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Potential Savings from Privatization and Competitive Procurement of Tank Waste Remediation Services at Hanford

A Report Prepared for
Jacobs Engineering Group, Inc. and
Advanced Sciences, Inc.
in support of the
Hanford Site
Tank Waste Remediation System
Environmental Impact Statement

by

David E. Serot, Ph.D.
Principal, DES Research

October 27, 1995

Introduction

This research report was written in response to a request from the Jacobs Engineering Group, Inc. in support of their work in preparing the Environmental Impact Statement for the Department of Energy's Hanford Site Tank Waste Remediation System. The report reviews studies of privatization and competitive procurement of government services and provides an estimate of the potential cost savings and labor savings from the use of privatized and/or competitive procurement of tank waste remediation services. This report does not contain any procurement sensitive information relating to any specific procurement action by the Department of Energy.

Privatization of government services and competitive procurement of government services (and products) are related and often overlapping concepts. These concepts differ from the traditional concept of a government-owned, contractor-operated facility used at Hanford. Under privatization, the facility (and related equipment) is owned by a private supplier, who provides services to the government or to the public under contractor to a government agency. Under competitive procurement, two or more suppliers compete to provide products and services to the government or to the public under contract to a government agency. The two concepts overlap when private companies and government agencies compete for contracts to provide goods or services.

This paper reviews cost and labor savings in three areas. The first is competitive procurement of government services. The second is competitive procurement of military equipment. The third is the application of industrial standards to Department of Energy projects instead of Department of Energy Orders. The results of this review are then used to estimate likely savings in costs and labor requirements for tank waste remediation.

Savings from Competitive Procurement: A Review

Competitive Procurement of Government Services

Donahue (1989) surveyed seven studies of public and contract trash collection services. Six of the seven showed that private contractors were more efficient. The seventh showed no difference. Savings ranged from 12 to 25 percent. Donahue also reports that studies of DOD contracting for support services (during the period October 1980 to October 1982) found competitive procurement resulted in an average 22 percent savings. Government workers who competed with private companies showed an 18 percent savings over previous costs. Similarly, Donahue cites a GAO study of office cleaning services. The GAO found that government supplied cleaning services cost $1.18 per square foot, contractor costs were $.73 per sq. ft., and owner-supplied services (in leased buildings) cost $.63 sq. ft. Quality was similar in all three categories. Lower wages accounted for much of the difference, but better equipment and more efficient procedures were significant factors in higher productivity by non-government workers.

Stevens (1984) studied public services in five counties in the Los Angeles area, examining eight different service functions (cited by Donahue 1989). For each function, there were ten cities that provided the service themselves and ten cities that used private contractors. Except for payroll preparation, significant savings were found in all functions using private contractors. Public agencies costs between 37 and 97 percent more than private contractors.

Hilke (1993) is a compilation of studies of cost savings from private contracting for government services, prepared for the Reason Foundation, a Los Angeles based "think-tank" that focuses on privatizing government functions. Over 100 studies were reviewed. They found cost savings ranging from 20 to 50 percent when competitive procurement was used.

Some specific examples (mentioning labor force and labor costs) from Hilke's compilation:

- Contract maintenance of aircraft reduced costs by 13 percent and increased availability of parts and aircraft. Contractor used 25 percent fewer personnel. (Savas, 1987)[1]
- Private contractors provided motor vehicle maintenance for 1 to 38 percent lower costs with equivalent or higher levels of service. In converting to private contractors, wages remained similar, but number of overhead and operating employees was reduced because of productivity increases. (Campbell, 1988)
- Another study of motor vehicle maintenance showed that competition lowered costs by about 17% through personnel reductions. The higher government costs were caused by staffing for peak demand, higher government fringe benefits, and difficulties in hiring and firing in government operations. (Stolzenberg and Berry, 1985)
- Contractor costs for wastewater/sewage treatment plants were found to be 20 to 50 percent less due to shorter construction lags and lower construction costs. Operating costs were reduced 20 to 50 percent in contractor facilities. (Hanke 1985)
- Contractor wastewater treatment costs were found to be 20 to 50% lower, because federally financed projects were subject to the Davis-Bacon Act, which increased construction costs and because of higher design costs. (Savas, 1987 and Moore, 1988)

Caver (1995) also surveys a number of studies (not found in the Hilke compilation) that examined the cost savings from competitive procurement of government services. These studies show savings ranging from 14 to 45 percent, with most examples falling in the 20 to 40 percent range. (In one case, contracting out long distance telephone services resulted in a 300 percent cost reduction, but this is an extreme example.) Caver cites an OMB study of results under OMB Circular A-76 (which established guidelines for procurement of government services through competitive bidding) showing a 30 percent reduction in labor force requirements as a result of competitive procurement.

On the other hand, the American Federation of State, County, and Municipal Employees (AFSCME) cites numerous examples of higher costs and poor service when public services are contracted out. These examples, however, are taken from newspaper reports and are not the result of systematic, quantitative studies. Similar news reports of higher costs and poor quality from government supplied services can be obtained. The preponderance of the evidence from analytical studies show cost savings from competition.

Competitive Procurement of Defense Systems

Berg, et. al. (1986) cites a number of studies of competitive procurement of weapons, munitions, and electrical components. These studies found that in most cases where competition resulted in a "winner-take-all" decision, costs were reduced significantly. When the competition resulted in a split contract, the costs savings were less likely and in some cases, there were cost increases.

The basic concept used by Berg, et. al. to explain the savings from competitive procurement is the "price improvement curve" or PIC. The PIC reflects the tendency for the price of a product to fall over time as the company making that product learns how to reduce its costs (also known as "learning-by-doing" in the economics literature). Berg, et. al. argue that the studies they cite show that competition provides greater incentives for companies to find and exploit opportunities to reduce their costs. This results in a significant, down-ward shift in the PIC when competition is introduced, creating greater reductions in prices.

Commercial Standards versus DOE Rules

The Department of Energy's Office of Defense Program prepared a study examining the adoption by DOE of industrial standards and practices to replace DOE Orders. This study compared DOE facilities to comparable industrial and other government facilities. This study was reviewed in draft. The conclusion

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[1] References cited in this list identify the sources listed by Hilke in his compilation.

of the study was that DOE requirements impose a 15 to 30 percent cost burden on DOE without compensating benefits.

Some of the conclusions reached by DOE/DP:

- Comparing two almost identical high explosive test facilities (one DOE, one private doing contract work for DOD and private industry), the study found that the DOE facility required 10 times more staff for oversight, three times more management time for environment, safety, and health (ES&H) activities, and conducted one-third fewer tests.
- Comparing two similar laundry facilities, the facility planned for Hanford and a commercial facility built in Richland instead, the study found that the planned DOE facility would have cost almost five times as much, would have taken five times as long to construct and would have occupied 66 percent more space.
- Comparing a DOE component manufacturing plant to similar private fabricators, the study found that the DOE facility required three times the ES&H staff as an IBM storage device manufacturing plant with three times the number of employees, required 13 time the ES&H staff of a comparable AT&T circuit board plant with more employees, was required to meet 30 DOE orders in addition to all of the same requirements for air and water quality, hazardous materials, solid wastes, and OSHA requirements met by the commercial plants, and had continuous oversight from a 75 person DOE contingent located next to the plant.
- Comparing explosive ordnance disposal conducted by the same company at a DOE site and a DOD site, the study found that the DOE site required 15 times more document preparation time, consumed 40 percent of total project resources for planning, documentation, review, and approval, while the DOD site required only 10 percent, required almost twice the training time as the DOD site, and required 15 time the number of copies of project documentation and five times the number of documents as the DOD site.
- Comparing two similar nuclear fuel manufacturing facilities within 100 miles of each other in the same state, the study found that the DOE facility required almost two time more ES&H staff for 480 employees than required for 700 employees at the commercial site, spent 15 to 18 percent of the total project budget on training, versus one percent for the commercial facility, and required signed documentation for all manufacturing steps even though the results in most cases were physically inspectable.

Other findings of the DOE/DP study included:

- DOE Order 6430.1A imposed a 14 percent cost burden on system design and as much as 100 percent on some components beyond industry standards for ground water clean-up. Design accounts for 65 percent of total estimated costs (TEC).
- Other DOE Orders added 15 percent to the cost of hard ware procurement for waste water cleanup, with hardware accounting for 32 percent of TEC.
- More DOE Orders added 80 percent to the cost of ground water cleanup documentation (which accounts for 3 percent of TEC).

The DOE/DP study also cited examples of cost savings from the use of best management practices, rather than standard DOE practices, by a contractor at Savannah River. Cost savings ranged from 20 to 40 percent of TEC with cost savings to date approximately $70,000,000.

Sources of Cost Savings from Competitive Procurement

Hilke (1993) identifies the following reasons why competitive procurements can lower costs:

- Better management techniques
- Better and more productive equipment

- Greater incentives to innovate
- Incentive pay structures
- More efficient deployment of workers
- Greater use of part-time and temporary workers
- Utilization of comparative-cost information
- More work scheduled for off-peak hours

According to Donahue (1989), Stevens, in her study of municipal services (Stevens 1984), identified the following factors as statistically significant differences between government agencies and private contractors in supplying municipal services:

- Direct labor accounted for 49 percent of cost for contractors and over 60 percent for government agencies.
- Contractor employees were 20 percent unionized and government employees 48 percent unionized.
- Contractor workers were younger and had less job tenure
- Contractor employees had fewer vacation days and a lower absentee rate
- There were 1.5 layers of management (on average) above labors for contractors and 1.9 layers for government agencies.
- Foremen could fire workers in 54 percent of the contractor cases, but only 16 percent of the government agency cases.
- Written reprimands were used in 33.8 percent of the contractor examples, but 72.t5 percent on the government examples.
- Twenty-seven percent of the contractor cases had employee incentive plans, while only 12 percent of the government agencies had such plans.
- Workers maintained their own equipment in 92.5 percent of the contractor cases and 48.1 percent of the government cases.
- Formal staff meeting were held in 54 percent of the contractor examples and 82 percent of the government examples.

Donahue (1989) adds: public sector wages tend to be similar across functions, while private sector wages vary substantially, municipal agencies are more structured and rule-bound, contractors are more flexible in their use of labor, provide a larger array of incentives and penalties, and often provide a more precise allocation of accountability. In general, contractors seem more focused on results than on processes.

<u>Implications for the Competitive Procurement of Tank Waste Cleanup at Hanford</u>

The technical complexity of the TWRS project, the specialized and possibly unique design and construction of the facility, uncertainty over DOE regulations and budget, technological uncertainty, etc. suggest a conservative estimate of the cost savings and labor force reductions from competitive procurement of the TWRS facilities.

Replacing DOE Orders, unique rules and operating procedures with industry standards and government regulations applicable to the rest of the government and the private sector would reduce facility design and construction costs by at least 20 percent. However, because the TWRS facility will process nuclear waste, including high-level waste, it is likely that some DOE Orders, unique rules, and procedures will remain in place. In that case a 10 percent cost reduction would be a more conservative estimate. This applies across the board, including engineering and design, equipment and materials, and labor. Construction time can also be shortened.

Competitive procurement should reduce operating costs (especially if administrative oversight and reporting requirements are reduced). A 20 percent cost reduction seems a conservative estimate, given the results of competitive procurement in other government operations. Again, a conservative estimate is suggested because of the complexity of the project and various uncertainties.

A cost reduction can mean different things in terms of labor force requirements, depending on the industry and the specific details of the project. A labor intensive project would mean that a 20 percent cost reduction would translate into at least a 20 reduction in labor requirements, if not more. In a capital intensive project, a 20 percent cost reduction may result in little or no labor force reductions. For that matter, all labor cost reduction could come from lower wages or salaries, and benefits.

Superior management, improved technology, reduced oversight and reporting burdens, etc. can all translate into reduced labor requirements, as well as the obvious case of improved labor efficiency and productivity. The TWRS project is capital-intensive. Therefore, I assume that a 20 percent cost reduction will translate into a less than 20 percent labor force reduction. At the same time, because the project is close-ended (i.e., once the tank wastes are processed, the project will shut down) improved efficiency will not lead to more demand for services, so that some labor force reduction can be expected.

I assume a 20 percent reduction in management and oversight functions, because of reduced DOE oversight and regulatory burden, and because more efficient and flexible management seems a common thread in the case studies.

I also assume a 10 percent reduction in operating personnel because a greater proportion of cost savings will come from capital services, energy, and materials, and from reduced labor costs per worker.

One other possibility is that cost reductions can come from reducing the time required to complete the project. That is, the labor force may remain the same, but the time to complete the project would be shorten as a result of improved efficiency from competitive procurement.

References

Documents Reviewed for this Report

Berg, Robert M., Richard L. Dennis, and James M. Jondrow, "Evaluation of Models and Techniques for Estimating the Effects of Competition," Alexandria, VA: Center for Naval Analysis, 1986.

Caver, Troy V., "Creating a Competitive Environment: Research Paper Relating to the Issues in Establishing Competition in Clean[-]up of Nuclear Waste at Hanford," Springfield, VA: Systems Management & Development Corporation, 1995.

Donahue, John D., The Privatization Decision, New York: Basic Books, 1989.

Hilke, John, "Cost Savings from Privatization: A Compilation of Study Findings," The Reason Foundation, 1993.

Additional References

The following references were cited by Hilke:

Campbell, A., "Private Delivery of Public Services: Sorting Out the Policy and Management Issues," Public Management 68(12), p. 3-5, December 1988.

Hanke, S., "The Literature on Privatization," in S. Butler, ed., The Privatization Option, Washington, D.C., The Heritage Foundation, 1985

Moore, S., Privatization in America's Cities: Lessons for Washington, Part I," Heritage Foundation Backgrounder #652, 1988.

Savas, E. Privatization: The Key to Better Government, Chatham, NJ, Chatham House, 1987.

Stolzenberg, R. and S. Berry, A Pilot Study of the Impact of OMB Circular A-76 on Motor Vehicle Maintenance Cost and Quality in the U. S. Air Force, Santa Barbara, CA, The Rand Corporation, 1985.

The following reference was cited by Donahue:

Stevens, Barbara J., ed. Delivering Municipal Services Efficiently, Washington, D. C., Housing and Urban Development, Office of Policy Development and Research, 1984.

[3] From: Carolyn C Haass at ~DOE4 10/17/95 4:03PM (1023 bytes: 17 ln)
To: Marc E Nelson at ~DOE_HANFORD_1, ^Jacobs Engineering Group at ~DOE_HANFORD_1
Subject: Hotline Request
---------------------------------- Forwarded ----------------------------------
From: Geoff Tallent at _Ecology_Lacey 10/17/95 3:41PM (785 bytes: 17 ln)
To: ^Jacobs Engineering Group at ~DOE_HANFORD_1, Carolyn C Haass at ~DOE4, Michelle Davis
Subject: Hotline Request
------------------------------- Message Contents -------------------------------

The following person called the TPA Hotline and requested that he be added to the TWRS-EIS mailing list:

Kirk Bose
Westinghouse Hanford Company
PO Box 1970 MS R3-2S
Richland, WA

(509) 372-3023

He would like an full copy of both the DEIS and the FEIS when available.

If you have any questions, please call me at (360) 407-7112.

-Geoff

Request Number 84

Jacobs Engineering Group
Engineering Information Request - TWRS EIS

Requested By: John Kuhn   Date: 9/21/95

Phone Number: 904 332 3318   Fax Number: 904 333 6651

Requested Information: Locations of "residences" near the Hanford site.
Please see attached sheet for additional informations.

Need Date: 9/28/95

Response:

Data Source/Accuracy:

Prepared By: Date Sent/Faxed:

Concurrence:
Marc Nelson - Deputy Project Manager

Location of Residences

Our previous analysis of radionuclide impacts was conducted to verify compliance with the Washington state standards, and used receptors that define the facility boundary. These receptors are appropriate for analysis of compliance with this standard. No exceedances of the state standard (25 mrem/yr) were predicted.

After the analysis was complete, it was determined that compliance with the National Emission Standard for emissions of radionuclides (10 mrem/yr) should be conducted. Using the same receptors as were used for analysis of compliance the state standard, an exceedance of the 10 mrem/yr value was predicted for the minimal retrieval, ISV scenario.

Use of these receptors for analysis of compliance with the national standard is inappropriate. The regulation states, "Compliance with this standard shall be determined by calculating the highest effective dose equivalent to any member of the public at any offsite point where there is a residence, school, business, or office." The regulation defines a "residence" as "any home, house, apartment building, or other place of dwelling which is occupied for any portion of the relevant year."

To properly analyze compliance with this standard, we will require the coordinates of these locations that are nearest to the 200 East and West areas, in each direction. In other words, the nearest location that is north of the areas, north-northwest of the areas, northwest of the areas, etc. Thus, approximately 16 locations should be provided. We ask that these locations be provided in the ASI coordinate system that we have been using.

Request Number 89

Jacobs Engineering Group
Engineering Information Request - TWRS EIS

Requested By: Arrie Bachrach

Date: 9/20/95

Phone Number:

Fax Number:

Request Information: Identification, location and parameters (length, width , acerage disturbed) for new roads associated with all alternatives (including borrow sites). Provoked by Ecology comment. Need for cultural and biological resources and land use disturbance.

Need Date: ASAP

Response: see attached

Data Source/Accuracy:

Prepared By: Colin Henderson

Date Sent/Faxed:

Concurrence:
Marc Nelson - Project Manager

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ENGINEERING INFORMATION REQUEST 89

Borrow Sites

1. Pit 30

Pit 30 is an existing borrow pit and has existing access roads established. No new roads would be associated with borrow site activities associated with the TWRS EIS alternatives.

2. McGee Ranch

The McGee Ranch borrow site is not a currently established borrow site. The area maps show the proposed boundry touching SR 24 in the South Eastern corner of the proposed Area A. The estimate used to date for the disturbed area at the borrow sites is based on volume of material required divided by a constant removal depth of 3 meters. I propose using a length of 750 meters by a width of 20 meters to establish an access road into the McGee Ranch area. This would be an area 15,000 square meters or 1.5 hectares.

Review of WHC-SD-EN-SE-002 Rev. 0 identifies that characterization work at McGee Ranch Site (Area A in the area maps) contains approximately 4.5 million cubic yards of fine-textured soils. This report also notes (pg. 8) that a number of closure plans and Part B permit applications have been submitted to WDOE containing commitments for McGee ranch soils as a component of a surface barrier.

3. Vernita Quarry

The Vernita quarry is an existing quarry located near SR 24. This quarry has been used in the past, approximately 10,700 cubic meters were removed in March of 1994 (Ref. BHI-00005 Rev. 00 Candidate Basalt Quarry Sites). Assume that the existing access roads into the quarry would be utilized for borrow site activities associated with TWRS. Roads may require some improvements to support the level of activity required for barrier construction.

Tanks

1. No Action- No new roads would be constructed

2. Long-Term Management- No new roads would be constructed. Access roads to the replacement tank farms would be constructed and are included in the disturbed area estimates.

3. In Situ Fill and Cap- No new roads outside of the area identified as temporarily disturbed would be constructed.

4. In Situ Vitrification- No new roads outside of the area identified as temporarily disturbed would be constructed.

5. Ex Situ Intermediate Separations- Access roads to each of the processing and support facilities would be constructed. There would be no new road construction outside of the existing site layout which is included in the disturbed area estimates.

6. Ex Situ No Separations- Access roads to each of the processing and support facilities would be constructed. There would be no new road construction outside of the existing site layout which is included in the disturbed area estimates.

7. Ex Situ Extensive Separations- Access roads to each of the processing and support facilities would be constructed. There would be no new road construction outside of the existing site layout which is included in the disturbed area estimates.

8. Ex Situ/In Situ Combination- Access roads to each of the processing and support facilities would be constructed. There would be no new road construction outside of the existing site layout which is included in the disturbed area estimates.

9. Staged Implementation-TBD

Table D.4.1.1 Atmospheric Radiological Emissions for No Action Alternative, Tank Waste			
Tank Farm Emissions		Evaporator Emissions	
Contaminants	Ci/yr Released	Contaminants	Ci/yr Released
Total Alpha[1,2]	8.64e-08	Total Alpha[1,2]	2.10e-05
Total Beta[1,2]	7.91e-07	Total Beta[1,2]	1.20e-05
^{90}Sr	1.81e-05		
^{137}Cs	5.38e-05		
^{129}I	4.60e-05		

Notes:
Source: (WHC 1995), Table 5.6. Henderson, C. Personal Communication. Jacobs Engineering Group, Kennewick, WA. September 1995. and Jacobs 1995)
(WHC 1995g) - No Disposal Action Engineering Data Package

[1] These emissions were analyzed without using decay equations.
[2] Total alpha is assumed to be Pu-239.
[3] Total beta is assumed to be Sr-90.

D.4.1.1.2 Transport

Ground Releases

Tank farm emissions

The tank farm atmospheric radiological operating emissions were modeled as a ground release. For modeling purposes, it was assumed that the source term would be released at a point in the 200 Areas represented by the meteorological conditions at the Hanford Meteorological Station. The analysis used the Hanford Meteorological Station joint frequency data from 10 m (33 ft) aboveground (Table D.35, Figure D.3).

For ground releases, dilution in the atmosphere would cause contaminant air concentrations and exposures to decrease with increasing distance from the source. Maximum individual exposures therefore would occur at the inner boundaries (i.e., closest distance to the source) of the defined receptor occupancy zones. For the non-involved worker, the maximum exposure would occur 100 m (330 ft) from the source (in an east-southeast direction). For the general public, the maximum exposure would occur 22 km (14 mi) from the source (i.e., the distance to the Hanford Site boundary in an east-southeast direction from the center of the 200 East Area).

The calculated Chi/Q values for ground releases from the tank farms were calculated by the GENII computer code to be 4.0E-04 sec/cm ($6.6E-03$ sec/in.^{3}) for the non-involved worker MEI and 6.0E-08 sec/cm^3 (9.8E-07 sec/in.^{3}) for the general public MEI. For the non-involved worker population of 10,900 occupying an area between 100 m (330 ft) from the source and the Hanford Site boundary, the population-weighted Chi/Q was 1.6E-03 sec/cm^3 (2.6E-02 sec/in.^{3}). For the general public population

ENVIRONMENTAL SCIENCE & ENGINEERING, INC.

PHONE CONVERSATION RECORD

DATE: October 26, 1995 TIME:

TO: Ray Smith FROM: Wayne Ingram

USGS Spokane, WA

PHONE NO.: 509/353-2633 PHONE NO.:

SUBJECT: Data for Columbia River near Hanford

PROJECT NO.: 8946001G-0100-8160

Summary of Conversation:
Ray gave me the following information and is mailing to me the WY 94 Water Resources Data book.

Flows at Priest Rapids Dam:

77-year record average = 118,600 cfs
77-year maximum = 692,600 cfs
77-year minimum (2/20/32) = 4,120 cfs
10-yr, 7-day low flow = 20,960 cfs

Water quality is available at the Vernida (sp?) Bridge. The station is a NASQWN station and has been in existance since 1974.

Five samplings were completed in WY 1994:

NO_2+NO_3 -- three samples <0.05 mg/L, 0.06 mg/L, and 0.05 mg/L
N (dissolved) -- all <0.01 mg/L except one sample 0.02 mg/L
Nitrogen Ammonia -- three <0.01 mg/L, 0.01 mg/L, 0.02 mg/L

Follow-up Required:

cc:

Signed: *[signature]* for Wayne Ingram

A New Method of Contaminant Plume Analysis

by P. A. Domenico and G. A. Robbins[a]

ABSTRACT

This paper develops an analytical expression for contaminant transport from a finite source in a continuous flow regime. The model requires some numerical integration and its degree of accuracy for near-field problems depends on discretization procedures applied to the source boundary. A second model for a continuous source is developed by extending a well-known pulse model. This second model is particularly useful in that it permits the determination of several potential unknowns directly from a concentration distribution. These include the source concentration, source dimensions, the position of the center of mass which is the product of the seepage velocity and the time since the contaminant first entered the ground water, and up to three dispersivities for a three-dimensional problem. As a demonstration of its utility, this second model is applied with reasonable success to a well-defined field condition. A comparison of the two models indicates that, except for minor differences in the very near field, the results from each are virtually identical.

INTRODUCTION

The use of models in problems of contaminant transport is rapidly increasing in response to the need to measure, monitor, and apply predictive approaches to contaminant plumes of various size and shape. An impressive array of numerical and analytical models is available, both for instantaneous pulses and for continuous sources. Many of the analytical models are quite sophisticated and generally require some numerical integration (Prakash, 1982). In the more simple closed form category for instantaneous pulses are the models of Baetsle (1969) and Hunt (1978). For continuous source problems, the hydrogeologist may draw on the relatively simple two-dimensional model of Wilson and Miller (1978) or the three-dimensional solution of Hunt (1978). Unfortunately, these latter models require that the source be treated as a point and, consequently, are only applicable to the far field. Whatever model is contemplated, one of the more formidable problems in contaminant transport is the difficulty in assessing the important parameters and coefficients, including source concentration and dimensions, seepage velocity, time since the contaminant first entered the ground water, and up to three dispersivities for a three-dimensional problem. This problem is addressed in this paper with the development of two continuous finite source models. The most rigorous of these models requires some numerical integration, and does not offer any special advantages over other models in that it offers no new methods by which to determine these parameters and coefficients. A second model, however, appears to be useful in these determinations. A comparative analysis is performed to assess their mutual reliability in field situations.

MATHEMATICAL CONSIDERATIONS

The dispersion-convection equation is of the form

$$\partial C/\partial t + v\partial C/\partial x - D_x\partial^2 C/\partial x^2 - D_y\partial^2 C/\partial y^2 - D_z\partial^2 C/\partial z^2 = 0 \quad (1)$$

where C is concentration in mass per unit volume of water; D_x, D_y, D_z are the principal values of the dispersion tensor; t is time; x, y, z represent Cartesian coordinates which are presumed to coincide with the principal directions of the dispersion tensor; and v is the ground-water seepage velocity. For the continuous finite source, the source condition is described by

$$F(x,y,z,t) = M \quad \text{for } x = 0,\ -Y < y < Y,\ -Z < z < Z,\ \text{all } t$$
$$= 0 \quad \text{otherwise} \quad (2)$$

where F represents the source term of the contaminants; Y and Z are the source dimensions in y and

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Received September 1984, revised November 1984, accepted December 1984.

Discussion open until January 1, 1986.

z, respectively; and M = the strength of the source, $mL^{-2}t^{-1}$. This describes a continuous injection mt^{-1} at x = 0 over the area $-Y < y < Y, -Z < z < Z$.

The solution to equation (1) with equation (2) is

$$C(x,y,z,t) = \int_0^t \int\int\int_{R_e} \{M/8[\pi^3 D_x D_y D_z (t-t')^3]^{1/2}\}$$

$$\exp\{-[x - x' - v(t-t')]^2/4D_x(t-t') -$$

$$(y-y')^2/4D_y(t-t') - (z-z')^2/4D_z(t-t')\} \cdot$$

$$dx', dy', dz', dt' \qquad (3)$$

where R_e indicates the triple integration over the region which x', y', and z' are extended. Integrating over dx' yields

$$C(x,y,z,t) = \int_0^t \{Mdt'/8\,[\pi^3 D_x D_y D_z (t-t')^3]^{1/2}\}$$

$$\exp - \{[x - v(t-t')]^2/4D_x(t-t')\} \int_{-Y}^{Y} \int_{-Z}^{Z} dy'\,dz'$$

$$\exp\{[-(y-y')^2/4D_y(t-t') - (z-z')^2/4D_z(t-t')]\}$$

$$\ldots\ldots\ldots \quad (4)$$

To make further progress with the finite source expression of equation (4), it is assumed that the order of integration can be interchanged, i.e., the operations involving dt' will be done before those involving dy' and dz'. In this case, equation (4) becomes

$$C(x,y,z,t) = \int_{-Y}^{Y} \int_{-Z}^{Z} dy'\,dz' \int_0^t$$

$$\{M\,dt'/8\,[\pi^3 D_x D_y D_z (t-t')^3]^{1/2}\}$$

$$\exp\{-[x - v(t-t')]^2/4D_x(t-t') -$$

$$(y-y')^2/4D_y(t-t') - (z-z')^2/4D_z(t-t')\}. \quad (5)$$

In the form, the integral over dt' has already been presented by Hunt (1978) for a continuous point source. Incorporating Hunt's (1978) results in equation (5) yields

$$C(x,y,z,t) = \int_{-Y}^{Y} \int_{-Z}^{Z} dy'\,dz' \cdot$$

$$[M \exp(xv/2D_x)/8\pi R (D_y D_z)^{1/2}] \cdot$$

$$[\exp(-Rv/2D_x)\,\mathrm{erfc}\,\{(R - vt)/2(D_x t)^{1/2}\} +$$

$$\exp(Rv/2D_x)\,\mathrm{erfc}\,\{(R + vt)/2(D_x t)^{1/2}\}] \qquad (6)$$

where

$$R = [x^2 + (y-y')^2\, D_x/D_y + (z-z')^2\, D_x/D_z]^{1/2} \quad (7)$$

The quantity R differs from the R in Hunt (1978) in that y and z are replaced by y − y' and z − z'. For a point source, y' = z' = 0 and the integrals over dy' and dz' would be dropped, resulting in Hunt's (1978) three-dimensional continuous point source solution.

The steady-state form of equation (6) is expressed

$$C'(x,y,z,\infty) = \int_{-Y}^{Y} \int_{-Z}^{Z} dy'\,dz' \cdot$$

$$[M/4\pi R(D_y D_z)^{1/2}]\ \exp\,[(x - R)v/2D_x] \qquad (8)$$

where C' indicates the steady-state concentration.

Given the complexity of equation (6), deriving a closed form solution which includes the temporal variations is virtually ruled out. The integrals in equation (8) can likely be worked out for a special type of elliptic source region, or for a circle, but these will be of limited value in real contamination problems. In spite of this difficulty, equation (6) is quite interesting in that it demonstrates how a closed form continuous point source solution is incorporated within a complex finite source solution. Hence, from a practical point of view, all that is required is the replacement of a continuous source region of any shape or size by an array of discrete points for which the solution is already known. The field distribution of concentration can then be determined by superposition. This is demonstrated in the following section.

SUPERPOSITION MODEL

As expressed by equation (6), the solution to the finite source problem is the integration of the point source model of Hunt (1978) over the area of the finite source. The numerical integration entails the following. First, the finite source is divided into a grid of node centered cells having equal area with a symmetrical distribution about the center point of the finite source. The volumetric flow rate through each cell is then equal to the total flow rate through the source divided by the number of cells. Second, the point source model of Hunt (1978) is used to calculate the concentration at a point of interest resulting from flow through each node. This entails adjusting the spatial coordinates of the point of interest with respect to each node's position relative to the center of the source. That is, each point of interest where a concentration determination is required is associated with an x, y, and z coordinate with respect to the center node of the source, as well as x', y', and z' coordinates with respect to each node within the source. Third, the

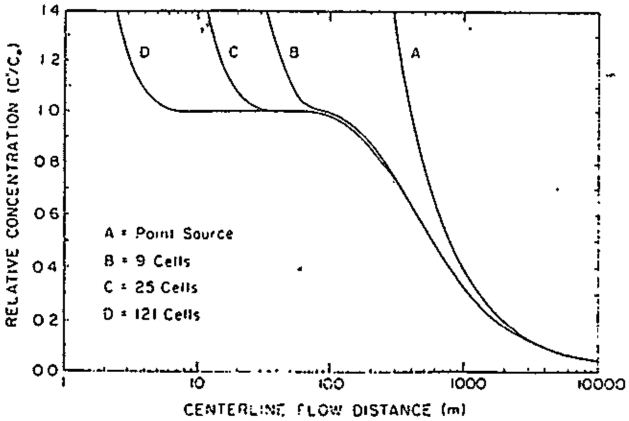

Fig. 1. Centerline steady-state relative concentration versus distance curves, for the superposition model.

calculated concentrations for all nodes are then summed. This approach can be applied to a source of any size or shape, and calculations are relatively straightforward and easily programmed for microcomputer analysis.

To illustrate the superposition model, a series of calculations were performed for a source having a square cross section. The source measured 5 X 5 m, the total source flow rate equals 250 cm^3 sec^{-1}, the seepage velocity is taken as 1×10^{-3} cm sec^{-1}, the longitudinal dispersion coefficient equals 1×10^{-3} cm^2 sec^{-1}, and the transverse coefficients in y and z are assumed equal and taken as 5×10^{-4} cm^2 sec^{-1}.

Figure 1 illustrates centerline (x, 0, 0) steady-state concentration ratio (C'/C_o) versus distance curves where the source was divided into grids having 9, 25, and 121 cells. Here, C' is the maximum steady-state concentration and C_o is the source concentration. For comparative purposes, centerline concentrations are presented for the case where the source is treated as a single point with Hunt's (1978) model. As demonstrated on the figure, as the number of cells increase, the configuration of the concentration distribution takes on the shape of a more normal breakthrough curve, and the distance at which the source concentration is predicted approaches the actual source position. This effect is due to the boundary condition in Hunt's (1978) model such that as x approaches zero, the concentration approaches infinity. These characteristics are best explained by Hunt's (1978) point source centerline concentration at steady state

$$C'(x,0,0,\infty) = C_o Q/4\pi\, x\, (D_y D_z)^{1/2} \qquad (9)$$

where C_o is the source concentration mL^{-3}, and Q is the point source flow rate L^3t^{-1}. Setting the maximum concentration C' equal to the source concentration C_o, and determining the position at which this concentration occurs gives

$$x = Q/4\pi (D_y D_z)^{1/2} \qquad (10)$$

Hence, the distance at which the near-field concentration converges on C_o does not coincide with the position x = 0, but is directly proportional to the volumetric source rate Q. As the number of cells in the superposition model increase, the magnitude of Q decreases for each node, although the total source Q remains constant. For example on Figure 1, the 121-cell model predicts the source concentration at a distance of only 7 m from the source. As expected, finite and point source calculations converge in the far field (Figure 1).

EXTENDED PULSE APPROXIMATION

The superposition model given above is relatively straightforward and can be readily applied to well-defined plumes emitting from some finite continuous source. This model, along with all transport models, incorporates several potential unknowns, including the source concentration and dimensions, the seepage velocity, time since the contaminant entered the ground water, and three dispersion coefficients. In this sense it offers no special advantages over straightforward numerical or other analytical approaches to the finite source problem. Cleary (1978), for example, presents several analytical solutions, all of which require some numerical integration. In a practical sense, it is advantageous to have a much simpler but still reasonably equivalent approximation to this model which is better suited for direct determination of the pertinent coefficients and parameters. As the development of such a model will require some approximations, its ultimate test will rely on how close its performance matches the more rigorous superposition model. A first-order attempt at obtaining such a model requires an extension of the parallelepiped instantaneous pulse shown in Figure 2. This parallelepiped model is given by Hunt (1978), and is of the form

$$C(x,y,z,t) = (C_o/8)\{\mathrm{erf}[x - vt + (X/2)/2(D_x t)^{1/2}] - \mathrm{erf}[x - vt - (X/2)/2(D_x t)^{1/2}]\}$$
$$\{\mathrm{erf}[y + (Y/2)/2(D_y t)^{1/2}] - \mathrm{erf}[y - (Y/2)/2(D_y t)^{1/2}]\}$$
$$\{\mathrm{erf}[z + (Z/2)/2(D_z t)^{1/2}] - \mathrm{erf}[z - (Z/2)/2(D_z t)^{1/2}]\} \quad \ldots. \ (11)$$

where X, Y, and Z refer to the original source dimensions. This solution describes the convection and dispersion of a substance deposited at time $t = 0$ in the region $-X/2 < x < X/2$, $-Y/2 < y < Y/2$, $-Z/2 < z < Z/2$, as shown in Figure 2. Clearly, in this solution, C_o approaches zero in the $x = 0$ plane as time gets large. For the continuous plane source of dimensions Y and Z [equation (5)], it is required that the concentration be maintained at C_o for all time in the $x = 0$ plane and, of course, be equal to zero at $x > 0$ for time equal to zero. This effect can be accomplished with the box of Figure 2 by extending the box to infinity in the minus x direction. Continuous mass flow from the $x = 0$ plane is then accomplished by the extended contaminant source. More commonly, the process is described by an infinite number of line sources resulting in an infinite number of elementary solutions which must be superposed, i.e., integrated from some x to infinity (Crank, 1979, p. 13). According to Crank (1979, p. 14), this is described as

$$C(x,t) = [C_o/2(\pi D_x t)^{1/2}] \int_x^\infty \exp(-\xi^2/4D_x t)\, d\xi$$

$$= [C_o/\pi^2] \int_{x/2(D_x t)^{1/2}}^\infty \exp(-\eta^2)\, d\eta \qquad (12)$$

where $\eta = \xi/2(D_x t)^{1/2}$. Equation (12) can be expressed by the simple complementary error function solution

$$C(x,t) = (C_o/2)\,\mathrm{erfc}\,[(x - vt)/2(D_x t)^{1/2}] \qquad (13)$$

which describes continuous mass flow from the $x = 0$ plane. Equation (13) is obtained exactly when X is extended to infinity in the first bracketed erf term in equation (11).

There still remains an accounting of the substance initially confined in the region $-Y/2 < y < Y/2$ and $-Z/2 < z < Z/2$. According to Crank (1979, p. 15) the integration here is from $y - Y/2$ to $y + Y/2$ and $z - Z/2$ to $z + Z/2$, instead of from x to infinity as in equation (12). This gives

$$C = (C_o/2)\,\mathrm{erf}\,[(y + Y/2)/2(D_y t)^{1/2}] - \mathrm{erf}\,[(y - Y/2)/2(D_y t)^{1/2}] \qquad (14\text{-}1)$$

$$C = (C_o/2)\,\mathrm{erf}\,[(z + Z/2)/2(D_z t)^{1/2}] - \mathrm{erf}\,[(z - Z/2)/2(D_z t)^{1/2}]\,. \qquad (14\text{-}2)$$

The product of these three integral solutions [equations (13) and (14)] describes a semi-infinite contaminated parcel which moves in the positive x direction with a one-dimensional velocity but which continually expands in size in directions transverse to x throughout the whole domain of x, i.e., in the positive and negative regions. This is because time t in the transverse spreading terms of equation (14) is interpreted as running time. Reinterpreting this time as x/v for a moving coordinate system, as is common in all transverse spreading models (Bruch and Street, 1967; Ogata, 1970; Domenico and Palciauskas, 1982), has the effect of maintaining the original source dimensions at $x = 0$ so that the condition $C \cong C_o$ is maintained at $x = 0$ for $t > 0$. Making this substitution and collecting equations (13) and (14) gives

$$C(x,y,z,t) = (C_o/8)\,\mathrm{erfc}\,[(x - vt)/2(D_x t)^{1/2}]$$
$$\{\mathrm{erf}[(y+Y/2)/2(D_y x/v)^{1/2}] - \mathrm{erf}[(y-Y/2)/2(D_y x/v)^{1/2}]\}$$
$$\{\mathrm{erf}[(z+Z/2)/2(D_z x/v)^{1/2}] - \mathrm{erf}[(z-Z/2)/2(D_z x/v)^{1/2}]\} \quad \ldots\ (15)$$

Equation (15) is given as the extended pulse approximation to the continuous finite source problem. It describes a semi-infinite contaminated parcel which moves with a one-dimensional velocity in the positive x direction. It is noted that at the source boundary $x = y = z = 0$ for time greater than zero, the product of the error functions equals four, and the argument of the complementary error function takes on a negative number. The value of the complementary error function ranges from plus two to zero, taking on the former value for arguments equal to negative infinity. However, in a practical sense, the maximum value of two is approximated for very small negative values of the argument. For example, when the argument $[(x - vt)/2(D_x t)^{1/2}]$ equals negative two, the complementary error function equals 1.99. Thus, in a practical sense, the source concentration is maintained at or near C_o for times greater than zero.

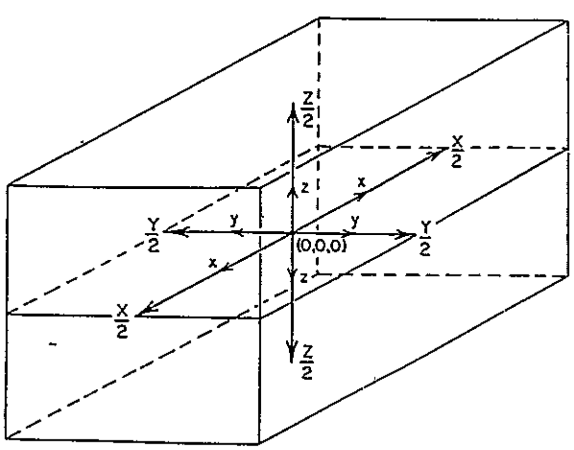

Fig. 2. Parallelepiped source.

Two forms of equation (15) are of interest. The first is for the centerline concentration (x,0,0,t)

$$C(x,0,0,t) = (C_o/2)\ \text{erfc}\ [(x - vt)/2(D_x t)^{1/2}]\ \text{erf}\ [Y/4(D_y x/v)^{1/2}]\ \text{erf}\ [Z/4(D_z x/v)^{1/2}] \quad (16)$$

The boundary condition at x = 0 is more apparent with this expression. At x = 0, the error function terms go to unity and for time greater than zero, the complementary error function rapidly approaches two. The second expression is for the steady-state concentration (i.e., the maximum at x,0,0) along the centerline, which is obtained at all $x << vt$

$$C' = C_o\ \text{erf}\ [Y/4(D_y x/v)^{1/2}]\ \text{erf}\ [Z/4(D_z x/v)^{1/2}] \quad (17)$$

where C' is the steady-state concentration. It is noted further that for Y and Z considerably larger than $4(D_y x/v)^{1/2}$ and $4(D_z x/v)^{1/2}$, respectively, the centerline concentration can approach the initial concentration throughout some distance x.

Equation (15) is quite versatile in describing different spreading geometries. As written, equation (15) applies to the spreading geometry schematically illustrated in Figure 3(b), which corresponds to the numerical integration of Hunt's (1978) point source model [equation (6)]. If the upper surface of a contaminant plume coincides with the water table so as to provide only downward z spreading, as illustrated in Figure 3(a), the quantities Z/2 in equation (15) are replaced by Z. This problem can be viewed as a contaminated parcel bounded at the top, z = 0, by a zero flux boundary, with transverse spreading in all y, but in only one vertical direction. In this form, equation (15) is analogous to a transverse dispersion solution presented by Domenico and Palciauskas (1982) with the exception that this current form has provisions for longitudinal dispersion. If contaminant spreading in z is restricted, as illustrated in Figure 3(c), equation (15) would be modified by changing $C_o/8$ to $C_o/4$ and dropping the error functions containing the Z terms. In this form, the model corresponds to a numerical integration of the Wilson and Miller (1978) line source model.

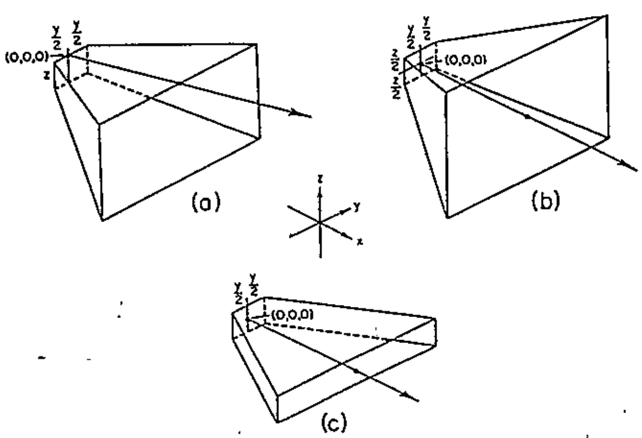

Fig. 3. Idealized contaminant migration geometries for various transverse spreading directions.

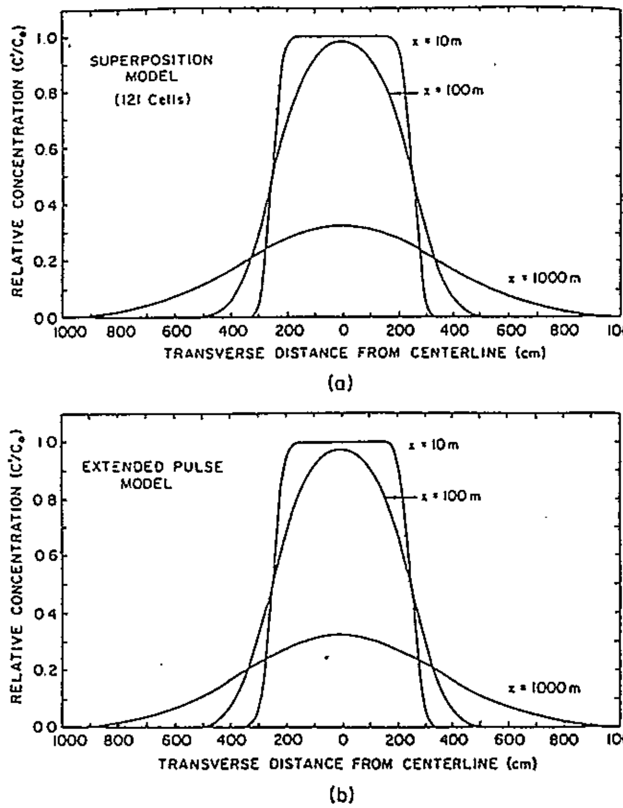

Fig. 4. Comparison of steady-state transverse concentration profiles with identical coefficients for (a) the superposition model, and (b) the extended pulse model.

Figure 4 shows steady-state transverse profiles for the extended pulse and the 121-cell superposition model as generated from the same data employed in Figure 1. At about two source sizes (10 m) and beyond, the extended pulse matches the 121-cell superposition result.

The results of an additional check are demonstrated in Figure 5 for a field size plume. Here, the same coefficients and parameters are employed in both the superposition and extended models for an assumed spreading geometry as given in Figure 3(b). The coefficients and parameters are as follows: $D_x = 1.06\ cm^2\ sec^{-1}$, $D_y = 0.21\ cm^2\ sec^{-1}$, $D_z = 0.00016\ cm^2\ sec^{-1}$, Y = 240 m, Z = 5 m, the seepage velocity $v = 2.49 \times 10^{-4}\ cm\ sec^{-1}$, $C_o = 850$ mg/l, time t is taken as 14 years, and the source flow rate Q is obtained from information on velocity and source size, or $3 \times 10^3\ cm^3\ sec^{-1}$. Thus, for this identical set of parameters and coefficients, the plumes should be identical provided the extended pulse is a reasonable approximation for the finite source problem, as described more rigorously by the superposition model. The superposition result is shown in Figure 5(a) and the extended pulse in Figure 5(b). Comparing the results of the two calculations, it is noted that within one source dimension (Y), the concentrations differ by less than 10 percent. At a distance within two source dimensions, the concentrations differ by less than two percent. Beyond two source dimensions, the results are virtually identical.

A METHOD OF CONTAMINANT PLUME ANALYSIS

In this section, a calibration method for determining the pertinent coefficients and parameters using the extended pulse model is discussed. The procedure employed is exactly the same procedure that has been used for decades in the application of well hydraulics—that is, the matching of real response data with an idealized mathematical model that presumably describes that response. As with well hydraulics, deviations from the ideal behavior are to be expected, and

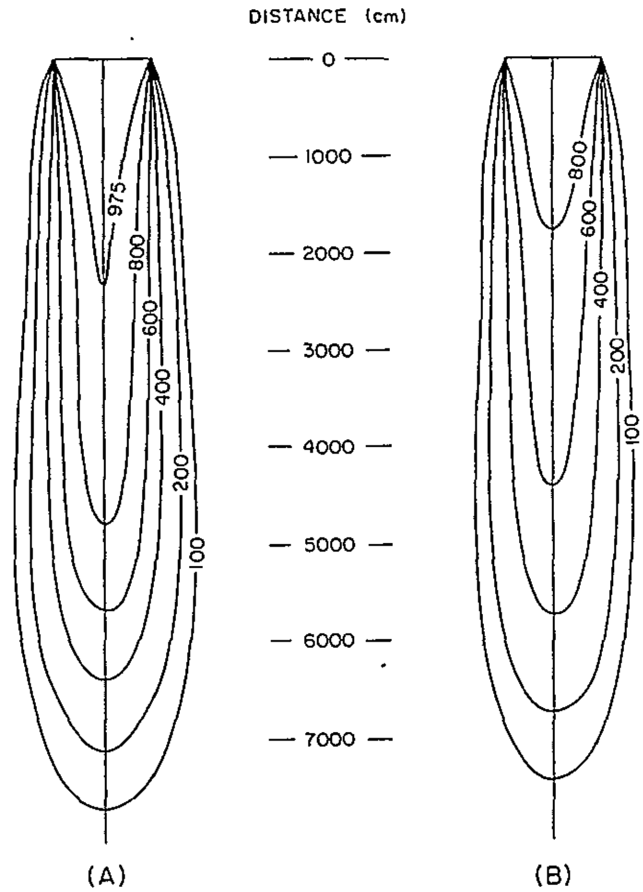

Fig. 6. Plan view of an ideal plume showing (A) plane of maximum concentrations and (b) plane of lower concentrations near the base of the source.

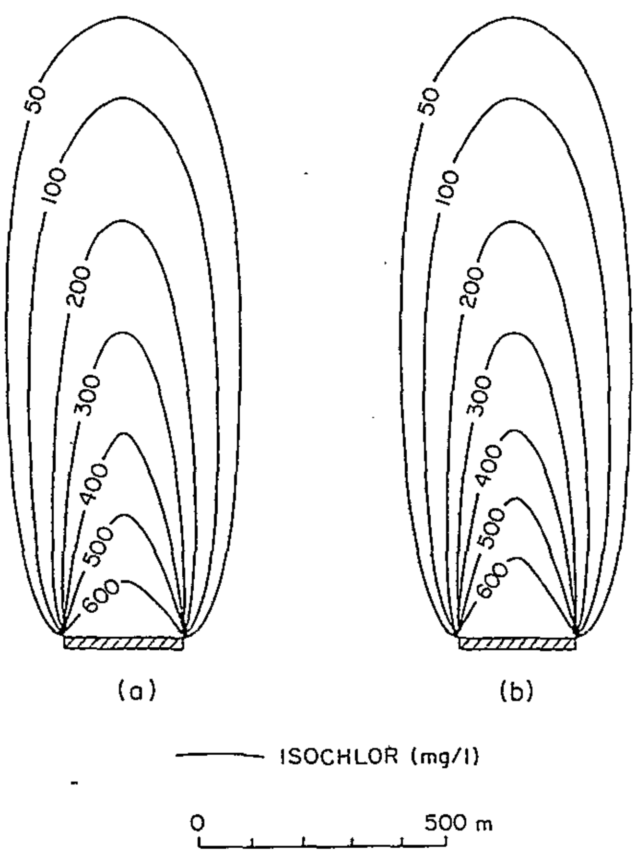

Fig. 5. Plan view concentration comparison with identical coefficients for (a) superposition model and (b) extended pulse model.

provide a measure of how much the real system departs from the ideal one. For this case, real response data are provided by some observed concentration distribution in space whereas the mathematical model of that response is provided by equation (15).

Figure 6 gives two plan views of an ideal plume generated with equation (15) for the case where the upper surface of the plume coincides with the water table [Figure 3(a)]. Figure 6(A) gives the concentration distribution C(x,y,0,t) at the water table, which is the plane of maximum concentration, whereas Figure 6(B) gives the concentration C(x,y,z,t) where z is taken at 50 cm above the base of the source. Due to this spreading geometry, the lowermost plane [Figure 6(B)] contains lower concentrations than the uppermost plane [Figure 6(A)]. For this idealized plume, the dispersivities α were assumed to be about tracer scale in magnitude, where $\alpha_x = 100$ cm, $\alpha_y = 10$ cm, and $\alpha_z = 1$ cm. In addition, the seepage velocity was assumed to be 10^{-4} cm/sec, the source dimensions Y and Z were taken as 1,000 and 500 cm, respectively, the source concentration was taken at 1,000 mg/l, and the time of interest is two years.

From the form of equation (15) appropriate to this problem, the following ratio for two concentrations may be derived for two points common to any single horizontal plane in the three-dimensional plume

$$C(x_1,y_1,z_1,t_1)/C(x_1,y_2,z_1,t_1) = \{\mathrm{erf}[(y_1 + Y/2)/2(\alpha_y x_1)^{1/2}] - \mathrm{erf}[(y_1 - Y/2)/2(\alpha_y x_1)^{1/2}]\} \div \{\mathrm{erf}[(y_2 + Y/2)/2(\alpha_y x_1)^{1/2}] - \mathrm{erf}[(y_2 - Y/2)/2(\alpha_y x_1)^{1/2}]\} \quad (18)$$

where $y_1 \neq y_2$. For a field application, where the concentration ratio in equation (18) is known from measurement, an iteration routine gives rather complete information on the relationship between α_y and Y. The results of this iteration are shown in Figure 7 (A) for various concentration ratios taken off the z = 0 plane [Figure 6 (A)]. For the close-in points (x = 4,000 cm), the transverse coefficient is very sensitive to the source dimension. The concentration ratio of equation (18) for these two particular points can be satisfied with any combination of Y and α_y taken off this curve. For the furthest points (x = 8,000 cm), the transverse coefficient is less sensitive to the source dimension Y, which is fully expected for points distant from some finite source. The concentration ratio of equation (18) for these particular points can be satisfied with any combination of Y and α_y taken off this curve. One property of the ideal plume is that those points closest to the source have the largest intercept on the α axis. The most important property is that the common point of intersection for the three curves of Figure 7 (A) provides the unique source dimension Y and transverse dispersivity α_y for the total field distribution, in this case 1,000 cm and 10 cm, respectively. It may be noted further that the use of a source dimension smaller than the actual results in a scaling upward of dispersivity, while use of a larger source dimension results in downward scaling.

A similar routine can be established for α_z and the source dimension Z by considering the concentrations $C(x_1,y_1,z_1,t_1)$ and $C(x_1,y_1,z_2,t_1)$. Figure 7 (B) gives the relationship between the transverse coefficient α_z and the source dimension Z for the ideal plume of Figure 6, with the point of intersection denoting the unique values. If $C(x_1,y_1,z_2,t_1)$ is unknown, as in the case of mapping a plume in the (x,y,0) plane, an iteration procedure can still be followed by taking the ratio of two steady-state concentrations in the (x,y,0) plane. For this model, the steady-state concentration is described

$$C'(x,y,0) = (C_o/2)\ \{\mathrm{erf}[(y + Y/2)/2(\alpha_y x)^{1/2}] - \mathrm{erf}[y - Y/2)/2(\alpha_y x)^{1/2}]\}\{\mathrm{erf}[Z/2(\alpha_z x)^{1/2}]\} \quad (19)$$

where C′ is the steady-state (maximum) concentration. If two steady-state concentrations are selected along the centerline (x,0,0), the ratio of the concentrations can be expressed

$$C'(x,0,0)/C'(x_2,0,0) = \{\mathrm{erf}[Y/4(\alpha_y x_1)^{1/2}]\ \mathrm{erf}[Z/2(\alpha_z x_1)^{1/2}]\} \div \{\mathrm{erf}[Y/4(\alpha_y x_2)^{1/2}] \cdot \mathrm{erf}[Z/2(\alpha_z x_2)^{1/2}]\} \quad (20)$$

which is readily iterated in terms of α_z and Z.

The procedures developed above would appear to be quite efficient in obtaining the transverse coefficients and appropriate source dimensions from field distributions of contaminants. It is noted that these parameters are obtained independent of source concentration, seepage velocity, longitudinal dispersivity, and time. This methodology can now be extended to determine the remaining unknowns in the problem. For the plume geometry under consideration, the steady-state centerline solution is expressed

$$C'(x,0,0) = C_o\ \mathrm{erf}[Y/4(\alpha_y x)^{1/2}]\ \mathrm{erf}[Z/2(\alpha_z x)^{1/2}] \quad (21)$$

If a steady-state concentration C′ (x,0,0) is known near the source, equation (21) can be solved directly for the source concentration C_o. For the ideal plume of Figure 6 (A), a concentration C (x, 0, 0) of 977 mg/l is noted at x = 2,400 cm. Solving

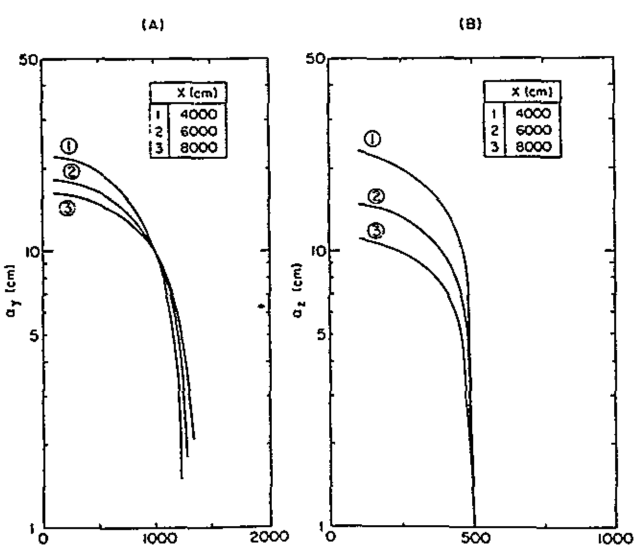

Fig. 7. Plot of (A) the transverse dispersivity α_y versus the source dimension Y and (B) the transverse dispersivity α_z versus the source dimension Z.

