrix and send that dissolved material to the Salt Processing Facility
  - Will have an estimated 27 $Ci/m^3 = 0.027$ Ci/l for Cs^{137}
  - Capability to process is currently available and needed to provide tank space

Cesium Removal Technology-1990's-2000's at Hanford

- At Hanford the WTP flowsheet settled on
  - The SuperLig 644 IX assuming two stages of IX with a factor of 100 decontamination factor per stage.
  - The WTP contract required a cesium-137 output concentration from the Pretreatment Plant to the Low Activity Vitrification Plant of 0.0017 Ci/l @ 7M sodium
  - The WTP Pretreatment Plant is now anticipated to begin hot processing post 2011
  - RF resin continues to be explored as a backup

Cesium Removal Technology-2000's at Hanford

- At Hanford Supplemental Pretreatment options explored
  - Draining of interstitial liquid, followed by salt cake "washing" and transfer of all that liquid to double shell tanks and then subsequent salt cake dissolution provides feed capable of bulk vitrification with cesium-137 concentrations of less than 0.007 Ci/l.
    - Demonstrated on tank S-112; being demonstrated on tank S-102; planned for tank S-109 in FY 2006 (latter in conjunction with bulk vitrification demonstration).

Cesium Removal Technology-2000's at Hanford (cont.)

- At Hanford Supplemental Pretreatment options explored (internally and through university/industry competitive, open solicitation)
  - Caustic side fractional crystallization currently being pursued in laboratory and with full scale design concepts being developed
  - Cesium-137 levels of less than 0.0017 Ci/l achieved for single shell and double shell simulants and actual tank waste
  - Deployment concepts could be implemented in 2009 time frame; not currently in base plans; further lab and full scale design concept work funded for FY 2006.

SRS Strontium-TRU Removal Technology-1990's-2000's

- Savannah River established cross flow filtration for solids-liquid separation to remove insoluble Sr and actinides
  - Monosodium titanate addition to remove soluble radioactive Sr and actinides by sorption, if needed, to meet class C concentration limits in the grouted waste form
  - Soluble concentrations of Pu, Np, U, Am and Sr will be reduced by 82%, 58%, 26%, 78%, and 95% respectively

Hanford Sr-TRU Removal Technology-1990's-2000's

- Hanford accepted cross flow filtration for solids-liquid separation to remove insoluble Sr and actinides in WTP
  - Strontium nitrate and permanganate addition to remove soluble radioactive Sr and actinides by precipitation, to meet WTP contract limits in the vitrified waste form
- For Supplemental Pretreatment, Hanford has decanted solids free dissolved saltcake (and hydrocyclone has been selected for the S-109 demonstration) and hasn't determined which solids-liquid separation method to use for conceptual design of production scale fractional crystallization equipment

Hanford Technetium-99 Removal Technology-1990's-2000's

- Hanford identified that much of the technetium-99 exists in the aqueous phase in the pertechnetate oxidation state
- The WTP research and development effort identified SuperLig 639 resin as a potential IX media for separating technetium-99 from aqueous feed after the Cs IX step.
  - DOE and the contractor determined in the early 2000's that this separation process was not viable for the current project, and the requirement to conduct the Tc-99 separation was deleted from the current project contract.

Hanford Technetium-99 Removal Technology-2000's

- Hanford Supplemental Pretreatment investigations have shown that the pertechnetate tracks with the Cs-137
  - It tends to stay in the aqueous phase exclusively in the salt cake dissolution and retrieval process and can be sent to the stream going to the WTP
  - In the fractional crystallization process it stays in the cesium rich phase and can be separated from the material headed for bulk vitrification (or other supplemental treatment immobilization process, if a different one is chosen).
- CSSX selectively separates Cs-137 from pertechnetate

Hanford Iodine-129 Removal Technology-2000's

- Hanford Supplemental Pretreatment investigations have shown that the iodine tracks with the Cs-137
  - It tends to stay in the aqueous phase exclusively in the salt cake dissolution and retrieval process and can be sent to the stream going to the WTP
  - In the fractional crystallization process it stays in the cesium rich phase and can be separated from the material headed for bulk vitrification (or other supplemental treatment immobilization process, if a different one is chosen).
- CSSX selectively separates Cs-137 from iodine

Conclusions

- Work at Hanford and Savannah River, supported by lab studies there and at national laboratories have provided experience and offer insight and potential possibilities for removal of cesium-137, strontium-90, transuranics, technetium-99, and iodine-99

Perspective on Definition of "Highly Radioactive" Waste

David C. Kocher
SENES Oak Ridge, Inc.
Oak Ridge, Tennessee

ACNW Working Group Meeting on
Waste Determinations

August 2, 2005

Discussion Topics

[1] Meaning and quantification of "highly radioactive" in context of defining high-level waste (HLW)

[2] Importance of "highly radioactive" to long-term performance of waste disposal systems

[3] Meaning of "highly radioactive radionuclides" in National Defense Authorization Act (NDAA)

Use of "Highly Radioactive" in Law

Term first appears in law in Nuclear Waste Policy Act (NWPA, 1982); HLW defined as –

(A) highly radioactive material from reprocessing of spent nuclear fuel … that contains fission products in sufficient concentrations; and

(B) other highly radioactive material that [NRC] … determines … requires permanent isolation.

No definition of "highly radioactive"; ambiguity about radionuclides included.

Earliest Descriptions of HLW

Mid-1950s – HLW has high levels of decay heat and external radiation, due mainly to high concentrations of shorter-lived fission products.

- Most important fission products in aged wastes were Sr-90 and Cs-137.

Liquid HLW required active or passive cooling and extensive shielding to protect <u>workers</u> during waste <u>operations</u> and <u>storage</u>.

Early Quantifications of Liquid HLW

[1] > 2 R/h; AEC (1957)

[2] > 10^6 MPC_{water}; ICRP (1960), ORNL (1969)

[3] > 100 Ci/m^3; Hanford (1967)

[4] > 10^4 Ci/m^3; IAEA (1970) [Category 5 (cooling of stored liquid waste necessary); > 0.1 Ci/m^3 required shielding (Category 4)]

Based mainly on concentrations of shorter-lived fission products (i.e., define "highly radioactive").

100 Ci (fission products) ~ 0.5-1 W

Subclassification of Liquid HLW

Hanford site (1963) –

[1] "Self-heating" waste, > 8-50 W/m^3

Capable of boiling in waste tanks; active cooling required.

[2] "Non-heating" waste, lower thermal power density

Only passive cooling required.

Similar subclassification at other AEC sites.

Early Quantifications of Solid HLW

Applied to solid waste acceptable for shallow-land burial, not solidified HLW –

[1] > 50 mR/h at 7.6 cm; on-site burial of beta/gamma waste at Savannah River (1967)

[2] > 3.5×10^4 Ci/m^3; Lennemann (1967) [arbitrary grouping for waste operations, handling, and statistical purposes]

[3] > 2 R/h; IAEA (1970) [Category 3 (requires special precautions for handling and transport)]

First Regulatory Definition of HLW (10 CFR Part 50, Appendix F; 1970)

[1] Source-based definition (constituents and radiological properties not mentioned, nor "concentrated wastes" defined)

[2] AEC (1969): definition implies that HLW –

- produces high levels of decay heat and external radiation (fission products);
- requires long-term isolation from biosphere to protect public health (transuranics).

Two properties apparently considered separate and distinct.

NRC's NUREG-0946 (1985)

Evaluated Clause (B) definition of HLW in NWPA.

[1] Class-C limits for near-surface disposal in 10 CFR Part 61 not appropriate for identifying waste that "requires permanent isolation."

[2] 30 × Class-C limits might define "requires permanent isolation," based on compositions of selected wastes (not based on risk analysis).

30 × Class-C (Sr-90, Cs-137) ~ 1 kW/m^3.

Did not consider meaning of "highly radioactive."

TRU Waste Acceptance Criteria (1)

Remote-handled (RH) TRU waste at WIPP –

[1] < 300 W/package (~ 1 m^3)

Based on limit of 30 kW/acre and prescribed areal density of waste packages to prevent impacts on salt (includes 5× safety factor).

