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David Tiktinsky - SS623
U.S. Nuclear Regulatory Commission
Division of Waste Management
Washington, D.C. 20555

"NRC Technical Assistance
for Design Reviews"
Contract No. NRC-02-85-002
FIN D1016

Dear David:

Enclosed with this letter is the trip report for the meeting on
"Review of BWIP ES-I Design Construction and Performance
Assessment" held in Richland, Washington, on 3-4 December 1985.
Mark Board and Adrian Brown attended this meeting for Itasca.

Please call me if you have any questions concerning this report.

Sincerely,

Roger D. Hart
Program Manager

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*Tiktinsky

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DWM Document Control Room

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ITASCA TRIP REPORT

DATES: 3-4 December 1985

LOCATION: Richland, Washington

PURPOSE: Review of BWIP ES-I Design Construction and Performance Assessment

ITASCA ATTENDEES: M. Board (Itasca)
A. Brown (Nuclear Waste Consultants)

Summary - The purpose of the meeting was to review the BWIP ES-I design, construction and performance assessment. The meeting agenda and attendance lists are given in Appendices A and B, respectively.

The first day was devoted to a review of the siting, design, and construction practices to be used in ES-I. Pierre Sarget of DOE gave an introduction to the agenda which was followed by a short discussion of the NRC position by M. Nataraja. Mr. Nataraja also reviewed the essential points of 10CFR 50.10(d) regarding long-term performance. This was followed by a review of past correspondence between NRC and DOE regarding the ES shaft. Finally, the five (5) general areas of concern within NRC regarding the shaft were reiterated:

- (1) shaft and seal design;
- (2) ES construction procedures;
- (3) sealing/grouting procedures;
- (4) testing/inspection procedures; and
- (5) QA for the above.

One important point given by Nataraja was that NRC had not identified any major safety-related effects as a result of sinking the ES shaft.

Dr. Phil Long of BWIP then presented a review of the site selection program for the repository and the ESTF within the repository. Dr. Long briefly reviewed the site selection process performed by Woodward-Clyde Consultants in their arrival at the present "A-H" reference repository locations (RRL). The RRL-2 borehole (the "principal" borehole) was drilled centrally within the area to allow greater flexibility in orientation of the eventual repository. This provides for a centrally-located ES shaft rather than the option of location the facility near the boundary of the RRL. As it later came out in the discussion by Alden McElrath (RKE/PB), there is a new plan to develop a "mini"-repository within the shaft pillar. This "mini"-repository will consist of two panels developed by the ESTF and connected to a num-

ber of 15'φ (approx.) repository shafts. This is obviously an attempt by BWIP to meet the schedule for repository loading but was veiled in terms of an experimental section of the repository for the purpose of monitoring.

Dr. Long also discussed the process of choice of the Cohasset Flow as the repository horizon. He stated that original reservations regarding the Umtanum Flow arose in the Spring of 1982, primarily as a result of high in-situ temperature. This prompted a systematic study, in May 1982, of flow comparison. The June 1982 discovery of the thick flow top in the Umtanum resulted in its elimination.

One somewhat bothersome point of Dr. Long's presentation was the very large difference in candidate flow "rating" based on the deterministic and probabilistic analyses (see viewgraphs presented at the meeting). As pointed out by Adrian Brown, a drastically different picture emerges for both analyses due to the fact that, because of the meager data base, single data points (such as that from RRL-2) can have significant import on decisions. The question which then arises is "How confident can one be of the inter- and intra-flow variations in the Cohasset flow when so many years were invested in the Umtanum only to be thrown away by results from one borehole?" Dr. Long states that much of this doubt can be answered by new research currently being conducted in geostatistical analysis; a document of this analysis is to be issued in the Spring of 1986.

A major change in direction of the program came to light through Dr. Long's talk. He stated that it is no longer considered taboo to construct repository drifts within the central vesicular zone of the Cohasset Flow. Jan Patricio of the BWIP staff stated that this change is based on a recent study by Dr. Nick Barton (current of the Norwegian Geotechnical Institute in Oslo), in which the Q-system of rock mass classifications was applied to determine stability. Dr. Barton's conclusion was that stable openings could be constructed. However, two points concerning the use of the Q-system must be noted:

- (1) the Q-system, like other rock classification schemes, is based on a data base of practical tunneling experience. The Q-system, in particular, is based on near-surface excavations in relatively massive rock masses in Scandinavia. To our knowledge, there is no data base on excavation in highly-vesicular basalts, particularly where high-pressure water may be present.

