Executive Summary

The Columbia River is a critical resource for residents of the Pacific Northwest. It provides for basic needs and is interrelated with the life style and quality of life for the Columbia Basin's many human and non-human residents. This resource was one of the key features that drew the Manhattan Project's planners to the site now called Hanford to produce nuclear weapon materials. Production of those materials has left behind a legacy of chemical and radioactive contaminants and materials that have affected and may be continuing to affect the Columbia River for the foreseeable future.

To address the cleanup needs of the Hanford Site, the U.S. Department of Energy (DOE) entered into a Federal Facility Agreement and Consent Order (unofficially known as the Tri-Party Agreement) in 1989 with the U.S. Environmental Protection Agency (EPA) and the Washington State Department of Ecology (Ecology). In the Tri-Party Agreement, milestones have been adopted that identify actions needed to ensure progress toward Hanford Site compliance with federal and state legal requirements.

We are conducting the Columbia River Comprehensive Impact Assessment in phases. The first phase is a screening assessment, the results of which are presented in Part I of this report. In the screening assessment, we evaluated the potential impact to the Columbia River resulting from current levels of Hanford-derived contaminants. The results of the screening assessment will be used to support decisions on Interim Remedial Measures. Part II of this report defines the requirements to conduct a comprehensive assessment of the Columbia River.

To evaluate the impact to the river from the Hanford-derived contaminants, DOE, EPA, and Ecology (the Tri-Party agencies) initiated a study referred to as the Columbia River Comprehensive Impact Assessment (CRCIA). To address concerns about the scope and direction of the CRCIA, as well as to enhance regulator, tribal, stakeholder, and public involvement, the CRCIA Management Team (CRCIA Team) was formed in August 1995. The CRCIA Team has met weekly to share information and provide input to decisions made by the Tri-Party agencies concerning the CRCIA. Representatives from the Confederated Tribes of the Umatilla Indian Reservation, Nez Perce Tribe, Yakama Indian Nation, Hanford Advisory Board, Oregon State Department of Energy, Tri-Party agencies, and Hanford contractors are active participants on the team.

The CRCIA Team has agreed to conduct the CRCIA using a phased approach. The initial phase, which is required and described in Tri-Party Agreement milestones M-15-80 and M-15-80C-T01 (Ecology et al. 1994), includes two components: 1) a screening assessment to evaluate the potential impact to the river, resulting from current levels of Hanford-derived contaminants in order to support decisions on Interim Remedial Measures, and 2) a definition of the essential work remaining to provide an acceptable comprehensive river impact assessment. The screening assessment is described in Part I of this report. The essential work remaining is described in Part II of this report.

Additional phases of CRCIA will be identified and decisions made regarding the conduct of the remaining work based on submittal of information as required by Tri-Party Agreement milestones M-15-80A, M-15-80B, and M-15-80B-T01 (Ecology et al. 1994).

Part I. Screening Assessment

The purpose of the CRCIA screening assessment is to support decisions on Interim Remedial Measures and to provide a focus for a subsequent and more comprehensive assessment. The objective of the screening assessment is to identify the study areas where the greatest potential exists for adverse effects on humans or the environment. The Hanford Reach of the Columbia River was evaluated in the screening assessment in a way that will be useful in the CERCLA (42 USC 9601: "Comprehensive Environmental Response, Compensation, and Liability Act of 1980") process but not necessarily in strict accordance with CERCLA procedures (for example, risk assessment methodology and remedial decision making). The screening assessment focused on a sub-set of potential contaminants, selected from a relatively broad set of possible contaminants. Part I of this report discusses the scope, technical approach, and results of the screening assessment. The screening assessment was conducted by the Pacific Northwest National Laboratory in consultation with the CRCIA Team.

Supporting information relative to the respective sections and appendixes in Part I has been published on diskettes, which have been issued with limited distribution. The CRCIA report with its diskettes are available on the Internet at http://www.hanford.gov/crcia/crcia.htm.

Scope

The scope of the CRCIA screening assessment is to evaluate potential risk to the environment and human health resulting from current levels of Hanford-derived contaminants. The study area for the screening assessment (see Figure 1 in the "Site Characterization" section) extends from upstream of the Hanford Site in areas unaffected by Hanford Site operations down to McNary Dam, which is the first dam downstream of the Hanford Site. The specific parameters of the scope are as follows:

- human health risk
- ecological risk
- Columbia River and adjacent riparian zone (vicinity of Priest Rapids Dam to McNary Dam)
- current conditions: January 1990-June 1996 (most recent date of data used in the screening assessment)
- contaminants of interest
    - radionuclides: tritium (hydrogen-3), carbon-14, cobalt-60, strontium-90, technetium-99, iodine-129, cesium-137, europium-152, europium-154, uranium-234, uranium-238, and neptunium-237
    - carcinogenic chemicals: benzene and chromium

- toxic chemicals: ammonia, chromium, copper, cyanide, diesel constituents (diesel oil, kerosene, xylenes), lead, mercury, nickel, nitrates, nitrites, phosphates, sulfates, and zinc

◆ environmental media

- direct use: Columbia River water, riverbank seep water, river and seep sediment, and external radiation

- indirect use: groundwater (surrogate for seep water), riparian soils, and aquatic and riparian biota (used for model comparison and verification)

Technical Approach

We organized Part I of the CRCIA report according to the process we followed in the screening assessment. First, the contaminants to be assessed were determined (Section 2.0). Then, the data were gathered for those contaminants (Section 3.0). Next, the species to be studied were selected (Section 4.1) and the risk to these species assessed (Section 4.2). Finally, the scenarios to be used were selected or developed (Section 5.1) and the risk to humans assessed (Section 5.2). A synthesis of the results is provided in Section 6.0.

The Tri-Party agencies and the CRCIA Team agreed that this screening assessment would address potential ecological and human risk resulting from currently known levels of contaminants in the Columbia River or in its immediate vicinity. The screening assessment does not address contaminant inventories currently moving towards the river from distant locations or other inventories that may be left by future cleanup activities at other Hanford Site locations. The components of the technical approach used in the screening assessment are summarized below.

Study Domain and Spatial Scale

The spatial domain and spatial scale of the analyses were established in consultation with the CRCIA Team. The agreed focus was on the Hanford Reach of the Columbia River and the areas immediately downstream as far as McNary Dam. The study area was broken down into 27 sections, or segments, to best represent the current environmental conditions and the state of knowledge of the contaminant concentrations in the river environment. Each segment represented a portion of the river and riparian area over which contaminated conditions can be expected to be similar. The segments, shown in Figure S.1, were selected based in part on environmental measurement densities, existing data representativeness, historical operations, and site knowledge of contaminated groundwater plumes entering the river. Human health and ecological risk assessments were performed on the segments individually to provide a consistent basis for determining areas of potential concern.