[2] < 100 rem/h at surface of waste package

Based on provisions for adequate personnel shielding and capacity of waste hoist.

TRU Waste Acceptance Criteria (2)

Contact-handled (CH) TRU waste –

[1] < 15 W/m^3 in stacked waste containers at WIPP (no credit for space between containers)

[2] < 40 W/m^3 in transport containers (heat generation not important to container design)

[3] < 0.2 R/h for handling and transport

Kocher and Croff (1987, 1988)

Quantified Clause (B) definition of HLW in NWPA.

"Highly radioactive" means –

[1] > 50 W/m^3 (e.g., Sr-90 Class-C limit); or

[2] > 100 rem/h at 1 m (~ Cs-137 Class-C limit).

Thermal power density based on levels requiring heat removal for safe storage or disposal.

Dose rate more arbitrary (supported by limit for RH TRU waste at WIPP); important for Cs-137 only.

Also quantified "requires permanent isolation."

IAEA Recommendations

[1] Current definition of HLW (1994) includes thermal power density > 2 kW/m^3.

Based on typical levels of 2-20 kW/m^3 up to 10 y after discharge of spent fuel (<u>not</u> based on impacts of heat generation).

[2] Definition in draft recommendations (2005) does not include thermal power density.

Description of HLW refers to "significant" quantities of decay heat.

Discussion (1)

[1] Description of HLW as “highly radioactive” (i.e., high decay heat and external radiation) based originally on need to protect workers during waste operations and storage.

Not based on requirements for safe disposal.

[2] Thermal power density is reasonable criterion to define “highly radioactive” for purposes of ensuring safe waste disposal.

Values > 10-100 W/m^3 need to be considered in designing disposal facilities.

Discussion (2)

[3] External dose rate requiring extensive shielding to protect workers is less useful criterion to define "highly radioactive" for purposes of waste disposal.

Photon dose rates < 1 Mrad/h probably do not significantly affect leaching of radionuclides from waste forms.

Alpha doses > 10^5 Mrad probably required to cause significant damage to waste forms.

What Radionuclides Make Waste "Highly Radioactive"?

[1] For purposes of disposal, "highly radioactive" clearly includes waste with high concentrations of shorter-lived ($T_{1/2}$ = 30 y) fission products.

E.g., > Class-C limits for Sr-90 and Cs-137.

[2] Concentrations of longer-lived transuranics (Pu-238, -239, -240; Am-241) in commercial spent fuel ~ 1 kW/m^3 ("highly radioactive").

Much lower concentrations of transuranics in DOE reprocessing wastes (e.g., ~ 0.1 W/m^3 in tank waste at Savannah River).

Language in NDAA

[1] Use of "highly radioactive radionuclides" in NDAA is new in law, regulations, or guidance.

Intent is not clear; e.g., are radionuclides that are not "highly radioactive" excluded?

DOE M 435.1-1 refers to "key radionuclides."

[2] Goal should be to remove radionuclides that significantly impact risks from disposal.

"Highly radioactive" as described historically probably not important to risks from *in situ* disposal of residual tank wastes.

References (1)

Presentation based on following references and citations therein.

International Atomic Energy Agency (1970). Standardization of Radioactive Waste Categories, Technical Reports Series No. 101.

International Atomic Energy Agency (1994). Classification of Radioactive Waste, Safety Series No. 111-G-1.1.

International Atomic Energy Agency (2005). Classification of Radioactive Waste, draft Safety Guide (March).

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Jacobs, D.G., Szluha, A.T., Gablin, K.A., and Croff, A.G. (1985). A Brief Historical Perspective on the Definition of High-Level Nuclear Wastes, ORNL/Sub/84-13833/1, Oak Ridge National Laboratory.

Kocher, D.C. (1990). Classification and Disposal of Radioactive Wastes – History and Legal and Regulatory Requirements, Radiation Protection Management 7:58-78.

References (2)

Kocher, D.C., and Croff, A.G. (1987). A Proposed Classification System for High-Level and Other Radioactive Wastes, ORNL/TM-10289, Oak Ridge National Laboratory; Radioactive Waste Management and the Nuclear Fuel Cycle 11(3):227-268 (1988).

National Council on Radiation Protection and Measurements (2002). Risk-Based Classification of Radioactive and Hazardous Chemical Wastes, NCRP Report No. 139.

National Research Council (1983). A Study of the Isolation System for Geologic Disposal of Radioactive Wastes.

Westinghouse Electric Corporation (1985). TRU Waste Acceptance Criteria for the Waste Isolation Pilot Plant, WIPP-DOE-069, Revision 2.

Status of Fluidic Technology For Retrieving Waste From Tanks

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AEA TECHNOLOGY
THE INNOVATION BUSINESS

Presentation

- Pulse Jet Mixers:- Bulk Waste Mobilization
- RFD Pumps:-Mobilization and Pumping
- Tank Grouting
- Consolidated system,:-Mobilization, pumping and grouting

Power Fluidics

Proven Technology with multiple deployments over the last 25 years.

No moving parts in contact with active waste.

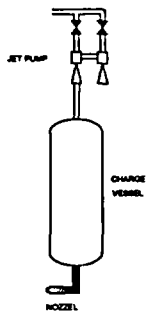
Maintenance free.

Reduces plant lifetime cost

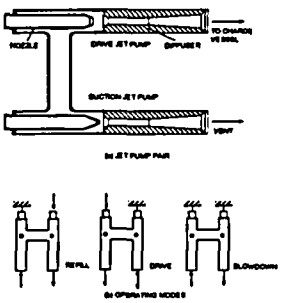
ALARA

No secondary waste.