- (2) The Q-system was developed for near-surface civil construction. There is very little flexibility for the inclusion of high in-situ stress in the empirical formulation. There is only a "stress reduction factor" which is very vague in nature.

Don Dodds, BWIP's geomechanics director gave the misinformed idea that, although the (uniaxial?) strength of the vesicular zone is 60% of the intact strength, the stress in the zone would be reduced because of lower modulus. This is not correct. There must be vertical stress equilibrium across the vesicular zone, and its pinching and swelling will likely result in nearly the same horizontal stress ratios.

Construction in the vesicular zone could lead to enhanced horizontal transport of radionuclides to a shaft and thus affect the vertical transit time.

Alden McElrath, manager of ES design for RKE/PB presented the ES shaft and surface facilities design. The presentation was a routine discussion of design drawings with two significant exceptions:

- (1) the total shaft depth has been reduced by some 300 feet; and
- (2) a "mini"-repository will be excavated from the ES facility if the repository is chosen at the Hanford site.

The latter point was discussed earlier; the first represents a major programmatic re-direction since issuance of the ESTP and draft EA. It was stated (by Pierre Sarget, DOE, and Harry Babad, Chief of BWIP Integration) that the Cohasset Flow is the only target horizon to be under consideration at this time as well as in the future. In other words, if the Cohasset does not prove satisfactory, there will be no moving to another flow, and the project will end. Babad stated that the final draft EA to be submitted in the spring is altered to reflect this change.

The exploratory test shafts will be used to ventilate the "mini"-repository during construction and will subsequently be taken from the ventilation system. All repository shafts are presently expected to be drilled and will have 12'-15' ϕ ID.

McElrath also stated that the original ES-I casing design is currently under re-evaluation to take into account the rock mass and grout loadings (discussed at the NRC pre-meeting in November). This re-evaluation will be released in about two months as Case Study 11. A seismic analysis using Hanford site standards is being performed by RKE/PB on the liner (according to Dave Becker,

to be 0.25 g horizontal acceleration). Dave Becker stated that RKE/PB also is re-evaluating the Hanford seismic design standards.

Alden McElrath then informed us that the liner and grout from ES-I and ES-II will be removed from the shaft over the dense interior portions of flows but will remain in place over flow tops and interbeds to avoid shaft flooding. The liner plays no role in isolation—only worker safety.

Ed Hershberger of Morrison-Knudsen Construction was next to speak. His discussion centered on the shaft construction and underground mining methods. The shaft drilling method was reviewed. Hershberger and M-K Consultant C. K. Presley stated that no particular problems are expected with rockbursting or stuck bits during shaft construction. The impression was given that this is essentially a standard, well-developed technology—that the material is basalt is of little consequence. Presley used examples of raise bore drilling in the Coeur d'Alene district as evidence of drilling in highly-stressed, bursting ground. His statements were erroneous, however, and he appeared to have little practical knowledge of the true conditions there, although he did mention one example from the Sunshine Mine shaft boring (3,000'+ back-reamed shaft = 12' diameter). In this mine, bursting at the bit during back-reaming of a 9" pilot hole caused severe shaking of the surface drilling rig.

Hershberger noted a change from original plans in that a mechanical breakage (rather than drill and blast) will be used for breakout into the Cohasset. Once breakout is achieved, standard drill and blast practice will be followed. Again, Hershberger felt there would be no particular problems with ground control (particularly rockbursting) and no contingency plans have been formulated. This is based on a 1985 report by Wilson Blake (attached). Blake feels that the heavily jointed structure of the basalt will act to diminish the rockburst hazard.

Greater definition on chemical seals was provided by R. L. Root, of Dowell-Schlumberger. Prior to seal ring installation, a chemical flush (heavier than water) will be used to clean the formation and provide proper setting conditions for the chemical grout. The chemical seal material will then be poured in place for 20 feet. Several feet above the chemical, a water flush is again made, followed by cement-based grout. The seal is expansive in nature. Root stated that the exact nature of the seal was proprietary. Hershberger noted that the chemical seal would be stripped from the shaft with the liner upon de-commissioning. A final statement by Sher Bahadur (NRC) was given for the record. Mr. Bahadur stated that NRC feels that the BWIP position on shaft and underground construction is lacking in concern for possible ground control problems. The shaft diameter, depth, rock condi-

tions, and stress field will likely result in problems, but documents received to date show little concern. There also appears to be no contingency plans in the event of problems. A final Rockwell statement indicated that there would be a formal review of the Phase I design criteria document in about 5 months.

