PDR-1
LPDR- WM-10 (2)
WM-11 (2)
WM-16 (2)

A Record File 101 WM Project 10, 11, 16
Docket No.
PDR ✓
XLPDR ✓ (B, H, S)

101.1/HEL/87/09/08

Distribution: 1

(Return to WM, 623-SS)

MEMORANDUM FOR: Ronald L. Ballard, Branch Chief
Technical Review Branch
Division of High-Level Waste Management
Office of Nuclear Material Safety
and Safeguards

THRU: Philip S. Justus, Section Leader
Geology/Geophysics Section
Technical Review Branch
Division of High-Level Waste Management
Office of Nuclear Material Safety
and Safeguards

FROM: Harold E. Lefevre
Keith McConnell
James Warner
Geology/Geophysics Section
Technical Review Branch
Division of High-Level Waste Management
Office of Nuclear Material Safety
and Safeguards

SUBJECT: REPORT DESCRIBING ACTIVITIES ASSOCIATED WITH THE AUGUST 2 THROUGH 6, 1987 YAKIMA FOLD BELT FIELD TRIP IN THE VICINITY OF THE HANFORD (BWIP) SITE

PLACES VISITED:

Ellensburg, Washington and Vicinity - Department of Geology at Central Washington University and numerous locations throughout the Yakima fold belt.

Yakima, Washington Vicinity - Geologic stop at Union Gap.

Toppenish, Washington and Vicinity - Offices of the Yakima Indian Nation and geologic stops at Toppenish Ridge.

Vicinity of Goldendale, Washington and The Dalles, Oregon - Geologic stops in the Columbia Hills.

DATES OF TRIP: August 2 through 6, 1987.

PERSONS PRESENT:

The following organizational representatives participated on one or more occasions, in the activities/events described in this trip report:

87294182
WM Project: WM-10, 11, 16
PDR w/encl
(Return to WM, 623-SS)

H

WM Record File: 101
LPDR w/encl

NRC	DOE	WESTINGHOUSE HANFORD (DOE)	YAKIMA NATION
F. R. Cook H. Lefevre K. McConnell J. Warner	R. Lassilla D. Marjaniemi	T. Tolan M. Parsons	S. Armstrong

WESTINGHOUSE HANFORD CONSULTANT (DOE)	LLNL (NRC)	BUREAU OF MINES (NRC)
J. Anderson (Independent) D. West (Golder Associates)	R. Galster L. McKague	R. Raney

NEZ PERCE AND UMATILLA INDIAN TRIBES CONSULTANT	YAKIMA INDIAN NATION CONSULTANT	WASHINGTON PUBLIC POWER SUPPLY SYSTEM
Michael West (CERT)	P. McGee (EWA)	W. Kiel

CENTRAL WASHINGTON UNIVERSITY	YAKIMA VALLEY COLLEGE	STATE OF OREGON
R. Bentley J. Powell	N. Campbell	J. Black

STATE OF WASHINGTON

W. Brewer[1]
W. Lingley, Jr. 1

PURPOSE AND BACKGROUND OF TRIP

The NRC, throughout its review of documentation submitted by the DOE in conjunction with its pre-Site Characterization activities at BWIP, has consistently queried DOE's bases relating to a number of geologic issues. (See NRC comments, Draft and Final Environmental Assessments, etc.) Recognizing that resolution of any issue requires sharing a mutual data base by all affected parties, the NRC staff invited cognizant technical personnel from numerous affiliations to participate in the field trip. This field trip permitted the NRC staff (and others) to consider additional information and alternative interpretations regarding two of BWIP's major unresolved issues - the prevalence of Quaternary faulting and the possibility of

---

1 Invited, but unable to attend. The State of Oregon representative, Jerry Black, served as a representative of the State of Washington also, since prior committments precluded the attendance of the Washington State representatives, W. Brewer, Office of Nuclear Waste Management, and W. Lingley, Jr., Division of Natural Resources.

tectonically-induced stratigraphic thinning across anticlines in the Yakima fold belt.