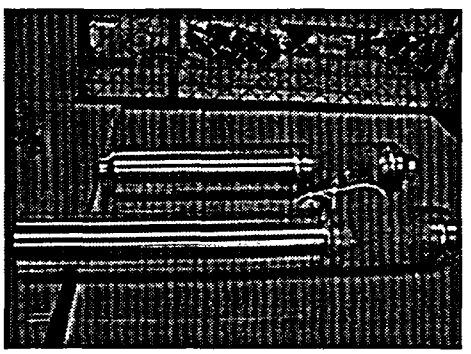
Key Components of Pulse Jet



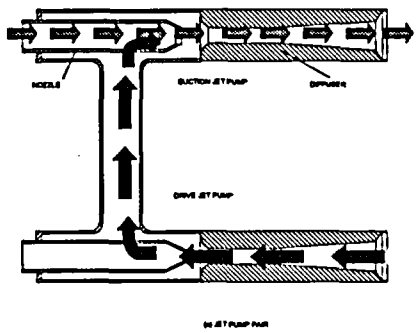
Jet Pump Pair



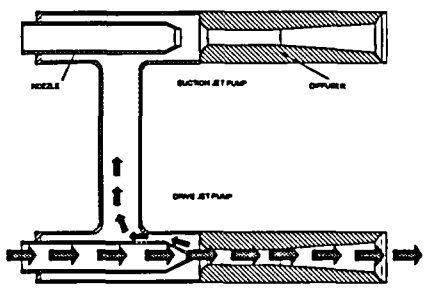
Jet Pump Pair



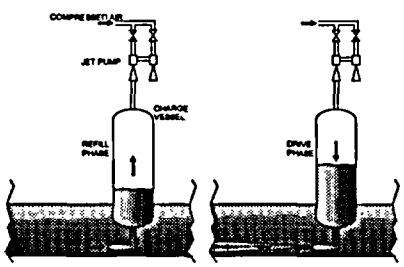
Suction Phase Of Jet Pump Pair



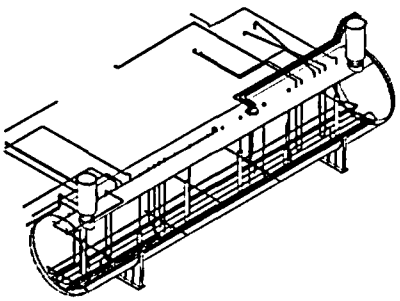
Drive Phase of Jet Pump Pair



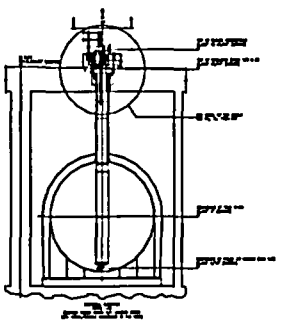
Pulse Jet Mixing



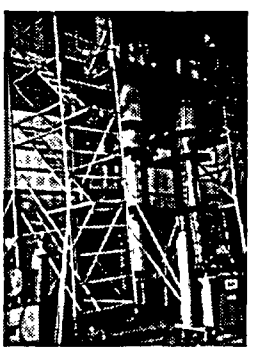
C Tank, showing Cooling Coils



C Tank Deployment

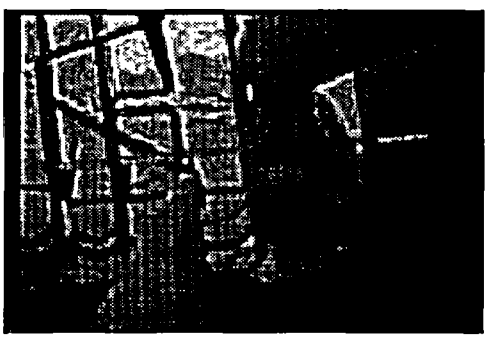


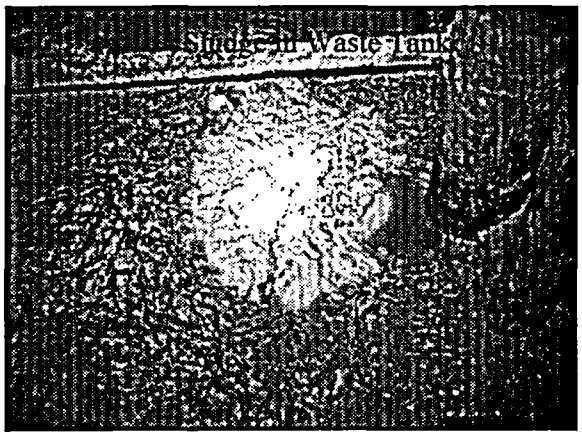
C Tank Charge Vessels

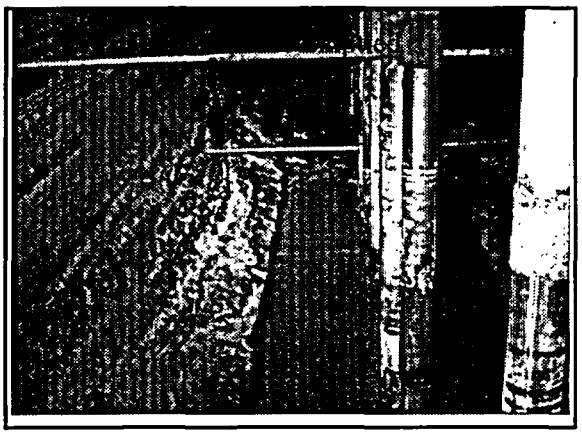


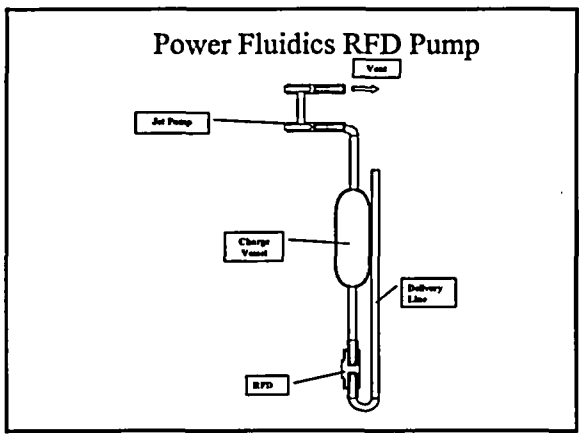
Tank Installation

Mixing Below Cooling Coils

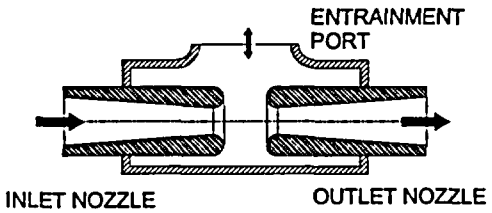



Sludge in Waste Tank

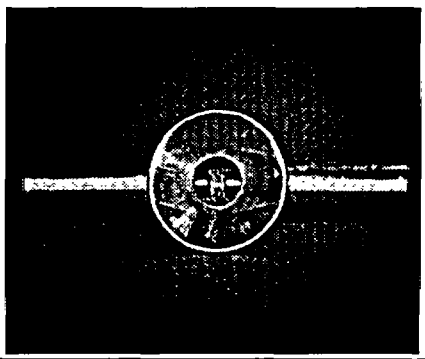



Power Fluidics RFD Pump
Vent
Jet Pump
Charge Vessel
Delivery Line
RFD

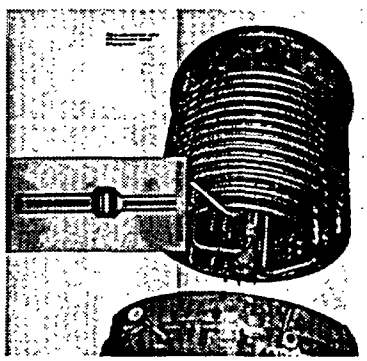
RFD



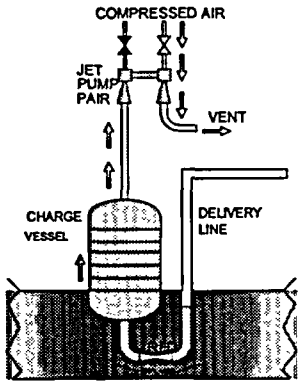
RFD Pump



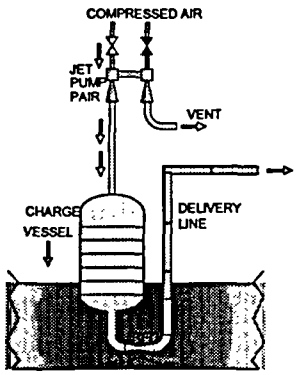
HLW Tanks RFD Installation



RFD Suction Phase

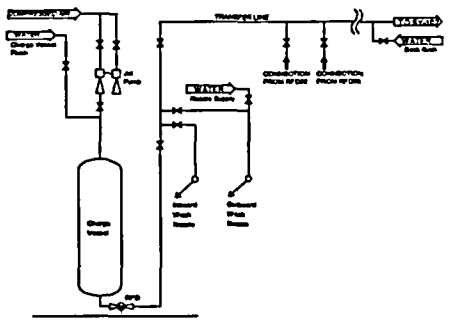


Drive Phase Of RFD

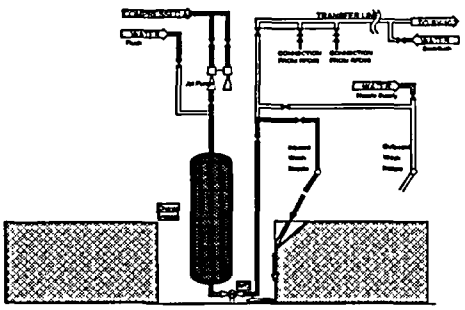


Minimal Water Requirement

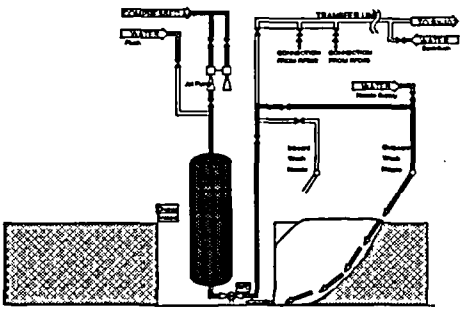
Salt Recovery System Outline



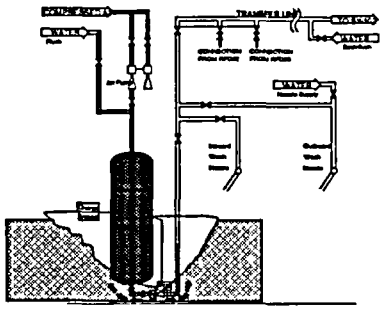
Operating Mode:- Wash In-board

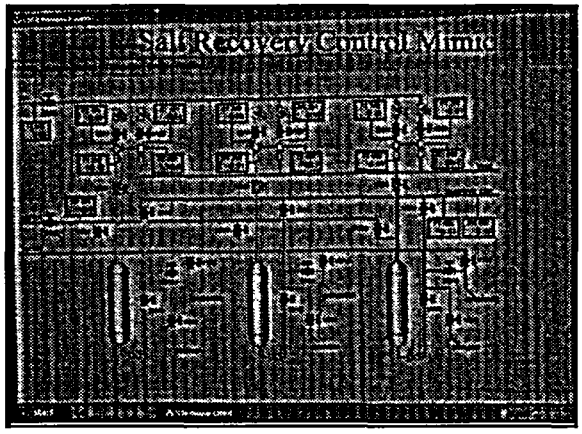


Operating Mode:- Wash Outboard

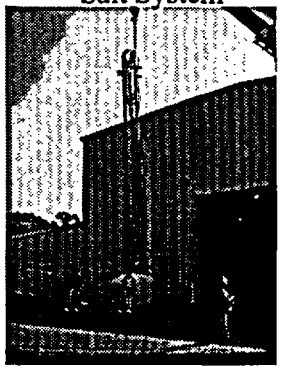


Operating Mode:-Clearing RFD

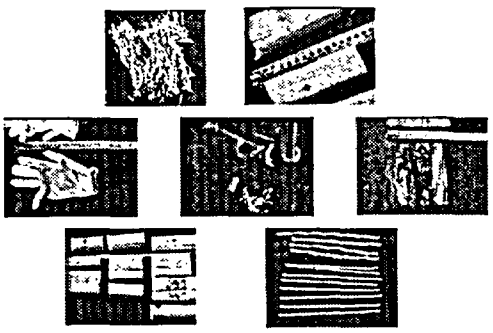




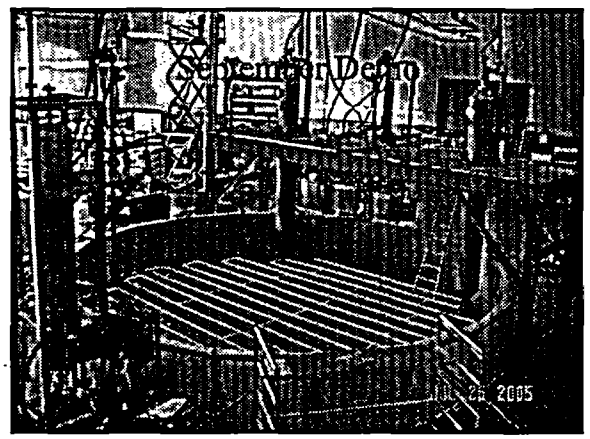
Salt System



Debris Testing



Jet Grouting Waste Demo



Summary

- Multiple Successful Deployments around complex
- Versatile system capable of adaptation
- Reusable skid mounted system