Tom Wintczak, Project Engineer on the Exploratory Shaft Program for Rockwell, spoke next on construction testing. During this discussion, it was stated that the 180° porthole orientation was simply made to orient one hole into the breakout direction; the 180° rotation for the second hole is simplest to drill. NRC made a strong point that this would provide data in only one plane, whereas holes at 90° intervals would yield better information. BWIP noted that the portholes are primarily for safety conditions. The liner is now in a yard at Pasco, Washington, with 180° portholes. BWIP will consider other orientations; however, new portholes are most easily added prior to liner installation.

The primary testing to be performed in the probe holes is constant head injection with increasing radial distance from the shaft. This data (according to BWIP) will provide some information on the properties in the disturbed zone. No decision has been made as yet on the plugging of probe holes.

The question was posed by NRC as to whether or not BWIP has developed a set of criteria (based on results of probe hole drilling into the Cohasset prior to breakout) for acceptance or rejection of the Cohasset Flow during initial breakout. This, obviously, is an important point—it was previously stated that the Cohasset was the only flow now under consideration. Sarget stated that the acceptance criteria are not available at this time but will be given at the end of the EIS. Tom Wintczak stated that there may be some long-term monitoring of the liner mechanical response. BWIP has prepared a report on possible instrumentation methods and is currently reviewing it.

The final speaker of the first day was Ned Hutchins, Manager of the Exploratory Shaft Program. He discussed the ES prerequisites plan which is designed to identify all elements necessary for ES construction to proceed. The component parts of this plan (functional analysis, readiness reviews, design/constructability reviews, and safety protection plans) were reviewed. All of this is leading toward a start-to-drill date of 1 August 1986. Sarget stated that thought has been given to placing an NRC official on the readiness review team. The readiness review chairman within BWIP (Hutchins) reports to Larry Fitch of RHO; the readiness review chairman within DOE reports to an as-yet-unidentified person within DOE.

In conclusion of the first day of the workshop, Sarget noted that, in ES-I design (early '82), there was not a "rigorous" performance assessment. One reason for this was that, at that time,

the ES shaft was to be placed at the edge of the repository block and was, therefore, of little concern in performance assessment.

The second day of the workshop opened with Ted Rolmeyer of BWIP Systems Engineering giving a discussion of the systems requirements tree-logic developed by BWIP. The SRT begins with a "shopping list" of data needs. This list was developed by BWIP experts (which is basically undocumented). NRC was concerned about what analyses have gone into the selection of data needs. BWIP states that there were no analyses, but only "absurd" data needs were not included in this initial list. Bob Cook (NRC) pointed out that there is a great reliance on the BWIP expert opinion and, for QA purposes, the process of data needs identification must be documented. BWIP stated that, although the present SRT is not complete, the final version will provide a cross-referencing to tests in the test plan and to resolution of questioning over the SRT approach. Further discussion was tabled until the testing meeting in early 1986.

Anthony Knepp, BWIP engineer, introduced the ES performance assessment. He first presented an ES construction potential impacts matrix which identified possible site characterization and isolation impacts from the geology, hydrology, geochemistry, and geomechanics aspects. There is currently no back-up for the ES matrix—all is based on expert opinion. The performance assessment modeling approach in use at BWIP is primarily a probabilistic approach using Monte Carlo sampling techniques. Deterministic models are also being used to perform sensitivity studies. Knepp states that BWIP is actually trying to tie down probability from performance assessment analyses.

R. M. Craig, Staff Engineer - Hydrology for BWIP, discussed the effects of shaft construction on hydrologic characterization. The shaft construction will affect site and facility flow directions and gradients. BWIP feels that shaft construction methods minimize the impact on hydrologic characterization of the host rock.

The current hydraulic baseline monitoring will be continued until a baseline measurement of the potentiometric surface is established. If this surface is not established before shaft drilling begins, the start-to-drill date will be delayed. Also, no large-scale hydraulic stress testing will be conducted while shaft sinking is occurring in the Grande Ronde flows.

The water in-flow calculations presented in the conceptual design document were reviewed. For normal operating conditions, a dense interior hydraulic conductivity of 10^{-11} was used (a conservative value, according to BWIP, since Cohasset values are 10^{-13} to 10^{-11} m/sec), resulting in a flow rate to the drifts of 0.023 gal/min. This is based on 17 downhole measurements of hydraulic

conductivity. The in-flow rate of 100 gpm for flow tops is based on 37 measurements of hydraulic conductivity with a mean of 10^{-7} m/sec. The maximum in-flow rate for a flow top is 3,400 gpm, based on a 6 m drift with hydraulic conductivity of 10^{-5} m/sec. This final scenario is felt to be highly improbable by BWIP.