Contaminants of Interest

The approach to estimating risk to the environment and humans began by determining which contaminants should be evaluated in the screening assessment. The process reduced the contaminant list to a manageable number of contaminants likely to produce the greatest risk to the environment or human

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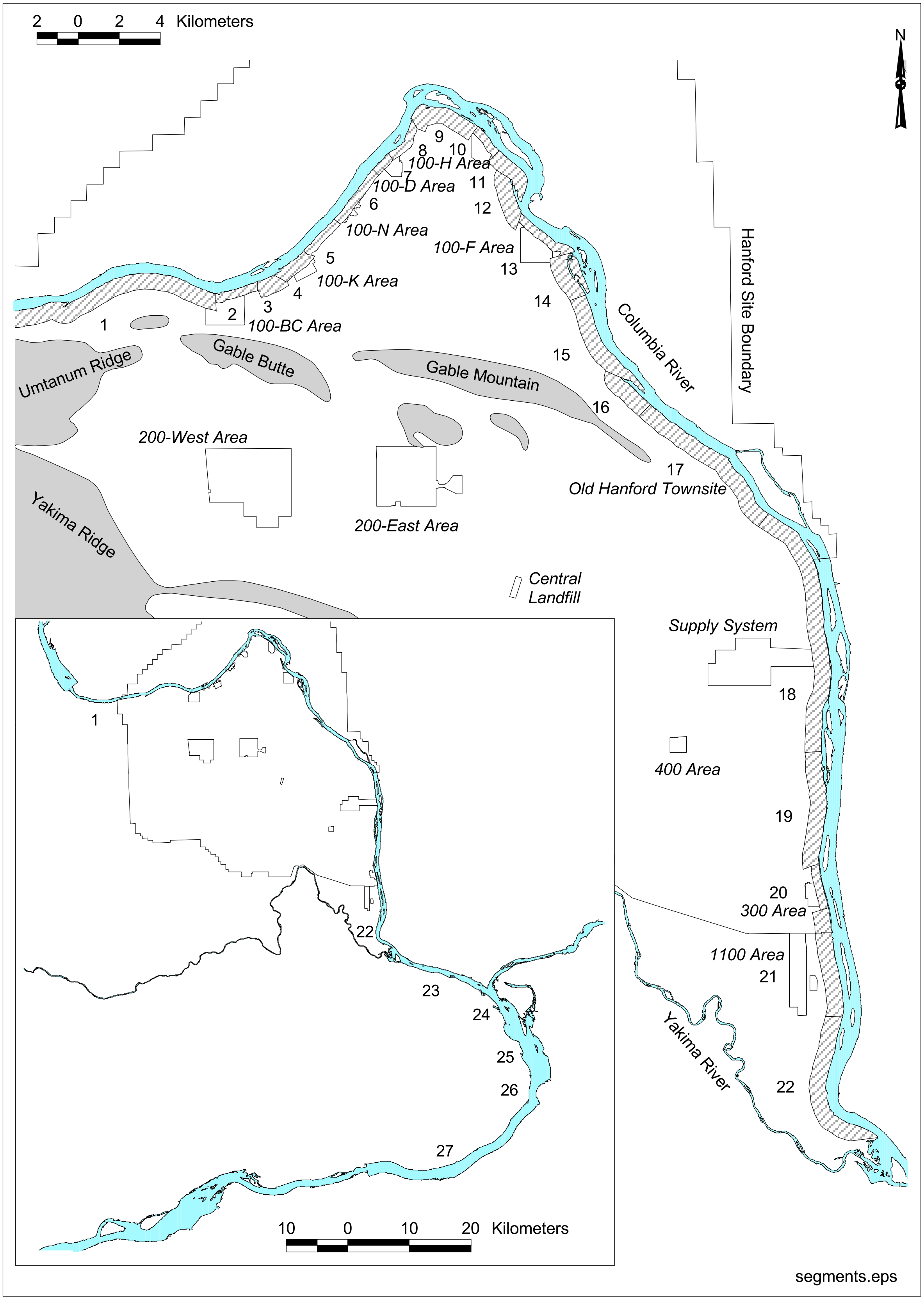
Figure S.1. Segmentation of the Columbia River and Groundwater Corridors



segments.eps

health. This process was based on a preliminary review of easily available records, environmental measurements, and process knowledge and on a set of simple exposure equations for people and biota. As a result, approximately 560 contaminants were screened down to a list of 26 contaminants that would be included in the human health and ecological assessments. The contaminant selection process is described in Section I-2 and Appendixes I-A.2 and I-A.3.

Data Collection and Processing

A detailed search was conducted to locate environmental measurements collected from 1990 through early 1996. Hanford and non-Hanford sources of environmental data were queried, including Hanford contractors, local municipalities, the States of Washington and Oregon, and federal agencies. Data were collected for contaminant measurements in Columbia River water, riverbank seep water, Columbia River sediment, riverbank seep sediment, interstitial water (interface between groundwater and the river within the river bottom), riparian zone soils, aquatic and riparian zone biota, external radiation, and Hanford Site groundwater. As a result of the data queries, a very large CRCIA database was established.

While the CRCIA database was extensive, contaminant measurements had not been made in many locations during the time period of interest. Consequently, data were not always available for all contaminants of interest in all segments. For these cases, substitute data, called surrogate or extrapolated data, were used. Rules were developed to ensure that the substitute data would be a good estimate of the local contamination levels. Surrogate data were used where contaminant data from one medium were substituted for another medium within the same segment. For instance, groundwater data were used where no riverbank seep data existed. Extrapolated data were used where contaminant data for one sample type from one segment were substituted for the same sample type in another segment. For example, river water from an upstream segment was used in downstream segments that did not have any river water sample results.

Once the database was established, the data were prepared for use in the screening assessment. A data outlier test was performed and, if appropriate, a maximum of one sample result was removed from each contaminant/medium/segment combination. A trend analysis was also performed on these combinations to determine the most representative maximum sample result. If an obvious upward or downward trend was observed, the most recent sample result was selected. For each segment, data sets were prepared for the human health and ecological assessments.

Species of Interest

A master species list, consisting of 368 species known to exist between Priest Rapids Dam and McNary Dam, was established and became the basis for selecting the species to include in the screening assessment. The master list was then ranked against six criteria, generating a Tier I list of 93 species. The CRCIA Team added 88 additional species to the Tier I list. Tier II ranking was a qualitative ranking of the Tier I list and resulted in 52 species being selected for the screening assessment. The Tier II ranking provided balance across taxonomic groups and exposure pathways. The list of 52 species includes the following (see Section 4.1 and Appendix I-C):

- algae - periphyton and phytoplankton
- amphibians - Woodhouse's toad
- aquatic invertebrates - clams/mussels/snails, crayfish, fresh water shrimp, mayfly, and water flea
- birds - American coot, American kestrel, American white pelican, bald eagle, California quail, Canada goose/mallard, cliff swallow, common snipe, diving ducks, Forster's tern, great blue heron, and northern harrier
- emergent vegetation - tule
- fish - channel catfish, common carp, largescale sucker, mountain sucker, mountain whitefish, Pacific lamprey, salmon, small mouth bass, trout, and white sturgeon
- fungi - as a taxonomic group
- macrophytes - Columbia yellowcress and water milfoil
- mammals - beaver, coyote, mule deer, muskrat, raccoon, weasel, and western harvest mouse
- reptiles - side-blotched lizard and western garter snake
- terrestrial vegetation - black cottonwood, dense sedge, ferns, reed canary grass, rushes, and white mulberry

Exposure Scenarios of Interest

Although the scope of the screening assessment is current environmental conditions, the scenarios developed for the human health assessment considered potential future uses. Twelve human exposure scenarios were developed that covered a wide range of potential exposures. The scenarios include those commonly used at Hanford (called the Hanford Site Risk Assessment Methodology-HSRAM-scenarios) as well as several scenarios developed for CRCIA to evaluate variables such as short-to-long exposure times, small-to-large ingestion rates of local foods, and multiple combinations of exposure pathways. CRCIA Team input was critical in defining Native American scenarios. The twelve scenarios are as follows (see Section I-5.1):

- industrial/commercial scenarios - industrial worker and fish hatchery worker
- wildlife refuge/wild and scenic river scenarios - ranger, avid recreational visitor, and casual recreational visitor
- Native American scenarios - subsistence resident, upland hunter, river-focused hunter and fisher, gatherer of plant materials, and Columbia River island user

- general population scenarios - resident and agricultural resident

Ecological and Human Health Assessments

> **To estimate the risk to the environment and humans, computer models were developed. Two types of analyses were performed to help understand how and why the assessment results might vary:**
>
> - **Potential risk was calculated using single, high values for each parameter (assumption) to identify potential worst-case results (deterministic analysis).**
> - **Potential risk was calculated using all possible combinations of parameter values to define a range and distribution of potential results and provide an indication of the most likely results (stochastic analysis).**

Computational models were developed for both the ecological and human health assessments. To the extent possible, the input parameters (assumptions) for the ecological and human health models were kept consistent. Transfer factors in human health models were derived from the ecological model results. The models, including test and verification activities, and input parameters are described in Sections I-4.2 and I-5.2 and the appendixes.