- Minimum water required in tank
- Capable of bulk waste recovery, heel recovery and jet grouting.
- September demonstration Charlotte

NRC Involvement in Waste Determinations

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August 2, 2005

Presented To: Advisory Committee on Nuclear Waste

Overview

- Background of Waste-Incidental-to-Reprocessing (WIR)
- Previous NRC Reviews
- Legislation
- Status, Programmatically and Technically

Concept of Incidental Waste

Management of waste can be based on the risk that the waste poses to human health and the environment, rather than the origin of the waste. For wastes that result during the reprocessing of spent fuel, some require disposal in a geologic repository while some do not.

Incidental Waste Description

- Examples of potential WIR are high-level waste (HLW) tank pumps, waste removed from tanks, or residual waste remaining in tanks
- WIR is not considered to be HLW, but instead is low-level waste (LLW) or transuranic (TRU) waste
- Potential WIR is located at Hanford, Idaho National Laboratory (INL), Savannah River Site (SRS), and West Valley

WIR Determination Criteria

- In 1993, the original three WIR criteria were in a Denial of a Petition for Rulemaking and forwarded in a letter to Hanford:
  - Waste processed to remove key radionuclides to the maximum extent technically and economically practical
  - Waste incorporated into a solid physical form at concentrations not exceeding Class C concentrations
  - Waste managed so that safety requirements comparable to the performance objectives in 10 CFR Part 61, Subpart C, are satisfied
- In 1999, DOE included essentially the same three criteria in its radioactive waste management program (DOE Order 435.1)

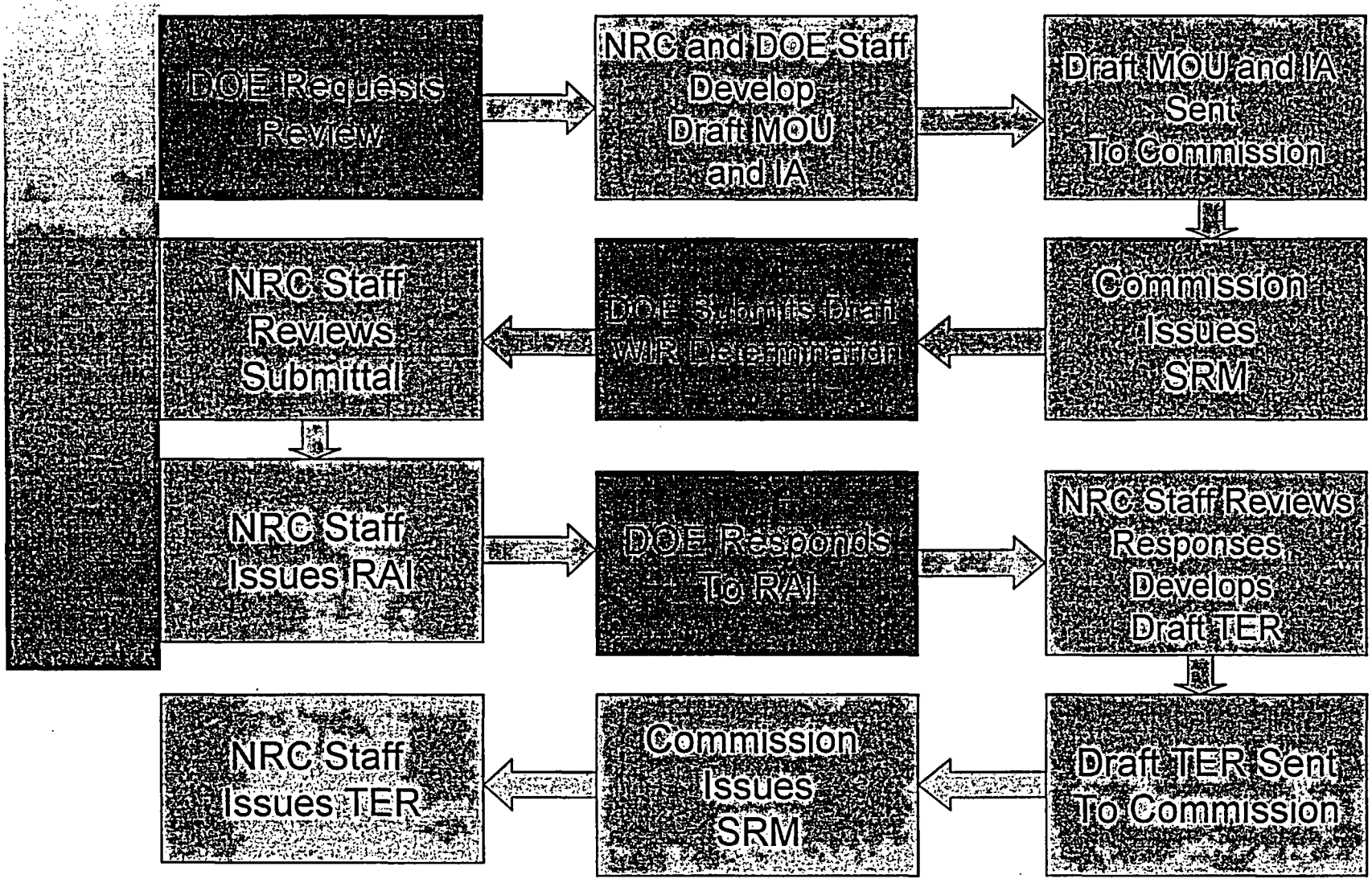
WIR Determination Criteria (cont'd)