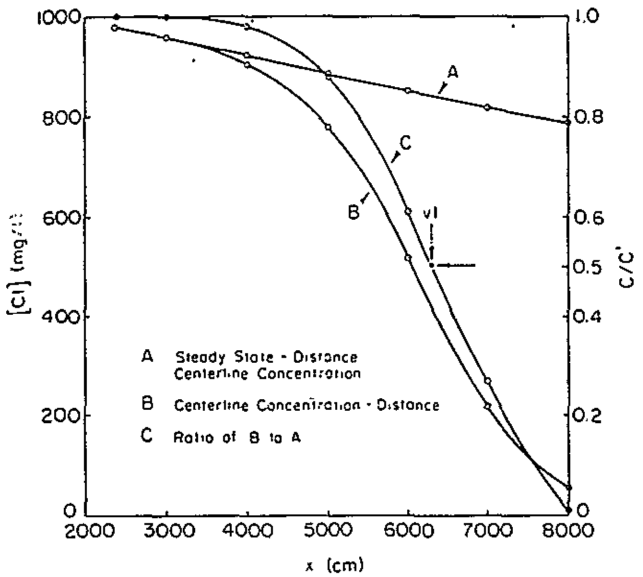

Fig. 8. Centerline concentrations for an ideal plume. Curve A shows steady-state concentrations, curve B shows field concentrations, and curve C is the relative concentration distribution.

equation (21) for C_o gives a source concentration of 999.8 mg/l, which is virtually identical to the designated value. For other concentrations at distances ranging from 1,000 cm to 2,600 cm, equation (21) continually yields a source concentration C_o in excess of 999.6. With all of the variables in equation (21) now known, this equation may be used to determine steady-state concentrations at any x along the centerline. The results of this calculation are shown in Figure 8. In this figure, the curve labeled B represents actual centerline concentrations for the ideal plume of Figure 6, and the curve labeled A depicts steady-state concentrations as determined with equation (21). Curve C is the relative concentration profile developed by taking the ratio of curve B to A, which has the form

$$C(x,0,0,t)/C'(x,0,0) = (1/2)\,\mathrm{erfc}\,[(x - vt)/2(\alpha_x vt)^{1/2}] \quad \ldots\ (22)$$

Equation (22) states that the ratio of actual to steady-state concentration at any x along the centerline of the ideal plume will be equal to one-half the value of the stated complementary error function. Thus, if the actual concentration is already at steady state, which can only occur where $x << vt$, the value of erfc approaches two, and the ratio C/C' approaches unity. From Figure 8 it is clear that the ideal plume is at steady state in the region from x equals zero to x equals approximately 3,000 cm. On the other hand, when x is set equal to vt, equation (22) states that the location of the center of mass (vt) will always be at some unique distance x where the concentration ratio C/C' equals 0.5. From Figure 8, the center of mass is determined to be at x = 6,300 cm, which corresponds to the distance predicted by the known velocity (10^{-4} cm/sec) and the known time (two years, or 6.3×10^7 sec). As the velocity v is understood to be the velocity of the contaminant, this procedure can be used for both attenuated and unattenuated contaminants without the necessity of retardation factors. If the plume is mapped at two different points in time, both velocity and time (as opposed to their product only) may be determined. For the case of an attenuated species mapped at two different points in time, the retardation factor is easily found by taking the ratio of the respective distances x = vt, as determined above.

The last remaining unknown, α_x, is readily determined with equation (22) and Figure 8 for any x in the unsteady portions of the plume. For points behind the determined vt of 6,300 cm, α_x averages 98.9 cm; for points in front of the determined vt, α_x averages 101.5 cm. The overall average is 99.8 cm, which compares favorably with the stipulated value of 100 cm. Indeed, if the actual value of vt was used (6,307.5 cm), all of the points employed above would yield an exact value of 100 cm. Thus, if the position of the center of mass is underestimated, however slight, an exact match in the unsteady portions of the plume requires a scaling up of α_x in front of vt, and a scaling down in the region behind vt. Presumably, the amount of scaling required will depend on the degree of error in determining the position of the center of mass. It is noted that the methods employed above do not require knowledge of the seepage velocity nor the time in ascertaining this position.

The procedures described above represent a systematic approach to obtaining the pertinent transport parameters and coefficients more or less independently of each other. These include the transverse dispersivities α_y and α_z, the source dimensions Y and Z, the source concentration C_o, the distance traveled by the center of mass vt, and the longitudinal dispersivity α_x. Unfortunately, the data demands are rather large and require concentrations within a given plane of a well-defined three-dimensional plume. If the field concentrations are not within this single plane but are determined at various depths for a three-dimensional problem, the point of uniqueness demonstrated on Figure 7 will not materialize. Indeed, when dealing with real data, an exact

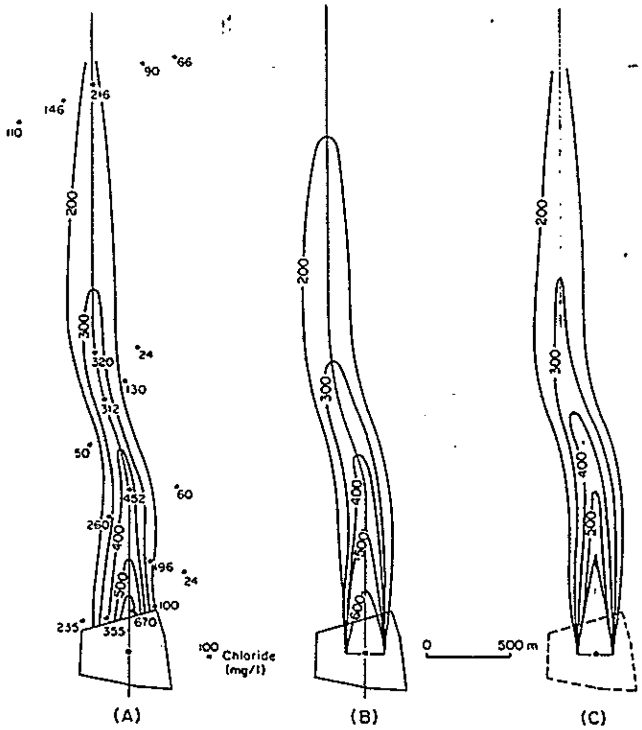

Fig. 9. Chloride concentration plumes: (A) observed at refuse tip, (B) reproduced by extended pulse model with α_y = 4 m and Y = 200 m, and (C) reproduced by extended pulse model with α_y = 2.65 m and Y = 220 m.

adherence to the idealized behavior shown on Figure 7 is not likely. Nevertheless, it is a worthwhile exercise to treat the data in this fashion to obtain reasonable bounds on the transverse dispersivity, and especially so if the source size is known already from other data.

A FIELD EXAMPLE

As a demonstration of a field application of the methodology discussed, a ground-water contamination study by Exler (1972) is used. The waste facility is believed to have been first put into operation in 1954. For this analysis, 1970 data are employed, where observation points extend to almost 3,500 m from the source, where surprisingly large concentrations are encountered. The spreading geometry is considered to be of the type already discussed in the construction of Figure 6.

The available data base and some contoured representation is shown in Figure 9(A). A ground-water mound exists beneath the refuse site, the center of which is taken as the point of origin for the plume. As noted, very little data are available in general and especially so in the upper one-third of the plume. The plume narrows considerably in its central portions and is not perfectly symmetrical near the source. The reasons for the narrowing are likely related to the geology of the transporting medium, which is reported to be marly clay with interlayers of sand. The plume obviously follows the favored pathways in sand and, where the pathways are not laterally extensive, the transverse spreading is constrained.

The relationship between the source dimension Y and the transverse coefficient α_y is shown in Figure 10. In the absence of actual data, contour values had to be used in this iteration, with most of the analysis taking place within three source sizes where control was the most abundant. As anticipated, uniqueness between Y and α_y was not obtained. On the positive side, however, the intercepts on the α_y axis become higher (greater) with decreasing distance from the source, as expected under ideal behavior (Figure 7). Further, upon closer observation, it is noted that α_y can vary from 1.85 m to 7.5 m over a source dimension variation of 225 m to 170 m. In general, the lowest α_y values and the largest source size determinations are from the data points furthest from the source. The relationships shown on Figure 10 are perhaps the best that can be expected under these conditions where the data are very sparse to the extent that contoured values had to be employed, and the geology very complex. Averaging the results of Figure 10 suggests an average α_y on the order of 4 m for a source dimension Y on the order of 200 m.

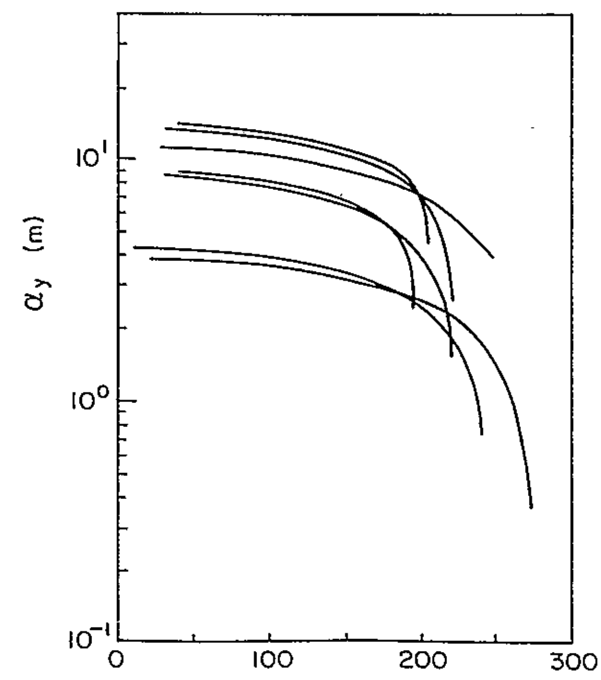

Fig. 10. Plot of the transverse dispersivity α_y versus the source dimension Y at various distances x for the chloride concentration plume.

In the absence of three-dimensional data, the transverse coefficient α_z and the source dimension Z was obtained by the procedures outlined in equations (19) and (20), averaging about 0.0064 m and 5 m, respectively. Vertical dispersion is obviously somewhat insignificant.

In accordance with the procedures outlined earlier, a plot such as Figure 8 is in order, where both the position of the center of mass vt and the longitudinal dispersivity α_x are determined. However, the results of such a plot indicate that the entire plume as mapped on Figure 9 is already at steady state throughout its length; that is, the concentrations are at their maximum values. This agrees with data presented by Exler (1972) who calculated the average velocity to range between 5 to 10 m day^{-1}. Even at one m day^{-1} for a 16-year plume, the center of mass would be located about 5,760 m from the source, or some 2,300 m beyond the last data points of Figure 9. This virtually assures steady state in the mapped region.

The steady-state ideal plume is presented in Figure 9(B) for α_y = 4 m; Y = 200 m, and α_z and Z as previously reported. As noted, the near field matches quite well, which is not surprising in that most of the data used in the analysis came from near-field observation points. In the far field, the 200 mg/l contour is not sufficiently extensive to match the real response. Reducing α_y to 2.65 m for a source size of 220 m, which corresponds to data points of Figure 10 which are furthest from the source, provides the plume of Figure 9(C). Here, the near-field model results start to depart from actual concentrations whereas the far field appears to be accurately depicted. From a simulation perspective, the results appear to be acceptable for a transverse dispersivity on the order of 3 m and a source dimension Y of about 220 m.

CONCLUSIONS

The methodology presented in this paper may be useful in the analysis of contaminant plumes. The calculations are relatively straightforward and easily programmed for microcomputer analysis, and the model can be manipulated to account for several spreading geometries. Most importantly, information on seven potential unknowns can be extracted directly from the concentration distribution, thereby providing a better physical basis for the model. It is argued that such procedures remove much of the nonuniqueness associated with contaminant plume analysis. As the information for the analysis is taken directly off the plume, the method can be applied to chemically retarded species without any regard to retardation coefficients.

On the negative side, the model has limitations common to all analytic expressions, namely the isotropic and homogeneous assumptions along with an assumed constant velocity system. In addition, the data demands are rather large, and the calibration procedure discussed should be viewed as a first try estimate based on an extended pulse approximation that realistically cannot be expected to adequately describe all portions of a plume.

REFERENCES

Baetsle, L. H. 1969. Migration of radionuclides in porous media. In Progress in Nuclear Energy, edited by A.M.F. Duhamel, Series XII, Health Physics. Pergamon, Elmsford, New York. pp. 707-730.

Bruch, J. and R. Street. 1967. Two dimensional dispersion. J. Sanitary Eng. Div., Proc. Am. Soc. Civ. Eng. v. 93, pp. 17-38.

Carslaw, H. S. and J. C. Jaeger. 1959. Conduction of Heat in Solids. Oxford University Press, New York. p. 56.

Cleary, R. W. 1978. Report on 208 Long Island pollution study. Water Resources Program, Princeton University.

Crank, J. 1979. The Mathematics of Diffusion. Clarendon Press, Oxford University Press, New York. pp. 13-15.

Domenico, P. A. and V. V. Palciauskas. 1982. Alternative boundaries in solid waste management. Ground Water. v. 20, pp. 303-311.

Exler, H. J. 1972. Defining the spread of groundwater contamination below a waste tip. In Groundwater Pollution in Europe, edited by J. A. Cole. Water Information Center, Inc., Port Washington, N.Y. pp. 215-241.

Hunt, B. 1978. Dispersive sources in uniform groundwater flow. J. Hydraul. Div., Proc. Am. Soc. Civ. Eng. v. 104, pp. 75-85.

Ogata, A. 1970. Theory of dispersion in a granular medium. U.S. Geol. Survey Prof. Paper 411-I. pp. 12-34.

Prakash, A. 1982. Groundwater contamination due to vanishing and finite size continuous sources. J. Hydraulic Div., Proc. Am. Soc. Civ. Eng. v. 108, pp. 572-590.

Wilson, J. L. and P. J. Miller. 1978. Two dimensional plume in uniform groundwater flow. J. Hydraul. Div., Proc. Am. Soc. Eng. v. 104, pp. 503-514.

* * * * *

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$$= 97.5 \text{ m} - \frac{0.29 \text{ m}^2/\text{day}}{1.2 \text{ m/d} \times 33 \text{ m}} \times 300 \text{ m}$$
$$= 97.5 \text{ m} - 2.2 \text{ m}$$
$$= 95.3 \text{ m}$$

5.14 STEADY FLOW IN AN UNCONFINED AQUIFER*

In an unconfined aquifer, the fact that the water table is also the upper boundary of the region of flow complicates flow determinations. Figure 5.17 illustrates the problem. On the left side of the figure, the saturated flow region is h_1 feet thick. On the right side, it is h_2 feet thick, which is $h_1 - h_2$ feet thinner than the left side. If there is no recharge or evaporation as the flow traverses the region, the quantity of water flowing through the left side is equal to that flowing through the right side. From Darcy's law, it is obvious that since the cross-sectional area is smaller on the right side, the hydraulic gradient must be greater. Thus, the gradient of the water table in unconfined flow is not constant; it increases in the direction of flow.

This problem was solved by Dupuit (1863), and his assumptions are known as the **Dupuit assumptions.** The assumptions are that (1) the hydraulic gradient is equal to the slope of the water table and (2) for small water-table gradients, the streamlines are horizontal and the equipotential lines are vertical. Solutions based on these assumptions have proved to be very useful in many practical problems. However, the Dupuit assumptions do not allow for a seepage face above the outflow side.

From Darcy's law,

$$q' = -Kh\frac{dh}{dx} \tag{5-58}$$

where h is the saturated thickness of the aquifer. At $x = 0$, $h = h_1$; at $x = L$, $h = h_2$.

Equation 5–58 may be set up for integration with the boundary conditions:

$$\int_0^L q'dx = -K\int_{h_1}^{h_2} hdh$$

Integration of the preceding yields

$$q'x\Big|_0^L = -K\frac{h^2}{2}\Big|_{h_1}^{h_2}$$

*The equations in this section are derived following methods used by Polubarinova-Kochina (1962) and Harr (1962).

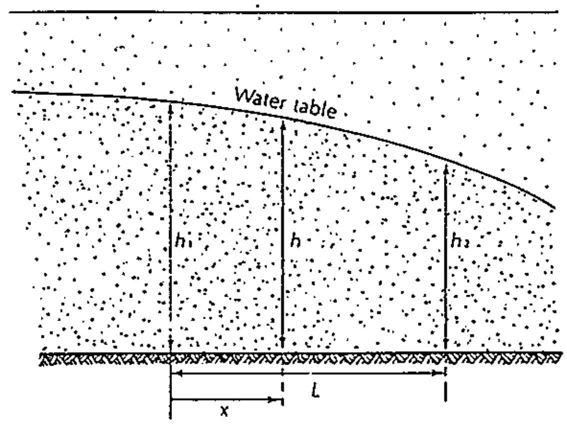

FIGURE 5.17 Steady flow through an unconfined aquifer resting on a horizontal impervious surface.

Substitution of the boundary conditions for x and h yields

$$q'L = -K\left(\frac{h_2^2}{2} - \frac{h_1^2}{2}\right) \tag{5-59}$$

Rearrangement of Equation 5–59 yields the **Dupuit equation:**

$$\boxed{q' = \frac{1}{2}K\left(\frac{h_1^2 - h_2^2}{L}\right)} \tag{5-60}$$

where

q' is the flow per unit width (L^2/T; ft²/d or m²/day)
K is the hydraulic conductivity (L/T; ft/d or m/day)
h_1 is the head at the origin (L; ft or m)
h_2 is the head at L (L; ft or m)
L is the flow length (L; ft or m)

If we consider a small prism of the unconfined aquifer, it will have the shape of Figure 5.18. On one side it is h units high and slopes in the x-direction. Given the Dupuit assumptions, there is no flow in the z-direction. The flow in the x-direction, per unit width, is q'_x. From Darcy's law, the total flow in the x-direction through the left face of the prism is

$$q'_x dy = -K\left(h\frac{\partial h}{\partial x}\right)_x dy \tag{5-61}$$

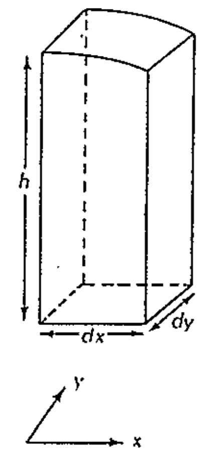

FIGURE 5.18 Control volume for flow through a prism of an unconfined aquifer with the bottom resting on a horizontal impervious surface and the top coinciding with the water table.

where dy is the width of the face of the prism. The discharge through the right face, q'_{x+dx}, is

$$q'_{x+dx}\,dy = -K\left(h\frac{\partial h}{\partial x}\right)_{x+dx} dy \tag{5-62}$$

Note that $\left(h\frac{\partial h}{\partial x}\right)$ has different values at each face. The change in flow rate in the x-direction between the two faces is given by

$$(q'_{x+dx} - q'_x)dy = -K\frac{\partial}{\partial x}\left(h\frac{\partial h}{\partial x}\right) dx\,dy \tag{5-63}$$

Through a similar process, it can be shown that the change in the flow rate in the y-direction is

$$(q'_{y+dy} - q'_y)dx = -K\frac{\partial}{\partial y}\left(h\frac{\partial h}{\partial y}\right) dy\,dx \tag{5-64}$$

For steady flow, any change in flow through the prism must be equal to a gain or loss of water across the water table. This could be infiltration or evapotranspiration. The net addition or loss is at a rate of w, and the volume change within the initial volume is $w\,dx\,dy$ where $dx\,dy$ is the area of the surface. If w represents evapotranspiration, it will have a negative value. As the change in flow is equal to the new addition,

$$-K\frac{\partial}{\partial x}\left(h\frac{\partial h}{\partial x}\right)dx\,dy - K\frac{\partial}{\partial y}\left(h\frac{\partial h}{\partial y}\right)dy\,dx = w\,dx\,dy \tag{5-65}$$

We can simplify Equation 5–65 by dropping out $dx\ dy$ and combining the differentials:

$$-K\left(\frac{\partial^2 h^2}{\partial x^2} + \frac{\partial^2 h^2}{\partial y^2}\right) = 2w \tag{5–66}$$

If $w = 0$, then Equation 5–66 reduces to a form of the Laplace equation:

$$\frac{\partial^2 h^2}{\partial x^2} + \frac{\partial^2 h^2}{\partial y^2} = 0 \tag{5–67}$$

If flow is in only one direction and we align the x-axis parallel to the flow, then there is no flow in the y-direction, and Equation 5–66 becomes

$$\frac{d^2(h^2)}{dx^2} = -\frac{2w}{K} \tag{5–68}$$

Integration of this equation yields the expression

$$h^2 = -\frac{wx^2}{K} + c_1 x + c_2 \tag{5–69}$$

where c_1 and c_2 are constants of integration.

The following boundary conditions can be applied: at $x = 0$, $h = h_1$; at $x = L$, $h = h_2$ (Figure 5.19). By substituting these into Equation 5–69, the constants of integration can be evaluated with the following result:

$$h^2 = h_1^2 - \frac{(h_1^2 - h_2^2)x}{L} + \frac{w}{K}(L - x)x \tag{5–70}$$

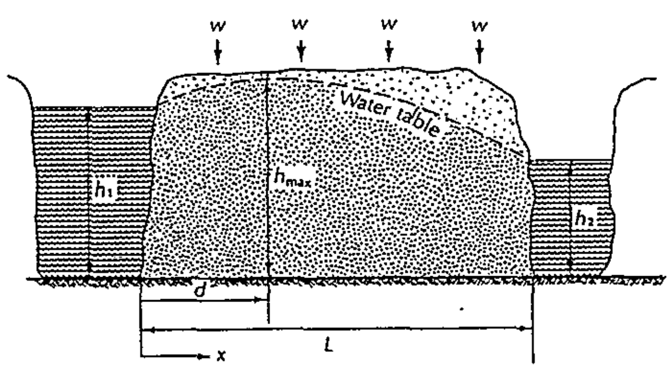

FIGURE 5.19 Unconfined flow, which is subject to infiltration or evaporation.

or

$$h = \sqrt{h_1^2 - \frac{(h_1^2 - h_2^2)x}{L} + \frac{w}{K}(L - x)x} \qquad (5\text{–}71)$$

where

- h is head at x (L; ft or m)
- x is the distance from the origin (L; ft or m)
- h_1 is the head at the origin (L; ft or m)
- h_2 is the head at L (L; ft or m)
- L is the distance from the origin at the point h_2 is measured (L; ft or m)
- K is the hydraulic conductivity (L/T; ft/d or m/day)
- w is the recharge rate (L/T; ft/d or m/day)

This equation can be used to find the elevation of the water table anywhere between two points located L distance apart if the saturated thickness of the aquifer is known at the two end points.

For the case in which there is no infiltration or evaporation, $w = 0$ and Equation 5–71 reduces to

$$h = \sqrt{h_1^2 - \frac{(h_1^2 - h_2^2)x}{L}} \qquad (5\text{–}72)$$

By differentiating Equation 5–70, and because $q'_x = -Kh(dh/dx)$, it may be shown that the discharge per unit width, q'_x, at any section x distance from the origin is given by

$$q'_x = \frac{K(h_1^2 - h_2^2)}{2L} - w\left(\frac{L}{2} - x\right) \qquad (5\text{–}73)$$

where

- q'_x is the flow per unit width at x (L^2/T; ft^2/day or m^2/day)
- x is the distance from the origin (L; ft or m)
- K is the hydraulic conductivity (L/T; ft/day or m/day)
- h_1 is the head at the origin (L; ft or m)
- h_2 is the head at L (L; ft or m)
- L is the distance from the origin at the point where h_2 is measured (L; ft or m)
- K is the hydraulic conductivity (L/T; ft/day or m/day)
- w is the recharge rate (L/T; ft/day or m/day)

If the water table is subject to infiltration, there may be a water divide with a crest in the water table. In this case, q'_x will be zero at the water divide. If d is the distance from the origin to a water divide, then substituting $q'_x = 0$ and $x = d$ into Equation 5–72 yields

$$d = \frac{L}{2} - \frac{K}{w}\frac{(h_1^2 - h_2^2)}{2L} \quad (5\text{–}74)$$

where

d is the distance from origin to water divide (L; ft or m)
h_1 is the head at the origin (L; ft or m)
h_2 is the head at L (L; ft or m)
L is the distance from the origin where h_2 is measured (L; ft or m)
K is the hydraulic conductivity (L/T; ft/day or m/day)
w is the recharge rate (L/T; ft/day or m/day)

Once the distance from the origin to the water divide has been found, then the elevation of the water table at the divide may be determined by substituting d for x in Equation 5–70.

$$h_{max} = \sqrt{h_1^2 - \frac{(h_1^2 - h_2^2)d}{L} - \frac{w}{K}(L - d)d} \quad (5\text{–}75)$$

EXAMPLE PROBLEM An unconfined aquifer has a hydraulic conductivity of 0.0020 cm/s and an effective porosity of 0.27. The aquifer is in a bed of sand with a uniform thickness of 31 m, as measured from the land surface. At well 1, the water table is 21 m below the land surface. At well 2, located some 175 m away, the water table is 23.5 m from the surface. What are (A) the discharge per unit width, (B) the average linear velocity at well 1, and (C) the water-table elevation midway between the two wells?

Part A: From Equation 5–60,

$$q' = K\frac{(h_1^2 - h_2^2)}{2L}$$

$$h_1 = 31\text{ m} - 21\text{ m} = 10\text{ m}$$

$$h_2 = 31\text{ m} - 23.5\text{ m} = 7.5\text{ m}$$

$$L = 175\text{ m}$$

$$q' = 1.7\text{ m/d} \times \frac{10^2\text{ m}^2 - 7.5^2\text{ m}^2}{2 \times 175\text{ m}}$$

$$= 0.21\text{ m}^2\text{/d per unit width}$$

Part B: From Equation 5–24,

$$v_x = \frac{Q}{n_e A}$$

As $Q = q' \times$ unit width and $A = h_1 \times$ unit width,

$$v_x = \frac{q'}{n_e h_1}$$
$$= \frac{0.21 \text{ m}^2/\text{d}}{0.27 \times 10 \text{ m}} = 0.08 \text{ m/day}$$

Part C: From Equation 5–71,

$$h = \sqrt{h_1^2 - (h_1^2 - h_2^2)\frac{x}{L}}$$
$$= \sqrt{(10 \text{ m})^2 - [(10 \text{ m})^2 - (7.5 \text{ m})^2]\left(\frac{87.5 \text{ m}}{175 \text{ m}}\right)}$$
$$= 8.8 \text{ m}$$

EXAMPLE PROBLEM A canal was constructed running parallel to a river 1500 ft away. Both fully penetrate a sand aquifer with a hydraulic conductivity of 1.2 ft/d. The area is subject to rainfall of 1.8 ft/y and evaporation of 1.3 ft/y. The elevation of the water in the river is 31 ft and in the canal it is 27 ft. Determine (A) the water divide, (B) the maximum water-table elevation, (C) the daily discharge per 1000 ft into the river, and (D) the daily discharge per 1000 ft into the canal.

Part A: From Equation 5–73,

$$d = \frac{L}{2} - \frac{K}{w}\frac{(h_1^2 - h_2^2)}{2L}$$
$$h_1 = 31 \text{ ft}$$
$$h_2 = 27 \text{ ft}$$
$$L = 1500 \text{ ft}$$
$$K = 1.2 \text{ ft/d}$$
$$w = 1.8 \text{ ft/y infiltration} - 1.3 \text{ ft/y evaporation}$$
$$= 0.50 \text{ ft/y accretion}$$
$$= 0.0014 \text{ ft/day}$$
$$d = \frac{1500 \text{ ft}}{2} - \frac{1.2 \text{ ft/day}}{0.0014 \text{ ft/day}}\left(\frac{(31 \text{ ft})^2 - (27 \text{ ft})^2}{2 \times 1500 \text{ ft}}\right)$$
$$= 680 \text{ ft from the river}$$

Part B: From Equation 5–75,

$$h_{\max} = \sqrt{h_1^2 - \frac{(h_1^2 - h_2^2)d}{L} + \frac{w}{K}(L - d)d}$$
$$= \sqrt{(31\text{ft})^2 - \frac{[(31\text{ ft})^2 - (27\text{ ft})^2]\,680\text{ ft}}{1500\text{ ft}} + \frac{0.0014\text{ ft/day}}{1.2\text{ ft/day}}(1500\text{ ft} - 680\text{ ft})680\text{ ft}}$$
$$= 39\text{ ft}$$

Part C: From Equation 5–73, for $x = 0$:

$$q_x = \left[\frac{K(h_1^2 - h_2^2)}{2L} - w\left(\frac{L}{2} - x\right)\right] \times \text{width}$$
$$= \left[\frac{(1.2\text{ ft/day})[(31\text{ ft})^2 - (27\text{ ft})^2]}{2 \times 1500\text{ ft}} - (0.0014\text{ ft/day})\left(\frac{1500\text{ ft}}{2} - 0\right)\right] \times 1000\text{ ft}$$
$$q_x = -960\text{ ft}^3\text{/day}$$

The negative sign indicates that flow is in the opposite direction of x, or into the river.

Part D: From Equation 5–73,

$$x = L$$
$$q_x = \left[\frac{K(h_1^2 - h_2^2)}{2L} - w\left(\frac{L}{2} - x\right)\right] \times \text{width}$$
$$q_x = \left[\frac{(1.2\text{ ft/day})[(31\text{ ft})^2 - (27\text{ ft})^2]}{2 \times 1500\text{ ft}} - (0.0014\text{ ft/day})\left(\frac{1500\text{ ft}}{2} - 1500\text{ ft}\right)\right] \times 1000\text{ ft}$$
$$q_x = 1100\text{ ft}^3\text{/day}$$

Flow is in the direction of x, or into the canal.

NOTATION

- A Area
- a Width of a flowtube in the derivation of the tangent law
- b Aquifer thickness
- b′ Aquitard thickness
- c Width of a flowtube in the derivation of the tangent law
- d Pore diameter
- dh/dl Hydraulic gradient
- dh/ds Grad h
- dx Length of one side of a control volume
- dy Length of one side of a control volume
- dz Length of one side of a control volume
- e Rate of vertical movement across an aquitard
- E_g Gravitational potential energy

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JACOBS ENGINEERING GROUP INC.

DATE 12/8/95 SUBJECT grout plant SHEET NO. 1 of 1

BY ________ CHKD. ________ JOB NO. 01K47101

Calculation of Grout plant capacity from HDW-EIS DOE/EIS 0113 vol 2

5300 m³/campaign x 5 campaigns per year

= 26,500 m³/yr.

26,500 m³/yr x 2.3 metric tons/m³

≅ 60,000 metric tons/year
x 1.1 tons/ton
= 67,000 tons/yr.

200T/da (vit) = 200T/d (365 d/yr)(.36 efficiency) = 26000 T/yr.

HDW-EIS says 5 campaigns/yr (1 month each) ≅ .41 efficient

0.36 ≅ 0.41 so

(67000T / 26000T) x 200 T/d ≅ 500 Tons/day for the grout plant

P. Branson 12/8/95

FORM 91-005-1 (4/81)

DOE/EIS-0113
VOLUME 2 of 5

VOLUME 2
APPENDICES A-L

FINAL ENVIRONMENTAL IMPACT STATEMENT

DISPOSAL OF HANFORD DEFENSE HIGH-LEVEL, TRANSURANIC AND TANK WASTES

Hanford Site
Richland, Washington

DECEMBER 1987

U.S. DEPARTMENT OF ENERGY

characteristics of the grout (Rockwell 1985; Tallent et al. 1986). The proportions of each component can be adjusted to meet various processing and performance requirements.

Processing requirements include physical and rheological characteristics such as critical flow rate, gel strength, and frictional pressure drop. These requirements are affected by the amount and type of grout formers used, the presence of entrained air and admixtures, and the mixture's water content. These characteristics affect the ease of mixing, pumping and emplacing of the grout mixture.

Long-term grout performance depends on such physical and mechanical properties as density, porosity, compressive strength, thermal expansion, thermal conductivity, and leachability (Young 1982). In addition, the environment in which the waste-form material would be placed must also be considered (Roy et al. 1980). To formulate optimal material for a specific site, the probable effects of exposure to the surrounding conditions throughout the required life span must be evaluated. Changes in the grout after curing are expected to occur slowly and might affect performance. Long-term containment of wastes would be enhanced by the Hanford Site's arid climate, which limits the mobility of the hazardous chemical and radionuclide constituents in the wastes.

Grout formulas would be tailored to each type of waste to ensure that a durable, safe waste form is created. Tests will be conducted to provide data required to improve assessments of the operational and long-term performance characteristics of each type of grout (DOE 1986b). If it is not possible to develop a grout formula adequate for near-surface disposal of a particular waste, several options exist: 1) the waste stream may be treated to remove or neutralize the waste component(s) of concern, 2) the waste stream may be converted to borosilicate glass in the Hanford Waste Vitrification Plant, or 3) the waste stream may be converted to another solid form, such as drummed concrete, and disposed of at a federal waste repository.

D.3.2 Feed-Tank Filling

Grouting would be conducted in scheduled campaigns that are determined by the capacity of the 3,800 m^3 waste-feed tank and by the capacity of the grout facilities (nominally 0.2 m^3 of grout per min). After initial startup operations, there would be on the average about five grout campaigns per year, each lasting about 1 month. About 3,800 m^3 of waste feed would be mixed with the grout formers to produce a total grouted waste volume of about 5,300 m^3 per campaign. At a rate of five campaigns per year, it would take about 20 years of operations to grout the total volume of the candidate feed waste streams. The resulting grouted waste volume would be about 4.9×10^5 m^3.

A campaign would begin with the filling of the feed tank with liquid wastes that have been determined to be, through prior testing, acceptable for grouting. The contents of the tank would be mixed to ensure that the chemical composition falls within predetermined bounds. A sample of the waste would be tested before grouting to ensure that the waste and resultant grout properties fall within acceptable limits.

From Table B-2 Cost Adjustment Factors
p B-9 WHC-SD-WM-OP-087, Rev 0
July 1995

Fiscal Year	Composite increase (mix of 55% labor + 45% material)	
1987	0.2 %	1.25 factor
8	3.4	
9	3.3	
90	1.4	
1	3.8	
2	1.6	
3	2.5	
4	2.9	
5	3.4	

To escalate a cost from 1987 to 1995, include cumulative effect from 1987 thru 1995 to estimate cost increase to end of year 1995

Use 1.25 multiplying factor

D Stein
12/8/95

TABLE D.10. Maximum Individual Total-Body Dose Commitment (rem) from Evaporation and Grouting of New Tank Waste

Pathway	Exposure Period 1 yr	70 yr
Air Submersion	4.6×10^{-17}	2.7×10^{-16}
Inhalation	2.7×10^{-9}	1.6×10^{-8}
Terrestrial (air paths)	2.8×10^{-8}	1.6×10^{-7}
Totals	3.1×10^{-8}	1.8×10^{-7}

D.8 COSTS

Costs for grouting wastes according to the reference alternative include construction, operation, and decontamination and decommissioning (D&D), as shown in Table D.11. The costs associated with grouting are significantly greater than previously estimated in RHO-RE-ST-30 P

TABLE D.11. Cost for Grouting Under the Reference Alternative   only DST

Phase	Cost, millions of $1987[a]
Construction	400
Operation	270
D&D[b]	14
Total	680

(a) Includes costs for research and development and construction of protective barriers. Data apply to the reference alternative (Rockwell 1987).
(b) D&D costs for a facility are assumed to be 20% of its construction cost.

680
1,330
~2B total
residuals

(Rockwell 1985), and the reasons for the increase are also discussed by Rockwell (1987). The increase is primarily due to the costs of vault construction, compared to the earlier trench design.

Costs for grouting only SST wastes are shown in Table D.12. The data in Table D.12 are provided to permit a comparison between the reference and geologic alternatives. Again the costs include construction, operation, and decontamination and decommissioning. Changes in grouting requirements delineated for the reference alternative also apply when estimating costs for grouting SST waste.

TABLE D.12. Costs for Grouting Single-Shell Tank Wastes

Phase	Cost, millions of $1987[(a)]
Construction	860
Operation	430
D&D	40
Total	1,330

(a) Costs include research and development costs plus construction costs for protective barriers.

D.9 REFERENCES

Department of Energy (DOE). 1986a. Environmental Assessment for the Grouting and Near-Surface Disposal of Low-Level Radioactive Phosphate/Sulfate Wastes from N-Reactor Operations. DOE EA 0312, Richland, Washington.

Department of Energy (DOE). 1986b. Interim Hanford Waste Management Technology Plan. DOE/RL/01030-T4, Richland Operations Office, Richland, Washington.

Electric Power Research Institute (EPRI). 1983. Low-Level Radwaste Solidification. Electric Power Research Institute, Chicago, Illinois.

Environmental Protection Agency (EPA). 1978. A Survey of Available Methods of Solidification for Radioactive Waste. ORP/TAD-78-2, Washington, D.C.

Environmental Protection Agency (EPA). 1980. Guide to the Disposal of Chemically Stabilized and Solidified Waste. SW-872, Washington, D.C.

International Atomic Energy Agency (IAEA). 1968. Treatment of Low- and Intermediate-Level Radioactive Waste Concentrates. Technical Report Series No. 82, Vienna, Austria.

Jolley, R. L., L. R. Dole, H. W. Godbee, and A. H. Kibbey. 1986. Treatment, Storage, Disposal, and Transportation Technologies and Constraints. Volume 2 of Low-Level Radioactive Waste from Commercial Nuclear Reactors. ORNL/TM-9846-V2, Oak Ridge National Laboratory, Oak Ridge, Tennessee.

Kibbey, A. H., and H. W. Godbee. 1980. A State-of-the-Art Report on Low-Level Radioactive Waste Treatment. ORNL/TM-7427, Oak Ridge National Laboratory, Oak Ridge, Tennessee.

McDaniel, E. W., et al. 1982. Strontium Leachability of Hydrofracture Grouts for Sludge-Slurries. ORNL/TM-8198, Oak Ridge National Laboratory, Oak Ridge, Tennessee.

Rockwell Hanford Operations. 1985. Hanford Defense Waste Disposal Alternatives: Engineering Support Data for the HDW-EIS, RHO-RE-ST-30 P, Richland, Washington.

Rockwell Hanford Operations. 1987. Engineering Support Data Update for the Hanford Defense Waste Environmental Impact Statement. RHO-RE-ST-30 ADD P, Richland, Washington.

Roy, D. M., M. W. Grutzeck and K. Mather. 1980. PSU-WES Inter-Laboratory Comparative Methodology Study of an Experimental Cementitious Repository Seal Material. ONWI-198, The Pennsylvania State University, University Park, Pennsylvania, and U.S. Army Engineer Waterways Experimental Station, Vicksburg, Mississippi.

REFORMING CONVENTIONAL RISK ASSESSMENT, RISK MANAGEMENT AND RISK-BASED LAND USE PLANNING METHODS AND CONCEPTS TO INCORPORATE TRIBAL CULTURAL INTERESTS AND TREATY-RESERVED RIGHTS

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Running Title: Cross-Cultural Risk Perspectives

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Abstract or Summary (if the format calls for one)

Risk assessment is increasingly being used as a primary analytical tool in risk-based decision making. It incorporates implicit and explicit values, biases, presumptions and even, due to the specific parametrics selected for analysis, risk management goals themselves. Thus, both the technical methodology and the values basis of risk assessment must be examined for their adequacy in addressing tribal cultural perspectives and the rights and interests of sovereign American Indian Nations. Conventional risk assessment is especially inadequate for assessing unique tribal activity and exposure patterns and risks to tribal cultures, health and identity. Further, the overall risk management framework frequently lacks holistic and coherent goals, as well as a process for ensuring equal access to the decision process. Specific examples are provided that relate to risk-based land use planning and remediation.

Several solutions are presented here, including the comparative risk approach as a basis for evaluating a wide range of risks, evaluation of risks and impacts to the "ecocultural-human landscape," and criteria used by the technical staff of the Confederated Tribes of the Umatilla Indian Reservation of northern Oregon for evaluating potential impacts to sovereignty and environmental, human and cultural health.

Can anyone outside of the tribal culture adequately address the tribal risks

I. Introduction

Risk assessment is increasingly being applied to pollution control and remediation decisions, particularly in the context of cost-risk-benefit analysis and land use planning. While there are certain advantages in using such methods to prioritize remedial actions and develop risk reduction strategies, conventional assessment methods and decision processes are plagued by inherent limitations in their ability to incorporate unique cultural perspectives and the rights and interests of affected communities, particularly those of sovereign American Indian Nations. Credible, technically defensible and politically acceptable risk management strategies will result only if reformed risk assessment practices and open risk management processes fully embrace the perspectives and values of communities directly affected by such decisions[1].

The issues described below have been identified as particular concerns to the technical staff of the Confederated Tribes of the Umatilla Indian Reservation (CTUIR, 1993a, 1993b, 1994a, 1994b, 1995) but are likely to be applicable to many other community situations. Risk assessment increasingly comprises the principal technical decision tool for federal agency decisions about off-reservation activities that may have critical implications or impacts both on-reservation and in off-reservation ceded lands where tribes have sovereign rights reserved to them to use resources and pursue traditional activities. Major federal facilities within tribal ceded lands include the Hanford Nuclear Site in southeastern Washington (the most severely contaminated site in the Western hemisphere), and the Umatilla Army Depot in northeastern Oregon (site of 12% of the nation's chemical and nerve agents stored under deteriorating conditions and slated for onsite incineration). The tribal reservation is downwind and downriver from both these facilities, putting at further risk the resources that tribal people have depended on for thousands of years.

Several major areas of deficiency have been identified in the overall Risk Assessment/Risk Management process: 1) lack of recognition of the range of risk information needed to provide a strong decisional information base, 2) growing recognition that conventional methods and metrics do not provide adequate details about impacts to tribal health, including ecocultural impacts and temporal descriptors, 3) the need for a higher integrative perspective for combining diverse types of risk information into a format useful for both stakeholders and risk managers, and 4) growing recognition

[1] This raises the point that western science and indigenous science often have different criteria (rules of evidence, or ways of knowing) for establishing the validity of knowledge (Stoffel and Evans, 1990), especially for impacts to tribal ecocultural-human health. Risk assessment is exceptionally vulnerable to this conflict because it is inherently predictive, untestable, and value-laden. Technical "experts" are often allowed to validate both the methods and the results while those who have been risk-assessed are limited to protesting this presumption of validity. Any resulting modifications in the methods, however, are likely to improve the accuracy of conventional (i.e. "approved") approaches by including factors that were heretofore overlooked.

that personal values and (un)recognized biases of the assessor and manager are implicit or explicit throughout the risk assessment and management process (CTUIR, 1995).

Conventional risk assessment is typically focused on "environmental safety and health" (ES&H) risks, overlooking much of what is actually at risk. Risks may directly impact not only human health and the environment -- a particular concern to subsistence-dependent tribal families -- but also tribal cultural values, traditional tribal lifestyles, and tribal cultures themselves for many generations to come. These risks are not often accounted for with existing methodologies, thus resulting in decisions which are "unstable" due to an inadequate information base. Impacts beyond ES&H risks are not just "considerations" to be used in risk management activities, and they are definitely different from conventional definitions of "perceived risk;"[2] they are real risks that require an analysis that is just as rigorous and systematic as that for ES&H risks, and that belong in the same quantitative risk framework (National Research Council, 1994; Vermont Agency of Natural Resources, 1991; California Environmental Protection Agency, 1994).

There is also a more basic deficiency in the entire Western approach to environmental management, and this is also seen in toxics risk assessment and management. An indigenous worldview would seldom rely first or solely on a risk-based approach to either toxics management or land use planning without first committing to principles such as sovereignty, protection, equity and sustainability. In other words, the entire decision context must be framed using the worldview (especially views about sustainability, balance, cyclical time and reciprocal relations) of the indigenous community, because it is logically inappropriate to use a Western context for evaluating impacts to Indigenous values and cultures (Margolis, 1987; Duran and Duran, 1995; LaDuke, 1995).

Several solutions are presented in this paper, and include suggestions for setting values-based integrated ecocultural risk management goals (particularly for complex remedial sites with multiple risk sources and multiple trustee resources), for re-defining the risk information needs to include appropriate culture-specific parametrics, and for using concrete but holistic evaluation criteria as "systems requirements." Whether the decision involves holistic conservation or prioritization ("cultural triage," Stoffle and Evans, 1990), these solutions should be useful.

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[2] Conventional risk approaches tend to evaluate "human health, environmental impacts and perception," or "hazard (i.e. real risks) and outrage (i.e. unreal risks)," or " cancer risk, ecological toxicity and knowledge/dread" (see for example Morgan et al., 1994), or "human health, habitat disruption and the social response to perceived risks" (see OSTP, 1995). None of these approaches evaluates cultural risk correctly, because an evaluation of cultural risk bears little if any resemblance to an evaluation of potential health symptoms due to anxiety and fear which may arise, in part, from recognition of danger (even though neurophysiological symptoms are very real health effects and should be included in the portion of the analysis that addresses direct health risks).

Potential Tribal Risk Model Characteristics

1. Sovereignty and Treaty-Reserved Rights: CTUIR has sovereign authority to, among other things, protect treaty-reserved rights and to promote and enhance tribal self-determination and cultural integrity, and to protect tribal and individual rights to pursue traditional activities, including religious and cultural practices, both on-reservation and in off-reservation ceded areas and beyond.

2. Tribal, state and federal governments, and their natural and cultural resource agencies, are responsible for protecting conditions and resources required for the above practices. Co-management and co-decision making by Sovereign Nations and other Trustees is an absolute requirement for technically defensible and politically acceptable decisions.

3. The fundamental goal of strategic land use planning should be long-term, culturally appropriate Integrated Eco-Cultural Management. The fundamental principles of such plans are sovereignty, protection, equity and sustainability.

4. Types of information that must form the risk information base *after* a principle-based mission plan is developed:

  a. Environmental/Ecological integrity and quality
  b. Human health effects (including multigenerations)
  c. Individual and community Sociocultural/religious well-being
  d. Temporal and spatial descriptors for each of the above.

II. Deficiencies in Conventional Risk Based Decision Making from a Tribal Perspective

Especially if a "course of action" at complex waste sites is composed of hundreds or thousands of individual decisions about risk, cost and schedule, it is important to develop (and enforce) a set of risk principles that reflect the perspectives of the impacted communities. However, decision rules alone do not guarantee adequate participation of sovereign nations, nor do they guarantee that tribal perspectives are understood, much less used in the decision process. A truly open process will ensure that "interested and affected parties" are involved throughout the decision process, and that their values, perspectives, rights and goals frame and guide the decision process from policy development, through problem formulation to decision implementation. It will necessarily shift some of the decision authority to tribal councils or other Trustees/stakeholders and will require some initial investment of time and effort on the part of the responsible agencies to establish an open co-management process. However, this will ultimately be more cost effective over the long term than approaches such as "decide-announce-defend," "repond-to-comments," or "develop a utilitarian equation and let the computer optimize" (the "science tells us that..." approach).

A. Risk management goals of achieving affordable, acceptable or allowable risk levels may not satisfy principles of equity, protection, or sustainability.

Risk management goals and risk assessment assumptions generally reflect the perspective of the decision maker or risk manager. Risk Management goals (e.g. achieving "acceptable risk," "allowable risk," or "affordable risk") are inherently value-based but are seldom developed democratically. A given level of risk may not be acceptable to stakeholders but may be "allowable" under some statutes or "affordable" under others. Frequently the terminology used to set risk management goals is confused, thus, for example, mistakenly equating safety or protection with available budget.

The basic problem statement of a decision process is often too narrow, and a coherent goal or mission plan is often lacking. It may not be clear whether the goal is to be health-protective, cost-effective, or utilitarian (health-per-dollar-effective). This type of confusion may lead to questions such as "How little do I have to clean?" (also stated as "Don't clean up what doesn't make sense"), or "What level of protection can I afford?" A narrowly focused risk manager may attempt to force a decision into a simplistic zero-sum format (for example, "More expensive remediation or less land use?"). This immediately creates competition among potential land users, especially between industrial users (who may tolerate "brownfield" cleanup standards) and prior-in-time-and-right users such as sovereign Indian Nations for whom the land and its resources are supposed to be held in trust by the U.S. government for members to safely use "for as long as the grass should grow."

Risk management methods of "trading" one type of impact for another are also contrary to indigenous worldviews, because people and their culture are, in reality, inextricably intertwined with the natural environment (Figure 1), with no component being of greater or lesser intrinsic value than any other component. Failure to recognize this cultural dichotomy has resulted in a long history of paternalistic policies on the part of government and technology, and paternalistic actions on the part of professional "experts" (Lowrance, 1985).

B. Ethical, legal, social issues are required parts of the information and planning base, not just a final clearance step, or part of post-decisional stakeholder acceptability.

Values should guide the development of the overall problem statement, the selection of metrics, the collection, analysis and integration of data, the construction of the information base, the selection of decision criteria, and the ultimate implementation of the decision. The evaluation of ecological and cultural risks is not a step to be postponed until the action is ready to be deployed in the field, because their evaluation encompasses much more than merely avoiding further harm (or minimizing future harm) to localized natural or cultural resources during implementation. This process actually begins with a values-based analysis of the available alternatives that will accomplish the mutually agreed upon goals. If protection of natural and cultural resources is perceived by managers solely as an end-of-process filter, this may result in, at best, project delay and stakeholder outrage, and, at worst, project abandonment. Rather, the original mission statement should, at a minimum, include specific goals related to the ethical and sociocultural issues that will ultimately determine the degree of acceptability of the decision. This is particularly true when so many factors that affect "health" lie outside conventional Euro-industrial medical boundaries (Lowrance, 1985) and exert a strong political or interpretive influence regardless of the weight of the technical evidence.

C. Particularly as risk results are presented as point estimates within risk ranges, uncertainty must also be managed.

Technical uncertainty is sometimes considered analagous to stakeholder perception. The assessor typically addresses technical uncertainty by collecting more data, while the manager seeks to reduce the amount of perceived risk with more communication or education. Both data and communication are thought of as improving the accuracy of the risk estimates, but this is not entirely true for either case. The collection of more detailed data within the original restricted categories is less important than collecting the appropriate breadth of data at proper precision levels. Similarly, the education of risk assessors and managers about cross-cultural perspectives and about the need to modify "approved" risk assessment methods and presumptive risk management goals may be more difficult than ensuring that a community group (or its experts) has a sufficient level of technical understanding to participate meaningfully in the decision process (Silbergeld, 1991; Shrader-Freschette, 1991).

D. Principles of Environmental Justice require changes in the fundamental goals of Risk Based Decision Making and the practice of risk assessment.

At least four factors tend to disproportionately increase risk to American Indian health from environmental contamination: 1) Dose (potentially increased exposure due to cultural lifestyle activities), 2) Response (potentially increased physiologic sensitivity due to genetic makeup, existing health conditions or concurrent exposures), 3) Mitigation (possible decreased access to health care, insurance compensation and other forms of post-harm amelioration), and 4) Cultural Health (potentially disproportionate impacts to individual and tribal community health and identity, and cultural values). In addition, the responsibility of the present generation toward future generations (regarding long term impacts of long-lived radioactive contaminants, for example) requires a description of the temporal risk profile and an evaluation of multigeneration and cumulative impacts. Conventional risk assessment addresses none of these systematically.

III. Specific Deficiencies in evaluating impacts to tribal health & identity.

Narrowly scoped risk analysis methods tend to omit metrics related to unique use of treaty-reserved resources, unique (non-surburban) lifestyle activities and exposure pathways, and eco/cultural health and tribal identity. Omission of a data integration step and a description of the temporal risk profile may be compounded by other faulty assumptions to further distort the risk picture. Without correcting these deficiencies, it is not possible to evaluate the potential for a disproportionate burden of risks to fall on tribal communities through time. However, if these (and other) deficiencies are corrected, then risk assessment can indeed be one useful tool for risk management, but only after overall integrated, holistic goals and value-based decision criteria are established.

A. Unique use of treaty-reserved resources for subsistence, ceremonial, cultural or religious practices must be evaluated with tribal guidance.

Tribal members use numerous sources of food and other ceremonial, medicinal and material resources that are not commonly used by the dominant society, and are thus ignored in conventional risk assessments. Given the close relationship between nature and tribal people and their culture, a complete understanding of contaminant exposure could only be obtained by charting whole ecosystems, as well as the cultural practices related to gathering and using many resources. Consideration of dietary factors alone includes a myriad of non-suburban plants and animals (along with a variety of plant and animal parts not part of the suburban diet), seasonally fluctuating consumption rates that would cause peaks in contaminant intake rates, a variety of storage and preparation methods, and a higher proportion of locally-obtained food than typical default exposure factors (EPA, 1989) used in conventional assessments.

Further, many species serve multiple purposes (food, medicines and materials). For example, the common cattail has many uses: in the spring the shoots are eaten, the roots are consumed, and the pollen is used in breads later in the season. The fibrous stalks are used in woven items such as baskets in which other foods may be stored or cooked, or mats used for sleeping and shelter (Harris, 1993, 1995). Thus, even describing multiple food uses does not necessarily describe all the ways people interact with even a single species. Further, even if it were possible (and only with tribal permission) to compile a catalog of dietary and medicinal species, biouptake and bioaccumulation factors are largely unknown for individual species. A more appropriate approach may be to start with an assumption that a given proportion (higher than the standard suburban default assumptions; EPA, 1989) of the total diet is obtained locally, and then to "anchor" the assessment with key species for which contaminant uptake, contaminant bioaccumulation, foodchain transfer and human ingestion rates are known.

In addition to the evaluation of direct and indirect foodchain exposures, part of an impact evaluation must include consideration of the loss of the traditional diet (including protein, vitamins, fiber and so on) which is physiologically optimal for the people who have undergone millenia of genetic adaptation.

B. Unique (non-suburban) lifestyle activities and exposure pathways can only be assessed in direct consultation with local tribes.

Cultural practices that are integral components of a traditional lifestyle may also result in increased exposure potential. Certain cultural, ceremonial and spiritual practices, such as sweat lodges, are unique to tribal people, and present multiple exposure pathways not addressed by conventional risk analyses. In addition, conventional parameters (such as the duration and frequency of time spent outdoors) may need to be increased to account for particular lifestyle practices. Again, a preferred approach begins with a recognition that exposure assumptions should be increased over suburban default levels, rather than attempting to catalog the myriad of individual, confidential and tribal- or clan-specific activities. Activity patterns and therefore exposures may also differ substantially with age and gender, making it important to anchor generic parameters with local knowledge. chosen by tribal members to represent particular lifestyles or activities of critical importance.[3]

C. Evaluations of Eco/Cultural health and cultural and spiritual values are core elements in the tribal risk information base.

The term "cultural risk" has been used in at least three ways. In the narrowest sense, it means risk to cultural and historic sites and resources. It may also include traditional activities and skills or knowledge, although this interpretation varies among applications. There are, in fact, significant issues relating to the exact definition of a "cultural resource" or "traditional cultural property" and exactly what constitutes an adverse effect (physical, chemical/radiological, and/or aesthetic). In a broader sense, cultural risk also

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[3] As with specific exposure data, it should be recognized that all resulting information belongs to the affected tribe, and can only be developed and used under their direction; the data do not belong to the assessor or ethnographer. At some point, too, it becomes ethically improper to pursue scholarly inquiry to the point of intrusion (Toelken, 1995), especially if the degree of improvement in "data quality" does not provide a comensurate benefit to the people whose lifestyles are being publicly examined, possibly without their full knowledge or informed consent. In this context, "benefit" does not mean increased "accuracy" in toxicity/exposure data and, as a consequence, relaxed pollution controls and increased allowable exposure levels, but rather some real increase in protection or the provision of health services (using the broadest definition of health).

includes impacts to cultural values and to cultures themselves, and is similar to definitions used in Comparative Risk projects. In some assessments, cultural risk is misused to mean culture-specific social and behavioral response to risk - this reflects a perceptually limited understanding of non-EuroAmerican cultures (i.e. sociological imperialism, Duran and Duran, 1995) that perpetuates cross-cultural communication problems, paternalism, and can even exacerbate adverse effects on tribal health.

Traditional tribal cultural practices evolved over long-term, sustainable associations between human and non-human species and their environment. The environmental landscape shapes modes of thinking, feeling and behaving in a way that goes beyond mere survival. Language, culture and religious symbols all coalesce together at particular locations in forms that reflect the unique local patterns of the naturospiritual realm. The people respond with a corresponding social organization and living religion that are unique to the area and inseparable from it, and that follow the area's natural rhythms and demands. This not only provides a time-proven effective design for sustainable survival, but also represents a way of knowing that reinforces a feeling of real presence in the environment and a continual awareness of the harmonious coexistence of the material and spiritual realms that Euroamericans seldom achieve (Jahner, 1989; Bennett, 1993).