Topics related to tectonics in the Yakima fold belt which we specifically requested Dr. Bentley and Dr. Anderson address on the field trip were:

1) Evidence for Quaternary faulting in the Pasco basin.

2) Evidence outlining the relationship of folding to faulting in the Pasco basin.

3) Evidence on the timing and rate of deformation in the area of the Pasco basin.

4) Deformation in synclinal areas, namely the Vantage syncline as an analogue to the Cold Creek syncline.

5) Evidence for Holocene faulting in the Columbia Hills area.

Additional topics that we did not specifically request but which were addressed on the field trip include:

6) The use and reliability of field criteria in basalt flow identification.

7) Invasive relationships in basalt-interbed interactions.

8) The reliability of using interbeds in stratigraphic and structural interpretations.

9) Along-strike segmentation of Yakima fold belt anticlines.

10) The role of northwest-trending structures in deformation in the Pasco basin.

This field trip was made possible primarily through the auspices of Dr. Robert Bentley and Jack Powell of Central Washington University at Ellensburg, Washington as well as that of Dr. James Anderson, formerly of Pomona College at Claremont, California. It is hoped that this field trip will provide a catalyst for further exchanges of information in the form of DOE-sponsored field trips and workshops.

SUMMARY OF PERTINENT POINTS:

The field trip was very successful in outlining to the NRC staff specific points about the geology of the Pasco basin that have a direct bearing on the tectonic stability of the proposed repository at Hanford. These specific points are outlined below and described in detail in Attachment AA.

- Efforts by the Bureau of Reclamation and Dr. Newell Campbell on possible Quaternary faults in the Saddle Mountains, Frenchmen Hills and on Toppenish Ridge suggest that a greater emphasis on neotectonics is required at Hanford.

- The possible presence of invasive flows suggests that interbeds which are not well defined within the stratigraphic succession may be unreliable indicators of thinning over anticlines.

- Evidence from the field trip suggests that tectonic features are probably more common in synclinal structures than the BWIP EA indicates.

- Data supporting the various interpretations of the timing and rate of deformation are not strong suggesting that, at this time, any estimates of the rate of deformation are largely unreliable.

- While criteria for both field and laboratory identification of flows seem to be fairly well defined, this information is scattered throughout the literature, with no single reference which lists the identification criteria for individual flows.

- The origin of many northwest-trending structures within the currently defined structural model of the Yakima fold belt is largely unknown.

PROBLEMS ENCOUNTERED:

1) NRC staff conclusions as stated in this report are based on (1) personal field observations and (2) unpublished data and information presented by the field trip leaders (Drs. Bentley and Anderson). Therefore our conclusions are preliminary, subject to future modification pending publication and review of Drs. Bentley and Anderson's interpretations and conclusions presented on the field trip.

2) The NRC staff and others on the field trip acquired valuable insight into the stratigraphy and tectonics of the region adjacent to the Hanford Reservation through field stops at numerous locations. However, the overall field trip would have benefited had DOE/BWIP chosen to permit its consultant, Westinghouse Hanford Company, to freely participate in the discussions and geologic field stops of August 3, 4 and 5, 1987.

PENDING ACTIONS:

1) Participation in DOE's suggested October 19, 1987 Workshop at Richland, Washington and in the October 20 - 22, 1987 field trip in order to gain additional insight regarding DOE's techniques for identification, mapping and correlation of the individual Columbia River Basalt Group flows and the Ellensburg formation units.

2) Participation, by Bureau of Reclamation invitation, in the late September field trip to the Saddle Mountains-O'Sullivan Dam areas, in order to observe firsthand the results of the Bureau's trenching in areas presently suspected to have been affected by Quaternary faulting.

3) Consideration of support for Dr. Bentley's publication of a series of papers/reports bearing upon selected topics identified in this report.

RECOMMENDATIONS:

1) Encouragement of Drs. R. Bentley and J. Anderson to document, through publication, their field trip statements and interpretations.

2) The Department of Energy should permit its contractor, Westinghouse Hanford Company, to participate in all segments of future field trips.