- In 2000, during a WIR review for SRS, the NRC dropped the second criterion regarding concentration, as the Commissioners deemed concentration to not be a direct measure of risk
- In 2002, only two criteria were in NRC's West Valley Policy Statement
- In 2004, new legislation passed that set waste criteria for SRS and INL

NRC Involvement in WIR

- In the past, DOE has asked NRC to provide technical advice and consultation on its methodology and conclusions of WIR determinations
- WIR determinations involve demonstrating compliance with the WIR criteria, and usually includes a performance assessment (PA)
- NRC assessed DOE WIR determinations for soundness of technical assumptions, analysis, and conclusions
- NRC has reviewed WIR determinations for Hanford (1997), SRS (2000), and INEEL (2002 and 2003)
- NRC reviews generally concluded that DOE methodologies were protective of public health and safety, and offered recommendations for improvement

Major Steps of Past NRC Reviews



Summary of Results

Review (year completed)	Criteria	Doses
Hanford/Waste removed from tanks and disposed on site (1997)	All 3 original criteria	Not provided in NRC report
SRS/Tanks closed in place (2000)	All 3 criteria reviewed by staff. In SRM, Commissioners stated criteria 1 and 3 would be sufficient	Public: 1.9 mrem/yr at 805 years Intruder drilling: 130 mrem/yr at 700 yrs, well at 1 m from tank farm Intruder teenager: 0.001 mrem/yr

Summary of Results (cont'd)

Review (year completed)	Criteria	Doses
INEEL/Sodium-bearing waste to be removed from tanks and disposed at WIPP (2002)	Criterion 1 only	Public: Not applicable Intruder: Not applicable Worker: Not provided by DOE
INEEL/Tanks to be closed in place (2003)	Criteria 1 and 3 only	Public: 1.4 mrem/yr at 890 yrs Intruder drilling at yr 100: 232 mrem for acute, 91.1 mrem/yr for chronic Intruder construction at yr 100: 0.93 mrem for acute, 26.1 mrem/yr for chronic Worker dose: 40 mrem/yr

Legislation

- South Carolina Senator Graham introduced legislative language that would allow a similar process at SRS
- The language went through multiple revisions
- NRC responded to letters from Senators Inhofe and Jeffords requesting our views
- On October 28, 2004, the President signed the Ronald W. Reagan National Defense Authorization Act for FY 2005

National Defense Authorization Act

- DOE must consult with NRC on all of its non-HLW determinations for SRS and INL
- The Act sets the criteria to be used in waste determinations, which are:
  - The waste does not require disposal in deep geologic repository
  - The waste has had highly radioactive radionuclides removed to the maximum extent practical, and
  - If the waste is Class C or less, its disposal must meet 10 CFR 61 Subpart C, or
  - If the waste exceeds Class C, its disposal must meet 10 CFR 61 Subpart C and DOE must consult with NRC on development of its disposal plans
- NRC must, in coordination with the State, monitor DOE's disposal actions to assess compliance with 10 CFR Part 61, Subpart C, and report any noncompliance

National Defense Authorization Act (cont'd)

- Applies only to INL and SRS
- Does not apply to waste shipped out of those States
- DOE will reimburse NRC for its activities in FY05, and thereafter NRC must seek appropriations
- Requires a one-year study by the National Academy of Sciences (NAS) of DOE's plans for the disposal of waste that exceeds Class C concentrations

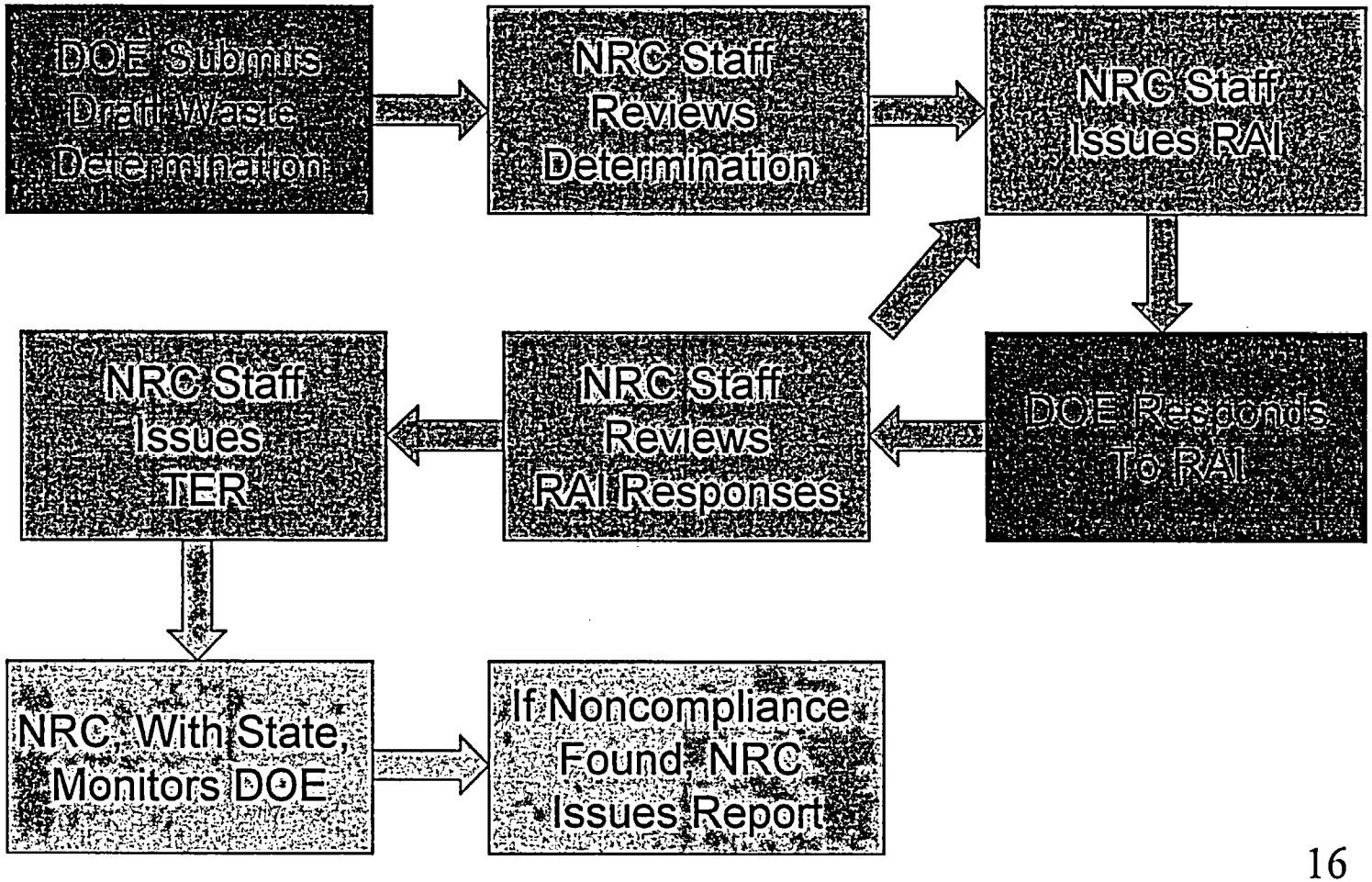
Status – Programmatic Activities

- SECY-05-0073 described staff's plans for implementing NDAA
- SRM approved the plans, with comments
- Established LLW section within DWMEP
- Beginning development of Standard Review Plan
- Established contract with CNWRA for technical support