Tribal identity includes culture, religion and place; if the link between the environment and the people is broken, the culture-religion is also broken (Figure 2). Tribal health includes personal well-being that derives from membership in a healthy community with strong traditional values and the ability to follow traditional lifestyle, healing, religious and educational practices in nondegraded surroundings. Since tribal culture-religion is inseparable from the place of origin, full and safe access to these places and their natural resources is required so that the cultural values of critical significance to the American Indian and her/his local community are preserved (Harris, 1995).

D. Faulty land use assumptions in the mental model bias the outcome.

Land use and exposure assumptions can bias the outcome of the risk assessment tremendously. For instance, the (highly questionable) presumption that institutional controls and restricted access will be enforced for as long as contamination remains (thereby preventing exposure and risk) precludes the use of typical residential exposure scenarios and the evaluation of subsistence or other cultural-based activities, and would likely lead to incorrect measures for evaluating progress in risk reduction. For instance, one might declare a site "safe for unrestricted surficial recreational use" while actually leaving in place a substantial amount of surface, subsurface and groundwater and/or surface water contamination that could pose ecological and cultural risks and could also pose unacceptable human risk under reasonable tribal use scenarios, particularly over long time periods.

Using a conventional narrow risk definition as justification for institutional controls, one could conclude that there is indeed no risk if there is no exposure. However, using the broader concept of risk, it is clear that such "mitigation" (i.e. breaking the exposure pathway) also breaks the land-connected culture pathway, which is both an immediate and a cumulative adverse effect on sovereign rights and the ability to safely follow traditional cultural practices. Risk managers may assume that this effect represents a zero-impact planning baseline, or that it is an "affordable" impact compared to other impacts, or even that preventing exposure by forbidding access to heritage lands provides a "net benefit." Similar arguments have been applied to natural resources (e.g. that contamination and restricted access may "protect" habitat from physical disturbance) and cultural resources (e.g. that contaminated gravesites are "protected" from looting). In at least one case, it has been proposed that "mitigation" of cultural impacts could occur through consultation with tribal members and payment for lost spiritual ceremonies on sites that are targeted for destruction through resource exploitation, to the abhorrence of traditional tribal peoples (Hall, 1994).

IV. Solution: Evaluate impacts to the Eco-Cultural landscape

A. Whether the decision context calls for strategies to prevent, mitigate, protect, remediate or restore, principles of Integrated Eco-Cultural Management still need to be followed.

The basic premise of this approach to strategic planning and impact evaluation is that Integrated Environmental Management must be combined with concepts of cultural landscapes and environmental justice into an Integrated Eco-Cultural Management approach (Figure 3). The spatial dimensions include surface and subsurface ground, groundwater and surface water, and air and biota; due to influences from and on nearby geologic and natural features, these boundaries may extend beyond reservation, ceded or traditional use boundaries. The temporal dimension includes cumulative past effects, present impacts (including future impacts deriving from present conditions), future impacts and cumulative multigeneration effects. The ethical dimension may extend far beyond minimal legal requirements for trust resource protection and intergovernmental consultation.

Land-based decisions begin with a rigorous characterization of land and its cultural and natural resources, and include the evaluation of current and potential impacts by stressors to environmental integrity and to human physical, sociocultural and spiritual health associated with use of those resources. Stressors include physical, radiological or chemical contamination and aesthetic impacts, including byproducts and side effects of actions or responses. With this wider evaluation, a different decision might be reached; for example, preservation or restoration of cultural/religious integrity may, in fact, be a key decision driver, and cleanup standards might be developed for ceremonial quality as well as for human health.

Principle: Temporary solutions to remedial actions may have lower short-term project costs but higher cumulative natural resource and sociocultural compensation costs. Interim and final states of remediation, restoration and disposal must be determined with Trustees during the problem definition stage.

B. A Land Use Plan should focus on Integrated Eco-Cultural Management goals. Non-conflicting risk-based priorities and remediation/restoration goals then can be established for individual risk sources or proposed actions.

If mission statements are phrased in holistic ecocultural terms, then specific goals will be more coherent and integrated, regardless of the specific application. For instance, if the mission is to evaluate either prospective (e.g. under NEPA) or retrospective (e.g. under CERCLA) impacts, then information across the entire span of environmental/ecological/ human/socio-cultural risks would strengthen the information base. If the mission is to design remediation and restoration strategies, then the result would be a long-term integrated approach (some or all of which might be risk-based), rather than piecemeal or project-by-project mitigation. If the mission is to choose among technical options, one would start with an "Alternatives Assessment" (O'Brien, 1994) to reflect the full range of stakeholders' underlying goals and key issues (Keeney, 1992) before developing risk-based standards and selecting a preferred alternative. Finally, if the mission is to develop land use plans, then end state land uses might include risk-based criteria for an equitable and sustainable combination of restored treaty-reserved rights, long-term growth management, conservation/preservation, environmental resource use, economic development, and protection/enhancement of health, safety and quality of life.

Neither "risk reduction" nor "land release" would be primary goals of a land use plan - they are secondary to the primary goal of equitable and sustainable integrated eco-cultural management. Only after value-based management principles have been established should risk-based evaluations (spanning the entire range of risk types) be used to prioritize actions for individual risk sources and to establish remedial and restorative goals relative to overall health-protectiveness and cost-effectiveness.

Principle: In a Land Use planning context (especially for complex sites), it is inappropriate to rely on a risk-based land use approach without first developing an integrated, holistic, principle-based mission statement and site-wide plan. Temporally phased and spatially fragmented cleanup and land release actions should not proceed until comprehensive value-based goals are established. Tribal perspectives start with holistic goals and then move to specific objectives directed toward established goals and endstates; they do not start with fragmented actions that are pieced together to construct some semblance of a whole plan.

V. Solution: Approaches for holistic risk evaluation

A. Comparative Risk Projects.

Several comparative risk projects (USEPA, 1993) have evaluated impacts to quality of life, human health and the environment. In particular, the Vermont (1991), California (1994) and Wisconsin Tribes (USEPA, 1992) projects stand out as examples where community values guided the selection of metrics for evaluating impacts ranging from human and environmental health to socioeconomic factors and aesthetics. The Wisconsin Tribes project modified conventional risk assessment concepts to accomodate unique tribal lifestyles and subsistence activities, overall tribal culture, natural resource use, cultural and religious values and tribal priorities. Even so, the predetermined framework for the analysis perpetuated some of the limitations related to the difficulties in evaluating temporal factors, equitable distribution of risk, and long-term sustainability indicators. However, the Wisconsin Tribes project demonstrates that it is indeed possible to modify conventional parameters and develop additional ones that together provide a much more complete and satisfactory description of risk.

B. Specific examples of ecocultural risk evaluation: map-based and parameter-based.

Two approaches are under development at the Pacific Northwest Laboratory that attempt to accomodate tribal perspectives on human-ecocultural risk. One approach uses GIS data layers relating to a variety of ecological resources (some of which may be threatened and endangered, and some of which are not endangered but are of critical importance to local tribal members) and identified cultural/historical resources. As work proceeds, human health risk "isopleths" using tribally-developed exposure scenarios and modeled contaminant concentrations over time will be added. In addition, a "heritage" map indicating general areas of special importance to Hanford Site Nations may also be developed. The philosophical issue here is that while it is necessary to relate impacts to tribal health, culture and identity directly to the land, it may be improper to attempt to "map" cultural values at all, since any zonation implies a judgement as to relative importance of certain species, or relative sacredness of different areas.

A more conventional approach has been to develop parameters reflecting ecocultural values expressed by local tribes, in addition to others modified from comparative risk projects. This approach also has limitations of being overly numerical and thus losing some of the cultural meaning behind the parameters, of inadvertently biasing the evaluation by the selection and wording of individual parameters, of including too little active participation by tribal staff, and of implying that one can prioritize some values over others. Both the map-based and parameter-based approaches do provide methodological starting points, however, and encourage the use of initial value statements to guide the development of parameters.

VI. Solution: The link between theory and practice - "CTUIR Criteria" applied within geographic, geosphere, biosphere, and ethicsphere boundaries.

The meaningful exercise of tribal treaty rights is entirely dependent on a healthy ecosystem; a right to fish or gather plants is hardly useful if the fish and plants themselves have vanished or become contaminated, or if the resources have been damaged to an extent that further exercise of rights will cause unacceptable injury to the resources (CTUIR, 1993a).

An adequate evaluation of impacts to tribal sovereignty, environmental, cultural and personal health requires a holistic and integrated approach that conventional risk assessment and management lack. As described above, natural resources form the basis of traditional diets, ceremonies, material items, recreation, trade and other cultural activities and practices. All indigenous plants and animals have religious significance to people who practice traditional Indian religion. People, culture and nature evolved together and co-adapted over many millenia; impacts to any one of these affects overall tribal health and identity, because impacts to a single resource may have ramifications for human health, environmental integrity and religious use.

General criteria for evaluating impacts spanning the range of concerns discussed above are shown below. Additional principles can be enumerated for specific proposed actions, such as "do not prejudice future options" through the choice or irretrievable waste forms or through the use of physical barriers between long-lived radioactive or chemical contaminants and the environment that must be replaced every 100 years for the next 10,000 years.

CTUIR Criteria for Evaluating the Impacts of Proposed Actions

1. **Protection of Tribal Sovereignty**, including protection of tribal rights in ceded territory and areas over which CTUIR exercises off-reservation treaty rights in perpetuity.

2. **Protection and Restoration of the Environment**, including the resources required for full and safe exercise of on- and off-reservation treaty rights.

3. **Protection of cultural, religious and archaeological resources**, cultural integrity and heritage, the conditions necessary for traditional, subsistence or religious activities (including aesthetic or spiritual qualities of an area or resource), tribal identity, and related Tribal rights.

4. **Protection of the Reservation and its members, including future generations**, from hazards originating in off-reservation ceded lands or elsewhere.

The spatial and temporal dimensions of such an evaluation may not stop at the boundary of the reservation or ceded territory, but extend for as far distant as the resource (aquifers, habitat, and so on) and its buffer zones extend, and for as far and as long as the impact persists on the land, natural resource, and human base of a whole and holistic community. It includes all environmental media (biotic and abiotic), and all uses, adaptations and effects. It includes considerations of ancillary and cumulative impacts to eco-cultural (including aesthetic) resources related to the exercise of treaty rights in either space or time. Finally, as recognition of a "global village" increases, an American Indian set of environmental ethics is required as the basis of a safe, healthy, equitable and sustainable future for us all.

References

JW Bennett, 1993. "Human Ecology as Human Behavior. Essays in Environment and Development Anthropology." Transaction Publishers, New Brunswick, NJ.

California Environmental Protection Agency, 1994. "Toward the 21st Century: Planning for the Protection of California's Environment." Final report by the California Comparative Risk Project, Sacramento, CA.

CTUIR, 1993a. "*Criteria for Evaluation of Proposed Changes to the Hanford Federal Facility Agreement and Consent Order.*" CTUIR Department of Natural Resources, Pendleton, OR, July 21, 1993.

CTUIR, 1993b. "*Comments on the Columbia River Impact Evaluation Plan.*" CTUIR Department of Natural Resources, Pendleton, OR, September 3, 1993.

CTUIR, 1994a. "*Scoping Issues for the Environmental Restoration Disposal Facility.*" CTUIR Department of Natural Resources, Pendleton, OR, February 18, 1993.

CTUIR, 1994b. "*Development of Draft Hanford Sitewide Groundwater Remediation Strategy and Perceived Impediments to its Effective Implementation.*" CTUIR Department of Natural Resources, Pendleton, OR, May 11, 1994.

CTUIR, 1995. "Scoping Report: Nuclear Risks in Tribal Communities. A Report by the Confederated Tribes of the Umatilla Indian Reservation Outlining Concerns About Risk-Based Approaches to Environmental Management Decision-Making." CTUIR Department of Natural Resources, Pendleton, OR.

E Duran and B Duran, 1995. "Native American Postcolonial Psychology." SUNY Press, Albany.

K Hall, 1994. "*Impacts of the Energy Industry on the Navajo and Hopi.*" In: RD Bullard, ed. "Unequal Protection. Environmental Justice and Communities of Color." Sierra Club Books, San Francisco.

SG Harris, 1993. "*The Nez Perce ERWM's Recommendations for Refinement of Risk Assessment Proposed by DOE's Columbia River Impact Evaluation Plan.*" Nez Perce Tribe Department of Environmental Restoration and Waste Management, Lapwai, ID, September 3, 1993.

SG Harris, 1995. "*A Limited Sample of Concerns of the Confederated Tribes of the Umatilla Indian Reservation Community on Using An Appropriately Defined Risk Assessment Model.*"Appendix B of CTUIR, 1995 "Scoping Report: Nuclear Risks in Tribal Communities." CTUIR Department of Natural Resources, Pendleton OR.

E Jahner, 1989. "*The Spiritual Landscape*" in: DM Dooling and P Jordan-Smith, "I Become Part of It. Sacred Dimensions in Native American Life." HarperSan Francisco, HarperCollins Publishers, New York.

RL Keeney, 1992. "Value Focused Thinking. A Path to Creative Decisionmaking." Harvard University Press, Cambridge, MA.

W LaDuke, 1993. "*A Society Based on Conquest Cannot Be Maintained. Native Peoples and the Environmental Crisis.*" In: R Hofrichter, ed. "Toxic Struggles. The Theory and Practice of Environmental Justice." New Society Publishers, Philadelphia, PA.

WW Lowrance, 1985. "Modern Science and Human Values." Oxford University Press, New York.

G Morgan, B Fischoff, L Lave, P Fischbeck, S Byram, K Jenni, G Louis, S McBride, L Painton, S Siegel and N Welch, 1995. "*A Procedure for risk ranking for Federal risk management agencies.*" unpublished report, Carnegie Mellon University, Pittsburgh, PA.

National Research Council, 1994. "Building Consensus. Risk Assessment and Management." National Academy Press, Washington, D.C.

M O'Brien, 1994. "*A proposal to address, rather than rank, environmental problems.*" In: AM Finkel and D Golding, eds. "Worst Things First? The Debate over Risk-Based National Environmental Priorities." Resources for the Future, Washington, D.C.

OSTP, 1995. "*Risk Assessment Research in the Federal Government.*" Draft discussion paper by the OSTP Committee on Environment and Natural Resources, Subcommittee on Risk Assessment; Mark Schaefer (lead author). Executive Office of the President, OSTP, Washington D.C., March 7, 1995.

KS Shrader-Freschette, 1991. "Risk and Rationality. Philosophical Foundations for Populist Reforms." University of California Press, Berkeley.

EK Silbergeld, 1991. "*Risk Assessment and Risk Management: An Uneasy Divorce.*" In: DG Mayo and RD Hollander, eds. "Acceptable Evidence. Science and Values in Risk Management." Oxford University Press, New York.

RW Stoffle and MJ Evans, 1990. "*Holistic conservation and cultural triage: American Indian perspectives on cultural resources.*" Human Organization 49(2): 91-99

B Toelken, 1995. "*Fieldwork Enlightenment.*" Parabola 20(2): 28-35.

U.S. Environmental Protection Agency, 1989. "Risk Assessment Guidance for Superfund, Volume I: Human Health Evaluation Manual (Part A). EPA/540/1-89/002.

U.S. Environmental Protection Agency, 1992. "Tribes at Risk. The Wisconsin Tribes Comparative Risk Project." Office of Policy, Planning and Evaluation, EPA/230-R-92-017.

U.S. Environmental Protection Agency, 1993. "A Guidebook to Comparing Risks and Setting Environmental Priorities." Office of Policy, Planning and Evaluation, EPA/230-B-93-003.

Vermont Agency of Natural Resources, 1991. "Environment 1991: Risks to Vermont and Vermonters." Waterbury, VT.

Figure 1. The "Double Helix" of Risk Assessment. People and Nature are intimately linked by Culture-Religion, and an evaluation of all three is necessary in order to develop an appropriately comprehensive and holistic an information base relevant to tribal health.

(modified from: Office of Technology Assessment, 1986. "Technologies for Detecting Heritable Mutations in Human Beings." Washington D.C., 1986 (page 24).

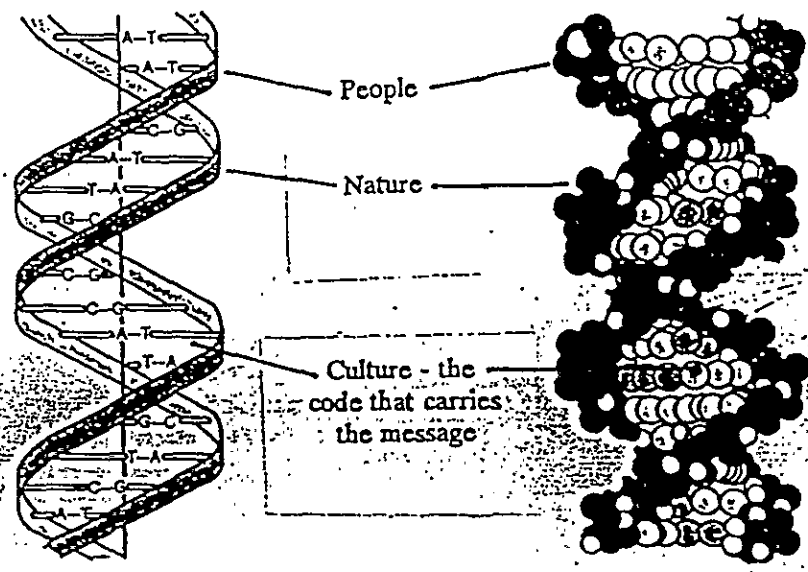

Figure 1

Figure 2. A Creator Paradigm, illustrating why full and safe access to a healthy ecosystem is necessary for tribal cultural-spiritual health. The term "treaties" refers to the various treaties between Indian Nations and the U.S. Government, under which natural and cultural resources necessary for a healthy environment and traditional lifestyle will be protected by the U.S. government in perpetuity for tribal people.

(with thanks to Russell Jim and Robert Cook, Yakama Indian Nation, and Stuart Harris, Confederated Tribes of the Umatilla Indian Reservation).

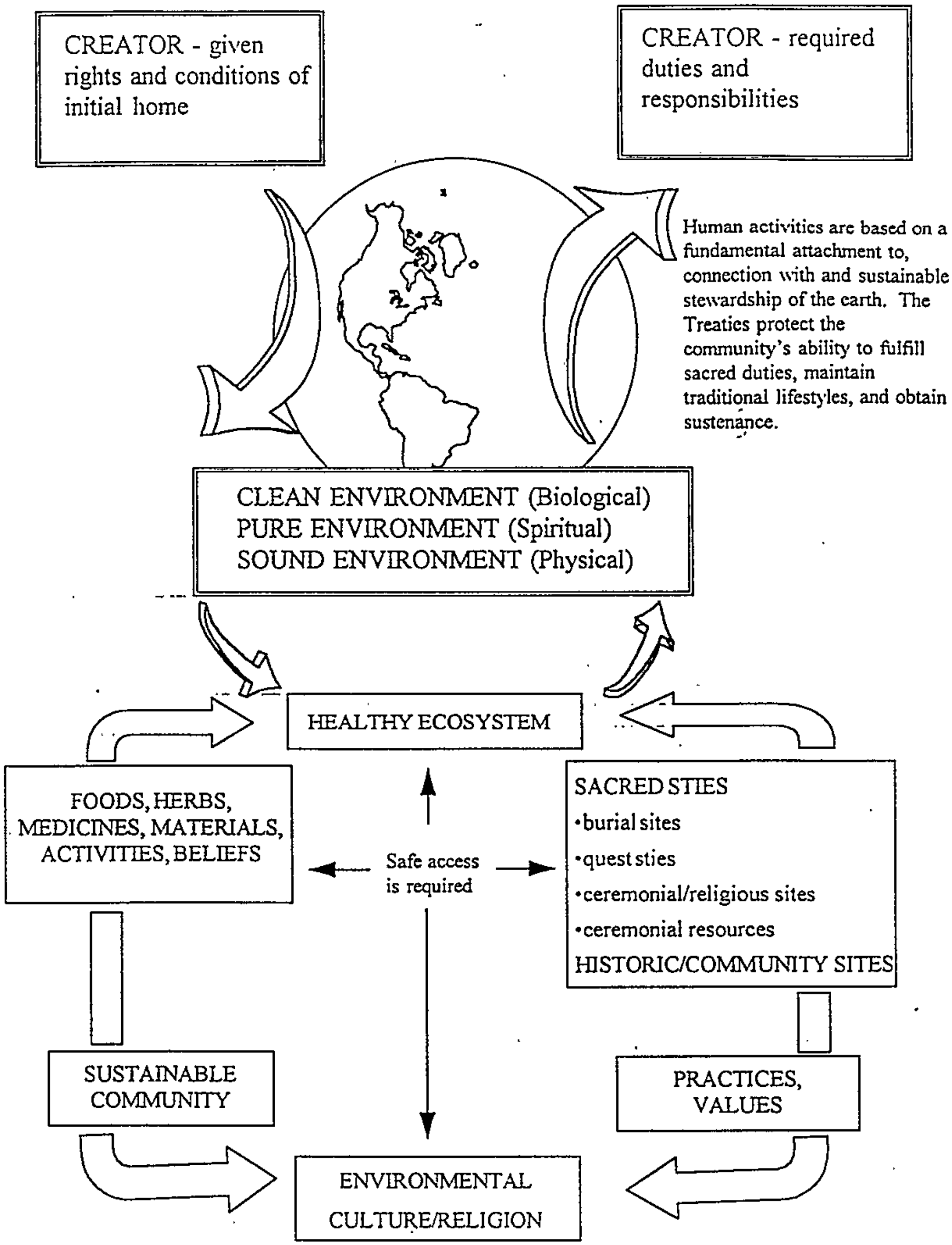
CREATOR - given rights and conditions of initial home
CREATOR - required duties and responsibilities
Human activities are based on a fundamental attachment to, connection with and sustainable stewardship of the earth. The Treaties protect the community's ability to fulfill sacred duties, maintain traditional lifestyles, and obtain sustenance.
CLEAN ENVIRONMENT (Biological)
PURE ENVIRONMENT (Spiritual)
SOUND ENVIRONMENT (Physical)
HEALTHY ECOSYSTEM
FOODS, HERBS, MEDICINES, MATERIALS, ACTIVITIES, BELIEFS
Safe access is required
SACRED STIES
•burial sites
•quest sties
•ceremonial/religious sites
•ceremonial resources
HISTORIC/COMMUNITY SITES
SUSTAINABLE COMMUNITY
PRACTICES, VALUES
ENVIRONMENTAL CULTURE/RELIGION

Figure 3. An Eco-Cultural Management Unit. The shaded areas within the four components of the ecocultural unit indicate that, from a holistic tribal perspective, conventional methods or standards address only a portion of what is "at risk." Environmental impacts that are significant to tribal members may occur even when regulatory standards are not violated; RAGS Superfund guidance (USEPA, 1989) is not appropriate for traditional lifestyles; single-species ecological toxicity does not address habitat and other landscape-scale impacts; a narrow legalistic definition of cultural resources ("stones and bones") does not reflect cultures and cultural values that may be at risk. Note that "severity" and "consequences" are not the same: severity is a (more or less) objective indicator of the level of harm that could occur to a given resource, while consequences measures severity plus the importance (weight) of the affected resource.

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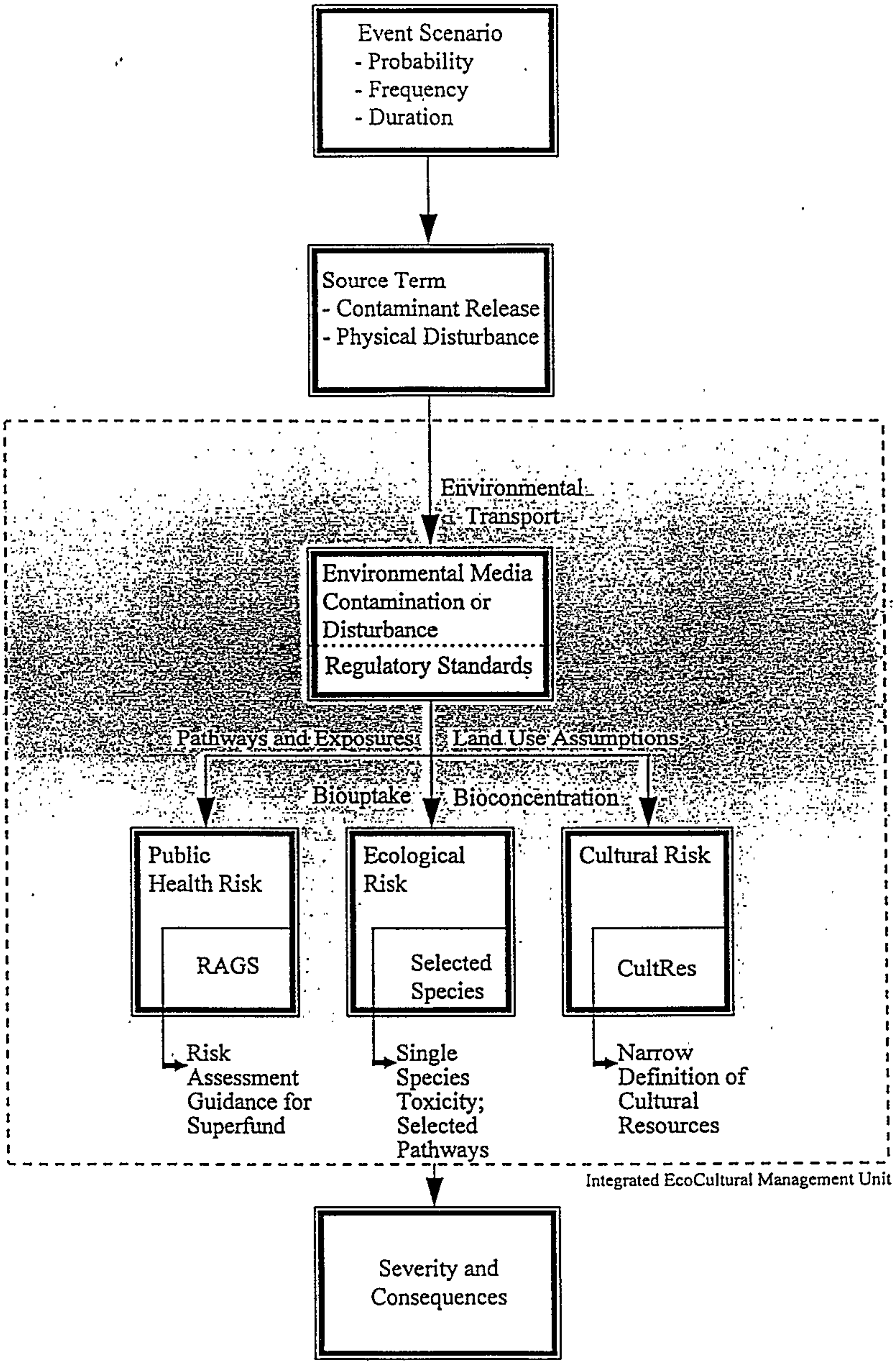

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Holistic Conservation and Cultural Triage: American Indian Perspectives on Cultural Resources

RICHARD W. STOFFLE and MICHAEL J. EVANS

The National Environmental Policy Act and other laws require American Indian cultural resource studies as part of the environmental impact assessment of development projects. Indian people make two general types of responses: *holistic conservation* ("this land is mine, go away") and *cultural triage* ("if you go ahead with the project then these are the cultural resources that require most protection"). The analysis is based on 11 cultural resource projects. The major findings are that (1) more policy impacts can be achieved by having both types of responses, (2) the research methods can influence whether or not both types of responses will be provided by Indian people, and (3) Indian people experience emotional and social risks when they engage in cultural triage.

Key Words: N.E.P.A., Native Americans, cultural resources, holistic conservation, cultural triage.

THIS PAPER IS ABOUT how the process of cultural resource assessment, conceived in Western epistemology and law, forces American Indian people to shift from a traditional resource position, termed here "holistic conservation," to one of resource prioritization, termed here "cultural triage." Analysis of 11 American Indian cultural resource studies suggests that contemporary Indian people prefer to protect all traditional cultural resources when they are potentially impacted by an externally proposed development project. Given their limited power in the decision making process, however, Indian people often must shift from conservation to prioritization in order to affect policy and provide some degree of protection for their traditional cultural resources. The paper suggests that this shift in position can be understood through the concept of cultural triage.

The findings are based on data derived from 11 American Indian cultural resource assessment studies conducted by one or both of the authors between 1978 and 1989[1]. These studies involved 26 official tribes, living in seven states (Arizona, California, Colorado, Nevada, New Mexico, Oklahoma, Utah) and representing 13 ethnic groups (Arapaho, Cheyenne, Comanche, Gosiute, Hopi, Jicarilla Apache, Kiowa, Kiowa-Apache, Mohave, Navajo, Southern Paiute, Shoshone, Ute). The projects assessed cultural resource impacts deriving from high voltage electrical transmission lines, coal development and transportation, radioactive waste disposal facilities, a land transfer to create a U.S. Army troop and tank maneuver area, and a U.S. Air Force proposal to build the world's largest electronic combat range. All studies involved American Indian traditional and historic use areas located beyond the boundaries of reservations.

Each study was guided by a common research methodology that involved five data gathering tasks: (1) meeting with tribal governments, (2) in-depth interviews with key cultural experts, (3) archival searches, (4) on-site visits with cultural experts, and (5) mailed survey of tribal members. A fuller discussion of the methodology is available elsewhere (Stoffle, Jake, Evans and Bunte 1981), so here the methodology is used to illustrate the potential relationship between the sequence of research tasks and the types of responses made by American Indian people.

This paper derives from an ongoing analysis of methods used in these cultural resource studies. Such analysis was used to modify the research methodology so as to provide more extensive American Indian cultural resource assessments. Once the holistic conservation and cultural triage model was formulated, its utility was evaluated through a retrospective analysis of hundreds of hours of meeting tapes and field notes generated during these eleven cultural resource studies. In all studies and in most interactions with Indian people, the "holistic conservation" and "cultural triage" model provided the most robust explanation of the American Indian responses.

Holistic Conservation

Previous ethnographic studies, including those in this analysis, indicate that American Indian people often perceive cultural resources to be elements of a single whole. This epistemological premise is often expressed though the concept of the integration of humans, nature, and the supernatural. Vecsey

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1980) suggests the term "environmental religions" to describe this relationship. One implication of this premise is that Indian people perceive themselves to be a functional and essential part of the natural elements in their traditionally occupied nds. They perceive this relationship to have been caused by the supernatural. Traditional lands, therefore, are their Holy Lands (Spicer 1957). Maintaining this relationship through their proper stewardship of these natural resources is perceived to be critical in their persistence as a people (Spicer 1971). Thus they tend to be conservative in the use of these natural resources.

Development projects in the western United States usually modify the natural visual landscape, soil, water systems, and population distributions of plants and animals. Even when development projects support extensive efforts to restore and protect affected areas, the environment is usually less natural than it was before the project. Impacts can be direct, as when the project itself involves above-ground structures, water use, and ground-breaking activities. Impacts also can be indirect, as when a project increases access to remote areas by constructing or improving roads, thus increasing off-road-vehicle use, rock hounding, plant gathering, animal killing, and pot hunting for Indian artifacts. Impacts can be cumulative (Sonntag et al. 1987), as when there are persistent additional impacts that derive from one impact or when two or more impacts are compounded to produce multiple impacts or interactive impacts (Peterson et al. 1987). Faced with these well documented adverse impacts, Indian people are usually not supportive of development projects being located on traditional Indian lands.

HOLISTIC CONSERVATION EXAMPLES. When formally asked for their evaluation of a proposed development project, lian people often make what is being termed in this analysis a holistic conservation statement. The following is a holistic conservation statement by an Owens Valley Paiute tribal chairman, made during a closed meeting attended by political leaders from 16 tribes involved in assessing cultural resources potentially impacted by the proposed high level radioactive waste facility at Yucca Mountain, Nevada (Stoffle, Evans and Halmo 1988a):

> The best thing that could happen to the United States of America is for a group of us Indian people to be elected to address the Supreme Court. Because there are so many things that they don't really understand. It is like this black thing [indicating a rock] I am holding. Where did it come from? The earth right, because all material is from the earth. Who is to say that this part [pointing to a part of the rock] is more important than that one over there [pointing to another part of the rock]. We have to put these things into perspective. It is like this thing [the high-level waste project proposal] that came out. They are saying, "We are not damaging that, all we are going to do is to cut down that tree." As an Indian person I feel I am important, but am I more important than that tree or is that tree more important than me. We are on this earth, we are significant. Indian people say, "What's more important: the earth that we stand on, the air that we breathe, or the water that we drink?" They all have their reason to be here and that is what we have to get over to the United States Supreme Court. We are nothing, but to put it all together it forms a circle. And we all have to live together no matter what, because it's our earth. These things are here, we didn't put them here, so who are we to move them. We didn't create them, but we are here to protect them.

The second example of a holistic conservation statement was provided by a Mohave elder in response to a low-level radioactive waste facility, mandated by State of California law to be located somewhere in the Mohave Desert. The interview was videotaped by the elder's daughter so the response could be added to the Colorado River Tribes' cultural heritage museum. The elder began the interview with a prayer (CALNUC 1986: 1885–2002):

> I would like to say this, that in going around, like what you are doing now, I know you have to do this because you have to say you spoke to different ones. But sometimes I wonder if you really use us. I have often thought about that. [pause] In my prayer I said that we always go do the things we want to do. The problem here is the water. Where are we going to put the waste? And yet, it seems we are hurting our fellow man that has some interest in different lands that we are talking about now. Right now it looks like a desert when you look over that valley. All of a sudden laws come in, that we have to develop our land [then] we have bulldozers running over the place, and it is different. It is different. When I was very small, I thought the only reservation was around the tribal building. That is all we knew about, small reservation, no roads, just that. But as I got older we talked about lands. All the way to San Bernadino. They were talking about that, where they use to roam. Up to Needles and there going to the Los Angeles area. They are always talking about it, in their songs they are always talking about it. And who knows, maybe in the future our younger generations are going to come up with a problem where we chose to deposit some of these things. Not too long ago we put chemical bottles on our reservation. We okayed one [place] on the California side, off in those hills. They told me! Where it was. All of a sudden it came up and they came to ask me where it was and I don't know where it was. I just know it was in those sand hills. They didn't map it out. We don't know where it is. So someday someone is going to run over it and boom! [gestures with hands raised], and I feel bad. Those are some of the things I am always looking out for. Something we do right now in haste without reason, it is going to hurt us little guys, some of the generations coming up. Those are some of the things that I would like to say before you get started. I am really looking for the generations that are coming up. Who knows, your children might be living in the desert.

ANALYSIS. It is important to understand holistic conservation statements because they are the first and often the only response of Indian people to a proposed development project. Analysis of such statements made during the 11 projects indicate common patterns in (1) style of presentation, (2) who makes the statement, (3) content of statement, (4) stage in the research process when the statement is made, and (5) the audience to whom the statement is addressed.

Style. The statements are presented in a formal oration style. The speaker stands up or assumes a more erect sitting posture if unable to stand up. The speaker will wait for the room to become silent; simultaneous conversation is common during informal discussion. Audiences seem able to make proper behavioral responses, like becoming silent, or by reading the nonverbal movements of a person who is about to make a formal oration statement. The researchers have never observed someone interrupt a formal oration statement, although interruptions occur frequently during informal conversation.

Presenter. Any person who belongs to the ethnic group can make a holistic conservation statement, regardless of his or her age, sex, or formal position with the tribe. Situation and group composition, however, tend to yield a patterned response. Given the presence at a meeting of all ages, sexes, and people with formal and informal government positions, the oldest male usually will make the holistic conservation statement.

Often tribal government leaders are young and female, so it is common for them not to make a holistic conservation statement. Rarely is more than one statement made at a meeting, although other people may refer to the statement as a rationale for their own thoughts.

Content. The contents of holistic conservation statements are generally similar. They include (1) an ethnic group's claim to lands being considered by the proposed project, (2) a description of the most extensive boundary of traditional lands, (3) an epistemological argument for the claim deriving from the supernatural, (4) contemporary evidence of the land claim, such as a recitation of traditional place names, trail songs, or names of specific people who resided in the area, (5) a concern about how future generations of the ethnic group will evaluate any contemporary decision, and (6) a general response to the project and its impacts. Despite their length, holistic conservation statements tend to have a simple message: "this land is ours, leave it alone."

Research Process. Holistic conservation statements are most likely to occur during an initial interaction between members of the ethnic group and researchers. Such interactions tend to be patterned by the sequencing of research tasks and, therefore, should be taken into consideration when designing methods, a point discussed later. These formal orations seem to be an essential component of initial interactions. The researchers have recorded basically the same holistic conservation statements from the same ethnic group members during a half-dozen project studies. This observation suggests that the statements are driven by cultural requirements rather than personality. The one exception occurs when the ethnic group member and the researcher know one another. Then the formal statement may be eliminated if the initial interaction does not occur in the presence of others. This exception raises the issue of audience.

Audience. Holistic conservation statements appear to have multiple audiences, including proposers and regulators of the project; past, present, and future generations of the ethnic group; and Indian and non-Indian people in general. The statements are more likely to occur when the speaker is surrounded by other members of his or her ethnic group. Indian people rarely participate in the project-specific cultural resource studies before either they make a holistic conservation statement in public or are present at a public meeting where one is presented so they can express their agreement with the statement. One apparent reason for this is that ethnic groups do not like their members talking about traditional culture to outsiders, so before any discussion can occur an Indian person must publicly reaffirm his or her commitment to basic ethnic group values and beliefs. Another reason is that people believe such statements are essential to their ethnic persistence.

POLICY IMPLICATIONS. American Indian people must accurately assess their power in order to have the maximum affect on the outcomes of development project proposals. Most power exists when the Indian people are involved in the early stages of a project's design, when the project involves reservation lands, and when the regulatory agencies have formal relationships with Indian tribal governments.

When Involved. New information about potential project impacts is usually only entered as evidence at prescribed points in the decision making process. There are four major phases in design and evaluation of a project. When impact assessment studies are expected to generate new information. Class One studies assess the best project location among a number of choices; they are often called Environmental Assessments. Class Two studies provide background information that is needed before one or more alternative project sites can be selected; there is no widely accepted term for these studies. Class Three studies evaluate one project location; they are usually called Environmental Impact Statements. Class Four studies evaluate potential impacts of projects that have already been approved by a regulatory agency, but the total environmental impacts are not understood; they are often called mitigation studies.

American Indian people were legally incorporated into the environmental impact assessment process through the Council on Environmental Quality (CEQ) regulation updating the National Environmental Policy Act (NEPA) of 1969 that appeared on November 29, 1978 in the *Federal Register* (Vol. 43 No. 230:44978–56007). According to Section 55989, Indian Tribes should have early knowledge of projects, are invited to participate in the formulation of issues and in the research itself, and are invited to comment on drafts of reports before they become available during the Public Comment Period." They have these rights, ". . . whenever a project can impact Indian people living on a reservation." The status of non-reservation and off-reservation Indian people is not specified, although recent studies have tended to involve these people (Stoffle and Evans 1988). Despite the 1978 CEQ clarification of NEPA and the passage of the American Indian Religious Freedom Act in 1978 (White 1980), Indian people continue to be involved late in the decision making process, often at the Class Three or Class Four stage.

Lands Involved. The power of Indian people to affect project decisions is reduced when the proposal involves traditional lands that are not part of an Indian reservation, especially when a project potentially affects traditional lands in a state other than where Indian people currently live. State boundaries become a key cultural resource assessment factor because there is a tendency for decision makers and project proposers to utilize the smallest possible "study area"; that is, the area assessed for potential environmental impacts. One strategy to reduce the size of the study area is to restrict analysis of potential impacts to the state where the project is proposed. Such a decision can eliminate from the decision making process most potentially affected American Indian ethnic groups, especially when traditional lands have been subdivided by state boundaries (e.g., Southern Paiute traditional lands are divided between four states) or when Indian people have been removed from traditional lands; most Indian ethnic groups from what is now the State of Colorado were forcibly removed to neighboring states.

Agency Involved. Indian people tend to be at a power disadvantage when a proposed project is regulated by an agency that has not developed formal guidelines for consultation with American Indian groups and consideration of their cultural resource concerns. When an agency does not have guidelines, Indian people tend not to be part of early project siting decisions and may have to initiate their own request to become part of the project's evaluation. American Indian requests for involvement in the process are met with very cautious responses that appear to derive in part from a concern that project precedents may establish agency policy. This concern has abated as state and federal land management agencies have adopted consultation guidelines. Today the National Park Service, Forest Service, Bureau of Land Management, and most western state agencies have consultation guidelines; but important agencies such as the Department of Energy, Department of Defense, and eastern state agencies (especially departments of natural resource management) still lack consultation guidelines.

The 26 Indian tribal governments in this analysis all requested information that would permit them to evaluate their power to affect the project, its design, its location, and whether or not it would be constructed on traditional lands. In all instances, tribal political and religious leaders decided to become involved with the cultural resource impact assessment study even though they concluded that there was little likelihood that potential cultural resource impacts would prevent the project from occurring. The remainder of this analysis is about why these Indian people made this decision and how they resolved the personal and cultural conflicts it created.

Development Dilemmas

American Indian people involved in these 11 studies often expressed the epistemological premise that all things are equally important; however, when considered in terms of specific needs, some things are more important than others. These and other Indian peoples have always been confronted with the competing demands of conservation and development, because they have the sacred obligation to protect their traditional resources and the need to use their environment in order to persist as a people. They have had to kill animals, harvest plants, ig up minerals, and change the flow of water sources. Vecsey (1980:22) suggests that the need to exploit nature combined with the religious obligation to protect it created a dissonance between Indian people and nature which was the crux of their environmental religions. Martin (1978) suggests that for some Indian people this dissonance periodically erupted into antagonism towards nature.

American Indian people involved in these 11 projects present a slightly different view of this development dilemma. They recognize the inherent conflict between having to develop their natural resources and to protect them, but argue that Indian controlled development activities are not in conflict with the preservation philosophy because of (1) who is doing the development and (2) how the development is done. In the first instance, these Indian people believe that they have a right to use the land because they have a supernaturally derived responsibility to care for it and to do so they must subsist as ethnic groups. Second, each American Indian ethnic group will have culturally prescribed procedures for using the land, plants, and animals. Southern Paiutes, for example, have use procedures that derive directly from the epistemological belief that the animals, plants, and even the land have a life force. These Indian people believe that everything has human-like rights, which derive from the human-like life force bestowed upon them at creation. "Talk to it" is one of the first normative instructions given when tribal elders tell children how to interact with plants, animals, and physical elements. Southern Paiute initiated and controlled developments, therefore, attempt to follow the normative requirements of this belief.

American Indian people commonly reject development proposals (Jorgensen 1984a) because of perceived negative effects on cultural resources. West (1982:80) describes this as the "identity-poverty" dilemma. According to West (1982:80), such adaptive strategies are functional for the retention of traditional cultural solidarity, but dysfunctional to economic development and release from oppressive poverty. Hackenberg (1976) shows that economic development often does not improve the quality of life for Indian people because there are no mechanisms for the effective distribution of tribal incomes to tribal members. Robbins and McNabb (1987) demonstrate that proposed oil developments in Alaska have caused a negative response from native peoples who perceive a threat to their other economic activities like fishing. The Soboba Indian people, according to Fernandez (1987), have experienced cumulative economic and social impacts due to loss of water to neighboring development projects.

Other development projects appear to have avoided the identity-poverty dilemma. A study of a modern electronics industry located on the Zuni Indian Reservation documents that Indian people can retain traditional cultural commitments and work in a modern industry when they participate in the development and operation of a culturally appropriate management policy (Stoffle 1975). The Kaibab Paiutes developed an on-reservation tourism program that reflects both their culture and the values of a segment of tourists who visit the Arizona Strip (Stoffle et al. 1979).

American Indian people certainly reject or support development projects for wide variety of reasons (Jorgensen 1984b); however, the studies noted above and this 11-project analysis argue for the proposition that Indian people are not rejecting development per se but are responding to who is controlling the project and how it is being conducted. This is not a new finding, for nearly four decades ago Dobyns (1951:31) concluded

> An induced technological change will succeed to a degree proportionate to the extent to which the administered people feel a need for it, are brought into its planning and executing, and feel it to be their own.

These data suggest that, given power through direct involvement and given culturally appropriate procedures (MacDonald 1980:170), Indian people will support some natural resource development projects.[2]

Indian people initially take a preservationist position regarding traditional cultural resources and development projects, expressing this viewpoint through holistic conservation statements. Holistic conservation positions, however, are only effective in protecting cultural resources when taking the position causes a project not to occur. If a project proceeds despite a holistic conservation position (and many projects have already been approved before Indian people are asked for a response), then Indian people must assume alternative positions in order to reduce adverse impacts and work for positive impacts. These alternative positions involve prioritizing cultural resources that are perceived to be equally valuable. This raises an ethical and intellectual dilemma, termed here the "holistic conservation-triage dilemma," for Indian people.

How can holistic conservation be consistent with prioritizing cultural resources? The authors have been grappling with this problem for years. The director of the Colorado River

Indian Tribes' cultural museum responded as follows to a project that the State of California had already determined would be in the Mohave Desert:

> You come in here knowing that something will happen in the desert and ask that one portion be chosen for protection over another. That is like lining up my children and asking which ones I want you not to shoot.

The researchers explained the holistic conservation-triage dilemma as follows (Stoffle et al. 1981:6):

> A Native American can say, without the statements being contradictory, that all of the land is sacred and that a specific area is clear of sacred resources and will not be harmed by construction. In the first case the response is to the general idea of having the development occur at all, while the latter is a conditional response which means that given the project goes ahead, a particular area has the fewest cultural resources.

This explanation has been utilized in previous studies to explain this dilemma, but the explanation has been incomplete.

In a recent cultural resource study involving six tribes and a proposed low-level radioactive waste disposal site in the Mohave Desert, dozens of elders initially took holistic conservation positions, expressing equal concern for all of their traditional cultural resources. Later, during on-site visits, many of the same elders noted that some cultural resources were less readily available and some traditional areas were more important than others; therefore some cultural resources should be categorized as having higher concern. When asked about the apparent conflict in positions, one elder responded, "Well the project is going to take something anyway, so we have to choose."

Further explication of the dilemma was provided by political leaders of 16 tribes who met to make cultural resource recommendations regarding the Yucca Mountain high level radioactive waste facility. Many leaders argued for making only a holistic conservation statement and rejecting the project. They suggested that any other position would weaken or compromise their concerns. The following argument for moving beyond such a position was made by an Owens Valley Paiute tribal chair:

> I don't know that what I am hearing you [another chair] saying can't be properly addressed. Because if we state—emphatically—that we are against the project and list all the reasons why we are against it, then we have a choice; to lose it all and have no say-so and possibly lose the ability to save some of these things for future generations—those things are our culture—because it is going to be done anyhow; so, you know, we can say no! When I hear us use the word compromise, we are not compromising our abilities, our customs, nothing. What we are compromising are those things that we have no control over. So, if we can say that we shoot for the moon and fight as much as we can—but no we couldn't stop the project. I would never sign a document that a hundred years from now, my ancestors could look back and see my name and see that I went along with something willingly and believed in it. No! If that document explains how much I was against it [the project] and thoroughly explains why these things are. You know, everyone of our great chiefs of the Indian people of all times that gave in over [their] choice. They watched their tribes being slaughtered, but they got away with saving some of their lives. They didn't have a choice. Those men were great warriors and great believers of nature and those things that we stand for. To me, being an Indian is a way of life.

The group was swayed by this argument and made both types of statements regarding what the Department of Energy should do if they proceed with the project (Stoffle et al. 1988a).

The holistic conservation-triage dilemma is resolved much as the conservation-development dilemma is resolved, that is by involving Indian people who are legitimate representatives of their ethnic group and who understand how to relate to cultural resources so they can achieve maximum protection in the face of a proposed development project. This type of involvement, plus a research methodology that permits triage to occur, will increase the probability that Indian people will engage in prioritizing cultural resources. The concept of triage helps explain the implications of prioritizing these resources.

Triage

The concept "triage" has been selected because it seems to convey the emotional cost inherent in choosing among cultural resources, all of which are equally valuable in traditional terms. The concept does not fully explain the feelings of American Indian people who are forced to prioritize cultural resources; but, like Spicer's introduction of the concept "Holy Land" to describe American Indian attachment to traditional lands (Spcier 1957), the triage concept is proposed in an effort to explain these feelings across cultural boundaries.

MEDICAL TRIAGE. "Triage" is a Euroamerican medical term that refers to "screening of patients to determine their priority for treatment" (Stedman 1982:1322). Triage is the process of rationing life-saving medical resources among patients who have varying levels of need (Winslow 1982). Patients are ranked according to criteria that reflect an agreed upon value position, such as "the greatest good for the greatest number." A choice can be forced when war creates more wounded than a medical facility can assist at one time, or when a new medical advance, such as the artificial heart, is more limited in supply than in demand. The crux of medical triage is that professionals must develop a corollary rule that partially violates the general principle from which it derives. So while medical professionals accept the principle that life is to be saved at any cost, situational constraints may force them to select some patients to increase their chances to be saved, while others have a reduced chance to live.

CULTURAL TRIAGE. "Cultural triage" should be defined as a forced choice situation in which an ethnic group is faced with the decision to rank in importance cultural resources that could be impacted by a proposed development project. Through this ranking the probability of certain cultural resources being protected is increased. On the other hand, it is understood that by selecting some cultural resources for special status, it relegates others to less-than-special status. Those defined as less-than-special, then, are placed at greater risk from the proposed project.

Medical professionals who triage patients accept the principle that all human life is valuable and, similarly, Indian cultural experts (at least those involved in the projects analyzed here) who triage cultural resources accept the principal that all traditional cultural resources are of equal importance. Triage occurs when a threatening situation precipitates a forced choice in the allocation of limited resources, a choice that must be based on some criteria. Medical criteria focus on a combination of factors, such as available medical resources, length of time before critical medical actions must occur with a patient, and an assessment of whether or not the person can be helped. Tribal elders similarly assess the nature and availability of cultural resources, the time available to make a decision, and whether or not certain resources can be better protected by their triage decision.

Risks Of Cultural Triage. Unlike medical triage, Indian people must consider whether or not attempting to save a cultural resource may further threaten it. For example, identification of trails can lead to pot hunting by Euroamericans. In the Kaiparowits coal development study (Stoffle et al. 1982:124), a Kaibab Paiute elder indicated he wanted to protect traditional trails, but that he would not reveal the location of those trails because once known they could be followed to hitherto undiscovered traditional Indian camps. Indian people often say that revealing Indian plant usages causes the plants to be taken by Euroamericans, who not only reduce the limited supply of the plants but also profit from what should only be an Indian resource. The curing or religious power associated with certain places can be reduced if the place and its function becomes known to other ethnic groups, including other Indian groups.

Triage Mitigation. Like medical triage, cultural triage does not guarantee that the lower ranked resources will be destroyed. Once the higher priority resources are protected, then efforts are directed towards doing whatever is possible for the remaining resources. This process is called "mitigating cultural resources." In some cases, cultural resources can be moved to safer zone such as transplanting medicinal or food plants or relocating artifacts to a museum. In most instances, however, the physical context of the cultural resources is broken. For ethnic groups like Southern Paiutes, who believe that all things including rocks and plants, have a life force and a reason for being where they are, mitigation through removal is a lesser of two unwanted actions. Only total destruction is less acceptable.

Like the medical professionals who are forced by circumstance to choose between patients (Winslow 1982, Zawacki 1985), tribal elders who are given a forced choice regarding the disposition of cultural resources experience ethical conflict, emotional stress, and even fear of reprisal. Elders express concern over whether being involved in triage will violate a traditional norm against sharing traditional knowledge with outsiders. Concern is expressed over how other tribal members and even future generations of tribal members will evaluate the decision to participate in triage. The concern over whether more harm than good will derive from a triage decision can cause a tribal elder and, in one instance, even a whole tribe (Stoffle et al. 1984) to be unable to respond to a cultural triage choice.

Triage Assessment Methodology

Because cultural triage involves some risk to the cultural resource itself as well as to the tribal elder who agrees to participate in triage, the consultation and identification methodology must achieve certain goals and proceed through sequential tasks in order to permit Indian people to make full and unrestricted response to a proposed project.

CULTURAL RESOURCE STUDY GOALS. Four cultural resource study goals are suggested by this analysis of 11 project experiences. Some goals, like providing opportunity to discuss the project and increasing knowledge about the project, can easily be achieved. Other goals, like establishing and maintaining trust and agreeing on the validity of evidence, require concerted and continuous effort.

Trust. Indian people must believe that their participation in consultation and identification of cultural resources is more likely to protect these cultural resources than would saying nothing at all. The credibility of the consultation process hinges on (1) the reputation of project personnel, (2) the reputation of the agency sponsoring the study with regard to past projects involving Indian cultural resources, and (3) written documents such as a Programmatic Memorandum of Agreement that define Indian people's rights to be consulted and to identify cultural resources.

Opportunity. Indian people must have the opportunity to discuss among themselves whether or not to participate before they are asked to proceed with the identification and triage of cultural resources. The research should therefore be conducted in phases separated by periods during which tribal discussions can occur.

Knowledge. Indian people must fully understand how the project could impact cultural resources. A tribal representative should view firsthand the study area and existing analogous projects. Videotape or still photography may assist this process. Providing background readings that illustrate other projects is useful. A face-to-face orientation session is especially useful. The educational materials must be neutral, presenting both positive and negative project impacts.

Validity. Western scientists and Indian people often have different criteria—rules of evidence—against which to assess the validity of knowledge. If the research findings are not accepted by scientists, regulatory agencies, and Indian peoples, then the study is invalid. Participation in the research process is perhaps the best means of assuring mutual validity of findings.

CULTURAL RESOURCE STUDY TASKS. A cultural resource study methodology can be designed to help achieve these four goals and, thus, be sensitive to the culture of American Indian people as well as to the rules of the regulatory agency. The following research methodology has eight tasks which have been developed and adapted over the past decade. The methodology is offered as an illustration of how study tasks and their sequence can influence cultural resource outcomes, but is not suggested as the formula for collecting data or achieving project goals.

Consultation. The first study task that generates original data is the initial contact with the tribal government to discuss the project and establish a consultation and research relationship. A consultation relationship is established after the tribe is contacted first by mail then by phone. Permission is requested to explain in person the project to tribal officials. During this presentation tribal political leaders learn enough about the project to make a reasoned decision regarding participating in the study. At this presentation tribal political and religious leaders make their holistic conservation statements.

OTCR Training. Once a tribal government agrees to participate in a study, a second study task is to establish a point of contact between them and the project. This person is called the Official Tribal Contact Representative (OTCR). The OTCR is trusted to follow the day-to-day progress of the project, to review technical reports, and to summarize findings for the tribal government. All OTCRs are trained together, which is both efficient and facilitates inter-tribal interactions during the course of the research. These relationships will be essential for reaching inner-tribal consensus on the mitigation of cultural resources.

Key Cultural Expert Interviews. The third study task is to interview key cultural experts who have been suggested by the tribal government. These persons are asked to speak for the cultural resources of the tribe and, consequently, they tend to repeat the holistic conservation statements made earlier by the tribal government. Key cultural experts, however, move beyond expressing general concerns for cultural resources by specifying what types of cultural resources are potentially impacted by the development project. These experts tend to define the variables that should be assessed by the study.

Archival Search. The fourth study task involves searching archives in order to determine whether or not other American Indian ethnic groups were associated with the study area and, therefore, should be incorporated into the study. Indian people often retain cultural ties to the land hundreds of years after leaving or being forcefully removed, so all ethnic groups with traditional or historic ties to a study area should be involved in the assessment. Documents also contribute to an ethnohistory of the study area which sets a cultural and historic frame for understanding contemporary concerns.

On-Site Visits. Study task five involves conducting on-site visits with tribal members. The tribal government is asked to specify a cultural resource expert or experts who will visit a study area in order to provide site-specific identification and interpretation of cultural resources. During on-site visits cultural resource experts may make holistic conservation statements, especially if they had not been contacted during previous research tasks; however, usually they focus on prioritizing cultural resources.

Mail Survey. When the study area is very large or there are many tribal members, a sixth study task is to survey by mail a sample of tribal members. The survey strives to measure variables defined by previous interviews with tribal members and issues that emerge clearly from the ethnographic and social impact assessment literatures. The instrument is developed in cooperation with tribal government representatives and mailed only after being approved by the tribal chair or council. Mail surveys are designed to elicit both holistic conservation and cultural triage data. Mailed surveys are especially important for reaching ethnic group members who live off the reservation. Surveys have been designed so that people can scale their concerns for cultural resources. Responses to scales provide a numeric score for all places, animals, plants, minerals, and sources of water potentially affected by the project (Stoffle et al. in press). When the numeric scores agree with the judgment of tribal elders, tribal governments have been confident in passing mitigation resolutions regarding how to triage cultural resources.