3) The "Summary of Pertinent Points" portion of this report (see page 4) identifies several issues that DOE should consider addressing extensively in its site characterization activities. Some of the identified issues include:

(a) Recognition that Quaternary faulting within the Yakima fold belt is more common than that reported in pre-SCP documentation.

(b) Tectonic structures (faulting) may be more common in synclines (including the Cold Creek syncline) than indicated in DOE documents such as the Final Environmental Statement.

(c) Interbeds (such as the Vantage and Mabton) are probably unreliable indicators of thinning over anticlines.

(d) DOE's development of procedures addressing the identification criteria for individual Columbia River Basalt Group flows as well as criteria for the identification of other stratigraphic units including the Ellensburg formation interbeds and the suprabasalt sediments.

(e) The Department of Energy should be encouraged to reopen (or even expand the area of investigation, if considered worthwhile) Dr. Newell Campbell's Toppenish Ridge trenches in order to confirm (or refute) the tectonic origin of the fault.

SIGNATURES	DATE
Harold E. Lefevre Harold E. Lefevre	09 SEPT 1987
Keith L. McConnell Keith McConnell	9/9/87
James Warner James Warner	9/9/87

Attachments:
Attachment AA - Detailed Description of Field Trip (Days 1 - 4)
Attachment A - Dr. Bentley's Field Trip (Days 1 - 3)
Attachment B - Dr. Anderson's Field Trip (Day 4)

ATTACHMENT AA

DETAILED FIELD TRIP DESCRIPTION:

The following is a detailed description of the field trip broken out by the specific topics requested to be addressed and additional topics which also were addressed. (NOTE: See Attachments A and B for the referenced pages).

1) EVIDENCE FOR QUATERNARY FAULTING IN THE PASCO BASIN:

On Day 1, Stop 1 (Attachment A, p. 2) Dr. Bentley showed the participants a thrust fault of possible Quaternary age on the Boylston Mountain anticline. At this exposure basalts of the Rocky Coulee flow are thrust over post-Wanapum basalt talus. No data is available to define the age of the talus so the exact age of faulting is uncertain, however, Dr. Bentley states that movement could be as young as Pleistocene. Dr. Bentley also showed the field trip participants extensional faults of possible Quaternary age near the axis of the Hog Ranch anticline (Stop 2-Attachment A, p. 2-3).

On Day 3, Newell Campbell gave an early morning presentation on possible Quaternary features. Quaternary faults on Toppenish Ridge and possible Quaternary faults at Union Gap, Smyrna Bench (Saddle Mountains) and O'Sullivan Reservoir were discussed.

Toppenish Ridge: Thrust faults occur on the toe of the Ridge and normal and reverse faults on the ridge itself (Attachment A, p. 91-96). Faulting took place in the last 13,000 years based on the presence of Touchet sediments. Trenches across the fault showed the fault to dip approximately 9° to the south with Ellensburg sediments faulted over colluvium. Displacement is at least 5 or 6 feet. The basalt above this fault zone is brecciated suggesting a tectonic origin.

Union Gap fault: The fault at Union Gap occurs on the north flank of Umtanum Mountain. At least 6-7 meters of offset was observed in a now covered roadcut. Caliche dated at 30,000 years was cut by the fault but Touchet sediments were not.

Smyrna Bench: Mike West is working on possible Quaternary faults for the Bureau of Reclamation. Smyrna Bench is composed largely of Ringold sediments (2.6 m.y.). A graben occurs at the break in slope between an anticline on the Saddle Mountains and the bench. This graben is ¼-½ mile wide and has enclosed basins. A second graben structure trends to the southeast. These grabens could be tectonic features or the result of slumping of Ringold sediments, the latter of which is doubted because there is no disruption of Ringold sediments.

O'Sullivan Reservoir: At an exposure along the shore, the Roza flow is displaced over colluvium and Ringold sediments. Slickensides are present and the basalt is highly brecciated. This feature will be trenched in the Bureau of Reclamation effort.