Status – Programmatic Activities (cont'd)

- Met with States to discuss roles and responsibilities
- Established IA with DOE for funding
- Drafting Memorandum of Understanding with DOE
- Continuing interactions with the NAS committee

Major Steps of NRC Review



Status – Technical Activities

- Savannah River Site:
  - DOE submitted draft determination for salt waste disposal in February 2005
  - RAIs transmitted on May 26
  - RAI responses July 1 and July 15
  - NRC staff is conducting technical review
  - DOE expects to submit determinations for tanks in September 2005

- INL:
  - DOE expects to submit draft determination for tanks in August 2005

Status – Technical Activities (cont'd)

- Hanford:
  - Established IA for review of tank waste retrieval actions
  - Hanford submitted documents in October 2004
  - Transmitted RAIs in January 2005
  - Waiting for RAI responses and PA

- West Valley:
  - Already have responsibilities under the West Valley Demonstration Project Act
  - Will use decommissioning criteria in NRC's West Valley Policy Statement
  - WIR information will be in DOE's EIS (Aug/Sept 2005) and Decommissioning Plan (summer 2006)

References

- SECY-05-0073 on new NRC responsibilities (ML050490264)
- SRM for SECY-05-0073 (ML051810375)
- Commission vote sheets on SECY (ML051820120)
- Saltstone RAIs (ML051440589)
- DOE's RAI responses (ML051920416, ML052030364)
- Letters to Senators Inhofe and Jeffords (ML041340235, ML041600400)
- Docket numbers:
  - SRS: PROJ0734
  - INL: PROJ0735
  - Hanford: PROJ0736

Department of Energy
Tank Wastes

Advisory Committee on Nuclear Wastes
Working Group Meeting
On Waste Determinations
August 2, 2005

U.S. Department of Energy

Today's Tank Waste Situation

Four sites have ~350,000 cubic meters and 700 million curies of tank wastes needing treatment, storage and disposal:

- Three DOE-owned sites:
  - » Hanford
  - » Savannah River Site (SRS)
  - » Idaho National Laboratory (INL)
- One State of New York-owned site:
  - » West Valley Demonstration Project (WVDP)

TANK WASTE MANAGEMENT STRATEGY

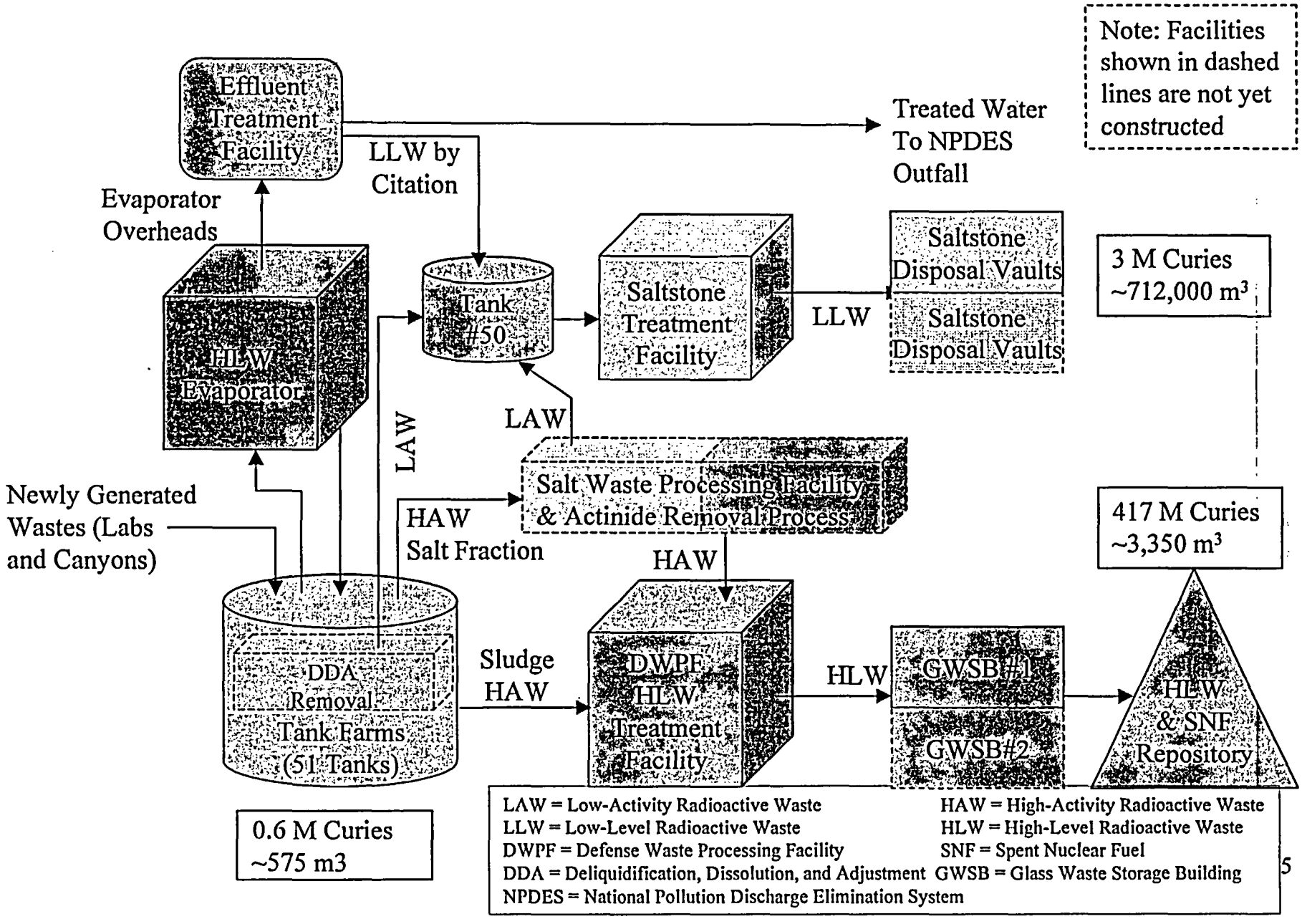
- Safely store waste in form of liquids, sludges, and saltcakes
- Retrieve waste for purposes of pretreatment, treatment, and disposal
- Pretreat alkaline waste (SRS, Hanford and WVDP), typically through a separations process to separate waste into:
  - Low-activity waste stream treated and disposed as low-level waste (LLW) onsite [except at WVDP] (most of volume)
  - High-activity waste stream treated and disposed as high-level waste (HLW) at a geologic repository (most of activity)
- Treat high-activity alkaline waste (SRS, Hanford and WVDP) using vitrification
- Dispose calcine (INL) either directly in its existing form or following alternative preparations for disposal in the HLW repository.
- Stabilize tank waste residues intended for in-place closure

(Need completion of National Environmental Policy Act (NEPA) actions at INL, Hanford and WVDP for disposition of tanks and related components)

Savannah River Site

- ~130,000 cubic meters of tank waste (11,000 m^3 sludge, 127,000 m^3 salt waste)
- ~430 million curies
- Alkaline waste, more homogenous waste than Hanford
- Facilities
  - 51 HLW storage tanks (2 interim closed) and infrastructure (3 HLW evaporators)
  - Sludge pretreatment
  - Defense Waste Processing Facility (DWPF) & HLW canister storage
    - » Over 1,500 canisters of HLW produced and stored onsite
  - Tank salt stream processing facilities being designed and constructed
- SRS Performance Management Plan Milestones:
  - 2019: Complete immobilization of all HLW
  - 2022: Complete closure of all HLW facilities