Tribal Review. Two types of tribal review occur during this seventh task in the research process. A preliminary draft of findings should be sent to the OTCR who reads the document for accuracy and suggests changes. A revised preliminary draft then will be sent to the tribal council for an official response to the report. These tribal responses should be incorporated at the end of the draft report.

Mitigation. The eighth task is to develop a set of mitigation recommendations that will be enacted if other environmental assessment studies potentially impact cultural resources and if the project is approved. Mitigation can only be achieved if all cultural resources have been identified and cultural triage has occurred during previous research tasks.

Conclusion

An applied anthropologist (or other social scientist) who is engaged in assessing the impacts of a project on American Indian cultural resources can have a significant impact on the findings and policy implications of the study. This analysis suggests that the single most important factor is whether or not the study design permits Indian people to engage in cultural triage. Data from these 11 projects suggest that unless a study is specially designed to move to the level of cultural triage analysis, the findings will be limited to holistic conservation positions. Although holistic conservation from an American Indian ethnic group's perspective often is the most appropriate response to a development project, experience demonstrates that such a response usually serves no more than to define the degree of anguish associated with cultural resource loss. Unless a project can be totally stopped, it is only at the cultural triage level of analysis where the Indian people can achieve a degree of protection of cultural resources.

It would be ideal to live in a society where cultural pluralism is a reality. The United States is not such a society. A recent case in point is the Supreme Court decision on the G-O Road case *Lyng v. Northwest Indian Cemetery Protective Association*, U.S., 108 S.Ct. 1319,1328, 99 L.Ed.2d 534 (1988) in which the higher court reversed the Ninth Circuit Court ruling that a planned U.S. Forest Service road would have a significant adverse effect on Indian religious practices and that this adverse impact violated their First Amendment rights (Theodoratus 1987). The Supreme Court took exception to the lower court's interpretation of the First Amendment. The Supreme Court read the word "prohibiting" in the Free Exercise Clause to mean an intentional attempt to discriminate against a particular religion or set of beliefs, and not simply an "incidental interference." The term "incidental" was used by the Court in the sense of not being intentional, even though the scope of the interference could be devastating to the ability to practice a belief. The Court concluded with the statement that whatever rights the Indians may have to use the area ". . . those rights do not divest the Government of its right to use what is, after all, *its* land."

Holistic conservation positions have failed to achieve their preservationist goals and the G-O Road case may sway regulatory agencies even further away from considering holistic conservation positions as part of natural resource allocation decisions. For example in *New Mexico Navajo Ranchers Association v. I.C.C.*, 850 F.2d 729 (D.C. Cir. 1988) the majority opinion on the case suggested that *Lyng* makes debatable an earlier ruling that AIRFA alone provided a private right of action to enjoin the government's construction of a road that impacted on Indian religious practices.

Given a legal milieu that is apparently becoming less willing to halt projects because of impacts to American Indian religious practices, it is the professional responsibility of the applied social scientist to design a study methodology that permits the expression of cultural triage as well as holistic conservation responses. When Indian people ask about how to affect project decisions, the social scientist should advise them as to the probabilities that holistic conservation or cultural triage will serve their cultural resource goals. Holistic conservation is strengthened, not compromised, by cultural triage.

There is a longstanding adversarial relationship between Indian people and other U.S. citizens regarding cultural resources located on traditional lands. There also are points of common interest. Indian people must decide when to go to court (litigate) and when to sit and talk (mitigate). A cultural resource study should provide data relevant to either action.

NOTES

[1] These 11 studies involved the following development projects: (1) Devers-Palo Verde, transmission line (Bean and Vane 1978), (2) Harry Allen-Warner Valley, nine transmission lines (Bean and Vane 1979); (3) Kaiparowits, Utah coal development with Utah and Arizona transportation routes (Environmental Research Technology 1980), (4) Intermountain Power Project (IPP), Nevada transmission line (Stoffle and Dobyns 1983), (5) IPP California transmission line (Bean and Vane 1982), (6) IPP Utah transmission line (Stoffle and Dobyns 1982); (7) IPP Nevada and Utah transmission line (Stoffle, Dobyns, and Evans 1983), (8) Fort Carson Colorado military maneuver area (Stoffle, Dobyns, Evans, and Stewart 1984), (9) California low-level radioactive waste disposal (Stoffle, Evans, and Jensen 1987, Bean and Vane 1987), (10) Yucca Mountain, Nevada, high level radioactive waste disposal (Stoffle, Evans and Harshbarger 1988, Stoffle, Evans and Halmo 1988a,b), and (11) U.S. Air Force Electronic Test Combat Test Capability in Utah (Stoffle, Halmo, and Olmsted 1989).

[2] Current social research findings suggest that acceptance of radioactive waste projects hinges on local people controlling similar project variables (Bord 1987).

REFERENCES CITED

Bean, L. J. and S. B. Vane, eds.
1978 Persistence and Power: A Study of Native American Peoples in the Sonoran Desert and the Devers-Palo Verde High Voltage Transmission Line. Rosemead, CA: Southern California Edison Company.
1979 Allen-Warner Valley Energy System: Western Transmission System Ethnographic and Historical Resources. Rosemead, CA: Southern California Edison Company.
1982 Intermountain Power Project Intermountain-Adelanto Bipole I Transmission Line Phase III Field Studies, California: Ethnographic (Native American Resources). Rosemead, CA: Southern California Edison Company.
1987 California Low-Level Radioactive Waste Disposal Project, Cultural Resources Surveying: Ethnographic Resources Candidate Site Selection Phase. Newport Beach, CA: US Ecology Inc.

Bord, R. J.
1987 Judgements of Policies Designed to Elicit Local Cooperation on LLRW Disposal Siting: Comparing the Public and Decision Makers. Nuclear and Chemical Waste Management 7: 99–105.

CALNUC
1986 Mohave Elder Interviews: Video Tape #4, California Low-Level Radioactive Waste Disposal Project. Ann Arbor, MI: Institute for Social Research, University of Michigan.

Dobyns, H. F.
1951 Blunders With Bolsas. Human Organization 10:25–32.

Environmental Research Technology, Inc.
1980 Kaiparowits Coal Development and Transportation Study. Salt Lake City, UT: Bureau of Land Management.

Fernandez, R.
1987 Evaluating the Loss of Kinship Structures: A Case Study of North American Indians. Human Organization 46:1–9.

Hackenberg, R.
1976 Colorado River Basin Development and Its Potential Impact on Tribal Life. Human Organization 35:303–311.

Jorgensen, J.
1984a Native Americans and Rural Anglos: Conflicts and Cultural Responses to Energy Developments. Human Organization 43:178–185.

Jorgensen, J., ed.
1984b Native Americans and Energy Development II. Boston and Forestville, MA: Anthropology Resource Center and Tribal Sovereignty Program.

MacDonald, P.
1980 Navajo Natural Resources. *In* American Indian Environments. C. Vecsey and R. Venables, eds. Pp. 162–170. Syracuse, NY: Syracuse University Press.

Martin, C.
1978 Keepers of the Game: Indian-Animal Relationships and the Fur Trade. Berkeley, CA: University of California Press.

Peterson, E., Y.-H. Chan, N. Peterson, G. Constable, R. Caton, C. Davis, R. Wallace, and Y. Yarronton
1987 Cumulative Effects Assessment in Canada: An Agenda for Action and Research. Hull, Quebec: Canadian Environmental Assessment Research Council.

Robbins, L. and S. McNabb
1987 Oil Developments and Community Responses in Norton Sound, Alaska. Human Organization 46:10–17.

Sonntag, N., R. Everitt, L. Rattie, D. Colnett, C. Wolf, J. Truett, A. Dorcey, and C. Holling
1987 Cumulative Effects Assessment: A Context for Further Research and Development. Hull, Quebec: Canadian Environmental Assessment Research Council.

Spicer, E.
1957 Worlds Apart—Cultural Differences in the Modern Southwest. Arizona Quarterly 13:197–230.
1971 Persistent Cultural Systems. Science 174:795–800.

Stedman, T.
1982 Stedman's Medical Dictionary, 24th ed. Baltimore: William Wilkins Company.

Stoffle, R.
1975 Reservation-Based Industry: A Case from Zuñi, New Mexico. Human Organization 34:217–226.

Stoffle, R. and H. Dobyns
1982 Puaxant Tuvip: Utah Indians Comment on the Intermountain Power Project. Kenosha, WI: University of Wisconsin–Parkside.
1983 Nuvagantu: Nevada Indians Comment on the Intermountain Power Project. Reno, NV: Bureau of Land Management.

Stoffle, R., H. Dobyns, and M. Evans
1983 Nungwu Uakapi: Southern Paiute Indians Comment on the Intermountain Power Project. Kenosha, WI: University of Wisconsin–Parkside.
Stoffle, R., H. Dobyns, M. Evans, and O. Stewart
1984 Toyavita Piavuhuru Koroin "Canyon of Mother Earth": Ethnohistory and Native American Religious Concerns in the Fort Carson Pinyon Canyon Maneuver Area. Denver, CO: Interagency Archaeology Services, National Park Service.
Stoffle, R. and M. Evans
1988 American Indians and Nuclear Waste Storage: The Debate at Yucca Mountain, Nevada. Policy Studies Journal 16:751–767.
Stoffle, R., M. Evans, and D. Halmo
1988a Recommended Actions for Reducing Potential Adverse Effects On Native American Cultural Resources Caused by Site Characterization Activities. Ann Arbor, MI: Institute for Social Research, University of Michigan.
1988b Native American Plant Resources In the Yucca Mountain Study Area. Ann Arbor, MI: Institute for Social Research, University of Michigan.
Stoffle, R., M. Evans, and C. Harshbarger
1988 Native American Interpretation of Cultural Resources in the Area of Yucca Mountain, Nevada (Interim Report). Las Vegas, NV: Science Applications International Corporation.
Stoffle, R., M. Evans, and F. Jensen
1987 Native American Concerns and State of California Low-Level Radioactive Waste Disposal Facility: Mohave, Navajo, Chemehuevi, and Nevada Paiute Responses. Ann Arbor, MI: Institute for Social Research, University of Michigan.
Stoffle, R., D. Halmo, M. Evans, and J. Olmsted
in press Calculating The Cultural Significance of American Indian Plants: Paiute and Shoshone Ethnobotany at Yucca Mountain, Nevada. American Anthropologist.
Stoffle, R., D. Halmo, and J. Olmsted
1989 Paitu Nanasuagaindu Pahonupi (Three Sacred Valleys): An Assessment of Native American Cultural Resources Potentially Affected by Proposed U.S. Air Force Electronic Combat Test Capability Actions and Alternatives at the Utah Test and Training Range. Ann Arbor, MI: Institute for Social Research, University of Michigan.
Stoffle, R., M. Jake, P. Bunte, and M. Evans
1982 Southern Paiute Peoples' SIA Responses to Energy Proposals. *In* American Indian SIA: The Social Impact Assessment of Rapid Resource Development on Native Peoples. C. Geisler, R. Green, D. Usner, and P. West, eds. Pp. 107–134. Ann Arbor, MI: Natural Resource Sociology Lab, University of Michigan.
Stoffle, R., M. Jake, M. Evans, and P. Bunte
1981 Establishing Native American Concerns in a Social Impact Assessment. Social Impact Assessment 65/66:11–16.
Stoffle, R., C. Last, and M. Evans
1979 Reservation-Based Tourism: Implications of Tourist Attitudes for Native American Economic Development. Human Organization 38:300–306.
Theodoratus, D.
1987 G-O Road: Northwest California Religion Case to be Reviewed by Supreme Court. News From Native California 1:5–6.
Vecsey, C.
1980 American Indian Environmental Religions. *In* American Indian Environments. C. Vecsey and R. Venables, eds. Pp. 1–37. Syracuse, NY: Syracuse University Press.
West, P.
1982 Tribal Control and the Identity-Poverty Dilemma. *In* American Indian SIA: The Social Impact Assessment of Rapid Resource Development on Native Peoples. C. Geisler, R. Green, D. Usner, and P. West, eds. Pp. 80–92. Ann Arbor: Natural Resource Sociology Research Lab, University of Michigan.
White, D.
1980 The American Indian Religious Freedom Act: Native American Religious Issues . . . Also Land Issues. Wassaja, The Indian Historian 13:39–44.
Winslow, G.
1982 Triage and Justice. Berkeley: University of California Press.
Zawacki, B.
1985 ICU Physician's Ethical Role in Distributing Scarce Resources. Critical Care Medicine 13:57–60.

DEPARTMENT of
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March 30, 1995

Mr. Mark Gilbertson, Program Director
Dr. Carol Henry, Director of Science and Policy
Department of Energy
Office of Integrated Risk Management, EM-6
Room 5A-031
1000 Independence Avenue, S.W.
Washington, DC 20585-0002

Subject: TRANSMITTAL OF CTUIR PAPER ON RISK ASSESSMENT

Dear Mr. Gilbertson and Dr. Henry:

Technical staff of the Confederated Tribes of the Umatilla Indian Reservation (CTUIR) understand that your office of the U.S. Department of Energy (DOE) has been compiling papers for a report to Congress, tentatively titled *Risks and the Risk Debate: Searching for Common Ground.* Enclosed is a paper, written by CTUIR technical staff, entitled: *Scoping Report: Nuclear Risks in Tribal Communities.* We formally request that you review this paper and submit it to Congress with your report.

To quote from the introduction to the CTUIR's paper:

> The purpose of this report is to advocate reform of current risk assessment practice in order to make risk assessment a more effective tool for public policy and environmental management decision making. In order to illustrate the need for reforms, this report focuses on direct, indirect, and cumulative impacts to CTUIR tribal communities from environmental management decision making at Hanford.
>
> This report provides a more focused perspective on how to establish both technically and politically defensible environmental management policy in an era of fiscal constraints. It also provides suggestions for developing sound values-based risk policy and technical guidance. These reforms will ultimately result in more clearly defined mission plans, more focused strategic planning

goals, and more timely, health-effective, and cost-effective remedial actions. Such a broader perspective will be much more capable of providing the sufficiently broad, representative, and credible information base necessary to facilitate and support the difficult decisions that must be made in order to establish priorities and cost-effectively "clean-up" DOE sites across the nation.

To provide context for our discussion, we have deliberately focused on the ways current risk assessment practice fails to protect communities such as the CTUIR. The paper, however, is much more than an indictment of current risk assessment methodology. The heart of our paper (Section IV, which is also the longest section) details recommendations for how to improve risk assessment practice in order to remedy these glaring technical and public policy shortfalls.

The text is followed by an encyclopedic collection of appendices, which address in greater detail a variety of issues raised in our report. Concerns such as the fundamental differences between tribal culture and mainstream culture, the role of the CTUIR at Hanford, risks posed by Hanford, and examples of reformed risk assessment methodologies are each, in turn, discussed in depth.

Throughout the report we have focused on the core moral, technical and public policy issues that frame the risk assessment debate. We anticipate that the CTUIR report will be of particular value to people participating in that debate, especially since many of these essential, moral concerns have, to date, been largely ignored in this debate.

Please review this paper and pass it on to others examining these fundamental human issues. Please, also, include the CTUIR paper in your report to Congress.

Our paper is intended to open up discussion of issues that have too-long been ignored or misunderstood. We anticipate it is only the beginning of a dialog between CTUIR staff and others involved in this debate. Consequently, we look forward to further discussions with you about these matters.

CTUIR staff are available to address your questions and concerns. Please address your inquiries to J. R. Wilkinson or Tom Gilmore, CTUIR Hanford Program. They can be reached by phone at (503) 276 - 0105 (voice) or (503) 276 - 0540 (fax).

Sincerely,

J. H. Richards
Acting Director

for Michael J. Farrow
Director
Department of Natural Resources

cc: Board of Trustees, Confederated Tribes of the Umatilla Indian Reservation
Donna Powaukee, Manager, ERWM Program, Nez Perce Tribe

Russell Jim, Manager, ERWM Program, Yakama Indian Nation
Hazel O'Leary, Secretary, U.S. Department of Energy
Thomas Grumbly, Assistant Secretary for Environmental Management, U.S. Department of Energy
Cindy Kelly, Director, Office of Public Accountability, U.S. Department of Energy
John Wagoner, Manager, Hanford Site, U.S. Department of Energy
Kevin Clarke, Indian Programs Manager, Hanford Site, U.S. Department of Energy
Carol Browner, Administrator, U.S. Environmental Protection Agency
Chuck Clarke, Administrator, Region 10, U.S. Environmental Protection Agency
Mary Riveland, Director, State of Washington Department of Ecology
Mary Lou Blazek, Director, Oregon Department of Energy

Confederated Tribes of the Umatilla Indian Reservation

Scoping Report: Nuclear Risks in Tribal Communities

Important information but
lacks references, may be seen as hearsay
Approach is inflammatory.
This sort of rhetoric is what leads decision makers to ignore tribal concerns.

This dicussion is far more than any regulator wants to hear or read. It is a struggle to read and understand. The marginally interested reader will probably give up.

Very poorly documented

Tries to say too much, too fast with too much hostility.
I agree with everything said in this report – I disagree with the way it is said – nothing constructive will come of this unless some level-headed person takes control and puts these issues in front of Congress over and over.

SCOPING REPORT:
NUCLEAR RISKS IN TRIBAL COMMUNITIES

A Report by the Confederated Tribes of the Umatilla Indian Reservation
Outlining Concerns About Risk-Based Approaches to
Environmental Management Decision-Making

Prepared By:

Confederated Tribes of the Umatilla Indian Reservation
Department of Natural Resources
Hanford Program

Prepared For:

U.S. Department of Energy
Office of Environmental Management
Office of Integrated Risk Management
Office of Strategic Planning and Analysis
Office of Public Accountability

United States Congress
Committees on Appropriations
Senate Committee on Energy and Natural Resources

March 1995

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Department of Natural Resources
Hanford Program

I. INTRODUCTION

Both the United States Congress and the U.S. Department of Energy (DOE) are actively considering the standardized use of risk-based remedial decision-making to address "clean-up"[1] of DOE nuclear production sites across the country. Congress has directed DOE to provide a full risk picture at DOE sites across the nation in order to facilitate cost-risk comparisons and prioritization of remedial actions (Appendix A).

Thus far, no comprehensive or sitewide evaluation of risks and costs has been performed at Hanford or any other DOE site. Risks[2] at DOE sites are associated with environmental, health, safety, and cultural threats resulting from historical operations and unsound disposal practices at DOE sites during the past half century. Those few risk analyses[3] that do exist are narrowly framed, based on very little substantive data, depend on numerous assumptions, result in high degrees of uncertainty, and tend to skew decisions toward actions that may not be thoroughly thought out or truly protective. Fulfilling this Congressional mandate will necessarily require focused information collection so that site risks, costs, benefits, and compliance agreement requirements can be evaluated in a comprehensive and not piecemeal fashion. A full risk picture must include addressing the impacts of time, of doing nothing now--or ever--and of "risking" the future health consequences, accumulating impacts, and the ever increasing public health care costs that will necessarily result if the real risks present are not proactively reduced.

Technical staff of the Confederated Tribes of the Umatilla Indian Reservation (CTUIR) are highly concerned that any approach based largely on conventional risk assessment and cost-risk methods may not adequately address those important cultural and social values and other considerations that are an integral part of any comprehensive risk management program. The risks posed by massive historical releases of hazardous chemicals and radioactive materials to the air, water, and soil column will directly impact not only human health and the environment--a particular concern in subsistence-dependent tribal families--but also tribal cultural values, traditional tribal lifestyles, and tribal cultures themselves for many generations to come--risks that often are not accounted for in existing methodologies.

The purpose of this report is to advocate reform of current risk assessment practice in order to make risk assessment a more effective tool for public policy and environmental management decision making. In order to illustrate the need for reforms, this report focuses on direct, indirect, and cumulative impacts to CTUIR tribal communities from environmental management decision making at Hanford.

This report provides a more focused perspective on how to establish both technically and politically defensible environmental management policy in an era of fiscal constraints. It also provides suggestions for developing sound values-based risk policy and technical guidance. These reforms will ultimately result in more clearly defined mission plans, more focused strategic planning goals, and more timely, health-effective, and cost-effective remedial actions. Such a broader perspective will be much more capable of providing the sufficiently broad, representative, and credible information base necessary to facilitate and support the difficult decisions that must be made in order to establish priorities and cost-effectively "clean-up" DOE sites across the nation.

II. TRIBAL CONCERNS WITH CONVENTIONAL RISK ASSESSMENT PRACTICE

Risk assessment is often praised for its ability to quantitatively characterize, and thus support ranking or prioritization of actions necessary to eliminate, control, or 'manage' risk.[4] But it is plagued nonetheless by a number of inherent limitations in its ability to reflect cultural or other social values, such as those of American Indian tribes, that are not easily quantified, numerically simulated, or modeled. Conventional risk assessment methods, having been adapted from other techniques for other purposes, inherently possess major shortcomings that now preclude their widespread application as effective or defensible public policy/environmental management tools. Reforms must be instituted so that assessment techniques address the full scope of risk, which necessarily includes qualitative attributes, cultural factors, personal biases, and subjective judgements. No true or comprehensive characterization of risk can ignore such considerations.

The concerns of American Indian communities and individual tribal members, including members of the CTUIR, who practice traditional lifestyles, readily highlight a number of the well recognized and underappreciated deficiencies and limitations of conventional risk assessment methodology. The inclusion of cultural values in a comprehensive evaluation process will have important implications for the use of such a tool in risk management and remedial action decision-making. Only through a values-based analysis within an American Indian-based holistic environmental management framework can the unique nature of tribal culture, needs, rights, and interests be adequately or appropriately represented.

Issues of vital concern to tribes that are not addressed by current risk assessment practice include: 1) unique and multiple use of treaty-reserved rights and resources for subsistence, ceremonial, cultural, or religious practices, 2) multiple exposure pathways that result from cultural resource use that are neither considered nor commonly included in typical "suburban" exposure scenarios, 3) that tribal communities often constitute critical segments of populations whose lifestyles result in disproportionately greater than average exposure potential, either sociologically or geographically, 4) the failure to address the role of time and to adequately assess risks to future generations, 5) issues of environmental justice and the right to a safe and healthful environment (the need for formally incorporating affected community input), and 6) more intangible considerations such as aesthetic, physical, economic, community, and future well-being, equity, peace of mind, and sustainability.

A. Unique Resource Use and Exposure Pathways: An Interdependent Food Web

Tribal culture and individual tribal people consider themselves as integral components of an interconnected and interdependent environment. This perspective stands in stark contrast to the predominant view in non-Indian society where humans are commonly viewed as separate from and superior to the environment in which they live. Tribal members depend upon numerous sources of food and other resources that are not commonly used by the dominant society, and that are thus ignored in traditional risk assessments (Appendix B). For example, tribal people are traditionally subsistence fishers, hunters, gatherers, and traders, and inherently value and utilize all parts of resources, many of which the dominant society simply discards. Consequently, through practicing traditional activities, tribal members may be readily exposed to multiple sources of contaminants along multiple exposure pathways not shared by the typical suburban residents that form the basis of conventional risk analyses and exposure scenarios. Cultural practices themselves also may result in increased exposure potential because the practices employed in food gathering and other cultural practices are themselves integral components of the process, and cannot be separated from it. Certain cultural, ceremonial, and spiritual practices, such as sweat lodges, are unique to tribal people, but present multiple exposure pathways not addressed by conventional risk analyses. Multiple resource use and multiple exposure pathways further compound the bioaccumulation potential of concentrating contaminants among food web trophic levels. For example, typical measures of contaminant concentrations in water do not adequately represent or protect human consumption or use of resources as riparian zone plants growing where contaminated shoreline seeps and springs discharge, salmon redds that overlie riverbottom contaminant discharge zones, or the organisms that in turn feed upon these food sources.

B. Critical Segments of Populations

Multiple resource use, multiple exposure pathways, and unique traditional lifestyles and cultural practices common in tribal communities mean such communities constitute critical segments of populations--indicator populations, if you will--that may be subject to much higher risk than most elements of non-Indian society. If the exposure and risk potential of a population as a whole can be simplistically modeled as a typical bell-shaped curve, then tribal communities would consistently fall at the high end of the spectrum--one that is underrepresented (or worse) in conventional risk analyses. This effect is still further compounded because the generally small size and limited geographic extent of most tribal populations fail to provide a "statistically significant" sample. Hence, conventional risk analyses ignore such conditions because they cannot be confidently or defensibly modeled, even though impacts may be well demonstrated. Furthermore, the limited areal extent of many waste sites, including significant, but localized discharges or exposure potential at Hanford, make it difficult to employ conventional epidemiologic methodology, which typically requires large populations and areas of coverage.

C. Multi-Generational Impacts and the Impacts of Time

One of the most serious deficiencies of conventional risk methods is that they fully ignore the impacts of time and of accumulating impacts to future generations. Hence, true risks as measured through time are vastly underestimated. Conventional methods address only current conditions. Even where attempts to account for future impacts are made, they must assume that the risk slate is wiped clean with each new generation. In point of fact, impacts accumulate through time, seemingly distinct actions or effects are environmentally interconnected, and the indirect impacts associated, for example, with non-cancerous effects are ignored. Equally severe or life-threatening impacts such as birth defects, reduced birth rates, reduced immunologic or metabolic function, and increased adverse health conditions whose origin may be difficult, if not impossible, to prove are just a few of the indirect impacts to current or future generations that simply cannot be addressed by current methodologies. Such impacts may be particularly important because of the very long-lived, mobile, and environmentally persistent nature of many Hanford contaminants, especially radionuclides, heavy metals, and organic compounds.

Conventional risk methods that ignore the element of time reflect the short-sighted values of the dominant non-Indian society and its obsessive focus on only the here and now. Such a view is largely unknown in tribal culture, where present generations feel a profound commitment to provide for elders and future generations--all of whom may be subject to greater adverse impacts. This is clearly reflected in the protective and sustainable environmental management philosophy that many tribes have long employed by asking the question, "What will be the impacts of our actions today seven generations hence?" For example, non-Indian society has developed techniques to establish remedial standards and standards of residual risk that measurably discount the value of future generations at increasing rates through time. Aside from the questionable moral and ethical considerations involved, this selfish, short-sighted approach is the ultimate slap in the face, as it provides no accountability or commitment to steward current lands and resources for the future. All such efforts only facilitate and encourage maximum environmental destruction now to maximize immediate returns, while at the same time severely prejudicing future options by passing on a worsening legacy of environmental pollution to our children and grandchildren.

D. Environmental Injustice

There are few better illustrations of environmental *in*justice than those provided by the nuclear industry from its very birth. From the dropping of the first atomic bomb on war-weary East

Asians, to the concentration of uranium mining activities in tribal lands in the American Southwest, to the preferential location of defense and commercial nuclear reactors and proposed waste storage "solutions" on tribal lands, the focus is consistently on remote areas and communities with little political power or influence--especially those of American Indian tribes. For example, three major defense production, storage, and training facilities are located within the ceded lands of the CTUIR. These include not only DOE's Hanford site, but also the Umatilla Army Depot, where 12% of the nation's arsenal of chemical weapons and agents are stored, and the Boardman Bombing Range, a training range for military pilots from Puget Sound bases. Hence, both tribal members and the Umatilla Reservation itself have long been burdened with a disproportionate share of risk and potential exposure to some of the most dangerous agents or conditions known to humans. These include Hanford's radioactive materials and the radiation they emit, a suite of heavy metals and other toxic or hazardous chemicals, the Umatilla Army Depot's nerve and mustard agents, rockets, and explosives (some of which are intermixed and reactive), and unknown quantities of unexploded ordnance at the Boardman Bombing Range.

Such sites constitute "hot spots," be they geographic (near-source) or sociologic (owing to subsistence dependence on contaminated resources). Issues of environmental justice have received increasing attention in the Executive Branch, as President Clinton has issued an Executive Order[5] directing each cabinet-level department--including DOE--to develop an implementation strategy for addressing such issues. This plan must define how departments will facilitate direct involvement of affected local communities in both recognizing and resolving the disproportionate impacts of federal government actions on critical segments of populations such as American Indian tribes. The development and application of improved risk assessment methodologies in environmental management decision making must be an essential feature of these reforms, and should be specifically addressed.

III. RISK ASSESSMENT CHALLENGES PRESENTED BY HANFORD

A. Overview of DOE Complex and Mission

The mission of the U.S. Department of Energy has shifted greatly in recent years. DOE facilities across the nation supported the massive arms build-up that proceeded steadily from the end of World War II through the 1980s. Growing public concerns over widespread safety questions, environmental problems, and regulatory compliance, however, forced shutdown of major portions of the complex across the nation during the 1980s, a process accelerated by the almost overnight end to the Cold War. But the legacy of the Cold War remains.

By the early 1990s, DOE's mission had shifted equally abruptly. DOE is now attempting to "clean-up" its legacy of widespread waste management problems and uncontrolled environmental pollution, that is, to restore the environment. The Department of Energy clearly recognizes the significant technical, institutional, and political challenges that it faces in cleaning up its legacy--and hints at a solution.

> "Solving the waste-management and contamination problems of this legacy will take decades and enormous resources. . . And even then the task will not be fully completed for those sites and facilities [such as Hanford] that will need continued guarding and monitoring.
>
> "The task of Environmental Management is to begin to close the circle on the splitting of the atom for weapons production through sustained efforts to understand the whole problem as well as its parts.
>
> "The nation faces daunting institutional and technical challenges in dealing with the environmental legacy of the Cold War. We have large amounts of radioactive materials that will be hazardous for thousands of years; we lack effective technologies and solutions for resolving many of these environmental and safety problems; we do not fully understand the potential health effects of prolonged exposure to materials that are both radioactive and chemically toxic; and we must clear major institutional hurdles in the transition from nuclear weapons production to environmental cleanup.
>
> "These challenges cannot be solved by science alone. In the midst of the complexities and uncertainties, one thing is clear: the challenges before us will require a similar--if not greater--level of commitment, intelligence, and ingenuity than was required by the Manhattan Project."[6]

As if such a mission alone were not challenging enough, DOE also is one of the larger federal agency managers of publicly owned lands and natural resources. DOE currently manages at least 137 defense and non-defense sites in 33 states and one U.S. territory that together cover some 3300 square miles and pose some 10,000 individual remedial challenges.[7]

This report focuses on issues at DOE's Hanford site in Washington State. Hanford lies within a portion of the CTUIR's ceded lands, within which the CTUIR maintain treaty-reserved rights and interests (Appendices B and C). Hanford poses some of the most difficult, complex, and pervasive "clean-up" problems of any DOE site in the nation (Appendix D).

B. The Risks at Hanford Are Real

DOE, as well as many other independent reviewers, clearly recognize that the DOE nuclear weapons complex poses a wide variety of risks and "clean-up" challenges.[8] These risks are characterized in terms of the source and severity of the risk, exposure pathways, and potential receptors. Among sites in the DOE complex, Hanford's problems are profound, complex, and often interrelated, and represent real risks to the surrounding communities, region, and nation that are unparalleled anywhere else within the DOE complex. Although the risks appear to be local, the potential impact from a catastrophic incident may have profound impacts to the region's international economy and agricultural base. Events such as the Chernobyl meltdown or the Tomsk tank explosion demonstrate that while distance dilutes awareness, knowledge, and concern about risks outside a commonly perceived area of influence, catastrophic events at one locale can have much more widespread, even global implications.

Historical releases from Hanford are traceable downstream along the Columbia River, spreading over hundreds of square miles of the Pacific Ocean, as far north as Canada and as far south as northern California, and downwind into eastern Washington, Oregon, and Idaho.[9] Such demonstrated historical impacts only hint at the full spatial and temporal scope of future risk. Outlining "real risks" to tribes, the public, site workers, and the environment necessarily combines toxicologic effects, risk perception, risk evaluation, qualitative values, and community or cultural impacts.

At Hanford, risks are present from a variety of conditions and operating practices--past, present, and future--and to a variety of receptors, including individuals dependent upon contaminated natural resources for subsistence or other cultural purposes, the human and ecological communities in which they live, and to future generations of humans and other organisms. The risks posed by these conditions and impacts are outlined in more detail in Appendix G under the following topics.

- Risks from Hanford Nuclear Production Facilities
- Risks from Hanford Tanks
- Risks from Hanford Spent Fuel
- Risks from Past Hanford Disposal Practices
- Risks to Communities and Cultures
- Risks through Time

Risks associated with the first four categories above have been widely recognized and discussed (even if little has actually been done about them), but the last two categories have been widely ignored and their true impacts greatly underappreciated.

C. Hanford Federal Facilities Compliance Agreement (Tri-Party Agreement)

In 1989, DOE, along with its regulators, the U.S. Environmental Protection Agency (EPA) and the Washington State Department of Ecology, signed a federal facility compliance agreement known as the Tri-Party Agreement (TPA). DOE had been operating its nuclear production facilities across the country, including Hanford, in defiance of federal and state environmental laws for years. The purpose of the TPA was to outline and schedule those tasks that would either permit or constitute "clean-up" of the Hanford site, and to bring operations into compliance with existing federal and state laws.

The TPA represents a unique product of both regulatory requirements and accomodation of public interests in the Pacific Northwest. By its very nature, the TPA incorporates qualitative values and may be considered as a regionally unique, democratic alternative to conventional risk assessment for establishing remedial priorities. Because it is also the product of a political process, as well as being based on technical demands and institutional requirements, it has received extensive public review and input and thus embodies at least some important social and cultural principles (e.g., protect the Columbia River).

In addition to its benefits, the TPA has its limitations. First and foremost, the TPA defines long-term commitments to Hanford clean-up that transcend typical short-term political vision, attention spans, and election cycles. This also means that a long-term political and financial commitment is required to accomplish the goals of the TPA and to comply with federal and state environmental laws. While they are not blameless, the TPA and regulators too often are singled out for stalling "clean-up," but tribal experience indicates that it is primarily DOE who most consistently fails to serve its "constituents." This failure is most clearly shown by not providing strict management control and responsibility, contractor accountability, an overall purpose and direction that DOE managers also believe in, and *any* good faith, proactive, on-the-ground commitment to "clean-up." It is a widely held belief, strongly supported by extensive historical government records, that Hanford truly is the most polluted place in the country. Hence, a prime purpose of the TPA is to maintain focus on the ultimate goal of environmentally sound waste management, remediation, and restoration of the Hanford site.

Federal (and state) environmental laws--whose principles are embodied directly in compliance agreements such as the TPA--often offer the only protection available against flagrant onslaughts of environmental contamination and the risks they pose to individuals, children, families, communities, lands and resources, and the freedom and right of choice that all such communities collectively depend upon. The bulk of these laws[10] were first passed because of unconscionable abuses such as Love Canal, and are a direct result of the dismal failure of trusting polluters interested only in short-term profits (benefits) to "self-regulate" or protect public resources.

Moreover, while private industry was the target of much of the original legislation, the shutdown of the nuclear weapons complex and other defense facilities made it especially clear that the federal government was in fact one of the most flagrant offenders. Because public agencies such as DOE continued to flaunt regulatory compliance, particularly under RCRA, and maintain its "right" to "self-regulate," the Federal Facilities Compliance Act was passed in 1992 in order to reinforce that federal government facilities were subject to the same laws as everyone else.

But the TPA does not address a number of critically important issues to communities. For example, these include off-site transportation of radioactive or hazardous chemicals, numerous facilities not directly under DOE control, and especially, the true costs of environmental contamination as manifested by adverse human and environmental health impacts and associated public costs, either near-term or long-term. Such impacts are currently and at best, poorly understood; more comprehensive and focused efforts must be directed at understanding the interrelation of such chemically-induced causes and health-related effects.[11]

Increased reliance on tools such as risk assessment or risk evaluation only diverts attention from the measurable health-related impacts to uniquely affected communities such as American Indian tribes, whose culture, traditions, and lifestyles put them at much greater risk than the population as a whole (Appendix B). These short-sighted approaches fail to account for the true long-term health impacts and the increased health care costs that directly result, because they fundamentally ignore short-term, long-term, acute, and chronic effects, the long latency period of many carcinogens or other health-impacting agents, the environmental persistence and bioaccumulation of long-lived contaminants and their breakdown products, or the long-term cumulative effects on future generations.

The TPA was not framed with the intent of characterizing, assessing, or prioritizing how much risk would actually be reduced, because little relevant risk information was available at the time the TPA was negotiated. Nevertheless, and although imperfect, the TPA currently constitutes the only generally agreed upon, negotiated combination of priorities and schedules of DOE, regulators, tribal governments, and Pacific Northwest residents, and it is continually evolving to meet new realities.

Fifty years of secrecy and a "self-regulated" license to pollute cannot easily be undone by only six years on the frontier with some semblance of democratic oversight and open tribal/public involvement. The commitment to close the circle must not succumb to short-sighted budgetary considerations, or to a failure of the federal government to take full responsibility for its historical actions by simply legislating "clean-up." Widespread contamination is present and will remain unless *action* is taken. Creating national sacrifice zones, by throwing up a fence and then just walking away from those communities who are directly affected by such unchecked impacts and actions, but have no say in those decisions, is totally unacceptable. Local affected communities who were given no choice in siting or managing such operations historically must not now be forced to disproportionately shoulder the current and future "clean-up" burdens--or their resulting health impacts--alone.

D. The Struggle of Political, Technical, Cultural, and Institutional Perspectives

For fifty years, DOE had only to meet its own institutional requirements. Because its operations were long hidden behind the secretive cloak of national security, policy and management issues were never open to public scrutiny. Consequently, such issues were debated only internally, and (paradoxically) enjoyed widespread and unquestioning political support in Congress and within the government structure as a whole. Moreover, seemingly insurmountable technical limitations were routinely overcome by a level of drive, ingenuity, and scientific creativity virtually unparalleled in U.S. (if not world) history. This ingenuity, however, was focused solely on the goal of producing weapons of war--not on cleaning up the equally fatal waste products of that production on American populations such weapons were ostensibly intended to protect.

With the shutdown of the weapons production complex and a new mission, DOE has struggled profoundly (and with only limited success) to change its own deeply entrenched Cold War "culture." DOE has made some piecemeal attempts to respond to the concerns of other cultures and communities that were long affected by its weapons production activities, but that previously had no say in their operation or resolution. New political realities rightly demand open democratic participation in, and accountability for, costly issues of national concern that have long been ignored by both technical managers and politicians. In addition, a new set of technical exigencies and current limitations now will require an equally diligent drive and dedication to overcome. DOE's continued dependence on a narrow, outmoded management philosophy and closed decision making processes, however, have made it difficult at best for DOE to openly embrace its new mission and achieve substantive progress beyond simply maintaining the status quo.

The unique legacy threatening Hanford (and other DOE sites) took fifty years to accumulate. It will not be resolved overnight, despite political and public impatience. Sustained action will be required to meet goals agreed to in good faith in compliance agreements, and this in turn will require a long-term commitment of both dollars and political will. Some problems will be more readily and quickly resolved than others. Some will require long-term actions and technologies that do not now exist--directly challenging traditional political, institutional, and technological limitations. The federal government has committed in both words and actions that these challenges will be met.

The risks that current and future conditions at DOE sites across the nation now pose are very real. As such, these risks cannot be eliminated or ignored simply because they are difficult, costly, or cannot be solved today or even tomorrow. *Widespread contamination cannot be willed away. Neither can "clean-up" be declared legislatively "complete" simply by altering regulations or so-called "clean-up" standards in order to satisfy political impatience or the short attention spans of the public or Congress. Similarly, "clean-up" cannot necessarily be considered complete simply because of pressure from current conflicting budgetary considerations or past budgetary mismanagement.* Without an adequate risk baseline, it will remain impossible to determine what, if any, actual "clean-up" progress is being made.

Existing wastes and contamination and the daily impacts they now have in human and ecological communities cannot be altered by legislative action, only by remedial actions. Turning Hanford or any other DOE site into a "national sacrifice zone" is not an acceptable legacy to leave to future generations. The paradox is that while such a short-sighted approach may be justified as "cost-effective" now, it fundamentally ignores the long-term consequences, risks, and true life-cycle costs to both affected communities and the U.S. government. *Congress and the public all benefited from the national security provided by the nuclear arsenal that created this legacy of polluted land and resources. Federal government commitments to "clean-up" must be kept and* *proactively fulfilled. Affected communities already have had to bear a disproportionate share of the impacts of "self-regulated" federal actions for 50 years; they should not also now be expected to bear a disproportionate amount of the "clean-up" burden as well.*

The Tri-Party Agreement at Hanford and other federal facility compliance agreements constitute the ultimate foundation of prioritization for risk management, risk-reduction strategies, and remedial actions. The TPA is a unique contract blending regulatory requirements, priorities, and the desires of residents of the Pacific Northwest. This agreement has benefited significantly from extensive public review and input and by its very nature prioritizes risk control and embodies public perspectives and regulatory compliance. *Thus the TPA comprises a much more democratic alternative than any strictly risk-based identification of remedial priorities, which both DOE and regulators directly entered into in good faith. Popular acceptance in the Pacific Northwest has resulted only with the firm understanding that the TPA constitutes a legally enforceable federal government commitment and schedule that would direct timely, substantive, and protective Hanford site "clean-up."*

Within a compliance agreement framework, risk evaluations can be an effective remedial decision-making tool, *but only if* a sufficiently comprehensive spectrum of information related to affected communities is considered directly by the process itself. The narrowness of traditional risk assessment alone cannot satisfy these requirements, and often serves simply as a seemingly objective, but in fact highly malleable technique to decide only how *little* is to be done. Unfortunately, this is especially true when--as in the case of DOE--the polluter also is responsible for directing "clean-up." The focus tends to be on defining how *much* pollution or how *little* "clean-up" is acceptable, rather than on a more holistic approach of more broadly defining what is truly desirable and achievable.' Conventional risk assessment defines and characterizes risks only very narrowly, for example, based on only single chemicals, exposure pathways, or a single risk factor such as cancer. Moreover, increasing criticism focused on characterizing remedial actions as overly protective (how can this even be possible??) is misdirected. *These narrow concerns ignore the critical importance of the unspoken values, biases, and judgement process embedded within a non-Indian myth that fundamentally violates and dismisses 13,000 years of protective and sustainable environmental management by American Indian tribes.*

Risks to cultures and to cultural values are just as real as risks to human health and the environment. This is especially true for American Indian communities, whose very culture, lifestyles, and tribal identity depend on a clean, healthy environment whose integrity has not been violated (Appendix B). In the Hanford region, sovereign tribes ceded title to vast tracts of their traditional homelands, but specifically retained rights in their treaties to lands, resources, and traditional activities. Hence, all decisions affecting Hanford site "clean-up" must respect tribal sovereignty and treaty-reserved rights, must enhance government-to-government communications, and must facilitate direct and early tribal involvement in decisions that may impact tribes, as mandated under the DOE Indian Policy.[12] Moreover, as one of the nation's larger land and natural resource managers, DOE has trustee responsibilities to protect and preserve its lands, natural, and cultural resources not only under the treaties, but also under numerous federal and state laws. Although some progress is beginning to be made in characterizing what might be termed the "ecocultural landscape,"[13] DOE has yet to effectively integrate American Indian cultures, cultural values, and its cultural resource protection and management responsibilities into its site "clean-up" decision-making processes.[14]

Widely recognized deficiencies of conventional risk assessment for comprehensive environmental decision-making have led to numerous independent attempts to create more comprehensive and holistic approaches to risk-based decision-making. The most successful and enduring of these approaches depend on a more integrated environmental management framework that intimately includes values and other qualitative considerations. Numerous, but by no means exhaustive, examples are highlighted within this report.[15] The approaches identified below are readily applicable--and in some cases, have been applied--to DOE sites across the nation, including Hanford.

There is no need to "reinvent the wheel." These examples all show that more comprehensive risk evaluation frameworks already have been developed, effectively utilized in wide ranging applications across the nation, and can be further adapted to site-specific DOE needs. There is, however, a critical need to have the conviction, courage, and forethought to move forward with incorporating a more holistic management philosophy within all levels of DOE, and to move beyond the historical piecemeal approach to risks, compliance, health, and environmental management in general.

IV. TOWARD A MORE JUST AND COMPREHENSIVE RISK EVALUATION PARADIGM

A. Risk Perception is the Cornerstone of Risk Assessment, Risk Evaluation, and Risk Management

1) There's More to Risk Than Just Numbers

Despite what we are frequently told, *science is never truly objective.* Science is in fact a highly value-laden product of the culture and society within which it occurs and which it serves. Because we all are members of this society and encounter science daily, we are often unaware or take for granted the imprint of our inherent cultural and personal biases. Furthermore, the nature of the judgement process we apply to filter through all the available information is highly complex and individual, and requires that we select and highlight some information and then ignore or discard the rest. The same is true for all societies or cultures: it is a universal human way to cope with information overload. For example, cultural values and biases dictate the kinds of questions asked in scientific inquiries--and more importantly, the questions not asked.

The term "risk" itself is a value word, like "safe" and "clean." It just *sounds* more numerical, technical, and therefore objective. Risk typically is defined in terms of methods, not goals, which only adds further confusion and contributes to its frequent misuse or misapplication. Further, many assumptions, uncertainties, and limitations are inherent in the risk assessment process, largely reflecting a lack of data or knowledge about risk, and have been well delineated (Appendix H). The chief failure of conventional risk assessment--and especially its application--is that it addresses only a part of the much bigger risk picture.

Many of the identified deficiencies with conventional quantitative risk assessment reflect the fact that risk is not only a function of readily quantifiable (if highly limited) measures of toxicity, dose, exposure duration and pathways, and induced health effects. Risk also inseparably depends upon more elusive, and difficult to measure qualitative factors, such as social and cultural values, along with personal and cultural biases and the relatively subjective or intuitive judgement process used by humans to select and weigh the spectrum of available information and attitudes. Ironically, in many important respects, more is known and quantifiable about "perceived" risk than about toxicological hazards, environmental pathways, and health impacts.[16]

Although often difficult to specify, such considerations are no less important than conventional measures to affected communities, to technically defensible risk management strategies, and to politically supportable decisions for remedial action. To the confoundment of many so-called experts, who are more comfortable with cold, hard statistics about mortality or accident rates, these often highly subjective considerations--often belittled as the "outrage" component--exert a disproportionate influence on decisions. Because such elusive factors are difficult to measure or model, they have been traditionally excluded from conventional risk assessment methodology, dismissed as only opinions or preferences, or if they are included, it's only as "guiding values" during a later risk management phase. *Yet the political reality is that environmental managers must comprehensively address the full scope of risk in order for decisions to have any true viability, lasting power, or popular support.*

qualitative and quantitative components

The full scope of risk also is profoundly influenced by personal experiences (which may be misleading), how information is presented (mortality versus survival rates), degree of familiarity, biased media coverage, strength of convictions (that remain steadfast regardless of evidence to the contrary), and a host of other highly variable individual factors. Moreover, when nuclear issues in particular are considered, factors such as uncontrollability, dread, catastrophic potential (on a global scale), fatal consequences, immediacy, high risk to future generations, and involuntariness take on a heightened influence.[17] For example, people are generally willing to accept risks from voluntary activities (such as skiing) that are roughly 1000 times greater than from involuntary hazards (such as food preservatives).[18]

Clearly, risk means different things to different people.[19] For example, a high degree of "perceived" risk typically is required to cause a change in behavior, such as avoidance, stricter discharge limits, or in the case of remedial decisions, "clean-up." It is time to move beyond the arbitrary and fallacious technical distinctions between "hazard" and "outrage," which are too commonly misinterpreted separately as "real" and "perceived" risks (i.e., not "real" to experts, those who matter, even if "real" to affected communities, who don't matter). In point of fact, factors commonly associated with "outrage" are more often than not found to be related to quality of life and cultural values that truly are at real risk.

2) It Always Returns to Values

Hence, conventional quantitative risk assessments alone tell only a limited part of the story. Numbers can provide a representative version of the truth--if the right data are collected--but a comprehensive characterization of risk and its role in risk management and remedial decision-making always returns to values and quality of life issues. The real question is whose values will govern the process. Will it be those of remote, uninvolved "experts," a distant, self-obsessed, and sometimes uninformed federal government, or those of the communities that are affected by such actions every day?

There is much more at risk than human health and the environment, although these are clear measures of health and risk. Important qualitative and cultural values--and cultures themselves--are at risk from DOE facilities and past, current, and future activities across the nation. This equally important cultural risk can only be determined by including both values and the affected communities directly in a rigorous and systematic evaluation process. Such concerns are at the very heart of the environmental justice reforms that all federal cabinet-level departments are implementing. These values cannot simply be applied as *post hoc* "scaling factors" to the "real" (read: legitimate) hazard data during a subsequent risk management phase, nor should they be used solely to modify the tail end of a decision process after the "experts" have already framed the discussion and established "their" boundaries as to the scope of the study or range of options.

Without a more rigorous, credible, and comprehensive process, decisions based on risk alone may result at best in unprotective or short-sighted remedial actions. At worst, they result in political decisions that are based solely on budgetary constraints and rely on a biased, fragmentary information base. To facilitate the widespread acceptance necessary for success and to comprise a credible approach to risk management and remedial action decision making, traditional risk evaluation must become a more responsive, open, and humane process.

B. Moving Beyond Conventional Risk Assessment

1) Overview

The widespread deficiencies and limitations of conventional risk assessment, both as a technical evaluation methodology and as a policy or political decision-making tool, are well recognized by many diverse interests (see Appendix H). Risk assessment is often praised for its ability to quantitatively characterize, and thus support ranking or prioritization of actions necessary to eliminate, control, or 'manage' risk.[20] But conventional risk methods are plagued nonetheless by a number of inherent limitations in their ability to reflect cultural or other social values--such as those of American Indian tribes--that are not easily quantified, numerically simulated, or modeled. Regardless, a full evaluation of risk remains a highly subjective matter, which necessarily includes qualitative attributes, cultural factors, and subjective judgements. No true or comprehensive characterization of risk can ignore such fundamental and integral considerations, which can only be identified and incorporated through comprehensive involvement of affected communities and their values throughout the process.

Because so many different sets of values (whose to choose?) are commonly involved, some of which may conflict, many processes and decisions simply leave it to the "experts" or settle for a solution that appears least objectionable to the most people at the surface, even if it is short-sighted or unprotective. Too often, "consensus" simply means compromising any real substance out of a process or decision.

> "When common ground is limited, we reach for acceptability, not desirability. In environmental management, when stakeholders have different value systems (cultures) we tend toward analytic thinking. Therefore, trying to get holistic thinking from people with different value systems is difficult. Analytic thinking supports science, individualism, and discovery. Holistic thinking supports management, consensus, and optimization. For [successful] environmental management, clearly we want to blend both holistic and analytic thinking in a situation where our differences force us toward analytic thinking.
>
> "We don't have to define desirability precisely. A rough estimate will do. . . . [A] rough estimate of desirability is not only easier, it's better. . . . [W]hen we define exact boundaries, people will tend to focus on the boundary and meet lower requirements.
>
> "The answer is to optimally blend holistic and analytic thinking and to trade off individualism and technology against unified values and management. Holistic thinking is in itself oriented toward this blend. The environment deserves a profound understanding of the harmonious blend of science and management."[21]

Is risk assessment becoming a scapegoat for politicians and bureaucrats

Risk evaluations, as integral components of a political process, should not be allowed to singularly substitute for the need to weigh a broad spectrum of relevant information and make tough decisions or political choices. Nor should tough choices simply default to the so-called "panel of experts" approach that only facilitates further disconnect from affected communities, justifies a "solicit input" and "respond to comments" approach, and isolates democratic decision-making from those activities that affect people's lives and their communities every day.

2) Building Consensus

These widely recognized limitations have led to numerous attempts to improve the quality, comprehensiveness, and responsiveness of risk evaluation efforts. One of these efforts was conducted in direct response to Assistant Secretary Grumbly's request before the National Research Council in November 1993, which resulted in a report called *Building Consensus Through Risk Assessment and Management of the DOE's Environmental Remediation Program* (1994). The *Building Consensus* report in particular attempts to outline a new risk evaluation framework. It begins by highlighting two elements essential to building a credible risk evaluation process: "it is vital to the quality of the [risk evaluation] process that independent external review and public [and tribal] participation occur throughout"[22] and the "importance of including considerations other than quantitative ones in risk assessment and risk management."[23]

The inclusion of meaningful and effective public/tribal participation in *all* phases of a credible risk evaluation program is the clearest way to build credibility, which *Building Consensus* spells out in some detail.

define "stakeholder"

> "Stakeholder[24] participation should begin with scoping and continue throughout the assessment process. It should be included in key decisions and integrated into the work plan. . . . It should begin early in the conceptual phases of a program and continue through[out] each phase. It should be interactive and iterative, and stakeholders should perform consultative roles in which they help define basic concepts and approaches, rather than exclusively the more traditional 'review and comment' role. Broad stakeholder participation can improve the quality of assessments by increasing the comprehensiveness of data; ensuring that all site-relevant pathways, end points, and land uses are taken into account and are based on an accurate understanding of habits, values, and preferences of affected people; and contributing to the discussion of appropriate and acceptable uses for risk assessment in the process of risk management. *Stakeholder participation in assessing risks at DOE facilities must be an integral component of any process that is expected to result in credible, broadly accepted assessments.*"[25] [emphasis added]

Moreover, Assistant Secretary Grumbly is particularly sensitive to the essential need for *credibility* in order to gain public, tribal, and regulator acceptance. Such credibility results directly from a responsive, responsible, and competent organization fully satisfying a comprehensive set of objectives. *Building Consensus* outlines six essential attributes that any risk evaluation "institution" must possess:

- "It needs to be perceived as being neutral and credible.
- "It needs the ability to conduct scientifically valid and responsible risk assessments.
- "Its assessments must be subjected to independent external review by technical experts [not just agents selected by the organization responsible, paradoxically, for both pollution and clean-up].
- "It needs the ability to plan, organize, manage, and facilitate public [and tribal] participation in [affected] communities.
- "It needs to have [financial and scientific] management capability.

- "It needs the ability to communicate complicated scientific information on potential risks and uncertainties effectively."[26]

"Building Consensus" then identifies four principal objectives for risk assessments:

- Providing "credibility,"
- The need to "operate expeditiously,"
- The need to "consider the *full range of risks of concern* to stakeholders in the light of social, religious, historical, political, land-use, and cultural values and needs," and
- Being "efficient and cost effective and produc[ing] results that contribute to identification of remedies and priorities."[27]

C. Toward Holistic/Integrated Environmental Management

What are these efforts?

A number of recently completed efforts directly confront recognized problems and limitations with conventional risk assessment methodology. Each attempts to establish criteria and process(es) that provide a sufficiently comprehensive information base to support credible, technically defensible, and politically acceptable risk management and remedial decisions.

A recurrent theme among all of these efforts has been the need to directly address those important qualitative issues, social/cultural values, and elements of time traditionally ignored in conventional risk assessment and piecemeal (crisis) environmental management. The focus of these efforts has been to develop a more comprehensive and rigorous framework that specifically includes qualitative considerations and social/cultural values as an integral component of the risk evaluation and decision making process. This focus is based on universal recognition that many factors in addition to quantitative data are relevant to priority setting and risk management, and that these must be included in the evaluation process in order to provide both credibility and comprehensiveness to the nature, magnitude, and urgency of risks identified. Moreover, there is consistent and universal recognition among these efforts of the critical need for integrated tribal/public participation throughout the decision making process for it to gain the credibility and popular support necessary for success.

These innovative risk evaluation efforts all have directly and successfully challenged the well recognized limitations of conventional risk assessment methodology. They have attempted to construct comprehensive and workable solutions that will improve both the usefulness and defensibility of risk evaluation as an analytical support technique and as a decision-making tool. These state-of-the-art studies consciously recognize and fully incorporate the full scope of risk into their process, and show how it can be done efficiently, cost-effectively, and credibly.

In many respects, these approaches can meet Assistant Secretary Grumbly's mandate by building in credibility and effective tribal/public participation throughout the process. The selected examples highlight numerous, workable, and cost effective alternatives. The critical obstacle yet to be overcome is the still deeply entrenched institutional resistance within DOE and its contractors that has effectively prevented even the consideration of new or more comprehensive approaches, let alone their implementation. The principal challenge now is to adapt and adopt these techniques into DOE's decision-making framework, both at the site-specific and complex-wide levels, and to foster DOE's recognition that such efforts will pay off both politically and financially with more widespread popular support and more timely, cost-effective results.

Nine different forums that explore comprehensive risk evaluation and holistic environmental management are highlighted in Appendix I; they are by no means exhaustive. These include the Blacksburg Forum, the Vermont Comparative Risk Project, the Wisconsin Tribes Comparative Risk Project, and the California Comparative Risk Project, and five Hanford-specific forums, Values-Based Risk Evaluation, the Hanford Future Site Uses Working Group, the Hanford Tank Waste Task Force, the Hanford Environmental Dose Reconstruction Project, and the Native American Working Group.

Each of these efforts has developed an innovative approach to characterizing risk and/or developing environmental priorities that are built upon meaningful and comprehensive tribal/public participation throughout the process and firm incorporation of social, cultural, and aesthetic values directly within their evaluation methodology. Each, however, has depended upon a combination of science, an upfront awareness of the critical role of perspective and uncertainty, and the combined judgement (recognizing its subjectivity) of scientists, citizens, and affected community members. The consistent and systematic application of evaluation criteria to both quantitative and qualitative considerations also permit ranking, where desired. Moreover, all forums independently agree that true risk cannot be accurately and comprehensively characterized--and hence broadly accepted risk evaluations result--without an overarching holistic perspective and breadth of data that fundamentally recognizes and incorporates values and qualitative measures of risk into integrated environmental management strategies.