To attempt to quantify the uncertainty, two calculation methods were used: deterministic and stochastic. For the deterministic method, the equations were calculated with single, upper-end values for each parameter to identify results for reasonably maximum exposed individuals. For the stochastic method, the equations were calculated with all possible combinations of parameter values, resulting in a distribution of results rather than a single value.

For the human health assessment, both deterministic and stochastic calculations were performed for all contaminants, all scenarios, and all river segments where contaminant concentration data were available. Surface water data for europium-152 were absent in Segments 1-18, so risk from this isotope was not estimated in those segments. Segments 11, 18, and 22-27 did not have sufficient seep water data (or a groundwater surrogate), so this medium was not included in the human health assessment in these segments. However, seep water generally was not the primary contributor to potential human health risk. Surface water data were extremely limited downstream of Segment 21 and were therefore extrapolated from Segment 21 for Segments 22-27 with few exceptions. The contaminants assessed fall into one of three categories (carcinogenic chemicals, toxic chemicals, and radionuclides), each resulting in a different type of risk. Individual calculations for each combination of contaminants/scenarios/segments were compared with toxicity or carcinogenicity indices as appropriate.

For the ecological risk analysis, deterministic calculations were performed for all available specie/ contaminant/segment combinations where media concentration data were available. Several segments (11,18, and 22-27) lacked data on any contaminant concentrations in pore water and no acceptable substitute data existed. Consequently, Segments 11, 18, and 22-27 were dropped from the ecological assessment because of lack of data. Risk from nitrite, sulfate, and phosphate was not evaluated because of the general lack of toxicity benchmarks. These contaminants present no risk from food-chain exposure, however, because they are readily metabolized. Risk from neptunium-237 and carbon-14 was not evaluated because of the lack of pore water data. Surface water data for europium-152 were absent in

Segments 1-18, so risk from this isotope was not estimated in those segments. Risk from certain other contaminants was not evaluated in all segments because of missing pore water data (see Figure 4.20 in Section I-4.2).

Stochastic calculations were only performed for combinations that resulted in an Environmental Hazard Quotient (EHQ) ratio greater than 1.0. (An EHQ ratio is environmental concentration/benchmark concentration.) Results of the stochastic calculations were compared with toxicological benchmarks, including the lowest concentrations that are known to produce a clinically toxic response in any member of a population (lowest observed effect level or LOEL) and the concentration of contaminants that are known to be lethal to 50 percent of an exposed population (LC_{50}).

One benefit in using stochastic calculations was that it allowed the results to be subjected to statistical comparisons. In these comparisons, the stochastic distribution of concentrations and resulting risk in each Hanford-influenced river segment could be compared with those in a reference segment upstream and out of the influence of the Hanford Site. These comparisons provide insight into the nature and magnitude of the incremental risks posed by Hanford releases and identify areas of concern.

Results of the Ecological and Human Health Screening Assessments

The screening assessment identified areas and contaminants along the Columbia River that do pose potential human and ecological risk as a result of Hanford Operations as well as other human activities. Figure S.2 identifies the contaminants and affected segments of the Columbia River that pose potential risk. The potential human risk identified in Figure S.2 and Table S.1 represents total risk and includes both Hanford and non-Hanford contributions.

Environmental levels of some contaminants appear to be elevated as a result of Hanford Site operations and from other human activities upstream of the Site. Both the ecological modeling and human exposure simulations identified contaminants and locations that pose a potential risk to both the environment and humans and that would benefit from further analyses or measurements. The results of the ecological and human health screening assessments are provided in Sections I-4.2 and I-5.2, respectively.

Figure S.2 summarizes the findings of the ecological risk and human health risk assessments. The figure identifies the contaminants and affected segments of the Columbia River that pose a potential risk according to the results of either the ecological or human risk assessments. It also identifies the locations where both the ecological and human health assessments identify potential risk. For most of the contaminants, segments identified by the ecological risk analysis were also identified by the human health analysis, but sometimes the contaminants were in media that affect biota more directly than humans, so human risk for those contaminant/segment combinations is below the reporting threshold. Conversely, segments identified in the human health analysis as indicating increased potential risk were not always identified in the ecological analysis.

The reporting thresholds used in Figure S.2 to identify potentially hazardous contaminants include chronic and acute effects on the environment and toxic and carcinogenic impact on humans. For the chronic ecological effects, a contaminant is identified if the number of stochastic simulation results exceeding a chronic toxicity benchmark is greater than 5 percent of the number estimated in the reference

Figure S.2. Summary of the Screening Assessment of the Hanford Contribution to Risk to the Ecosystem and Human Health (The reporting thresholds in this figure identify potentially hazardous contaminants, chronic and acute effects to all plants and animals, and toxic and carcinogenic impacts on human health for all scenarios considered in this report. Under the analytes, the "chromium/car" indicates chromium treated as a carcinogenic chemical.)

- Minimal risk
- Ecological risk above threshold[(a)]
- Human risk above threshold (greater than 1 in 1,000,000 or Hazard Index of 0.01)
- Above both ecological and human risk thresholds

	Segments																										
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
	Priest	B/C		KE/KW	K-	N		D		H		White	F	F		Hanf.	Hanf.	Supp.		300	1100		Yakima	Snake	Boise	Walla	McNary
Analyte	Rapids	Area		Area	Trench	Area		Area	Horn	Area		Bluffs	Area	Slough		Slough	Town.	Sys.		Area	Area	Richland	Riv.	Riv.	Casc.	Walla R.	Res.
Ammonia																											
Benzene																											
Carbon-14																											
Cesium-137																											
Chromium/Car																											
Cobalt-60																											
Copper																											
Cyanide																											
Diesel																											
Europium-152																											
Europium-154																											
Iodine-129																											
Kerosene																											
Lead																											
Mercury																											
Neptunium-237																											
Nickel																											
Nitrate																											
Nitrite																											
Phosphate																											
Strontium-90																											
Sulfate																											
Technetium-99																											
Tritium																											
Uranium-234																											
Uranium-238																											
Xylene																											
Zinc																											

(a) For chronic ecological effects, a contaminant is identified if the number of stochastic simulation results exceeding a chronic toxicity benchmark is greater than 5 percent than the number estimated in the reference segment for that contaminant. For acute ecological effects, a contaminant is identified if the sum of acute risk indices across all species for a contaminant is more than twice the equivalent total for the reference segment.

segment for the contaminant (shown by yellow in Figure 4.20 of Section I-4.2). For the acute ecological effects, a contaminant is identified as potentially hazardous if the sum of acute risk indices across all species for a contaminant is more than twice the equivalent total for the reference segment (shown by red in Figure 4.20 of Section 4.2). Those values were chosen to reflect potentially important differences.

Table S.1 provides additional details about the magnitude and sources of the potential risk identified in Figure S.2. The table identifies which contaminants, at what locations, and in which media pose a potential risk. The table includes the "Ranger" and "Native American Subsistence Resident" scenarios, which are representative of the lower and higher risk groups, respectively.

The numbers in the table are shown in scientific notation, a type of shorthand for numbers. For example, we could write the number 1 billion as 1,000,000,000 or, using scientific notation, as 1E+09 or 1 x 10^9. To translate from scientific notation to a traditional number, move the decimal point either left or right from its present position. For example, if the value given is 2E+03, move the decimal point three numbers to the right. The number would then read 2,000. If the value given is 2E-05, move the decimal point five numbers to the left of its present location. The result would read 0.00002.