Bob Baca of BWIP reviewed the performance assessment calculations performed by B. Sagar and R. Seitz. Two new references concerning this work were given:

- (1) Cottam, A. E. "An Evaluation of the Extent and Properties of the Zone of Disturbed Rock around a Vertical Shaft Excavated through Basalt Flows at BWIP," SD-BWI-TI-128, 1983; and
- (2) Fredenburg, E., and ? Sonicker. "Performance Assessment in Support of Task V Engineering Studies, 5, 6, 7, 8, 9," SD-BWI-ER-006, 1985.

Baca described a computer simulation using the PORFLO (porous media flow) two-dimensional program for examining the effect of the shaft on radionuclide transport. The coupled processes of groundwater flow, heat transfer, and radionuclide transport were modeled assuming a radionuclide release time of 6,000 years (the entire inventory is assumed to dissolve instantaneously in the emplacement rooms). The disturbed zone around the shaft and underground workings was estimated using an LBL study of permeability vs radial distance around a circular opening. This analysis is very crude and is not based on any physical evidence. In particular, the DRZ was assumed to be very small around the repository and did not appear to recognize the significantly large yield zone which will exist in the actual repository. The resulting effect of these analyses was a hydraulic conductivity of 10^{-8} m/sec in the shaft DRZ. The result is that the preferred flow path for water at the shaft base is up the DRZ around the shaft until a flow top is intersected. At this time, the high permeability and large flow rates in the flow top carry the particles horizontally. The preferred path for the water particles within the repository is horizontally within the backfilled drifts. Where the particles leak horizontally from the horizon was not made clear.

The major point of these discussions is that the shaft seals do little but seal the shaft itself. The flow occurs up the DRZ around the seals. The ultimate finding is that less than 1% of total release from the repository goes through the shaft seals subsystem.

Krishan Wahi raised the point that these conclusions appear to be in conflict with a paper presented by IT Corp. (a BWIP contractor) at a recent meeting in Pasco, Washington. This study indi-

cated substantial flow rates in the shaft. BWIP had little to say about this, except that IT had assumed a 300 m drop in head in the aquifer overlying the Cohasset (?).

The shaft seals design was reviewed by E. A. Fredenburg, Manager of the Repository Seals Program. BWIP is presently going with a design which calls for plugging the shaft with a 75% crushed basalt/25% bentonite backfill. The shaft liner will be removed by impactors over the dense interior flow portions but left in place over flow tops and interbeds. Several schemes of excavation of the shaft wall and emplacement of fill materials to provide a seal for the DRZ were discussed. These include excavation of the wall by smooth wall blasting, rock sawing, and overlapping drill holes. In every case, the DRZ would be extended somewhat around the new excavation. There is some doubt, therefore, as to the utility of doing any of this work. Battelle PNL is using the UDEC code to attempt better analysis of DRZ development and interaction with the shaft seals.

Fredenburg then reviewed the performance assessment calculations for the shaft presented in CR-015, showing how the 1,000 year travel time criteria can be met. Although BWIP makes this point (in conclusion), that the ES-I excavation will not compromise repository performance, NRC notes that we will not know if the repository has been compromised until construction occurs.

The major points of the two-day meeting are reviewed in Appendix B.

Miscellaneous Comments — A tour of the shaft drill rig and the NSTF was held on 9/2/85. The tour was led by Don Brown and Tom Wintczak of BWIP. After the tour, Mark Board participated in informal discussions with BWIP geomechanics staff at the CDC building in Richland. Here, the BWIP staff expressed the desire for NRC to be a bit more forceful in its demands for computational results, particularly those concerning modeling of repository stability and DRZ development. There evidently is a great deal of friction between Rockwell technical staff and DOE and its subcontractors (RKE/PB and M-K). Apparently, DOE and its subcontractors feel that there will be little or no problem in high in-situ stress, ground stability, or in the analysis of the DRZ, whereas BWIP engineers are very concerned. DOE does not support BWIP's desire to perform further analyses in this area; however, BWIP feels that, if NRC makes a case for these studies, DOE will relent.