D. Risks, Costs, and Benefits are Interrelated

Reducing risks requires action on (or in) the ground. The magnitude, breadth, severity, and urgency of the multiple threats that Hanford poses will necessarily result in involuntary human suffering, accumulating environmental damage, and growing associated public health costs, either immediately or over the long-term. Avoiding the adverse impacts, whether direct or indirect, that result directly from such threats can only occur by effectively removing or reducing the risks.

Real risk reduction cannot be accomplished legislatively by gutting current environmental laws, by removing the rights of citizens and communities to enforce such laws on their own if government will not, or by establishing remedial standards or residual risk levels that are not truly protective, but merely the result of intense political pressure and "compromise." True risk reduction must be focused where the greatest risks are really located, which is *not* in the halls of

Congress or DOE (even though some might disagree). Not only affected communities, but society as a whole will truly benefit, over both the short- and long-term, from substantive actions that demonstrably protect human health, the environment, and cultural values. Many people simply don't trust government and government officials these days--and rightfully so--because of government's persistent failures to live up to commitments. Congress and especially DOE also would benefit enormously and immeasurably from society's restored faith and trust in a government that does not often seem to protect the interests of society as a whole.

The current annual Hanford EM budget (FY 95) is on the order of $1.4 billion. Current planning in both DOE and Congress indicates that such order-of-magnitude levels are unlikely to continue, regardless of actual field conditions. Allocation of the current Hanford budget is split between various programs including Waste Management, Nuclear Materials and Facility Stabilization, Environmental Restoration, Landlord, and others (Appendix J). For example, funding for Environmental Restoration nationwide totals about 25% of DOE's EM budget, but at Hanford this program accounts for only 13% of expenditures. Moreover, while it is expected that the overall EM budget will decline in real dollars over the next few years, major new "clean-up" responsibilities, such as the Savannah River Site, SC, and the Mound Plant, OH, will be added, leaving even fewer dollars available for existing commitments.

As most people would perceive it, very little of this budget is directed at actual "clean-up" (i.e., the proactive components of remediation and restoration, decontamination and decommissioning); the bulk of funds are spent on "waste management," or simply maintaining the status quo. For example, at Hanford, fully two-thirds of the dollars now spent go simply to monitor and maintain existing conditions (or confirm that they are growing worse) at tank farms, in contaminated facilities, and to store hazardous wastes, and nothing more. Another 20% goes directly for "overhead;" additional major indirect costs that further inflate this figure are hidden throughout each program's budget. *If progress in achieving "clean-up" is ever to occur, a fundamental change in thinking, goals, and decision-making frameworks is desperately required.*

1) The Need for a Proactive On-the-Ground Commitment

"Clean-up" of DOE sites has come under increasing scrutiny by tribes, the public, and Congress because considerable expenditures of public funds over the past five years have resulted in little apparent accomplishment of outlined goals. Outside of DOE, there is widespread support for proactive remedial and restoration *actions*: remove or stabilize existing wastes and contamination, stop discharges into the Columbia River, pump-and-treat contaminated groundwater, stabilize tank wastes and spent fuel, remove or reuse outmoded facilities, etc. To most of Hanford's "stakeholders" and to most individuals of whatever community, these types of *actions* are what most people think of as "clean-up."

It's not that enough money is not available, it's more a lack of proactive commitment and focus to actually conduct meaningful "clean-up" in the field and not just maintain the status quo.

Prioritization alone is not enough. The basic problem has been a refusal to act. Endless discussions at DOE center on ancillary issues, having all the answers before beginning, waiting for better/cheaper technology, residual risk and clean-up standards, duplicative monitoring, and a focus on the letter but not spirit of regulatory requirements. *These distractions have in common that they are all forms of delay or doing nothing.* Together they have led to a remarkable lack of action in the field to actually reduce or eliminate those very real risks that are affecting both human and ecological communities every day.

Risk evaluation or prioritization cannot become yet another excuse for rationalizing still further delays or doing nothing, for continuing to stall meaningful actions while contamination spreads, for failing to develop values-based remedial designs, or for refusing to accept responsibility for tough decisions that lead to action. It is especially critical that, in an era of budgetary constraints, limited resources must target meaningful actions and focused data collection that directly reduce current and future risks to humans and other communities, not just continued monitoring. The longer we wait, the more complex, difficult, costly, and widespread problems will become. Fences (or other institutional controls) alone cannot mitigate these threats, either now or in the future.

2) Impacts of Proposed Budget Reductions for Cost-Effective Risk Reduction

Proposed EM budget reductions over the next several years have been self-imposed at the DOE-Headquarters level in an attempt to avoid perhaps a less selective Congressional budget axe. Currently proposed major cutbacks for FY 1996 and 1997 mean that available funds will be inadequate to meet scheduled TPA milestones, which constitute legally binding commitments on the federal government. The focus of proposed cuts would appear to bring virtually all meaningful field remediation efforts, such as groundwater pump-and-treat programs, to a grinding halt. To make matters worse in the eyes of tribes, the public, regulators, and stakeholders, the Environmental Restoration Program appears to be the disproportionate focal point of cuts year after year. Moreover, expensive new production activities that are now being proposed cannot take precedence, and must not be permitted at the expense of "cleaning up" the legacy of past weapons production activities. DOE appears to be deliberately setting itself up to fail in the eyes of tribes, the public, and Congress when it proposes the largest cutbacks in just those areas that demonstrate the most visible on-the-ground action and have the greatest popular support to accomplish what most people would consider "clean-up."

DOE appears to be heading down the same road to failure because, in its panic to address both real and feared budget cutbacks, it has retreated into its former (?) secretive habits and failed to seek the support and involvement of its "constituents." By not involving its constituents, their values, and interests in the hard decisions to be made, DOE is bound to repeat its past mistakes and fail once again. For example, groundwater pump-and-treatment programs have received widespread support from a diverse group of interests because they are proven to be highly effective and meaningfully contribute to removing, reducing, or controlling further contaminant migration--both at Hanford and elsewhere. Few other "clean-up" programs share such a high degree of popular support and demonstrated field success. Specifically, one groundwater pump-and-treat project addressing carbon tetrachloride contamination in the Hanford 200 Areas has been enormously successful.[28] But DOE and especially its contractors have been disturbingly quiet about this unabashed success story--perhaps because they then might be expected to implement such programs more widely.

Contractors must not be allowed to control and further stall meaningful progress out of simple self-interest and greed. It is not unusual for contractors to stall or oppose implementing an agreed upon approach in order to simply perpetuate and institutionalize the incoming federal dollars. The increasing proliferation of contractors (and contractor employees) at the Hanford site has greatly compounded already exacerbated communications problems and work efficiency. Moreover, having too many contractors also has facilitated an "empire-building" mentality consisting largely of petty turf battles. Many program managers appear to have lost all sight of the overall purpose and direction of "clean-up" in their narrowly focused zeal to control programs, staff, workscope, and ever more dollars. Unfortunately, contractors often contribute more to Hanford's problems than to its desperately needed solutions.

Those who only question what is done without simultaneously asking how it is done miss the point. Over a year ago, the Hanford Federal Facility Compliance Agreement was amended to include a Cost and Management Efficiency Initiative geared to result in a savings of $1 *billion* at Hanford alone over the next five years. Yet DOE and its contractors appear to have done little to actually implement this desirable program, to actually eliminate top-heavy management, excessive overhead and indirect costs, bureaucratic inefficiency, excessive and redundant oversight, focus employee activities, and to actually get the dollars focused into on-the-ground actions--such as Hanford groundwater pump-and-treat projects. To our knowledge, few if any measures of success have been developed for this effort, and no attempts to solicit values, involve outside interests, and to develop an overarching philosophy for improvement have yet been made.

Similarly promising efforts such as the Schedule Optimization Study (1992) and the Project Performance Improvement Plan (1994)--studies specifically commissioned by DOE--also have faded into oblivion, once the initial fanfare and excitement has dissipated. These forums directly address true obstacles to "clean-up" progress, but their recommendations are consistently ignored by DOE managers who are much more a part of the problem than the solution. Rather than let themselves be blamed, attention is diverted from the crux of the problem. For example, many now call for scrapping the TPA, because "it" can be blamed as the source of delays and excessive costs. This diversionary tactic is their first choice, *even though DOE has made few good faith efforts up to this point to live up to the agreements it signed*, which were negotiated in good faith. Another DOE strategy has been to reduce, postpone, or eliminate workscope and staff in the field, but not in the managers' offices. What does this portend for DOE's already tarnished credibility and trustworthiness in the eyes of tribes, the public, or Congress?

3) Action in the Field, Not the Halls of Congress, Is Required

Action in the field will not be accomplished without action in Congress.

Enough is known now about the most urgent and severe Hanford risks and conditions to begin meaningful action in the field. More data or information is always desirable and in fact must be collected in order to better understand and comprehensively characterize the full scope of Hanford risks sitewide and support their prioritization for resolution. But there are many things that can be done immediately to move ahead with "clean-up" in the field.[29] Use the lessons learned along the way to adjust and make necessary improvements; valuable data and new insights will result. *The key point now is to start.* Make major management and decision-making framework changes, involve affected communities in all aspects of decisions and programs, refocus programs to accomplish timely, good faith results in the field, etc.

"Changing the rules" by legislating "clean-up" approaches or remedial standards without sustained, effective, and comprehensive "clean-up" of the nation's Cold War legacy in the field will only lead to further, magnified, and more widespread problems in the future. While creating "national sacrifice zones" apparently can be rationalized by some as cost-effective in the short-term, this short-sighted approach will necessarily result in proportionally much greater public health, environmental, and societal costs over the full period of *many thousands of years* that such risks will persist, grow, and spread. This legacy, imposed upon tribal and other communities without their knowledge or consent, appears to be rooted in a profound belief that science can be legislated, that both legal and moral considerations can be dismissed if they're inconvenient, and that federal government commitments can remain unfulfilled.

V. CONCLUDING OBSERVATIONS

Cost-risk-benefit analyses will increasingly be used to support budget allocation, prioritization, and remedial standards. Because of the unforgiving potential consequences of poor or politically expedient decisions, it is more important than ever to improve and better integrate risk assessment, risk management, and decision analysis tools to fit the data needs, public desires, and federal government responsibilities. Within any particular decision context, it is imperative to maintain a consistency of philosophy and a clear understanding of the information needs (breadth, precision, and uncertainty) at different decision levels. Furthermore, this participatory democratic process should be driven by values-based goals, and supported by the most appropriate and defensible tools chosen specifically to accomplish the identified goals.

- Equal access to a shared decision process is often lacking. Full tribal/public participation should influence all stages of the process, from scoping, to values identification, to information requirements, to the final decision.
- The process must *begin* with statements of values, principles, and decision criteria, rather than simply with narrow technical problem statements. Values are system requirements, not just opinions or preferences that can be "addressed" later.

A. The Lessons of Piecemeal Environmental Management

The current lack of an integrated environmental management policy based on comprehensive and clearly stated principles and objectives, either at Hanford specifically or throughout the DOE complex in general, has resulted in a long and frustrating history of poor decisions, lost time, and inestimatable sums of wasted public dollars. Constant internal reorganizations and perpetually high staff turnover at DOE effectively prevent learning from either past mistakes or successes. For example, the following recent failures from Hanford illustrate the dire need for an overarching vision and consistency of purpose, a more sound integration of technical, institutional, and cultural perspectives, a more sound and open intergovernmental decision process, and a solid base of information to begin with.

- N-Springs barrier (failed to address cultural sensitivity and overlooked technical feasibility issues in rush to act),
- Waste entombment in grout (did not satisfy health and retrievability requirements and failed to involve and meet public/tribal acceptance),
- EMSL siting and resiting (ignored cultural resource protection concerns voiced by both tribes and DOE's own contractor),
- Proposal to quarry rip-rap or barrier material from sacred sites such as Gable Mountain (failure to consider affected tribal community/spiritual values and long-term, cumulative environmental impacts to on- or offsite quarry sites),
- Aesthetic degradation of Gable Mountain from proposed nearby SMES siting (failure to consider affected tribal community/spiritual values),
- Location of ERDF within prime sage-steppe habitat (decision made without tribal/ public/natural resource trustee input, considering long-term environmental impacts, or habitat mitigation requirements),
- Deficiencies of simple surface barriers for long-term environmental and value protection (failure to provide long-term protectiveness, indirect and cumulative impacts of mining vast amounts of hard rock and cover soils from external sites),
- Proposal to renege on 300 Process Trenches ROD (original agreement to remove wastes now deemed "too hazardous" to workers), and
- Claim to have "cleaned up" 45% of the Hanford site (a highly deceptive public relations campaign because only an infinitesimal fraction of 1% of contamination--none radioactive--was involved, and restoration of disturbed areas is highly limited).

B. The Strength of Integrated/Holistic Environmental Management

On the other hand, defensible and widely acceptable decisions are much harder to enumerate. Where they exist, each has in common components of the broader integrated environmental management philosophy described herein, which depend upon a more effective and substantive tribal/public involvement in values identification and multiple phases of decision making, and a more solid, if still incomplete, information base. The examples below owe their success to an overarching vision that reflects widely accepted values and a consistency of purpose--elements that are blatantly missing from any of the above failures.

- Recently completed Environmental Restoration Program Refocusing amendments to Hanford Tri-Party Agreement (which DOE balked at signing for months),
- Some Facility Transition planning, and
- The identified "Path Forward" for spent fuel in the K-basins.

In fact, the development of clearly defined principles, goals, and decision criteria and a single sitewide engineering design basis which directly incorporates values, expectations, interests, and rights will be essential to provide the holistic framework necessary for both technically defensible and politically acceptable decisions. This process must include the fundamental establishment of a comprehensive and effective intergovernmental process built together with tribal sovereigns, and not just in response to them.

C. Returning to Congress' Mandate

The success of DOE's environmental management program overall and the permanence of decisions that result ultimately will require a much stronger information base than now exists. Effective prioritization of activities can only occur with sufficient information, which will also provide a baseline against which risk reduction progress can be measured in terms of both health-effectiveness and cost-effectiveness, and for which cost-risk-health goals can be developed. Credibility, however, will depend upon developing clear and focused data objectives and will require an open process that facilitates the equal participation of affected communities and a comprehensive inclusion and evaluation of all major issues of concern. Current data quality ranges from zero to subjective to (occasionally) relative and (rarely) qualitative or quantitative. *Because of a long history of successful and sustainable environmental management, tribes would appear to be one of the few sources of sound technical and policy guidance on what information is needed for various decision contexts and how to collect it cost-effectively.*

- What is the relation between compliance agreement requirements and actual environment, health, and safety effectiveness?
- Under what circumstances is a life-cycle/cost-risk approach needed, when will a budget-based approach suffice, and when must cultural values predominate?

In returning to these original questions that Congress sought answers to, it is imperative to note that credible cost-risk-benefit analyses cannot take place until a more comprehensive and defensible risk picture begins to develop. This will require the integration of both a sufficient information base and the values of affected communities. This critical point appears to be recognized by both Departmental and Congressional leaders, *but now must result in actions being implemented to provide the necessary scope of information together with the necessary* *process that facilitates involvement of affected communities.* Only then can the questions Congress has asked be adequately, comprehensively, credibly, and defensibly addressed.

Notes

1. The term *"clean-up"* constitutes one of the most overused and abused terms associated with DOE's new environmental restoration mission at many of its sites. Although this term is often used as shorthand for a variety of activities, its overuse has led to a loss in any real meaning and in fact its use frequently obscures the true nature of actions taking place. In this report, the term *"clean-up"* is used only in a general sense to convey an overall image. Specific actions are referred to by the appropriate term, such as environmentally sound waste management, environmental remediation, or environmental restoration. Although more cumbersome, these terms more accurately and correctly describe the specific nature of actions being undertaken.

2. For the purposes of this report, *'risk'* may be defined as the likelihood of adverse consequences from an action or condition. Quantitative risk assessments tend to substitute the term 'probability' for 'likelihood,' with the implication of greater mathematical rigor and precision.

3. Risk analyses may encompass a wide variety of techniques and approaches. Approaches may produce either quantitative (numerical, probabilistic) results, or result in qualitative rankings such as high, medium, or low levels of risk. Types of analyses commonly in use include, but are not limited to: quantitative risk assessment, comparative risk assessment, qualitative risk assessment, values-based evaluation, alternatives assessment, worst-case scenarios, fault-tree analyses, and other techniques.

4. At first glance, risk assessment appears to offer a number of distinct advantages. In remedial decision-making, for example, a number of potential benefits have been recognized.

- Risk assessment helps in *ranking* the relative importance of individual contributions to overall risk.
- Risk assessment helps to *identify risks that are easily reduced or eliminated*.
- Risk assessment can provide an objective [?] *basis for decisions* on controlling or managing risks.
- Risk assessment can provide important quantitative information as input to decisions for *allocating resources* to remediate sites.
- Risk assessment makes it possible to *rank remedial alternatives* in terms of risk to workers, the environment, and the public.
- Perhaps most important, risk assessment can provide a *process for consensus* and a *forum for the participation of stakeholders* in the development of the risk assessment process and the identification of important social, cultural, and tribal values in the selection of factors to be assessed and remediation alternatives to be analyzed. This process will hopefully lead to greater acceptance of the eventual result of that remediation as well as provide insights as to how to reduce public health impact during and after remediation. [emphasis added]

from *Building Consensus*, p. 13-14.

5. President Clinton issued Executive Order 12898, "Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations," on February 11, 1994. "The purpose of this Order is to underscore certain provisions of existing laws that can help ensure that all communities and persons across the nation live in a safe and healthful environment." The cover letter to the Order further states that "[e]ach Federal agency shall analyze the environmental effects, including human health, economic and social effects, of Federal actions, including effects on minority communities and low-income communities, when such analysis is required

by the National Environmental Policy Act of 1969 (NEPA). . ." Among the requirements in this Order is the identification of differential patterns of consumption of natural resources, and considerations of environmental and human health risks as well as social and economic impacts.

6. *Closing the Circle on the Splitting of the Atom, The Environmental Legacy of Nuclear Weapons Production in the United States and What the Department of Energy is Doing About It*: U.S. Department of Energy, Office of Environmental Management, January 1995, p. 9.

7. *Closing the Circle*, and *Environmental Management 1995*: U.S. Department of Energy, Office of Environmental Management, February 1995.

8. *Closing the Circle.*

9. See supplemental documentation in Appendix F.

10. E.g., the Comprehensive Environmental Response, Compensation and Liability Act, "CERCLA or 'Superfund'," 42 U.S.C. § 9601 et seq., the Emergency Planning and Community Right-to-Know Act "EPCRA," 42 U.S.C. § 11001 et seq., and the Resource Conservation and Recovery Act, 42 U.S.C. 6901§ et seq.

11. Forcing ATSDR to more meaningfully fulfill its CERCLA mandate would be a step in the right direction. Few of its current efforts have anything to do with understanding or assessing impacts to communities and their health, either presently or in the future.

12. See Appendix C.

13. The term *'ecocultural landscape'* refers to a combination of "landscape ecology" plus the term "cultural landscape," as used by the U.S. Forest Service. It is intended to convey a more all-inclusive ecosystem concept in which humans and their values are an integral part of the whole system and not separate from it.

14. The crisis created by DOE contractors unearthing American Indian cultural artifacts during site grading operations for the Environmental and Molecular Sciences Laboratory (EMSL) in April 1994 is a case in point. Following release of the initial Environmental Assessment for siting EMSL in 1992, the CTUIR submitted comments emphasizing the high potential for cultural artifacts being present along this river margin bluff site. Similar reservations also were expressed by cultural resources staff of DOE's own contractor, the Pacific Northwest Laboratory (PNL). These concerns were ignored. Instead, the favored river view site was chosen in spite of voiced concerns and the availability of two less risky siting options. After artifacts were discovered on the second day of site activities, the process came to a screeching halt while restoration activities began. After several months delay, the building was resited to one of the original alternative locations. This fiasco unnecessarily cost the U.S. taxpayers between S3 and 8 million, solely because DOE failed to listen to legitimate and widely expressed concerns.

15. See Section IV, Subsection C, Toward Integrated/Holistic Environmental Management, and Appendix I.

16. Slovic, Paul, 1987, Perception of risk: Science, v. 236, p. 281-283.

17. See Slovic, Paul, 1987, Perception of Risk: *Science*, v. 236, Figure 1, p. 282.

18. Slovic, Paul, 1987, Perception of risk: *Science*, v. 236, p. 282.

19. These ideas, which are further expanded upon within this note, are largely adapted from Slovic, Paul, 1987, Perception of risk: *Science*, v. 236, p. 280-285.

This is particularly the case with rapidly evolving chemical and nuclear technology issues and the impacts these technologies increasingly have on modern society and the environment--technologies that are unfamiliar and incomprehensible to most people. Harmful consequences may be rare or delayed, hence difficult to quantify or statistically analyze. Such consequences, however, often may be catastrophic, long-lasting, involuntary, not easily reduced, have fatal consequences, appear uncontrollable, pose a high or increasing risk to future generations, and receive much public attention (see Figure following Appendix G). Events like the 1986 Chernobyl meltdown in the former Soviet Union, the 1985 Bhopal chemical release accident in India, or the 1979 accident at the Three-Mile Island nuclear plant in the northeastern United States fit this category.

Such events have been interpreted as "signals" by some researchers that "effort and expense beyond that indicated by a [conventional] cost-benefit analysis might be warranted to reduce the possibility of 'high-signal accidents.'" *Events involving nuclear weapons (war), nuclear weapons fallout, nuclear reactor accidents, and radioactive waste all are specifically identified as "particularly likely to have the potential to produce large ripples. As a result, risk analyses involving these hazards need to be made sensitive to these possible higher order impacts."*

"In short, 'riskiness' means more to people than 'expected number of fatalities.' Attempts to characterize, compare, and regulate risks must be sensitive to this broader conception of risk. . . . [T]here is wisdom as well as error in public attitudes and perceptions. Lay people sometimes lack certain information about hazards. *However, their basic conceptualization of risk is much richer than that of experts and reflects legitimate concerns that are typically omitted from expert risk assessments.* As a result, risk communication and risk management efforts are destined to fail unless they are structured as a two-way process. Each side, expert and public, has something valid to contribute. Each side must respect the insights and intelligence of the other." [emphasis added]

20. Refer to Endnote 4, above.

21. *Report of the Blacksburg Forum: The First Step Toward the Holistic Approach to Environmental Management*: Management Systems Laboratory, Virginia Polytechnic Institute and State University, Blacksburg, VA, 1991, p. 19-20.

22. *Building Consensus Through Risk Assessment and Management of the Department of Energy's Environmental Remediation Program*: National Research Council, Committee to Review Risk Management in the DOE's Environmental Remediation Program: National Academy Press, Washington, D.C., 1994, p. 21.

23. *Building Consensus*, p. 23.

24. The term *'stakeholder'* is commonly used to encompass all 'interested and affected parties' that may be impacted by a particular action or proposed action. A catch-all term, it often indiscriminantly lumps together state and local governments, public interest groups, business and labor interests, environmental groups, and others, in addition to sovereign tribal nations. But not all 'stakeholders' are created equal. Tribal nations comprise a unique legal entity whose rights, interests, and responsibilities are both distinct from and superior to those of state and local governmental interests and any public interest groups. Tribal sovereignty is formally recognized and protected in treaties signed with the United States government, in which tribes specifically reserved rights to utilize lands and resources and to perform traditional activities as they have for thousands of years. Moreover, the treaties also imposed a trust responsibility upon the U.S. government to protect and preserve those lands and resources upon which tribes depend for subsistence or other cultural activities. Furthermore, Columbia Plateau tribes are unusual

among many tribal nations in that their treaties specifically provide off-reservation treaty rights and guarantee access to resources throughout the lands ceded to the United States in the treaties and throughout all other usual and accustomed locations. The sovereignty of tribal nations also requires the U.S. government to establish formal government-to-government relations and to proactively consult with tribes concerning any proposed federal action or program that may affect the interests of tribes, as mandated in the DOE Indian Policy. Tribes are also designated as Natural Resource Trustees under CERCLA, and thus must be formally consulted in the planning, management, and execution of any "clean-up" programs developed under CERCLA that may impact their sovereignty, treaty-reserved rights, lands, natural and cultural resources, or other interests. *No other entities commonly considered 'stakeholders' share these unique and distinct rights and privileges.* This point is a consistent source of confusion among many state and federal agencies and elements of the public, especially outside the Pacific Northwest where such conditions are rare. Hence, tribes should always be separately identified and their unique rights and interests formally acknowledged.

25. *Building Consensus*, p. 36-37.

26. *Building Consensus*, p. 37-38.

27. *Building Consensus*, p. 24, 26.

28. It is especially interesting to note that any quantitative risk assessment conducted to define the current risk posed by carbon tetrachloride contamination in the 200 Areas would show that the current risk is far below regulatory thresholds that normally would trigger a response action. Thus, such a result would more typically be used to support non-action at the site because there are not now viable exposure pathways to humans or the accessible environment, in the absence of considering this groundwater as a drinking water source. This narrow view, of course, totally ignores any future threat posed when existing contamination migrates and begins to discharge into the Columbia River at concentrations far above permissible standards, as shown in modeling results. Furthermore, this unique scenario clearly emphasizes how risk assessments may or may not be used for political reasons or in response to public concerns. In this case, social values and qualitative concerns about the potential future impacts of this known carcinogen and its inevitable discharge into the Columbia River vastly outweigh the strictly quantitative assessment which in and of itself would show that only a 'negligible' risk is now present.

29. Refer to Section III, Sub-section B, and Appendix G.

APPENDIX A

DOE's RISK REPORT TO CONGRESS

APPENDIX A

DOE's RISK REPORT TO CONGRESS

Several different Committees of both houses of the United States Congress and various offices within the U.S. Department of Energy are examining standardized use of risk-based remedial decision-making to prioritize, and presumably allocate budgets for, "clean-up" of DOE nuclear production sites across the nation.

A. Congressional Mandate

Congress passed Public Law 103-126, the National Defense Authorization Act, on October 28, 1993, in which *". . . the Department [of Energy] is directed to review [federal facility] compliance agreements and to submit by June 30, 1995 a report to the Committees on Appropriations evaluating risks to the public health and safety posed by conditions at weapons complex facilities that are addressed by compliance agreement requirements."*[1]

Based on a recommendation of the Conference Committee report on the FY94 Energy and Water Development Appropriation, *"the objective for this report was for the Department to provide information and evaluation to support the eventual development of a mechanism for establishing priorities among competing cleanup requirements in light of limited Federal discretionary budgets."* The conference report emphasized that "these efforts should be done without performing exhaustive, formal risk assessments of the thousands of cleanup activities addressed in compliance agreements." Rather, the review should constitute a qualitative "estimate of the risk addressed by the requirements based on the *best scientific evidence available*." [emphasis added]

B. Department of Energy (DOE) Responses

1) Background

In November 1993,[2] Assistant Secretary Grumbly announced DOE's intent to develop *"a credible risk evaluation program which will support the Department's EM mission"* within two years. "Good risk management, which cannot happen without good risk assessment, is critical to program success," Grumbly observed.

He identified *"credible risk evaluation"* as key to DOE success in:

- Protection of public health, safety, and the environment,
- Becoming technological world leaders in environmental restoration, and
- Establishing DOE as outstanding stewards of public resources.

Mr. Grumbly fully recognized the inherent difficulties and limitations associated with conventional risk assessment when he asked, *"Should 'risk' be defined only by a set of numbers, or are there qualitative values that need to be factored in?"* He stated that the following closely related issues must be addressed:

1) "We obviously need some meaningful quantitative data, but we need to remember who our customers are--the public--and not get lost in debates over numbers that keep us from seeing the forest for the trees.
2) "We need to balance the concerns of the public health community, which is concerned with the results of and threats from past events and their consequences, and the risk assessment community, which tends to focus more on current and future problems.
3) "We need to remember that there are more than just technical problems to consider in risk assessment. *We have to address hard institutional and political problems too.* [emphasis added]
4) "Who does risk assessment matters."

Mr. Grumbly concluded, "We must have assessments that are acceptable to the scientific and public health communities and the affected public--that's the only thing we will accept, nothing less."

2) Current Tools DOE is Using to Prepare Its Report to Congress

In the past, DOE has employed a number of different tools to prioritize its funding allocations, only some of which have focused directly on risk.[3] Few, if any, of these methods have withstood the test of time, largely because they do not truly and comprehensively address legitimate concerns about funding being directed specifically at problem resolution in the field, the full scope of risks presented by DOE facilities, or tribal/public issues, values, and the direct involvement of affected communities.

Currently, DOE is adopting several different, and in some cases, independent mechanisms to utilize in preparing a report to Congress (tentatively titled "Risks and the Risk Debate: Searching for Common Ground"). This report will outline DOE's approach to identifying, characterizing, and prioritizing risks and developing risk-based decision mechanisms for addressing tribal, public, and environmental health and safety concerns posed by DOE sites across the nation.

At least three independent (?) efforts are now ongoing in support of the preparation of DOE's report to Congress. Two of these are occurring within the Department of Energy: the Consortium for Environmental Risk Evaluation (CERE) report and the Baseline Environmental Management Report (BEMR). DOE also is conducting another internal review known as the EM Qualitative Risk Initiative, or Risk Data Sheet (RDS) activity; the nature, scope, and results of this late effort are not known to CTUIR staff. An external report is being coordinated by Steve Blush, former DOE staffer, at the request of the Senate Energy and Natural Resources Committee. The Blush report also is examining risks and costs associated with "clean-up" of DOE sites, with particular focus on Hanford. The degree of coordination between these efforts is unclear.

Unfortunately, none of these reports for were available to CTUIR staff prior completion of our report,[4] with the exception of a draft of the CERE evaluation. An initial evaluation of the proposed methods, however, indicates that none of these efforts is likely to provide the desired information base of sufficient scope, breadth, and comprehensiveness to support an adequate description of the full nature of hazards and risks associated with the nuclear weapons complex. Hence, this report has been prepared to assist DOE is assembling a more comprehensive and truly representative version of the risk puzzle: the more pieces of the puzzle that are available, the better chance we all will have of understanding and seeing the whole picture.

The inferred narrowness of existing approaches and their limited ability to provide a full risk picture are strongly supported by our cursory review of the draft report provided to CTUIR staff by the CERE program. The CERE program purports to assess how well weapons complex risks and "clean-up" costs are understood by conducting a qualitative evaluation of existing quantitative risk assessments at six selected DOE sites now governed by compliance agreements. A distinctly separate part of CERE's program is "cataloging concerns of minority, disadvantaged groups, and disproportionately affected communities" as a means of providing DOE with a "laundry list" of public concerns for consideration in its report to Congress.[5]

Only a draft of the CERE report was publicly available at the time this report is being prepared (March 1995). Unfortunately, the CERE draft made available to CTUIR staff contained no new ideas or evaluation processes, and tended simply to reflect the narrowly focused "panel of experts" approach (yawn) that is, in fact, so much a part of the problem. Furthermore, the CERE approach deliberately fails to consider significant risk elements such as offsite transportation of radioactive, mixed, and hazardous chemical wastes, tribal cultural issues, tribally unique resource use and exposure pathways, a sufficiently broad spectrum of land-use options, multiple and cumulative impacts, and the effects of time, among others. CERE defines an overly broad scope, but then depends on a narrow and selective information base, fails to incorporate values and meaningful tribal/public involvement, and draws broad, sweeping conclusions from highly limited data sets. Thus no credible either sitewide or complex-wide risk evaluations and comprehensive cost-benefit analyses are possible. Additional discussion of CERE program limitations is provided in Appendix D.

DOE also is conducting an internal review of its current Fiscal Year budget commitments in order to assess current resources directed specifically at identifying and characterizing risks, remedial costs, compliance agreement requirements, and benefits. A simple review of current budget commitments, however, will comprise neither a sufficient nor representative measure of true risks through time, acute and chronic health impacts, life-cycle costs, short- and long-term benefits, and compliance agreement requirements. Budgets and the priorities they fund are the bedraggled by-product of multiple political compromises. They still require the application of judgement and values. The question is *whose* values will govern the decision making process.

This report intends to broaden the "clean-up" debate to include a *full scope of pertinent risks and costs*, many of which are now effectively ignored by the more narrowly defined approaches DOE is employing, or has employed in the past. *The chief failure of the current DOE decision-making framework is that it is dominated by the institutional values of DOE managers and policy makers alone. It does not reflect the breadth and comprehensive perspective required to build either credible technical evaluations or achievable risk management and remedial decisions that share widespread popular support.* Our report focuses attention on major critical issues now not being considered or that are even being undermined in the dynamic risk debate. By including such issues, DOE can create a more inclusive and responsive framework that will satisfy valid Congressional concerns that budgeted funds must be directed at efficiently and effectively solving real problems and permit DOE to both embrace and proactively accomplish its new mission. Most importantly, only through adopting such a reform will DOE be able to meaningfully protect affected communities from the real risks they face, both now and in the future.

Notes

1. The following material is excerpted from *"Fact Sheet: June 1995 Report to Congress,"* Draft, July 13, 1994, obtained from CERE, February 14, 1995.

2. *"Working Toward Meaningful Risk Evaluation,"* speech by Thomas Grumbly at National Research Council Workshop to Review Risk Management in the Department of Energy's Environmental Management Program, National Academy of Science, Washington, D.C., November 3, 1993.

3. Examples of some of these include the RASS (Resource Allocation Support System), the Project Management System (DOE Order 4700.1), and the current PPG (Project Planning Priority Grid). It is critical to note that each of these systems, along with others, depend solely on the values, biases, and judgement process of DOE managers, and not DOE "constituents." Moreover, some approaches, such as RASS, fail to integrate budget priorities across DOE programs, overcome deeply entrenched institutional barriers, and are based only on narrowly framed or selective evaluation and weighting criteria and a judgement process based solely on institutional requirements. Hence, these highly limited approaches typically focus on analytical/numerical approaches that fail to address concerns and values of affected communities.

4. A copy of the Blush report, *Train Wreck along the River of Money, An Evaluation of the Hanford Cleanup*, by Steven M. Blush and Thomas H. Heitman, was received by CTUIR staff only a couple of days prior to completion of this report. Hence, sufficient time was not available for an adequate review.

5. This CERE program overview based on *Tulane/Xavier CERE Program Qualitative Risk Evaluation Fact Sheet*, December 6, 1994.

APPENDIX B

SAMPLES OF CTUIR CONCERNS ABOUT LIMITATIONS OF CONVENTIONAL RISK ASSESSMENT METHODOLOGY

APPENDIX B

A LIMITED SAMPLE OF CONCERNS OF THE CONFEDERATED TRIBES OF THE UMATILLA INDIAN RESERVATION COMMUNITY ON USING AN APPROPRIATELY DEFINED RISK ASSESSMENT MODEL

by Stuart Gerald Harris, Natural Resource Specialist, CTUIR Hanford Program;
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INTRODUCTION

The Umatilla Indian Reservation located near Pendleton, Oregon is occupied by descendants of three Columbia Plateau Tribes, the Cayuse, the Walla Walla, and the Umatilla (Tribes). The Tribal Government is referred to as the Confederated Tribes of the Umatilla Indian Reservation (CTUIR). As a full service government, the CTUIR Board of Trustees (BOT), makes the decisions on providing detailed information regarding culturally sensitive information.

Under these Tribes' Treaty of 1855 [12 Stat. 945], the Tribes ceded lands to the United States. The lands comprising the eastern portion of the U. S. Department of Energy's (DOE) Hanford Site is among the lands ceded by the Tribes. Under the treaty the Tribes retained rights to perform many activities on those lands, including but not limited to fishing, hunting, gathering roots, berries, and pasturing livestock.

Long standing U.S. Supreme Court precedent holds that the federal government (including its executive agencies) has a trust responsibility to Indian Tribes. This means that the U.S. has a fiduciary responsibility to protect the rights of Indian tribes, including tribes' property and treaty rights. Additionally, a succession of U.S. Presidents beginning with President Nixon, have affirmed a federal policy of upholding tribal sovereignty and dealing with tribal governments on a "government to government" basis. Furthermore, there are federal laws to protect tribes' cultural, religious, and archeological sites, access to, and exclusive use, of those sites, and of traditions, activities, and practices associated with those sites as well as Hanford as a whole. Finally, environmental laws also confer rights upon the tribes. For example, the CTUIR is a Trustee for Natural Resources under the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA).

CTUIR - AN INTERDEPENDENT CULTURE AND ENVIRONMENT

The CTUIR is a sovereign government, that has legal interest in the natural resources upon which the CTUIR's Treaty rights are based, including lands of the Hanford Site. Effective exercise of these treaty rights depends on the health of the natural resources. The CTUIR does not want the people exercising their treaty rights to be placed at risk.

A risk from nuclear or hazardous waste that potentially affects one person of the CTUIR community may have lasting impacts throughout all of the community. In other words, a wave of risk can ripple outwards affecting all of the individuals in our culture, just like a wave generated and propagated in a tapestry. The unique CTUIR culture can be irrevocably changed or extinguished if enough of the environment and the natural resources on which the CTUIR treaty rights are based are irreparably harmed. Without the natural resources, the cultural values of critical significance to the traditional CTUIR American Indian, and her/his community would be lost. If a culture dies, the only remnant is the material culture. In the event of the unthinkable happening, a continuously sustainable natural resource based material culture, such as the CTUIR would rapidly disperse into the natural environment leaving no trace of the living CTUIR culture.

The people of the CTUIR are a unique culture, that has long been complexly intertwined with the environment through their cultural, familial ties, (e.g., marriage, gender, extended families), and relationships with other tribes. The CTUIR people have enjoyed since time immemorial, many types of native foods and artistically constructed items of material culture (e.g., cookware, clothing, etc.). Individual members are an inextricable part of the environment. These members, their community and the environment are essentially one in the same.

The CTUIR culture, which has co-evolved with nature and through thousands of years of ecological education, has provided its' people with their unique and valid version of holistic environmental management. The traditional CTUIR American Indian is aware from cultural teachings that the appropriate behavior leads to continuous sustainable success in gathering food and material. Traditional education regarding food or raw material gathering practices are passed on from one generation to the next, and is done to ensure food for the next season or generation. The knowledge of the many gathering seasons and areas the traditional CTUIR American Indians get to utilize during the year has been handed down from generation to generation. Some CTUIR families teach cultural knowledge in complete secrecy on the maternal or paternal side of the family/tribal unit in order to protect tribal cultural/spiritual knowledge from exploitation from the non-American Indian societies and governments. Within the traditional lifestyle or culture, it simply is not enough to know that there are supposed to be salmon runs at certain times of the year. To sustain the tribes during the remaining interim periods when salmon are not returning to spawn and other foods are available, there has to be knowledge about other interrelated food chain cycles, gathering techniques, preparation, and cultural/spiritual relationships about what is needed for sustenance. This interdependency of the collective knowledge about the seasonal foods not only affects traditional individuals, but affects the whole tribe as a culture. One person can not be expected to know all things. In practical terms, if a tribe depended on one critical individual, the loss of that one "all knowing" person would effectively end or severely disrupt subsistence existence for the rest of the cultural unit. The same is true of oral tribal history, songs, heritable religious practices and numerous other cultural practices Continuity may depend on specialized knowledge in each generation.

The natural world in the Northern temperate zone operates on a seasonal clock. Traditional American Indians of the CTUIR are influenced by this clock, and expectantly look forward to the next cyclic event. These events include not only birth and death but change in general. Throughout the year, when the CTUIR traditional American Indian participates in activities, (e.g. hunting and gathering for foods, medicines, ceremonial, and/or subsistence), the associated activities are as important as the end product. In the Judeo-Christian tradition, an analogy would be "kosher" dietary practices. In the exercise of these activities, the traditional CTUIR American Indian may cover hundreds of square miles, thousands of feet of relative elevation, and cross numerous types of physiographic provinces. All of the country crossed in the search for food has special meaning to the traditional American Indian and each area demands special effort and behavior. This traditional activity is a key to the hunting of, and gathering of, traditional American Indian foods and culturally significant materials.

All the foods and implements gathered and manufactured by the traditional American Indian are interconnected in at least one, but more often in many ways. For example, trade made up for what could not be physically gathered by one person in one time period. Salmon caught on the Columbia River are often traded for roots, other produce, or material culture. This trade creates a web of interaction and interdependence cutting across families, bands, and tribes. These objects of life are as important to the traditional American Indian as the materials that comprise them.

The people of the CTUIR community follow cultural teachings or lessons brought down through history from the elders. The goal of these teachings is to foster community cohesion and interdependence. Emphasis is placed upon cooperation and helping others in the community, cultivating close community interactions. This is an ancient oral tradition of cultural norms. The material or fabric of this tradition is unique, and is woven into a single tapestry that extends from the past into the future.

RISK ASSESSMENT PATHWAYS

The methodologies used in classical risk assessments are being critically considered by the CTUIR. The classical risk assessment has many deficiencies, including a limited breadth of coverage and lack of integration. Through a pseudo-scientific methodology, the classic risk assessment: 1) ignores time, 2) extrapolates from the lab into the field, 3) contains biotoxicological effects that are not fully understood, 4) ignores multiple pathways and complex contaminants, 5) contains enormous uncertainties, 6) ignores long term impacts, effects to health, environment, workers and society, 7) prejudices future options, 8) loses the big picture by ignoring cumulative effects related to assessing only one chemical/one path/one site assessment at a time, 9) ignores eco-cultural sustainability, and 10) is based on a suburban lifestyle. The holistic environmental management strategies outlined in the *Blacksburg forum*[1] or *Toward the 21st Century: Planning for the Protection of California's Environment*[2] highlight these major problems.

In order to encompass the wide range of factors directly tied to the traditional American Indians of the CTUIR, a risk assessment has to be scaled appropriately. In effect, a re-structuring of the risk assessment process must occur in order to address the overwhelming problems including but not limited to, lack of breadth of coverage, lack of integration and deficiencies related to not addressing the CTUIR traditional American Indians' quality of life, the interrelated eco-culture and their unique exposure parameters and pathways. Other deficiencies include the failure to address the role of time to adequately assess risks to future generations of CTUIR members. The process of American Indian Tribes supplying cultural conversion metrics for risk assessments is, at best, subject to the legislative processes of the various sovereign Tribal governments. Unfortunately for the risk assessor there are few traditional American Indians willing and able to supply the appropriate pathway information, and to say they can speak for any one but themselves. A risk assessor in search of identifying American Indian data gaps has to identify the affected tribe(s) and approach the subject of lifestyles tentatively identified with a potential risk through the proper protocol of the individual tribal government. Until that information is obtained, the results of the classic risk assessment in no way suggest the potential pathways or exposure routes that fall within the breadth, depth, and richness of the CTUIR's culture. Unfortunately, the processes, the approach and even the necessity to account for traditional American Indian lifestyles have gone unnoticed in classical risk assessments that typically focus on suburban lifestyles.

The potential exposure pathways specifically oriented towards the traditional American Indian lifestyles need further identification to ensure protection of the CTUIR and the resources on which CTUIR culture is based. This must be done to provide risk assessors with the most accurate information possible. The principal concerns that affect the CTUIR traditional American Indian relate to a lack of identification of the critical pathways. In addition some risk assessments identify these pathways, "consider" them, and then ignore them, or label them as "insignificant." These multiple potential pathways to exposure are not included in typical suburban exposure pathway model, which has a seriously deficient relationship to the lifestyle of the traditional CTUIR American Indian. Each path stems from unique and multiple uses of the resources for food, ceremonial, cultural, or religious practices. Just as important to the people of the CTUIR are the more intangible considerations such as: aesthetics; physical, economic, community, future well-being, and equity; peace of mind; and sustainability.

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[1] *Report of the Blacksburg Forum: The first Step Toward the Holistic Approach to Environmental Management: Management Systems Laboratory, Virginia Polytechnic Institute and State University, Blacsburg, VA, 1991.*
[2] *Toward the 21st Century: Planning for the Protection of California's Environment, California Comparative Risk Project, Final Report, May 1994.*

A risk assessment covering only mechanistic exposure routes linking a single toxicological component to simple one celled organisms, to mega fauna, then to humans, without accounting for the time involved, does little to express the complexity of the interrelationships between the traditional American Indian, their lifestyles, their relationship with the earth and the natural resources. Anyone attempting to derive and plot on a chart the life cycles of all the native plants, animals, as well as the methods of storage, preparation, and all the unique interrelationships that stem from the area of concern, in order to deduce the complete functional pathways for exposure, will find that the process is probably beyond our capabilities and is expensive. Charting whole ecosystems is certainty not in the realm of this paper, moreover, the thought of placing a value on each and every organism for the purposes of producing a number, does not convey what is a traditional American Indian entity. Even if a number could be produced, this does not take into account the traditional American Indian values, let alone uptake rates, absorption rates, mutation rates, bioaccumulation rates, and other food chain data needed to make a decision on what is important and what may affect the CTUIR traditional American Indian.

There are some common food plants such as the common cattail, the tule, the willow, and the nettle, that serve dual or more purposes. These could be considered by risk assessors, if nothing less than to point out the enormous data gaps involved. The traditional tribal communities often constitute critical segments of populations whose cultural lifestyles result in disproportionately greater than average exposure potential. Gathering, cleaning, eating, and using these plants may potentially expose many traditional American Indians multiple times, and may subject critical CTUIR population groups to unneeded exposure. The life of the cultural items made from potentially contaminated plants may last years; exposure may occur daily or more, over multiple generations.

Traditional American Indians of the CTUIR have to bear a disproportionate amount of risk in relation to the longevity of radionuclide contaminated groundwater. Take, for example, the common cattail: in the spring the shoots are eaten, the roots are consumed, and the fibrous stalks and leaves are split, woven or twisted. Later in the year the pollen is used in breads, and the stalks are used. The woven products may include food storage bags, food storage baskets, cook hole layers, cooking baskets, mats for the floor, mats for the sweat lodge, or mats for the funerary. Each of these activities necessitates a behavior pattern that encompasses: traveling to the plants, selection, gathering, sorting, cleaning, stripping, peeling, splitting, chewing, and forming of the plant materials. This is just for one type of plant among the hundreds of plants and animals that are used by traditional CTUIR American Indians.

CRITICAL SUB-POPULATIONS OF THE CTUIR

Even during the quest for some food, a typical CTUIR member may potentially be exposed through a variety of pathways. The riverbank walk towards the spring where the plant of interest grows may contain discreet particles of radioactive material, such as Co^{60}. This affects certain subgroups within the CTUIR population more than expected, such as the women and the children. The classic risk assessment focuses on a healthy suburban male of average mass. In comparison the women and children as a result of their smaller mass and shorter stature will receive a higher dose[3]. The mud surrounding some Hanford springs may potentially contain Cr [+6], Sr^{90}, or H^3.

During the assessment of the quality of the plants (i.e., which ones to select for gathering), a process that demands time standing in spring water, or in spring water saturated mud, could result in absorption of H^3 through the skin[4]. The women and children, due to their physical characteristics and their culture, may receive greater exposure. Children in particular may be at much higer risk of radionuclide contamination of the environment than adults. Children have a much shorter stature and less body mass than adults, meaning that they have less natural shielding and are closer to source materials.

The gathering process involves not only continued immersion in the spring water, but immersing the hands and compacting mud under and around the fingernails as well. Sorting the plants afterwards, either at the site or elsewhere involves more handling and washing. The bulbs or root of the food plant may have special cleaning needs. Roots may not be uniformly smooth as carrots or potatoes but undulated, having places where the earth can not be washed out, and if eaten, creates an ingestion pathway for potential exposure. The skin of the root may need to be peeled. Peeling roots is a difficult and time consuming chore involving not only the hands but in many cases a knife and the teeth. Splitting the leaves involves a lot of handling and the experience comes with cuts and abrasions, and more soil accumulation under the nails. If the food is to be eaten and not stored, another potential pathway for contamination is revealed through traditional cooking methods. Local rocks are gathered and heated with local wood. A hole is dug. The heated rocks are dumped in the hole. The rocks are covered with the cattail leaves. The cleaned, peeled, roots are placed on the leaves, and covered with more leaves. This is covered with soil, and a fire is built over the covered cook pit. The result is tasty, but in certain places this type of unique cultural activity could increase exposure. Thus, traditional CTUIR American Indians can be exposed to radionuclides through digging, breathing smoke, breathing dust, breathing steam, eating dust and soil, storing vegetables underground, and eating steamed vegetables.

This risk scenario is but one of many that can be played out for one food, at one site, during one time of the year. The complexities involved with hunting and gathering foods are extremely time consuming and involve at a very primary level many traditional American Indians and the environment. Other significant factors include higher intake rates per body mass for children than adults, the fact that primary gathers are likely to be women of childbearing age, variations

[3] *U.S. Environmental Protection Agency. 1993. External Exposure To Radionuclides In Air, Water, And Soil. Federal Guidance Report No. 12. September 1993. EPA 402-R-93-081*

[4] *Ohtake, H., Silver S. 1994. Bacterial Detoxification of Toxic Chromate. Biological Degradation and Remediation of Toxic Chemicals. Ed. G. R. Chaudhry. Portland, Oregon: Dioscorides Press 403-415*

in metabolic parameters, and increased risk to CTUIR elders with age-dependent decreased physiological resistance or underlying health problems. Because the CTUIR is unique, risk assessors must realize and accept that the threat to the whole living CTUIR culture begins with two reasons for increased risk: increased exposure and increased sensitivity

"The Columbia River continues to be very important to the traditional American Indians that live around it. The river provides a link to the past and a path [for] the future of their children. Understanding the ecosystem and how the traditional American Indian is associated with it is critical for these people and their survival. The health of the river is dependent on the health of the groundwater; the peoples' health is dependent on the river and all that comes from it." (Harris, 1994)

The need for understanding the pathways that directly involve the traditional American Indian cannot be understated. The ties to the environment are much more fixed than is currently understood. These ties will play a very important role in determining how risk assessment methodology is produced and how effective risk management will be. The issues of environmental racism, environmental justice, and the right to a healthy environment, highlight a need to formally incorporate affected tribal input.

References:

[1] Report of the Blacksburg Forum: The First Step Toward the Holistic Approach to Environmental Management: Management Systems Laboratory, Virginia Polytechnic Institute and State University, Blacksburg, VA, 1991.

[2] Toward the 21st Century: Planning for the Protection of California's Environment, California Comparative Risk Project, Final Report, May 1994.

[3] U.S. Environmental Protection Agency, 1993, External Exposure To Radionuclides In Air, Water, And Soil. Federal Guidance Report No. 12, September 1993, EPA 402-R-93-081.

[4] Ohtake, H., and Silver S., 1994, Bacterial Detoxification of Toxic Chromate, Biological Degradation and Remediation of Toxic Chemicals, G. R. Chaudhry (ed.), Portland, Oregon: Dioscorides Press, p. 403-415.

Harris, S.G., 1994, The Nez Perce ERWM's Recommendations for Refinement of Risk Assessment Proposed by DOE's Columbia River Impact Evaluation Plan: Waste Management 94, U.S. Department of Energy Conference, Tucson, Arizona, March 1994.

APPENDIX C

CTUIR CRITERIA FOR THE EVALUATION OF PROPOSED CHANGES TO THE HANFORD FEDERAL FACILITIES COMPLIANCE AGREEMENT (JULY 1993)

GENERAL COUNCIL
and
BOARD OF TRUSTEES

CONFEDERATED TRIBES
of the
Umatilla Indian Reservation

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July 21, 1993

Ms. Mary Riveland, Director
State of Washington
Department of Ecology
P.O. Box 47600
Olympia, Washington 98504-7600

Ms. Dana Rasmussen
Regional Administrator
U.S. Environmental Protection Agency
Region 10
1200 Sixth Avenue
Seattle, Washington 98101

Mr. John D. Wagoner
Manager
U.S. Department of Energy
Richland Field Office
P.O. Box 550
Richland, Washington 99352

RE: Criteria for Evaluation of Proposed Changes to the Hanford Federal Facility Agreement and Consent Order.

Dear Ms. Riveland, Ms. Rasmussen and Mr. Wagoner:

On April 23, 1993, representatives of the Washington Department of Ecology (Ecology) met with the Board of Trustees of the Confederated Tribes of the Umatilla Indian Reservation (CTUIR) to discuss proposed changes to the Hanford Federal Facility Agreement and Consent Order (the Tri-Party Agreement, or TPA). At this meeting, Ecology requested that the CTUIR prepare "criteria" which would represent the CTUIR's standards for reviewing proposed changes to the TPA. Ecology has solicited similar criteria from other interested governments, including the States of Washington and Oregon.

Enclosed is a document entitled Criteria for Evaluation of Proposed Changes to the Hanford Federal Facility Agreement and Consent Order (Criteria). The Criteria outlines the CTUIR's general concerns about Hanford issues; the basis of the CTUIR's interests in Hanford; specific CTUIR concerns about the TPA revision process; and specific criteria by which the CTUIR will measure proposed changes to the TPA. This document represents a good faith effort to respond to Ecology's request.

Please note that, as the TPA revision process is a fluid process, so are a government's needs to respond to new issues as they develop. Please be advised that the CTUIR may develop additional or revised criteria in the future as new issues present themselves.

Sincerely,

William H. Burke

for Elwood H. Patawa
Chairman
Board of Trustees

Enclosure: Criteria for Evaluation of Proposed Changes to the Hanford Federal Facility Agreement and Consent Order

cc: Dan Silver, Ecology
Paul Day, EPA

Criteria for Evaluation of Proposed Changes

to the

Hanford Federal Facility Agreement and Consent Order

July 21, 1993

Confederated Tribes of the Umatilla Indian Reservation
Department of Natural Resources
Environmental Planning and Rights Protection Program
Hanford Environmental Restoration Project

CONFEDERATED TRIBES OF THE UMATILLA INDIAN RESERVATION

INTRODUCTION

In 1989, the State of Washington, the U.S. Environmental Protection Agency (EPA), and the U.S. Department of Energy (DOE) entered into an agreement known as the "Hanford Federal Facility Agreement and Consent Order." This agreement is commonly referred to as the "Tri-Party Agreement," or TPA.

The TPA was created because the DOE was operating the Hanford Nuclear Reservation in violation of numerous federal and state environmental laws. The TPA set requirements and deadlines for DOE to bring Hanford into compliance with those laws. The current TPA's deadlines for the Hanford cleanup are arrayed along a 30 year timeline.

Now, the DOE has requested a revision of the agreement, including an extension of the timeline. The State of Washington and its cognizant agency, the Department of Ecology (Ecology), will be evaluating DOE's proposed changes by applying criteria the State has developed. Ecology has requested that other interested governments submit criteria of their own to aid Ecology in its analysis of DOE's proposed changes. One of the governments is the Confederated Tribes of the Umatilla Indian Reservation (CTUIR).

THE CTUIR'S CONCERNS RELATING TO HANFORD

The CTUIR's concerns relating to Hanford fall into four general categories:

I. Protection of Tribal sovereignty, including protection of tribal rights in CTUIR ceded territory and areas over which the CTUIR exercises off-reservation treaty rights.

II. Protection and restoration of the environment, both on the Hanford site and in areas affected by Hanford over which the CTUIR exercises off-reservation treaty rights. Protecting the environment guards the resources upon which treaty rights are based, including Columbia River fisheries and related resources.

III. Protection of cultural, religious and archeological resources and Tribal rights relating to them.

IV. Protection of the Umatilla Indian Reservation and its members and residents from hazards caused by Hanford activities and from hazards caused by transportation of radioactive and hazardous materials to and from Hanford.

FOUNDATION OF THE CTUIR'S GOVERNMENTAL INTEREST IN HANFORD

Under the Tribes' Treaty of 1855, the Tribes ceded certain lands to the United States. The lands comprising the eastern portion of what is now the Hanford Nuclear Reservation are among the lands ceded by the Tribes. Under the treaty, the Tribes retained rights to perform certain activities on those lands. According to the Treaty:

> [T]he exclusive right of taking fish in the streams running through and bordering said [Umatilla Indian] reservation is hereby secured to said Indians, and at all other usual and accustomed stations in common with citizens of the United States, and of erecting suitable buildings for curing the same; the privilege of hunting, gathering roots and berries and pasturing their stock on unclaimed lands in common with citizens, is also secured to them.[1]

The CTUIR has usual and accustomed fishing stations on the Columbia in and around Hanford. Moreover, prior to Hanford's becoming a secured area, the CTUIR members hunted and performed other treaty activities at the site. The CTUIR's jurisdiction at Hanford is based upon these treaty rights.