SRS Tank Farm Overview



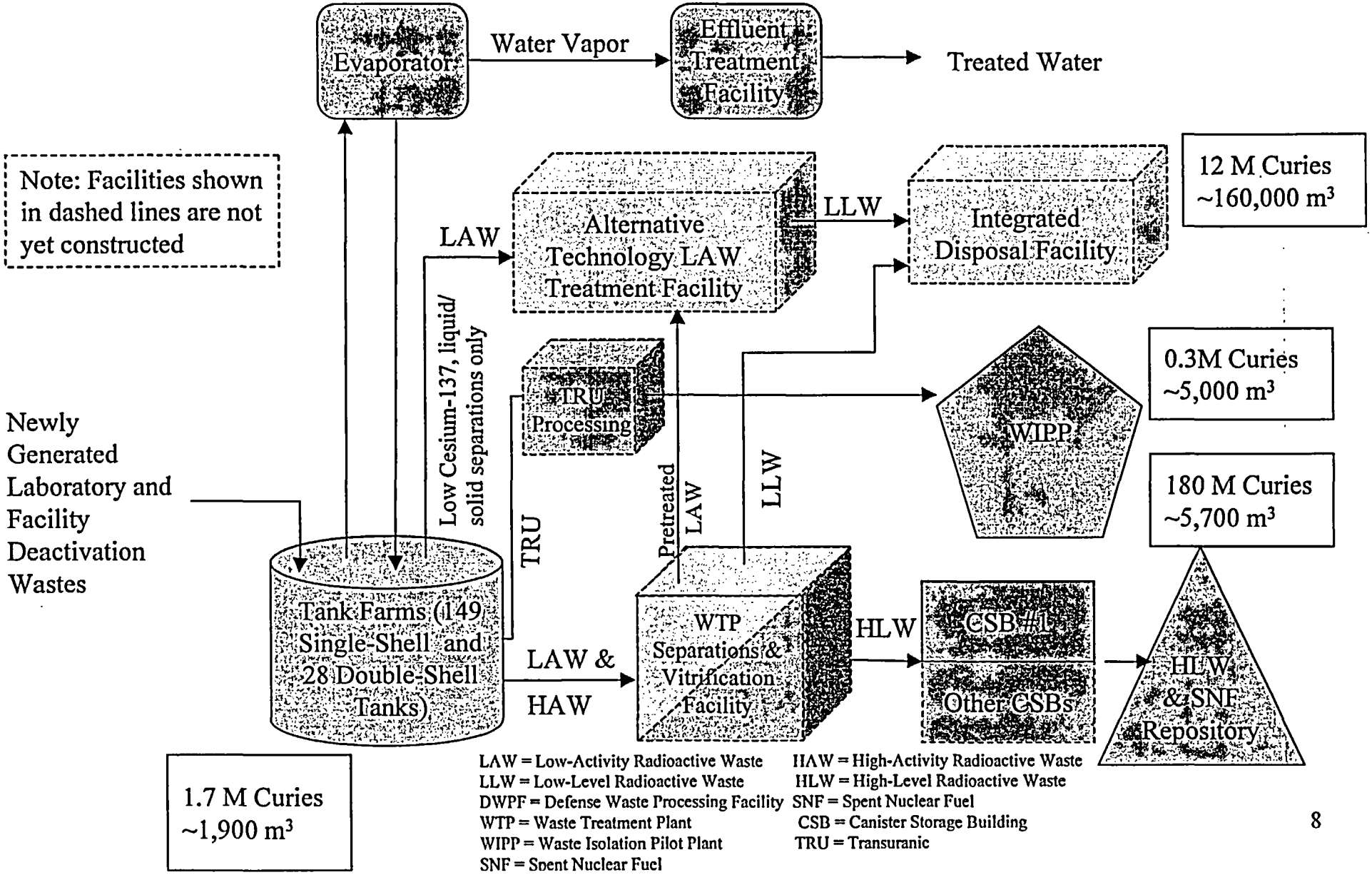
SRS Tank Waste Status

- Retrieving and preparing sludge waste for disposal through vitrification in DWPF – ongoing since 1996
- Future planned retrieval, separation of low-activity fraction of salt waste through following:
  - Interim Salt Processing to begin late Calendar Year 2005 or early CY 2006 until Calendar Year 2009
  - Full-capability Salt Waste Processing Facility using caustic-side solvent extraction, and monosodium titanate precipitation
- Treatment and onsite disposal of low-activity salt waste through Saltstone Facility (dependent upon waste determination per Section 3116 of the Ronald W. Reagan National Defense Authorization Act (NDAA) for Fiscal Year 2005)
- Stabilization of residual waste in tanks via grout per NEPA document and dependent upon waste determination per Section 3116 of NDAA (2 tanks cleaned and operationally closed in 1997)

Hanford
(Office of River Protection)

- ~200,000 cubic meters
- ~200 million curies in tanks
- Alkaline waste, several waste types resulting from different spent fuel reprocessing technologies
- Facilities
  - 177 HLW storage tanks including 1 evaporator
    - » 149 single-shell tanks
    - » 28 double-shell tanks
  - HLW canister storage building (HLW and spent nuclear fuel)
- Tri-Party Agreement (DOE, Environmental Protection Agency, State of Washington) requires:
  - 2024: Close all single-shell tanks
  - 2028: Complete immobilization of all high-level waste