2) EVIDENCE OUTLINING THE RELATIONSHIP OF FOLDING TO FAULTING IN THE PASCO BASIN

On Day 1, Stop 12 (Attachment A, pages A15-A17 and A48), Dr. Bentley presented evidence which suggested that the model relating faulting to folding along Umtanum Ridge as outlined by the DOE (Price, 1982) was incorrect. Dr. Bentley indicated that the Umtanum fault along the northern limb of Umtanum was independent of the folds. Folds in the hanging wall of the Umtanum fault locally plunge out while the fault continues (Attachment A, p. A48). On Day 4 Stop 1 (Attachment B, p. B2), Dr. Anderson also presented evidence that the fold model outlined in Price (1982), which indicates that no strain or deformation is present in synclines, is incorrect. The evidence presented by Anderson suggesting Price's model is incorrect is the deformation (i.e., faulting) observed in the syncline between the Columbia Hills and Horse Heaven Hills anticlines (see #4 below).

3) EVIDENCE FOR THE TIMING AND RATE OF DEFORMATION IN THE AREA OF THE PASCO BASIN

The age of deformation on Yakima fold belt structures, which remains an unresolved problem, appears to span an interval from late Grande Ronde time to the Holocene. In addition, there is disagreement concerning the rate of uplift. Reidel (1984) (used in the USDOE EA, 1986; Section 3.2.3.8) favors a model of relatively rapid (250 m/my) uplift in late Grande Ronde time, followed by a decrease in uplift rate (to 40 m/my) into the end of the Miocene (until about 3.5 mya). In contrast, Dr. Bentley believes that the majority of significant uplift occurred episodically during post-Frenchman Springs time.

(a) Pre-Frenchman Springs Time Deformation

Dr. Anderson showed that the Frenchman Springs flows (Ginkgo and Sand Hollow flows) thin with proximity to the frontal fault of the Columbia Hills anticline (Day 4, Stop 2-Attachment B, pgs. B2, B3, B7, B8) . This is used as evidence for pre-Frenchman Springs time (15.6 mybp) uplift on the Columbia Hills structure. Dr. Anderson also showed that wrench faulting (Laurel fault zone) was possibly underway in the Dalles-Umatilla syncline (south of the Columbia Hills anticline) before the emplacement of the Frenchman Springs flows (Day 4, Stops 3 and 4-Attachment B, pgs. B3-B5). His evidence includes:

(1) a missing Vantage interbed on the upthrown side (eastern side) of the fault zone. We actually observed a thin (approximately 4-8 cm), relatively coarse Vantage interbed during the stop. The stratigraphic level of the Vantage interbed on the downthrown side of the fault zone is below the

ground surface, but Dr. Anderson indicated that this unit is exposed in other areas of the Dalles-Umatilla syncline.

(2) the presence of an anomalously inclined Ginkgo flow basal colonnade on the western side of the fault. This is typically a result of an inclined cooling surface in intracanyon flows; however, at this location it is interpreted to be a result of flow emplacement following fault offset

(3) offset and basalt stratigraphy variation across the fault zone.

Dr. Anderson's data are consistent with the work of Reidel and Fecht (1981 and 1983), Reidel et al. (1983), and Reidel (1984), who support the idea that significant deformation in the Yakima fold belt took place during late Grande Ronde through Wanapum time.

Dr. Bentley stated that his isopach data does not support the existence of significant late-Grande Ronde/early Frenchman Springs uplift on Yakima fold belt anticlines. In contrast to the BWIP-Westinghouse view that presently expressed structures have been the dominant control on flow isopach trends since late Grande Ronde time, he favors a model of relatively minor irregular subsidence and uplift during Grande Ronde and Wanapum time along structures that do not necessarily coincide with presently recognized structures (for example, see the discussion of Stop 14-Attachment B, pgs. B18 and B19, Dr. Bentley states that much of the Saddle Mountains-Hanson Creek area was a structural low during Wanapum time).

Dr. Bentley believes that the oldest flow distribution that definitely reflects anticlinal uplift is that of the Roza flow, and he has presented outcrop data (discussed in (b) below) as evidence for two periods of post-Wanapum uplift in the Saddle Mountains.