Mark Board

Mark Board
19 December 1985

mb/ks

APPENDIX A

DOE-NRC Workshop ES Design, BWIP Participants

APPENDIX B

Major Points/Observations

1. The shaft depth has been changed and only the Cohasset Flow is currently being considered as a potential repository horizon. The EA has been changed to read that only the Cohasset Flow is a possibility.
2. The ES facility will be developed into a "mini"-repository within the shaft pillar prior to development of the full-scale facility.
3. The casing liner design is currently being re-evaluated by including additional loading sources. The seismic design criteria is currently being re-evaluated by BWIP staff. A report covering the new liner design will be submitted to NRC when completed: Case Study 11, issued in 2 months.
4. The post-closure seals in the shaft will consist of crushed basalt (75-80%) and bentonite (20-25%). The liner and grout will be stripped from the shaft over the dense portions of Grande Ronde flows and left in place at the flow tops and interbeds as well as all flows above Vantage.
5. The performance assessment of the shaft indicates vertical flow at the shaft occurs within the DRZ, virtually by-passing seals. BWIP results do not agree with IT Corp. results.
6. BWIP plans to use both probabilistic and deterministic models for performance assessment.
7. BWIP feels there will be no problems with shaft drilling method or drifting; however, no contingency plans or substantive details on ground stability considerations were given. NRC feels that depth, high stress magnitude, large deviatoric stresses, and heavily-jointed structures may cause ground control problems not anticipated by BWIP.
8. NRC has no argument with RRL location or ES shaft location within the RRL based on the data supplied.
9. Construction is judged by BWIP to be safe within the Cohasset vesicular zone and may occur during repository development.
10. NRC would like to get chemical composition of the chemical flushes and chemical seal materials.

11. NRC cannot agree that ES will not compromise the repository horizon. This will not be known until construction is complete.
12. Portholes are placed in the liner at 180° intervals for ease in drilling. Drilling could be performed at other angles consistent with shaft services. This would require new portholes placed in the liner prior to installation.
13. Pierre Sarget stated that there will be no compression of the testing schedule even if construction delay slips occur.
14. Drilling of the shaft is to begin in August 1986, but date will probably slip.
15. Shaft sinking will not begin until a hydrologic baseline is established. No large-scale hydro-stress testing will occur during shaft sinking in Grande Ronde.
16. Rockwell does not plan to trace mud infiltration into the wall rock.
17. Agreement was reached on the definition of performance assessment.
18. Pierre Sarget wishes to have no field changes in design or testing.
19. BWIP defines its system mission as the isolation of high-level waste from the accessible environment. The project mission is to prove whether or not the Hanford site is an adequate location for a repository.
20. A formal ES-I design criteria update will be released in 5 months and will be submitted to NRC.
21. There are no plans, at present, to monitor the liner or grout after installation, although an instrument plan was recently completed and is under review.
22. Acceptance criteria for decision on the initial suitability of the Cohasset prior to breakout will be at the end of the EIS.
23. BWIP feels that the ES shaft:
 - (1) will have no appreciable effect on site hydrologic characterization—i.e., no adverse effect on site characterization;
and

- (2) does not play a major role in radionuclide transport to the accessible environment (<10% of total flow)—i.e., BWIP feels that the shaft will not compromise isolation capability of the repository.

DOE-NRC Workshop ES/Design, BWIP
IVAN COTTLE

12-2-85
4-424-5258

Appendix A

CK Presley CONSULT. M-IC

509-834-2156

303 293-0556

BILLY MCLAURIN DRESSER MAGCOR

GEORGE JACKSON ROCKWELL/BWIP

(505) 376-4572

F.C. LARVIE MORRISON KNUDSEN

(303) 752-8586

Bob Marusich RITC

(501) 376 3759

MIKE NICOL Rockwell/BWIP QA

(509) 376-5424

DENNIS H. IRBY DOE/NV

755 575-1696

TED PETRIC DOE/RL

444-0216

George Huang ONWI

976-5093

JR Schmeeman Parsons Brinckerhoff/
PB-KBB

713/531-6069

Kamsu Kim

BWIP

376-4934

Ed Friedenburg

Rockwell/BWIP

755 444-4934

P.L. Bealeau

DOE RL

376-7943

R.P. SAGET

DOE RL

376-5039

Michael Ault

RITC

376-7250

376-7133

R.M. YBARRO

RITC

376-4527

M.J. Smith

RNO

376-7001

Joe Fernandez

SNC

846-2365 (FTL)