In addition, long-standing U.S. Supreme Court precedent holds that the federal government (including its executive agencies) has a trust responsibility to Indian tribes. This means that the U.S. has a fiduciary responsibility to protect the rights of Indian tribes, including tribes' property and treaty rights. Under this duty, agencies such as DOE and EPA have a legal duty to guarantee that their decisions do not harm tribal interests. According to the DOE Indian Policy, "The Department recognizes that some Tribes have treaty-protected interests in resources outside reservation boundaries."[2]

Third, a succession of U.S. Presidents, beginning with President Nixon, have affirmed a federal policy of upholding tribal sovereignty and dealing with tribal governments on a "government-to-government" basis. Both DOE and EPA have adopted Indian

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[1]Treaty with the Walla Walla, Cayuse and Umatilla 1855, June 9, 1855, art. I, 12 Stat. 945.

[2]DOE Indian Policy, Item one.

Policies which purport to apply this federal policy.[3] These agencies must comply with the terms of their own policies.

Fourth, federal laws protect tribes' cultural, religious and archeological sites. Hanford is rich in sites of great cultural, religious and archeological importance to the CTUIR. DOE and its regulators have a duty to comply with these laws in conducting their activities at Hanford, including "cleanup" activities.

Finally, environmental laws affecting Hanford decision-making confer rights upon Indian tribal governments. For instance, the CTUIR is a Trustee for Natural Resources under the Comprehensive Environmental Response, Compensation and Liability Act. Likewise, community safety statutes applicable to Hanford recognize the roles of tribal governments such as the CTUIR. As an example, the CTUIR's Tribal Hazardous Materials Safety Committee has been designated as an official "emergency response commission" as defined under the Emergency Planning and Community Right-to-Know Act.

GOALS OF THE BOARD OF TRUSTEES

The Tribes ratified a Constitution and Bylaws on December 7, 1949, which created a governing body known as the Board of Trustees. The Board has adopted a Mission Statement and Goals. This statement and goals are the CTUIR's guiding principles for its interaction with all other governments.

Board of Trustees
<u>Tribal Mission Statement</u>

> In the best interest of the Confederated Tribes of the Umatilla Indian Reservation, the Board of Trustees shall exert the Tribe's sovereign authority to protect the rights reserved by the Treaty of 1855 and to promote the interests of the members and residents of the Umatilla Indian Reservation. The Board of Trustees shall exercise the authority of the Confederated Tribes so as to promote, enhance and achieve the maximum

[3] Item one of the DOE Indian Policy states, in part: "1. THE DEPARTMENT RECOGNIZES AND COMMITS TO A GOVERNMENT-TO-GOVERNMENT RELATIONSHIP WITH AMERICAN INDIAN TRIBAL GOVERNMENTS." Item one of the EPA Indian Policy states, in part: "EPA will work directly with Tribal Governments as the independent authority for reservation affairs, and not as political subdivisions of States or other governmental units."

degree of self-government, self-sufficiency and self-determination in all Tribal affairs. Doing so objectively and ably is the abiding mission of the Board of Trustees of the Confederated Tribes of the Umatilla Indian Reservation.

Goals

1. To protect and exercise the sovereign, tribal and individual rights and to maintain the cultural integrity of the CTUIR.

2. To optimize the development of all tribal resources and opportunities within the Umatilla Indian Reservation and the ceded area of the Confederated Tribes as recognized and documented in the Treaty of 1855.

3. To provide, protect and maintain all service and entitlements to the CTUIR.

4. To responsibly assert and develop relationships and cooperate with those governments or governmental agencies - federal, state or tribal - that are willing and able to recognize and respect the sovereignty of the Confederated Tribes and which can assist the Tribe in protecting its rights and interests.

THE CTUIR'S CONCERNS RELATING TO THE TPA PROCESS

As a sovereign government, the CTUIR is an entity with rights apart from the public. Activities such as public meetings and public education do not, alone, fulfill the responsibility to consult with the CTUIR on a government-to-government basis.

In order to facilitate such a relationship, the CTUIR believes that, at a minimum, TPA signatories should:

1. Formally commit to a government-to-government relationship with the CTUIR.

2. Hold regularly scheduled meetings with the CTUIR to exchange views on policy;

3. Exchange staff reviews of technical information and testimony;

4. Coordinate activities of their technical staff with technical staff of the CTUIR to maximize the efficient gathering and dissemination of information;

5. Actively seek CTUIR comments on proposed TPA revisions, on implementation of the revised TPA and on regulatory schemes associated with the TPA.

6. Consistently give timely notice of all TPA-related activities so that the CTUIR can meaningfully participate in the process.

It is vital to successful government-to-government relations that local representatives of federal agencies -- representatives who are familiar with CTUIR concerns from working with the tribes -- take concrete steps to educate their superiors in Washington, D.C. about CTUIR rights and concerns. It is equally vital that those Washington, D.C. managers respect arrangements made between knowledgeable local agency personnel and the CTUIR.

The CTUIR reserves the right to perform its own review of TPA revisions to ensure compliance with the Treaty of 1855 and other legal rights of the CTUIR.

The CTUIR reserves the right to coordinate its activities with other tribes, governmental units, concerned citizens, chartered organizations and other parties in a manner which fosters mutual benefits.

THE CTUIR'S CRITERIA FOR ANALYZING PROPOSED CHANGES TO THE TPA

The CTUIR has begun a process of establishing criteria for reviewing proposed changes to the TPA from the perspective of the CTUIR's interests. The following is a list of criteria and supporting laws and regulations which address the concerns listed on page 1. This is not an all-inclusive list. Additional criteria may be developed in the future.

I. TRIBAL SOVEREIGNTY

Criteria

Much of the foregoing discussion has already dwelt at length with the issue of tribal sovereignty. Protection of tribal rights is the primary, all-inclusive goal of the CTUIR. All other issues are viewed with this principle foremost in mind. No resolution of other issues can take place where CTUIR rights are ignored.

II. ENVIRONMENTAL PROTECTION AND RESTORATION

Criteria:

Environmental protection and restoration is a primary purpose of the TPA. The meaningful exercise of tribal treaty rights to Hanford-affected resources is entirely dependent upon the health of the ecosystems upon which those resources depend. A treaty right to fish, wildlife or plants is hardly useful if the fish, wildlife or plants have vanished, or themselves threaten human health. A revised TPA must guarantee that treaty resources are protected or restored to a level which allows the CTUIR to fully exercise its rights to the resources without fear of injury to either the resource or to CTUIR members.

Treaty resources are significant to the CTUIR for a variety of reasons. Tribal members are subsistence hunters and gatherers. Wild game and fish form a major part of the diet of many tribal members. Likewise, plants collected from healthy wild ecosystems form an important feature of many tribal members' diets. Besides consumption as food, these treaty resources are collected for religious ceremonies, cultural uses such as decoration and traditional crafts, and recreational purposes. <u>All</u> indigenous plants and animals have religious significance to CTUIR members who practice traditional Indian religion. In addition, these treaty resources, such as Tribal salmon resources, can be of great economic importance to the CTUIR.

Laws and Regulations Supporting Environmental Criteria:

<u>Resource Conservation and Recovery Act</u> - RCRA provides a "cradle-to-grave" framework for managing hazardous wastes. The Act, which was amended in 1992 by the Federal Facilities Compliance Act to make RCRA's provisions apply to Federal facilities, provides a regulatory decision-making process for cleaning up hazardous waste sites. This process includes soliciting public comments and incorporating them into the process. The CTUIR, although not regulators of the Hanford site, have treaty rights within the area which mandate the CTUIR's participation on a government-to-government basis in the restoration of Hanford.

<u>Comprehensive Environmental Response, Compensation, and Liability Act</u> - CERCLA creates regulatory decision-making processes for responding to hazardous substance releases. The Act also assigns liability and determines compensation for certain parties injured by hazardous substances releases. These processes also include measures for public and tribal participation in the decision-making process. Furthermore, the CERCLA Natural Resource Damage

Assessment (NRDA) process provides for payment of damages for unremediated injuries to natural resources. These payments are made to Trustees for Natural Resources (governments with interests in the injured natural resources). The CTUIR has been recognized as a Trustee for Natural Resources in the NRDA process established under CERCLA § 107(f) and § 301(c). Decisions made in the TPA revision process will largely determine the degree of unremediated injury to CTUIR natural resources.

National Environmental Policy Act - NEPA was passed by Congress to evaluate the effects that actions of the Federal government may have on the environment. NEPA requires that before the government takes any action, the environmental impacts of that action need to be studied and alternatives proposed. The law also contains explicit public involvement procedures. NEPA provides the framework within which proposed actions by DOE for Hanford restoration are integrated. The Act provides guidance on the level of analysis and requires an assessment of the cumulative effects of federal actions.

State Environmental Policy Act (Washington) - SEPA provides the State of Washington an integrative approach to environmental planning and managing natural resources. Similar to NEPA, the Act provides the framework within which the State involves citizens in the decision-making process and provides guidance on the level of analysis.

Wild and Scenic Rivers Act - The W&SRA was enacted to protect and preserve selected rivers which, with their immediate environments, possess outstandingly remarkable scenic, recreational, geologic, fish and wildlife, historic, or cultural values. These rivers are to be preserved in their free-flowing condition for the benefit of present and future generations. The Hanford Reach of the Columbia River is the last free-flowing stretch of the mainstem Columbia and is being studied for protection under the Wild and Scenic Rivers Act. Protection of river-related values such as water quality, historic and cultural values, fisheries and wildlife resources is considered by the CTUIR to be of utmost importance, due to the loss of key habitat in the Columbia Basin from dam construction. Restoration actions at Hanford must protect and/or enhance Columbia River resources.

Clean Water Act - The goals and policy of the CWA are to restore and maintain the chemical, physical and biological integrity of the Nation's waters. The CWA establishes effluent limitations for pollutant discharges from point sources into navigable waters. Section 311 of the Act prohibits discharge of hazardous substances to the Nation's waters and creates a regulatory framework for responding to such releases. Section 316 provides for limitation of thermal discharges. Nonpoint sources of water and groundwater pollution are also regulated by the Act. The CWA requires permits for discharge of pollutants into navigable waters and for dredging and filling activities. CWA permitting requirements and other standards apply to federal facilities. Moreover, CWA standards are important to the CERCLA process because they are Applicable or Relevant and Appropriate Requirements (ARARs).

Safe Drinking Water Act - This Act, enacted in 1974, is designed to protect drinking water supplies from contamination. This includes ground water used for public drinking water. The law requires EPA to establish chemical-specific Maximum Contaminant Levels (MCLs) for public drinking supplies. Federal facilities, such as DOE's Hanford site, are subject to the law where wellhead areas or single source aquifers are threatened with contamination such as those effluent to the Columbia River. The SDWA also restricts underground injection wells that may pose a threat to drinking water sources. There are numerous wells above MCL located along the Columbia River.

Clean Air Act - This Act was designed to protect and enhance the quality of the Nation's air resources. The law established the National Emission Standards for Hazardous Air Pollutants (NESHAPs) which have also been developed for radionuclide particulate emissions from DOE facilities. These standards are directly enforceable against DOE facilities such as Hanford and are considered under CERCLA to be Applicable or Relevant and Appropriate Requirements (ARARs).

Endangered Species Act - The purpose of the ESA is to insure that all Federal departments and agencies seek to conserve threatened and endangered plant, animal and fish species and utilize their authorities in furtherance of conservation of such threatened and endangered species, and to take such steps as may be appropriate to achieve the purposes of the international treaties and conventions set forth in the Act. The ESA imposes a duty on federal agencies to consult with wildlife agencies to insure that any action authorized by the agency is not likely to jeopardize the continued existence of any threatened or endangered species or result in the destruction or adverse modification of a species' critical habitat.[4]

[4] Over 47 fish, wildlife and plant species considered rare (either sensitive, threatened or endangered) occur on or have habitat on the Hanford Reservation, including the Hanford Reach of the Columbia River. Currently,

III. CULTURAL RESOURCES

Criteria

The CTUIR affirms its authority and commitment to preserve, protect and promote Tribal culture and heritage. Such authority is an inherent feature of Tribal sovereignty. This authority and commitment is embodied in various federal and state laws as well as the CTUIR's Comprehensive Plan, Board of Trustees Resolutions and the proposed CTUIR Cultural Resources Protection and Management Code (Cultural Resources Code). Changes to the TPA must recognize the CTUIR interest in protecting and preserving cultural resources.

Cultural sites and resources include those associated with traditional foods and other natural resources, sites of great religious importance such as Gable Mountain, habitations, and historical events and personalities. It is the intent of the Tribes to protect, preserve and manage cultural resources on the reservation and ceded lands by the use of policy, statutory prohibitions and regulations. At Hanford, cultural resources sites have not been effectively protected from pothunters. It is DOE's responsibility to ensure that these sites are effectively protected and that violators are fully punished. In addition, many cleanup activities (such as drilling new wells or constructing new facilities) can violate cultural resources sites. TPA signatories must integrate protection of cultural resources into their cleanup planning. The proposed Cultural Resources Code provides policy guidance and procedures for DOE's Hanford restoration and management which is complemented by the Federal Native American Graves and Repatriation Act.

Laws and Regulations Supporting Cultural Criteria:

Native American Graves Protection and Repatriation Act - The NAGPRA provides for the protection of Native American graves and for the return to Indian tribes of human remains, burial artifacts, sacred objects and objects of cultural patrimony, for

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DOE does not have a policy directed towards management of State Sensitive and Candidate Species such as the Ferruginous hawk, burrowing owl, common loon, great blue heron, shortface lanx, Columbia pebblesnail, Perisistentsepal yellowcress, southern mudwort, shining flatsedge, or dense sedge. It is imperative that a policy designed to enhance habitat and restore viable populations of fish, wildlife, and plant species be developed in consultation with CTUIR to insure that: (1) additional species do not become threatened or endangered, (2) Tribal Treaty resources are maintained, and (3) DOE fulfills its trust responsibility in managing natural resources.

the ultimate purpose of repatriation of such remains and objects. NAGPRA's provisions recognize the authority of traditional Indian religious leaders and provide a role for these leaders in carrying out the Act's functions. Inventories for the above artifacts must be conducted in consultation with Indian tribes. This Act protects cultural resources at the DOE Hanford facility.

American Indian Religious Freedom Act - This Act defines the policy of the United States to protect and preserve for American Indians their inherent right of freedom to believe, express and exercise the traditional religions of the American Indian, Eskimo, Aleut, and Native Hawaiians, including but not limited to access to sites, use and possession of sacred objects and the freedom to worship through ceremonial and traditional rights. The Hanford site was used significantly by the Wallulapum band (now part of the CTUIR), as well as others.

National Historic Preservation Act - This Act requires federal agencies to assess the impacts of their activities on properties included in or eligible for the National Register of Historic Places. The Act requires such planning on actions as may be necessary to minimize harm to any National Historic Landmark that may be directly and adversely affected by an undertaking. Section 106 of the Act requires federal agencies to take into account the effect of their undertaking on important historic properties for all actions involving federal funds, approval or assistance that could affect archeological resources. The Hanford Reach could potentially be eligible for designation as a historic district on the National Register of Historic Places, and also as a traditional cultural property.[5]

Archaeological Resources Protection Act of 1979 - The Act imposes criminal and civil penalties upon persons without permits who excavate or remove archeological resources from public or Indian lands. ARPA provides for stronger protection for archeological sites through law enforcement monitoring. Over 400 archeological sites are documented by the CTUIR within the Hanford Reservation. Additional cultural resource surveys need to be completed to thoroughly document and re-record these resources. Protection of these resources is a significant concern of the CTUIR and may require additional security.

[5]Under the Hanford Future Site Uses Working Group Final Report, Cleanup Scenario A for the Reactors Along the River includes removing all reactors and all other structures, contaminated and uncontaminated in the 100 area. To insure that Native American uses can continue, the CTUIR prefer this option over maintaining structures on site.

IV. TRIBAL COMMUNITY HEALTH AND SAFETY

Criteria

As a Hanford downwind community, the CTUIR could be severely injured by a catastrophic event at Hanford. Moreover, radioactive and hazardous materials transported to and from Hanford regularly pass through the Umatilla Indian Reservation and along the tributaries of the Umatilla River. A transportation accident on the reservation or the river involving Hanford's radioactive or hazardous materials would pose a great danger to the Tribal community. Protection of the Umatilla Indian Reservation and its members and residents from these hazards must be considered in the TPA revision process.

TPA changes should accomplish several goals, including:

1. reducing the risk of a catastrophic event at Hanford,
2. reducing the volume of hazardous and radioactive materials to be transported off-site for disposal, and
3. reducing the total volume of hazardous materials used in the processing of Hanford waste.

Laws and Regulations Supporting Health and Safety Criteria:

Nuclear Waste Policy Act - This Act provides for the development of repositories for the disposal of high-level radioactive waste and spent nuclear fuel. In this process, the CTUIR was recognized as an "affected nation" which must be coordinated with on a government-to-government basis in the development of repositories and disposal of radioactive waste.

Emergency Planning and Community Right-to-Know Act - EPCRA establishes a duty for facilities containing extremely hazardous substances to participate with local communities in planning for emergency response in the event of releases of those substances. Hanford is a facility subject to EPCRA requirements. As a neighboring community, the CTUIR has a right to participate in Hanford-related emergency planning activities.

Hazardous Materials Transportation Uniform Safety Act - This Act regulates the labelling and transportation of hazardous materials. The Act provides for the training of Tribal public sector employees to respond to accidents involving hazardous materials. Transportation of hazardous and radioactive materials is a subject of particular importance to the CTUIR, as the main highway and rail routes for Hanford materials pass through the reservation.

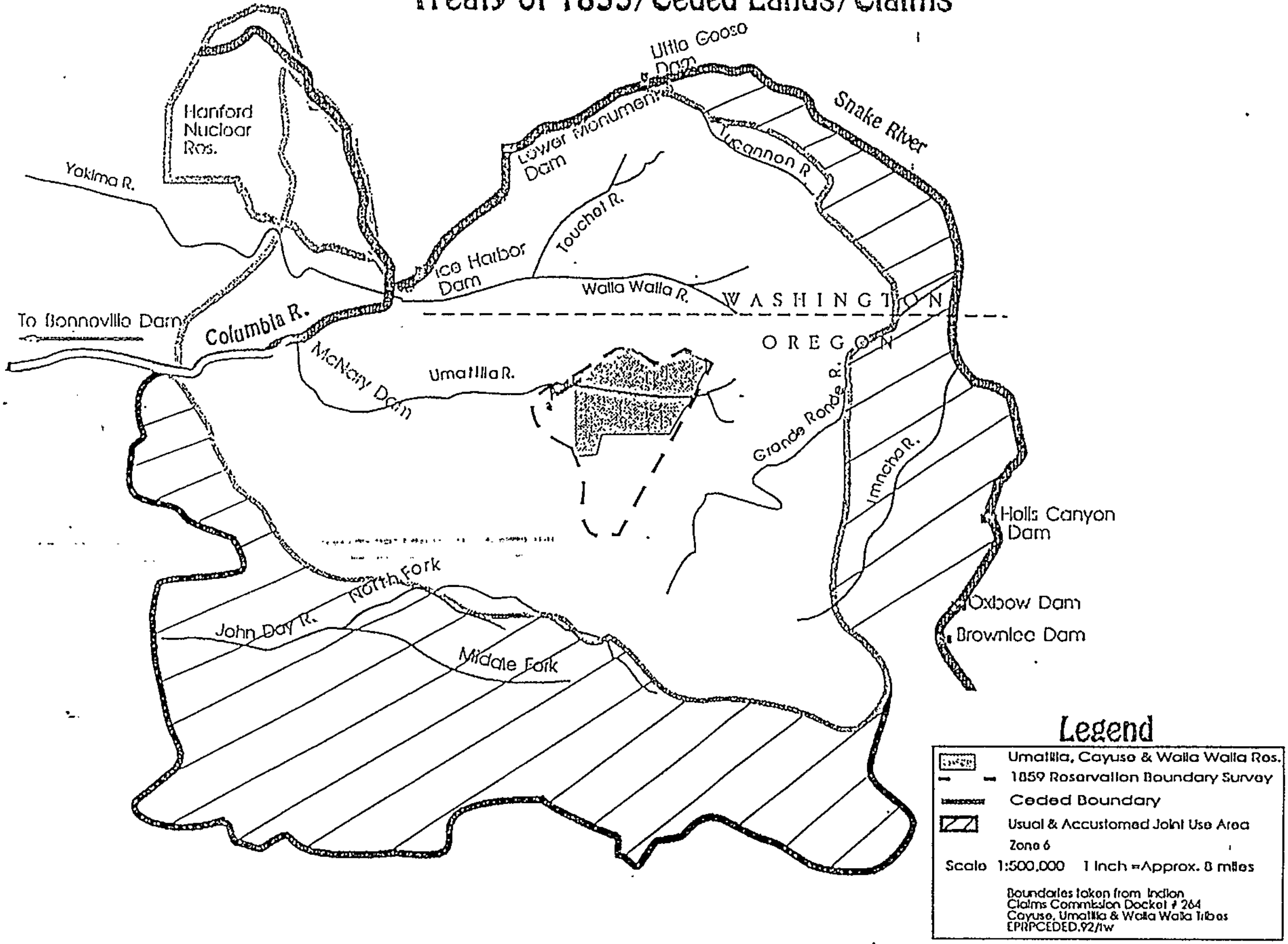
CTUIR Hazardous Materials Emergency Response Plan - Amended in November of 1991, this plan outlines the roles and responsibilities of various agencies involved in hazardous materials emergency response. The Plan contains a section dealing specifically with Hanford.

CONCLUSION

The criteria and supporting laws and regulations listed above are tools the CTUIR will use to analyze revisions and implementation of the TPA. The CTUIR has numerous rights and interests in the Hanford Nuclear Reservation. These rights derive from the Treaty of 1855, the federal trust responsibility, federal statutes and federal policy. Moreover, the CTUIR has committed itself to preservation of its Tribal sovereignty and exercise of its authority over Tribal resources. The CTUIR desires to work on a formalized government-to-government basis with the TPA signatories on environmental restoration, waste management, and environmental enhancement of the Hanford Nuclear Reservation, including revision and implementation of the TPA.

Confederated Tribes of the Umatilla Indian Reservation

Treaty of 1855/Ceded Lands/Claims



APPENDIX D

INTRODUCTION TO HANFORD

APPENDIX D

INTRODUCTION TO HANFORD

Within the framework of the DOE nuclear materials production and weapons complex, Hanford played a unique role in that, more than any other single DOE site, its scope of operations included multiple phases of this cycle. This breadth of historical operations has led in turn to the proportional magnitude and scope of environmental, health, and safety problems that exist today at Hanford, many of which date from the very birth of the atomic age. No other single DOE site shares either the magnitude, scope, or complexity of problems to be addressed nor the equally unique factor that "clean-up" at Hanford directly affects the rights and interests of nearby sovereign American Indian tribes with off-reservation treaty rights (Appendix C).

A. Historical Perspective

Just over 50 years ago, the U.S. Government searched across the nation for sites to host then-secret facilities for the Manhattan Project, designed to develop, manufacture, and deploy nuclear weapons. Among the three facilities sited was the Hanford Nuclear Reservation, which covers more than 560 square miles astride the Columbia River near Richland, Washington; its secrecy required displacing all earlier residents and uses, including tribes. During the previous century, American immigrants settled in the area and began to farm the arid soils with water from this major regional water course. In fact, these lands, waters, and the abundance and diversity of the Columbia River ecosystem--especially the salmon--supported some of the largest indigenous American Indian populations in the Pacific Northwest. Prior to the arrival and widespread immigration of non-Indians only a century and a half ago, tribes hunted, gathered, and fished from the lands and waters throughout this region in sustainable harmony with their environment for at least 13,000 years.

B. Hanford Overview and Legacy

During the past 50 years, Hanford evolved into a facility that performed many steps in the nuclear cycle. For example, raw uranium ore was manufactured into fuel elements (300 Area), fuel elements were irradiated in nuclear production reactors to produce weapons-grade plutonium and enriched uranium (100 Areas), and weapons-grade material was chemically separated from other "contaminant" constituents by a succession of processes and facilities (200 Areas).

Each step of this process consumed tremendous amounts of resources, and also generated tremendous volumes of hazardous chemical and radioactive wastes that were routinely released to the air, water, and soil column. The long history and the sheer magnitude of the discharges have resulted in the risks now faced by all communities, especially by American Indian tribes, near (and not so near) these facilities or dependent upon surrounding lands and natural resources.

Without closing the circle, today's legacy of polluted land and resources will adversely affect human and ecological communities long into the future.

More than 1300 individual waste sites have been identified across the Hanford site, and have been grouped into 78 operable units in order to facilitate planning and management of "clean-up" under various state and federal laws. The magnitude of the problem at this single site alone is almost incomprehensible. In total, more than 444 billion gallons of contaminated liquid wastes containing approximately 678,000 Curies of radioactivity were discharged directly to the ground between 1944 and 1989. These discharges contaminated more than 200 square miles of groundwater, along with vast quantities of soils above the groundwater table, with dozens of potentially harmful radioactive and hazardous chemicals. Many contaminant plumes discharge directly into the Columbia River at numerous locations.

Solid and some liquid wastes were buried, often unsegregated, in hundreds of unlined burial trenches; total volumes are estimated at some 22 million cubic feet and contain more than 4.88 million Curies of radioactivity. The most dangerous high-level radioactive and mixed chemical wastes--61 million gallons worth--are still stored in 177 huge underground storage tanks, and alone constitute more than half of the total radioactivity now present near the surface at Hanford. Many of these tanks have exceeded their design life and now leak their contents into the environment or pose other serious, more immediate safety hazards; the nature and extent of these hazards is not well known. And the dozens of facilities that created these wastes are now shut down, but still highly contaminated; their decontamination and decommissioning now face an uncertain future.

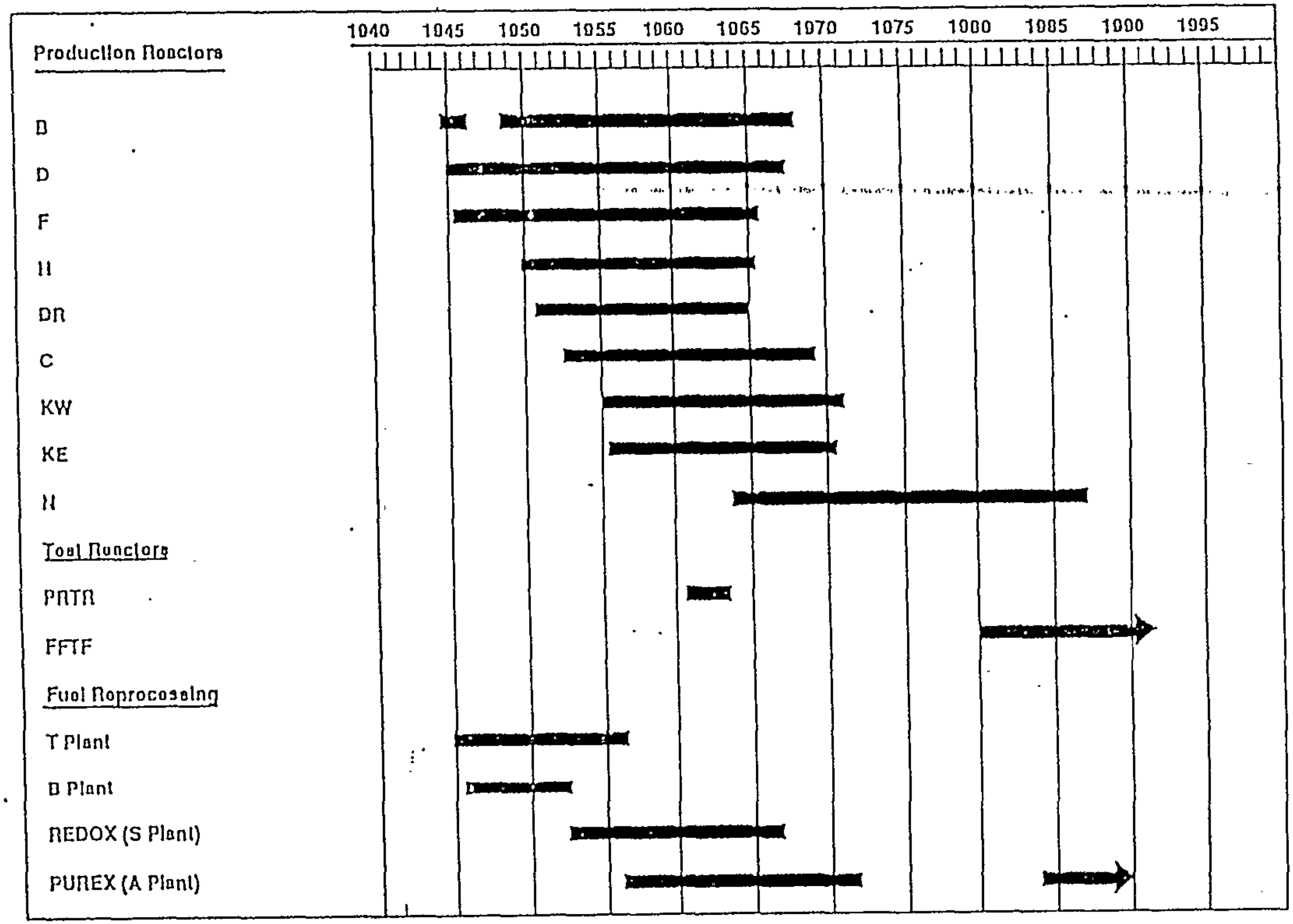
On the other hand, Hanford's very isolation under a cloak of secrecy for so many years has in fact preserved unique and rapidly disappearing elements of the historical Pacific Northwest that have succumbed to the advances of modern civilization elsewhere. For example, Hanford contains the largest remaining expanses of near-natural shrub-steppe habitat in Washington, supports a large number of bald eagle nesting sites and other endangered species, and preserves the last free-flowing stretch of the Columbia River in the United States, a 51-mile segment of which is currently recommended to be designated as a Wild and Scenic River. In addition, Hanford's restricted access has preserved hundreds of American Indian cultural sites and resources from the extensive looting they have suffered elsewhere on easily accessed public and private lands.

C. The Cost of Doing Business at Hanford

The modern Hanford environment includes a broad spectrum of interests and players, including political, technical, institutional, and cultural components. Each of these elements plays an important role in the overall Hanford "clean-up" program, but the interests and role of some are more narrowly or broadly defined than others. Moreover, many of these groups tend to try to persuade DOE to budget more and more "clean-up" funds to their preferred projects, some of which are only peripherally related to actual "clean-up." The list below is intended merely to illustrate the breadth of interest groups and some of their principal goals, and is not intended to be comprehensive, representative, or exhaustive.

- Department of Energy (continue status quo, perpetuate bureacracy)
- DOE Contractors (institutionalize federal dollars, prolong clean-up)
- Federal and State Regulators (EPA/Ecology; legal and regulatory compliance)
- American Indian Tribes (sovereign governments with treaty-reserved rights)
- States of Washington and Oregon (protection of public health, environment)
- Other Federal and State Agencies (trustee responsibilities for land or resources)
- Local Governments (control land-use planning and expand tax bases)
- Local Labor Interests (perpetuate high employment, salaries, government contracts)
- Local Business Interests (subsidized economic development, growth, and profit)
- Agricultural Interests (expanded land base for cropping, habitat alteration)
- Environmental Groups (environmental clean-up and compliance)
- Public Health Community (understanding contaminant cause and health effects)

Major Plant Operating Periods



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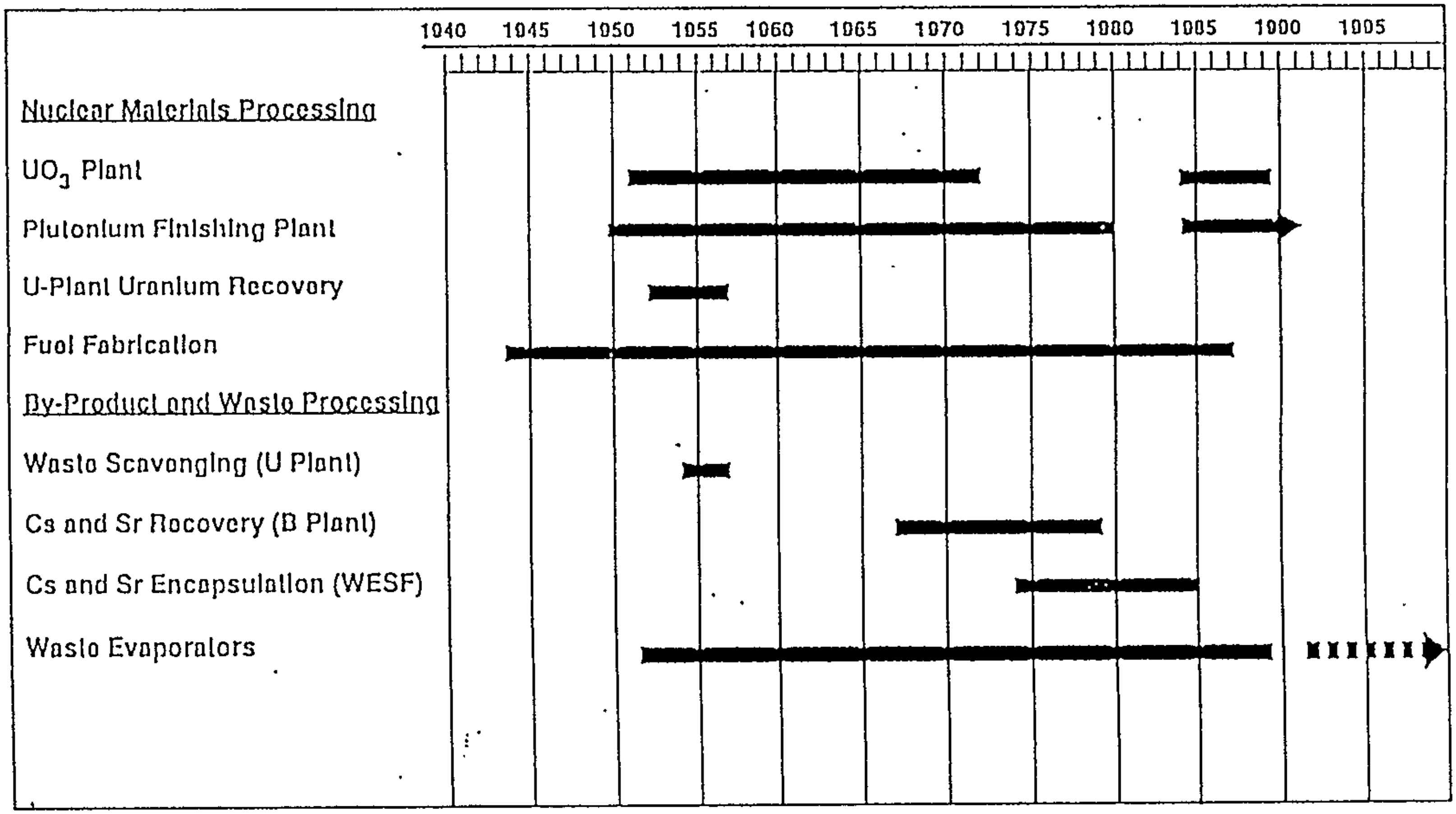
Major Plant Operating Periods (Cont.)



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Hanford Waste Management Units

(Sites that received radioactive and/or hazardous chemical waste)

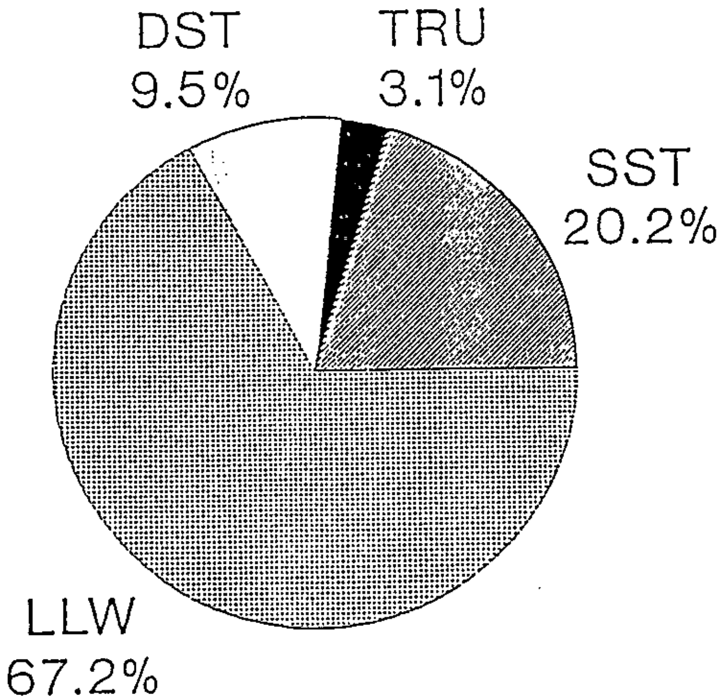
Surplus Facilities (building)	77
Septic Tanks	96
Single- and Double-Shell Tanks and Ancillaries (catch tanks, diversion boxes, tank leaks*, etc.)	311
Other Treatment and Storage Units (existing & future)	130
Miscellaneous Underground Storage Tanks (such as gasoline tanks)	26
Unplanned Release or Spills Sites*	224
Waste Disposal Sites*	508
	1,372

*The radioactive liquid and solid waste sites described in this report are in these categories

Reactor Releases to the Columbia River

Radionuclide	Half-Life	Ci
Sodium-24	15 hr.	13,000,000
Phosphorus-32	14.3 day	230,000
Zinc-65	244 day	490,000
Arsenic-76	26.4 hr.	2,500,000
Neptunium-239	2.4 day	6,300,000
Scandium-46	83.8 day	120,000
Chromium-51	27.8 day	7,200,000
Manganese-56	2.5 hr.	80,000,000
Gallium-72	14 hr.	3,700,000
Yttrium-90	64 hr.	440,000
Iodine-131	8 day	48,000
Gross Beta - 4 hr. decay		66,300,000

QUANTITIES OF HANFORD WASTE

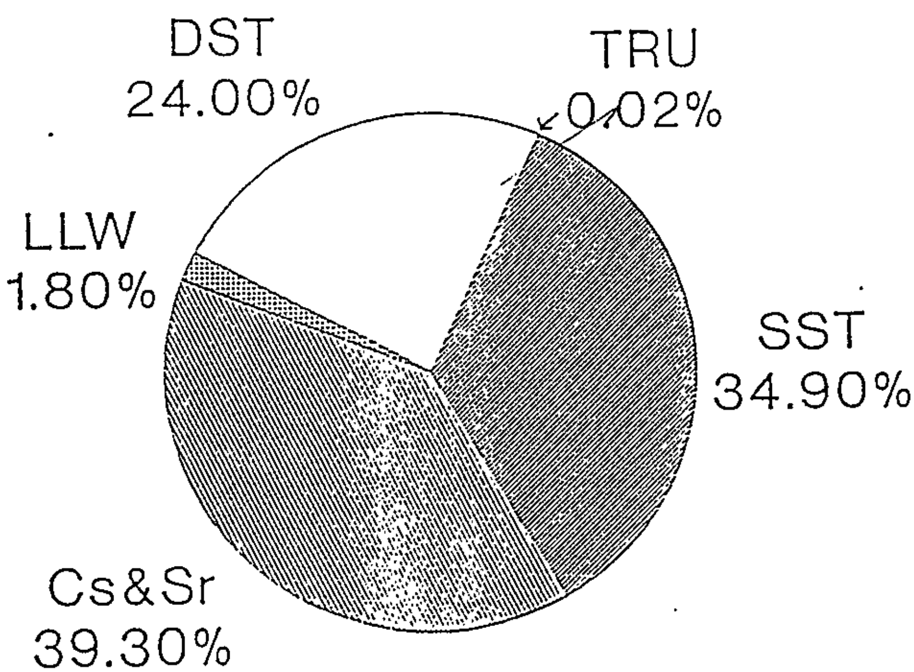


VOLUME

TOTAL VOLUME:

821,000 cubic meters

[Enough to cover 6 football fields each to a depth of 100 ft.]



RADIOACTIVITY

TOTAL RADIOACTIVITY:

458 million curies

Table 2: Where is the dangerous material at Hanford?

	Soil/ Groundwater	Tanks	Special Nuclear Material (inc. SNF/Pu)	Solid Waste
Volume	99%	< 1%	< 1%	< 1%
Radio-nuclide Mass		55%	45%	
Hazardous Waste Mass (Metals/ Organics)	25%	60%		15%

Source: Jim Honeyman, Al Pajunin, Roy Gephart

APPENDIX E

CERE's ROLE IN DOE's RISK EVALUATION PROGRAM

APPENDIX E

CERE's ROLE IN DOE's RISK EVALUATION PROGRAM

In response to both internal DOE and Congressional mandates, a number of separate examinations of risk-based approaches to remedial decision-making are occurring.[1] To complete its report to Congress, DOE is employing several different approaches in order to examine compliance agreement requirements, current site risks across the complex, and tribal/public concerns about these risks.

As one element of this process, DOE contracted with the Consortium for Environmental Risk Evaluation (CERE), a partnership of universities and corporations, in order to evaluate risks associated with "clean-up" of six selected DOE nuclear weapons production facilities now governed by compliance agreements. A distinctly separate part of CERE's program is "cataloging concerns of minority, disadvantaged groups, and disproportionately affected communities"[2] as a means of providing DOE with a "laundry list" of public concerns for consideration in its report to Congress.

Risk "evaluations" can take a number of forms including: quantitative risk assessment, comparative risk assessment, qualitative risk assessment, values-based assessment, alternatives assessment, worst-case scenarios, and other techniques. The CERE team is conducting a qualitative evaluation of selected existing quantitative risk assessments at six of the seventeen DOE facilities whose current mission now includes environmental restoration.

A. Purpose and Scope of CERE Risk Evaluation

The CERE program[3] purports to assess how well the weapons complex risks and costs are understood. The purpose of the CERE program is to:

1) Provide DOE with a credible evaluation of immediate threats and long-term risks under existing conditions to public and tribal health, to worker health and safety, and to the environment caused by EM activities associated with compliance agreements,
2) Assist DOE in documenting, developing, and evaluating cost estimates for EM-managed activities, and
3) Provide DOE with a review of the public concerns related to risks associated with EM-managed activities.

The following DOE sites are included in the CERE evaluation: Oak Ridge National Laboratory, TN; Fernald Feed Materials Facility, OH; Rocky Flats, CO; Idaho National Engineering Laboratory, ID; Savannah River, SC; and Hanford, WA. These facilities were chosen because "clean-up" at each site is governed by a federal facility compliance agreement between DOE, EPA, and state regulators, and because these sites are the largest in the DOE complex, in terms of physical size, magnitude of environmental problems, and "clean-up" budgets.

Qualitative risk evaluation, as applied by CERE, is *"a process for interpreting available information concerning various risks to public health, workers, or the environment and drawing qualitative conclusions regarding the nature, severity, extent, and urgency of these risks."*[4] The project is based on site- and selected operable-unit[5]-specific evaluations of available studies by external experts and the CERE team. Specifically at Hanford, CERE's sitewide evaluations and conclusions are based on examining only six quantitative risk assessments.

Within this framework, CERE correctly recognizes that all risk assessments involve judgement, and that the size and complexity of the DOE complex makes the nature of such judgements central to the study. In addition, CERE further recognizes that the quality, availability, and consistency of relevant information varies widely among DOE installations and is thus difficult to combine into a complex-wide quantitative risk assessment.

B. Xavier University's Inventory of Public Concerns

In a related but separate initiative to the CERE project, Xavier University, is "cataloging concerns of minority, disadvantaged groups, and disproportionately affected communities."[6] This task should be a critical and integral component of any overall program of evaluating risks. Unfortunately, a simple and separate "cataloging" of issues does nothing to expand, correct, or repair the well recognized inability of conventional risk assessment to incorporate these typically qualitative and otherwise difficult to quantify values of unique cultures and communities such as those of American Indian tribes.

This separate "cataloging" process does indicate that Xavier University investigators apparently do not understand the distinct and unique rights, roles, and responsibilities of sovereign tribal governments. For example during the first CERE workshop in Phoenix in October 1994, a tribal representative found it necessary to provide appropriate clarification and direction to Co-Principal Investigator Sarah O'Conner of Xavier University:

> "While it is important that the Indian perspective be cataloged, it is also critical that readers differentiate those opinions held by Indian people from those documented as policy statements of sovereign tribal governments. The opinions of Indian people and tribal governments are often similar; however, tribal policy statements carry the additional weight of legal authority, as defined by federal or state recognition, and are backed by Supreme Court rulings on tribal government sovereignty."[7]

Because this "catalog" was not received by CTUIR staff prior to completion of our report, no further analysis of the defined approach, activities, or conclusions of Xavier can be provided. From the beginning of any such program, however, it is imperative that such "panels of experts" first fully understand and then be able to distinguish tribal government perspectives, and the unique legal rights, role, and status of tribes from others.[8] Such rights extend far beyond simply having them "cataloged" with and otherwise indiscriminantly lumped together with the public's perspective. Furthermore, CERE/Xavier's defined approach of a distinct and separate process to catalog tribal/public issues alone would not appear to even recognize, let alone directly address and resolve, the tendency--and chief deficiency--of conventional risk assessment methodology to ignore generally qualitative, but inseparable aspects of the full scope of risk.

C. Topical Problems with CERE Process and CERE/Hanford Evaluation

The CERE risk evaluation project is characterized by problems both recognized and unrecognized by CERE with the chosen process, methodology, and conclusions. The CERE report itself identifies many of CERE's limitations. Major problems with the CERE effort itself are summarized below.

- An overly broad and unfocused mission/scope with far too short a timeline for completion,
- Failure to incorporate meaningful tribal/public involvement in project planning, scoping, and concluding phases, independent technical review, or a tribal/public comment period sufficient to meaningfully review and address identified deficiencies,
- Drawing broad, sweeping conclusions from limited or incomplete sets of data, or from site profiles that will not be completed until *after* conclusions are drafted,
- Exclusion of potentially significant risks associated with off-site transportation of hazardous and radioactive materials, particularly with regard to mixed waste compliance,
- Failure to address cultural resources protection, operating facilities, waste management, or pending site mission redefinition. Such critical omissions along with CERE's admitted inability to fully recognize and address tribal issues directly point to CERE's very limited ability to provide a credible and comprehensive perspective on either major overall complex-wide or site-specific risks,
- Failure to address the risks of doing nothing now and the increased risks and costs simply postponed into the future, from spreading contaminant plumes, for example,
- Highly selective "representation" of the magnitude and scope of risk and other problems facing Hanford site remediation in site profiles,
- Failure to consider an appropriate spectrum of future land-use decisions in risk evaluation,
- Blanket acceptance of data, methodology, results, and conclusions of site-specific quantitative risk assessments that form the basis of CERE's qualitative evaluation; no attempt has been made to assess any underlying assumptions, uncertainties, biases, basis, and limitations of original data and conclusions, which are simply carried through,
- Lack of comprehensive impacts review from unique resource use and pathway exposure to specific members of communities such as tribes;

- Failure to include the element of time in any risk evaluations, and how levels of contaminant discharge, exposure, and associated risks change as a function of time,
- CERE site profiles at Hanford based only on selected DOE and contractor documents,
- Failure to recognize and incorporate values from successful DOE-sponsored forums such as Hanford Future Site Uses Working Group and Hanford Tank Waste Task Force, and tribes, regulators, natural resource trustees, or stakeholders, and
- CERE satisfies too few of the basic objectives and institutional criteria laid out in *Building Consensus* report (see main text, Section IV, Sub-Section B (2)).

CERE *could* have chosen to conduct a considerably more comprehensive qualitative risk evaluation. They *could* have chosen both to recognize the fundamental importance of tribal/public involvement *throughout* the process. They *could* have chosen to examine the wealth of additional and related data available, some of which may not be directly included in a formal quantitative risk assessment because dose, exposure, or other factors were uncontrolled. Nevertheless, such information--which constitutes a much larger fraction of the available data--is still highly valuable and directly indicative of risk in a qualitative evaluation. To many, the particular value of a qualitative approach is to be able to include and consider the wealth of data sources that cannot automatically plug into a quantitative risk assessment. For example, the following relevant data sources or other information were not considered, but easily could have been included in a more comprehensive qualitative risk evaluation program based on CERE's direction to evaluate the *"best scientific evidence available."*

- The wealth and breadth of available site monitoring data for a variety of environmental media and biota,
- A comprehensive literature search,
- A review of extensive tribal and public comments submitted in response to DOE documents, work plans, records of decision, etc.,
- Medical reports and public health surveys,
- Worker complaints and observations,
- Chemical and toxicity profiles, discussing the quality, significance, and applicability of laboratory data and research, such as those mandated by CERCLA § 104 to be developed by the Agency for Toxic Substances and Disease Registry (ATSDR),
- Environmental toxicological studies of relevant ecological conditions and species, both terrestrial and aquatic, in published scientific journals
- Worst-case analyses, or
- Environmental impact and alternatives analyses.

In short, the CERE evaluation has mechanically repeated or compounded many of the traditional limitations of conventional risk assessment approaches. As a direct result, CERE has failed to provide a either a comprehensive or credible evaluation of risks at *any* DOE complex sites. This failure stems largely from the failure to include meaningful tribal/public involvement throughout the process, failure to recognize and integrate values into the evaluation process, and from a narrow examination of sometimes extremely limited data sources, and an overdependence on risk "experts," their values, and judgement process rather than those of directly affected communities.

Notes

1. At least three independent (?) efforts are now ongoing, two of which are occurring within the Department of Energy: the Consortium for Environmental Risk Evaluation (CERE) report and the Baseline Environmental Managaement Report (BEMR). A third report is being coordinated by Steve Blush, former DOE staffer, at the request of the Senate Energy and Natural Resources Committee. The Blush report also is examining risks and costs associated with "clean-up" of DOE sites, but was received only a few days before this report was completed. Hence, insufficient time was available for its adequate review. Our report primarily addresses the CERE report and process, with which we are most familiar. Nevertheless, because of the intense current scrutiny on risk-based decision-making in general, our report also may be applicable to these other efforts.

2. *Tulane/Xavier CERE Program Qualitative Risk Evaluation Fact Sheet*, dated 12-6-94.

3. This section describing the CERE program is excerpted, verbatim in places, from the *Tulane/Xavier CERE Program Qualitative Risk Evaluation Fact Sheet*, dated 12-6-94.

4. CERE Fact Sheet.

5. The term *'operable unit'* is employed under the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) to group together contaminated sites based on similarities such as contaminants, media (air, soil, surface water, or groundwater), source terms, geologic/hydrologic or environmental conditions, or remedial needs. At Hanford, where more than 1300 individual waste sites have been identified thus far, 78 operable units have been designated, including 5 groundwater operable units, to facilitate planning and management of remedial activities.

6. CERE Fact Sheet.

7. From meeting of Co-Principal Investigator Sarah O'Conner, Xavier University, and tribal representatives at second CERE workshop held in Salt Lake City, Utah, on January 31 and February 1, 1995.

8. The term *'stakeholder'* is commonly used to encompass all 'interested and affected parties' that may be impacted by a particular action or proposed action. A catch-all term, it often indiscriminantly lumps together state and local governments, public interest groups, business and labor interests, environmental groups, and others, in addition to sovereign tribal nations. But not all 'stakeholders' are created equal. Tribal nations comprise a unique legal entity whose rights, interests, and responsibilities are both distinct from and superior to those of state and local governmental interests and any public interest groups. Tribal sovereignty is formally recognized and protected in treaties signed with the United States government, in which tribes specifically reserved rights to utilize lands and resources and to perform traditional activities as they have for thousands of years. Moreover, the treaties also imposed a trust responsibility upon the U.S. government to protect and preserve those lands and resources upon which tribes depend for subsistence or other cultural activities. Furthermore, Columbia Plateau tribes are unusual among many tribal nations in that their treaties specifically provide off-reservation treaty rights and guarantee access to resources throughout the lands ceded to the United States in the treaties and throughout all other usual and accustomed locations. The sovereignty of tribal nations also requires the U.S. government to establish formal government-to-government relations and to proactively consult with tribes concerning any proposed federal action or program that may affect the interests of tribes, as

mandated in the DOE Indian Policy. Tribes are also designated as Natural Resource Trustees under CERCLA, and thus must be formally consulted in the planning, management, and execution of any "clean-up" programs developed under CERCLA that may impact their sovereignty, treaty-reserved rights, lands, natural and cultural resources, or other interests. *No other entities commonly considered 'stakeholders' share these unique and distinct rights and privileges.* This point is a consistent source of confusion among many state and federal agencies and elements of the public, especially outside the Pacific Northwest where such conditions are rare. Hence, tribes should always be separately identified and their unique rights and interests formally acknowledged.

APPENDIX F

PROFILES OF HISTORICAL HANFORD CONTAMINANT RELEASES
(from Hanford Environmental Dose Reconstruction Project)

Summary:

Radiation Dose Estimates from Hanford Radioactive Material Releases to the Air and the Columbia River

April 21, 1994

The Technical Steering Panel of the Hanford
Environmental Dose Reconstruction Project

Air Exposure Pathway

Irradiating uranium fuel rods in a nuclear reactor produces plutonium and a large number of other radioactive materials. Once produced in Hanford's reactors, the plutonium was separated from other radioactive materials in chemical separations plants. Four chemical separations plants–called T, B, REDOX, and PUREX–operated at various times on the Hanford Site from 1944 through 1990. The rods containing the fuel were dissolved in acid and the plutonium was extracted. During the first few years of operations, large amounts of radioactive materials–primarily iodine-131–were released to the air during this process. Once in the atmosphere, the radioactive materials were dispersed throughout eastern Washington and into neighboring states. The dominant direction of transport is to the northeast.

People who lived in the Columbia Basin and other areas of eastern Washington, northeastern Oregon, and western Idaho may have been exposed to the radioactive materials released from Hanford. The radiation dose to people could have occurred from a variety of pathways. Exposures to radioactive materials released to the air may have come from eating food containing radioactive materials, inhaling contaminated air or by direct exposure to radioactivity in soil or air.

The process for estimating doses from the atmospheric pathway began with estimating the amount of material produced in the reactors and transferred to the separations plants. This allowed for an estimate of the amount of radioactive materials discharged to the air from Hanford's separation plants. The concentrations in the air and deposited on the soil were then calculated. Once this was known, scientists determined the effects of environmental accumulation. Dose estimates were then made using lifestyle information for average or typical groups of people. Much of this work was done using computer models. The computer models were thoroughly tested to confirm they were reliable and valid. These tests are described elsewhere in this summary.

Scientists calculated doses to persons from radioactive releases to the atmosphere from a number of exposure pathways during the years 1944 to 1992. The dose calculations are for representative (or typical) persons in a 75,000 square mile area surrounding Hanford. This area extends from central Oregon to northern Washington, and from the crest of the Cascade Mountains to the eastern edge of northern Idaho. It is about 306 miles from north to south and 246 miles from east to west. The Project study area is shown in Figure 2 (page 10).

The principal radioactive material of interest released to the air is iodine-131. Figure 3 (page 11) shows the iodine-131 release estimates from the reprocessing plants from 1944 through 1951. Iodine-131 releases total nearly 730,000 curies during these years. As filtering systems were added, and then improved, the releases were dramatically reduced. Production processes were also changed to reduce the releases. Rough estimates made early in the Project showed iodine-131 would account for most of the radiation dose people could have received from Hanford.