(b) Post-Frenchman Springs Time Deformation

Dr. Bentley supports the idea that the majority of Yakima fold belt anticlinal uplift occurred as two tectonic pulses following the emplacement of the Priest Rapids flow (Attachment A, p. A90). During field trip Stop 8 (Attachment A, pgs. A10 and A11), he used deformed, post-Priest Rapids time basalt clast-bearing and overlying yellow metaquartzite pebble-bearing fanglomerates as evidence for episodic post-Priest Rapids time (14 ± .5 mybp) and post-Elephant Mountain time (9 ± 1 mybp) (and possibly post-Snipes Mountain gravel time - 7 ± 1 mybp) uplift, respectively. NRC staff noted the fine-grained, basalt clast-free nature of the Vantage and Rattlesnake Ridge interbeds at several stops; thus, the interpretation of coarse, basalt clast-bearing fanglomerates as a result of an interval of rapid uplift is interesting. Dr. Bentley's model would interpret the fine-grained, basalt clast-free nature (as opposed to the fanglomerates seen at Stop 8) of many of the Ellensburg Formation sediments observed on the field trip (such as the numerous outcrops of the Vantage interbed) to be a result of little or no

tectonically-induced topographic relief during late Grande Ronde time. Alternatively, Reidel's model (Reidel, 1984; his fig. 14) would presumably account for this by the burial of incremental uplift by successively emplaced basalt flows.

4) DEFORMATION IN SYNCLINAL AREAS, NAMELY THE VANTAGE SYNCLINE AS AN ANALOGUE TO THE COLD CREEK SYNCLINE:

Dr. Anderson showed the field trip participants a generally south-dipping intra-Sentinel Gap thrust that is located in the intervening syncline between the Columbia Hills and Horse Heaven Hills anticlines (Day 4, Stop 1-Attachment B, pgs. B2 and B6). Dr. Bentley took us to a small-scale thrust that terminates into a sinistral tear fault along the crest of the NW-trending Ryegrass Mountain anticline south, which is a NW-striking, low amplitude anticline that is located between the Frenchman Hills and Saddle Mountains anticlines (Attachment A, pgs A9, A10, and A23). Dr. Bentley used this fault as an example of a small compressional fault that has developed on a low amplitude anticline within a broad synclinal area. The ages of these thrusts can not be constrained; however, their position within synclines and the identification of tectonic breccia zones in Hanford boreholes suggest that small-scale thrusting may have occurred in the Cold Creek syncline (and may still be occurring as evidenced by shallow earthquake swarms).

5) EVIDENCE FOR HOLOCENE FAULTING IN THE COLUMBIA HILLS AREA:

On Day 4 Stop 2, Dr. James Anderson was asked about his interpretation of Holocene faulting along the Luna Butte fault that was published in an abstract (Anderson and Tolan, 1986). He indicated that after looking at the material displaced he was more convinced that the Luna Butte fault offset Holocene flood gravels. No further information was provided.

6) THE USE AND RELIABILITY OF FIELD CRITERIA IN BASALT FLOW IDENTIFICATION:

There is a general consensus among the field trip leaders that the upper Grande Ronde, Wanapum, and Saddle Mountains basalts are relatively homogeneous over large areas and can initially be identified in areas of good exposure by diagnostic phenocryst textures and position relative to regionally persistent interbeds of the Ellensburg Formation. These identifications are then confirmed by determining paleomagnetic polarity and chemical composition (TiO_2, CrO_2, and P_2O_5 are diagnostic within the Frenchman Springs Member; MgO is diagnostic within the upper Grande Ronde Formation). After well-exposed sections are measured, workers carry packages of flows and interbeds along strike to zones of less exposure. Dr. Bentley has not utilized chemical analyses as extensively as Westinghouse-BWIP geologists, who have a wealth of unpublished Columbia River Basalt chemical data. It would be a substantial contribution if the integrated approach to flow identification that is used by Westinghouse-BWIP staff was formalized as a document. A positive note concerning Columbia River basalt chemical data is that all of the primary workers in the area have

utilized the XRF lab at Washington State University, thus providing a consistent data base.