The contaminants identified in Figure S.2 as potentially hazardous are listed in Table S.1 with additional details about the magnitude and sources of the potential risk. Table S.1 presents the contaminants of highest potential risk identified in either the ecological risk assessment or the human health risk assessment, the segments in which they were identified, the medium or media that provided the dominating component of the risk, and the range of estimated human risk. To demonstrate the range of human risk, the table shows the median stochastic values of lifetime risk (carcinogenic chemicals and radionuclides) and hazard index (toxic chemicals) for both the Ranger and Native American Subsistence Resident scenarios. (The Ranger Scenario was selected as representative of the lower risk group, and the Native American Subsistence Resident Scenario was selected as representative of the higher group.) The risk values presented in Table S.1 represent total risk (background level plus Hanford contributions). The risk associated with Segment 1 (reference level) has not been subtracted.

The potential risk to humans is expressed in one of two ways in Table S.1. For contaminants that cause cancer, the risk is shown as the estimated lifetime probability of an individual contracting cancer from the exposure. For contaminants that have a toxic response, the risk is shown as a hazard index, which is the ratio of the estimated intake to the maximum safe intake rate. In Figure S.2, a contaminant is identified as potentially hazardous to humans if the estimated hazard index for a given contaminant for any scenario is greater than 0.01 or if the estimated lifetime risk for any scenario is greater than 10^{-6} (1 in 1 million).

The potential ecological risk is greatest to species associated with sediment in areas of groundwater upwelling and pore water. Potential risks to terrestrial species are driven by cobalt-60, chromium, cesium-137, mercury, and lead in sediment and pore water. Potential risk to aquatic species is due to cyanide, chromium, copper, mercury, ammonia, lead, and zinc in pore water and somewhat in sediment.

Results of the ecological assessment indicate that some contaminants pose potential hazards to some plants, herbivores, omnivores consuming riverine organisms (especially insects as prey), and weasels in some areas. Terrestrial species that are potentially most affected are swallows, mallards, American coots, harvest mice, Canada geese, and raccoons. However, risk within the study area that is above reference levels is limited

Table S.1. Potentially Hazardous Contaminants Identified by River Segment and Contaminating Media (This table presents the contaminants by river segment and media and the estimated range of human risk.)

	Ecological Risk		Human Risk					
	River		River		Ranger Scenario		Native American Sc.	
Contaminant	Segment	Medium	Segment	Medium	Haz. Index	Risk	Haz. Index	Life Risk
Benzene			5	SP				2.6E-05
			13	SP				2.6E-05
Carbon-14			4	SP				2.9E-05
			6	SP				1.2E-05
Cesium-137			2	SW				7.0E-06
			3	SW(2)				7.5E-06
			4	SW(2)				1.1E-05
			5	SW(2)				1.3E-05
			6	SW				1.8E-05
	7	SD	7	SW(6)				2.2E-05
			8	SW				2.8E-05
			9	SW(8)				2.8E-05
	10	SD	10	SW(8)				3.1E-05
			11	SW(8)				2.9E-05
	12	SD	12	SW(8)				2.9E-05
			13	SW(8)				3.3E-05
			14	SW(8)				2.4E-05
			15	SW(8)				2.4E-05
			16	SW(8)				2.6E-05
			18	SW				1.3E-05
			19	SW(18)				2.0E-05
			21	SP(GW)				1.6E-05
Chromium	2	SD+SP	2	SW+SD		2.6E-04	2.3E-02	2.6E-01
	4	SD+SP	4	SD+SP		2.1E-04	3.3E-02	1.1E-01
	5	SD+SP	5	SD		2.1E-04	1.4E-02	6.3E-02
			6	SW		5.9E-05		4.2E-02
			7	SD		1.5E-04		6.9E-02
			8	SW+SP		5.6E-05	1.4E-02	8.7E-02
	9	SD+SP	9	SD+SP		1.0E-04	2.5E-02	6.7E-02

GW = Groundwater
SD = Sediment
SP = Seep water
SP(GW) = Seep water surrogated with groundwater
SW = Surface water
SW(21) = Surface water extrapolated from upstream Segment 21

Note: Only human risk values greater than 1.0E-6 or a hazard index of 0.01 are shown.

Table S.1. (contd)

	Ecological Risk		Human Risk					
	River		River		Ranger Scenario		Native American Sc.	
Contaminant	Segment	Medium	Segment	Medium	Haz. Index	Risk	Haz. Index	Life Risk
Chromium (contd)	10	SD+SP	10	SD+SP		1.4E-04	1.7E-02	5.9E-02
			13	SD		7.2E-05		5.3E-02
			18	SD		1.9E-04		3.9E-02
			19	SD		2.5E-04		1.1E-01
			20	SD		1.6E-04		7.0E-02
			27	SD		1.5E-04		1.6E-02
Cobalt-60			2	SD				3.5E-06
(Diffuse)			3	SW(2)				2.2E-06
			4	SW(2)				3.0E-06
			5	SW(2)				2.7E-06
	6	SD	6	SD				1.1E-05
	7	SD	7	SD				2.6E-06
	8	SD	8	SW				3.7E-06
	9	SD	9	SD				2.5E-06
			10	SW(8)				1.9E-06
			11	SW(8)				2.2E-06
	12	SD	12	SW(8)				2.0E-06
	13	SD	13	SP(GW)				6.6E-06
			14	SW(8)				1.5E-06
			15	SW(8)				2.1E-06
			16	SW(8)				2.1E-06
			17	SP				2.1E-06
			18	SW				3.5E-06
			19	SW(18)				8.5E-06
			21	SP(GW)				2.9E-06
Copper	4	SP	4	SD			2.4E+00	
			11	SD			2.6E+00	
			14	SD			2.8E+00	
			17	SD			2.5E+00	
	20	SP						
			23	SW			6.5E+00	
			24	SW(23)			4.3E+00	
			25	SW(23)			6.3E+00	
			26	SW(23)			5.3E+00	
			27	SW(23)			6.9E+00	

GW = Groundwater
SD = Sediment
SP = Seep water
SP(GW) = Seep water surrogated with groundwater
SW = Surface water
SW(21) = Surface water extrapolated from upstream Segment 21
Note: Only human risk values greater than 1.0E-6 or a hazard index of 0.01 are shown.

Table S.1. (contd)

	Ecological Risk		Human Risk					
	River		River		Ranger Scenario		Native American Sc.	
Contaminant	Segment	Medium	Segment	Medium	Haz. Index	Risk	Haz. Index	Life Risk
Cyanide	20	SP(GW)						
	21	SP(GW)						
Europium-152			13	SP(GW)				6.3E-05
Europium-154			6	SP				2.9E-06
			8	SP				9.2E-06
			13	SP(GW)				1.3E-05
			17	SW				3.1E-06
			18	SW(17)				3.2E-06
			20	SP				1.7E-06
			21	SP(GW)				1.5E-05
Iodine-129			19	SP(GW)				2.2E-06
Lead	2	SD+SP						
	3	SD+SP						
			4	SD			4.3E-01	
	5	SD+SP	5	SD			3.6E-01	
	7	SD+SP						
	9	SD+SP						
	13	SD+SP						
	17	SD+SP	17	SD			1.2E+00	
	19	SD+SP	19	SD			6.5E-01	
	20	SD+SP	20	SD			4.7E-01	
	21	SD+SP						
			22	SW(21)			3.8E-01	
Mercury	3	SD						
	4	SD						
	6	SD						
	8	SD						
	9	SD						
	10	SD						
	12	SD						
	13	SD						
	14	SD						
	15	SD						
	16	SD						
	19	SD+SP						
	20	SD+SP						

GW = Groundwater
SD = Sediment
SP = Seep water
SP(GW) = Seep water surrogated with groundwater
SW = Surface water
SW(21) = Surface water extrapolated from upstream Segment 21
Note: Only human risk values greater than 1.0E-6 or a hazard index of 0.01 are shown.