Doses from iodine-131 releases for the maximum release years (1944-1951) are calculated for 12 age, sex, and lifestyle categories at 1,102 different locations. In addition, dose calculations were made for six radionuclides–strontium-90, ruthenium-103, ruthenium-106, iodine-131, cerium-144, and plutonium-239–for eight locations for the years 1944 through 1972. These six radionuclides make up 99

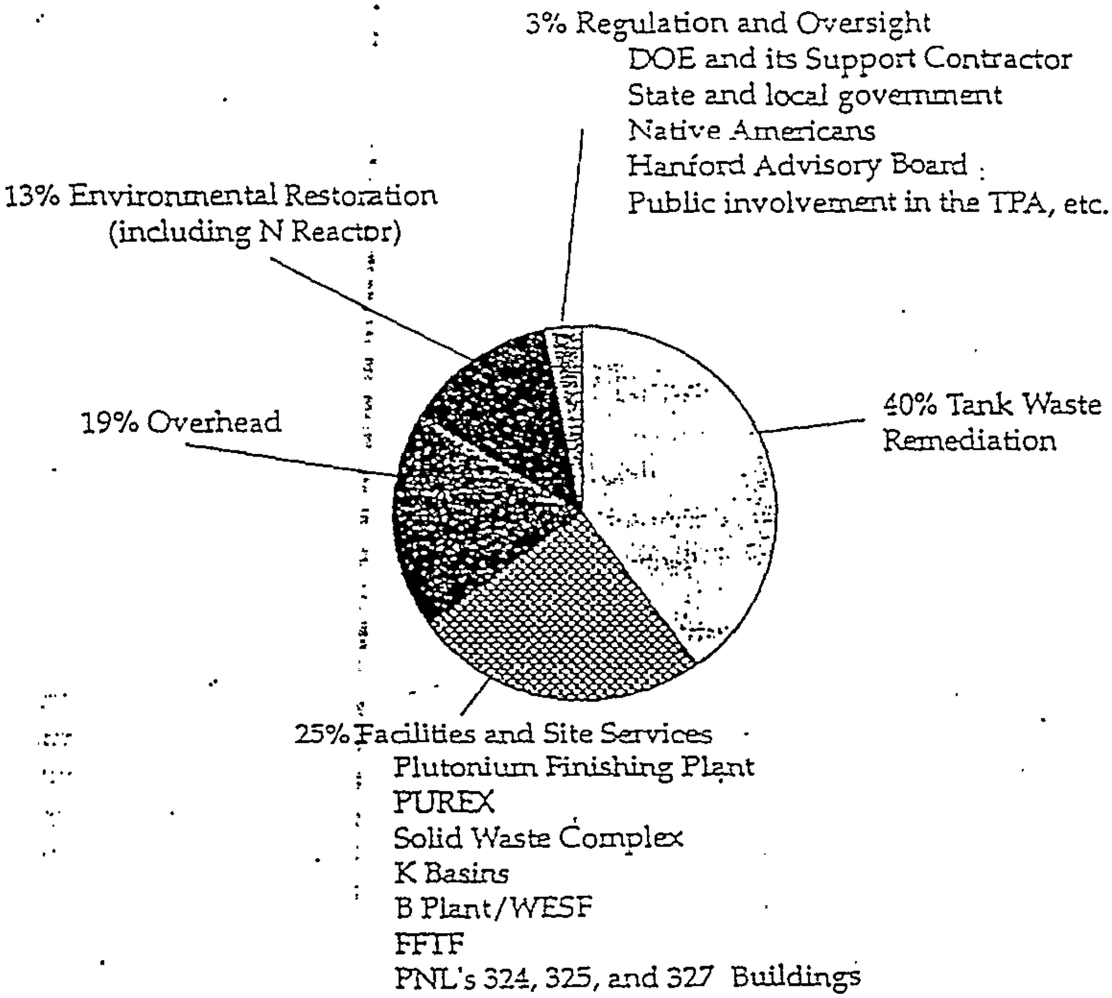
ENVIRONMENTAL MANAGEMENT

FY 1996 Congressional Request

RICHLAND	FY 1995 Adjusted /DP Trans	FY 1996 HQ Prelim Passback	Add'l Reductions: Productivity Efficiency	Add'l Reductions: HQ Reductns	Add'l Reductions: Pro Rata Reductns	Add'l Reductions: Contractor Reductions	Add'l Reductions: TOTAL REDUCTS	Revised FY 1996 Request	Program Adjustments	FY 1996 CONO REQUEST	Uncosted Balances	NET FY 1996 REQUEST	FY 1997 Target
Defense													
Waste Mgmt/Correc Act	967,861	950,696	—	—	(12,181)	(16,253)	(28,434)	922,262	11,762	934,024	(45,906)	888,118	779,561
Environ Rest	203,540	215,562	(24,000)	—	(2,439)	(3,255)	(29,694)	185,868	(12,414)	173,454	(10,313)	163,141	143,165
D&D Fund	0	0	—	—	—	—	0	0	0	0	0	0	0
Trans Mgmt	1,258	6,217	—	—	(81)	(108)	(189)	6,028	(2,217)	3,811	(292)	3,519	3,115
Facil Transition	237,655	239,687	—	—	(3,097)	(4,133)	(7,230)	232,457	(5,850)	226,607	(9,544)	217,063	190,607
Analysis Pilot & Risk	0	0	—	—	0	0	0	0	0	0	0	0	0
Compl & Prog Coord	8,892	9,990	—	—	(90)	(120)	(210)	9,780	16,091	25,871	(3,330)	22,541	19,268
Subtotal, Def	1,439,206	1,422,152	(24,000)	0	(17,883)	(23,869)	(65,757)	1,356,395	7,372	1,363,767	(69,385)	1,294,382	1,136,216
Non-Defense													
Waste Mgmt/Correc Act	11,897	9,411	—	—	(122)	(163)	(285)	9,126	3,238	12,364	0	12,364	10,902
Environ Rest	0	0	—	—	0	0	0	0	0	0	0	0	0
Facil Transition	62,724	55,343	—	—	(725)	(968)	(1,693)	53,650	5,850	59,500	(1,503)	57,997	50,916
Subtotal, Non-D	74,621	64,754	0	0	(847)	(1,131)	(1,978)	62,776	9,088	71,864	(1,503)	70,361	61,818
D&D Fund													
Environ Rest	0	0	—	—	—	—	0	0	0	0	0	0	0
TOTAL	1,513,827	1,486,906	(24,000)	0	(18,735)	(25,000)	(67,735)	1,419,171	16,460	1,435,631	(70,888)	1,364,743	1,198,034

SPECIFIC DIRECTION/NOTES:

- Assumes additional reduction in work force of 2,709 contractor employees
- Assumes implementation of prioritization options
  Transfer $15M from EM-40 to EM-30 to accelerate K-Basin efforts
  Re-prioritize least effective projects within EM-40 to get $15M
- Increase efficiency at Tank Farms and meet urgent risks
  Assumes some renegotiation with the State, but limit renegotiation on the EM-40 side
- Transferred $2,586K for EM-40 program direction from Headquarters to cover base program FTE expenses
  NOTE: An additional shift within the program dollars allocated is required to cover the FTEs allotted through the EM Pilot Program.



Hanford Site Budget — FY 95

Major Environmental Management Sites FY 1996 Budget Request

(Dollars in Thousands)

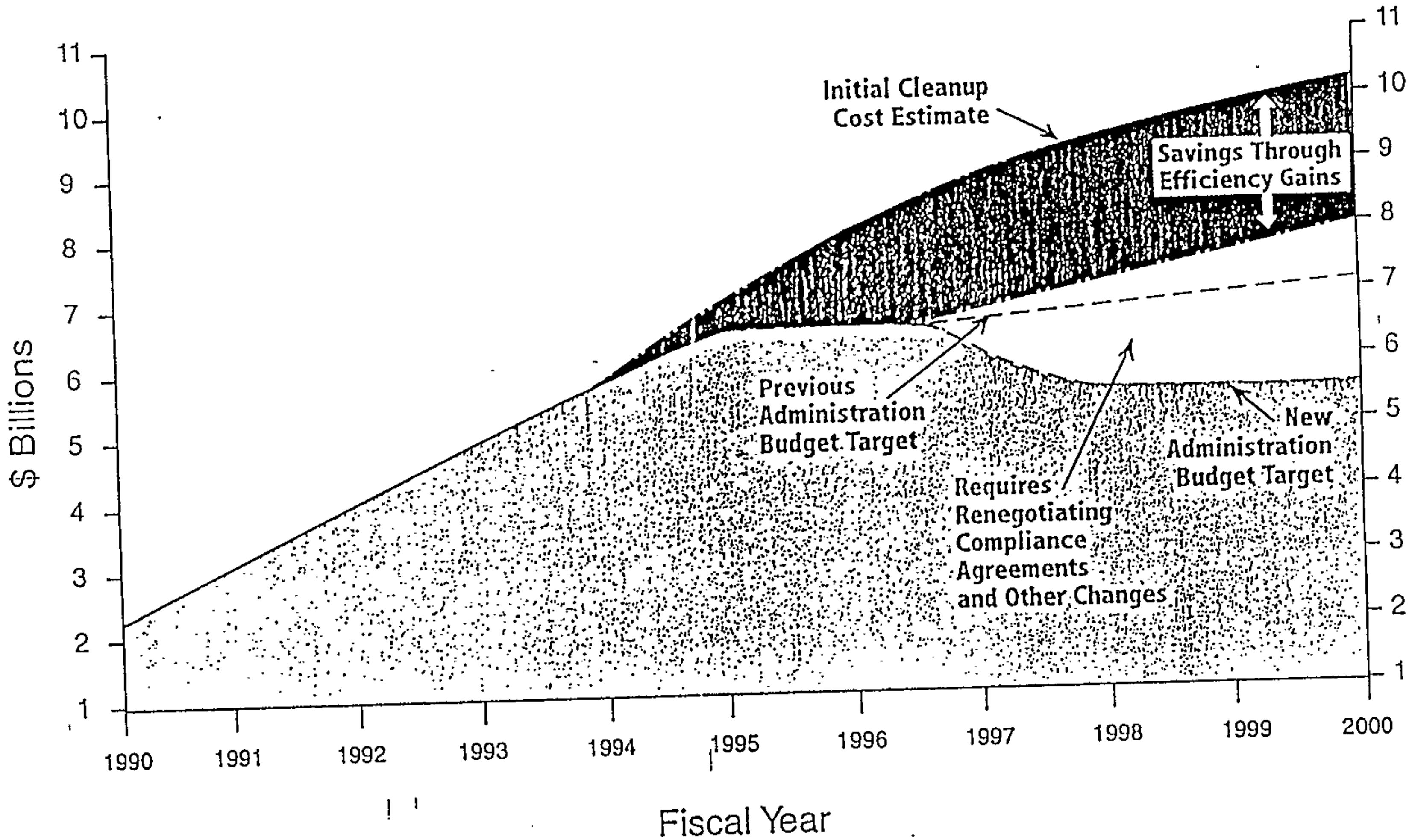
	Waste Management	Environmental Restoration	Nuclear Materials & Facilities Stabilization	Totals*	% Δ From FY 1995 Totals**
Hanford, WA	946,388	173,454	286,107	1,434,688	-16.3%
Savannah River Site, SC	553,757	104,163	686,146	1,344,352	89%
Rocky Flats, CO	97,978	147,753	393,804	639,918	3.4%
Idaho***	225,462	87,914	162,147	481,145	10%
Fernald, OH	0	256,330	0	256,330	-2%
Waste Isolation Pilot Plant, NM	172,700	0	0	172,700	-0.9%
Oak Ridge K-25 Plant, TN	60,472	16,725	630	160,461	-29.4%
Oak Ridge National Laboratory, TN	68,698	61,822	14,130	147,470	19.6%
Los Alamos National Laboratory, NM	64,309	64,804	6,824	135,995	-16.2%
West Valley Demonstration Project, NY	122,100	0	0	122,100	-2.4%
Mound Plant, OH	10,386	46,091	53,821	110,298	156.1%

* *Totals may also include funding for Transportation Management, Uranium Enrichment D&D Fund, and Program Direction. Technology Development site allocations are not reflected in the site totals. Technology Development funds will be distributed for FY 1996 after appropriation.*

** *Savannah River and Mound include large Defense Programs transfer amounts in FY 1996.*

*** *Excludes Argonne National Laboratory-West and Naval Reactors Facility.*

DOE CLEANUP WILL BE "REINVENTED"
Efficiency Improvements Have Already Achieved Large Savings



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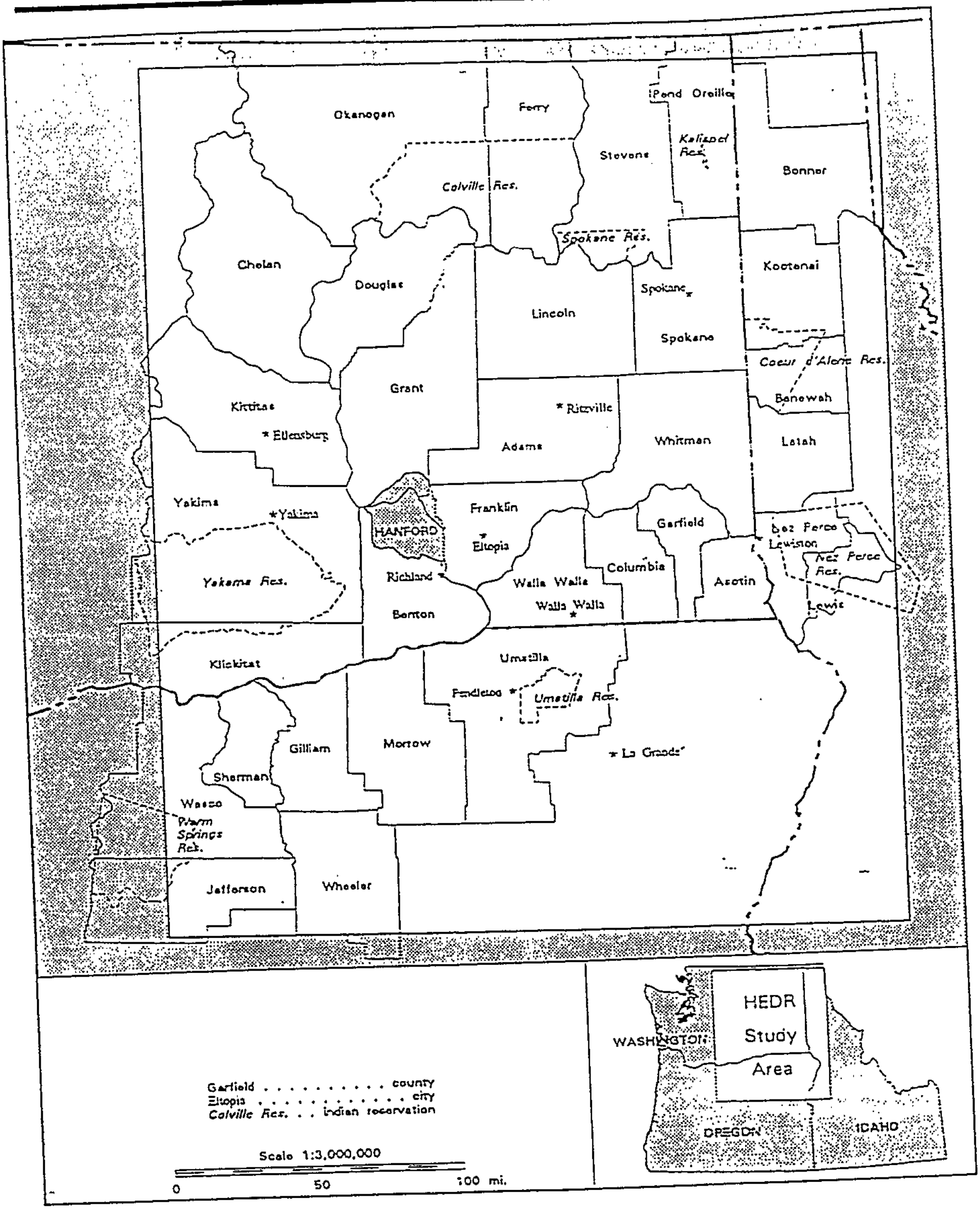

Figure 2. Project Study Area (Air Exposure Pathway)

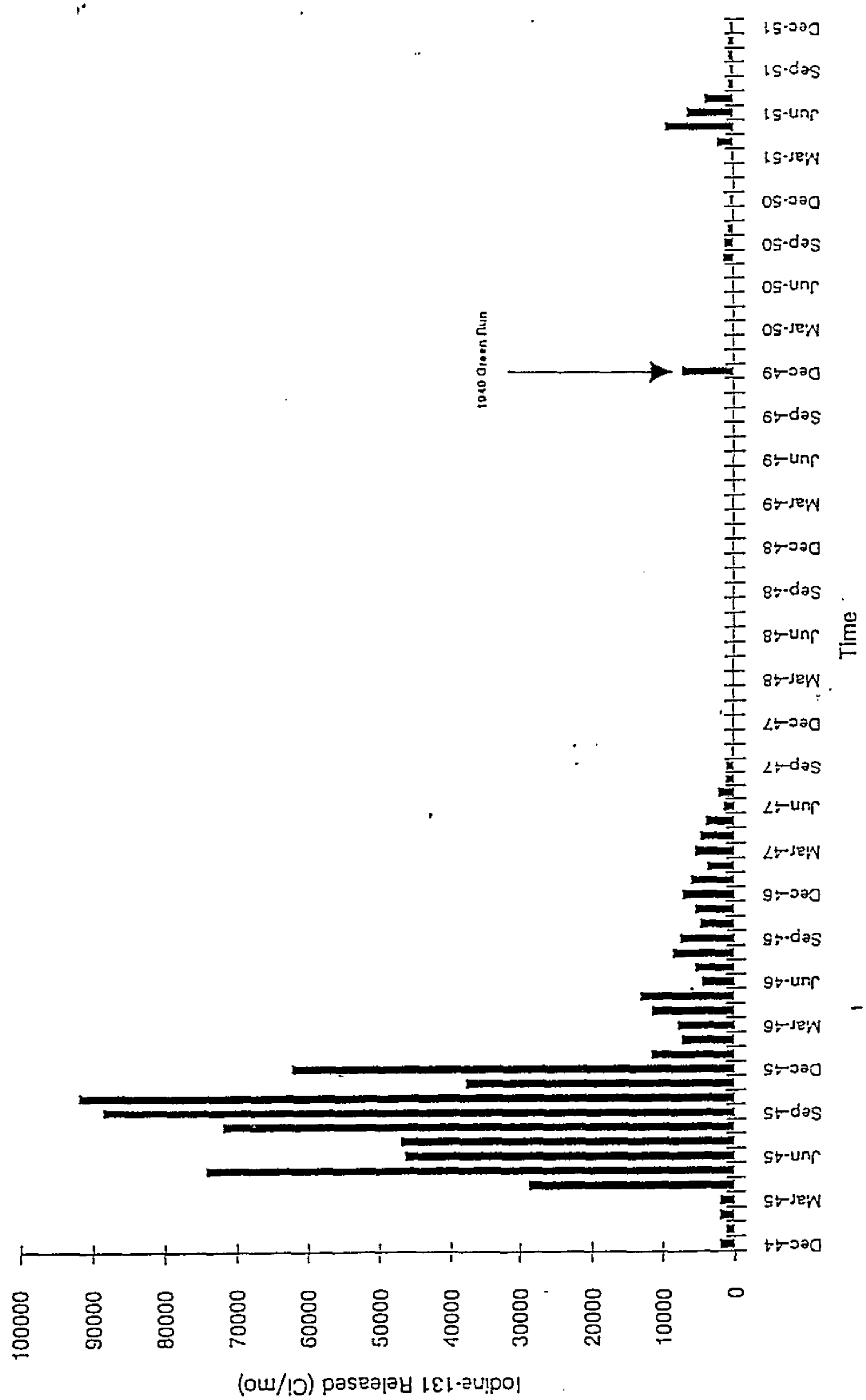

Figure 3. Monthly Iodine-131 Releases, 1944–1951

percent of the potential radiation dose from the atmospheric pathways. Previously published Hanford Annual Report doses were summarized to complete the dose history for the years 1973 through 1992.

Iodine-131 disappears within a few months of its release. That's because it decays rapidly–half decays every eight days, half of what remains in another eight days, and so on. Because iodine-131 transforms into an element that is not radioactive, within 80 days (10 half-lives) the radioactivity is basically gone.

Once the iodine-131 was released to the air, it traveled in the wind. As the iodine-131 traveled over land, some fell onto vegetation and the ground. During the growing season, iodine that deposited on pasture used by dairy cows and goats would have been eaten by the cows and goats. The iodine-131 went to their milk. The radiation dose to a person is, therefore, largely dependent upon the source of milk and the amount of milk consumed by the person.

Much of the radioactive iodine-131 consumed by people would go to the thyroid gland, an organ that needs iodine to function. After six days, about half of the iodine-131 absorbed by the thyroid gland still remains. Part of the loss results from radioactive decay, and part is from biological excretion processes.

The largest radioactive material releases to the air consisted of iodine-131 coming from the separations plants during the first three years of Hanford operations. Ruthenium releases were the next highest, followed by cerium-144, strontium-90 and finally plutonium-239 releases. Releases of tritium, carbon-14, and argon-41 from reactor stack gas systems and from reactor effluent cooling water were found to be very small.

Monitoring of Radioactive Materials from Hanford

Scientists studied environmental and emissions monitoring records to find out how much radioactive materials were released, and how and where they were deposited. Emissions monitoring began with the start-up of Hanford facilities in 1944. It consisted of measuring the amounts of radioactive materials vented to the atmosphere and released to soils and to the Columbia River. The technology to accurately measure atmospheric releases evolved for several years before measurements became reliable. Until then, releases to the air were estimated on the basis of production data and estimated filter efficiencies after filters were installed in 1948.

RECONSTRUCTING THE MILK SYSTEM

Pinpointing people's source of milk is an important part of estimating doses from Hanford radioactive material releases. Milk from a cow or goat that ate pasture grass in the downwind area would contain higher levels of iodine-131 than milk from cows pastured in less contaminated areas. Milk from cows that ate stored feed would also contain lower levels of contamination. Family cow and goat milk may yield the highest doses because it was consumed immediately by the owners or their neighbors. In contrast, milk produced commercially might be mixed at the creamery with milk from other, less contaminated areas. It also may not be consumed for several days after milking. This could result in a lower dose to the person who drinks the milk.

To answer some of these questions, it was necessary to reconstruct the milk production and distribution system near the Hanford Site in the late 1940s. Very few records remain from the dairy industry during this time. Scientists consulted dairy farmers, agricultural extension agents, dairy industry specialists from universities and employees of dairies operating during this time. They sought information on where dairies got their milk, where they sold it, and how much dairy farmers relied on pasture to feed their herds. The dairy system from the 1940s was reconstructed by putting together information from all these sources.

Environmental studies started before the Hanford facilities began operating. These consisted of meteorological measurements and observations of atmospheric plume behavior to predict the path of radioactive materials released to the air.

Environmental studies were expanded to include measurements of radioactive materials in the air, ground, vegetation, food, wildlife, Columbia River water, drinking water, sediment, fish, and other aquatic life. It was not until the mid-1950s, however, that the possibility of milk as a pathway for radioactive iodine was recognized. As a result, milk containing iodine-131, which resulted in radiation exposures of as much as 10 to more than 100 times more exposure than from breathing iodine-131, was not monitored during the period of highest releases of iodine-131 (1944 through 1947).

Air Pathway Computer Models

Each step in the dose estimation process involves the use of conceptual and mathematical computer models. These models are needed because there is not enough data about radioactive material concentrations in air, soil, vegetation, and foodstuffs for necessary locations and time periods.

Project scientists developed several computer programs referred to collectively as HEDRIC (Hanford Environmental Dose Reconstruction Integrated Codes) to estimate radiation doses and their uncertainties. HEDRIC consists of four collections of programs with well-defined interfaces. The programs, which must be executed in sequence, implement:

- a source-term model
- an atmospheric transport model
- an environmental pathways model
- a dose model.

The first part of HEDRIC consists of three programs that calculate the source term. These are the Reactor Model (RM), Do Iodine (DOI), and the Source Term Release Model (STRM). Collectively, these programs use information about the operation of Hanford's reactors and processing plants to estimate hourly releases of radioactive materials from the processing plant stacks to the air. Appendix 2 shows the annual summary of the six radioactive materials released to the air between 1944 and 1972 that are used in the dose calculations.

Unusual release events such as the December 1949 Green Run were included in STRM. This experimental release from the T Plant occurred when a dissolver was loaded with fuel that had been discharged from the reactor after an unusually short cooling time. The Green Run was conducted to measure how airborne radioactive materials spread. Filtering systems were bypassed to be sure that the release carried enough radioactive material to be measured. The Green Run accounts for about 7,000 curies of I-131 released to the air.

DEFINITIONS

Code–Instructions that tell a computer to do something. A computer program consists of code. When a reference is made to the project software consisting of 60,000 lines of code, it refers to the code contained in all of the programs in the Hanford Environmental Dose Reconstruction Integrated Codes (HEDRIC).

Program–A complete set of code. When you tell a computer to run a program it does something. HEDRIC consists of ten programs plus several data files.

Model–A mathematical formula, algorithm, or combination of them that can be used to predict the behavior of something in the real world. Reactor Model (RM) is a program (consisting of a few lines of code) that contains a model of how a reactor works. Battelle used RM to calculate the amount of iodine produced by the Hanford reactors.

The second part of HEDRIC is the atmospheric transport model. The model in RATCHET (Regional Atmospheric Transport Code for Hanford Emission Tracking) combines the radioactive material release information with observed meteorological data. It then calculates daily air concentrations and surface contamination throughout the Project study region. These estimates are made for over 2,000 locations within the Project study area on a daily basis.

The third part of HEDRIC is the environmental accumulation program, called Dynamic Estimates of Concentrations And Radionuclides in Terrestrial Environments (DESCARTES). DESCARTES is comprised of several environmental models, which together calculate concentrations of radioactive material in the environment and the food chain. Radioactive material transported through the atmosphere deposited on soil and plants, providing the possibility for human exposure and dose. DESCARTES uses the daily inputs from RATCHET to calculate estimates of the concentrations of radioactive materials in several types of vegetation, crops, and animal products. This calculation requires the input of extensive data about the agricultural production and distribution systems during 1944-1951.

Results provide the concentration in vegetables, grains, and fruits eaten by people and in plants (grass, alfalfa, silage, grain) used for animal feed. Animal feed concentrations are then used to determine concentrations in animal products (beef, venison, poultry, eggs, milk). Finally, the radioactive material concentrations in commercially distributed milk are calculated.

The fourth and last part of HEDRIC is a program called CIDER (Calculations of Individual Doses from Environmental Radionuclides) which calculates individual doses. It uses data from the preceding programs to estimate exposure and dose for people living within the Project study area.

The environmental accumulation models establish the concentrations of radioactive materials in environmental media and food products for all locations and times of interest. In the individual dose model, people are introduced into the calculation. The dose model calculates dose by four exposure pathways:

- submersion in contaminated air;
- inhalation of contaminated air;
- irradiation from contaminated surfaces and soils; and
- ingestion of contaminated farm products and vegetation.

The individual dose model is designed to calculate doses to reference individuals and real people. Annual and cumulative doses are reported. These are calculated as a sum of daily exposures from all sources. The person's movements about the study area may be accounted for, as well as his or her probable sources and quantities of food.

Distributions

For this Project, scientists felt it was important to consider differences in radiation doses that would result from differences in age, sex, lifestyle, food habits, geographical location, agricultural production, month, season, year, and other factors. To accomplish this objective, input data to the Project model consists of distributions instead of single-number estimates.

For example, instead of using one number to represent the amount of milk all people in the study area drank per day, the Project uses a distribution of amounts of milk that people–by age and sex–could have drunk. This approach accounts for variability and recognizes that actual milk consumption can range from none to more than a quart a day, and that a person often can't remember exactly how much milk he or she drank 45 years ago. The use of distributions enables the dose estimates to reflect differences in milk consumption.

Deposition Patterns

The total 1945 deposition of iodine-131 across the study area is shown in Figure 4 (page 15). This figure provides an example of the iodine-131 "footprint" or location of deposition. The figure is not intended to give an accurate representation of the iodine-131 concentration in the soil at any given time. It cannot be used to estimate doses. The figure shows the cumu-

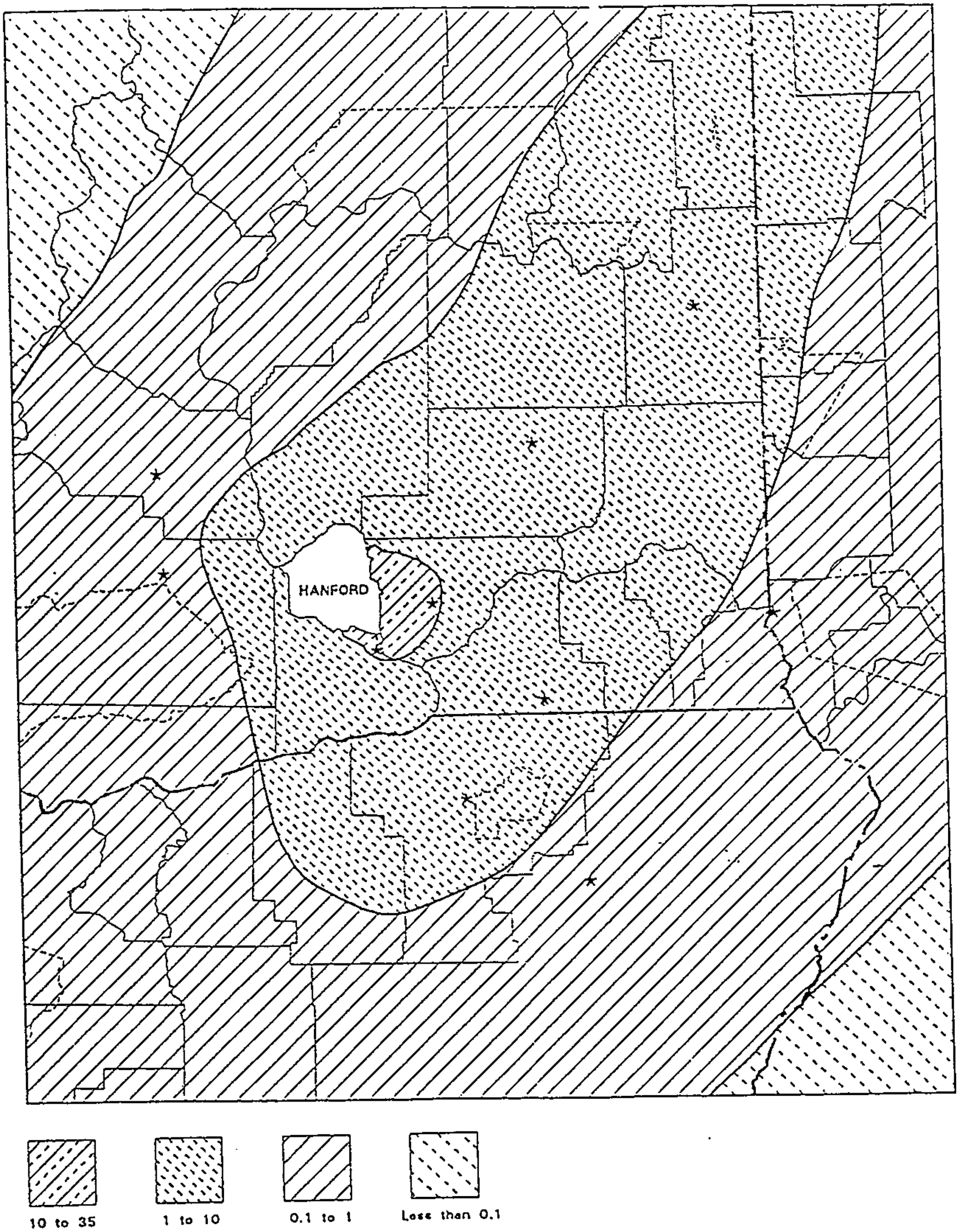

Figure 4. Cumulative Iodine-131 Deposition for 1945 (microcuries per square meter undecayed)

lative undecayed deposition at each location. Because iodine-131 is constantly decaying with an eight day half-life, the actual concentrations in surface soils would be less.

The figure shows that in general the iodine-131 is deposited to the northeast of Hanford. There is a slight southeastern component to the pattern as well. These findings are consistent with the prevailing winds in the region. Material released to the atmosphere at Hanford is generally transported from the site in a southeastern direction toward the Tri-Cities. It is then moved to the northeast with the continental winds.

The total amount of iodine-131 deposited in the project study area during 1945 as shown in Figure 4 is about 260,000 curies. This accounts for roughly half of the 555,000 curies estimated to have been released during that year. On average, 55 percent of the iodine-131 released from Hanford is estimated to have been deposited within the Project study area. Some 10 percent decayed during atmospheric transport within the study area. The remaining 35 percent was either deposited outside of the study area or decayed during atmospheric transport beyond the study area.

Dose Calculations

For a given person, the dose program calculates the radiation dose from a single radioactive material, iodine-131, at a single location. To calculate the dose at more than one location, the calculation is repeated for each location of interest.

Doses are calculated for people of various ages because an individual's dose response to a given intake amount changes with age. Dose factors are provided for several age/sex groups. Dosimetry for male and female children through about age 15 is essentially the same and is modeled as being identical; the only potential variable is the difference in food consumption by the sexes.

Doses from external exposure and inhalation are functions only of location and age. The model in the CIDER program uses equations that are commonly used in environmental dosimetry calculations. Project scientists determined that air submersion is a minor pathway.

For the purpose of estimating the dose to persons who were exposed to the atmospheric pathway, a set of representative persons was selected. The characteristics of these persons are intended to approximate those of selected segments of the general population.

There are a number of different factors that describe the characteristics of these representative individuals. The most important is diet. The dietary information used was derived from United States Department of Agriculture dietary data collected in 1977. Based on this diet and the knowledge that people generally consumed more milk, eggs, and vegetables and less beef and poultry in 1945 than in 1977, it was possible to estimate a typical diet in 1945.

The representative dose estimates were calculated using some general assumptions regarding the source of foods eaten and the type of feed provided to milk-producing cows. The dose from iodine-131 is highly dependent upon the amount of milk consumed and the source of that milk. The doses were determined to be the largest for persons consuming large amounts of milk from cows that were grazed on fresh pasture. Doses are much lower for persons who consumed less milk or whose milk was obtained from a cow that was fed stored feed. The milk from a cow that was fed stored feed is lower than that of a cow on fresh pasture because of the radiological decay of iodine-131 during the time the feed was stored.

Representative dose estimates were prepared for three general food source scenarios:

1) The person consumes foods grown in a backyard garden or farm. All foods including milk, leafy vegetables, other vegetables, fruit, grain, eggs, poultry and beef come from the same location at which the person lives. The cow that provides all the milk for this person feeds on fresh pasture.
2) Identical to the first except that the person obtains milk from a cow fed with stored feed.
3) The person consumes milk and leafy vegetables obtained from a local commercial source such as a grocery store or other market.

Columbia River Exposure Pathway

The Project estimated doses to persons who may have used the Columbia River as a source of drinking water or who ate fish or waterfowl from the river. Some dose could also have been received by swimming in or boating on the river. Doses may have also been received by persons who ate salmon which had migrated up the river or by eating shellfish from Pacific Ocean estuaries.

To calculate doses, scientists needed to know:

- the type and amount of radioactive materials released to the river from Hanford reactors;
- how radioactive materials were transported in Columbia River water;
- the accumulation of radioactivity in fish and waterfowl; and,
- people's diets and lifestyle.

> SOIL AND GROUND WATER
>
> From the time Hanford facilities first began operating, highly radioactive liquids were routed to underground storage tanks, and slightly less radioactive liquids were discharged directly to the ground in ponds, ditches, and engineered structures called cribs. Some of the radioactive liquids moved through the soils into ground water. Some, such as tritium, traveled in the ground water and reached the Columbia River. These radioactive liquids contributed very little to the much larger amounts of radioactive liquids that were routinely discharged into the Columbia River as part of the cooling water from the original reactors.

TSP and Battelle scientists estimated the historic releases of eleven radioactive materials to the Columbia River during the operation of Hanford's eight original reactors. These reactors operated at Hanford from 1944-1971. N Reactor, the ninth and last operating production reactor, recirculated water within its core and did not discharge directly to the river. N Reactor continued operation until 1987.

The use of river water to cool the reactors resulted in the release of radioactive materials to the Columbia River. Releases of radioactive materials to the ground resulted in smaller releases to the river.

Nineteen radioactive materials were initially examined to determine their significance to dose. Of these, five (sodium-24, phosphorus-32, zinc-65, arsenic-76, and neptunium-239) are included in the dose calculations because they contributed about 94 percent of the estimated dose to people (see Appendix 2). Six others (scandium-46, chromium-51, manganese-56, yttrium-90, iodine-131, and neptunium-239) were included in the source term estimates either because they were needed to validate the river transport model or they were of particular interest to the TSP. The other eight were considered not to have any significant impact on doses.

Columbia River water for use in cooling the reactors was pumped into a treatment plant. Chemicals were added to purify the water and help prevent corrosion of the piping and reactor tubes. The processed river water was then filtered and pumped into large holding tanks. From the tanks it was pumped to the reactor.

Radioactive materials were created when neutrons in the reactor core activated elements present in the cooling water and elements added during water treatment processes. Reactor neutrons also produced radioactive materials by activating elements in the metals used for process tubes and fuel cladding. The resulting radioactive materials were released in the cooling water discharged to the Columbia River.

During its brief passage through the reactor core (1 to 2 seconds), the water was heated to over 212°F in the highest-powered tubes. The hot effluent water was discharged from the reactor into holding ponds near the Columbia River. After cooling and allowing time for the shortest-lived radioactive materials to decay, the water was discharged to the river.

As the reactors operated, film deposits built up on both the tubing and the fuel elements. Plant operators periodically removed or "purged" the film buildup. Because the film contained radioactive materials, purges resulted in increased radioactive discharges to the river. But these releases were minor compared to routine operational releases and fuel-element failures.

Nearly 2,000 fuel-element failures occurred in the eight original Hanford reactors. A failure is a crack in the aluminum rod that contained the uranium fuel, allowing coolant water direct access to the fuel. Each failure resulted in the release of fission products to the water in the reactor. The reactor was shut down when a rupture occurred. Scientists found many records of ruptures in Hanford reports. The data was included in the source term, but contributed only a small amount to the total released.

River Monitoring Information

Extensive monitoring data are available to help scientists in their research. Discharges from each reactor were measured daily in 1964-1966. Weekly measurements were taken of river water at several locations. Drinking water was sampled at Richland, Pasco, and to a lesser extent, Kennewick. Several kinds of fish were sampled — especially whitefish — which could be caught year-round. Whitefish had among the higher concentrations of important radioactive materials, such as phosphorus-32. External radiation along the river bank from sediments containing radioactive materials were also measured.

However, even with these extensive records, it is not possible to make dose calculations for the river pathway based entirely upon historical monitoring data. That's because sampling was not done at every location along the river on a constant basis for radioactive materials of interest. Therefore, computer modeling was needed to fill in these gaps.

Columbia River Computer Modeling

The process of estimating doses to persons from the river pathway starts with estimating the amount of radioactive materials discharged to the Columbia River. This is the Source Term. The Source Term data provided monthly average releases from each of the eight reactors from January 1950 through January 1971. This was done by using reactor operating history and measurements of radioactive material concentrations, where the latter were available. The radioactive material releases were corrected for decay from the time of release from the reactors to the time of discharge to the Columbia River.

A distinct seasonal cycle is evident in the data. During late spring and summer the melting snow in the Cascades and Rocky Mountains increased the river flow, causing increased dilution of radioactive materials. Reduced Columbia River flow in the winter resulted in the maximum concentrations occurring at this time of the year.

Figure 21 (page 41) shows the annual releases of the five key radioactive materials used for dose calculations.

Using the source term estimates, scientists calculated the concentrations of key radioactive materials in the Columbia River water at several downstream locations (see Figure 22 page 42). This was done by simulating radioactive material flow and transport in the river.

A computer program called CHARIMA, which contains a river model, was used to simulate transport of specific radionuclides from the Hanford reactors to Portland, Oregon. The length of river considered extended from Priest Rapids Dam near Hanford to river mile 100, just downstream of the Willamette

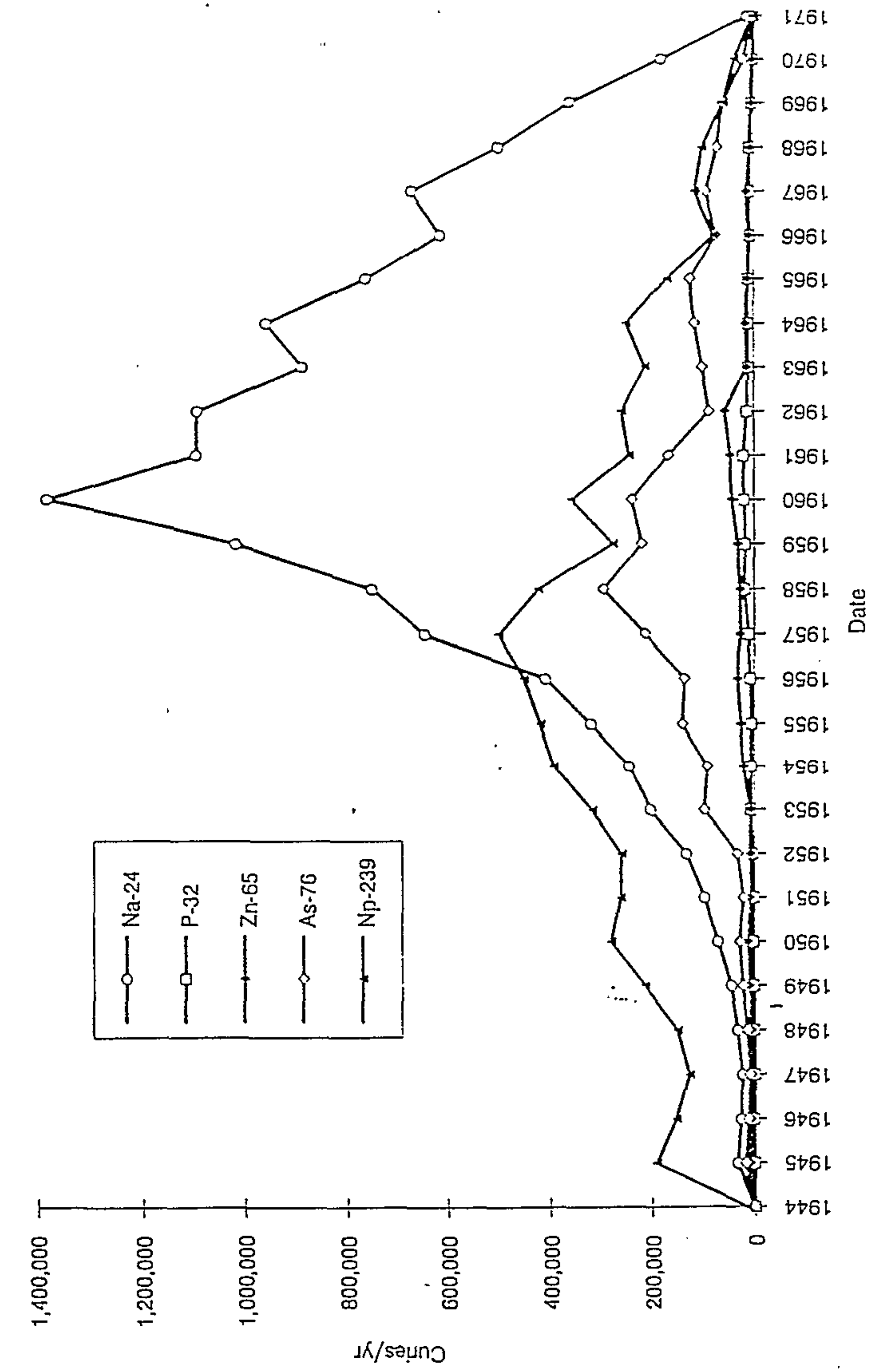

Figure 21. Key Radionuclides Released to the Columbia River by Year, 1944–1971

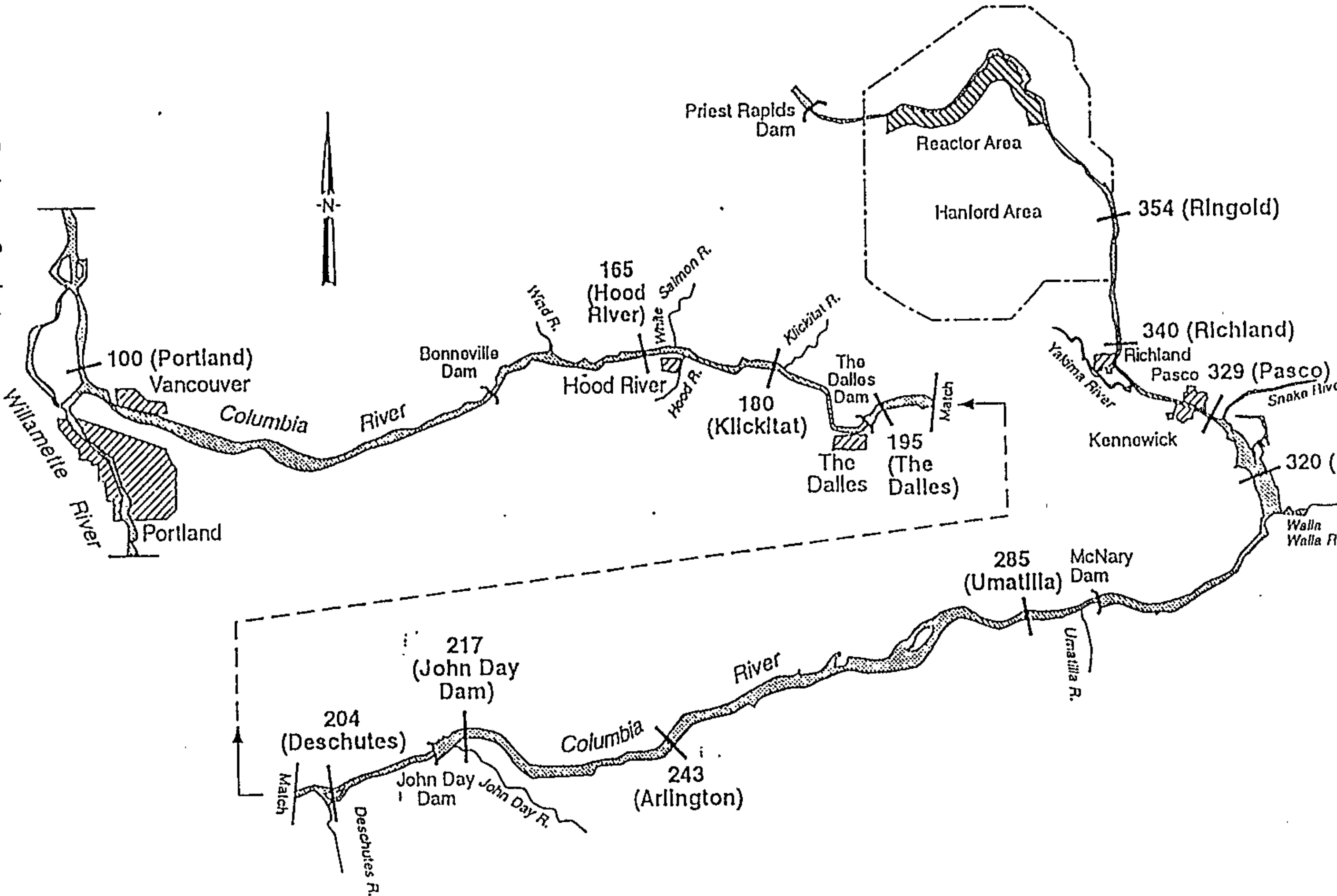

Figure 22. Columbia River Pathway Study Area

River confluence at Portland. The time frame spans a 21-year period from January 1950 through January 1971.

Monthly average water concentrations were reconstructed at 12 locations for sodium-24, phosphorus-32, zinc-65, arsenic-76, and neptunium-239. Concentrations for chromium-51 were computed to help validate the transport model, but were not considered significant for use in dose estimates. Where actual monitoring data were limited, concentrations were calculated by using measurements of releases from the reactors along with information about dilution in the river.

These water concentrations were then used to calculate dose estimates. Historical river monitoring data was used to validate computed water concentrations.

The CHARIMA program can account for tributary inflows, multiple channels within a river and the presence of dams and reservoirs. It also has the capability to route contaminants to any specified location.

The results of the modeling indicated that the five key radioactive materials can be separated into two groups, based on their transport characteristics in the Columbia River. The first group, radioactive materials with relatively short half-lives — sodium-24, arsenic-76, and neptunium-239 — was sensitive to downstream travel time. After dams were constructed below the Snake River, transport speeds were significantly reduced. The reduced flow increased the travel time and allowed more radioactive decay to occur. Downstream travel times were significantly increased after 1953 when the operation of McNary Dam began. The raising of the reservoir behind The Dalles Dam in March 1957 did not have as great an effect as McNary Dam, probably because of its proximity to the Bonneville Dam and reservoir. John Day Dam began operating in April 1968, and a reduction in concentrations was evident. Because of the dams, water concentrations for the three radioactive materials at downstream locations were much lower than they would have been under open channel conditions.

The second group — consisting of phosphorus-32 and zinc-65 — was not as much affected by dam construction because of their longer half-lives. Phosphorus-32 has a half-life of 14.3 days. Zinc-65 has a half-life of 245 days. These are long enough to greatly reduce the effects of travel time.

Major gaps in the information base were due to the lack of specific radioactive material concentration measurements before 1951 and the absence of monitoring data during some months. Missing data were reconstructed using statistical analysis of existing data coupled with modeling techniques.

Radioactive Material Concentrations in Aquatic Organisms

In order to estimate doses to individuals who ate fish or waterfowl taken from the Columbia River, scientists needed to estimate the radioactive material concentrations in those organisms. Several different approaches were used. Each approach relied heavily on historical monitoring data collected by Hanford researchers and by other State and Federal government agencies and universities.

The concentration of radioactive material in fish and waterfowl can be related to the radioactive material concentration in the water in which they live and feed. A large historical database of measured radioactive material concentrations in Columbia River fish, waterfowl, and water was assembled. This was used to develop bioconcentration factors specific for the Columbia River. These factors directly relate the radioactive material concentration in the organism to the concentration in the Columbia River water.

Waterfowl

Two types of ducks were included in this study — diver ducks that eat small fish and invertebrates, and puddle ducks that eat near-surface water plants and grain crops. Geese, which feed in a similar manner to puddle ducks, were included in this summary because historical data were available for them. No seasonal dependence was found in the historical sampling data. Therefore, the bioconcentration factors are for all seasons.

Shellfish

Zinc-65 and phosphorus-32 concentrations in shellfish near the mouth of the Columbia River were first detected in the 1950s. Information was compiled on phosphorus-32 and zinc-65 in shellfish for locations such as Willapa Bay, Astoria, Cannon Beach, Coos Bay, Seaside Beach, Tillamook Bay, and Agate Beach. Oysters generally contained higher concentrations of zinc-65 than did other marine organisms.

Salmon and Steelhead

Anadromous species (fish that live part of their lives in freshwater and part in salt water) such as chinook salmon, sockeye salmon, coho salmon, and steelhead trout travel up the Columbia River to spawn. Sockeye and other Pacific salmon species do not feed once they enter fresh water and head upstream to their spawning area. The fish rely on reserves of fat and protein stored up during their ocean residence to reach their spawning area.

Juvenile salmon and steelhead feed during their three to 24 month river migration downstream to the ocean. However, it is thought that anadromous species such as salmon and steelhead in the Columbia River took in radioactive materials primarily while feeding in the ocean. Fish in the ocean may have accumulated radioactive materials from both Hanford discharge and fallout from atmospheric testing of nuclear weapons. Information on 47 historical samples of salmon caught in the Columbia River show that 37 samples were below the minimum detection limit (0.1 picocuries per gram — pCi/g) for zinc-65. The rest of the samples varied from just above the detection limit to a maximum of 13 pCi/g. The median value for zinc-65 was 0.6 pCi/g.

The TSP determined that doses from salmon and steelhead should be calculated using two approaches. The first approach would be to use available monitoring data. The second approach assumed that the salmon spend their entire lives in the Columbia River and accumulate radioactive materials as do resident species. The second approach provided an upper limit for doses from ingestion of salmon and steelhead. It was used to estimate the uncertainty in salmon and steelhead doses. It yielded zinc-65 concentrations in salmon ranging from about 1 pCi/g to 100 pCi/g.

Standard dose assessment methods were used to translate the radioactive material concentrations in environmental media into the radiation dose that could have been received by a person. The environmental media of concern for the Columbia River pathway include treated and untreated drinking water, resident fish, waterfowl, salmon, and shellfish. The Columbia River Dosimetry Code (CRD) calculates doses for twelve specific river segments. The segment names and approximate locations are as follows:

1. Ringold (from below reactor areas to north of Richland)
2. Richland (from north of Richland to above the Yakima River)
3. Kennewick/Pasco (from below the Yakima River to above the Snake River)
4. Snake/Walla Walla River (from below the Snake River to McNary Dam)
5. Umatilla/Boardman (from below McNary Dam to near Arlington, Oregon)
6. Arlington (Arlington, Oregon area)
7. John Day Dam/Biggs (from John Day River to Deschutes River)
8. Deschutes River (Deschutes River mouth area)
9. The Dalles/Celilo (The Dalles/Celilo area)
10. Klickitat River (Klickitat River mouth area)
11. White Salmon/Cascade Locks (from White Salmon River to Bonneville Dam)
12. Lower River (from Bonneville Dam to Columbia River mouth)

Doses resulting from eating shellfish from Willapa Bay and from salmon and steelhead caught at any location in the Columbia River were also calculated.

Specific information relating to exposure must be supplied by each person for whom a radiation dose is to be calculated. The information to be supplied for use in the CRD program includes:

a. river use: swimming (hours/month)
b. river use: boating (hours/month)
c. untreated drinking water ingestion (Liters/month)
d. treated drinking water ingestion (Liters/month)
e. resident fish (omnivore) ingestion (kilogram/month — a kilogram is about 2.2 pounds)
f. resident fish (first-order predator) ingestion (kg/month)
g. resident fish (second-order predator) ingestion (kg/month)
h. waterfowl ingestion (kg/month)
i. Willapa Bay shellfish ingestion (kg/month)
j. Columbia River anadromous fish (salmon/steelhead) ingestion (kg/month)

APPENDIX G

THE RISKS AT HANFORD ARE REAL

APPENDIX G

THE RISKS AT HANFORD ARE REAL

DOE, as well as many other independent reviewers, clearly recognize that the DOE nuclear weapons complex poses a wide variety of risks and "clean-up" challenges.[1] These risks are characterized in terms of the source and severity of the risk, exposure pathways, and potential receptors. Among sites in the DOE complex, Hanford's problems are many and serious, and represent real risks to the surrounding communities, region, and nation that are unparalleled anywhere else within the DOE complex. Although the risks appear to be local, the potential impact from a catastrophic incident may have profound impacts to the region's international economy and agricultural base. Events such as the Chernobyl meltdown or the Tomsk tank explosion demonstrate that while distance dilutes awareness, knowledge, and concern about risks outside a commonly perceived area of influence, catastrophic events at one locale can have much more widespread, even global implications.

Historical releases from Hanford are traceable downstream along the Columbia River, spreading over hundreds of square miles of the Pacific Ocean, as far north as Canada and as far south as northern California, and downwind into eastern Washington, Oregon, and Idaho. Such demonstrated historical impacts only hint at the full spatial and temporal scope of future risk, if current myopic planning either dismisses or falls short of comprehensively identifying and addressing the full scope of potential risks. Outlining "real risks" to tribes, the public, site workers, and the environment necessarily combines toxicologic effects, risk perception, risk evaluation, qualitative values, and community or cultural impacts.

A. Risks from Hanford Nuclear Material Production Facilities

Significant risks to site workers and to the environment exist from aging nuclear materials production facilities at Hanford. Among these, for example, is the Plutonium Finishing Plant, which now stores approximately 11 metric tons of special nuclear materials[2] in a variety of chemical forms. Many of these materials are not in a physically or chemically stable form that would permit safe long-term storage, and currently represent a particular risk to workers at the plant. Significant quantities of plutonium also exist in the ventilation ducts of the plant and represent a significant source of concern for release to the environment, particularly because this antiquated, above-ground repository does not meet even minimal seismic safety standards. Potential for release of radioactive contaminants through ventilation ducts and other vectors also exist for many other processing plants including PUREX, Redox, T-Plant, and B-Plant.

Other hazards also exist owing to the aging state of nuclear production reactors along the river. In recent years, the condition of these facilities has deteriorated to the point where site workers have been injured, one fatally. Ironically, considerable sums must be spent to maintain and even upgrade structures slated for eventual removal.

B. Risk from Hanford Tanks

Hanford tank wastes have long been recognized as one of the most significant problems faced by DOE anywhere in the nation. Current Hanford tank wastes are complexly mixed combinations of reactive or poorly compatible constituents, unlike the more uniform composition of tank wastes at Savannah River, for instance. Their poorly understood, but continuing chemical and physical evolution poses numerous safety problems including episodic flammable gas releases ("burping"), high heat generation, and criticality potential.

Several years ago, safe storage of these high-level radioactive and mixed wastes became such a concern that Congress passed a law designating certain tanks as "watch list" tanks[3] because of the potential for uncontrolled release of radioactive and hazardous substances or other health and safety hazards. Any catastrophic release could be expected to fatally injure many site workers, severely impact offsite populations for a considerable distance, adversely affect the Columbia River ecosystem in a complex, accumulating manner, and render an unknown area uninhabitable and an even larger region unfarmable long into the future. In addition, Hanford's single-shell tanks have greatly exceeded their design life and continue to fail at an average of about one per year, allowing highly radioactive wastes to leak into the soil and further contaminate the vadose zone, groundwater, and the Columbia River.

C. Risks from Hanford Spent Nuclear Fuel

Nearly 80% of the spent nuclear fuel from throughout the DOE complex is stored at Hanford. Of the over 2100 metric tons of spent nuclear fuel stored at Hanford, most is now located in the K-East and K-West basins in very close proximity to the Columbia River. The K-East basin is an acknowledged leaker releasing very high concentrations of tritium into shallow groundwater that quickly reaches the river; leaks are concentrated at unreinforced joints in the huge concrete basin. An earthquake comparable to recorded historical events might cause catastrophic failure of the basin that would rapidly release large volumes of tritiated water and other contaminants to the soil, groundwater, and the Columbia River. The unencapsulated and poor condition of the bulk of the fuel in the K-East basin in particular and deterioration of the fuels cladding and the fuel itself have raised major concerns about long-term stability and a safe long-term storage configuration owing to the fuel's pyrophoric nature.

