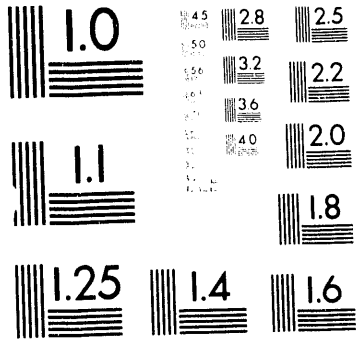
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BN-SA-3799 HEDR

SOFTWARE REQUIREMENTS SPECIFICATIONS

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July 1993

Presented at the
Technical Steering Panel Meeting
July 15-17, 1993
Post Falls, Idaho

Prepared for
the U.S. Department of Energy
Contract DE-AC06-76RLO 1830

Pacific Northwest Laboratory
Richland, Washington 99352

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AUG 09 1993

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1.0 General Requirements

All software shall allow for the semi-automated transfer of data from one module to the next. No manual manipulation of data shall be done.

2.0 Quality Assurance Requirements

2.1 The software development and design shall be subject to the quality assurance (QA) requirements in the Hanford Environmental Dose Reconstruction (HEDR) Project QA plan (QAP #OHE-003, Rev. 5, dated 7/21/92) and the Battelle, Pacific Northwest Laboratories (BNW) Software Control Procedures (SCP) in PNL-MA-70.

2.2 Any software and/or data acquired from other sources shall be formally tested and accepted according to BNW Software Control Procedures (SCP) in PNL-MA-70.

2.3 The software shall log names and versions of files used, data identification labels, version of the software, and any other information needed to provide complete traceability of the output.

2.4 The software generated by HEDR Project staff shall be documented with the following items:

a. Software development plan (SDP)
b. Software design document (SDD)
c. Interface requirements specification (IRS)
d. Data dictionary (DD)
e. Configuration management plan (CMP)
f. Users' guide (UG)
g. Module development folders (MDF)
h. Software requirements specification (SRS)
i. Software test plan (STP)
j. Software test results (STR)

2.5 The software generated by HEDR Project staff shall be subjected to the following HEDR internal reviews:

a. Software design review
b. Code walk-through
c. Final internal development review
d. Independent testing review
e. Operational readiness review

Requirements for each review shall be identified in the SDP.

3.0 Source Term Module

3.1 The software shall operate on the HEDR Sun 690 platform.

3.2 The software shall provide a procedure to allow operation by a trained non-developer through the use of script or text-control files.

3.3 The software shall support stochastic calculations for gross beta, sodium-24, phosphorus-32, scandium-46, chromium-51, manganese-56, zinc-65, gallium-72, arsenic-76, yttrium-90, iodine-131. and neptunium-239.

3.4 The source term data should be in units of curies (Ci) per month discharged from each reactor area retention basin as the discharge enters the Columbia River.

3.5 Source term data shall be calculated monthly for the period September 1944 through January 1971 inclusive, for a total of 317 months.

3.6 Source term data shall be provided to the river transport code for seven radionuclides: sodium-24, phosphorus-32, scandium-46, chromium-51, zinc-65, arsenic-76, and neptunium-239. Data shall be provided for the months January 1950 through January 1971 for a total of 253 months. The data shall be in the form of monthly average discharges for each of the eight single-pass reactors.

3.7 For the purpose of estimating uncertainty, 100 realizations of the source term model predictions (curies/month) for each month, reactor, and radionuclide shall be obtained using Monte Carlo simulation methods.

3.8 The source term discharge data for each realization should be transferred as eight files, one for each reactor, containing the monthly data for each of the seven radionuclides. The format shall be as follows with one record per line:

Record	Field	Description
1	1	Jan 1950
	2	sodium-24 discharge (Ci)
	3	phosphorus-32 discharge (Ci)
	4	scandium-46 discharge (Ci)
	5	chromium-51 discharge (Ci)
	6	zinc-65 discharge (Ci)
	7	arsenic-76 discharge (Ci)
	8	neptunium-239 discharge (Ci)
2	1	Feb 1950
.		
.		
.		
253	8	neptunium-239 discharge (Ci)

3.9 The data shall be in a human-readable format (ASCII).

3.10 The software shall provide the capability to generate random numbers from the following statistical distributions:

a. Uniform
b. Piecewise uniform
c. Discrete uniform
d. Loguniform (base 10 and base e)
e. Normal
f. Lognormal (base 10 and base e)
g. Triangular
h. Constant

Generation of values from the normal and lognormal distributions shall be truncated at the tail probabilities of 0.01 and 0.99.