Table S.1. (contd)

	Ecological Risk		Human Risk					
	River		River		Ranger Scenario		Native American Sc.	
Contaminant	Segment	Medium	Segment	Medium	Haz. Index	Risk	Haz. Index	Life Risk
Neptunium-237			8	SD				6.5E-05
			9	SD				8.3E-05
Nickel	20	SD						
Nitrates			4	SP			1.6E-01	
			10	SP			1.0E-01	
			12	SP(GW)			8.9E-02	
			14	SP			1.4E-01	
			17	SP			1.4E-01	
			20	SP			2.4E-01	
Nitrites			19	SP			1.1E-02	
Strontium-90			2	SD				8.4E-06
			3	SD				6.7E-05
			4	SW(3)				1.1E-05
			5	SD				1.3E-04
			6	SD				6.7E-04
			8	SP				1.8E-05
			9	SW				1.4E-05
			10	SD				1.1E-04
			12	SW(10)				6.4E-06
			13	SD				4.4E-05
			15	SD				5.9E-05
			16	SW				3.0E-05
			20	SW				6.1E-06
			21	SW				5.4E-06
			24	SW(21)				6.5E-06
			26	SW(21)				5.8E-06
			27	SW(21)				6.6E-06
Sulfates			7	SP(GW)			1.1E-02	
Technetium-99			3	SD				2.8E-06
	8	SD	8	SD				1.2E-06
	9	SD	9	SD				
	10	SD	10	SD				2.8E-06
	14	SD						
			17	SD				1.3E-06
	19	SD	19	SD				2.5E-06

GW = Groundwater
SD = Sediment
SP = Seep water
SP(GW) = Seep water surrogated with groundwater
SW = Surface water
SW(21) = Surface water extrapolated from upstream Segment 21

Note: Only human risk values greater than 1.0E-6 or a hazard index of 0.01 are shown.

Table S.1. (contd)

	Ecological Risk		Human Risk					
	River		River		Ranger Scenario		Native American Sc.	
Contaminant	Segment	Medium	Segment	Medium	Haz. Index	Risk	Haz. Index	Life Risk
Tritium (Hydrogen-3)			2	SP				1.3E-05
			4	SP(GW)				6.7E-06
			6	SP				1.7E-05
			8	SP				5.0E-06
			9	SP				4.3E-06
			17	SP				2.2E-04
			19	SP(GW)				2.4E-05
			20	SP				8.9E-06
Uranium-234			12	SD				4.6E-05
			14	SP				7.3E-05
			17	SP				7.6E-05
			20	SP				9.3E-04
Uranium-238			4	SD				5.2E-05
			10	SD				1.5E-04
			11	SD				4.9E-05
			12	SD				4.5E-05
			14	SP				6.5E-05
			17	SD				5.8E-05
			19	SW+SP				1.1E-04
			20	SP+SD				8.7E-04
Zinc	4	SP+SD	4	SD			1.7E-01	
	7	SP+SD						
	8	SP+SD						
			12	SP(GW)			3.8E-01	
			16	SD			1.5E-01	
	17	SP+SD	17	SD			1.6E-01	
			19	SD			2.3E-01	
	20	SP+SD						

GW = Groundwater
SD = Sediment
SP = Seep water
SP(GW) = Seep water surrogated with groundwater
SW = Surface water
SW(21) = Surface water extrapolated from upstream Segment 21
Note: Only human risk values greater than 1.0E-6 or a hazard index of 0.01 are shown.

to only a few locations within the study area (see Figure 4.23 in Section I-4.2). The other species, including bald eagles, have relatively low risk in both absolute and relative (to reference) terms. A key pathway of exposure for the terrestrial organisms is predation of the aquatic species with high body burdens, which is ultimately related to the concentration of contaminants in pore water.

Aquatic species most likely to be affected by acute or chronic toxic effects from contaminants of Hanford Site origin are Columbia pebblesnail, freshwater shrimp, crayfish, Woodhouse's toad, suckers, clams, mussels, juvenile salmon and trout, and water fleas. The main reason for the high relative risk of these aquatic species is their exposure to pore water and sediment. Most of these aquatic organisms have a benthic life style. They spend all or a high proportion of their life in direct contact with sediment or pore water. Thus, the pore water concentrations tend to drive their body burdens, or contaminant concentrations, in tissue.

The following contaminants present the greatest potential ecological risk in a particular segment:

- Segment 2 - chromium and lead in the 100-B/C Area
- Segment 3 - mercury and lead
- Segment 4 - chromium, copper, mercury, and zinc in the 100-K Area
- Segment 5 - chromium and lead
- Segment 6 - cobalt-60 and mercury in the 100-N Area
- Segment 7 - cesium-137, cobalt-60, lead, and zinc in the 100-D Area
- Segment 8 - cobalt-60, mercury, and technetium-99
- Segment 9 - chromium, cobalt 60, lead, technetium-99, and mercury
- Segment 10 - cesium-137, chromium, mercury, and technetium-99 in the 100-H Area
- Segment 12 - cesium-137 and cobalt-60
- Segment 13 - cobalt-60, lead, and mercury in the 100-F Area
- Segment 14 - mercury and technetium-99
- Segment 15 - mercury
- Segment 16 - cobalt-60 and mercury
- Segment 17 - lead, but results suspect, and zinc
- Segment 19 - lead and mercury
- Segment 20 - cyanide, lead, mercury, nickel, technetium-99, and zinc in the 300 Area—all results suspect
- Segment 21 - cyanide and lead

The following segments present potential acute ecological risk:

- Segment 4 - chromium and zinc
- Segment 5 - lead
- Segment 8 - mercury
- Segment 9 - chromium, lead, and mercury
- Segments 10 and 14 - mercury
- Segment 13 - lead and mercury

- Segment 17 - lead
- Segment 20 - copper and zinc

The screening assessment only addresses potential risk to individuals of a species. The overall potential impact on populations and the river and riparian ecosystems is not known. Insufficient knowledge is available about the distribution of species, their migration patterns, and their interactions over the entire Hanford Reach. It is possible to say that there is a risk to individual members of certain species, those that frequent the locations of highest contamination.

The potential human risk is to individuals consuming Hanford Site groundwater and large quantities of food from the river and/or riparian zone in some locations along the Hanford Reach. The greatest potential human risk for any given scenario (identified using an estimated hazard index greater than 1.0 or an estimated lifetime risk greater than 1 in 10,000) is the result of chromium, copper, tritium, lead, strontium-90, and uranium in seep water, sediment, and in some cases surface water.

The human health assessment evaluated a wide variety of life styles and identified those most likely to be affected. Humans in the region of the Hanford Site may have a wide variety of exposures, from low to high (see Figures 5.1-5.3 in Section I-5.2.3.1). Generally, the scenarios for the fish hatchery worker, industrial worker, and ranger have the lowest exposures and, therefore, are lowest in terms of health risk. As defined in Section I-5.1, none of the people involved in these scenarios consume foods grown in the Columbia River riparian zone or drink seep water. Therefore, the exposures are mostly incidental external exposures and inhalation of resuspended materials, although the fish hatchery and industrial workers also consume a moderate amount of Columbia River water. The risk to workers from these pathways is quite low compared with those projected for people potentially exposed in other ways.