O.E. Trapp

RKE/PB

(415)-268-5083

TOM DAVIES

DOE/RL

(509) 376 7924

TERRY BATES

WESTON/HERBES

(301) - 963-6850

Name	Organization	Phone
Fred Sargent	Rockwell/Licensing	(509) 376-2554
JOSEPH J. KRUPAR	DOE/RL/LIS	FTS 444-2385
Bill Heilman	RHO/BWIP	(509) 376-2554
J.M. McKinney	RHO/BWIP/QA	376-5191
T. Wintzack	RHO/BWIP	509-376-7654
John Graham	RHO/BWIP	509-376-8506
Bruce Nicoll	DOE-RL	509-376-6006
Philip Long	RHO/BWIP	509-376-6246
RALPH GIMERT	RHO/BWIP	509-376-8919
PAUL HILDBRAND	USNRC	303 236 2518
JOHN LINDEMAN	NRC	FTS 427-4622
John Buckley	NRC	FTS -427-4544
Sher Bahadur	NRC	FTS 427-4495
KRISHAN WAHI	NRC/Sandia	FTS 844-6268
HAROLD LEFEVRE	NRC	FTS 427-4532
FR COOK	NRC	943 4669
Tony Knapp	DOE-RL	FTS-376-4934
Don Dodds	RHO	FTS 444 9581
LARRY CALDWELL	HOC	(509) 946-9039

<u>Name</u>	<u>Organization</u>	<u>Phone</u>
R. E. West	SAIC/NNWSI	702-295-0050
DG Price	RHO/BWIP	373-1037
L Connell	Rockwell Int	376-8795
K.A. HADLEY	RHO LICENSING	376-6204
V.G. REISER	RHO INTEGRATION	376-1059
P.C. MICLEA	RKE/PB	(415)-268-6288
Harry Zabad	RHO BWIP Integration	(509) 376-7984
Norb Drouhand	Downwind Farmer	830 Grosscup Bldg. 4 W. Richland, wa
PATRICK DOUGHALTY	PARSONS-REDPATH	
Jan Patricia	RHO	(509) 376-9978
Dean Stucker	DOE/HQ	FTS 252-1244
TOM MERSEN	NNWSI/LOS ALAMOS	(202) FTS 843-5726
Alden McElrath	RKE/PB	415-468-6161
D.I. HERBORN	RHO	FTS 444-1853
G.C. Evans	RHO	376 5264
RC Bacon	RHO	FTS 444-2496
WH Hutchins	RHO	(509) 376 8218
MD Veatch	RHO	509 376-6786
E.E. Hershberger	H-K	509 373-3190
R L Root	Dowell Schlumberger	303 773-8800
WJ Dodson	RKE/PB	509 376-1346

<u>Name</u>	<u>Organization</u>	<u>Phone</u>
V. NGUYEN	EWA, INC / YAKIMA	612/559-3706
V. RAJARAM	Self Employed / E.I. Consultant	312-767-4307
Peter Huel	Engineers International	
Jack Daemen	Univ of Arizona	602 621 2501
M. S. Nataraja	US NRC	427-4319 (301)
JAKE PHILIP	US NRC	(301) 4274604
AMITABHA MUKHERJEE	ENGINEERS INTERNATIONAL	(312) 963-3460
Michael Sokaski	U.S. Bureau of Mines	509 4891610
Mike Beus	" " " "	" " " "
Mark Board	Itasca Consulting Group	(612) 623-9599
ADRIAN BROWN	NUCLEAR WASTE CONSULTANTS	(303) 472-2040
DAVID A. STEWART-SMITH	ORE. DEPT. OF ENERGY	(503) 378-3187
Robert R. Romanel	Murtison-Knudsen Co	509-373-3062
Larry Ritch	Rockwell BWIP	509-376-6846
M J FORMAN	DOE - RL	509-376-7062
R. D. Hudson	DOE - RL	509-376-7074
H. H. Aronson	YAKIMA FROM NAPS	303 794-7936
J. H. LARUE	RHO	509 373 3106
Bill Brewer	State of WA	206 459-6676

DOE-NRC Workshop
ES Design December 3, 1985

<u>Name</u>	<u>Organization</u>	<u>Phone</u>
Rick Nolting	RKE/PB	415/268-6308
Michael Weber	NRC - WMGT	FIS 427-4746
M. Bensky	Rockwell	444-9299
J. Dorsey	Rockwell	
R. Michael Gray	RHO/BWEP	444-2292(FIS)
J. J. Lane	Rockwell	373-1901