1.0 Introduction

In the screening assessment component of the Columbia River Comprehensive Impact Assessment (CRCIA) Project, current ecological and human risk from contaminants in the Columbia River was evaluated. The risk studied was that attributable to past and present activities at the Hanford Site. These activities resulted in radioactive and hazardous materials that can affect the environment and human health. As a result, ecological risk was evaluated relative to the health of the current river ecosystem. Human risk was evaluated for a range of river use options.

For the screening assessment, we attempted to answer the following questions:

- **What contaminants need to be studied?**
- **What information already exists about contamination to the river from activities at Hanford?**
- **What species should be studied to identify the possible effects of contamination on the environment?**
- **What exposures (scenarios) do humans have to river contamination?**
- **What levels of contamination exist in the study area?**

1.1 Purpose and Objective

The purpose of the CRCIA screening assessment is to support decisions on Interim Remedial Measures and to provide focus to a subsequent and more comprehensive risk assessment. The objective of the screening assessment was to identify areas having the greatest potential for adverse effects on humans or the environment. While decisions on Interim Remedial Measures (such as pump and treat, soil washing, and effluent pipe removal) are not expected to be made solely based on screening assessment results, the information generated will be useful input for the decision makers. The Hanford Reach of the Columbia River was evaluated in the screening assessment in a way that will be useful in the CERCLA process (Comprehensive Environmental Response, Compensation, and Liability Act of 1990), but not necessarily in strict accordance with CERCLA procedures (for example, risk assessment methodology and remedial decision making).

The purpose of Part I of this report is to provide the results of the screening assessment conducted by the Pacific Northwest National Laboratory (PNNL) in consultation with the CRCIA Team. The requirements for the remaining work to be done have been written by the CRCIA Team and are included as Part II of this report.

1.2 Scope of Work

The scope of the CRCIA screening assessment was to evaluate potential risk to the environment and human health resulting from current levels of Hanford-derived contaminants. The screening assessment has several primary components:

- determining study domain and spatial scale
- identifying contaminants to be assessed
- identifying a variety of species to evaluate ecological exposure to the contaminants

- identifying a variety of exposure scenarios to evaluate human exposure to the contaminants
- identifying, collecting, and preparing monitoring data available for the contaminants
- assessing risk to human health and the environment posed by exposure to the contaminants

A screening assessment by its very nature is a limited assessment. Such limited assessments are used to indicate whether the issues under study warrant a full investigation. Screening assessments often express risk in relative terms rather than absolute terms because of the number and type of assumptions required to drive risk models, the degree of uncertainty inherent in model input, and the limitations in available environmental data. The value of conducting a screening assessment is that the assumptions, uncertainties, and limitations are applied consistently across the study area, resulting in useful information relative to the areas thought to be of greatest concern. The limitations of the CRCIA screening assessment were that it was restricted to 1) current conditions, 2) the area between the vicinity of 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.

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. Historical data indicate that the concentrations of contaminants in this reach of the Columbia River are as high as or higher than those in areas downstream of McNary Dam (see the environmental monitoring reports for the Hanford Site published since 1958, the most recent of which is Dirkes and Hanf 1996). Other factors determining the study area include the availability of appropriate environmental data to conduct the screening assessment, the lack of such data downstream of McNary Dam, the known discharge of contaminants into the river (primarily via groundwater seepage) along the Hanford Site, and the resource constraints (time and dollars) originally imposed on the screening assessment. The specific parameters of the scope of the screening assessment are shown below.

Area Columbia River (vicinity of Priest Rapids Dam to McNary Dam), groundwater (up to 0.8 kilometer/0.5 mile in from the river), and adjacent riparian zone

Time January 1990 - June 1996 (most recent date of data used in the screening assessment) with data gaps filled by earlier data where available

Contaminants

Radionuclides

• tritium (hydrogen-3)	• technetium-99	• europium-154
• carbon-14	• iodine-129	• uranium-234
• cobalt-60	• cesium-137	• uranium-238
• strontium-90	• europium-152	• neptunium-237

Carcinogenic Chemicals

• benzene	• chromium

Toxic Chemicals

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

See Section 2.0 and Appendix I-A.

Data Sources

City of Pasco, City of Richland, Environmental Restoration Contractors, Hanford Environmental Information System, Oregon State Department of Energy, Pacific Northwest National Laboratory, U.S. Army Corps of Engineers, U.S. Geological Survey, Washington Public Power Supply System, Washington State Department of Ecology, Washington State Department of Health, Westinghouse Hanford Company

See Section 3.0 and Appendix I-B.