At the other extreme, people assumed to live along the Columbia River, to eat substantial quantities of foods grown in the riparian zone, to eat fish and wildlife from the river, and to drink seep water have much larger potential exposures and, thus, estimated health risk. This category includes nearly all of the remainder of the scenarios described in Section I-5.1. From a risk assessment standpoint, very few differences appear between any of the Native American scenarios and recreational/residential scenarios. All assume individuals who spend all or most of their time in the riparian zone along the river, consume riparian-zone foods, and drink untreated seep water.

The contaminants presenting the greatest potential human health risk for any given scenario in a particular segment are listed below. These contaminants are identified using the estimated hazard index greater then 1.0 and/or an estimated lifetime risk greater than 1E-4 (1 in 10,000).

- Segment 2 - chromium
- Segment 4 - chromium and copper
- Segments 5 and 6 - chromium and strontium-90
- Segments 7-9 - chromium
- Segment 10 - chromium, strontium-90, and uranium-238
- Segment 11 - copper
- Segment 13 - chromium

- Segment 14 - copper
- Segment 17 - copper, lead, and tritium
- Segment 18 - chromium
- Segment 19 - chromium and uranium-238
- Segment 20 - chromium and uranium-238
- Segments 23-27 - copper

By using multiple exposure scenarios, the possible activities of people who could come into contact with the contaminants were evaluated. In general, risk to people today is low because of restricted access to the Hanford Site. Casual visitors and even people working in jobs associated with the Columbia River are not at risk unless they frequent limited areas and consume seep or spring water in which high concentrations of contaminants are present. However, potentially increased risk is possible if people were to move onto the Hanford Site and derive large percentages of their daily food intake from crops and animals in the river's riparian zone. In most cases, this higher risk is limited in extent to a few regions of highest contamination. Although many cultural differences exist between the general population and Native Americans, the common pathways of food and water consumption could affect both groups. These common pathways are the ones by which most exposure would be received. The key differences come in the source of the water and food products.

Hanford and Non-Hanford Sources of Contaminants

Contaminants present in the Columbia River environs result from operations at Hanford as well as from human activities upstream of the Hanford Site. Contaminants for which a Hanford source appears to be indisputable include ammonia, cesium-137, chromium, cobalt-60, europium-152, europium-154, nitrates, strontium-90, technetium-99, tritium (hydrogen-3), and uranium isotopes. Other contaminants for which the Hanford Site may be a contributor, at least at specific locations, include copper, cyanide, lead, mercury, and zinc. The analyses indicate relatively high potential risk from these latter contaminants. However, the upstream risk from these contaminants is also high, and the Hanford Site increment over the upstream value is generally factors of two to three or less, making exact identification difficult.

Potentially Hazardous Contaminants

Of the 26 contaminants of interest screened in the screening assessment, the contaminants discussed here are those identified by the ecological and human health screening assessments to be potentially hazardous (see Figure S.2 and Table S.1). The intent of the discussion of each potentially hazardous contaminant is to enhance the understanding of the potential risks and focus possible remedial decisions on those contaminants and media with the potential for the greatest risk reductions.

Benzene. No downstream measurements of benzene in surface water exceed that in reference Segment 1. However, benzene is found in low concentrations in seep water, frequently in conjunction with xylenes. It is a measurement surrogate for petroleum hydrocarbons. Some instances of petroleum contamination are known at the Hanford Site, with the highest levels found at the 100-K and 100-F Areas. The primary exposure pathway is consumption of seep water.

Carbon-14. Carbon-14 is not detected in surface water. The Native American and Resident scenarios are controlled by ingestion of carbon-14 derived from seep water. Contaminant concentrations in seep water were substituted for contaminant concentrations in groundwater in almost all segments along the Hanford Site. A single, particularly high value in the 100-K Area is evident in the deterministic data.

Cesium-137. Cesium-137 is a constituent of worldwide fallout and is present in soil and river sediment both upstream and downstream of the Hanford Site. While the concentrations of cesium-137 in sediment are similar upstream, along, and downstream of the Hanford Site (Dirkes and Hanf 1996), the measurements along and downstream of the site vary more, indicating that localized zones of increased concentration may exist. The primary risk is to biota that burrow into or consume the sediment. The primary pathway is external irradiation of these biota. For humans, the scenarios with high fish consumption show somewhat elevated risks from surface water, but this is largely driven by the surrogation process from a very few measured segments.

Chromium. This metal is identified as existing in elevated concentrations in several Hanford Reach river segments. For biota, the primary media of concern are sediment and pore water within the sediment (modeled using measurements of seep water or groundwater), and for humans the primary media are also sediment and the associated seeps. This indicates that the primary problem is groundwater contamination inland of the areas of the seeps, which is resulting in contamination of the sediment around the point where the groundwater issues into the river.

Cobalt-60. This radionuclide exists in both discrete particulate form and as generalized diffuse contamination. The particles have higher discrete activity and are somewhat easier to detect, but a more significant problem is with the diffuse sources. As with cesium-137, the primary ecological problem is direct external irradiation of biota that burrow into or consume the sediment contaminated with diffuse cobalt-60 contamination.

Copper. In general, the risk to humans or biota from copper is similar upstream and downstream of the Hanford Site. However, in absolute terms, the modeling indicates this metal has one of the highest estimated risks to biota and humans. The assessment results indicate that pore water (modeled using groundwater measurements) in the 100-K Area and 300 Area may be elevated, thus exposing biota. Possible positive identification in other segments results from adding contributions from several media (for example, water plus sediment). Copper is one of the metals that may also be enhanced from upstream anthropogenic (created by humans) sources, such as mining.

Cyanide. The excess risk calculated for this chemical compound is associated with pore water (modeled using groundwater) for biota and with seep water (also modeled using groundwater) for humans.

Europium-152. Europium-152 is an activation product, similar in source to cobalt-60. Although discernible above the reference concentration throughout the Hanford Reach in sediment, the risk to humans from europium-152 is primarily from ingestion of seep water in Segment 13.

Europium-154. Like europium-152, the activation product europium-154 is slightly elevated throughout the Hanford Reach. The primary exposures are via seep water, although the primary mechanism in Segments 17 and 18 is via surface water.

Iodine-129. Iodine-129 is detectable above the reference concentration at very low levels in Hanford surface water, but the primary pathway of exposure is via drinking seep water. The only segment with concentrations measured sufficiently high to score over a risk of 1 in 1,000,000 is Segment 19.

Lead. The risk to biota from lead is dominated by concentrations in sediment and pore water, and the risk to humans is dominated by concentrations in sediment. Lead is one of the metals that may also be enhanced in sediment from upstream sources, but signs indicate that lead may be somewhat enhanced in Hanford Site groundwater, particularly in the vicinity of the old Hanford townsite.

Mercury. The risk from mercury is primarily to biota from sediment. Mercury is one of the metals that may also be enhanced from upstream sources.

Neptunium-237. The only positive measurements for neptunium-237 occur in sediment in Segments 8 and 9, which in the modeling lead to small ingestion intakes. These are single point measurements and do not represent wide area contamination.

Nickel. The ecological modeling identifies nickel in sediment as a possible problem in the 300 Area only.

Nitrates. The risk to humans from nitrates is derived from the pathway of drinking seep water. Nitrates are known to be elevated in Hanford Site groundwater with samples in groundwater above the EPA drinking water standards in several of the reactor areas (see, for example, Dirkes and Hanf 1996).

Strontium-90. The primary risk to humans from strontium-90 comes from consuming foods grown in contaminated sediment. Risk from consumption of seep water comes in a close second. The concentrations in the sediment most likely are related to the seep water concentration at most of the locations that are coincident with reactor areas.

Sulfates. Sulfates are measured in surface water and seeps in many locations. The primary pathway is direct ingestion. The concentrations averaged in Segment 7 are slightly higher than elsewhere, but the risk from sulfates is generally low.