3.11 The software shall provide the capability to generate all random numbers using a stratified sampling technique.

4.0 River Transport Module

4.1 The software calculations shall implement the CHARIMA (CHArriage des RIvieres MAillees) computer model as documented in:

> Holly, F. M., Jr., J. C. Yang, P. Schwarz, J. Schafer, S. H. Hsu, and R. Einhellig. 1990. Numerical Simulation of Unsteady Water and Sediment Movement in Multiply Connected Networks of Mobile-Bed Channels. IIHR Report No. 343, Iowa Institute of Hydraulic Research, University of Iowa, Iowa City, Iowa.

4.2 The software shall operate on an IBM compatible personal computer.

4.3 The software shall provide a procedure to allow operation by a trained non-developer through the use of script or text-control files.

4.4 The software shall calculate average cross-section concentrations of sodium-24, phosphorus-32, scandium-46, chromium-51, zinc-65, arsenic-76, and neptunium-239 in Columbia River water.

4.5 The software shall be designed to produce monthly average concentrations of cross sections of Columbia River water. The cross sections shall be representative of each of 12 river segments for each radionuclide. The segment names and approximate locations are as follows:

a. Ringold (below reactor areas to N. Richland)
b. Richland (N. Richland to mouth of Yakima River)
c. Kennewick/Pasco (Yakima River to Snake River)
d. Snake/Walla Walla Rivers (Snake River to Walla Walla River)

e. Umatilla/Boardman (Umatilla River to Boardman, Oregon)
f. Arlington (Arlington, Oregon vicinity)
g. John Day Dam/Biggs (John Day River to Biggs Junction, Oregon)
h. Deschutes River (mouth of Deschutes River vicinity)
i. The Dalles/Celilo (Dalles/Celilo vicinity)
j. Klickitat River (Klickitat River mouth vicinity)
k. White Salmon/Cascade Locks (White Salmon River to Bonneville Dam)
l. Lower River (Bonneville to Columbia River mouth)

4.6 The software shall accept data from the source term module (see requirement 92, 196 above). These data shall be in units of curies (Ci) per month for each radionuclide discharged from the retention basin of each reactor as the discharge enters the Columbia River.

4.7 The software shall produce monthly arithmetic average concentrations of Columbia River water for the specified months, locations, and radionuclides. The concentrations are to be the average cross-section concentrations including sediment corrections but not plume corrections.

4.8 Plume-correction factors shall be estimated for three locations. The correction factors are the average shoreline concentrations relative to the average river water cross-section concentrations. An ASCII file with the correction factors by month (253 months) for each location shall be provided for dose calculations. The factors are to be estimated at the following locations:

a. East shoreline at Ringold
b. West shoreline at Richland pumping station
c. North shoreline at Pasco pumping station

4.9 The CHARIMA model shall operate in a deterministic mode meaning the parameters of the model shall be considered to be known with certainty. The rationale for this approach shall be demonstrated by evaluating the uncertainty of CHARIMA model output using limited Monte Carlo computer simulations or by using a limited set of possible combinations of parameter values.

4.10 The CHARIMA model shall be run for each of the 100 realizations of the source term produced by the source term model.

4.11 Uncertainty in river transport shall be represented by the multiple runs of the CHARIMA model with different possible input values for transport related parameters and a unit source term.

5.0 Environmental Accumulation Data

5.1 Bioconcentration factors shall be produced that are dependent upon radionuclide, season, and species of organism. The bioconcentration factors shall be used to estimate the radionuclide concentration in the edible meat of a particular organism based on the modelled average concentrations of cross sections of Columbia River water including sediment effects. Data specific to the Columbia River for water and organisms shall be used to develop the factors. If no differentiation in bioconcentration factors by species and/or season is noted in the available

data, then bioconcentration factors that are applicable to more than one season or species shall be prepared. If no data are available for the Columbia River, the literature values shall be used. A minimum of 5 (radionuclide dependent, species and season independent) and a maximum of 100 (radionuclide, species, season dependent) bioconcentration factors shall be prepared. Factors shall be prepared for the following organisms:

a. Omnivores (whitefish, bullhead, catfish, sturgeon, carp, suckers)
b. First order predators (bluegill, perch, crappie)
c. Second order predators (trout, bass)
d. Waterfowl (harvested species only)

The bioconcentration factors shall be provided for five radionuclides: sodium-24, phosphorus-32, zinc-65, arsenic-76, and neptunium-239. The bioconcentration factors are to be dependent on season where applicable data exist. The following five seasons are to be considered:

a. Winter (Jan/Feb/Mar)
b. Spring (Apr/May)
c. Summer (Jun/Jul/Aug)
d. Early fall (Sep/Oct)
e. Late fall (Nov/Dec)

5.2 The bioconcentration factors provided for dose calculations are to be the mean values as derived from the available data. The expected range and distribution for each bioconcentration factor shall be provided but not used in the deterministic dose calculations. The range and distributions shall be used in uncertainty analyses (see requirement 6.3).