Measured Media

Groundwater, sediment, seeps, surface water, external radiation, riparian soil, biota

Species

Algae

- periphyton
- phytoplankton

Amphibians

- Woodhouse’s toad

Aquatic Invertebrates

- clams/mussels/snails
- crayfish
- fresh water shrimp
- mayfly
- 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
- northern harrier

Emergent Vegetation

- tule

Fish

- channel catfish
- common carp
- largescale sucker
- mountain sucker
- mountain whitefish
- Pacific lamprey
- salmon
- small mouth bass
- trout
- white sturgeon

Fungi as a taxonomic group

Macrophytes

- Columbia yellowcress
- water milfoil

Mammals

- beaver
- coyote
- mule deer
- muskrat
- raccoon
- weasel
- western harvest mouse

Reptiles

- side-blotched lizard
- western garter snake

Terrestrial Vegetation

- black cottonwood
- dense sedge
- ferns
- reed canary grass
- rushes
- white mulberry

See Section 4.1 and Appendix I-C.

Human Exposure Scenarios

Industrial/Commercial Scenarios

- industrial worker
- fish hatchery worker

Wildlife Refuge/Wild and Scenic River Scenarios

- ranger
- avid recreational visitor
- casual recreational visitor

Native American Scenarios

- subsistence resident
- upland hunter
- river-focused hunter and fisher
- gatherer of plant materials
- Columbia River island user

General Population Scenarios
- resident
- agricultural resident

See Section 5.1 and Appendix I-E.

1.3 Approach

To best represent the current environmental conditions and state of knowledge relative to contaminant concentrations in the Columbia River, the study area was divided into 27 segments along the river. The segmentation also provides meaningful information that is associated directly with the site operable units (that is, specific areas designated for cleanup) and that will be useful in evaluating future remedial actions. The screening assessment estimated risk to the environment and humans consistently for each segment by using the 1) data showing the current level of each contaminant, 2) data for each species, and 3) parameters developed for each human scenario.

The approach to estimating risk to the environment and humans began by determining which contaminants should be evaluated in the screening assessment. Contaminants were selected before data were gathered, so the data-gathering efforts were focused on the specific contaminants to be screened in the assessment.

The 560 contaminants that could possibly be associated with past Hanford operations were evaluated. This contaminant identification process, described in Section A.2, was based on a preliminary review of easily available records, environmental measurements, and process knowledge. The initial list contained nearly 100 possible environmental contaminants. Although a considerable effort was expended to compile this list, its use was to focus the remaining data gathering on only contaminants of greatest interest. Therefore, not all possible available measurements are included. Refinements are described below.

The initial list of potential contaminants was screened (using a multi-stage screening process described in Section A.3) to a manageable number of contaminants likely to produce the greatest environmental or human health risk. This process was based on a set of simple exposure equations for people and biota. The final list was established to provide reasonable assurance that the preponderance of the risk addressed for humans was either toxicity or long-term carcinogenicity and for other species either acute toxicity or long-term survival. Additional considerations were given to known sources of radiation and radioactive materials.

The contaminants assessed fall into one of three categories: carcinogenic chemicals, toxic chemicals, and radionuclides. Carcinogenic chemicals are those that cause or promote cancer. Toxic chemicals are those that in relatively small doses either kill or seriously impair the functions of organs or tissues. Radionuclides are radioactive isotopes that have cancer-inducing properties. The selection of contaminants is described in Section 2.0 and Appendix A.

Because the three categories of contaminants result in different types of risk, the estimates for each category are reported differently. The estimates for carcinogenic chemicals are reported as the probability of the incidence for cancer. The estimates for toxic chemicals are reported as a ratio between the reference dose determined by the U.S. Environmental Protection Agency (EPA) to be safe and the exposure dose that has been estimated. The estimates for radionuclides are reported as the risk of cancer fatality.

Although the primary focus was on the Columbia River and its associated riparian zone, the potential for influx of contaminants via groundwater through seeps and springs was addressed by relying on additional measurements of the potential contaminants in groundwater some distance inland from the river shoreline. Depending on the availability of groundwater measurements, this distance varied up to 0.8 kilometer (0.5 mile) in from the river, with the larger distance corresponding to areas with fewer measurements.

A detailed search for environmental measurements was made. Hanford and non-Hanford sources were queried, including Hanford contractors, local municipalities, the States of Washington and Oregon, and federal agencies. Data were collected for measurements in the surface water of the Columbia River itself, river sediment, seeps and springs within the Hanford Reach, and Hanford Site groundwater. Only relatively current data were used, defined as being within the period from 1990 to present (June 1996), to avoid evaluating problems that no longer exist. A large database was prepared. However, for many of the contaminants of interest in many locations, measurements have not been made. For these cases, a series of surrogation and extrapolation rules was devised, as described in Section 3.5.1. (Where use of these approximations identified a contaminant of potential hazard, the use of the substitute values is highlighted to indicate the need for further confirmatory measurements.) The final database is much larger and better substantiated than that used in the initial selection of contaminants for consideration, but it is limited to those selected for evaluation.