Technetium-99. Environmental concentrations of technetium-99 are not high, but the soil-to-plant uptake factor for technetium is very large. Vegetation has a strong propensity to concentrate technetium from soil. The key medium for technetium-99 is sediment. The ecological risk is actually related to the chemical toxicity of technetium in plants. The human health risk is associated with consumption of food plants grown in the technetium-contaminated sediment in the riparian zone.

Tritium (Hydrogen-3). Tritium is widely distributed in Hanford Site groundwater. However, it has a low biological uptake and generally short retention time in plants and animals because it is associated with water. In addition, tritium is a very low energy beta emitter and has no gamma rays. The primary route of exposure to humans is via consumption of seep water. The most extensive region where seep water contaminated with tritium enters the Columbia River is the vicinity of the old Hanford townsite.

Uranium-234/238. Although uranium is also pervasive in the environment, several areas have concentrations elevated above reference levels. The media of interest include sediment and seep water near the 300 Area. A prominent pathway is the consumption of prey animals by animals farther up the food chain.

Zinc. The risk to biota is predominantly influenced by pore water and sediment. This metal provides the highest absolute contribution of risk to biota, but the estimated risk for the downstream river segments is generally less than that estimated for the reference segment for risk to humans. Zinc is one of the metals that may also be enhanced from upstream sources.

Uncertainty and Perspective

The CRCIA screening assessment was, by definition, limited in some respects. The CRCIA screening assessment was restricted to 1) current conditions, 2) the Columbia River and adjacent riparian zone between Priest Rapids Dam and McNary Dam, 3) a limited number of contaminants, 4) a limited amount of monitoring data, 5) a limited number of species, and 6) a limited number of scenarios. For the assessment results to be useful, these limitations, the study's assumptions, and the study's approach to conducting the assessment must be understood and considered in context with the intended use. Site-specific considerations should be added to the general results presented here during the decision making process to ensure responsible actions that protect the Columbia River.

Screening assessments are used to indicate whether the issues under study warrant further investigation or corrective action. Screening assessments often use total risk to screen out potential concerns that are identified as irrelevant and to identify important contaminants, species, and locations. Screening assessments also are often used to express risk in relative, rather than absolute, terms because of the number and type of assumptions required to drive risk models, the degree of uncertainty inherent in the models' input, and the limitations in available environmental data. These assumptions, uncertainties, and limitations are applied consistently across the study area, resulting in useful information about the magnitude and location of risk within the study area. Relative risk is useful in determining the potential risk that is the result of a specific activity, such as Hanford operations, as opposed to risk associated with background (natural or anthropogenic) conditions.

The screening assessment was designed to focus attention on contaminants with the most immediate potential for human and ecological risk. However, some future potential parameters were included. In addition, some data gaps limited the assessment. Therefore, the focus, the assumptions, and the limitations of this assessment are important considerations when evaluating the results. Because a contaminant has been identified as potentially posing a risk does not necessarily mean that humans or the environment is at imminent risk from this contaminant. Just as important, the converse may also be true. Because the risk of a contaminant in certain segments has not been identified does not necessarily mean that a risk does not exist. It just may not have been measured yet.

Uncertainty is inherent in any risk assessment. The levels of contaminants varied both among and within environmental media and among and within individual river segments. In addition, uncertainty exists in most of the parameters used in the risk calculations. For example, uncertainties include those associated with the exposure models and the large number of parameters they contain, measured media data, representativeness of the data, use of surrogate and extrapolated data, exposure scenarios, accuracy of modeled processes, and toxicological and dose responses. This implies that considerable variability and uncertainty also exist in the screening assessment results and should be considered in context with the intended use. The uncertainty within the data, ecological assessment, and human health assessment is discussed in Sections I-3.5.2, I-4.2.10 and I-5.2.3.3, respectively.

As discussed earlier, the screening assessment analyses are based on the currently available data, and information is not available for all contaminants in all river segments during this time period. Where appropriate, substitute data were used to fill some of the data gaps, but others remain. Therefore, the final results of the screening assessment are limited by the scope constraints and the available information. In addition, the lack of data contributes to the uncertainty associated with the results of the screening assessment. The assessment has indicated that portions of the Hanford Reach of the Columbia River have concentrations of contaminants, particularly in sediment and groundwater, that are high enough to warrant additional investigation and possible remediation. These areas are identified in this report. However, because of the data gaps, it is not possible to state that concentrations of some of the contaminants in other locations are not also of concern.

The density of data within segments available for the assessment is inconsistent. Segments with an abundance of data were treated the same as segments with very little data, thereby introducing another source of uncertainty in the results. For some river segments, relatively few data were available during the study period. While additional sampling may be advisable in these areas, before that is done or remedial action is taken, consideration first must be given to additional information not used in this analysis and the likelihood of acquiring additional useful information. For example, systematic radiological surveys (EG&G 1990; Sula 1980) indicate little potential for finding additional highly radiologically contaminated areas along the river.

For the analysis, the spatial extent of the river segments was defined to be large enough to overestimate the extent of elevated risk in the deterministic assessment. The deterministic assessment uses maximum concentrations that are present in relatively small localized areas within a segment and that are not representative of the entire segment. On the other hand, the size of the segment may partially mask the presence of hot spots (local high concentrations) in the stochastic assessment. The stochastic risk results tend to average out over segments as much as a few miles long. As a result of this and the data density issue discussed above, hot spots may be masked and it is not possible to state categorically that elevated levels of contaminants do not exist in areas other than those previously identified.

The screening assessment results indicate Hanford operations may have contributed to potential human health and/or ecological risk resulting from heavy metals. However, sources of heavy metal releases to the Columbia River can be found upstream of Hanford. Thus, amounts of these metals, particularly chromium, copper, lead, mercury, and zinc, in sediment and water are being transported through the Hanford Reach from operations such as mining upstream (Munn et al. 1995; Serdar 1993; Johnson et al.

1990). Recent events have shown that upstream tributaries of the Columbia River may carry very high levels of metals, particularly during periods of high runoff (*Tri-City Herald* 1997). The concentrations are sufficient to be acutely toxic to wildlife. Recent studies of rivers other than the Columbia also indicate that the Hanford Reach is not unique (Pinza et al. 1992). The source of contaminants must be considered when considering further investigation or evaluating Interim Remedial Measure alternatives.

Many contaminant metals tend to sorb to fine-grained sediments, which deposit in slack water areas. Sizable quantities of sediments are deposited in the study area in the Hanford sloughs as well as behind both Priest Rapids Dam upstream (a portion of Segment 1) and McNary Dam downstream (Segments 22-27). These variations in sediment deposition and composition (grain size and organic content) may help explain some of the assessment results. A clear understanding of these complex relationships is essential to ensuring the environmental data and the resultant analyses using these data are accurately interpreted.

The bioavailability of some of these heavy metals also has been identified as a significant source of uncertainty in the ecological assessment (see Sections 4.2.7 and 4.2.10). Some of these metals (copper, zinc, chromium, and nickel, in particular) serve as nutrients, and many organisms are capable of regulating the concentrations of these metals over a fairly wide range of environmental concentrations. As a result, transfer factors for these contaminants are highly variable and often are over- or under-estimated in ecological assessments. A better understanding of the bioavailability and biotolerance of these contaminants in the Hanford Reach would allow the risk associated with these contaminants to be more accurately estimated.

The scenarios used to establish the potential for human exposure all have a common starting assumption: the individual described performs all of the described activities within the selected segment and within the river or immediately adjacent riparian zone. The likelihood of a person actually deriving all food and water from the ripanian zone has not been included in the scenario definitions. However, to simplify the analyses and to provide a common basis for comparison, the same assumptions have been used for all river segments. Thus, while the results discussed above may indicate potential risk for various residential scenarios, the probability of such activities occurring is not considered in this assessment.