5.3 Radionuclide-dependent water-treatment factors are to be prepared for the five individual radionuclides. These factors are the ratio of the average concentration in municipally treated drinking water to the average river water cross-section concentrations. These factors shall be developed for the time period of concern, 1950 to 1971, but will not be time or location dependent. These factors shall be used to estimate realistic drinking-water concentrations from the average river water cross-section concentrations including plume effects.

5.4 Factors shall be prepared that account for the probability that any given waterfowl became contaminated from the Columbia River. The probability factor shall be location-dependent only and shall be multiplied by the location-dependent average water cross-section concentration and by the waterfowl bioconcentration factor to estimate the concentration of each radionuclide in the edible portions of birds taken by hunters. The probability factor shall be developed using regional environmental monitoring data collected in the 1960s.

5.5 Annual average media concentrations shall be estimated using available source term and environmental monitoring data. Factors that relate the annual average radionuclide discharge from all reactors for a given radionuclide to the measured media concentrations shall be developed. Ratios of annual average media concentrations to annual radionuclide discharges shall be estimated for the following media and radionuclides:

a. Columbia River anadromous fish (zinc-65, phosphorus-32)
b. Willipa Bay shellfish (zinc-65)

The factors shall have the units of pCi/kg (edible media) per Ci/year for each media and radionuclide. The Willipa Bay shellfish factor shall be developed using monitoring data for clams, oysters, and crabs sampled from Willipa Bay.

6.0 Environmental Accumulation and Dose Module

6.1 The software shall operate on an IBM compatible personal computer.

6.2 The software shall run in a deterministic mode only.

6.3 In addition to the deterministic dose calculations, uncertainty analyses shall be done with an automated tool (computer software) such as Crystal Ball®.

6.4 The software shall be in the form of a spreadsheet or other simple programming language.

6.5 The software shall support deterministic environmental accumulation and dose calculations for five radionuclides: sodium-24, phosphorus-32, zinc-65, arsenic-76, and neptunium-239.

6.6 The software shall be designed to produce intermediate data that include average radionuclide concentrations in key environmental media for each month and location.

6.7 The software shall not implement a production and/or distribution network for any media.

6.8 Physical locations shall be specified by river segment. Up to 12 river segments shall be supported. Doses from consumption of media from two other locations shall be supported. These other media/location pairs are shellfish from Willipa Bay and anadromous fish caught at any location in the Columbia River.

6.9 The environmental accumulation software shall be able to accept information from CHARIMA in monthly time steps.

6.10 The environmental accumulation software shall provide an environmental accumulation database to the dose code for monthly intervals. Environmental accumulation estimates shall be made for the following media for each river segment, month and radionuclide:

a. Omnivores (whitefish, bullhead, catfish, sturgeon, carp, suckers)
b. First Order Predators (bluegill, perch, crappie)
c. Second Order Predators (trout, bass)
d. Waterfowl (harvested species only)
e. Untreated river water
f. Treated river water

6.11 Annual average media concentrations for the following media shall be estimated for the indicated radionuclides:

a. Columbia River anadromous fish (zinc-65, phosphorus-32)
b. Willipa Bay shellfish (zinc-65)

The concentrations shall be developed using the procedure described in requirement 92, 196 above.

6.12 The software shall be able to calculate doses for reference individuals.

6.13 The dose software shall function internally on a monthly time step.

6.14 The dose software shall utilize environmental concentration values from each river segment. Each dose calculation shall be based on an individual's consumption of water, fish, and waterfowl from only one primary location.

6.15 The dose software calculations shall account for holdup times (decay between collection and consumption). The estimated dose for any month shall include the consumption of all fish caught that month including fish that are held for more than one month.

6.16 The dose software shall calculate doses to all river segments simultaneously.

6.17 The dose software shall calculate doses for all months simultaneously.

6.18 The dose software shall allow the selection of exposure and consumption rates by month of the year for the following media:

a. Columbia River use (hours/year)
b. Untreated drinking water (l/day)
c. Treated drinking water (l/day)
d. Resident fish (omnivore) ingestion (g/day)
e. Resident fish (1st predator) ingestion (g/day)
f. Resident fish (2nd predator) ingestion (g/day)
g. Waterfowl ingestion (g/day)
h. Willipa Bay shellfish ingestion (g/day)
i. Columbia River anadromous fish (salmon/steelhead) ingestion (g/day)

6.19 The dose software shall report doses on an annual basis.

6.20 The dose software shall report cumulative doses over the entire time period.

6.21 The dose software shall be able to report doses to the red bone marrow, lower large intestine and effective dose for the following pathways:

a. External
b. Drinking water ingestion
c. Resident fish ingestion
d. Shellfish ingestion
e. Anadromous fish (salmon/steelhead) ingestion
f. Waterfowl ingestion
g. Total overall pathways

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