ORP Tank Farm Overview



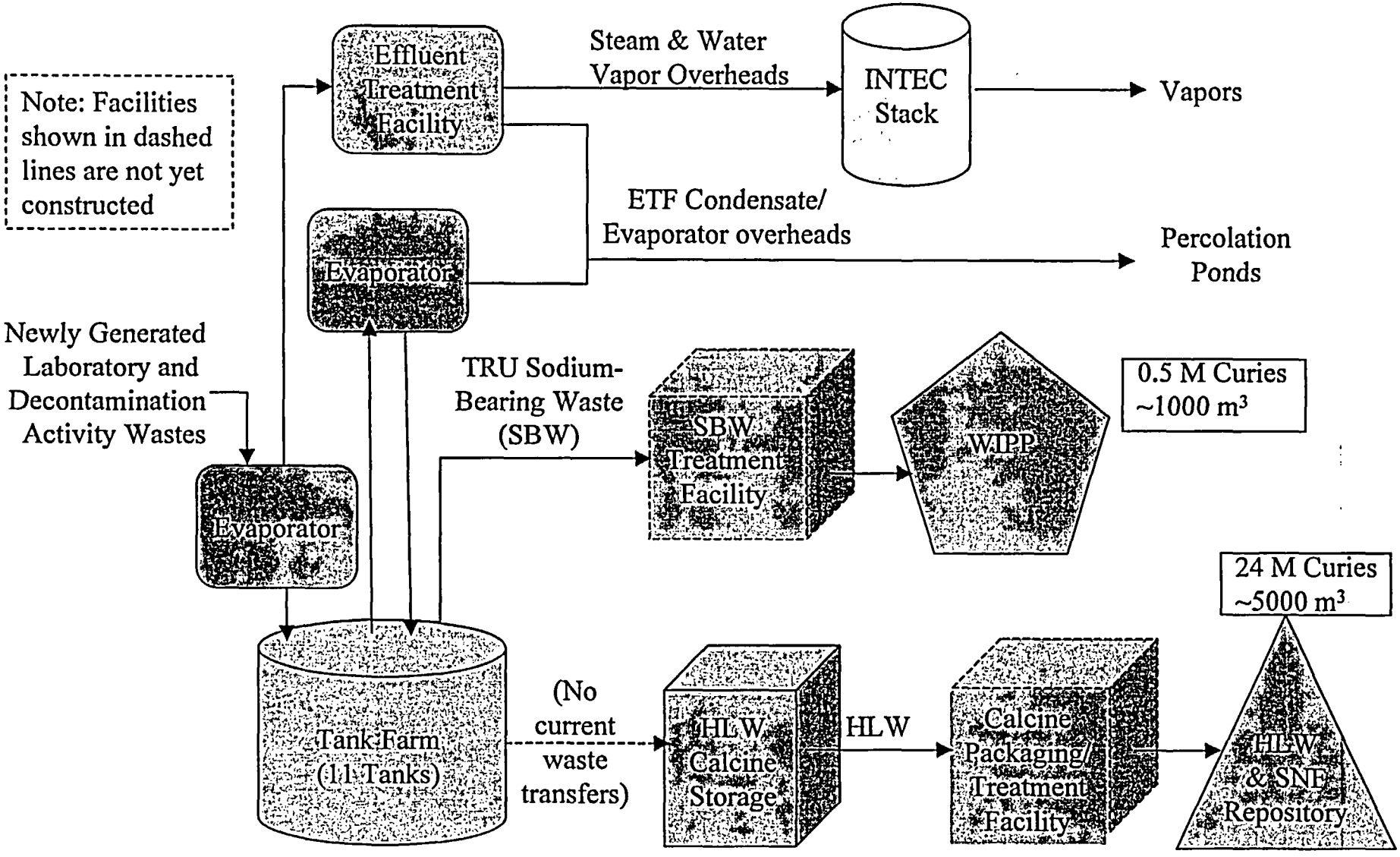
Hanford Tank Waste Status

- Completed transfer of bulk liquids from single-shell tanks to double-shell tanks to promote safe storage
- Completing Waste Treatment Plant:
  - Facility to separate tank waste in low-activity and high-activity waste fractions
  - Facility to vitrify all high-activity waste for ultimate disposal in a geologic repository
  - Facility to vitrify ~ 50% of low-activity waste for onsite disposal as low-level waste
- Demonstrating technology to treat the remainder of low-activity waste for onsite disposal as low-level waste
- Completed cleaning of high-heat tank C-106
- NEPA in progress for evaluating alternatives for closure of single-shell tanks
- Strategy for certain tank wastes not resulting from reprocessing to be treated and disposed at Waste Isolation Pilot Plant

Idaho National Laboratory (INL)

- ~10,000 cubic meters HLW calcine and sodium-bearing waste
- ~25 million curies
- Acidic waste of which majority has been denitrated and is stored in engineered-bins in a dry calcine form
- Facilities
  - 11 primary storage tanks (and 4 smaller auxiliary tanks) for acidic wastes
  - HLW calcine facility (conversion to dry, stable, granular form)
  - 7 calcine bin sets (one not yet used
- Settlement agreement/Consent Order with Idaho
  - Complete treatment of sodium-bearing liquid tank wastes by 2012
  - Cease use of tanks by 2012
  - Treat calcined wastes to be "road-ready" for disposal by 2035

Idaho Tank Farm Overview



SNF = Spent Nuclear Fuel
TRU = Transuranic
HLW = High Level Waste
INTEC = Idaho Nuclear Technology and Engineering Center
SBW = Sodium Bearing Waste
ETF = Effluent Treatment Facility
WIPP = Waste isolation Pilot Plant

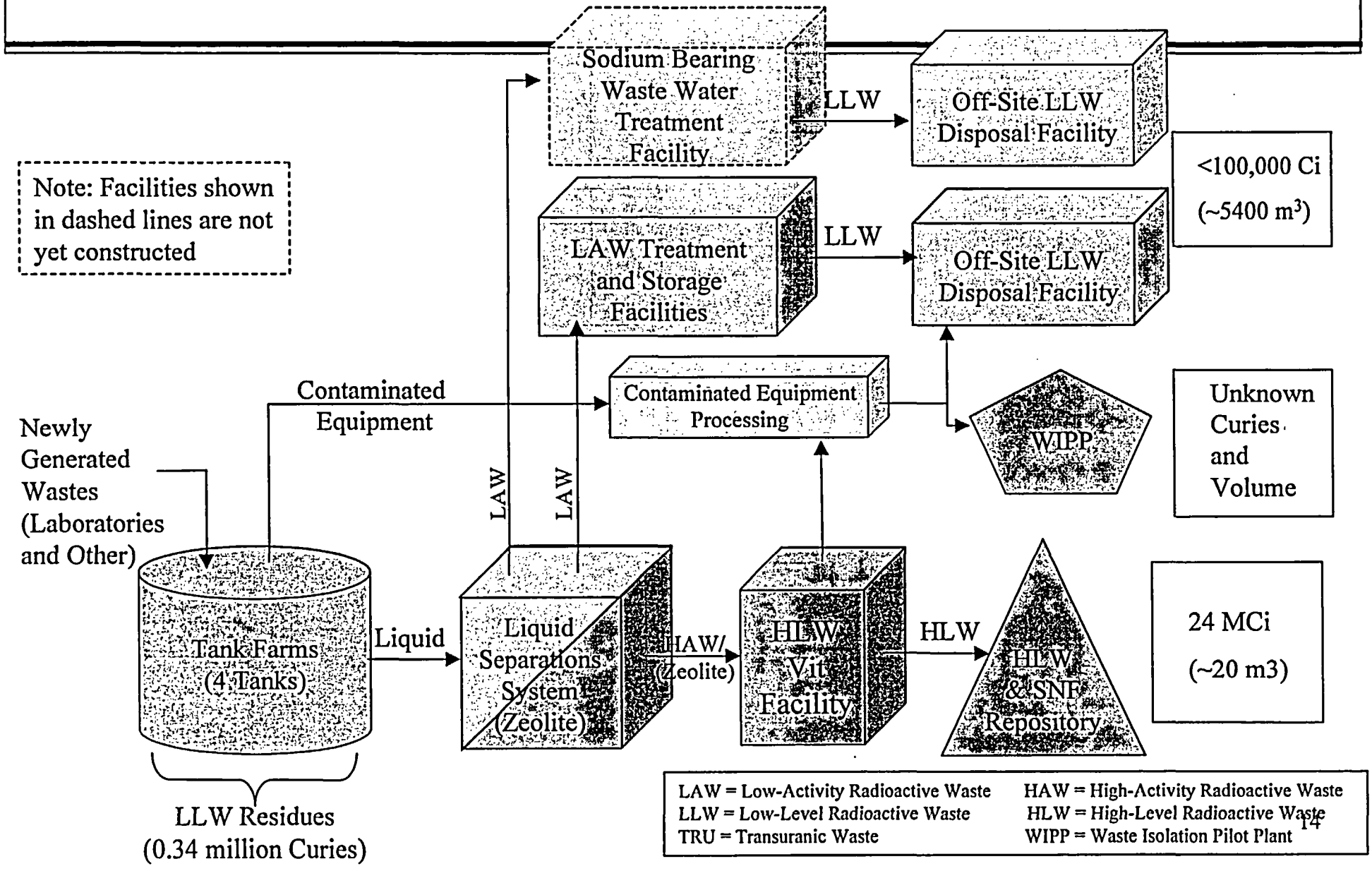
Idaho National Laboratory Status

- Completed calcining first-cycle and majority of second and third-cycle reprocessing wastes in 2000
- Evaluating technologies for treating remaining 3,400 m^3 of liquid sodium-bearing waste primarily resulting from decontamination activities at INL with intent to dispose at Waste Isolation Pilot Plant (will require some form of waste determination)
- Completed cleaning and characterizing 5 of 11 major storage tanks
  - Average less than 500 gallon residual waste in tanks
  - State of Idaho approved Resource Conservation and Recovery Act (RCRA) closure plan for these tanks
- Stabilization of residual waste in tanks via grout per NEPA document and dependent upon waste determination per Section 3116 of NDAA

West Valley Demonstration Project

- ~2300 cubic meters
- ~ 25 million curies
- Primarily alkaline waste, (small amount of Thorex/acidic waste)
- Facilities
  - 2 primary storage tanks (2 smaller tanks)
  - Vitrification facility (being dismantled)
  - HLW canister storage facility (275 in racks in old Chem Proc. Cell)
  - Drum cell storage facility for LAW waste
  - Pretreatment facility
- Unresolved issues with State of New York

West Valley Radioactivity Overlay



West Valley Demonstration Project Status

- Completed tank waste pretreatment in mid 1990's using specially formulated grout mixture, currently stored onsite in approximately 20,000 71-gallon drums for ultimate offsite disposal
- Completed vitrification of HLW in 2002 with 275 canisters in storage
- Initial project dismantlement and cleaning ongoing since 2002
- Closure of facilities used during conduct of the WVDP Project and other related facilities being evaluated in an Environmental Impact Statement