The ecological risk evaluated is for injury to individual plants or animals. The overall potential impact on the ecosystem is not known. The current state of scientific knowledge does not allow extrapolation to impact on the ecosystem with this level of information. Insufficient knowledge exists about the distribution of species, their migration patterns, and their interactions over the entire Hanford Reach. Similarly, human risk is limited to individual toxic response or long-term carcinogenicity. The scenarios do not address cultural impact or multigenerational impact of the exposures.

The CRCIA screening assessment has provided an extensive amount of information relative to the human health and ecological risk associated with Hanford-origin contaminants in the Columbia River environment. The assessment has been successful in identifying contaminants that pose a significant potential risk. In addition to humans, ecological species most likely to be exposed to elevated levels of contaminants have been identified. The assessment identifies in what media the contaminants are concentrated and through what pathway the contaminants reach the species. In addition, the locations of the problem areas have been identified within the spatial scale provided for in the assessment. The assessment defines the activities that could result in an adverse exposure to the contaminants. Uncertainties associated with the screening assessment are discussed. The screening assessment provides information to support Interim Remedial Measure decisions, to help guide ongoing environmental surveillance programs, and to focus a subsequent and more comprehensive assessment.

Part II. Requirements for a Comprehensive Assessment

As the screening assessment documented in Part I was being conducted, the assessment specified in Part II was developed by the CRCIA Team. Active participants on the CRCIA Team have been representatives from the Confederated Tribes of the Umatilla Indian Reservation, Nez Perce Tribe, Yakama Indian Nation, Hanford Advisory Board, Oregon State Department of Energy, Washington State Department of Ecology, U.S. Environmental Protection Agency, and, acting as host in a non-negotiating role, DOE. (See the Part II disclaimer for a definition of DOE's role.) The CRCIA Team developed Part II to explicitly require that any future assessment of Hanford Site impact on the Columbia River embody, at a minimum, the methods, characteristics, and controls described here. Analyses involving the Columbia River that adhere to the spirit and substance of these requirements are far more likely to be acceptable to the governments and institutions involved and far more meaningful in guiding cleanup decisions.

HOW TO USE THIS DOCUMENT

Part II consists of narrative sections (Sections 1-4) and specification sections (Appendixes II-A-D). The specification sections specify the technical and management requirements for conducting the assessment. The appendixes are for the analysts who will perform the technical work. The narrative sections supplement the specification sections with general guidance and non-technical explanations of the requirements. While each section is complete in its own right, the reader may find it useful to study the narrative and appendixes in parallel.

This is the only composite assessment of how effective the cleanup of the Hanford Site will be in terms of impact to the Columbia River. Other analyses address only some of the elements of the needed assessment. This is a composite assessment partly because all potentially harmful radioactive and chemical materials within the Hanford Site boundary (those planned at the completion of cleanup) are included in a single evaluation of impacts. The purpose of the CRCIA is to assess the effects of Hanford-derived materials and contaminants on the Columbia River environment, river-dependent life, and users of river resources for as long as these contaminants remain intrinsically hazardous. This purpose is envisioned to be carried out by developing a suite of integrated analysis tools, which would be used for each revision of DOE's intended waste disposal plans that define the Hanford Site's final end state. As such, CRCIA becomes a major, critical part of the Hanford Site's final baseline risk assessment. CRCIA is also a tool for estimating the effectiveness of each alternative considered in strategic planning exercises, environmental impact statements, and various projects' studies. This assessment was defined and this part of the document was prepared by the CRCIA Team (not DOE or its contractors) under a new public involvement paradigm described later in this summary, in Section II-4.0 and in Appendix II-D.

In facing the question of what constitutes a comprehensive assessment, a serious problem soon became apparent: How can the assessment include all of the factors significant to potential river impacts while keeping the effort to a manageable size that can be funded? Using expert judgment to "assume the assessment down to size" was rejected as an acceptable solution to this problem. Instead, a principle (specified as a requirement in Part II) was borrowed from other industries that routinely deal with large, complex problems yet have limited resources. This principle requires the study's planning process to be based on sensitivity analyses and parametric analyses that sort the dominating factors from the smaller contributors to impact. Consequently, for any given level of resources allocated to this assessment, the biggest contributors to potential river impact will always be addressed. The challenge for both analysts and managers is not to arbitrarily discard parts of the assessment to cut it down to size but rather to ensure that no factor that would dominate the study results is left out.

Part II has been developed to be fiscally responsible in defining the requirements for the technical work that must be conducted regardless of speculations on probable funding availability or limits presumed to exist in analytical methods, data collection techniques, or related technologies. Every effort was made to ensure that the assessment will always focus on major contributors in such a way as to avoid confusion and misdirection of efforts by the many smaller considerations.

Since the screening assessment in Part I of this document was scoped to be a less than comprehensive limited-resource effort focused on identifying the most significant existing effects on the Columbia River, the comprehensive assessment in Part II subsumes the screening assessment in identifying both existing and future effects from the composite of all Hanford activities. In spite of the care in developing this document, it is recognized that it can and should be improved upon, especially in view of inevitable changes in waste disposal plans and experience gained in conducting this and similar assessments. This is intended to be a living document with changes controlled by the authoring institutions.

Part II defines a new paradigm for predecisional participation by those affected by Hanford cleanup decisions. The CRCIA Team developed the requirements in Part II as well as the approach and structure for conducting and managing future assessment work. Appendix II-D describes this new paradigm and the associated management requirements. It is recognized that some time may be needed to make the adaptations in existing Hanford practices this new paradigm calls for. An implementation period is expected, during which special attention will be given to working within existing policies and procedures while adaptations are being made. The CRCIA Team believes that early participation by affected groups, during the formative period of decisions, is necessary for an effective and responsive cleanup of the Hanford Site.

Following the "Introduction" and the discussion of principles and general requirements, Part II is divided into four key sections: *WHAT* is to be analyzed, *HOW WELL* the results must represent actual and future impact to the Columbia River, technically *HOW* the assessment is to be performed, and what the *MANAGEMENT* structure is to be for the analysis work. Explanations and descriptions of these four areas are in the sections below. Lists of the technical requirements in Appendixes II-A through II-D parallel this structure in this introduction. The parallel sections/appendixes are as follows:

- Section 1.0/Appendix II-A, "What the Assessment Must Include." These sections specify *what* factors must be included in assessing river impact. They include the extent of Hanford Site activities and materials to be addressed, transport mechanisms and travel times, and contaminant introduction into the river. The requirements also address the distribution of the contaminants within the Columbia River as well as identification of habitat or other water uptake locations. The requirements specify potential species, ecosystems, human populations, and cultures that could be affected by Hanford-derived contaminants in the Columbia River. This section also includes probable scenarios for the time frame of interest in which substantive change occurs to the river or ecosystem and cultural dependency on the river.

- Section 2.0/Appendix II-B, "How Good the Impact Assessment Results Must Be." Requirements in these sections prescribe how complete the assessment results must be and *how good* the analysis must be to produce the needed results.

- Section 3.0/Appendix II-C, "Analytical Approach and Methods." Given the factors specified in the first two sections (1.0 and 2.0), these sections stipulate *how* the technical analyses are to be planned to ensure no dominant contributor is overlooked. Analytical methods, modeling requirements, data quality, uncertainty, and verification requirements are among the specifications included. While these requirements avoid specifying what tasks must be done or in what sequence work is to be performed, it is clear that this section must heavily influence how the assessment work is to be defined and what preparatory work must precede the start of the analysis.

- Section 4.0/Appendix II-D, "Conducting and Managing the Assessment." These sections address the *management* requirements, including methods to determine funding prioritization, sequence of technical work, the roles of peer reviewers, integration with Hanford Site strategic planning and other analyses, and support of environmental impact statement preparations. These sections also address the continuing involvement and authority of affected people and groups.

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