At the same time that the data were being gathered, the CRCIA Team established the indicators that would be used to judge the degree of hazard. For the ecological risk assessment, this consisted of defining a set of indicator species that would be compared against toxicological benchmarks. The selection of these indicator species is defined in Section 4.1. For the human risk assessment, a suite of 12 human exposure scenarios was prepared. These are described in Section 5.1. Individual calculations for each of these scenarios are compared with both toxicity and carcinogenicity indices.

Computational models were developed for all of the ecological species and human scenarios. A computational model is the tool used to produce quantitative results. It includes the algorithms and input data implemented on a computer to produce a solution. The computerized models and their parameters are described in Sections 4.2 and 5.2 and in the appendices. The models were tested and verified before they were used.

At the direction of the CRCIA Team, we calculated the equations using two methods: deterministic and stochastic.

- **A deterministic analysis is a single calculation performed with a single value selected for each parameter. In a deterministic analysis, a single (conservatively high) data value is used to represent the existing condition. For example, for someone who works in the 100-D Area and ingests soil contaminated with lead, we would narrow the various levels of lead measured in the soil at the 100-D Area (Segment 7) down to one representative value and then apply that value to the ingestion rate near the upper bound for a worker. The ingestion rate of soil has several parameters: rate of intake, the frequency of exposure, and the duration of exposure. In a deterministic calculation, PNNL in conjunction with the CRCIA Team selected each of these parameters to help establish a reasonable maximum exposure.**

- **A stochastic analysis involves a set of calculations performed over the range of parameters. In a stochastic analysis, the entire range of data values is used. Using the worker in the 100-D Area again as an example, for a stochastic analysis, we would use all the various levels of lead measured in the soil at the 100-D Area (Segment 7) and apply them simultaneously across the range of parameters for ingesting soil. This is a repetitive process because the values for each parameter are paired randomly with values for each of the other parameters. The entire set of resulting answers defines the possible results.**

The data gathered about environmental levels of contaminants showed variability among and within both environmental media and individual river segments. In addition, almost all of the many parameters used in the ecological and human exposure and risk calculations have uncertainty. This implies that any of the calculated results also have considerable variability and uncertainty. Therefore, the results were calculated in a way that incorporates these uncertainties. First, the calculations were performed with single conservative values for the parameters (tending to give larger exposures) that gave conservative results. This portion of the analysis is called deterministic. Then, a stochastic analysis was performed in which all possible combinations of the parameter values were evaluated, and an output distribution rather than a single value was performed. For the human risk calculations, both deterministic and stochastic calculations are available for all contaminants in all river segments. For the ecological risk analysis, the deterministic calculations were performed for all species/contaminant/segment combinations, but the stochastic calculations were only performed for those combinations where any risk appeared to be possible.

One benefit in using the stochastic calculations was that it enabled the results to be subjected to statistical comparisons. In these comparisons, the concentrations and resulting risk of the contaminants in each Hanford-influenced river segment could be compared with those in a river segment upstream, one supposedly not influenced by Hanford releases. These comparisons gave insight into the nature and magnitude of the incremental risk posed by Hanford releases.

The initial reports on the selection of contaminants, data, species, and scenarios for the screening assessment were published as drafts and submitted for review by external technical reviewers, the CRCIA Team, and the public. The comments received on those draft reports were taken into consideration in the final selection of contaminants, data, species, and scenarios to be used in the screening assessment. The following sections on contaminants (Section 2.0), data (Section 3.0), species (Section 4.1), and scenarios (Section 5.1) now reflect the changes that resulted from the comments.

In addition to this revised information, Part I also contains new information. This new information provides the results of the screening assessment of potential risk posed by exposure of species (Section 4.2 and Appendix I-D) and humans (Section 5.2 and Appendixes I-E and I-F) to the contaminants selected for study. Section 6.0 provides a synthesis of the results, and Section 7.0 provides the screening assessment's references.

When numbers are very large or very small, we present them using scientific notation. Scientific notation is 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 the number. For example, if the value given is 2E+03 (2.0 x 10^3), move the decimal point three numbers (insert zeros if no numbers are given) to the right of its present location. The number would then read 2,000. If the value given is 2E-05 (2.0 x 10^{-5}), move the decimal point five numbers to the left of its present location. The result would become 0.00002.

Supporting information relative to the respective sections and appendixes has been published on diskettes, which are being issued with limited distribution. This report, including the diskettes and updated version of Volume II (Miley et al. 1997), are available on the Internet at http://www.hanford.gov/crcia/crcia.htm.