7) INVASIVE FLOW RELATIONSHIPS IN BASALT-INTERBED INTERACTIONS:

The role of invasive flows is a key element in understanding stratigraphy and structure of the area. This topic first came up on Day 1, Stop 13 (Attachment A, p. A17. Dr. Bentley indicated that local thinning of the Vantage on the Yakima Ridges and the Hog Ranch axis was, at least in part, the result of invasive relations with the Ginkgo flow. In a discussion at Stop 13, Dr. Anderson implied that Dr. Bentley was relying on assumed invasive flow relations to discount pre-Vantage deformation and that this perhaps was not a valid assumption. Dr. Bentley indicated that invasive flow relations were present east of this exposure and that assuming that a similar relationship existed here was justified.

Invasive flows also came up on Day 4, Stop 1 (Attachment B, p. 2). At this exposure, the Ginkgo flow was invasive into the Vantage. Vantage occurs both above and below the Ginkgo at this locality. This led to the question of whether members of the Ellensburg formation can be used for determining the age of deformation.

8) THE RELIABILITY OF USING INTERBEDS IN STRATIGRAPHIC AND STRUCTURAL INTERPRETATIONS:

Due to problems with recognizing invasive flows, the thinning of interbeds may not be useful for determining the timing of deformation in the Pasco basin. This question was asked of Dr. Anderson and his conclusion was that they probably were not reliable indicators unless very good control was available. Dr. Lassilla stated that there were places in the Cold Creek syncline where the thicknesses of the Vantage varied substantially also implying that interbeds may not be reliable indicators of deformation. On Day 2, Dr. Galster indicated that there was no Vantage in the basin north of the Saddle Mountains while it does occur locally on the Saddle Mountains. Dr. Galster also indicated that where the palagonite layer thickens, the Vantage thins. The overall consensus seemed to be that interbeds were probably not reliable indicators of deformation.

9) ALONG-STRIKE SEGMENTATION OF YAKIMA FOLD BELT ANTICLINES:

Extensive mapping of first-order Yakima fold belt anticlines by Dr. Bentley and Jack Powell has shown that the structures vary along strike with respect to fold vergence, fold amplitude, fold trend and plunge, and direction of thrusting. Furthermore, numerous NW-striking (primarily dextral) and NE-striking (primarily sinistral) strike-slip or oblique dip-slip faults segment the folds (for example, see Attachment A, p. 39 - note the along-strike

variability of the Whiskey Dick anticline and associated faults). Dr. Anderson has mapped similar strike-slip faults in the Columbia Hills area (Day 4, Stops

3 and 4-Attachment B, pgs. B3-B5). Reidel (1984, p. 968) provides a discussion of tear faulting between various structural segments of the Saddle Mountains anticline. The most obvious potential manifestation of tear or strike-slip faulting near the RRL is along the Gable Mountain/Gable Butte anticline, which shows a left-stepping en echelon pattern (Attachment A, p. A23). If such features are present along the buried eastern extension of the Yakima anticline, they would project northward towards or into the RRL.

10) THE ROLE OF NORTHWEST TRENDING STRUCTURES IN THE TECTONIC MODEL:

Many of the stops during Days 1 and 4 dealt with northwest-trending structures such as the Hell's Kitchen fault, Kittitas linear, and Luna Butte fault. While many of these features can be attributed to a dextral shear in north-south compression, features such as the Naneum-Hog Ranch structure, north-south trending folds east of the Naneum-Hog Ranch structure as outlined by Tabor and others (1982) as well as the northeast directed Hells Kitchen thrust fault are difficult to explain in a dextral shear model. These features as well as north-northwest trending reverse faults such as those possibly associated with the May Junction monocline and possibly the Cold Creek barrier are not adequately explained by the structural models currently in existence.

REFERENCES:

Anderson, J. L., and Tolan, T.L., 1986, Ages of wrench faulting in interridge basins, southwest Columbia Plateau, Washington and Oregon: Geological Society of America Abstracts with Programs, v. 18, no. 2, p. .

Campbell, N.P. and Bentley, R.D., 1981, Late Quaternary deformation of the Toppenish ridge uplift in south-central Washington, Geology, v. 9, November, 1981, pp. 519-524.