D. Risks from Past Hanford Disposal Practices

Historical disposal practices at Hanford have created widespread areas of extensive contamination in both the soils and groundwater across the Hanford Site. Concentrations of contaminants in the environment greatly exceed established regulatory standards and risk levels. Hazardous chemical substances, including carbon tetrachloride, trichlorethylene, chloroform, and hexavalent chromium, have been identified in Hanford groundwater at concentrations as much as

1,000 times applicable health and environmental standards. Radioactive contaminants, including uranium isotopes, strontium-90, tritium, and technetium-99, also exceed risk-based standards (where they exist) in soil and groundwater across the Hanford Site. The extent of contamination continues to expand, and the failure to act creates ever more difficult control, containment, and "clean-up" challenges.

Previous treatment efforts directed at increasing tank storage capacity and separating and removing the principal radioactive and thermal heat generating materials during the 1950s and 1960s resulted in the encapsulation of several thousand cesium- and strontium-compound capsules. Individual capsules measure only about 2.6 by 21-inches and hold about six pounds, but contain about 50,000 Curies of radioactivity each. To put it in perspective, the more than 2200 cesium capsules now stored in Hanford's Waste Encapsulation and Storage Facility now contain more radioactivity than the approximately 45 million gallons of high-level waste contained in all 149 single-shell tanks. These 2200 capsules comprise far less than 1% of the total waste volume now present at Hanford, but alone account for more than 39% of total radioactivity in surface wastes (excluding that in soil and groundwater). These materials must be kept safely shielded and cooled for hundreds of years.

E. Risks to Communities and Cultures

Risks to communities and cultures are widespread, but much more difficult to quantify. As such, they are often dismissed or belittled by the "experts" as simply uninformed opinion, "outrage," or "perception." But to affected communities and the ecocultural landscape, risks to the health and safety of the Columbia River ecosystem and its resources threaten traditional tribal subsistence lifestyles, spiritual beliefs about the sanctity of nature and the environment, long-term survival, and the very basis and future of tribal culture, spirituality, and tribal identity.

Human health and ecological risks are important measures, but only one aspect, of risks impacting unique and disappearing indigenous cultures of North America. For example, risks associated with transportation of hazardous chemical and radioactive materials across tribal reservations, not only along highways and railroads, but also along culturally significant, treaty-protected corridors such as the Columbia River, are an especially grave concern. In fact, such risks will increase considerably given the Federal Facilities Compliance Act requirements for treatment and disposition of mixed wastes and current DOE planning strategies, regardless of whether one or fifty such facilities are built.[4]

If a permanent geologic repository is ever constructed, massive transportation campaigns of unprecedented volume, frequency, and duration will shuttle high-level wastes disproportionately to, from, and through Indian lands around the country, but especially in western states. Such risks threaten the very land and natural and cultural resource base that is the core of tribal cultures and communities, and threaten cultural extinction if that essential land base and spiritual center of tribal culture and identity is irreparably damaged.

F. Risks through Time

The risks extending through time and the risk of doing nothing now pose among the greatest and most underappreciated threats to human health, the environment, and cultures and communities from DOE facilities and activities. Too many political leaders and even technical managers are disturbingly willing, even anxious, to bury their heads in the sand and pass on a legacy that will increasingly threaten future generations by arrogantly and unjustifiably discounting their value and prejudicing their options. In government at many levels these days, there is excessive focus on only the immediate crisis at hand (cost), and this narrow focus tends to lead to just as narrowly framed, poorly conceived, and short-sighted actions that will not stand up to the test of time. *The impacts or risks through time and the risk of doing nothing or doing only as little as possible now must comprise central elements of any truly comprehensive and politically supportable risk evaluation strategy. Otherwise, the true long-term risks, costs, and benefits of current risk management and remedial decisions for addressing dangerous, long-lived, mobile, and environmentally persistent contaminants, conditions, and their potential impacts to communities simply cannot be understood in any comprehensive or defensible manner.*

For example, existing contamination in the soil and groundwater at Hanford--some estimates indicate that's where 99% of it is--will spread much more extensively, intermix in unknown ways, and greatly increase from current discharge levels into the Columbia River for thousands of years into the future. Such threats will pose ever greater risks to humans, via concentrated uptake into biological systems and the resources upon which humans depend. Much larger land and resource areas than now necessarily will have to be placed *off limits* to control dose levels and exposure pathways for periods of time that challenge conventional political planning processes. Fences or other institutional controls do nothing to remove or reduce this threat, either now or in the future, and will effectively "institutionalize" the threat. In the end, whether paid for *now*, or *later* with much more expensive dollars and much more extensive and complex remedial efforts required, or *never*, the true costs to both the public and the federal government in terms of remediation and especially adverse health impacts in the future will only grow geometrically with further inaction now.

The responsibility of the current generation of American Indians to future generations is a core cultural value not widely shared by the non-Indian community. This fundamental difference results in an Indian perspective that is fundamentally focused on minimizing long-term, accumulating, multi-generational impacts, whereas perspectives of the dominant society are far more narrowly focused on only the here and now. Hence, within such narrow perspectives, the dominant society can easily discount or dismiss far more profound future impacts. Simply because such impacts now may be poorly characterized, they are, nevertheless, fully recognized, and their more pernicious, long-term effects are too easily dismissed by short-sighted decision makers because they might be "costly" or affect "progress."

Notes

1. *Closing the Circle on the Splitting of the Atom, The Environmental Legacy of Nuclear Weapons Production in the United States and What the Department of Energy is Doing About It:* U.S. Department of Energy, Office of Environmental Management, January 1995.

2. Special nuclear materials include enriched uranium, plutonium, and other isotopes that have value in weapons production. While considerable debate still surrounds this issue, these materials are still considered assets--not wastes--by the U.S. government at the present time, severely complicating their ultimate disposition.

3. As of December 1994, 54 of Hanford's 177 tanks are on the "Watch List;" 10 of these are on more than one "Watch List." (Source: Hanlon, B.M., *Waste Tank Summary for Month Ending December 31, 1994*: Westinghouse Hanford Company, WHC-EP-0182-81, February 1995.)

4. See attached figures outlining current mixed waste inventories by state and intended disposition (from training course on Federal Facilities Compliance Act).

Table 1. Volume of Mixed Low-Level Waste (by State) and Proposed Treatment Locations.

Inventory plus 5-year projected generation in cubic meters (m^3)

STATE	DOE WASTE TREATED IN STATE	STATES RECEIVING WASTE FROM OUT-OF-STATE DOE SITES									TREATMENT LOCATION NOT SPECIFIED		TOTAL
		CO	FL	ID	NM	SC	TN	TX	UT[3]	WA	INVENTORY WASTES	WASTES NOT YET GENERATED	
California [1]	1,067.9	2.4	4.7	44.4	9.9		0.7	3.7	3.5	245.4	36.3	22.5	1,441.4
Colorado	16,251.1	—		931.8	659.8		142.6			203.7	0.0[2]		18,189.0
Connecticut						7.0				7.3			14.3
waii	0.5									2.2			2.7
Iowa							0.3			0.0[2]			0.3
Idaho	26,721.2			—			8.9						26,730.1
Illinois	107.8						11.6		26.4	29.5	0.1	1,512.8	1,688.2
Kentucky							588.1			161.8	116.8		866.7
Maine	0.2									0.6			0.8
Missouri	1,774.8	0.5					60.1		0.4	1.7			1,837.5
New Jersey	14.7										24,480.0	5.5	24,500.2
New Mexico	965.4		4.5		—		9.3		8.2		269.9		1257.3
Nevada	4,160.0		0.2								2.7		4,162.9
New York	9.8					13.7	13.7	4.0	5.7	42.3	76.6	31.1	201.9
Ohio	14,313.3						840.9		471.5	13.5	273.2	25.0	15,937.4
Pennsylvania	0.1			0.2		1.1				14.9			16.3
South Carolina	5,688.8			7.7		—					2,902.8	675.6	9,274.9
Tennessee	25,579.9						—		586.5		9,871.0	0.2	36,037.6
Texas	285.4		0.0[2]				9.4	—	5.8			—	300.6
Virginia	1.0			2.5		0.5							4.0
Washington	122,964.6						45.4			—	48.9	105.3	123,164.2
STATE TOTALS	219,906.5	2.9	9.4	986.6	669.7	27.3	1,731.0	7.7	1,108.0	722.9	38,078.3	2,378.0	265,628.3

DSTP options summary database as of August 22, 1994

Volumes for California waste do not reflect the latest DSTP for Lawrence Livermore National Laboratory.

2 Less than 0.05 cubic meters of waste.

3 Some waste proposed may not require treatment.

from Slovic, P., 1987, Perception of risk: Science, v. 236, p. 280-285.

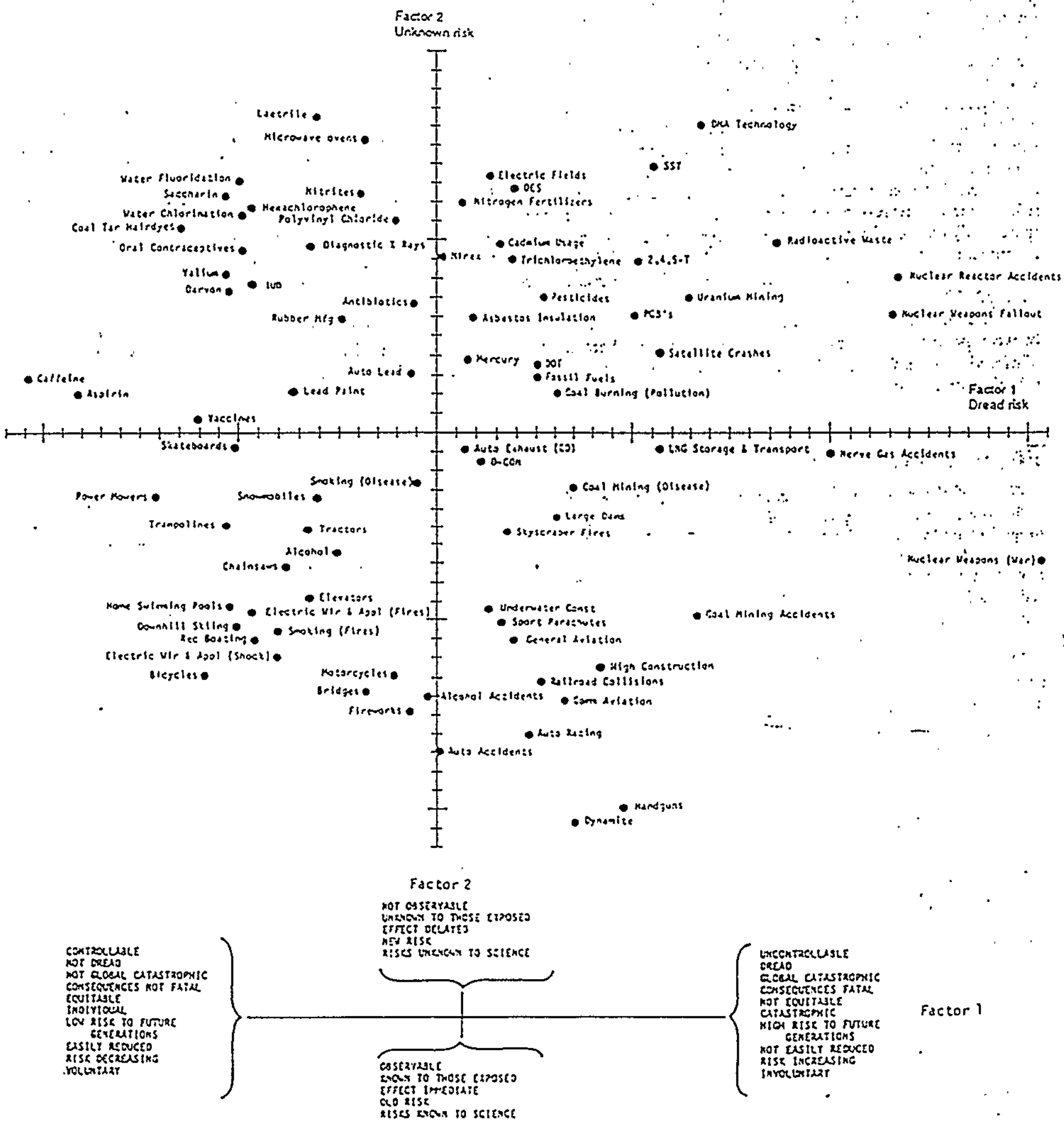

Fig. 1. Location of 81 hazards on factors 1 and 2 derived from the relationships among 18 risk characteristics. Each factor is made up of a combination of characteristics, as indicated by the lower diagram (25).

APPENDIX H

LIMITATIONS OF CONVENTIONAL RISK ASSESSMENT

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LIMITATIONS OF CONVENTIONAL RISK ASSESSMENT

Risk assessment methods comprise an increasingly common tool used to support remedial action decisions and a wide variety of other environmental planning and management decisions by numerous federal and state agencies. Conventional risk assessment methods, however, deserve close scrutiny both for its technical merits and limitations and for the political implications of its use as a decision-making tool. Risk assessment is often praised for its ability to quantitatively characterize, and thus support ranking or prioritization of actions necessary to eliminate, control, or 'manage' risk. But it is plagued nonetheless by a number of inherent limitations in its ability to reflect cultural or other social values--such as those of American Indian tribes--that are not easily quantified, numerically simulated, or modeled. Regardless, *assessing the full scope of risk remains a highly subjective matter, which necessarily includes qualitative attributes, cultural factors, personal biases, and subjective judgements.* No true or comprehensive characterization of risk can ignore such considerations, if it seeks credibility and tribal/public acceptance.

The following set of bullets summarizes a wide spectrum of concerns expressed by diverse interests over the inherent limitations of conventional quantitative risk assessment. This list should in no way be considered comprehensive or complete. Some concerns are narrow technical issues related to various steps of the risk evaluation process. Others are much broader, overarching concerns about how risk assessment--particularly in light of its inherent limitations--is used in the political decision-making process of a democratic society.

- Risk alone should not predominate the decision-making process.
- Focusing on quantitative aspects of risk *does not provide enough information on the qualitative aspects*, such as anxiety about the future, involuntariness of exposure, and equity concerns.
- Risk assessment and the comparative risk model are *not solely "science-based"* but incorporate *judgements* and *values* and are limited by a *high degree of uncertainty*. These elements should be, but commonly are not, explicitly acknowledged.
- Comparative risk projects *often neglect the public participation and social/cultural values* needed to make good decisions about environmental priorities that will be supported by affected parties.
- Risk assessment does not and indeed *cannot* consider *cumulative and indirect impacts* over either time or space. Risks from multiple or successive hazardous actions or chemicals are additive, and the risk slate is not wiped clean with each new generation: *impacts accumulate*.
- Risk assessment *ignores the interdependence of various elements of ecosystems*.
- Risk assessment examines contaminant impacts to a hypothetical "average" person, which either *ignores or facilitates victimization of disproportionately affected population segments*.
- Risk assessment, under current regulations, *consciously permits and justifies toxic releases* that

will result in the random murder of one in every ten thousand to one in every million citizens, without either their knowledge or consent.

- Risk assessment is *inherently anti-democratic*, because the complexity of the process requires "expert" understanding, judgement, and resources beyond the capabilities of normal citizens.
- Decisions to permit toxic discharges assume that *chemicals are innocent until proven guilty*. Significant and demonstrable harm must occur to health or environment *before* any regulation or discharge reduction requirements will be considered--a time- and resource-consumptive process--by which time irreparable damage may have occurred.
- Risk assessment *assumes that some "safe" or "insignificant" level of exposure to toxic chemicals exists*, which can be singularly and quantitatively determined.
- Risk assessment examines only *one chemical and one exposure pathway at a time*. Hence, any additive, synergistic, or cumulative effects of multiple contaminants and/or other conditions, either in humans, other organisms, or the environment, are ignored.
- Risk assessment is generally *conducted only for current conditions*; it fundamentally ignores both the past history that has led to current conditions and the changing conditions and associated risks in the future. The element of time is especially critical for long-lived, highly mobile, or environmentally persistent contaminants.
- Risk assessment assumes that *specific toxicity levels* can be determined in a laboratory, under controlled conditions, to cause specific health effects and then unquestioningly extrapolates such values to *highly variable natural conditions and environments*.
- Risk assessment assumes that *scientists fully understand* all important factors influencing the environmental fate and transport of toxic chemicals, current or historical dose levels, exposure pathways, and duration, which then can be "accurately" calculated, the full range of human or ecological response to toxics, and diverse impacts to biological systems, bioaccumulation factors between ecological trophic levels, and specific health effects to humans or other organisms. Effects that are not known, suspected, or studied are not included.
- Hazardous elements or other factors not quantified or not easily included in a standard risk analysis are generally treated as "zero" in the computations, often without justification or acknowledgement.
- Risk assessment *encourages ranking or prioritizing, rather than focusing on solving environmental problems*, either explicitly or implicitly indicating that some problems are "more important" than others and/or that some problems can just be ignored.
- Risk assessment *does not identify or assess a full range of reasonable and desirable alternatives* to toxic releases or leaving existing contamination in place, but rather, simply *defines levels of acceptability* while justifying new or existing pollution up to designated levels.

As outlined above, conventional risk assessment commonly asks narrowly defined questions such as, "How much of each particular toxin can the environment or organisms, including humans, be exposed to or assimilate without causing damage?" rather than broader questions such as "What options do we have to best repair and/or minimize the amount of damage that human activities do to the environment and other organisms?" The nature of questions asked dictates the narrowness or breadth of the scientific investigations conducted to answer these questions. The results may have enormous political and societal impacts, especially because some groups inevitably will be more affected than others. Such inquiries are in fact intimately intertwined with the political process. They should not, however, be allowed to substitute for the need to weigh and make tough political choices or default to the so-called "panel of experts" approach that only facilitates insulation from political decision making and from those activities that affect people's lives and their communities.

Even though quantitative risk assessments typically back their analyses with seemingly objective, authoritative, and rigorous numerical analyses, these 'analyses' often mask huge areas of ignorance. Often, the lack of pertinent data or knowledge requires adopting many wide ranging assumptions at any step in the process to fill in the holes or data gaps. This in turn induces a high degree of uncertainty in the analyses and results, which makes definitive conclusions difficult to defend. A detailed and critical examination of the sources or basis of such numerical values and analyses is always required so that the validity, accuracy and representativeness of such values is scientifically defensible. Blind reliance on seemingly objective and authoritative numbers whose origin is uncertain or even questionable may give an unjustified and unwarranted appearance of fact, precision, and certainty that is in fact baseless.

Interpretation of these numerical results then requires subjective judgement and is profoundly influenced by personal or cultural biases, whether recognized or not. Typically, such judgement has been left to the so-called "technical experts," but increasingly, informed citizens and other community members have rightfully demanded to be included in risk-based decision making. Risk-based decision-making can only be politically effective if it is based directly on community values, needs, and impacts, and if it is directed toward actually addressing and resolving community-identified risks. After all, it is these groups that are most affected by risk-based decisions to allow toxic discharges into the environment at certain levels or to "clean-up" risky sites contaminated by environmentally unsound disposal practices only to certain levels. How clean is clean (enough)? Well, it surely depends on whether or not you're affected by it, and whether you believe, in a democratic society, that people have the right to participate in decisions affecting their lives and the future of their children.

APPENDIX I

MODELS OF INTEGRATED/HOLISTIC ENVIRONMENTAL MANAGEMENT

APPENDIX I

TOWARD HOLISTIC/INTEGRATED ENVIRONMENTAL MANAGEMENT

A. Overview

This section highlights a number of recently completed efforts that directly confront recognized problems and limitations with conventional risk assessment methodology. Each attempts to establish criteria and process(es) that provide a sufficiently comprehensive information base to support credible, technically defensible, and politically acceptable risk management and remedial decisions.

Several states and a tribal organization recently have been funded by EPA, DOE, and other funding mechanisms to experiment with developing new risk evaluation paradigms to help alleviate the common deficiencies of conventional risk assessment. These efforts attempt to more comprehensively understand and compare the true costs, benefits, and risks of environmental compliance and management in times of tightening budgets; some also attempt to prioritize. Other independent efforts also are highlighted, including several specific to Hanford site needs and interests.

B. Models of Comprehensive Risk Evaluation and Holistic Environmental Management

Nine different forums that explore comprehensive risk evaluation and holistic environmental management are highlighted below; they are by no means exhaustive. These include the Blacksburg Forum, the Vermont Comparative Risk Project, the Wisconsin Tribes Comparative Risk Project, and the California Comparative Risk Project, and five Hanford-specific forums, Values-Based Risk Evaluation, the Hanford Future Site Uses Working Group, the Hanford Tank Waste Task Force, the Hanford Environmental Dose Reconstruction Project, and the Native American Working Group.

Each of these efforts has developed an innovative approach to characterizing risk and/or developing environmental priorities that are built upon meaningful and comprehensive tribal/public participation throughout the process and firm incorporation of social, cultural, and aesthetic values directly within their evaluation methodology. Each, however, has depended upon a combination of science, an upfront awareness of the critical role of perspective and uncertainty, and the combined judgement (recognizing its subjectivity) of scientists, citizens, and other community members. Some have concentrated on risks alone, whereas others have started with priorities and recommendations or a mixture of risks and priorities, but many common themes emerge.

New conceptual frameworks, methods, criteria, and measures either have been identified, experimented with, or further refined in each of the various approaches. Each effort culminates in a largely qualitative evaluation, but individual analyses are based on rigorous and systematic quantitative data to the maximum extent that data availability permits. Moreover, all forums independently agree that true risk cannot be accurately and comprehensively characterized--and hence broadly accepted risk evaluations result--without an overarching holistic perspective and breadth of data that fundamentally recognizes and incorporates values and qualitative measures of risk into integrated environmental management strategies.

1) Blacksburg Forum

The Blacksburg Forum (1991) was convened as an outgrowth of ongoing communications problems between DOE, American Indian tribes in the Hanford region, and state representatives in the State and Tribal Government Working Group (STGWG). This forum sought to integrate differing perspectives, problems, and solutions to effective environmental management. Success required emphasizing the fundamental importance of values, the essential need for an overarching philosophy or vision and consistency of purpose, an intimately interrelated judgement process that blends holistic and analytic thinking, and the need to seek desirability rather than simply acceptability. The resulting report outlines "three perspectives [that are] important to building an integrated comprehensive approach to managing the environment--technical, institutional, and cultural."[1]

> "The technical perspective relies on scientific principles, laws of nature, and methods for implementing knowledge of those principles and laws into programs of both preventive and remedial nature. The institutional perspective anchors on regulations, laws of society, and policies. We usually approach and explain culture in human terms: values, norms, traditions, beliefs and attitudes. By broadening our perspective, we can study environmental culture where humans are just one component Thus the cultural perspective recognizes the values, traditions, and norms of the environment as opposed to the values, norms, and traditions of the societies interacting with the environment."[2]

As a result of its deliberations, the Blacksburg Forum identified six broadly defined rules for successfully implementing holistic environmental management.

- Consider relationships and interactions over components,
- Get stakeholders' predecisional involvement and maintain focus on overcoming short-term impatience (and distractions) for long-term results,
- Get a systems integrator in addition to a strategic manager,
- Listen to what the environment tells us,
- Break narrow discipline barriers to eliminate parochial advocacy to a technology or any single perspective, and
- Consider permanency of the environment and those who evolve with it over transient needs and peoples.

The Blacksburg Forum concludes with some overarching interpretations of the issues and perspectives that define a focused integration of holistic and analytical thinking.

> "Successful environmental management requires holistic thinking. For success, environmental managers need an overarching philosophy and a constancy and consistency of purpose. Philosophy and purpose come from participatively-generated and universally-supported mission, vision, and principles statements.
>
> "We must accept the idea of perception as being as important as reality. Informed or uninformed, what people perceive to be the case is reality--the reality environmental managers must manage. Perceptions often outweigh reality such that the distinction between the two is usually irrelevant for an environmental manager. These managers must make decisions that satisfy both reality and perception. . . . Knowing how people perceive and use information is central to understanding how they solve problems.
>
> "Stakeholders and the experts they choose must help set and evaluate standards and measurements for production, technological, and institutional constraints resulting from the criteria and boundary conditions of the environmental values, beliefs, and goals and objectives."[3]

2) Vermont/Northeast Center for Comparative Risk Project

The Vermont Comparative Risk Project (1991) constitutes one of the first substantive efforts to meaningfully address risks to quality of life as well as traditional analyses of risk to human and ecosystem health. The Vermont approach first identified environmental problems facing the state and its residents, *focusing on residual risks remaining after existing controls (or regulations) had their effect*.[4] The resulting list depended upon technical and scientific analyses of issues by experts, identification of important social/public values through public forums and formal opinion surveys, and personal judgement from Committee members to integrate the technical and social issues and qualitatively rank the risks. Significantly, the Committee discovered during the evaluation process that "the technical information often conflicted with the public's perception of risk."[5]

Ultimate ranking always required judgement to bridge technical data gaps and/or insufficient public input. The Vermont group was unusual in explicitly acknowledging and emphasizing the role of uncertainty in their decisions.

> "Officials and scientists sometimes try to downplay or deny uncertainties, probably out of a mistaken belief that doing so improves their public credibility. Such false confidence usually leads to public disillusionment with government."[6]

The Vermont process also adopted a largely holistic overview of environmental problems by recognizing that many different problems commonly have interrelated causes and effects, that existing laws and regulations tend to focus only on discrete aspects of problems, and deliberately blurring the artificial distinctions often made between human health, ecosystem health, and quality of life (values). *The definition and application of values actually facilitated the Committee reaching consensus or agreement on rank order or environmental priorities more readily than in the absence of such information.*

Based upon public forums, opinion polls, and surveys, the Advisory Committee identified seven criteria for evaluating impacts to Vermont's quality of life including aesthetics, economic well-being, fairness, future generations, peace of mind, recreation, and sense of community.

> "Although these qualitative descriptions of risk often lack precision and scientific objectivity, they focus attention on specific critical issues and thus are useful tools for comparing the problems systematically and consistently.
>
> *"The problems that the Advisory Committee ranked the highest tend to be those with the most serious ecological impacts. These problems affect several criteria, including aesthetics, recreation, economic well-being, and, most importantly, future generations. As it did in its ranking of risks to ecosystems, the Committee concluded that the most serious risks to Vermonters' quality of life are those with very long-term effects." The Vermont project identifies alteration/destruction of natural habitats as posing the greatest risk to both ecosystem health and quality of life values.*[7] [emphasis added]

The Vermont project concludes with several important recommendations. First, "reducing risks to human health, ecosystems, and quality of life should be the primary goal of environmental policy." Second, "government should share more information about risk with the public, and, more importantly, share more decision-making power with the public. More [affected individuals and communities] need to be directly involved in assessing risks and deciding how to manage them." Furthermore, "environmental problems have been exacerbated by fragmented, uncoordinated policies."[8]

Major environmental problems such as those identified in this report, which many recognize to be complex, interrelated, and to have potentially significant long-term social and economic impacts, too often are shunted aside in the interests of political expediency, quick solutions, and the tendency to focus only on the immediate crisis at hand. Developing and implementing technically sound and politically supportable environmental management decisions will necessarily require more, not less, tribal and public involvement throughout risk assessment, risk management, and decision making. This will require a more all-inclusive, comprehensive, flexible, responsive, and long-term decision-making framework than is now commonly employed at both the technical and policy levels.

3) Wisconsin Tribes Comparative Risk Project

The Wisconsin Tribes Comparative Risk Project (1992) was the first comparative risk evaluation project to specifically focus on environmental risks faced by tribes; in this case, 11 tribes located in Wisconsin. The project depended upon conventional risk assessment methodology, modified so as to accomodate unique tribal lifestyles, culture, and values, and it ranked problems separately "in terms of [human] health risks, ecological risks, and social and economic damages they pose to tribes."

> "The Indian Tribes of Wisconsin have a lifestyle, culture, values, and environment different than most Americans. Their reservations are relatively isolated and undeveloped and are much more nearly in their natural condition than the land surrounding them. The Tribes rely extensively on harvesting of local fish, game, and plants for subsistence. They also place high cultural value on preserving the quality of their environment, and seek to manage their activities so as to maintain their lands in undiminished condition for future generations."[9]

As a result, standard risk evaluation methodology was modified to better accomodate unique tribal resource use, exposure pathways, values, and priorities.

> "In estimating health risks, particular attention was given to the influence of tribal lifestyles on exposure pathways. Heavy subsistence consumption of local fish and game was very important. In evaluating social and economic damages, two non-traditional categories of damages were given great weight: damages to Indian cultural and religious values, and damages to subsistence activities. One traditional damage category was also emphasized--damages to natural resources of commercial value to the tribes. For ecological risks, traditional assessment methods were not changed. We [EPA] maintained that the methods and conclusions about ecological risks in a particular area should be the same whether the study is performed from the perspective of Native Americans, the mainstream culture, or any other group."[10]

Interestingly, both the human health and social and economic damages evaluations indicated that *food contamination* constituted the highest risk to Wisconsin tribes.

The Wisconsin project also highlighted numerous limitations with the conventional risk evaluation approach for including important tribal values. For example,

> "other factors *which EPA must consider* include tribes' reliance on natural resources for subsistence and the cultural importance of the environment to American Indians." Moreover, "EPA's comparative risk framework tends to emphasize current, demonstrated environmental risks without focusing on how environmental problems may increase in the future. In addition to analyzing the

> risks from current environmental problems, it is also necessary to consider: a) the need to protect the land and Indian culture from risks for the very long term future; and b) the expected vulnerability of the small amount of reservation land to growing risks from outside the reservations in the future. . .
>
> "In addition, the tribes place high value on their traditional harmonious relationship with their natural surroundings. They are limited in pursuing their traditional activities to the small vestigial reservation areas. *These areas must remain undamaged for centuries into the future if the tribes are to maintain their ancestral values [and identity].*"[11] [emphasis added]

4) California Comparative Risk Project

The California Comparative Risk Project (CCRP; 1994) constitutes one of the most thorough approaches yet developed to address comprehensive comparative risk evaluation. Innovative approaches were defined in broad ranging analyses of human health, ecological health, social welfare, environmental justice, education, and economics perspectives. The crowning accomplishment of the CCRP, however, is its emphasis on the importance of social/cultural issues in risk evaluation, which led to the development of one of the most innovative, comprehensive, and rigorous approaches yet devised to characterizing and including qualitative considerations in a comprehensive risk evaluation program.

The CCRP approach includes establishment of a series of both social welfare criteria and measures, followed by an assessment of these considerations using a matrix format. The assessment is based not only on technical evaluations, but also on examining both individual and community case histories and public testimony. This new methodology and framework were developed by first identifying seven principal evaluation criteria: environmental and aesthetic well-being, economic well-being, physical well-being, peace of mind, future well-being, equity, and community well-being. Eight measures then were developed "to evaluate the extent of impacts associated with each criterion: number of people exposed, number of people impacted, severity, irreversibility, involuntariness, uneven distribution, potential for catastrophic impact, and lack of detectability."[12]

The criteria and measures then were laid out in a matrix format, where a qualitative (but clearly defined) "ranking" of high, medium, or low levels of concern was assigned to each combination by reviewers along with a single, subjectively-weighted summary of overall social welfare rank. Final evaluations were a result of detailed discussions among committee members of available data, differences of opinion, and values "because social welfare impact assessment necessarily requires value judgements, not simply scientific measurements of impacts, and *it matters whose values are used in making those judgements.*"[13] [emphasis added]

'*Environmental decision-making is a multi-dimensional process.* [Quantitative] risk-based rankings of environmental topic areas are valuable and should be used for priority-setting in conjunction with other factors, including economics, public input, the potential for pollution prevention, the need to address the existence of disparate impacts on different populations, and the emergence of future risks. Sustainability (improving the quality of life while preserving environmental potential for the future -- or "living within the Earth's means") was a sixth factor identified as important in environmental decision-making."[14]

The CCRP concludes with strong recommendations that "social welfare must be considered in any similar policy exercise or assessment of risk," and that "social welfare analysis should be integrated into regulatory decision-making." Furthermore, the evaluation process "must include community and public participation and input at every stage of the process, and in particular, impacted communities must be involved." Finally, the environmental management decision-making process "should give due consideration to the sometimes amorphous beliefs, fears, hopes, and perceptions of the public. Values are an important component of prioritizing risk or risk-reduction strategies, and should be made explicit where possible."[15]

5) Hanford-Specific Forums

Although the previous forums address issues of environmental management around the nation, the following Hanford-specific forums represent successful application of similar approaches that implement many of the themes identified in previous forums. Historically, Hanford depended upon its secrecy and "self-regulation" to manage its resources and programs. Today, regulatory oversight, citizen advisory boards, and tribes participate in various forums designed to provide an exchange of information, to address legitimate issues of concern, and to communicate values. Examples of Hanford-specific forums below show how many of the key elements from national comparative risk exercises described above can be directly applied, in one form or another, to DOE planning and management decisions.

One of the first and often most difficult steps to resolving the complex environmental, regulatory, health, and legal issues present at DOE sites involves getting polarized parties to sit down at the same table. Making technically sound and politically acceptable decisions involves ensuring community leaders, tribal representatives, and other interested parties that the risks being addressed and (hopefully) reduced by expenditure of public funds at Hanford provide specific, immediate, and long-term benefits to residents and the environment of the Pacific Northwest. Although Hanford appears to be a regional issue, the nation as a whole has benefitted from 50 years of a Hanford-based nuclear deterrent and, as a nation, must now complete paying the mortgage.

a) Values-Based Risk Evaluation

Values-based risk evaluation, an ongoing effort being developed by the Pacific Northwest Laboratory at the Hanford site, is a promising technique to measure and integrate qualitative and cultural values into an improved, broad-based risk assessment methodology in a rigorous, scientifically defensible, and cost-effective manner.

The overall focus is on both "process" (the establishment of a forum in which leadership is shared among impacted parties and risk assessors, and education flows equally in both directions), and on "substance" (any modifications or additions to conventional assessment methods required to accomodate different cultural perspectives and information needs). The ultimate goal of this type of evaluation is to produce an information base broad enough to support stable decisions, and thorough enough to serve as initial technical guidance for developing values-based decision criteria, information-based engineering design criteria, proactive remediation specifications, and protective remedial standards.

The first element of a values-based risk evaluation (namely an open forum with co-leadership) recognizes that the overall decision is driven primarily by values, and is supported by risk data that informs the debate but does not drive the decision. It also recognizes that the impacted parties are the "experts" about the values and principles at risk, while the assessors are the "experts" in data collection and processing. Experience indicates that just as much effort must be expended to educate the assessors about values as to educate the communities about technical methods (refer to each comparative risk project highlighted above).

The second element is a description of the "ecocultural landscape," which includes both culture and environment. The particular characteristics of the landscape at risk will guide the selection of specific metrics for human health, ecological/environmental integrity, and quality of life, using the comparative risk approach described above. Because the Hanford landscape is historically a function of tribal cultural perspectives, a shift from conventional engineering and risk assessment perspectives is a prerequisite both to the development of an acceptable Hanford mission plan that enjoys widespread popular acceptance, and to successful implementation of the plan.

Once the shift in perspective is made, parameters can be (and are being) developed to reflect and integrate both values and the information needs. Conventional risk methods must be expanded to include parameters related to culture-specific consumption patterns and exposure pathways, as well as threats to natural and cultural resources, traditional activities, cultural values, and community well-being. Most of the requisite parameters are under development at Hanford, and the actual data collection could proceed relatively smoothly. The most time-consuming and difficult portion of this process appears to be related to the reluctance of risk assessors to fundamentally change narrow, outmoded approaches or expand entrenched scientific data collection habits. Where this change occurs, however, decisions are widely acknowledged to be more technically defensible, more politically acceptable, and more cost-effective, especially over the long-term. Risk assessment principles recently published by DOE[16] reflect a refreshing understanding of this process and both the monetary and political benefits to be gained from its application.

b) Hanford Future Site Uses Working Group

The Hanford Future Site Uses Working Group (1992) was convened by DOE in order to develop an array of options for ways that different parts of the site could be used in the future. The final report[17] identifies various clean-up scenarios necessary to enable these future uses, along with major recommendations regarding priorities for clean-up and ways to focus clean-up more efficiently. The CTUIR participated in the organizing committee for the Working Group and participated as a tribal government once convened. Working Group membership was diverse, and included federal, state, tribal, and local governments, agriculture, local business and economic development, labor, academic, and environmental interest groups.

The signatories to the TPA committed to using the Working Group's products to inform and guide them in all relevant aspects of their clean-up decisions. The Working Group's principal tasks included:

- "To examine Hanford and identify a range of potential future uses for the site,
- "To select appropriate clean-up scenarios necessary to make these future uses possible in light of potential exposure to contamination, if any, after clean-up, and
- "To probe for convergences among the Group's clean-up scenarios for any priorities or criteria which could prove useful in focusing or conducting the clean-up of Hanford."

A Charter and a set of groundrules established the framework for achieving these goals. The process began with developing a common base of information relevent to the Group's charge. In addition, four critical caveats were identified.

- Future use options were included in the report if they were advocated by one or more members of the Working Group and should not be considered to be recommendations of the Working Group for future uses.
- The Working Group did not assign priorities to future use options or clean-up scenarios; the order of their presentation in the final report has no significance.
- Future use options identify the general kinds of uses that were considered and clean-up scenarios identify levels of access, based on existing contamination levels and extent, needed to make those uses possible.
- Specific future use options proposed for each geographic area may not preclude or exclude other uses from occurring simultaneously in the same geographic area. In some cases, a mix of future use options was identified for an area.

In order to facilitate discussions about particular areas of Hanford's large and diverse landbase, the site was divided into six geographical areas: Arid Lands Ecology Reserve; North of the River; Columbia River; Reactors on the River (100 Areas); Central Plateau (200 Areas); and All Other Areas. Future use options were deliberately generalized and included: Agriculture; Industrial and Commercial Development; Wildlife and Habitat Preserves; Environmental Restoration and Waste Management Activities; Public Access and Recreation; and Native American Uses such as hunting, gathering, and religious practices.

One caveat in the report states that, *"The [report] is not a land use report per se. The Working Group did not intend to specify and delineate the exact future uses which would occur throughout the site. To have done so would have meant addressing the issue of future site management and/or ownership which was beyond the scope of the Working Group's Charter."*[18] By defining future use options, the Working Group could then define four levels of access necessary to permit those uses to occur: unrestricted, restricted, exclusive, and buffer.

The Working Group concludes by identifying seven findings that reflect its overarching vision and expectations at Hanford, while simultaneously retaining sufficient flexibility about specific uses and their implementation that does not prejudice future options.

- *Hanford is Important.* Its history, economic benefits, importance to American Indian tribes, and pristine ecosystems all contribute to the Pacific Northwest. Risks posed by existing contamination are now driving clean-up and regulatory actions.
- *Clean-Up is Now DOE's Primary Mission at Hanford.* This statement guides Hanford's current mission.
- *The Hanford Site Will Change as Clean-Up Proceeds.* The Working Group fully recognizes this changing reality, and thus makes no predictions regarding to whom, by what time, or to what extent land might be transferred, sold, or disposed. Its recommendations are framed to expect changes and maximize flexibility.
- *Both Clean-Up and Future Land Uses Face Significant Constraints.* The Working Group recognizes that the volume and variety of contaminants and the potential risks associated with some of them create difficulties in planning future options, as does the current lack of treatment technologies to address some types of contamination.
- *Native American Treaty Rights Exist.* The entire Hanford site is within the boundaries of lands ceded by the Yakama Indian Nation and the Walla Walla Band of the CTUIR in their 1855 treaties. The Group specifically acknowledges those treaty rights, believes that these rights are embedded within all of the Working Group's findings, and recognizes that they will have significant bearing on the actual future use after clean-up and/or surplusing of excess land by DOE.
- *Uncertainity and Risk Surround the Clean-Up.* The Working Group was confronted by the fact that current information about the nature and extent of contamination at the site is incomplete, and that this lack of knowledge exacerbates the sense of

risk associated with clean-up. Unplanned and unanticipated threats may exist throughout the full range of Hanford waste management and environmental restoration activities. Significant uncertainity and debate exsits about the health and environmental effects, especially cumulatively, from exposure to various contaminants or combinations.

- *Time is a Critical Element in Focusing the Clean-Up.* Given the long time horizon of the clean-up and the long life span of the contaminants, a critical question for future land use is when various clean-up objectives will eventually be acheived. Ultimately, the Working Group desires to see that all of Hanford would be clean enough for future uses other than waste management.

Nine recommendations that constitute overarching or guiding values applicable to Hanford clean-up as a whole emerged from the Working Group, representing a remarkable degree of agreement among a highly diverse group of Pacific Northwest interests on both purpose and direction.

- *Protect the River.* The Columbia River is a vital resource in the Pacific Northwest. Several contaminated groundwater plumes from throughout the site connect with the River as it traverses the site and cause various degrees of concern for human and ecological safety, both now and in the future.
- *Deal Realistically and Forcefully with Groundwater Contamination.* A large volume and areal extent of groundwater beneath Hanford is contaminated with a wide variety of hazardous chemical and radioactive contaminants. In addition to representing both current and future threats to human health and the River, the presence of contaminated groundwater poses significant constraints and issues for possible future land use.
- *Use the Central Plateau Wisely for Waste Management.* To facilitate clean-up of the rest of the site, wastes from throughout the Hanford site should be concentrated on the Central Plateau. Wastes generated in or coming into the Central Plateau from other areas would not necessarily be permanently disposed of in the Central Plateau. This area would have an exclusive level of access with a surrounding buffer zone in order to reduce exposure to long-term risks.
- *Do No Harm During Clean-Up or with New Development.* The Working Group believes that both clean-up and future development decisions should be guided by the principle to "do no harm." Wise application of this principle is likely to maximize effective clean-up over time as well as support sound, long-term development of the site.
- *Clean-Up of Areas of High Future Use Value is Important.* Future use value as a clean-up priority need not conflict with, and may complement, risk-based critieria. Two areas were identified specifically as priorities for Hanford clean-up: the Columbia River corridor and the southeast corner of the site (near the city of Richland).
- *Clean Up to the Level Necessary to Enable the Future Use Option to Occur.* In developing clean-up scenarios for the various future use options, the Group

specified the relevent level of access -- restricted, unrestricted, or exclusive. Where residual contamination could still enable a particular future use, restricted use was applied. It is important to note that unrestricted status would, by and large, enable all future use options to occur.

- *Transport Waste Safely and Be Prepared.* The Working Group recognized that decisions related to the Hanford clean-up will have a direct impact on the transportation of radioactive and hazardous materials within, to, and from the Hanford site, including frequency of shipments.
- *Capture Economic Development Opportunities Locally.* The Working Group urges DOE and its contractors to help the tribes, state, and local communities create the potential for meaningful economic development as clean-up progresses.
- *Involve the Public in Future Decisions about Hanford.* The Working Group process is an excellent example of the type of tribal/public involvement in forum planning, values identification, and decision-making that should serve as a model for other DOE planning and decision-making efforts.

c) Hanford Tank Waste Task Force

While the Future Site Group identified a range of land use options and designated general levels of clean-up necessary to support such uses, the Hanford Tank Waste Task Force (1993) was chartered to develop and help integrate a broad cross-section of 'stakeholder' values on tank waste remediation issues into planned revisions to the Tri-Party Agreement. Many of the representives to the Future Site Uses Working Group also participated on the Task Force and the accumulated experience, information base, and familiarity with common issues from the Working Group effort provided a valuable and broad based foundation for activities of the Task Force.

"The report of the Task Force is worthy of significant consideration for three major reasons:"[19]

- It highlights important stakeholder views on clean-up without selecting specific remedial alternatives or technical solutions, and it provides guidance on important objectives and areas needing attention in order for clean-up to succeed.
- It conveys a strong Pacific Northwest perspective on the proper direction of the clean-up, and it can be displayed to Congress with the conviction that Hanford clean-up can succeed and is worthy of essential national support.
- It illustrates the critical imperative of building tribal, local government, and public input into all phases of key Hanford decisions and activities.

The primary intention of the Task Force was to aid negotiations over tank farm remediation, but discussions about the role and impacts of the TPA itself naturally emerged. The Final Report[20] is divided into four sections based on key Task Force values surrounding the TPA, and these values are highlighted below within the following overarching themes.

- The Tri-Party Agreement as a Whole,
- The Agreement as a Management Vision and Tool,
- The Agreement and its Effect on the Environment, and
- The Timing of Actions in the Agreement.

The Tri-Party Agreement as a Whole

The TPA needs strengthening and improvement and should be enforceable, binding, and contain milestones or other measures of progress and accountability. In addition, DOE should comply with all existing environmental laws and should acknowledge and preserve existing treaty rights. The three signatories should increase public involvement that leads to a partnership in the "goals, scope, pace, and oversight of the clean-up." The Task Force expects that the renegotiated TPA will be implemented, that TPA "milestones should be considered an obligation of the federal government," and that DOE "is bound to seek funding from Congress to meet the milestones. Milestones should provide methods of assessing performance that are meaningful, measurable, and understandable."

The Agreement as a Management Vision and Tool

The TPA should accelerate the process of continous improvement in the management and operation of the Hanford site. It is imperative that specific means and measures be developed that advance the changes needed to achieve effective clean-up of Hanford and that the TPA *"should encourage imagination to solve problems that arise because of regulatory complexity, jurisdictional problems, or technical difficulties and other barriers to progress."* This includes a demonstrated accountability for the expenditures of funds for specific projects or activities, a portfolio of technological options and strategic investment, and a recognition of not promoting "further research on unlikely options." Once clean-up actions and associated milestones are established, the TPA should direct the parties to implement programs in ways that contribute to the community's economic transition initiatives and mitigate adverse socioeconomic impacts.

The Agreement and its Effect on the Environment

This section of the final report identifies ten principles regarding the impact of clean-up on the environment, including:

- Minimize land use for waste management,
- Avoid contamination of uncontaminated land,
- Avoid further harm to cultural resources, natural resources, and the environment, especially critical habitat and groundwater,
- Protect the Columbia River,

- Do not depend on dilution of effluent wastes to effect safe conditions,
- Accomplish conservation and reuse of resources,
- Recognize the importance of preserving the biodiversity of the Hanford site and the Columbia River,
- Integrate CERCLA-Natural Resource Damage Assessment processes into appropriate TPA milestones to minimize overall restoration costs,
- Preserve natural resource rights embodied in treaties, and enforce laws protecting natural and cultural resources, and
- Include CERCLA-like risk assessments for natural and cultural resources in environmental restoration/waste management actions and all other site activities.

The Timing of Actions in the Agreement

The TPA should measurably chronicle that the three agencies are getting on with clean-up and are not relying on procedural milestones to delay or avoid difficult tasks or choices. The end of clean-up is predictable, even if a specific date is not.

The final report of the Task Force includes a chapter on "Values" and outlines five broad, overaching issues and seven specific implementation-related values. The five issues include:

- Protect the environment,
- Protect tribal/public/worker health and safety,
- Get on with clean-up, to achieve substantive progress in a timely manner,
- Apply a systems design approach that keeps endpoints in mind as intermediate decisions are made, and
- Establish management practices that ensure accountability, efficiency, and allocation of funds to high priority items.

Seven specific issues are then outlined as critical to effectively implementing and applying the identified values.

- *Timing* details what "getting on with cleanup" means,
- *Management* outlines systems design and management practices,
- *Tank Leaks* identifies values related to "clean-up" of the actual tank farms,
- *Technology* refines and focuses application of research and development and emphasizes the need for a folio of available options,
- *Waste Form and Storage* establishes values with the output of tank farm remediation, treatment, and disposition options,
- *Transportation* recognizes both on- and offsite values and impacts associated with achieving cleanup, and
- *Training* "for everyone who will be on the site is critically important."

The Task Force was not intended to focus on specific technical aspects of any option or alternative, nor to provide specific recommendations on the technical merits, or lack thereof, of any specific option or alternative.

d) Hanford Environmental Dose Reconstruction Project and Technical Steering Panel

The release of historical DOE documents during the mid-1980's, and their subsequent scientific, public, and tribal review, demonstrated that potentially significant impacts to offsite populations resulted from the magnitude and extent of Hanford releases, particularly early airborne releases (1940s) and river releases during the peak reactor operating periods (1960s). These results--and legitimate concerns raised by residents throughout the Pacific Northwest--prompted the development of a computer model to estimate a site- and individual-specific radiation dose received by typical Pacific Northwest residents from historical Hanford operations--the Hanford Environmental Dose Reconstruction Project (HEDRP).

This highly complex and never-before-attempted integrated approach required a comprehensive identification of source term, environmental dispersal and transport mechanisms, bioaccumulation factors, and receptor pathways. Devising a computer model with this capability, however, necessarily required consideration of political and social dynamics, and unique exposure potential of particularly vulnerable population segments such as American Indian tribes. To address this problem, a panel of nationally recognized scientists, known as the Technical Steering Panel (TSP), was convened to guide the development of a computer model whose codes could systematically estimate an individual's dose based on known temporal and geographic exposure factors and that person's life history and food consumption patterns.

The TSP/HEDRP assembled, analyzed, and assessed a tremendous volume of historical information. Any model of such inherent variability and complexity will necessarily oversimplify or smooth over some interdependent environmental conditions or the relationships between variables; hence, there is always some sticking point that individuals or groups can use to discount the findings of the TSP. Nevertheless, this integration of at least four different computer models to develop a single individual dose estimate represents a state-of-the-art model for integrating widely variable scientific data, techniques, and cultural values. Moreover, this model offers an independent check on at least some Hanford risk assessment/evaluation methodologies and conclusions, even though its primary purpose is not to predict potential health outcomes.

A subsequent effort, the Hanford Thyroid Disease Study (HTDS), which is now completing its pilot phase, will take HEDRP-generated dose estimates and predict the incidence of thyroid disease among Pacific Northwest residents and critical segments of populations. This study is an outgrowth of rigorous scientific debates, which have identified a clear cause-and-effect relationship between exposure to radioactive iodine-131 and incidence of thyroid cancer. The study will focus on the 1944-1957 time period when airborne iodine releases from Hanford's chemical separation plants were very high. Lessons learned from both the HEDRP and HTDS efforts may provide unique opportunities for comparison with independently generated risk evaluation results.

e) The TSP and the Native American Working Group

The TSP *"believes that direct Tribal involvement appropriately recognizes the sovereignty of Tribal government[s]."*[21] Based on the HEDRP results, many Indian, as well as non-Indian, communities recognize that Columbia Basin tribes may have received radiation doses consistently higher than the general public. Such doses are associated with traditional tribal practices involving subsistence fishing, hunting, gathering, and other social behaviors throughout the region that result in increased dose potential, multiple exposure pathways, and more frequent exposures. These patterns are distinctly different from the non-Indian population.

In recognition of the unique demographics, lifestyles, and dietary cultural patterns practiced by Columbia Basin American Indian tribes, the TSP established the Native American Working Group (NAWG) in order to advise and guide incorporation of tribal research into HEDRP. Nine tribes,[22] including the CTUIR, are now participating in the forum; each tribe has received an individual contract to participate through Centers for Disease Control.

The NAWG provides a valuable forum for tribal staff to develop and coordinate tribe-specific technical activities in support of scientifically defensible data collection, methodology, and information/conclusions for HEDRP research within the TSP framework. For example, during 1991 and 1992, CTUIR staff gathered preliminary information about specific and unique demographic, lifestyle, and dietary cultural patterns. Factors affecting these patterns are typically tribe-specific, based largely on spatial distribution around Hanford and duration of exposure, but individual variability between tribes, individuals, and dose estimates can be attributed to dietary differences, population distribution, social patterns, military service, school attendance locations, food and farm product source areas, and a host of other individual factors. Hence, reconstructing accurate and representative tribal dietary, population, and lifestyle information for a period nearly fifty years ago is both a technically complex and culturally sensitive task. The more rigorous primary phase is currently underway at several reservations.

With the HEDRP nearing completion, the NAWG has nearly completed its original charge. Tribal representatives, however, recognize that much further research is needed both as HTDS progresses and in support of activities underway by the Agency for Toxic Substances and Disease Registry (ATSDR). Moreover, the NAWG comprises a valuable forum for expressing and coordinating tribal health issues and the provides a solid foundation for building broad-based information collection and analysis capabilities focused on tribal issues. With a new operation plan and bylaws to guide its work, the NAWG recently has evolved into the Inter-tribal Council on Hanford Health Projects (ICHHP), a forum designed to offer coordinated input and to support scientific defensibility, tribal sovereignty, and effective management of resources for ongoing studies of health impacts related to Hanford. This forum may facilitate the now-missing links and cultural ties between environmental releases and health outcomes in the future as more specific and focused data are collected and methodologies are developed.

6) Summary

A recurrent theme among all of these efforts has been the need to directly address those important qualitative issues and social/cultural values traditionally ignored in conventional risk assessment and piecemeal (crisis) environmental management. The focus of these efforts has been to develop a more comprehensive and rigorous framework that specifically includes qualitative considerations and social/cultural values as an integral component of the risk evaluation and decision making process. This focus is based on universal recognition that many factors other than quantitative data are relevant to priority setting and risk management, and that these must be included in the evaluation process in order to provide both credibility and comprehensiveness to the nature, magnitude, and urgency of risks identified. Moreover, there is consistent and universal recognition among these efforts of the critical need for integrated public/tribal participation throughout the decision making process for it to gain the credibility and popular support necessary for success.

These innovative risk evaluation efforts all have directly and successfully challenged the well recognized limitations of conventional risk assessment methodology. They have attempted to construct comprehensive and workable solutions that will improve both the usefulness and defensibility of risk evaluation as an analytical support technique and as a decision-making tool. These state-of-the-art studies consciously recognize and fully incorporate the full scope of risk into their process, and show how it can be done efficiently, cost-effectively, and credibly.

In many respects, these approaches can meet Assistant Secretary Grumbly's mandate by building in credibility and effective tribal/public participation throughout the process. The above examples highlight numerous, workable, and cost effective alternatives. The critical obstacle to be overcome is the still deeply entrenched institutional resistance within DOE and its contractors that has effectively prevented even the consideration of new or more comprehensive approaches, let alone their implementation. The principal challenge now is to adapt and adopt these techniques into DOE's decision-making framework, both at the site-specific and complex-wide levels, and to foster DOE's recognition that such efforts will pay off both politically and financially with more widespread popular support and more timely, cost-effective results.

Notes

1. *Report of the Blacksburg Forum: The First Step Toward the Holistic Approach to Environmental Management*: Management Systems Laboratory, Virginia Polytechnic Institute and State University, Blacksburg, VA, 1991.

2. *Blacksburg Forum.*

3. *Blacksburg Forum*, p. 6-7.

4. It should be noted that this approach would be much more difficult to apply to DOE facilities, where residual risks associated with long-lived radioactive contaminants often are measured in thousands to hundreds of thousands of years.

5. *Environment 1991: Risks to Vermont and Vermonters, A report by the Public Advisory Committee, The Strategy for Vermont's Third Century*: Vermont Agency of Natural Resources, p. 5.

6. *Environment 1991: Risks to Vermont and Vermonters*, p. 6.

7. *Environment 1991: Risks to Vermont and Vermonters*, p. 14.

8. *Environment 1991: Risks to Vermont and Vermonters*, p. 40-41.

9. *Tribes at Risk: The Wisconsin Tribes Comparative Risk Project*: U.S. Environmental Protection Agency, Region 5, p. vii.

10. *Tribes at Risk: The Wisconsin Tribes Comparative Risk Project*, p. viii.

11. *Tribes at Risk: The Wisconsin Tribes Comparative Risk Project*, p. x-xi.

12. *California Comparative Risk Project*, Report of the Social Welfare Committee, p. 207-208.

13. *California Comparative Risk Project*, Report of the Social Welfare Committee, p. 208.

14. Report of the Statewide Community Advisory Committee for the California Comparative Risk Project, *California Comparative Risk Project, Summary Report*, p. 16, 52.

15. *California Comparative Risk Project*, Report of the Social Welfare Committee, p. 218.

16. "DOE Issues Principles Defining Major Roles for Risk in ite Cleanups," *DOE Risk Policy Report*, February 21, 1995.

17. Copies of the *Final Report: Future Site Uses Working Group*, is available from Environmental Data Management Center, Westinghouse Hanford Company, P.O. Box 1970, Mail Stop H6-08, Richland, WA, 99352.

18. "The Future For Hanford: Uses and Cleanup," Summary of the Final Report of the Hanford Future Site Uses Working Group, December 1992, p. 4. Much of the main text following this footnote is quoted directly or paraphrased from this report.

19. Cover letter accompanying Final Report of the Hanford Tank Waste Task Force.

20. *Final Report of the Hanford Tank Waste Task Force*, September 1993.

21. *Columbia Basin's American Indians Involved in Hanford Dose Reconstruction*, Technical Steering Panel, Fact Sheet 13, June 1992.

22. The represented tribes include: Couer d'Alene, Colville, Kalispel, Nez Perce, Spokane, Umatilla, Warm Springs, Yakama, and more recently, North Idaho Kootenai, which were recently designated as a federally recognized tribe.

APPENDIX J

DOE BUDGET FIGURES