Landon, R.D., 1985, Deep borehole stratigraphic correlation charts, BWIP Report SD-BWI-DP-035.

Malone, S.D., Rothe, G.H., Smith, S.W., 1975, Details of microearthquake swarms in the Columbia basin, Washington, Seismological Society of America Bulletin, v. 65, pp. 855-864.

Paillet, F.L. and Kim, K., 1987, Character and distribution of borehole breakouts and their relationship to in-situ stresses in deep Columbia River basalts, Journal of Geophysical Research, v. 92, pp. 6223-6234.

Price, E.H., 1982, Structural geometry, strain distribution, and mechanical evolution of eastern Umtanum Ridge and a comparison with other selected localities within Yakima fold structures, south-central Washington: RHO-BWI-SA-138, 223 p.

Reidel, S.P., 1984, The Saddle mountains: the evolution of an anticline in the Yakima fold belt, American Journal of Science, v. 284, October, 1984, pp. 942-978.

Reidel, S.P., Cross, R.W., and Fecht, K.R., 1983, Constraints on tectonic models as provided by strain rates, in: Caggiano, J.A. and Duncan, D.W.

(eds.), Preliminary interpretation of the tectonic stability of the reference repository location, Cold Creek syncline, Hanford site, BWIP Report RHO-BW-ST-19P.

Reidel, S.P. and Fecht, K.R., 1981, Wanapum and Saddle Mountains basalts of the Cold Creek syncline area, in: Myers, C.W. and Price, S.M. (eds.), Subsurface geology of the Cold Creek syncline, BWIP Report RHO-BWI-SA-162A.

Reidel, S.P. and Fecht, K.R., 1983, The Miocene evolution of a Yakima fold, Geological Society of America Abstracts with Programs, v. 15.

Tabor, R.W., Waitt, R.B., Jr., Frizzell, V.A., Jr., Swanson, D.A., Byerly, G.R., and Bentley, R.D., 1982, Geologic map of the Wenatchee 1:100,000 Quadrangle, central Washington, U.S. Geological Survey Miscellaneous Investigations Map I-1311.

USDOE, DOE/RW-0070, 1986, Environmental assessment, reference repository location, Hanford site, Washington, v. 1.

USNRC-Office of Nuclear Reactor Regulation, 1982, Safety evaluation report related to the operation of WPPSS nuclear project no. 2, NUREG-0892, Supplement No. 1.

SEP 11 1987

101.1/HEL/87/09/08

OFFICIAL CONCURRENCE AND DISTRIBUTION RECORD

MEMORANDUM FOR: Ronald L. Ballard, Chief
Technical Review Branch
Division of High-Level Waste Management

FROM: Harold Lefevre, Keith McConnell, James Warner
Geology/Geophysics Section
Technical Review Branch
Division of High-Level Waste Management

SUBJECT: REPORT DESCRIBING ACTIVITIES ASSOCIATED WITH THE AUGUST 2 THROUGH 6, 1987 YAKIMA FOLD BELT FIELD TRIP IN THE VICINITY OF THE HANFORD (BWIP) SITE

DATE:

DISTRIBUTION

HLWM/SF, 101.0 ✓	NMSS RF	RBrowning, HLWM	MBell, HLWM
JBunting, HLSE	BYoungblood, HLOB	RBallard, HLTR	PJustus, HLTR
HLefevre, HLTR & RF	JLinehan, HLOB	DChery, HLTR	JTrapp, HLTR
AIbrahim, HLTR	MBlackford, HLTR	KMcConnell, HLTR	JWarner, HLTR
SWastler, HLOB	DBrooks, HLTR	MNataraja, HLTR	RCook, HLWM OR
HLTR R/F	PDR		

CONCURRENCES

ORGANIZATION/CONCUREE	INITIALS	DATE CONCURRED
HLTR/HLefevre	HLef	87/09/09
HLTR/KMcConnell	KMc	87/09/09
HLTR/JWarner	JW	87/09/09
HLTR/PJustus	PJ per phone	87/09/09

NOTE: ATTACHMENTS ON FILE IN THE DOCKET CENTER.